Appendix F

Water & Air Research, Inc. 2010. Mollusc survey of the Homosassa River; Purchase Order #08POSOS1805. Gainesville, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Erratum: *Geukensia demissa is misspelled on page 3 and in Table 6.*

Mollusc Survey of the Homosassa River

Purchase Order # 08POSOW1805

Prepared for

Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34604-6899

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Contents

1.0 Introduction

The Southwest Florida Water Management District (SWFWMD) is responsible for establishing minimum flows and levels (MFLs) in water bodies of the District to ensure that water withdrawals do not pose significant harm to aquatic resources and the ecology of the area. Water & Air Research, Inc. (Water & Air) was retained by SWFWMD to provide qualitative and quantitative mollusc data to augment quantitative benthic infauna data reported by Grabe and Janicki (2009).

2.0 Methods

Rapid-survey methods were employed on September 30 and October 1, 2008 to census the macro-mollusc communities of the Homosassa River, Florida. The Homosassa River was sampled at transects established at various intervals from river kilometer (RK) 7.5 to the head springs areas. Molluscs were sampled at 5 transect locations: RK 7.5, RK 10.5, and RK 12.0, plus one transect in the northwest fork of the Homosassa spring head, and one transect in the southeast fork of the Homosassa spring head (Figure 1). In addition to the collection of quantitative samples along transects, qualitative samples were collected in the lower portion of the river (Figure 2). Locations of live oyster beds were mapped from the river mouth to their upstream extent (Figure 2). GPS coordinates were recorded to mark the location of oyster beds and mollusc sampling locations (Table 1).

Because the primary objective of the study is to identify patterns in species spatial distribution, samples were collected across each transect at representative sites. Raw data from each sampling point within a given transect were reviewed to discern any patterns in species distribution that may be related to measured and observed environmental conditions (e.g., water depth, habitat type). The data were pooled for each entire transect to summarize results. All transects were established in single-channel reaches.

Collection of intertidal samples was biased by two criteria. First, accreting banks were selected over eroding ones, meaning, in practice, that the insides of bends were preferred over outsides, and samples were collected more from point-bars, marsh islands, and shoals than from steeply inclined banks. Second, a sampling preference was given for the bank judged to be least altered by human activity. Sea walls and filled areas were avoided where possible.

Subtidal samples (< Mean Low Water) were collected using a petite Ponar grab (0.0232 square meters). Three samples were collected along each transect, one near each shoreline and one from a mid-channel location, yielding a total sampling surface area of 0.0696 square meters per transect. Contents of each sample were concentrated over a 3.0 millimeter sieve and processed in the field. Live specimens were identified, counted, and released in the field, when practical. Dead specimens were collected and identified in the laboratory. Representative of live specimens of unknown taxa were contained and placed on ice, or relaxed with magnesium sulfate and then preserved in 10% formalin, and returned to Water & Air biological laboratory for identification.

Three intertidal samples (> Mean Low Water) were collected by spade at Station RK 7.5 with each sample having an area approximately equal to the sampling area of a petite Ponar dredge (0.0232 square meters), yielding a total sampling area of 0.0696 square meters. Intertidal areas at transects upstream of RK 7.5 consisted of vertical banks. Vertical banks within the intertidal zone were not sampled quantitatively, but were inspected for presence of molluscs. Intertidal habitats, including needle rush (*Juncus roemerianus*), mangroves (*Rhizophora mangle*), submerged logs, and limestone, were carefully inspected for rare and cryptic species such as the mussels, oysters, and gastropods which were collected by hand or dip net and recorded or preserved separately from the spade and petite Ponar samples. In addition to the transect locations shown in Figure 1, molluscs were collected qualitatively from the lower portion of the river at locations indicated in Figure 2.

In situ water quality data were collected at each site where mollusc samples were collected, except in intertidal areas where sediments were exposed. Water quality data consisted of meter readings of water temperature, specific conductance, pH, and salinity at the surface, bottom, and at one-meter intervals in between. Mid-column measurements were collected where water depth was less than one meter.

3.0 Results and Discussion

3.1 Water Column Physico-chemical Data

Salinity and dissolved oxygen at the water surface and bottom varied at RK 10.5, RK 12.0, and Spring head of NW run, indicating stratification (Table 2). In contrast, RK 7.5 and the SE run spring head appeared well mixed.

Mean water column salinity ranged from 0.42 ppt at SE Run spring head to 13.83 ppt at RK 7.5 (Table 3). Mean water column dissolved oxygen ranged from near 7 mg/L at the SE and NW spring heads to 11.5 mg/L at RK 10.5. Water column profile measurements were collected at different times during the day. Observed differences between the sites may simply be a result of diurnal (daily temporal) fluctuations in dissolved oxygen, rather than true spatial patterns oxygen availability. Throughout the study area, mean water column pH ranged from 7.21 to 7.80.

3.2 Oyster Beds

Approximate locations of live oyster beds observed in September 2008 are shown in Figure 2. Oyster bars were defined as intertidal mounds of living oysters and dead shell. Three oyster bars were observed in the river channel occurring within 1.3 km of the river mouth. Oyster bar #1 was located at RK 0.1 closest to the mouth of the river, and oyster bar # 3 was located farthest upstream at RK 1.3 (Figure 2; Table 4).

Although live oyster beds were not observed in the upper reaches of the Homosassa during the current survey, Grabe and Janicki (2009) reported presence of oysters in dredge samples between RK 4 and RK 9.

3.3 Mollusc Distribution

Live and dead molluscs collected quantitatively in the subtidal and intertidal zones by spade and petite Ponar dredge are presented in Table 5. Living specimens of *Polymesoda caroliniana*, *Mytilopsis leucophaeta*, and hybrobiid snails were collected in low densities (14 to 29 per square meter). Bivalve and gastropod dead shells collected in the dredge samples indicate the possible presence of a more abundant and diverse mollusc fauna historically. Other living benthic invertebrate fauna collected by dredge included polychaetes, oligochaetes, crustaceans, and insects listed in Table 5.

Qualitative collections are presented in Table 6. Oysters (*Crassostrea virginica*) were observed attached to limestone and submerged dead wood and *Guekensia demissa* were attached to a submerged dead palm log at RK 6.2. The snails, *Cerithidea scalariformis*, *Littorina irrorata*, and *Melampus coffeus*, were observed attached to needlerush in the intertidal zone. *L. irrorata* was also observed on red mangrove roots. Crown conch (*Melongena corona*) was found attached to limestone at RK 1.3.

Mollusc raw counts for dredge and spade samples are provided in unpooled and pooled form in Tables 7 and 8, respectively.

In comparison to the current survey, Grabe and Janicki (2009) reported presence of a more diverse and more abundant living mollusc fauna in Young-modified Van Veen dredge samples collected in May 2008. A larger number of samples was collected in May 2008 (104 samples, each with 0.04 square-meter sample area) than in August/September 2008 (18 samples, each with a 0.0232 square-meter sample area). The difference in level of sampling effort may, in part, explain the collection of a higher number of mollusc taxa in May 2008.

4.0 Conclusions

Qualitative observations of dead shells during the current study indicated that, historically, the Homosassa River mollusc fauna may have been more diverse and abundant than the living fauna collected at the time of this survey. Mollusc data collected in May 2008 by Janicki and Grabe (2009) also documented presence of a more diverse and more abundant living mollusc assemblage than is suggested by less robust sampling performed in August/September 2008. Influencing factors that may have lead to the ***apparent*** reduction in diversity and abundance are not well understood. A sampling design more robust than the current study may be required to gain a better understanding of temporal and spatial distribution of molluscs in the Homosassa River.

5.0 References

Grabe, S.A., A. Janicki. 2009. Characterization of Macroinvertebrate Communities of the Homosassa and Hall's Rivers. Purchase Order # 07PO0001718. Report Prepared by Janicki Environmental, Inc. for the Southwest Florida Water Management District.

Figures

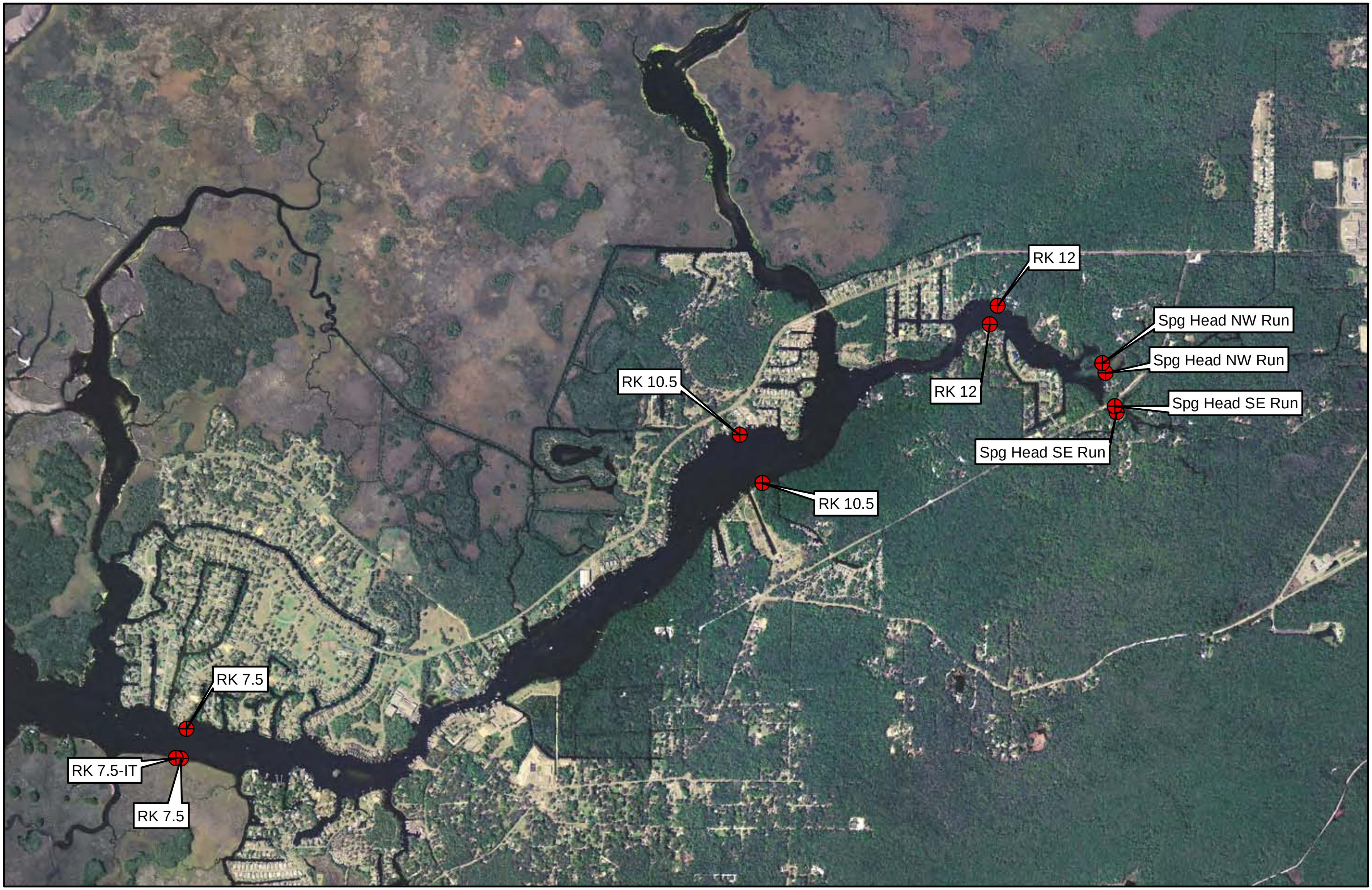

Figure 1.
Transect Sampling Locations in the Upper Homosassa River

Source: LABINS, 2004; Water & Air Research, Inc., 2010.

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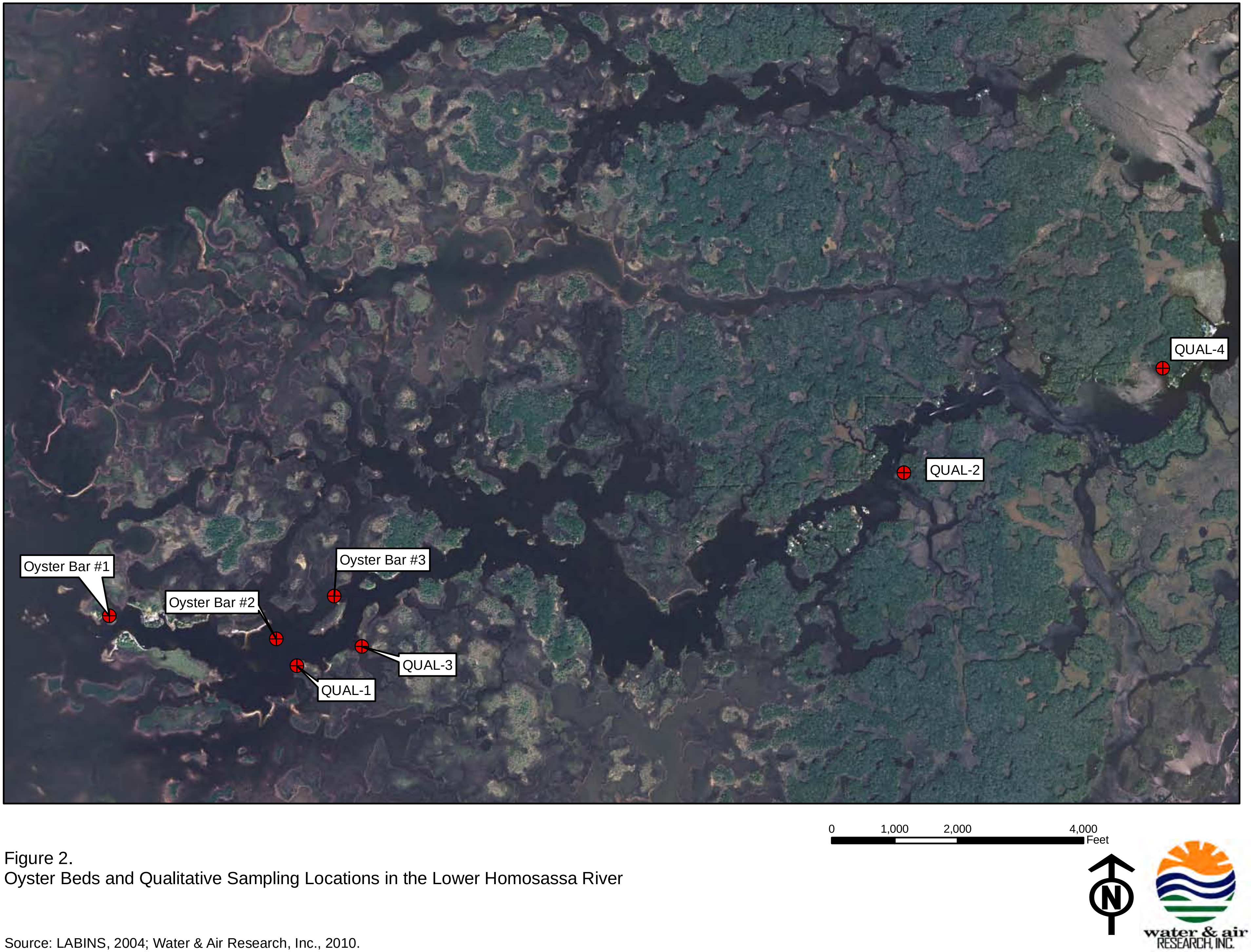

Figure 2.
Oyster Beds and Qualitative Sampling Locations in the Lower Homosassa River

Source: LABINS, 2004; Water & Air Research, Inc., 2010.

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Tables

Table 1. Coordinates of Mollusc Survey Sampling Locations, Homosassa River, September 30 - October 1, 2008

Sampling Site Name	Apprx. RK	Type of Sample	Position (decimal degrees)
003 (Live oyster bed)	0.1	Qualitative	N28.77134 W82.69496
004 (Live oyster bed)	0.6	Qualitative	N28.77044 W82.68665
QUAL-1	1.0	Qualitative	N28.76927 W82.68562
QUAL-3	1.3	Qualitative	N28.77016 W82.68240
006 (Live oyster bed)	1.4	Qualitative	N28.77234 W82.68382
QUAL-2	4.7	Qualitative	N28.77807 W82.65564
QUAL-4	6.2	Qualitative	N28.78280 W82.64286
RK 7.5-ST (North end of transect)	7.5	Quantitative	N28.78429 W82.63091
RK 7.5-ST (South end of transect)	7.5	Quantitative	N28.78311 W82.63115
RK 7.5-IT (Intertidal)	7.5	Quantitative	N28.78313 W82.63138
RK 10.5 (North end of transect)	10.5	Quantitative	N28.79624 W82.60621
RK 10.5 (South end of transect)	10.5	Quantitative	N28.79434 W82.60516
RK 12 (South end of transect)	12.0	Quantitative	N28.80074 W82.59504
RK 12 (North end of transect)	12.0	Quantitative	N28.80148 W82.59469
Spg Head NW Run (South end of transect)	13.0	Quantitative	N28.79889 W82.58980
Spg Head NW Run (North end of transect)	13.0	Quantitative	N28.79926 W82.58995
Spg Head SE Run (South end of transect)	13.2	Quantitative	N28.79733 W82.58929
Spg Head SE Run (North end of transect)	13.2	Quantitative	N28.79756 W82.58936

Table 2. Physical and Chemical Vertical Profile Data, Homosassa River, Florida

Station	Date	Time	Depth (m)	Temperature (C)	pH	Specific Conductance (umho/cm)	Salinity (ppt)	Dissolved Oxygen (% Sat.)	Dissolved Oxygen (mg/l)	Total Water Depth (m)
RK 7.5 -ST1	9/30/2008	1000	1.25	26.33	7.61	24469	14.82	107	7.95	2.5
RK 7.5 -ST2	9/30/2008	1020	0.10	26.27	7.53	20499	12.28	121	9.08	2
RK 7.5 -ST2	9/30/2008	1023	1.00	26.33	7.60	23185	13.97	110	8.20	2
RK 7.5 -ST2	9/30/2008	1025	2.00	26.37	7.60	25692	15.58	102	7.53	2
RK 7.5 -ST3	9/30/2008	1039	0.50	26.26	7.62	20930	12.50	117	8.77	1
RK10.5 -ST1	9/30/2008	1454	0.75	26.52	7.65	9973	5.61	179	13.94	1.25
RK10.5 -ST2	9/30/2008	1507	0.10	27.08	7.89	7949	4.60	161	12.55	2
RK10.5 -ST2	9/30/2008	1509	1.00	26.43	7.84	9879	5.54	154	12.06	2
RK10.5 -ST2	9/30/2008	1511	2.00	26.74	7.37	16945	9.94	91	6.90	2
RK10.5 -ST3	9/30/2008	1523	0.50	26.37	7.87	7434	4.11	154	12.06	1
RK 12-ST1	9/30/2008	1604	0.90	25.19	8.01	4340	2.31	159	12.89	1.8
RK 12-ST2	9/30/2008	1616	0.10	25.44	7.82	1898	0.96	130	10.60	3.5
RK 12-ST2	9/30/2008	1618	1.00	24.48	7.66	4154	2.20	127	10.45	3.5
RK 12-ST2	9/30/2008	1620	2.00	26.05	8.05	7949	4.40	183	14.46	3.5
RK 12-ST2	9/30/2008	1622	3.00	26.34	7.76	12264	7.01	136	10.53	3.5
RK 12-ST2	9/30/2008	1624	3.50	26.35	7.63	12003	7.01	90	6.93	3.5
RK 12-ST3	9/30/2008	1635	0.85	24.62	7.68	3890	2.12	128	10.58	1.7
Spg Head SE Run-ST1	10/1/2008	1005	1.00	23.22	7.27	858	0.42	79	6.74	2
Spg Head SE Run-ST2	10/1/2008	1025	0.10	23.38	7.52	815	0.40	91	7.76	1
Spg Head SE Run-ST2	10/1/2008	1027	0.50	23.32	7.54	836	0.41	90	7.59	1
Spg Head SE Run-ST2	10/1/2008	1029	1.00	23.31	7.54	848	0.42	87	7.38	1
Spg Head SE Run-ST3	10/1/2008	1036	0.45	23.49	7.60	898	0.45	88	7.44	0.9
Spg Head NW Run- ST1	10/1/2008	918	0.75	22.97	6.82	2967	1.66	84	7.06	1.5
Spg Head NW Run- ST2	10/1/2008	932	0.10	22.90	7.25	1679	0.85	83	7.06	1.8
Spg Head NW Run- ST2	10/1/2008	934	1.00	23.10	7.24	3513	1.84	86	7.27	1.8
Spg Head NW Run- ST2	10/1/2008	936	1.80	24.99	7.35	7427	4.09	131	10.67	1.8
Spg Head NW Run- ST3	10/1/2008	946	0.85	23.19	7.38	2951	1.54	84	7.08	1.7

Mid-channel profile highlighted in yellow. Additional readings were collected in relatively shallow areas near each river bank.

Table 3. Physical and Chemical Vertical Profile Data - Mean Values, Homosassa River, Florida

Station	Date	Temperature (C)	pH	Specific Conductance (umho/cm)	Salinity (ppt)	Dissolved Oxygen (% Sat.)	Dissolved Oxygen (mg/l)	Total Water Depth (m)
RK 7.5	9/30/2008	26.31	7.59	22955	13.83	111	8.31	2
RK10.5	9/30/2008	26.63	7.72	10436	5.96	148	11.50	2
RK 12	9/30/2008	25.50	7.80	6643	3.72	136	10.92	3.5
Spring Head SE Run	10/1/2008	23.34	7.49	851	0.42	87	7.38	1
Spring Head NW Run	10/1/2008	23.43	7.21	3707	2.00	93	7.83	1.8

Table 4. Locations of Oyster Beds Observed in the Lower Homosassa River

ID	Date	Time	Latitude	Longitude	River Kilometer	Orientation	*Tidal Stage (Feet Above Mean Lower Low Water)	Oyster Bar Submerged / Exposed
1	9/30/2008	11:44	28.77134	-82.69496	0.1	North-South	0.01	Exposed
2	9/30/2008	12:03	28.77044	-82.68665	0.9	North-South	0.05	Submerged
3	9/30/2008	12:48	28.77234	-82.68382	1.3	North-South	0.26	Submerged

* Source of tidal stage data:
http://tbone.biol.sc.edu/tide/tideshow.cgi?site=Tuckers+Island%2C+Homosassa+River%2C+Florida+(sub)&units=f

Table 5. Living Molluscs Densities (No. per Square Meter) and Presence/Absence (X Indicates Presence) of Dead Molluscs and Other Living Invertebrates Collected by Petite Ponar Dredge, Homosassa River, September 30 - October 1, 2008

Taxa	Zone	Subtidal	Intertidal	Subtidal	Subtidal	Subtidal	Subtidal
	River Kilometer	**RK 7.5**	**RK 7.5**	**RK 10.5**	**RK 12.0**	**NW Spring Run**	**SE Spring Run**
	Number of Replicates	3	3	3	3	3	3
Living Molluscs							
	Polymesoda caroliniana	14	0	0	29	0	0
	Mytilopsis leucophaeta	0	0	14	0	0	14
	Hydrobiidae (LPIL)	0	0	0	0	0	14
Dead Molluscs							
Bivalves	*Ischadium recurvum*	x					
	Mytilopsis leucophaeta	x		x	x	x	
	Tellinidae	x					
	cf. Mytilidae	x					
	Polymesoda caroliniana		x	x			
	Corbicula fluminea						x
Gastropods	*Elimia cf. floridensis*		x				
	Melampus coffeus		x				
	Melanoides tuberculata				x	x	x
	Haitia cubensis				x	x	x
	Hydrobiidae					x	
	Micromenetus floridensis						
	Planorbella scalaris					x	x
Other Living Invertebrates							
Polychaetes	*Hobsonia florida*	x					
	Neanthes succinea	x			x	x	
	cf. Dipolydora socialis	x					
Oligochaetes	*Oligochaeta*					x	
Crustaceans	*Hargeria rapax*						
	Leptocheliidae						
	Corophium sp.			x	x	x	x
	Gammarus sp.					x	
	cf. Orchestia sp.		x				
	Cyathura polita	x				x	x
	Rhithropanopeus harrisii	x		x	x		
	Balanomorpha		x				
Insects	*Tipulidae*		x				
	Chironomidae					x	x

Note: Intertidal zones at most transect locations were vertical banks. Quantitative dredge/spade samples could only be collected along transect at RK 7.5.

Table 6. Presence/Absence (X Indicates Presence) of Living Molluscs Collected in Qualitative Samples, Homosassa River, September 30 - October 1, 2008

Taxa	Station	Qual-1	Qual-1	Qual-3	Qual-3	Qual-2	Qual-4
	Habitat	Needlerush	Mangrove	Needlerush	Limestone	Needlerush	Submerged Palm Log
	Approximate River Kilometer	1.0	1.0	1.3	1.3	4.6	6.2
Molluscs							
Bivalves	*Guekensia demissa*						x
	Crassostrea virginica				x		x
	Cerithidea scalariformis	x					
Gastropods	*Littorina irrorata*	x	x	x			
	Melampus coffeus					x	
	Melongena corona				x		

Note: Samples were collected by hand picking organisms attached to various substrates. No molluscs were observed along vertical river banks at transect locations.

Table 7. Raw Counts (Number per Sample) of Living Molluscs and Presence/Absence (X Indicates Presence) of Dead Molluscs and Other Living Benthic Invertebrates Collected by Petite Ponar Dredge, Homosassa River, September 30 - October 1, 2008 - Unpooled Data

Taxa	Zone	Subtidal	Subtidal	Subtidal	Intertidal	Intertidal	Intertidal	Subtidal	Subtidal	Subtidal	Subtidal	Subtidal	Subtidal
	River Kilometer	RK 7.5	RK 7.5	RK 7.5	RK 7.5	RK 7.5	RK 7.5	RK 10.5	RK 10.5	RK 10.5	RK 12.0	RK 12.0	RK 12.0
	Replicate Number	1	2	3	1	2	3	1	2	3	1	2	3
Living Molluscs													
	Polymesoda caroliniana			1							2		
	Mytilopsis leucophaeta							1					
	Hydrobiidae (LPIL)												
Dead Molluscs													
Bivalves	*Ischadium recurvum*	x											
	Mytilopsis leucophaeta	x							x	x	x		x
	Tellinidae	x	x										
	cf. Mytilidae		x										
	Polymesoda caroliniana						x			x			
	Corbicula fluminea												
Gastropods	*Elimia cf. floridensis*				x								
	Melampus coffeus					x							
	Melanoides tuberculata										x		
	Haitia cubensis												x
	Hydrobiidae												
	Micromenetus floridensis												
	Planorbella scalaris												
Other Living Invertebrates													
Polychaetes	*Hobsonia florida*		x										
	Neanthes succinea			x							x		
	cf. Dipolydora socialis			x									
Oligochaetes	*Oligochaeta*												
Crustaceans	*Hargeria rapax*												
	Leptocheliidae												
	Corophium sp.							x		x	x		x
	Gammarus sp.												
	cf. Orchestia sp.					x							
	Cyathura polita			x									
	Rhithropanopeus harrisii			x						x			x
	Balanomorpha					x							
Insects	*Tipulidae*				x								
	Chironomidae												

Note: Intertidal zones at most transect locations were vertical banks. Quantitative dredge/spade samples could only be collected along transect at RK 7.5.
Dead shells and living non-molluscan organisms were not counted.

Table 7 (cont.) Raw Counts (Number per Sample) of Living Molluscs and Presence/Absence (X Indicates Presence) of Dead Molluscs and Other Living Benthic Invertebrates Collected by Petite Ponar Dredge, Homosassa River, September 30 - October 1, 2008 - Unpooled Data

Taxa	Zone	Subtidal	Subtidal	Subtidal	Subtidal	Subtidal	Subtidal
	River Kilometer	NW Spring Run	NW Spring Run	NW Spring Run	SE Spring Run	SE Spring Run	SE Spring Run
	Replicate Number	1	2	3	1	2	3
Living Molluscs							
	Polymesoda caroliniana						
	Mytilopsis leucophaeta						1
	Hydrobiidae (LPIL)				1		
Dead Molluscs							
Bivalves	*Ischadium recurvum*						
	Mytilopsis leucophaeta	x		x			
	Tellinidae						
	cf. Mytilidae						
	Polymesoda caroliniana						
	Corbicula fluminea					x	
Gastropods	*Elimia cf. floridensis*						
	Melampus coffeus						
	Melanoides tuberculata	x		x	x	x	x
	Haitia cubensis			x		x	x
	Hydrobiidae	x					
	Micromenetus floridensis						
	Planorbella scalaris			x	x	x	x
Other Living Invertebrates							
Polychaetes	*Hobsonia florida*						
	Neanthes succinea		x				
	cf. Dipolydora socialis						
Oligochaetes	*Oligochaeta*			x			
Crustaceans	*Hargeria rapax*						
	Leptocheliidae						
	Corophium sp.	x		x		x	
	Gammarus sp.		x				
	cf. Orchestia sp.						
	Cyathura polita		x				x
	Rhithropanopeus harrisii						
	Balanomorpha						
Insects	*Tipulidae*						
	Chironomidae			x		x	

Note: Intertidal zones at most transect locations were vertical banks. Quantitative dredge/spade samples could only be collected along transect at RK 7.5.
Dead shells and living non-molluscan organisms were not counted.

Table 8. Raw Counts (Number per Sample) of Living Molluscs and Presence/Absence (X Indicates Presence) of Dead Molluscs and Other Living Benthic Invertebrates Collected by Petite Ponar Dredge, Homosassa River, September 30 - October 1, 2008 - Pooled Data

Taxa	Zone	Subtidal	Intertidal	Subtidal	Subtidal	Subtidal	Subtidal
	River Kilometer	RK 7.5	RK 7.5	RK 10.5	RK 12.0	NW Spring Run	SE Spring Run
	Number of Pooled Replicates	3	3	3	3	3	3
Living Molluscs							
	Polymesoda caroliniana	1			2		
	Mytilopsis leucophaeta			1			1
	Hydrobiidae (LPIL)						1
Dead Molluscs							
Bivalves	*Ischadium recurvum*	x					
	Mytilopsis leucophaeta	x		x	x	x	
	Tellinidae	x					
	cf. Mytilidae	x					
	Polymesoda caroliniana		x	x			
	Corbicula fluminea						x
Gastropods	*Elimia cf. floridensis*		x				
	Melampus coffeus		x				
	Melanoides tuberculata				x	x	x
	Haitia cubensis				x	x	x
	Hydrobiidae					x	
	Micromenetus floridensis						
	Planorbella scalaris					x	x
Other Living Invertebrates							
Polychaetes	*Hobsonia florida*	x					
	Neanthes succinea	x			x	x	
	cf. Dipolydora socialis	x					
Oligochaetes	*Oligochaeta*					x	
Crustaceans	*Hargeria rapax*						
	Leptocheliidae						
	Corophium sp.			x	x	x	x
	Gammarus sp.					x	
	cf. Orchestia sp.		x				
	Cyathura polita	x				x	x
	Rhithropanopeus harrisii	x		x	x		
	Balanomorpha		x				
Insects	*Tipulidae*		x				
	Chironomidae					x	x

Note: Intertidal zones at most transect locations were vertical banks. Quantitative dredge/spade samples could only be collected along transect at RK 7.5.
Dead shells and living non-molluscan organisms do not have counts associated.

Appendix G

Culter, J.K. 2010. Evaluation of the spatial extent, density and growth rates of barnacles in Crystal, Homosassa and Withlacoochee Rivers, Florida. Mote Marine Laboratory. Sarasota, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

EVALUATION OF THE SPATIAL EXTENT, DENSITY, AND GROWTH RATES OF BARNACLES IN THE CRYSTAL, HOMOSASSA AND WITHLACOOCHEE RIVERS, FLORIDA

Technical Report Submitted to:

Southwest Florida Water Management District
2379 Broad St.
Brooksville, FL. 34604-6899

Submitted by:
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Photo. Balanus and a polychaete worm tube on an artificial substrate.

Photo. Balanus illustration by Darwin.

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I. INTRODUCTION

Early naturalists considered barnacles to be members of the Phylum Mollusca. It wasn't until 1819 that the Cirripedia were determined to be crustaceans. Charles Darwin produced a monograph on the Balanidae (the sessile Cirripedes) which was published in 1884. In the Introduction of this volume Darwin comments that there is considerable variation in the barnacle shell lamenting that "*...I have enlarged on this subject and have shown that there is scarcely a single external character which is not highly variable in most of the species."* The morphological plasticity of the barnacle seems to emulate the physiological tolerance of wide salinity ranges. Within the arthropods the thoracic Cirripedia (barnacles) are quite unique comprising one of only three arthropod groups that have developed the ability to retain and build up portions of the exoskeleton of the carapace while frequently molting the exoskeleton of the rest of the body (Newman et al. 1965).

The Southwest Florida Water Management District (District) had been receiving complaints of barnacle infestation on boats and pilings within the Homosassa and Crystal Rivers. This provided an opportunity to document distributional changes in the fouling community of the tidal portions of three river systems with differing source waters, i.e., springs versus drainage basin. The Withlacoochee River was added as a drainage basin river although it does receive a level of base flow from upstream springs primarily Rainbow Springs and Lake Panasoffkee (Estevez et al. 1990). A long period of below-average precipitation and runoff and reduced spring discharges, were believed to be the most likely proximate causes of the barnacle invasion owing to the strong influence of springs on river circulation and salinity. Other factors may also be involved such as the increase of man-made fixed hard substrate, such as seawalls, pilings, floating docks, drainage culverts and boat hulls, which offer ideal colonization substrate for planktonic barnacle spat. Naturally occurring hard-substrate is limited to rock outcroppings and deadfall from trees growing along the river banks.

An increase in the prevalence of barnacles suggests a hypothesis that the freshwater flows of the river systems may no longer adequate to prevent colonization of estuarine fauna from areas that were historically tidal freshwater environments. Any effect of reduced freshwater flows would also be exacerbated by sea level rise which would enable salt wedges to travel farther upstream. Beyond concerns for alterations of the natural systems, the reaction of boaters to barnacle fouling of hulls is to apply biocides in the form of antifouling paint coatings. Such coatings are known to release toxic compounds into the water. The war against biofouling has a history as old as ships. Innumerable benign and highly toxic compounds have been tried over the centuries. Copper has been the traditional compound used as a biocide in antifouling paints. In the 1970s, organotin copolymer anti-fouling paints were developed that provided five or more years of protection for ships and were considered environmentally safe. Organotins released from anti-fouling paints were subsequently found to be environmentally damaging with TBT (tributyltin), the most commonly used organotin anti-fouling agent, claimed to be the most toxic compound ever intentionally introduced into the marine environment. Consequently, an unexpected indirect effect of large and permanent barnacle populations may be an increasing threat of chemical contamination in relatively small but highly important habitats.

The Crystal and Homosassa / Halls River systems are relatively short and are entirely contained within the low coastal plain. The main springs of both the Crystal and Homosassa River are approximately 10 to 12 kilometers, respectively, upstream of the rivers' confluence with the Gulf of Mexico. In Crystal River the multiple headsprings area known as Kings Bay has been heavily developed with housing and recreational boating facilities. Canal systems and seawall hardened shorelines are prevalent on the east and south sides of Kings Bay with the southwest and west areas bordered by marshland. The Homosassa River system is similarly developed with riverside housing and commercial resort facilities along much of the upper sections of river. The Halls River which flows into the Homosassa River is largely undeveloped with the exception of housing in the vicinity of Highway 19. Extensive marshes border much of the Halls River, and extensive tidal marshes adjoin both Crystal and Homosassa Rivers in their downstream reaches, which are much less developed than the upstream areas of those rivers.

In contrast to the Crystal and Homosassa systems, the Withlacoochee is a much longer combination black water and spring-fed river with it origin in the Green Swamp in west central Florida. Approximately 138 kilometers long (86 miles), the Withlacoochee winds through the sandhill area as it moves northwest and is bordered by hardwood forests with an understory of cabbage palm and saw palmetto. As the river nears the coast it flows through lush swampland with cypress, gum and maple. Much of the river flows through the Withlacoochee State Forest, but there are scattered residential areas along the river. The Withlacoochee also receives a significant base flow of water from the spring-fed tributary the Rainbow River. The Rainbow Springs system is the fourth largest spring in Florida. There are two Withlacoochee(ie) Rivers in Florida. This project investigated the Withlacoochee River that flows into the Gulf of Mexico at Yankeetown. A second spring-fed Withlacoochee (also often spelled with-"ie") River is a tributary to the Suwannee River.

The fouling communities of tidal rivers progress from high diversity in polyhaline zones to low diversity in areas that are more oligohaline. The barnacle fauna of the Florida west coast is relatively species depauperate, especially across low salinity gradients. Some species of *Balanus*, for example, do especially well in waters that are nearly freshup to 16 ppt (Poirrier and Partridge, 1979) or may be able to tolerate fresh water for part of the year (Kaplan 1988), a tolerance also pointed out by Darwin (1854). Poirrier and Partridge noted that *B. subalbidus* appears to occur in a lower salinity zone than *B. improvisus* and suspected *B. subalbidus* has probably been confused with *B. improvisus* because it has been assumed that *B. improvisus* was the only barnacle which extends into oligohaline waters in Atlantic coast and Gulf of Mexico estuaries. As was lamented by Darwin barnacle species show considerable environmentally induced variation in skeleton structure. More recently phenotypic plasticity was observed in *Chthamalus fissus* from the California coast that developed significantly narrower opercula in the presence of predatory snails as compared to a control group.

A study of *Balanus amphitrite* in Japan showed significant detrimental effects on survival and development at salinity $\leq$10 PSU but showed no stress in the salinity range of 15 to 35 PSU. Notably there seemed to be accommodation of larvae that as embryos were exposed to salinities of 10 PSU which as larvae survivorship and length of development were independent of the salinity that the embryo had experienced. For larvae cultured at 15 and 35 PSU, exposing embryos to 10 PSU resulted in lower larval survival and longer larval development time. When cypris larvae were exposed to 10 PSU juvenile growth was not altered but it did result in lower survivorship. The authors concluded that osmotic stress experienced in one life-stage can be passed over to the next life-stage (Qiu and Qian 1999).

A study of Caspian Sea *Balanus improvisus* showed larval size decrease with increasing salinity for development from nauplius II larva to cypris larva. Larval survival was highest at 12 PSU and lowest at 36 PSU (Nasrolahi et al 2006).

The most common Florida species of barnacles are within the genera of *Balanus* and *Chthamalus.* A river reconnaissance on March 18, 2009 resulted in the collection and preliminary identification of two species of *Balanus* and verified the presence of live barnacles within low salinity areas of all three rivers. Examination of specimens identified the majority of specimens as *Balanus subalbidus* with specimens of *Balanus amphitrite* being recovered only from the lower Withlacoochee River. Specimens of *B. subalbidus* contained eggs/sperm as well as larval stages indicating that the low salinity in these areas does not inhibit reproduction.

Balanus amphitrite, an exotic species in the U.S, is very common and is one of the most broadly distributed and abundant coastal and estuarine biofouling organisms found in warm and temperate waters worldwide (Desai et al. 2006). It is found on almost any natural or man-made hard surface. The native range of *B. amphitrite* is uncertain but is considered to be the Indian Ocean to the southwestern Pacific, based on its presence in the Pleistocene fossil record (Cohen 2005).

The United States Geological Survey (USGS) list of nonindigenous aquatic species list describes *B. amphitrite* as established in Florida coastal waters by 1975 (Henry and McLaughlin 1975, Carlton and Ruckelshaus 1997), but the initial introduction most likely occurred much earlier and the first reports of the species in Florida date to at least the 1940s. It may be possible other species are present in the systems particularly in the downstream sections of the Withlacoochee River. However, it was not feasible to dissect all of the barnacles collected for this project. *B. amphitrite* is recognizable by the presence of pink or purplish stripes and was infrequent in occurrence for this survey

Other similar in appearance barnacles may occur in this area. *Balanus improvisus*, the white bay barnacle, is a common species and is often confused with *B. eburneus*, the ivory barnacle. *B. improvisus* is usually smaller than *B. eburneus*, but definitive identification between species this similar in external appearance usually requires examination of the shape of the terga and scuta through dissection. We examined a fairly large number of specimens and all appeared to be *Balanus subalbidus*. However, considerable age dependent variation in the terga was also observed.

It is of considerable importance that *B. eburneus* is known to be capable of self-fertilization (Furman and Yulea 1990). Hermaphroditism is universal in sessile barnacles, but only a few species are known to be facultative self-fertilizers. The ability to self-fertilize is advantageous for individuals of a species such as *B. improvisus*, which often has sparse and isolated populations. Such a reproductive mechanism may offer an advantage when colonizing areas such as a tidal river where an influx of new planktonic recruits may be intermittent and hindered by seasonal changes in river flow.

As for the occurrence of barnacles in the upper estuarine zones, according to Southward and Crisp (1987, p. 127), Darwin "noted that *Balanus improvisus* was found in a small stream in the estuary of La Plata, near Monte Video, where at high water specimens apparently were covered by the brackish and occasionally almost fresh waters of the estuaries." Branscomb (1976) reported that a population in the Chesapeake Bay "appeared unaffected by unusually high freshwater run-off in June which lowered salinities in the bay for 1972."

There are few studies of rates of barnacle growth for tropical and subtropical regions where settlement and subsequent growth is rapid. Studies at Mote Marine Laboratory, Sarasota, showed that under favorable conditions species of *Balanus* can grow to 1 centimeter basal diameter within 30 days post-settlement and become reproductive within 15 days post-settlement (Culter 1996).

II. MATERIALS AND METHODS

Site visits were made to the study rivers on three occasions. A field reconnaissance that included the placement of artificial substrates at six sites in the rivers was conducted on March 18, 2009. These artificial substrates were collected on May 14th and processed in the laboratory. Artificial substrates were placed at thirty-five sites on May 14 and 15, including redeployment at four sites from the first sampling effort. A final trip was made from June 29 to July 2 to retrieve the artificial substrates from the second deployment, make in-situ measurements, and collect field scrape samples of barnacles from hard substrates (e.g. pilings) that occur in the rivers.

The reconnaissance survey in March was for the purpose of locating existing barnacle habitats and determination of the most upriver extent of barnacles. Information on salinity distributions within the tidal sections of these rivers was provided by the District which served as the basis to determine the reconnaissance survey areas. Along the chosen sections of each river fixed hard substrates were examined for evidence of barnacle growth. Suitable barnacle substrate consisted primarily of channel markers, dock pilings, metal sign posts and PVC pipes. Deadwood snags and submerged rocks were also examined in areas where these were present.

After deliberation of the field reconnaissance information, it was decided there would be two main components of the study; field measurements on available hard substrates in the rivers, and monitoring barnacle growth on artificial substrates placed in close proximity to the field sites. Field measurements would provide information on the local extent of barnacle populations on existing surfaces, while the artificial substrate incubations would allow for determination of late spring colonization and growth rates. It is difficult to quantify colonization rates by examination of natural communities. There are numerous variables present in a natural fouling community, including; substrate type and age, tidal position (depth), orientation of substrate, water flow, etc. The deployment of artificial substrates was intended to reduce the potential number of variables for evaluation of the relative rate of colonization within salinity zones of each river system.

Sampling site nomenclature for the Homosassa and Withlacoochee Rivers was based on a river kilometer (Rkm) system provided by the District, with river kilometer zero (Rkm 0) located at the designated mouth of the river. Sampling sites within Kings Bay were not based on a linear system. Sampling sites were distributed to provide a broad representation of the system.

Locations of the barnacle sampling sites in the rivers are shown in **Figures 1, 2 and 3** (pages 6 - 8). Unless specified otherwise, the same sites were used for the examination of barnacles on existing hard substrates in the rivers and the placement of artificial substrates for barnacle growth measurements.

II.1. Barnacle Sampling and Measurement on Existing Hard Substrates

The objectives of the field sampling of barnacles on existing hard substrates is the rivers were to:

1) Identify barnacle species,
2) Determine the relative proportion of live to dead,
3) Determine the size range, based on basal diameter.
4) Determine the farthest upriver extent of live / dead barnacles.
5) Apply items 1-4 to a river kilometer system for Homosassa and Withlacoochee Rivers and salinity strata for Kings Bay in Crystal River.

The intention of the field survey was to identify in-situ both living and dead barnacles with respect to species and basal diameter. However, when conducting the field work, limited water visibility, color, and heavy epiphytic growth of algae, tube dwelling amphipods and other organisms prevented quantitative observation of living versus dead barnacles for most locations. The March site reconnaissance showed that the predominant fixed position hard substrata were channel markers and dock pilings. These substrates proved to be the most utilitarian structures on which to base field measurements and collections. As will be described in Section II.2, artificial substrates were also placed at these same structures.

Sampling sites were spatially distributed to reflect that the Homosassa and Withlacoochee Rivers have horizontal salinity gradients that are generally linear, with salinity values increasing upstream. A different sampling design was employed in the Kings Bay area of Crystal River, where the large headspring area has a more complex circulation and salinity structure due to multiple spring vents, small islands, canals and creeks.

In Florida estuaries, barnacles are usually found in greatest abundance within the intertidal zone with the greatest abundance typically at or near mean low water. Near-surface waters are generally high in plankton abundance and are well circulated both of which seem to enhance barnacle growth. In the Homosassa and Withlacoochee Rivers, the most upstream barnacles were exclusively limited to the deep mid-zone or near-bottom zone, reflecting the upstream most extent of the tidal salinity wedge. These deep barnacles were not initially planned for in the survey and the upstream-most settling plates, located in the deep tidal zone, did not always exhibit colonization as a result of the influence of the freshwater flows at those depths.

Figures 1, 2, and 3 and associated text on the following pages.

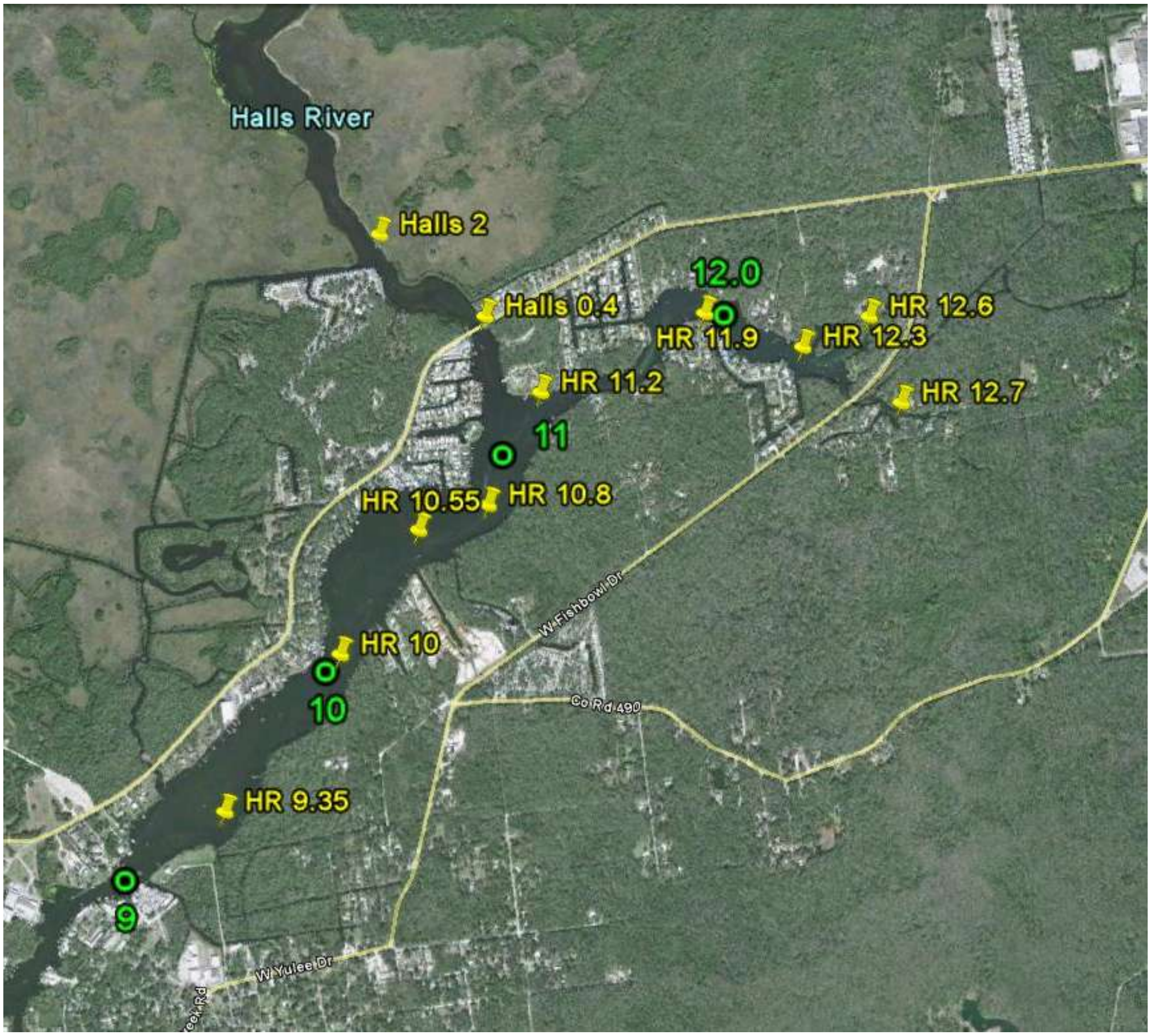


Figure 1. Sampling sites marked as river kilometer positions in the Homosassa River with river kilometer distances also shown as green numbers and circles. Sampling at each site included both the scraping of barnacles from hard substrates and the placement of artificial substrates.

The Homosassa River does have some lateral salinity gradients that warranted examination due to different salinity values in the Halls River and the Southeast Fork compared to the main stem of the river. Sampling in the Homosassa River consisted of 10 stations arranged along the longitudinal axis of the river upstream of McRae's Fish Camp, near river kilometer 9, as shown in **Figure 1**. Sampling at these sites consisted of steps 1 through 5 on page 5. Three of these sampling sites were associated with the Halls River at the W. Halls River Road Bridge, the Homosassa main spring, and the Southeast Fork. In these three areas, transects were also visually reconnoitered to qualitatively classify the distribution of barnacles across river. However, cross river transects did not provide much useful information due to the lack of uniform cross-river hard substrates. The sampling design was dependent on the availability of uniform hard substrate which generally consisted of channel marker and dock pilings. In areas were cross-river investigations were made there did not appear to be differences in the fouling community.

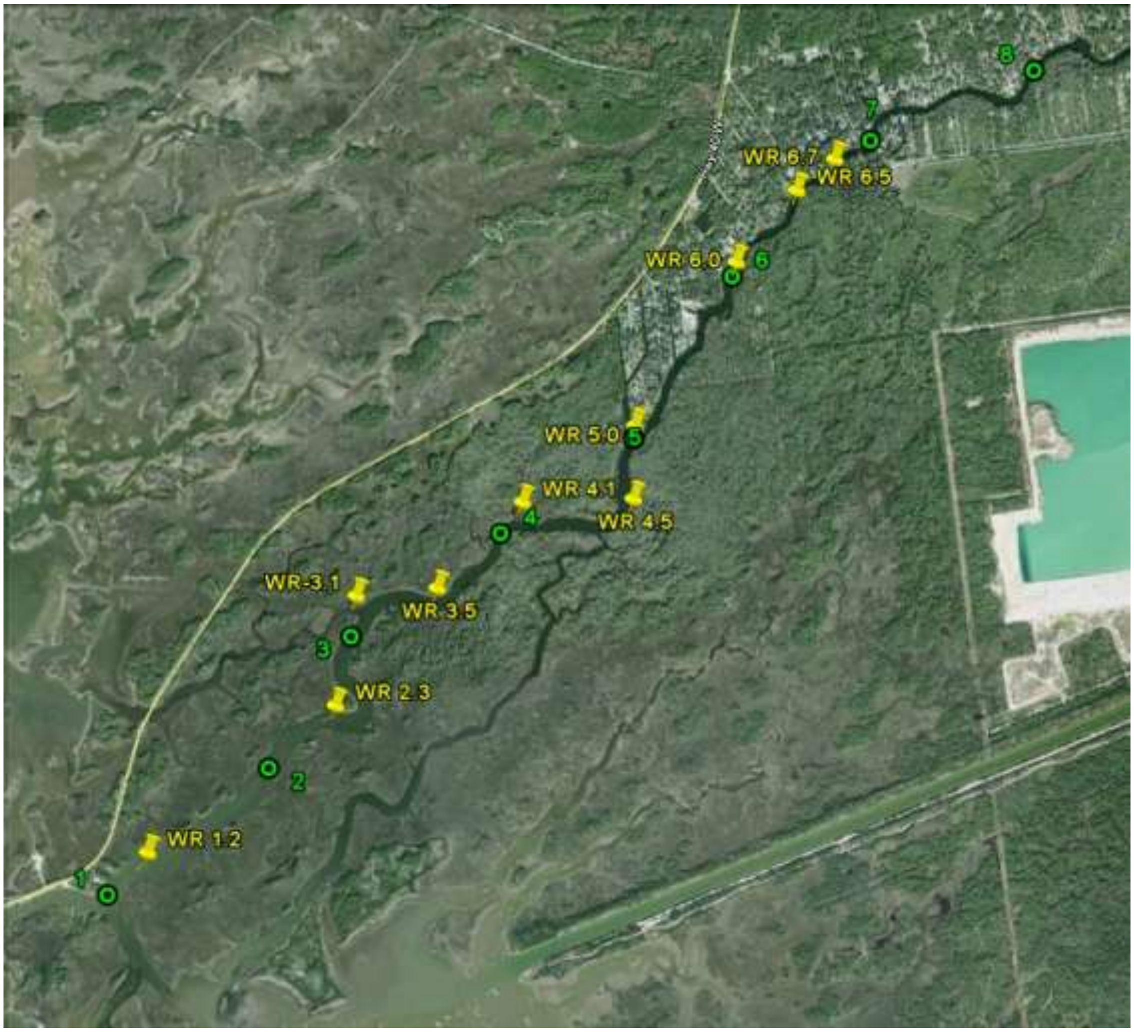


Figure 2. Sampling sites marked as river kilometer positions in the Withlacoochee River with river kilometer distances also shown as green numbers and circles. Sampling at each site included both the scraping of barnacles from hard substrates and the placement of artificial substrates.

The Withlacoochee River was evaluated on a river kilometer basis with sampling intervals targeted to include an approximate 6.0 kilometer survey distance **(Figure 2)**. For the Withlacoochee, tasks 1-5 (described on page 5) were completed at each of 10 locations exhibiting barnacles. For much of the length of the survey area the Withlacoochee River exhibits a deeply incised channel with limestone rock exposed on portions of the banks and riverbed. This deep channel allows for salinity stratification. The barnacles located farthest upriver were found near the bottom, a reversal of the normal barnacle occupancy of the intertidal zone.

Figure 3. Sampling sites in Kings Bay (Crystal River). Sampling at each site included both the scraping of barnacles from hard substrates and the placement of artificial substrates.

For Crystal River the focus was on Kings Bay, the broad area that contains the headsprings of the river. Data provided by the District illustrated that there were subtle salinity gradients within Kings Bay due to spring flow from numerous vents. Based on salinity data provided by the District, thirteen sampling sites were selected within Kings Bay, with one site (KB-1) located in the river channel approximately one kilometer downstream of Kings Bay (**Figure 3)**. Other areas were also visually reconnoitered to qualitatively classify the distribution of barnacles, but the lack of uniform hard substrate generally limited the utility of the observational data.

Where barnacles were present, field measurements of basal diameter were made at each survey site. At each sampling the largest, densest, or most developed barnacle community on the existing hard substrate was sampled. At some sampling sites such as in the Withlacoochee River, the number of barnacles was sparse and all barnacles at the site were measured. Salinity, pH, water temperature and dissolved oxygen profiles were measured at each barnacle survey site.

Removal of barnacles from the substrate is usually very destructive, resulting in many broken barnacle fragments. Therefore at each site, the feasibility of identifying live versus dead barnacles in situ was also evaluated. For many sites it was not possible to identify live versus dead barnacles due to water color, turbidity, and the growth of epiphytic algae and other organisms among the barnacles. If the substrate was intertidal, such as a piling, the range of the colony from the uppermost to the lowermost dead and live barnacles was measured. After in situ characterization, the area of greatest barnacle density in a 10 x 10 cm^2 area was measured in place or collected by scraping from the substrate into a net. A minimum of 25 barnacles or all of the barnacles that could be found at a site were examined and measured. The material scraped from the substrate was placed in a jar and preserved with 10% Formalin™ solution.

In the laboratory the scrape samples were sorted and barnacles were identified as either *Balanus subalbidus* Darwin 1854 or *Balanus amphitrite* Darwin 1854 (striped barnacle) and were noted as live or dead. Since measurements were taken in the field, no additional measurements were made in the laboratory as most of the shells were broken in the removal process.

II.2. Artificial Substrates

Artificial settling plates were first deployed in the river on March 18, 2009 at six sites listed in **Table 6** (page 26). These substrates were retrieved and data for barnacle growth at these sites were measured on May 14th, yielding a 57 day incubation period. Artificial substrates were also placed at thirty-five sites on May 14th and 15th, including redeployment at four sites from the previous sampling effort. These substrates were retrieved between June 29 and July 2, yielding incubation periods between 46 to 48 days. These thirty-five sites were deployed at the same locations and structures as the hard substrate sampling effort (**Figures 1-3**).

Artificial substrates were constructed of square gray PVC plates that measured 15 cm x 15 cm. The sites from the second deployment were visited again to collect and process the settlement plates and conduct the field survey to delineate the distribution of barnacles. Latitude / longitude positions were recorded for each survey location. The objectives of the artificial substrate survey were to provide measures of barnacle settlement and growth for each river and location. The following metrics were measured for each artificial substrate panel.

1) Deploy artificial substrates (15cm x 15cm) for comparison of barnacle colonization rates between locations.
2) Measure the number of barnacles per unit area.
3) Measure basal diameters of 25 barnacles per plate from randomly selected 4 cm^2 grid blocks up to a count of 25 barnacles.
4) Measure the basal diameter of the largest and smallest barnacle on each plate.
5) Measure barnacle biomass as wet weight and dry weight, grams per unit area.

III. RESULTS

The results are presented sequentially with the first sections presenting the data for salinity for the current field work, as well as District records for each river (sections III.1 to III.3). This is followed by discussion of the data for the field observations of the barnacle distribution within the rivers (III.4) and the colonization and size data for the artificial substrates (III.5).

To successfully colonize an area, barnacles need hard or firm fixed substrate in addition to favorable salinity and water quality. Hard substrate is limited throughout most of the natural areas of each river. Rock outcrops are present in all three rivers, but the overall areal extent of natural rock is small in comparison to the sand, muddy sand and marsh dominated shorelines and river bottom. The barnacle fouling problem as a boat nuisance may be, in-part, exacerbated by coastal development. Development of these rivers has resulted in the increase of hard substrate available to fouling organisms. The presence of seawalls, bridge pilings, channel markers, information signs, boats, and mooring structures have dramatically increased the "hard bottom" areas compared to pre-development conditions. This is particularly true for the intertidal areas favored by barnacles.

For the period June 29 - July 2 there were abnormally high tides in all three rivers due to the weather patterns in the Gulf of Mexico. **Figure 4** illustrates the tide level at the Withlacoochee River boat ramp (RK 7.1) on June 30. The high tides enabled documentation of salinity incursions that were significantly greater than average conditions.

Figure 4. Withlacoochee River boat ramp on June 30, illustrating the unusually high tide.

III.1 Stations and Salinity -Homosassa and Halls Rivers

Table 1 presents salinity and depth data for the sampling locations in each river system for the dates of sampling June 29 - July 2, 2009. Data are arranged from highest to lowest surface salinity for each river. The unusually high tides during this period contributed to pronounced tidally induced salinity stratification in all three rivers. Average and maximum salinity values in the top meter and bottom waters at nearby stations in the three rivers sampled by the District are also listed in **Table 1.** The District data for the Homosassa and Halls Rivers were collected on nine dates between February 2008 and March 2009.

Average and maximum salinity values for the District data are also graphically displayed for the three rivers in **Figures 5, 6, and 7**. To aid the comparison between rivers, top meter salinity values are shown for the Homosassa and Crystal Rivers, as barnacles are abundant in the intertidal zones of those rivers and the bottom depths of the sites vary considerably. Near bottom salinity values are shown for the Withlacoochee River, as barnacles are typically most abundant at deeper depths in that river due to more pronounced vertical salinity stratification.

Table 1. Surface and near bottom salinity values for the three river systems sampled June 29 - July 2, 2009 ranked by decreasing surface salinity along with average and maximum salinity values from nearby stations sampled by the District.

Location	Overall* Depth (m)	River ** Kilometer	Salinity (PSU) Surface (0.5m)	Near Bottom	District Data Salinity (PSU) Top Meter Average	Top Meter Maximum	Nr. Bottom Average	Nr. Bottom Maximum
HR-9.35	2.8	9.35	10.7	13.4	3.9	7.1	4.6	10
HR-10	3.7	10.0	8.2	14.0				
HR-10.55	2.9	10.55	5.9	11.7				
HR-10.8	2.8	10.8	5.4	7.9	2.8	4.8	3.1	5.8
HR-11.2	3.9	11.2	2.4	9.7				
Halls 0.4	2.8	0.4	5.9	6.4	2.9	4.4	2.9	4.4
HR-11.9	4.3	11.9	1.8	8.8				
HR-12.3	3.9	12.3	1.2	6.8	1.6	2.0	2.4	2.9
HR-12.6	3.6	12.6	1.0	2.4				
HR-12.7	0.8	12.7	0.6	0.7	0.5	0.6	0.5	0.6
Location	**Overall Depth (m)**	**River ** Kilometer**	**Salinity (PSU) Surface (0.5m)**	**Nr. Bottom**	**District Data Salinity (PSU) Top Meter Average**	**Top Meter Maximum**	**Nr. Bottom Average**	**Nr. Bottom Maximum**
WR-1.2	2.4	1.2	8.1	9.1	13.7	20.8	18.0	25.7
WR-2.3	4.7	2.3	6.5	8.2	11.0	20.3	19.0	25.8
WR-3.1	1.1	3.1	4.7	5.2	4.7	8.1	14.0	24.3
WR-3.5	4.0	3.5	3.6	12.5	4.2	8.0	14.5	23.5
WR-4.1	5.1	4.1	2.5	15.7	2.5	5.5	12.1	23.0
WR-4.5	4.1	4.5	2.0	14.2	1.8	4.5	11.1	22.3
WR-5.0	5.1	5.0	1.4	14.5	1.0	3.0	12.9	26.7
WR-6.0	5.5	6.0	0.2	12.2	0.8	3.0	6.5	19.9
WR-6.5	4.8	6.5	0.2	10.7	0.5	1.8	5.8	19.1
WR-6.7	6.5	6.7	0.2	9.2	---	---	---	---
Location	**Overall Depth (m)**	**River ** Kilometer**	**Salinity (PSU) Surface (0.5m)**	**Nr. Bottom**	**District Data Salinity (PSU) Top Meter Average**	**Top Meter Maximum**	**Nr. Bottom Average**	**Nr. Bottom Maximum**
KB-1	4.0	na	4.8	6.1	4.0	6.6	5.1	7.8
KB-10	0.7	na	2.9	2.9	1.9	2.7	2.0	2.8
KB-9	1.0	na	2.7	2.8	2.1	2.5	2.2	2.6
KB-4	1.2	na	2.6	3.7	2.1	3.4	2.9	6.8
KB-5	1.8	na	2.5	3.6	2.1	3.4	2.9	6.8
KB-14	1.5	na	2.4	3.7	2.0	2.6	2.3	3.3
KB-11	1.3	na	2.0	2.5	1.7	2.6	2.3	3.5
KB-12	2.4	na	1.8	2.7	0.9	1.5	0.9	1.5
KB-15	1.7	na	1.8	2.9	1.8	2.5	2.5	3.5
KB-13	2.1	na	1.6	2.6	1.1	1.7	1.2	2.0
KB-6	2.3	na	0.9	3.4	1.4	2.5	1.7	3.5
KB-3	1.5	na	0.6	1.7	0.6	1.8	0.9	2.3
KB-8	1.9	na	0.5	0.8	---	---	---	---
KB-2	1.2	na	0.5	2.2	0.7	1.7	0.9	2.4
KB-7	1.1	na	0.2	0.2	0.6	1.4	0.7	1.8

Footnotes: * Overall depth = at site of salinity reading. **river kilometer of barnacle site, not assigned for Kings bay. HR-12.6 reading taken at no entry signs downstream of spring.

The salinity values at the Halls River station recorded during the barnacle survey were greater than nearby stations in the Homosassa River. Furthermore, the bottom salinity values in both rivers were greater than the surface salinities at most locations, possibly due to strong salinity incursions during the very high tide on that sampling day. The average top-meter and bottom salinity values from the District data indicate less vertical stratification. Also, the surface salinity readings taken on June 29, 2009 were generally greater than the average top-meter values recorded by the District. However, the maximum values recorded by the District over the preceding period were more similar to the values recorded during the barnacle survey.

On June 29, the surface and bottom readings observed at the no entry signs of the Homosassa headspring were 1.0 and 2.4 PSU respectively. There were no barnacles present within the run from the headsprings and no barnacles were present on the "No Entry" sign pilings. A few small barnacles (~5mm basal diameter) were found on the pilings at the park gazebo approximately 5 feet below the water line and 2-3 ft off the bottom. No barnacles were present in the small bay to the south, HR-12.7, nor were there barnacles present on the concrete bridge structure for West Fishbowl Drive. Surface and bottom salinity at HR-12.7 were 0.6 and 0.7 PSU respectively at the time of sampling, Table 1. At HR-12.3 there was a well developed fouling community on the lower portion of the marker piling (near the south shore at a canal junction) which extended from near bottom to ~1.25 meters above the bottom. Overall water depth at this location was ~2.14 meters. Surface salinity at HR-12.3 was 1.6 PSU and the bottom salinity was 6.8 PSU. The District average top-meter salinity in this vicinity was 1.6 PSU (**Figure 5**), with an average bottom value of 2.4 PSU (**Table 1**) The barnacle community at this location appears dependent on the incursion of the saltwater wedge along the river bottom.

At location HR-11.9 there was a barnacle-mussel community that extended from the bottom to 1.14 meters above the bottom. Overall depth at this location was ~2.5 meters. Due to low light levels and a coating of algae it was not possible to tell live from dead barnacles, although most barnacles appeared to be living. For the sampling date surface salinity at this location was 1.8 PSU and bottom salinity 8.8 PSU.

At location HR-11.2 near the confluence of the Homosassa and Halls River surface salinity was 2.4 PSU and bottom salinity 9.7 PSU. Mussels were more numerous than barnacles at this location. Overall depth was approximately 1.5 meters with the barnacle / mussel community extending from near the bottom to approximately 0.3 meters below the surface of the water. For normal tides the barnacle community is present throughout the intertidal range.

Station Halls-0.4 was located in Halls River at the bridge for West Halls River Road. Surface and bottom salinities at this location were 5.9 and 6.4 PSU respectively. Barnacles on the concrete bridge pilings dominated the fouling community. Visibility was very poor due to highly colored tannic water from the Halls River. Barnacles were present over the entire depth of the location, 0.9 meters.

Location HR-10.8 also exhibited poor visibility due to the tannins from Halls River. Surface and bottom salinity values were 5.4 and 7.9 PSU respectively. The bottom salinity was slightly less than that of site HR-11.2 possibly due to increased surface to bottom mixing in this portion of the river. Overall depth of this site was 2.8 meters and barnacles were present from the bottom to a depth of 1.5 meters.

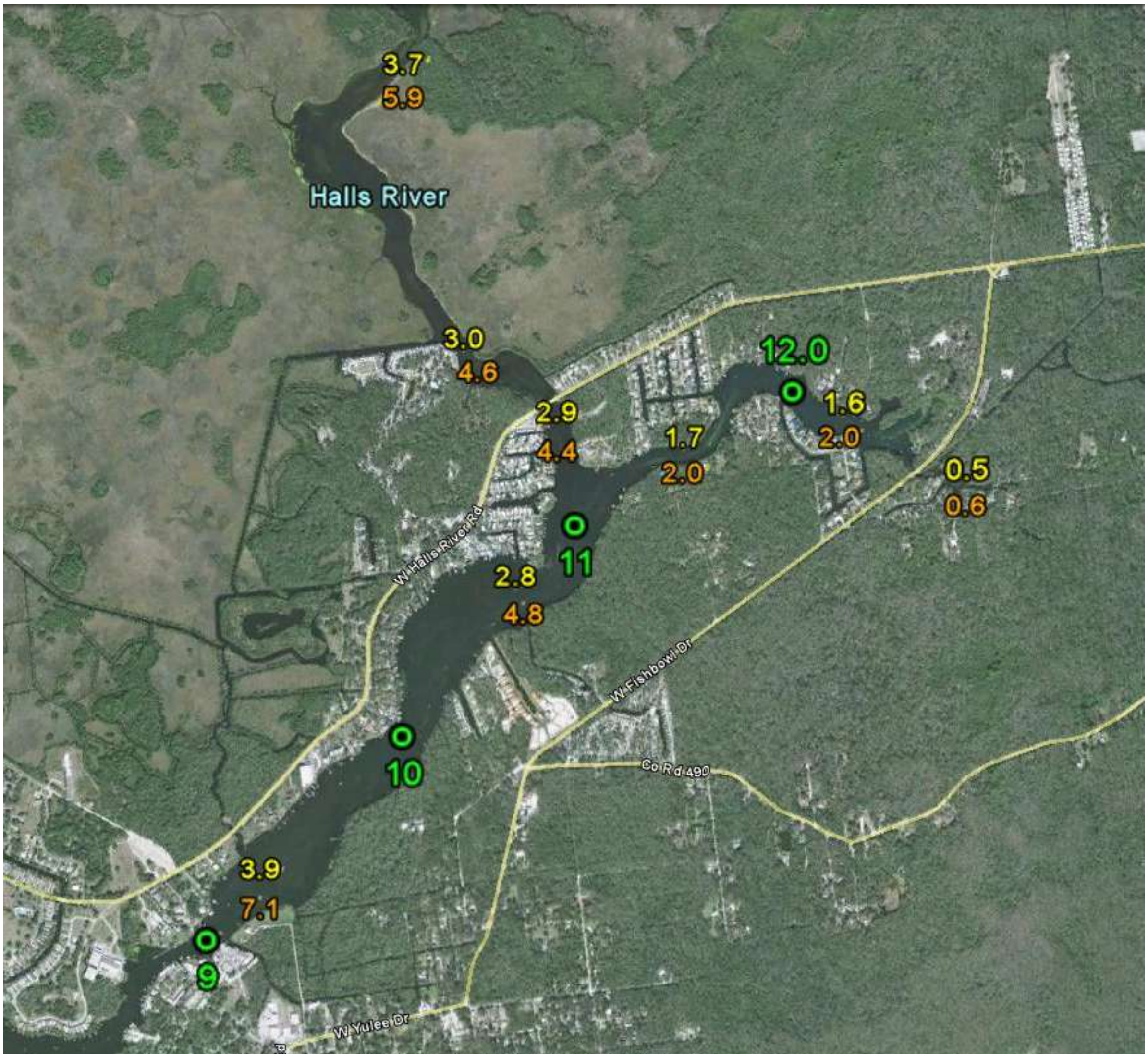


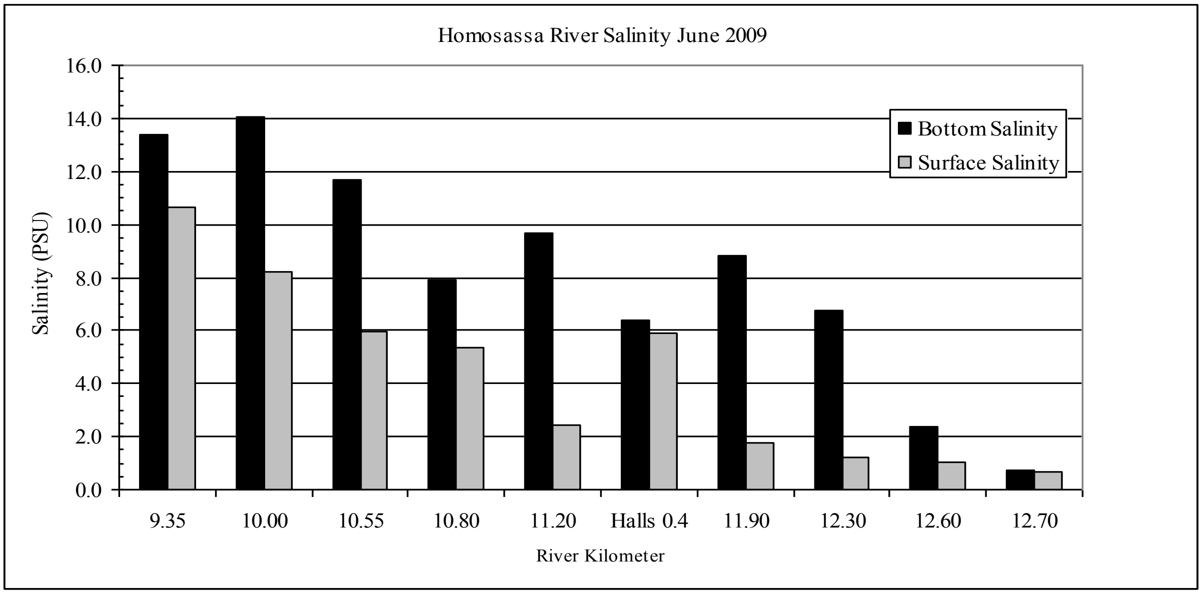
Figure 5. Average (yellow) and maximum (orange) salinity values recorded in the top meter of water at in the Homosassa and Halls Rivers sampled by the District between February 2008 and March 2009. River kilometers shown as green circles.

Location HR-10.55 exhibited barnacles throughout the entire depth range of 2.9 meters with the exception of the near surface zone (~0.25 meters) covered by the exceptional high tide. Surface salinity for this location was 5.9 PSU and bottom salinity 11.7 PSU.

At location HR-10 the piling used for a scrape sample was located slightly up-river of the artificial substrate location. Barnacles occurred throughout the entire depth range of ~2.1 meters with the exception of the near surface zone (~0.25 meters) which was covered by the exceptional high tide. Surface salinity for this location was 8.2 PSU and bottom salinity 14.0 PSU.

Location HR-9.35 was at the green "3" navigation marker Barnacles occurred throughout the entire depth range of ~1.0 meter with the exception of the near surface zone (~0.1 meters). Salinity readings in the deeper channel showed a surface value of 10.7 PSU and bottom salinity of 13.4 PSU at 2.77 meters depth.

From HR-12.3 downstream barnacles were present at all locations. Mussels were a dominant fauna at station HR-11.9 and HR-11.2. Salinity conditions for the benthos of the Homosassa River downstream and including station HR-12.3 for the June - July sampling were upper estuarine ranging in salinity from 6.4 to 14.0 PSU. **Figure 6** illustrates the surface and bottom salinity readings for the sampling sites on the Homosassa River arranged by distance upstream (kilometers) for the sampling in June (top graph) as compared to average salinity values for top meter and bottom waters based on District data (bottom graph).



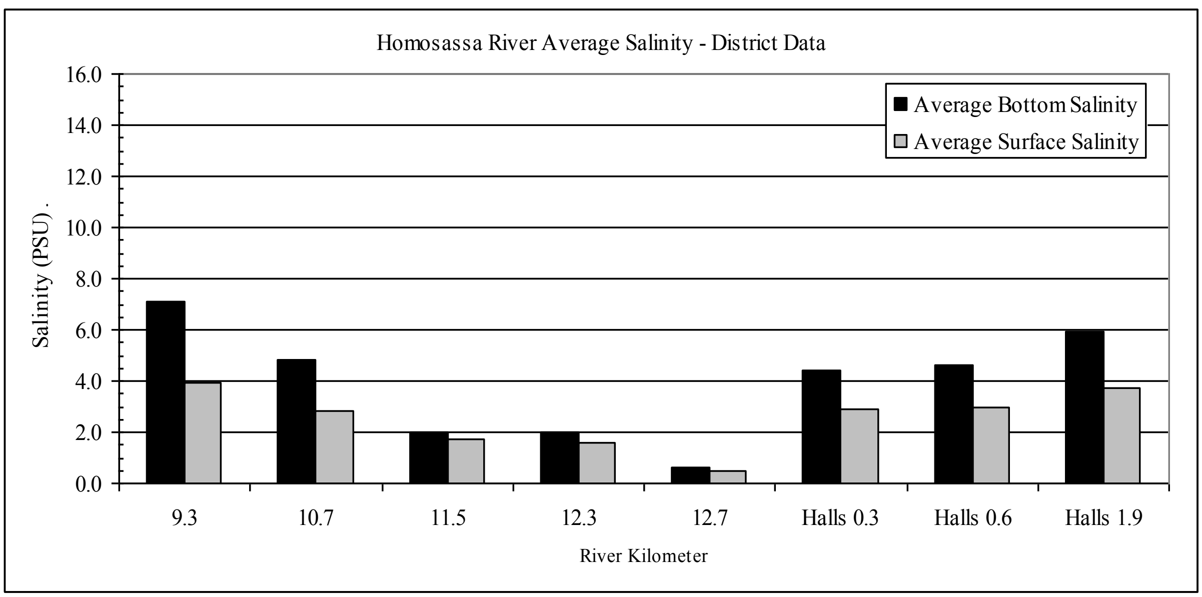


Figure 6. Surface and bottom salinity for Homosassa River stations for June 29, 2009 (top) and average values for the top meter and bottom waters from District data (bottom).

III.2 Stations and Salinity - Kings Bay, Crystal River

Historic data for Kings Bay at the head of Crystal River have shown the bay does not exhibit a simple linear salinity gradient. Multiple spring vents and irregular spring flows coupled with tides create a complex salinity regime within the bay. **Figure 7** illustrates the barnacle sampling sites in Kings Bay with average and maximum top-meter salinity values based on District sampling on six dates between July 2008 and June 2009. Locations KB-1 through KB-14 included artificial substrate samples and natural substrate barnacle collections.

During the field days of this study, spring flows were low and brackish water was observed in most areas of the bay. Salinity values for the field sampling of June 29 to July 2, 2009 are shown in **Table 1** and plotted as **Figure 8**. Surface salinity in Kings Bay ranged from 0.2 to 4.8 PSU and bottom salinity ranged from 0.2 to 6.1 PSU. Only two locations KB-7 and KB-8 exhibited bottom salinities of less than 1.0 PSU for the days of sampling in July. At location KB-15, salinity measurements were made and an observational dive was made into the large spring vent at this site. Barnacles growing on the limestone walls of the spring vent were measured and sampled.

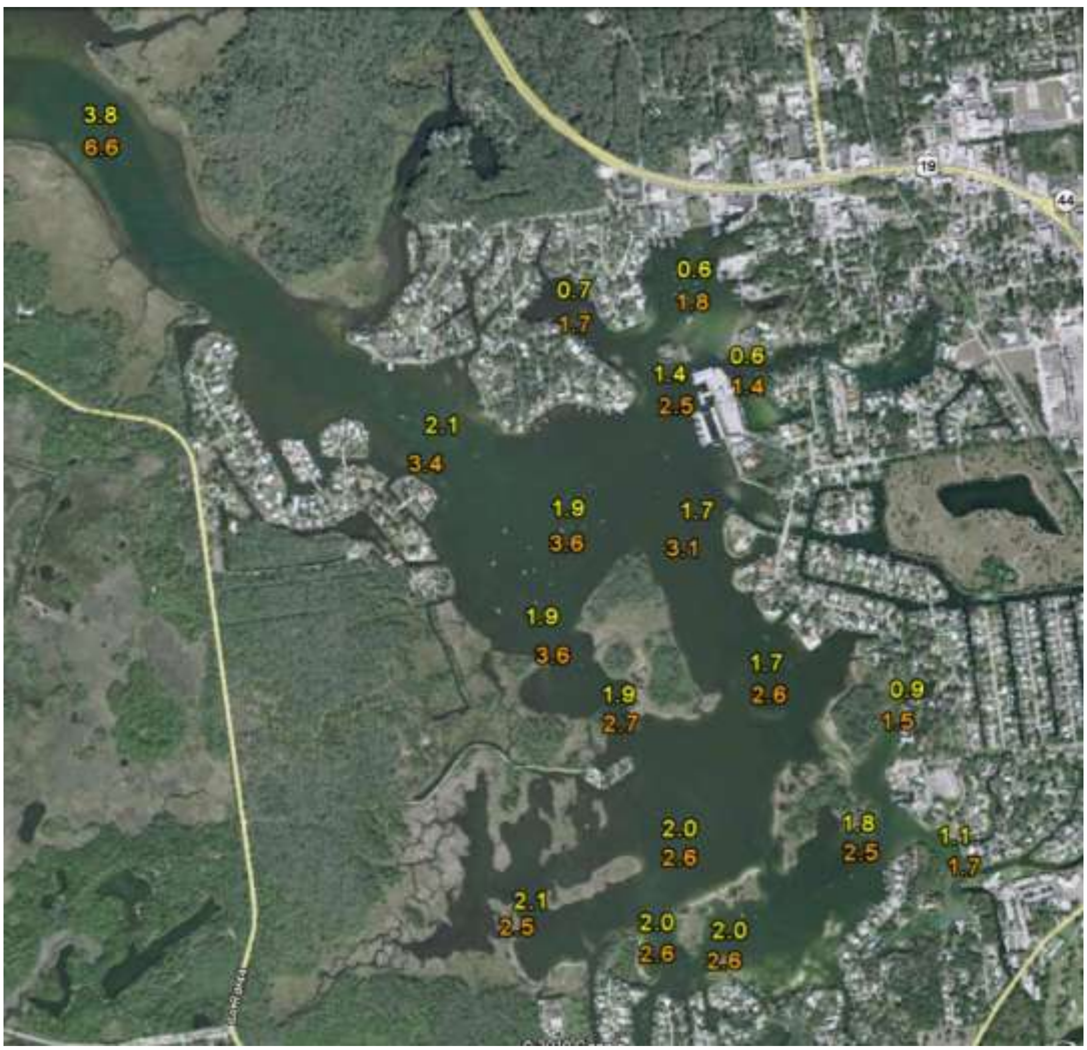


Figure 7. Average (yellow) and maximum (orange) salinity values recorded in the top meter of water in Crystal River / Kings Bay sampled by the District between July 2008 and June 2009.

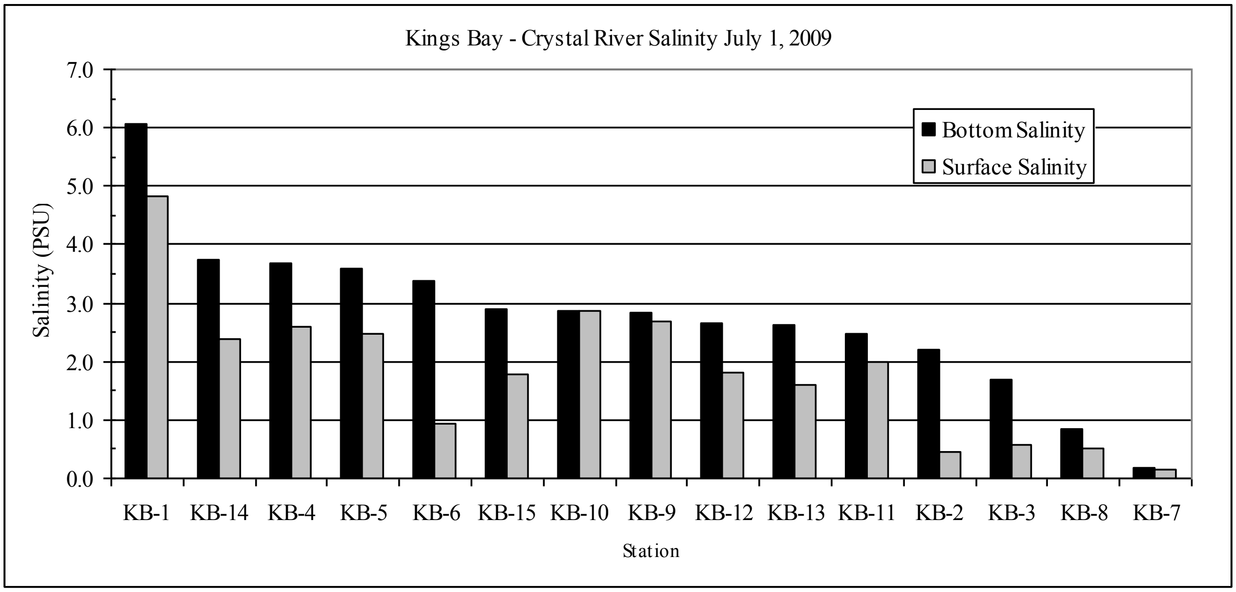


Figure 8. Surface and bottom salinity for Kings Bay stations for July 1 and 2, 2009, with stations shown in rank order of highest to lowest bottom salinity.

Figure 9 illustrates the average and maximum top meter salinity values for 17 locations in Kings Bay and one in the river measured by the District. The data illustrate that there were four areas of the bay with average salinity values below 1.0 PSU, twelve areas representing a gradual gradient between 1.0 and 2.0 PSU and three sites that averaged above 2.0 PSU, with the highest salinity recorded at KB 1, a site in Crystal River, approximately 1.7 kilometers downstream of Kings Bay proper.

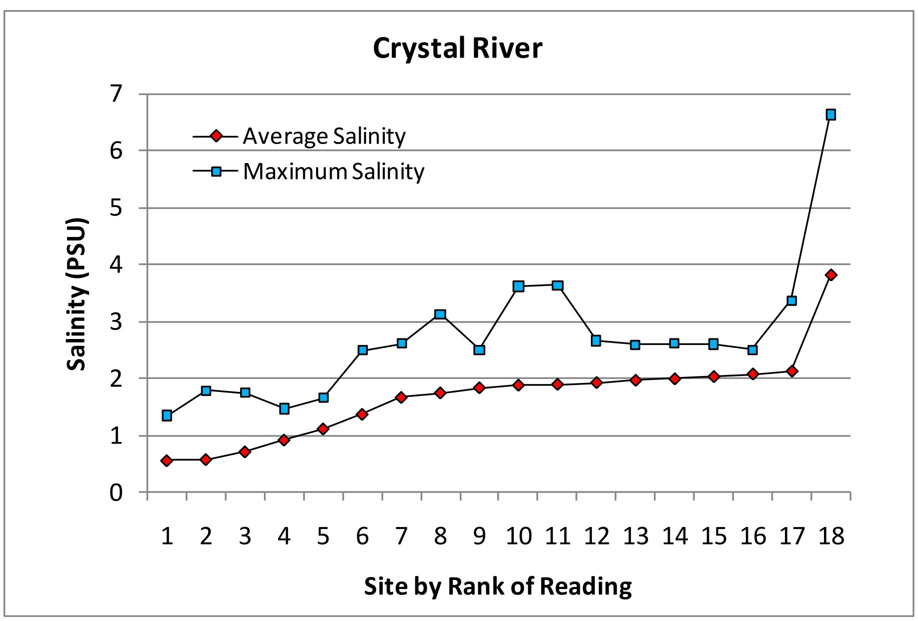


Figure 9. Rank order of average and maximum values for top meter salinity for stations in Kings Bay and one in Crystal River measured by the District.

III.3 Stations and Salinity - Withlacoochee River

Barnacle sampling sites in the Withlacoochee River are shown in **Figure 10**, along with average and maximum top-meter and bottom salinity values based on District sampling between October 2008 and June 2009 (n = 9 to 14). Station designations are based on a river kilometer scale provided by the District. Salinity values for the sampling sites for June 30, 2009 are shown plotted in **Figure 11**. The most curious feature of this graphic is the high levels of bottom salinity at stations 3.5 to 6.7 kilometers, the most upstream locations. The Withlacoochee River has a deeply incised channel which generally becomes somewhat shallower farther downstream. The deeper section allows for significant salinity stratification for a significant distance upstream. The results in **Figure 11** were also affected a very high tide on the sampling day due to a low pressure weather system and associated winds in the Gulf of Mexico, as previously exhibited by **Figure 4**. For visual comparison to the salinity data from June 2009, the average top meter and bottom salinity data from the District sampling conducted between October 2008 and June 2009 are plotted in **Figure 12.**

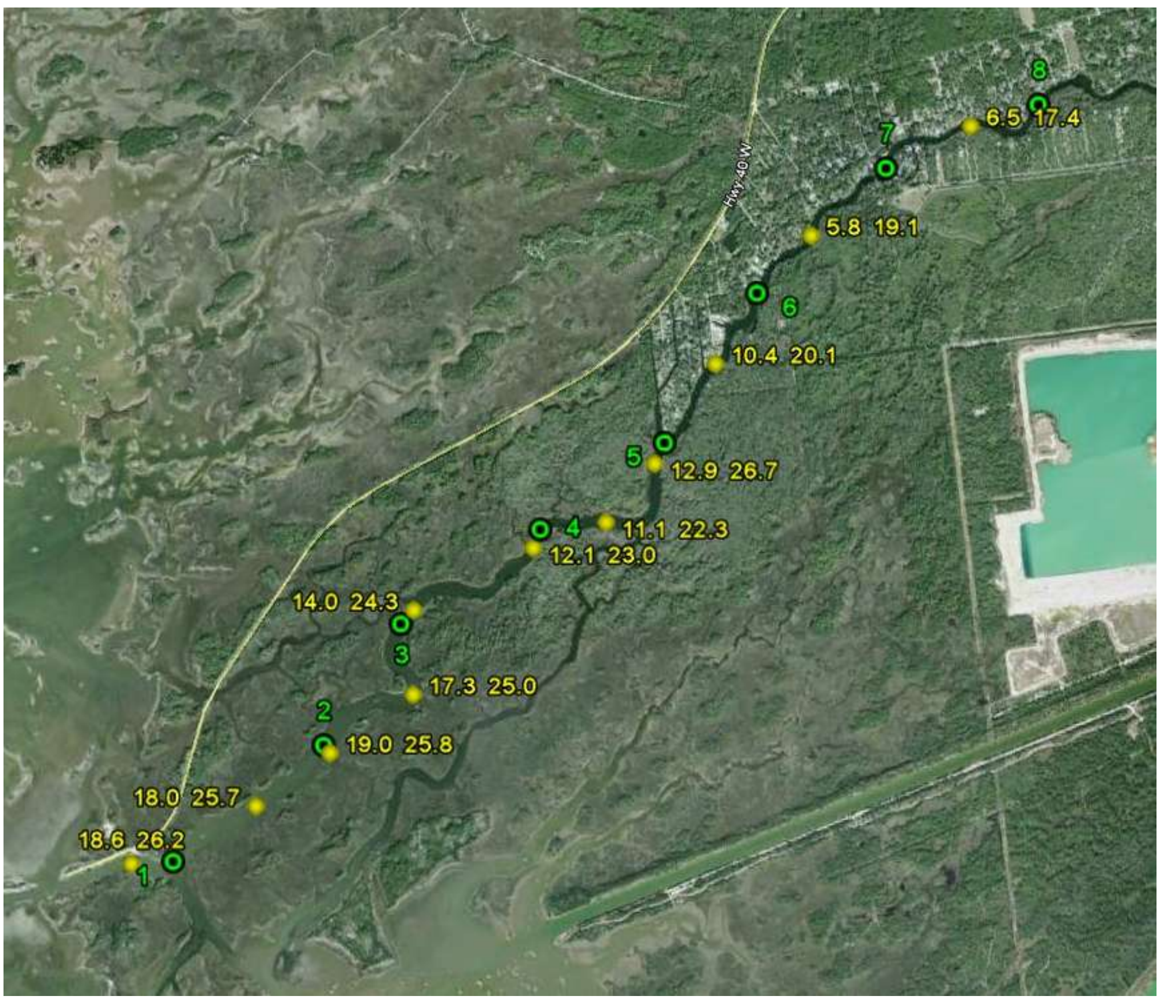


Figure 10. Average and maximum salinity values for near-bottom waters in the Withlacoochee River recorded by the District between October 2008 and June 2009.

The first barnacles that were found on hard substrates occurred at location WR-6.5. At this site sparse barnacles were observed growing in a zone 0.7 to 1.3 meters above the bottom. The total depth at the location for a very high tide was 2.7 meters. This trend held for stations WR-6.0, WR-5.0, WR-3.1. Sites downstream of station WR-3.1 had robust intertidal oyster / barnacle communities. It was not possible to sample barnacles growing on pilings at WR-1.2 or WR-2.3 due to the heavy dominance of oysters and other fouling organisms. In-situ barnacles could not be measured at WR-4.1 due to a lack of available substrates.

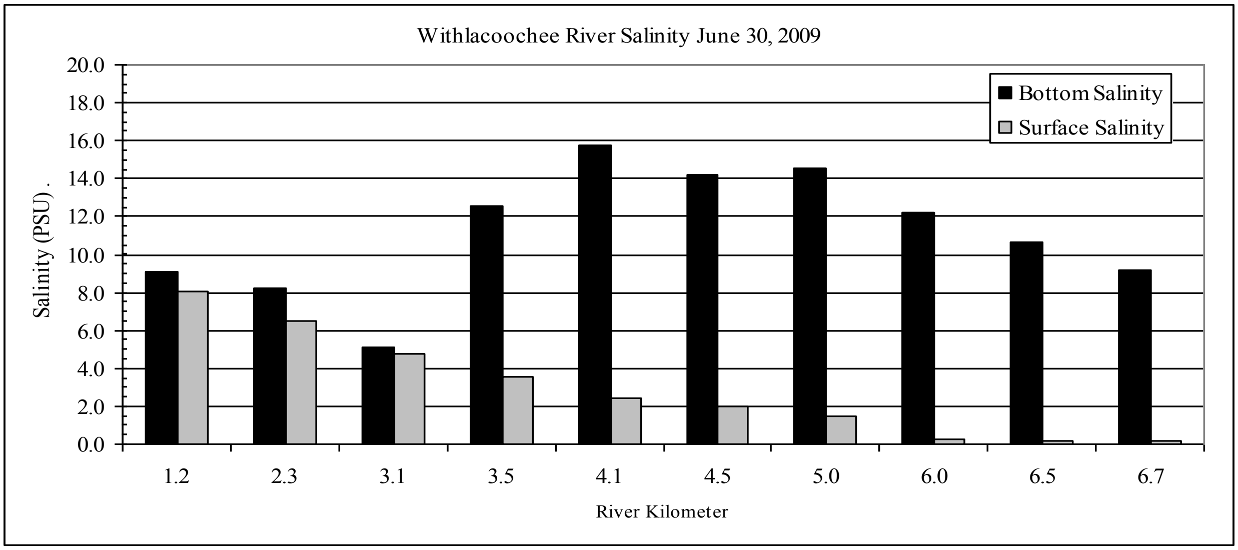


Figure 11. Salinity values for surface (0.5m) and near bottom for the Withlacoochee River, June 30, 2009.

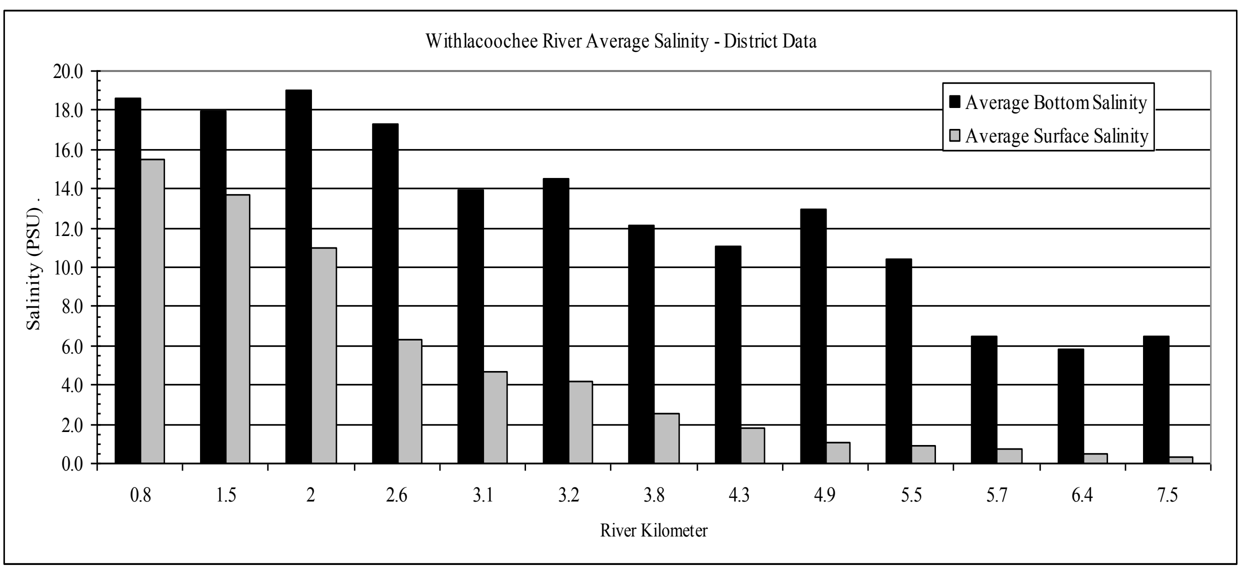


Figure 12. Average surface and near bottom salinity values for the lower Withlacoochee River recorded by the District.

III.4 Survey of Barnacles on Existing Hard Substrates

Basal diameters (BD) of the barnacles measured on hard substrates (pilings) in the rivers during the June 30 – July field trip are summarized in **Table 2**. Graphic representations of the data of Table 2 are shown in **Figures 13, 14 and 15,** ranked by the bottom salinity at each station on the sampling day. The largest barnacles on average were recovered from Kings Bay (16.81mm BD overall average) followed by the Withlacoochee (11.51 mm BD) and Homosassa Rivers (10.72 mm BD).

Table 2. Field measured barnacle basal diameters.

Field measured barnacle diameter										
Location (RK)	**Avg. Basal Diameter (mm)**	**St.Dev**		**Location**	**Avg. Basal Diameter (mm)**	**St.Dev**		**Location**	**Avg. Basal Diameter (mm)**	**St.Dev**
HR-9.35	11.76	4.02		WR-1.2	OC	OC		KB-1	12.88	4.35
HR-10.0	10.40	4.68		WR-2.3	OC	OC		KB-2	19.82	3.79
HR-10.55	12.04	3.63		WR-3.1	9.28	2.75		KB-3	26.32	4.37
HR-10.8	12.00	4.17		WR-4.1	np	np		KB-4	18.48	3.98
HR-11.2	13.56	6.96		WR-5.0	10.46	5.09		KB-5	13.32	4.39
HR-11.9	8.36	1.90		WR-6.0	12.83	4.12		KB-6	17.10	3.84
HR-12.3	4.56	1.58		WR-6.5	13.48	2.94		KB-7	np	np
HR-12.7	np	np		WR-6.7	np	np		KB-8	17.14	4.75
HR-12.6	np	np						KB-9	20.48	3.52
Halls 0.4	13.07	4.10						KB-10	6.36	2.10
								KB-11	16.26	3.26
								KB-12	18.48	3.94
								KB-13	14.02	2.72
								KB-14	20.80	4.37
								KB-15	13.84	2.28
All Mean:	10.72			All Mean	11.51			All Mean	16.81	
Notes: OC = oyster community, np = not present or no suitable substrate										

Table 3 presents the data for the counts of live and dead barnacles of the species *Balanus subalbidus* and *B. amphitrite* collected from the field scrapes of pilings. There is some undetermined error in these table values, since removing barnacles from an exact measured area underwater is difficult. Although *B. amphitrite* was observed in the Lower Withlacoochee during the March 18th reconnaissance trip, this species was only observed in the field scrape samples collected from the Homosassa River.

Overall, the greatest number of barnacles for a 100 cm sq area was recovered from HR-12.3 (303 barnacles / 100 cm^2). Areas where barnacles were not present (np) at two sites on the Homosassa, HR-12.7 and HR-12.6, two sites on the Withlacoochee WR-4.1 and WR-6.7 and one site in Kings Bay, KB-7. Graphic representation of barnacle counts for each station arranged from greatest to lowest salinity on the sampling days for the Homosassa River and Kings Bay are shown in **Figures 16** and **17**. Locations where very low numbers of barnacles were found are listed as <1. **Appendix Table 1** provides a list of other fauna that were associated with the barnacle scrape samples. Barnacle colonies serve as a structural basis for many other estuarine organisms.

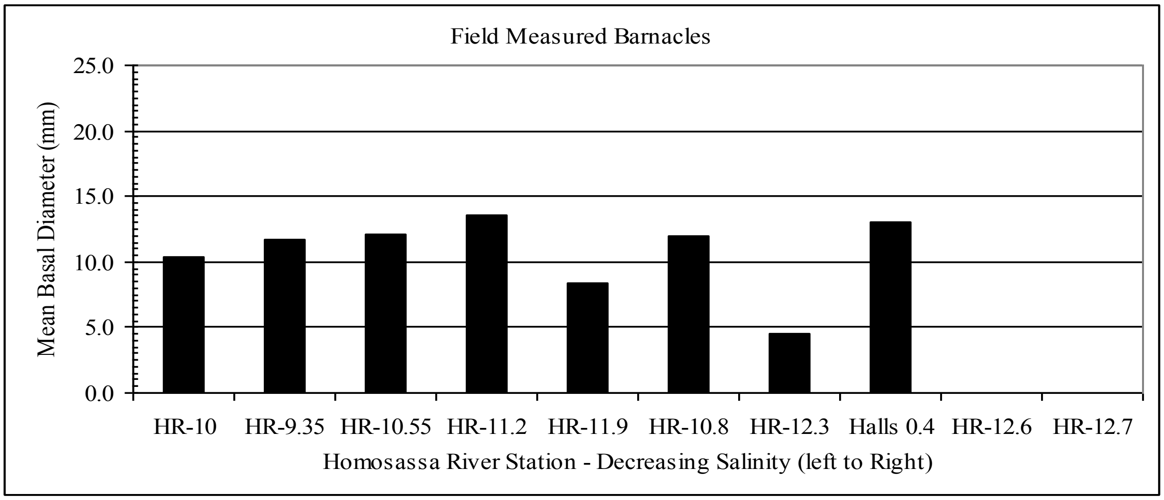


Figure 13. Mean basal diameter of barnacles in the Homosassa River.

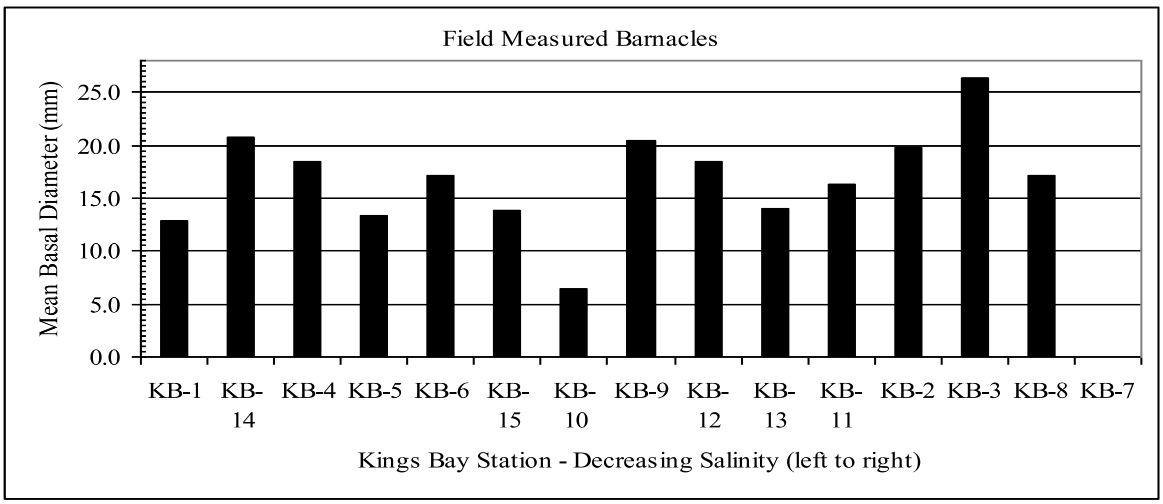


Figure 14. Mean basal diameter of barnacles in Kings Bay, Crystal River.

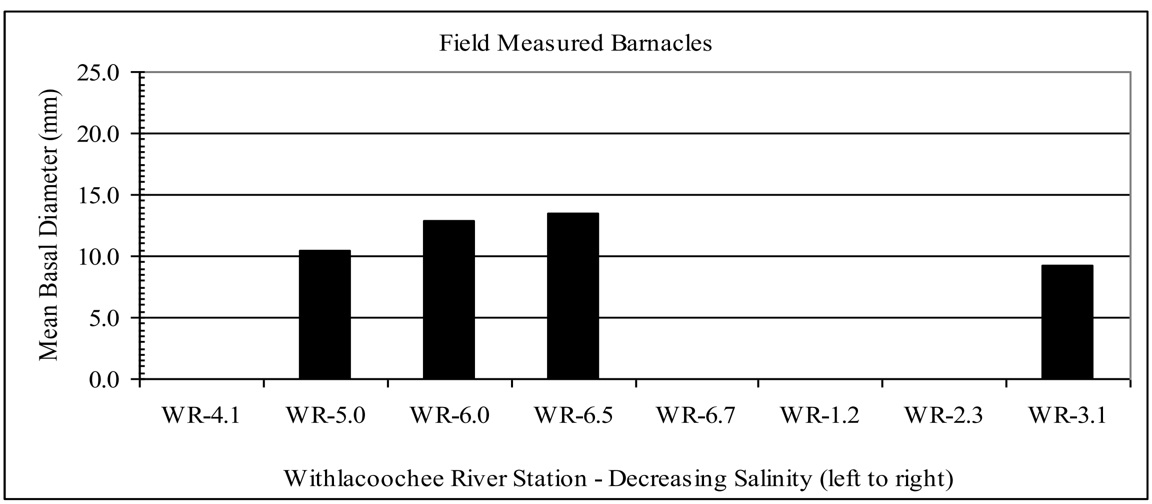


Figure 15. Mean basal diameter of barnacles in the Withlacoochee River.

Table 3. Barnacle counts for field scrape samples.

Station	*Balanus subalbidus* (count/100cm2)				*Balanus amphitrite* (count/100cm2)		
	Live	Dead	Total	Live/Dead	Live	Dead	Total
HR-9.35	162	13	175	12.5	0	0	0
HR-10	164	7	171	23.4	0	0	0
HR-10.55	107	17	124	6.3	0	0	0
HR-10.8	128	6	134	21.3	0	0	1
HR-11.2	144	22	168	6.5	0	0	0
HR-11.9	100	3	103	33.3	0	0	1
HR-12.3	303	9	312	33.7	1	0	1
HR-12.6	np	np	np	--	np	np	np
HR-12.7	np	np	np	--	np	np	np
Halls-0.4	143	2	145	71.5	0	0	1
KB-1	93	8	101	11.6	0	0	0
KB-2	47	0	47	--	0	0	0
KB-3	51	0	51	--	0	0	0
KB-4	114	20	134	5.7	0	0	0
KB-5	159	5	164	31.8	0	0	0
KB-6	145	11	156	13.2	0	0	0
KB-7	np	np	np	0.0	np	np	np
KB-8	78	15	93	5.2	0	0	0
KB-9	207	0	207	--	0	0	0
KB-10	26	0	26	--	0	0	0
KB-11	84	1	85	84.0	0	0	0
KB-12	93	6	99	15.5	0	0	0
KB-13	95	4	99	23.8	0	0	0
KB-14	47	2	49	23.5	0	0	0
KB-15	96	7	103	13.7	0	0	0
WR-3.1	239	12	251	19.9	0	0	0
WR-5.0	29	1	30	29.0	0	0	0
WR-6.0	<1	0	<1	0	0	0	0
WR-6.5	<1	0	<1	0	0	0	0
Total:	2,854	171	3,027	--	1	0	4

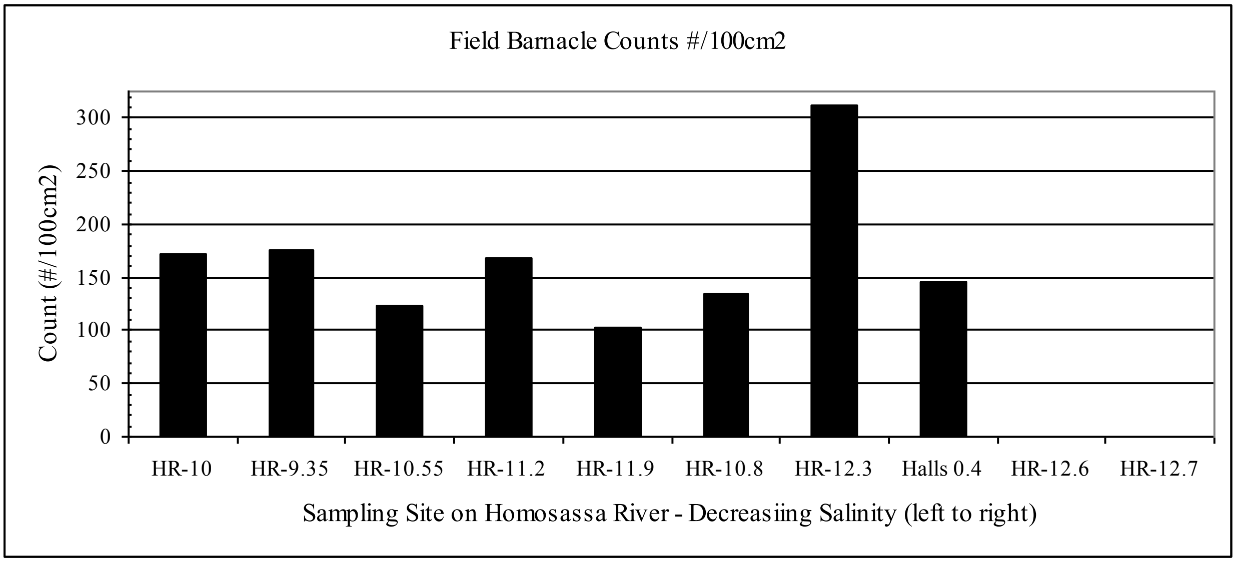


Figure 16. Total barnacle counts for the Homosassa River stations.

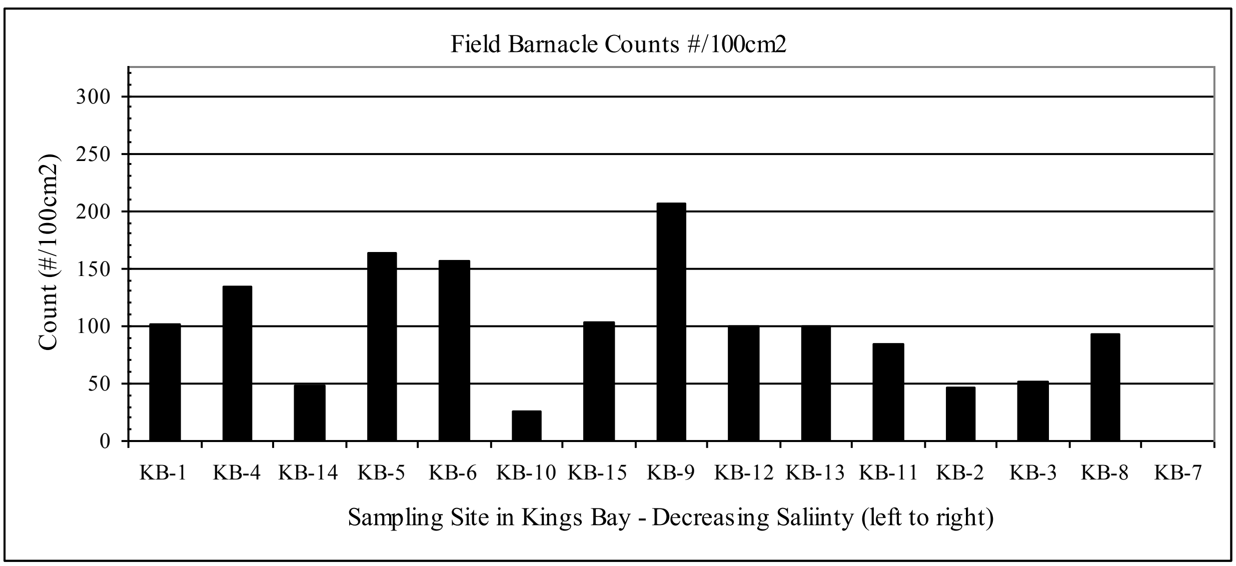


Figure 17. Total barnacle counts for the Kings Bay stations.

After measurement of barnacles, the field scrape samples were dried and combusted at ~525°C to determine the relative proportion of organic material versus organic shell material. **Table 4** presents the results of that analysis with the stations arranged in order of highest to lowest bottom salinity at time of collection. **Figures 18- 21** graphically illustrate the data of Table 5.

Table 4. Biomass values for 100 cm^2 scrape samples.

Station	Bottom Salinity (PSU)	Surface Salinity (PSU)	Total Dry Weight (g/100cm2)	Volatile Solids (% loss on combustion)	Volatile solids (g/100cm2)	Inorganic (shell g/100cm2)
HR-10	14.0	8.2	72.25	4.10	2.96	69.29
HR-9.35	13.4	10.7	17.01	4.37	0.74	16.26
HR-10.55	11.7	5.9	64.59	4.71	3.04	61.54
HR-11.2	9.7	2.4	58.89	6.37	3.75	55.14
HR-11.9	8.8	1.8	30.15	5.55	1.67	28.48
HR-10.8	7.9	5.4	27.88	6.82	1.90	25.98
HR-12.3	6.8	1.2	17.48	12.33	2.15	15.33
Halls-0.4	6.4	5.9	47.75	5.24	2.50	45.25
HR-12.6	2.4	1.0	np	np	np	np
HR-12.7	0.7	0.6	np	np	np	np
KB-1	4.8	6.1	82.10	3.36	2.76	79.34
KB-10	2.9	2.9	2.93	7.61	0.22	2.71
KB-9	2.7	2.8	123.32	4.80	5.92	117.40
KB-4	2.6	3.7	123.15	7.27	8.95	114.20
KB-5	2.5	3.6	95.18	3.01	2.86	92.31
KB-14	2.4	3.7	41.19	5.96	2.46	38.73
KB-11	2.0	2.5	42.95	3.17	1.36	41.58
KB-12	1.8	2.7	42.95	4.27	1.83	41.12
KB-15	1.8	2.9	90.54	3.17	2.87	87.66
KB-13	1.6	2.6	26.02	3.83	1.00	25.02
KB-6	0.9	3.4	102.53	3.19	3.27	99.26
KB-3	0.6	1.7	62.33	20.21	6.27	56.06
KB-8	0.5	0.8	65.87	4.42	2.91	62.96
KB-2	0.5	2.2	24.83	4.20	1.04	23.78
KB-7	0.2	0.2	np	np	np	np
WR-4.1	15.7	2.5	np	np	np	np
WR-5.0	14.5	1.4	12.77	4.53	0.58	12.19
WR-3.5	12.5	3.6	np	np	np	np
WR-4.5	14.2	2.0	np	np	np	np
WR-6.0	12.2	0.2	np	np	np	np
WR-6.5	10.7	0.2	np	np	np	np
WR-6.7	9.2	0.2	np	np	np	np
WR-1.2	9.1	8.1	np	np	np	np
WR-2.3	8.2	6.5	np	np	np	np
WR-3.1	5.2	4.7	43.97	2.77	1.22	42.75

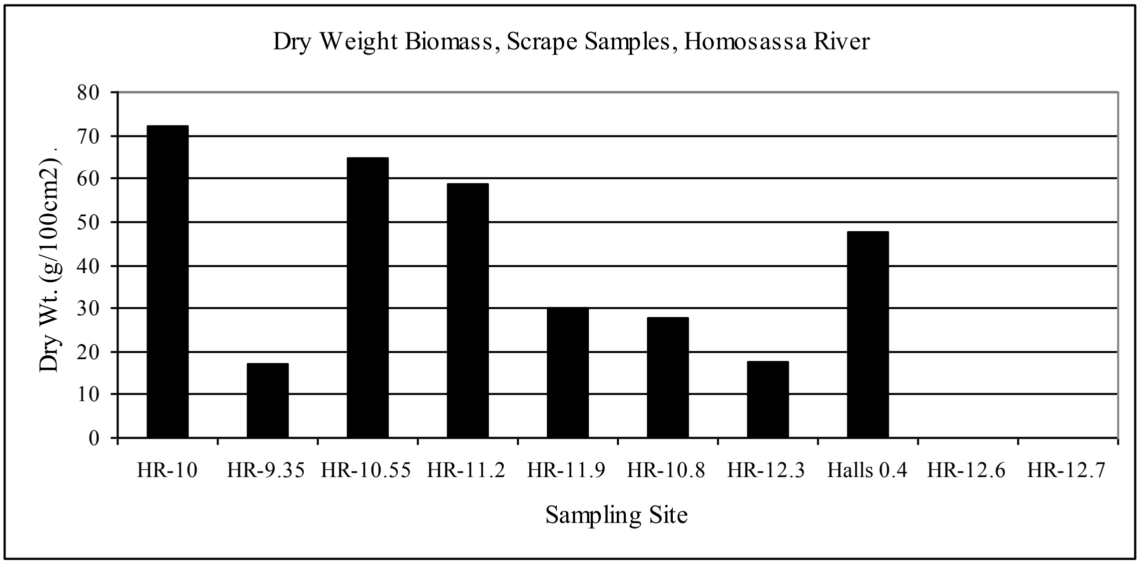


Figure 18. Dry weight biomass for barnacle community scrape samples arranged in order of highest to lowest observed field bottom salinity (L-R), Homosassa River.

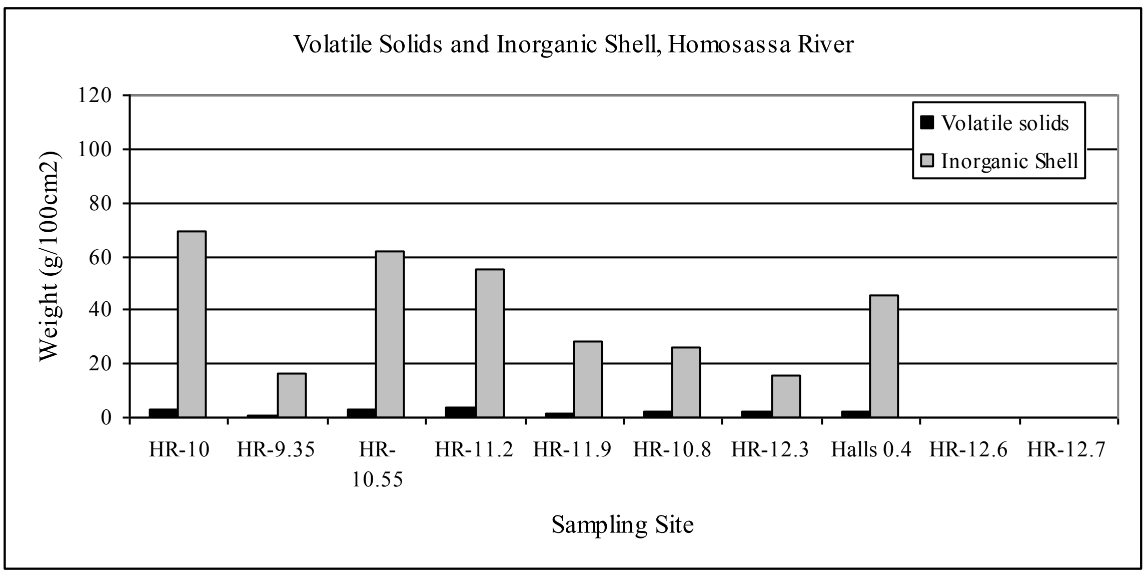


Figure 19. Volatile solids and inorganic shell for barnacle community scrape samples arranged in order of highest to lowest observed field bottom salinity (L-R), Homosassa River.

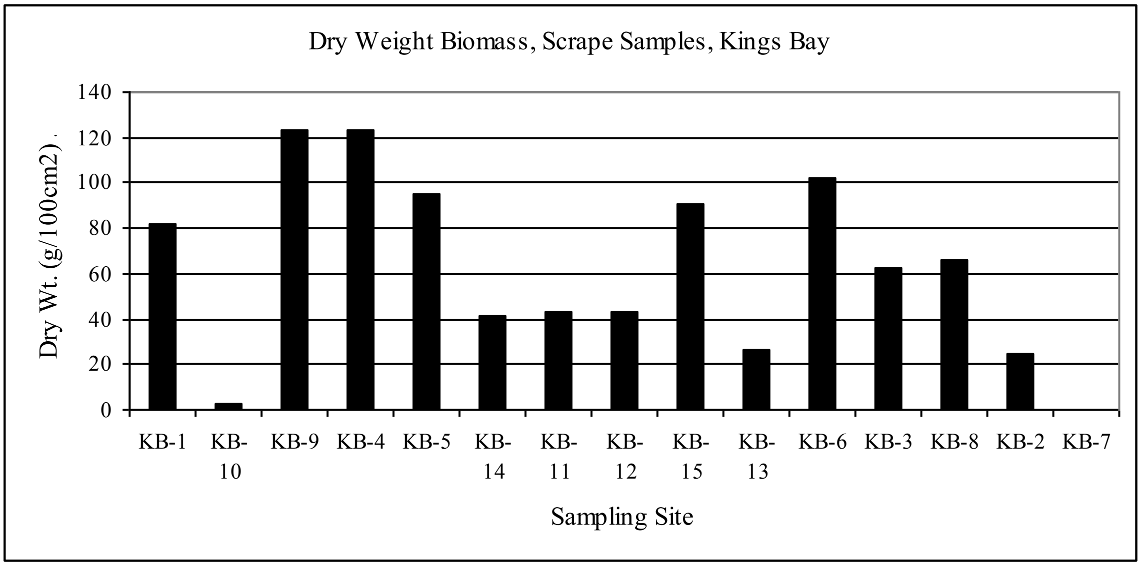


Figure 20. Dry weight biomass for barnacle community scrape samples, Kings Bay.

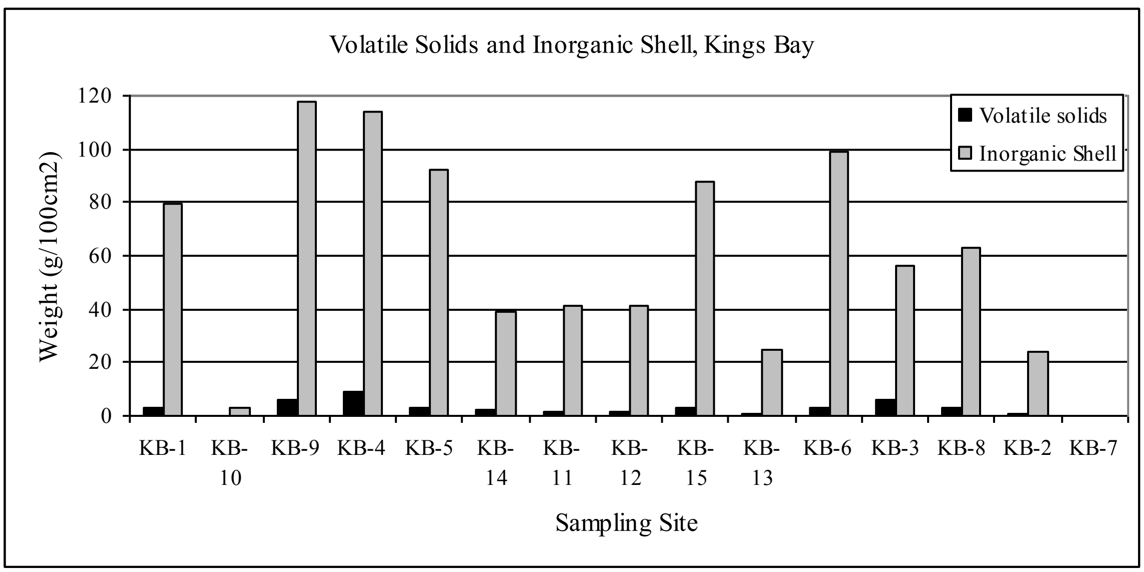


Figure 21. Volatile solids and inorganic shell for barnacle community scrape samples, Kings Bay.

III.5 Barnacle growth on Settlement Plates

During the field reconnaissance on March 18, 2009, artificial substrates were deployed at six locations among the three rivers. The substrates were subsequently retrieved on May 14th. **Table 5** summarizes the barnacle growth data for the resulting 57 day incubation period. Growth rates were estimated by dividing the maximum barnacle size by the total incubation period. The implied growth rates are subject to error since the exact time of settlement of the maximum sized barnacle could not be determined. The greatest growth rate was observed at Halls 0.9, which was located upstream of Halls 0.4. The slowest barnacle growth rates were observed at WR-6 and KB-1. **Figure 22** illustrates the size ranges of the barnacles that grew on the substrates over the same period. **Appendix Figures A1-A6** illustrates the graphs for the individual stations.

Table 5. Barnacle growth size ranges for the period March 18 - May 14, 2009.

Location	Size (mm)		Growth Rate
	Smallest	Largest	(mm/day)
HR-11.2	0.75	9.15	0.16
Halls 0.9	1.5	11.55	0.20
Halls 0.4	1.5	10.65	0.19
KB-1	0.45	4.5	0.08
KB-SW Buzzard Is.	0.3	6.3	0.11
WR-6.0 (WR-5)	0.9	4.35	0.08
Average	0.90	7.75	0.14
St. Dev	0.51	3.13	0.05
Coeff. Var.	0.57	0.40	0.40

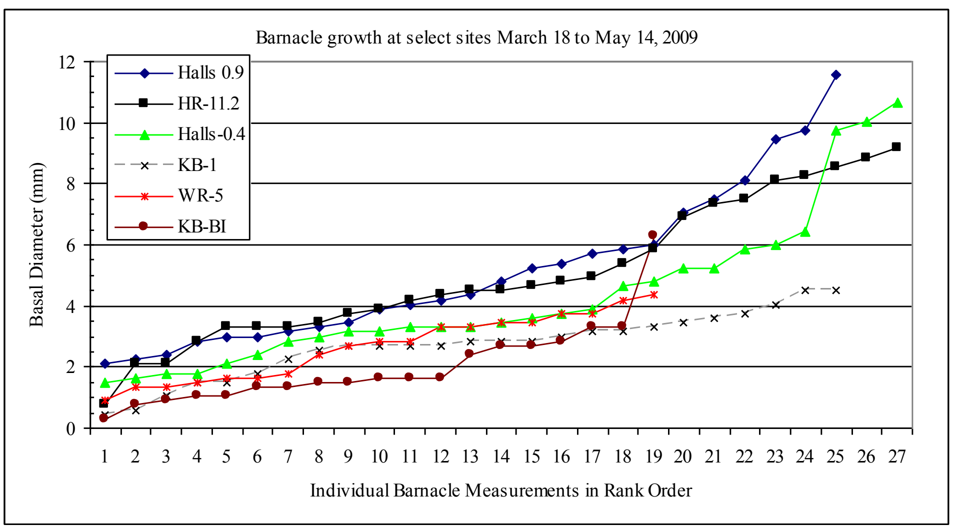


Figure 22. Barnacle basal diameters for 25 randomly picked barnacles for each artificial substrate plus the smallest and largest. Graph represents 6 sites with artificial substrate incubation period of 57 days, March 18 to May 14, 2009. Some sites had fewer than 25 barnacles.

A second set of artificial substrate settlement plates were deployed at thirty-five sites on May 14 and 15, 2009, including redeployment at four sites that were sampled by the first sampling period (sites Halls 0.9 and KB-SW Buzzard Island in Table 6 were deployed only once). The settlement plates were retrieved between June 29 -July 2, resulting in incubation periods of 46 to 48 days. For substrates that exhibited more than 25 barnacles, 23 randomly chosen barnacles were measured. In addition, the largest and smallest barnacles on the plate were measured for a total of 25 measures.

Results for laboratory measurements of basal diameters are shown in **Table 6,** together with the surface and bottom salinity measured on the date of retrieval and average salinity values for nearby stations recorded by the District. The station order is arranged from highest to lowest surface salinity at time of sampling, since barnacles typically are most abundant in the intertidal zone. Bottom salinity is also listed and at some sites there was considerable difference in surface and bottom salinity, possibly due to the very high tide on that day. This somewhat confounds the issue of barnacle distribution as related to salinity, particularly in shallow areas such as Kings Bay and portions of the Homosassa River.

There appeared to be a fairly clear lower surface salinity limit for settlement of barnacles at approximately 2.0 PSU. This relationship was most evident in Homosassa River, but not quite as clear in Kings Bay, where two artificial substrates exhibited significant number of barnacles at salinity values at or below 2.0 PSU (stations KB-11 and KB-6). However, a general pattern was found as there were no barnacles recorded at six or the eight sites which had salinity values of less than or equal to 2.0 PSU.

The settlement of barnacles is not only related to salinity. The relatively low numbers of barnacles found on the settling plate of KB-1 was likely due to very heavy colonization of the plate by tube building amphipods which clearly had an inhibitory effect on the colonization by barnacles (**Figure 23).** The artificial substrate located at KB-6 had a significant number of barnacles and bottom salinity was considerably greater than the surface salinity. The plate at this site had a coating of green filamentous algae, but barnacles were able to colonize the plate (**Figure 24)**.

An unexpected barnacle occurrence was at site KB-15, located at the deep spring vent in Kings Bay described as site 32 known as Hammett 16/King Spring/Grand Canyon Spring (VHB 2009) near the south-east side of Banana Island. This is the area that is typically marked off as a no entry zone for manatee protection during the winter months. We did not originally plan to sample this location as it was assumed that the spring flow would inhibit colonization of barnacles on the limestone. However, on July 2 we examined the vent which did not show any indication of significant water flow. Barnacles were found at this location extending down the limestone walls and into the cave. Barnacles were subsequently measured and a scrape sample was obtained. **Figure 25** illustrates barnacles growing on the walls inside the cave. Small calcareous polychaete tubes were also present. These tube dwelling polychaetes of Family *Serpulidae* have also been observed on the walls of offshore karst features and are believed to subsist on sulfur reducing bacteria associated with the sulfur cycling at the oxic / hypoxic interface.

Table 6. Barnacle growth on artificial substrates for periods from May 14 or May 15, 2009, to June 29 through July 2, 2009, with incubation periods ranging from 46 to 48 days.

Station ID	Number Barnacles	Avg. Basal Diameter (mm)	Salinity on Sampling Day		Average Salinity Values From District	
			Surf	**Bottom**	**Top meter**	**Near Bottom**
HR-9.35	>25	5.08	10.7	13.4	3.9	4.6
HR-10	>25	5.57	8.2	14.0		
HR-10.55	>25	4.27	5.9	11.7		
Halls-0.4	>25	6.85	5.9	6.4	2.9	4.4
HR-10.8	>25	5.05	5.4	7.9	2.8	3.1
HR-11.2	>25	5.32	2.4	9.7		
HR-11.9	0	--	1.8	8.8		
HR-12.3	0	--	1.2	6.8	1.6	2.4
HR-12.6	0	--	1.0	2.4		
HR-12.7	0	--	0.6	0.7	0.5	0.5
			Surf	**Bottom**	**Top meter**	**Near Bottom**
KB-1	11	4.79	4.8	6.1	4.0	5.1
KB-10	13	10.53	2.9	2.9	1.9	2.0
KB-9	23	7.46	2.7	2.8	2.1	2.2
KB-4	>25	7.00	2.6	3.7	2.1	2.9
KB-5	>25	6.81	2.5	3.6	2.1	2.9
KB-14	2	8.18	2.4	3.7	2.0	2.3
KB-11	8	8.57	2.0	2.5	1.7	2.3
KB-12	0	--	1.8	2.7	0.9	0.9
KB-15	NA	--	1.8	2.9	1.8	2.5
KB-13	0	--	1.6	2.6	1.1	1.2
KB-6	24	7.02	0.9	3.4	1.4	1.7
KB-3	0	--	0.7	1.7	0.6	0.9
KB-8	0	--	0.5	0.8	----	----
KB-2	0	--	0.5	2.2	0.7	0.9
KB-7	0	--	0.2	0.2	0.6	0.7
			Surf.	**Bottom**	**Top meter**	**Near Bottom**
WR-1.2	>25	5.43	8.1	9.1	13.7	18.0
WR-2.3	>25	3.44	6.5	8.2	11.0	19.0
WR-3.1	18	3.77	4.7	5.2	4.7	14.0
WR-4.1	0	--	2.5	15.7	2.5	12.1
WR-3.5	1	3.75	2.2	12.5	4.2	14.5
WR-5.0	0	--	1.4	14.5	1.0	12.9
WR-4.5	0	--	0.9	14.2	1.8	11.1
WR-6.0	0	--	0.2	12.2	0.8	6.5
WR-6.5	0	--	0.2	10.7	0.5	5.8
WR-6.7	0	--	0.2	9.2	------	-----

Figure 23. Artificial substrate from Site KB-1 illustrating thick amphipod coverage.

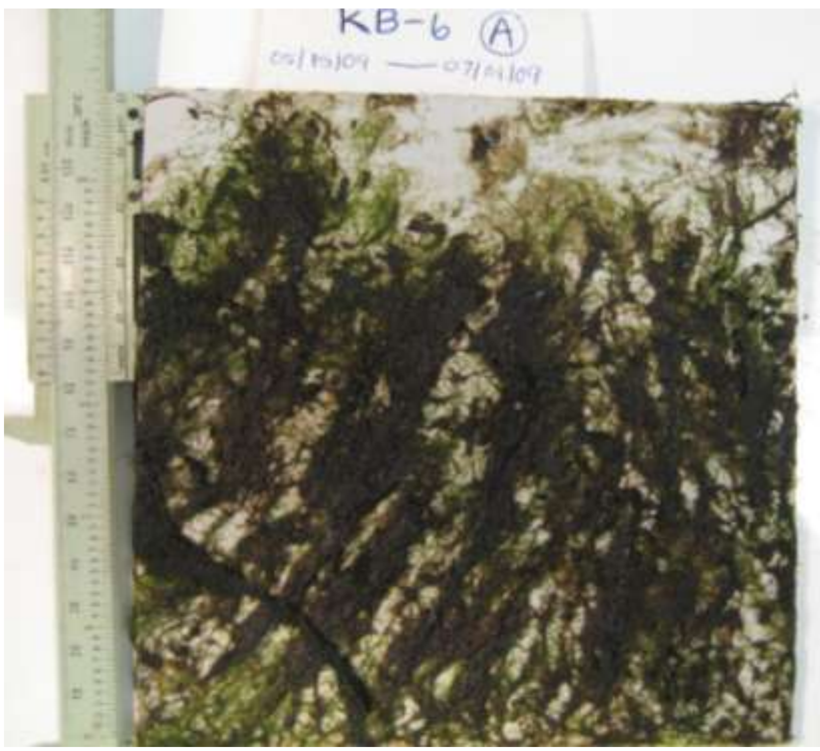


Figure 24. Artificial substrate from Site KB-6 illustrating algae and barnacles.

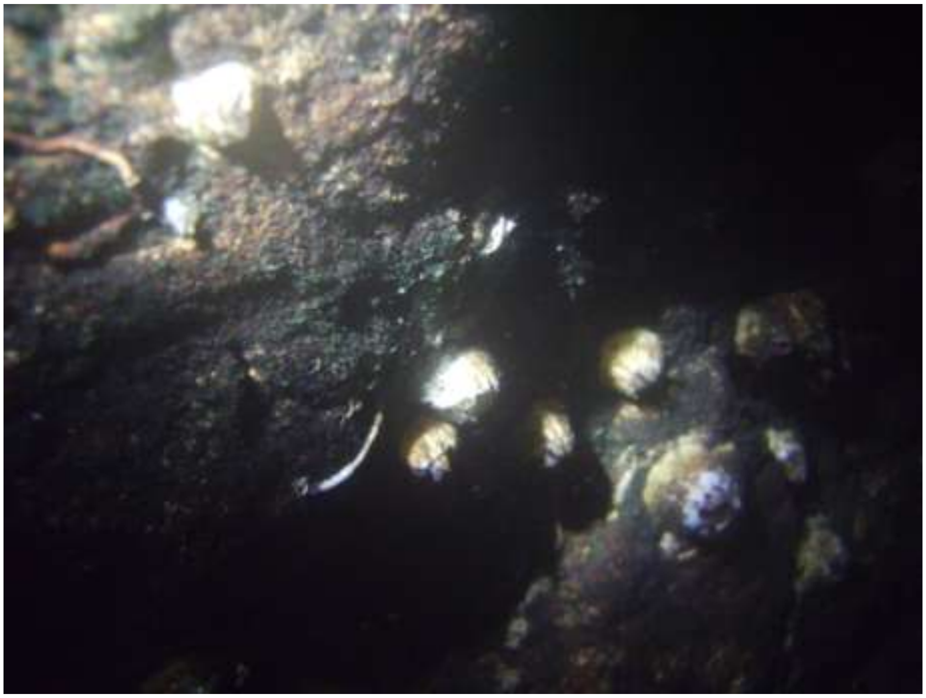


Figure 25. Barnacles growing in the cave of the Hammett 16 spring vent, KB-15. Note the small tube like structures which are the calcareous tubes of polychaete worms.

Biomass on Artificial Substrates

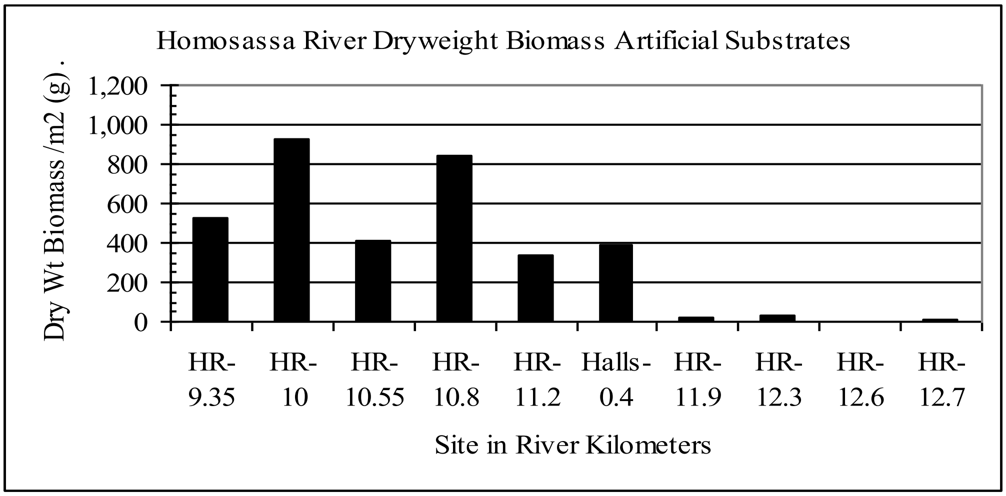
Biomass values for the settlement plates are shown in **Table 7** with the station data arranged in order of decreasing bottom salinity for each river. Graphic representations of dry weight (grams/m^2) and percentage volatile solids are shown as **Figures 26 - 31**. Overall, the Homosassa River exhibited the greatest dry weight biomass and the most discernable trend as related to salinity. The five of most downstream sites on the Homosassa River and the Halls river site exhibited dry weight biomass greater than 340 grams/m^2. However, all sites located upstream of kilometer 11.9 (station HR-11.9) had biomass values less than 30 grams/m2.

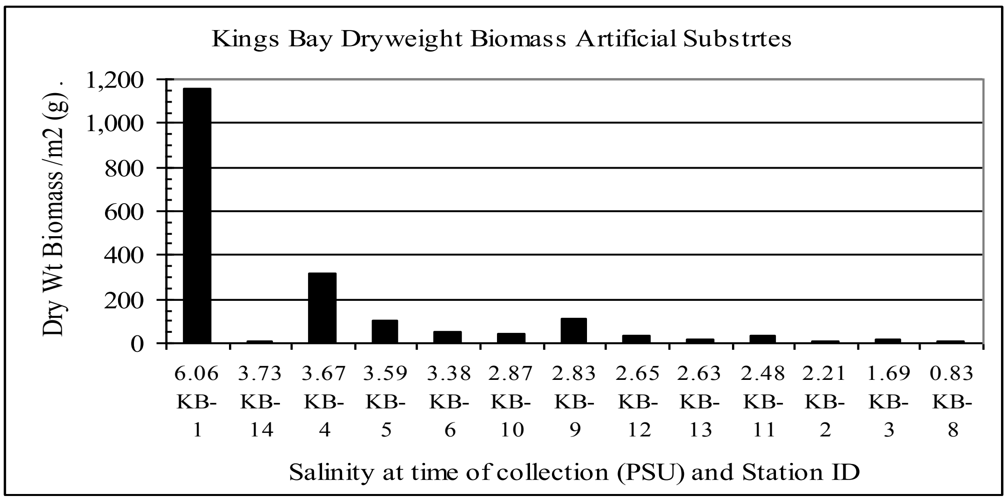
Site K-1 in Crystal River downstream of Kings Bay had a dry weight biomass of 1,160 grams/ m^2, but the majority of sites (10 of 15) in Kings Bay had dry weight biomass values of less than 100 grams/ m^2. Values over 100 grams/m^2 were observed at sites K4, K5, and K9, all of which are near the western side of Kings Bay, which is typically more brackish than the eastern side. The Withlacoochee River also exhibited one site with a very high biomass (WR-1.2) with a dry weight value of 815 grams/ $m^{2,}$, but all other sites had biomass values of less than 110 grams/ m^2. There was no apparent relationship between dry weight biomass and volatile solids as shown in **Figure 32**. The lack of any relationship between these parameters is the result of the differing biological communities found on the substrates from each area.

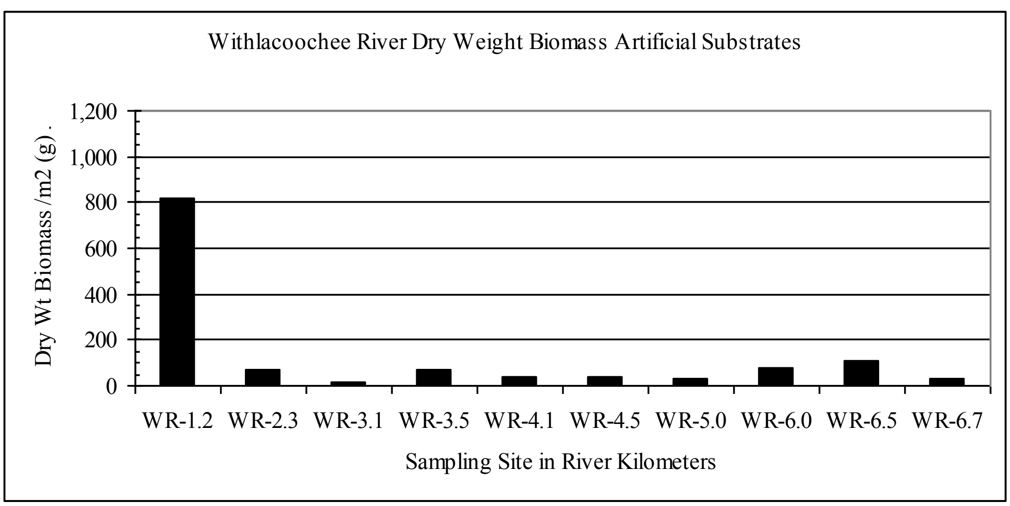
Ash weight primarily represents the quantity of barnacle and mollusk shell present in each sample. **Figures 33**, **34** and **35** are plots of the grams of shell produced per square meter of substrate for each river. Of the 10 sites sampled within the Homosassa River six showed shell of greater than or equal to 299 grams per square meter. In contrast most of the stations within Kings Bay and the Withlacoochee River had an ash shell component far below 299 grams per square meter with the notable exceptions of stations KB-1 and WR-1.2.

Table 7. Biomass measures for artificial substrates placed in each river.

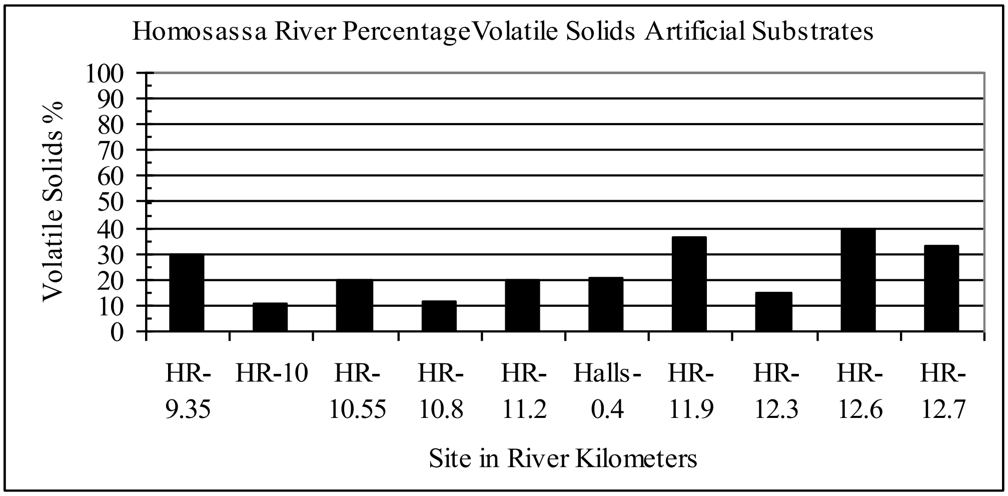
River and Station	Surface Salinity (PSU)	Bottom Salinity (PSU)	Dry Wt. Biomass g/m2	Volatile Solids %	Volatile Solids g/per m2	Ash % Barnacle shell	Ash (Barnacle shell) g/m2
HR-9.35	10.7	13.4	522	29.5	140	70.5	382
HR-10	8.2	14.0	923	10.7	97	89.3	826
HR-10.55	5.9	11.7	406	20.2	73	79.8	333
HR-10.8	5.4	7.9	845	11.4	111	88.6	734
HR-11.2	2.4	9.7	341	19.9	43	80.1	299
Halls-0.4	5.9	6.4	392	20.9	52	79.1	340
HR-11.9	1.8	8.8	24	36.3	11	63.7	13
HR-12.3	1.2	6.8	29	14.8	5	85.2	24
HR-12.6	1.0	0.7	4	39.6	1	60.4	3
HR-12.7	0.6	2.4	14	33.4	4	66.6	9
KB-1	4.8	6.1	1,160	58.3	446	91.7	713
KB-10	2.9	2.9	43	28.8	5	71.2	38
KB-9	2.7	2.8	113	24.9	19	75.1	94
KB-4	2.6	3.7	321	12.3	41	87.7	281
KB-5	2.5	3.6	100	28.2	20	71.8	79
KB-14	2.4	3.7	11	34.2	4	65.8	7
KB-11	2.0	2.5	33	31.6	11	68.4	22
KB-12	1.8	2.7	36	30.5	11	69.5	25
KB-13	1.6	2.6	19	44.9	6	55.1	13
KB-6	0.9	3.4	54	39.8	20	60.2	34
KB-3	0.6	1.7	15	30.6	4	69.4	12
KB-8	0.5	0.8	10	65.4	7	34.6	2
KB-2	0.5	2.2	8	28.7	2	71.3	5
KB-7	0.2	0.2	0	0.0	0	0.0	0
WR-4.1	2.5	15.7	41	40.8	17	59.2	24
WR-5.0	1.4	14.5	33	24.5	8	75.5	24
WR-4.5	2.0	14.2	37	67.8	26	32.2	11
WR-3.5	3.6	12.5	70	34.6	24	65.4	45
WR-6.0	0.2	12.2	76	4.0	6	46.0	70
WR-6.5	0.2	10.7	109	48.3	10	51.7	99
WR-6.7	0.2	9.2	28	28.5	10	71.5	19
WR-1.2	8.1	9.1	815	6.7	58	93.3	757
WR-2.3	6.5	8.2	73	25.6	19	74.4	54
WR-3.1	4.7	5.2	12	15.0	2	85.0	10

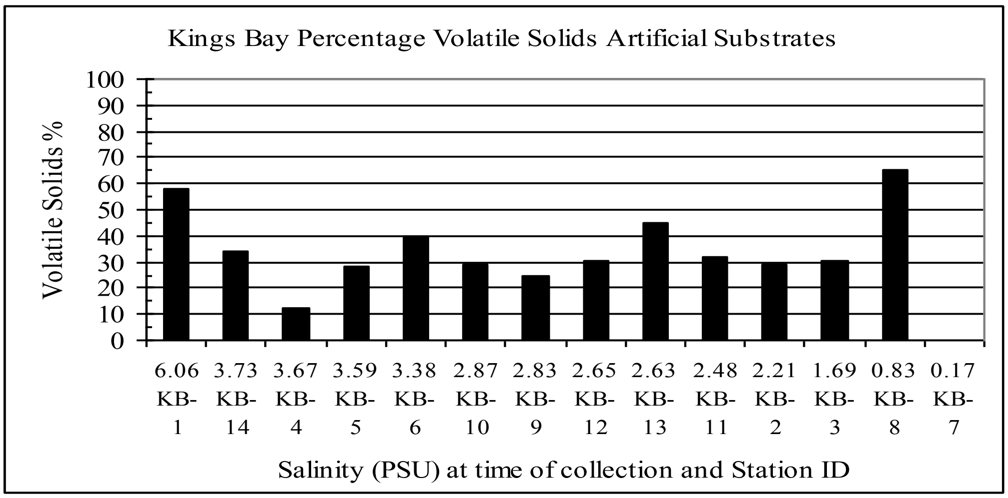


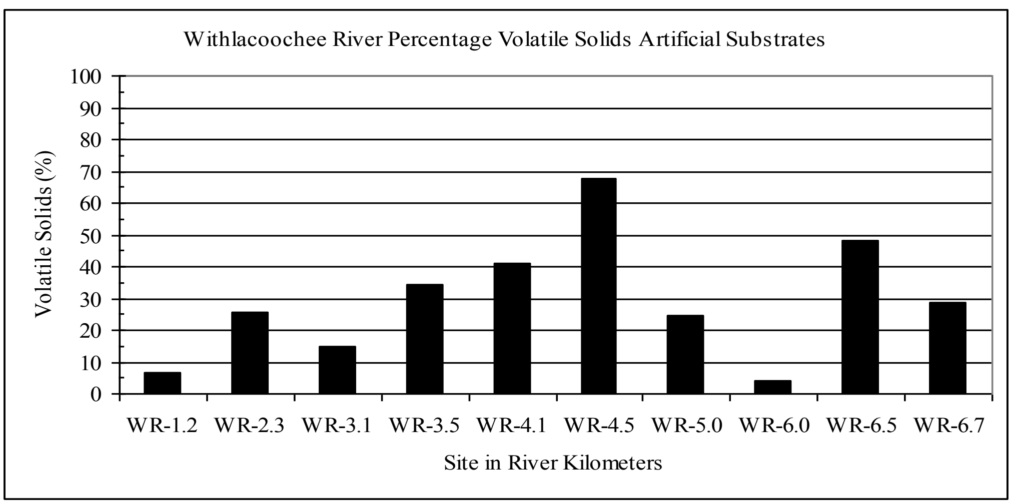




Figures 26, 27 and 28. Dry weight biomass for each river system artificial substrate samples.







Figures 29, 30 and 31. Percentage volatile solids for the three rivers, artificial substrate samples.

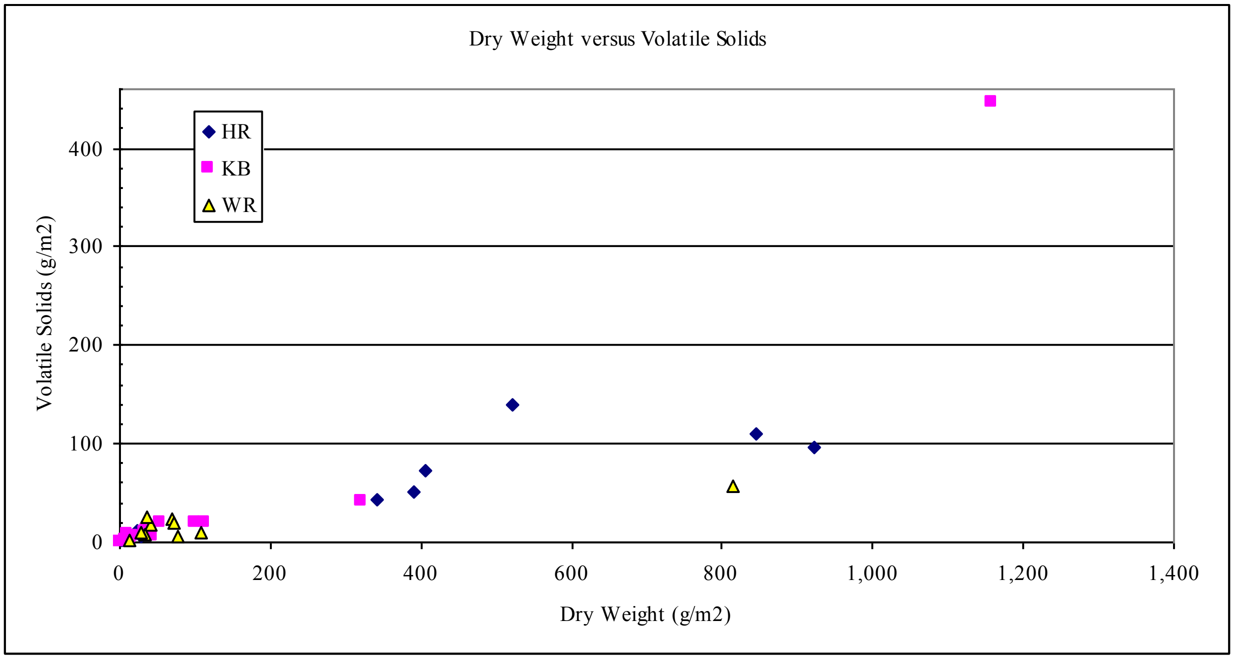
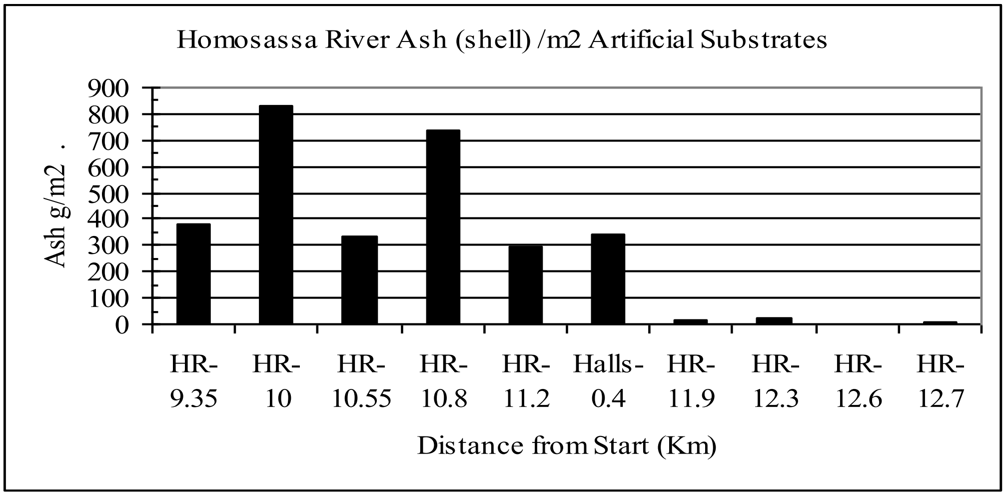
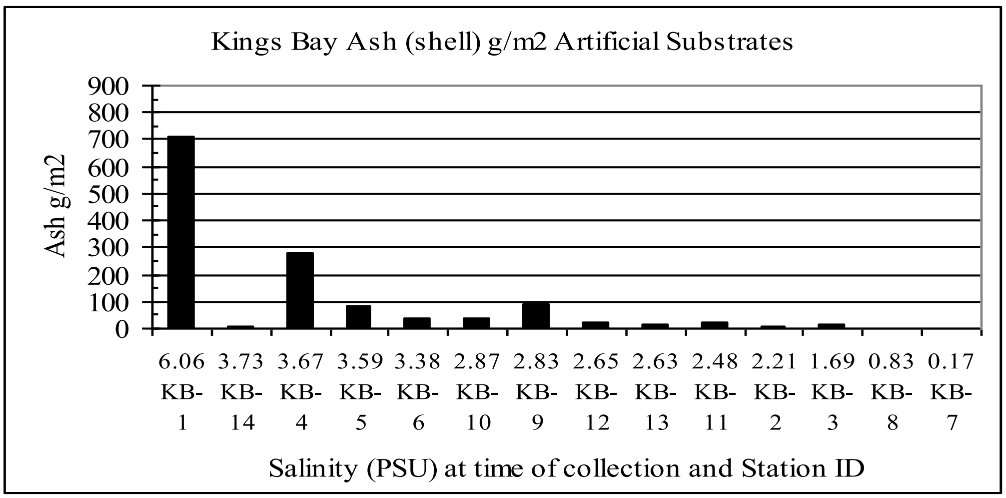
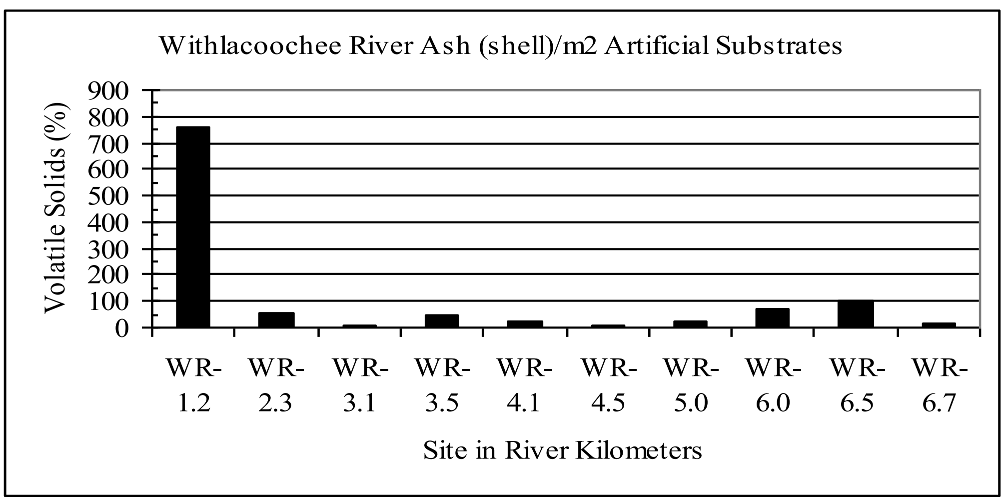


Figure 32. Plot of dry weight (grams/m^2) versus volatile solids (grams/m^2) for artificial substrate data from all three rivers.







Figures 33, 34 and 35. Ash (shell) content of artificial substrate samples for the three rivers.

IV. SUMMARY AND DISCUSSION

From March to July 2009 a series of visits were made the tidal portions of the Homosassa, Crystal and Withlacoochee Rivers on the Florida Gulf coast. The objective was to investigate and map the distribution of barnacles in these three systems, focusing on the upstream tidal freshwater and low salinity areas of the rivers. The barnacle populations in higher salinity downstream areas were not sampled. In all likelihood, barnacle populations in the farther downstream areas are more widespread and dense.

Site observations were supplemented with quantitative data describing the relative density and biomass of the barnacle communities in the three river systems. There were some patterns observed in each of the three rivers. The data from the deployment of settlement plates suggests that salinity lower than ~2.0 PSU may have an inhibitory effect on barnacle settlement. However, barnacles were present at a few sites with salinity values lower than 2.0 PSU, although not in great abundance. The implication is that once settled and growing, barnacles may be able to tolerate very low levels of salinity. Total time duration to exposure to low salinity may also be an important factor for barnacle survival. During the final site visits on June 29 through July 2, a very high tide illustrated that there is significant salt water incursion along the bottom that would otherwise under more normal tides would be much more oligohaline.

In the Homosassa River the barnacle community extended upstream to a point bordered by the main spring run into the river. The fresh water flowing from the shallow spring run is adequate to keep barnacles from penetrating further upstream, but brackish water conditions were observed in the deeper parts of the river. In the upper reaches of the river the barnacle communities do not occur in the intertidal zone; rather, they are restricted to the near bottom zone which could be characterized as a salinity tide.

In the Withlacoochee River the upstream confinement of barnacles to a near-bottom higher salinity zone was more pronounced. In the Withlacoochee the barnacles were located so deep in the upriver areas that they were not observed during the reconnaissance survey when intertidal and subtidal areas were inspected. As for the Homosassa River, barnacles in the upper reaches of the Withlacoochee survey area seem to be limited by the vertical extent of the bottom salinity tide.

In Kings Bay the distribution of barnacles seems to be more complex, but they are generally found throughout the entire bay and were found at every sampling site with the exception of KB-7 where freshwater spring flow was still significant. As noted earlier, *B. subalbidus* is known to be a self fertilizing hermaphrodite. This capability enhances the ability of this barnacle to colonize new areas where the presence of adjacent individuals is not necessary. Perhaps the most surprising area where barnacles were found was the large spring vent known as Hammett 16, where barnacles were discovered inside the cave of this once-flowing vent. At the time of this inspection, the water clarity of the area was very poor with a strong green color due to phytoplankton and an abundance of filamentous green algae which covered most of the bottom in this area. High primary production may be a factor in the maintenance of the robust barnacle population. Typically spring water is depauperate in organic particulates that could serve as barnacle food. Visibility in the area over Hammett 16 was less than 6 feet at the time of the survey compared to visibility of greater than 30 feet (surface to bottom) when the spring was actively flowing (author's personal observation). The large quantities of filamentous algae growing in the southeastern portions of the bay are a strong indication of eutrophication. There was also a paucity of fish and crabs that in years past were abundant at this site (Culter personal observation). There is the possibility that a reduction in euryhaline barnacle grazing species such as Sheepshead (fish) and crabs could be contributing to an overall increase in barnacle populations.

The longevity of barnacles in the three systems that were surveyed is unknown. The settling plate data showed that barnacles were growing up to 12.6 mm basal diameter within 48 days and are likely reproductive within that period. A study of intertidal populations of *B. amphitrite* in Australia estimated a mean longevity to be 22 months and a maximum age of 5-6 years (Calcagno et al 1998). Thus it is quite possible that barnacles that settle as a result of optimal salinity conditions may persist for a number of years in the absence of any new recruitment episodes.

The presence of man-made hard substrates within Kings Bay may also play a role in the maintenance of barnacle populations. All of the substrates sampled for this project were man-made. Although most of the pilings for sings and navigation markers were wood, they are fixed in place and are pressure treated thus not able to rot in a natural process. Natural tree deadfall in Kings Bay is very limited. In the Withlacoochee River natural wood was examined for barnacles but no suitably colonized materials could be located. Natural wood in these systems does not seem to provide a suitable substrate for barnacles perhaps because the normal rotting process makes natural wood too soft and prone to sloughing off surface layers. Oddly most of the sea walls that were inspected did not exhibit robust barnacle populations, but this may have been an observational oversight as pilings and floating docks were targeted in the surveys after having been determined that these were optimal barnacle settling sites.

Having determined that the barnacle colonization in the Homosassa River and Kings Bay are prevalent in all but the most oligohaline sections, what is the future prognosis? The short term condition of these areas as to whether Crystal River and Homosassa / Halls Rivers will continue to biologically function as rivers with both tidal freshwater and estuarine zones depends on spring flows and surface freshwater inflows. If freshwater flows decrease, the Homosassa and Crystal Rivers will become more estuarine in nature and could ultimately reduce the historic freshwater areas to small refugia around the individual spring vents that continue to flow. The fact that barnacles and associated estuarine fauna were nearly ubiquitous in the main channel of the Homosassa River and the open basin of Kings Bay, illustrates the freshwater flows during and preceding the field work of this project were not sufficient to maintain predominantly freshwater faunal characteristics in many upstream areas of those rivers

For the Withlacoochee River, the estuarine zone will migrate upriver somewhat, depending on river flows although the process would presumably occur at a much slower rate since the size of the drainage basin is much larger than the Crystal and Homosassa Rivers. The other invertebrates associated with the barnacle communities from the artificial substrates illustrate a "typical" estuarine fauna, complete with polychaetes and a robust microcrustacean fauna, particularly amphipods and isopods.

The long term biological condition of these areas will be tied to sea-level change, for which spring flow would have to increase to maintain the status quo. Increases in sea-level are consistent with robust data that illustrate average global increases in temperature. Global average sea-level rose at an average rate of 1.8 mm per year over 1961 to 2003 and at an average rate of about 3.1 mm per year from 1993 to 2003. Whether this faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer term trend is unclear. Since 1993 thermal expansion of the oceans has contributed about 57% of the sum of the estimated individual contributions to the sea-level rise, with decreases in glaciers and ice caps contributing about 28% and losses from the polar ice sheets contributing the remainder (IPCC 2007).

A recently published analysis suggests that a sea level rise of 75 to 190 cm for the period 1990–2100 is probable (Vermeera and Rahmstorf 2009). The authors point out that observed sea-level rise exceeded that predicted by models (best estimates) by ≈50% for the periods 1990–2006 and 1961–2003. The increase modeled by Vermeera and Rahmstorf is considerably greater than the 1993-2003 average annual rates (3.1 mm/year) which if applied linearly to the next 90 years would result in an approximate 28 cm sea-level rise.

A recent graphic constructed by NOAA of the monthly mean sea level for the Cedar Key area without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents is shown as **Figure 37**. The long-term linear trend is also shown, including its 95% confidence interval. The plotted values are relative to the most recent Mean Sea Level datum established by CO-OPS. The current rate of seal level increase is and 1.80 mm/year for Cedar Key and 2.36 mm/year for St. Petersburg. These observed rates for historical data are less than the projected rate of annual increase suggested by Vermeera and Rahmstorf.

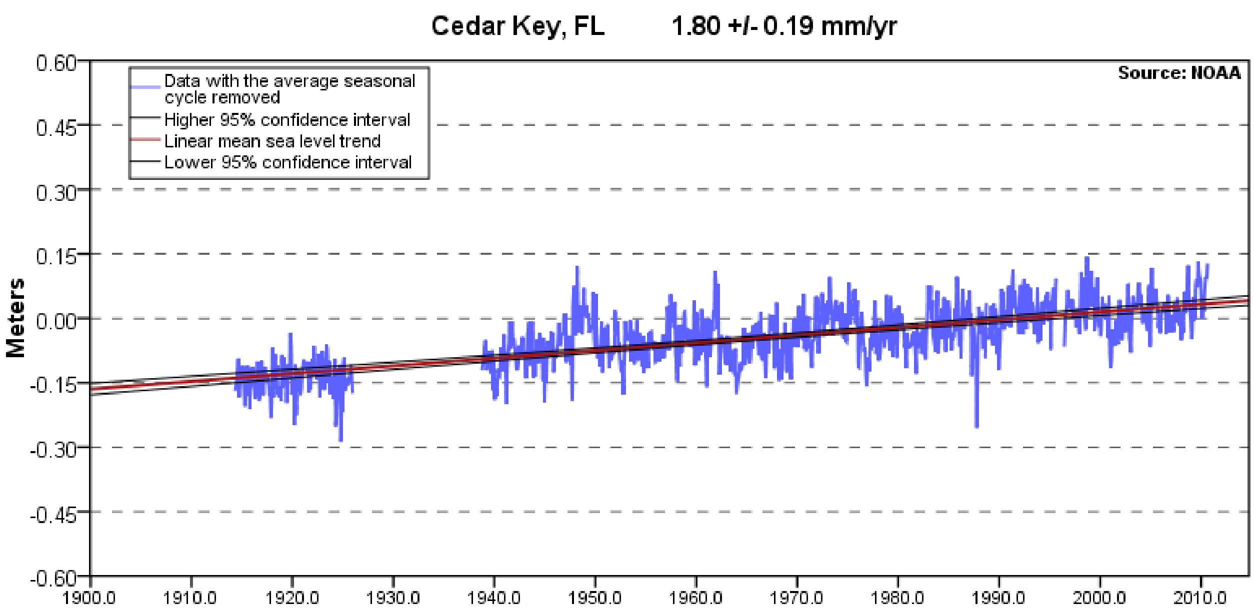


Figure 36. Current rate of sea level rise as constructed by NOAA based on of the monthly mean sea level for the Cedar Key water level tide monitoring station.

Regardless of the model that one chooses to use for planning, it seems certain that sea-level will continue to rise and the time frame where significant coastal alterations of natural systems will manifest is now within a human lifetime. Even small increases in sea-level will increase the frequency of salt wedges pushing into former freshwater and oligohaline areas of tidal river systems. The use of biological remains as indicators of Biological Mean Sea Level Indicators (BMSIs -Laborel et al., 1994) dates back to the 1950's (Donner 1959). The accuracy of such determinations by BMSIs has generally been between 5 and 20 centimeters, suitable for geologic determinations of sea level rise and fall. Comparatively the documented incursion of barnacles into the shallow tidal runs of coastal springs may be a first indicator of persistent biological changes that will accompany sea level rise.

Unless freshwater spring discharges increase to keep pace with sea-level rise, the Homosassa and Crystal Rivers will be altered to an estuarine condition with only small pockets of freshwater communities around spring vents of significant flow. In fact, such an alteration is now in progress as a probable result of long term reduced rainfall and reduced spring flows. During this survey the only section of Kings Bay that was notably absent of barnacles was the spring run upstream of KB-7. Even at KB-7 there were a few barnacles on a nearby PVC pipe and a floating dock. The barnacle based fouling community is evidence that estuarine fauna are presently invading these areas. The presence of barnacles and calcareous tube dwelling polychaetes within a cave of a once flowing spring are dramatic evidence of a shift in the biological community.

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Spivey, H.R. 2009. Shell morphometry in barnacles: quantification of shape and shape change in Balanus. Journal of Zoology **Volume 216 Issue 2, Pages 265 - 294.**

Vermeer, M., Rahmstorf, S. Global sea level linked to global temperature**.** *Proceedings of the National Academy of Sciences*, 2009; DOI: 10.1073/pnas.0907765106

ON-LINE RESOURCES

Crystal River
http://www.protectingourwater.org/watersheds/map/springs_coast/
http://en.wikipedia.org/wiki/Crystal_River_(Florida)
http://www.floridacaves.com/crystalriver.htm

Homosassa River
http://www.protectingourwater.org/watersheds/map/springs_coast/

Withlacoochee River
http://www.protectingourwater.org/watersheds/map/withlacoochee/
http://en.wikipedia.org/wiki/Withlacoochee_River_(Florida)
http://www.amyhremleyfoundation.org/php/education/features/CoastalRivers/Withlacoochee.php

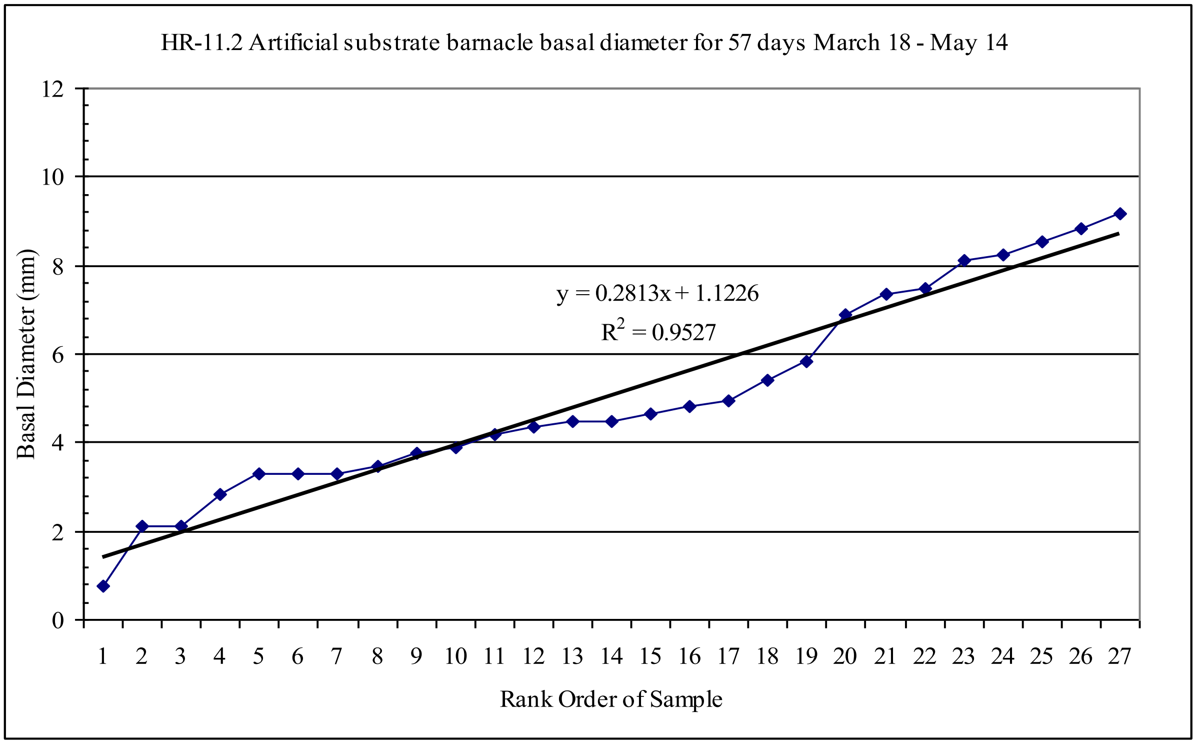
Barnacles
http://darwin-online.org.uk/
http://en.wikipedia.org/wiki/Barnacle

Sea Level Trends
http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8727520

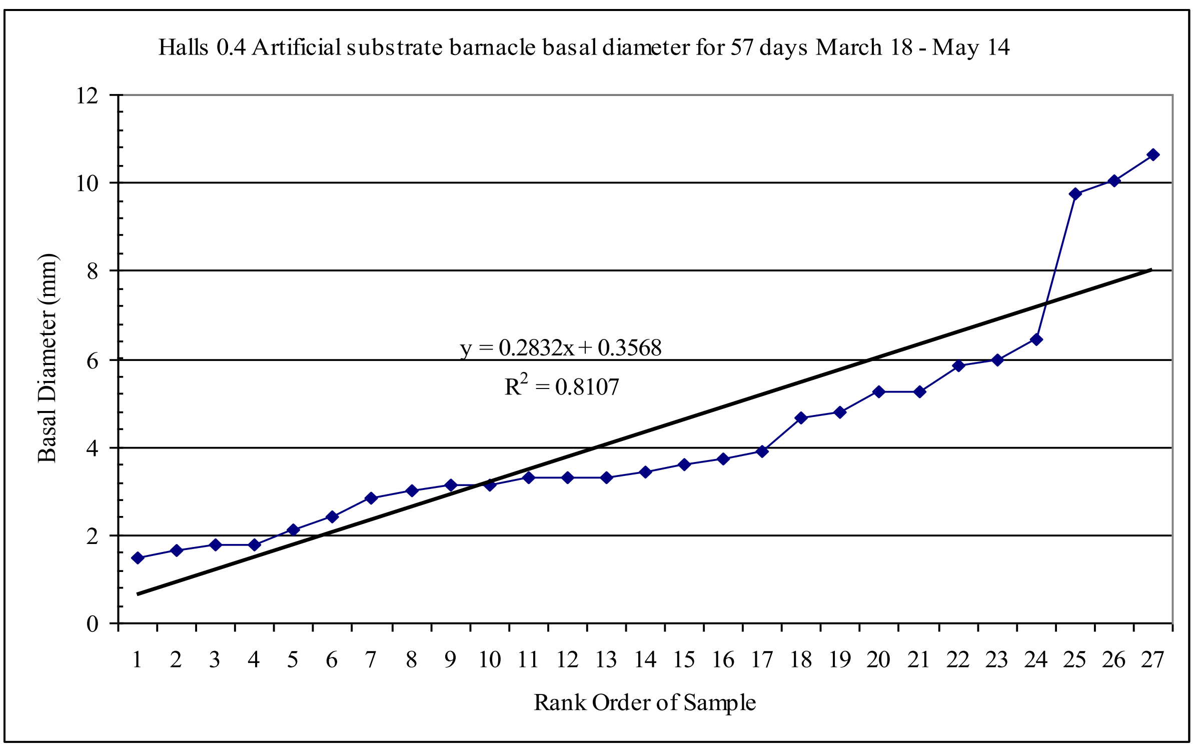
APPENDICES

Appendix Table 1. Barnacles and associated fauna collected in field scrape samples from pilings.

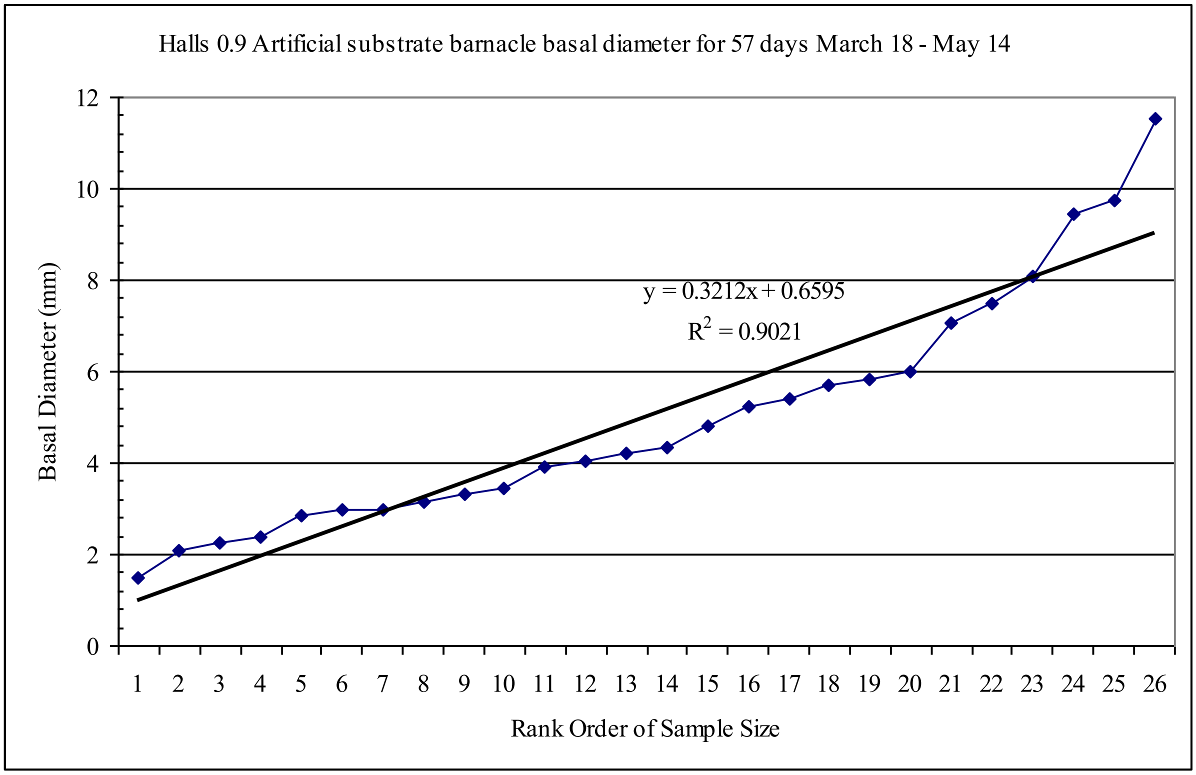
	Balanus subalbidus (count/100cm2)			Balanus amphitrite (count/100cm2)			Mussels (count/100cm2)			Other Invertebrates								
Station	**Live**	**Dead**	**Total**	**Live**	**Dead**	**Total**	**Live**	**Dead**	**Total**	**Amphipods**	**Isopods**	**Decapods**	**Chironomidae**	**Polychaetes**	**Tanaidacea**	**Insect Larvae**	**Snails**	**Fish**
HR-9.35	162	13	175	0	0	0	163	3	166	>100	20	2	15	20	>100	0	0	0
HR-10	164	7	171	0	0	0	132	8	140	400	48	4	0	8	124	0	0	0
HR-10.55	107	17	124	0	0	0	135	10	145	37	94	3	6	15	>100	0	0	2
HR-10.8	128	6	134	0	0	1	116	2	118	>100	3	2	0	12	77	0	0	0
HR-11.2	144	22	168	0	0	0	660	108	768	252	80	8	4	4	236	0	4	0
HR-11.9	100	3	103	0	0	1	>250	3	>250	65	1	0	11	5	47	0	0	0
HR-12.3	303	9	312	1	0	1	>225	3	0.228	7	6	4	7	11	>100	0	0	0
HR-12.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HR-12.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hall-0.4	143	2	145	0	0	1	19	1	20	>100	5	1	1	0	0	0	0	0
KB-1	93	8	101	0	0	0	20	4	24	7560	176	4	0	0	40	0	0	0
KB-2	47	0	47	0	0	0	16	0	16	18	12	0	27	4	0	14	20	0
KB-3	51	0	51	0	0	0	13	0	13	142	23	0	26	0	74	26	0	0
KB-4	114	20	134	0	0	0	4	0	4	800	4	4	4	0	0	0	0	0
KB-5	159	5	164	0	0	0	4	0	4	1360	40	4	0	0	196	0	0	0
KB-6	145	11	156	0	0	0	12	0	12	376	28	0	12	0	172	0	0	4
KB-7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB-8	78	15	93	0	0	0	56	0	56	384	52	8	0	0	84	0	0	4
KB-9	207	0	207	0	0	0	16	0	16	568	40	0	44	0	0	0	0	0
KB-10	26	0	26	0	0	0	0	0	0	8	0	0	0	0	4	0	1	0
KB-11	84	1	85	0	0	0	4	0	4	90	2	4	26	0	38	6	0	0
KB-12	93	6	99	0	0	0	28	0	28	196	8	8	12	0	48	4	4	0
KB-13	95	4	99	0	0	0	1	0	1	43	0	2	1	1	0	1	0	0
KB-14	47	2	49	0	0	0	30	0	30	502	4	0	4	0	46	0	1	0
KB-15	96	7	103	0	0	0	100	4	104	8	8	0	0	8	0	0	0	0
WR-3.1	239	12	251	0	0	0	0	1	1	97	0	1	68	2	0	0	1	0
WR-5.0	29	1	30	0	0	0	8	2	10	38	3	0	5	0	0	0	2	0
WR-6.0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WR-6.5	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	2,854	171	3,027	1	0	4	1,537	149	1,680	12,951	657	59	273	90	1,186	51	33	10



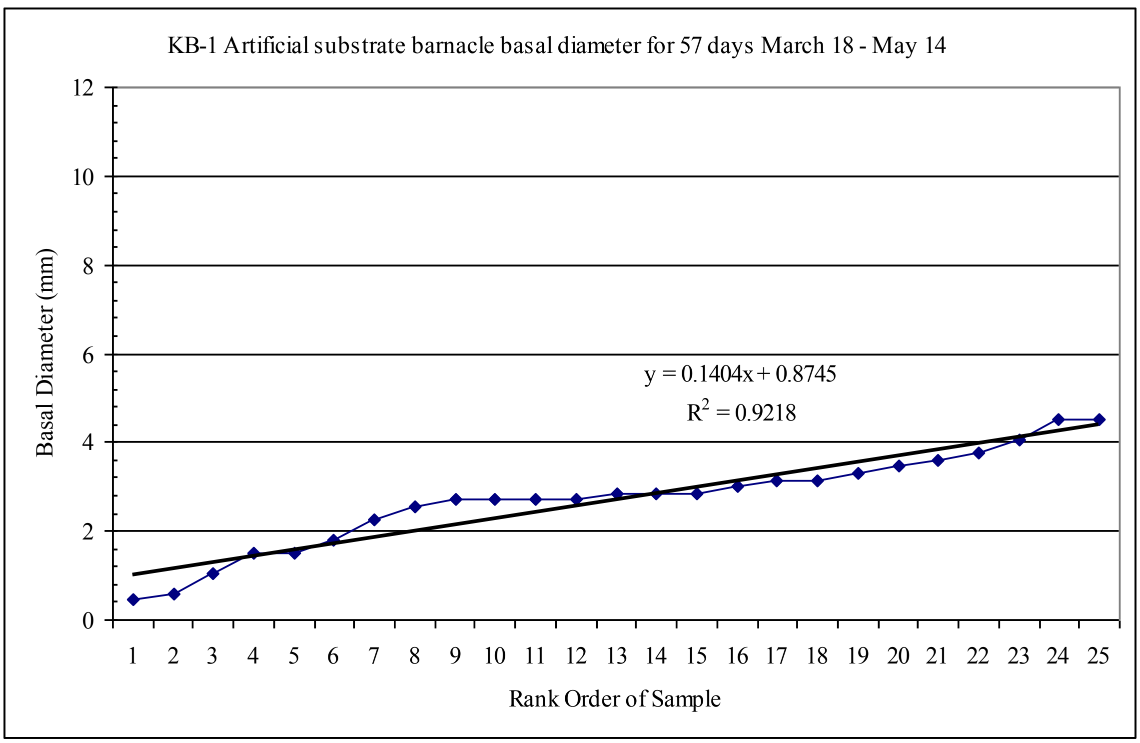
Appendix Figure A.1. Barnacle sizes for Homosassa River 11.2, for March – May 2009.



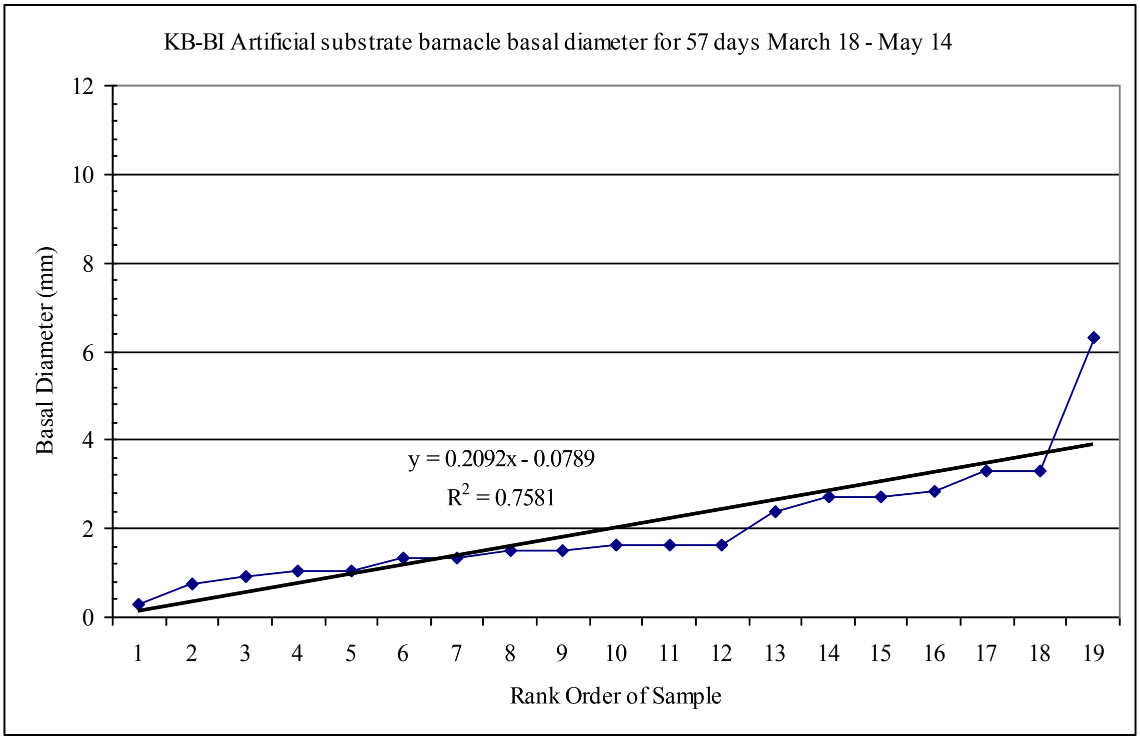
Appendix Figure A.2. Barnacle sizes for Halls River 0.4, for March – May 2009.



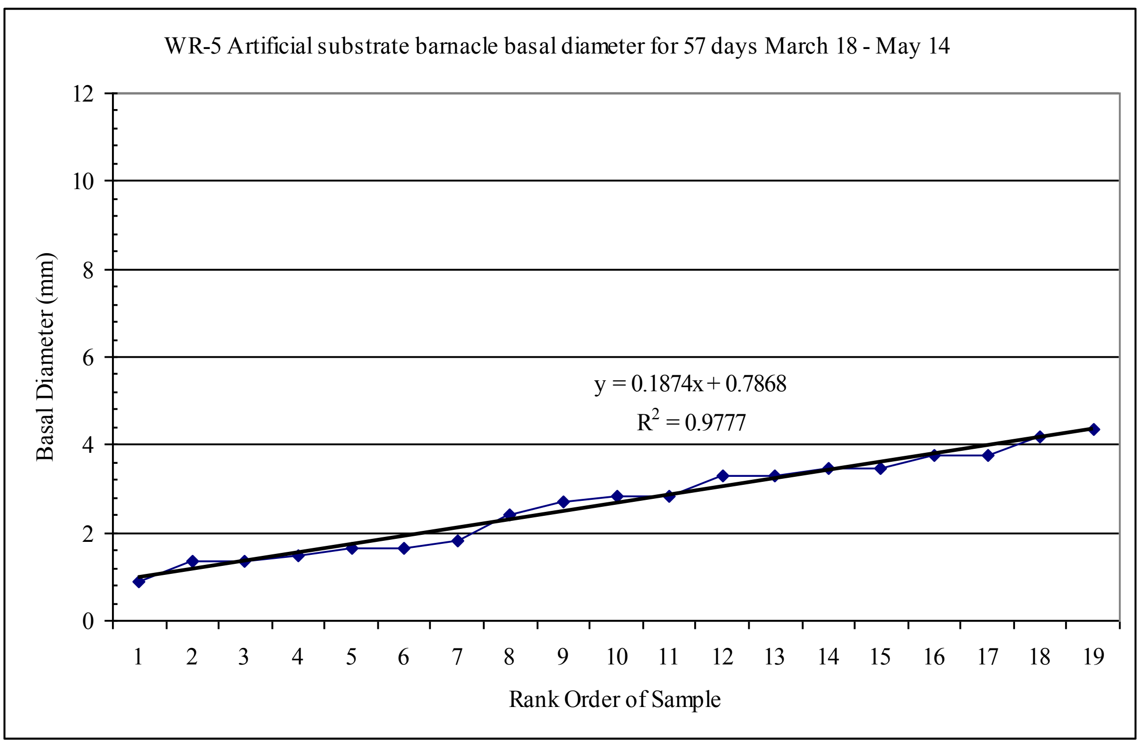
Appendix Figure A.3. Barnacle sizes for Halls River 0.9, for March – May 2009.



Appendix Figure A.4. Barnacle sizes for Crystal River (Kings Bay) at marker 27, for March – May 2009.

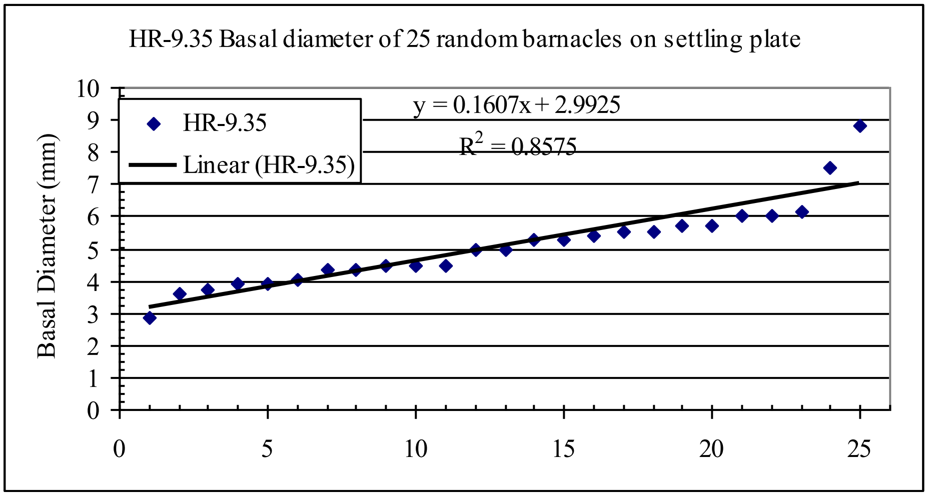


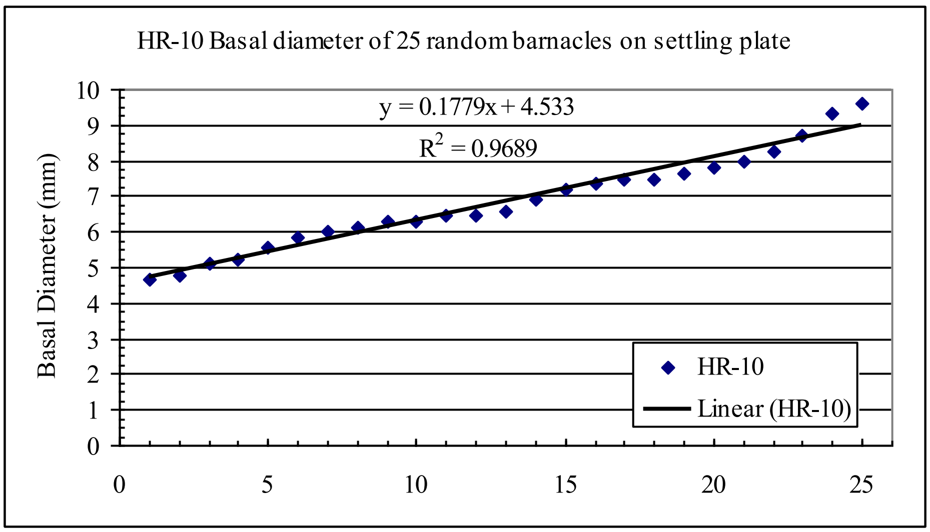
Appendix Figure A.5. Barnacle sizes for Buzzard Island in Kings Bay, Crystal River for March – May 2009.

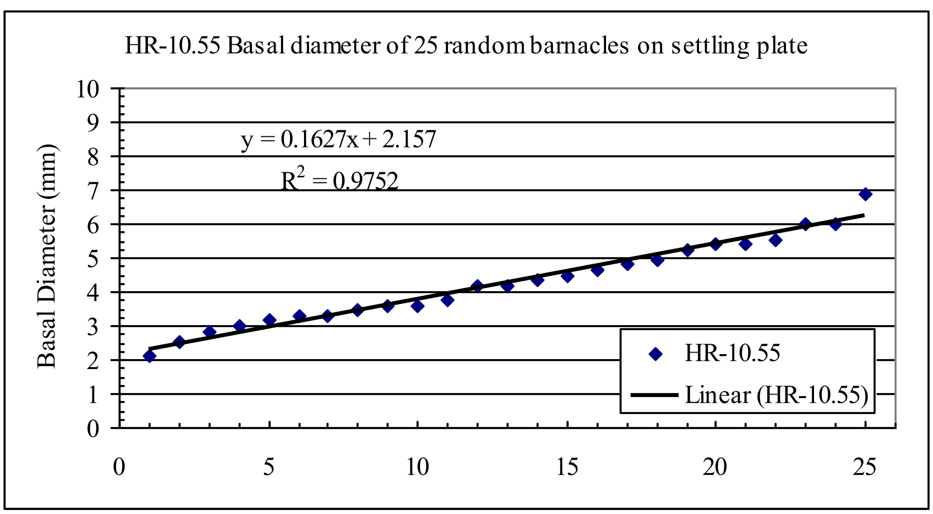


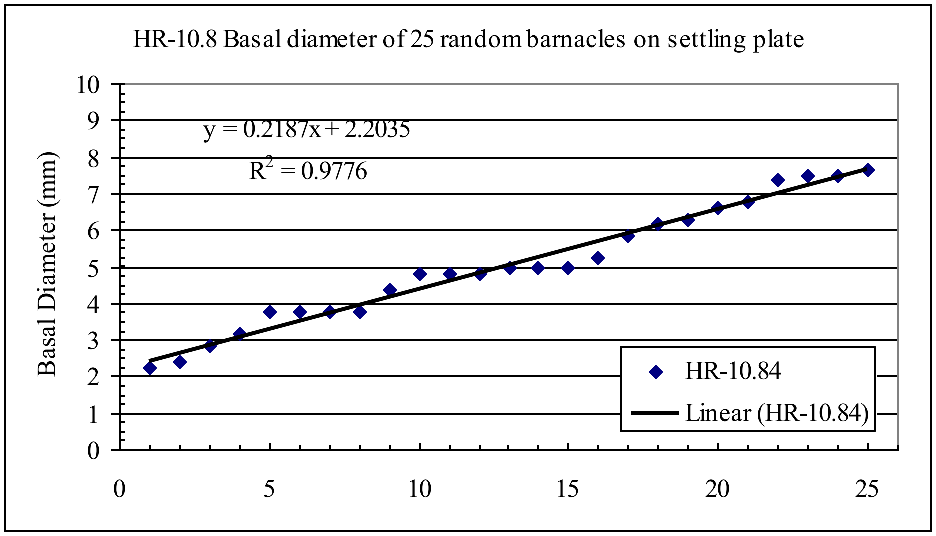
Appendix Figure A.6. Barnacle sizes for Withlacoochee River for March – May 2009.

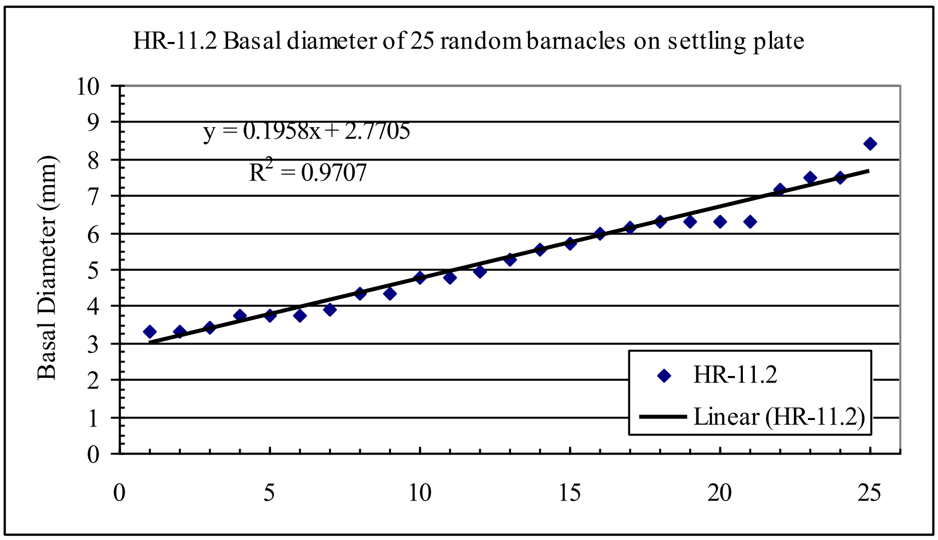
Appendix Figures A.7-A.12. Plots of barnacle sizes on artificial substrates Homosassa River.

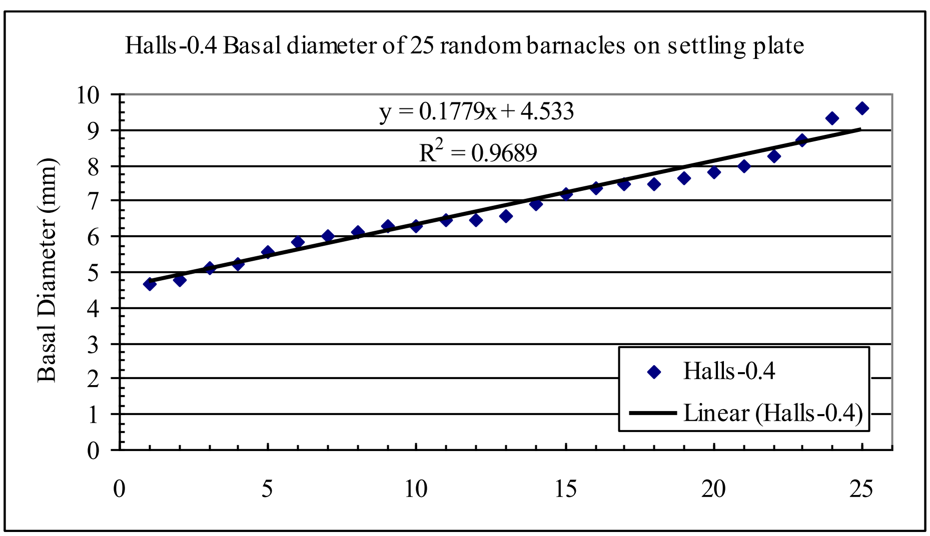




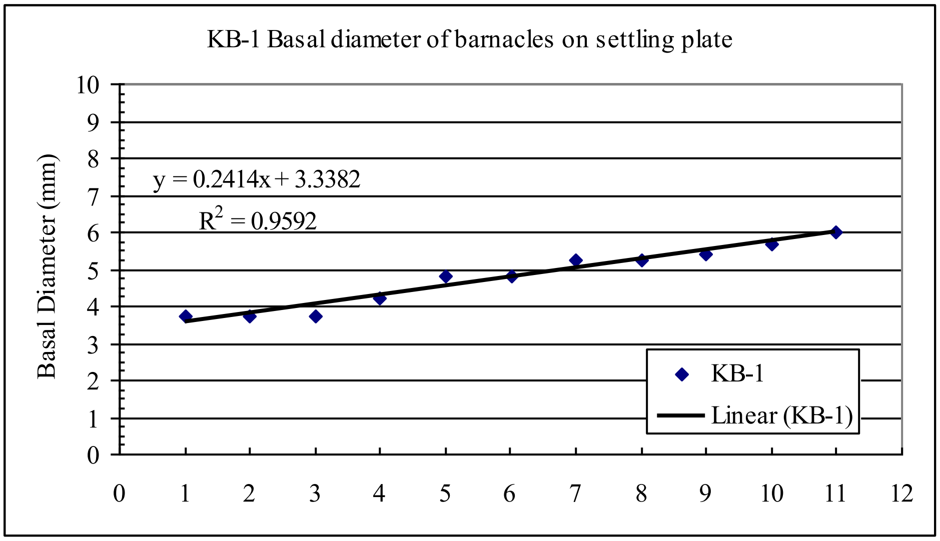


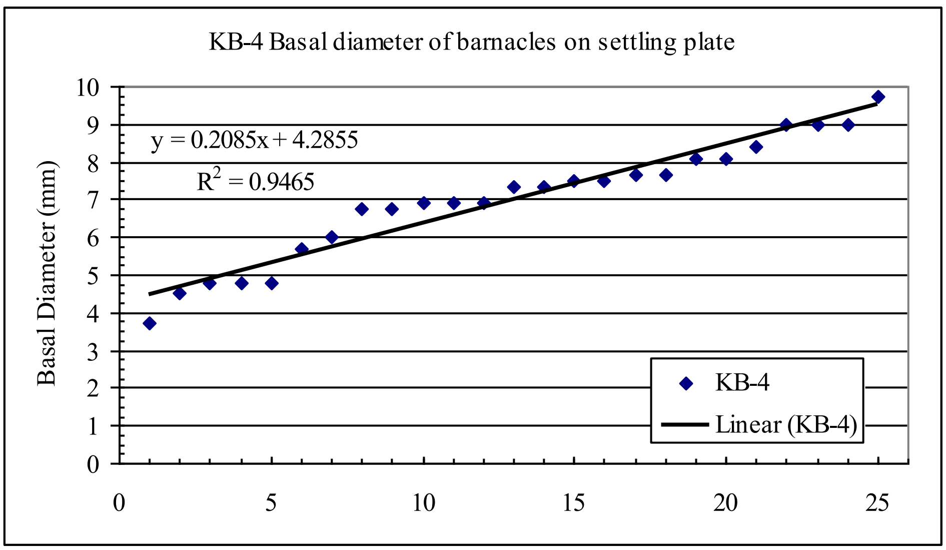

HR-10.8 Basal diameter of 25 random barnacles on settling plate
y = 0.2187x + 2.2035
R2 = 0.9776
Basal Diameter (mm)
HR-10.84
Linear (HR-10.84)
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25

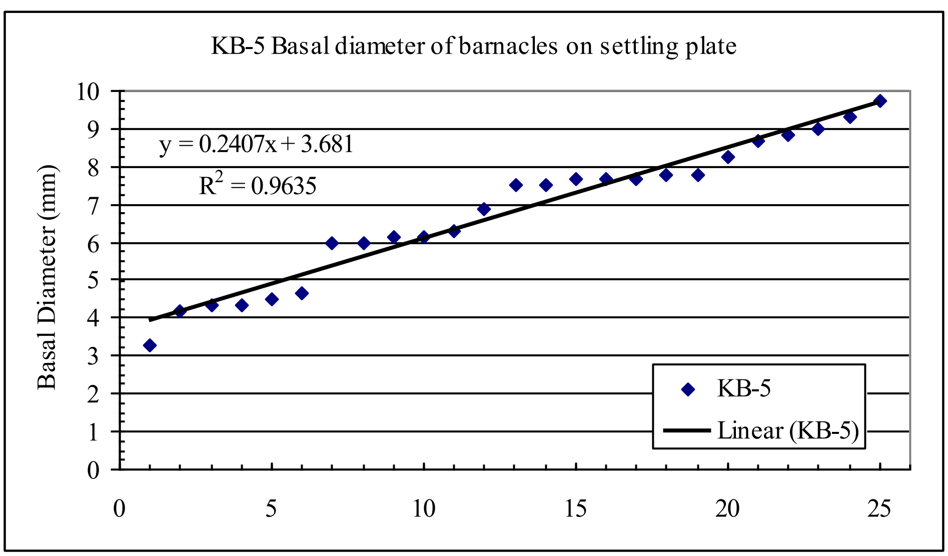

HR-11.2 Basal diameter of 25 random barnacles on settling plate
y = 0.1958x + 2.7705
R2 = 0.9707
Basal Diameter (mm)
HR-11.2
Linear (HR-11.2)
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25

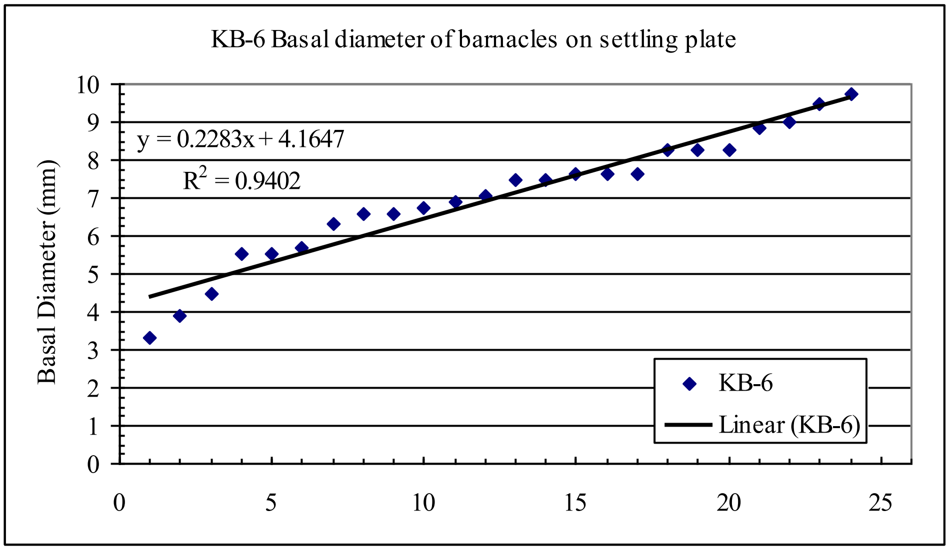

Halls-0.4 Basal diameter of 25 random barnacles on settling plate
y = 0.1779x + 4.533
R2 = 0.9689
Basal Diameter (mm)
Halls-0.4
Linear (Halls-0.4)
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25

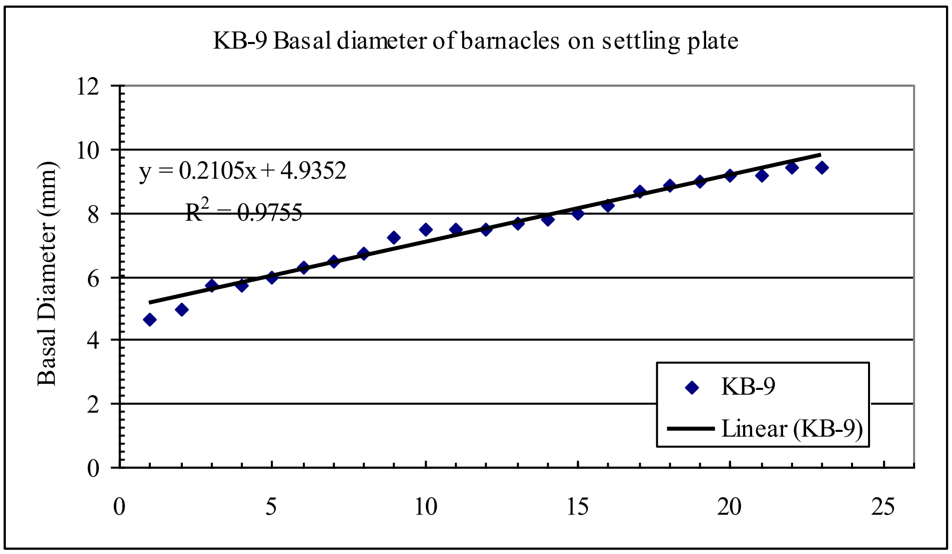
Appendix Figures A.13-A.20. Plots of barnacle sizes on artificial substrates, Kings Bay.

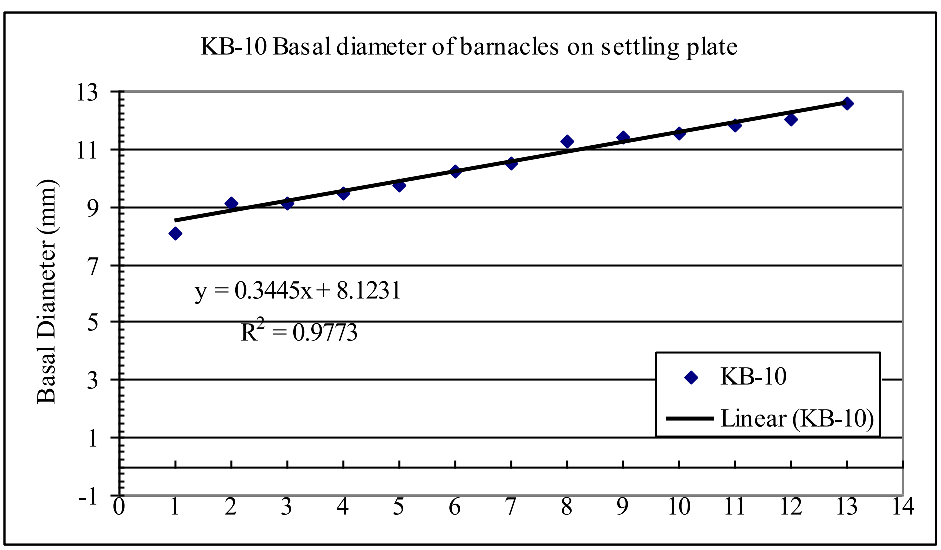


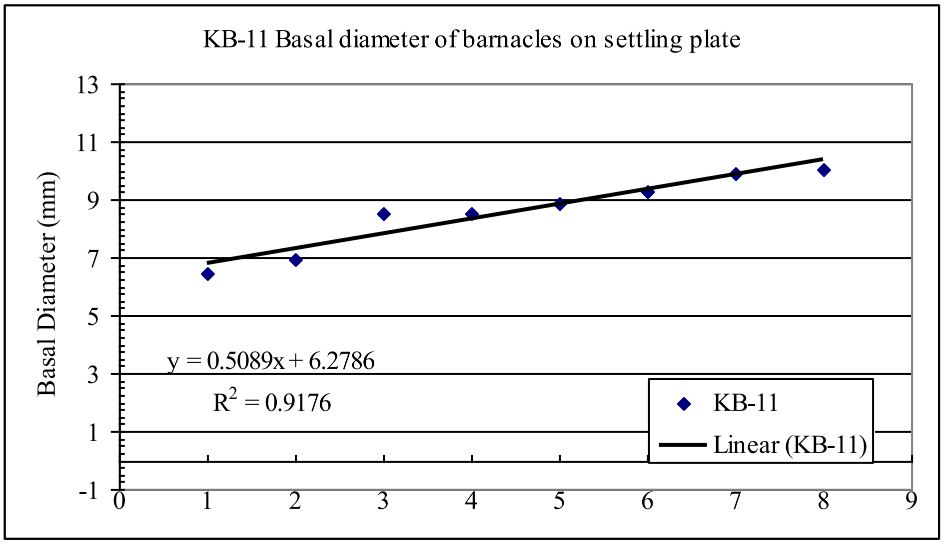


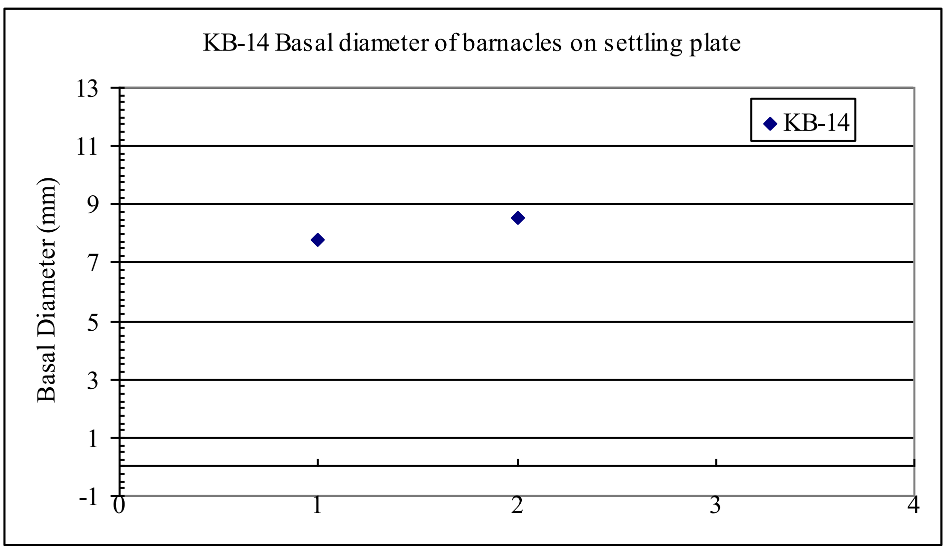



KB-6 Basal diameter of barnacles on settling plate
y = 0.2283x + 4.1647
R2 = 0.9402
Basal Diameter (mm)
10
9
8
7
6
5
4
3
2
1
0
0
5
10
15
20
25
KB-6
Linear (KB-6)

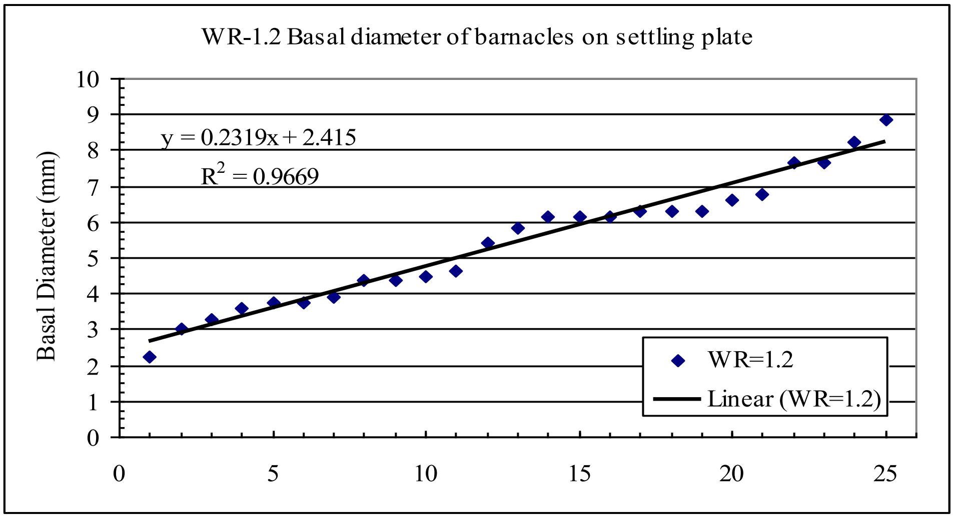

KB-9 Basal diameter of barnacles on settling plate
y = 0.2105x + 4.9352
R2 = 0.9755
Basal Diameter (mm)
12
10
8
6
4
2
0
0
5
10
15
20
25
KB-9
Linear (KB-9)

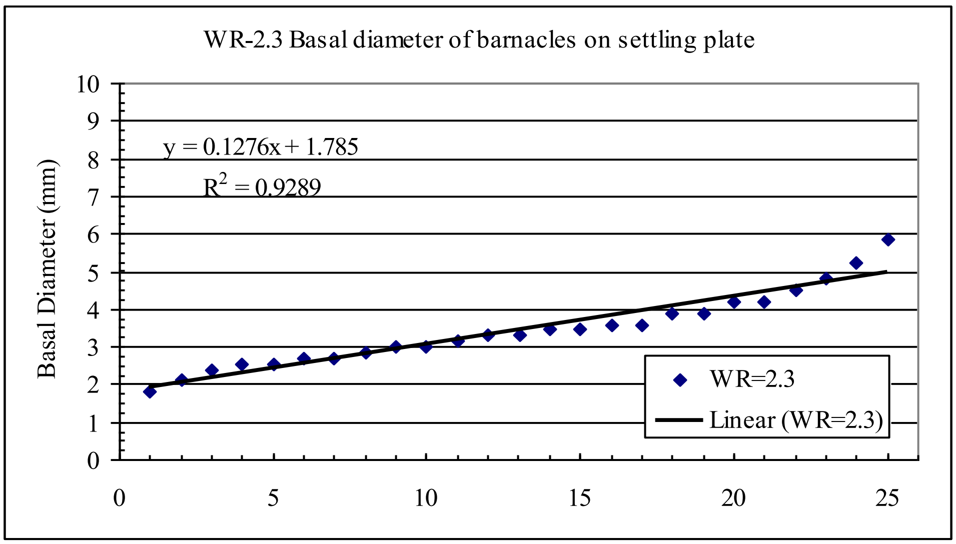

KB-10 Basal diameter of barnacles on settling plate
y = 0.3445x + 8.1231
R2 = 0.9773
Basal Diameter (mm)
13
11
9
7
5
3
1
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
KB-10
Linear (KB-10)

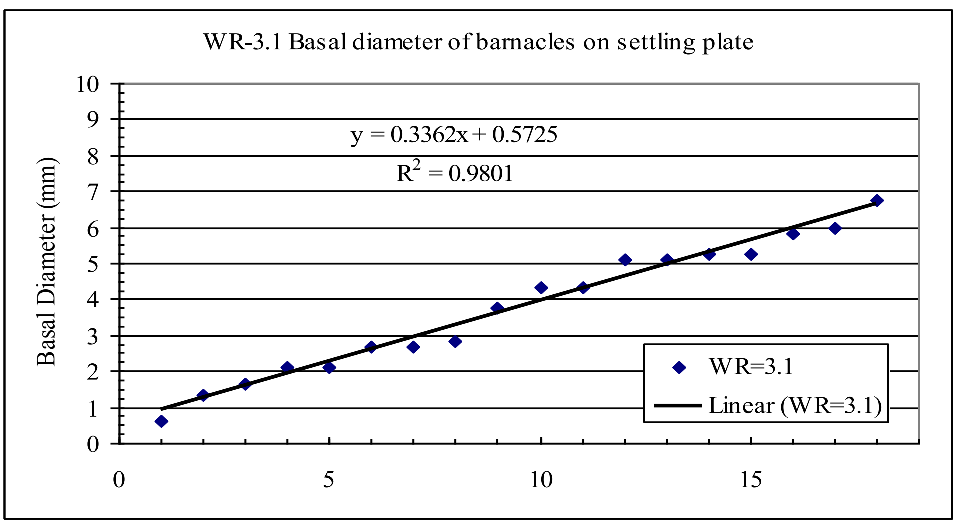

KB-11 Basal diameter of barnacles on settling plate
Basal Diameter (mm)
13
11
9
7
5
3
1
-1
0
1
2
3
4
5
6
7
8
9
y = 0.5089x + 6.2786
R^2 = 0.9176
KB-11
Linear (KB-11)


KB-14 Basal diameter of barnacles on settling plate
Basal Diameter (mm)
13
11
9
7
5
3
1
-1
0
1
2
3
4
KB-14

Appendix Figures A.21-A.23. Plots of barnacle sizes on artificial substrates, Withlacoochee River.







Appendix H

Peebles, E.B., MacDonald, T.C., Burghart, S.E., Guenther, C., Matheson, R.E., Jr., and McMichael, R.H., Jr. 2009. Freshwater inflow effects on fish and invertebrate use of the Homosassa River estuary. University of South Florida College of Marine Science and Florida Fish and Wildlife Conservation Commission. St. Petersburg, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Errata: *Numerous scientific names in the third paragraph on page 29 should be italicized.*

The word "from" is misspelled in line three on page 30.

The document by Peebles and Flannery (2002) cited on page 30 is not included in the references section.

The document by Merriner et al. (1976) cited on page 31 is not included in the references section.

The document by Peebles (2002) cited on page 31 is not included in the references section.

The word "appearance" is misspelled in line 28 on page 73.

The word "estuary" is misspelled in line nine on page 74.

Labels for the y-axis are incorrect for figures I1 through I40 in Appendix I. The labels should read: "ln(catch-per-unit-effort, animals + 1. 100 m^{-2}."

FRESHWATER INFLOW EFFECTS ON FISH AND INVERTEBRATE USE OF THE HOMOSASSA RIVER ESTUARY

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C. Guenther[2], R.E. Matheson, Jr.[2]; R.H. McMichael, Jr.[2]

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Brooksville, Florida 34609-6899

SWFWMD Agreement No. 07C00000063
May 29, 2009

TABLE OF CONTENTS

SUMMARY

Quantitative ecological criteria are needed to establish minimum flows and levels for rivers and streams within the Southwest Florida Water Management District (SWFWMD), as well as for the more general purpose of improving overall management of aquatic ecosystems. As part of the approach to obtaining these criteria, the impacts of managed freshwater inflows on downstream estuaries are being assessed. A two year study of freshwater inflow effects on habitat use by estuarine organisms in the Homosassa River estuary was undertaken from December 2006 to November 2008. The general objective of the present data analysis was to identify patterns of estuarine habitat use and organism abundance under variable freshwater inflow conditions and to evaluate responses. Systematic monitoring was performed to develop a predictive capability for evaluating potential impacts of proposed freshwater withdrawals and, in the process, to contribute to baseline data. The predictive aspect involves development of regressions that describe variation in organism distribution and abundance as a function of natural variation in inflows. These regressions can be applied to any proposed alterations of freshwater inflows that fall within the range of natural variation documented during the data collection period.

For sampling purposes, the Homosassa River estuary was divided into seven zones from which plankton net, seine net and trawl samples were taken. Sampling was conducted on a monthly basis for the first year of the study (December 2006 to November 2007) and every two months for the remainder of the study (December 2007 to November 2008). Salinity, water temperature, dissolved oxygen and pH measurements were taken in association with each net deployment. Daily freshwater inflow estimates for the Homosassa River estuary were derived from gauged stream flow records (USGS gauges 02310678 and 02310688). A large body of descriptive habitat-use information was generated and is presented in accompanying appendices.

Larval gobies and anchovies dominated the larval fish catch. More gobies of the genus *Gobiosoma* were collected than *Microgobius* gobies, and the anchovies were strongly dominated by the bay anchovy (*Anchoa mitchilli*). The bay anchovy is usually associated with surface-fed estuaries and may be an indicator of eutrophication in the

Homosassa River—abundance of this species was higher than in other spring-fed estuaries, but was lower than in surface-fed estuaries. Other abundant larval fishes included rainwater killifish (*Lucania parva*), silversides (*Menidia* spp.), blennies (blenniids, apparently with the Florida blenny, *Chasmodes saburrae*, being dominant), skilletfish (*Gobiesox strumosus*) and mojarras (*Eucinostomus* spp.).

The plankton-net invertebrate catch was dominated by larval crabs (decapod zoeae and megalopae), larval shrimps (decapod mysis), gammaridean amphipods, the mysid *Americamysis almyra*, cumaceans, and the copepod *Acartia tonsa*. *Americamysis almyra* and *Acartia tonsa* are usually associated with surface-fed estuaries and may be indicators of eutrophication in the Homosassa River. The gammaridean amphipods were abundant throughout most of the survey area, being somewhat less abundant near the Gulf of Mexico. In contrast, cumaceans were most abundant downstream, which is a commonly observed pattern in other estuaries. The larval crabs, larval shrimps, the mysid *Americamysis almyra* and the copepod *Acartia tonsa*, were all widely distributed throughout the survey area.

Nearly 70% of the fish catch from seines in the Homosassa River estuary was comprised of just three taxa (rainwater killifish, menidia silversides, and eucinostomus mojarras). Fish collections from deeper, trawled areas were dominated by eucinostomus mojarras, rainwater killifish, bay anchovy, and tidewater mojarra. These four taxa comprised almost 80% of total trawl catch of fishes. Invertebrates collected by seines were dominated by three species of grass shrimp (brackish grass shrimp, daggerblade grass shrimp, and riverine grass shrimp) and blue crabs, which together comprised over 96% of total invertebrate catch in seines. Nearly 90% of the trawl catch was comprised of just two species (blue crab, and brackish grass shrimp).

The eggs of the bay anchovy (*Anchoa mitchilli*), silversides (*Menidia* spp.), killifishes (*Fundulus* spp., *Lucania parva*) and unidentified sciaenid fishes were collected from the survey area. Sciaenid eggs were the most abundant egg type, followed by eggs of the bay anchovy—both types were most abundant in the lower part of the tidal river, peaking 3-6 km upstream of the river mouth. Early-stage sciaenid larvae, however, were nearly absent from the survey area – a total of only 3 *Bairdiella chrysoura* and 2 *Menticirrhus* spp. larvae were collected. Bay anchovies were more abundant as relatively older postflexion larvae, suggesting that most bay anchovies originated from spawning grounds located outside the survey area. The data suggest blennies spawned most heavily near the river mouth, whereas skilletfish (*Gobiesox strumosus*) and gobies (primarily *Microgobius* spp. and *Gobiosoma* spp., but also *Bathygobius soporator*) may have spawned within the interior of the tidal river.

Estuary-dependent taxa are spawned at seaward locations and migrate into tidal rivers during the late larval or early juvenile stage. Overall, four of the ten most abundant taxa in the trawl catch (54% of total abundance collected in trawls) and three of the ten most abundant taxa in the seine catch (12% of total abundance collected in seines) can be considered estuary-dependent. These estuary-dependents included blue crab, a species of recreational and commercial importance, and other taxa of ecological importance due to high abundance (i.e., pinfish, tidewater and eucinostomus mojarras).

More taxa in the plankton-net collections were collected during the warmer months than during winter—alteration of flows would appear to have the lowest potential for impacting many taxa during the period from September through February, which is the period when the fewest estuarine taxa were present. The highest potential to impact many species would appear to be from April through June. Most species tended to be most abundant during the spring and summer.

Taxon richness in the seine and trawl data was lowest from January to April and highest from June to July and in October for the shoreline habitat sampled with seine nets in the Homosassa River estuary. There were no clear seasonal patterns of taxon richness in the deeper-water habitats sampled with trawls. Abundance data from both the seine and trawl nets suggested that the Homosassa River estuary was important to nekton throughout the year, with no obvious period where flow alterations would have the least potential to impact the nekton community.

Among the 64 plankton-net taxa evaluated for distribution relationships with freshwater inflow, 42% (n = 27) exhibited significant responses. Eleven of these were negative responses, wherein animals moved downstream as inflows increased. Downstream movement is the typical inflow response seen in tidal rivers on Florida's west coast. However, more taxa (n = 16) moved upstream (against the flow) as flows increased. Some of these relationships had very good fit, suggesting that these relationships are not spurious. Some of these upstream-moving taxa may have become entrained in two-layered circulation (i.e., bottom water moving upstream to replace surface water moving downstream), or may have responded to stronger olfactory cue delivery by moving into the river to seek out the source of the olfactory cues. Overall, time lags for the responses were highly variable, with many occurring within a seasonal time frame.

Thirteen (>24%) of the 53 seine- or trawl-caught pseudo-species evaluated for distributional responses to freshwater inflow exhibited significant responses for at least one lagged flow period. Centers of abundance for eleven of the 13 pseudo-species moved upstream in response to decreasing inflow (negative response) whereas centers of abundance of two pseudo-species moved downstream in response to decreasing inflow (positive response). The change in centers of abundance ranged from 1.0 to 5.8km. The lag period for most of the pseudo-species were relatively long (>56 days), with only three pseudo-species having a response to lags of 21 days or less. A higher than expected proportion of the Halls River pseudo-species tested from the shoreline habitats demonstrated a distributional response to inflow. The lags associated with the positive responses were generally long, ranging from 36 d to the maximum lag evaluated, 120 d. The 120 d lags are likely seasonal in nature, whereas the responses of podocopid ostracods and *E. affinis* may have represented short-term population responses to inflow variation. Inflow variations were very small relative to those surface-fed rivers, which makes detection of abundance responses more difficult.

Among the 64 plankton-net taxa evaluated for abundance relationships with freshwater inflow, 44% (n = 28) exhibited significant responses. All except five of these were negative responses. Negative responses are usually caused by elevated flows washing organisms out of the survey area. The organisms that had positive responses were the estuarine tanaid *Hargeria rapax*, postflexion larvae of the oligohaline fish *Lucania parva*, freshwater podocopid ostracods, the estuarine copepod *Acartia tonsa*, and the oligohaline copepod *Eurytemora affinis*. It could be concluded that more positive results were not observed because no stations were positioned in the Gulf of Mexico to account for species that moved downstream and increased in number in response to increased inflow.

Forty (75%) of the 53 pseudo-species analyzed from the seine and trawl catches had a significant abundance response to average inflow. Twenty-seven of these pseudo-species had linear responses and the remaining 13 demonstrated quadratic responses of abundance to inflow. Twelve of the linear responses were negative, such that abundance increased with decreasing inflow, and the remaining 15 linear responses were positive. Pseudo-species with quadratic relationships between inflow and abundance were split among situations with the maximum abundance at intermediate inflows ('intermediate-maximum', n=7) and minimum abundance at intermediate inflows ('intermediate-minimum', n=6). The percentage of significant abundance responses to inflow ranged from 57% of tested pseudo-species in nearshore spawners to 88% in tidal river residents. Of the fifteen pseudo-species collected with seines from the Halls River that were tested, all demonstrated an abundance response to inflow. The most common response for these Halls River pseudo-species was a negative linear response among tidal river residents (n=6). The salinity of the Halls River increased in response to increased inflow in the Homosassa River and may explain this trend.

Estuarine zooplankton communities formed the typically continuous ordination observed in other estuaries, with downstream communities being most different from upstream communities, and with intermediate locations being positioned in the expected order. The two upstream-most zones, Zones 5 and 6, exhibited the widest variability. Zone 5, the zone nearest the spring, was dominated by gammaridean amphipods, crab larvae (*Rhithropanopeus harrisii*), fly and midge larvae, mysids, and pododopid (freshwater) ostracods. Zone 6 (Halls River) differed from adjacent Zone 5 (downstream of the spring) primarily in having higher abundances of the same taxa as in Zone 5. Zone 1 near the Gulf of Mexico was dominated by a diversity of crab and shrimp larvae, cumaceans, gamaridean amphipods, the mysid *Bowmaniella dissimilis*, the copepod *Acartia tonsa*, sagittid arrow worms, polychaete worms, and the isopod *Harrieta faxoni*.

The zooplankton communities were also differentiated by season, with communities from November through February being different from the remainder of the year. The widest consistent difference was between January and May. During May, there were more crab and shrimp larvae, gammaridean amphipods, goby larvae (*Gobiosoma* and *Microgobius*), cumaceans, mysids (*Bowmaniella dissimilis* and *Americamysis almyra*), *Acartia tonsa* and sagittid arrow worms than during January. The relationship between community heterogeneity (relative dispersion) and springflow was positive and approached significance at the α=0.05 level, indicating there was a mild decrease in community heterogeneity during summer low-flow periods, when marine organisms tended to invade and cause community composition to become similar throughout the lower estuary.

There were significant differences in seine- and trawl-caught nekton community structure between the zones of the study area and also between year-months. Most notable was the difference between adjacent zones four (river km 8.6-11.19) and five (river km 11.2-13.0) in the shoreline habitats of the study area. These two Homosassa River zones meet where the Halls River discharges into the Homosassa River. Zone five was characterized by relatively high abundance of bluefin killifish, gray snapper, Eastern mosquitofish, and largemouth bass. Changes in community structure over the study period exhibited annual cycles, which tended to be more regular than the correlation with physicochemical variables, including inflow. There was no discernible relationship between inflow and heterogeneity, or dispersion, for the shoreline community, although the community in the channel habitat did have a positive relationship which approached significance at the α=0.05 level. Shoreline nekton communities in the lower Homosassa River zones did not show a trend of increasing similarity with the upper most zone (Zone 5) as flows decreased when months with different flows between years were compared. The same analysis in channel habitats, however, indicated a linear increasing trend in similarity as flows decreased.

Synthesis. Some characteristics of the plankton community in the Homosasa River estuary suggest that the area has become more eutrophic. Compared with other spring-fed estuaries, the abundances of the copepod *Acartia tonsa*, the mysid *Americamysis almyra*, and the bay anchovy *Anchoa mitchilli* were relatively high, but not as high as in surface-fed estuaries. The regular occurrence of large transitions from hypoxia to hyperoxia (supersaturation) is also evidence of this trend. In surface-fed estuaries, these indicator species and water-quality attributes tend to occur at more or less predictable locations that can be modeled as a response to freshwater inflow. In the Homosassa River estuary, however, these indicators did not appear to have any consistent relationships with inflow, although higher levels of inflow were more likely to move overly productive water masses downstream, where greater tidal dispersion will generally occur.

Organism responses to inflow were more mixed than in other estuaries surveyed on Florida's west-central coast. Different organisms moved either upstream or downstream in response to increasing inflows, whereas in most of the other surveyed estuaries, organisms primarily moved downstream as flows increased. The Homosassa estuary has a relatively deep channel (>2 m) thoughout much of its length, and this channel may facilitate two-layered estuarine circulation, where bottom water moves landward during high inflows to replace water that has moved seaward due to friction with seaward-moving surface flows. In other west-central Florida estuaries where upstream movement against increasing flows has been observed, deeper channels were also present.

The seasonality of organism use of the Homosassa estuary was typical, but showed some signs of being contracted relative to estuaries at lower latitudes. This was evident in regard to seasonal trends in species richness and also single-species seasonality. Bay anchovy seasonality was more restricted than that observed farther south.

In comparison with surface-fed estuaries, the ichthyoplankton community in the Homosassa estuary had relatively few eggs and larvae of broadcast-spawning, estuarine-depedent or coastal species, but instead was dominated by the larvae of small, resident species that have adhesive eggs which hatch into planktonic larvae. Relatively few species used the area as spawning habitat.

As with distribution responses, abundance reposnses to inflows were mixed, with a large proportion of negative responses. The seasonality of inflows was nearly six months out of phase with the seasonal rainfall pattern (highest flows during winter and lowest during summer), and therefore some of the negative abundance responses may have been related to spawning season (Fig. 3.6.1.1) rather than inflow. Most coastal fish species spawn during spring and summer, which is when inflows were lowest in the Homosassa estuary, and this may have created the appeanace negative abundance responses to inflow.

Comparisons between the spring run area (Zone 5) and the Halls River (Zone 6) are particularly interesting because these two areas represent adjacent, low salinity habitats with different flow rates (with Halls River being lower). The zooplankton compositions of the two zones were similar, but the low-flow Halls River apparently had better retention of planktonic organisms, as evidenced by its having higher abundances (densities) of the same animals that were present in the spring run area (Zone 5).

There was a mild decrease in community heterogeneity during summer low-flow periods, when marine organisms tended to invade and cause community composition to become more similar in the lower estuary. In surface-fed estuaries, it is common for these marine invasions to suddenly penetrate far upstream when inflows fall below esutuary-specific threshold values. Spring flows into the Homosassa estuary were sufficient to prevent this seasonal collapse of community heterogeneity.

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1.0 INTRODUCTION

Rivers export nutrients, detritus, and other productivity promoting materials to the estuary and sea. Freshwater inflows also strongly influence the stratification and circulation of coastal waters, which in itself may have profound effects on coastal ecosystems (Mann and Lazier 1996). Estuary-related fisheries constitute a very large portion of the total weight of the U.S. fisheries yield (66% of finfish and shellfish harvest, Day et al. 1989; 82% of finfish harvest, Imperial et al. 1992). The contribution of estuary-related fisheries is consistently high among U.S. states that border the Gulf of Mexico, where the estimates typically exceed 80% of the total weight of the catch (Day et al. 1989). Examples from around the world indicate that these high fisheries productivities are not guaranteed, however. In many locations, large amounts of fresh water have been diverted from estuaries to generate hydroelectric power or to provide water for agricultural and municipal use. Mann and Lazier (1996) reviewed cases where freshwater diversions were followed by the collapse of downstream fisheries in San Francisco Bay, the Nile River delta, James Bay, Canada, and at several inland seas in the former U.S.S.R. Sinha et al. (1996) documented a reversal of this trend where an increase in fisheries landings followed an increase in freshwater delivery to the coast.

Fishery yields around the world are often positively correlated with freshwater discharge at the coast (Drinkwater 1986). These correlations are often strongest when they are lagged by the age of the harvested animal. In south Florida, Browder (1985) correlated 14 years of pink shrimp landings with lagged water levels in the Everglades. Associations between river discharge and fisheries harvests have also been identified for various locations in the northern and western Gulf of Mexico (Day et al. 1989, Grimes 2001). Surprisingly, discharge-harvest correlations sometimes extend to non-estuarine species. Sutcliffe (1972, 1973) reported lagged correlations between discharge of the St. Lawrence River and the harvest of non-estuarine species such as American lobster and haddock. In recognition of the potential complexities behind these correlations, Drinkwater (1986) advised that the effect of freshwater inflows be considered on a species-by-species basis.

Freshwater influence on coastal ecosystems extends beyond its immediate effects on fisheries. Because of the intricate nature of many food web interactions, changes in the abundance of even a single species may be propagated along numerous pathways, some anticipated and some not, eventually causing potentially large changes in the abundance of birds, marine mammals and other groups of special concern (Christensen 1998, Okey and Pauly 1999). Mann and Lazier (1996) concluded “one lesson is clear: a major change in the circulation pattern of an estuary brought about by damming the freshwater flows, a tidal dam, or other engineering projects may well have far reaching effects on the primary and secondary productivity of the system.”

This project was conducted to support the establishment of minimum flows for the Homosassa River estuarine system by the Southwest Florida Water Management District (SWFWMD). Minimum flows are defined in Florida Statutes (373.042) as the “limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.” In the process of establishing minimum flows for an estuarine system, the SWFWMD evaluates the effects of the freshwater inflows on ecological resources and processes in the receiving estuary. The findings of this project will be used by the SWFWMD to evaluate the fish nursery function of the Homosassa River estuary in relation to freshwater inflows. It is not the purpose of this project to determine the level of effect that constitutes significant harm, as that determination will be made by the Governing Board of the SWFWMD.

2.0 METHODS

2.1 Study Area

The Homosassa River is a spring-fed river system in Citrus County in west central Florida. Water flowing from its springs primarily originates from the upper Floridan aquifer. River length is approximately 13 km from the main spring complex to the Gulf of Mexico (Fig. 2.1.1). About 1.5 km downstream of the main spring complex, the Homosassa River is joined from the north by Halls River, a 4 km long spring-fed tributary. Near the river's mouth at the Gulf of Mexico, the semi-diurnal tide ranges <1.5 m. Bottom substrates in the tidal river are dominated by mud and sand, although limestone outcroppings are common.

Mangrove (black mangrove, *Avicennia germinans*, and red mangrove, *Rhizophora mangle*) and brackish marsh shoreline occur along the Gulf of Mexico shore and the lower 7.5 km of river. The remaining shoreline has moderate development with isolated areas of coastal-hammock trees and shrubs (USGS 2008, PBS&J 2009). Shading of the river by terrestrial vegetation is minimal to non-existant (Frazer et al. 2006). Patches of submerged aquatic vegetation and filamentous algae are common in the Gulf of Mexico and near the river mouth. Submerged aquatic vegetation in the area was observed to decline between 1998 and 2005 (Frazer et al. 2006).

2.2 Survey Design

Three gear types were implemented to monitor organism distributions: a plankton net deployed during nighttime flood tides and a bag seine and otter trawl deployed during the day under variable tide stages. The plankton net surveys were conducted by the University of South Florida College of Marine Science, and the seine and trawl surveys were conducted by the Fisheries-Independent Monitoring (FIM) program of the Fish and Wildlife Research Institute (Florida Fish and Wildlife Conservation Commission).

The small organisms collected at night by the plankton net represent a combination of the zooplankton and hyperbenthos communities. The term *zooplankton* includes all weakly swimming animals that suspend in the water column during one or more life stages. The distribution of such animals is largely subject to the motion of the waters in which they live. The term *hyperbenthos* applies to animals that are associated with the bottom but tend to suspend above it, rising higher into the water column at night or during certain times of year (vertical migrators). The permanent hyperbenthos of estuaries (non-transient hyperbenthos) tends to be dominated by peracarid crustaceans, especially mysids and amphipods (Mees et al. 1993). Many types of hyperbenthos are capable of actively positioning themselves at different places along the estuarine gradient by selectively occupying opposing tidal flows.

The faunal mixture that forms in the nighttime water column includes the planktonic eggs and larvae of fishes (ichthyoplankton). One of the most common reasons for using plankton nets to survey estuarine waters is to study ichthyoplankton. Although fish eggs and larvae are the intended focus of such studies, invertebrate plankton and hyperbenthos almost always dominate the samples numerically. The invertebrate catch largely consists of organisms that serve as important food for juvenile estuary-dependent and estuary-resident fishes. In an effort to characterize the invertebrate catch more completely, all water-column animals collected by the plankton net were enumerated at a practical taxonomic level.

Seines and trawls were used to survey larger organisms that typically evade plankton nets. Generally speaking, the data from seine hauls document habitat use by shallow-water organisms whereas the data from trawls document habitat use in deeper areas. The dominant catch for both gear types is juvenile fishes, although the adults of smaller species are also commonly caught. The seines and trawls also regularly collect a few of the larger macroinvertebrate species from tidal rivers, notably juvenile and adult blue crabs (*Callinectes sapidus*) and juvenile pink shrimp (*Farfantepenaeus duorarum*).

Sampling in the Homosassa River and Halls River began in December 2006 and ended in November 2008. Collections were made once per month during the first year and in alternating months during the second year, resulting in a total of 18 collections. The survey area was divided into seven collection zones (Fig. 2.1.1, Table 2.2.1). During each of the 18 collections, two plankton-net tows were made in Zone 1–6. Plankton nets could not be deployed in Zone 7 (upper Halls River) due to shallow depths and obstructions. Likewise, rocky substrates and obstructions prevented trawl deployments in Zones 1, 2, 5 and 7. Three seine hauls were made in each zone during each of the 18 collections. The locations for seine and trawl deployment were randomly selected within each zone during each survey, whereas the plankton-net collections were made at fixed stations. The longitudinal position of each station was measured as the distance from the mouth of the tidal river, following the geometric centerline of the channel, as defined by SWFWMD.

Fig. 2.1.1. Map of survey area. Numbers in circles identify sampling zones. The Homosassa Spring is located in the upstream portion of Zone 5. Zones 6 and 7 are in the Halls River tributary.

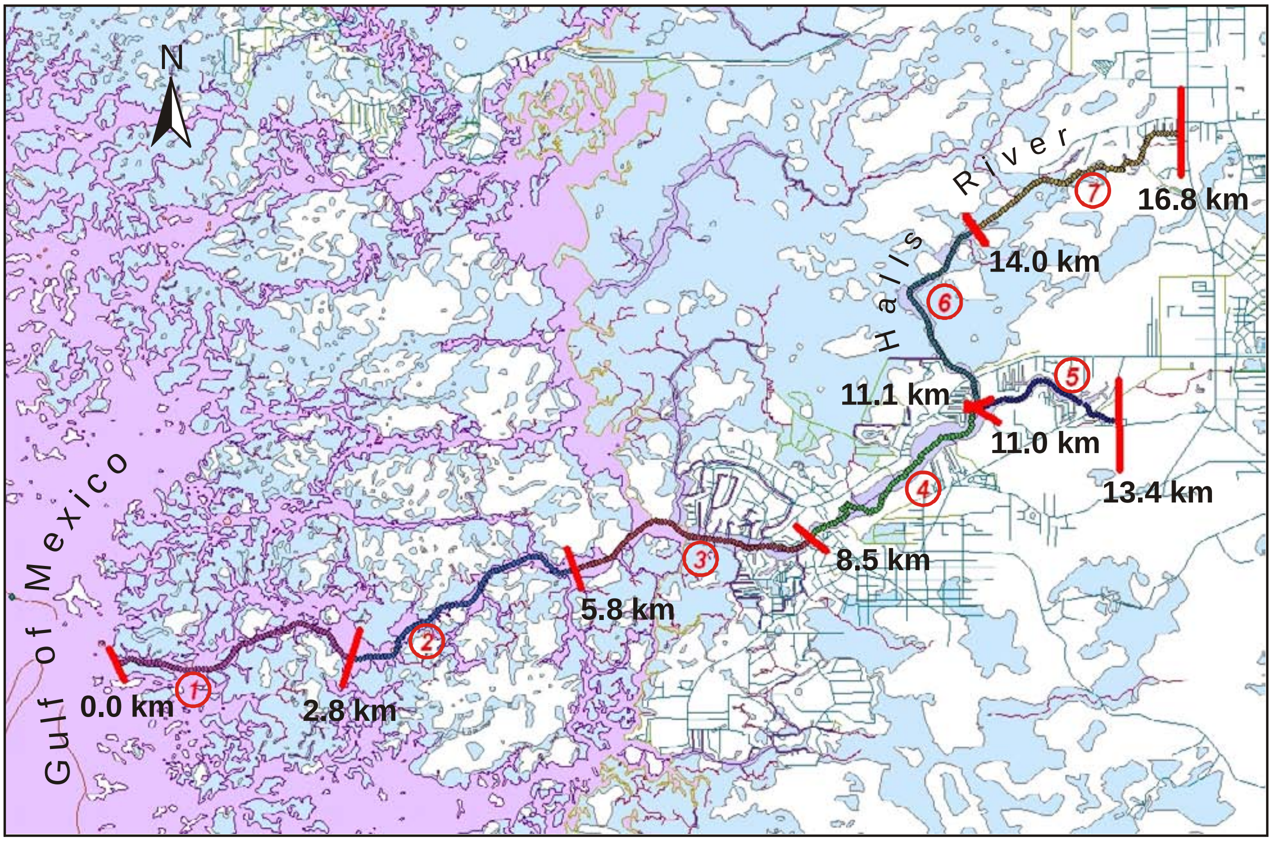

Table 2.2.1. Distribution of sampling effort within the tidal Homosassa River (December 2006–November 2008). Collections were made once per month during the first year and in alternating months during the second year, resulting in a total of 18 collections. Zone position (river km) is measured relative to river mouths (see Fig. 2.1.1).

Zone	River km	Plankton	Seine	Trawl
1	0.0–2.8	36	54	0
2	2.8–5.8	36	54	0
3	5.8–8.5	36	54	18
4	8.5–11.0	36	54	18
5	11.0–13.4	36	54	0
6	11.1–14.0 (Halls R.)	36	54	18
7	14.0–16.8 (Halls R.)	0	54	0
Totals		216	378	54

2.3 Plankton Net Specifications and Deployment

The plankton gear consisted of a 0.5-m-mouth-diameter 500-µm-mesh conical (3:1) plankton net equipped with a 3-pt nylon bridle, a calibrated flow meter (General Oceanics model 2030R), a 1-liter plastic cod-end jar, and a 9-kg (20-lb.) weight. The net was deployed between low slack and high slack tide, with sampling beginning within two hours after sunset and typically ending less than four hours later. Tow duration was 5 min, with tow time being divided equally among bottom, mid-water and surface depths. The fishing depth of the weighted net was controlled by adjusting the length of the tow line while using tachometer readings to maintain a constant line angle. The tow line was attached to a winch located on the gunnel near the transom. Placement of the winch in this location caused asymmetry in the steering of the boat, which caused propeller turbulence to be directed away from the towed net. Tow speed was approximately 1.3 m s^{-1}, resulting in a tow length of >400 m over water and a typical filtration of 70-80 m^3. Upon retrieval of the net, the flowmeter reading was recorded, and the contents of the net were rinsed into the cod-end jar using an electric wash-down pump and hose with an adjustable nozzle. The samples were preserved in 6-10% formalin in ambient saline.

The net was cleaned between surveys using an enzyme solution that dissolves organic deposits. Salinity, temperature, pH and dissolved oxygen were measured at one-meter intervals from surface to bottom after each plankton-net deployment.

2.4 Seine and Trawl Specifications and Deployment

The gear used in all seine collections was a 21.3-m center-bag seine with 3.2-mm mesh and leads spaced every 150 mm. Deployment of seines along shoreline habitats (i.e., shorelines with water depth ≤1.8 m in the Homosassa and Halls rivers) were conducted by positioning a member of the seine crew near the shoreline with one end of the seine, after which the boat payed out the net in a semicircle until the boat reached a second drop-off point near the shoreline. The lead line was retrieved simultaneously from both ends, with effort made to keep the lead line in contact with the bottom. This process forced the catch into the bag portion of the seine. Area sampled by each boat-deployed seine collection was approximately 68 m^2.

The 6.1-m otter trawl was constructed of 38-mm stretched mesh with a 3.2-mm mesh liner and tickler chain. It was towed for five minutes in either an arc or a straight line. Tow speed averaged 0.6 m s^{-1}, resulting in a typical tow length of about 180 m. Trawl width averaged 4 m, giving an approximate area sampled by a typical tow of 720 m^2. Salinity, temperature, pH, and dissolved oxygen were measured at the surface and at 1-m intervals to the bottom in association with each gear deployment.

2.5 Plankton Sample Processing

All aquatic taxa collected by the plankton net were identified and counted, except for invertebrate eggs and organisms that were attached to debris (sessile stages of barnacles, bryozoans, sponges, tunicates and sessile coelenterates). During sorting, the data were entered directly into an electronic database via programmable keyboards that interfaced with a macro-driven spreadsheet. Photomicrographs of representative specimens were compiled into a reference atlas that was used for quality-control purposes.

Most organisms collected by the plankton net fell within the size range of 0.5-50 mm. This size range spans three orders of magnitude, and includes mesozooplankton (0.2-20 mm) macrozooplankton/micronekton (>20 mm) and analogous sizes of hyperbenthos. To prevent larger objects from visually obscuring smaller ones during sample processing, all samples were separated into two size fractions using stacked sieves with mesh openings of 4 mm and 250 µm. The >4 mm fraction primarily consisted of juvenile and adult fishes, large macroinvertebrates and large particulate organic matter. In most cases, the fishes and macroinvertebrates in the >4 mm fraction could be identified and enumerated without the aid of microscopes.

A microscope magnification of 7-12X was used to enumerate organisms in the >250 µm fraction, with zoom magnifications as high as 90X being available for identifying individual specimens. The >250 µm fraction was usually sorted in two stages. In the first sorting stage, the entire sample was processed as 10-15 ml aliquots that were scanned in succession using a gridded petri dish. Only relatively uncommon taxa (n<50) were enumerated during this first stage. After the entire sample had been processed in this manner, the collective volume of the aliquots was recorded within a graduated mixing cylinder, the sample was inverted repeatedly, and then a single 30-60 ml aliquot was poured. The aliquot volume typically represented about 12-50% of the entire sample volume. The second sorting stage consisted of enumerating the relatively abundant taxa within this single aliquot. The second sorting stage was not required for all samples. The second stage was, however, sometimes extended to less abundant taxa (n<50) that were exceptionally small or were otherwise difficult to enumerate.

2.5.1 Staging Conventions.

All fishes were classified according to developmental stage (Fig. 2.5.1.1), where

> **preflexion** larval stage = the period between hatching and notochord flexion; the tip of the straight notochord is the most distal osteological feature.
>
> **flexion** larval stage = the period during notochord flexion; the upturned notochord or urostyle is the most distal osteological feature.
>
> **postflexion** larval stage = the period between completion of flexion and the juvenile stage; the hypural bones are the most distal osteological feature.
>
> **metamorphic** stage (clupeid fishes) = the stage after postflexion stage during which body depth increases to adult proportions (ends at juvenile stage).
>
> **juvenile** stage = the period beginning with attainment of meristic characters and body shape comparable to adult fish and ending with sexual maturity.

Decapod larvae were classified as zoea, megalopa or mysis stages. These terms are used as terms of convenience and should not be interpreted as technical definitions. Planktonic larvae belonging to Anomura and Brachyura (crabs) were called zoea. Individuals from these groups displaying the planktonic to benthic transitional morphologies were classified as megalopae. All other decapod larvae (shrimps) were classified as mysis stages until the uropods differentiated into exopods and endopods (5 total elements in the telsonic fan), after which they were classified as postlarvae until they reached the juvenile stage. The juvenile stage was characterized by resemblance to small (immature) adults. Under this system, the juvenile shrimp stage (e.g., for *Palaemonetes*) is equivalent to the postlarval designation used by some authors.

In many fish species, the juvenile stage is difficult to distinguish from other stages. At its lower limit, the juvenile stage may lack a clear developmental juncture that distinguishes it from the postflexion or metamorphic stage. Likewise, at its upper limit, more than one length at maturity may be reported for a single species or the reported length at maturity may differ between males and females. To avoid inconsistency in the staging process, length-based staging conventions were applied to the more common taxa. These staging conventions agree with stage designations used by the U.S. Fish and Wildlife Service (e.g., Jones et al. 1978). The list in Table 2.5.1.1 is comprehensive, representing the conventions that have been required to date by various surveys. Some of the species or stages in the list were not encountered during the surveys covered by this report.

Table 2.5.1.1. Length-based staging conventions used to define developmental stage limits. Fish lengths are standard length (SL) and shrimp length is total length.

Postflexion-juvenile transition (mm):

Lucania parva	10
Menidia spp.	10
Eucinostomus spp.	10
Lagodon rhomboides	10
Bairdiella chrysoura	10
Cynoscion arenarius	10
Cynoscion nebulosus	10
Sciaenops ocellatus	10
Menticirrhus spp.	10
Leiostomus xanthurus	15
Orthopristis chrysoptera	15
Achirus lineatus	5
Trinectes maculatus	5
Gobiesox strumosus	5
Eugerres plumieri	10
Prionotus spp.	10
Symphurus plagiusa	10
Anchoa mitchilli	15
Sphoeroides spp.	10
Chilomycterus schoepfii	10
Lepomis spp.	10
Micropterus salmoides	10
Membras martinica	10
Chloroscombrus chrysurus	10
Hemicaranx amblyrhynchus	10
Micropogonias undulatus	15
Chaetodipterus faber	5

Juvenile-adult transition (mm):

Anchoa mitchilli	30
Lucania parva	15
Gambusia holbrooki	15
Heterandria formosa	10
Menidia spp.	35
Eucinostomus spp.	50
Gobiosoma bosc	20
Gobiosoma robustum	20
Microgobius gulosus	20
Microgobius thalassinus	20
Gobiesox strumosus	35
Trinectes maculatus	35
Palaemonetes pugio	20
Membras martinica	50
Syngnathus spp.	80
Poecilia latipinna	30
Anchoa hepsetus	75

Metamorph-juvenile transition (mm):

Brevoortia spp.	30
Dorosoma petenense	30

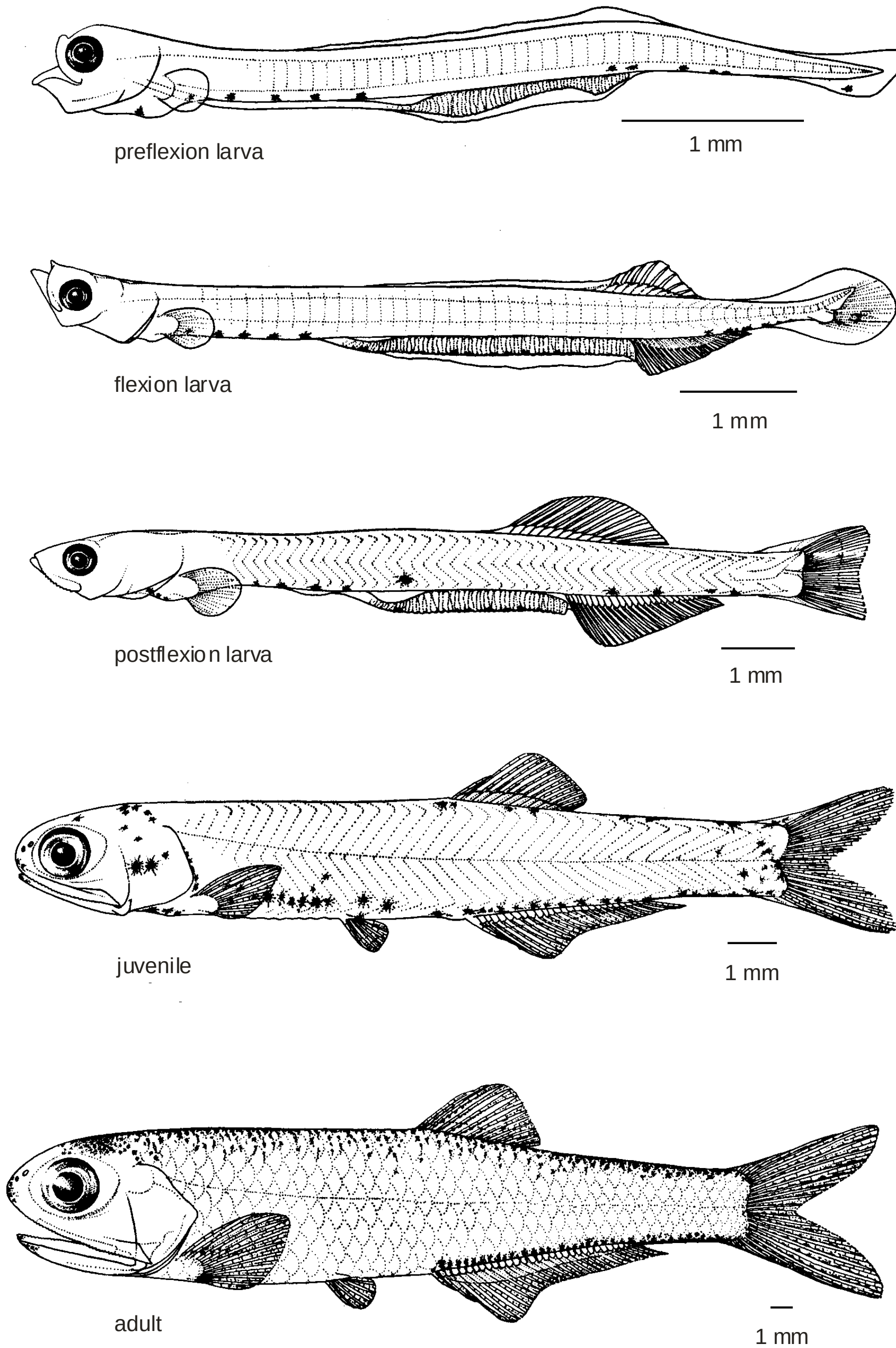

Fig. 2.5.1.1. Fish-stage designations, using the bay anchovy as an example. Specimens measured 4.6, 7.0, 10.5, 16, and 33 mm standard length.

2.6 Seine and Trawl Sample Processing

Fish and selected crustaceans collected in seine and trawl samples were removed from the net into a bucket and processed onboard. Animals were identified to the lowest practical taxonomic category, generally species. Representative samples (three individuals of each species from each gear on each sampling trip) were brought back to the FWC/FWRI laboratory to confirm field identification. Species for which field identification was uncertain were also brought back to the laboratory. A maximum of 10 measurements (mm) were made per taxon, unless distinct cohorts were identifiable, in which case a maximum of 10 measurements were taken from each cohort; for certain economically valuable fish species, twenty individuals were measured. Standard length (SL) was measured for fish, total length [TL] for seahorses, disk width [DW] for rays, post-orbital head length (POHL) for pink shrimp, and carapace width (CW) for crabs. Animals that were not measured were identified and counted. When large numbers of individuals (>> 1,000) were captured, the total number was estimated by fractional expansion of sub-sampled portions of the total catch split with a modified Motoda box splitter (Winner and McMichael 1997). Animals not chosen for further laboratory examination were returned to the river.

Due to frequent hybridization and/or extreme difficulty in the identification of smaller individuals, members of several abundant species complexes were not identified to species. We did not separate menhaden, *Brevoortia*, species. *Brevoortia patronus* and *B. smithi* frequently hybridize, and juveniles of the hybrids and the parent species are difficult to identify (Dahlberg 1970). *Brevoortia smithi* and hybrids may be the most abundant forms on the Gulf coast of the Florida peninsula, especially in coastal embayments (Dahlberg 1970), and we treated them as one functional group. The two abundant silverside species (genus *Menidia*) tend to hybridize, form all-female clones, and occur in great abundance that renders identification to species impractical due to the nature of the diagnostic characters (Duggins et al. 1986; Echelle and Echelle 1997; Chernoff, personal communication). Species-level identification of mojarras (genus *Eucinostomus*) was limited to individuals ≥ 40 mm SL due to great difficulty in separating *E. gula* and *E. harengulus* below this size (Matheson, personal observation). The term “eucinostomus mojarras” is used for these small specimens. Species-level identification of gobies of the genus *Gobiosoma* (i.e., *G. robustum* and *G. bosc*) was limited to individuals ≥ 20 mm SL for the same reason; smaller individuals are hereafter referred to as “gobiosoma gobies”. Similarly, needlefishes (*Strongylura* spp.) other than *S. notata* were only identified to species at lengths ≥ 100 mm SL. *Lepomis* spp (sunfishes; <20mm SL) and species of the genera *Oreochromis* and *Sarotherodon* (tilapia; <40mm SL) were similarly not identified to species because of difficulties in species-level identifications at these small sizes.

2.7 Data Analysis

2.7.1 Freshwater Inflow (*F*)

Inflow rates to the study area include data from two gauged streamflow sites, USGS sites 02310678 (Homosassa Springs at Homosassa Springs, FL) and 02310688 (SE Fork Homosassa Spring at Homosassa Springs, FL). Missing data (5% of daily records) were estimated 1) by regressing the two gauged flows against each other and using values from one gauge to predict values in the other, or 2) when data from both gauges were missing, by obtaining interpolated estimates from SWFWMD personnel. All flow rates were expressed as average daily flows in cubic feet per second (cfs).

2.7.2 Organism-Weighted Salinity (SU)

The central salinity tendency for catch-per-unit-effort (CPUE) was calculated as

$$S_U = \frac{\sum (S \cdot U)}{\sum U}$$

where U is CPUE (No. m^{-3} for plankton data and No. 100 m^{-2} for seine and trawl data), and S is water-column average salinity during deployment.

2.7.3 Center of CPUE (km_U)

The central geographic tendency for CPUE was calculated as

$$km_U = \frac{\sum(km \cdot U)}{\sum U}$$

where km is distance from the river mouth.

2.7.4 Organism Number (N) and Relative Abundance ($\overline{N}$)

Using plankton-net data, the total number of organisms in the Homosassa study area was estimated by summing the products of mean organism density ($\overline{U}$, as No. m^{-3}) and tide-corrected water volume (V) from five collection zones as

$$N = \sum(\overline{U} \cdot V)$$

Zone volumes (NAVD88, m^3) for 26 river reaches were provided by SWFWMD (Fig. 2.7.4.1), where Zone 1 ≅ Reaches 1-6, Zone 2 ≅ Reaches 7-11, Zone 3 ≅ Reaches 12-17, Zone 4 ≅ Reaches 18-23, and Zone 5 ≅ Reaches 24-26. Base volumes were adjusted to the water level at the time of collection by multiplying zone surface areas (elevation 0.0, NAVD88, same reach assignments as above) by water-level data provided by SWFWMD (USGS gauge 2310700, Homosassa R at Homosassa FL, NGVD29, gauge height = 0.00 ft). A datum shift of -0.814 ft (NOAA VERTCON) was applied to water-level data prior to conversion to meters. Halls River catch and volume data were excluded from abundance analysis due to lack of streamflow data.

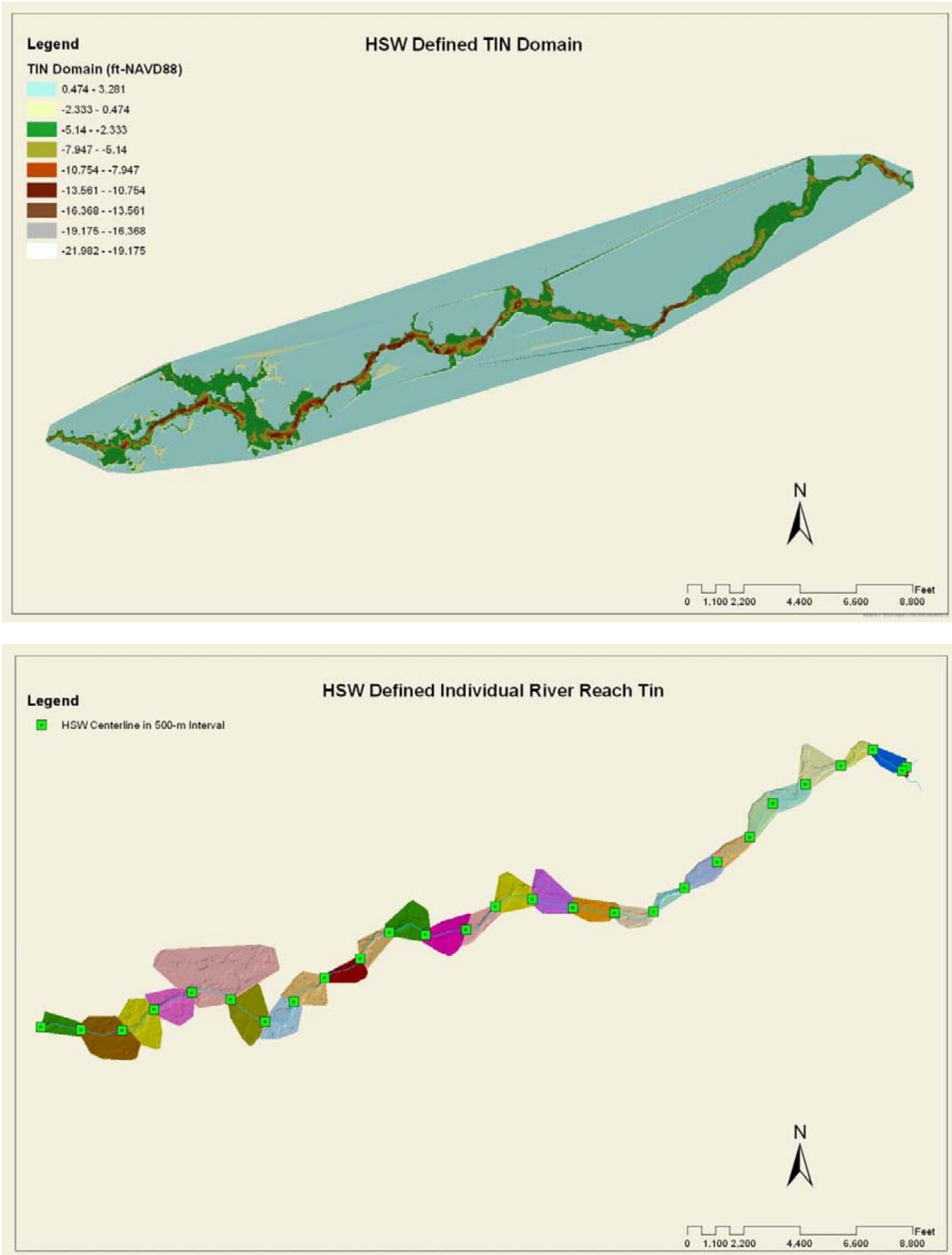

Fig. 2.7.4.1. Limits of horizontal domain (upper panel) and river reaches (lower panel) used to approximate plankton-net collection-zone base volumes. River reach numbers (1-26, not shown) increase in the upstream direction (source: HSW Engineering, Inc., Tampa, FL via SWFWMD).

For seine and trawl data, relative abundance (mean number per 100 m^2 sampled area) in the Homosassa River estuary was calculated as

$$\overline{N} = 100 \times \frac{N_{total}}{A_{total}}$$

where N_{total} = total number of animals captured in that month and A_{total} is the total area sampled in that month. $\overline{N}$ is also referred to as catch-per-unit-effort, or CPUE, in some instances.

2.7.5 Inflow Response Regressions

Regressions were run for km_U on F, N on F, and $\overline{N}$ on F. N, $\overline{N}$, km_U (seine/trawl data only) and F were Ln-transformed prior to regression to improve normality. To avoid censoring zero values in seine and trawl regressions, a constant of 1 was added to $\overline{N}$, F, and km_U values prior to transforming the data.

Regressions using plankton-net data were limited to taxa that were encountered during a minimum of 10 of the monthly surveys. The fits of the following regression models were compared to determine if an alternative model produced consistently better fit than the linear model (Y = a + b**F*):

Square root-Y: Y = (a + b**F*)^2
Exponential: Y = exp(a + b**F*)
Reciprocal-Y: Y = 1/(a + b**F*)
Square root-*F*: Y = a + b*sqrt(*F*)
Reciprocal-*F*: Y = a + b/*F*
Double reciprocal: Y = 1/(a + b/*F*)
Logarithmic-*F*: Y = a + b*ln(*F*)
Multiplicative: Y = a**F*^b
S-curve: Y = exp(a + b/*F*)

where Y is km_U or N. In these regressions, F was represented by same-day inflow and by mean inflows extending as far back as 120 days prior to the sampling date. The combination of consecutive dates that produced the maximum regression fit was used to model the N and km_U responses to F for each taxon. This approach provided an indication of the temporal responsiveness of the various taxa to inflow variations. An organism was considered to be responsive if the regression slope was significantly different from zero at $p<0.05$.

Seine and trawl regressions were limited to taxa that were reasonably abundant (total abundance>100 in seines, >50 in trawls) and frequently collected (present in at least 5% of collections for each gear). Monthly length-frequency plots (Appendix C) were examined in order to assign appropriate size classes ('pseudo-species') and recruitment windows for each of these taxa. For distribution regressions (km_U), all months were considered when a pseudo-species was collected in at least one sample from that month. For abundance regressions ($\bar{N}$), all samples collected within a determined recruitment period from monthly length-frequency plots (Appendix C) were considered. Mean flows from the date of sampling, as well as continuously lagged seven day averages from the day of sampling to 203 d before sampling (i.e., average flow of sampling day and preceding 6 days, average flow of sampling day and preceding 13 days, etc.), were considered and linear and quadratic regressions were evaluated. Lag periods up to 364 days which have typically been used in past reports were not used here due to the consistency of average flows, over long lag periods, within the Homosassa River estuary; lag periods between 210 and 364 days varied by 5 cfs or less for all sampling dates.

2.7.6 Community-level Analyses

2.7.6.1. Plankton. All taxon-specific densities U were transformed using square-root to reduce the influence of overly abundant taxa, and then all samples were compared pairwise as Bray-Curtis percent similarity (Bray and Curtis 1957), with the pairwise similarities contained within a triangular resemblance matrix using PRIMER v6 software (PRIMER-E Ltd. [UK]; Clarke and Gorley 2006). Spatial and temporal differences in community structure were investigated using two-way Analysis of Similarities (ANOSIM; Clarke 1993) with zone and year-month as factors. The data were also displayed graphically using Non-metric Multidimensional Scaling (MDS; Clarke 1993). The taxa contributing most to differences among zones or months were identified using the SIMPER routine in PRIMER. Variation in community heterogeneity under different springflow levels was examined using the MVDISP routine (Warwick and Clarke 1993; Travers and Potter 2002), which is calculated as mean Bray-Curtis dissimilarity scaled to a typical value for the entire data set, producing a relative index of dispersion that varies about 1.0 and is >1.0 when community variability (heterogeneity) is relatively high.

2.7.6.2 Seines and Trawls. To investigate the effects of varying freshwater inflow on the nekton communities, various multivariate analyses were undertaken using PRIMER v6 software (PRIMER-E Ltd. [UK]; Clarke and Gorley 2006). Taxa were divided into the same pseudo-species used for regression analyses. Data were ln(x+1)-transformed to reduce the influence of patchy, abundant species. Data from each deployment technique (boat-set seine and trawl) were treated separately. Inflow data were the same as used for regression analyses.

Bray-Curtis similarities (Bray and Curtis 1957) were calculated between each pair of samples. Spatial and temporal differences in community structure were investigated using two-way Analysis of Similarities (ANOSIM; Clarke 1993) with zone and year-month as factors. The data were also displayed graphically using Non-metric Multidimensional Scaling (MDS; Clarke 1993). Pseudo-species characterizing each zone of the sampling area were determined using Similarity Percentages Analysis (SIMPER; Clarke 1993).

To investigate the extent that monthly changes in community structure correlated with changes in physicochemical variables and annual cycles, the community and physicochemical data were averaged by year-month. Community similarities between months were again calculated with Bray-Curtis similarity (Bray and Curtis 1957). The extent to which change in community structure represented regular annual cycles was investigated using the RELATE routine (see Greenwood et al. [2007] for details). Correlations between nekton community change over the study period and 7-day mean inflow were assessed using the BIO-ENV routine (Clarke 1993). BIO-ENV was also used to assess the correlation between community change and physicochemical variables (temperature, salinity, dissolved oxygen, pH, water depth [at seine center bag/trawl and seine wing], and quantity of bycatch). The analysis was initially conducted for up to five physicochemical variables at once, and was then repeated to assess the highest correlating single variable. The RELATE and BIO-ENV analyses in tandem allowed the relative importance of regular annual cycles (e.g., spawning seasonality) and physicochemical variables to be elucidated.

It was hypothesized that variability in nekton community structure would increase with increasing inflow. This hypothesis was examined using the MVDISP routine in PRIMER (Warwick and Clarke 1993; Travers and Potter 2002), an index of relative dispersion that increases with increasing community variability (heterogeneity).

There was relatively little change in flow over the study period and the initial community analyses suggested that annual cycles in community structure dominated changes attributable to varying inflows or other physicochemical variables. Comparisons were therefore undertaken between the same month in different years of the study period, e.g., January 2007 with January 2008. It was hypothesized that the similarity in community structure between the uppermost and lowermost sampling zones of the study area would increase as flows decreased. For each pair of months, data from the samples in each of the zones were averaged and the Bray-Curtis similarity between the zones was calculated. The similarity between the zones in year 2 of the study was then expressed as a percentage of the similarity of the zones in year 1. The resulting index was then compared to the corresponding 7-day mean flow in year 2 of the study expressed as a percentage of flow in year 1 of the study. An inverse relationship between the two indices would indicate that Bray-Curtis similarity between the uppermost and lowermost zones had indeed increased, i.e., the community had become more homogeneous with decreasing flow.

2.7.7 Data Limitations and Gear Biases

All nets used to sample aquatic organisms are size selective. Small organisms pass through the meshes and large organisms evade the gear altogether. Intermediate-sized organisms are either fully retained or partially retained. When retention is partial, abundance becomes relative. However, temporal or spatial comparisons can still be made since, for a given deployment method and size of organism, the selection process can be assumed to have constant characteristics over space and time. The 500-µm plankton gear retains a wide range of organism sizes completely, yet it should be kept in mind that many estimates of organism density and total number are relative rather than absolute. Organism measurements from Little Manatee River and Tampa Bay plankton samples (Peebles 1996) indicate that the following taxa will be collected selectively by 500-µm mesh: marine-derived cyclopoid copepods, some cladocerans, some ostracods, harpacticoid copepods, cirriped nauplii and cypris larvae, the larvacean *Oikopleura dioica*, some decapod zoeae, and some adult calanoid copepods. Taxa that are more completely retained include cumaceans, chaetognaths, insect larvae, fish eggs, most fish larvae and postlarvae, some juvenile fishes, gammaridean amphipods, decapod mysis larvae, most decapod megalopae, mysids, isopods, and the juveniles and adults of most shrimps. This partitioning represents a very general guide to the relative selectivities of commonly caught organisms.

The plankton nets were deployed during nighttime flood tides because larval fishes and invertebrates are generally more abundant in the water column at night (Colton et al. 1961, Temple and Fisher 1965, Williams and Bynum 1972, Wilkins and Lewis 1971, Fore and Baxter 1972, Hobson and Chess 1976, Alldredge and King 1985, Peebles 1987, Haney 1988, Lyczkowski-Shultz and Steen 1991, Olmi 1994) and during specific tide stages (Wilkins and Lewis 1971, King 1971, Peebles 1987, Olmi 1994, Morgan 1995a, 1995b). Organisms that selectively occupy the water column during flood tides tend to move upstream, and organisms that occupy the water column during all tidal stages tend to have little net horizontal movement other than that caused by net estuarine outflow (Cronin 1982, McCleave and Kleckner 1982, Olmi 1994). The plankton catch was therefore biased toward organisms that were either invading the coastal embayments or were attempting to maintain position within the coastal embayments. This bias would tend to exclude the youngest larvae of some estuarine crabs, which are released at high tide to facilitate export downstream with the ebb tide (Morgan 1995a). However, as the young crabs undergo their return migrations at later larval stages, they become most available for collection during nighttime flood tides (Olmi 1994, Morgan 1995b).

Seines and trawls tend to primarily collect small fish, either adults of small-bodied species or juveniles of larger taxa. Trawls tend to capture larger fish than seines (Nelson and Leffler 2001), and whether this is due to gear characteristics or preferred use of channel habitat by larger fish is uncertain. Sampling efficiency inevitably varies by species and size class (Rozas and Minello 1997), but we assume reasonable consistency between samples collected with a given gear type. We acknowledge that movement of various taxa (e.g. killifishes, Fundulidae and Cyprinodontidae) into emergent vegetation at high water levels occurs (Rozas and Minello 1997) and could complicate interpretation of some results.

3.0 RESULTS AND DISCUSSION

3.1 Streamflow Status During Survey Years

Groundwater inflows into the Homosassa estuary had distinct annual cycles that were out of phase with annual rainfall patterns; inflows were highest during winter and lowest during summer (Fig. 3.1.1). Flows from the Homossasa Spring are correlated with groundwater levels and tides, and low tides allow greater springflow as there is less head pressure over the spring vents (Sid Flannery, pers.comm.). Tidal ranges are generally both higher and more variable during winter, which agrees with the observed springflow pattern. Compared with flows in surface-fed rivers, flows in the Homosassa underwent very minor variation. The data presented in Fig. 3.1.1 had a coefficient of variation (CV) of only 17%, whereas flows in the surface-fed Anclote River to the south had a CV of 237% (July 2004 to September 2005).

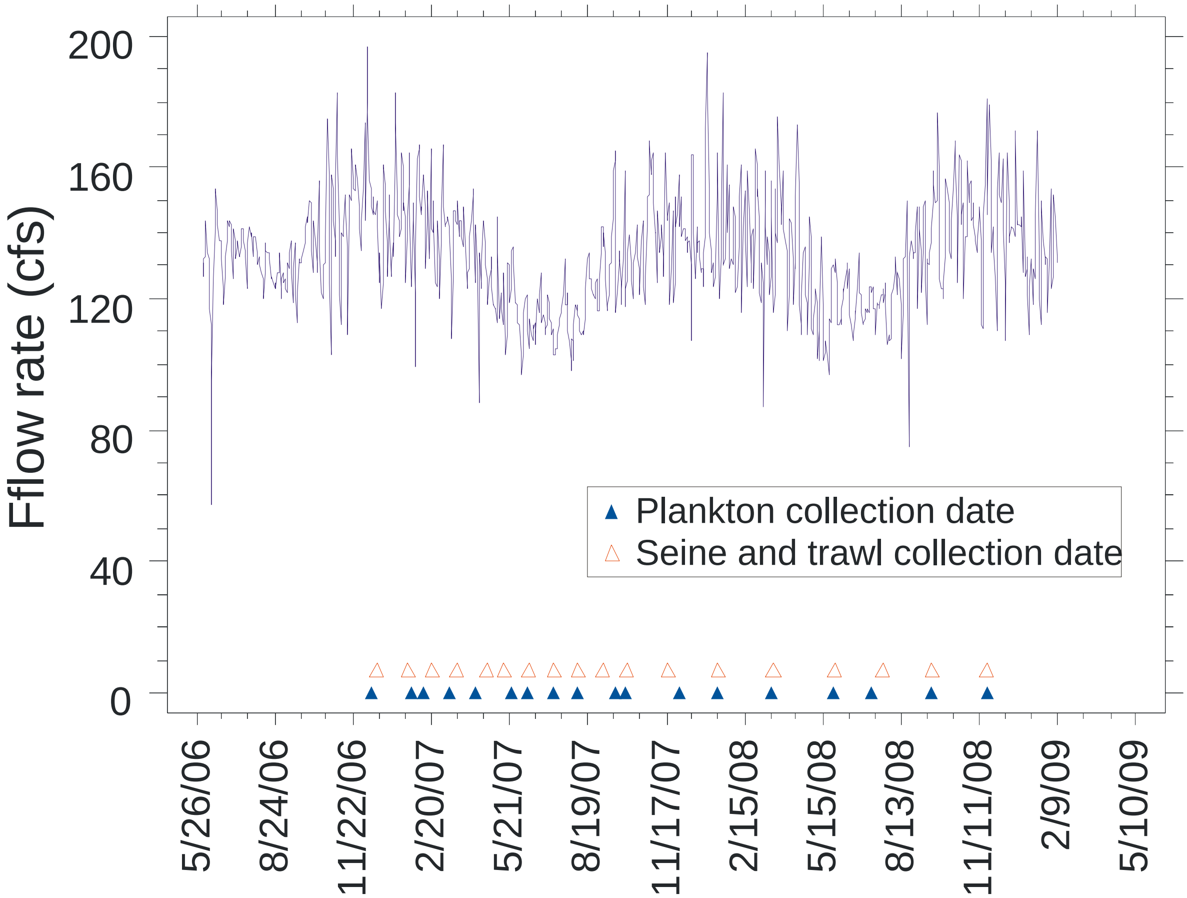

Fig. 3.1.1. Gauged flow into the Homosassa River estuary as sum of flows from USGS sites 02310678 (Homosassa Springs at Homosassa Springs, FL) and 02310688 (SE Fork Homosassa Spring at Homosassa Springs, FL).

3.2 Physico-chemical Conditions

Summary statistics from the electronic meter data collected during plankton sampling are presented in Table 3.2.1. Temperatures underwent seasonal variation within a typical range, but with nearly constant temperatures associated with upstream groundwater dischrge (Fig. 3.2.1). The 2007 and 2008 reductions in salinity (Fig. 3.2.1) occurred during fall, preceding the annual peaks in springflow and likely reflecting a general reduction in salinities in the coastal Gulf of Mexico waters caused by the summer wet season. Dissolved oxygen concentrations below the state instantaneous standard for Class III waters (<4.0 mg/l) was observed in 10 of the 18 surveys (56%). The lowest dissolved oxygen (DO) levels were observed during spring 2007 and summer 2008 in reaches upstream of km 6 km (Table 3.2.1). DO occasionally reached strong supersaturation levels during the winter and spring months, which suggests that microalgal blooms were sometimes present. These occurred both upstream and downstream.

Table 3.2.1. Electronic meter summary statistics during plankton net deployment. Mean depth is mean depth at deployment. Sample sizes (n) reflect the combination of survey frequency (18 monthly surveys) and depth of measurement. Measurements were made at surface, bottom and at one-meter intervals between surface and bottom.

Location	Mean	Salinity (psu)					Water Temperature (°C)					Dissolved Oxygen (mg/l)					pH				
(km from mouth)	Depth (m)	n	mean	std. dev.	min.	max.	n	mean	std. dev.	min.	max.	n	mean	std. dev.	min.	max.	n	mean	std. dev.	min.	max.
0.5	1.8	83	19.2	3.6	13.4	27.8	83	24.8	6.5	14.2	32.8	83	7.8	2.5	4.8	14.6	83	7.9	0.2	7.1	8.2
1.8	3.5	75	16.5	4.3	8.0	25.3	75	24.6	5.8	15.6	32.7	75	7.4	2.0	4.6	12.7	75	7.9	0.2	7.4	8.2
3.0	3.4	86	14.0	4.2	7.2	22.3	86	25.1	5.7	15.9	32.7	86	6.9	1.7	4.4	10.0	86	7.8	0.2	7.2	8.1
4.4	2.7	90	11.9	3.9	6.1	18.5	90	25.0	5.8	16.2	32.7	90	6.9	1.5	4.3	9.7	90	7.8	0.2	7.4	8.1
6.1	2.5	72	10.1	2.9	4.9	15.6	72	25.4	6.0	14.8	32.8	72	6.9	1.3	4.4	9.0	72	7.8	0.1	7.4	8.0
7.1	1.9	56	8.1	3.2	3.2	15.7	56	24.6	5.3	16.0	32.5	56	7.2	1.4	3.3	9.4	56	7.8	0.2	7.5	8.2
9.0	2.2	46	4.1	2.1	2.0	9.3	46	25.3	4.3	17.7	31.4	46	7.6	1.3	5.0	10.2	46	7.9	0.2	7.4	8.3
9.8	1.8	58	3.7	2.2	1.7	10.3	58	25.0	4.1	18.1	32.1	58	7.6	1.9	2.7	10.7	58	7.9	0.3	7.4	8.5
11.1	1.5	47	1.8	0.5	1.2	4.1	47	23.9	1.6	20.9	26.7	47	7.0	1.6	4.9	11.2	47	7.9	0.3	7.5	8.4
11.9	2.0	73	2.2	1.6	0.8	9.4	73	23.7	1.2	21.6	27.8	73	5.1	2.0	2.3	13.1	73	7.7	0.3	7.3	8.6
11.4 (Halls R.)	1.0	47	2.9	0.9	1.6	6.0	47	24.5	4.7	15.7	31.6	47	7.7	2.4	3.8	11.9	47	7.8	0.3	7.3	8.7
13.0 (Halls R.)	0.9	37	3.2	1.0	0.4	5.8	37	24.4	5.2	15.9	32.1	37	6.8	2.1	3.6	12.5	37	7.8	0.3	7.3	8.4

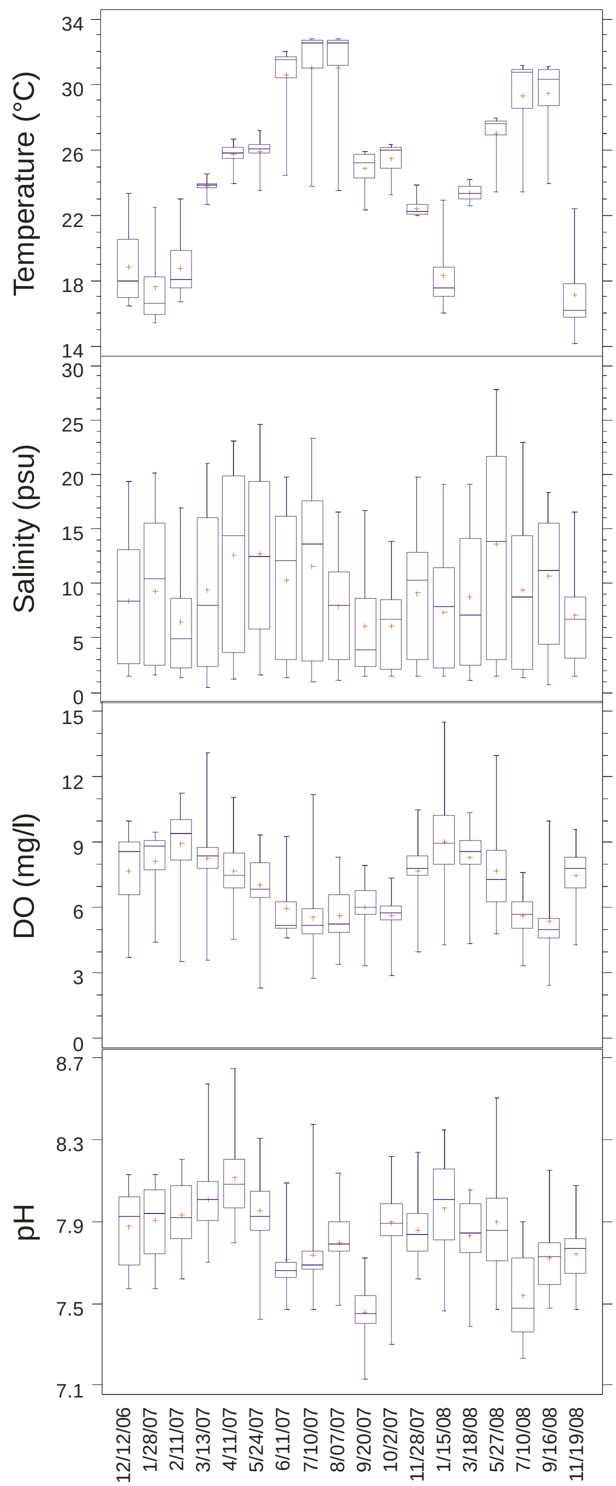

Fig. 3.2.1. Electronic meter data associated with plankton net deployment, where the cross identifies the mean, the horizontal line identifies the median, the box delimits the interquartile range, and the whiskers delimit the total range.

3.3 Catch Composition

3.3.1 Fishes

3.3.1.1 **Plankton net.** Larval gobies and anchovies dominated the larval fish catch (Table A1). More gobies of the genus *Gobiosoma* were collected than *Microgobius* gobies, and the anchovies were strongly dominated by the bay anchovy (*Anchoa mitchilli*). The bay anchovy is usually associated with surface-fed estuaries and may be an indicator of eutrophication in the Homosassa River—abundance of this species was higher than in other spring-fed estuaries, but was lower than in surface-fed estuaries. Other abundant larval fishes included rainwater killifish (*Lucania parva*), silversides (*Menidia* spp.), blennies (blenniids, apparently with the Florida blenny, *Chasmodes saburrae*, being dominant), skilletfish (*Gobiesox strumosus*) and mojarras (*Eucinostomus* spp.). *Menidia* silversides can be exceptionally abundant within estuaries, but can also complete their life cycle within fresh water.

3.3.1.2 **Seine.** The seine catch (Table B1) of fishes in the Homosassa River estuary was dominated by rainwater killifish (*Lucania parva*), menidia silversides (*Menidia* spp.) and eucinostomus mojarras (*Eucinostomus* spp.) less than 40mm. These three taxa comprised nearly 70% of the total seine catch of fishes. Freshwater-oriented taxa such as shiners (*Notropis petersoni, Notropis harperi,* and *Notemigonus crysoleucas)*, bluefin killifish (*Lucania goodei*), largemouth bass (*Micropterus salmoides*) and several species of sunfishes (*Lepomis macrochirus*, *Lepomis microlophus*, and *Lepomis punctatus*) were commonly encountered in the upper reaches of the Homosassa and Halls rivers (zones 5, 6, and 7) (Appendix B5), but comprised a relatively small portion of the total catch in any single zone (<6%).

3.3.1.3 **Trawl.** The trawl catch (Table B2) was dominated by mojarra less than 40mm (*Eucinostomus* spp.), rainwater killifish (*L. parva*), bay anchovy (*Anchoa mitchilli*) and tidewater mojarra greater than 40mm (*E. harengulus*). These taxa represent 77% of the total trawl catch of fishes.

3.3.2. Invertebrates.

3.3.2.1. **Plankton net.** The plankton-net invertebrate catch (Table A1) was dominated by larval crabs (decapod zoeae and megalopae), larval shrimps (decapod mysis), gammaridean amphipods, the mysid *Americamysis almyra*, cumaceans, and the copepod *Acartia tonsa*. *Americamysis almyra* and *Acartia tonsa* are usually associated with surface-fed estuaries and may be indicators of eutrophication in the Homosassa River. The gammaridean amphipods were abundant throughout most of the survey area, being somewhat less abundant near the Gulf of Mexico (Table A3). In contrast, cumaceans were most abundant downstream, which is a commonly observed pattern in other estuaries. The larval crabs, larval shrimps, the mysid *Americamysis almyra* and the copepod *Acartia tonsa*, were all widely distributed throughout the survey area.

3.3.2.2. **Seine.** The seine catch (Table B1) was dominated by brackish grass shrimp (Palaemonetes intermedius), daggerblade grass shrimp (P. pugio), riverine grass shrimp (P. paludosus) and blue crab (Callinectes sapidus). These four taxa comprised over 96% of the total invertebrate catch in seines.

3.3.2.3. **Trawl.** The trawl catch (Table B2) was dominated by blue crab (*Callinectes sapidus*) and brackish grass shrimp (*P. intermedius*). These two taxa represent nearly 90% of the total invertebrate trawl catch.

3.4 Use of Area as Spawning Habitat

The eggs of the bay anchovy (*Anchoa mitchilli*), silversides (*Menidia* spp.), killifishes (*Fundulus* spp., *Lucania parva*) and unidentified sciaenid fishes were collected from the survey area (Table A1). Sciaenid eggs were the most abundant egg type, followed by eggs of the bay anchovy—both types were most abundant in the lower part of the tidal river, peaking 3-6 km upstream of the river mouth (Table A3). Early-stage sciaenid larvae, however, were nearly absent fro the survey area – a total of only 3 *Bairdiella chrysoura* and 2 *Menticirrhus* spp. larvae were collected. Bay anchovies were more abundant as relatively older postflexion larvae, suggesting that most bay anchovies originated from spawning grounds located outside the survey area. The data in Tables A3 and 3.4.1 suggest that blennies spawned most heavily near the river mouth, whereas skilletfish (*Gobiesox strumosus*) and gobies (primarily *Microgobius* spp. and *Gobiosoma* spp., but also *Bathygobius soporator*) may have spawned within the interior of the tidal river. The repeated collection of very small juveniles of live-bearing Gulf pipefish (*Syngnathus scovelli*) within the interior of the tidal river suggests that this species is also reproducing within the local area. A review of trends in spawning habitat among coastal fishes is presented by Peebles and Flannery (1992).

Table 3.4.1. Relative abundance of larval stages for non-freshwater fishes with a collection frequency >10 for the larval-stage aggregate, where *Pre* = preflexion (youngest larval stage), *Flex* = flexion stage (intermediate larval stage) and *Post* = postflexion (oldest larval stage). **X** identifies the most abundant stage and x indicates that the stage was present.

Taxon	**Common Name**	**Pre**	**Flex**	**Post**
blenniids	blennies	**X**	x	x
Gobiesox strumosus	skilletfish	**X**	x	x
Gobiids	gobies	**X**	x	x
Anchoa spp.	anchovies	x	x	**X**
Menidia spp.	silversides	x	x	**X**
Brevoortia spp.	menhaden			**X**

3.5 Use of Area as Nursery Habitat

Estuarine-dependent taxa that spawn in offshore and nearshore waters were present, but not prominent in our samples. Overall, four of the ten most abundant taxa in deeper habitats (54% of total abundance collected in trawls) and three of the ten most abundant taxa in nearshore habitats (12% of total abundance collected in seines) can be considered estuary-dependent taxa that spawn in offshore or nearshore waters. These dependents included blue crab, a species of recreational and commercial importance, and other taxa of ecological importance due to high abundance (i.e., pinfish, tidewater and eucinostomus mojarras). Most of the top ten abundant taxa in both shoreline and channel habitats were tidal river residents or estuarine spawners.

3.6 Seasonality

3.6.1. Plankton Net.

The number of taxa collected during an individual survey is not a true measure of species richness because many taxa could not be identified to species level. Nevertheless, this index produces a clear seasonal pattern. Specifically, more taxa tend to be collected during the warmer months than during winter (Fig. 3.6.1.1).

Species diversity tends to be highest near the mouths of tidal rivers due to an increased presence of marine-derived species and at the upstream end due to the presence of freshwater species. This creates a low-diversity zone in the middle reaches of tidal rivers (Merriner et al. 1976). Changes in streamflow can shift this pattern downstream or upstream.

For a given species of fish, the length of the spawning season tends to become shorter at the more northerly locations within a species' geographic range, but the time of year when spawning takes place is otherwise consistent for a given species. Among species with long or year-round spawning seasons, local conditions have been observed to have a strong influence on egg production within the spawning season (Peebles 2002). Local influences include seasonally anomalous water temperature, seasonal variation in the abundance of prey, and seasonal variation in retention or transport of eggs and larvae after spawning. The latter processes (prey availability and retention and transport) are influenced by freshwater inflows at the coast.

Alteration of flows would appear to have the lowest potential for impacting many taxa during the period from September through February, which is the period when the fewest estuarine taxa were present. The highest potential to impact many species would appear to be from April through June. Most species tended to be most abundant during the spring and summer (Fig. 3.6.1.2). The appearance of higher abundances during 2007 is largely an artifact caused by a sampling frequency that was double the sampling frequency of 2008.

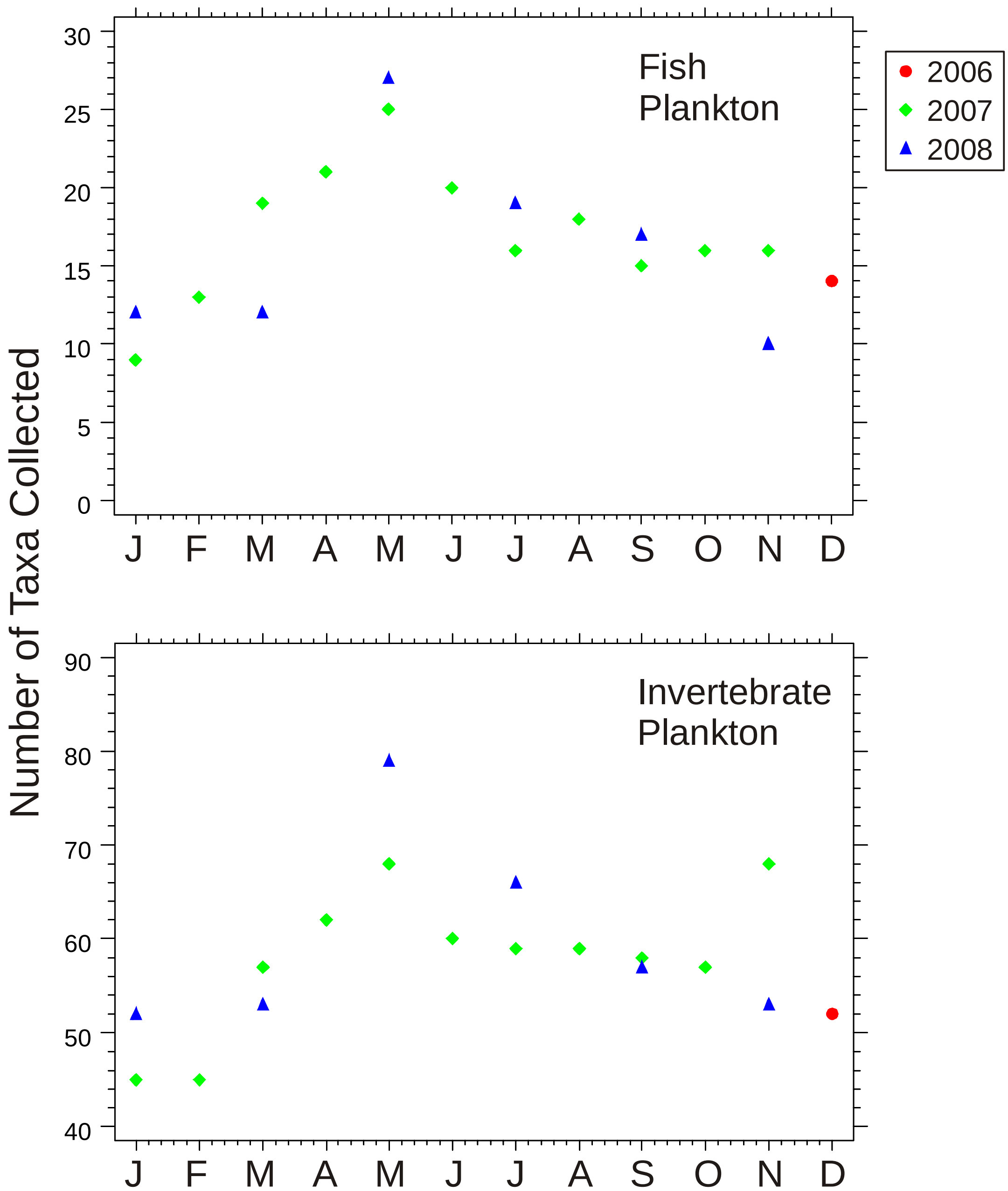

Fig. 3.6.1.1. Number of taxa collected per month by plankton net in the Homosassa River estuary, December 2006 – November 2008.

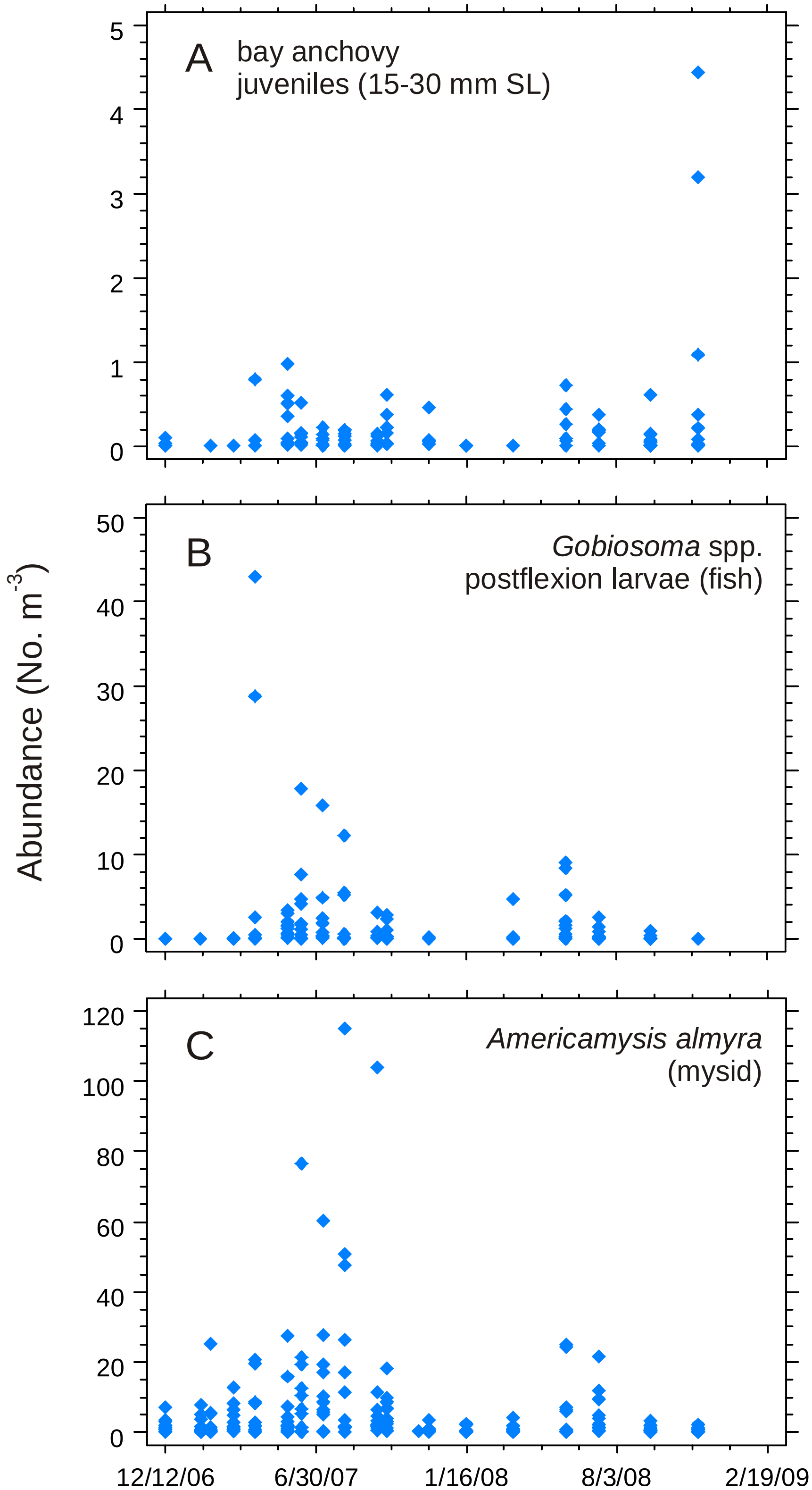

Fig. 3.6.1.2. Examples of species-specific seasonality from plankton-net data.

3.6.2. Seine and Trawl

Seasonal patterns of taxon richness were evident in the nearshore (seined) area of the Homosassa River estuary (Fig. 3.6.2.1). Richness in the nearshore area was low from January to April, increased in May, was particularly high from June to July and in October, and remained elevated until December. There were no clear patterns of taxon richness in the deeper (trawled) regions of the study area. Overall abundances of newly recruited nekton taxa indicate extensive use of the study area during all months (see Appendices B and C).

Thirty-three relatively abundant (more than 100 or 40 individuals collected for seines and trawls, respectively) and frequently occurring (≥5% occurrence) species were assessed to determine seasonality in either the deeper, trawled habitats or in shallow, seined habitats. Most species of tidal river residents were collected in the Homosassa River estuary over the entire year (Fig. 3.6.2.2), but peaks in abundance occurred in January, April to June, and August. Except for the silver perch (*Bairdiella chrysoura*), most species of estuarine spawners were also present in the estuary during all months with peaks in abundance during April to July, September, October, and December. Each of the species of nearshore spawners (species spawning in coastal waters outside the estuary) was present in the estuary year round, but with abundance peaks in February, May, and from September to December. Offshore spawners had peaks in abundance during February to May and in September, October, and December.

Newly recruited nekton (i.e., the smallest one to three 5-mm size classes captured by our gears) were present in the study area throughout the year (Fig. 3.6.2.3). Of the 29 species for which these trends were assessed, offshore spawners recruited to the study area mostly from January to March and in September; nearshore spawners had larger recruitment peaks from December to February, and from August to September; estuarine spawners had more peaks from December to January, May to June, and September to October; and peaks in tidal-river residents' recruitment occurred in all months except November and December but were concentrated in

January and from April to May. Overall, the results suggested that the study area was important for nekton throughout the year.

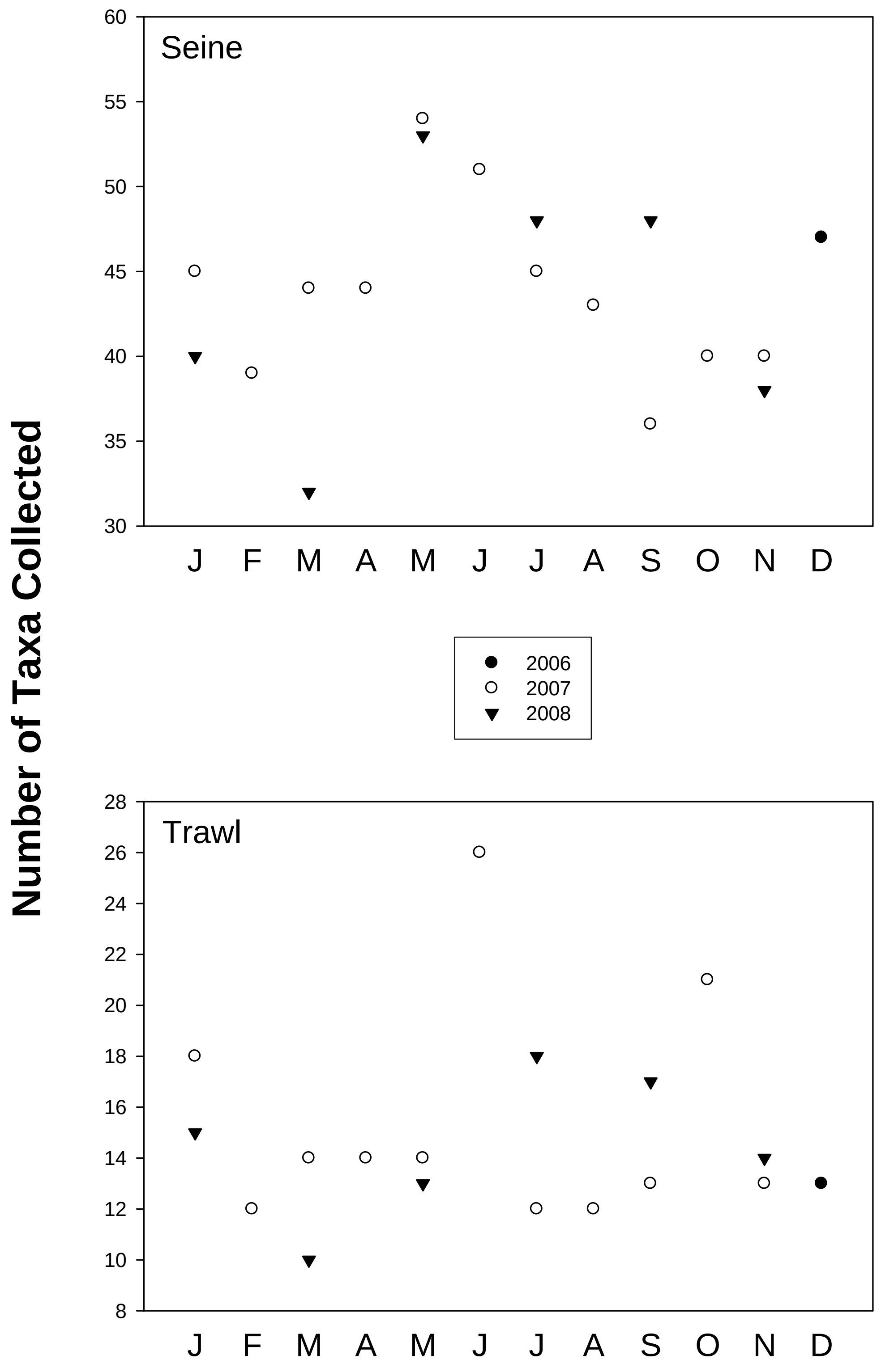

Fig. 3.6.2.1. Number of taxa collected per month by seine and trawl in the Homosassa River estuary, December 2006 – November 2008.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Offshore Spawners												
F. duorarum	st	s	st		s	st		st	ST	ST	st	St
L. rhomboides	st	s	ST	St	St	st	st	st	st	st	st	s
L. xanthurus	s	S	S	s	s	s						s
Total Peaks		1	3	1	1				2	2		1
Nearshore Spawners												
C. sapidus	st	St	st	st	sT	st	st	st	st	st	st	St
E. gula	s	s	s	s	s	s	s	s	S	s	S	s
E. harengulus	st	st	st	st	st	st	st	st	sT	ST	st	st
Total Peaks		1			1				2	2	1	1
Estuarine Spawners												
P. pugio	s	s	s	s	S	s	S	s	s	s	s	s
P. paludosus	s	s	s	s	s	s	s	s	s	S	s	s
P. intermedius	St	st	st	s	sT	sT	s	s	st	sT	st	st
A. mitchilli	t	s	s		s	st	St	st	sT	St	s	S
S. notata	s	s	s	s	s	s	S	s	s	s	s	s
S. timucu	s	s	s	s	s	s	s	S	s	s	S	s
F. carpio	s	S	s	s	s	s			s		s	S
S. scovelli	st	st	st	sT	ST	sT	s	s	st	st	st	st
B. chrysoura			s		S	s	s					
T. maculatus	s	s	st	sT	s	st	st	st	St	sT	s	St
Total Peaks	1	1		2	5	2	3	1	2	4	1	3
Tidal River Residents												
N. crysoleucas	s			s	S	S	S	S	s	s		
N. petersoni	s		s	s	s	s	s	S	S	s	s	s
N. harperi	s	s	s	s	S	s	s	S	s	s	s	
C. variegatus	s	S	s	S	S		s		s	s	s	s
F. grandis	S	S	s	S	s				s		s	s
F. seminolis	s	s	s	s	S	s	s	s	s	s	s	S
L. parva	sT	st	st	St	St	ST	st	s	st	st	st	st
L. goodei	s	s	s	s	s	s	s	S	s	s	s	s
G. holbrooki	S	s	s	s	s	s	s	s	s	s	s	s
P. latipinna	s	s	s	s	S	S	s		s	s	s	S
H. formosa	S	s	s	s	S	s	s	s	s	s	s	s
L. macrochirus	s	s	s	s	s	s	S	S	s	s	s	s
L. microlophus	s	s	s	s	S	s	s	s	s	S	s	s
L. punctatus	s	s	s	s	S	S	s	s	s	s	s	s
M. salmoides	s	s	s	S	S	s	s	s	s	s	s	s
G. bosc	St	s	st	s	sT	s	sT	s	st	st	st	st
M. gulosus	st	s	st	sT	ST	St	st	St	st	st	st	s
Total Peaks	5	2		5	13	6	3	6	1	1		2

Fig. 3.6.2.2. Top months of relative abundance for abundant species collected with seines (S) and trawls (T) in the Homosassa River estuary, December 2006 – November 2008. Dark gray shading indicates peak months (abundance >=15% of total relative abundance) for either trawls or seines. A lower case letter (s or t) indicates that a species was present but at an abundance of less than 15% of its total relative abundance while an upper case letter (S or T) indicates that a species was present at an abundance of ≥15% of its total relative abundance.

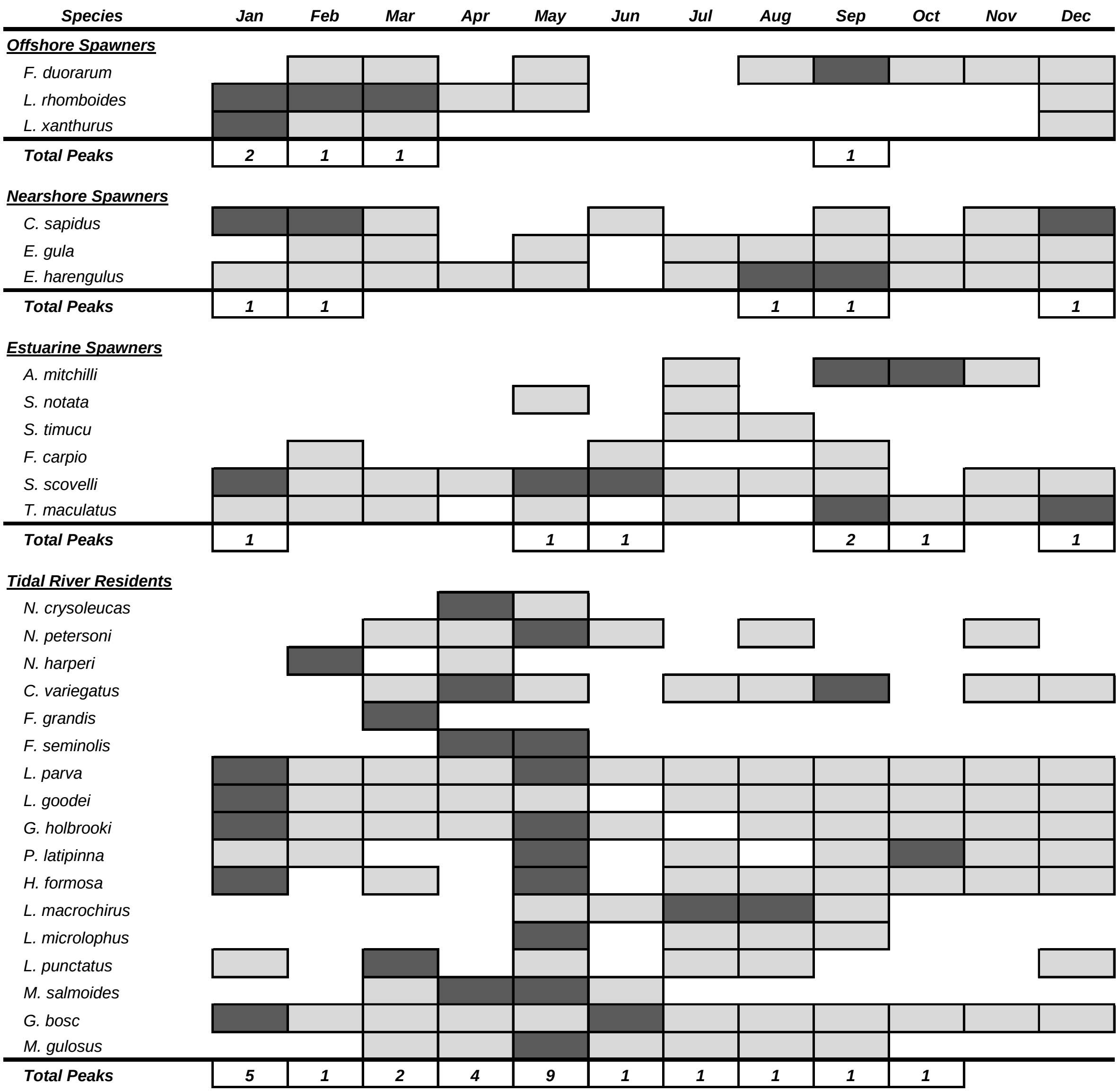

Fig. 3.6.2.3. Months of occurrence (□) and peak abundance (■) for newly recruited nekton collected with seines and trawls in the Homosassa River estuary, December 2006 – November 2008.

3.7 Distribution (kmu) Responses to Freshwater Inflow

3.7.1 Plankton Net

Among the 64 plankton-net taxa evaluated for distribution relationships with freshwater inflow, 42% (n = 27) exhibited significant responses (Table 3.7.1.1, Appendix F). Eleven of these were negative responses, wherein animals moved downstream as inflows increased. Downstream movement is the typical inflow response seen in tidal rivers on Florida's west coast. However, more taxa (n = 16) moved upstream (against the flow) as flows increased. Some of these relationships had very good fit (e.g., various types of goby larvae), suggesting that these relationships are not spurious. Some of these upstream-moving taxa may have become entrained in two-layered circulation (i.e., bottom water moving upstream to replace surface water moving downstream), or may have responded to stronger olfactory cue delivery by moving into the river to seek out the source of the olfactory cues. Overall, time lags for the responses were highly variable, with many occurring within a seasonal time frame.

Table 3.7.1.1. Plankton-net organism distribution (km_U) responses to mean freshwater inflow (Ln *F*), ranked by linear regression slope. Other regression statistics are sample size (*n*), intercept (*Int.*), slope probability (*P*) and fit (adjusted r^2, as %). *D* is the number of daily inflow values used to calculate mean freshwater inflow. Most of the time series data were not serially correlated (*DW*, Durbin-Watson statistic, p>0.05 for all except three taxa).

Description	*Common Name*	*n*	*a*	*b*	*p*	*r2*	*DW*	*D*
Menidia spp. preflexion larvae	silversides	16	125.564	-24.096	0.0021	50		113
Sinelobus stanfordi	tanaid	14	121.121	-23.570	0.0197	38		117
decapod mysis	shrimp larvae	18	90.125	-17.450	0.0112	34		120
polychaetes	sand worms, tube worms	18	73.585	-13.953	0.0271	27		15
Anopsilana jonesi	isopod	10	64.366	-12.336	0.0136	55		24
oligochaetes	freshwater worms	12	56.440	-9.353	0.0351	37		57
Erichsonella attenuata	isopod	18	34.140	-6.302	0.0078	37		7
Eurytemora affinis	copepod	12	39.605	-5.824	0.0298	39		85
Temora turbinata	copepod	15	24.893	-4.648	0.0177	36		1
dipterans, pupae	flies, mosquitoes	18	29.361	-3.758	0.0164	31		120
cumaceans	cumaceans	18	19.380	-3.396	0.0203	29		7
chaetognaths, sagittid	arrow worms	16	-17.180	3.763	0.0043	45		120
Xenanthura brevitelson	isopod	11	-25.302	6.443	0.0236	45		3
Monstrilla sp.	copepod	11	-34.680	7.457	0.0103	54		120
Edotea triloba	isopod	18	-31.285	7.897	0.0356	25		86
cymothoid sp. a (Lironeca) juveniles	isopod	18	-43.572	10.474	0.0375	24		80
pelecypods	clams, mussels, oysters	17	-48.153	10.997	0.0074	39		8
Americamysis almyra	opossum shrimp, mysid	18	-74.967	16.660	0.0039	42		120
gobiid flexion larvae	gobies	15	-76.878	17.364	0.0000	76		12
unidentified Americamysis juveniles	opossum shrimps, mysids	18	-82.155	18.094	0.0058	39		120
gobiid preflexion larvae	gobies	17	-82.786	18.446	0.0000	69	x	33
Microgobius spp. flexion larvae	gobies	14	-88.576	19.849	0.0000	79		11
Callinectes sapidus juveniles	blue crab	10	-97.328	20.663	0.0386	43		120
decapod megalopae	post-zoea crab larvae	18	-106.792	22.912	0.0130	33	x	120
Microgobius spp. postflexion larvae	gobies	16	-114.467	25.190	0.0000	91		52
Palaemonetes pugio juveniles	daggerblade grass shrimp	12	-141.050	30.336	0.0040	58		120
Cyathura polita	isopod	10	-186.828	39.649	0.0008	78	x	120

3.7.2 Seine and Trawl

Over 24% (n=13) of the 53 pseudo-species/gear/river segment combinations (hereafter simply referred to as ‘pseudo-species’) evaluated for distributional responses to freshwater inflow exhibited significant response for at least one lagged flow period. For the purposes of this discussion, we refer only to the best fit models for each of these thirteen pseudo-species (i.e., statistically significant [$\alpha<0.05$] models with normally distributed residuals that explain the greatest proportion of the variance [highest r^2 value] for each pseudo-species) (Table 3.7.2.1). Best fit models are plotted for each pseudo-species in Appendix G.

Eleven of the thirteen pseudo-species with distributional responses to inflow showed the pattern of upstream movement in centers of abundance in response to decreasing inflow. The two pseudo-species that moved upstream in response to increasing inflow were *Strongylura notata*, an estuarine spawner, and *Notemigonus crysoleucas*, a tidal river resident. The range in the predicted distributional changes (maximum to minimum change) tended to be relatively small (1.0 – 1.6 km; median = 1.2 km) for tidal river resident species (TRR) and higher (1.2 – 5.8 km; median = 3.7 km) for estuarine, nearshore, and offshore spawners. The species with the largest change in predicted distribution was the offshore spawner, *Leiostomus xanthurus* (spot) which moved 5.8 km upstream as flows decreased from 153 to 116 cfs. The best fit response to lag period for almost half the pseudo-species (n=6) was the longest lag period analyzed (91 days) while only three of the pseudo-species demonstrated relatively short lag periods (≤21 days).

Although only 15 of the 53 pseudo-species tested (28%) were collected from the shoreline habitat of the Halls River, seven (46.6% of the pseudo-species with significant response) demonstrated a distributional response to freshwater inflow. Six of the Halls River pseudo-species centers of abundance moved downstream with increased inflow, while *Notemigonus crysoleucas* (golden shiner) moved upstream. The golden shiner tends to be found in clear, quiet vegetated, shallow waters and may have moved upstream in the Halls River to avoid unfavorable conditions in the lower Halls and Homosassa rivers as flows increased in the Homosassa River.

Table 3.7.2.1. Best-fit seine and trawl-based pseudo-species distributional response to continuously-lagged mean freshwater inflow (ln(km_U) vs. ln(inflow)) for the Homosassa and Halls River estuary. River segments (River Seg.) are defined as Homosassa River (HR), Halls River (HA), or a combination of the Homosassa and Halls rivers (HR/HA, river kilometers 5.8 – 11.1 on the Homosassa River and river kilometers 11.1 – 14.1 on the Halls River). Life History categories are Estuarine Spawners (ES), Tidal River Residents (TRR), Nearshore Spawners (NS), and Offshore Spawners (OS). Degrees of freedom (*df*), intercept (Int.), slope, probability that the slope is significant (*P*), and fit (Adj-r^2) are provided. The number of days in the continuously-lagged mean inflow is represented by *D*. An "x" in *DW* indicates that the Durbin-Watson statistic was significant (p<0.05), a possible indication that serial correlation was present.

Species	***Common name***	***Life History***	***Gear***	***River Seg.***	***Size (mm)***	***df***	***Int.***	***Slope***	***P***	***Adj. r2***	***DW***	***D***
Palaemonetes paludosus	Riverine grass shrimp	ES	Seine	HA	All	16	4.246	-0.288	0.024	0.237		91
Palaemonetes pugio	Daggerblade grass shrimp	ES	Seine	HR	All	16	8.299	-1.187	0.001	0.613	x	91
Palaemonetes intermedius	Brackish grass shrimp	ES	Trawl	HR/HA	All	11	10.031	-1.536	0.020	0.349		63
Callinectes sapidus	Blue crab	NS	Trawl	HR/HA	>50	15	6.236	-0.789	0.001	0.571		14
Notemigonus crysoleucas	Golden shiner	TRR	Seine	HA	All	8	0.666	0.450	0.046	0.335		7
Notropis petersoni	Coastal shiner	TRR	Seine	HA	All	15	3.877	-0.220	0.030	0.228		56
Strongylura notata	Redfin needlefish	ES	Seine	HR	All	16	-6.583	1.751	0.030	0.215		21
Lucania goodei	Bluefin killifish	TRR	Seine	HA	All	16	4.243	-0.289	0.018	0.258	x	91
Syngnathus scovelli	Gulf pipefish	ES	Seine	HA	All	15	5.185	-0.492	0.038	0.206		91
Lepomis punctatus	Spotted sunfish	TRR	Seine	HA	≥20	16	4.184	-0.277	0.032	0.210		91
Micropterus salmoides	Largemouth bass	TRR	Seine	HA	All	15	4.420	-0.328	0.002	0.451		91
Lagodon rhomboides	Pinfish	OS	Seine	HR	All	16	13.682	-2.414	0.001	0.489		49
Leiostomus xanthurus	Spot	OS	Seine	HR	All	8	17.145	-3.110	0.001	0.785		35

3.8 Abundance (N, $\bar{N}$) Responses to Freshwater Inflow

3.8.1 Plankton Net

Among the 64 plankton-net taxa evaluated for abundance relationships with freshwater inflow, 44% (n = 28) exhibited significant responses (Table 3.8.1.1, Appendix H). All except five of these were negative responses. Negative responses are usually caused by elevated flows washing organisms out of the survey area. The organisms that had positive responses were the estuarine tanaid *Hargeria rapax*, postflexion larvae of the oligohaline fish *Lucania parva*, freshwater podocopid ostracods, the estuarine copepod *Acartia tonsa*, and the oligohaline copepod *Eurytemora affinis*. It could be concluded that more positive results were not observed because no stations were positioned in the Gulf of Mexico to account for species that moved downstream and increased in number in response to increased inflow.

The lags associated with the positive responses were generally long, ranging from 36 d to the maximum lag evaluated, 120 d. The 120 d lags are likely seasonal in nature, whereas the responses of podocopid ostracods and *E. affinis* may have represented short-term population responses to inflow variation. Inflow variations were very small relative to those surface-fed rivers, which makes detection of abundance responses more difficult.

Table 3.8.1.1. Plankton-net organism abundance responses to mean freshwater inflow (Ln *F*), ranked by linear regression slope. Other regression statistics are sample size (*n*), intercept (*Int.*), slope probability (*P*) and fit (adjusted r^2, as %). *DW* identifies where serial correlation is possible (x indicates p<0.05 for Durbin-Watson statistic). *D* is the number of daily inflow values used to calculate mean freshwater inflow.

Description	*Common Name*	*n*	*a*	*b*	*p*	*r2*	*DW*	*D*
Gobiosoma spp. postflexion larvae	gobies	16	145.423	-27.173	0.0001	66		32
decapod zoeae	crab larvae	18	134.592	-24.143	0.0004	56		16
decapod mysis	shrimp larvae	18	122.821	-22.172	0.0000	72		16
gobiid flexion larvae	gobies	15	111.054	-20.112	0.0001	72	x	20
gobiid preflexion larvae	gobies	17	111.229	-20.093	0.0011	52	x	13
Cassidinidea ovalis	isopod	18	93.659	-16.865	0.0001	61		17
Anchoa mitchilli juveniles	bay anchovy	17	84.624	-14.977	0.0178	32	x	120
Microgobius spp. postflexion larvae	gobies	16	81.404	-14.401	0.0070	42	x	14
Bowmaniella dissimilis	opossum shrimp, mysid	18	76.013	-12.591	0.0039	41		113
Edotea triloba	isopod	18	71.411	-12.124	0.0039	41		20
cymothoid sp. a (Lironeca) juveniles	isopod	18	64.261	-11.212	0.0004	56		47
Palaemonetes pugio juveniles	daggerblade grass shrimp	12	61.161	-10.466	0.0182	44		17
decapod megalopae	post-zoea crab larvae	18	63.694	-10.343	0.0355	25		1
Anopsilana jonesi	isopod	10	58.417	-10.129	0.0018	72	x	43
Taphromysis bowmani	opossum shrimp, mysid	13	55.436	-9.126	0.0084	48		1
Cyathura polita	isopod	10	48.087	-8.040	0.0092	59	x	7
Parasterope pollex	ostracod, seed shrimp	16	47.079	-7.258	0.0238	31		16
Americamysis almyra	opossum shrimp, mysid	18	50.709	-7.093	0.0000	69		1
amphipods, caprellid	skeleton shrimps	17	43.526	-6.681	0.0007	55		20
dipterans, pupae	flies, mosquitoes	18	42.402	-6.331	0.0075	37	x	1
unidentified Americamysis juveniles	opossum shrimps, mysids	18	46.748	-6.252	0.0008	52		1
Anchoa spp. preflexion larvae	anchovies	10	38.964	-5.862	0.0467	41		1
branchiurans, Argulus spp.	fish lice	11	35.263	-5.414	0.0014	70		42
Hargeria rapax	tanaid	18	-43.376	11.195	0.0183	30		117
Lucania parva postflexion larvae	rainwater killifish	12	-49.467	11.652	0.0023	62		120
ostracods, podocopid	ostracods, seed shrimps	16	-48.019	11.990	0.0331	29		58
Acartia tonsa	copepod	18	-59.762	15.169	0.0183	30	x	120
Eurytemora affinis	copepod	12	-89.289	19.978	0.0482	34		36

3.8.2 Seine and Trawl

Among the 53 pseudo-species considered in these analyses, abundances of over 75% (n=40) were significantly related to average inflow (Table 3.8.2.1). The greatest proportion of variance in abundance (best fit model; Appendix I) was explained by linear regressions for 27 pseudo-species and by quadratic regressions for 13 pseudo-species. Of the 27 linear models, 12 were negative relationships, indicating increasing abundance with decreasing inflow and 15 showed positive relationships. Pseudo-species with quadratic relationships between inflow and abundance were split between situations with the maximum abundance at intermediate inflows (‘intermediate-maximum’, n=7) and minimum abundance at intermediate inflows (‘intermediate-minimum’, n=6).

The percentage of significant abundance responses to inflow ranged from 57% of tested pseudo-species in nearshore spawners to 88% in tidal river residents (Fig. 3.8.2.1). Most life history categories exhibited linear responses to inflow (68%) with more positive (i.e., abundance increased with increasing inflow, n=15) than negative (n=12) responses. Relationships between inflow and abundance showed an intermittent maximum response in approximately 20% and 14% of the best fit relationships for tidal river residents and estuarine spawners, respectively. Intermittent minimum relationships were the most common response in estuarine spawners (n=4).

Short-term increases in the Homosassa River inflow tended to result in slightly higher salinity in Halls River (Figure 3.8.2.2) over the inflow ranges encountered during the sampling events of this study (average daily inflow of 103 to 163 cfs; mean of 132 cfs). It seems likely that increased inflows in the Homosassa River pulled off the fresher, surface water from the Halls River raising its salinity slightly. The abundance response of nekton in the Halls River was profound, with all seine collected pseudo-species (n=15) that were tested showing an abundance response to inflow. Eight of these responses were negative (all tidal river residents) in which abundance in the Halls River decreased with increasing inflow in the Homosassa River.

Long-term lag periods accounted for the highest percentage of the regression models in each of the life-history categories (Fig. 3.8.2.3), except near-shore spawners where the highest percentage of models were not significant. Long lags were especially prevalent (50% of pseudo-species) in offshore spawners. Short-term inflows (≤14 days) were most common among tidal river residents indicating that they tended to respond more directly to freshwater inflow changes than the other life history categories.

Twelve pseudo-species had greater than 50% of the variance in their abundance explained by inflow. These twelve pseudo-species with the strongest relationships to inflow included eight tidal river residents, three offshore spawners, and one nearshore spawner. Of these twelve, eleven were analyses conducted on data collected by seines in the shoreline habitat. Relationships of abundance to flow in these twelve pseudo-species were positive linear (n=6; Appendix Figs. I3, I10, I25, I26, I27, and I28), negative linear (n=4; Appendix Figs. I5, I6, I31, and I37), ‘intermediate-maximum’ (*Heterandria formosa*; Appendix Fig. I20), and ‘intermediate-minimum’ (*Lepomis macrochirus*; Appendix Fig. I22). An increase in abundance with increased flow (positive linear response) may suggest beneficial aspects of increased nutrient input, for example, or perhaps better detection of the tidal-river nursery area. A decrease in abundance with increased inflow (negative linear response) could indicate a physical displacement to unsuitable habitats, a movement into flooded habitats that have become available (emergent marshes), or a dilution of the chemical cues that draw animals into the tidal-river nursery areas. Intermediate-maximum relationships, where abundance is greatest at mid-range flows and lower at both lower and higher flows, perhaps indicate differing forces operating at opposite ends of the inflow spectrum. At low flows, opportunities for either chemical detection of tidal nursery habitats or selective tidal-stream transport may be reduced, and at high flows, physical displacement may occur, or perhaps undesirable properties of fresher water (e.g., low pH) become more prominent.

Table 3.8.2.1. Best-fit seine and trawl-based pseudo-species abundance ($\bar{N}$) response to continuously-lagged mean freshwater inflow (ln(cpue) vs. ln(inflow)) for the Homosassa River estuary. River segments (River Seg.) are defined as Homosassa River (HR), Halls River (HA), or a combination of the Homosassa and Halls rivers (HR/HA, river kilometers 5.8 – 11.1 on the Homosassa River and river kilometers 11.1 – 14.1 on the Halls River). Life History categories are Estuarine Spawners (ES), Tidal River Residents (TRR), Nearshore Spawners (NS), and Offshore Spawners (OS). The type of response (*Resp.*) is either linear (L) or quadratic (Q). Degrees of freedom (*df*), intercept (*Int.*), slope (*Linear coef.*), probability that the slope is significant (*Linear P*), quadratic coefficient (*Quad. coef.*), probability that the quadratic coefficient is significant (*Quad. P*) and fit (*Adj. r^2*) are provided. The number of days in the continuously-lagged mean inflow is represented by *D*. An "x" in *DW* indicates that the Durbin-Watson statistic was significant (p<0.05), a possible indication that serial correlation was present.

										Linear		Quadratic				
Species	***Common name***	***Life History***	***Gear***	***River Seg.***	***Size (mm)***	***Period***	***Resp.***	***df***	***Int.***	***Coef.***	***P***	***Coef.***	***P***	***Adj-r^2***	***DW***	***D***
Palaemonetes intermedius	Brackish grass shrimp	ES	Seine	HR	All	Jan. to Dec.	L	16	-34.788	7.652	0.013	.	.	0.289		63
Palaemonetes paludosus	Riverine grass shrimp	ES	Seine	HA	All	Jan. to Dec.	Q	15	5552.469	-2266.036	0.045	231.271	0.048	0.160	x	175
Palaemonetes intermedius	Brackish grass shrimp	ES	Trawl	HR/HA	All	Jan. to Dec.	Q	15	-646.181	264.851	0.047	-27.120	0.047	0.139		84
Callinectes sapidus	Blue crab	NS	Seine	HR	0 to 30	Jan. to Dec.	L	16	-66.445	13.809	0.001	.	.	0.560		182
Callinectes sapidus	Blue crab	NS	Trawl	HR/HA	0 to 30	Jan. to Dec.	L	16	-17.272	3.566	0.002	.	.	0.438		182
Callinectes sapidus	Blue crab	NS	Seine	HR	>30	Jan. to Dec.	L	16	-16.522	3.479	0.009	.	.	0.320	x	70
Callinectes sapidus	Blue crab	NS	Trawl	HR/HA	>50	Jan. to Dec.	L	16	18.754	-3.687	0.005	.	.	0.363	x	7
Notemigonus crysoleucas	Golden shiner	TRR	Seine	HA	All	Apr. to Oct.	L	8	28.142	-5.449	0.004	.	.	0.636	x	1
Notropis petersoni	Coastal shiner	TRR	Seine	HA	All	Jan. to Dec.	L	16	62.221	-12.149	0.001	.	.	0.521		98
Strongylura notata	Redfin needlefish	ES	Seine	HR	All	Jan. to Dec.	Q	15	-3031.948	1242.757	0.009	-127.302	0.008	0.420	x	203
Strongylura timucu	Timucu	ES	Seine	HR	All	Jan. to Dec.	Q	15	547.748	-227.051	0.039	23.537	0.037	0.338	x	7
Cyprinodon variegatus	Sheepshead minnow	TRR	Seine	HA	All	Jan. to Dec.	Q	15	3278.856	-1342.938	0.022	137.526	0.022	0.240		175
Fundulus grandis	Gulf killifish	TRR	Seine	HR	All	Jan. to May	L	6	-25.551	5.430	0.012	.	.	0.628		1
Fundulus seminolis	Seminole killifish	TRR	Seine	HA	All	Jan. to Dec.	L	16	26.326	-5.090	0.006	.	.	0.349	x	63
Lucania parva	Rainwater killifish	TRR	Seine	HR	All	Jan. to Dec.	L	16	-53.560	11.765	0.025	.	.	0.232	x	203
Lucania parva	Rainwater killifish	TRR	Seine	HA	All	Jan. to Dec.	L	16	38.322	-6.731	0.001	.	.	0.495		7
Lucania parva	Rainwater killifish	TRR	Trawl	HR/HA	All	Jan. to Dec.	Q	15	-2243.555	918.378	0.036	-93.919	0.037	0.187		105
Lucania goodei	Bluefin killifish	TRR	Seine	HA	All	Jan. to Dec.	L	16	25.199	-4.539	0.028	.	.	0.222		14

Species	Common name	Life History	Gear	River Seg.	Size (mm)	Period	Resp.	df	Int.	Linear Coef.	Linear P	Quadratic Coef.	Quadratic P	Adj-r^2	DW	D
Floridichthys carpio	Goldspotted killifish	ES	Seine	HR	All	Jan. to Dec.	Q	15	2932.867	-1206.984	0.025	124.186	0.025	0.357		140
Gambusia holbrooki	Eastern mosquitofish	TRR	Seine	HR	All	Jan. to Dec.	L	16	-75.932	15.830	0.004	.	.	0.387		126
Gambusia holbrooki	Eastern mosquitofish	TRR	Seine	HA	All	Jan. to Dec.	L	16	47.285	-9.388	0.006	.	.	0.348		7
Poecilia latipinna	Sailfin molly	TRR	Seine	HR	All	Jan. to Dec.	L	16	-14.725	3.092	0.009	.	.	0.313		14
Poecilia latipinna	Sailfin molly	TRR	Seine	HA	All	Jan. to Dec.	Q	15	-3310.424	1359.001	0.013	-139.371	0.013	0.261	x	98
Heterandria formosa	Least killifish	TRR	Seine	HA	All	Jan. to Dec.	Q	15	-1480.200	614.829	0.005	-63.724	0.005	0.543		7
Syngnathus scovelli	Gulf pipefish	ES	Seine	HA	All	Jan. to Dec.	L	16	-28.946	6.149	0.033	.	.	0.207		203
Syngnathus scovelli	Gulf pipefish	ES	Trawl	HR/HA	All	Jan. to Dec.	L	16	-20.789	4.300	0.017	.	.	0.265	x	203
Lepomis macrochirus	Bluegill	TRR	Seine	HR	≥20	Jan. to Dec.	Q	15	1302.098	-531.893	0.002	54.324	0.002	0.538		42
Lepomis macrochirus	Bluegill	TRR	Seine	HA	≥20	Jan. to Dec.	L	16	28.295	-5.541	0.020	.	.	0.249	x	7
Lepomis punctatus	Spotted sunfish	TRR	Seine	HA	≥20	Jan. to Dec.	L	16	-45.400	9.612	0.025	.	.	0.231		203
Micropterus salmoides	Largemouth bass	TRR	Seine	HR	All	Apr. to Aug.	L	5	-70.8301	14.991	0.005	.	.	0.779		98
Micropterus salmoides	Largemouth bass	TRR	Seine	HA	All	Apr. to Aug.	L	5	-99.285	20.694	0.021	.	.	0.625	x	203
Eucinostomus harengulus	Tidewater mojarra	OS	Trawl	HR/HA	≥40	Jan. to Dec.	L	16	40.798	-8.194	0.0001	.	.	0.619	x	168
Lagodon rhomboides	Pinfish	OS	Seine	HR	All	Jan. to Oct.	L	13	-56.001	11.957	0.001	.	.	0.541	x	182
Lagodon rhomboides	Pinfish	OS	Trawl	HR/HA	>45	Mar. to Nov.	L	12	6.219	-1.228	0.005	.	.	0.446		1
Leiostomus xanthurus	Spot	OS	Seine	HR	All	Jan. to May	L	6	-161.044	32.915	0.011	.	.	0.639		147
Gobiosoma bosc	Naked goby	TRR	Seine	HR	All	Jan. to Dec.	Q	15	-2088.045	851.897	0.043	-86.847	0.044	0.202		182
Microgobius gulosus	Clown goby	TRR	Seine	HR	All	Jan. to Dec.	L	16	39.109	-7.695	0.002	.	.	0.430		21
Microgobius gulosus	Clown goby	TRR	Seine	HA	All	Jan. to Dec.	L	16	49.670	-9.640	0.000	.	.	0.747		28
Microgobius gulosus	Clown goby	TRR	Trawl	HR/HA	All	Jan. to Dec.	Q	15	-1778.362	730.117	0.011	-74.895	0.011	0.280	x	84
Trinectes maculatus	Hogchoker	ES	Trawl	HR/HA	All	Apr. to Dec.	Q	10	1095.468	-449.155	0.031	46.047	0.031	0.355	x	126

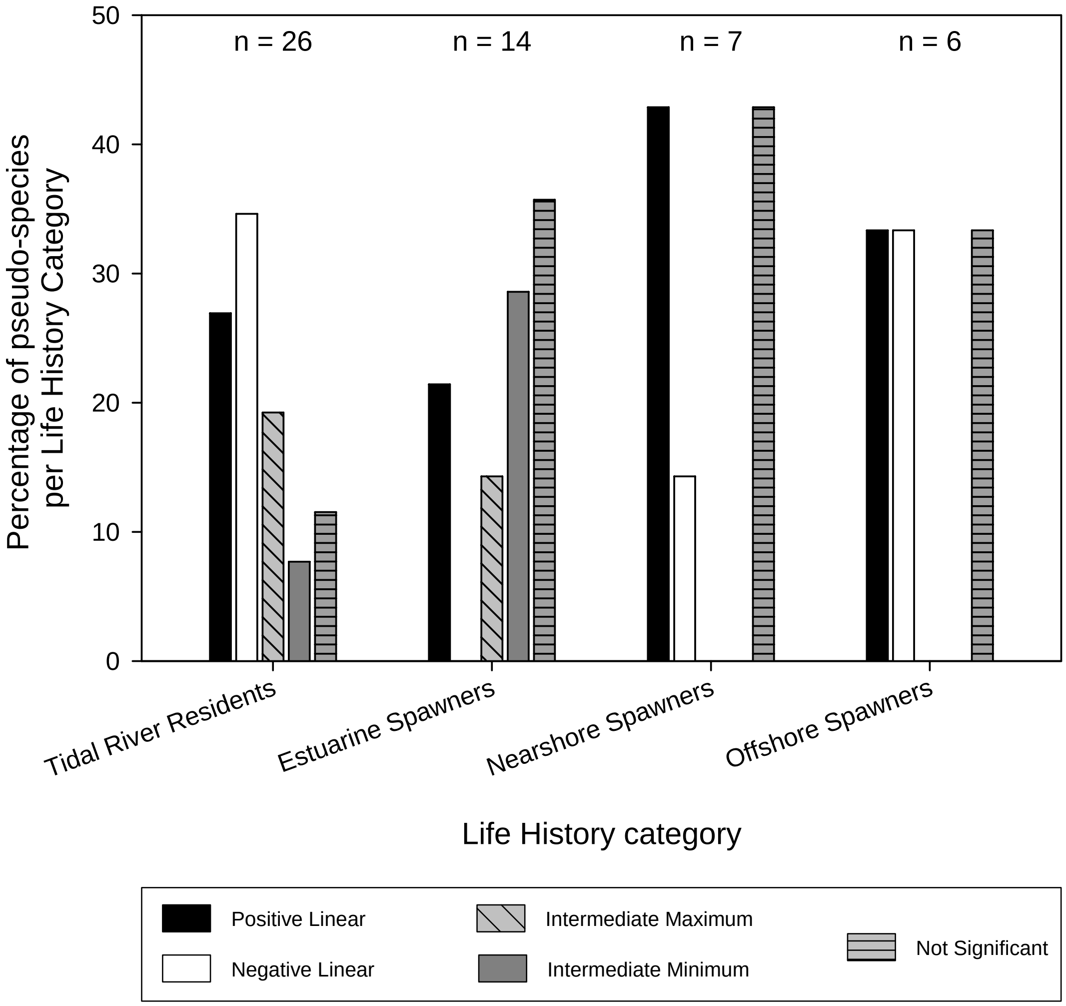

Fig. 3.8.2.1. Summary of regression results by response type and life history category for the 53 pseudo-species assessed for abundance ($\overline{N}$) in relation to inflow from the Homosassa River estuary. Positive and negative indicate a linear increase and decrease in abundance with increasing inflow, respectively, while intermediate-maximum and intermediate-minimum indicate maximum and minimum abundance at intermediate inflows, respectively. The number of pseudo-species within each life history category that did not have significant abundance responses to inflow are also displayed (Not Significant). The numbers at the top of the graph indicate the number of pseudo-species assessed within each life history category.

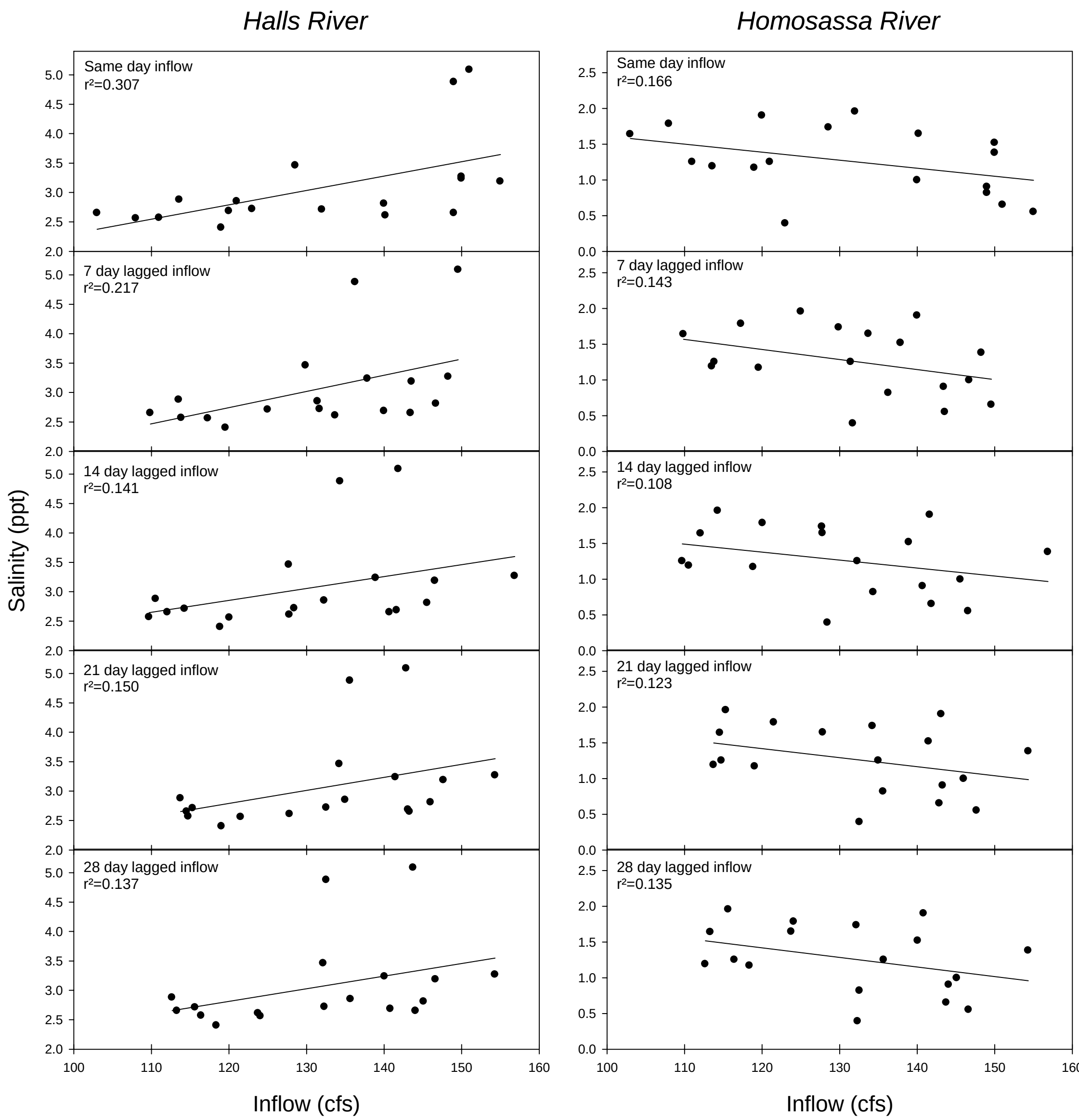

Figure 3.8.2.2. Relationship between freshwater inflow on the Homosassa River and salinity in the Halls River and Zone 5 of the Homosassa River for nekton sampling events in the Homosassa River estuary. Lag periods (7 day intervals from 1 to 28 days) and percent of variability explained (r^2) by the regression are depicted in the upper left of each plot.

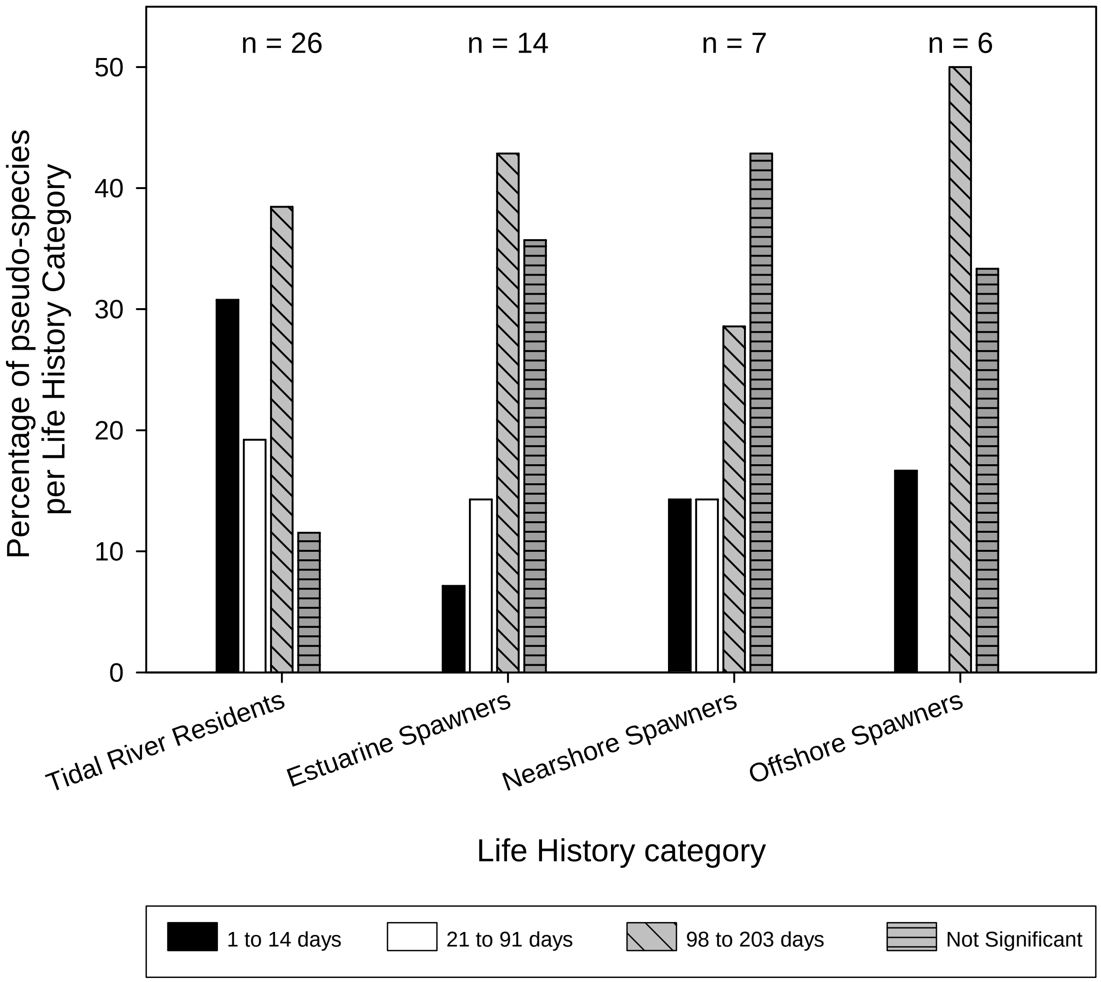

Fig. 3.8.2.3. Summary of best-fit regression results by lag period and life history category for the 53 pseudo-species assessed for abundance ($\bar{N}$) in relation to inflow from the Homosassa River estuary. Lag periods were categorized as short (1 to 14 days), medium (21 to 91 days), and long (98 to 203 days). The number of pseudo-species within each life history category that did not have significant abundance responses to inflow are also displayed (Not Significant). The numbers at the top of the graph indicate the number of pseudo-species assessed within each life history category.

3.9 Community Structure

3.9.1 Plankton net.

The community structure of the plankton-net catch (fishes and invertebrates together) formed the typically continuous ordination observed in other tidal rivers, with downstream communities being most different from upstream communities, and with intermediate locations being positioned in the expected order (Fig. 3.9.1.1, ANOSIM R = 0.28, P = 0.001). The two upstream-most zones, Zones 5 and 6, exhibited the widest variability. Zone 5, the zone nearest the spring, was dominated by gammaridean amphipods, crab larvae (*Rhithropanopeus harrisii*), fly and midge larvae, mysids, and pododopid (freshwater) ostracods. Zone 6 (Halls River) differed from adjacent Zone 5 (downstream of the spring) primarily in having higher abundances of the same taxa as in Zone 5. Zone 1 near the Gulf of Mexico was dominated by a diversity of crab and shrimp larvae, cumaceans, gamaridean amphipods, the mysid *Bowmaniella dissimilis*, the copepod *Acartia tonsa*, sagittid arrow worms, polychaete worms, and the isopod *Harrieta faxoni*.

Community structure was also differentiated by season, with communities from November through February being different from the remainder of the year (Fig. 3.8.1.2, ANOSIM R = 0.41, P = 0.001). The widest consistent difference was between January and May. During May, there were more crab and shrimp larvae, gammaridean amphipods, goby larvae (*Gobiosoma* and *Microgobius*), cumaceans, mysids (*Bowmaniella dissimilis* and *Americamysis almyra*), *Acartia tonsa* and sagittid arrow worms than during January. The relationship between community heterogeneity (relative dispersion) and springflow was positive and approached significance at the α=0.05 level, indicating there was a mild decrease in community heterogeneity during summer low-flow periods, when marine organisms tended to invade and cause community composition to become similar throughout the lower estuary.

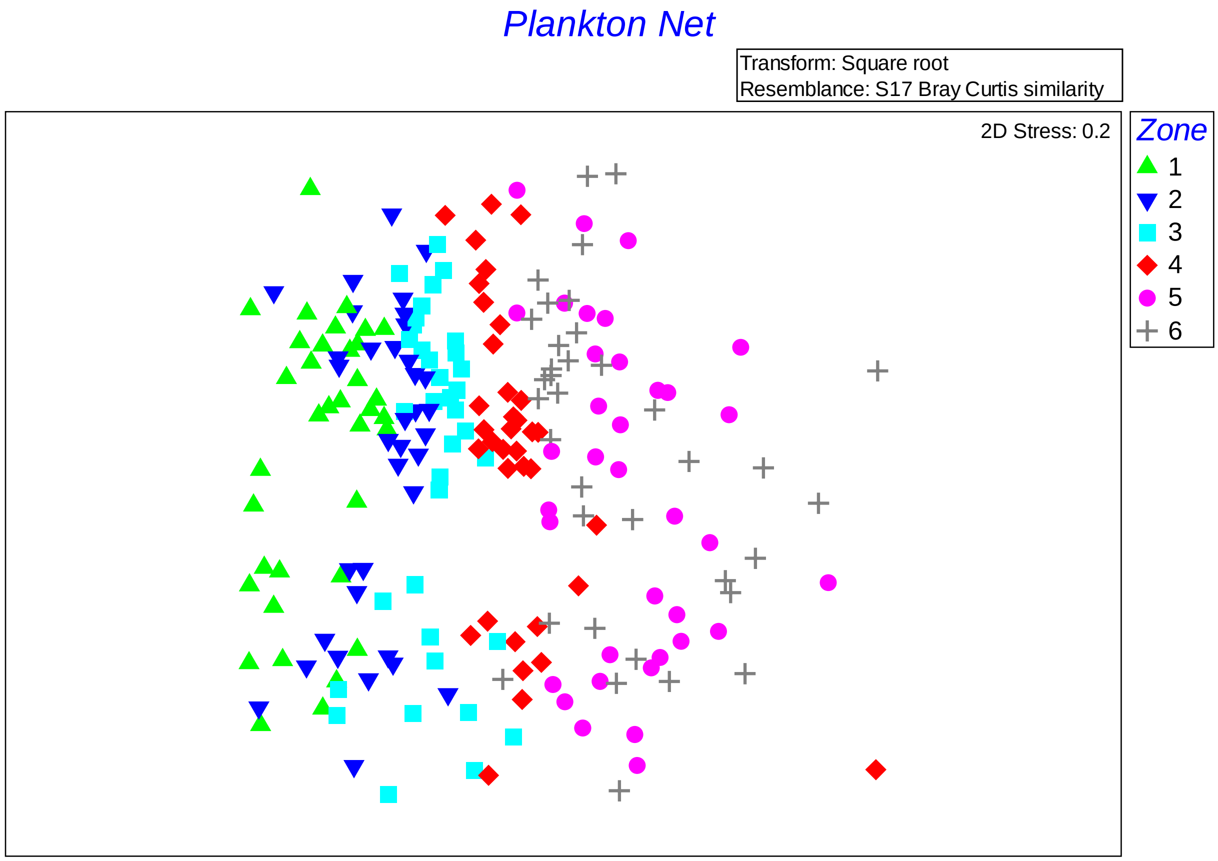

Fig. 3.9.1.1. Nonmetric Multidimensional Scaling (MDS) ordination plot of the plankton community structure in the Homosassa River, with symbols coded by collection zone.

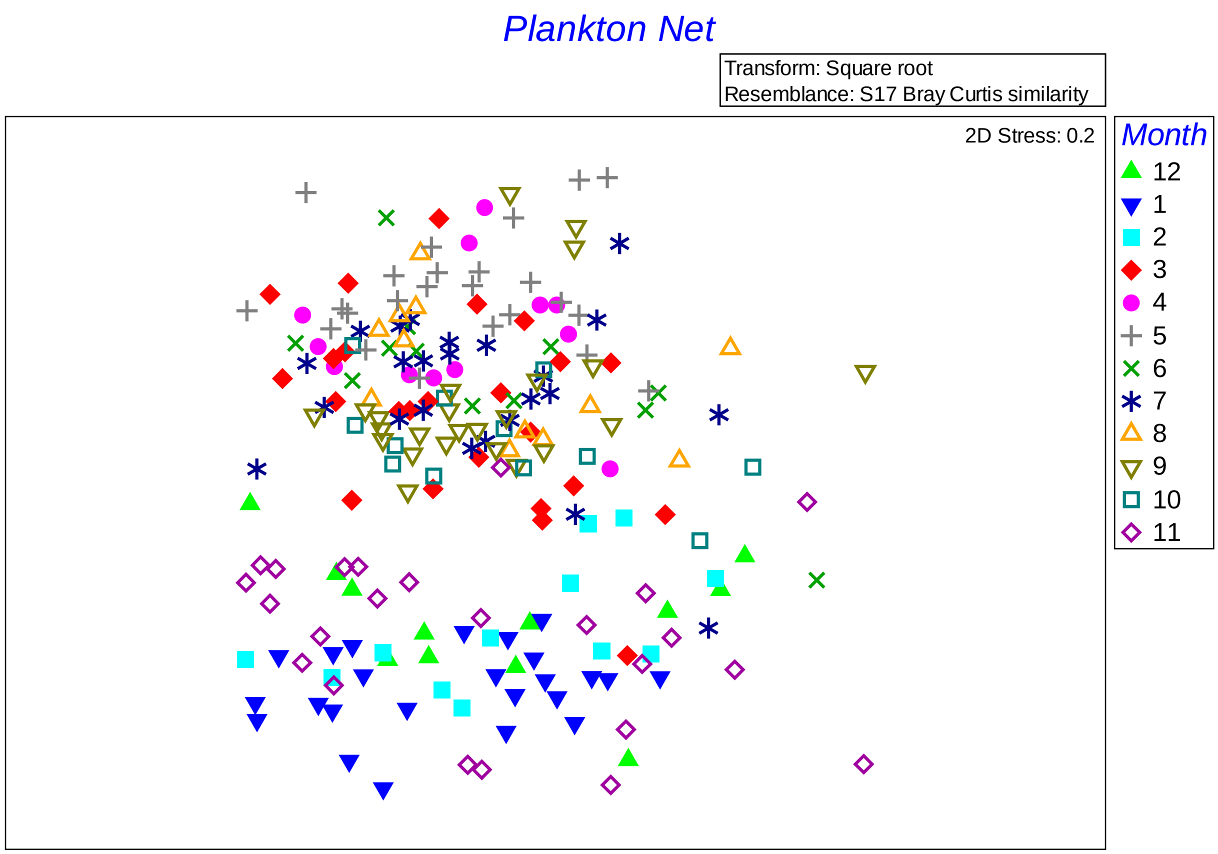

Fig. 3.9.1.2. Nonmetric Multidimensional Scaling (MDS) ordination plot of the plankton community structure in the Homosassa River, with symbols coded by month.

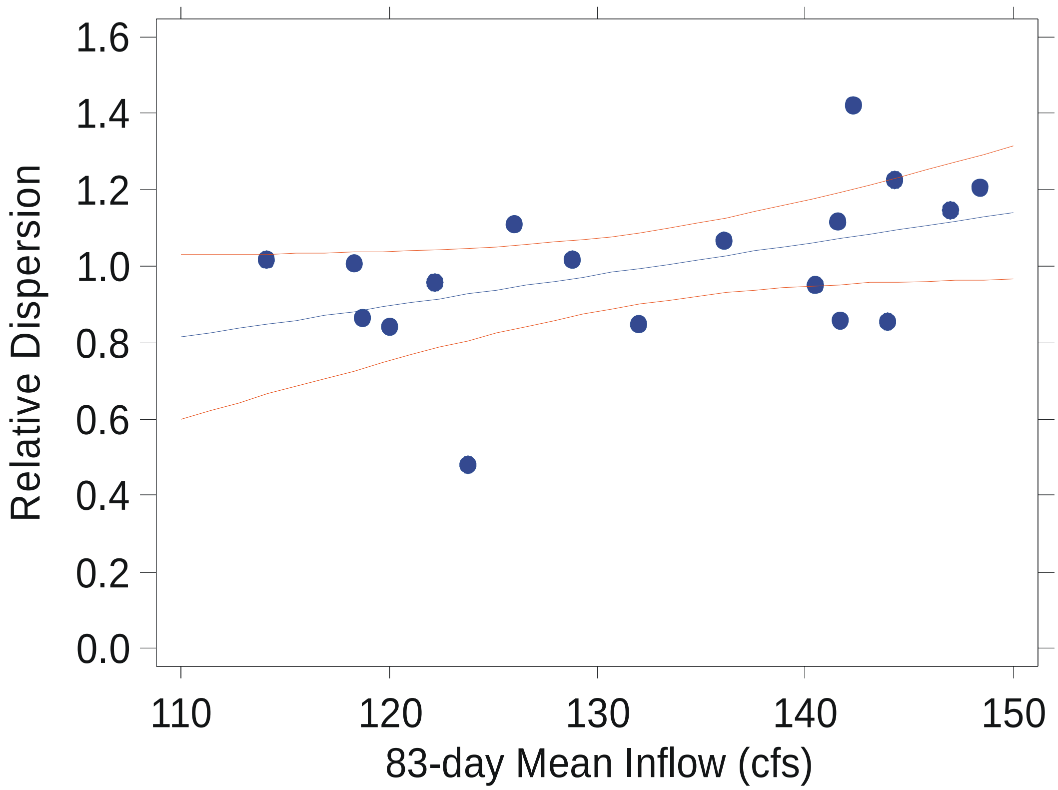

Fig. 3.9.1.3. Relationship between spring inflows and zooplankton community heterogeneity in the Homosassa River (measured as relative dispersion), with fitted regression line and 95% confidence intervals.

3.9.2. Seine and Trawl

Community structure changed spatially and temporally in all of the surveyed habitats of the Homosassa River. In the shoreline (21.3-m seined) area, community structure was significantly different between zones (ANOSIM R = 0.506, P = 0.001). In general, pairwise comparisons revealed that the difference in community structure between adjacent zones increased with movement upstream through zone five (river km's 11.2-12.9); differences in community structure between adjacent zones five through seven were slightly lower. There was relatively little difference between zone one and zone two (ANOSIM R = 0.137), whereas there was considerable difference in community structure between zones four and five (ANOSIM R = 0.541, P = 0.001) and somewhat less difference between zones six and seven (ANOSIM R = 0.314, P = 0.001) (Table 3.9.2.1). This was reflected in the MDS plot, wherein the samples from zones four and five did not overlap with the samples from the other zones to as great an extent as each of the other zones overlap with adjacent zones (Fig. 3.9.2.1). *Lucania goodei, Lutjanus griseus*, *Gambusia holbrooki*, and *Micropterus salmoides* were very abundant in zone five (river km 11.2-13.0), and were the main drivers in the differences in community structure (Table 3.9.2.2). There were also significant differences in community structure between month-years in the shoreline habitat (ANOSIM R = 0.429, P = 0.001). Community structure in this habitat changed annually in a regular, cyclical manner (RELATE ρ = 0.705, P = 0.001); the correlation with an annual cycle was considerably greater than the correlation with monthly physicochemical changes or changes in flow (Table 3.9.2.3).

Table 3.9.2.1. Pairwise differences in community structure from 21.3-m seines set along shorelines of the Homosassa River.

Zone Pairs		**ANOSIM *R***	***P***
Zone 1 (0.00-2.89 km)	Zone 2 (3.00-5.79 km)	0.137	0.003
Zone 1 (0.00-2.89 km)	Zone 3 (5.80-8.59 km)	0.331	0.001
Zone 1 (0.00-2.89 km)	Zone 4 (8.60-11.19 km)	0.607	0.001
Zone 1 (0.00-2.89 km)	Zone 5 (11.20-13.00 km)	0.758	0.001
Zone 1 (0.00-2.89 km)	Zone 6 (11.20-14.09 km)	0.799	0.001
Zone 1 (0.00-2.89 km)	Zone 7 (14.10-16.70 km)	0.694	0.001
Zone 2 (3.00-5.79 km)	Zone 3 (5.80-8.59 km)	0.102	0.005
Zone 2 (3.00-5.79 km)	Zone 4 (8.60-11.19 km)	0.515	0.001
Zone 2 (3.00-5.79 km)	Zone 5 (11.20-13.00 km)	0.675	0.001
Zone 2 (3.00-5.79 km)	Zone 6 (11.20-14.09 km)	0.747	0.001
Zone 2 (3.00-5.79 km)	Zone 7 (14.10-16.70 km)	0.640	0.001
Zone 3 (5.80-8.59 km)	Zone 4 (8.60-11.19 km)	0.344	0.001
Zone 3 (5.80-8.59 km)	Zone 5 (11.20-13.00 km)	0.722	0.001

Zone 3 (5.80-8.59 km)	Zone 6 (11.20-14.09 km)	0.830	0.001
Zone 3 (5.80-8.59 km)	Zone 7 (14.10-16.70 km)	0.660	0.001
Zone 4 (8.60-11.19 km)	Zone 5 (11.20-13.00 km)	0.541	0.001
Zone 4 (8.60-11.19 km)	Zone 6 (11.20-14.09 km)	0.800	0.001
Zone 4 (8.60-11.19 km)	Zone 7 (14.10-16.70 km)	0.548	0.001
Zone 5 (11.20-13.00 km)	Zone 6 (11.20-14.09 km)	0.356	0.001
Zone 5 (11.20-13.0 km)	Zone 7 (14.10-16.70 km)	0.488	0.001
Zone 6 (11.20-14.09 km)	Zone 7 (14.10-16.70 km)	0.314	0.001

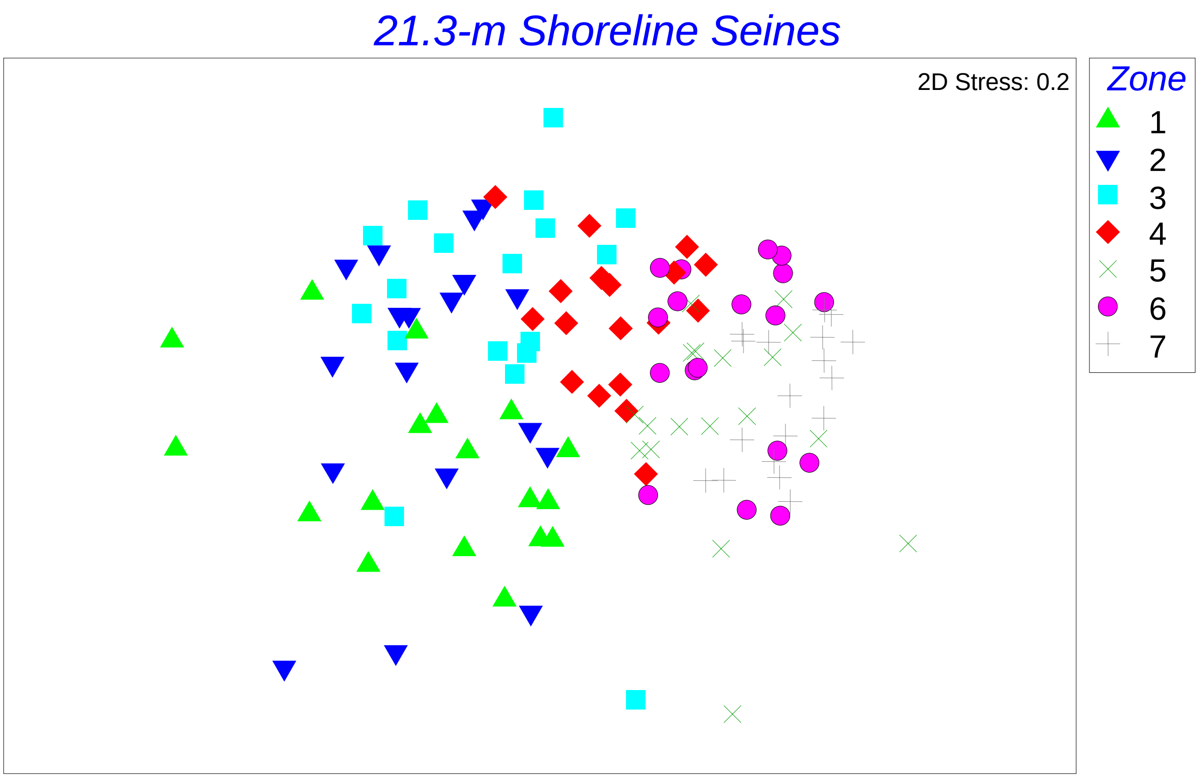

Fig. 3.9.2.1. Nonmetric Multidimensional Scaling (MDS) ordination plot of the shoreline 21.3-m-seine nekton community structure in the Homosassa River.

Table 3.9.2.2. Pseudo-species characterizing each of the sampling zones in the Homosassa River. Abundance index represents the mean of the ln(x+1)-transformed abundance per seine haul or per 720 m^2 trawled.

21.3-m shoreline seines

Homosassa River Zone 1 (0.0-2.79 km)

Taxa	Abund. Index
P. intermedius	2.02
L. rhomboides 51-100 mm	0.85
Eucinostomus spp. < 31 mm	0.82
L. parva <31 mm	1.22
L. rhomboides 31-50 mm	0.85
E. gula 51-100 mm	0.75
L. rhomboides <31 mm	0.87
L. parva 31-50 mm	0.59
Menidia spp. 31-50 mm	0.66
Menidia spp. 51-100 mm	0.6

Homosassa River Zone 2 (2.8-5.79 km)

Taxa	Abund. Index
E. harengulus 51-100 mm	1.13
L. rhomboides 51-100 mm	0.65
Eucinostomus spp. < 31 mm	0.94
P. intermedius	0.96
Eucinostomus spp. 31-39mm	0.79
Menidia spp. 51-100 mm	0.77
Menidia spp. 31-50 mm	0.86
E. gula 51-100 mm	0.53
L. rhomboides 31-50 mm	0.34
L. rhomboides < 31 mm	0.38

Homosassa River Zone 3 (5.8-8.59 km)

Taxa	Abund. Index
E. harengulus 51-100 mm	1.48
Menidia spp. 31-50 mm	1.69
L. rhomboides 51-100 mm	0.99
Eucinostomus spp. < 31 mm	1.08
E. harengulus 31-50 mm	0.81
C. sapidus < 31 mm	0.82
L. parva < 31 mm	0.73
Eucinostomus spp. 31-39 mm	0.86
Menidia spp. < 31 mm	0.71
P. intermedius	0.48

Homosassa River Zone 4 (8.6-11.19 km)

Taxa	Abund. Index
L. parva < 31 mm	3.28
Menidia spp. 31-50 mm	2.6
Eucinostomus spp. < 31 mm	2.15
E. harengulus 51-100 mm	2.03
Eucinostomus spp. 31-39 mm	1.72
Menidia spp. < 31 mm	1.51
E. harengulus 31-50 mm	1.24
P. pugio	1.31
Mi gulosus < 31 mm	0.99
G. bosc < 31 mm	0.83

21.3-m shoreline seines

Homosassa River Zone 5 (11.2-13.0 km)

Taxa	Abund. Index
L. parva < 31 mm	3.45
L. goodei < 31 mm	2.48
L. griseus > 100 mm	0.22
Eucinostomus spp. < 31 mm	1.15
E. harengulus 51-100 mm	0.9
G. holbrooki < 31 mm	1.02
Menidia spp. 31-50 mm	1.21
M. salmoides 31-50 mm	0.55
P. pugio	0.85
M. gulosus 31-50 mm	0.73

Halls River Zone 6 (11.2-14.09 km)

Taxa	Abund. Index
L. parva < 31 mm	4.37
Menidia spp. 31-50 mm	2.44
Menidia spp. < 31 mm	2.52
M. gulosus 31-50 mm	1.4
M. gulosus < 31 mm	1.39
L. parva 31-50 mm	1.28
L. goodei < 31 mm	0.94
E. harengulus 51-100 mm	1.15
Eucinostomus spp. < 31 mm	0.95
E. harengulus 31-50 mm	0.85

Halls River Zone 7 (14.1-16.7 km)

Taxa	Abund. Index
L. parva < 31 mm	4.28
L. goodei < 31 mm	2.45
P. paludosus	1.84
M. gulosus < 31 mm	1.22
Menidia spp. < 31 mm	1.59
H. formosa < 31 mm	1.46
N. petersoni 31-50 mm	1.61
P. intermedius	0.9
Menidia spp. 31-50 mm	1.51
M. gulosus 31-50 mm	1.02

6.1-m trawls

Homosassa River Zone 3 (5.8-8.59 km)

Taxa	Abund. Index
C. sapidus > 100 mm	1.46
C. sapidus 51-100 mm	1.46
E. harengulus 51-100 mm	1.07
L. rhomboides 51-100 mm	0.94
C. sapidus < 31 mm	0.71
P. intermedius	0.55
F. duorarum < 31 mm	0.62
Eucinostomus spp. < 31 mm	0.77
Eucinostomus spp. 31-39 mm	0.52

Homosassa River Zone 4 (8.6-11.19 km)

Taxa	Abund. Index
Eucinostomus spp. < 31 mm	2.15
C. sapidus 51-100 mm	1.54
C. sapidus > 100 mm	1.11
Eucinostomus spp. 31-39 mm	1.46
E. harengulus 51-100 mm	1.19
L. parva < 31 mm	1.3
E. harengulus 31-50 mm	1.11
T. maculatus < 31 mm	0.63
C. sapidus < 31 mm	0.7

Halls River Zone 6 (11.2-14.09 km)

Taxa	Abund. Index
L. parva < 31 mm	2.52
Eucinostomus spp. < 31 mm	1.45
E. harengulus 51-100 mm	1.12
S. scovelli 51-100 mm	1.01
C. sapidus 51-100 mm	0.99
C. sapidus > 100 mm	0.82
T. maculatus 51-100 mm	0.65
E. harengulus 31-50 mm	0.78
M. gulosus 31-50 mm	0.82

Table 3.9.2.3. Summary of results correlating monthly change in nekton community structure with seasonal and physicochemical changes in the shoreline (21.3-m seines) and deeper habitats (6.1-m trawls) of the Homosassa River.

Gear	**Correlation with regular annual cycle (RELATE)**	**BIO-ENV (up to five variables)**	**BIO-ENV (single variable)**	**BIO-ENV (7-d mean flow)**
Boat seine	0.705	0.572 (bottom temp., wing depth)	0.546 (bottom temp.)	0.561
Trawl	0.606	0.473 (surface DO, bottom temp., river km)	0.360 (bottom DO)	0.285

The trawled, deeper nekton community significantly differed between year-months (ANOSIM R = 0.281, P = 0.001) and zones (ANOSIM R = 0.218, P = 0.001). There was a significant difference in community structure between zones three and four (ANOSIM R = 0.141, P = 0.004), three and six (ANOSIM R = 0.407, P = 0.001), and four and six (ANOSIM R = 0.103, P = 0.026) (see Fig. 3.9.2.2). Differences in nekton community between zones three and four were mainly driven by lower abundance of *Lagodon rhomboides*, *Palaemonetes intermedius*, and *Farfantepenaeus duorarum* in Zone 4. Differences between zones four and six were driven by decreased abundance in larger *Eucinostomus* spp., small *Trinectes maculatus*, and small *Callinectes sapidus* combined with increased abundances of *Syngnathus scovelli*, large *T. maculatus*, and *Microgobius gulosus* (Table 3.9.2.2). The trawled nekton community demonstrated significant annual cycles in structural change, with this pattern correlating to a considerably greater extent with monthly changes in community than any combination of physicochemical variables or flow (Table 3.9.2.3).

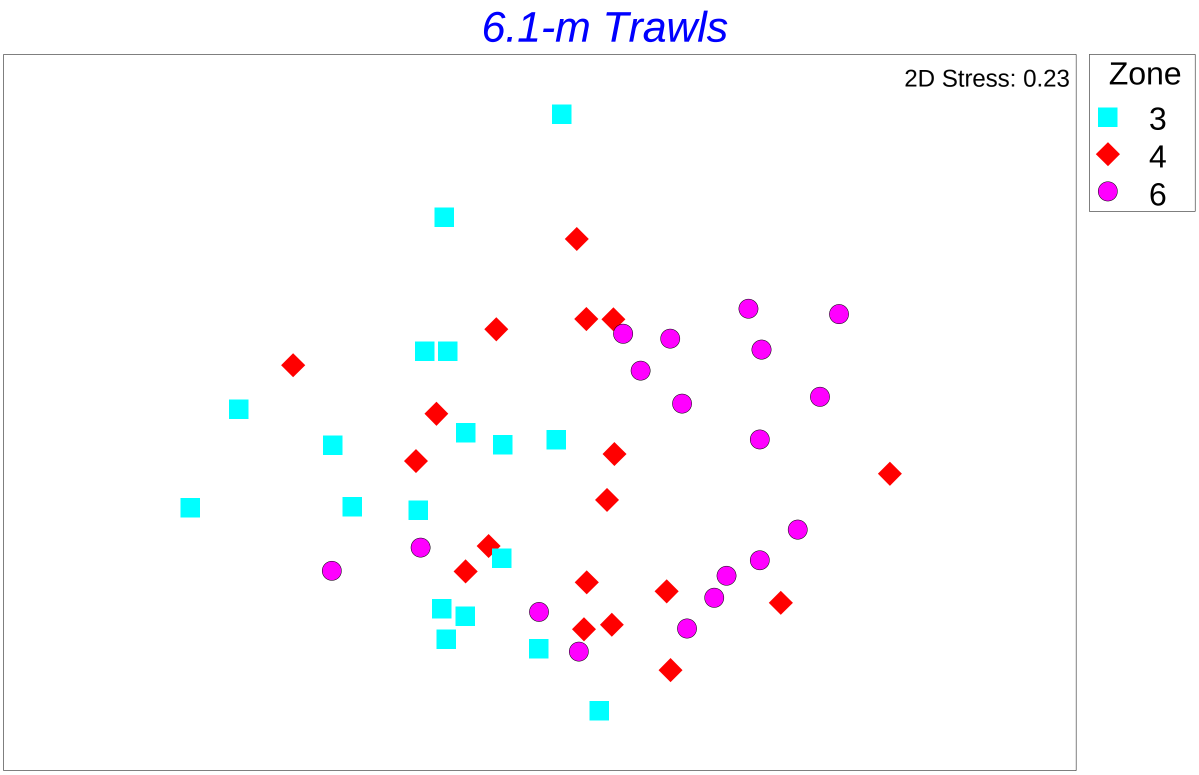

Fig. 3.9.2.2. Nonmetric Multidimensional Scaling (MDS) ordination plot of the 6.1-m-trawl nekton community structure in the Homosassa River.

The heterogeneity in nekton community structure of the shoreline habitat of the Homosassa River was not significantly related to freshwater inflow (although there was a non-significant positive trend, P = 0.23; Fig. 3.9.2.3). However, the relationship between heterogeneity in nekton community structure and freshwater inflow in trawled habitats was positive and approached significance at the α=0.05 level (P = 0.056; Fig. 3.9.2.3). Comparison of the same month with different flows between years did not show the hypothesized trend of increasing similarity between the shoreline nekton community and the uppermost Homosassa River zone as flows decreased (Fig. 3.9.2.4). There was however, a linear trend in these data indicating increasing similarity between nekton communities for the deeper, trawled habitats (Fig. 3.9.2.4).

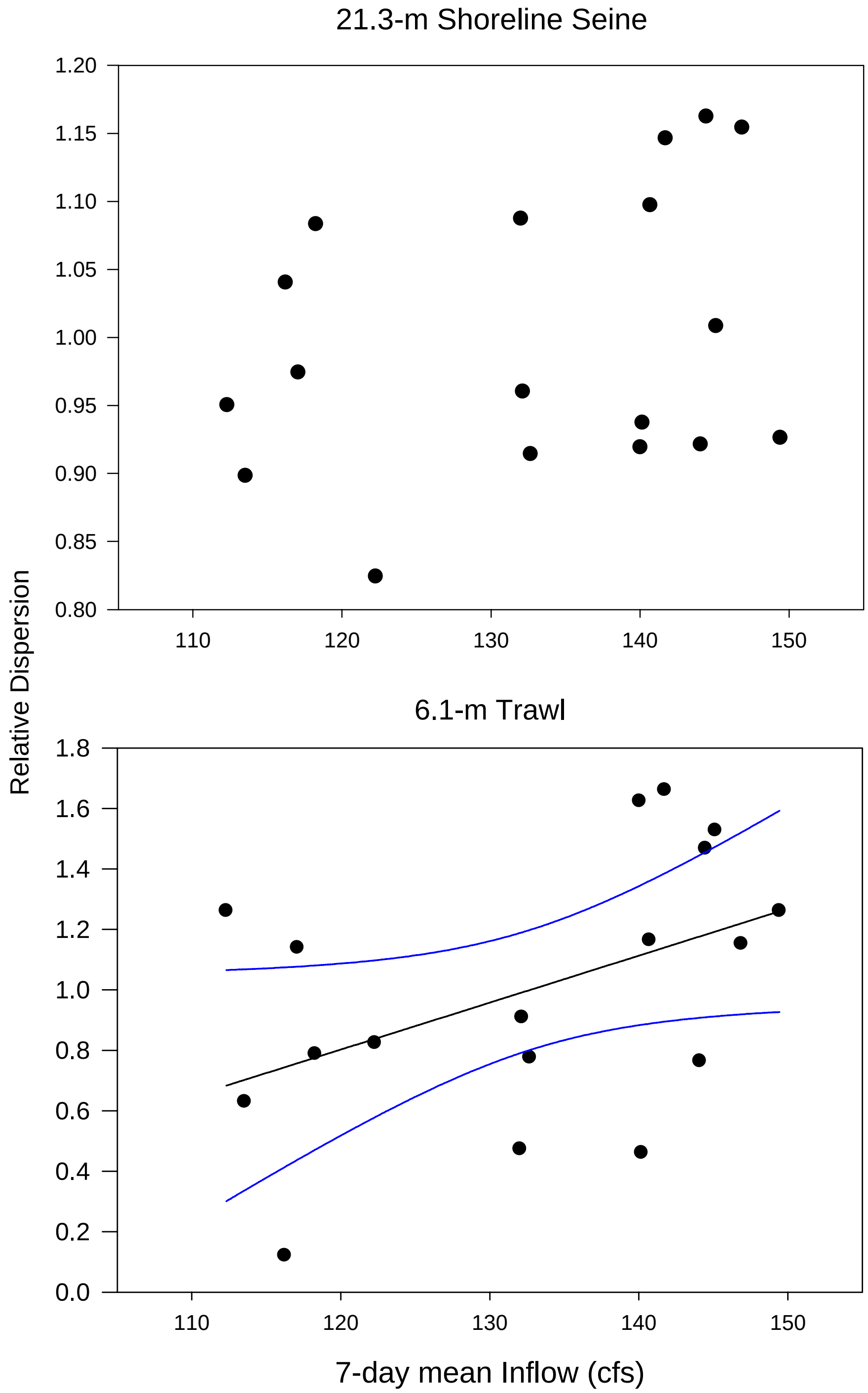

Fig. 3.9.2.3. Relationship between spring inflows and nekton community heterogeneity in the Homosassa River (measured as relative dispersion). Fitted regression lines (—) and 95% confidence intervals (—) are plotted for 6.1-m trawls.

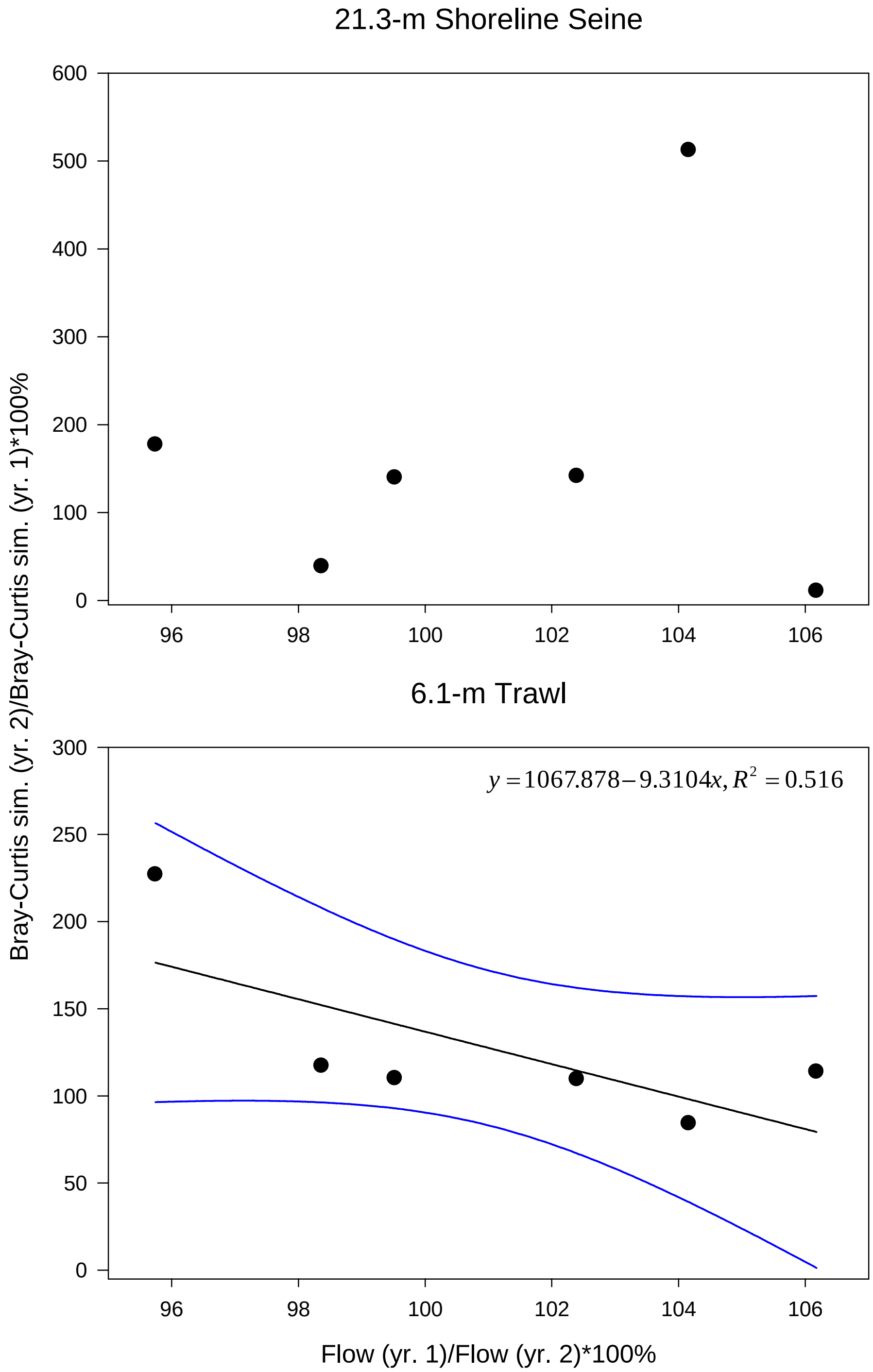

Fig. 3.9.2.4. Bray-Curtis similarity of nekton community structure between Homosassa River zone 1 (km 0.0-2.9) and the Homosassa River zone 5 (km 11.2–12.9) for 21.3-m shoreline seines, and between river zone 3 (km 5.8-8.5) and zone 6 (13.0-14.0) for 6.1-m trawls from a given month in year 2 of the study compared to the same month in year 2 (with similarity in year 2 expressed as a percentage of year 1), in relation to flows in year 2 expressed as a percentage of flows in year 1.

4.0 CONCLUSIONS

4.1 Descriptive Observations

1) **Dominant Catch.** Larval gobies and anchovies dominated the larval fish catch. More gobies of the genus *Gobiosoma* were collected than *Microgobius* gobies, and the anchovies were strongly dominated by the bay anchovy (*Anchoa mitchilli*). The bay anchovy is usually associated with surface-fed estuaries and may be an indicator of eutrophication in the Homosassa River—abundance of this species was higher than in other spring-fed estuaries, but was lower than in surface-fed estuaries. Other abundant larval fishes included rainwater killifish (*Lucania parva*), silversides (*Menidia* spp.), blennies (blenniids, apparently with the Florida blenny, *Chasmodes saburrae*, being dominant), skilletfish (*Gobiesox strumosus*) and mojarras (*Eucinostomus* spp.).

The plankton-net invertebrate catch was dominated by larval crabs (decapod zoeae and megalopae), larval shrimps (decapod mysis), gammaridean amphipods, the mysid *Americamysis almyra*, cumaceans, and the copepod *Acartia tonsa*. *Americamysis almyra* and *Acartia tonsa* are usually associated with surface-fed estuaries and may be indicators of eutrophication in the Homosassa River. The gammaridean amphipods were abundant throughout most of the survey area, being somewhat less abundant near the Gulf of Mexico. In contrast, cumaceans were most abundant downstream, which is a commonly observed pattern in other estuaries. The larval crabs, larval shrimps, the mysid *Americamysis almyra* and the copepod *Acartia tonsa*, were all widely distributed throughout the survey area.

Seine collections of fish were dominated by a mixture of small-bodied resident and transient taxa, with most species characteristic of estuaries such as rainwater killifish (*Lucania parva*), silversides (*Menidia* spp.), and eucinostomus mojarras (*Eucinostomus* spp.). Freshwater-oriented species such as shiners (*Notropis petersoni, Notropis harperi,* and *Notemigonus crysoleucas*), bluefin killifish (*Lucania goodei*), largemouth bass (*Micropterus salmoides*) and sunfishes (*Lepomis macrochirus*, *Lepomis microlophus*, and *Lepomis punctatus*) tended to be limited to the upper, oligohaline or limnetic reaches of the Homosassa and Halls Rivers. Eucinostomus mojarras (*Eucinostomus* spp.), rainwater killifish (*L. parva*), bay anchovy (*Anchoa mitchilli*) and tidewater mojarra greater than 40mm (*E. harengulus*) dominated the trawl catch of fishes. Invertebrate catches in both seines and trawls were largely composed of brackish grass shrimp (*Palaemonetes intermedius*) and blue crab (*Callinectes sapidus*).

2) **Use of Area as Spawning Habitat.** The eggs of the bay anchovy (*Anchoa mitchilli*), silversides (*Menidia* spp.), killifishes (*Fundulus* spp., *Lucania parva*) and unidentified sciaenid fishes were collected from the survey area. Sciaenid eggs were the most abundant egg type, followed by eggs of the bay anchovy—both types were most abundant in the lower part of the tidal river, peaking 3-6 km upstream of the river mouth. Early-stage sciaenid larvae, however, were nearly absent fro the survey area – a total of only 3 *Bairdiella chrysoura* and 2 *Menticirrhus* spp. larvae were collected. Bay anchovies were more abundant as relatively older postflexion larvae, suggesting that most bay anchovies originated from spawning grounds located outside the survey area. The data suggest blennies spawned most heavily near the river mouth, whereas skilletfish (*Gobiesox strumosus*) and gobies (primarily *Microgobius* spp. and *Gobiosoma* spp., but also *Bathygobius soporator*) may have spawned within the interior of the tidal river. The repeated collection of very small juveniles of live-bearing Gulf pipefish (*Syngnathus scovelli*) within the interior of the tidal river suggests that this species is also reproducing within the local area.

3) **Use of Area as Nursery Habitat.** Estuary-dependent taxa spawned outside the Homosassa River estuary that use the study area as a nursery were prevalent in the samples. These included numerically abundant taxa that undoubtedly play a vital ecological role in the Homosassa River estuary ecosystem (i.e., pinfish and juvenile mojarras). Also prominent were taxa of recreational and commercial importance (i.e., juvenile blue crab and pink shrimp). Compared to other locations in southwest Florida, some taxa were notably reduced in abundance (e.g., *Anchoa mitchilli*) or absent (e.g., red drum, *Sciaenops ocellatus,* and sand seatrout, *Cynoscion arenarius*) from the Homosassa River estuary. The juvenile nursery habitats for selected species were

characterized from seine and trawl data in terms of preference for shallower or deeper areas, zone of the study area, type of shoreline, and salinity (Appendix D).

4) **Plankton Catch Seasonality.** More taxa were collected during the warmer months than during winter—alteration of flows would appear to have the lowest potential for impacting many taxa during the period from September through February, which is the period when the fewest estuarine taxa were present. The highest potential to impact many species would appear to be from April through June. Most species tended to be most abundant during the spring and summer.

5) **Seine and Trawl Catch Seasonality.** Seasonality was evident in the nearshore (seined) habitat of the Homosassa River estuary, with highest values during the summer period. For species spawning far offshore, the January–March period was a very important period of juvenile recruitment, whereas May–August had the most peaks in recruitment for those species spawning in the estuary and those residing in the river throughout the year. The succession of species throughout the annual cycle meant that recruitment of species occurred year-round, with the result that flow alterations to the study area have the potential to affect aquatic organisms at any time of the year.

4.2 Responses to Freshwater Inflow

1) **Plankton Catch Distribution Responses.** Among the 64 plankton-net taxa evaluated for distribution relationships with freshwater inflow, 42% (n = 27) exhibited significant responses. Eleven of these were negative responses, wherein animals moved downstream as inflows increased. Downstream movement is the typical inflow response seen in tidal rivers on Florida's west coast. However, more taxa (n = 16) moved upstream (against the flow) as flows increased. Some of these relationships had very good fit (e.g., various types of goby larvae), suggesting that these relationships are not spurious. Some of these upstream-moving taxa may have become entrained in two-layered circulation (i.e., bottom water moving upstream to replace surface water moving downstream), or may have responded to stronger olfactory cue delivery by moving into

the river to seek out the source of the olfactory cues. Overall, time lags for the responses were highly variable, with many occurring within a seasonal time frame.

2) **Seine and Trawl Catch Distribution Responses.** For seine and trawl data, 13 (24.5%) of the 53 pseudo-species evaluated for distributional responses to freshwater inflow exhibited a significant response for at least one lagged flow period. The best-fit models tended to involve longer lag periods (≥56 days). All but two of the significant responses were negative (i.e., animals moved upstream with decreasing freshwater inflow). Typically, a pseudo-species' center of abundance will shift downstream during periods of higher inflow and upstream during periods of lower inflow because individuals tend to occupy areas with suitable salinities or food sources. Over half of the animals with significant responses (7 of 13) were collected from the shallow waters of the Halls River even though less than 30% of the animals tested came from this area. Most distributional responses in the Halls River were negative, but one freshwater-oriented species, the golden shiner, moved further up the Halls River in response to increased freshwater inflow in the Homosassa River.

3) **Plankton Catch Abundance Responses.** Among the 64 plankton-net taxa evaluated for abundance relationships with freshwater inflow, 44% (n = 28) exhibited significant responses. All except five of these were negative responses. Negative responses are usually caused by elevated flows washing organisms out of the survey area. The organisms that had positive responses were the estuarine tanaid *Hargeria rapax*, postflexion larvae of the oligohaline fish *Lucania parva*, freshwater podocopid ostracods, the estuarine copepod *Acartia tonsa*, and the oligohaline copepod *Eurytemora affinis*. It could be concluded that more positive results were not observed because no stations were positioned in the Gulf of Mexico to account for species that moved downstream and increased in number in response to increased inflow.

The lags associated with the positive responses were generally long, ranging from 36 d to the maximum lag evaluated, 120 d. The 120 d lags are likely seasonal in nature, whereas the responses of podocopid ostracods and *E. affinis* may have represented short-term population responses to inflow variation. Inflow variations were very small relative to those surface-fed rivers, which makes detection of abundance responses more difficult.

4) **Seine and Trawl Catch Abundance Responses.** Forty (>75%) of the 53 pseudo-species examined from the seine and trawl data demonstrated significant relationships between abundance and average inflow. The majority (27) of these relationships were linear with 12 pseudo-species exhibiting negative (i.e., abundance decreased with increasing inflow) and 15 pseudo-species exhibiting positive responses. The thirteen pseudo-species with non-linear responses of abundance to inflow were split between the 'intermediate-maximum' (n=7; highest abundance during intermediate inflows) and 'intermediate minimum' (n=6; lowest abundance during intermediate inflows) scenarios. The percentage of significant abundance responses to inflow ranged from 57% of tested pseudo-species in nearshore spawners to 88% in tidal river residents. Linear (n=27) were more common than non-linear (n=13) responses. All of the pseudo-species tested from the shallow waters of the Halls River (n=15) exhibited an abundance response to inflow, with over half of these relationships being negative linear responses in tidal river residents. Twelve pseudo-species had abundance inflow relationships that accounted for more than 50% of the variability in the data. All but one of these twelve pseudo-species were collected by seines in the shoreline habitats and more than half (n=8) were tidal river residents. The relationship between flow and abundance in these twelve pseudo-species were positive linear (n=6), negative linear (n=4), intermediate maximum (n=1) and intermediate minimum (n=1). An increase in abundance with increased flow (positive linear response) may suggest beneficial aspects of increased nutrient input, or perhaps better detection of the tidal-river nursery area. A decrease in abundance with increased inflow (negative linear response) could indicate a physical displacement to unsuitable habitats, a movement into flooded habitats that have become available (emergent marshes), or a dilution of the chemical cues that draw animals into the tidal-river nursery areas. Intermediate-maximum relationships, where abundance is greatest at mid-range flows and lower at both lower and higher flows, perhaps indicate differing forces operating at opposite ends of the inflow spectrum. At low flows, opportunities for either chemical detection of tidal nursery habitats or selective tidal-stream transport may be reduced, and at high flows, physical

displacement may occur, or perhaps undesirable properties of fresher water (e.g., low pH) become more prominent.

4.3 Community Structure

1) **Plankton Net Community Responses to Freshwater Inflow.** Estuarine zooplankton communities formed the typically continuous ordination observed in other estuaries, with downstream communities being most different from upstream communities, and with intermediate locations being positioned in the expected order. The two upstream-most zones, Zones 5 and 6, exhibited the widest variability. Zone 5, the zone nearest the spring, was dominated by gammaridean amphipods, crab larvae (*Rhithropanopeus harrisii*), fly and midge larvae, mysids, and pododopid (freshwater) ostracods. Zone 6 (Halls River) differed from adjacent Zone 5 (downstream of the spring) primarily in having higher abundances of the same taxa as in Zone 5. Zone 1 near the Gulf of Mexico was dominated by a diversity of crab and shrimp larvae, cumaceans, gamaridean amphipods, the mysid *Bowmaniella dissimilis*, the copepod *Acartia tonsa*, sagittid arrow worms, polychaete worms, and the isopod *Harrieta faxoni*.

The zooplankton communities were also differentiated by season, with communities from November through February being different from the remainder of the year. The widest consistent difference was between January and May. During May, there were more crab and shrimp larvae, gammaridean amphipods, goby larvae (*Gobiosoma* and *Microgobius*), cumaceans, mysids (*Bowmaniella dissimilis* and *Americamysis almyra*), *Acartia tonsa* and sagittid arrow worms than during January. The relationship between community heterogeneity (relative dispersion) and springflow was positive and approached significance at the $\alpha=0.05$ level, indicating there was a mild decrease in community heterogeneity during summer low-flow periods, when marine organisms tended to invade and cause community composition to become similar throughout the lower estuary.

2) **Seine and Trawl Catch Community Analyses.** There were significant differences in community structure between the zones of the study area and also between year-months. Most notable was the difference between adjacent zones four (river km 8.6-11.19) and five (river km 11.2-13.0) in the shoreline habitats of the study area. These two Homosassa River zones meet where the Halls River discharges into the Homosassa River. Zone five was characterized by relatively high abundance of *Lucania goodei, Lutjanus griseus*, *Gambusia holbrooki*, and *Micropterus salmoides*. Changes in the community structure of both the shoreline and channel habitat over the study period exhibited annual cycles, which tended to be more regular than the correlation with physicochemical variables, including inflow. There was no discernible relationship between inflow and relative dispersion (heterogeneity) of the shoreline community, although in the channel habitats a positive relationship (P = 0.056) between heterogeneity and flow was observed. Shoreline nekton communities in the lower Homosassa River zones did not show a trend of increasing similarity with the upper most zone (Zone 5) as flows decreased when months with different flows between years were compared. The same analysis in channel habitats, however, indicated a linear increasing trend in similarity as flows decreased.

4.4 Synthesis

Some characteristics of the plankton community in the Homosasa River estuary suggest that the area has become more eutrophic. Compared with other spring-fed estuaries, the abundances of the copepod *Acartia tonsa*, the mysid *Americamysis almyra*, and the bay anchovy *Anchoa mitchilli* were relatively high, but not as high as in surface-fed estuaries. The regular occurrence of large transitions from low dissolved oxygen concentrations (<4 mg/l) to hyperoxia (supersaturation) is also evidence of this trend. In surface-fed estuaries, these indicator species and water-quality attributes tend to occur at more or less predictable locations that can be modeled as a response to freshwater inflow. In the Homosassa River estuary, however, these indicators did not appear to have any consistent relationships with inflow, although higher levels of inflow were more likely to alleviate the problem by moving overly productive water masses downstream, where greater tidal dispersion will generally occur.

Organism responses to inflow were more mixed than in other estuaries surveyed on Florida's west-central coast. Different organisms moved either upstream or downstream in response to increasing inflows, whereas in most of the other surveyed estuaries, organisms primarily moved downstream as flows increased. The Homosassa estuary has a relatively deep channel thoughout much of its length (Fig. 2.7.4.1), and this channel may facilitate two-layered estuarine circulation, where bottom water moves landward during high inflows to replace water that has moved seaward due to friction with seaward-moving surface flows. In other west-central Florida estuaries where upstream movement against increasing flows has been observed, deeper channels (>2 m) were also present.

The seasonality of organism use of the Homosassa estuary was typical, but showed some signs of being contracted relative to estuaries at lower latitudes. This was evident in regard to seasonal trends in species richness (Fig. 3.6.1.1) and also single-species seasonality. Bay anchovy seasonality (Fig. 3.6.1.2) was more restricted than that observed farther south.

In general, the ichthyoplankton community had relatively few eggs and larvae of broadcast-spawning, estuarine-depedent or coastal species, but instead was dominated by the larvae of small, resident species that have adhesive eggs which hatch into planktonic larvae. Relatively few species used the area as spawning habitat.

As with distribution responses, abundance reposnses to inflows were mixed, with a large proportion of negative responses observed. The seasonality of inflows was nearly six months out of phase with the seasonal rainfall pattern (highest flows during winter and lowest during summer), and therefore some of the negative abundance responses may have been related to spawning season (Fig. 3.6.1.1) rather than inflow. Most coastal fish species spawn during spring and summer, which is when inflows were lowest in the Homosassa estuary, and this may have created the appeanace negative abundance responses to inflow.

Comparisons between the spring run area (Zone 5) and the Halls River (Zone 6) are particularly interesting because these two areas represent adjacent, low salinity habitats with different flow rates (with Halls River being lower). The zooplankton compositions of the two zones were similar, but the low-flow Halls River apparently had better retention of planktonic organisms, as evidenced by its having higher abundances (densities) of the same animals that were present in the spring run area (Zone 5).

There was a mild decrease in community heterogeneity during summer low-flow periods, when marine organisms tended to invade and cause community composition to become more similar in the lower estuary. In surface-fed estuaries, it is common for these marine invasions to suddenly penetrate far upstream when inflows fall below esutuary-specific threshold values. Spring flows into the Homosassa estuary were sufficient to prevent this seasonal collapse of community heterogeneity.

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Appendix A: Plankton-net summary tables

Table A1, page 1 of 5.

Plankton-net catch statistics (December 2006 through November 2008, n = 216 samples)

Halls River data are included. Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	*Kmu* (km)	*Su* (psu)	Mean CPUE (No./10^3 m^3)	Max CPUE (No./10^3 m^3)
foraminiferans	foraminiferans	3	2	3.4	14.7	0.18	25.70
medusa sp. d	hydromedusa	3	2	2.8	12.8	0.17	24.78
medusa sp. e	hydromedusa	3	1	4.4	18.2	0.16	35.33
medusa sp. f	hydromedusa	1	1	0.5	22.6	0.06	13.68
medusa, Obelia sp.	hydromedusa	2	1	0.5	27.4	0.12	25.12
Clytia sp.	hydromedusa	8	4	1.0	17.9	0.46	50.53
Mnemiopsis mccradyi	comb jelly, ctenophore	752	16	6.7	11.9	46.56	3164.57
turbellarians	flatworms	32	6	11.5	2.2	2.14	183.39
nematodes	roundworms, threadworms	265	38	6.4	11.0	17.18	543.33
polychaetes	sand worms, tube worms	8,033	169	8.7	6.2	489.27	35396.01
oligochaetes	freshwater worms	1,199	37	12.1	3.0	97.15	7178.73
hirudinoideans	leeches	128	50	10.6	3.8	8.87	248.69
pycnogonids	sea spiders	125	9	1.4	24.9	8.00	987.05
acari	water mites	47	18	11.8	2.5	2.88	102.24
collembolas, podurid	springtails	20	11	11.2	2.4	1.22	51.49
ephemeropteran larvae	mayflies	177	27	12.4	2.7	15.29	1825.60
odonates, zygopteran larvae	damselflies	11	6	12.6	3.5	0.94	101.56
odonates, anisopteran larvae	dragonflies	1	1	11.9	2.1	0.04	9.40
hemipterans, corixid juveniles	water boatmen	49	5	12.2	3.3	3.27	457.73
hemipterans, corixid adults	water boatmen	53	6	13.0	3.0	3.81	656.07
hemipterans, naucorid adults	creeping water bugs	3	1	11.4	2.9	0.22	47.31
hemipterans, gerrid adults	water striders	26	12	7.0	9.7	1.60	62.67
coleopterans, elmid adults	riffle beetles	5	3	10.4	4.0	0.34	47.31
coleopterans, curculionid adults	beetles	4	2	9.9	4.5	0.22	33.53
coleopterans, scirtid larvae	marsh beetles	1	1	11.4	2.4	0.07	14.97
coleopterans, chrysomelid larvae	beetles	1	1	11.1	1.7	0.06	12.41
coleopterans, dryopid larvae	long-toed water beetles	2	1	11.9	2.1	0.09	18.79
dipterans, pupae	flies, mosquitoes	7,713	108	11.6	2.7	477.65	20937.93
dipteran, Chaoborus punctipennis larvae	phantom midge	197	39	11.3	3.0	11.92	328.82
dipterans, chironomid larvae	midges	4,920	119	11.8	3.0	335.02	14376.51
dipterans, tabanid larvae	deer flies	5	1	11.9	2.1	0.22	46.99
dipterans, ceratopogonid larvae	biting midges	124	45	10.3	4.2	7.51	148.56
dipterans, stratiomyid larvae	soldier flies	5	2	11.4	2.1	0.24	33.53
trichopteran larvae	caddisflies	8	7	11.6	2.6	0.55	37.88
lepidopterans, pyralid larvae	aquatic caterpillars	1	1	11.4	2.5	0.07	14.44
Penilia avirostris	water flea	501	3	11.1	1.9	28.74	6130.37
cladocerans, Daphnia spp.	water fleas	55	6	9.3	3.5	3.19	311.17
Simocephalus vetulus	water flea	8,705	16	12.8	2.9	962.31	185861.57
Ilyocryptus sp.	water flea	11	2	13.0	3.0	0.82	140.63
Sida crystallina	water flea	1	1	3.0	14.3	0.06	12.53
Leydigia sp.	water flea	2	2	11.3	2.7	0.12	13.83
branchiurans, Argulus spp.	fish lice	31	24	5.9	8.8	1.92	38.62
unidentified calanoids	copepods	20	2	11.1	1.6	1.10	223.77
Labidocera aestiva	copepod	3,807	27	0.6	24.1	235.19	46820.47
Acartia tonsa	copepod	53,391	156	7.3	8.3	3268.50	94034.80
Pseudodiaptomus coronatus	copepod	2,032	117	3.2	13.9	123.19	2161.13
paracalanids	copepods	1	1	4.4	10.5	0.06	13.65
Diaptomus spp.	copepods	41	15	10.7	2.5	2.53	83.96
Calanopia americana	copepod	209	9	0.7	13.8	12.63	1860.89
Eurytemora affinis	copepod	923	50	11.1	2.5	62.21	1401.79
Temora turbinata	copepod	245	41	4.0	15.6	14.89	568.73
unidentified freshwater cyclopoids	copepods	32	7	11.9	2.4	2.07	122.22
Oithona spp.	copepods	1	1	9.0	5.9	0.06	13.68
Mesocyclops edax	copepod	3	1	7.1	10.9	0.19	40.29
Orthocyclops modestus	copepod	17	6	11.9	2.5	1.03	70.90
Macrocyclops albidus	copepods	80	23	11.8	2.7	5.58	379.50
Saphirella spp.	copepods	12	5	6.4	11.0	0.72	41.85
unidentified harpacticoids	copepods	161	33	3.9	14.6	9.81	389.28
siphonostomatids	parasitic copepods	42	17	1.6	21.1	2.52	125.60
Monstrilla sp.	copepod	353	25	1.1	19.5	21.46	1810.19
Parasterope pollex	ostracod, seed shrimp	664	52	1.8	18.1	40.52	957.58

Table A1, page 2 of 5.

Plankton-net catch statistics (December 2006 through November 2008, n = 216 samples)

Halls River data are included. Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	*Kmu* (km)	*Su* (psu)	Mean CPUE (No./10^3 m^3)	Max CPUE (No./10^3 m^3)
Sarsiella zostericola	ostracod, seed shrimp	231	47	1.6	17.0	13.95	591.03
myodocopod sp. a	ostracod, seed shrimp	6	5	2.3	17.5	0.36	27.71
ostracods, podocopid	ostracods, seed shrimps	14,418	71	12.2	3.5	1306.10	157943.78
Squilla empusa larvae	mantis shrimp	2	1	0.5	27.4	0.12	25.12
unidentified Americamysis juveniles	opossum shrimps, mysids	91,500	208	6.6	9.2	5727.42	86120.83
Americamysis almyra	opossum shrimp, mysid	86,219	202	7.6	8.4	5630.40	114823.67
Americamysis bahia	opossum shrimp, mysid	143	6	1.8	16.9	8.35	885.47
Bowmaniella dissimilis	opossum shrimp, mysid	18,265	107	2.6	15.9	1075.79	22107.58
Taphromysis bowmani	opossum shrimp, mysid	2,036	66	11.1	4.3	160.77	6450.36
Spelaeomysis sp.	opossum shrimp, mysid	11	7	5.5	11.0	0.63	40.29
amphipods, gammaridean	amphipods	308,414	216	8.7	7.4	19848.25	211149.02
amphipods, caprellid	skeleton shrimps	304	57	2.0	16.7	18.47	398.76
Munna reynoldsi	isopod	328	51	11.1	4.1	22.72	555.39
Xenanthura brevitelson	isopod	90	23	6.2	10.4	5.16	248.80
Cyathura polita	isopod	56	27	8.6	7.6	3.81	137.32
Sphaeromatid (Dynamenella)	isopod	1	1	1.8	13.8	0.07	14.38
Sphaeroma quadridentata	isopod	8	6	3.2	14.7	0.51	29.55
Harrieta faxoni	isopod	4,686	86	1.3	19.1	278.50	28896.31
Cassidinidea ovalis	isopod	1,644	105	4.3	15.9	96.82	4852.60
Sphaeroma terebrans	isopod	5	3	9.6	4.7	0.30	40.07
Edotea triloba	isopod	3,100	131	7.4	9.2	193.54	12058.03
Erichsonella attenuata	isopod	2,165	98	2.5	17.5	126.32	12298.25
Erichsonella filiforme	isopod	1	1	0.5	21.0	0.06	12.85
cymothoid sp. a (Lironeca) juveniles	isopod	133	61	7.2	8.0	7.94	120.45
Anopsilana jonesi	isopod	54	19	5.5	10.5	3.39	249.18
Probopyrus sp. (attached)	isopod	9	1	13.0	4.0	0.70	150.40
Isopod, Paracerceis caudata	isopod	5	2	1.5	18.6	0.30	51.34
Tanaid sp. c	tanaid	2	2	1.2	15.9	0.13	14.38
Hargeria rapax	tanaid	2,616	118	4.0	14.7	164.89	21511.39
Sinelobus stanfordi	tanaid	92	35	7.2	9.5	5.80	372.06
Apseudes sp.	tanaid	2,135	45	1.1	16.7	132.57	21145.54
Hoplomachus propinquus	tanaid	35	9	1.8	17.7	2.08	166.87
cumaceans	cumaceans	78,288	164	2.9	16.3	4732.03	77625.56
Lucifer faxoni juveniles and adults	shrimp	96	25	2.4	15.4	6.05	311.93
penaeid postlarvae	penaeid shrimps	229	33	1.7	20.0	13.45	753.61
penaeid metamorphs	penaeid shrimps	114	26	2.1	12.3	6.95	358.89
Farfantepenaeus duorarum juveniles	pink shrimp	27	6	1.1	17.2	1.64	214.68
Farfantepenaeus duorarum adults	pink shrimp	4	3	2.8	14.2	0.24	26.83
Palaemonetes spp. postlarvae	grass shrimps	1,472	80	7.0	11.3	91.49	5623.80
Palaemonetes pugio juveniles	daggerblade grass shrimp	2,104	70	12.0	3.7	146.32	17378.35
Palaemonetes pugio adults	daggerblade grass shrimp	58	21	10.9	5.8	4.29	467.92
Palaemonetes vulgaris juveniles	grass shrimp	4	2	1.4	17.2	0.24	40.25
Palaemonetes vulgaris adults	grass shrimp	1	1	4.4	14.2	0.06	12.56
Palaemonetes paludosus juveniles	grass shrimp	2	1	13.0	4.0	0.15	33.42
Periclimenes spp. juveniles	shrimps	24	8	1.6	12.8	1.47	80.49
Periclimenes longicaudatus juveniles	longtail grass shrimp	10	4	2.3	15.4	0.57	61.49
alphaeid mysis larvae	snapping shrimps	8	2	4.8	15.5	0.52	69.26
alphaeid postlarvae	snapping shrimps	1,277	34	1.3	22.1	77.48	9003.42
alphaeid juveniles	snapping shrimps	46	9	2.4	19.8	2.73	193.94
Alpheus viridari adults	snapping shrimp	3	1	3.0	16.8	0.20	43.25
Hippolyte zostericola postlarvae	zostera shrimp	421	25	1.1	22.5	25.56	2925.44
Hippolyte zostericola juveniles	zostera shrimp	12	8	5.9	10.3	0.99	62.17
Hippolyte zostericola adults	zostera shrimp	23	4	0.7	18.1	1.34	221.37
Tozeuma carolinense juveniles	arrow shrimp	1	1	0.5	14.7	0.06	12.22
Ogyrides alphaerostris mysis larvae	estuarine longeye shrimp	2	2	2.4	13.7	0.12	14.03
Ogyrides alphaerostris juveniles and adults	estuarine longeye shrimp	1	1	0.5	18.2	0.06	13.42
processid postlarvae	night shrimps	60	5	0.7	24.2	3.72	681.27
callianassid mysis larvae	ghost shrimps	1	1	0.5	24.3	0.06	13.36
callianassid postlarvae	ghost shrimps	9	3	2.5	12.3	0.55	70.17
callianassid juveniles	ghost shrimps	115	10	5.6	10.3	6.66	671.56
Callianassa spp. juveniles	ghost shrimps	76	6	5.0	15.2	4.60	267.67

Table A1, page 3 of 5.

Plankton-net catch statistics (December 2006 through November 2008, n = 216 samples)

Halls River data are included. Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	*Kmu* (km)	*Su* (psu)	Mean CPUE (No./10^3 m^3)	Max CPUE (No./10^3 m^3)
Upogebia spp. mysis larvae	mud shrimps	3	2	2.1	20.9	0.19	26.28
Upogebia spp. postlarvae	mud shrimps	866	15	0.7	25.2	51.74	5413.41
Upogebia spp. juveniles	mud shrimps	11	4	3.0	19.4	0.71	73.66
decapod mysis	shrimp larvae	68,876	174	5.1	13.7	4179.46	114904.00
paguroid juveniles	hermit crabs	1	1	0.5	27.4	0.06	12.56
Callinectes sapidus juveniles	blue crab	21	17	4.3	12.6	1.24	26.83
Portunus sp. juveniles	swimming crab	23	12	3.9	13.7	1.32	61.49
xanthid juveniles	mud crabs	10	4	10.5	6.8	0.73	55.45
Rhithropanopeus harrisii juveniles	Harris mud crab	15	4	12.8	3.8	1.14	137.32
decapod zoeae	crab larvae	726,050	195	7.4	9.3	44966.99	712237.53
decapod megalopae	post-zoea crab larvae	81,569	119	9.9	5.3	5003.29	191282.57
pelecypods	clams, mussels, oysters	1,721	104	9.1	5.7	135.54	6030.72
gastropods, prosobranch	snails	9,308	127	11.3	3.3	848.25	42898.90
gastropods, opisthobranch	sea slugs	31	22	4.8	11.9	1.88	42.56
ophiuroidean juveniles	brittlestars	1	1	1.8	8.5	0.06	13.42
ophiopluteus larvae	brittlestars	1	1	0.5	17.7	0.06	12.80
appendicularian, Oikopleura dioica	larvacean	2	2	0.5	17.9	0.11	12.39
chaetognaths, sagittid	arrow worms	7,139	59	1.3	21.0	426.06	14121.65
ascidiacean larvae	tunicate larvae	167	5	2.6	22.2	10.39	1430.41
Lepisosteus sp. flexion larvae	gar	5	4	10.7	2.5	0.29	25.33
Lepisosteus sp. postflexion larvae	gar	6	2	8.3	8.1	0.35	49.54
Lepisosteus sp. juveniles	gar	9	2	11.4	2.6	0.52	101.31
Elops saurus postflexion larvae	ladyfish	12	6	8.6	4.5	0.69	72.82
Myrophis punctatus juveniles	speckled worm eel	3	2	0.5	19.5	0.17	24.60
Anchoa spp. eggs	anchovies	3	1	6.1	13.7	0.18	38.75
Anchoa spp. preflexion larvae	anchovies	160	39	5.9	13.0	9.47	153.04
Anchoa spp. flexion larvae	anchovies	38	13	7.1	9.7	2.31	137.49
Anchoa hepsetus postflexion larvae	striped anchovy	2	1	1.8	21.6	0.13	27.71
Anchoa hepsetus juveniles	striped anchovy	9	4	5.9	13.0	0.52	46.87
Anchoa mitchilli eggs	bay anchovy	6,576	37	4.4	15.7	368.70	14507.60
Anchoa mitchilli postflexion larvae	bay anchovy	187	41	6.4	8.9	11.53	260.69
Anchoa mitchilli juveniles	bay anchovy	1,706	98	8.2	6.0	103.72	4437.44
Anchoa mitchilli adults	bay anchovy	275	49	7.0	6.5	16.93	404.00
clupeid preflexion larvae	herrings	23	9	11.4	3.4	1.51	70.94
Brevoortia smithi juveniles	yellowfin menhaden	4	3	9.1	6.2	0.24	26.72
Brevoortia spp. postflexion larvae	menhaden	24	13	8.0	7.0	1.59	58.54
Brevoortia spp. metamorphs	menhaden	9	6	6.2	12.4	0.55	42.47
Dorosoma petenense juveniles	threadfin shad	3	3	5.5	14.1	0.19	16.10
Opisthonema oglinum flexion larvae	Atlantic thread herring	2	1	11.1	1.8	0.11	22.72
Notemigonus crysoleucas preflexion larvae	golden shiner	3	2	11.9	1.9	0.18	25.75
Notropis spp. preflexion larvae	minnows	3	2	12.2	1.7	0.19	28.23
Notropis spp. flexion larvae	minnows	1	1	11.9	2.0	0.06	13.60
Synodus foetens metamorphs	inshore lizardfish	1	1	4.4	18.2	0.05	11.78
Opsanus beta juveniles	gulf toadfish	3	3	7.8	9.6	0.18	14.19
Mugil cephalus juveniles	striped mullet	3	3	3.7	12.2	0.18	13.33
Membras martinica preflexion larvae	rough silverside	2	1	0.5	27.4	0.12	25.12
Membras martinica postflexion larvae	rough silverside	1	1	0.5	27.4	0.06	12.56
Membras martinica juveniles	rough silverside	3	3	4.6	17.6	0.18	14.69
Menidia spp. eggs	silversides	9	4	11.8	4.0	0.60	37.88
Menidia spp. preflexion larvae	silversides	379	77	8.9	6.7	24.90	927.95
Menidia spp. flexion larvae	silversides	207	20	12.2	3.6	15.84	1704.40
Menidia spp. postflexion larvae	silversides	441	21	12.8	3.3	36.22	5473.01
Menidia spp. juveniles	silversides	292	23	12.7	3.9	22.43	3342.26
Menidia spp. adults	silversides	76	5	13.0	4.0	5.82	1169.79
Hyporhamphus meeki adults	false silverstripe halfbeak	1	1	0.5	17.7	0.06	12.80
Hyporhamphus unifasciatus postflexion larvae	silverstripe halfbeak	1	1	0.5	27.4	0.06	12.56
Fundulus spp. eggs	killifishes	8	2	12.9	3.6	0.85	170.34
Fundulus spp. postflexion larvae	killifishes	1	1	11.1	1.7	0.06	12.41
Lucania goodei postflexion larvae	bluefin killifish	1	1	11.4	3.2	0.06	13.57
Lucania goodei juveniles	bluefin killifish	6	2	13.0	3.4	0.44	61.03
Lucania goodei adults	bluefin killifish	10	2	12.7	3.8	0.75	133.69

Table A1, page 4 of 5.

Plankton-net catch statistics (December 2006 through November 2008, n = 216 samples)

Halls River data are included. Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	*Kmu* (km)	*Su* (psu)	Mean CPUE (No./10^3 m^3)	Max CPUE (No./10^3 m^3)
Lucania parva eggs	rainwater killifish	3	2	11.7	2.4	0.20	30.33
Lucania parva postflexion larvae	rainwater killifish	191	34	12.0	3.4	17.56	1238.11
Lucania parva juveniles	rainwater killifish	94	17	12.0	2.9	8.09	297.79
Lucania parva adults	rainwater killifish	223	21	12.3	3.3	21.32	1287.77
Gambusia holbrooki juveniles	eastern mosquitofish	28	9	12.3	4.2	2.37	170.34
Gambusia holbrooki adults	eastern mosquitofish	4	2	12.7	2.9	0.30	54.01
Heterandria formosa juveniles	least killifish	4	2	12.7	3.5	0.30	49.90
Heterandria formosa adults	least killifish	1	1	9.0	6.8	0.05	11.82
Hippocampus zosterae juveniles	dwarf seahorse	1	1	3.0	15.3	0.06	12.74
Syngnathus floridae juveniles	dusky pipefish	7	3	9.4	6.7	0.42	42.47
Syngnathus louisianae juveniles	chain pipefish	1	1	9.8	5.5	0.06	13.36
Syngnathus scovelli juveniles	gulf pipefish	43	23	9.6	6.1	2.70	78.23
fish eggs, percomorph	sciaenid eggs (primarily)	9,658	24	2.3	20.3	561.43	53418.77
Lepomis macrochirus juveniles	bluegill	7	3	13.0	4.1	0.60	83.56
Lepomis punctatus juveniles	spotted sunfish	7	1	13.0	4.0	0.54	116.98
Lepomis spp. preflexion larvae	sunfishes	9	2	12.8	2.9	0.73	144.04
Lepomis spp. flexion larvae	sunfishes	15	8	11.5	2.1	0.89	37.86
Lepomis spp. postflexion larvae	sunfishes	2	2	12.1	2.5	0.15	18.00
Lutjanus griseus juveniles	gray snapper	1	1	4.4	6.1	0.06	13.00
Eucinostomus spp. postflexion larvae	mojarras	15	6	8.8	5.9	1.18	97.34
Eucinostomus spp. juveniles	mojarras	52	19	3.5	11.5	3.12	138.95
Eucinostomus harengulus juveniles	tidewater mojarra	39	9	11.7	5.0	3.44	267.41
Eucinostomus harengulus adults	tidewater mojarra	3	2	13.0	3.2	0.34	50.02
Eugerres plumieri postflexion larvae	striped mojarra	1	1	7.1	9.4	0.07	15.14
Eugerres plumieri juveniles	striped mojarra	1	1	9.8	4.0	0.06	13.85
Lagodon rhomboides juveniles	pinfish	107	7	1.0	18.5	6.46	862.07
Bairdiella chrysoura postflexion larvae	silver perch	2	1	6.1	12.7	0.11	23.44
Bairdiella chrysoura juveniles	silver perch	1	1	6.1	12.7	0.05	11.72
Leiostomus xanthurus postflexion larvae	spot	1	1	4.4	8.0	0.06	12.85
Leiostomus xanthurus juveniles	spot	3	3	4.4	8.8	0.18	13.62
Menticirrhus spp. preflexion larvae	kingfishes	1	1	1.8	24.8	0.07	14.73
Menticirrhus spp. postflexion larvae	kingfishes	1	1	0.5	23.0	0.06	12.55
blenniid preflexion larvae	blennies	166	34	2.4	18.2	10.13	388.91
Chasmodes saburrae flexion larvae	Florida blenny	14	6	1.8	21.3	0.81	75.27
Chasmodes saburrae postflexion larvae	Florida blenny	11	3	1.3	23.0	0.67	120.22
Lupinoblennius nicholsi flexion larvae	highfin blenny	1	1	0.5	23.0	0.06	12.55
Gobiesox strumosus preflexion larvae	skilletfish	162	43	4.4	11.6	10.07	259.34
Gobiesox strumosus flexion larvae	skilletfish	9	4	3.5	17.0	0.51	47.56
Gobiesox strumosus postflexion larvae	skilletfish	8	3	6.2	12.0	0.50	44.06
Gobiesox strumosus juveniles	skilletfish	8	6	4.6	14.5	0.43	23.78
gobiid preflexion larvae	gobies	21,906	154	5.6	13.0	1330.28	21431.83
gobiid flexion larvae	gobies	8,244	128	5.9	11.9	497.91	8287.90
Bathygobius soporator preflexion larvae	frillfin goby	9	7	2.6	17.0	0.54	27.71
Gobiosoma spp. postflexion larvae	gobies	17,502	114	7.3	9.1	1084.51	42982.85
Gobiosoma bosc juveniles	naked goby	33	17	9.2	7.9	2.29	75.02
Gobiosoma bosc adults	naked goby	4	3	11.4	4.9	0.36	50.02
Gobiosoma robustum juveniles	code goby	2	2	11.3	4.1	0.15	18.94
Gobiosoma robustum adults	code goby	1	1	11.4	2.9	0.29	62.17
Microgobius spp. flexion larvae	gobies	1,019	79	9.7	5.8	63.97	1330.83
Microgobius spp. postflexion larvae	gobies	2,767	102	9.8	5.7	174.40	10542.96
Microgobius gulosus juveniles	clown goby	156	19	11.9	3.5	10.82	717.10
Microgobius gulosus adults	clown goby	7	4	12.4	3.1	0.48	60.77
Microgobius thalassinus juveniles	green goby	5	2	10.6	4.1	0.32	55.32
Achirus lineatus postflexion larvae	lined sole	5	3	2.2	19.7	0.30	27.71
Symphurus plagiusa postflexion larvae	blackcheek tonguefish	1	1	1.8	21.6	0.06	13.85
Trinectes maculatus flexion larvae	hogchoker	1	1	0.5	13.7	0.06	13.29
Trinectes maculatus postflexion larvae	hogchoker	3	2	6.8	7.9	0.18	25.70
Trinectes maculatus juveniles	hogchoker	7	5	4.3	12.4	0.44	32.21
Trinectes maculatus adults	hogchoker	1	1	7.1	3.5	0.07	14.35
Monacanthus setifer juveniles	pygmy filefish	1	1	1.8	13.8	0.07	14.38
Sphoeroides nephelus juveniles	southern puffer	1	1	0.5	18.7	0.06	12.30

Table A1, page 5 of 5.

Plankton-net catch statistics (December 2006 through November 2008, n = 216 samples)

Halls River data are included. Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	*Kmu* (km)	*Su* (psu)	Mean CPUE (No./10^3 m^3)	Max CPUE (No./10^3 m^3)
Sphoeroides parvus juveniles	least puffer	2	2	1.2	21.7	0.13	14.73
unidentified flexion larvae	fish	5	1	11.1	1.9	0.34	72.98

Table A2. Page 1 of 6.

Plankton net catch by month (December 2006 to Novenber 2008). Halls River data are included.

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (24)	Feb (12)	Mar (24)	Apr (12)	May (24)	Jun (12)	Jul (24)	Aug (12)	Sep (24)	Oct (12)	Nov (24)	Dec (12)
foraminiferans	foraminiferans	1		2									
medusa sp. d	hydromedusa							1	2				
medusa sp. e	hydromedusa					3							
medusa sp. f	hydromedusa							1					
medusa, Obelia sp.	hydromedusa					2							
Clytia sp.	hydromedusa				1		2	1		4			
Mnemiopsis mccradyi	comb jelly, ctenophore					232	21	499					
turbellarians	flatworms		9		13	9							1
nematodes	roundworms, threadworms	39	5	17	25			39	26	15	6	84	9
polychaetes	sand worms, tube worms	130	77	1059	107	394	628	295	3551	108	55	1171	458
oligochaetes	freshwater worms	38	2	51	11	58		63	28	212	473	263	
hirudinoideans	leeches	10	12	4	11	24	10	5	11	1	5	15	20
pycnogonids	sea spiders					116		7	1	1			
acari	water mites	3	2	3	13	16		1					9
collembolas, podurid	springtails		2	8			1	2		3		4	
ephemeropteran larvae	mayflies	6	1	5	7	22		4	1	1	36	79	15
odonates, zygopteran larvae	damselflies					1	2	3		4			1
odonates, anisopteran larvae	dragonflies					1							
hemipterans, corixid juveniles	water boatmen					49							
hemipterans, corixid adults	water boatmen	3		1		45			3			1	
hemipterans, naucorid adults	creeping water bugs					3							
hemipterans, gerrid adults	water striders				2	8	1	9	3	2		1	
coleopterans, elmid adults	riffle beetles					3			1			1	
coleopterans, curculionid adults	beetles					3						1	
coleopterans, scirtid larvae	marsh beetles	1											
coleopterans, chrysomelid larvae	beetles							1					
coleopterans, dryopid larvae	long-toed water beetles					2							
dipterans, pupae	flies, mosquitoes	78	345	227	183	858	2861	2022	644	59	102	190	144
dipteran, Chaoborus punctipennis larvae	phantom midge		3	2	3	43	18	59	34	22	9		4
dipterans, chironomid larvae	midges	41	96	1135	169	718	65	124	32	26	301	296	1917
dipterans, tabanid larvae	deer flies					5							
dipterans, ceratopogonid larvae	biting midges	1	1	21	12	21	23	22	16	6	1		
dipterans, stratiomyid larvae	soldier flies					5							
trichopteran larvae	caddisflies					2		2	1	2		1	
lepidopterans, pyralid larvae	aquatic caterpillars			1									
Penilia avirostris	water flea			501									
cladocerans, Daphnia spp.	water fleas	50		4								1	
Simocephalus vetulus	water flea			1	4	2	2	11	5	1166	78	7436	
Ilyocryptus sp.	water flea		2					9					
Sida crystallina	water flea							1					
Leydigia sp.	water flea									1	1		
branchiurans, Argulus spp.	fish lice	3	2				2	6	5	6	4	2	1
unidentified calanoids	copepods												20
Labidocera aestiva	copepod	5		2	21	3735	24	1		1		18	
Acartia tonsa	copepod	5884	637	16440	10054	15125	1327	1096	207	45	45	340	2191
Pseudodiaptomus coronatus	copepod	60	43	242	25	251	84	292	419	112	106	231	167
paracalanids	copepods											1	
Diaptomus spp.	copepods	20	3	14								4	

Table A2. Page 2 of 6.

Plankton net catch by month (December 2006 to November 2008). Halls River data are included.

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (24)	Feb (12)	Mar (24)	Apr (12)	May (24)	Jun (12)	Jul (24)	Aug (12)	Sep (24)	Oct (12)	Nov (24)	Dec (12)
Calanopia americana	copepod									21	154	34	
Eurytemora affinis	copepod	296	227	100	38	3	1			3	114	70	71
Temora turbinata	copepod	39		47	41	47	22	32	1	5	2	9	
unidentified freshwater cyclopoids	copepods	8	10		7	2			5				
Oithona spp.	copepods							1					
Mesocyclops edax	copepod					3							
Orthocyclops modestus	copepod			3	2	6					6		
Macrocyclops albidus	copepods	4	2	16	8	6	1	4			11	28	
Saphirella spp.	copepods					3		4	3			2	
unidentified harpacticoids	copepods	5	7	59	30	3		14	2	5		16	20
siphonostomatids	parasitic copepods	1		3	11	15		3		4	3	2	
Monstrilla sp.	copepod			3	19	52		162	1	62	45	9	
Parasterope pollex	ostracod, seed shrimp	3		109	17	151	37	95	99	60	21	35	37
Sarsiella zostericola	ostracod, seed shrimp	4	3	78	2	17	2	10	11	48	23	25	8
myodocopod sp. a	ostracod, seed shrimp			1	1	2				1		1	
ostracods, podocopid	ostracods, seed shrimps	60	108	806	124	255	11	79	425	6244	1135	4904	267
Squilla empusa larvae	mantis shrimp					2							
unidentified Americamysis juveniles	opossum shrimps, mysids	2739	3562	4070	3813	11227	11263	10652	21832	9376	8366	1052	3548
Americamysis almyra	opossum shrimp, mysid	2022	2427	3964	5010	9995	12482	15357	20274	7814	4193	1082	1599
Americamysis bahia	opossum shrimp, mysid					2		2		32		35	72
Bowmaniella dissimilis	opossum shrimp, mysid	134	22	210	293	5552	1326	1531	1263	2006	1658	2288	1982
Taphromysis bowmani	opossum shrimp, mysid	31	131	519	105	234	15	112		16	189	41	643
Spelaeomysis sp.	opossum shrimp, mysid					3	4	1			1	1	1
amphipods, gammaridean	amphipods	10258	9432	55011	35669	77115	13825	17471	11753	13684	17339	30275	16582
amphipods, caprellid	skeleton shrimps	7		16	10	66	9	56	44	19	34	34	9
Munna reynoldsi	isopod	9	16	68	97	11	4	2		13	19	47	42
Xenanthura brevitelson	isopod			53	2	13	3	9		4	2	4	
Cyathura polita	isopod	1	3	9		24		7	7	3		2	
Sphaeromatid (Dynamenella)	isopod											1	
Sphaeroma quadridentata	isopod			5				2		1			
Harrieta faxoni	isopod	17	4	2561	151	527	88	203	116	280	109	179	451
Cassidinidea ovalis	isopod	3	5	178	74	884	131	169	93	62	25	17	3
Sphaeroma terebrans	isopod					3	1			1			
Edotea triloba	isopod	11	53	337	190	1486	59	172	263	212	161	135	21
Erichsonella attenuata	isopod	20	9	1588	62	152	70	49	60	61	33	33	28
Erichsonella filiforme	isopod			1									
cymothoid sp. a (Lironeca) juveniles	isopod	3	1	8	2	27	20	15	9	25	15	6	2
Anopsilana jonesi	isopod				1	4	5	15	23	1	1	3	1
Probopyrus sp. (attached)	isopod												9
Isopod, Paracerceis caudata	isopod							4		1			
Tanaid sp. c	tanaid											2	
Hargeria rapax	tanaid	26	59	2124	128	75	14	8	29	25	27	56	45
Sinelobus stanfordi	tanaid	5		11	1	8		7	7	5	12	36	
Apseudes sp.	tanaid	3		96	2	20	3	26	159	1661	154	11	
Hoplomachus propinquus	tanaid					5		17				13	
cumaceans	cumaceans	2255	835	23807	3644	14038	6170	9568	2547	3301	2496	5890	3737
Lucifer faxoni juveniles and adults	shrimp			36	1	4	1	2		4		48	
penaeid postlarvae	penaeid shrimps				8	117	37	6	3	38	17	3	

Table A2. Page 3 of 6.

Plankton net catch by month (December 2006 to November 2008). Halls River data are included.

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (24)	Feb (12)	Mar (24)	Apr (12)	May (24)	Jun (12)	Jul (24)	Aug (12)	Sep (24)	Oct (12)	Nov (24)	Dec (12)
penaeid metamorphs	penaeid shrimps							6	26	10	57	6	9
Farfantepenaeus duorarum juveniles	pink shrimp								4	23			
Farfantepenaeus duorarum adults	pink shrimp			1						3			
Palaemonetes spp. postlarvae	grass shrimps	5		115	171	991	90	49	9	12	16	9	5
Palaemonetes pugio juveniles	daggerblade grass shrimp			8	4	1886	52	83	20	24	4	4	19
Palaemonetes pugio adults	daggerblade grass shrimp	2	2			6	2	3		7	6		30
Palaemonetes vulgaris juveniles	grass shrimp									4			
Palaemonetes vulgaris adults	grass shrimp									1			
Palaemonetes paludosus juveniles	grass shrimp												2
Periclimenes spp. juveniles	shrimps									5	1	18	
Periclimenes longicaudatus juveniles	longtail grass shrimp	2		1									7
alphaeid mysis larvae	snapping shrimps				3	5							
alphaeid postlarvae	snapping shrimps			14	4	990	226	34	2	1	5	1	
alphaeid juveniles	snapping shrimps					30	14				2		
Alpheus viridari adults	snapping shrimp			3									
Hippolyte zostericola postlarvae	zostera shrimp				33	335	14	13		8	7	11	
Hippolyte zostericola juveniles	zostera shrimp		1					1		2	1	1	6
Hippolyte zostericola adults	zostera shrimp									2		1	20
Tozeuma carolinense juveniles	arrow shrimp											1	
Ogyrides alphaerostris mysis larvae	estuarine longeye shrimp							1	1				
Ogyrides alphaerostris juveniles and adults	estuarine longeye shrimp									1			
processid postlarvae	night shrimps					59		1					
callianassid mysis larvae	ghost shrimps					1							
callianassid postlarvae	ghost shrimps								9				
callianassid juveniles	ghost shrimps					23	1	91					
Callianassa spp. juveniles	ghost shrimps					56	20						
Upogebia spp. mysis larvae	mud shrimps				2			1					
Upogebia spp. postlarvae	mud shrimps					819	45	1		1			
Upogebia spp. juveniles	mud shrimps					9			2				
decapod mysis	shrimp larvae	100	25	5902	1905	24528	17048	8356	6718	3487	715	81	11
paguroid juveniles	hermit crabs					1							
Callinectes sapidus juveniles	blue crab		1	1	3	3		2		4	1	2	4
Portunus sp. juveniles	swimming crab	3				6	1			2		1	10
xanthid juveniles	mud crabs					8	2						
Rhithropanopeus harrisii juveniles	Harris mud crab	1			1	9						4	
decapod zoeae	crab larvae	78	207	108821	77888	255771	56435	84396	54931	61224	24199	2086	14
decapod megalopae	post-zoea crab larvae	14	1	46	24430	53459	1734	450	74	98	308	14	941
pelecypods	clams, mussels, oysters	67	367	156		18	17	78	58	62	122	621	155
gastropods, prosobranch	snails	842	1329	2002	389	256	50	77	705	607	1503	445	1103
gastropods, opisthobranch	sea slugs	6		5	5	1	1		3	6	1		3
ophiuroidean juveniles	brittlestars											1	
ophiopluteus larvae	brittlestars	1											
appendicularian, Oikopleura dioica	larvacean						1		1				
chaetognaths, sagittid	arrow worms	2		141	2590	2623	44	293	42	39	522	509	334
ascidiacean larvae	tunicate larvae					166		1					
Lepisosteus sp. flexion larvae	gar			3	2								
Lepisosteus sp. postflexion larvae	gar			4	2								
Lepisosteus sp. juveniles	gar				9								

Plankton net catch by month (December 2006 to November 2008). Halls River data are included.

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Elops saurus postflexion larvae	ladyfish	8		4									
Myrophis punctatus juveniles	speckled worm eel			1									2
Anchoa spp. eggs	anchovies							3					
Anchoa spp. preflexion larvae	anchovies			5	26	80	17	22	7	3			
Anchoa spp. flexion larvae	anchovies			1	1	17	2	10	7				
Anchoa hepsetus postflexion larvae	striped anchovy					2							
Anchoa hepsetus juveniles	striped anchovy					8	1						
Anchoa mitchilli eggs	bay anchovy			2030	3945	572	3	1		19	6		
Anchoa mitchilli postflexion larvae	bay anchovy				33	29	15	34	72	3	1		
Anchoa mitchilli juveniles	bay anchovy	3	1	2	62	343	86	118	57	123	126	771	14
Anchoa mitchilli adults	bay anchovy		17	3		8	18	35	18	10	47	110	9
clupeid preflexion larvae	herrings			8	11	2	1	1					
Brevoortia smithi juveniles	yellowfin menhaden					3	1						
Brevoortia spp. postflexion larvae	menhaden		1	16	5	2							
Brevoortia spp. metamorphs	menhaden				4	4		1					
Dorosoma petenense juveniles	threadfin shad							3					
Opisthonema oglinum flexion larvae	Atlantic thread herring				2								
Notemigonus crysoleucas preflexion larvae	golden shiner	1										2	
Notropis spp. preflexion larvae	minnows			1						2			
Notropis spp. flexion larvae	minnows										1		
Synodus foetens metamorphs	inshore lizardfish					1							
Opsanus beta juveniles	gulf toadfish				2	1							
Mugil cephalus juveniles	striped mullet	2	1										
Membras martinica preflexion larvae	rough silverside					2							
Membras martinica postflexion larvae	rough silverside					1							
Membras martinica juveniles	rough silverside					3							
Menidia spp. eggs	silversides				2	5							2
Menidia spp. preflexion larvae	silversides	22	30	68	43	66	18	54	21	18	32	5	2
Menidia spp. flexion larvae	silversides	6	2	2	54	91	31	10	1	6			4
Menidia spp. postflexion larvae	silversides	1		7	26	319	41	19	1	8	6	2	11
Menidia spp. juveniles	silversides	2		3	12	12	12	5	2	13	27	3	201
Menidia spp. adults	silversides				2	2		1	1				70
Hyporhamphus meeki adults	false silverstripe halfbeak	1											
Hyporhamphus unifasciatus postflexion larvae	silverstripe halfbeak					1							
Fundulus spp. eggs	killifishes		1								7		
Fundulus spp. postflexion larvae	killifishes							1					
Lucania goodei postflexion larvae	bluefin killifish									1			
Lucania goodei juveniles	bluefin killifish					4							2
Lucania goodei adults	bluefin killifish												10
Lucania parva eggs	rainwater killifish		1	2									
Lucania parva postflexion larvae	rainwater killifish	1	8	13	5	3	4	4	2	73	7	51	20
Lucania parva juveniles	rainwater killifish	8	3		3	13			3	12	23	11	18
Lucania parva adults	rainwater killifish	18	17		22	80	1	3		7		21	54
Gambusia holbrooki juveniles	eastern mosquitofish					10	2	5			7	4	
Gambusia holbrooki adults	eastern mosquitofish						4						
Heterandria formosa juveniles	least killifish					1			3				
Heterandria formosa adults	least killifish					1							
Hippocampus zosterae juveniles	dwarf seahorse									1			

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Syngnathus floridae juveniles	dusky pipefish				4	3							
Syngnathus louisianae juveniles	chain pipefish					1							
Syngnathus scovelli juveniles	gulf pipefish	1			11	14	5	1		5		1	5
fish eggs, percomorph	sciaenid eggs (primarily)			377	8232	4	679	340	26				
Lepomis macrochirus juveniles	bluegill											2	5
Lepomis punctatus juveniles	spotted sunfish												7
Lepomis spp. preflexion larvae	sunfishes						8		1				
Lepomis spp. flexion larvae	sunfishes			2		3	5	2	2	1			
Lepomis spp. postflexion larvae	sunfishes						1					1	
Lutjanus griseus juveniles	gray snapper		1										
Eucinostomus spp. postflexion larvae	mojarras								9		4		2
Eucinostomus spp. juveniles	mojarras					2		6		19	14	7	4
Eucinostomus harengulus juveniles	tidewater mojarra							11	1	2	7	18	
Eucinostomus harengulus adults	tidewater mojarra										1	2	
Eugerres plumieri postflexion larvae	striped mojarra									1			
Eugerres plumieri juveniles	striped mojarra									1			
Lagodon rhomboides juveniles	pinfish	103	1										3
Bairdiella chrysoura postflexion larvae	silver perch					2							
Bairdiella chrysoura juveniles	silver perch					1							
Leiostomus xanthurus postflexion larvae	spot	1											
Leiostomus xanthurus juveniles	spot	1	2										
Menticirrhus spp. preflexion larvae	kingfishes					1							
Menticirrhus spp. postflexion larvae	kingfishes				1								
blenniid preflexion larvae	blennies	1		67	44	19	3	5	2	24	1		
Chasmodes saburrae flexion larvae	Florida blenny			1	6	5	2						
Chasmodes saburrae postflexion larvae	Florida blenny				1	10							
Lupinoblennius nicholsi flexion larvae	highfin blenny				1								
Gobiesox strumosus preflexion larvae	skilletfish		2	83	3	18	3		5	21	24	3	
Gobiesox strumosus flexion larvae	skilletfish					5	4						
Gobiesox strumosus postflexion larvae	skilletfish					6	2						
Gobiesox strumosus juveniles	skilletfish				1	4	3						
gobiid preflexion larvae	gobies	17	39	1364	3685	10976	571	2049	1320	1025	853	2	5
gobiid flexion larvae	gobies	8	15	122	1229	3285	1315	803	736	457	271		3
Bathygobius soporator preflexion larvae	frillfin goby					3			1	5			
Gobiosoma spp. postflexion larvae	gobies	1		366	5362	3542	3211	2225	1730	523	523	16	3
Gobiosoma bosc juveniles	naked goby			1		18	5	3	3			3	
Gobiosoma bosc adults	naked goby					2						2	
Gobiosoma robustum juveniles	code goby					1	1						
Gobiosoma robustum adults	code goby		1										
Microgobius spp. flexion larvae	gobies	104	90	115	285	103	41	127	39	65	50		
Microgobius spp. postflexion larvae	gobies	46	20	49	668	1278	87	178	264	142	33	2	
Microgobius gulosus juveniles	clown goby				4	76	2	65	7	1	1		
Microgobius gulosus adults	clown goby					1	1	4					1
Microgobius thalassinus juveniles	green goby							1			4		
Achirus lineatus postflexion larvae	lined sole					4				1			
Symphurus plagiusa postflexion larvae	blackcheek tonguefish					1							
Trinectes maculatus flexion larvae	hogchoker										1		
Trinectes maculatus postflexion larvae	hogchoker							2		1			

Table A2. Page 6 of 6.

Plankton net catch by month (December 2006 to Novenber 2008). Halls River data are included.

Number of monthly samples is indicated in parentheses.

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Trinectes maculatus juveniles	hogchoker							2	1	4			
Trinectes maculatus adults	hogchoker								1				
Monacanthus setifer juveniles	pygmy filefish											1	
Sphoeroides nephelus juveniles	southern puffer												1
Sphoeroides parvus juveniles	least puffer					1						1	
unidentified flexion larvae	fish											5	
unidentified flexion larvae	fish											5	

Table A3, page 1 of 6. Location specific plankton-net catch .

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	0.5	1.8	3.0	4.4	6.1	7.1	9.0	9.8	11.1	11.9	Halls R. 11.4	Halls R. 13.0
foraminiferans	foraminiferans	1.43	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00
medusa sp. d	hydromedusa	1.38	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00
medusa sp. e	hydromedusa	0.00	0.00	0.00	1.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
medusa sp. f	hydromedusa	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
medusa, Obelia sp.	hydromedusa	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clytia sp.	hydromedusa	4.88	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mnemiopsis mccradyi	comb jelly, ctenophore	0.00	3.17	10.07	85.25	197.78	135.88	71.36	53.98	0.00	1.24	0.00	0.00
turbellarians	flatworms	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.65	12.80	4.24	0.00
nematodes	roundworms, threadworms	69.05	5.02	28.39	2.84	2.76	3.58	4.38	2.18	34.81	5.05	3.85	44.20
polychaetes	sand worms, tube worms	250.83	629.11	301.21	87.78	44.00	511.80	336.08	564.57	2103.72	825.75	111.49	104.87
oligochaetes	freshwater worms	0.00	0.00	1.46	0.00	0.00	14.08	2.81	82.01	206.87	226.89	15.97	615.77
hirudinoideans	leeches	0.71	0.74	2.07	2.78	0.71	0.71	15.39	10.18	21.53	11.03	25.06	15.57
pycnogonids	sea spiders	32.37	56.98	6.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
acari	water mites	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	12.08	2.43	8.36	10.85
collembolas, podurid	springtails	0.00	0.00	0.00	0.00	0.00	1.37	1.50	0.67	0.00	7.41	1.52	2.14
ephemeropteran larvae	mayflies	0.00	0.00	0.00	0.00	0.72	0.00	0.00	1.45	27.38	16.74	15.18	122.05
odonates, zygopteran larvae	damselflies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.74	0.77	9.17
odonates, anisopteran larvae	dragonflies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00
hemipterans, corixid juveniles	water boatmen	0.00	0.00	0.00	0.00	0.00	0.00	1.95	2.23	4.35	0.00	5.26	25.43
hemipterans, corixid adults	water boatmen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.84	44.07
hemipterans, naucorid adults	creeping water bugs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63	0.00
hemipterans, gerrid adults	water striders	1.38	4.38	4.22	0.00	0.00	0.00	0.00	0.00	3.12	0.00	0.84	5.26
coleopterans, elmid adults	riffle beetles	0.00	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.76	0.00	2.63	0.00
coleopterans, curculionid adults	beetles	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.00	1.86	0.00	0.00	0.00
coleopterans, scirtid larvae	marsh beetles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00
coleopterans, chrysomelid larvae	beetles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.00	0.00
coleopterans, dryopid larvae	long-toed water beetles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00
dipterans, pupae	flies, mosquitoes	1.50	1.32	0.70	1.36	5.99	2.02	94.69	282.57	1183.45	692.62	2148.93	1316.62
dipteran, Chaoborus punctipennis larvae	phantom midge	0.00	0.00	0.00	0.00	0.00	3.01	1.31	9.97	27.97	25.24	66.61	8.96
dipterans, chironomid larvae	midges	10.47	2.88	10.93	6.59	3.47	10.65	96.75	139.04	480.71	1160.90	821.62	1276.20
dipterans, tabanid larvae	deer flies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.61	0.00	0.00
dipterans, ceratopogonid larvae	biting midges	1.47	0.00	4.81	1.40	1.29	2.63	6.93	9.16	25.40	11.85	10.95	14.19
dipterans, stratiomyid larvae	soldier flies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.86	1.04	0.00	0.00
trichopteran larvae	caddisflies	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	2.24	0.78	0.79	2.10
lepidopterans, pyralid larvae	aquatic caterpillars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00
Penilia avirostris	water flea	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00	340.58	0.00	3.70	0.00
cladocerans, Daphnia spp.	water fleas	0.00	0.00	0.00	0.00	0.00	1.53	18.62	17.29	0.81	0.00	0.00	0.00
Simocephalus vetulus	water flea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.04	2.37	1173.45	10362.83
Ilyocryptus sp.	water flea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.81
Sida crystallina	water flea	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leydigia sp.	water flea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.77	0.00
branchiurans, Argulus spp.	fish lice	4.24	2.29	2.89	2.70	0.72	1.48	1.48	3.05	0.69	0.00	1.54	2.00
unidentified calanoids	copepods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.43	0.74	0.00	0.00
Labidocera aestiva	copepod	2664.76	123.76	12.67	13.43	2.71	0.00	0.00	0.00	1.96	2.33	0.00	0.70
Acartia tonsa	copepod	2016.13	2632.20	3269.99	5976.31	2010.30	2782.98	4477.53	7077.80	3764.32	910.65	4074.71	229.12
Pseudodiaptomus coronatus	copepod	215.16	339.68	499.79	219.99	94.02	73.13	6.57	4.68	8.71	3.10	2.36	11.08
paracalanids	copepods	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A3, page 2 of 6. Location specific plankton-net catch .

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	0.5	1.8	3.0	4.4	6.1	7.1	9.0	9.8	11.1	11.9	Halls R. 11.4	Halls R. 13.0
Diaptomus spp.	copepods	0.00	0.00	0.00	0.00	2.25	1.59	2.22	0.00	10.10	5.43	5.95	2.87
Calanopia americana	copepod	135.43	14.65	0.00	0.00	0.74	0.77	0.00	0.00	0.00	0.00	0.00	0.00
Eurytemora affinis	copepod	0.00	0.00	0.74	0.00	1.43	0.00	136.75	82.23	181.73	35.61	117.33	190.65
Temora turbinata	copepod	37.11	38.72	38.90	28.17	1.91	2.24	0.00	0.00	0.00	0.00	31.60	0.00
Oithona spp.	copepods	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00
Mesocyclops edax	copepod	0.00	0.00	0.00	0.00	0.00	2.24	0.00	0.00	0.00	0.00	0.00	0.00
Orthocyclops modestus	copepod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.94	5.56	0.00	2.90
Macrocyclops albidus	copepods	0.00	0.00	0.00	0.00	0.00	0.82	0.65	0.73	11.99	7.15	25.86	19.80
Saphirella spp.	copepods	0.76	0.00	3.62	0.00	0.00	0.00	1.95	0.00	0.00	0.00	2.32	0.00
siphonostomatids	parasitic copepods	15.65	8.79	4.36	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.00
Monstrilla sp.	copepod	180.09	47.87	25.55	2.65	1.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parasterope pollex	ostracod, seed shrimp	150.44	227.64	80.23	14.52	12.74	0.71	0.00	0.00	0.00	0.00	0.00	0.00
Sarsiella zostericola	ostracod, seed shrimp	79.98	61.82	13.54	2.20	3.67	5.47	0.73	0.00	0.00	0.00	0.00	0.00
myodocopod sp. a	ostracod, seed shrimp	0.81	2.82	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracods, podocopid	ostracods, seed shrimps	0.70	1.54	0.00	0.66	0.00	23.33	5.53	2884.57	781.37	1008.01	175.04	10792.49
Squilla empusa larvae	mantis shrimp	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified Americamysis juveniles	opossum shrimps, mysids	3666.63	4852.33	9808.57	13312.40	7474.59	5495.57	5841.89	4208.22	1900.98	1001.35	3106.41	8060.12
Americamysis almyra	opossum shrimp, mysid	1932.75	3470.16	4021.58	14043.64	6297.48	9130.95	6028.73	3345.37	2014.81	605.73	1698.55	14975.00
Americamysis bahia	opossum shrimp, mysid	75.92	0.80	0.00	0.00	23.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bowmaniella dissimilis	opossum shrimp, mysid	3167.96	3936.01	2389.25	2309.15	726.46	330.12	46.63	2.91	0.00	1.04	0.00	0.00
Taphromysis bowmani	opossum shrimp, mysid	13.66	38.66	15.57	53.19	4.46	78.08	51.33	13.30	29.31	315.68	801.75	514.30
Spelaeomysis sp.	opossum shrimp, mysid	0.00	0.00	1.35	1.31	2.64	2.24	0.00	0.00	0.00	0.00	0.00	0.00
amphipods, gammaridean	amphipods	5789.91	7897.20	24121.19	20566.86	16314.70	12885.13	18910.84	23748.30	24532.49	13242.43	26851.47	43318.45
amphipods, caprellid	skeleton shrimps	76.88	70.98	45.35	19.89	6.89	0.00	0.77	0.84	0.00	0.00	0.00	0.00
Munna reynoldsi	isopod	0.00	1.32	3.01	2.78	3.53	7.49	20.31	35.28	48.10	9.19	57.62	84.04
Cyathura polita	isopod	2.14	1.56	5.80	1.35	3.83	3.19	2.73	4.58	2.13	4.14	5.74	8.54
Sphaeromatid (Dynamenella)	isopod	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sphaeroma quadridentata	isopod	2.35	1.64	0.00	0.70	0.75	0.00	0.00	0.00	0.00	0.00	0.72	0.00
Harrieta faxoni	isopod	2131.91	499.20	560.17	118.67	23.86	2.93	3.78	0.74	0.00	0.74	0.00	0.00
Cassidinidea ovalis	isopod	84.21	113.90	242.74	444.45	151.10	64.80	14.11	5.50	0.69	3.52	4.64	32.17
Sphaeroma terebrans	isopod	0.00	0.00	0.00	0.00	0.00	0.00	0.73	2.86	0.00	0.00	0.00	0.00
Edotea triloba	isopod	21.83	37.64	84.98	74.75	338.66	1128.50	236.76	227.20	11.87	26.12	38.81	95.31
Erichsonella attenuata	isopod	252.43	744.09	244.79	146.92	70.41	33.76	20.58	2.23	0.63	0.00	0.00	0.00
Erichsonella filiforme	isopod	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cymothoid sp. a (Lironeca) juveniles	isopod	2.22	5.29	3.92	8.59	18.05	13.45	21.08	16.15	2.76	3.72	0.00	0.00
Anopsilana jonesi	isopod	0.72	1.36	2.16	11.82	17.40	4.47	1.95	0.74	0.00	0.00	0.00	0.00
Probopyrus sp. (attached)	isopod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.36
Isopod, Paracerceis caudata	isopod	0.75	2.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tanaid sp. c	tanaid	0.72	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hargeria rapax	tanaid	57.44	90.13	1269.14	148.94	208.44	82.93	15.96	6.82	55.31	13.78	9.46	20.35
Sinelobus stanfordi	tanaid	5.65	4.03	4.28	2.02	21.37	3.19	8.87	4.68	0.69	1.56	3.76	9.46
Apseudes sp.	tanaid	1188.34	119.26	218.98	42.52	15.67	5.26	0.79	0.00	0.00	0.00	0.00	0.00
Hoplomachus propinquus	tanaid	8.29	12.47	2.13	0.00	2.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cumaceans	cumaceans	12415.48	12993.92	17144.60	7296.45	3386.68	2558.71	240.28	186.58	46.42	3.37	265.86	246.04
Lucifer faxoni juveniles and adults	shrimp	29.01	16.38	9.87	7.54	4.36	3.83	0.81	0.81	0.00	0.00	0.00	0.00
penaeid postlarvae	penaeid shrimps	98.90	27.74	13.12	5.42	7.13	8.33	0.73	0.00	0.00	0.00	0.00	0.00
penaeid metamorphs	penaeid shrimps	26.83	32.65	11.44	5.50	2.82	4.12	0.00	0.00	0.00	0.00	0.00	0.00

Table A3, page 3 of 6. Location specific plankton-net catch .

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	0.5	1.8	3.0	4.4	6.1	7.1	9.0	9.8	11.1	11.9	Halls R. 11.4	Halls R. 13.0
Farfantepenaeus duorarum juveniles	pink shrimp	15.38	1.46	0.71	2.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Farfantepenaeus duorarum adults	pink shrimp	1.49	0.00	0.00	0.68	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Palaemonetes spp. postlarvae	grass shrimps	327.37	25.06	20.12	28.24	37.66	26.47	106.74	228.91	76.08	3.67	54.31	163.26
Palaemonetes pugio juveniles	daggerblade grass shrimp	7.87	6.03	22.91	12.54	13.42	16.41	46.44	53.07	82.37	1.67	299.29	1193.87
Palaemonetes pugio adults	daggerblade grass shrimp	4.24	0.00	2.05	0.70	1.44	1.49	0.00	0.00	2.88	0.00	3.30	35.35
Palaemonetes vulgaris juveniles	grass shrimp	2.24	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Palaemonetes vulgaris adults	grass shrimp	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Palaemonetes paludosus juveniles	grass shrimp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.86
Periclimenes spp. juveniles	shrimps	5.69	8.33	3.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Periclimenes longicaudatus juveniles	longtail grass shrimp	4.13	0.00	1.36	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00
alphaeid mysis larvae	snapping shrimps	0.00	3.85	0.00	0.00	0.00	0.00	0.00	2.36	0.00	0.00	0.00	0.00
alphaeid postlarvae	snapping shrimps	577.27	221.22	89.94	24.19	16.37	0.00	0.00	0.81	0.00	0.00	0.00	0.00
alphaeid juveniles	snapping shrimps	1.48	19.92	5.48	5.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alpheus viridari adults	snapping shrimp	0.00	0.00	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hippolyte zostericola postlarvae	zostera shrimp	214.36	46.07	42.25	2.11	0.00	0.00	1.95	0.00	0.00	0.00	0.00	0.00
Hippolyte zostericola juveniles	zostera shrimp	3.53	1.54	1.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.39	0.00
Hippolyte zostericola adults	zostera shrimp	13.79	2.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tozeuma carolinense juveniles	arrow shrimp	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ogyrides alphaerostris mysis larvae	estuarine longeye shrimp	0.00	0.78	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ogyrides alphaerostris juveniles and adults	estuarine longeye shrimp	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
processid postlarvae	night shrimps	38.55	4.81	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
callianassid mysis larvae	ghost shrimps	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
callianassid postlarvae	ghost shrimps	0.69	3.90	0.00	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
callianassid juveniles	ghost shrimps	0.00	1.43	4.87	18.75	46.42	5.71	2.72	0.00	0.00	0.00	0.00	0.00
Callianassa spp. juveniles	ghost shrimps	0.00	0.00	20.44	7.85	9.79	17.10	0.00	0.00	0.00	0.00	0.00	0.00
decapod mysis	shrimp larvae	7805.31	6946.78	4823.87	9598.39	4923.58	4188.05	3107.92	4491.45	445.23	255.08	1056.13	2511.69
paguroid juveniles	hermit crabs	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Callinectes sapidus juveniles	blue crab	2.25	2.18	2.16	4.19	1.29	0.66	1.31	0.00	0.00	0.00	0.00	0.78
Portunus sp. juveniles	swimming crab	4.16	0.74	4.73	0.76	2.64	0.00	2.75	0.00	0.00	0.00	0.00	0.00
Rhithropanopeus harrisii juveniles	Harris mud crab	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.83	12.20
decapod zoeae	crab larvae	34715.78	34982.16	41173.17	60357.79	66135.00	57480.24	41327.55	63086.01	19987.55	16791.31	39097.71	64469.61
decapod megalopae	post-zoea crab larvae	232.77	466.97	583.00	497.54	1218.14	2584.26	12151.11	17107.27	7196.55	1353.52	14480.38	2167.93
pelecypods	clams, mussels, oysters	6.55	34.69	56.29	127.33	100.96	395.81	16.10	2.23	210.61	11.52	423.71	240.66
gastropods, prosobranch	snails	88.36	25.36	27.63	14.44	15.88	44.41	1276.64	696.44	291.10	567.84	4018.38	3112.48
gastropods, opisthobranch	sea slugs	2.84	5.07	0.00	6.19	2.98	0.00	3.90	0.00	0.00	0.00	1.57	0.00
ophiuroidean juveniles	brittlestars	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ophiopluteus larvae	brittlestars	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
appendicularian, Oikopleura dioica	larvacean	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognaths, sagittid	arrow worms	2646.16	1843.19	455.90	137.32	21.24	5.46	0.00	2.74	0.65	0.00	0.00	0.00
ascidiacean larvae	tunicate larvae	7.68	31.00	79.47	6.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lepisosteus sp. flexion larvae	gar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34	0.69	0.00	1.41	0.00
Lepisosteus sp. postflexion larvae	gar	0.00	0.00	1.46	0.00	0.00	0.00	0.00	0.00	2.75	0.00	0.00	0.00
Lepisosteus sp. juveniles	gar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	5.63	0.00
Elops saurus postflexion larvae	ladyfish	0.00	0.00	0.00	0.00	0.00	2.07	5.35	0.81	0.00	0.00	0.00	0.00
Myrophis punctatus juveniles	speckled worm eel	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anchoa spp. eggs	anchovies	0.00	0.00	0.00	0.00	2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anchoa spp. preflexion larvae	anchovies	14.36	15.44	17.67	4.68	3.71	18.59	13.55	4.69	9.19	5.60	6.16	0.00

Table A3, page 4 of 6. Location specific plankton-net catch .

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	0.5	1.8	3.0	4.4	6.1	7.1	9.0	9.8	11.1	11.9	Halls R. 11.4	Halls R. 13.0
Anchoa spp. flexion larvae	anchovies	0.00	0.66	3.63	7.64	3.74	0.00	1.45	2.68	3.27	0.00	4.62	0.00
Anchoa hepsetus postflexion larvae	striped anchovy	0.00	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anchoa hepsetus juveniles	striped anchovy	0.00	0.77	0.00	0.00	3.24	2.24	0.00	0.00	0.00	0.00	0.00	0.00
Anchoa mitchilli eggs	bay anchovy	324.47	623.81	771.48	911.12	1098.40	669.50	20.87	4.72	0.00	0.00	0.00	0.00
Anchoa mitchilli postflexion larvae	bay anchovy	2.08	11.05	19.07	13.40	21.00	35.13	7.42	15.34	5.99	0.00	7.82	0.00
Anchoa mitchilli juveniles	bay anchovy	5.08	15.60	40.14	67.39	102.63	208.73	382.34	376.16	33.89	0.79	10.16	1.70
Anchoa mitchilli adults	bay anchovy	4.07	10.77	14.24	18.96	9.09	64.11	54.50	26.75	0.72	0.00	0.00	0.00
clupeid preflexion larvae	herrings	0.00	0.00	0.00	0.00	0.00	0.00	3.94	1.34	4.01	1.69	0.00	7.09
Brevoortia smithi juveniles	yellowfin menhaden	0.00	0.00	0.00	0.00	0.00	0.74	0.00	2.16	0.00	0.00	0.00	0.00
Brevoortia spp. postflexion larvae	menhaden	0.74	0.77	0.00	1.40	2.88	3.12	4.04	3.17	0.00	0.00	0.00	2.90
Brevoortia spp. metamorphs	menhaden	1.48	0.71	0.00	0.00	0.65	0.66	0.00	3.10	0.00	0.00	0.00	0.00
Dorosoma petenense juveniles	threadfin shad	0.00	0.00	0.72	0.00	0.72	0.89	0.00	0.00	0.00	0.00	0.00	0.00
Opisthonema oglinum flexion larvae	Atlantic thread herring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26	0.00	0.00	0.00
Notemigonus crysoleucas preflexion larvae	golden shiner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.21	0.00	0.00
Notropis spp. preflexion larvae	minnows	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57	0.00	0.71
Notropis spp. flexion larvae	minnows	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00
Synodus foetens metamorphs	inshore lizardfish	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Opsanus beta juveniles	gulf toadfish	0.00	0.00	0.00	0.00	0.00	1.40	0.79	0.00	0.00	0.00	0.00	0.00
Mugil cephalus juveniles	striped mullet	0.00	0.68	0.74	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Membras martinica preflexion larvae	rough silverside	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Membras martinica postflexion larvae	rough silverside	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Membras martinica juveniles	rough silverside	0.00	0.00	0.74	0.65	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Menidia spp. eggs	silversides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01	1.26	0.00	0.00	3.96
Menidia spp. preflexion larvae	silversides	15.92	26.29	15.65	11.52	12.33	21.61	20.38	19.95	17.90	6.17	39.26	91.78
Menidia spp. flexion larvae	silversides	5.25	1.99	0.74	0.00	0.00	0.00	1.40	0.00	20.43	1.46	9.74	149.01
Menidia spp. postflexion larvae	silversides	0.00	0.00	1.32	0.65	0.00	0.00	0.00	0.00	13.78	10.62	29.66	378.66
Menidia spp. juveniles	silversides	0.00	0.00	0.00	0.00	3.46	0.00	1.97	0.74	0.63	0.00	29.12	233.25
Menidia spp. adults	silversides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	69.17
Hyporhamphus meeki adults	false silverstripe halfbeak	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hyporhamphus unifasciatus postflexion larvae	silverstripe halfbeak	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fundulus spp. eggs	killifishes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	9.46
Fundulus spp. postflexion larvae	killifishes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.00	0.00
Lucania goodei postflexion larvae	bluefin killifish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00
Lucania goodei juveniles	bluefin killifish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.25
Lucania goodei adults	bluefin killifish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57	7.43
Lucania parva eggs	rainwater killifish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	1.69	0.00	0.00
Lucania parva postflexion larvae	rainwater killifish	0.00	0.00	0.00	1.99	0.64	0.00	1.47	1.47	7.43	8.87	100.43	88.40
Lucania parva juveniles	rainwater killifish	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	17.20	2.61	33.25	43.41
Lucania parva adults	rainwater killifish	0.00	0.68	0.00	0.65	0.00	0.00	1.31	0.00	10.73	0.00	86.65	155.80
Gambusia holbrooki juveniles	eastern mosquitofish	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	6.05	20.96
Gambusia holbrooki adults	eastern mosquitofish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	3.00
Heterandria formosa juveniles	least killifish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	2.77
Heterandria formosa adults	least killifish	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00
Hippocampus zosterae juveniles	dwarf seahorse	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Syngnathus floridae juveniles	dusky pipefish	0.00	0.00	0.00	0.00	0.00	0.00	2.74	2.36	0.00	0.00	0.00	0.00
Syngnathus louisianae juveniles	chain pipefish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.00
Syngnathus scovelli juveniles	gulf pipefish	2.19	2.92	0.00	0.62	0.00	0.00	4.33	2.36	4.98	0.00	7.48	7.49

Table A3, page 5 of 6. Location specific plankton-net catch .

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

Description	Common Name	Location (km from mouth) 0.5	1.8	3.0	4.4	6.1	7.1	9.0	9.8	11.1	11.9	Halls R. 11.4	Halls R. 13.0
fish eggs, percomorph	sciaenid eggs (primarily)	880.71	2391.49	3264.35	194.78	2.54	0.00	0.00	0.00	3.27	0.00	0.00	0.00
Lepomis macrochirus juveniles	bluegill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.17
Lepomis punctatus juveniles	spotted sunfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.50
Lepomis spp. preflexion larvae	sunfishes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00	8.00
Lepomis spp. flexion larvae	sunfishes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.84	4.31	1.48	0.00
Lepomis spp. postflexion larvae	sunfishes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81	0.00	0.00	1.00
Lutjanus griseus juveniles	gray snapper	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eucinostomus spp. postflexion larvae	mojarras	0.00	0.78	0.68	0.00	4.89	1.59	0.00	0.00	0.00	0.00	0.78	5.41
Eucinostomus spp. juveniles	mojarras	15.10	6.70	3.47	2.20	1.41	3.67	0.00	0.00	1.41	0.00	1.57	1.86
Eucinostomus harengulus juveniles	tidewater mojarra	0.00	0.00	0.00	0.00	3.52	4.28	0.00	0.00	0.00	0.00	1.50	31.98
Eucinostomus harengulus adults	tidewater mojarra	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.13
Eugerres plumieri postflexion larvae	striped mojarra	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00
Eugerres plumieri juveniles	striped mojarra	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00
Lagodon rhomboides juveniles	pinfish	50.14	23.86	3.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bairdiella chrysoura postflexion larvae	silver perch	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bairdiella chrysoura juveniles	silver perch	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leiostomus xanthurus postflexion larvae	spot	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leiostomus xanthurus juveniles	spot	0.00	0.76	0.00	0.72	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00
Menticirrhus spp. preflexion larvae	kingfishes	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Menticirrhus spp. postflexion larvae	kingfishes	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
blenniid preflexion larvae	blennies	39.14	30.38	32.17	4.81	12.52	2.52	0.00	0.00	0.00	0.00	0.00	0.00
Chasmodes saburrae flexion larvae	Florida blenny	7.06	0.00	0.74	1.31	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00
Chasmodes saburrae postflexion larvae	Florida blenny	6.68	0.00	0.74	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00
Lupinoblennius nicholsi flexion larvae	highfin blenny	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gobiesox strumosus preflexion larvae	skilletfish	3.60	23.12	26.01	18.72	30.64	13.45	4.55	0.76	0.00	0.00	0.00	0.00
Gobiesox strumosus flexion larvae	skilletfish	0.70	1.26	2.64	0.00	0.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00
Gobiesox strumosus postflexion larvae	skilletfish	1.31	0.00	0.00	0.00	2.45	0.00	0.00	2.23	0.00	0.00	0.00	0.00
Gobiesox strumosus juveniles	skilletfish	0.66	0.63	1.93	0.00	0.00	0.66	1.31	0.00	0.00	0.00	0.00	0.00
gobiid preflexion larvae	gobies	1887.89	1272.36	1941.90	1517.88	3334.30	2424.70	1613.26	950.77	322.32	135.57	295.67	266.73
gobiid flexion larvae	gobies	390.58	183.95	807.99	1221.33	927.93	1008.10	523.60	527.51	190.13	42.15	52.05	99.55
Bathygobius soporator preflexion larvae	frillfin goby	0.69	2.27	2.08	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gobiosoma spp. postflexion larvae	gobies	214.49	190.36	735.13	1972.56	1673.31	2466.12	2347.90	2956.40	255.78	97.96	66.18	37.94
Gobiosoma bosc juveniles	naked goby	0.00	0.00	2.04	1.37	4.78	3.72	0.65	4.16	0.00	0.70	0.00	10.04
Gobiosoma bosc adults	naked goby	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.74	0.00	0.00	0.00	2.78
Gobiosoma robustum juveniles	code goby	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00	1.05
Gobiosoma robustum adults	code goby	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.45	0.00
Microgobius spp. flexion larvae	gobies	2.24	4.46	37.62	60.78	20.04	77.60	75.61	123.70	83.52	32.14	58.78	191.10
Microgobius spp. postflexion larvae	gobies	35.24	41.53	64.86	213.45	88.23	117.39	75.05	214.00	378.25	56.12	113.35	695.33
Microgobius gulosus juveniles	clown goby	0.00	0.00	0.00	1.31	2.11	7.14	8.31	11.07	2.05	0.00	4.80	93.05
Microgobius gulosus adults	clown goby	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.65	0.00	0.00	4.38
Microgobius thalassinus juveniles	green goby	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	3.07	0.00
Achirus lineatus postflexion larvae	lined sole	0.00	2.27	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Symphurus plagiusa postflexion larvae	blackcheek tonguefish	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trinectes maculatus flexion larvae	hogchoker	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trinectes maculatus postflexion larvae	hogchoker	0.00	0.00	0.00	0.00	0.75	1.43	0.00	0.00	0.00	0.00	0.00	0.00
Trinectes maculatus juveniles	hogchoker	2.18	0.00	0.00	0.00	0.68	2.44	0.00	0.00	0.00	0.00	0.00	0.00
Trinectes maculatus adults	hogchoker	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00

Table A3, page 6 of 6. Location specific plankton-net catch .

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	0.5	1.8	3.0	4.4	6.1	7.1	9.0	9.8	11.1	11.9	Halls R. 11.4	Halls R. 13.0
Monacanthus setifer juveniles	pygmy filefish	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sphoeroides nephelus juveniles	southern puffer	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sphoeroides parvus juveniles	least puffer	0.72	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified flexion larvae	fish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.05	0.00	0.00	0.00

Appendix B: Seine and trawl summary tables

Table B1, page 1 of 1. Seine catch statistics for Homosassa River estuary.
(December 2006 to November 2008, n=378).
Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	S_U (psu)	km_U (km)	Mean CPUE (No./Seine)	Max CPUE (No./Seine)
Farfantepenaeus duorarum	Pink shrimp	107	9.5	7.98	6.99	0.42	25.00
Palaemonetes spp.	Grass shrimps	244	7.7	9.59	7.09	0.95	85.29
Palaemonetes intermedius	Brackish grass shrimp	4,703	35.2	12.00	5.51	18.30	722.06
Palaemonetes paludosus	Riverine grass shrimp	2,459	22.0	2.91	15.48	9.57	1,514.71
Palaemonetes pugio	Daggerblade grass shrimp	2,568	22.8	4.34	11.25	9.99	926.47
Palaemon floridanus	Florida grass shrimp	37	0.5	15.02	1.08	0.14	52.94
Alpheidae spp.	Snapping shrimp	2	0.5	14.15	1.05	0.01	1.47
Hippolyte zostericola	Zostera shrimp	37	1.1	17.52	0.82	0.14	44.12
Callinectes sapidus	Blue crab	1,222	34.9	8.77	6.43	4.75	355.88
Dasyatis sabina	Atlantic stingray	5	1.1	7.90	8.12	0.02	2.94
Dasyatis say	Bluntnose stingray	3	0.8	2.38	12.57	0.01	1.47
Lepisosteus spp.	Gars	3	0.5	2.80	15.10	0.01	2.94
Lepisosteus osseus	Longnose gar	3	0.8	2.40	13.53	0.01	1.47
Lepisosteus platyrhincus	Florida gar	24	5.0	3.40	12.21	0.09	5.88
Elops saurus	Ladyfish	12	1.9	3.89	11.54	0.05	5.88
Brevoortia spp.	Menhadens	433	2.4	6.09	9.05	1.68	301.47
Dorosoma petenense	Threadfin shad	1	0.3	2.30	12.00	0.00	1.47
Harengula jaguana	Scaled sardine	61	0.8	14.03	6.85	0.24	83.82
Anchoa hepsetus	Striped anchovy	6	1.6	10.23	7.13	0.02	1.47
Anchoa mitchilli	Bay anchovy	4,052	13.2	10.34	7.41	15.76	1,135.29
Synodus foetens	Inshore lizardfish	17	3.4	17.47	3.60	0.07	4.41
Cyprinidae spp.		5	0.3	2.40	15.40	0.02	7.35
Notemigonus crysoleucas	Golden shiner	416	8.2	2.57	13.93	1.62	104.41
Notropis spp.	Notropis shiners	6	0.5	2.43	13.73	0.02	7.35
Notropis harperi	Redeye chub	918	6.1	0.89	12.64	3.57	622.06
Notropis petersoni	Coastal shiner	2,531	18.3	2.90	14.58	9.85	672.06
Erimyzon sucetta	Lake chubsucker	110	2.9	2.69	14.06	0.43	91.18
Ariopsis felis	Hardhead catfish	1	0.3	2.55	12.90	0.00	1.47
Opsanus beta	Gulf toadfish	56	5.0	10.89	5.99	0.22	22.06
Gobiesox strumosus	Skilletfish	1	0.3	18.10	0.10	0.00	1.47
Strongylura spp.	Needlefishes	4	1.1	5.91	10.00	0.02	1.47
Strongylura marina	Atlantic needlefish	9	2.1	5.41	9.63	0.04	2.94
Strongylura notata	Redfin needlefish	261	23.5	11.14	6.66	1.02	27.94
Strongylura timucu	Timucu	209	18.5	4.38	10.84	0.81	38.24
Cyprinodon variegatus	Sheepshead minnow	238	11.6	4.02	11.55	0.93	64.71

Table B1, page 2 of 3. Seine catch statistics for Homosassa River estuary.
(December 2006 to November 2008, n=378).
Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	S_U (psu)	km_U (km)	Mean CPUE (No./Seine)	Max CPUE (No./Seine)
Fundulus confluentus	Marsh killifish	6	1.1	3.35	11.62	0.02	2.94
Fundulus grandis	Gulf killifish	235	7.1	8.32	5.00	0.91	113.24
Fundulus chrysotus	Golden topminnow	2	0.5	2.95	14.60	0.01	1.47
Fundulus similis	Longnose killifish	24	1.6	11.23	3.00	0.09	19.12
Fundulus seminolis	Seminole killifish	383	22.0	2.95	13.73	1.49	27.94
Lucania parva	Rainwater killifish	41,571	72.2	3.38	12.40	161.73	3,207.35
Lucania goodei	Bluefin killifish	4,713	34.7	1.99	13.75	18.34	572.06
Floridichthys carpio	Goldspotted killifish	319	6.6	14.14	2.75	1.24	107.35
Gambusia holbrooki	Eastern mosquitofish	3,372	16.9	1.56	12.70	13.12	1,476.47
Poecilia latipinna	Sailfin molly	707	14.0	3.16	13.47	2.75	183.82
Heterandria formosa	Least killifish	934	19.6	2.74	14.35	3.63	194.12
Menidia spp.	Menidia silversides	32,436	57.1	4.19	11.03	126.19	3,204.41
Syngnathus louisianae	Chain pipefish	1	0.3	16.40	1.50	0.00	1.47
Syngnathus scovelli	Gulf pipefish	322	28.3	4.03	12.30	1.25	29.41
Hippocampus erectus	Lined seahorse	1	0.3	16.85	2.30	0.00	1.47
Hippocampus zosterae	Dwarf seahorse	3	0.8	12.58	1.60	0.01	1.47
Prionotus tribulus	Bighead searobin	5	1.3	10.05	4.40	0.02	1.47
Centropomus undecimalis	Common snook	2	0.5	7.53	8.50	0.01	1.47
Lepomis spp.	Sunfishes	271	11.9	3.05	13.75	1.05	52.94
Lepomis macrochirus	Bluegill	530	17.7	2.37	13.64	2.06	183.82
Lepomis microlophus	Redear sunfish	103	9.5	2.43	13.99	0.40	22.06
Lepomis punctatus	Spotted sunfish	581	20.1	2.67	14.54	2.26	95.59
Micropterus salmoides	Largemouth bass	929	26.5	2.67	12.98	3.61	160.29
Etheostoma fusiforme	Swamp darter	2	0.3	0.30	12.70	0.01	2.94
Echeneis neucratoides	Whitefin sharksucker	1	0.3	5.25	15.50	0.00	1.47
Caranx hippos	Crevalle jack	1	0.3	1.70	12.10	0.00	1.47
Chloroscombrus chrysurus	Atlantic bumper	1	0.3	16.65	5.70	0.00	1.47
Oligoplites saurus	Leatherjack	34	3.4	6.88	8.47	0.13	8.82
Trachinotus falcatus	Permit	1	0.3	7.90	7.10	0.00	1.47
Lutjanus griseus	Gray snapper	74	7.1	4.07	11.14	0.29	19.12
Eucinostomus spp.	Eucinostomus mojarras	8,607	47.9	5.44	9.43	33.48	1,023.53
Eucinostomus gula	Silver jenny	397	17.7	17.55	2.35	1.54	104.41
Eucinostomus harengulus	Tidewater mojarra	4,473	57.9	5.74	9.53	17.40	411.76
Orthopristis chrysoptera	Pigfish	1	0.3	14.90	1.10	0.00	1.47

Table B1, page 3 of 3. Seine catch statistics for Homosassa River estuary.

(December 2006 to November 2008, n=378).

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	S_U (psu)	km_U (km)	Mean CPUE (No./Seine)	Max CPUE (No./Seine)
Lagodon rhomboides	Pinfish	2,983	39.7	11.46	4.87	11.61	517.65
Archosargus probatocephalus	Sheepshead	7	1.9	9.38	7.36	0.03	1.47
Cynoscion nebulosus	Spotted seatrout	14	1.9	13.04	6.79	0.05	10.29
Bairdiella chrysoura	Silver perch	298	3.4	12.33	6.03	1.16	352.94
Leiostomus xanthurus	Spot	688	10.6	12.13	3.85	2.68	216.18
Sciaenops ocellatus	Red drum	3	0.8	9.90	4.50	0.01	1.47
Mugil cephalus	Striped mullet	25	2.4	11.08	4.64	0.10	7.35
Mugil curema	White mullet	18	0.5	5.13	8.23	0.07	25.00
Mugil gyrans	Whirligig mullet	1	0.3	16.90	0.40	0.00	1.47
Chasmodes saburrae	Florida blenny	1	0.3	23.35	0.30	0.00	1.47
Gobiosoma spp.	Gobiosoma gobies	177	14.3	3.79	10.21	0.69	101.47
Gobiosoma bosc	Naked goby	321	24.9	4.45	9.80	1.25	48.53
Gobiosoma robustum	Code goby	6	1.3	14.96	3.42	0.02	2.94
Microgobius gulosus	Clown goby	2,971	51.1	3.59	12.01	11.56	430.88
Paralichthys albigutta	Gulf flounder	4	1.1	17.91	2.28	0.02	1.47
Symphurus plagiusa	Blackcheek tonguefish	1	0.3	19.35	2.90	0.00	1.47
Trinectes maculatus	Hogchoker	156	12.7	3.05	10.36	0.61	57.35
Achirus lineatus	Lined sole	12	1.3	14.62	4.06	0.05	7.35
Monacanthus ciliatus	Fringed filefish	1	0.3	18.25	0.60	0.00	1.47
Stephanolepis hispidus	Planehead filefish	2	0.3	17.30	1.60	0.01	2.94
Acanthostracion quadricornis	Scrawled cowfish	1	0.3	16.90	0.40	0.00	1.47
Sphoeroides nephelus	Southern puffer	22	3.2	17.90	1.96	0.09	10.29
Chilomycterus schoepfii	Striped burrfish	4	1.1	20.31	1.58	0.02	1.47
Pseudemys suwanniensis	Suwannee cooter	1	0.3	1.80	11.80	0.00	1.47

Table B2, page 1 of 2. Trawl catch statistics for Homosassa River estuary

(December 2006 to November 2008, n=54).

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	S_U (psu)	km_U (km)	Mean CPUE (No./trawl)	Max CPUE (No./trawl)
Farfantepenaeus duorarum	Pink shrimp	45	25.9	6.99	8.19	0.13	2.87
Palaemonetes spp.	Palaemonetes grass shrimps	3	5.6	3.50	10.24	0.01	0.15
Palaemonetes intermedius	Brackish grass shrimp	118	38.9	4.00	11.50	0.34	5.10
Palaemonetes paludosus	Riverine grass shrimp	27	13.0	2.70	12.14	0.09	2.47
Palaemonetes pugio	Daggerblade grass shrimp	26	9.3	3.12	12.55	0.07	2.10
Callinectes sapidus	Blue crab	769	83.3	4.75	9.65	2.07	17.40
Dasyatis sabina	Atlantic stingray	8	11.1	4.30	8.77	0.02	0.30
Dasyatis say	Bluntnose stingray	1	1.9	11.58	6.10	0.00	0.15
Lepisosteus osseus	Longnose gar	3	3.7	3.94	9.56	0.01	0.25
Lepisosteus platyrhincus	Florida gar	1	1.9	4.45	13.70	0.00	0.17
Anchoa hepsetus	Striped anchovy	1	1.9	15.80	5.90	0.00	0.22
Anchoa mitchilli	Bay anchovy	612	14.8	3.32	10.24	1.56	74.47
Synodus foetens	Inshore lizardfish	6	5.6	14.59	6.20	0.02	0.90
Erimyzon sucetta	Lake chubsucker	1	1.9	2.90	13.70	0.00	0.15
Ariopsis felis	Hardhead catfish	12	7.4	5.02	10.73	0.03	1.05
Opsanus beta	Gulf toadfish	6	11.1	8.56	6.84	0.02	0.17
Fundulus confluentus	Marsh killifish	3	1.9	2.05	12.30	0.01	0.67
Fundulus seminolis	Seminole killifish	2	3.7	2.74	13.61	0.01	0.15
Lucania parva	Rainwater killifish	1,012	50.0	2.63	12.32	3.30	56.81
Lucania goodei	Bluefin killifish	3	3.7	3.49	10.50	0.01	0.27
Gambusia holbrooki	Eastern mosquitofish	1	1.9	2.10	10.30	0.00	0.22
Poecilia latipinna	Sailfin molly	1	1.9	3.00	12.80	0.00	0.15
Menidia spp.	Menidia silversides	13	5.6	2.93	13.03	0.04	1.35
Syngnathus louisianae	Chain pipefish	2	3.7	8.78	6.73	0.01	0.17
Syngnathus scovelli	Gulf pipefish	157	35.2	2.92	11.56	0.44	5.25
Prionotus tribulus	Bighead searobin	6	9.3	8.67	6.84	0.02	0.27
Lepomis spp.	Sunfishes	12	1.9	2.90	13.70	0.03	1.80
Lepomis macrochirus	Bluegill	1	1.9	2.90	13.70	0.00	0.15
Lepomis microlophus	Redear sunfish	1	1.9	2.90	13.70	0.00	0.15
Lepomis punctatus	Spotted sunfish	2	1.9	2.90	13.70	0.01	0.30

Table B3, page 1 of 5. Seine catch by month for Homosassa River

(December 2006 to November 2008)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Jan (42)	Feb (21)	Mar (42)	Apr (21)	May (42)	Jun (21)	Jul (42)	Aug (21)	Sep (42)	Oct (21)	Nov (42)	Dec (21)	Tot (378)
Farfantepenaeus duorarum	Pink shrimp	3	2	2	.	1	1	.	4	53	17	3	21	107
Palaemonetes spp.	Palaemonetes grass shrimps	27	48	.	1	8	40	27	2	1	9	8	73	244
Palaemonetes intermedius	Brackish grass shrimp	1,108	293	534	18	430	55	808	18	358	116	643	322	4,703
Palaemonetes paludosus	Riverine grass shrimp	159	116	178	56	164	52	141	17	362	1,039	151	24	2,459
Palaemonetes pugio	Daggerblade grass shrimp	342	52	89	10	858	27	708	4	140	33	254	51	2,568
Palaemon floridanus	Florida grass shrimp	.	.	36	.	.	1	.	.	.	.	.	.	37
Alpheidae spp.	Snapping shrimp	1	.	.	.	.	.	.	.	.	.	.	1	2
Hippolyte zostericola	Zostera shrimp	2	.	.	.	.	2	.	.	.	.	.	33	37
Callinectes sapidus	Blue crab	81	387	88	78	178	58	23	5	32	12	24	256	1,222
Dasyatis sabina	Atlantic stingray	.	.	.	.	.	.	1	2	1	1	.	.	5
Dasyatis say	Bluntnose stingray	.	.	.	.	.	1	2	.	.	.	.	.	3
Lepisosteus spp.	Gars	.	.	.	.	3	.	.	.	.	.	.	.	3
Lepisosteus osseus	Longnose gar	1	.	.	.	.	.	1	1	.	.	.	.	3
Lepisosteus platyrhincus	Florida gar	3	.	1	1	6	1	7	.	2	.	.	3	24
Elops saurus	Ladyfish	.	.	.	.	9	.	2	1	.	.	.	.	12
Brevoortia spp.	Menhadens	.	.	.	1	337	86	9	.	.	.	.	.	433
Dorosoma petenense	Threadfin shad	.	.	.	.	.	1	.	.	.	.	.	.	1
Harengula jaguana	Scaled sardine	.	.	.	.	.	.	60	.	1	.	.	.	61
Anchoa hepsetus	Striped anchovy	.	.	.	.	2	1	2	.	1	.	.	.	6
Anchoa mitchilli	Bay anchovy	.	22	50	.	180	177	1,236	55	859	606	7	860	4,052
Synodus foetens	Inshore lizardfish	.	.	.	1	3	1	4	.	2	4	1	1	17

Table B3, page 2 of 5. Seine catch by month for Homosassa River

(December 2006 to November 2008)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Jan (42)	Feb (21)	Mar (42)	Apr (21)	May (42)	Jun (21)	Jul (42)	Aug (21)	Sep (42)	Oct (21)	Nov (42)	Dec (21)	Tot (378)
Cyprinidae spp.	Carps and minnows	.	.	.	.	5	.	.	.	.	.	.	.	5
Notemigonus crysoleucas	Golden shiner	1	.	.	43	88	49	142	67	18	8	.	.	416
Notropis spp.	Notropis shiners	.	.	.	.	.	.	6	.	.	.	.	.	6
Notropis harperi	Redeye chub	55	2	64	8	282	17	3	429	3	54	1	.	918
Notropis petersoni	Coastal shiner	26	.	61	42	369	143	346	476	649	99	227	93	2,531
Erimyzon sucetta	Lake chubsucker	.	.	1	9	84	15	1	.	.	.	.	.	110
Ariopsis felis	Hardhead catfish	.	.	.	.	.	.	.	.	1	.	.	.	1
Opsanus beta	Gulf toadfish	2	3	.	3	27	15	3	1	1	.	1	.	56
Gobiesox strumosus	Skilletfish	.	.	.	.	.	.	.	.	.	.	.	1	1
Strongylura spp.	Needlefishes	.	.	.	.	3	.	1	.	.	.	.	.	4
Strongylura marina	Atlantic needlefish	.	3	.	.	1	1	1	1	.	.	1	1	9
Strongylura notata	Redfin needlefish	42	21	9	1	13	11	58	22	26	15	38	5	261
Strongylura timucu	Timucu	32	6	10	1	6	3	24	23	15	8	70	11	209
Cyprinodon variegatus	Sheepshead minnow	12	46	26	29	58	.	16	.	9	25	11	6	238
Fundulus confluentus	Marsh killifish	3	.	1	.	.	.	.	.	.	.	2	.	6
Fundulus grandis	Gulf killifish	118	31	27	25	13	.	.	.	3	.	1	17	235
Fundulus chrysotus	Golden topminnow	1	.	.	.	1	.	.	.	.	.	.	.	2
Fundulus similis	Longnose killifish	14	2	.	8	.	.	.	.	.	.	.	.	24
Fundulus seminolis	Seminole killifish	4	3	16	30	92	27	67	26	53	18	6	41	383
Lucania parva	Rainwater killifish	4,365	880	3,095	4,727	10,379	4,350	4,978	978	3,159	1,614	1,384	1,662	41,571
Lucania goodei	Bluefin killifish	793	87	117	444	600	503	319	597	502	415	185	151	4,713
Floridichthys carpio	Goldspotted killifish	22	106	35	5	56	3	.	.	49	.	3	40	319

Table B3, page 3 of 5. Seine catch by month for Homosassa River

(December 2006 to November 2008)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Jan (42)	Feb (21)	Mar (42)	Apr (21)	May (42)	Jun (21)	Jul (42)	Aug (21)	Sep (42)	Oct (21)	Nov (42)	Dec (21)	Tot (378)
Gambusia holbrooki	Eastern mosquitofish	2,191	72	27	47	408	182	326	9	7	3	12	88	3,372
Poecilia latipinna	Sailfin molly	76	20	10	27	203	76	131	.	9	56	20	79	707
Heterandria formosa	Least killifish	191	4	60	56	287	18	76	42	83	66	39	12	934
Menidia spp.	Menidia silversides	135	396	1,046	997	7,747	3,725	11,070	3,209	2,553	749	314	495	32,436
Syngnathus louisianae	Chain pipefish	.	.	.	.	.	.	.	.	1	.	.	.	1
Syngnathus scovelli	Gulf pipefish	27	15	30	26	114	25	21	10	24	3	11	16	322
Hippocampus erectus	Lined seahorse	.	.	.	.	.	.	.	.	.	.	1	.	1
Hippocampus zosterae	Dwarf seahorse	2	.	.	.	.	.	.	.	.	.	.	1	3
Prionotus tribulus	Bighead searobin	.	.	1	.	.	.	.	.	.	.	1	3	5
Centropomus undecimalis	Common snook	.	.	.	.	2	.	.	.	.	.	.	.	2
Lepomis spp.	Sunfishes	1	.	1	1	103	86	15	34	9	10	2	9	271
Lepomis macrochirus	Bluegill	21	19	18	7	38	8	146	177	36	16	28	16	530
Lepomis microlophus	Redear sunfish	2	1	8	1	26	8	11	9	19	12	4	2	103
Lepomis punctatus	Spotted sunfish	33	17	91	39	127	70	79	12	11	25	37	40	581
Micropterus salmoides	Largemouth bass	15	8	21	239	453	83	41	34	6	5	8	16	929
Etheostoma fusiforme	Swamp darter	2	.	.	.	.	.	.	.	.	.	.	.	2
Echeneis neucratoides	Whitefin sharksucker	.	.	.	.	.	.	.	.	1	.	.	.	1
Caranx hippos	Crevalle jack	1	.	.	.	.	.	.	.	.	.	.	.	1
Chloroscombrus chrysurus	Atlantic bumper	.	.	.	.	.	.	.	.	.	1	.	.	1
Oligoplites saurus	Leatherjack	.	.	.	.	.	.	8	16	3	7	.	.	34
Trachinotus falcatus	Permit	.	.	.	.	.	.	.	1	.	.	.	.	1
Lutjanus griseus	Gray snapper	19	1	12	.	4	.	1	.	2	9	24	2	74

Table B3, page 4 of 5. Seine catch by month for Homosassa River

(December 2006 to November 2008)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Jan (42)	Feb (21)	Mar (42)	Apr (21)	May (42)	Jun (21)	Jul (42)	Aug (21)	Sep (42)	Oct (21)	Nov (42)	Dec (21)	Tot (378)
Eucinostomus spp.	Eucinostomus mojarras	1,037	329	491	39	16	.	905	714	1,064	363	1,626	2,023	8,607
Eucinostomus gula	Silver jenny	10	36	19	10	23	14	6	18	128	14	112	7	397
Eucinostomus harengulus	Tidewater mojarra	53	129	699	197	379	100	274	388	611	618	698	327	4,473
Orthopristis chrysoptera	Pigfish	.	.	1	.	.	.	.	.	.	.	.	.	1
Lagodon rhomboides	Pinfish	226	251	825	320	813	180	98	115	99	42	10	4	2,983
Archosargus probatocephalus	Sheepshead	.	.	.	1	2	1	1	1	.	1	.	.	7
Cynoscion nebulosus	Spotted seatrout	.	.	.	.	2	.	9	1	2	.	.	.	14
Bairdiella chrysoura	Silver perch	.	.	1	.	254	3	40	.	.	.	.	.	298
Leiostomus xanthurus	Spot	88	275	206	33	78	2	.	.	.	.	.	6	688
Sciaenops ocellatus	Red drum	.	.	1	.	.	.	.	.	.	.	2	.	3
Mugil cephalus	Striped mullet	6	5	4	.	4	.	.	.	.	.	.	6	25
Mugil curema	White mullet	.	.	.	.	1	17	.	.	.	.	.	.	18
Mugil gyrans	Whirligig mullet	.	.	.	.	.	.	.	.	1	.	.	.	1
Chasmodes saburrae	Florida blenny	.	.	.	.	1	.	.	.	.	.	.	.	1
Gobiosoma spp.	Gobiosoma gobies	26	4	2	.	88	2	17	2	10	2	17	7	177
Gobiosoma bosc	Naked goby	109	17	27	7	16	20	42	1	18	8	37	19	321
Gobiosoma robustum	Code goby	.	.	5	.	1	.	.	.	.	.	.	.	6
Microgobius gulosus	Clown goby	43	37	64	109	1,015	481	473	304	285	51	23	86	2,971
Paralichthys albigutta	Gulf flounder	.	.	.	1	2	1	.	.	.	.	.	.	4
Symphurus plagiusa	Blackcheek tonguefish	.	.	.	.	.	.	.	1	.	.	.	.	1
Trinectes maculatus	Hogchoker	4	2	12	1	19	9	8	2	36	3	5	55	156
Achirus lineatus	Lined sole	.	.	.	1	.	.	5	.	6	.	.	.	12

Table B3, page 5 of 5. Seine catch by month for Homosassa River

(December 2006 to November 2008)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Jan (42)	Feb (21)	Mar (42)	Apr (21)	May (42)	Jun (21)	Jul (42)	Aug (21)	Sep (42)	Oct (21)	Nov (42)	Dec (21)	Tot (378)
Monacanthus ciliatus	Fringed filefish	.	.	.	.	.	.	.	.	.	.	.	1	1
Stephanolepis hispidus	Planehead filefish	.	.	.	.	.	.	.	.	.	.	2	.	2
Acanthostracion quadricornis	Scrawled cowfish	.	.	.	.	.	.	.	.	1	.	.	.	1
Sphoeroides nephelus	Southern puffer	.	.	.	4	3	9	1	.	.	.	3	2	22
Chilomycterus schoepfii	Striped burrfish	.	.	.	.	.	2	2	.	.	.	.	.	4
Pseudemys suwanniensis	Suwannee cooter	.	.	.	.	.	.	.	1	.	.	.	.	1
Totals		11,535	3,748	8,122	7,704	26,485	10,763	22,802	7,830	11,325	6,157	6,057	6,995	129,523

Table B4, page 1 of 3. Trawl catch by month for Homosassa River

(December 2006 to November 2008)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Jan (6)	Feb (3)	Mar (6)	Apr (3)	May (6)	Jun (3)	Jul (6)	Aug (3)	Sep (6)	Oct (3)	Nov (6)	Dec (3)	Tot (54)
Farfantepenaeus duorarum	Pink shrimp	2	.	4	.	.	1	.	1	20	8	7	2	45
Palaemonetes spp.	Palaemonetes grass shrimps	.	.	.	.	.	.	.	.	.	.	1	2	3
Palaemonetes intermedius	Brackish grass shrimp	14	1	8	.	42	27	.	.	5	14	3	4	118
Palaemonetes paludosus	Riverine grass shrimp	7	1	1	.	15	3	.	.	.	.	.	.	27
Palaemonetes pugio	Daggerblade grass shrimp	3	.	.	.	.	8	.	.	.	14	1	.	26
Callinectes sapidus	Blue crab	22	39	86	41	262	39	102	69	35	14	31	29	769
Dasyatis sabina	Atlantic stingray	3	.	.	.	1	.	.	1	.	.	1	2	8
Dasyatis say	Bluntnose stingray	.	.	.	.	.	.	1	.	.	.	.	.	1
Lepisosteus osseus	Longnose gar	.	1	.	2	.	.	.	.	.	.	.	.	3
Lepisosteus platyrhincus	Florida gar	.	.	.	.	.	.	.	.	1	.	.	.	1
Anchoa hepsetus	Striped anchovy	.	.	.	.	.	.	1	.	.	.	.	.	1
Anchoa mitchilli	Bay anchovy	14	.	.	.	.	1	1	1	593	2	.	.	612
Synodus foetens	Inshore lizardfish	.	.	.	.	.	.	4	.	.	1	1	.	6
Erimyzon sucetta	Lake chubsucker	.	.	.	.	.	1	.	.	.	.	.	.	1
Ariopsis felis	Hardhead catfish	.	.	.	.	.	.	10	.	2	.	.	.	12
Opsanus beta	Gulf toadfish	.	.	1	.	2	1	.	.	.	.	2	.	6
Fundulus confluentus	Marsh killifish	3	.	.	.	.	.	.	.	.	.	.	.	3
Fundulus seminolis	Seminole killifish	.	.	.	.	.	1	1	.	.	.	.	.	2
Lucania parva	Rainwater killifish	270	11	33	28	152	380	42	.	4	43	44	5	1,012
Lucania goodei	Bluefin killifish	2	.	.	.	.	.	.	.	.	.	1	.	3
Gambusia holbrooki	Eastern mosquitofish	1	.	.	.	.	.	.	.	.	.	.	.	1
Poecilia latipinna	Sailfin molly	.	.	.	.	.	.	.	.	.	1	.	.	1

Table B4, page 2 of 3. Trawl catch by month for Homosassa River

(December 2006 to November 2008)

Organisms are listed in phylogenetic order.

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Tot*
Taxon	*Common Name*	(6)	(3)	(6)	(3)	(6)	(3)	(6)	(3)	(6)	(3)	(6)	(3)	(54)
Menidia spp.	Menidia silversides	.	.	.	.	.	2	2	.	.	9	.	.	13
Syngnathus louisianae	Chain pipefish	.	.	.	.	.	1	.	.	1	.	.	.	2
Syngnathus scovelli	Gulf pipefish	14	4	12	31	50	36	.	.	1	1	4	4	157
Prionotus tribulus	Bighead searobin	2	.	.	.	.	1	.	1	.	2	.	.	6
Lepomis spp.	Sunfishes	.	.	.	.	.	12	.	.	.	.	.	.	12
Lepomis macrochirus	Bluegill	.	.	.	.	.	1	.	.	.	.	.	.	1
Lepomis microlophus	Redear sunfish	.	.	.	.	.	1	.	.	.	.	.	.	1
Lepomis punctatus	Spotted sunfish	.	.	.	.	.	2	.	.	.	.	.	.	2
Micropterus salmoides	Largemouth bass	.	.	.	1	.	3	.	.	.	.	.	.	4
Echeneis neucratoides	Whitefin sharksucker	.	.	.	.	.	.	.	.	.	.	.	1	1
Lutjanus griseus	Gray snapper	.	.	4	1	1	.	.	.	1	.	11	.	18
Eucinostomus spp.	Eucinostomus mojarras	77	11	3	18	1	.	118	4	1,085	284	114	66	1,781
Eucinostomus gula	Silver jenny	.	1	.	1	.	.	1	.	1	.	6	2	12
Eucinostomus harengulus	Tidewater mojarra	12	2	4	21	13	20	32	21	207	133	56	5	526
Lagodon rhomboides	Pinfish	2	16	148	3	21	11	15	15	5	8	4	.	248
Cynoscion nebulosus	Spotted seatrout	.	2	.	.	.	.	.	.	2	.	.	.	4
Bairdiella chrysoura	Silver perch	.	.	.	.	5	.	2	3	6	.	.	.	16
Leiostomus xanthurus	Spot	7	.	1	.	3	9	2	3	.	4	.	.	29
Chaetodipterus faber	Atlantic spadefish	.	.	.	.	.	.	3	.	.	.	.	.	3
Gobiosoma spp.	Gobiosoma gobies	.	.	.	2	34	.	.	.	.	1	.	.	37
Gobiosoma bosc	Naked goby	5	.	2	.	22	.	9	.	1	2	1	2	44
Microgobius gulosus	Clown goby	4	.	4	67	246	30	19	2	13	1	1	.	387

Table B4, page 3 of 3. Trawl catch by month for Homosassa River

(December 2006 to November 2008)

Organisms are listed in phylogenetic order.

Taxon	*Common Name*	*Jan* (6)	*Feb* (3)	*Mar* (6)	*Apr* (3)	*May* (6)	*Jun* (3)	*Jul* (6)	*Aug* (3)	*Sep* (6)	*Oct* (3)	*Nov* (6)	*Dec* (3)	*Tot* (54)
Symphurus plagiusa	Blackcheek tonguefish	.	.	.	.	.	1	1	.	.	.	.	.	2
Trinectes maculatus	Hogchoker	.	4	1	21	4	6	23	13	18	21	8	12	131
Achirus lineatus	Lined sole	.	.	1	.	.	.	.	.	.	1	.	.	2
Sphoeroides nephelus	Southern puffer	1	.	.	1	.	1	2	.	.	.	1	.	6
Pseudemys suwanniensis	Suwannee cooter	.	.	.	.	.	.	1	.	.	.	.	.	1
Pseudemys peninsularis	Peninsula cooter	.	.	.	.	.	.	.	.	.	1	.	.	1
Totals		465	93	313	238	874	599	392	134	2,001	565	298	136	6,108

Table B5, page 1 of 5.

Location-specific seine catch.

Organisms are listed in phylogenetic order.

		Homosassa River					Halls River		
Taxon	Common Name	0 – 2.79 km (54)	2.8 – 5.79 km (54)	5.8 – 8.59 km (54)	8.6 – 11.19 km (54)	11.2 – 12.99 km (54)	11.2 – 14.09 km (54)	14.1 – 16.7 km (54)	Total (378)
Farfantepenaeus duorarum	Pink shrimp	17	19	9	62	.	.	.	107
Palaemonetes spp.	Palaemonetes grass shrimps	70	75	2	18	2	46	31	244
Palaemonetes intermedius	Brackish grass shrimp	2,420	713	132	380	213	174	671	4,703
Palaemonetes paludosus	Riverine grass shrimp	8	.	1	30	198	83	2,139	2,459
Palaemonetes pugio	Daggerblade grass shrimp	1	4	94	1,062	403	667	337	2,568
Palaemon floridanus	Florida grass shrimp	37	.	.	.	.	.	.	37
Alpheidae spp.	Snapping shrimp	2	.	.	.	.	.	.	2
Hippolyte zostericola	Zostera shrimp	37	.	.	.	.	.	.	37
Callinectes sapidus	Blue crab	155	292	350	346	14	56	9	1,222
Dasyatis sabina	Atlantic stingray	1	.	2	1	.	.	1	5
Dasyatis say	Bluntnose stingray	.	.	.	.	1	1	1	3
Lepisosteus spp.	Gars	.	.	.	.	.	.	3	3
Lepisosteus osseus	Longnose gar	.	.	.	.	.	2	1	3
Lepisosteus platyrhincus	Florida gar	.	.	1	4	9	6	4	24
Elops saurus	Ladyfish	.	.	.	5	3	4	.	12
Brevoortia spp.	Menhadens	.	3	196	225	1	8	.	433
Dorosoma petenense	Threadfin shad	.	.	.	.	.	1	.	1
Harengula jaguana	Scaled sardine	.	.	61	.	.	.	.	61
Anchoa hepsetus	Striped anchovy	.	1	4	1	.	.	.	6
Anchoa mitchilli	Bay anchovy	4	1,035	1,444	1,523	28	18	.	4,052

Table B5, page 2 of 5.

Location-specific seine catch.

Organisms are listed in phylogenetic order.

Taxon	Common Name	Homosassa River 0 – 2.79 km (54)	Homosassa River 2.8 – 5.79 km (54)	Homosassa River 5.8 – 8.59 km (54)	Homosassa River 8.6 – 11.19 km (54)	Homosassa River 11.2 – 12.99 km (54)	Halls River 11.2 – 14.09 km (54)	Halls River 14.1 – 16.7 km (54)	Total (378)
Synodus foetens	Inshore lizardfish	7	7	3	.	.	.	.	17
Cyprinidae spp.	Carps and minnows	.	.	.	.	.	.	5	5
Notemigonus crysoleucas	Golden shiner	.	.	.	.	103	116	197	416
Notropis spp.	Notropis shiners	.	.	.	.	1	.	5	6
Notropis harperi	Redeye chub	.	.	.	.	902	16	.	918
Notropis petersoni	Coastal shiner	.	.	.	1	113	782	1,635	2,531
Erimyzon sucetta	Lake chubsucker	.	.	.	.	3	82	25	110
Ariopsis felis	Hardhead catfish	.	.	.	.	.	1	.	1
Opsanus beta	Gulf toadfish	6	19	26	5	.	.	.	56
Gobiesox strumosus	Skilletfish	1	.	.	.	.	.	.	1
Strongylura spp.	Needlefishes	.	.	1	1	2	.	.	4
Strongylura marina	Atlantic needlefish	1	1	1	.	5	1	.	9
Strongylura notata	Redfin needlefish	50	80	28	50	24	11	18	261
Strongylura timucu	Timucu	5	11	26	62	42	27	36	209
Cyprinodon variegatus	Sheepshead minnow	7	7	1	58	.	141	24	238
Fundulus confluentus	Marsh killifish	.	.	1	.	.	5	.	6
Fundulus grandis	Gulf killifish	25	123	67	9	1	8	2	235
Fundulus chrysotus	Golden topminnow	.	.	.	.	.	.	2	2
Fundulus similis	Longnose killifish	7	17	.	.	.	.	.	24
Fundulus seminolis	Seminole killifish	.	.	.	18	49	159	157	383

Table B5, page 3 of 5.

Location-specific seine catch.

Organisms are listed in phylogenetic order.

Taxon	Common Name	Homosassa River 0 – 2.79 km (54)	Homosassa River 2.8 – 5.79 km (54)	Homosassa River 5.8 – 8.59 km (54)	Homosassa River 8.6 – 11.19 km (54)	Homosassa River 11.2 – 12.99 km (54)	Halls River 11.2 – 14.09 km (54)	Halls River 14.1 – 16.7 km (54)	Total (378)
Lucania parva	Rainwater killifish	803	610	202	8,542	7,155	12,344	11,915	41,571
Lucania goodei	Bluefin killifish	.	.	.	47	2,399	327	1,940	4,713
Floridichthys carpio	Goldspotted killifish	150	168	1	.	.	.	.	319
Gambusia holbrooki	Eastern mosquitofish	.	.	.	79	2,372	394	527	3,372
Poecilia latipinna	Sailfin molly	10	29	10	15	63	158	422	707
Heterandria formosa	Least killifish	.	.	.	11	183	133	607	934
Menidia spp.	Menidia silversides	587	885	5,507	7,330	4,919	8,474	4,734	32,436
Syngnathus louisianae	Chain pipefish	1	.	.	.	.	.	.	1
Syngnathus scovelli	Gulf pipefish	18	7	6	48	28	92	123	322
Hippocampus erectus	Lined seahorse	1	.	.	.	.	.	.	1
Hippocampus zosterae	Dwarf seahorse	3	.	.	.	.	.	.	3
Prionotus tribulus	Bighead searobin	2	1	2	.	.	.	.	5
Centropomus undecimalis	Common snook	.	.	1	1	.	.	.	2
Lepomis spp.	Sunfishes	.	.	.	22	44	76	129	271
Lepomis macrochirus	Bluegill	.	.	4	5	125	194	202	530
Lepomis microlophus	Redear sunfish	.	.	.	.	39	9	55	103
Lepomis punctatus	Spotted sunfish	.	.	2	5	64	80	430	581
Micropterus salmoides	Largemouth bass	.	.	2	95	343	189	300	929
Etheostoma fusiforme	Swamp darter	.	.	.	.	2	.	.	2
Echeneis neucratoides	Whitefin sharksucker	.	.	.	.	.	.	1	1

Table B5, page 4 of 5.

Location-specific seine catch.

Organisms are listed in phylogenetic order.

Taxon	Common Name	Homosassa River 0 – 2.79 km (54)	Homosassa River 2.8 – 5.79 km (54)	Homosassa River 5.8 – 8.59 km (54)	Homosassa River 8.6 – 11.19 km (54)	Homosassa River 11.2 – 12.99 km (54)	Halls River 11.2 – 14.09 km (54)	Halls River 14.1 – 16.7 km (54)	Total (378)
Caranx hippos	Crevalle jack	.	.	.	.	1	.	.	1
Chloroscombrus chrysurus	Atlantic bumper	.	.	1	.	.	.	.	1
Oligoplites saurus	Leatherjack	.	1	16	17	.	.	.	34
Trachinotus falcatus	Permit	.	.	1	.	.	.	.	1
Lutjanus griseus	Gray snapper	2	6	3	7	45	6	5	74
Eucinostomus spp.	Eucinostomus mojarras	561	709	1,147	3,065	1,655	1,282	188	8,607
Eucinostomus gula	Silver jenny	214	170	12	1	.	.	.	397
Eucinostomus harengulus	Tidewater mojarra	115	432	642	1,798	654	648	184	4,473
Orthopristis chrysoptera	Pigfish	1	.	.	.	.	.	.	1
Lagodon rhomboides	Pinfish	1,330	382	728	470	56	5	12	2,983
Archosargus probatocephalus	Sheepshead	1	1	2	3	.	.	.	7
Cynoscion nebulosus	Spotted seatrout	1	1	9	3	.	.	.	14
Bairdiella chrysoura	Silver perch	48	1	249	.	.	.	.	298
Leiostomus xanthurus	Spot	301	226	87	74	.	.	.	688
Sciaenops ocellatus	Red drum	1	1	1	.	.	.	.	3
Mugil cephalus	Striped mullet	10	1	12	.	.	1	1	25
Mugil curema	White mullet	.	.	17	1	.	.	.	18
Mugil gyrans	Whirligig mullet	1	.	.	.	.	.	.	1
Chasmodes saburrae	Florida blenny	1	.	.	.	.	.	.	1
Gobiosoma spp.	Gobiosoma gobies	4	8	7	112	16	25	5	177

Table B5, page 5 of 5.

Location-specific seine catch.

Organisms are listed in phylogenetic order.

Taxon	Common Name	Homosassa River 0 – 2.79 km (54)	Homosassa River 2.8 – 5.79 km (54)	Homosassa River 5.8 – 8.59 km (54)	Homosassa River 8.6 – 11.19 km (54)	Homosassa River 11.2 – 12.99 km (54)	Halls River 11.2 – 14.09 km (54)	Halls River 14.1 – 16.7 km (54)	Total (378)
Gobiosoma bosc	Naked goby	9	37	10	159	49	39	18	321
Gobiosoma robustum	Code goby	4	1	.	1	.	.	.	6
Microgobius gulosus	Clown goby	37	67	80	731	479	1,079	498	2,971
Paralichthys albigutta	Gulf flounder	3	1	.	.	.	.	.	4
Symphurus plagiusa	Blackcheek tonguefish	.	1	.	.	.	.	.	1
Trinectes maculatus	Hogchoker	.	1	1	103	21	28	2	156
Achirus lineatus	Lined sole	3	8	1	.	.	.	.	12
Monacanthus ciliatus	Fringed filefish	1	.	.	.	.	.	.	1
Stephanolepis hispidus	Planehead filefish	2	.	.	.	.	.	.	2
Acanthostracion quadricornis	Scrawled cowfish	1	.	.	.	.	.	.	1
Sphoeroides nephelus	Southern puffer	16	2	4	.	.	.	.	22
Chilomycterus schoepfii	Striped burrfish	3	1	.	.	.	.	.	4
Pseudemys suwanniensis	Suwannee cooter	.	.	.	.	.	1	.	1
Totals		7,106	6,165	11,217	26,606	22,829	27,999	27,601	129,523

Table B6, page 1 of 2.

Location-specific trawl catch.

Organisms are listed in phylogenetic order.

		Homosassa River		Halls River	
Taxon	Common Name	5.8 – 8.59 km (18)	8.6 – 11.19 km (18)	11.2 – 14.09 km (18)	Total (54)
Farfantepenaeus duorarum	Pink shrimp	31	13	1	45
Palaemonetes spp.	Palaemonetes grass shrimps	1	.	2	3
Palaemonetes intermedius	Brackish grass shrimp	20	7	91	118
Palaemonetes paludosus	Riverine grass shrimp	.	.	27	27
Palaemonetes pugio	Daggerblade grass shrimp	1	1	24	26
Callinectes sapidus	Blue crab	226	357	186	769
Dasyatis sabina	Atlantic stingray	4	3	1	8
Dasyatis say	Bluntnose stingray	1	.	.	1
Lepisosteus osseus	Longnose gar	1	2	.	3
Lepisosteus platyrhincus	Florida gar	.	.	1	1
Anchoa hepsetus	Striped anchovy	1	.	.	1
Anchoa mitchilli	Bay anchovy	57	555	.	612
Synodus foetens	Inshore lizardfish	6	.	.	6
Erimyzon sucetta	Lake chubsucker	.	.	1	1
Ariopsis felis	Hardhead catfish	3	2	7	12
Opsanus beta	Gulf toadfish	5	1	.	6
Fundulus confluentus	Marsh killifish	.	.	3	3
Fundulus seminolis	Seminole killifish	.	.	2	2
Lucania parva	Rainwater killifish	5	182	825	1,012
Lucania goodei	Bluefin killifish	1	.	2	3
Gambusia holbrooki	Eastern mosquitofish	.	1	.	1
Poecilia latipinna	Sailfin molly	.	.	1	1
Menidia spp.	Menidia silversides	.	.	13	13
Syngnathus louisianae	Chain pipefish	2	.	.	2
Syngnathus scovelli	Gulf pipefish	5	71	81	157
Prionotus tribulus	Bighead searobin	6	.	.	6
Lepomis spp.	Sunfishes	.	.	12	12
Lepomis macrochirus	Bluegill	.	.	1	1
Lepomis microlophus	Redear sunfish	.	.	1	1

Table B6, page 2 of 2.

Location-specific trawl catch.

Organisms are listed in phylogenetic order.

		Homosassa River		Halls River	
Taxon	Common Name	5.8 – 8.59 km (18)	8.6 – 11.19 km (18)	11.2 – 14.09 km (18)	Total (54)
Lepomis punctatus	Spotted sunfish	.	.	2	2
Micropterus salmoides	Largemouth bass	.	1	3	4
Echeneis neucratoides	Whitefin sharksucker	1	.	.	1
Lutjanus griseus	Gray snapper	16	2	.	18
Eucinostomus spp.	Eucinostomus mojarras	106	1,316	359	1,781
Eucinostomus gula	Silver jenny	12	.	.	12
Eucinostomus harengulus	Tidewater mojarra	60	298	168	526
Lagodon rhomboides	Pinfish	125	113	10	248
Cynoscion nebulosus	Spotted seatrout	2	2	.	4
Bairdiella chrysoura	Silver perch	16	.	.	16
Leiostomus xanthurus	Spot	18	11	.	29
Chaetodipterus faber	Atlantic spadefish	3	.	.	3
Gobiosoma spp.	Gobiosoma gobies	1	6	30	37
Gobiosoma bosc	Naked goby	1	30	13	44
Microgobius gulosus	Clown goby	17	206	164	387
Symphurus plagiusa	Blackcheek tonguefish	2	.	.	2
Trinectes maculatus	Hogchoker	23	65	43	131
Achirus lineatus	Lined sole	1	1	.	2
Sphoeroides nephelus	Southern puffer	6	.	.	6
Pseudemys suwanniensis	Suwannee cooter	.	.	1	1
Pseudemys peninsularis	Peninsula cooter	.	.	1	1
Totals		786	3,246	2,076	6,108

Appendix C: Length-frequency plots for selected taxa

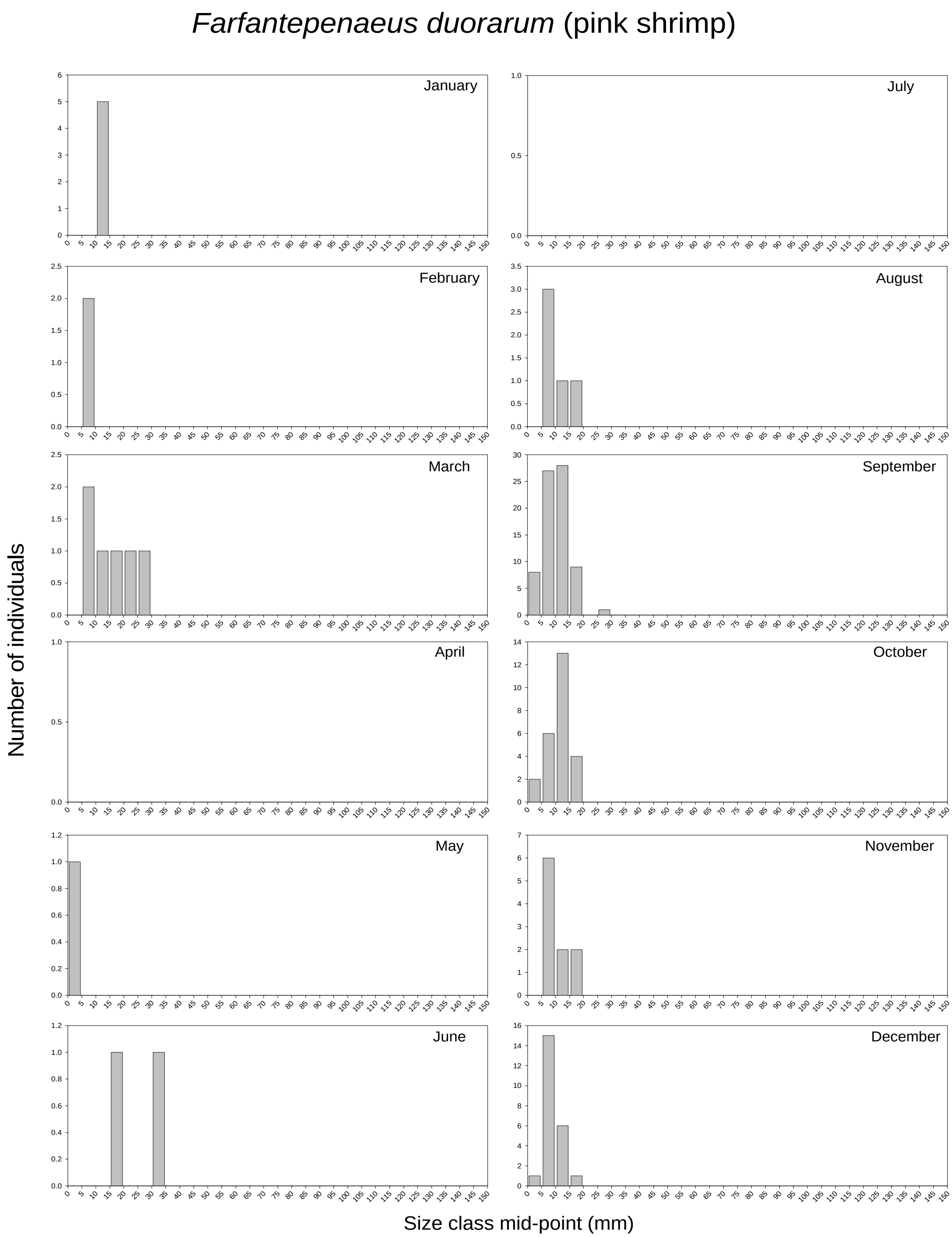


Fig. C1. Monthly length frequencies of *Farfantepenaeus duorarum* (pink shrimp) collected in the Homosassa River estuary.

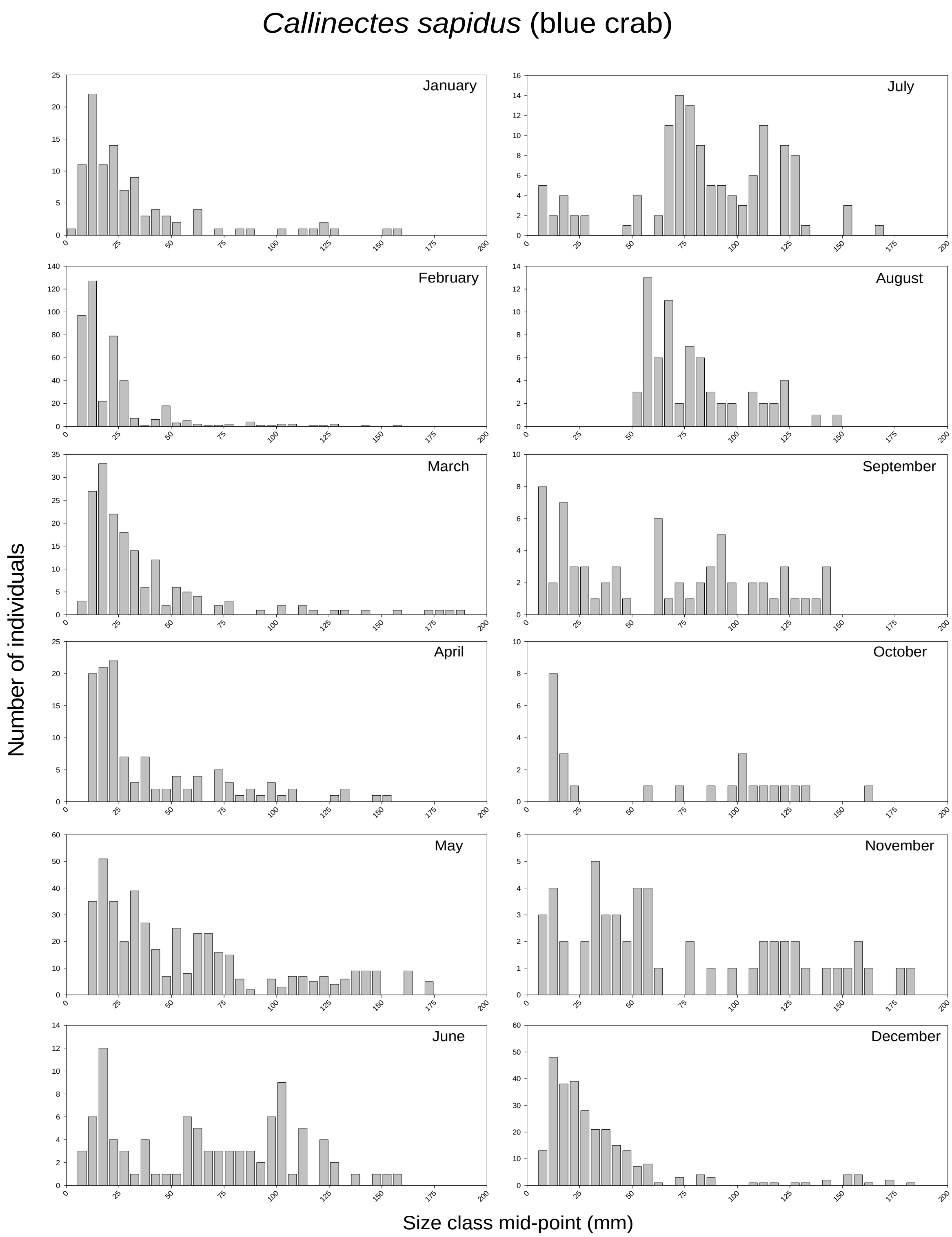


Fig. C2. Monthly length frequencies of *Callinectes sapidus* (blue crab) collected in the Homosassa River estuary.

Anchoa mitchilli (bay anchovy)

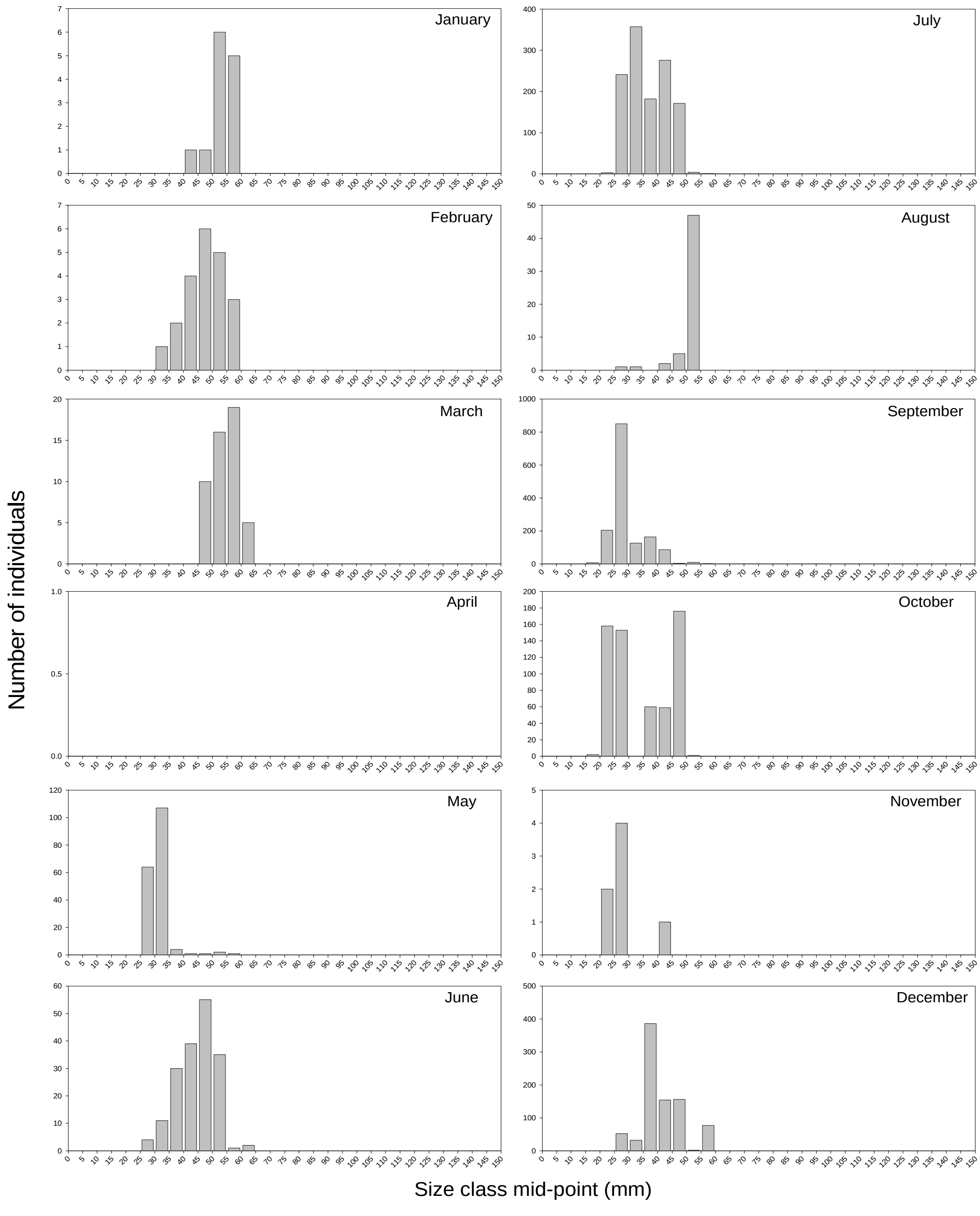


Fig. C3. Monthly length frequencies of *Anchoa mitchilli* (bay anchovy) collected in the Homosassa River estuary.

Notemigonus crysoleucas (golden shiner)

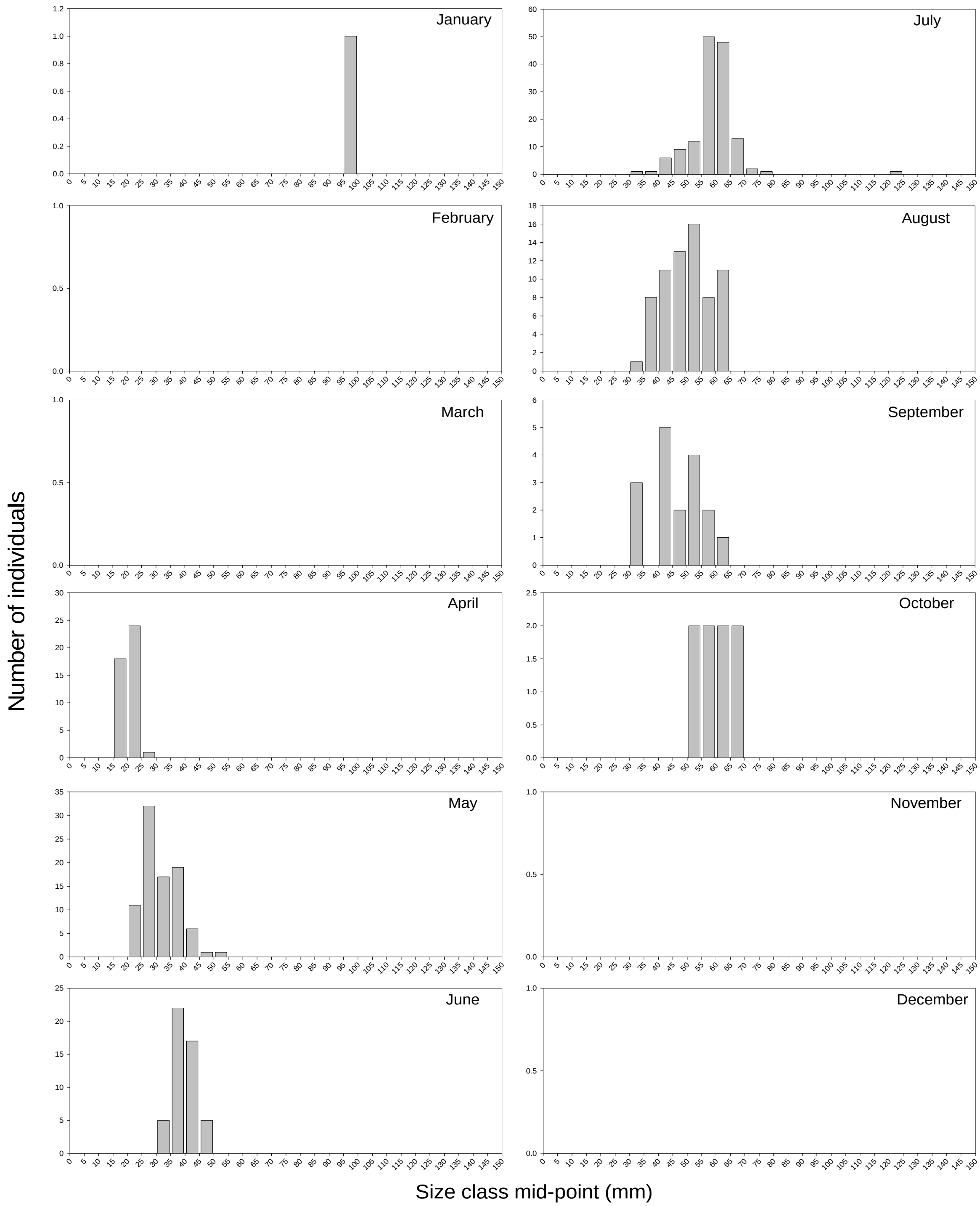


Fig. C4. Monthly length frequencies of *Notemigonus crysoleucas* (golden shiner) collected in the Homosassa River estuary.

Notropis harperi (redeye chub)

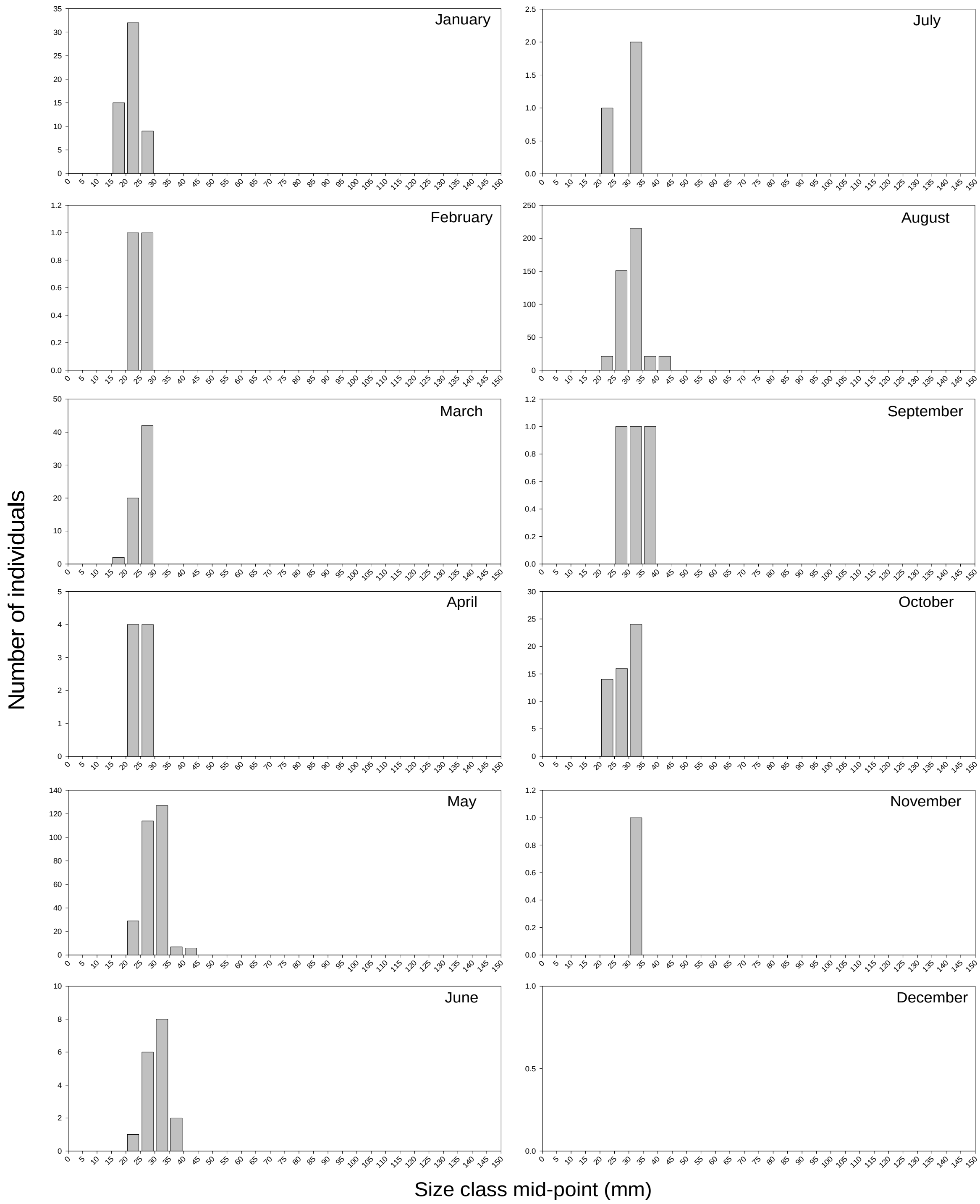


Fig. C5. Monthly length frequencies of *Notropis harperi* (redeye chub) collected in the Homosassa River estuary.

Notropis petersoni (coastal shiner)

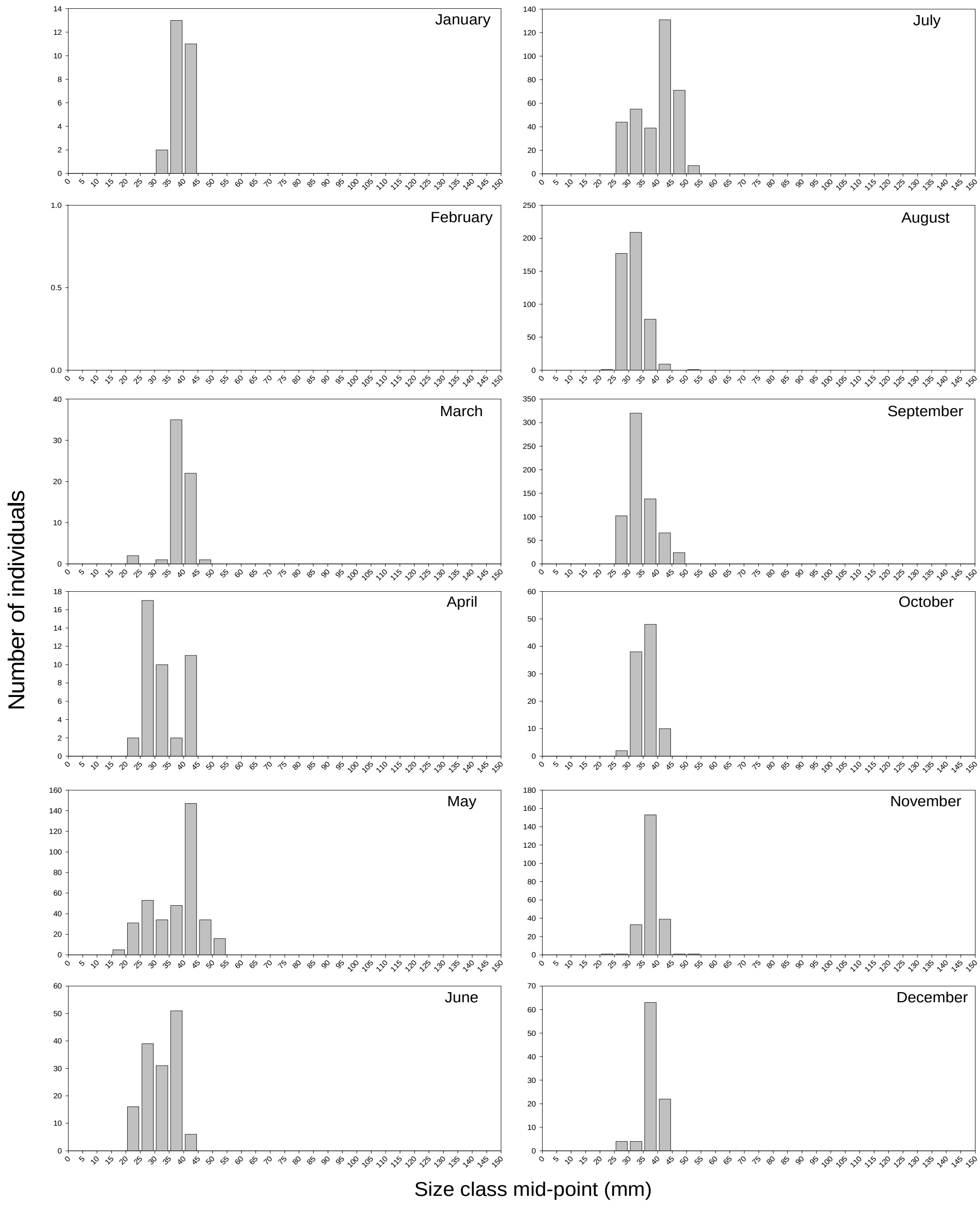


Fig. C6. Monthly length frequencies of *Notropis petersoni* (coastal shiner) collected in the Homosassa River estuary.

Opsanus beta (Gulf toadfish)

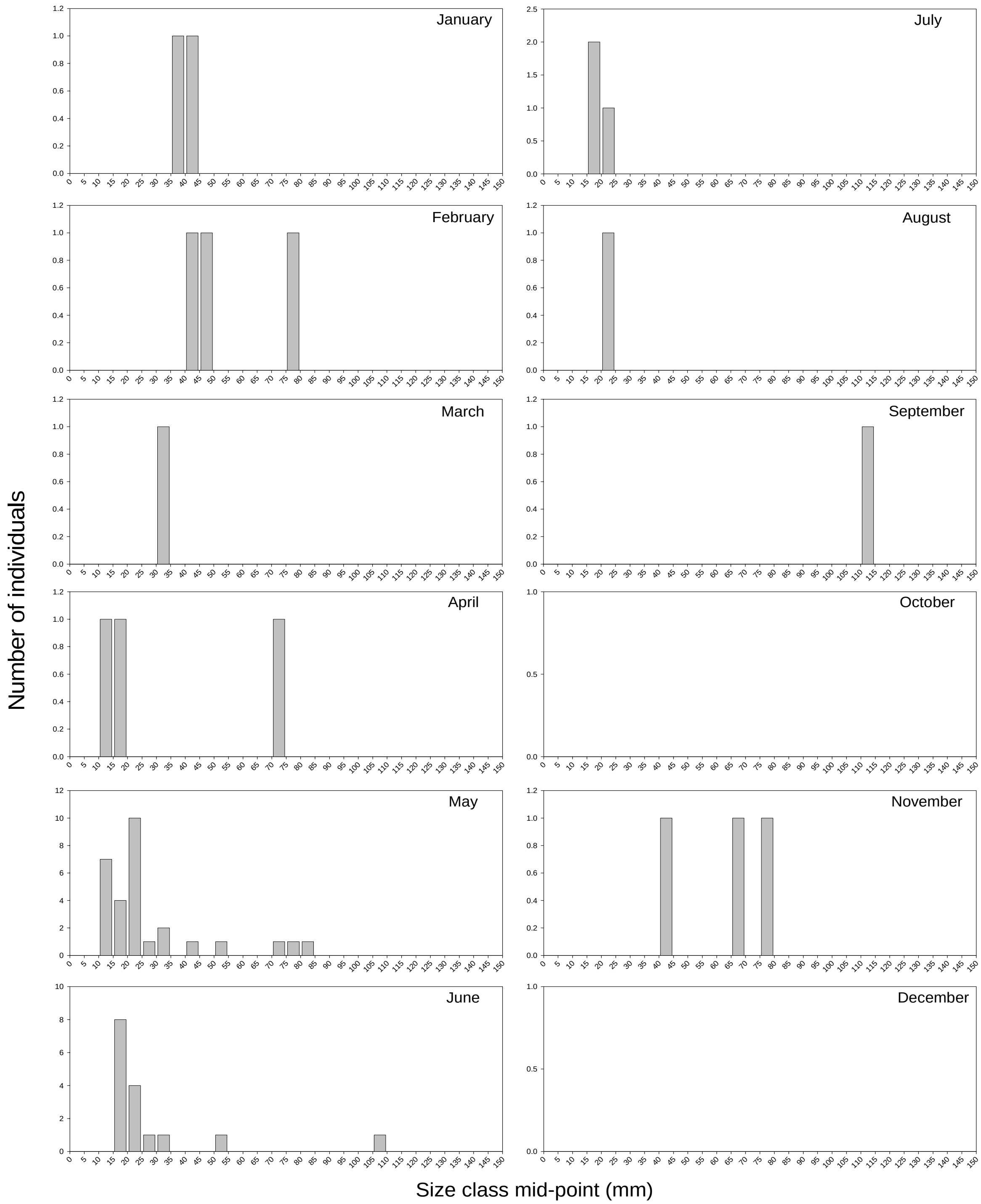


Fig. C7. Monthly length frequencies of *Opsanus beta* (Gulf toadfish) collected in the Homosassa River estuary.

Strongylura notata (redfin needlefish)

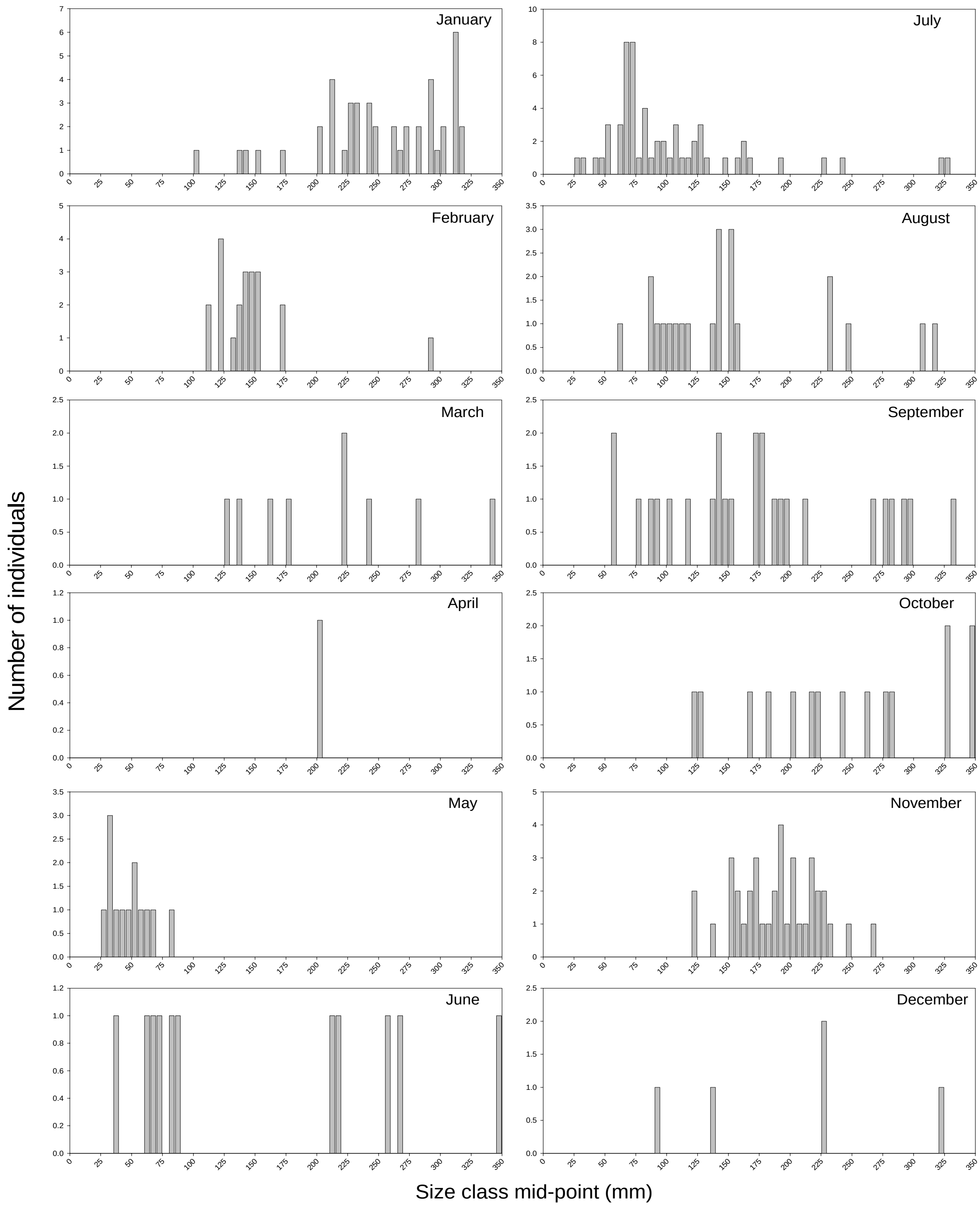


Fig. C8. Monthly length frequencies of *Strongylura notata* (redfin needlefish) collected in the Homosassa River estuary.

Strongylura timucu (timucu)

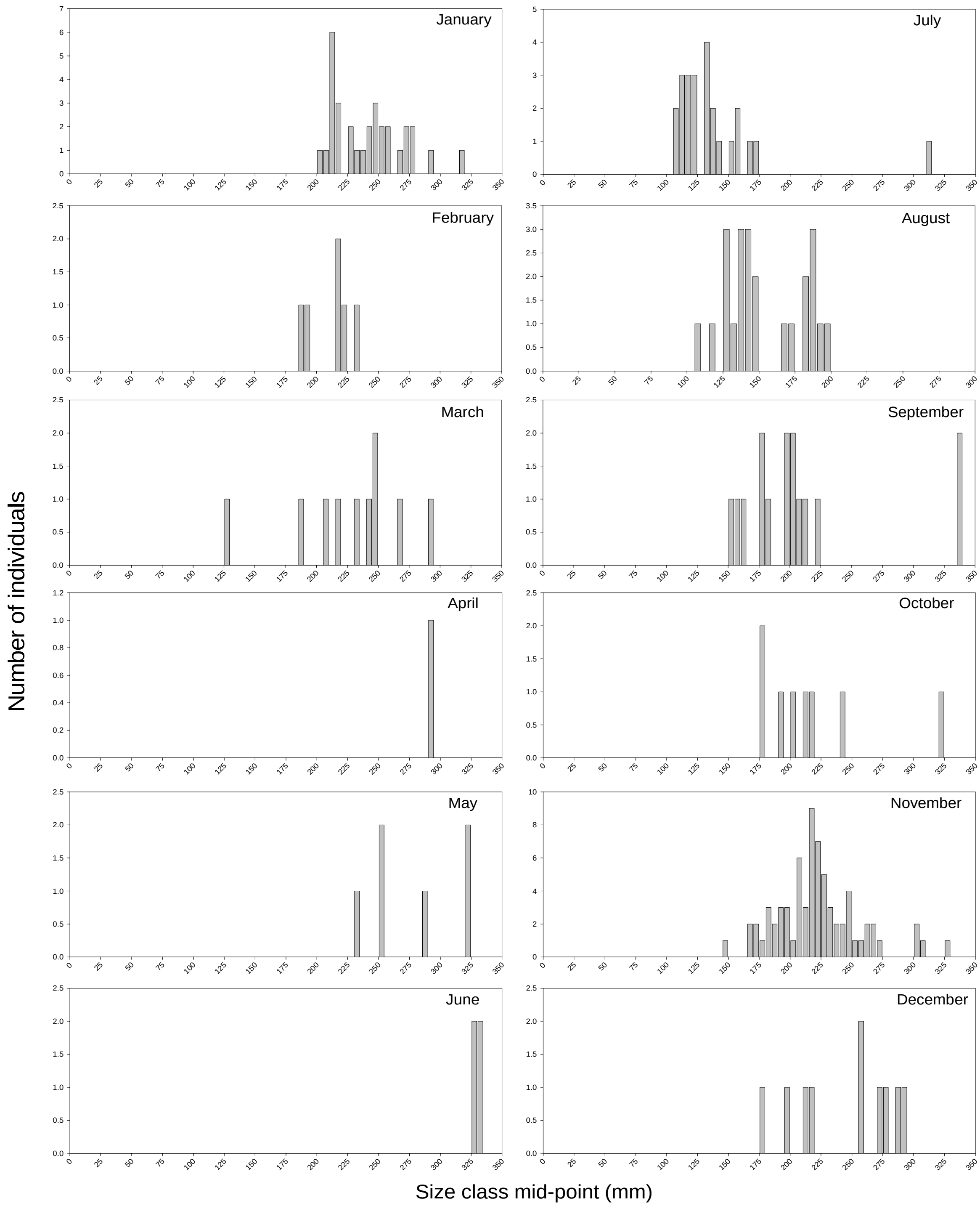


Fig. C9. Monthly length frequencies of *Strongylura timucu* (timucu) collected in the Homosassa River estuary.

Cyprinodon variegatus (sheepshead minnow)

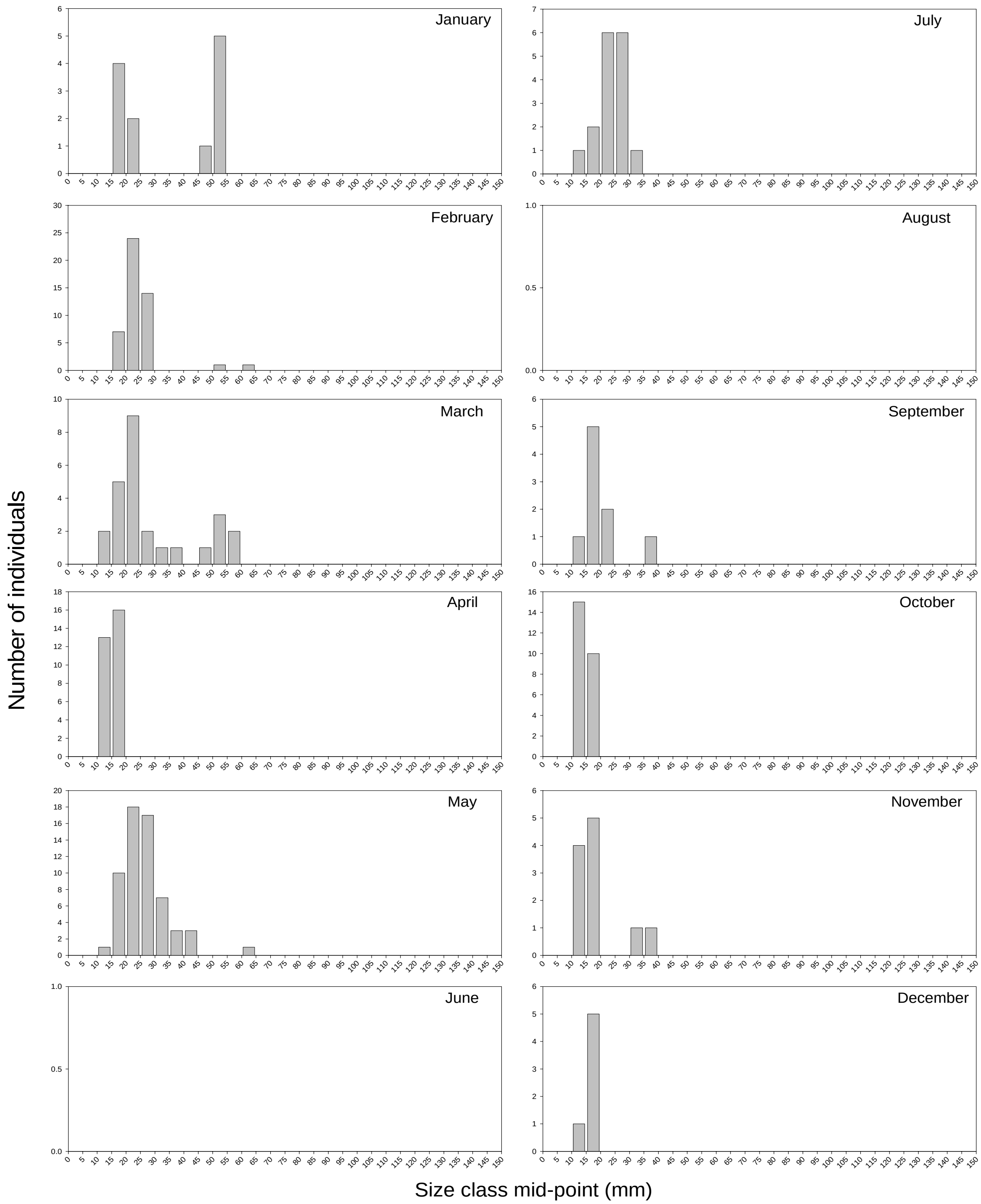


Fig. C10. Monthly length frequencies of *Cyprinodon variegatus* (sheepshead minnow) collected in the Homosassa River estuary.

Fundulus grandis (Gulf killifish)

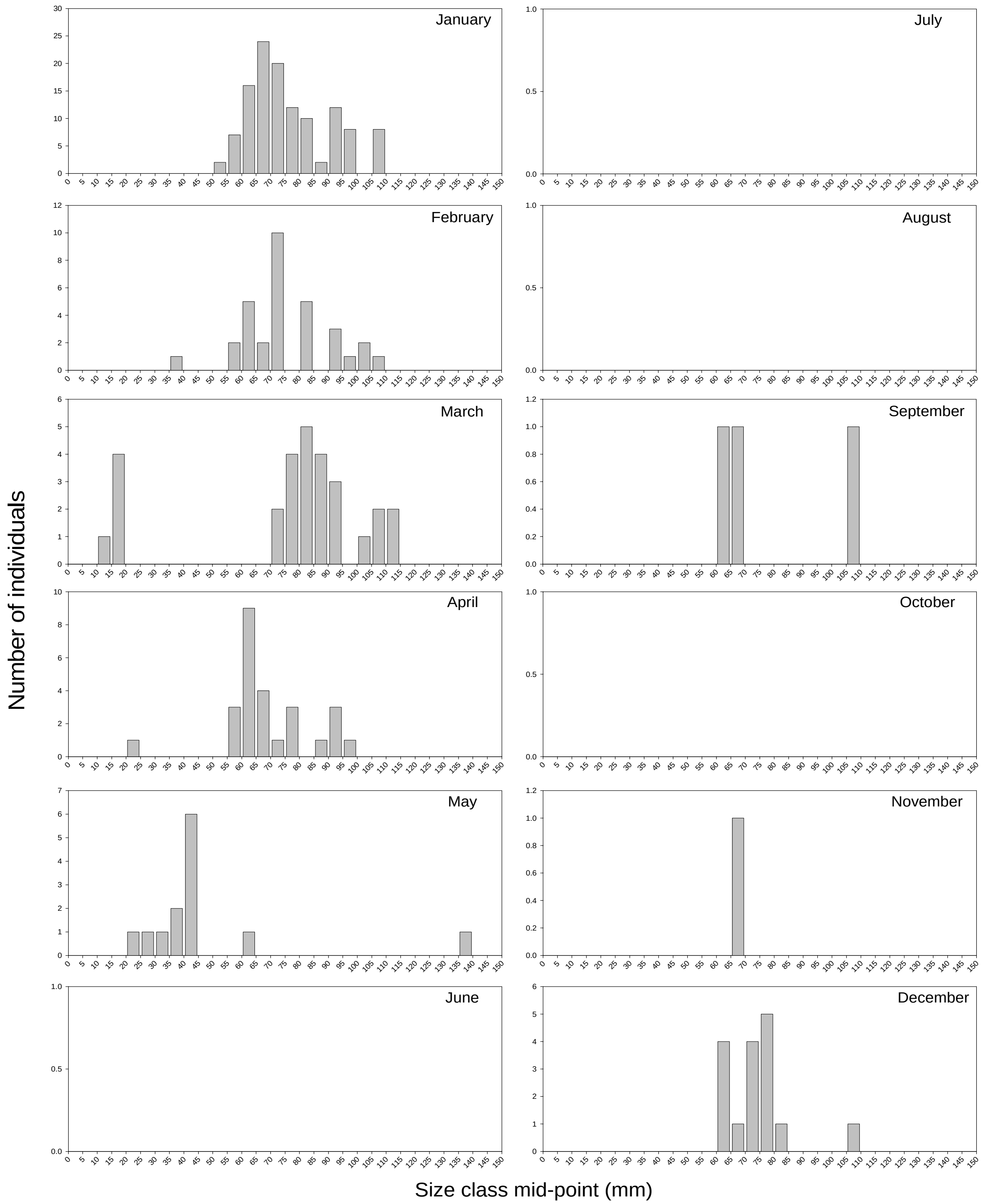


Fig. C11. Monthly length frequencies of *Fundulus grandis* (Gulf killifish) collected in the Homosassa River estuary.

Fundulus seminolis (Seminole killifish)

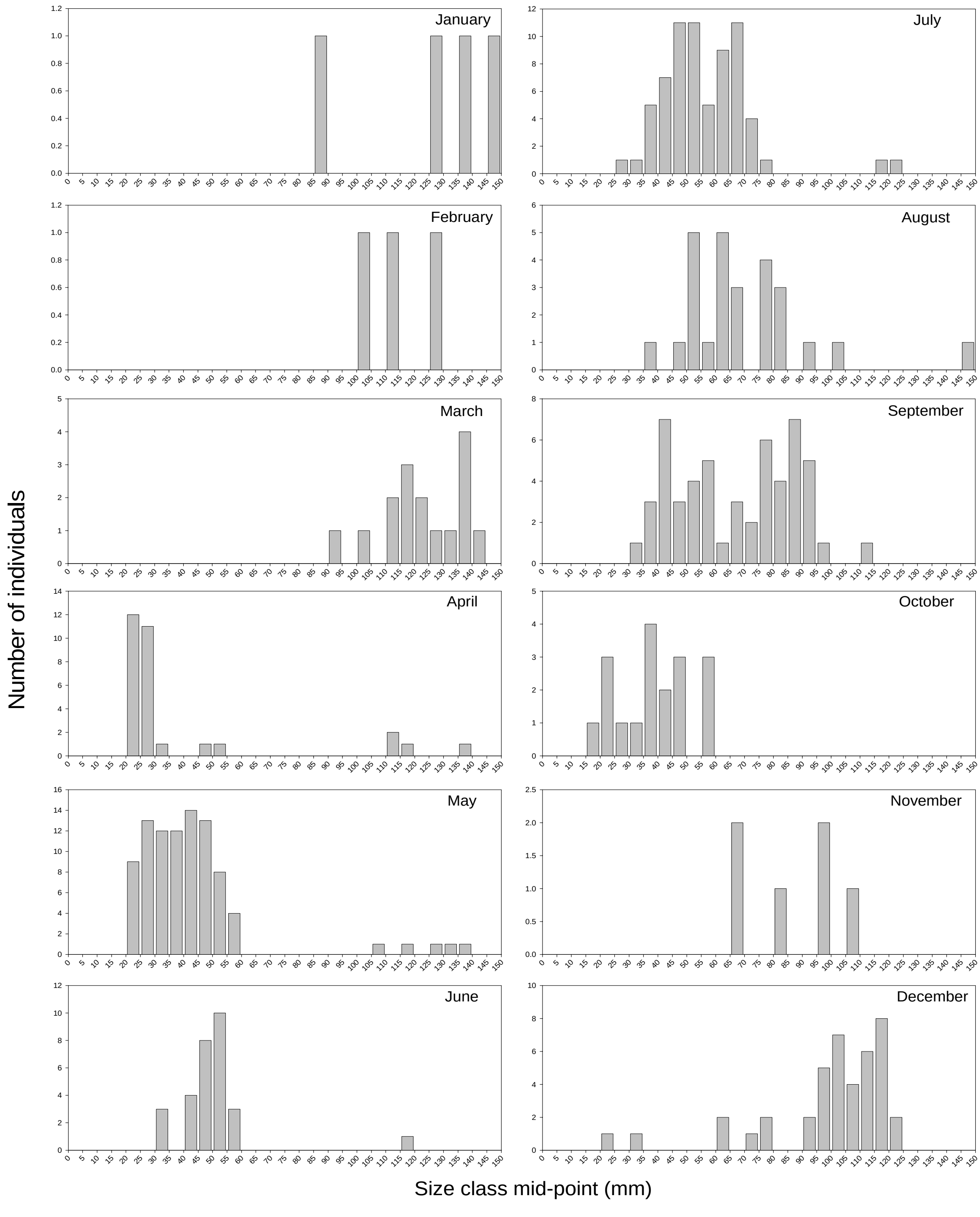


Fig. C12. Monthly length frequencies of *Fundulus seminolis* (Seminole killifish) collected in the Homosassa River estuary.

Lucania parva (rainwater killifish)

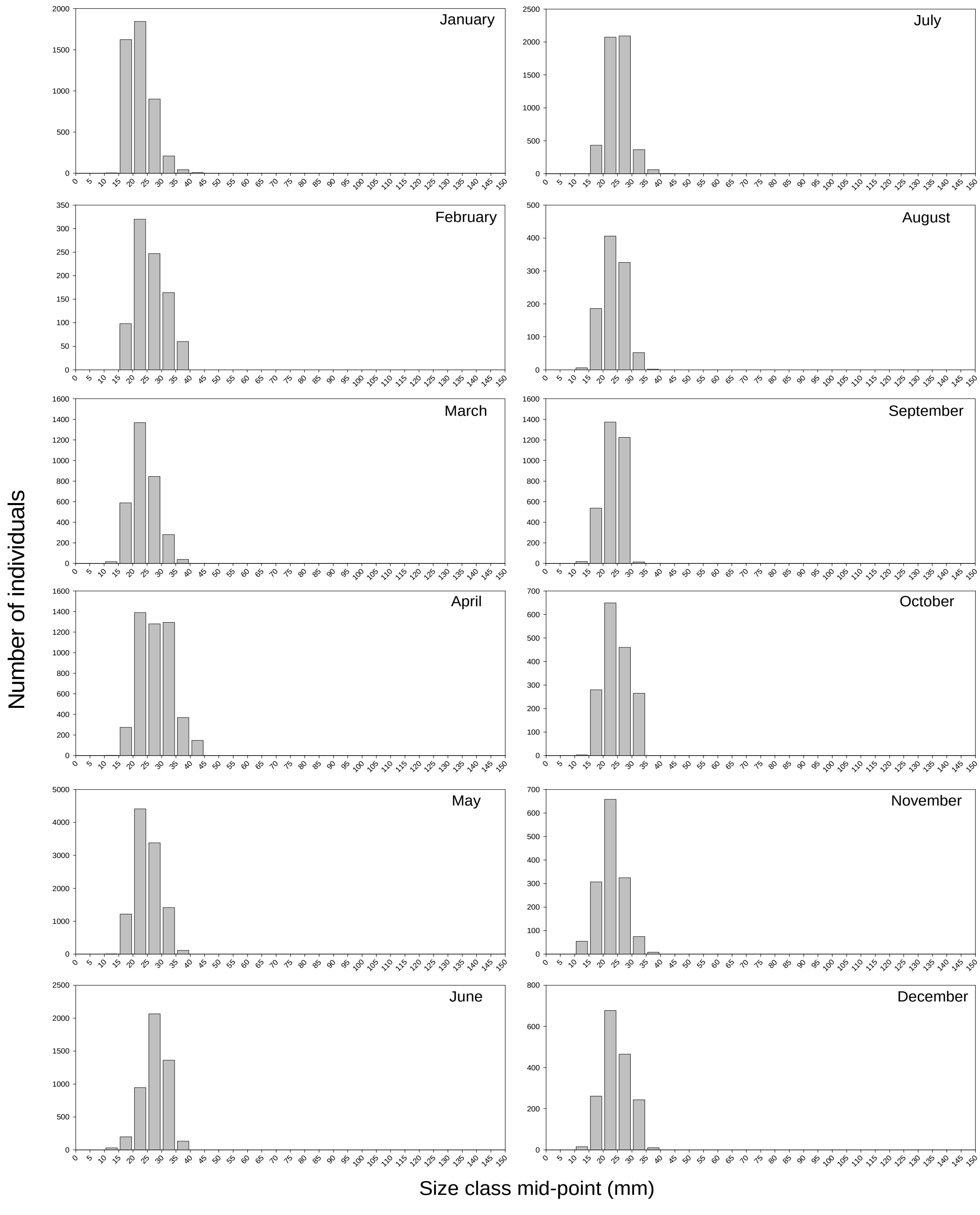


Fig. C13. Monthly length frequencies of *Lucania parva* (rainwater killifish) collected in the Homosassa River estuary.

Lucania goodei (bluefin killifish)

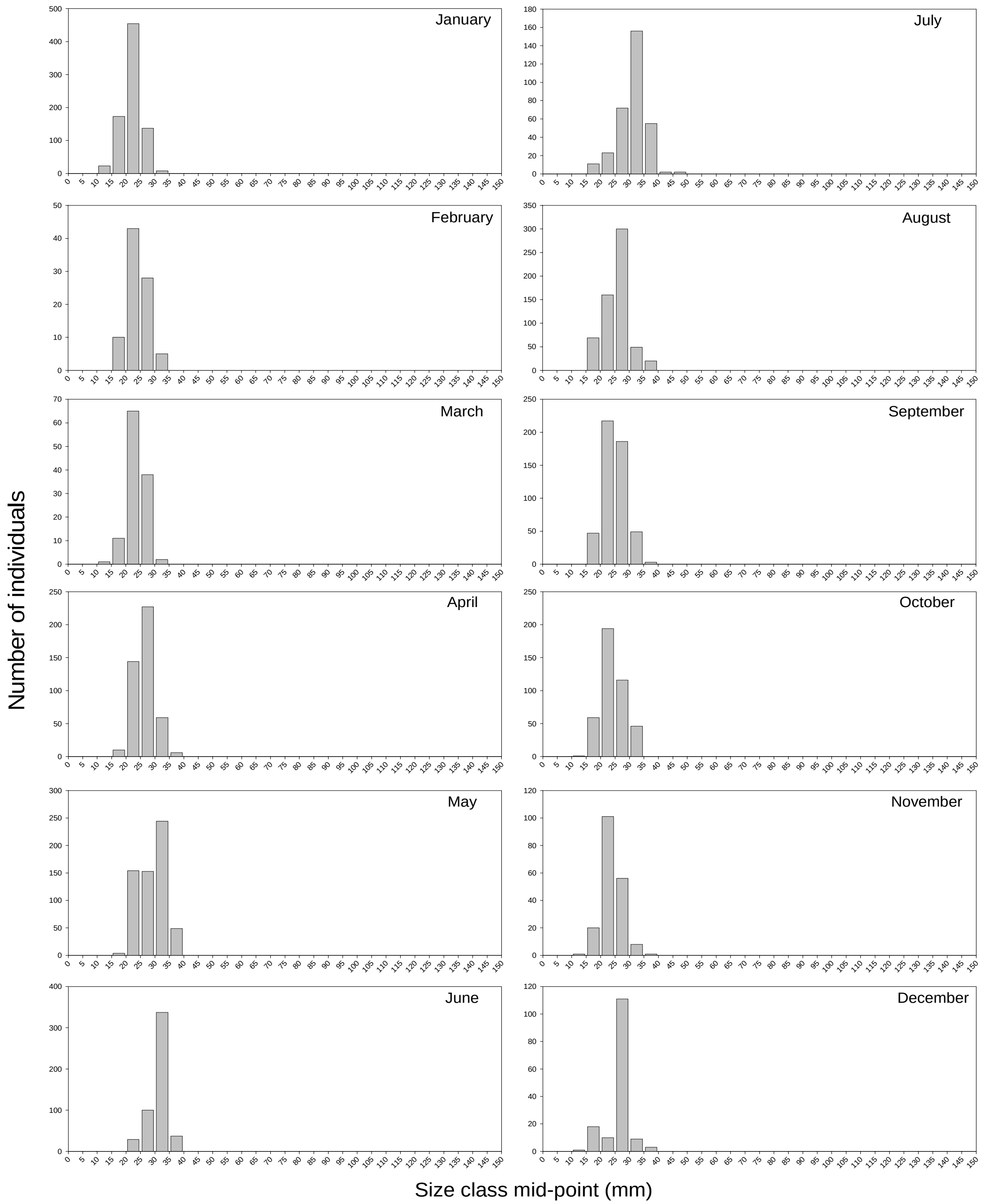


Fig. C14. Monthly length frequencies of *Lucania goodei* (bluefin killifish) collected in the Homosassa River estuary.

Floridichthys carpio (goldspotted killifish)

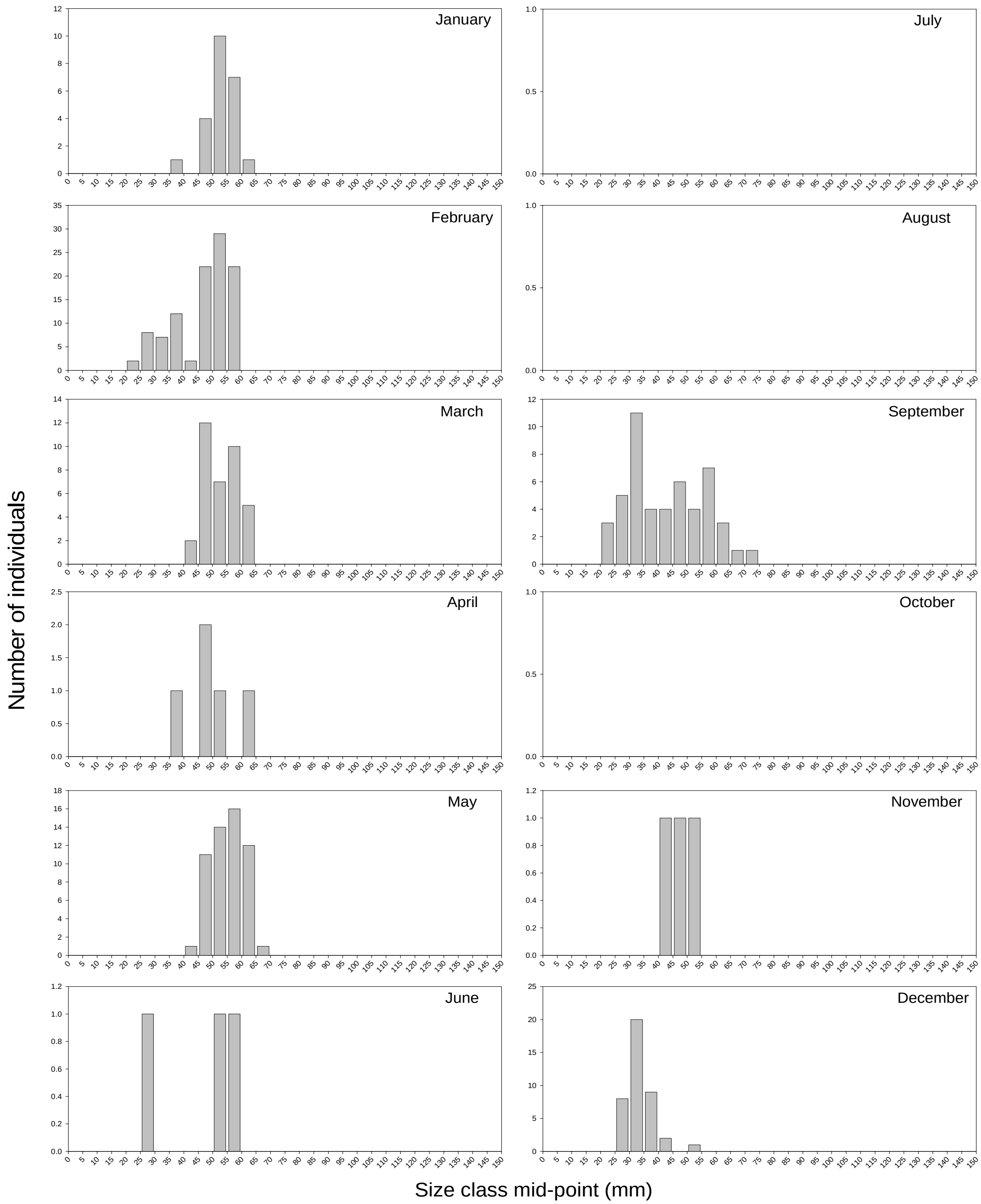


Fig. C15. Monthly length frequencies of *Floridichthys carpio* (goldspotted killifish) collected in the Homosassa River estuary.

Gambusia holbrooki (Eastern mosquitofish)

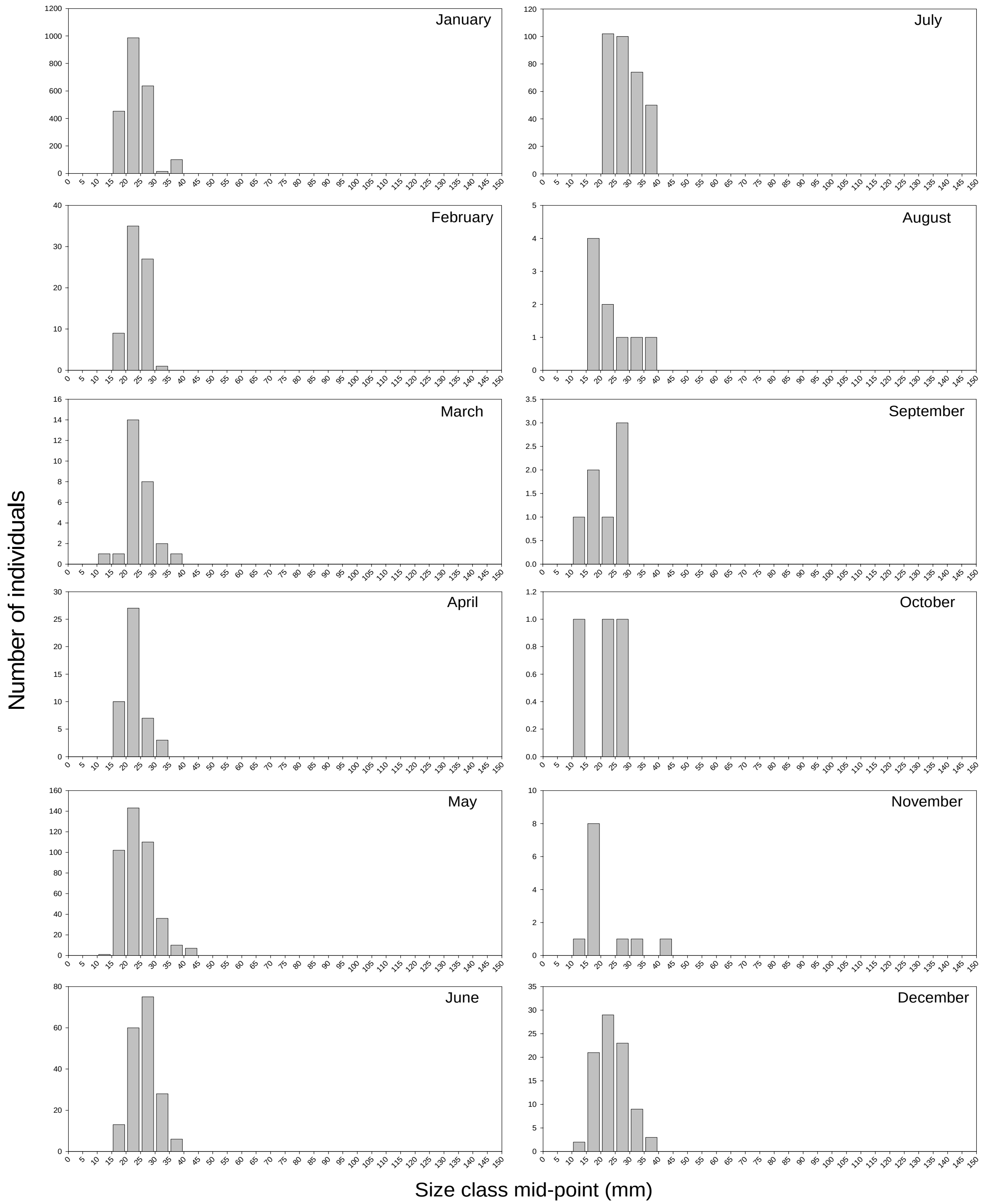


Fig. C16. Monthly length frequencies of *Gambusia holbrooki* (Eastern mosquitofish) collected in the Homosassa River estuary.

Poecilia latipinna (sailfin molly)

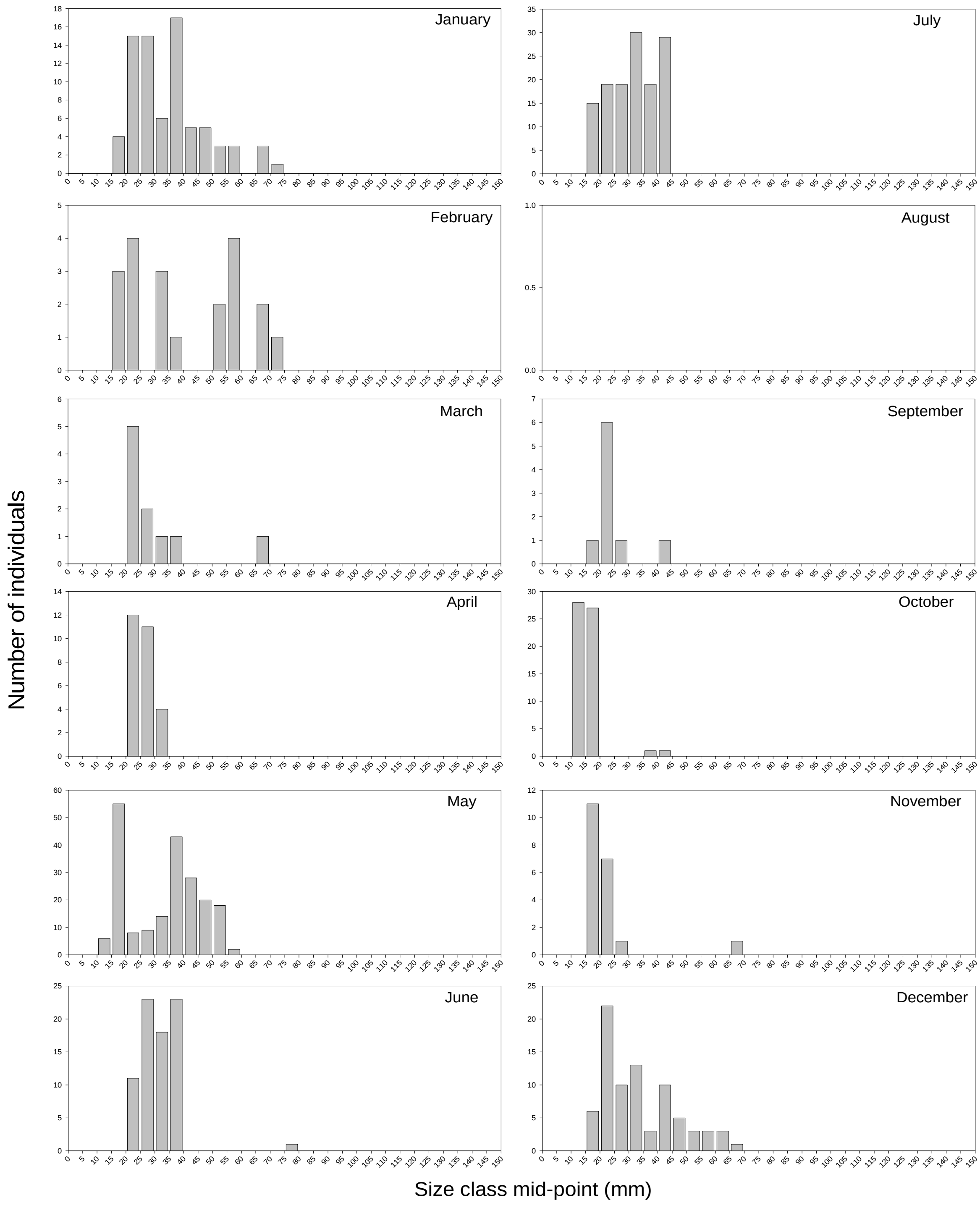


Fig. C17. Monthly length frequencies of *Poecilia latipinna* (sailfin molly) collected in the Homosassa River estuary.

Heterandria formosa (least killifish)

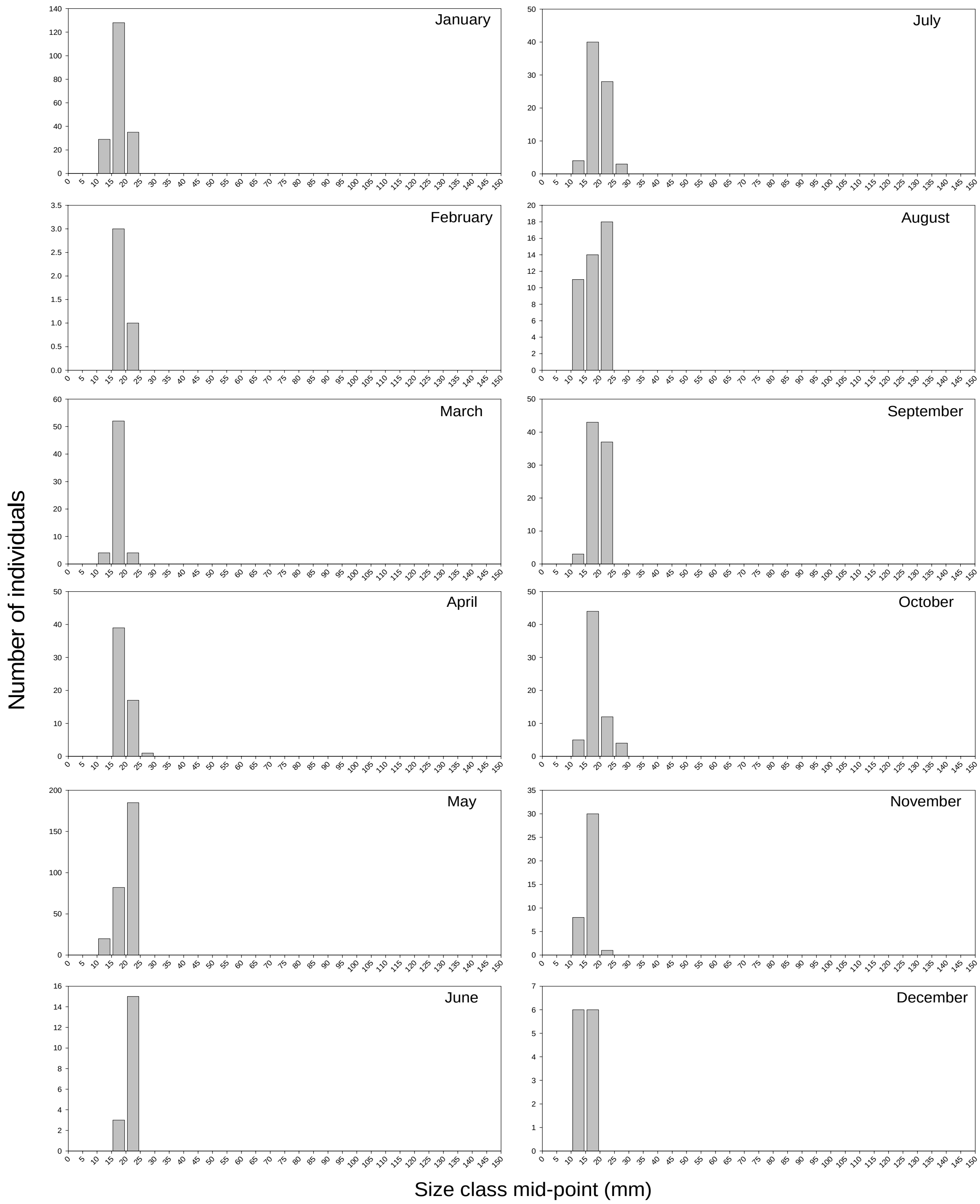


Fig. C18. Monthly length frequencies of *Heterandria formosa* (least killifish) collected in the Homosassa River estuary.

Syngnathus scovelli (Gulf pipefish)

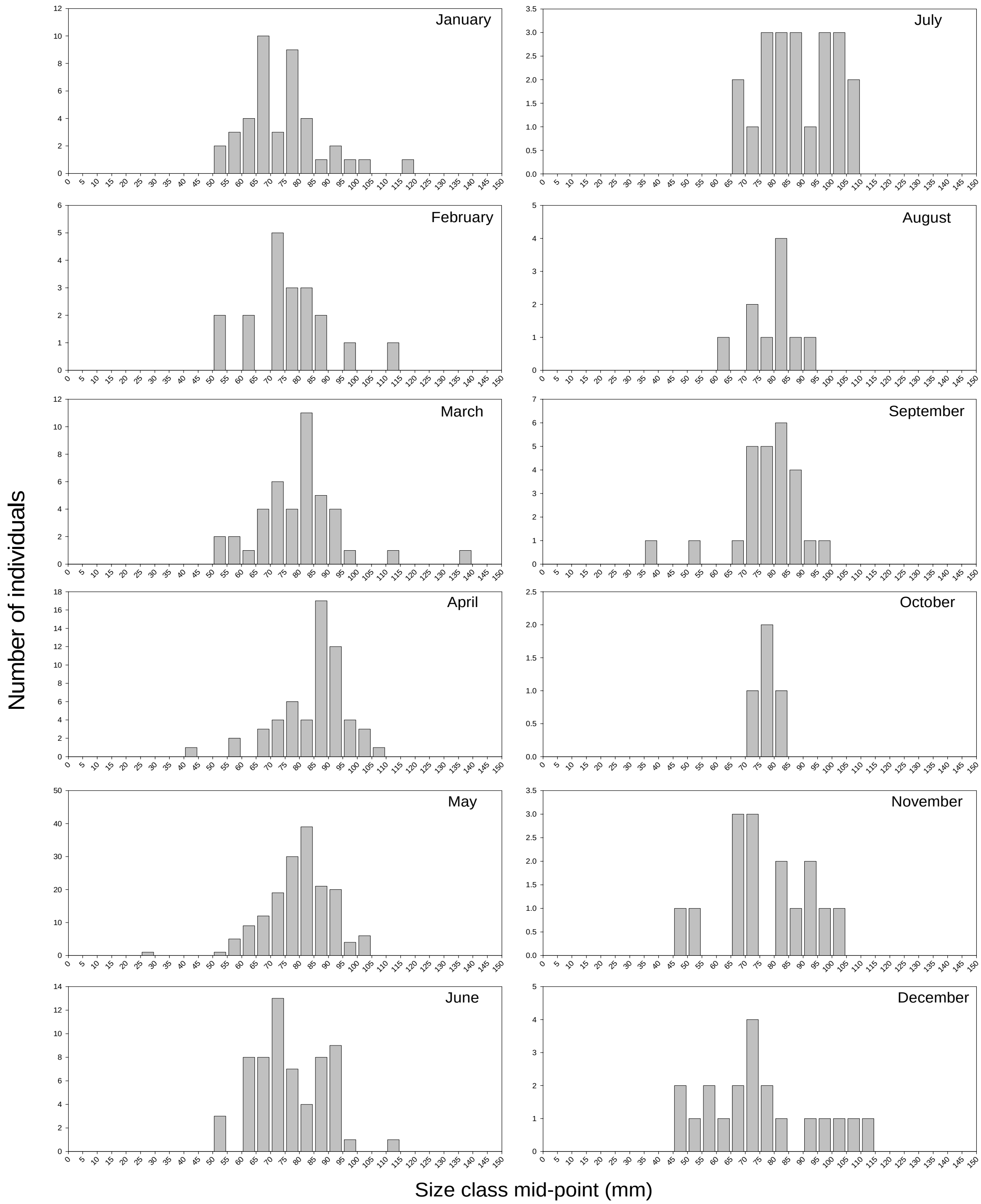


Fig. C19. Monthly length frequencies of *Syngnathus scovelli* (Gulf pipefish) collected in the Homosassa River estuary.

Lepomis macrochirus (bluegill)

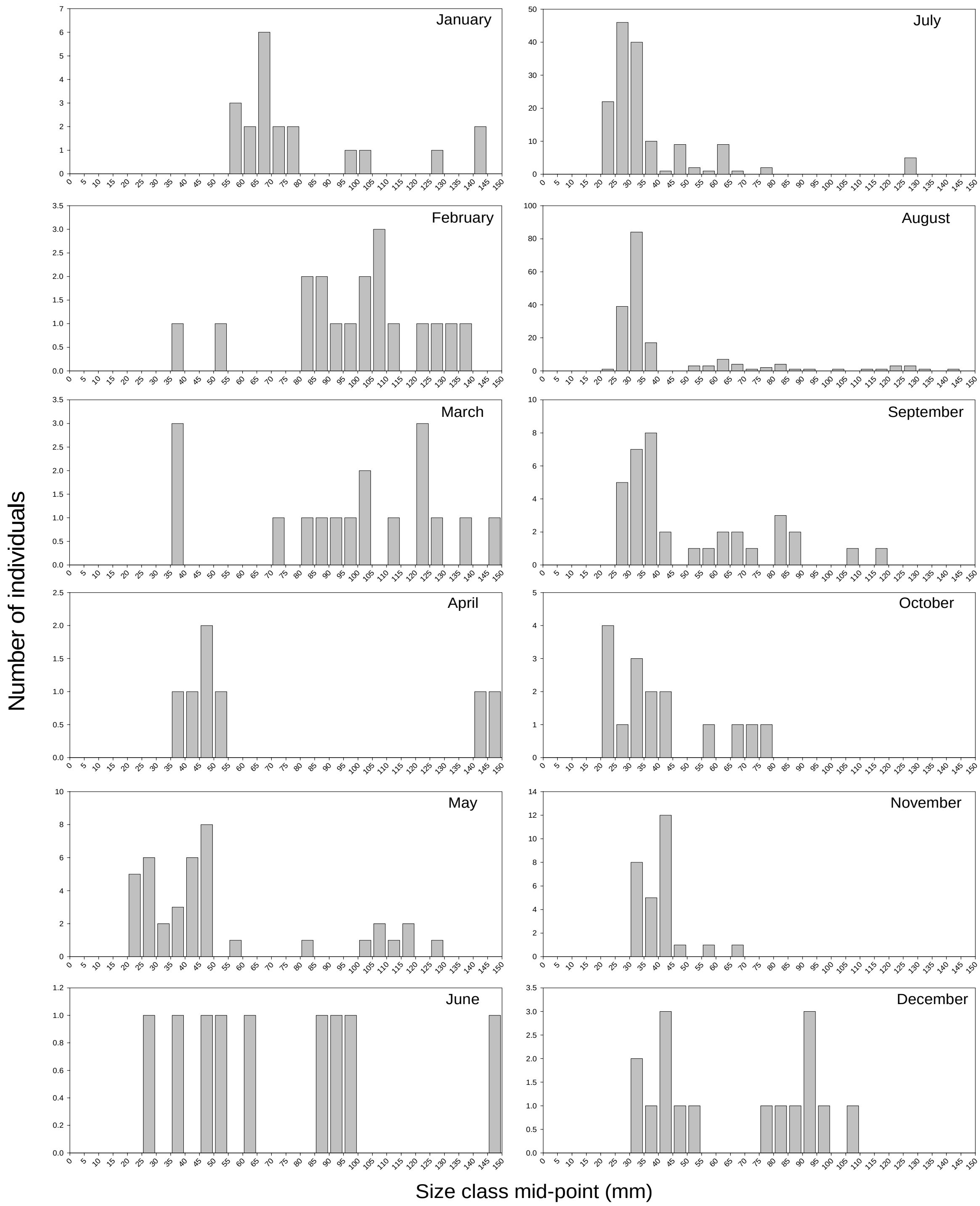


Fig. C20. Monthly length frequencies of *Lepomis macrochirus* (bluegill) collected in the Homosassa River estuary.

Lepomis microlophus (redear sunfish)

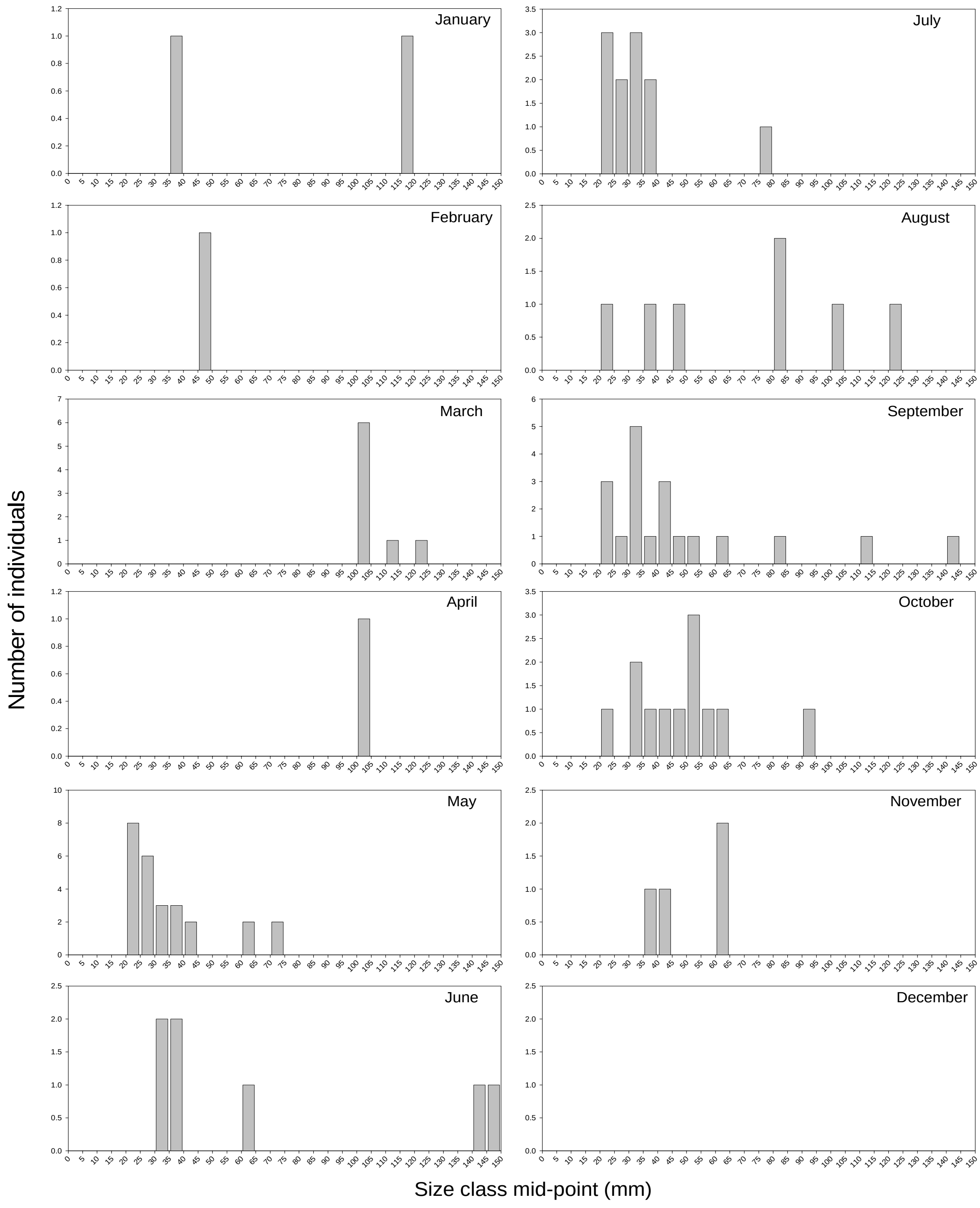


Fig. C21. Monthly length frequencies of *Lepomis microlophus* (redear sunfish) collected in the Homosassa River estuary.

Lepomis punctatus (spotted sunfish)

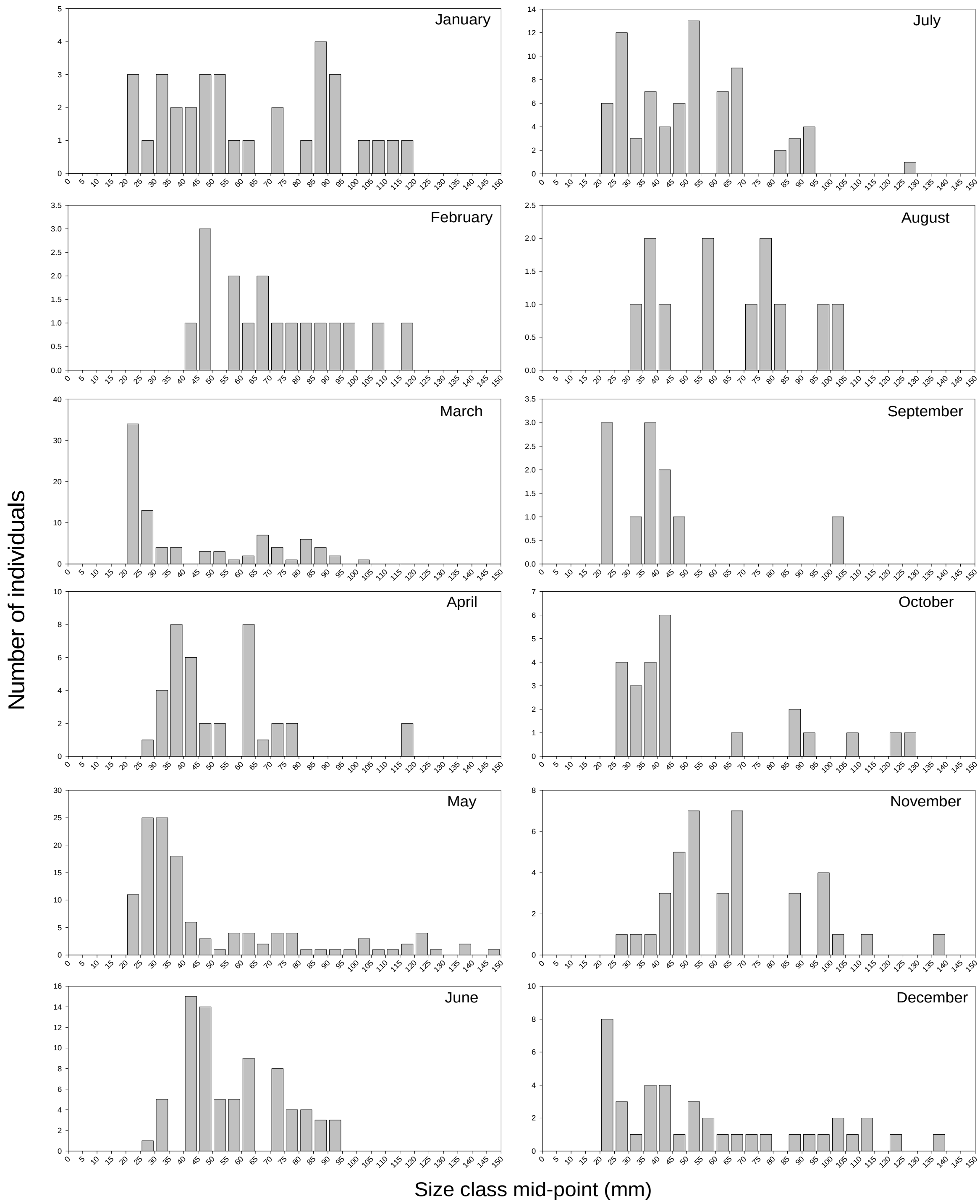


Fig. C22. Monthly length frequencies of *Lepomis punctatus* (spotted sunfish) collected in the Homosassa River estuary.

Micropterus salmoides (largemouth bass)

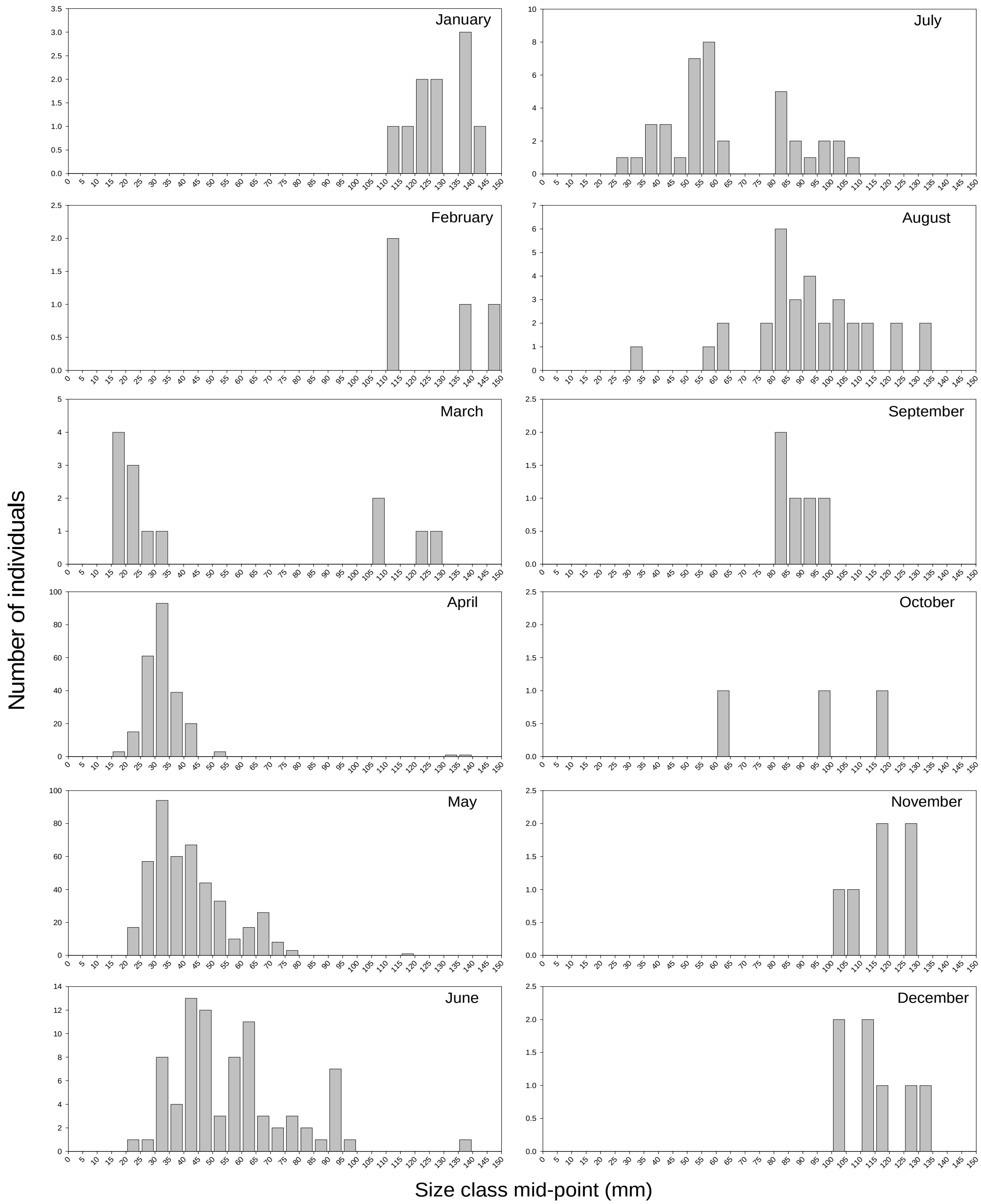


Fig. C23. Monthly length frequencies of *Micropterus salmoides* (largemouth bass) collected in the Homosassa River estuary.

Lutjanus griseus (gray snapper)

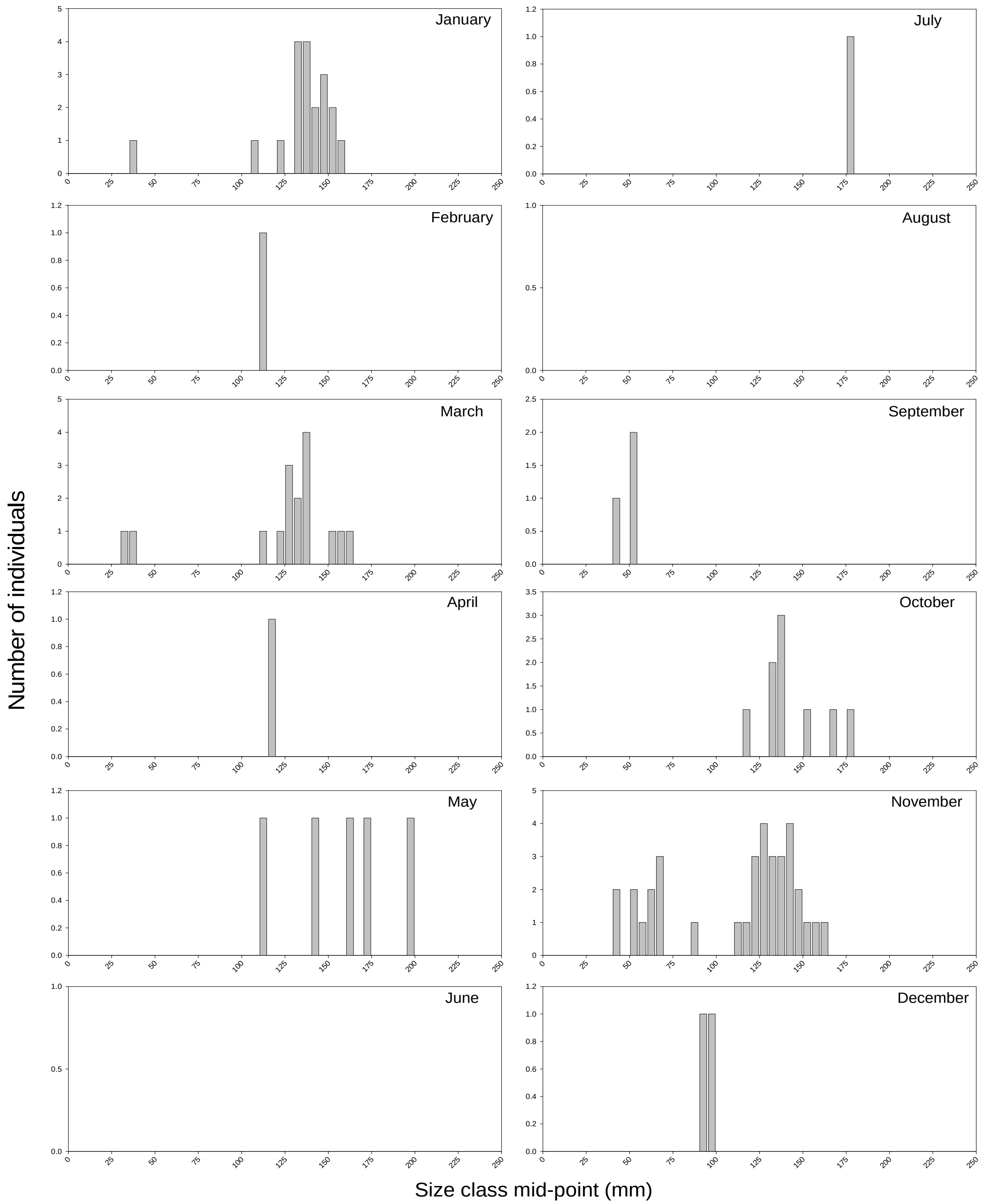


Fig. C24. Monthly length frequencies of *Lutjanus griseus* (gray snapper) collected in the Homosassa River estuary.

Eucinostomus gula (silver jenny)

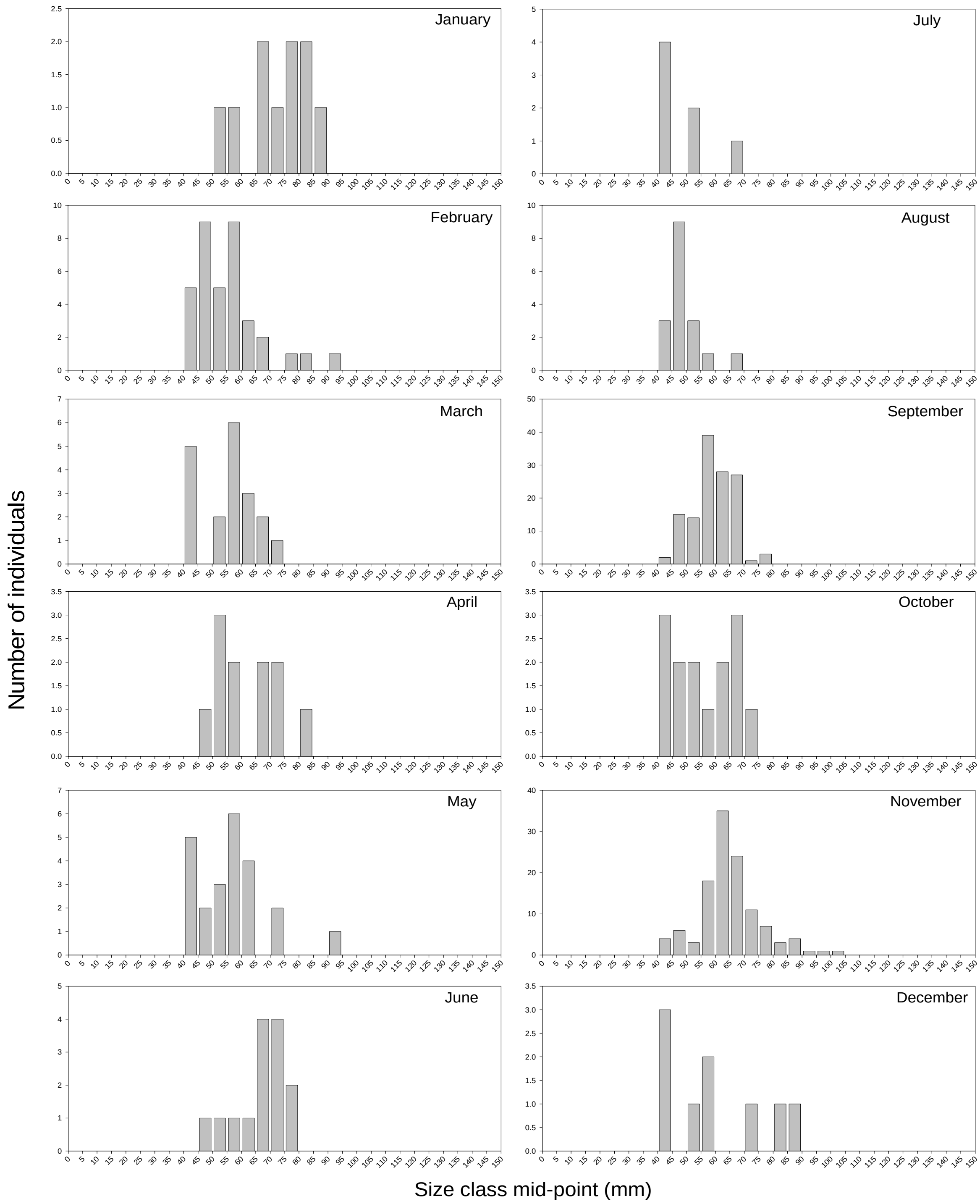


Fig. C25. Monthly length frequencies of *Eucinostomus gula* (silver jenny) collected in the Homosassa River estuary.

Eucinostomus harengulus (tidewater mojarra)

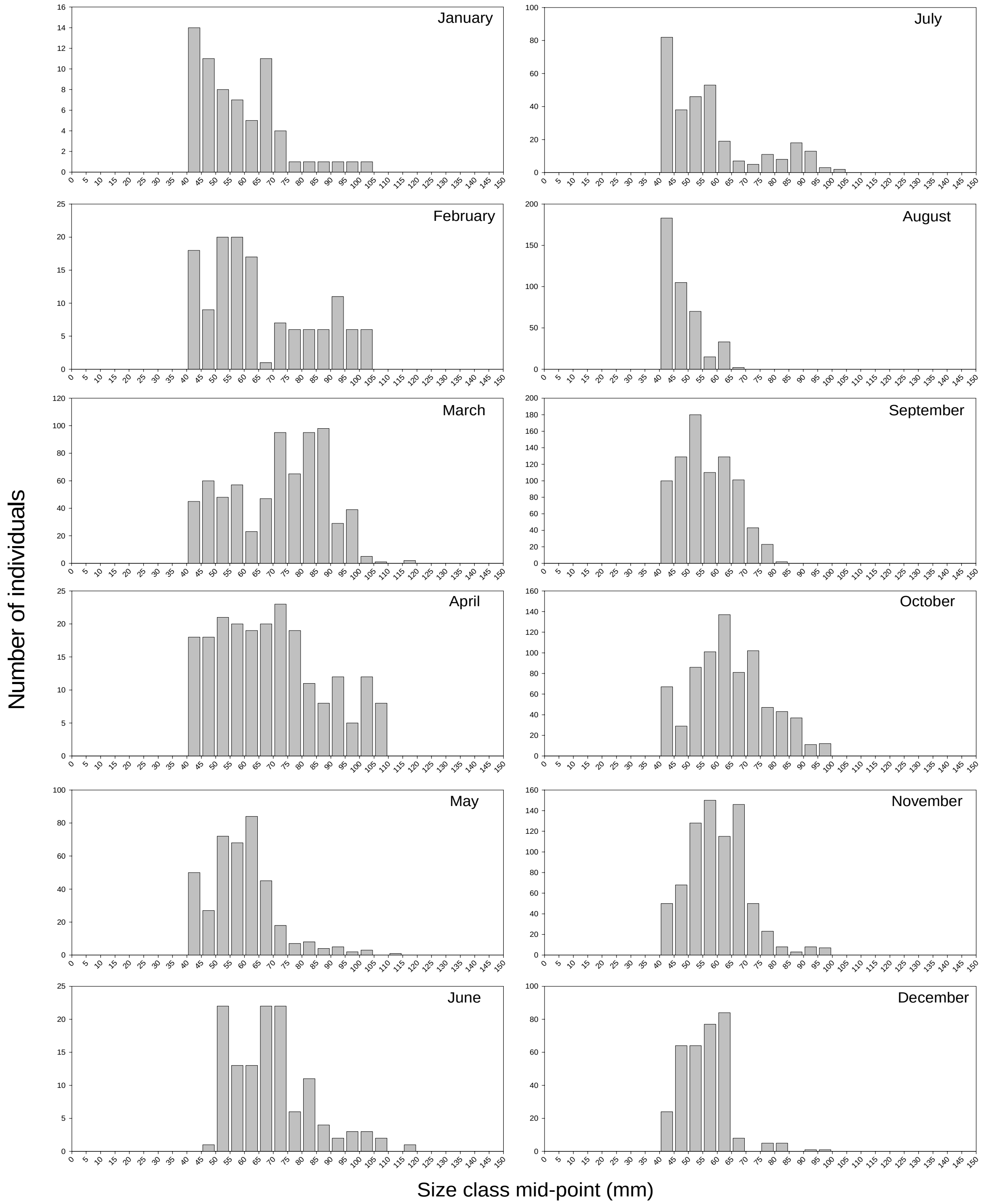


Fig. C26. Monthly length frequencies of *Eucinostomus harengulus* (tidewater mojarra) collected in the Homosassa River estuary.

Lagodon rhomboides (pinfish)

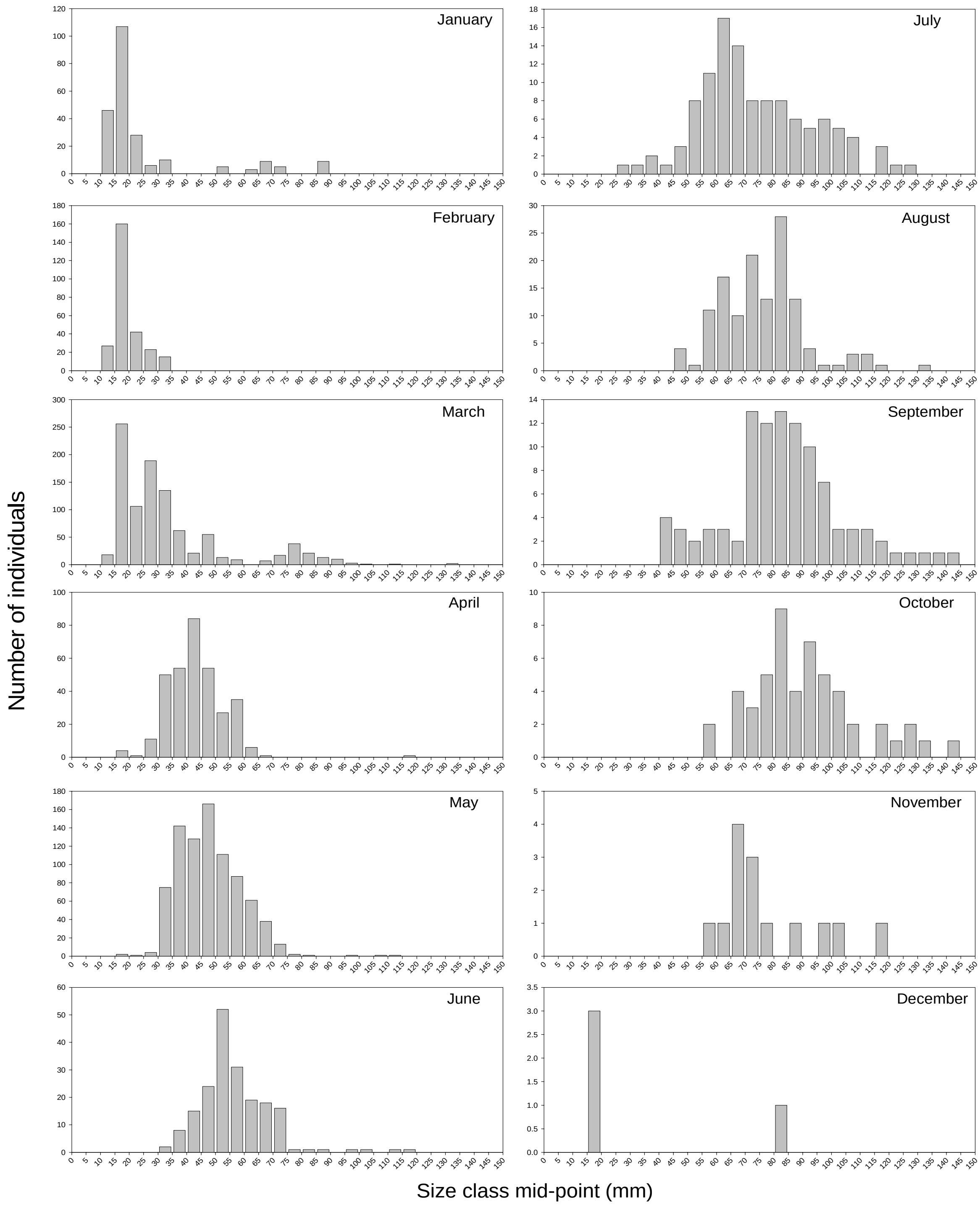


Fig. C27. Monthly length frequencies of *Lagodon rhomboides* (pinfish) collected in the Homosassa River estuary.

Leiostomus xanthurus (spot)

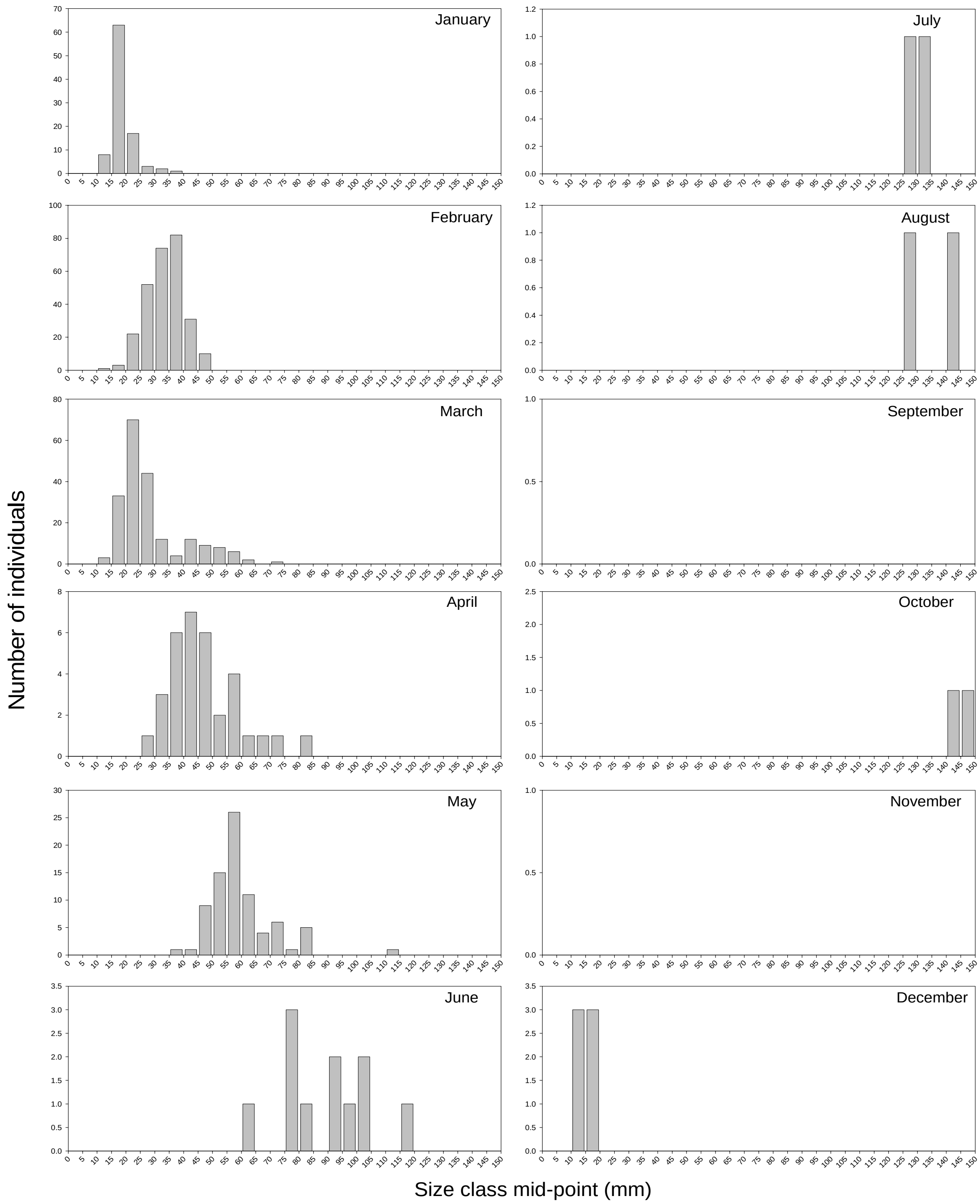


Fig. C28. Monthly length frequencies of *Leiostomus xanthurus* (spot) collected in the Homosassa River estuary.

Gobiosoma bosc (naked goby)

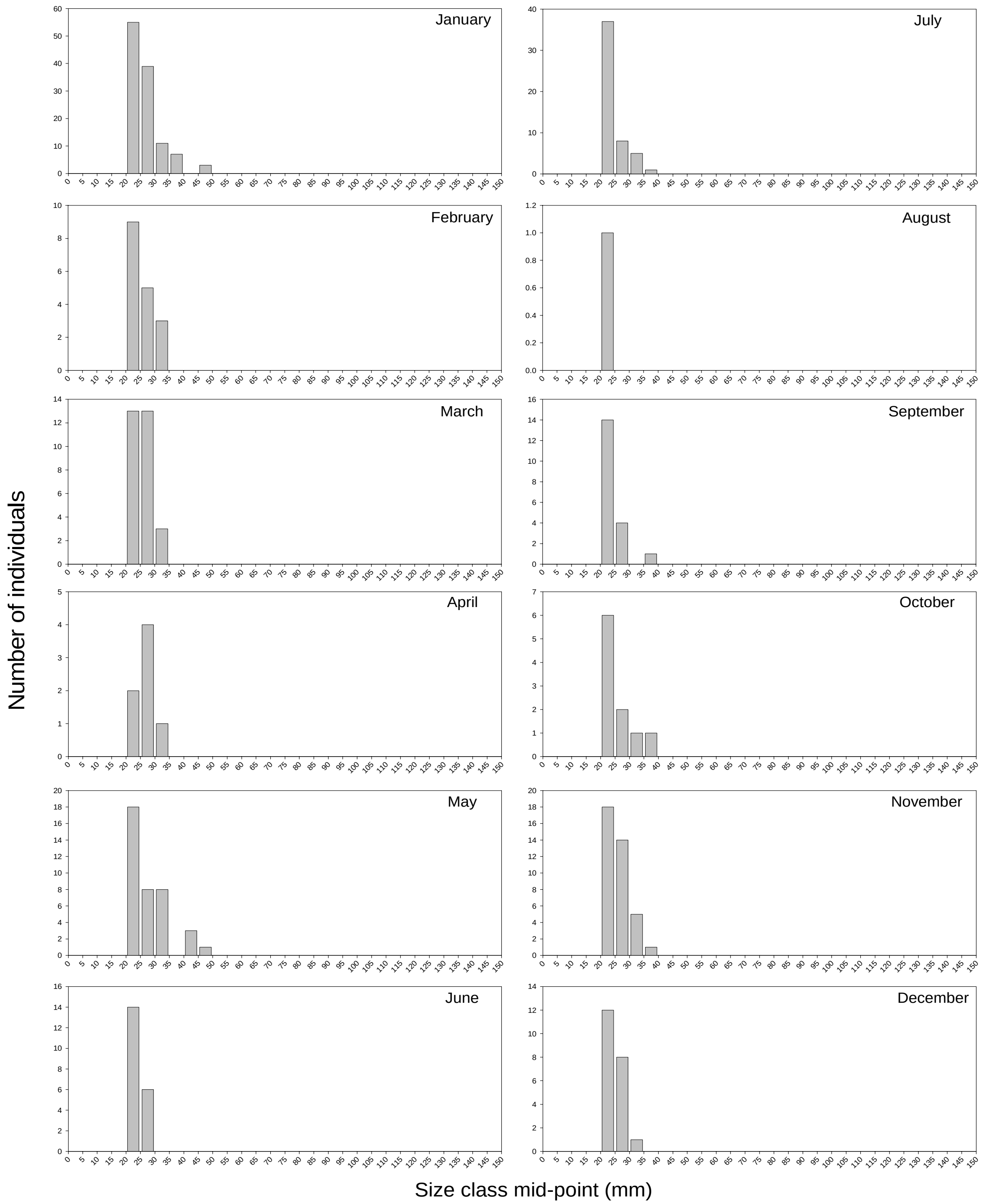


Fig. C29. Monthly length frequencies of *Gobiosoma bosc* (naked goby) collected in the Homosassa River estuary.

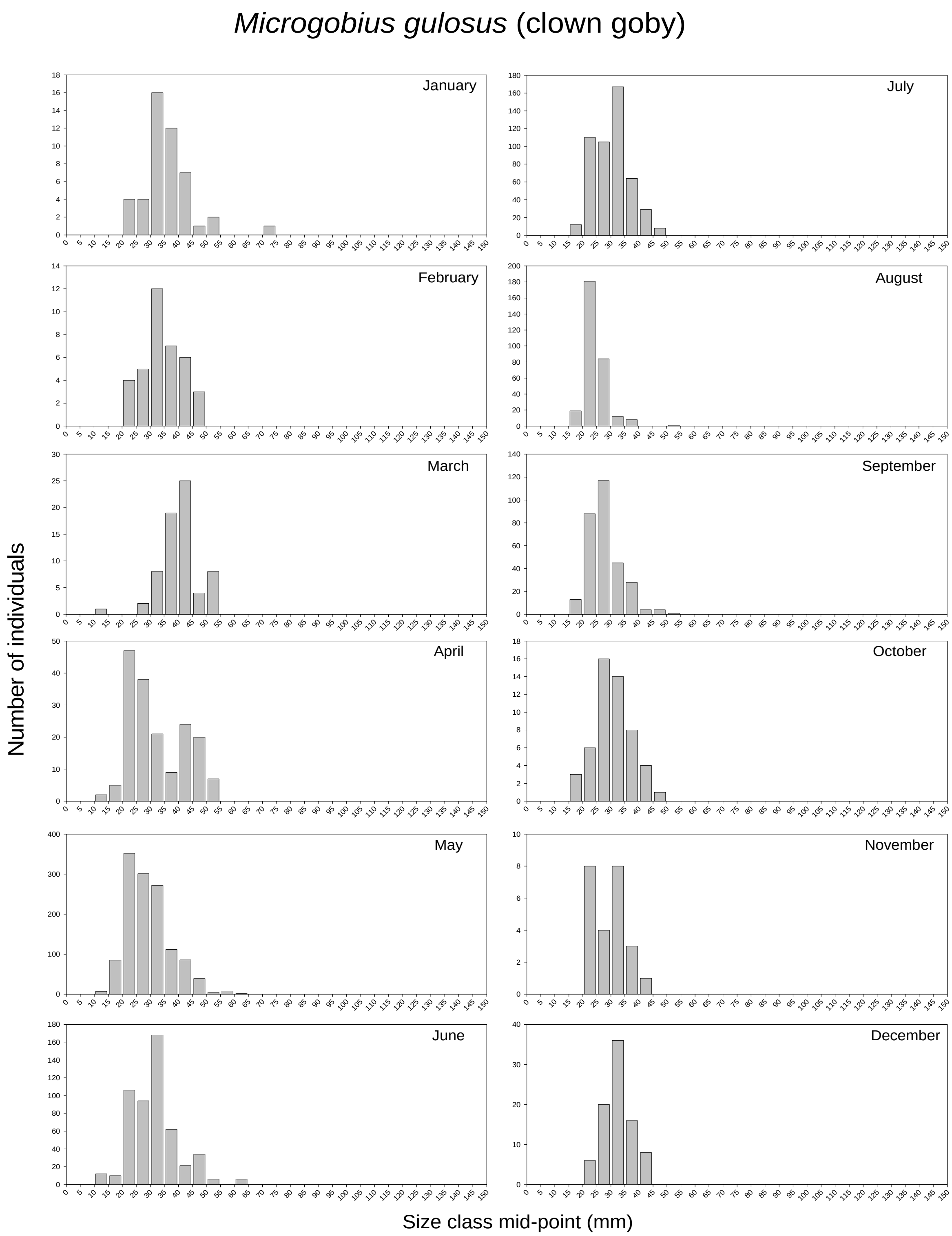


Fig. C30. Monthly length frequencies of *Microgobius gulosus* (clown goby) collected in the Homosassa River estuary.

Trinectes maculatus (hogchoker)

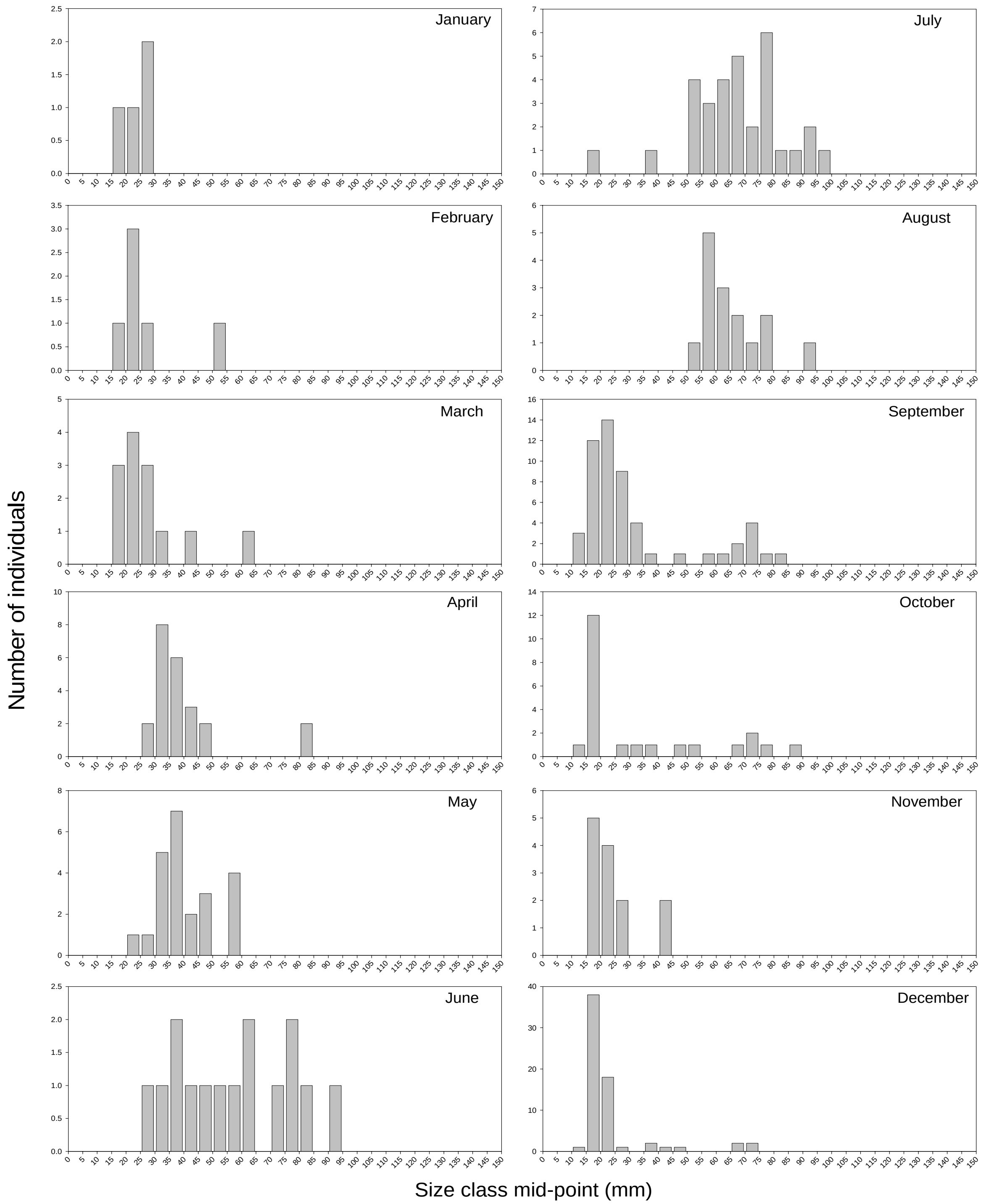


Fig. C31. Monthly length frequencies of *Trinectes maculatus* (hogchoker) collected in the Homosassa River estuary.

Appendix D: Seine catch overview plots

Farfantepenaeus duorarum (pink shrimp) in seines

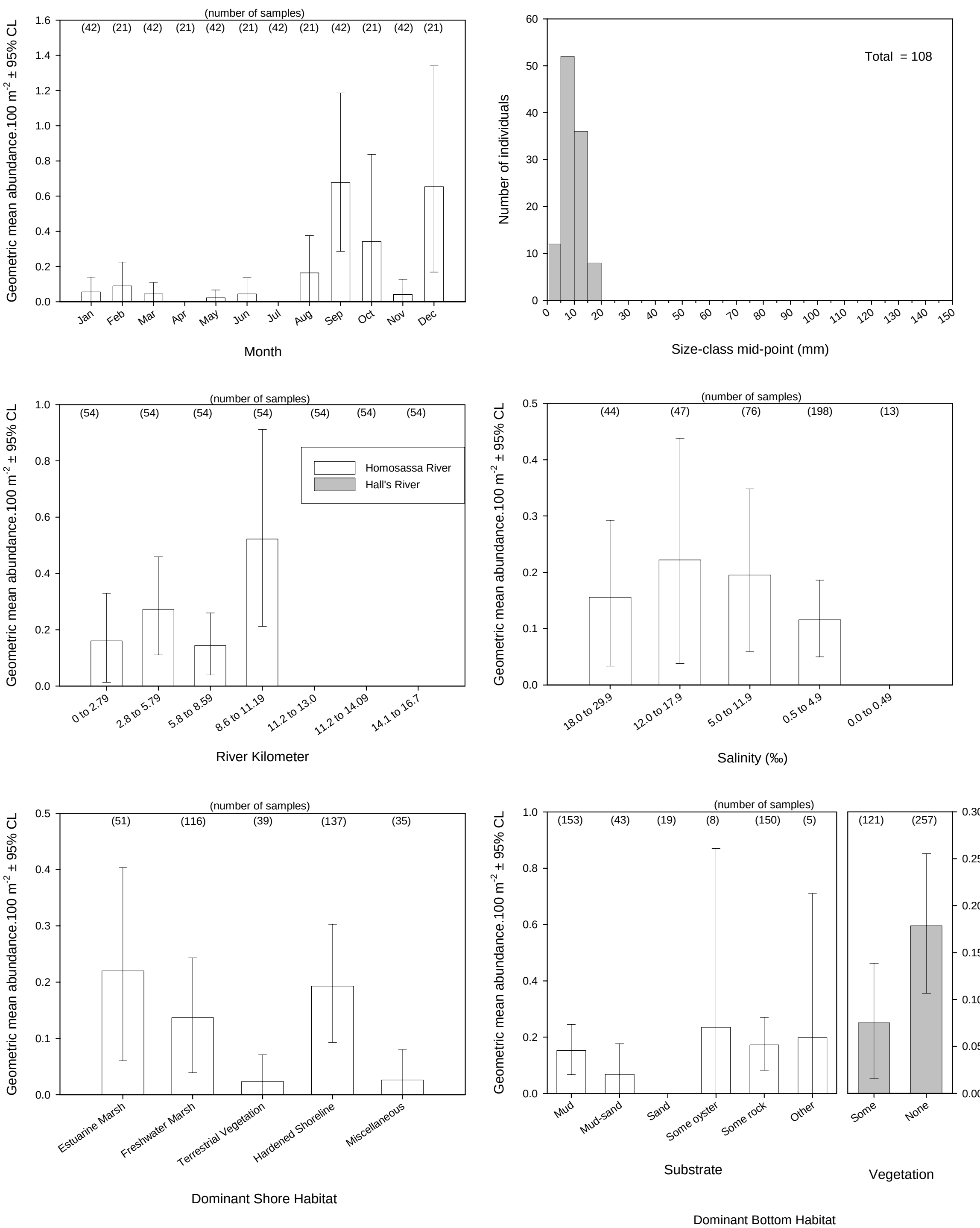


Fig. D1. Relative abundance of *Farfantepenaeus duorarum* (pink shrimp) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Palaemonetes intermedius (brackish grass shrimp) in seines

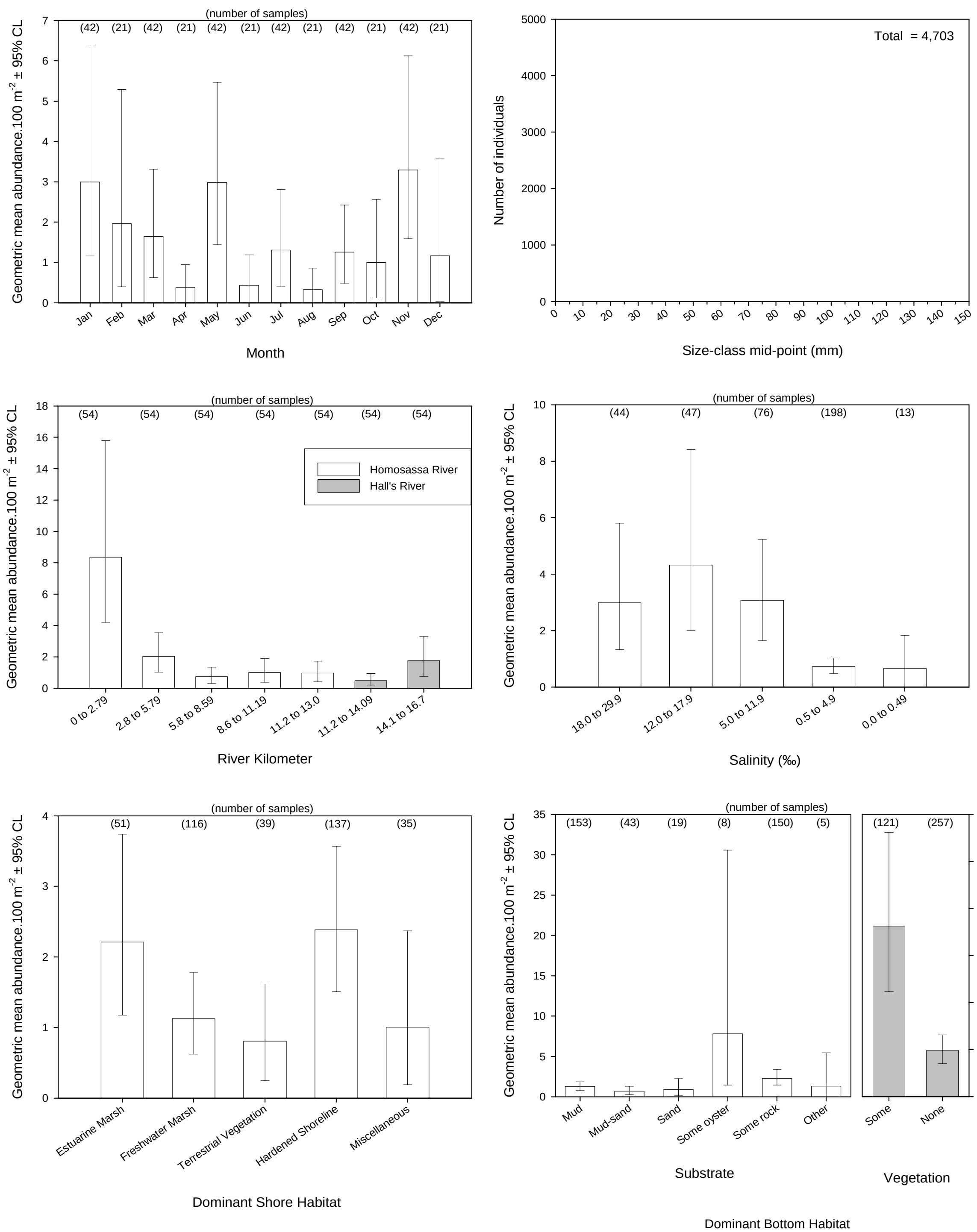


Fig. D2. Relative abundance of *Palaemonetes intermedius (*brackish grass shrimp) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Palaemonetes paludosus (riverine grass shrimp) in seines

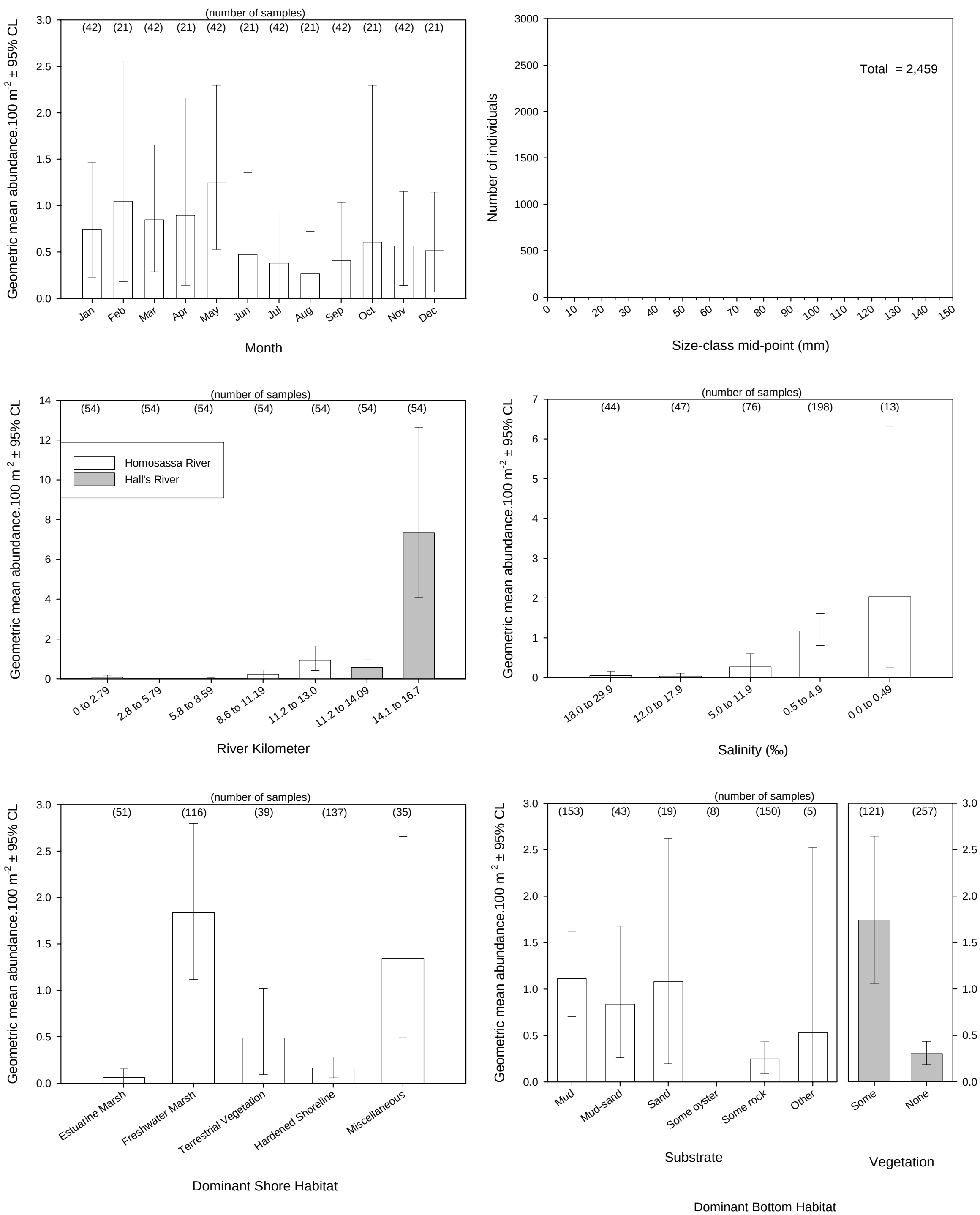


Fig. D3. Relative abundance of *Palaemonetes paludosus* (riverine grass shrimp) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Palaemonetes pugio (daggerblade grass shrimp) in seines

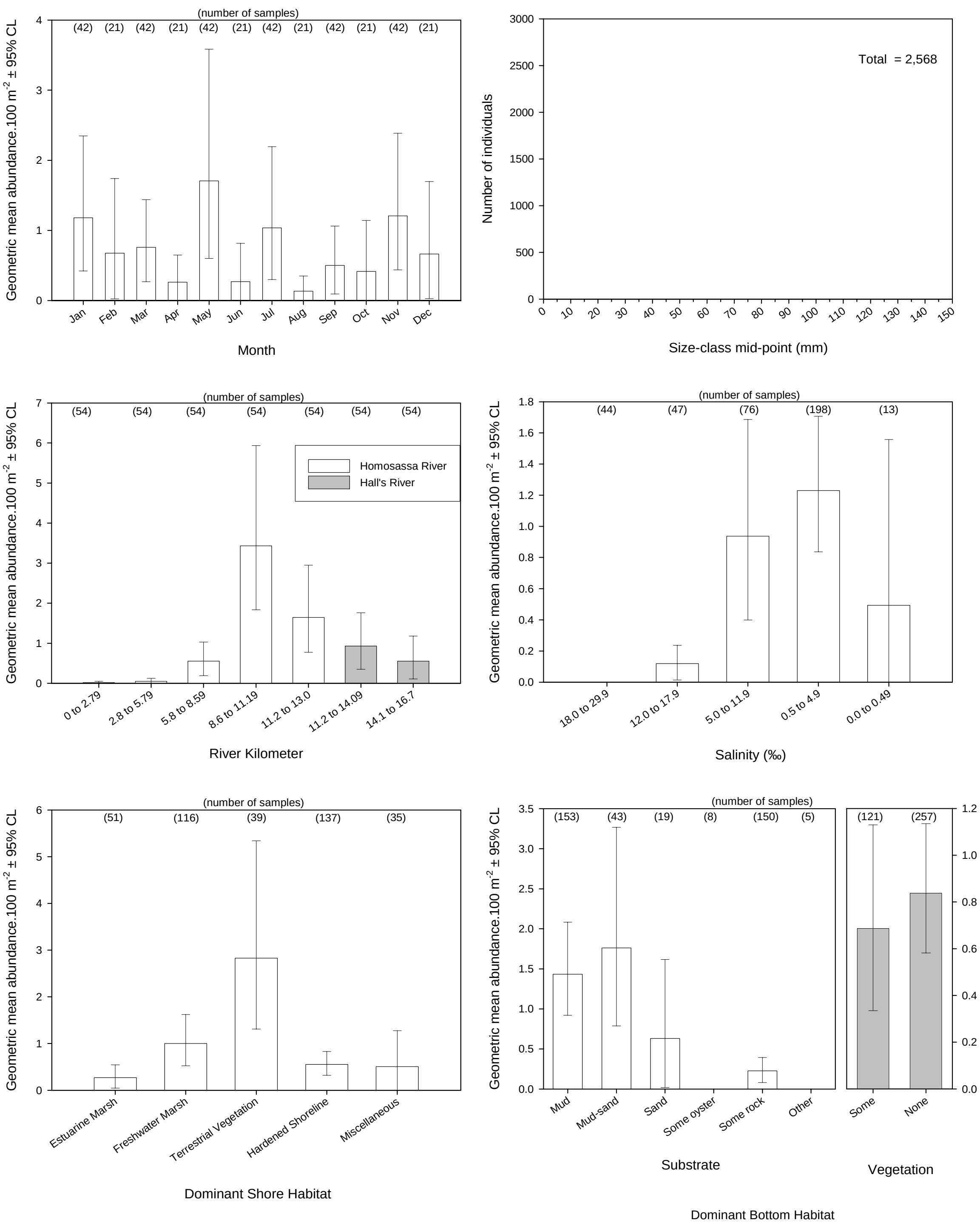


Fig. D4. Relative abundance of *Palaemonetes pugio* (daggerblade grass shrimp) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Callinectes sapidus (blue crab) in seines

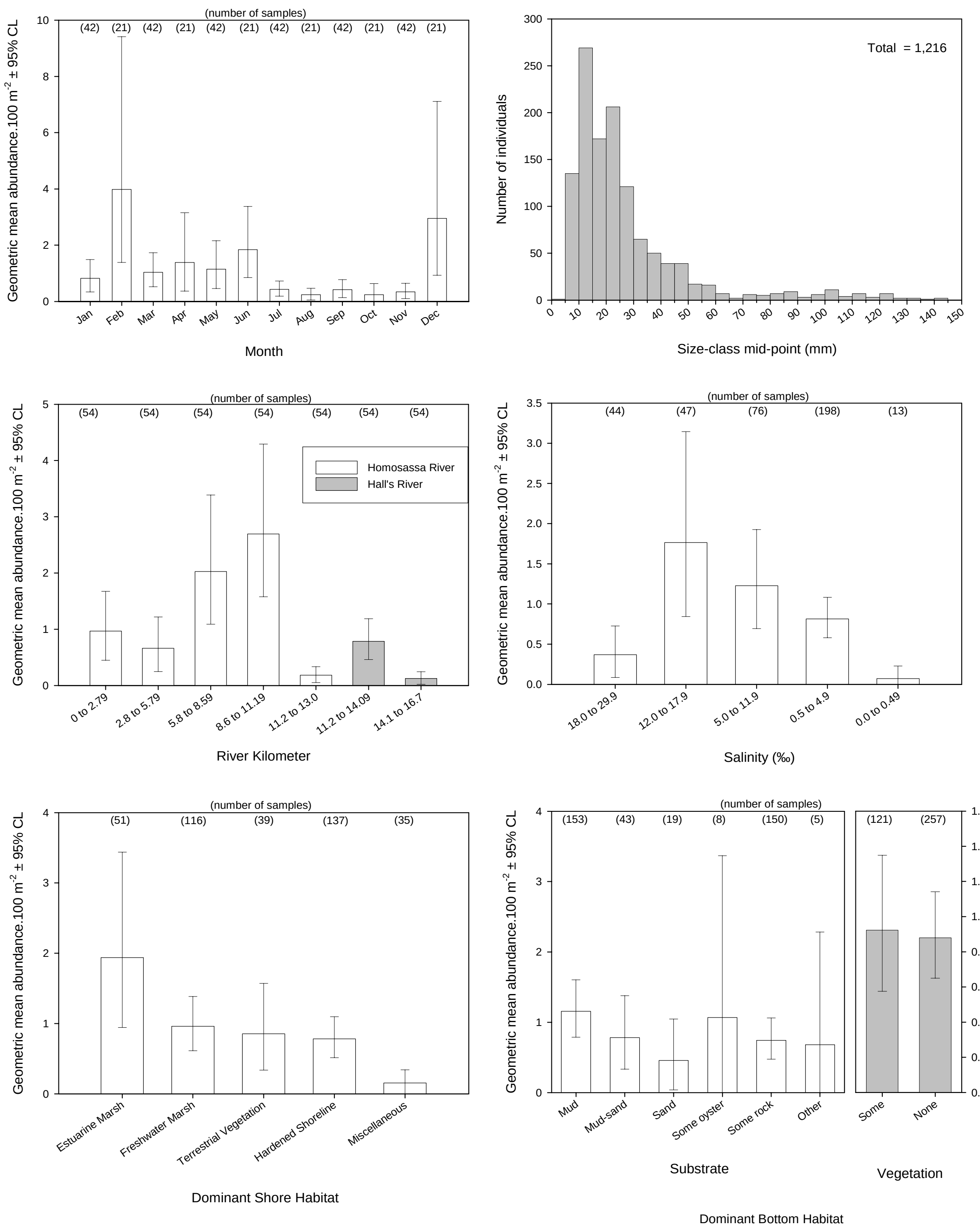


Fig. D5. Relative abundance of *Callinectes sapidus* (blue crab) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Anchoa mitchilli (bay anchovy) in seines

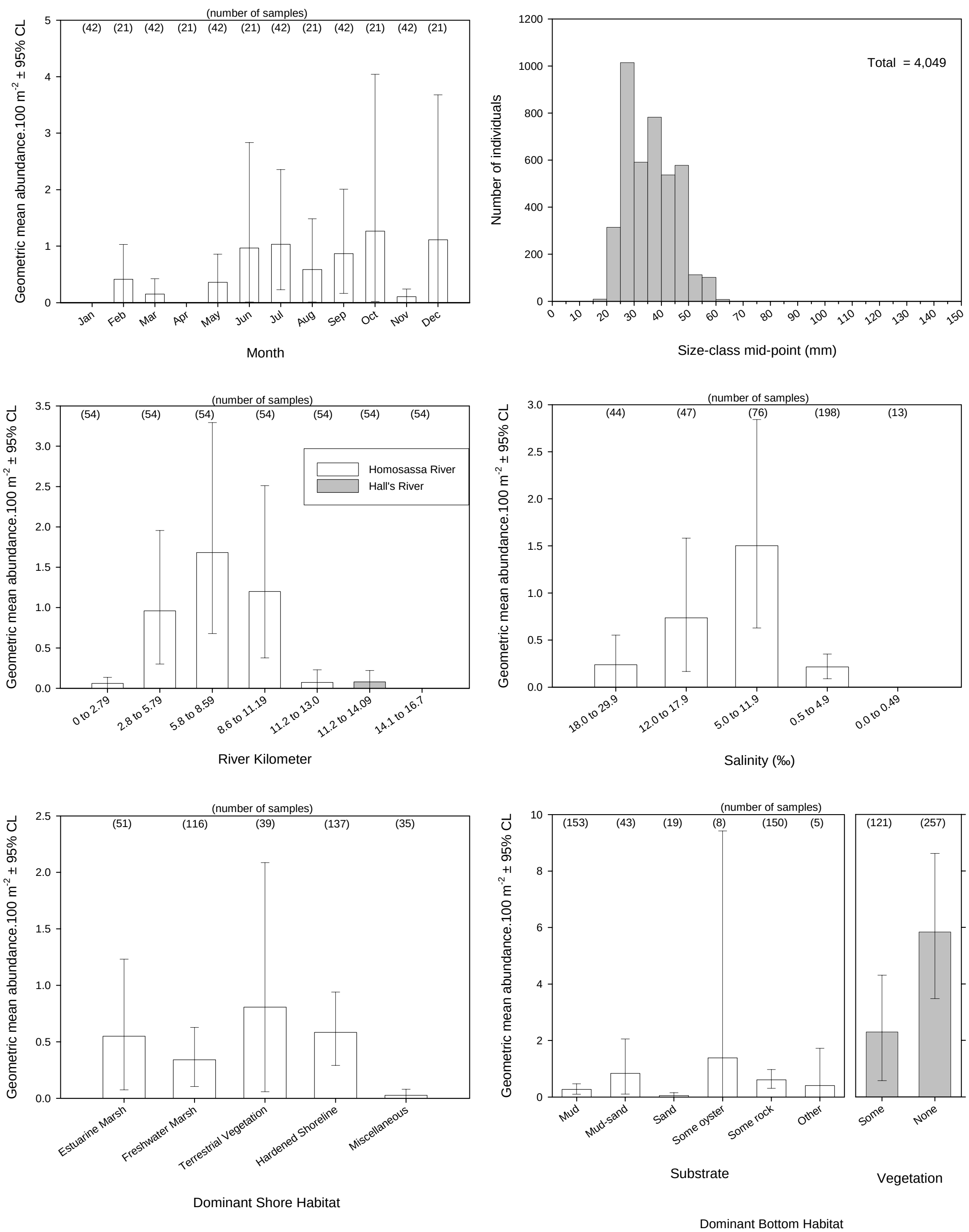


Fig. D6. Relative abundance of *Anchoa mitchilli* (bay anchovy) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Notemigonus crysoleucas (golden shiner) in seines

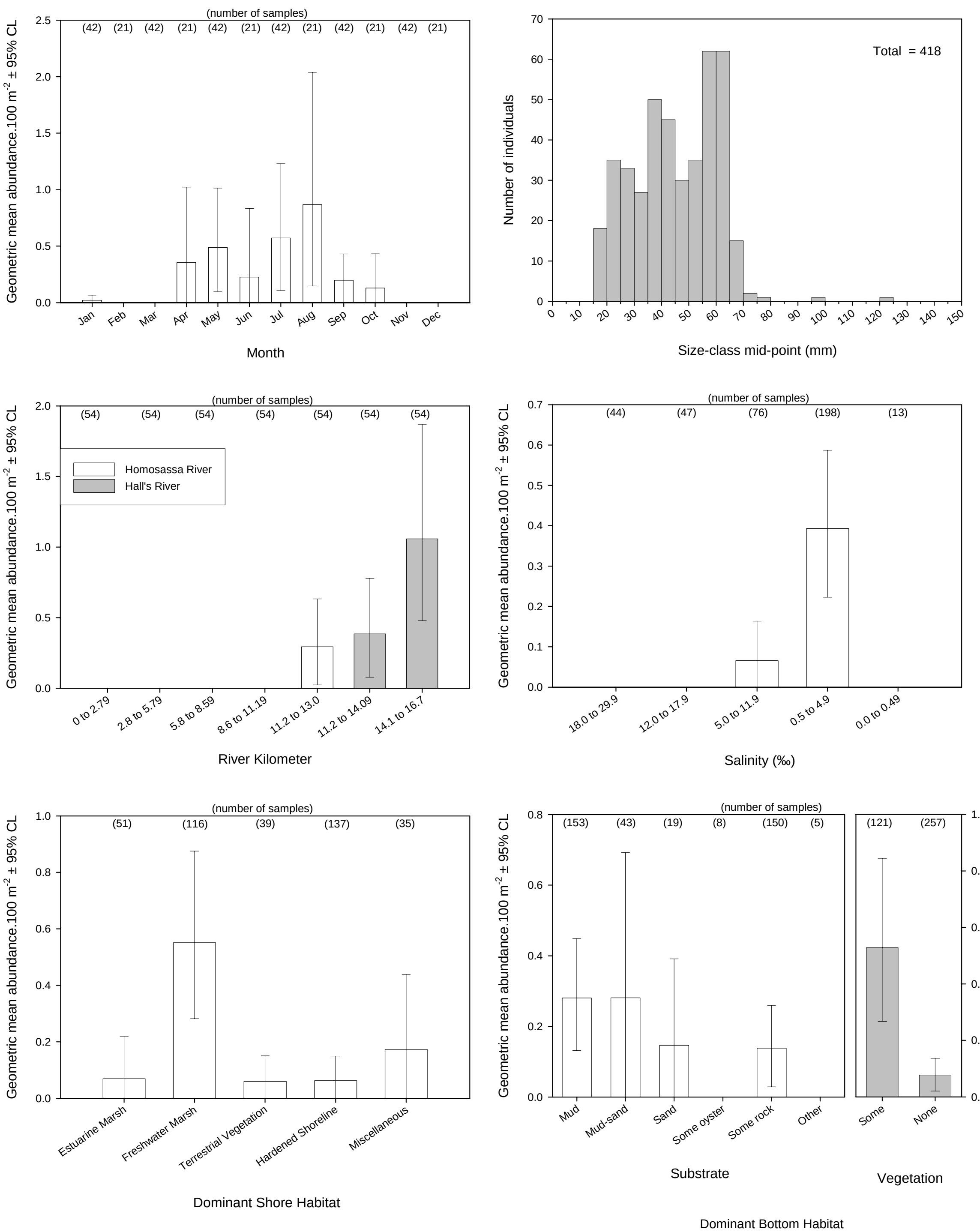


Fig. D7. Relative abundance of *Notemigonus crysoleucas* (golden shiner) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Notropis harperi (redeye chub) in seines

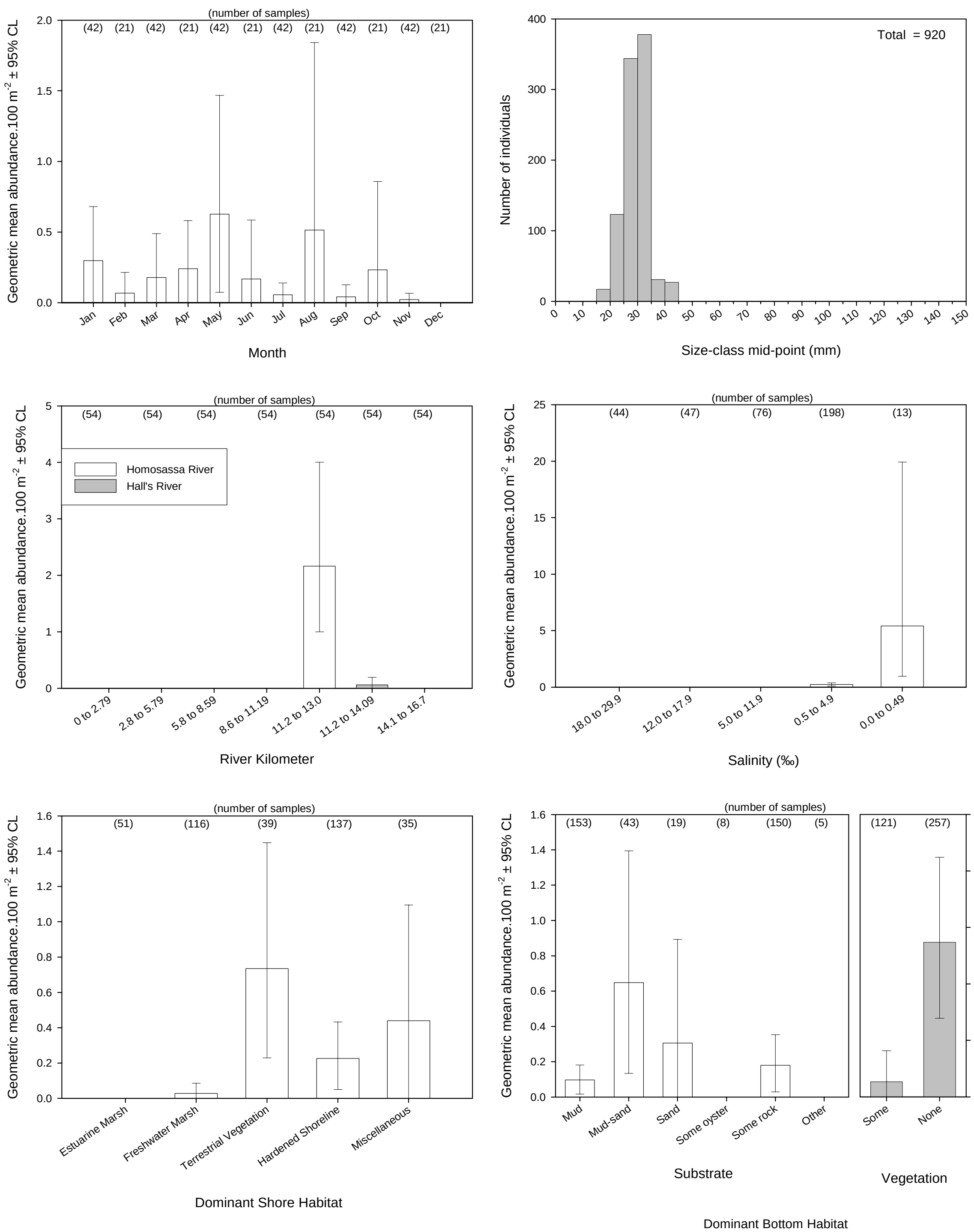


Fig. D8. Relative abundance of *Notropis harperi* (redeye chub) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Notropis petersoni (coastal shiner) in seines

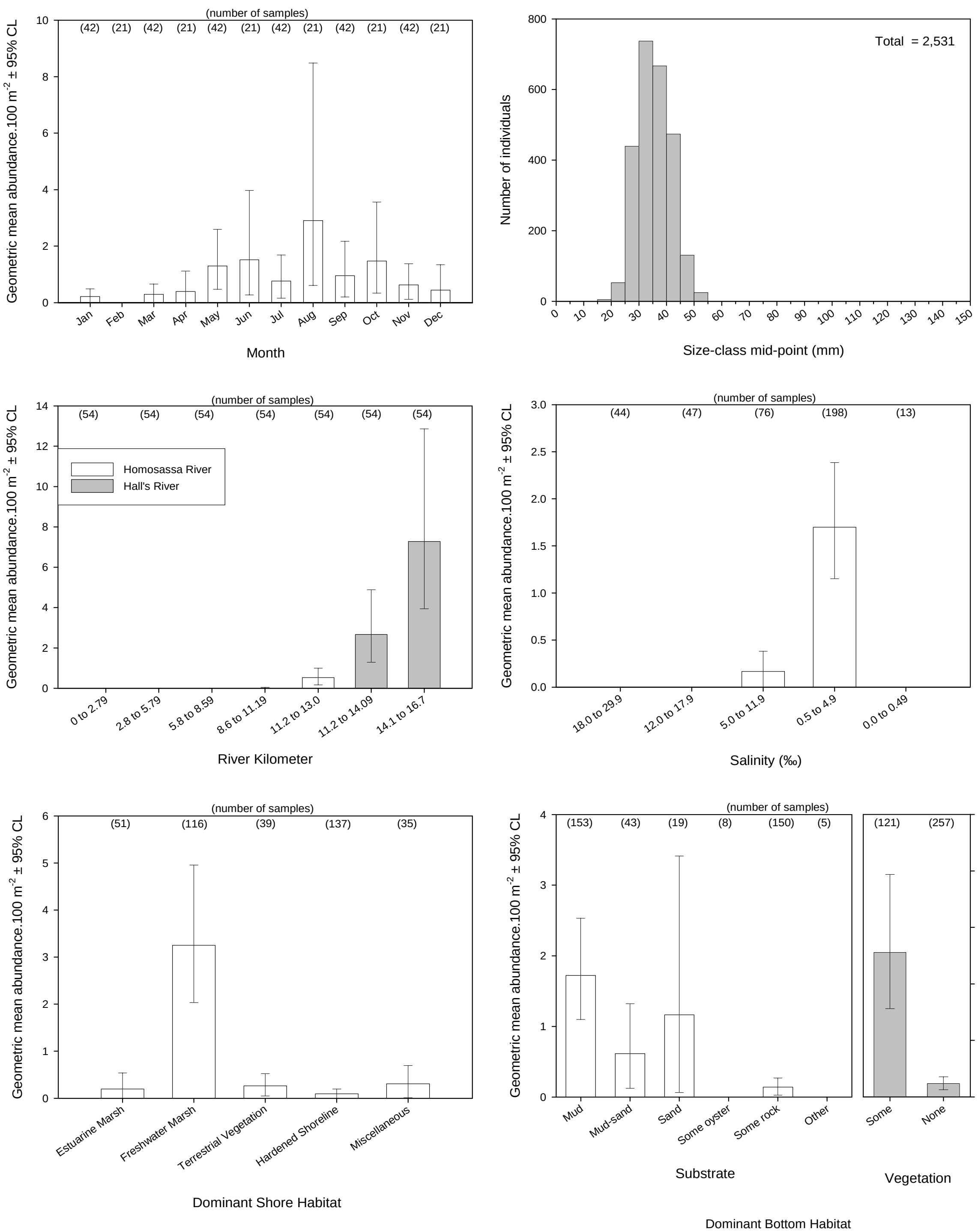


Fig. D9. Relative abundance of *Notropis petersoni* (coastal shiner) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Opsanus beta (Gulf toadfish) in seines

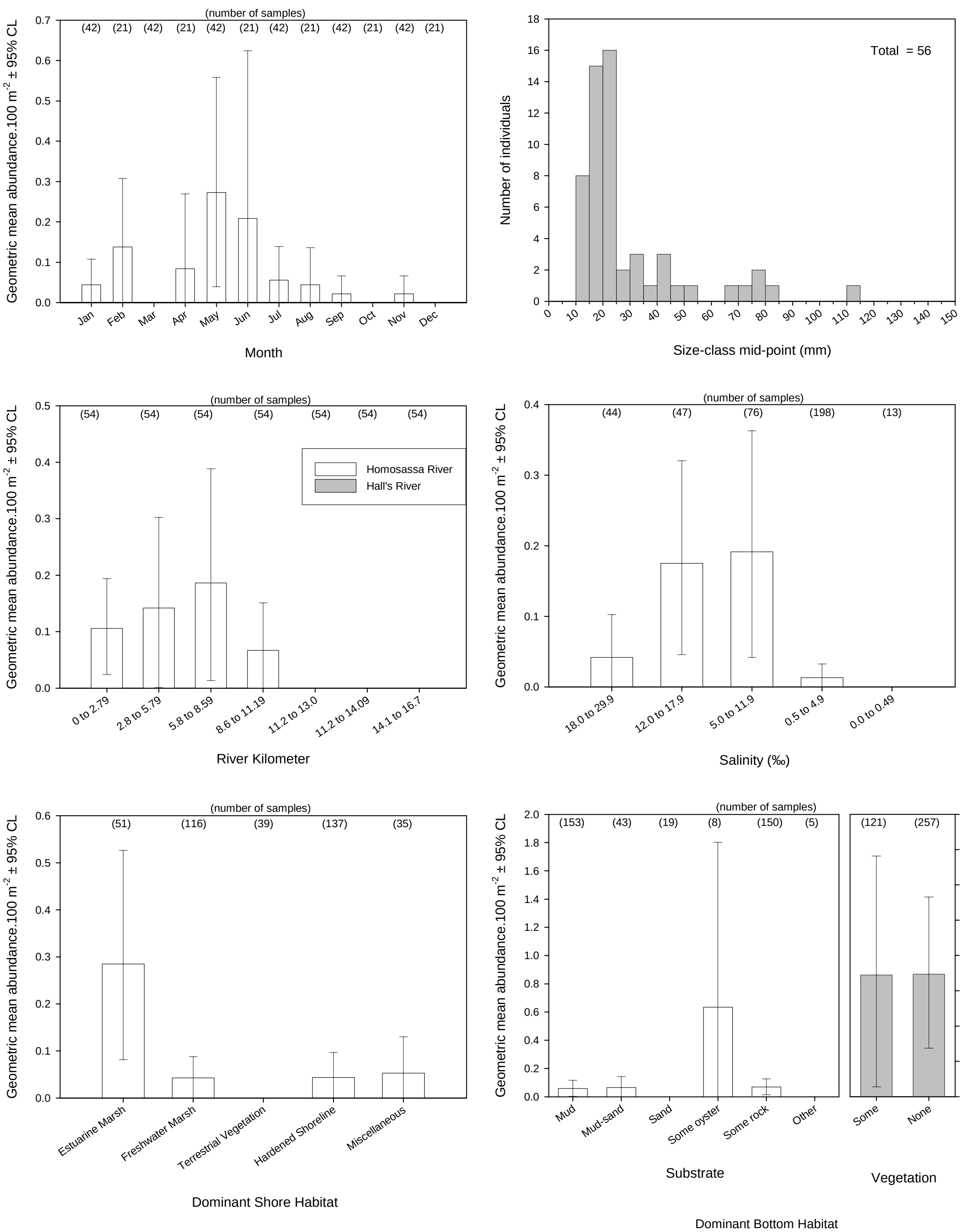


Fig. D10. Relative abundance of *Opsanus beta* (Gulf toadfish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Strongylura notata (redfin needlefish) in seines

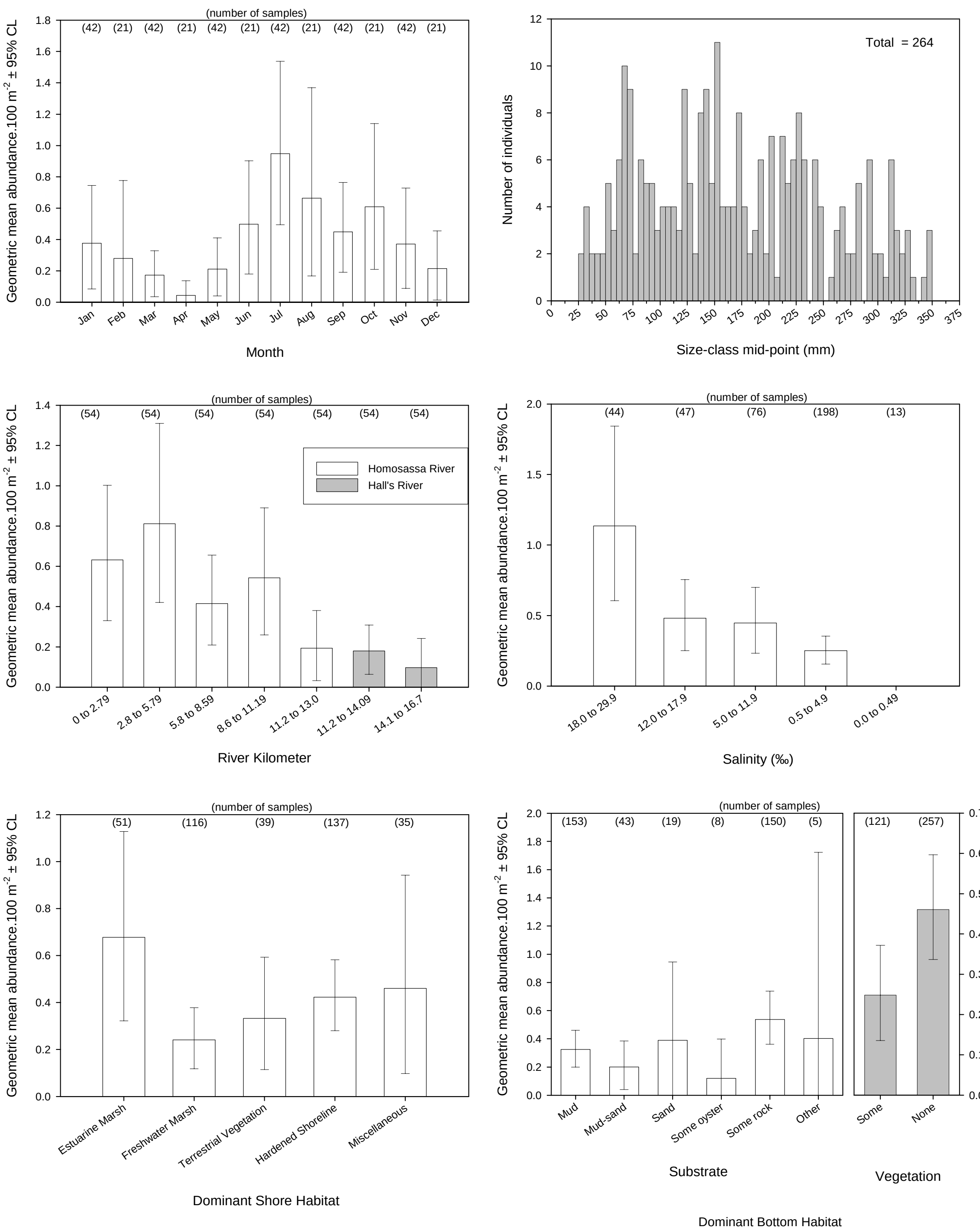


Fig. D11. Relative abundance of *Strongylura notata* (redfin needlefish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Strongylura timucu (timucu) in seines

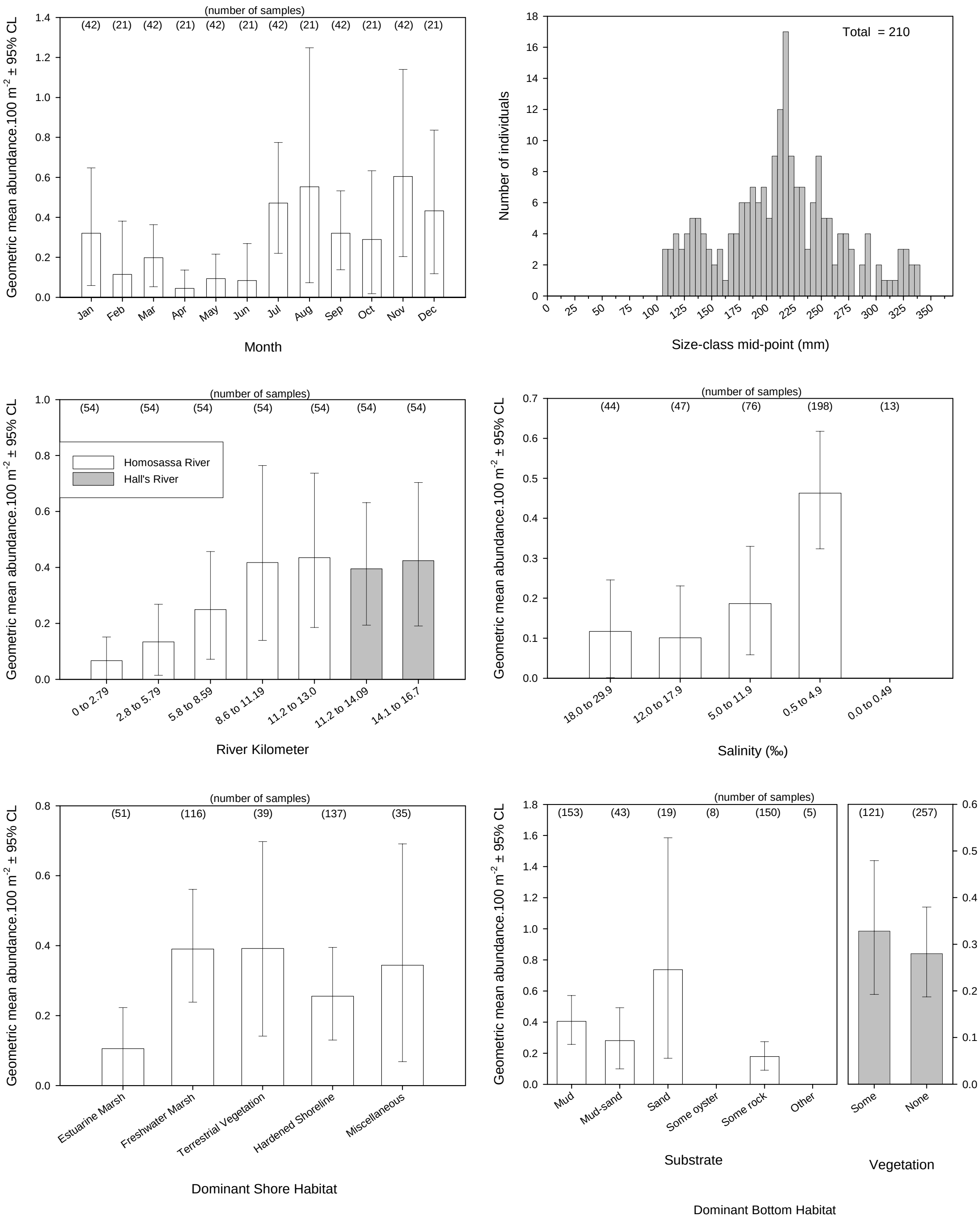


Fig. D12. Relative abundance of *Strongylura timucu* (timucu) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Cyprinodon variegatus (sheepshead minnow) in seines

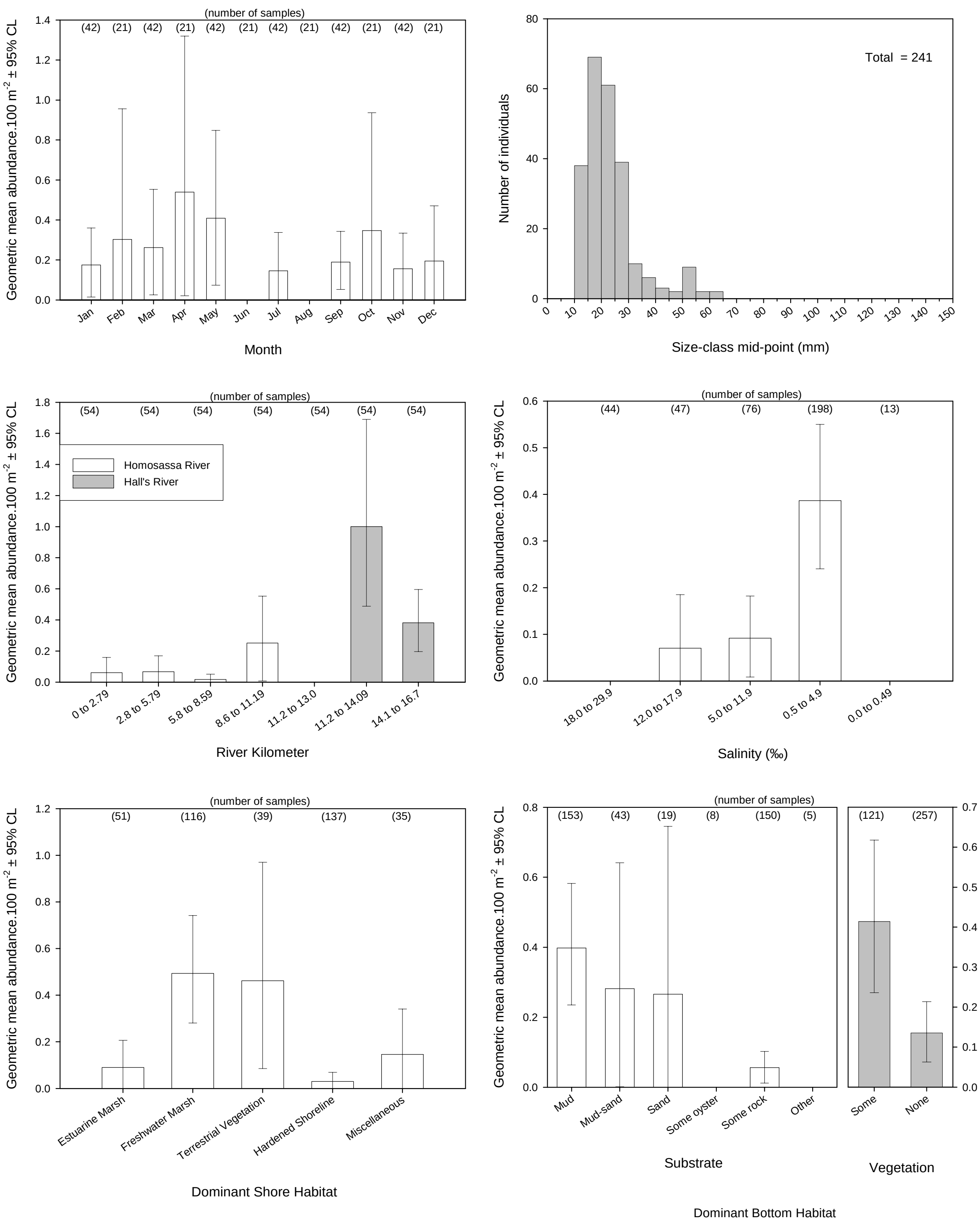


Fig. D13. Relative abundance of *Cyprinodon variegatus* (sheepshead minnow) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Fundulus grandis (Gulf killifish) in seines

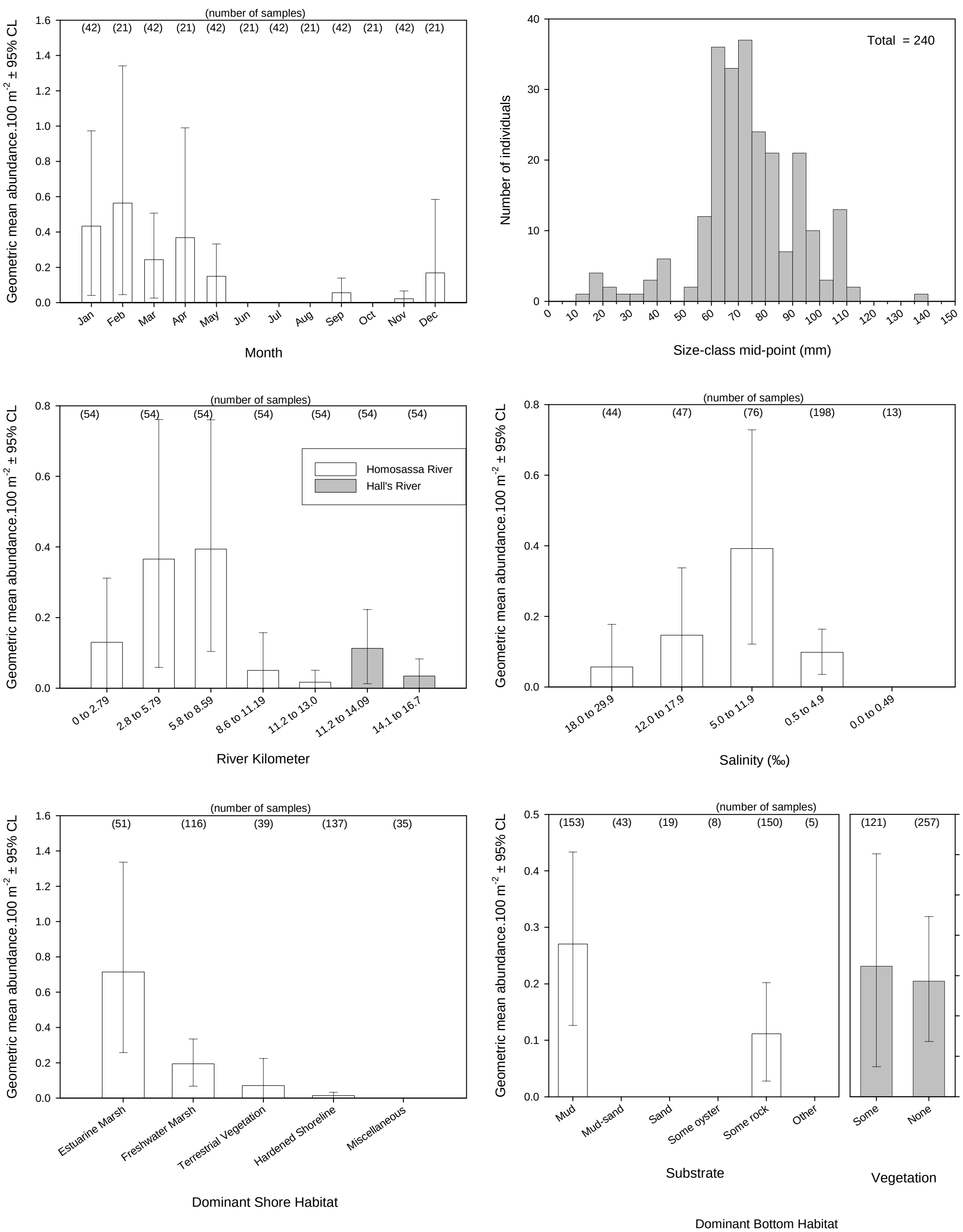


Fig. D14. Relative abundance of *Fundulus grandis* (Gulf killifish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Fundulus seminolis (Seminole killifish) in seines

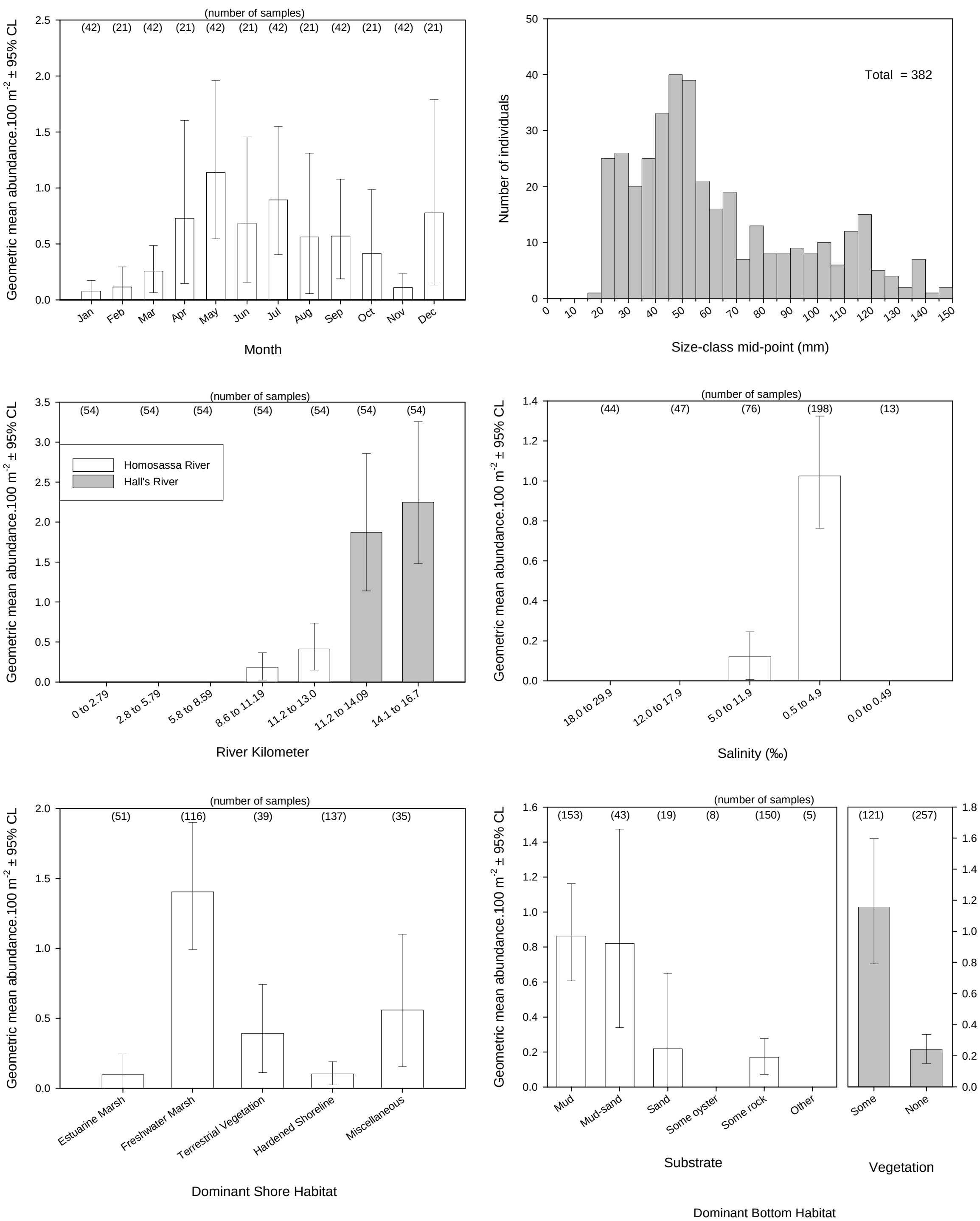


Fig. D15. Relative abundance of *Fundulus seminolis* (Seminole killifish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Lucania parva (rainwater killifish) in seines

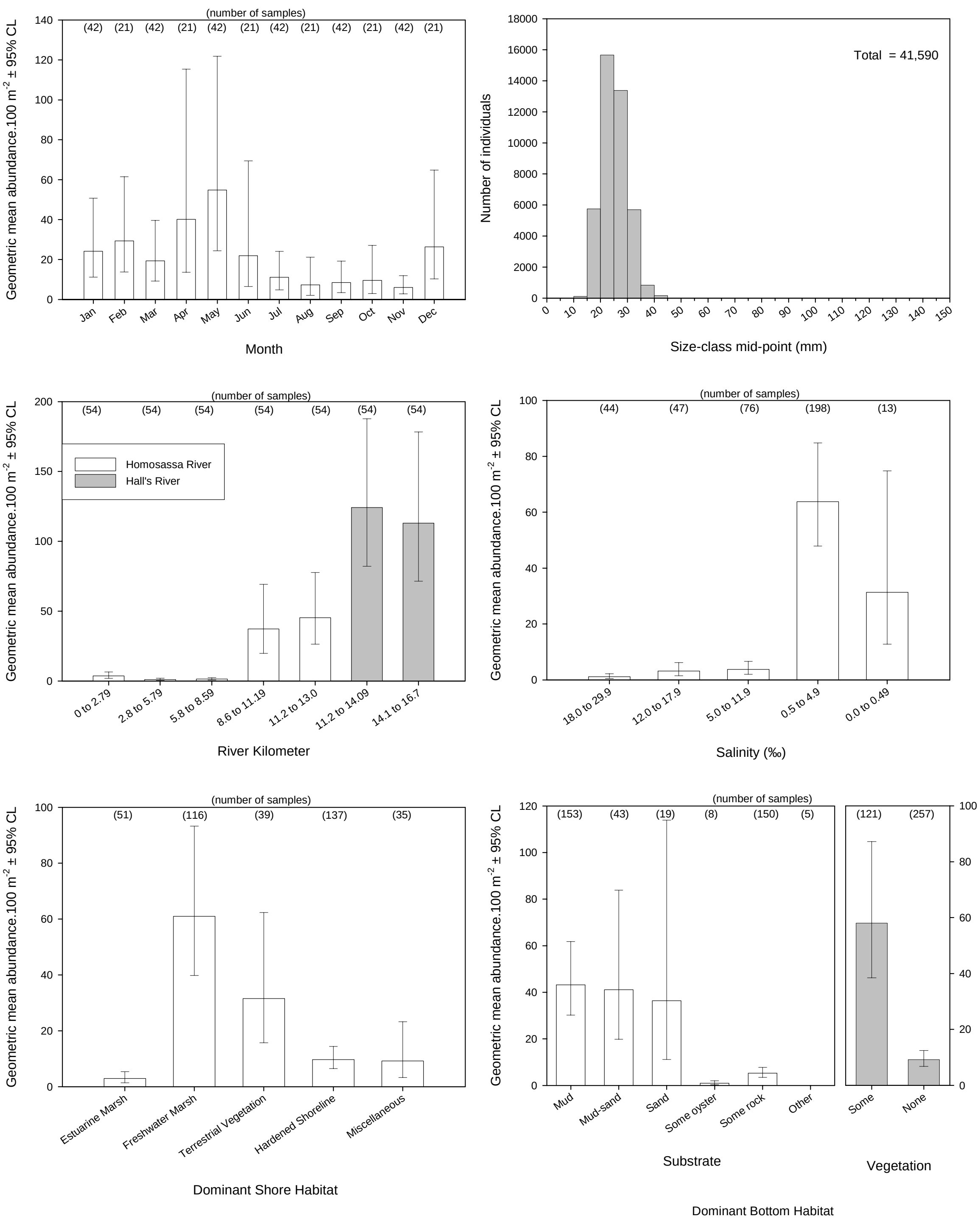


Fig. D16. Relative abundance of *Lucania parva* (rainwater killifish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Lucania goodei (bluefin killifish) in seines

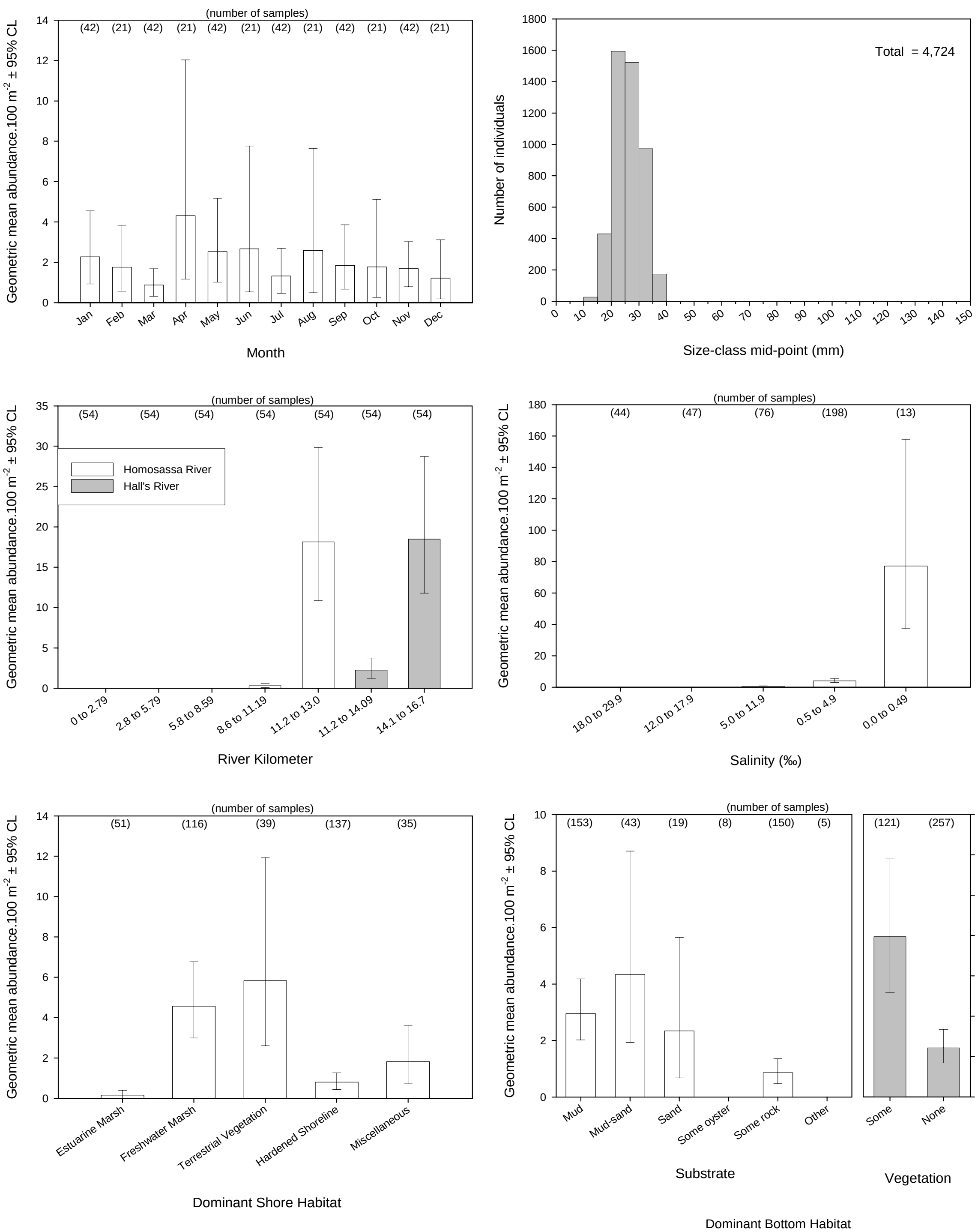


Fig. D17. Relative abundance of *Lucania goodei* (bluefin killifish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Floridichthys carpio (goldspotted killifish) in seines

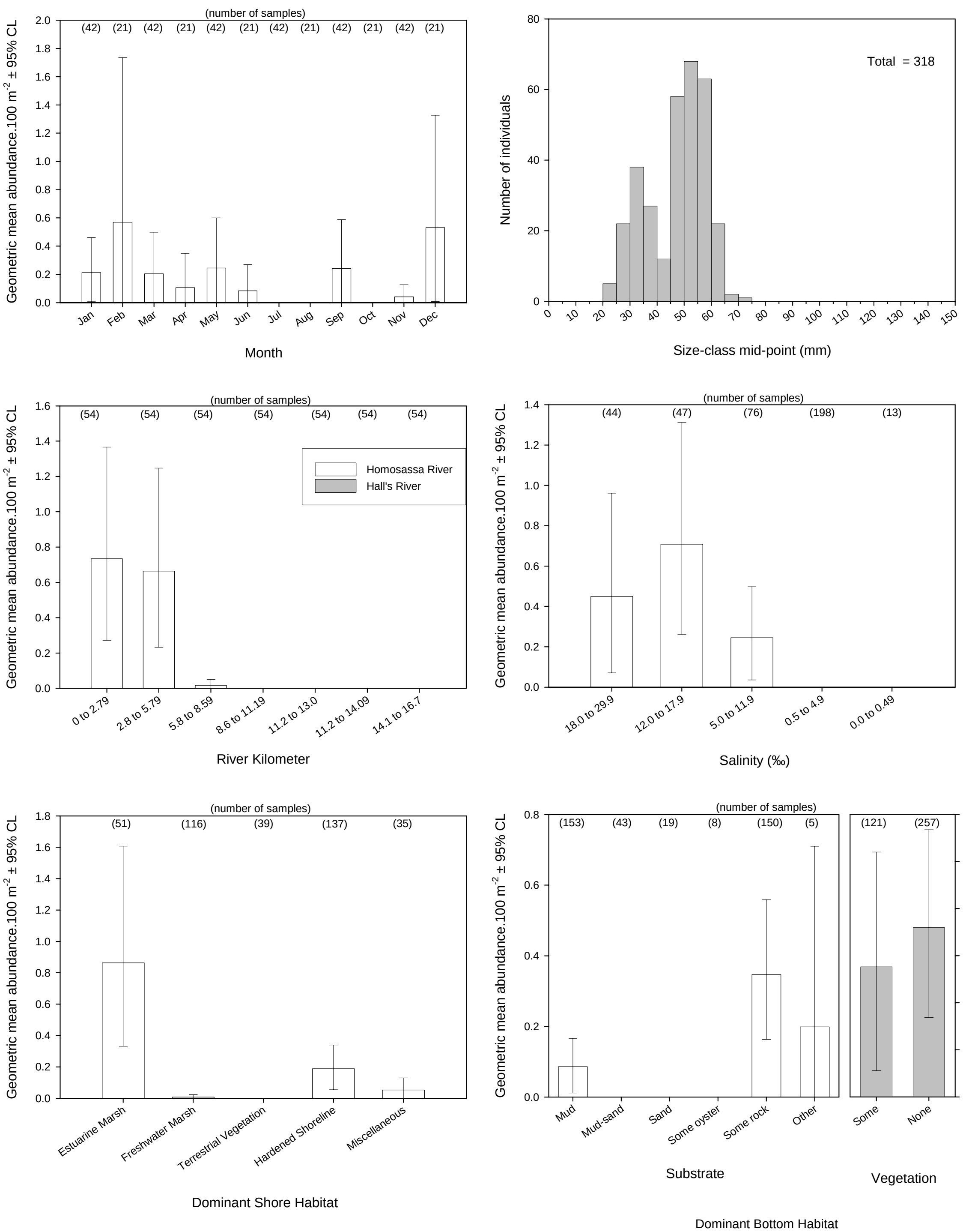


Fig. D18. Relative abundance of *Floridichthys carpio* (goldspotted killifish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Gambusia holbrooki (Eastern mosquitofish) in seines

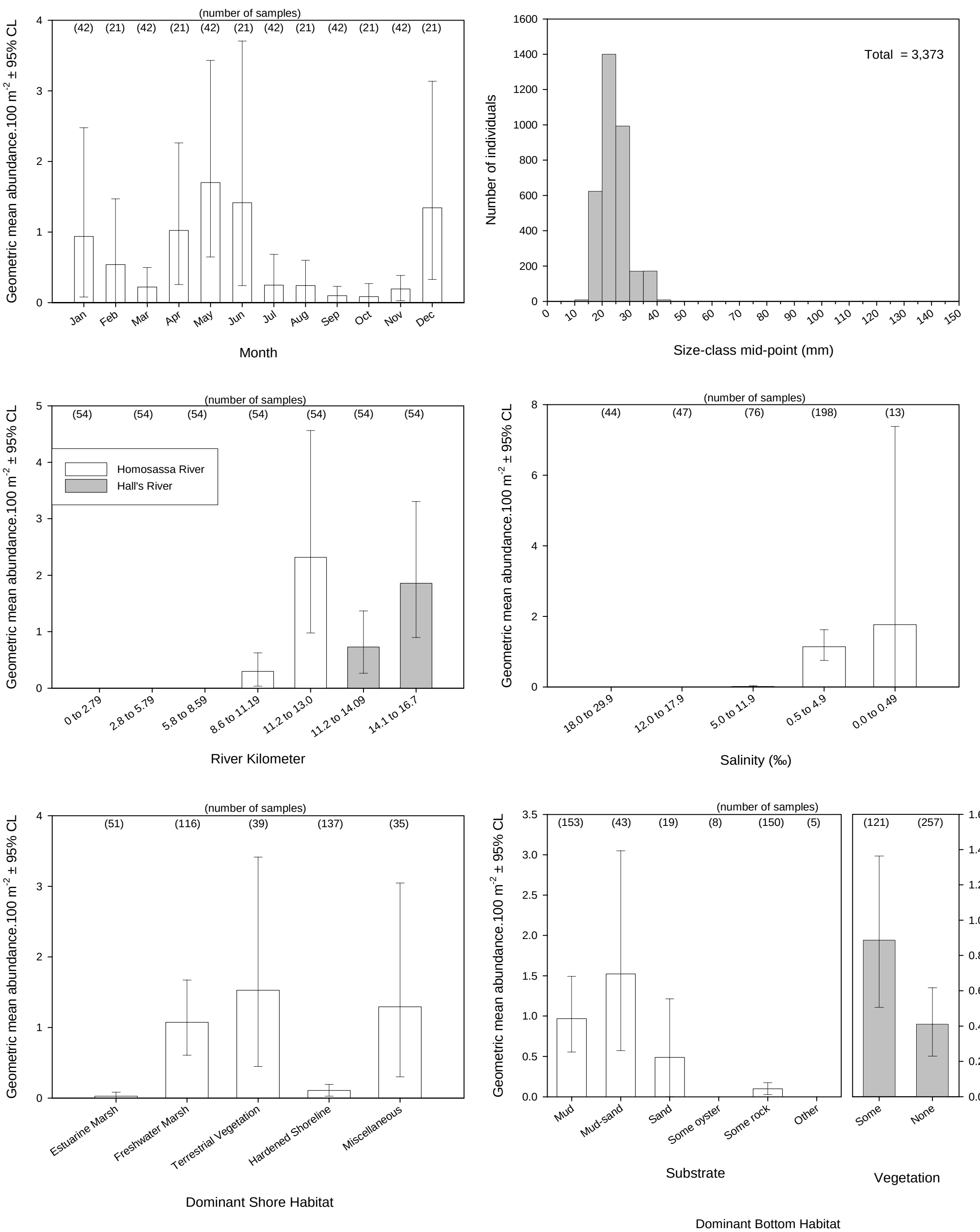


Fig. D19. Relative abundance of *Gambusia holbrooki* (Eastern mosquitofish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Poecilia latipinna (sailfin molly) in seines

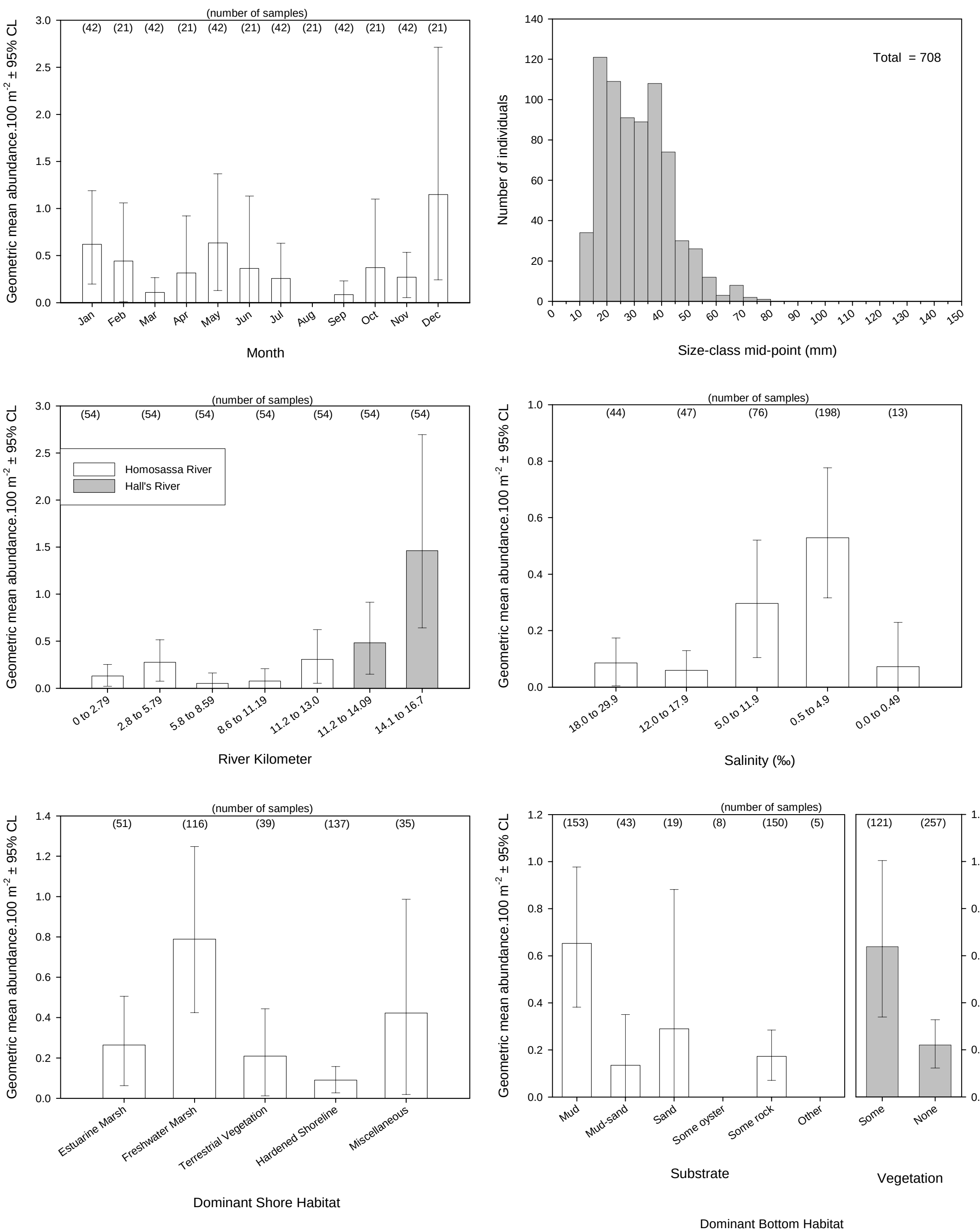


Fig. D20. Relative abundance of *Poecilia latipinna* (sailfin molly) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Heterandria formosa (least killifish) in seines

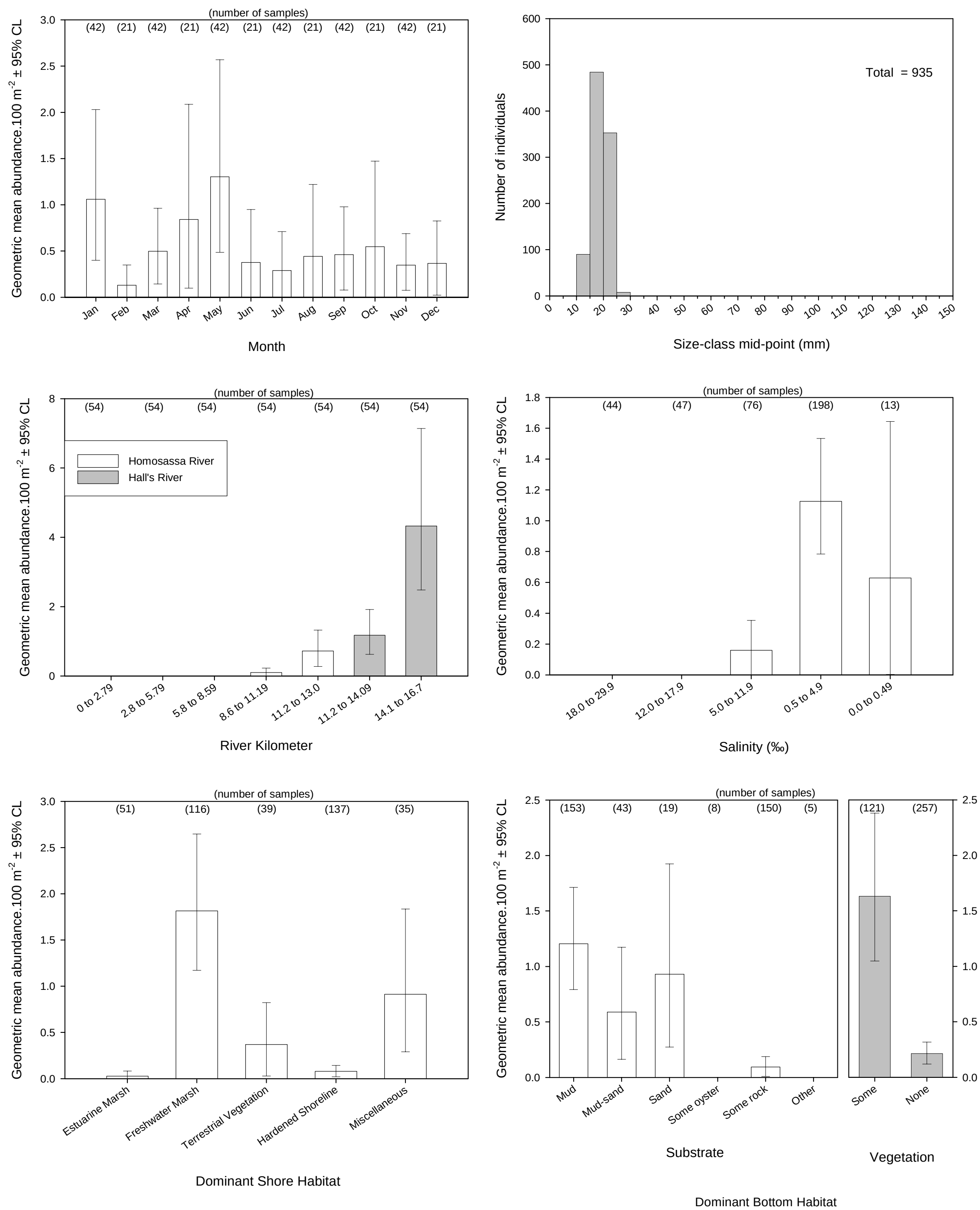


Fig. D21. Relative abundance of *Heterandria formosa* (least killifish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Syngnathus scovelli (Gulf pipefish) in seines

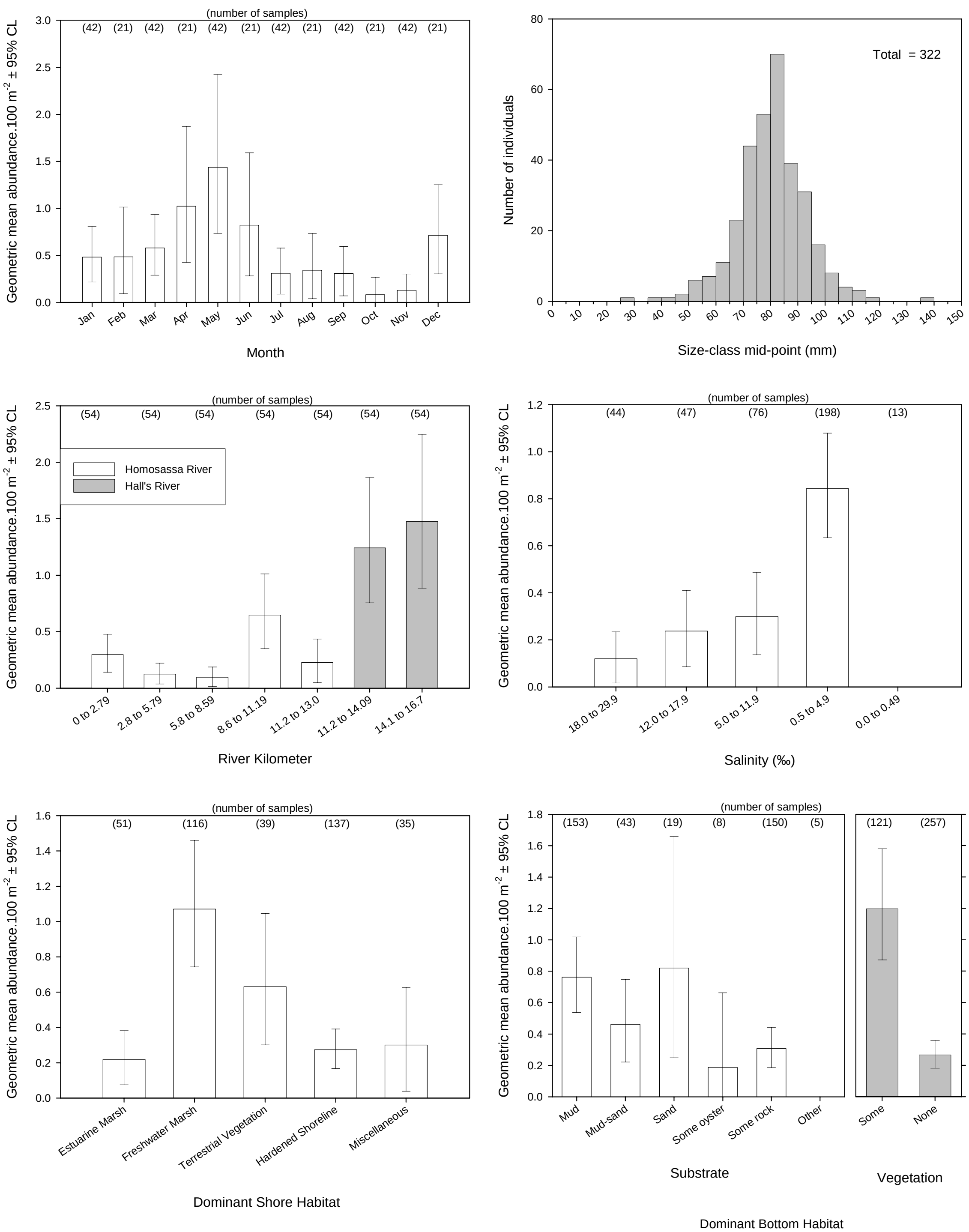


Fig. D22. Relative abundance of *Syngnathus scovelli* (Gulf pipefish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Lepomis macrochirus (bluegill) in seines

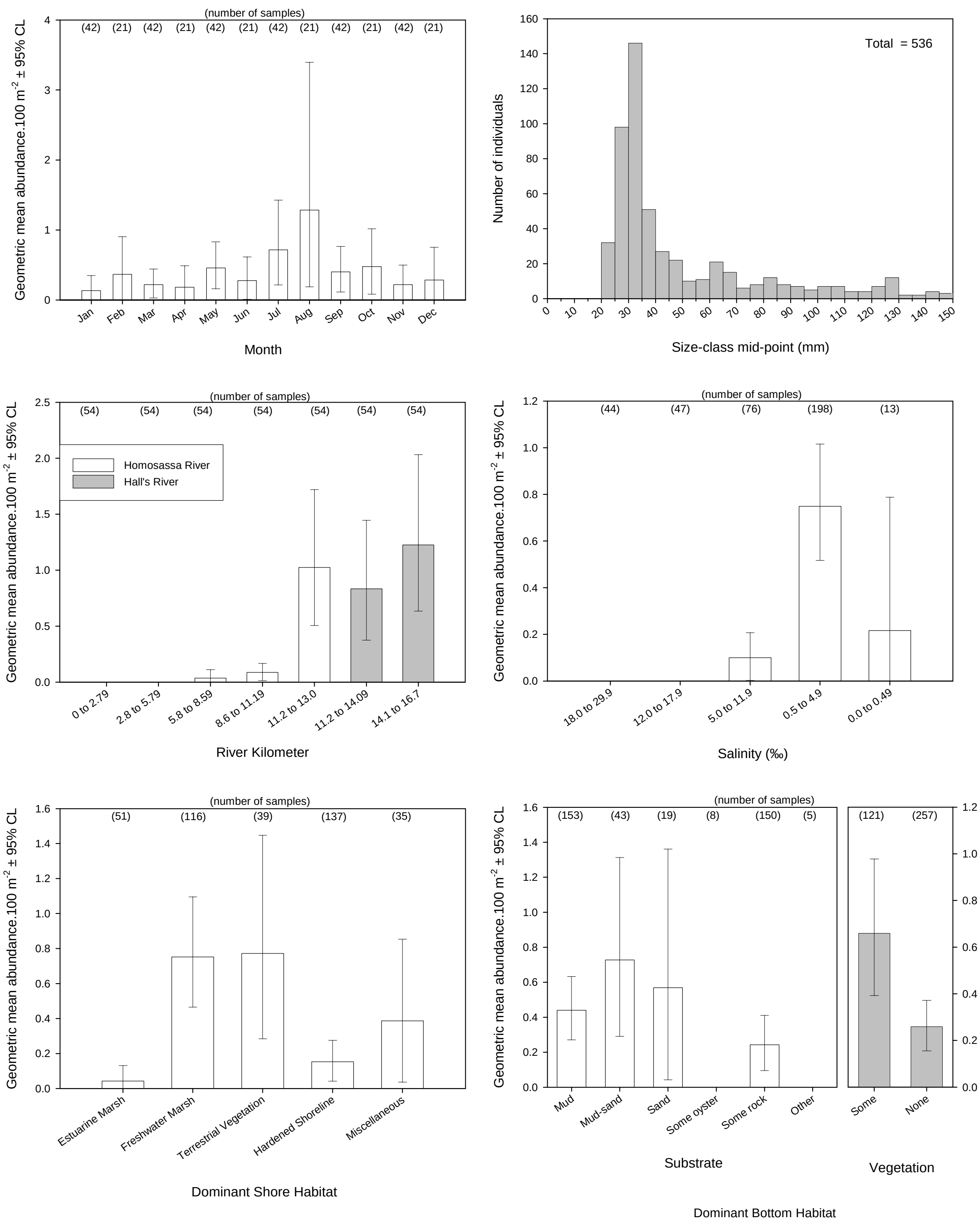


Fig. D23. Relative abundance of *Lepomis macrochirus* (bluegill) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Lepomis microlophus (redear sunfish) in seines

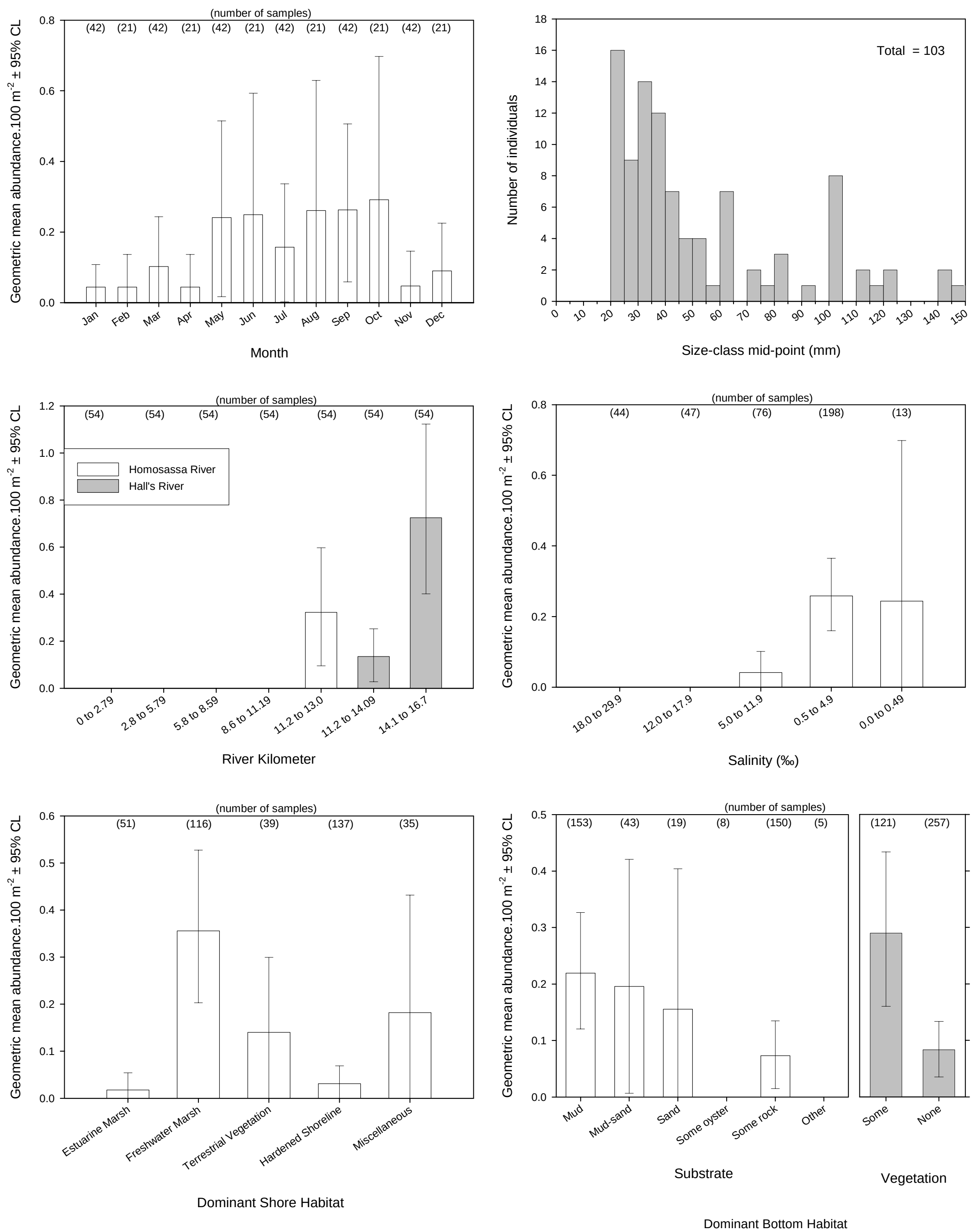


Fig. D24. Relative abundance of *Lepomis microlophus* (redear sunfish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Lepomis punctatus (spotted sunfish) in seines

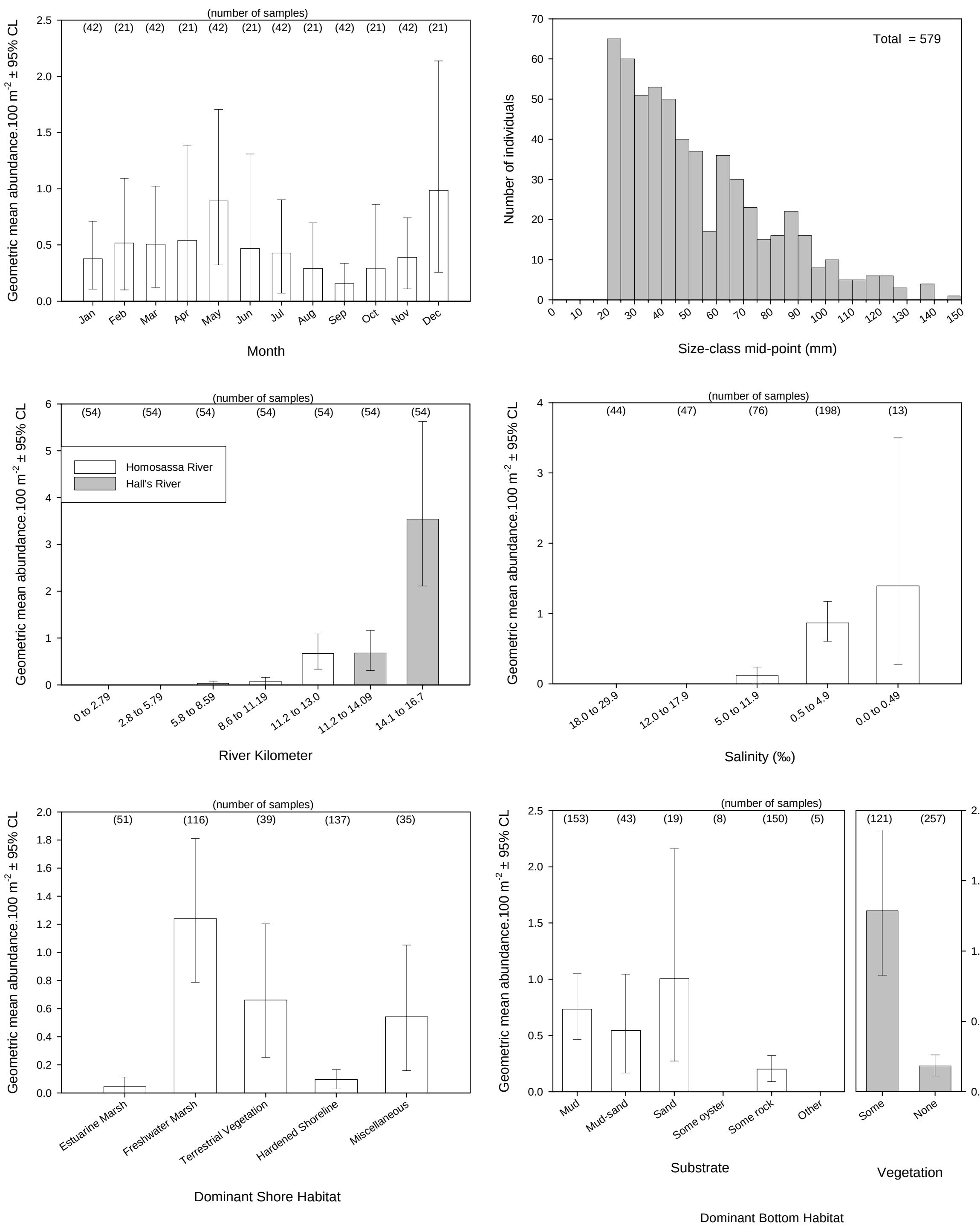


Fig. D25. Relative abundance of *Lepomis punctatus* (spotted sunfish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Micropterus salmoides (largemouth bass) in seines

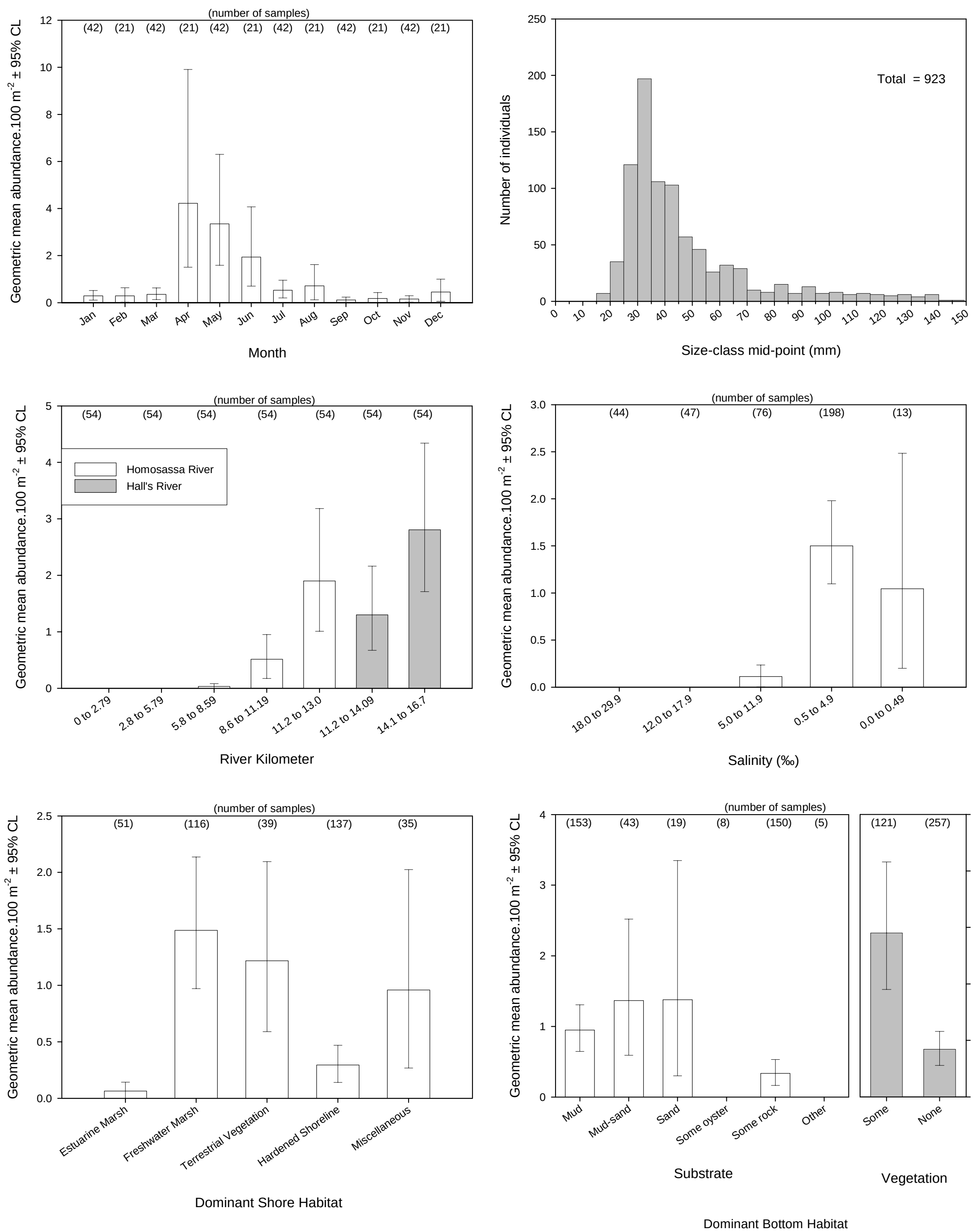


Fig. D26. Relative abundance of *Micropterus salmoides* (largemouth bass) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Lutjanus griseus (gray snapper) in seines

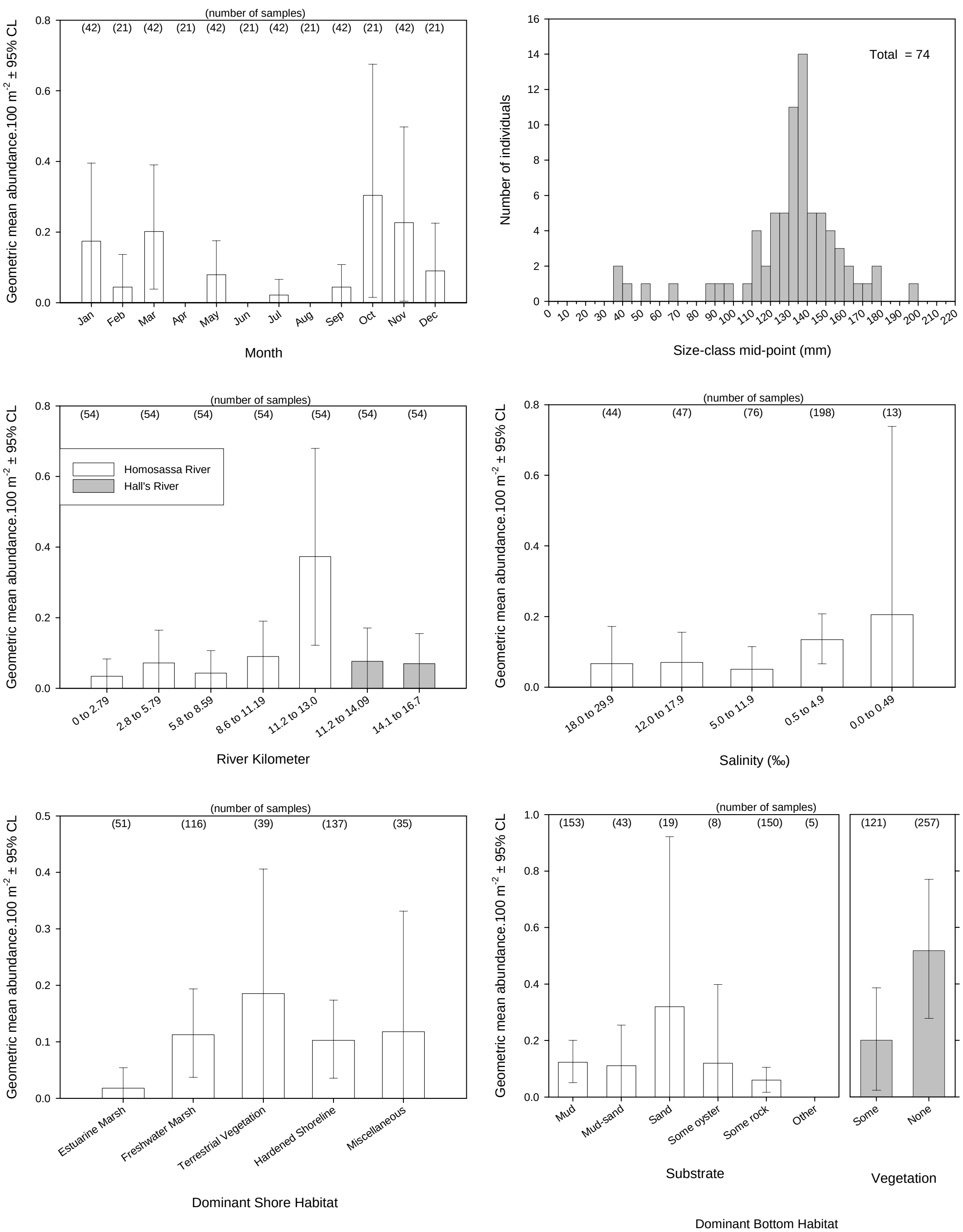


Fig. D27. Relative abundance of *Lutjanus griseus* (gray snapper) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Eucinostomus gula (silver jenny) in seines

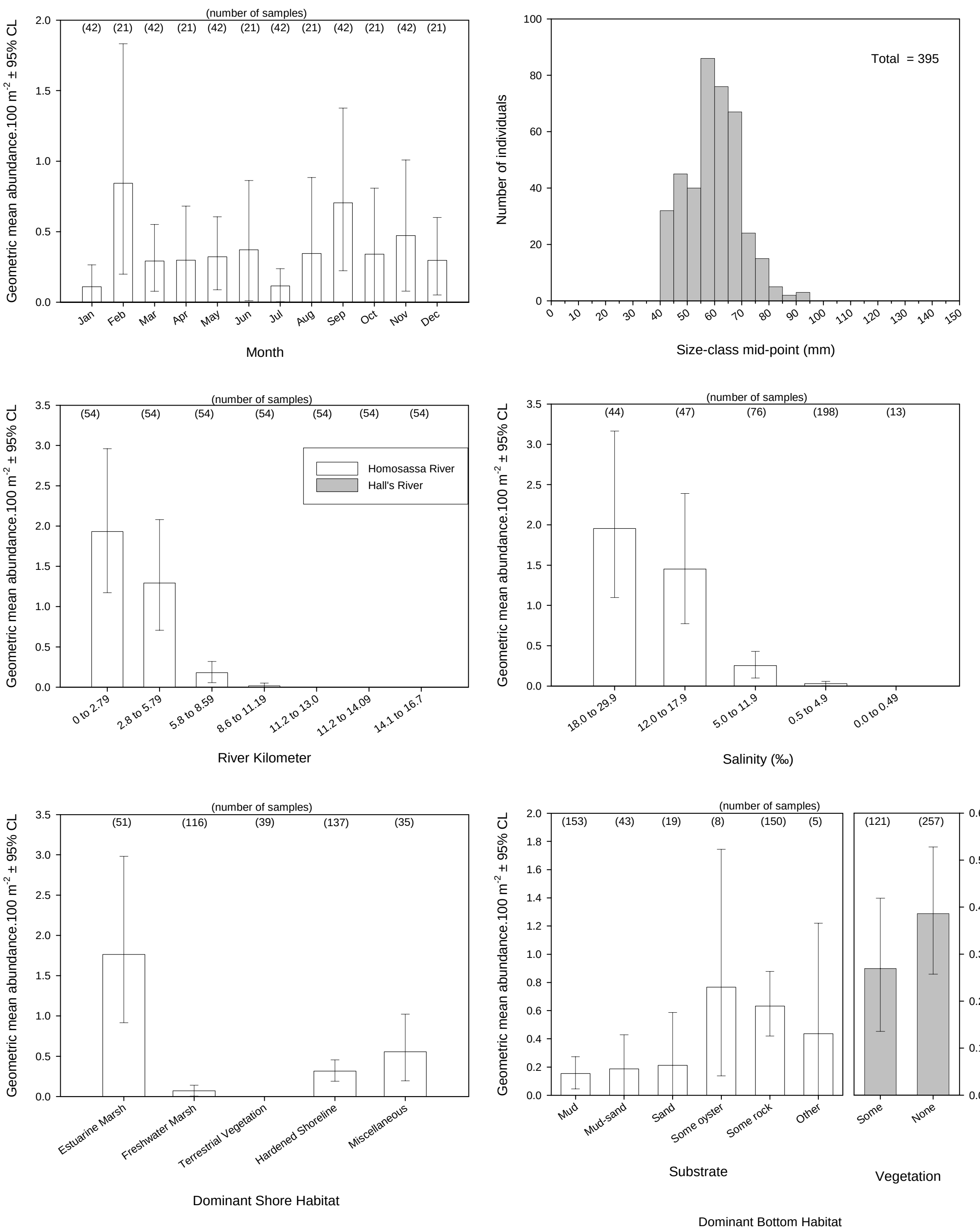


Fig. D28. Relative abundance of *Eucinostomus gula* (silver jenny) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Eucinostomus harengulus (tidewater mojarra) in seines

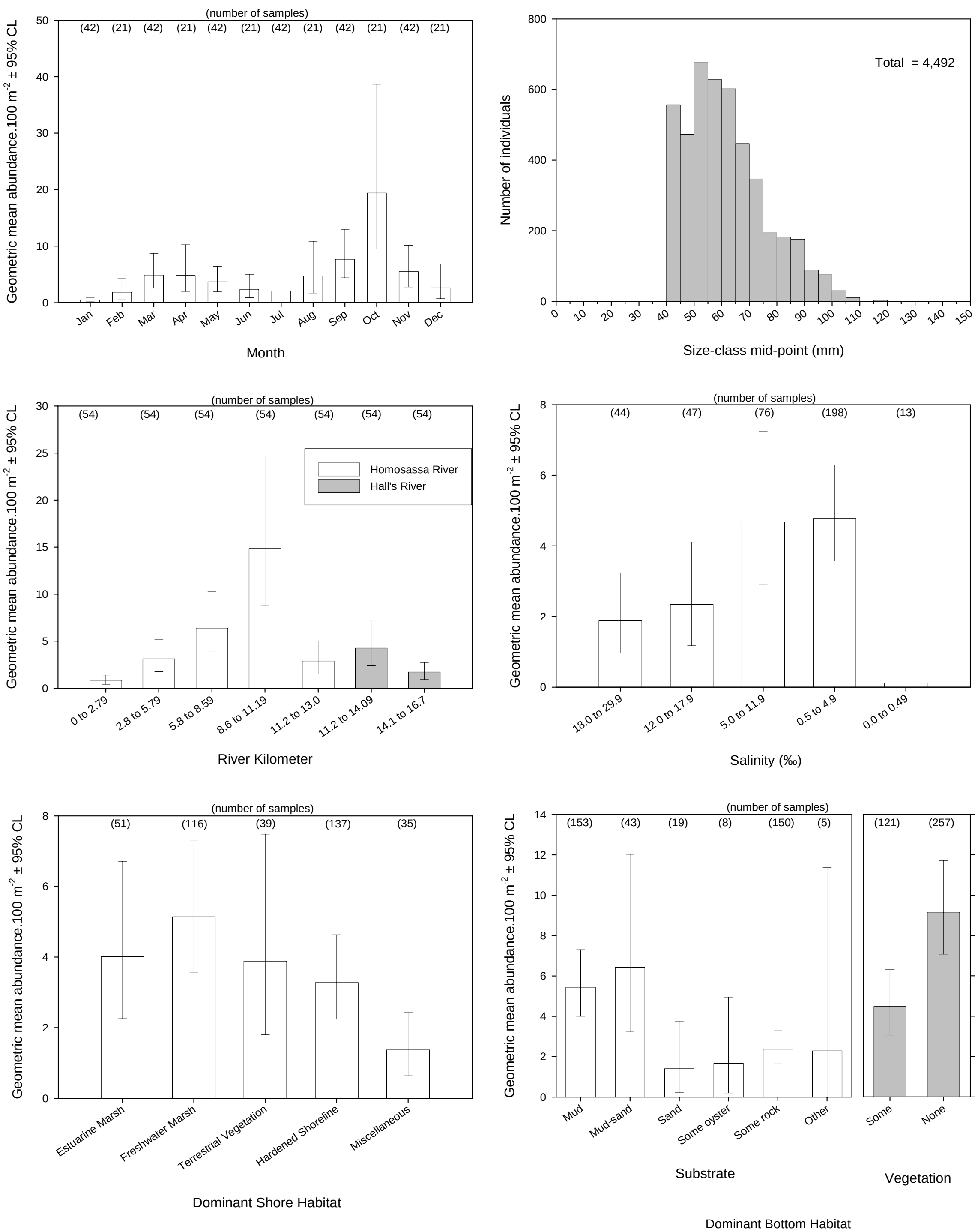


Fig. D29. Relative abundance of *Eucinostomus harengulus* (tidewater mojarra) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Lagodon rhomboides (pinfish) in seines

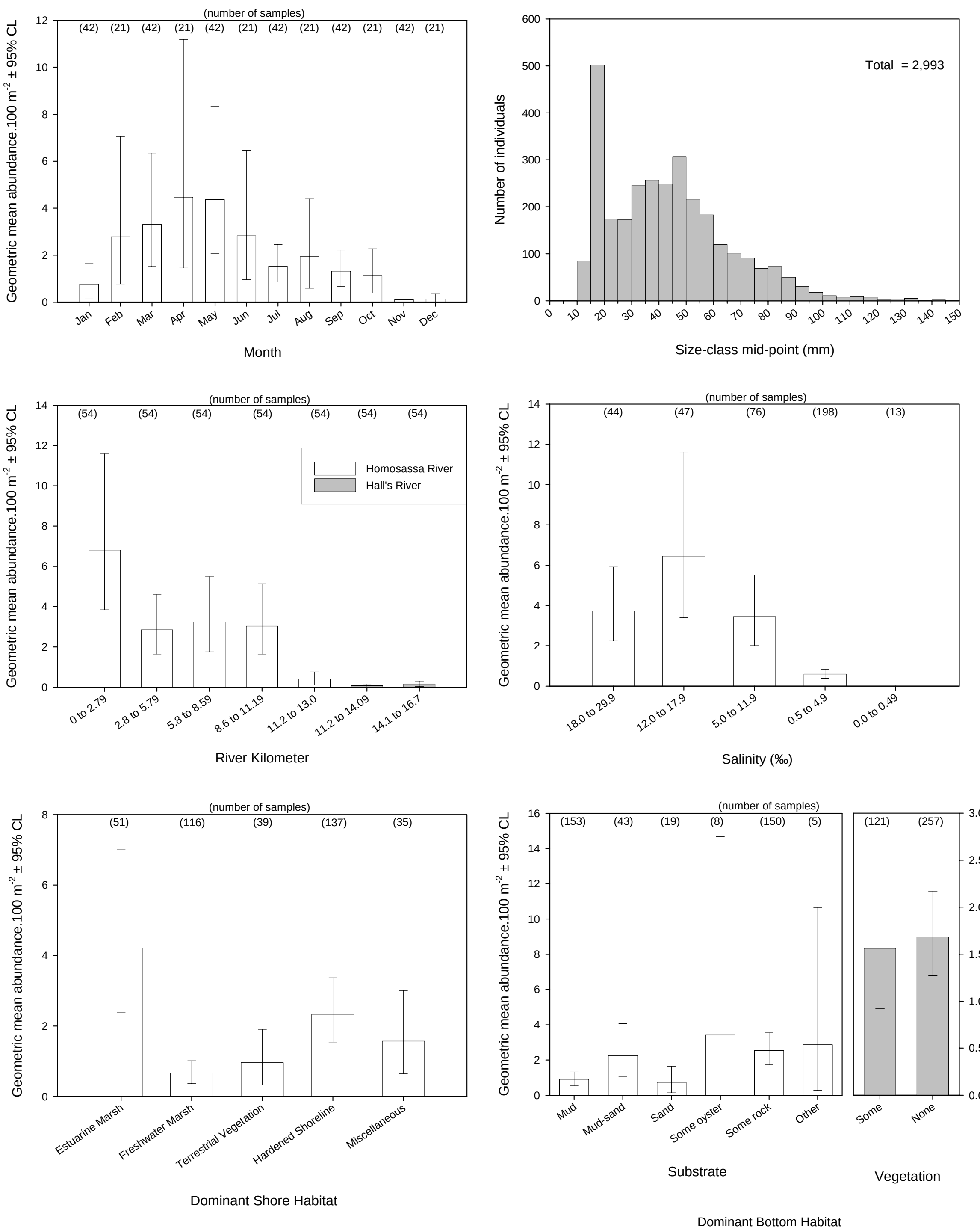


Fig. D30. Relative abundance of *Lagodon rhomboides* (pinfish) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Leiostomus xanthurus (spot) in seines

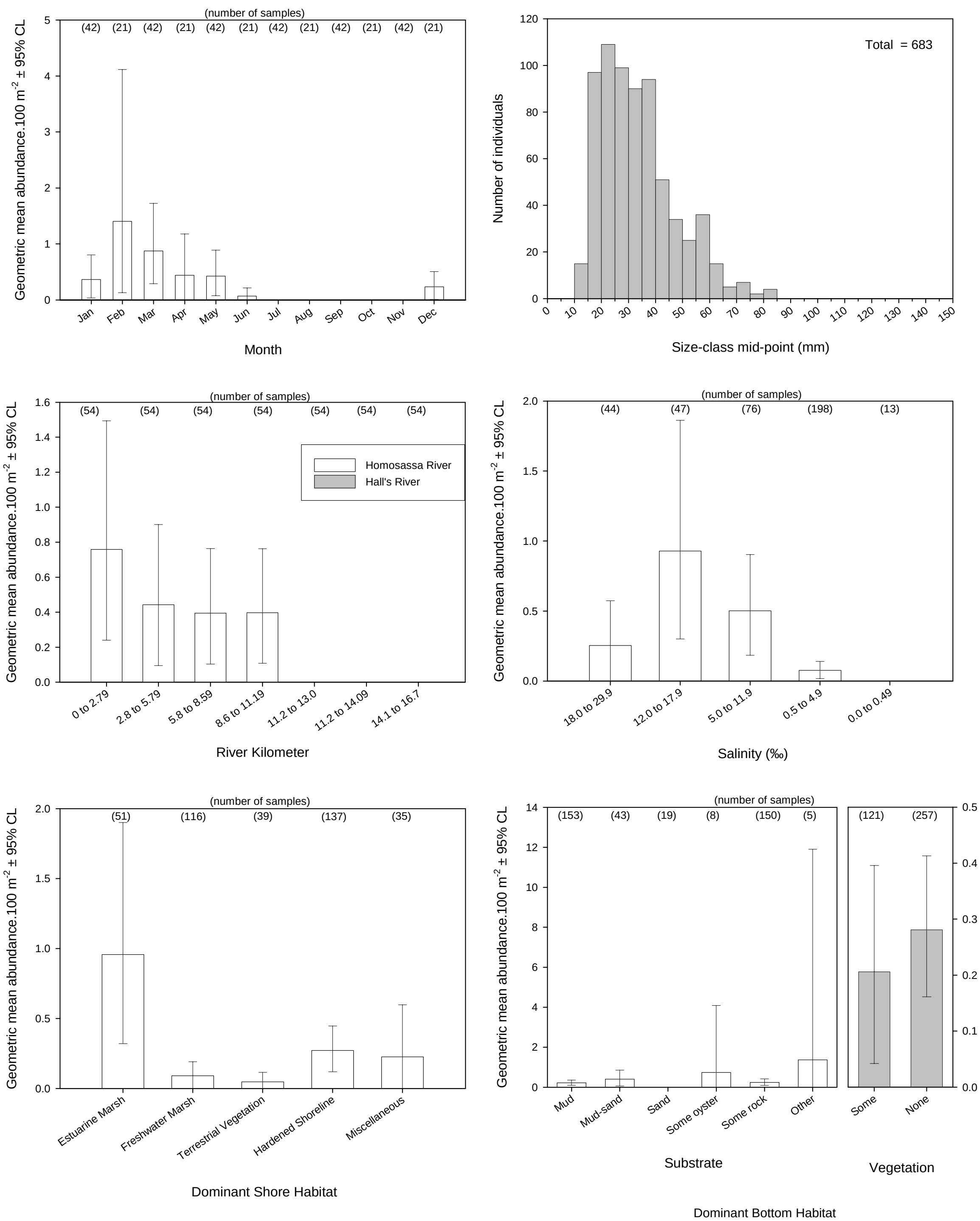


Fig. D31. Relative abundance of *Leiostomus xanthurus* (spot) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Gobiosoma bosc (naked goby) in seines

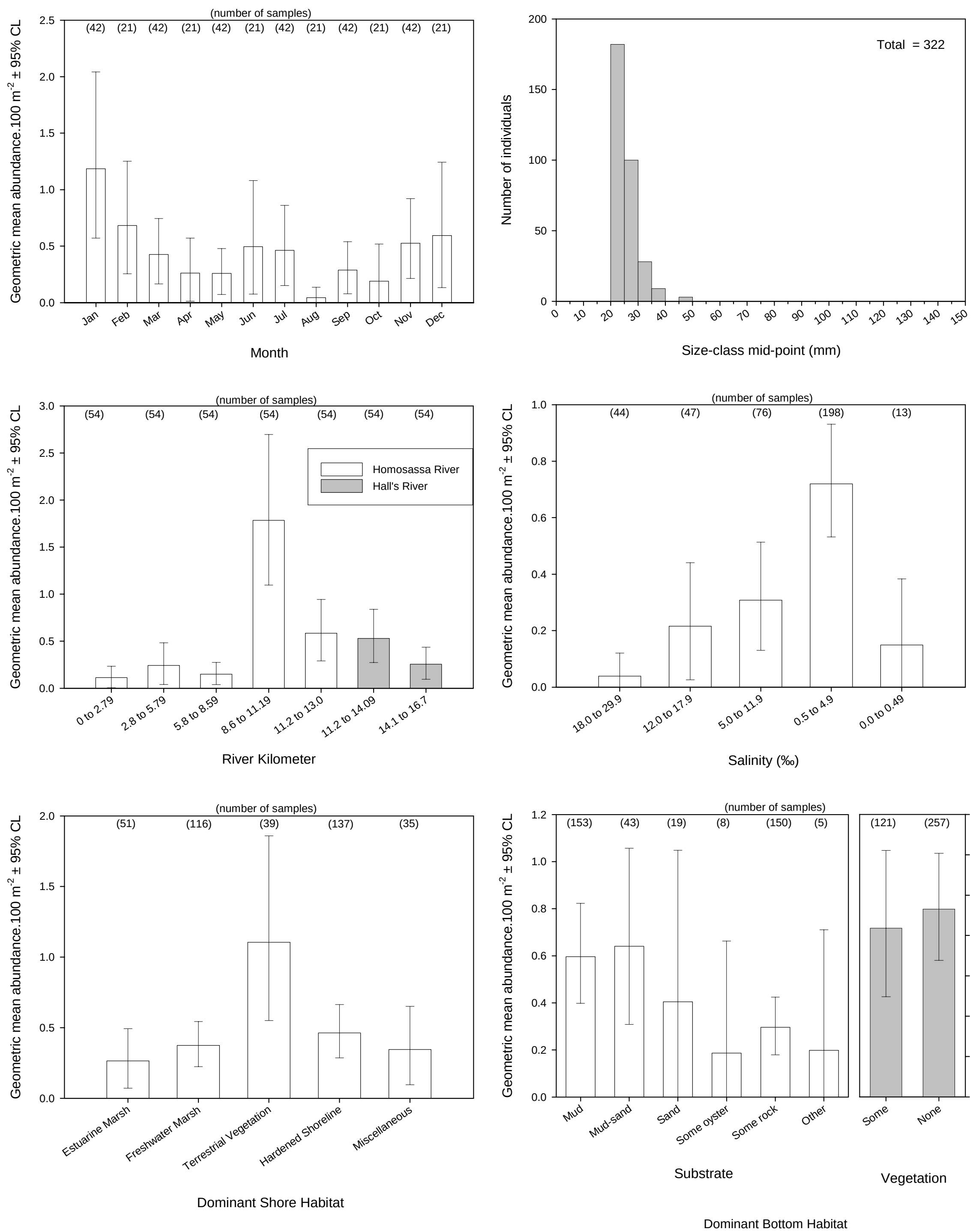


Fig. D32. Relative abundance of *Gobiosoma bosc* (naked goby) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Microgobius gulosus (clown goby) in seines

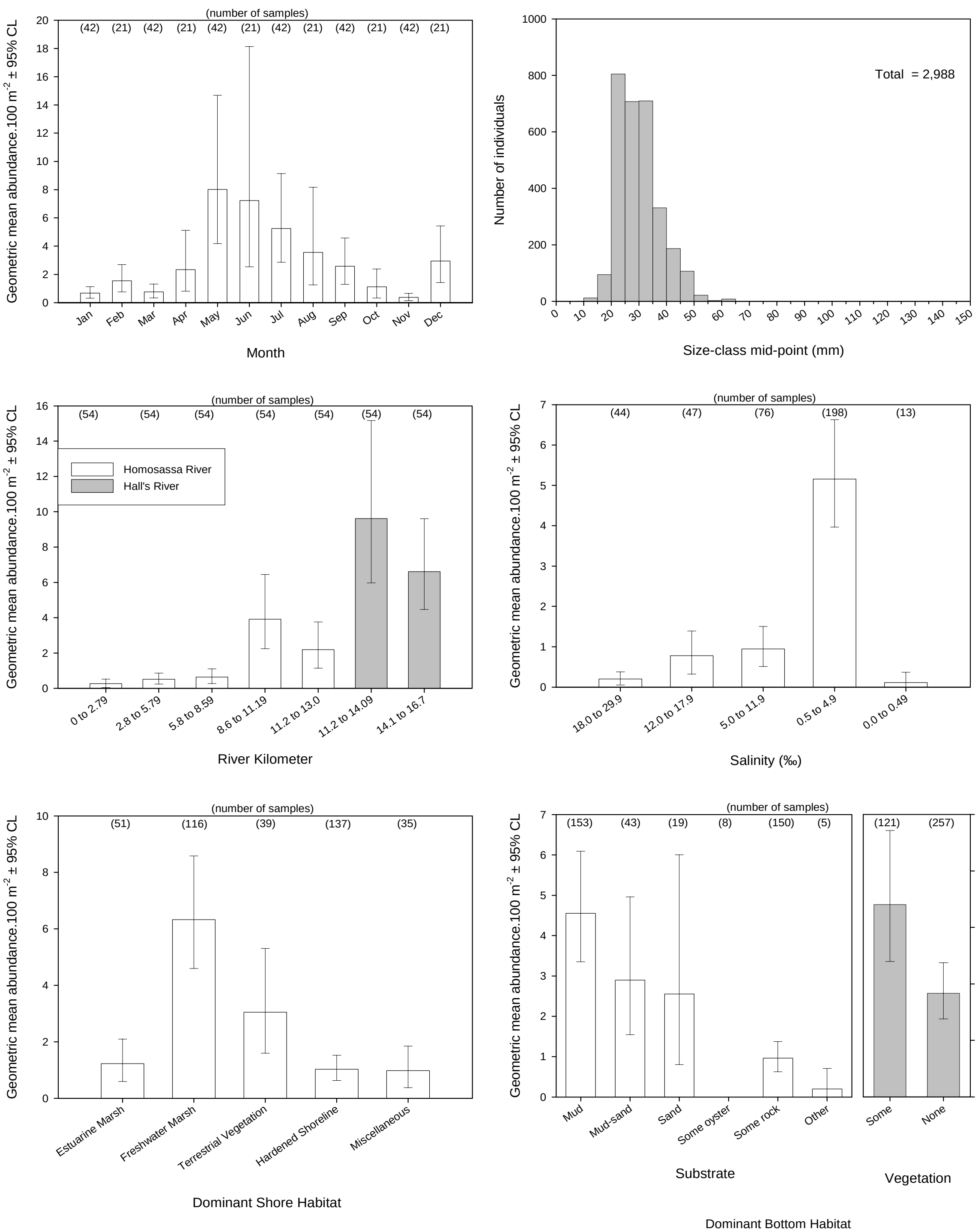


Fig. D33. Relative abundance of *Microgobius gulosus* (clown goby) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Trinectes maculatus (hogchoker) in seines

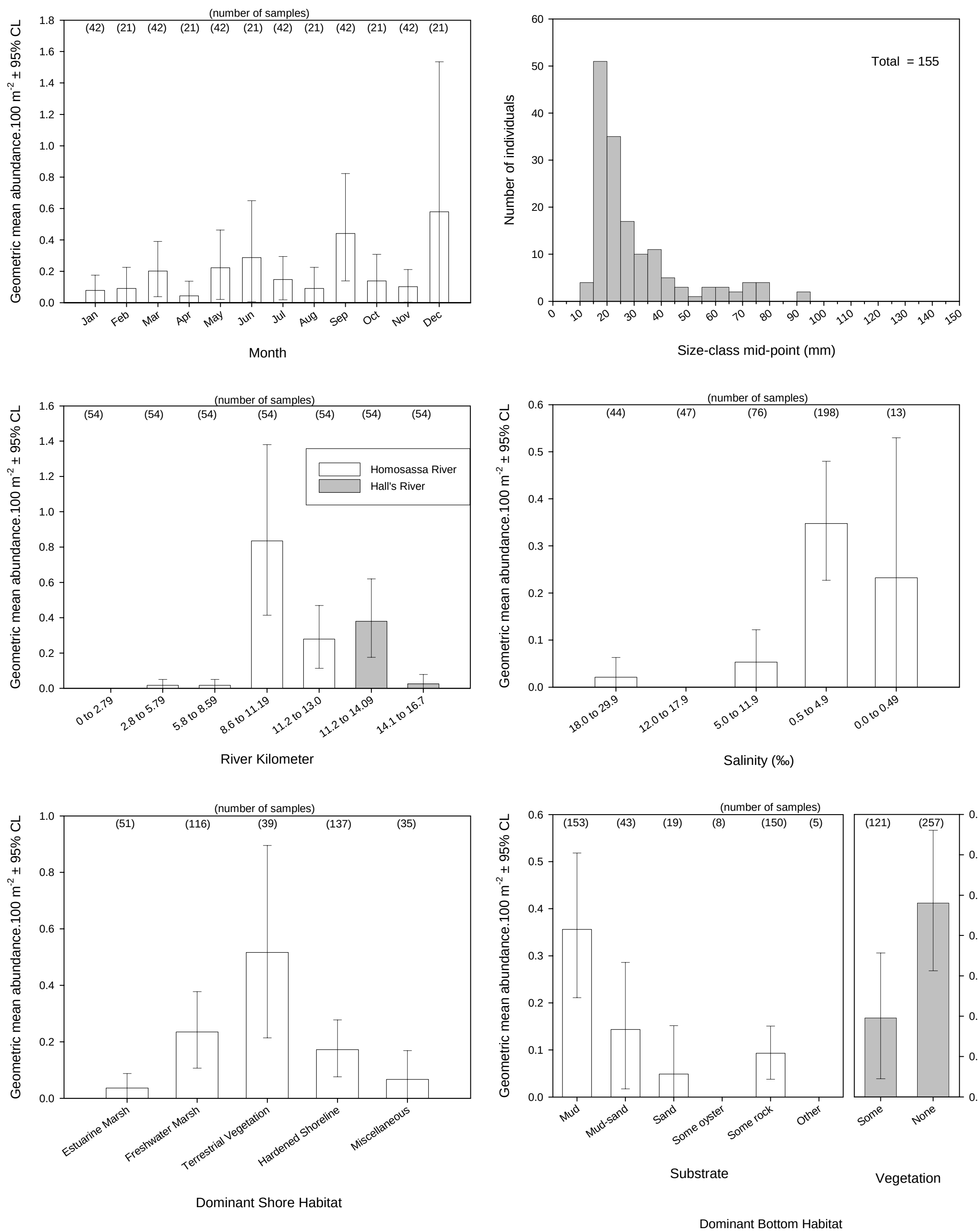


Fig. D34. Relative abundance of *Trinectes maculatus* (hogchoker) collected with seines (water depths <= 1.8-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Appendix E: Trawl catch overview plots

Palaemonetes intermedius (brackish grass shrimp) in trawls

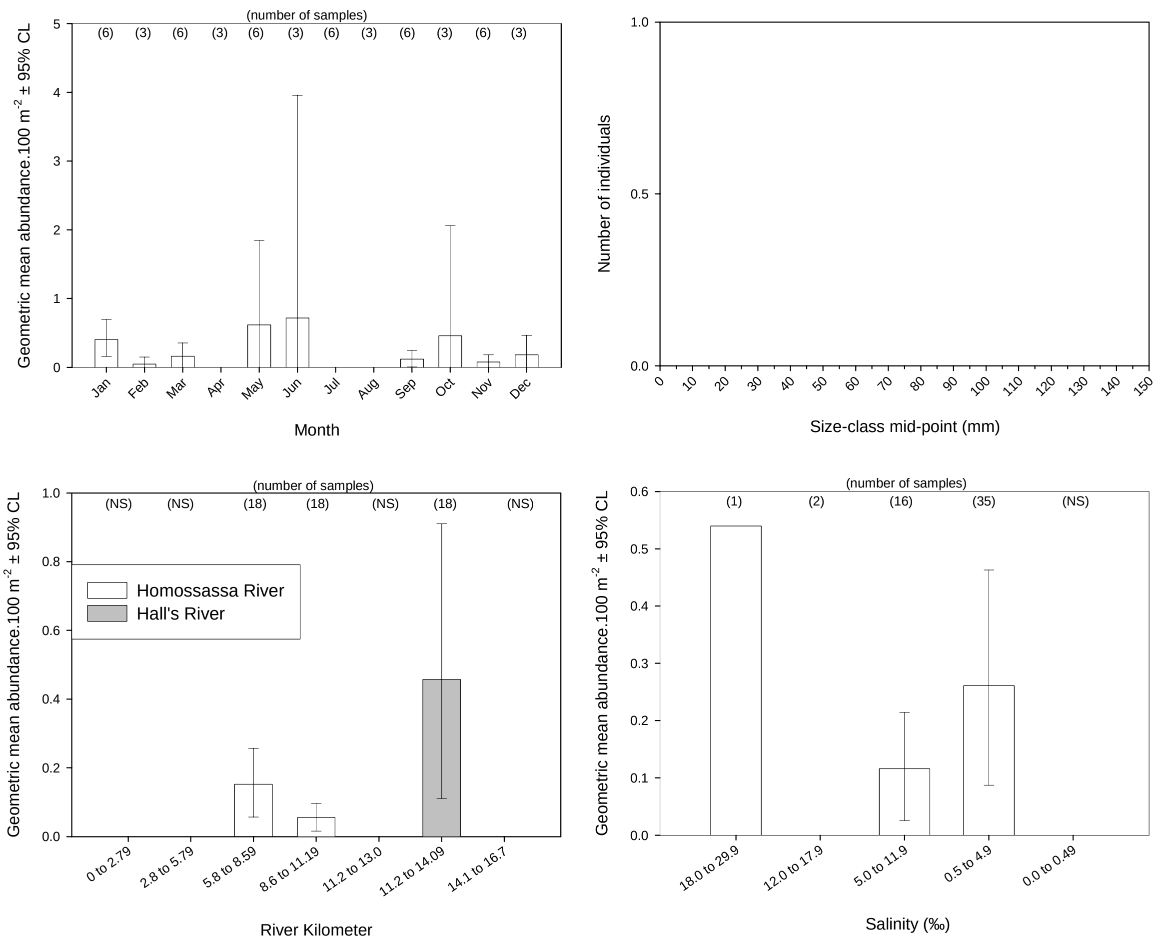


Fig. E1. Relative abundance of *Palaemonetes intermedius (*brackish grass shrimp) collected with trawls (water depths >= 2.0-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Callinectes sapidus (blue crab) in trawls

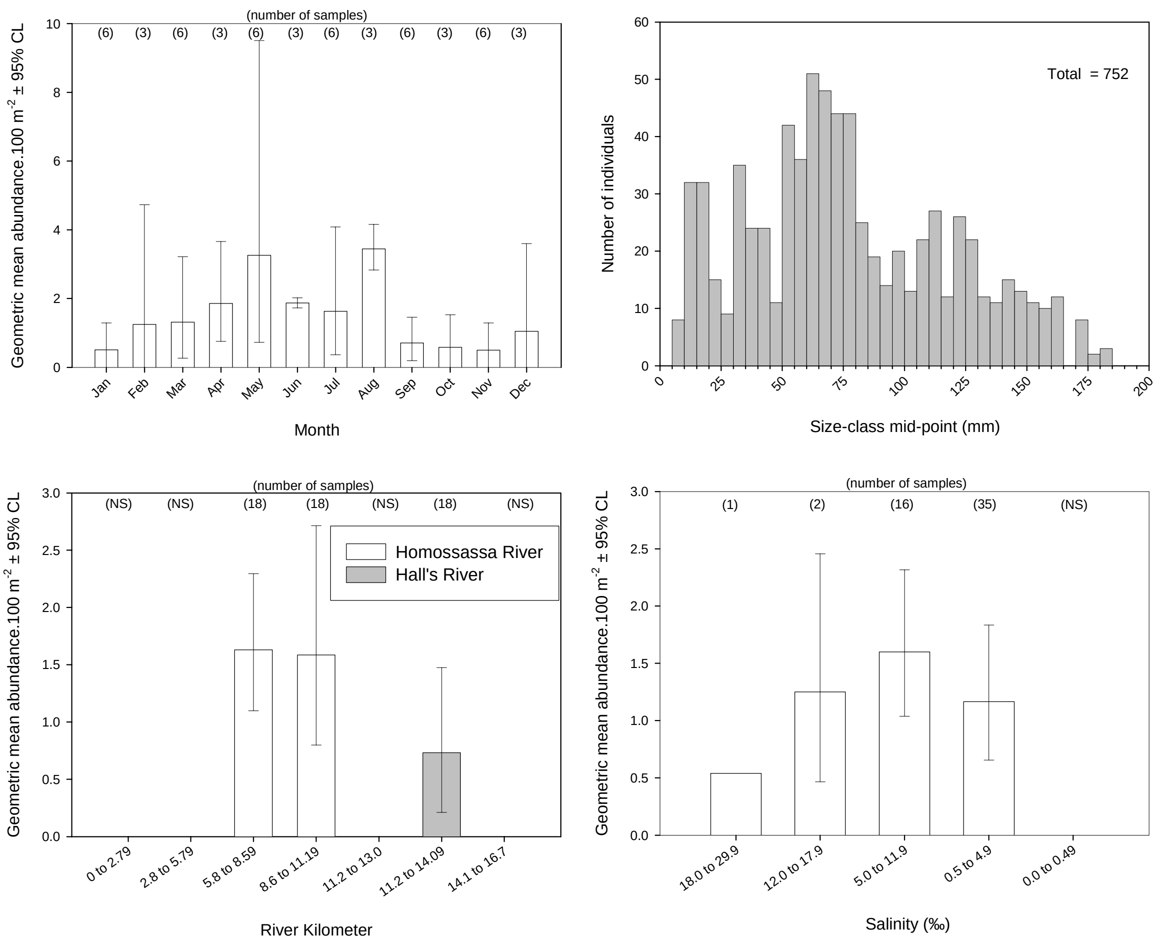


Fig. E2. Relative abundance of *Callinectes sapidus* (blue crab) collected with trawls (water depths >= 2.0-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Anchoa mitchilli (bay anchovy) in trawls

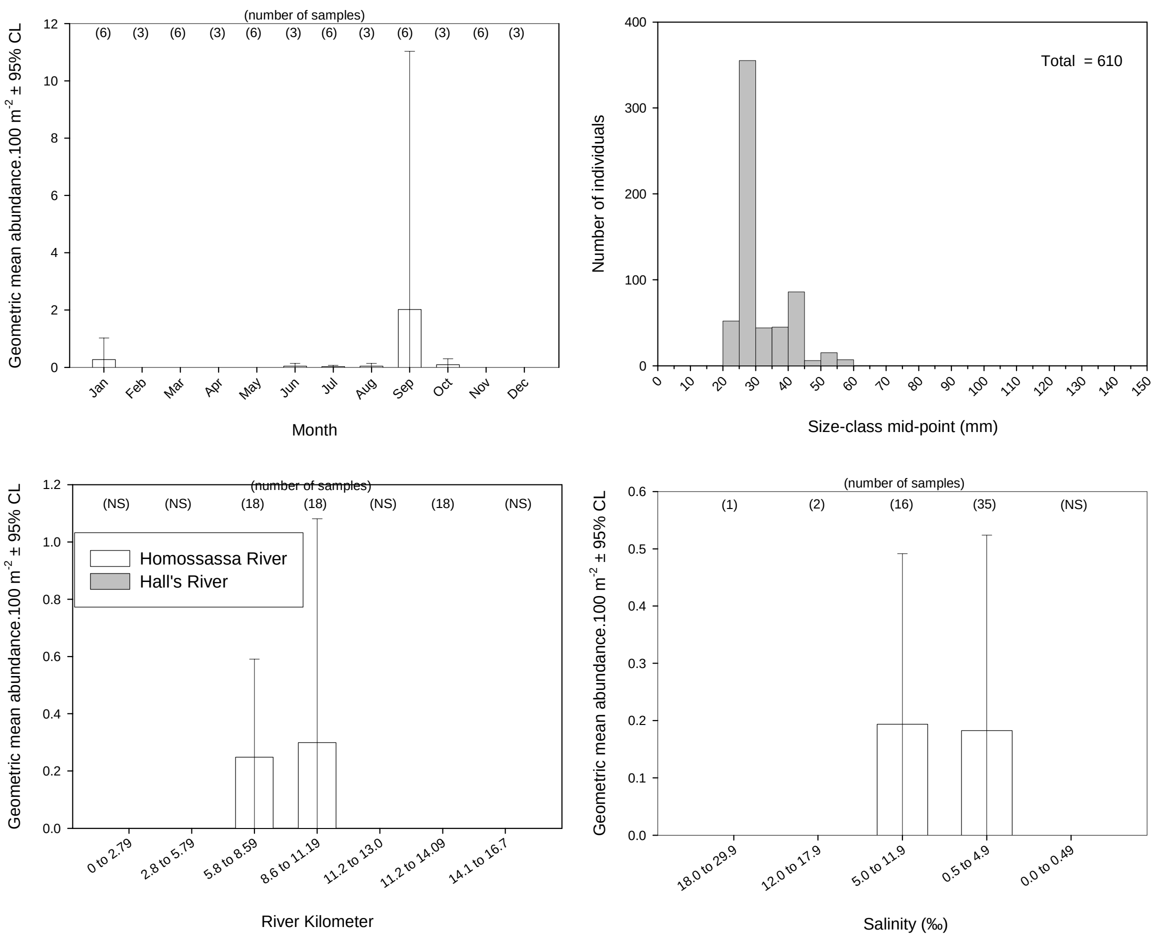


Fig. E3. Relative abundance of *Anchoa mitchilli* (bay anchovy) collected with trawls (water depths >= 2.0-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Lucania parva (rainwater killifish) in trawls

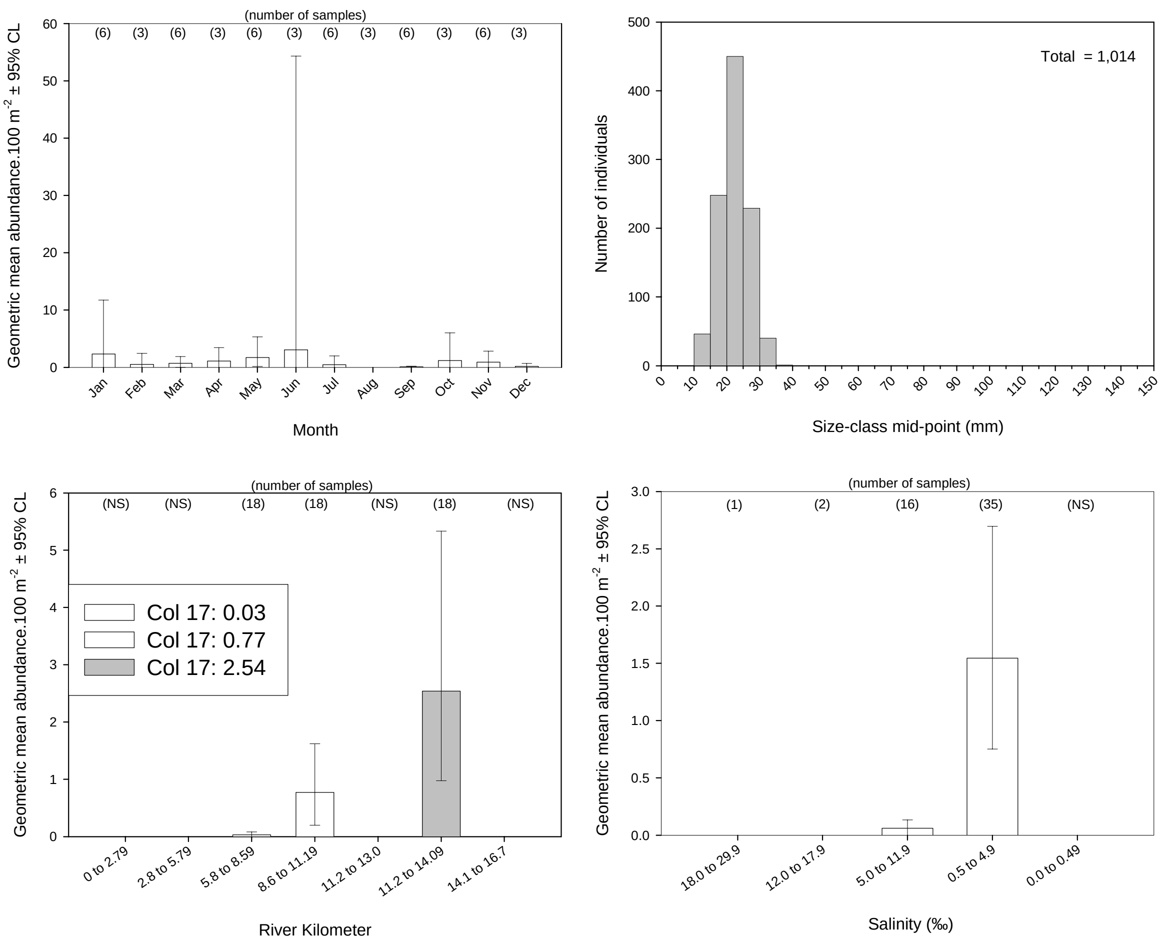


Fig. E4. Relative abundance of *Lucania parva* (rainwater killifish) collected with trawls (water depths >= 2.0-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Syngnathus scovelli (Gulf pipefish) in trawls

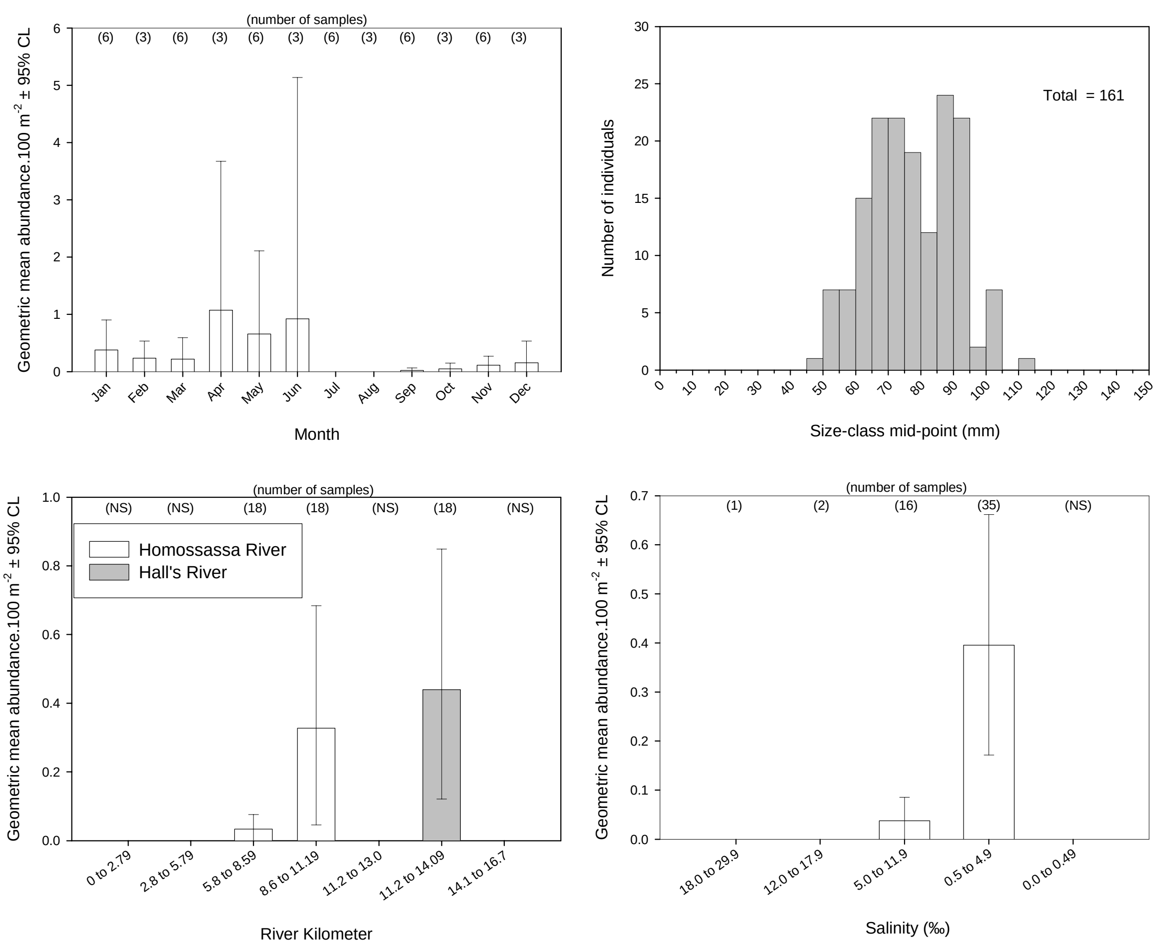


Fig. E5. Relative abundance of *Syngnathus scovelli* (Gulf pipefish) collected with trawls (water depths >= 2.0-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Eucinostomus harengulus (tidewater mojarra) in trawls

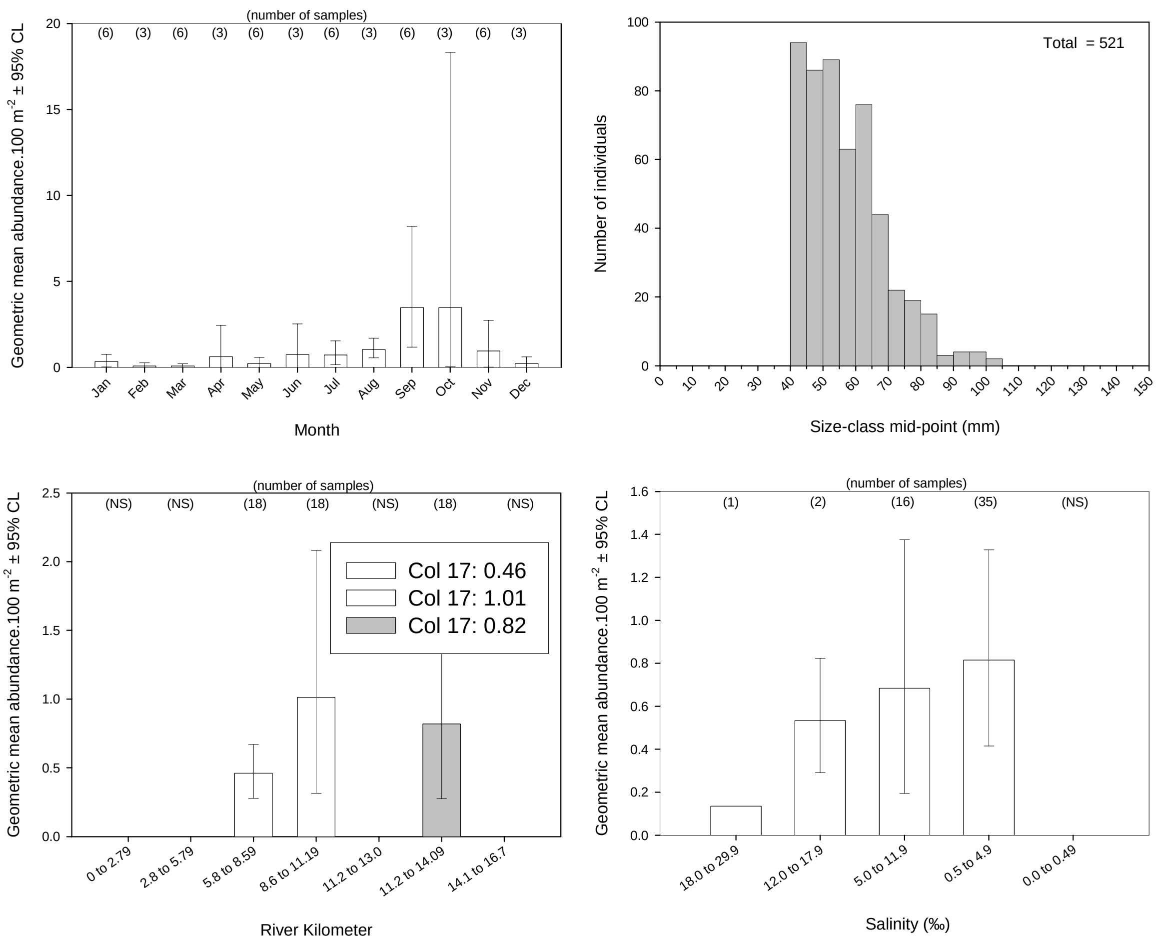


Fig. E6. Relative abundance of *Eucinostomus harengulus* (tidewater mojarra) collected with trawls (water depths >= 2.0-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Lagodon rhomboides (pinfish) in trawls

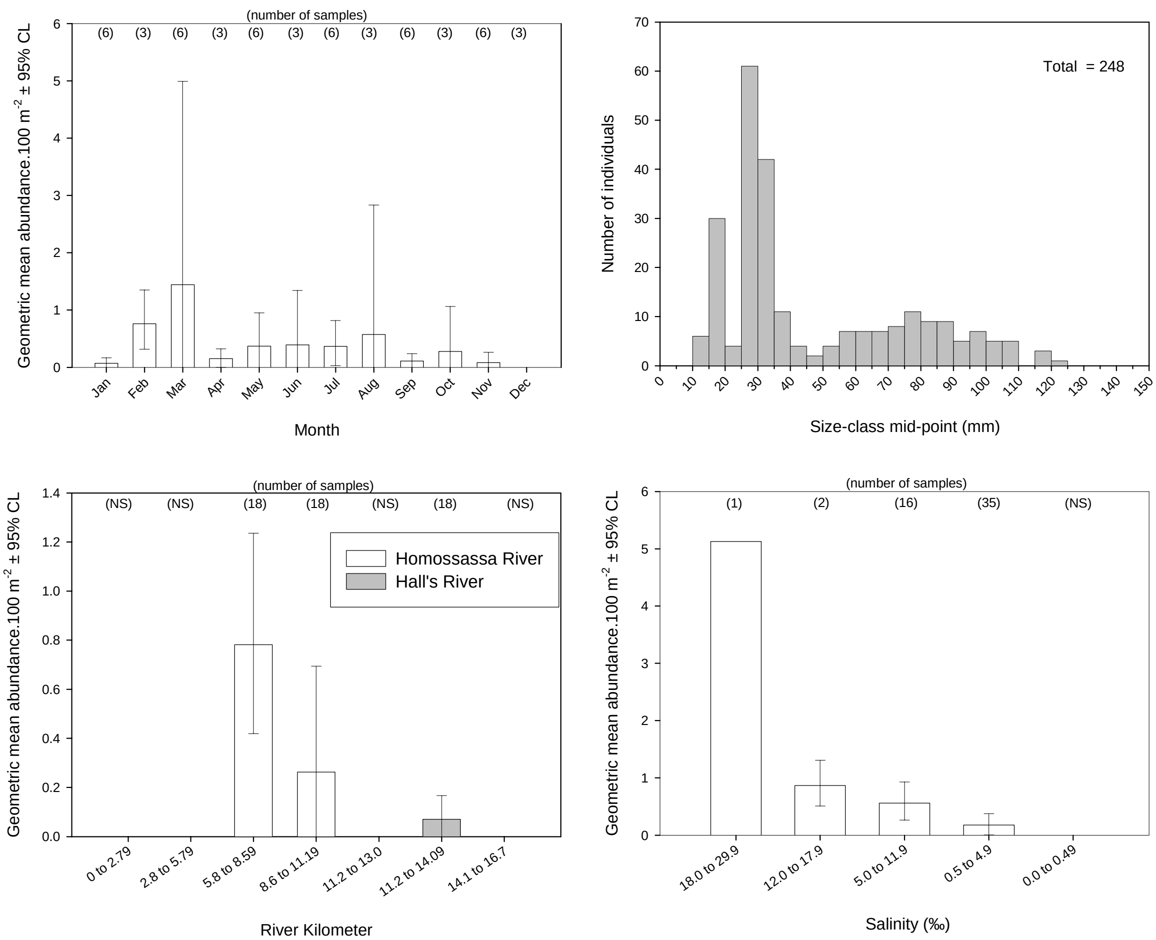


Fig. E7. Relative abundance of *Lagodon rhomboides* (pinfish) collected with trawls (water depths >= 2.0-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Microgobius gulosus (clown goby) in trawls

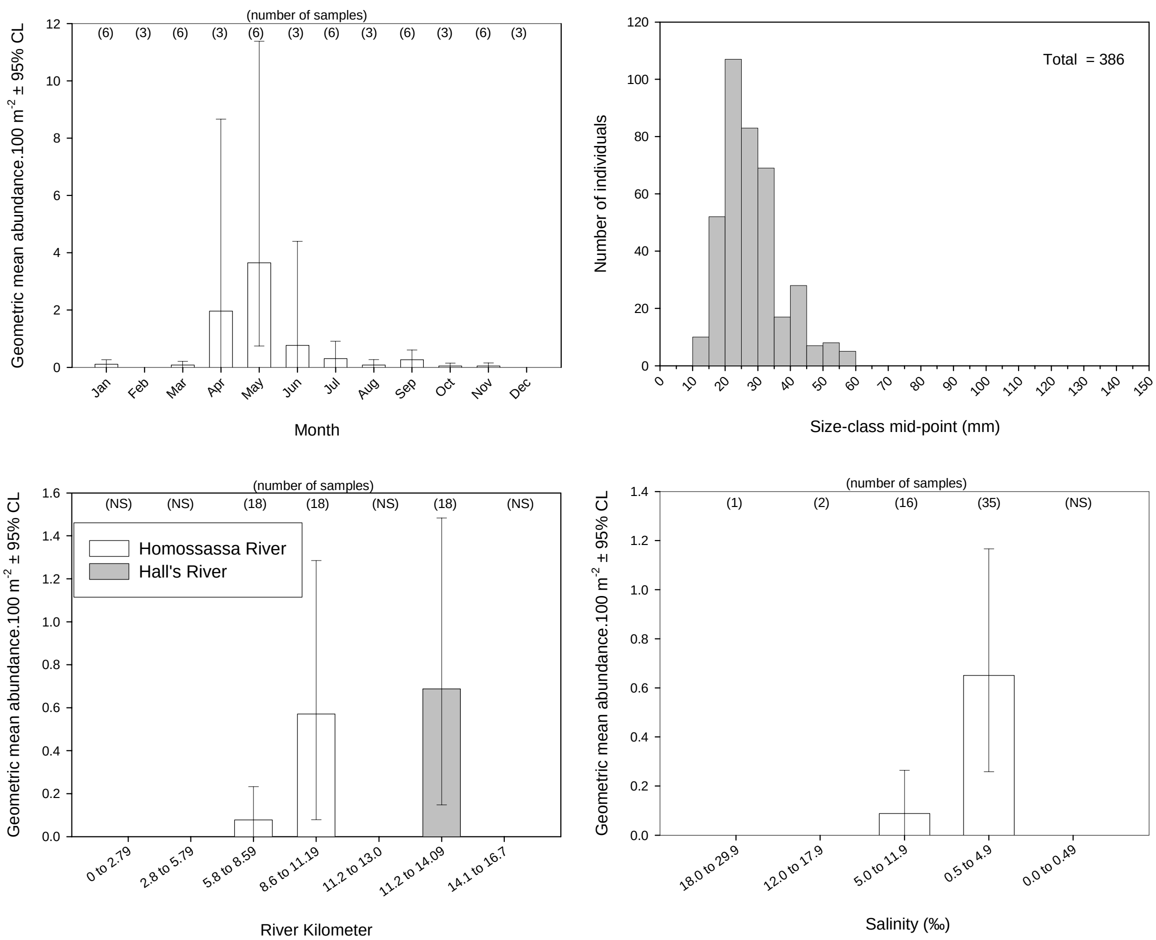


Fig. E8. Relative abundance of *Microgobius gulosus* (clown goby) collected with trawls (water depths >= 2.0-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Trinectes maculatus (hogchoker) in trawls

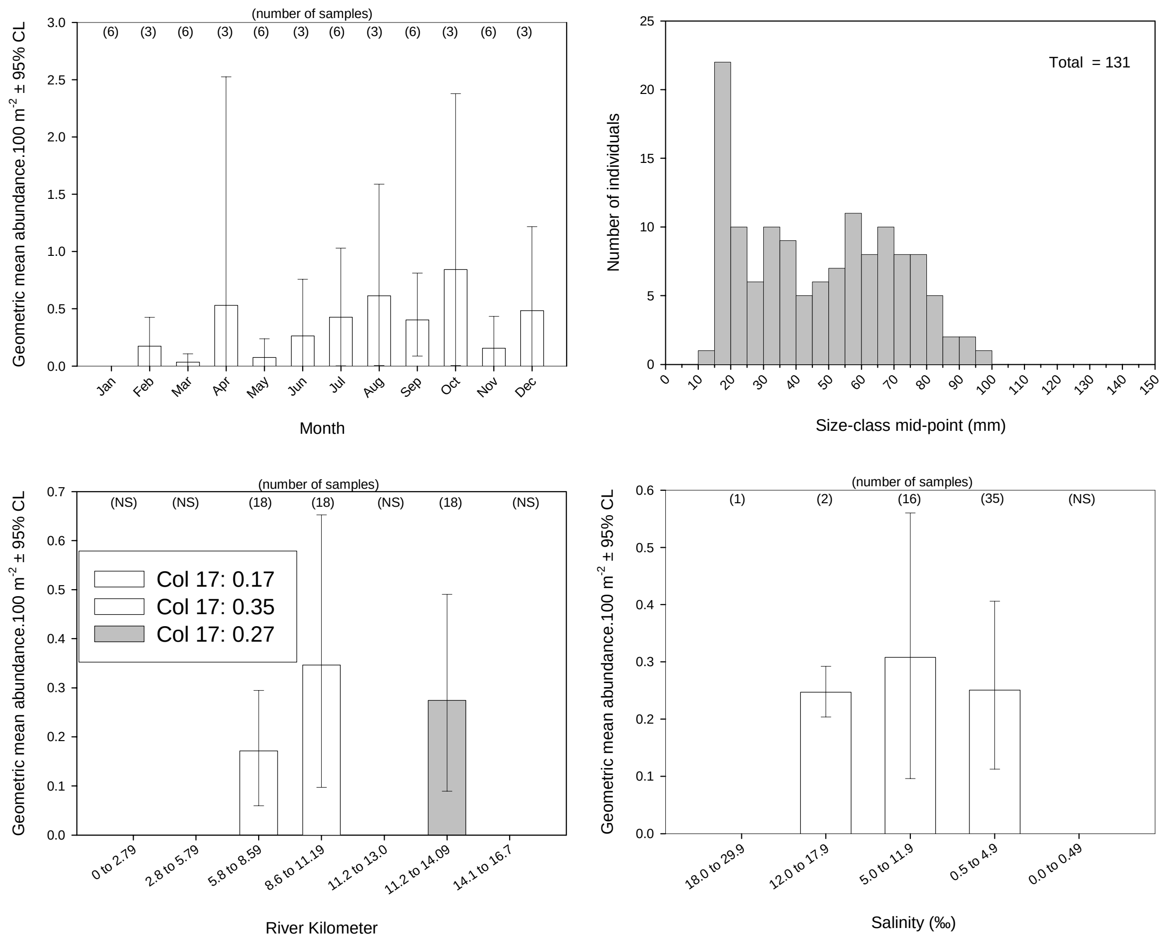
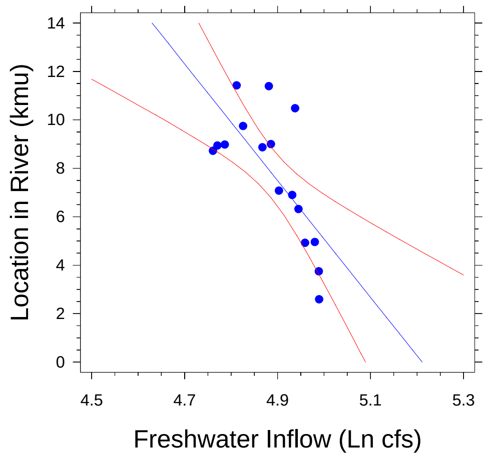


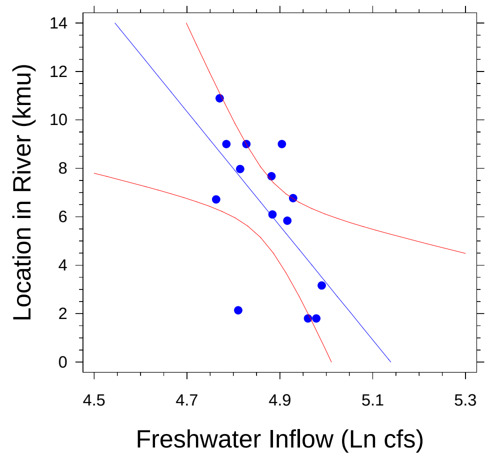
Fig. E9. Relative abundance of *Trinectes maculatus* (hogchoker) collected with trawls (water depths >= 2.0-m) in the Homosassa River estuary. Box: average relative abundance; error bars: 95% CI.

Appendix F: Plots of the plankton-net distribution responses in Table 3.7.1.1 with 95% confidence limits for predicted means

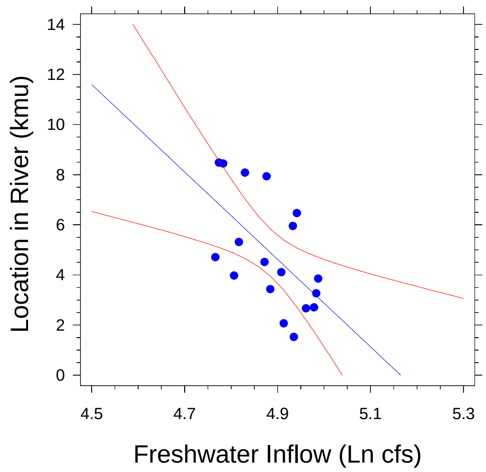
Menidia spp. preflexion larvae



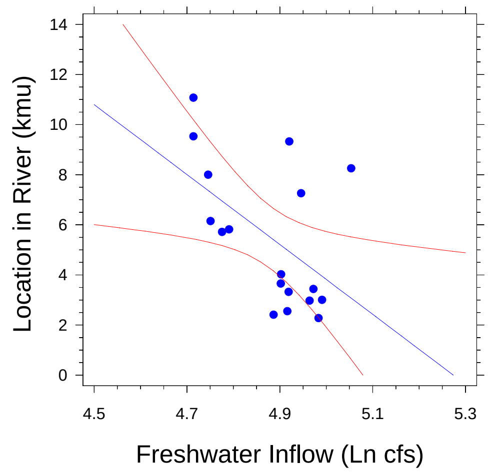
Sinelobus stanfordi



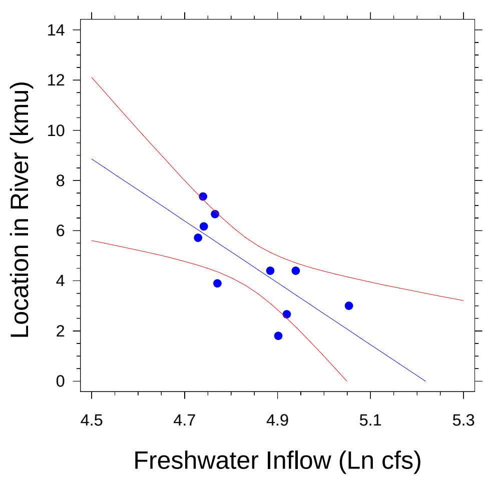
decapod mysis



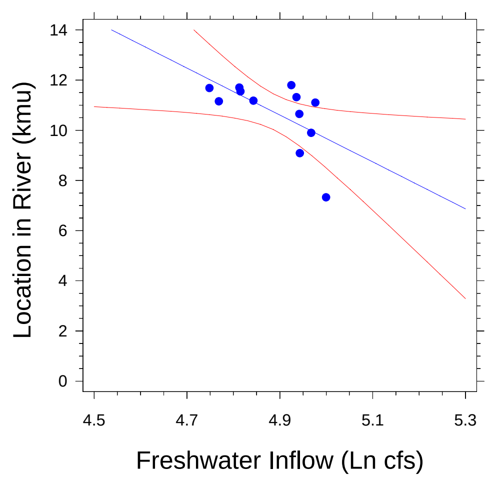
polychaetes

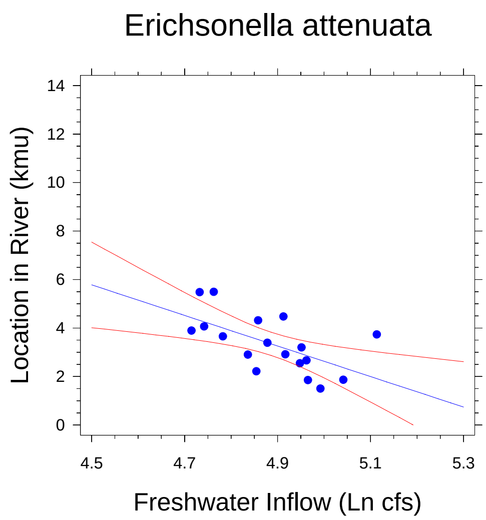


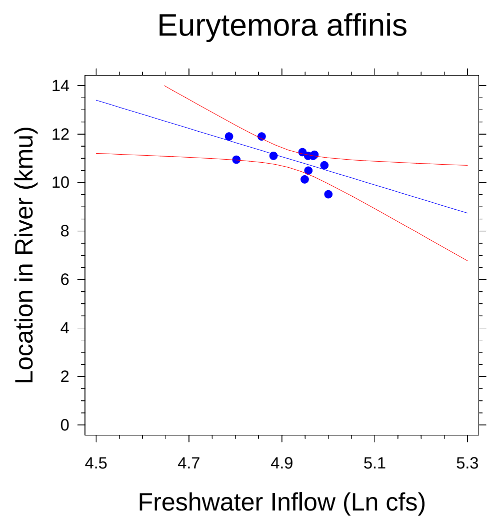
Anopsilana jonesi

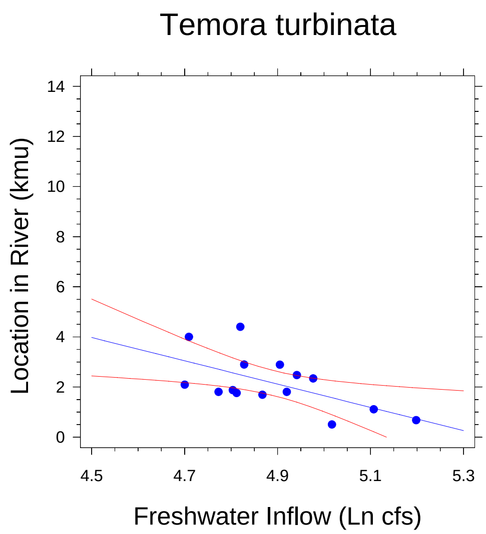


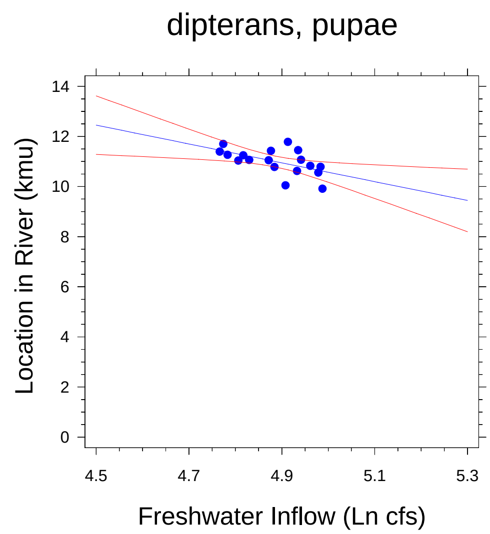
oligochaetes

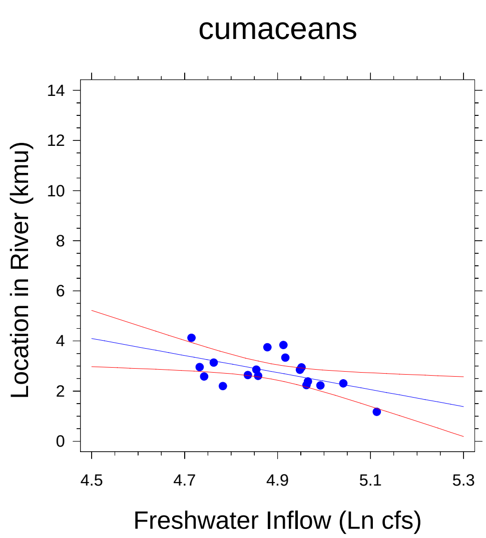


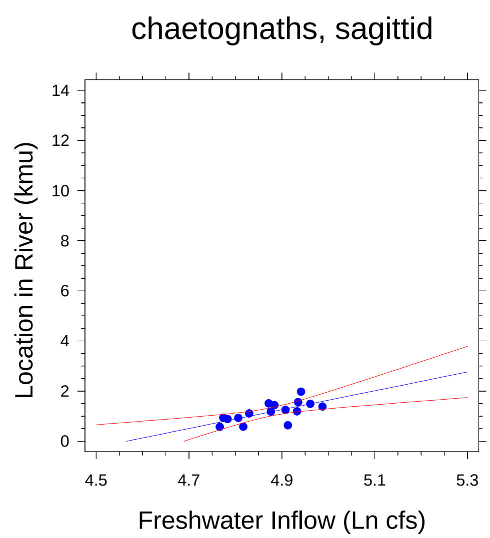

Erichsonella attenuata
Location in River (kmu)
Freshwater Inflow (Ln cfs)
0
2
4
6
8
10
12
14
4.5
4.7
4.9
5.1
5.3


Eurytemora affinis
Location in River (kmu)
Freshwater Inflow (Ln cfs)
0
2
4
6
8
10
12
14
4.5
4.7
4.9
5.1
5.3

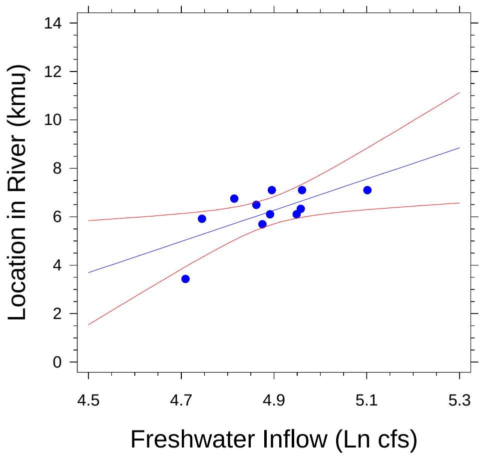

Temora turbinata
Location in River (kmu)
Freshwater Inflow (Ln cfs)
0
2
4
6
8
10
12
14
4.5
4.7
4.9
5.1
5.3


dipterans, pupae
Location in River (kmu)
Freshwater Inflow (Ln cfs)
0
2
4
6
8
10
12
14
4.5
4.7
4.9
5.1
5.3

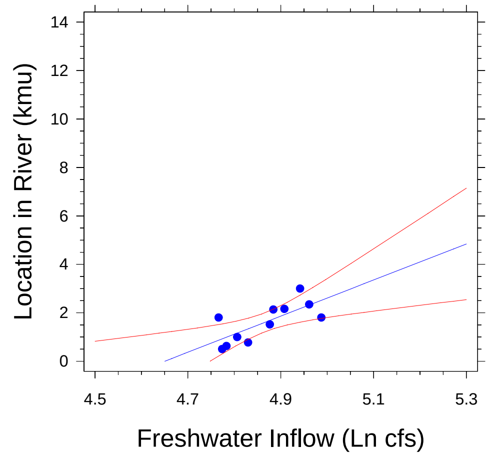

cumaceans
Location in River (kmu)
Freshwater Inflow (Ln cfs)
0
2
4
6
8
10
12
14
4.5
4.7
4.9
5.1
5.3


chaetognaths, sagittid
Location in River (kmu)
Freshwater Inflow (Ln cfs)
0
2
4
6
8
10
12
14
4.5
4.7
4.9
5.1
5.3

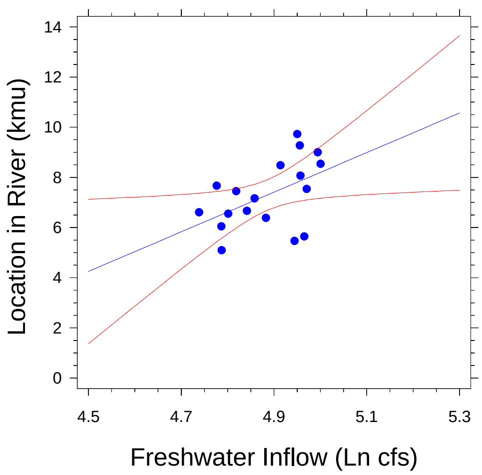
Xenanthura brevitelson



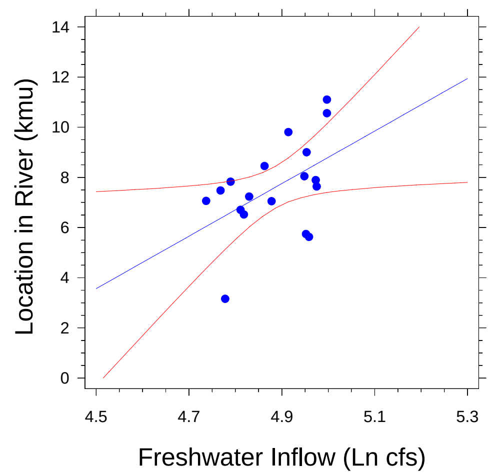
Monstrilla sp.



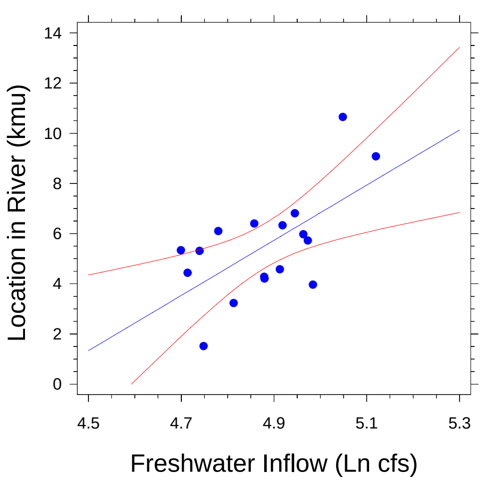
Edotea triloba



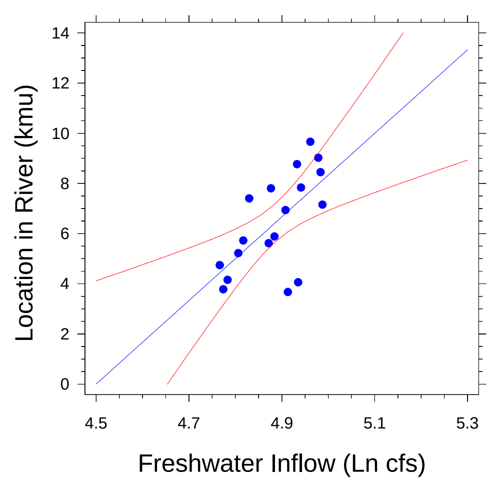
cymothoid sp. a (Lironeca)



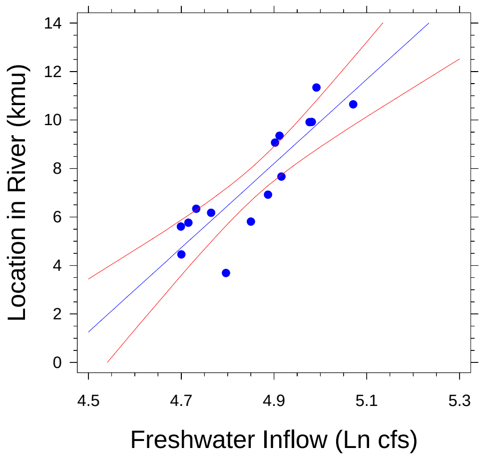
pelecypods



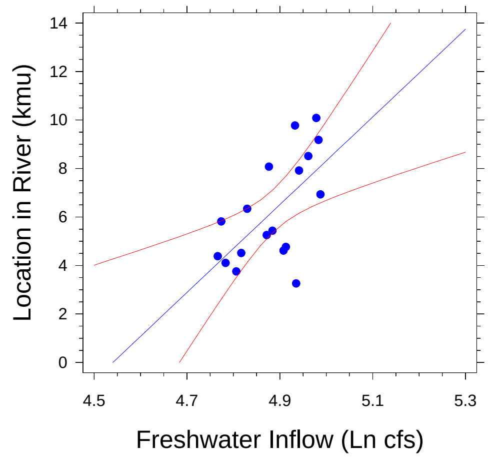
Americamysis almyra



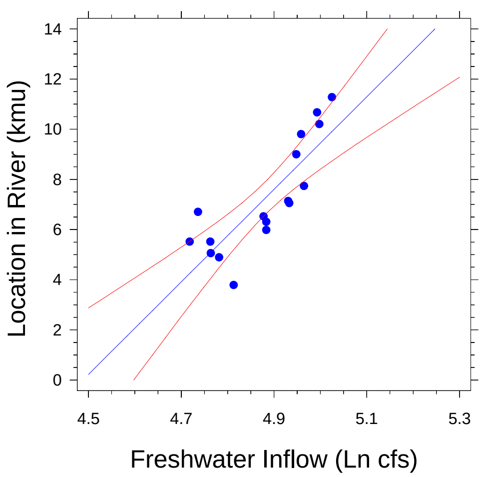
gobiid flexion larvae



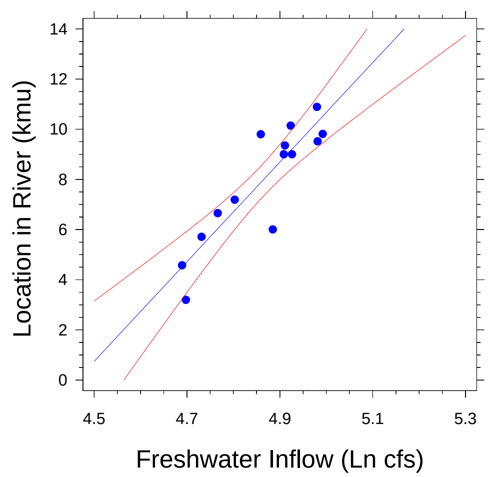
unidentified Americamysis juveniles



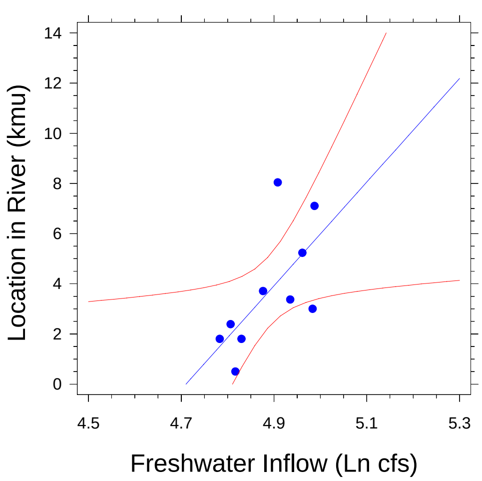
gobiid preflexion larvae



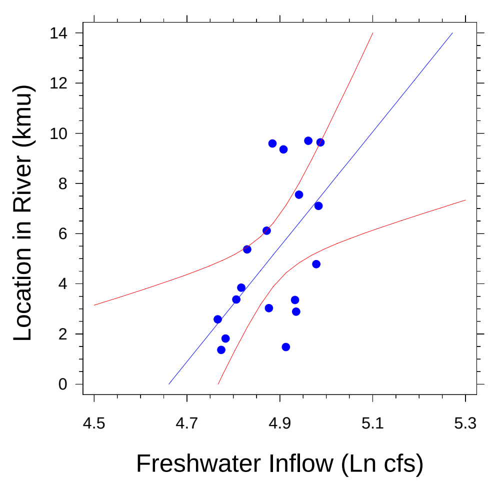
Microgobius spp. flexion larvae

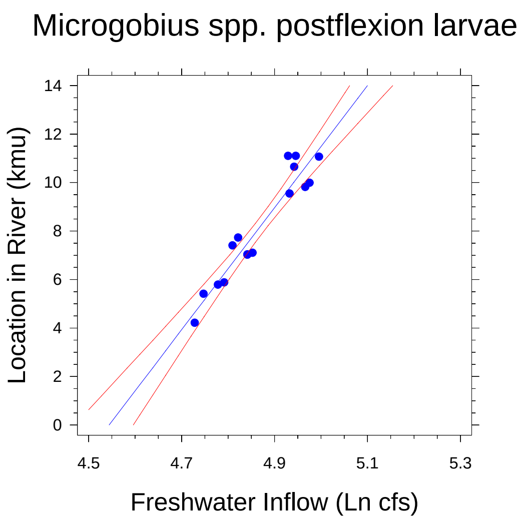


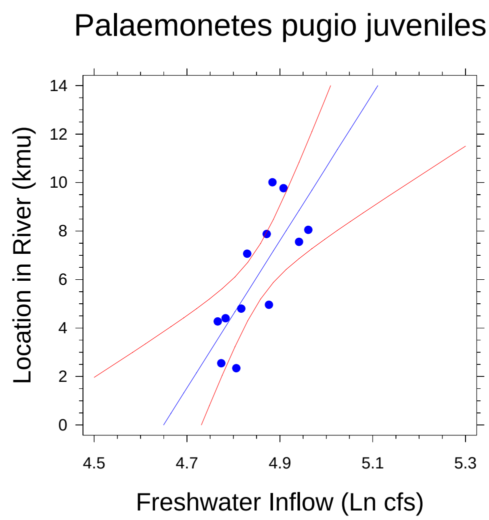
Callinectes sapidus juveniles

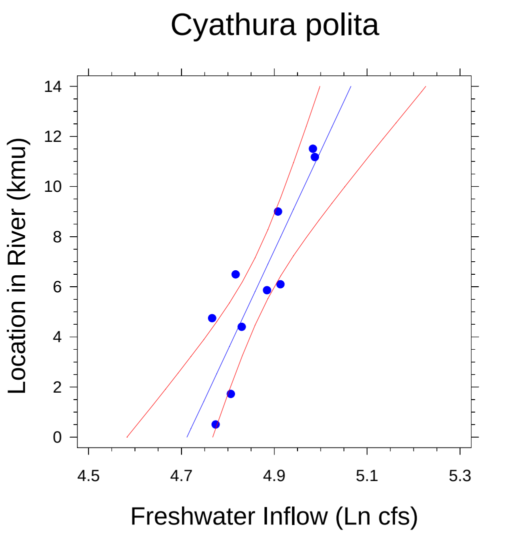


decapod megalopae




Microgobius spp. postflexion larvae
Location in River (kmu)
Freshwater Inflow (Ln cfs)
0
2
4
6
8
10
12
14
4.5
4.7
4.9
5.1
5.3


Palaemonetes pugio juveniles
Location in River (kmu)
Freshwater Inflow (Ln cfs)
0
2
4
6
8
10
12
14
4.5
4.7
4.9
5.1
5.3


Cyathura polita
Location in River (kmu)
Freshwater Inflow (Ln cfs)
0
2
4
6
8
10
12
14
4.5
4.7
4.9
5.1
5.3

Appendix G: Plots of the seine and trawl distribution responses in Table 3.7.2.1 with 95% confidence limits for predicted means

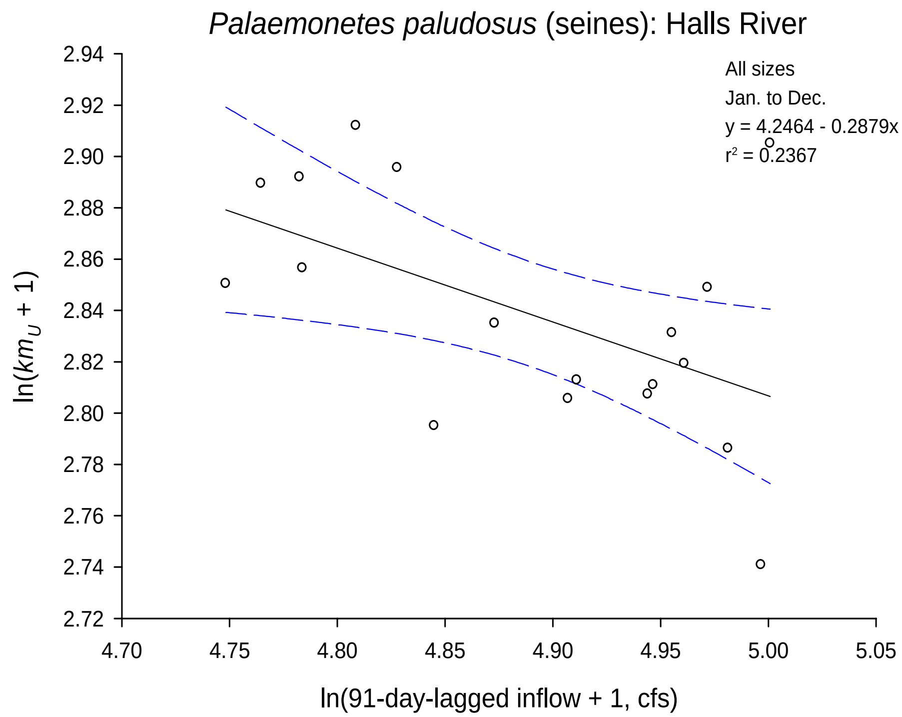


Fig. G1. Distribution response of riverine grass shrimp (all sizes) in the Homosassa River estuary to 91-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

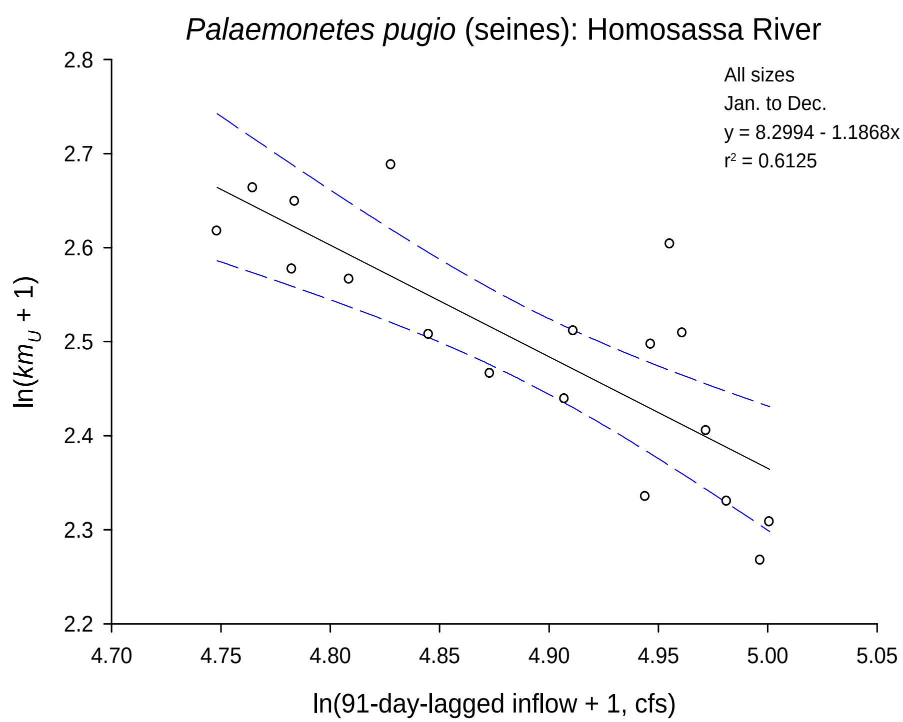


Fig. G2. Distribution response of daggerblade grass shrimp (all sizes) in the Homosassa River estuary to 91-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

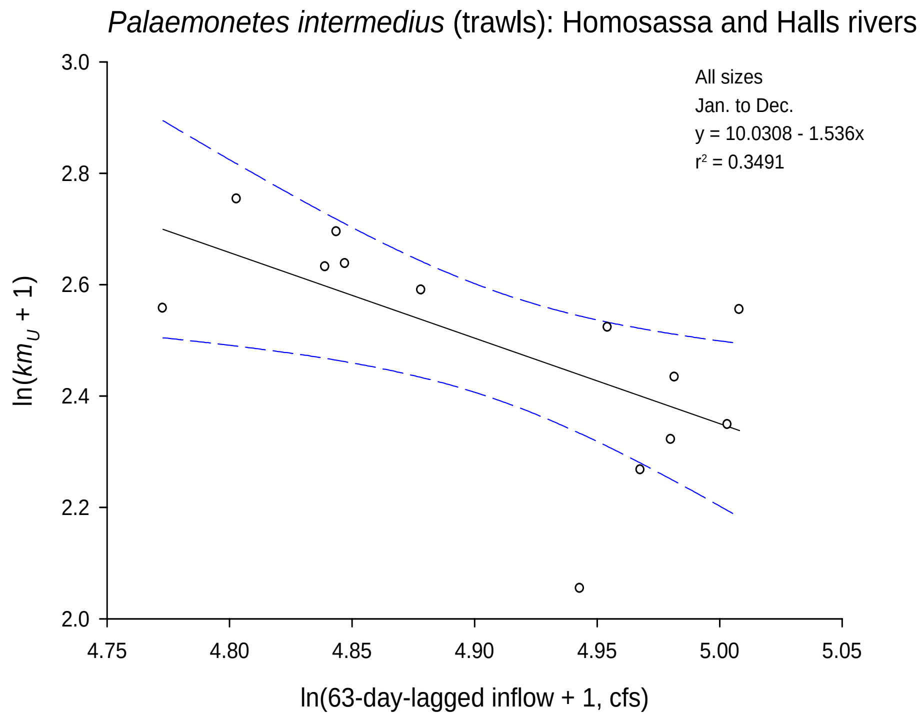


Fig. G3. Distribution response of brackish grass shrimp (all sizes) in the Homosassa River estuary to 63-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

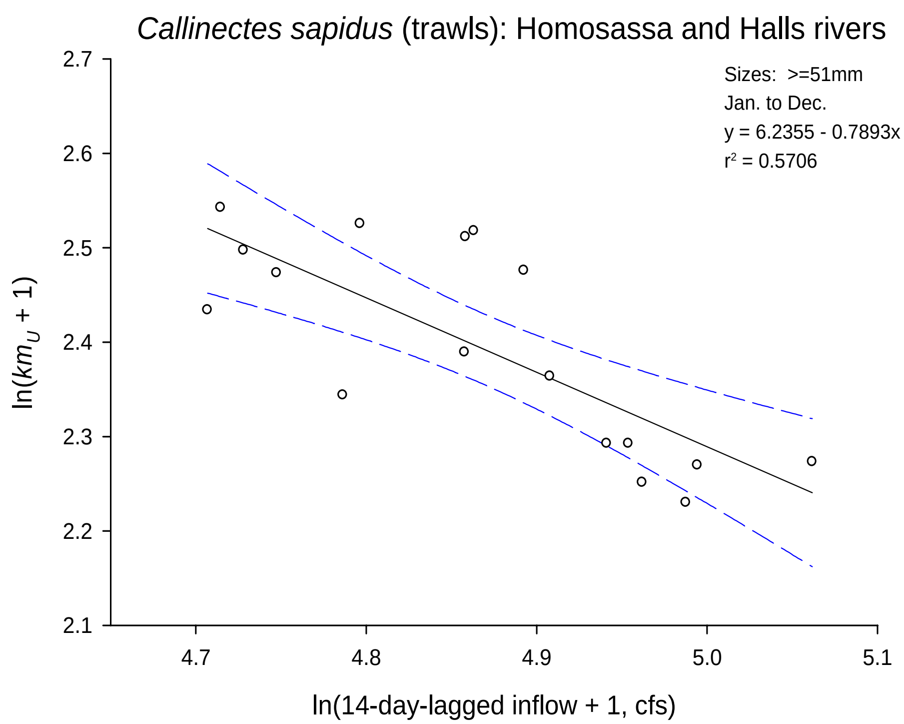


Fig. G4. Distribution response of blue crab (>=51 mm) in the Homosassa River estuary to 14-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

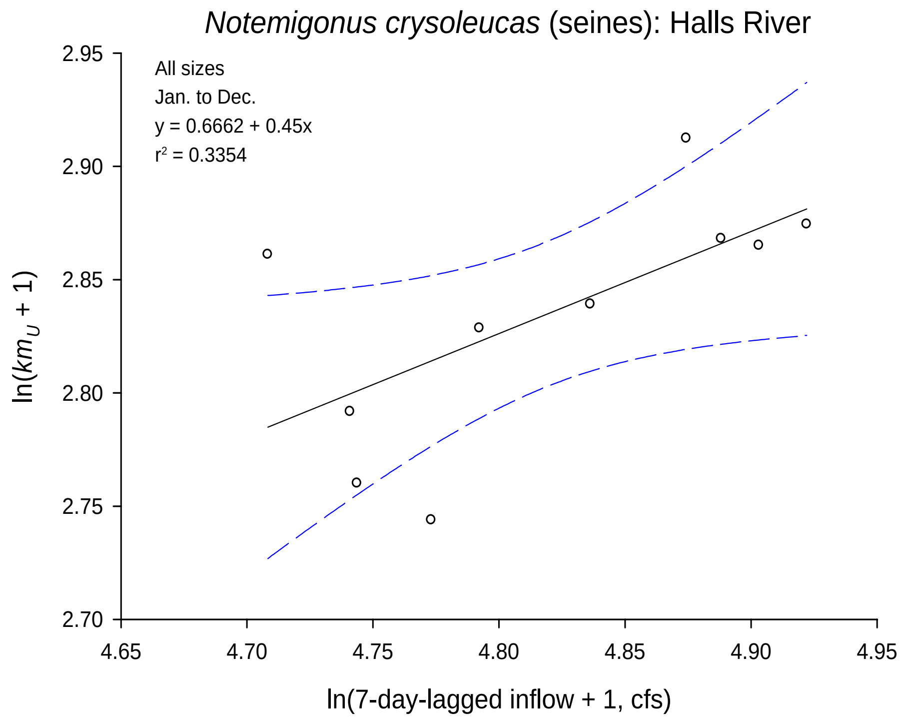


Fig. G5. Distribution response of golden shiner (all sizes) in the Homosassa River estuary to 7-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

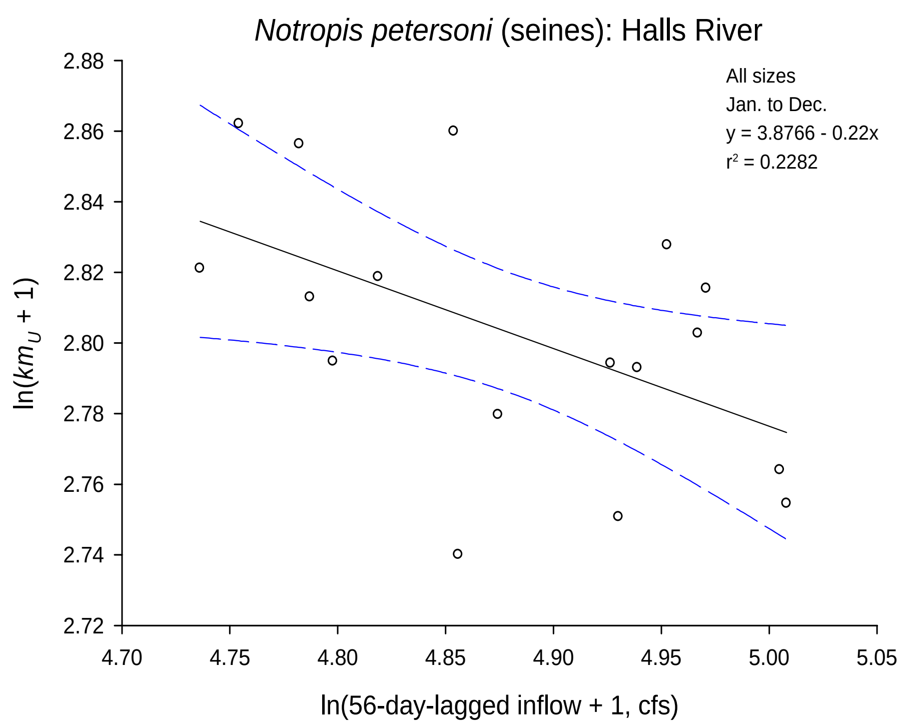


Fig. G6. Distribution response of coastal shiner (all sizes) in the Homosassa River estuary to 56-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

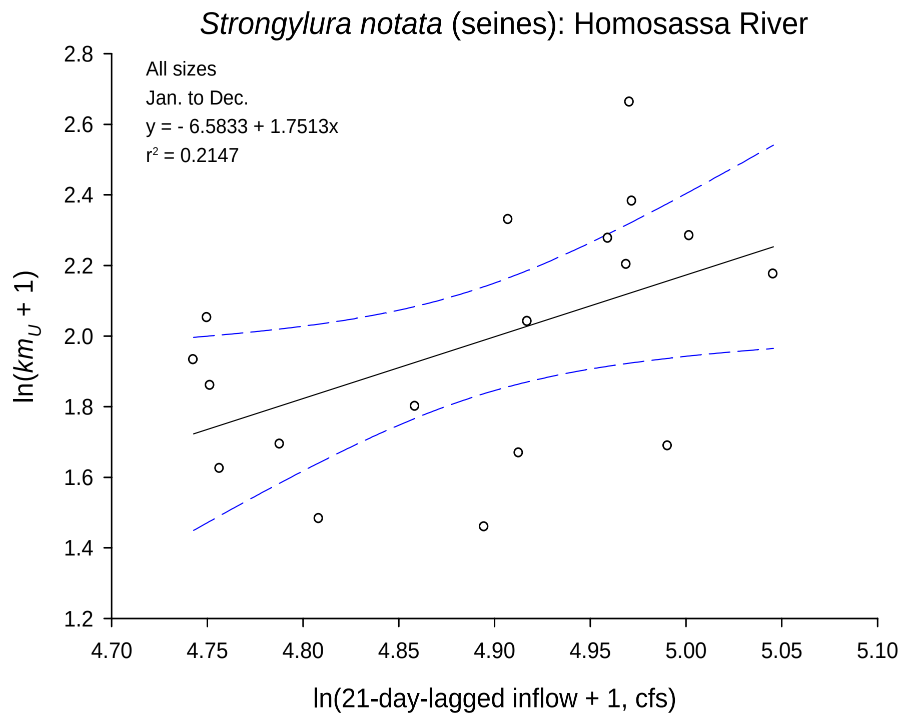


Fig. G7. Distribution response of redfin needlefish (all sizes) in the Homosassa River estuary to 21-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

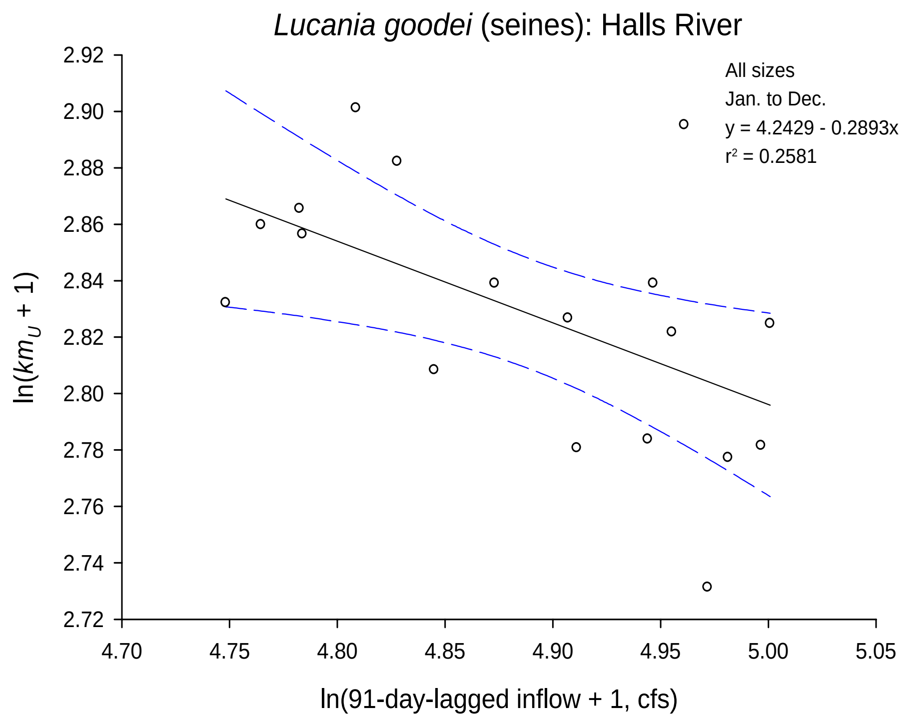


Fig. G8. Distribution response of bluefin killifish (all sizes) in the Homosassa River estuary to 91-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

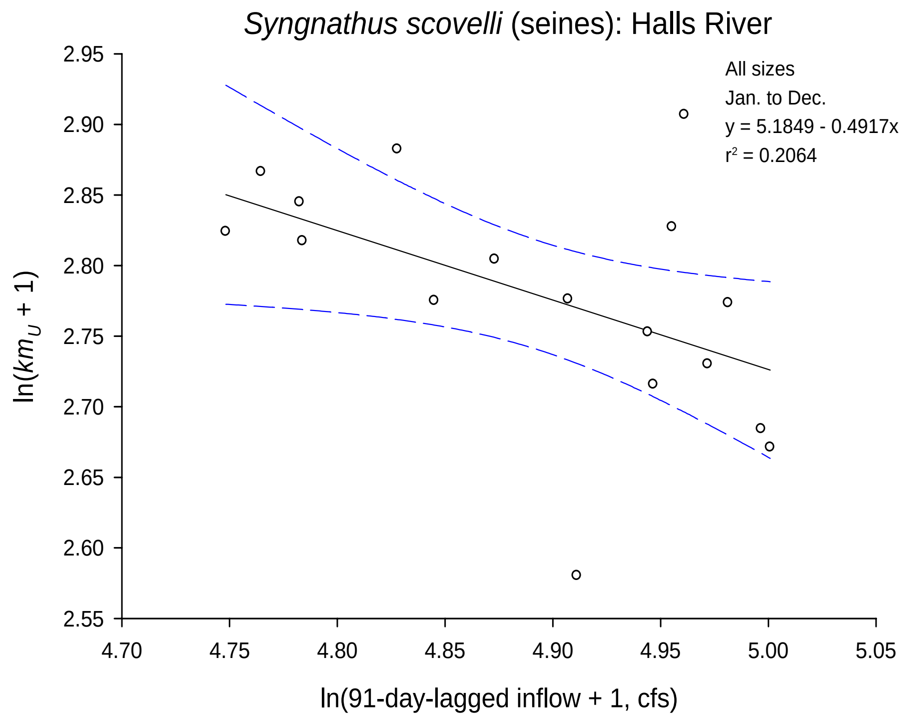


Fig. G9. Distribution response of Gulf pipefish (all sizes) in the Homosassa River estuary to 91-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

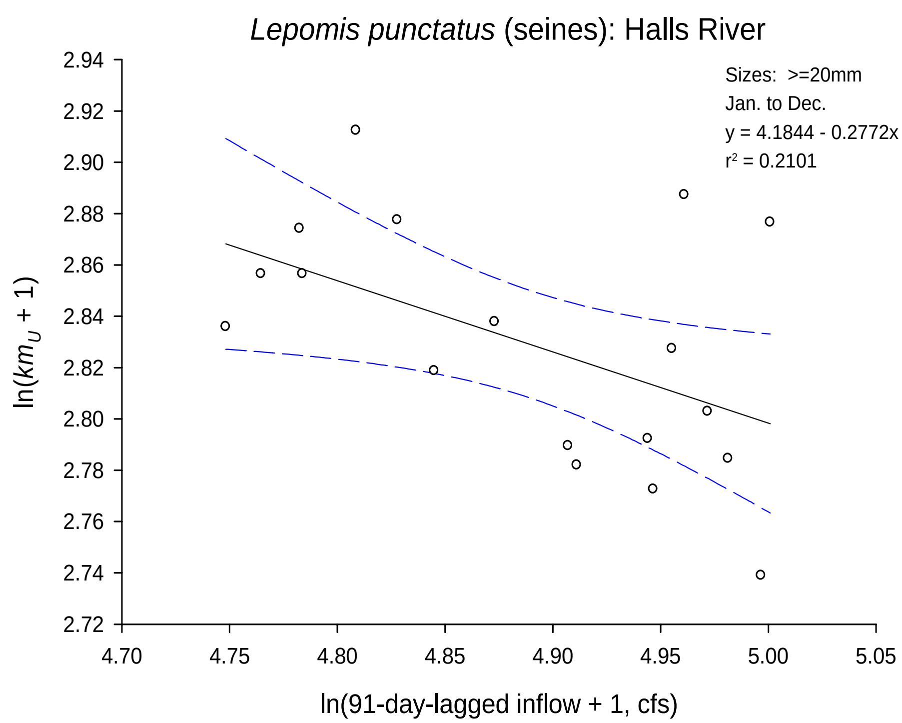


Fig. G10. Distribution response of spotted sunfish (>=20 mm) in the Homosassa River estuary to 91-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

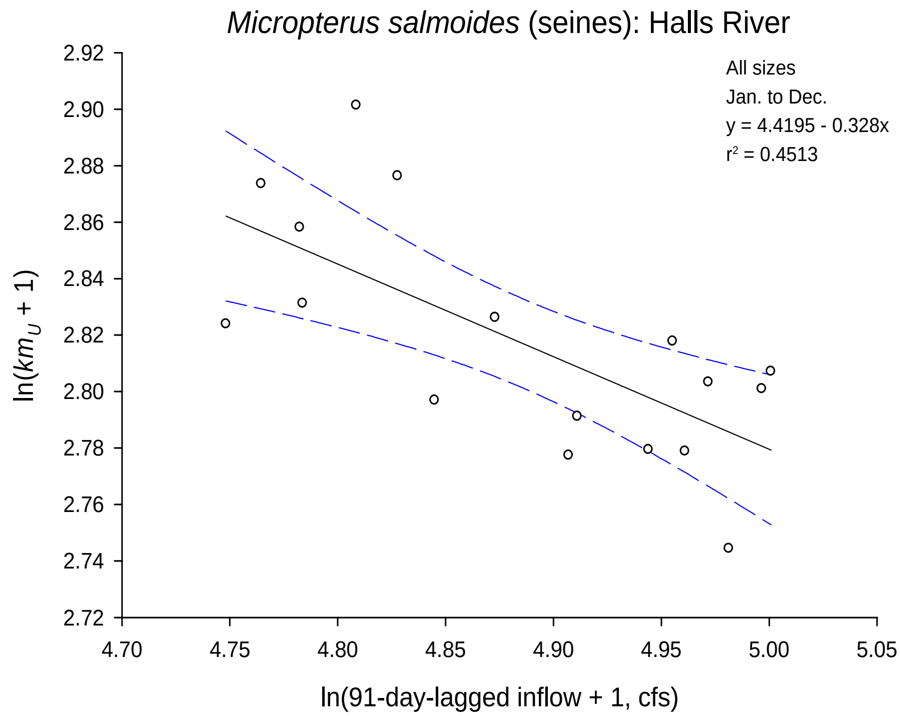


Fig. G11. Distribution response of largemouth bass (all sizes) in the Homosassa River estuary to 91-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

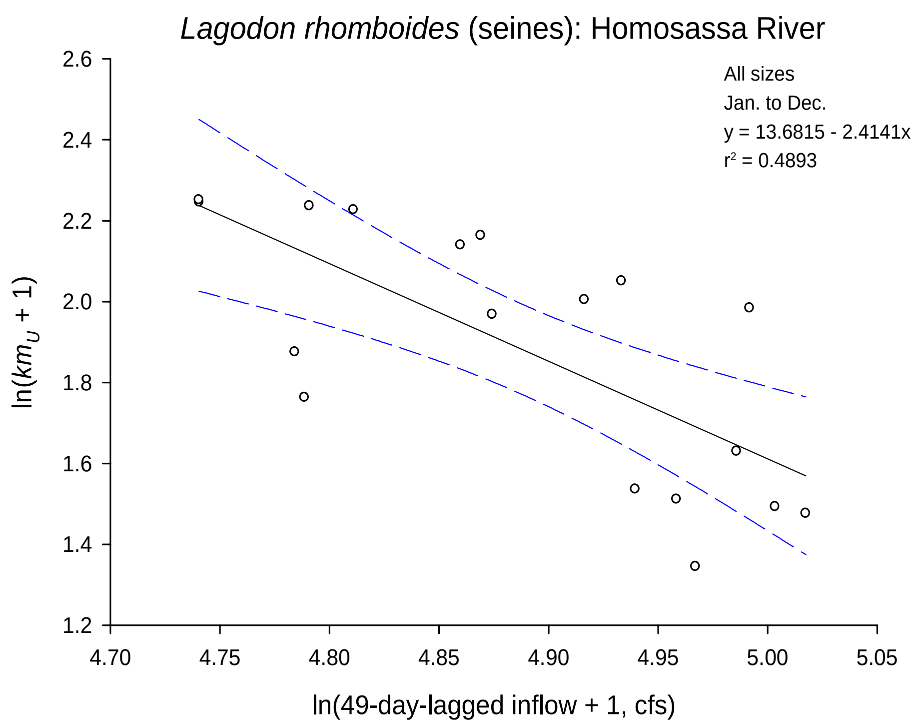


Fig. G12. Distribution response of pinfish (all sizes) in the Homosassa River estuary to 49-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

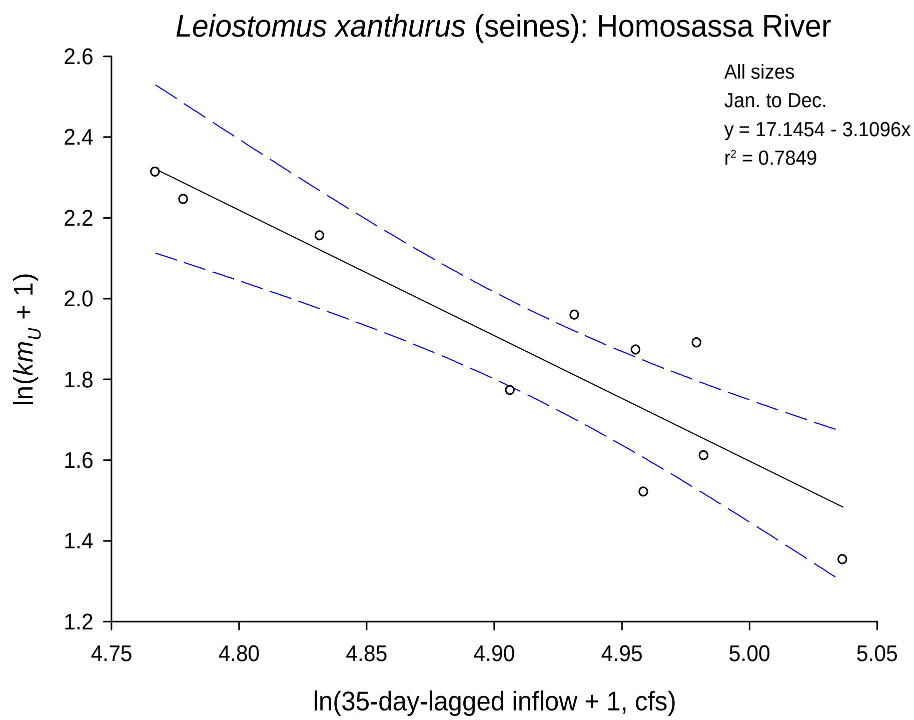
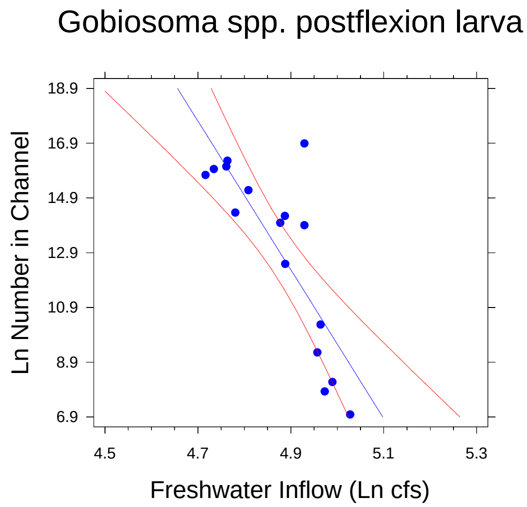
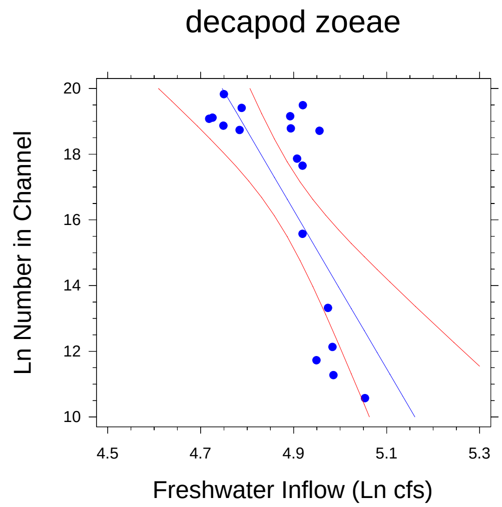
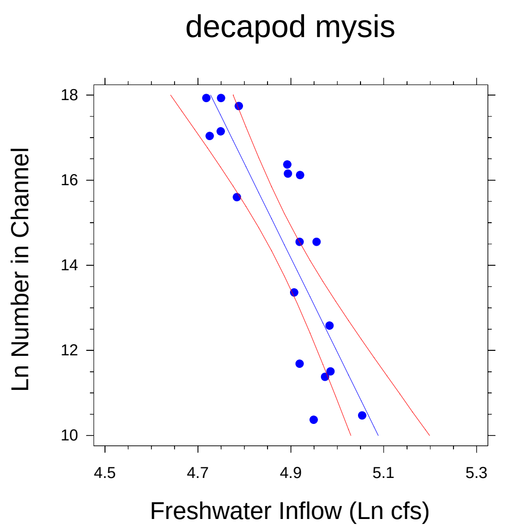


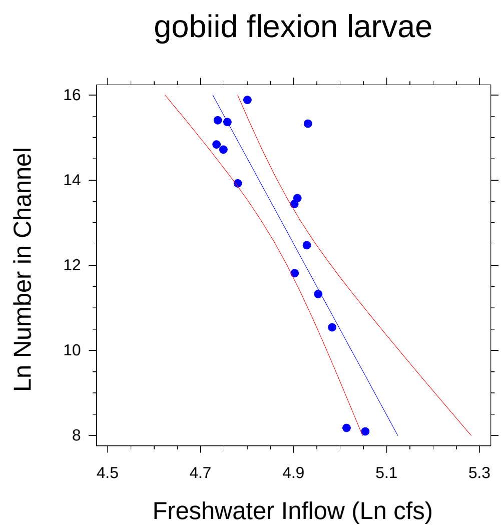
Fig. G13. Distribution response of spot (all sizes) in the Homosassa River estuary to 35-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

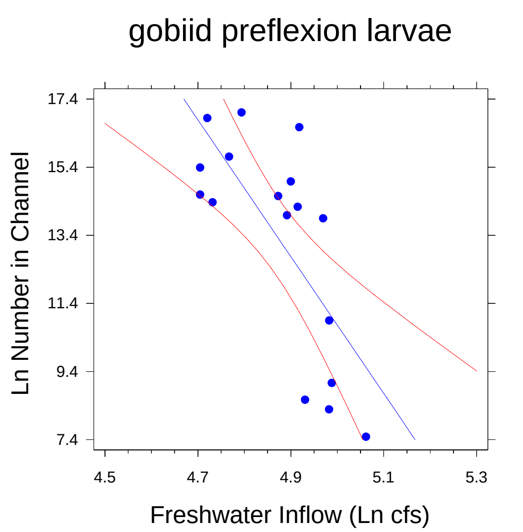
Appendix H: Plots of the plankton-net abundance responses in Table 3.8.1.1 with 95% confidence limits for predicted means

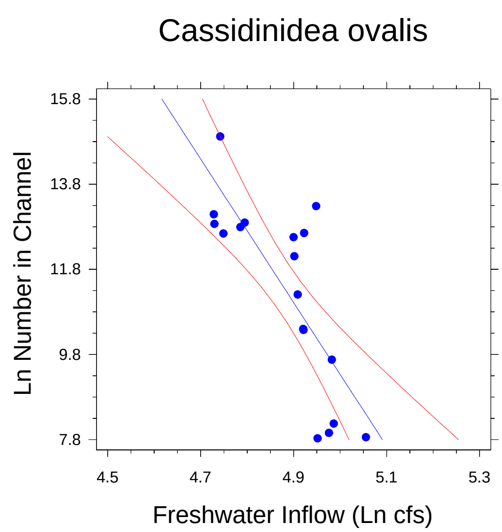

Gobiosoma spp. postflexion larva
Ln Number in Channel
18.9
16.9
14.9
12.9
10.9
8.9
6.9
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)


decapod zoeae
Ln Number in Channel
20
18
16
14
12
10
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)

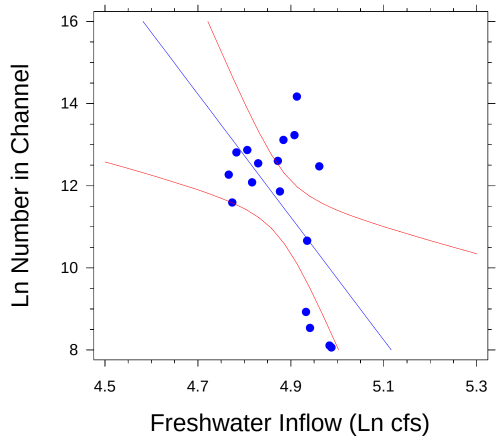

decapod mysis
Ln Number in Channel
18
16
14
12
10
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)


gobiid flexion larvae
Ln Number in Channel
16
14
12
10
8
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)

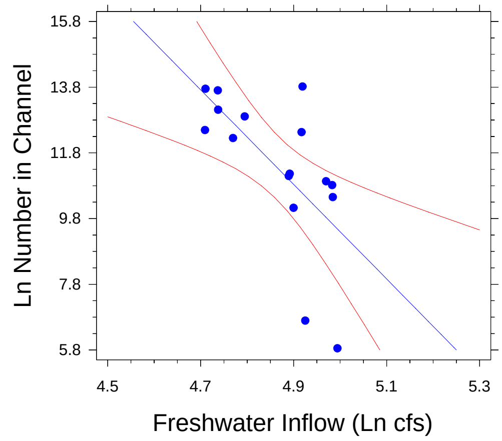

gobiid preflexion larvae
Ln Number in Channel
17.4
15.4
13.4
11.4
9.4
7.4
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)


Cassidinidea ovalis
Ln Number in Channel
15.8
13.8
11.8
9.8
7.8
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)

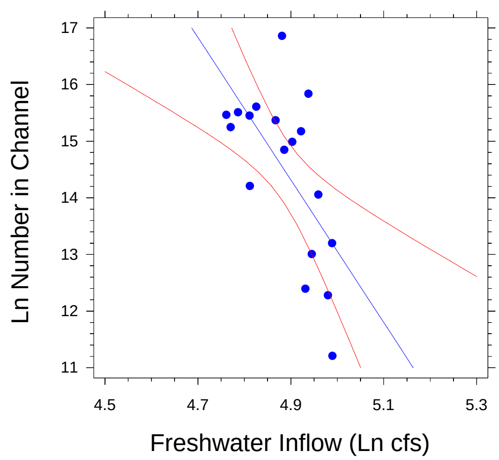
Anchoa mitchilli juveniles



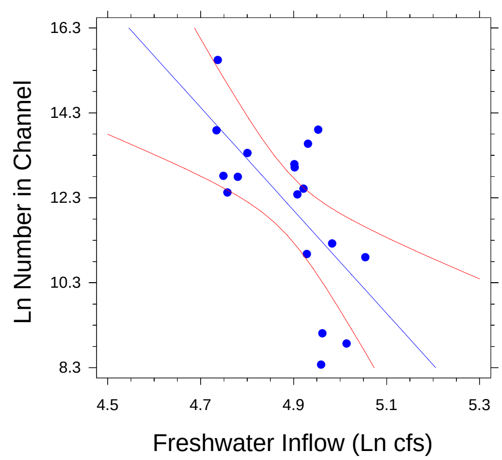
Microgobius spp. postflexion larvae



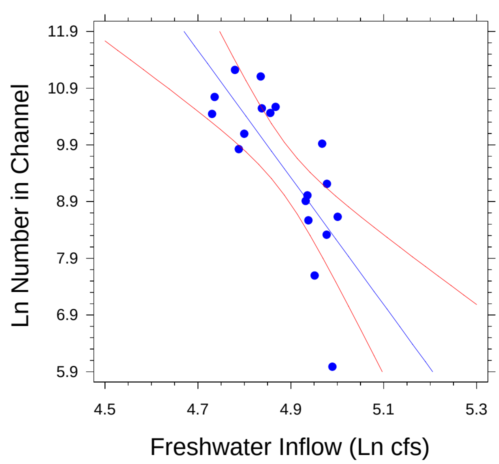
Bowmaniella dissimilis



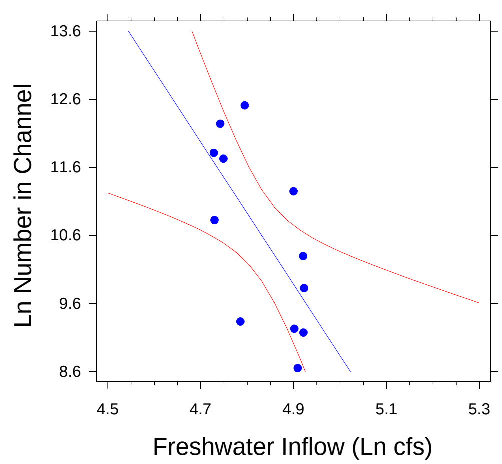
Edotea triloba

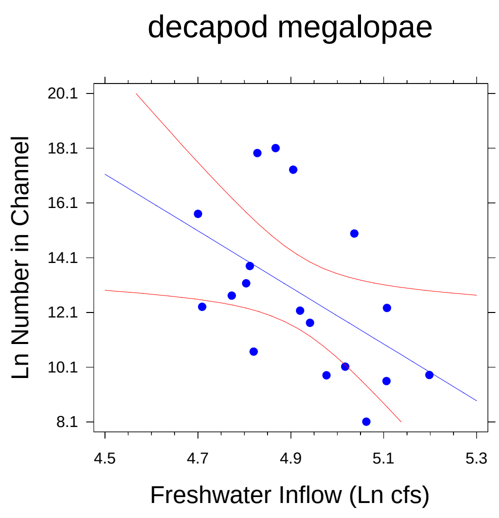


cymothoid sp. a (Lironeca)

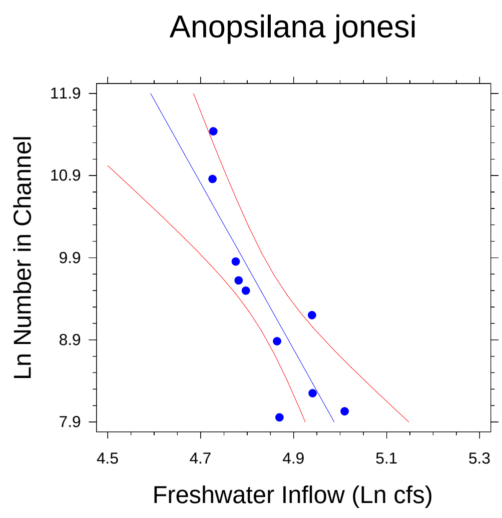


Palaemonetes pugio juveniles

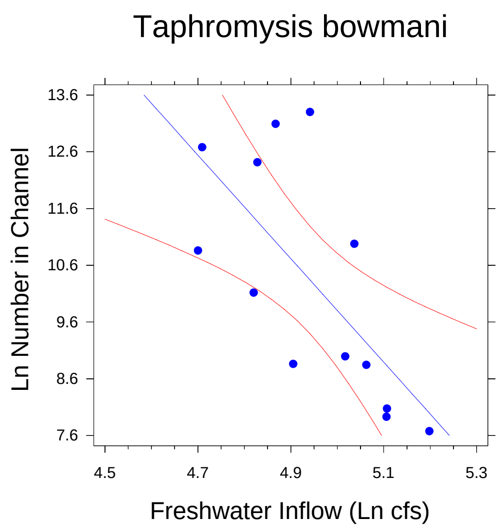




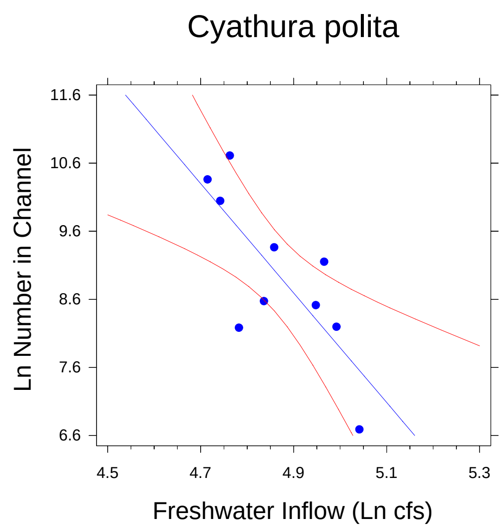
decapod megalopae
Ln Number in Channel
20.1
18.1
16.1
14.1
12.1
10.1
8.1
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)



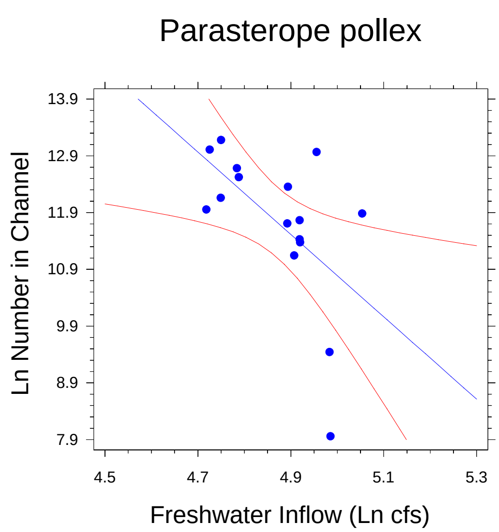
Anopsilana jonesi
Ln Number in Channel
11.9
10.9
9.9
8.9
7.9
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)



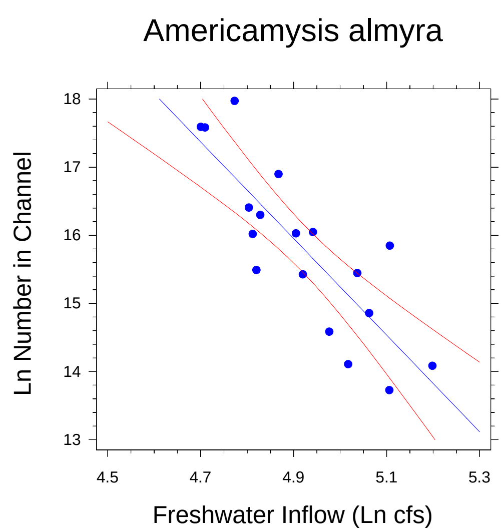
Taphromysis bowmani
Ln Number in Channel
13.6
12.6
11.6
10.6
9.6
8.6
7.6
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)



Cyathura polita
Ln Number in Channel
11.6
10.6
9.6
8.6
7.6
6.6
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)

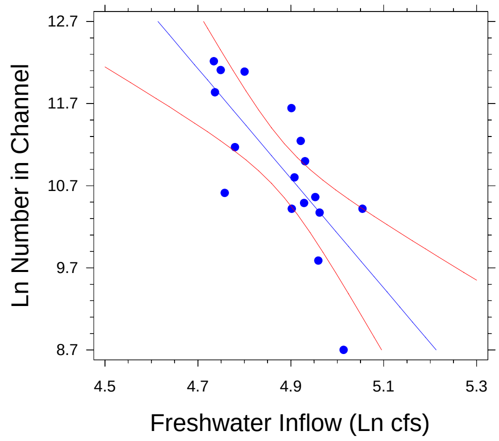


Parasterope pollex
Ln Number in Channel
13.9
12.9
11.9
10.9
9.9
8.9
7.9
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)

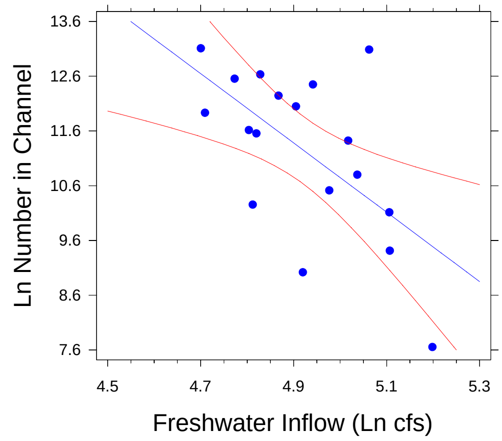


Americamysis almyra
Ln Number in Channel
18
17
16
15
14
13
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)

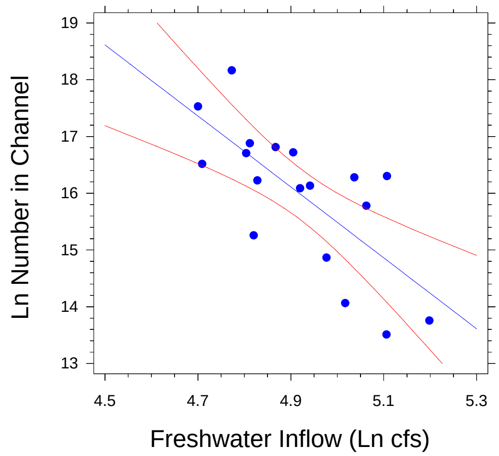
amphipods, caprellid



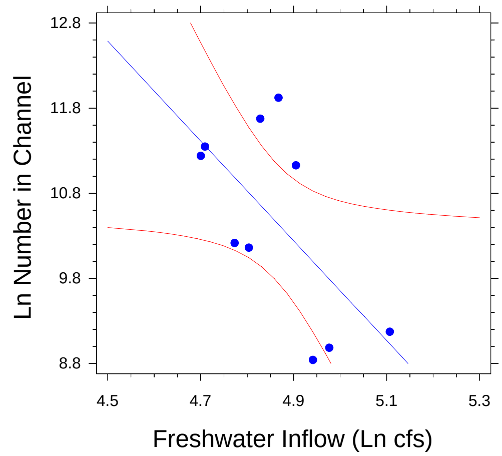
dipterans, pupae



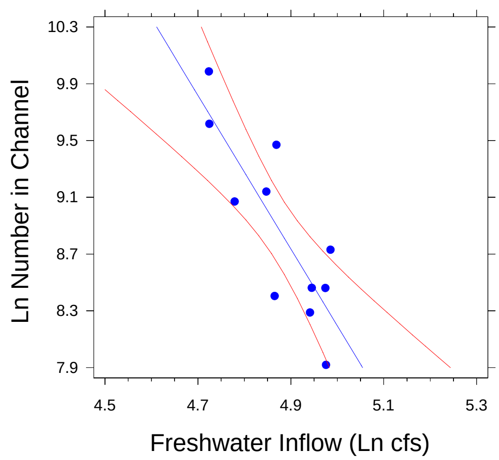
unidentified Americamysis juveniles



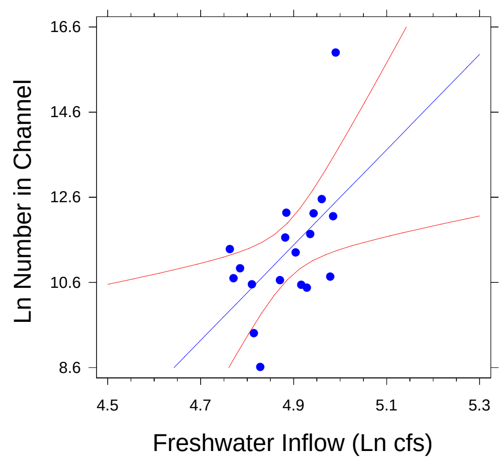
Anchoa spp. preflexion larvae

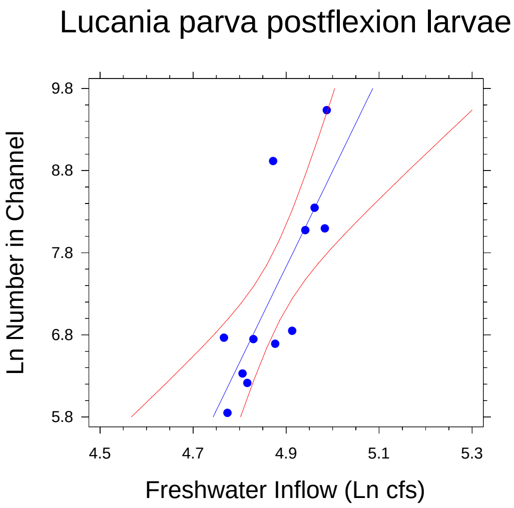


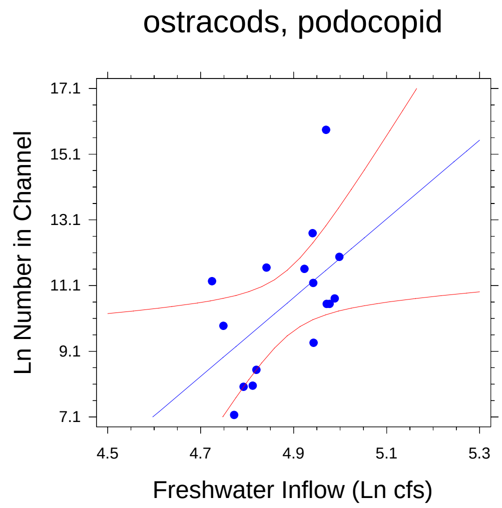
branchiurans, Argulus spp.

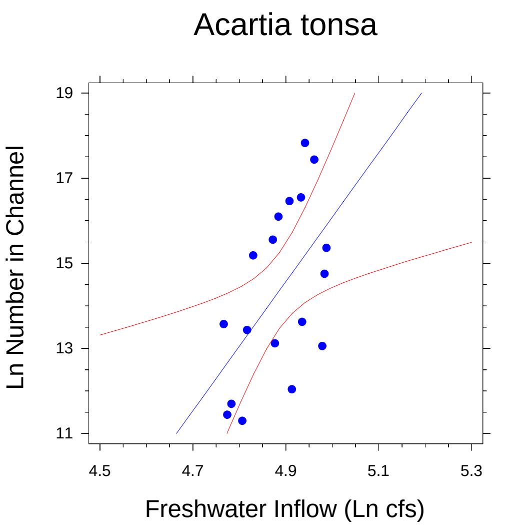


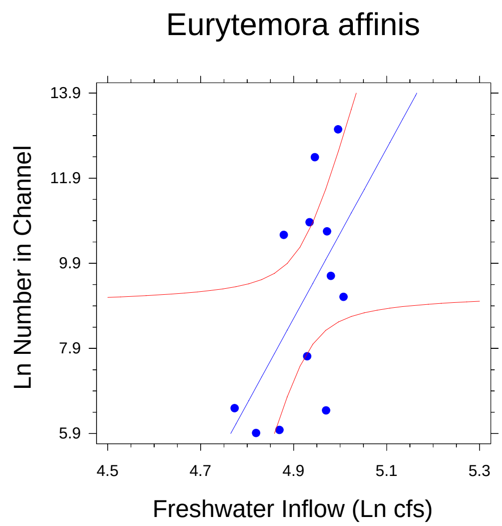
Hargeria rapax




Lucania parva postflexion larvae
Ln Number in Channel
9.8
8.8
7.8
6.8
5.8
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)


ostracods, podocopid
Ln Number in Channel
17.1
15.1
13.1
11.1
9.1
7.1
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)


Acartia tonsa
Ln Number in Channel
19
17
15
13
11
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)


Eurytemora affinis
Ln Number in Channel
13.9
11.9
9.9
7.9
5.9
4.5
4.7
4.9
5.1
5.3
Freshwater Inflow (Ln cfs)

Appendix I: Plots of the seine and trawl abundance responses in Table 3.8.2.1 with 95% confidence limits for predicted means

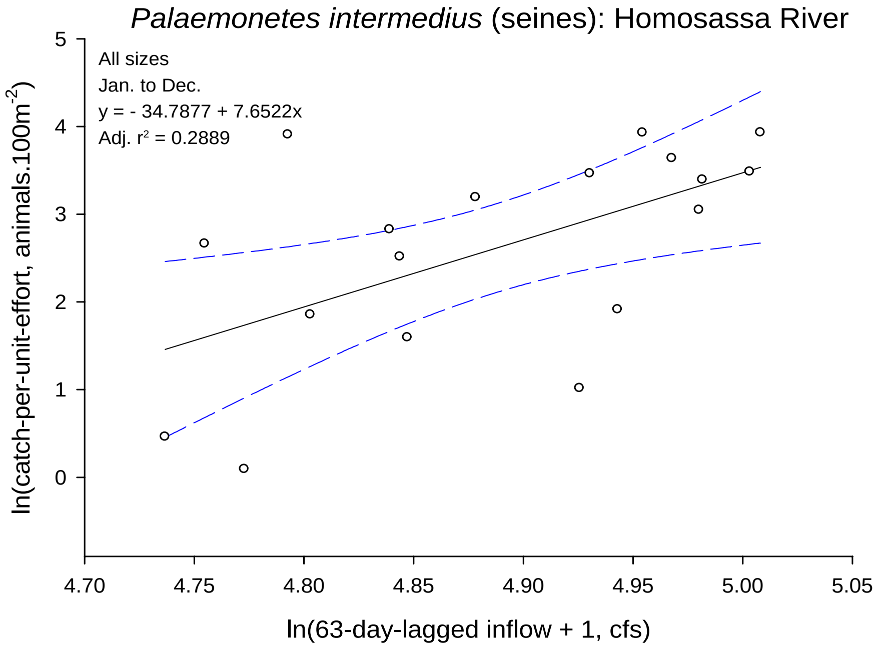


Fig. I1. Abundance response of brackish grass shrimp (all sizes) in the shoreline habitat of the Homosassa River estuary to 63-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

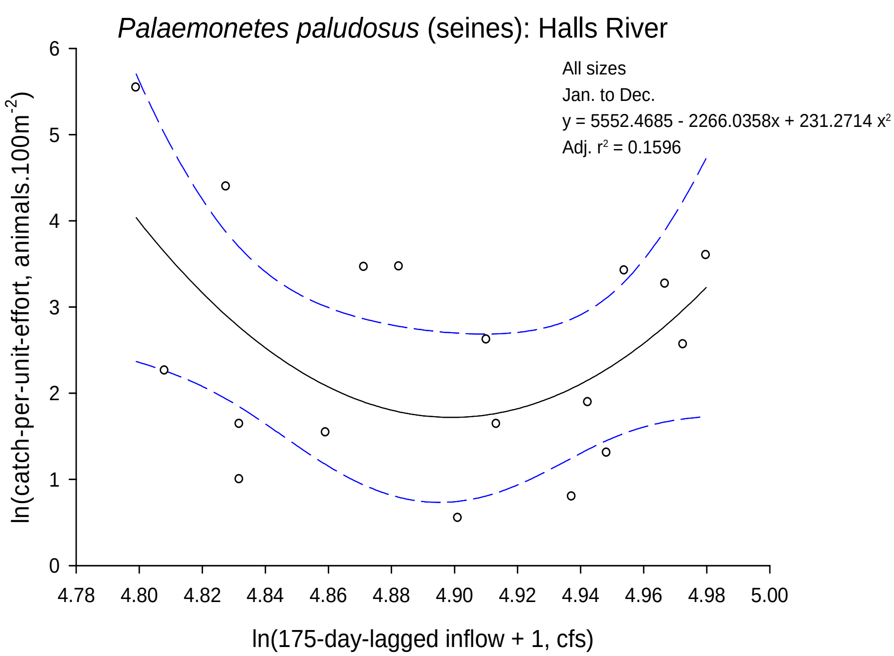


Fig. I2. Abundance response of riverine grass shrimp (all sizes) in the shoreline habitat of the Homosassa River estuary to 175-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

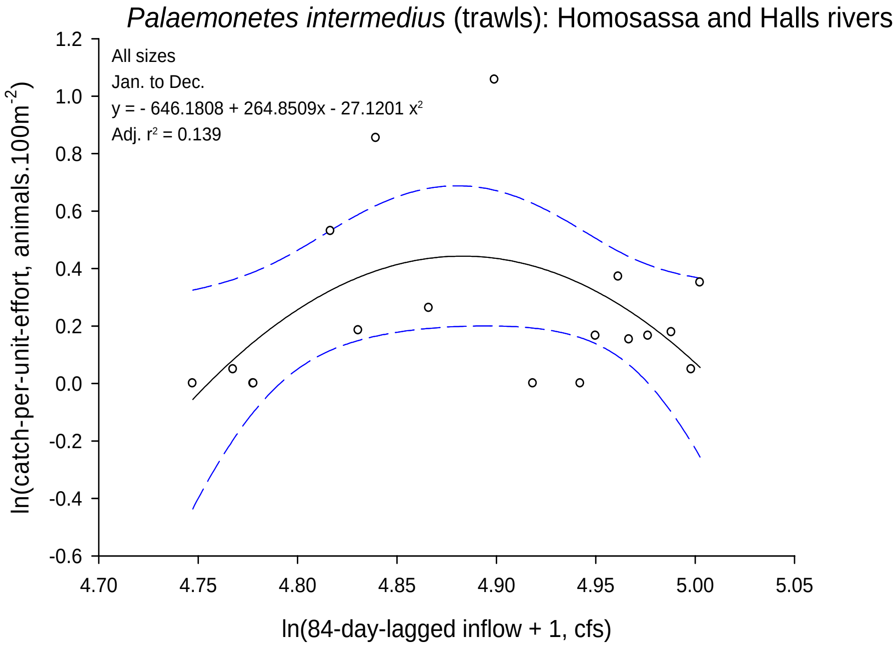


Fig. I3. Abundance response of brackish grass shrimp (All sizes) in the channel habitat of the Homosassa River estuary to 84-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

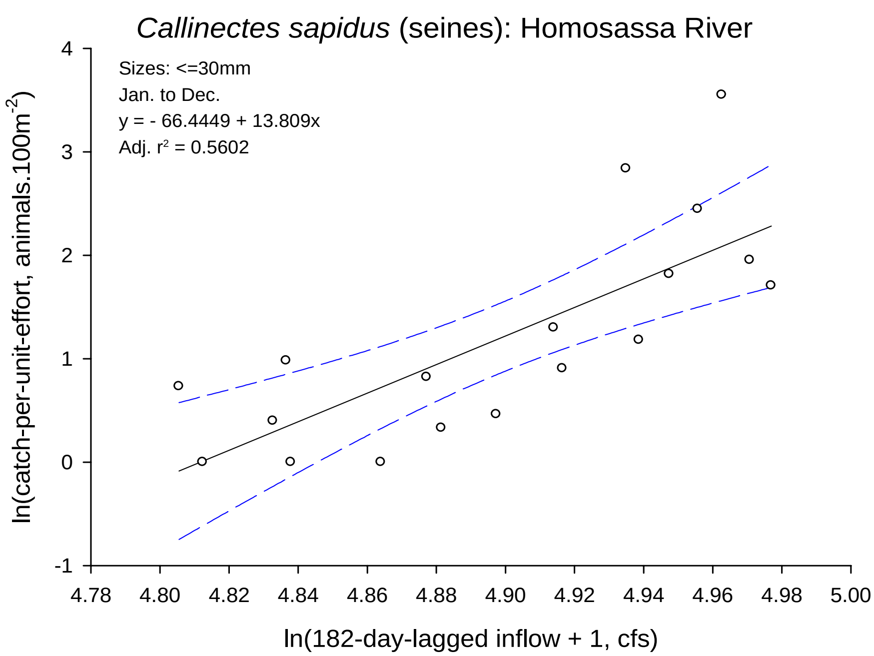


Fig. I4. Abundance response of blue crab (<=30mm) in the shoreline habitat of the Homosassa River estuary to 182-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

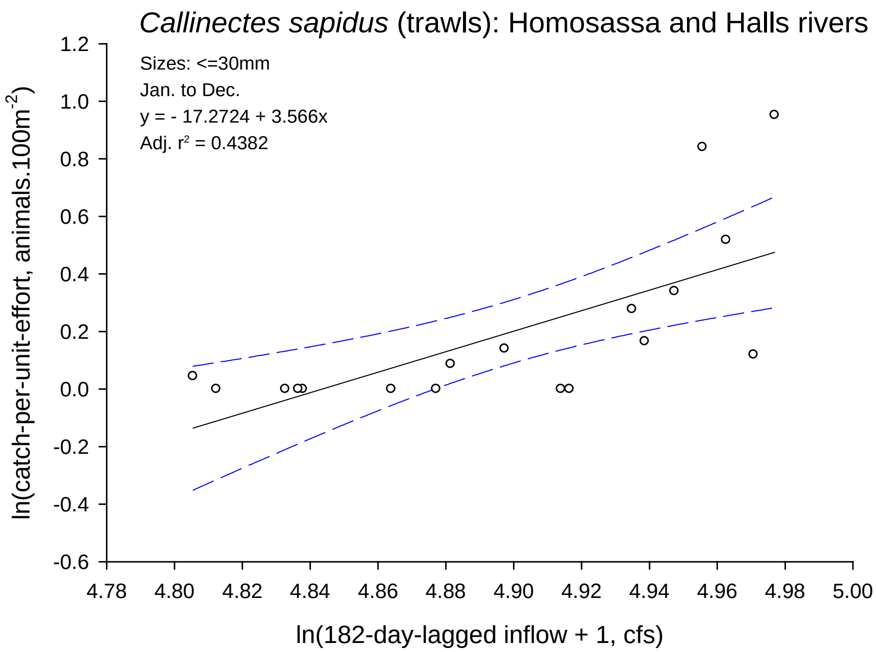


Fig. I5. Abundance response of blue crab (<=30mm) in the channel habitat of the Homosassa River estuary to 182-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

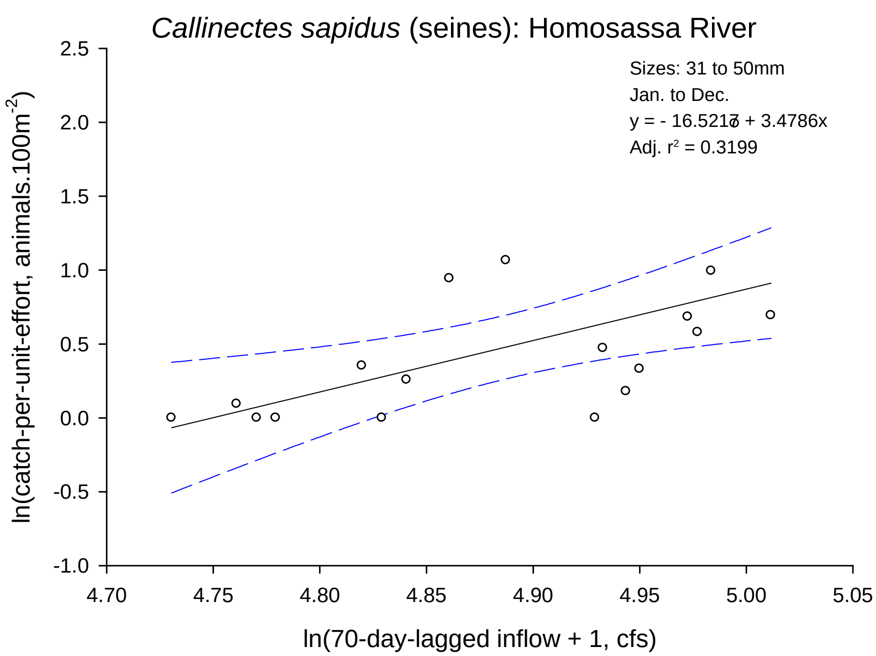


Fig. I6. Abundance response of blue crab (31 to 50mm) in the shoreline habitat of the Homosassa River estuary to 70-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

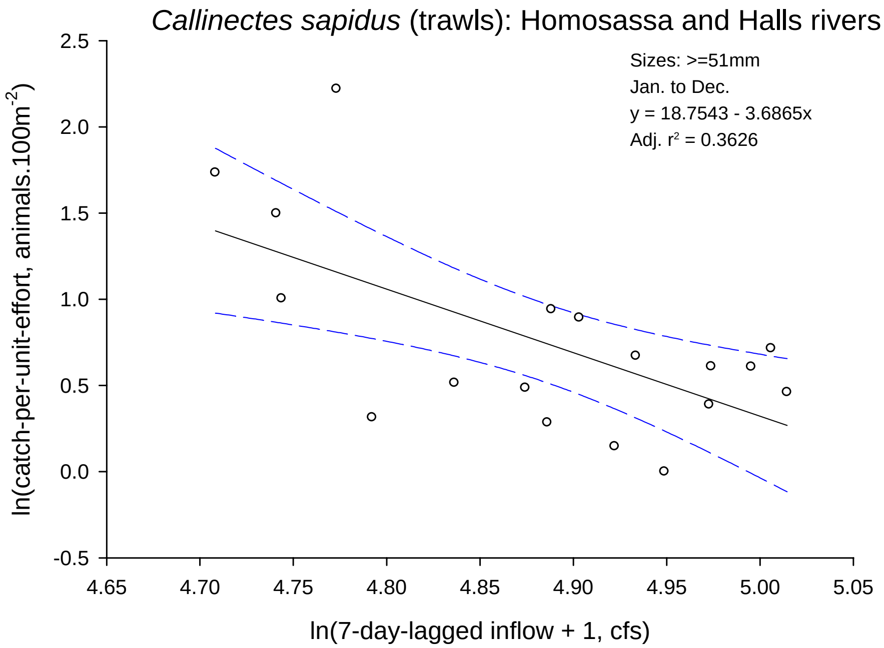


Fig. I7. Abundance response of blue crab (>=51mm) in the channel habitat of the Homosassa River estuary to 7-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

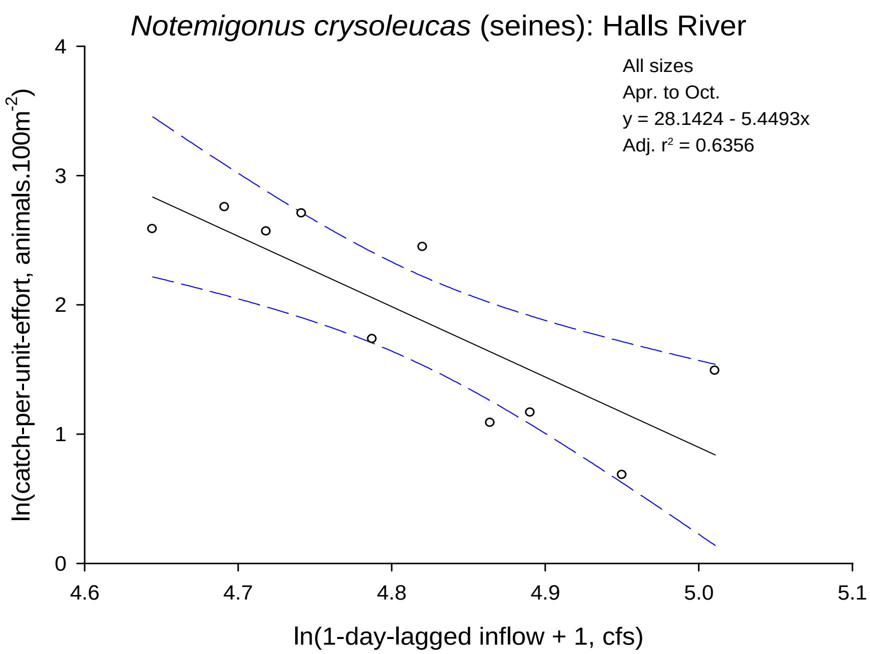


Fig. I8. Abundance response of golden shiner (all sizes) in the shoreline habitat of the Homosassa River estuary to same day inflow. Solid line: predicted values; dashed lines: 95% CI.

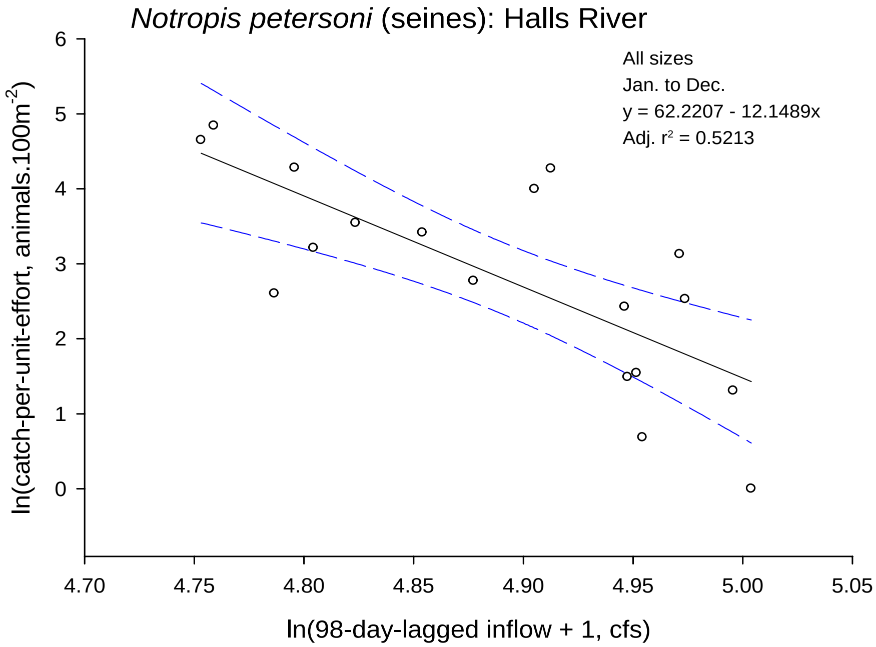


Fig. I9. Abundance response of coastal shiner (all sizes) in the shoreline habitat of the Homosassa River estuary to 98-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

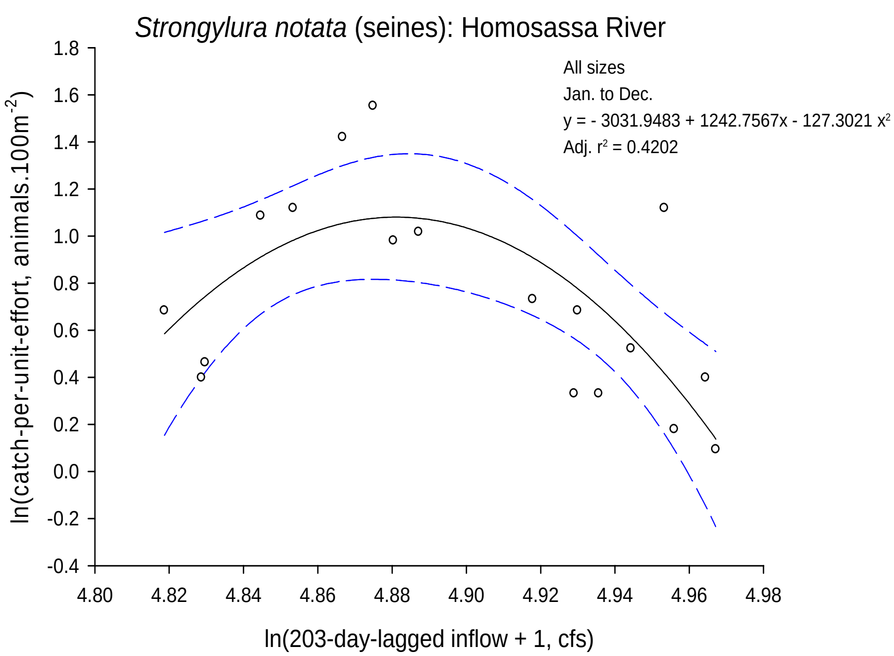


Fig. I10. Abundance response of redfin needlefish (all sizes) in the shoreline habitat of the Homosassa River estuary to 203-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

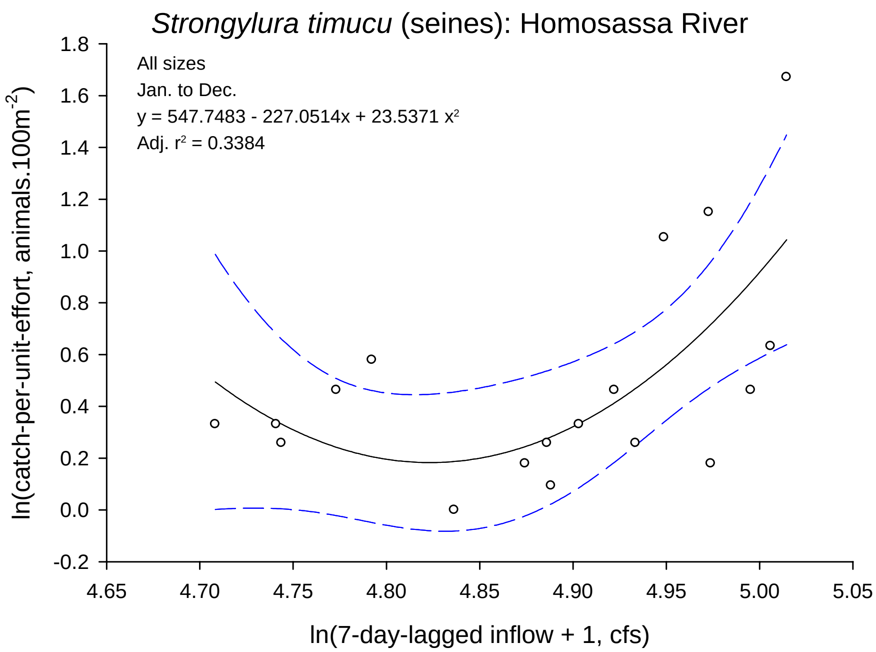


Fig. I11. Abundance response of timucu (all sizes) in the shoreline habitat of the Homosassa River estuary to 7-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

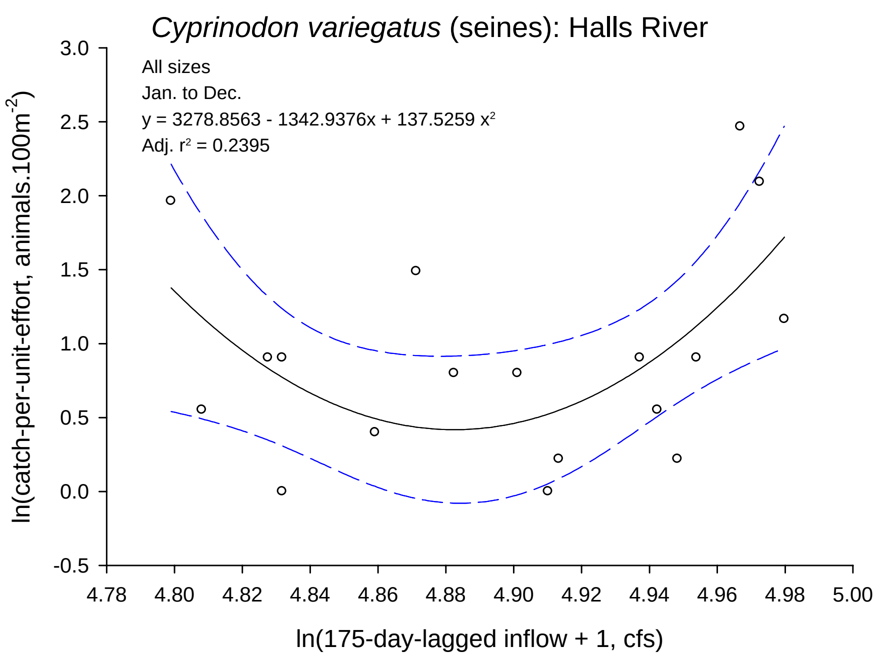


Fig. I12. Abundance response of sheepshead minnow (all sizes) in the shoreline habitat of the Homosassa River estuary to 175-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

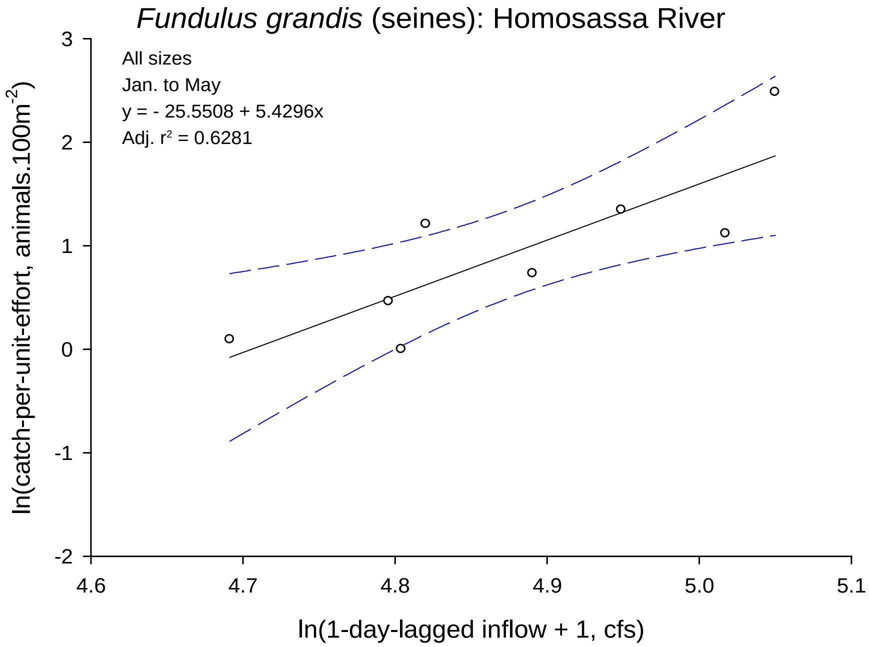


Fig. I13. Abundance response of Gulf killifish (All sizes) in the shoreline habitat of the Homosassa River estuary to same day inflow. Solid line: predicted values; dashed lines: 95% CI.

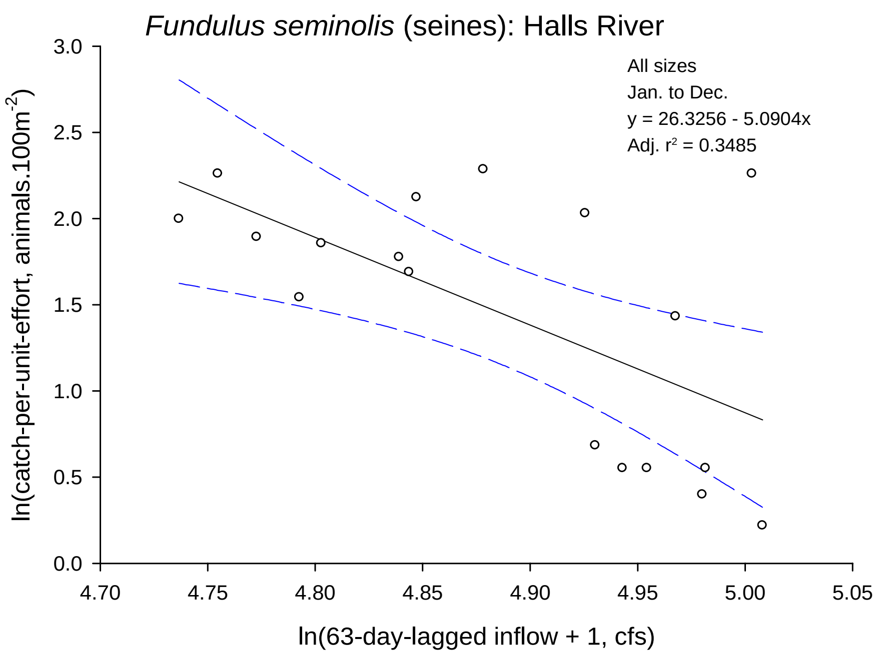


Fig. I14. Abundance response of Seminole killifish (All sizes) in the shoreline habitat of the Homosassa River estuary to 63-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

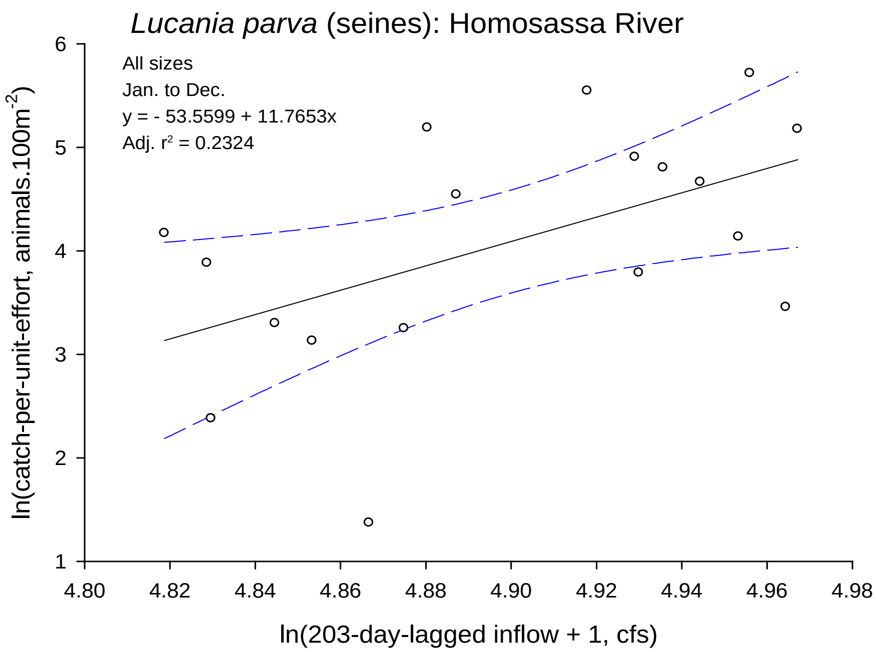


Fig. I15. Abundance response of rainwater killifish (All sizes) in the shoreline habitat of the Homosassa River estuary to 203-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

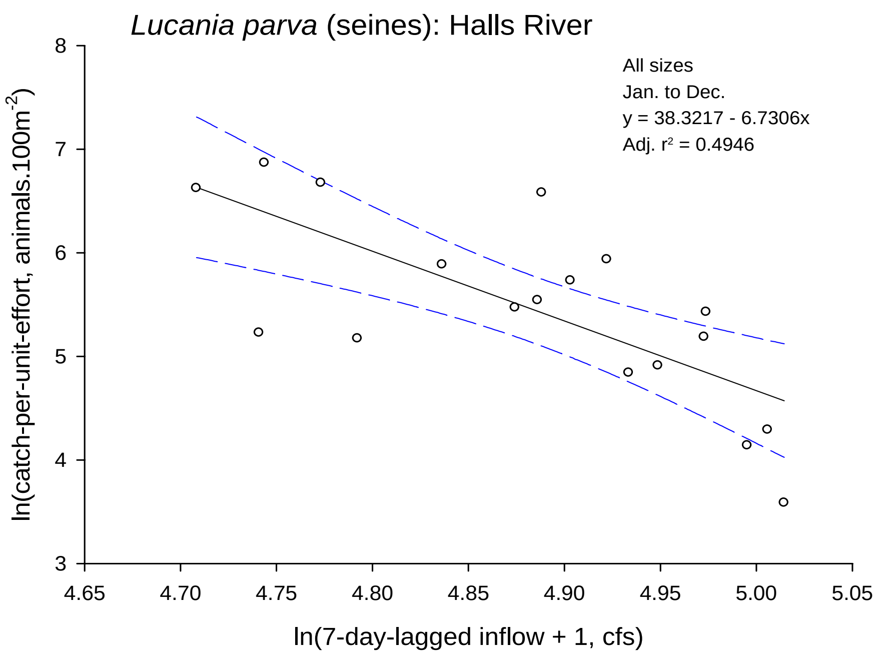


Fig. I16. Abundance response of rainwater killifish (All sizes) in the shoreline habitat of the Homosassa River estuary to 7-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

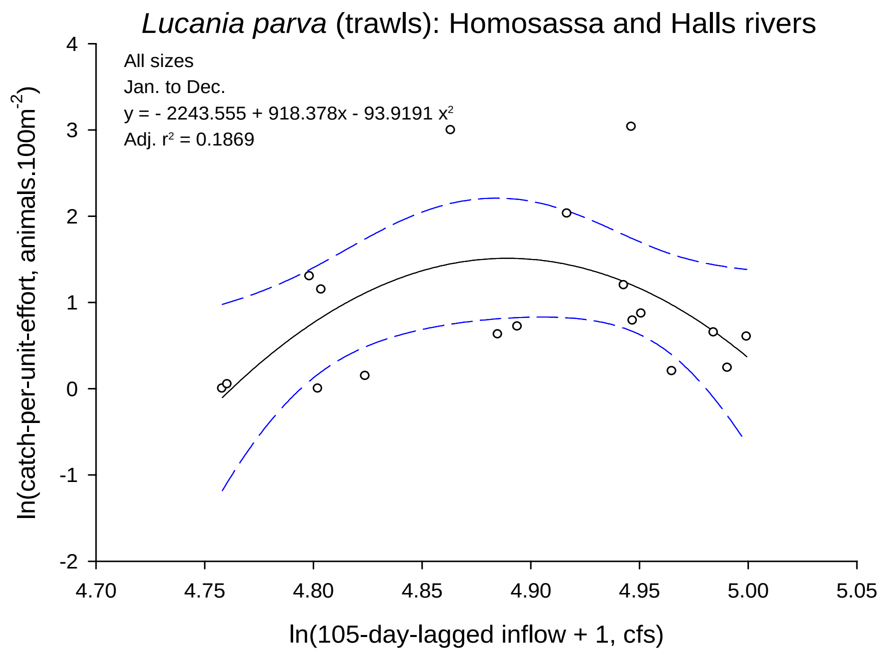


Fig. I17. Abundance response of rainwater killifish (All sizes) in the channel habitat of the Homosassa River estuary to 105-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

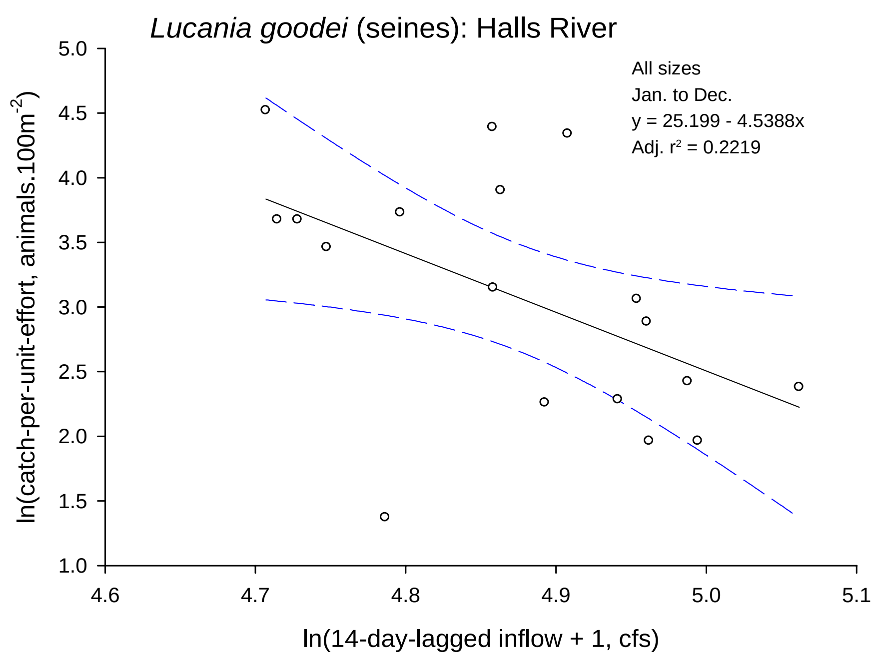


Fig. I18. Abundance response of bluefin killifish (All sizes) in the shoreline habitat of the Homosassa River estuary to 14-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

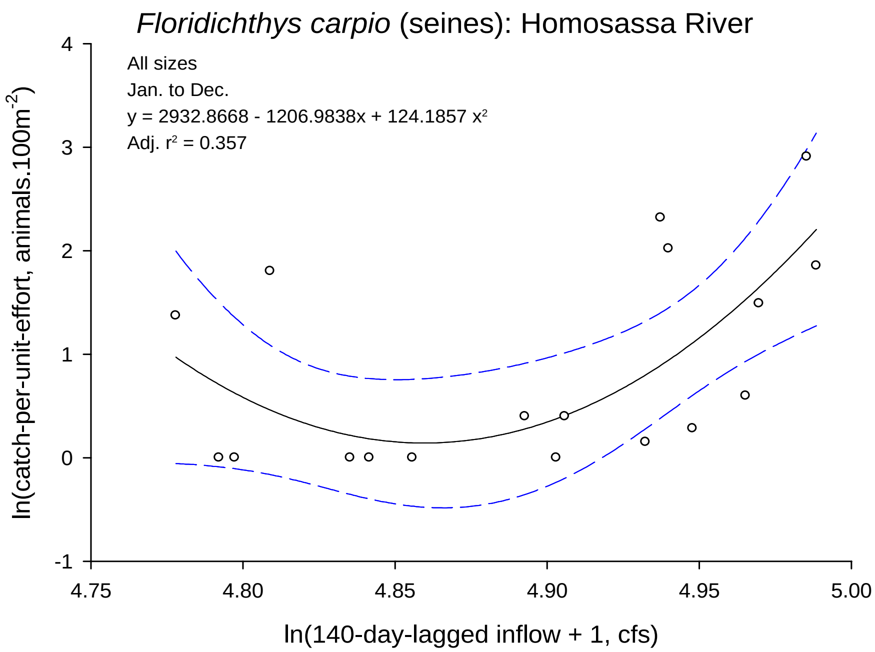


Fig. I19. Abundance response of goldspotted killifish (All sizes) in the shoreline habitat of the Homosassa River estuary to 140-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

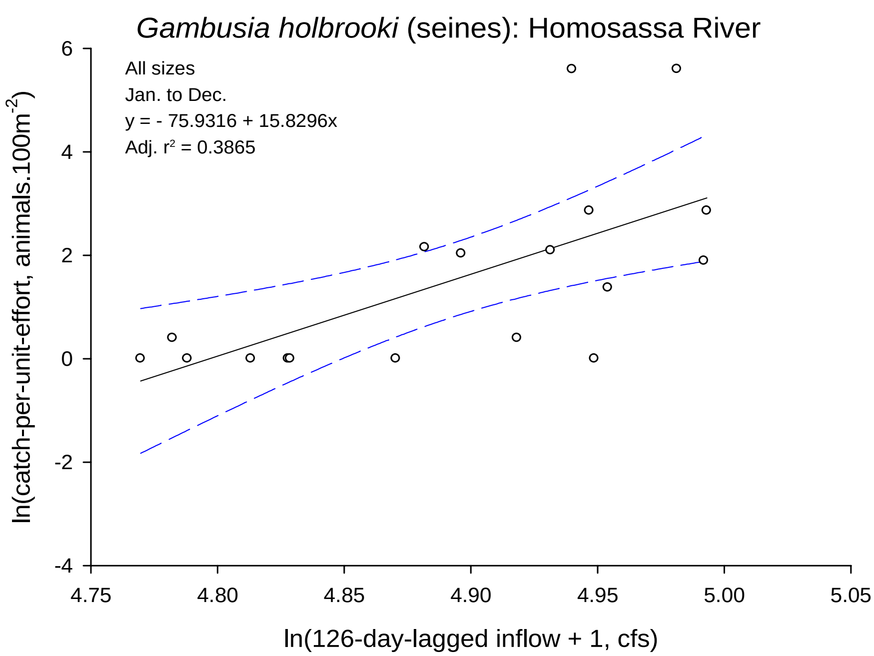


Fig. I20. Abundance response of eastern mosquitofish (All sizes) in the shoreline habitat of the Homosassa River estuary to 126-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

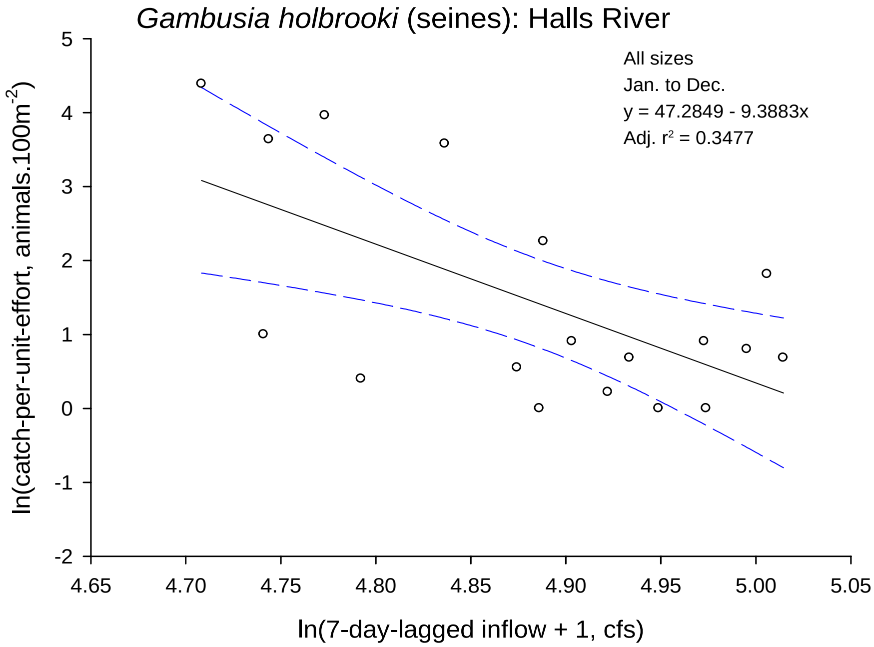


Fig. I21. Abundance response of eastern mosquitofish (All sizes) in the shoreline habitat of the Homosassa River estuary to 7-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

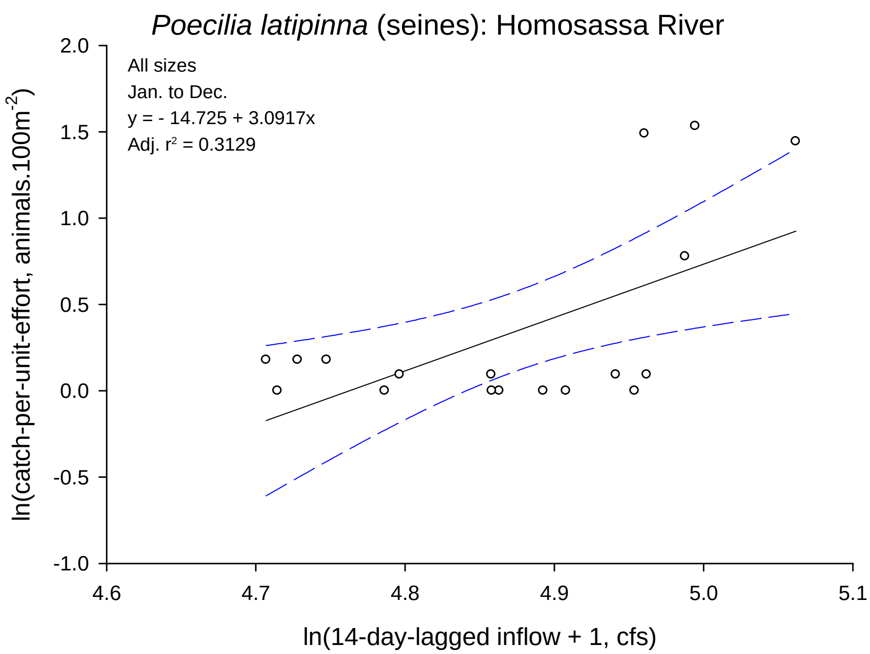


Fig. I22. Abundance response of sailfin molly (All sizes) in the shoreline habitat of the Homosassa River estuary to 14-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

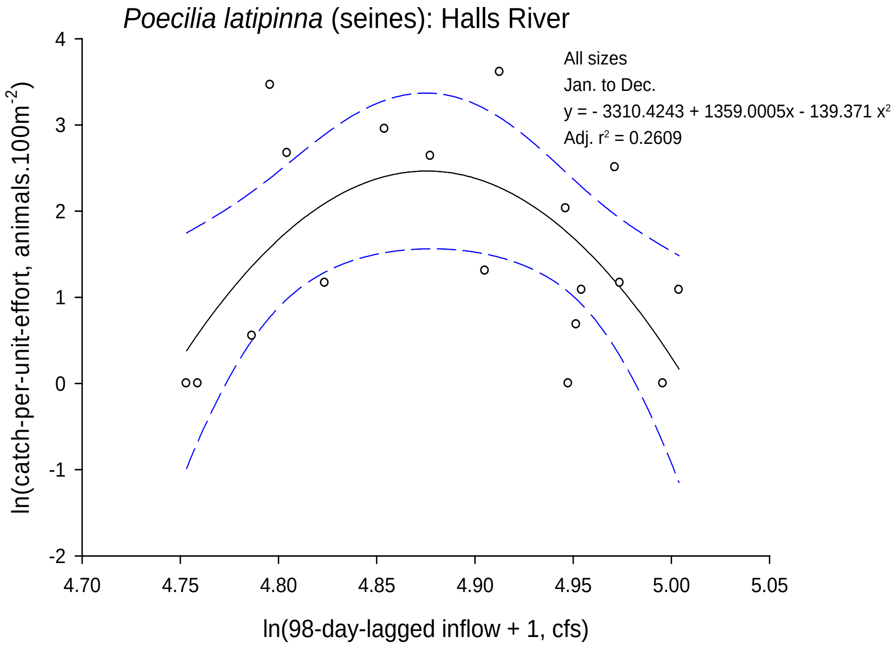


Fig. I23. Abundance response of sailfin molly (All sizes) in the shoreline habitat of the Homosassa River estuary to 98-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

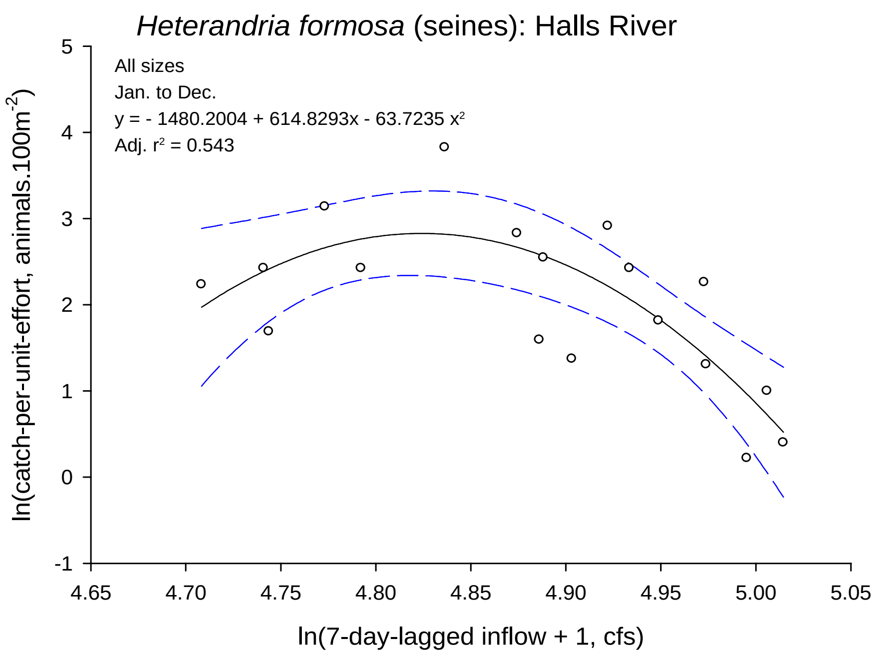


Fig. I24. Abundance response of least killifish (All sizes) in the shoreline habitat of the Homosassa River estuary to 7-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

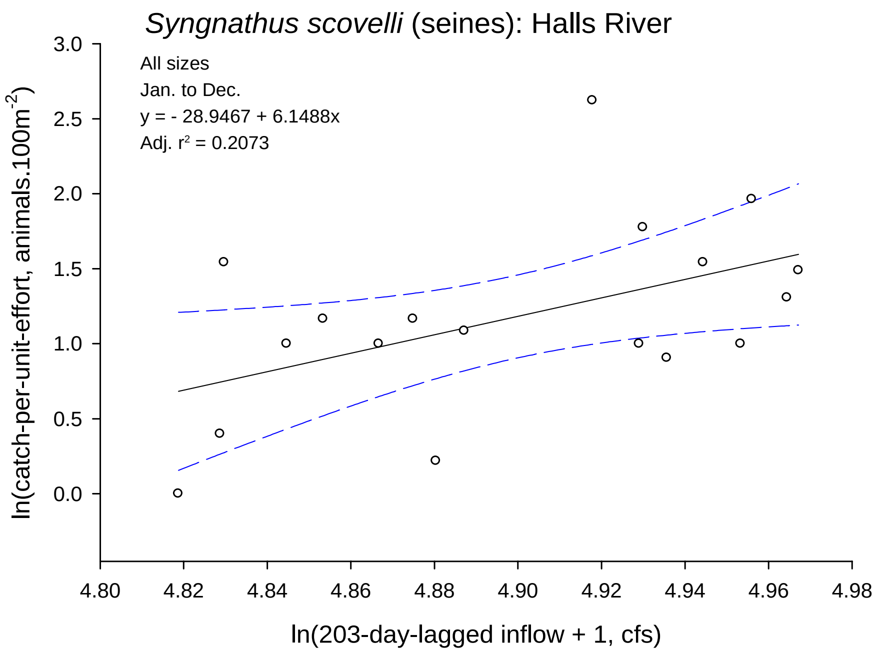


Fig. I25. Abundance response of Gulf pipefish (All sizes) in the shoreline habitat of the Homosassa River estuary to 203-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

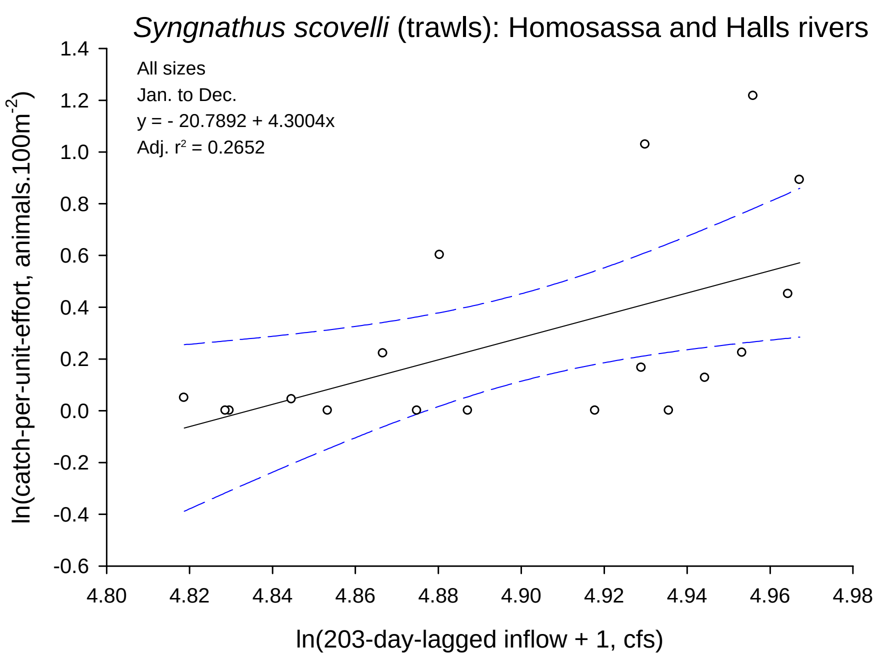


Fig. I26. Abundance response of Gulf pipefish (All sizes) in the channel habitat of the Homosassa River estuary to 203-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

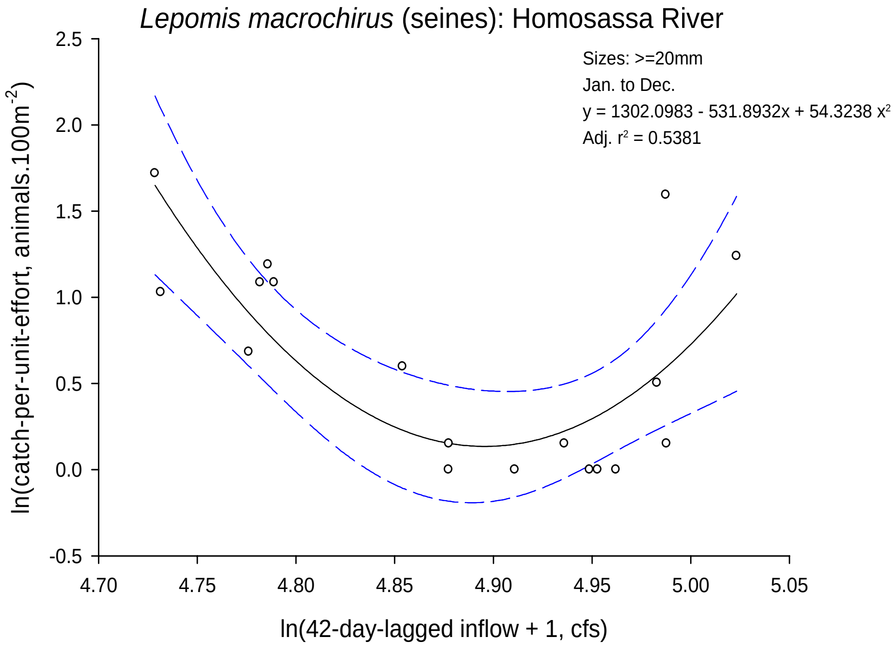


Fig. I27. Abundance response of bluegill (>=20mm) in the shoreline habitat of the Homosassa River estuary to 42-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

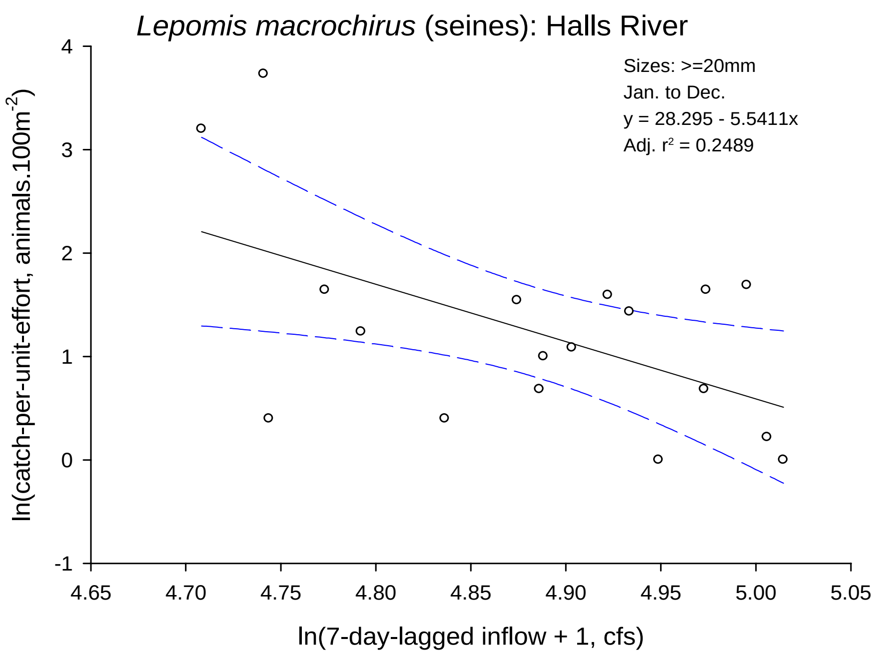


Fig. I28. Abundance response of bluegill (>=20mm) in the shoreline habitat of the Homosassa River estuary to 7-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

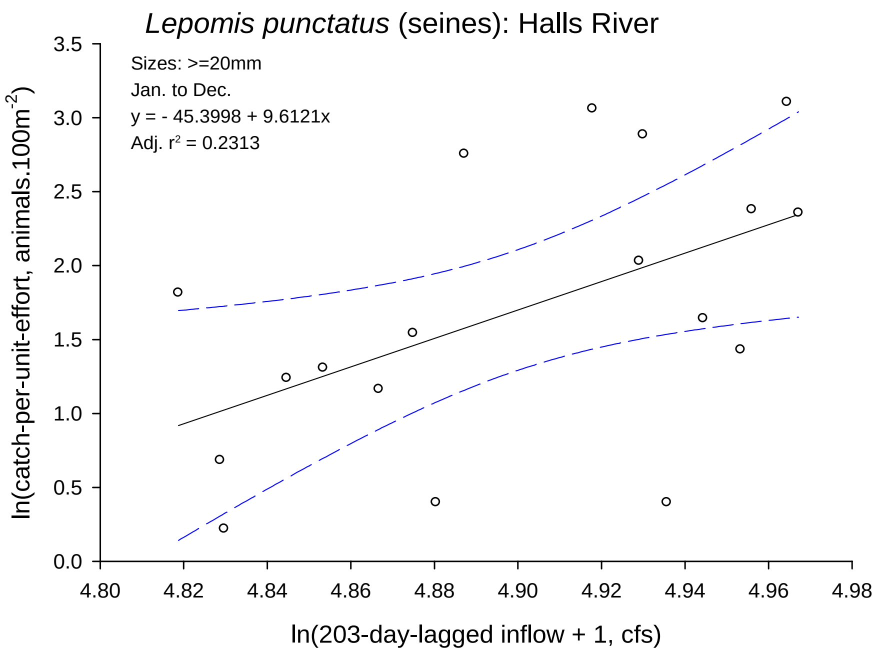


Fig. I29. Abundance response of spotted sunfish (>=20mm) in the shoreline habitat of the Homosassa River estuary to 203-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

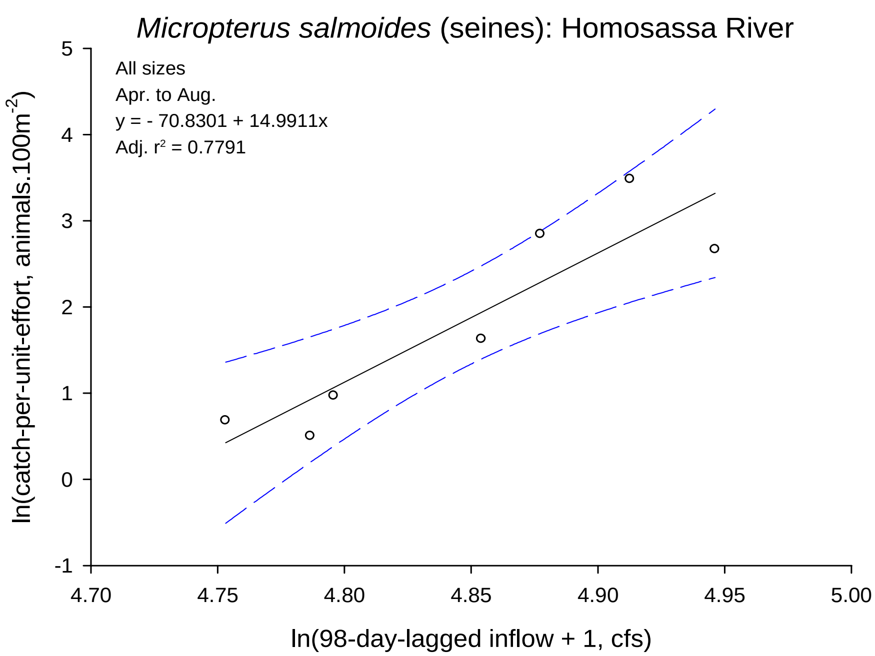


Fig. I30. Abundance response of largemouth bass (All sizes) in the shoreline habitat of the Homosassa River estuary to 98-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

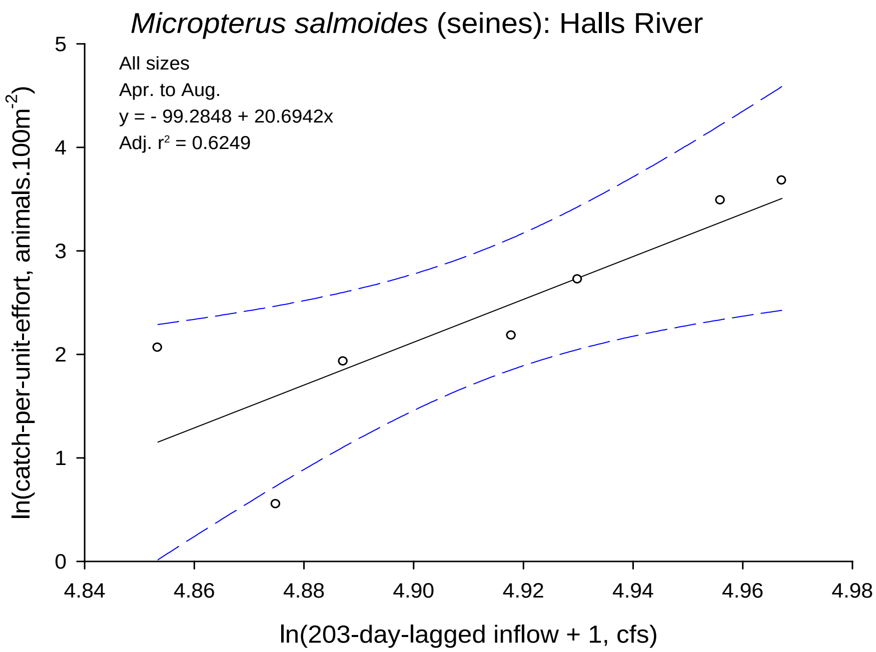


Fig. I31. Abundance response of largemouth bass (All sizes) in the shoreline habitat of the Homosassa River estuary to 203-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

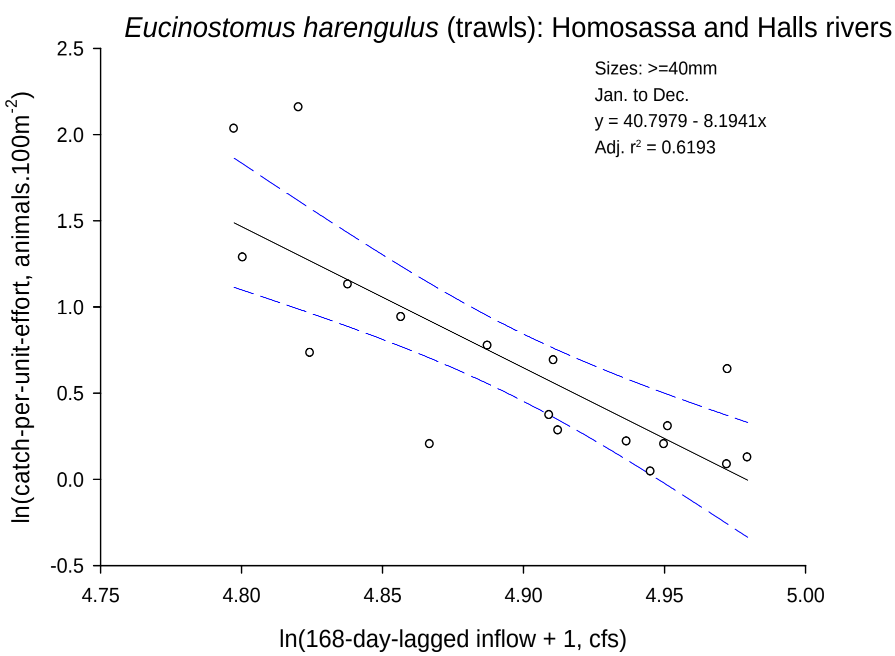


Fig. I32. Abundance response of tidewater mojarra (>=40mm) in the channel habitat of the Homosassa River estuary to 168-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

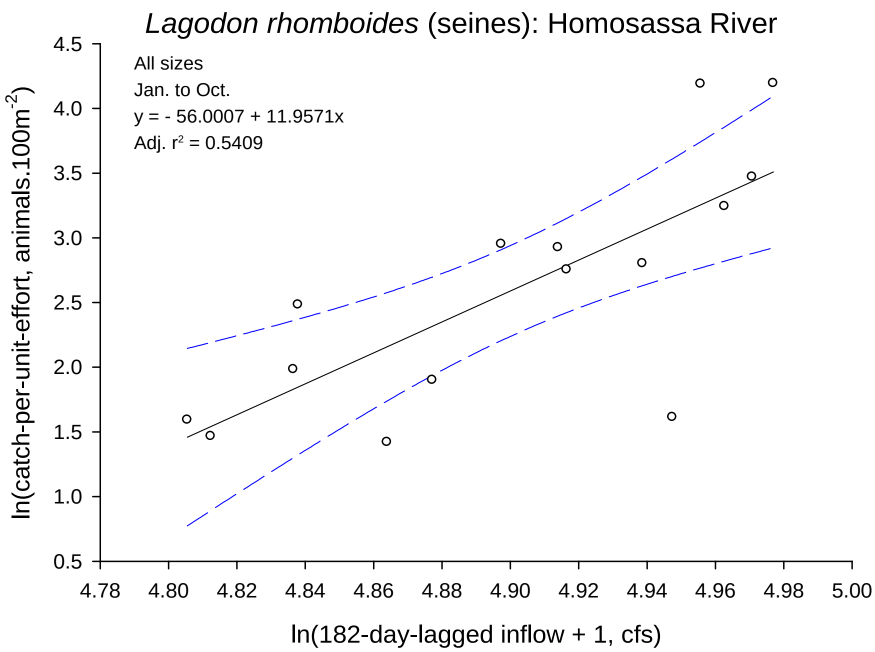


Fig. I33. Abundance response of pinfish (All sizes) in the shoreline habitat of the Homosassa River estuary to 182-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

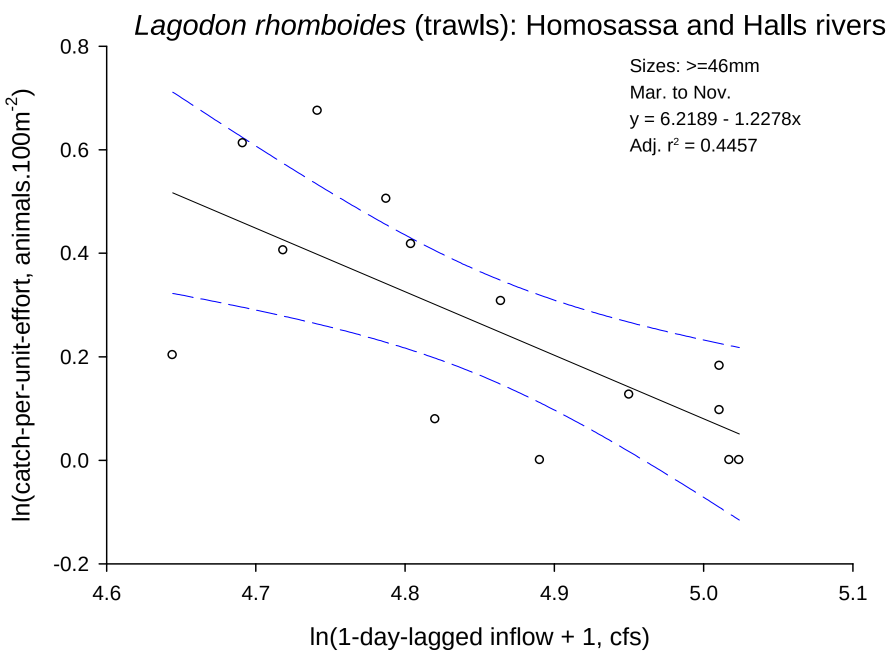


Fig. I34. Abundance response of pinfish (>=46mm) in the channel habitat of the Homosassa River estuary to same day inflow. Solid line: predicted values; dashed lines: 95% CI.

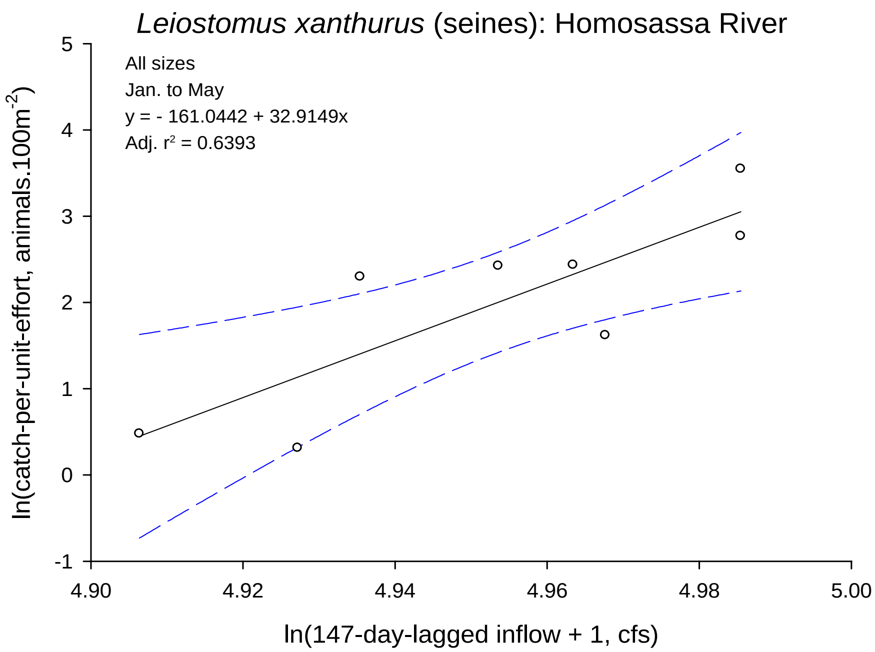


Fig. I35. Abundance response of spot (All sizes) in the shoreline habitat of the Homosassa River estuary to 147-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

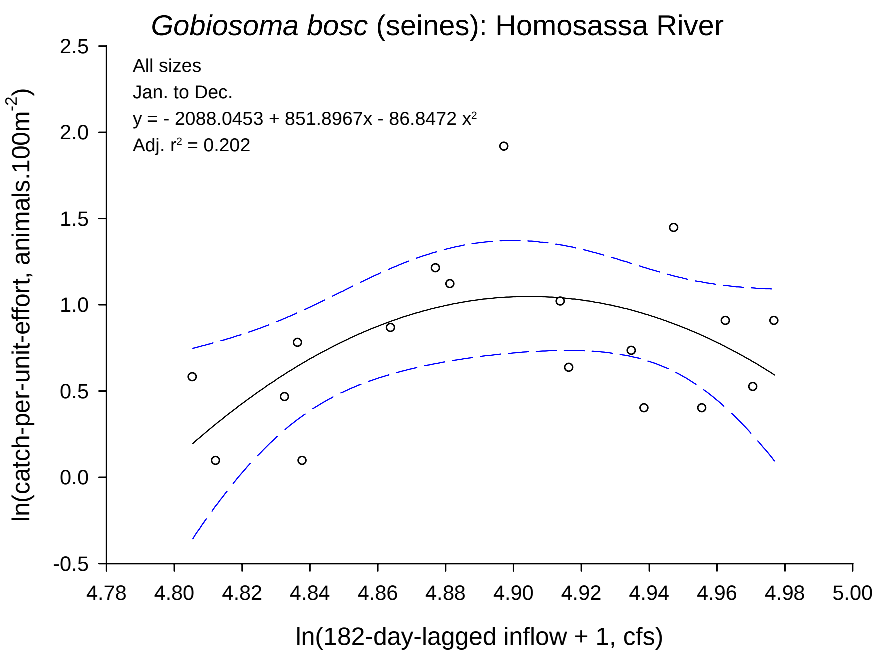


Fig. I36. Abundance response of naked goby (All sizes) in the shoreline habitat of the Homosassa River estuary to 182-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

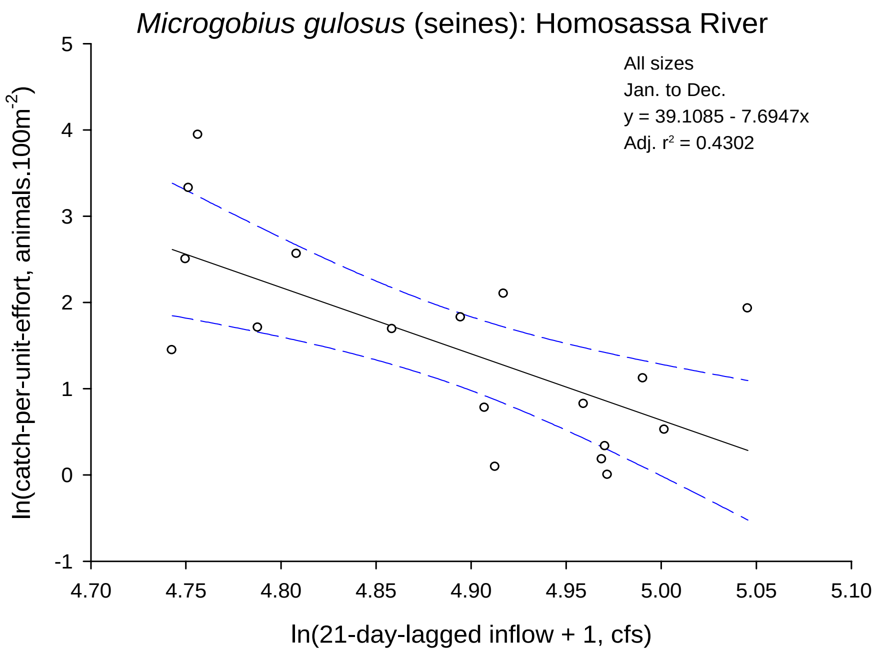


Fig. I37. Abundance response of clown goby (All sizes) in the shoreline habitat of the Homosassa River estuary to 21-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

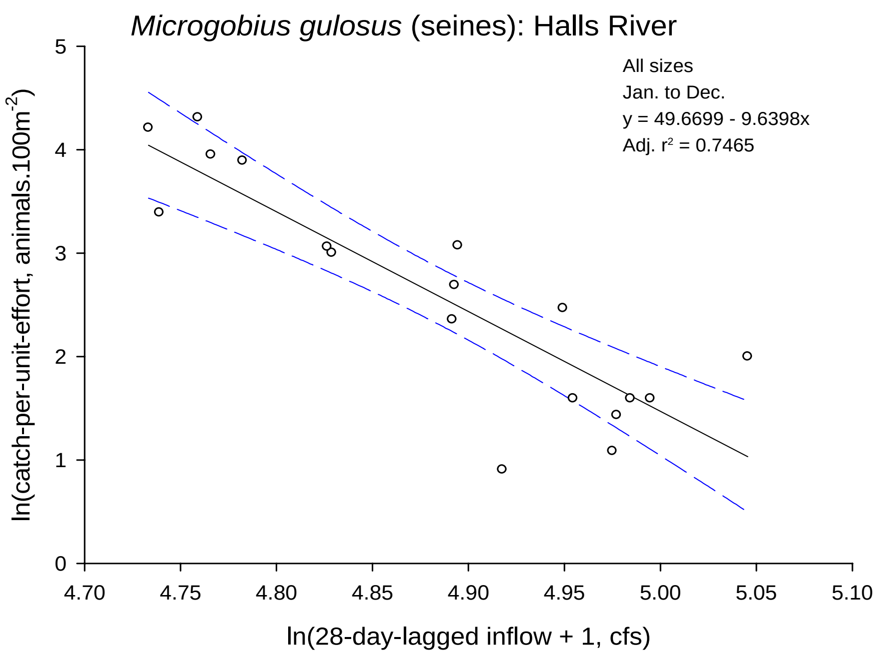


Fig. I38. Abundance response of clown goby (All sizes) in the shoreline habitat of the Homosassa River estuary to 28-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

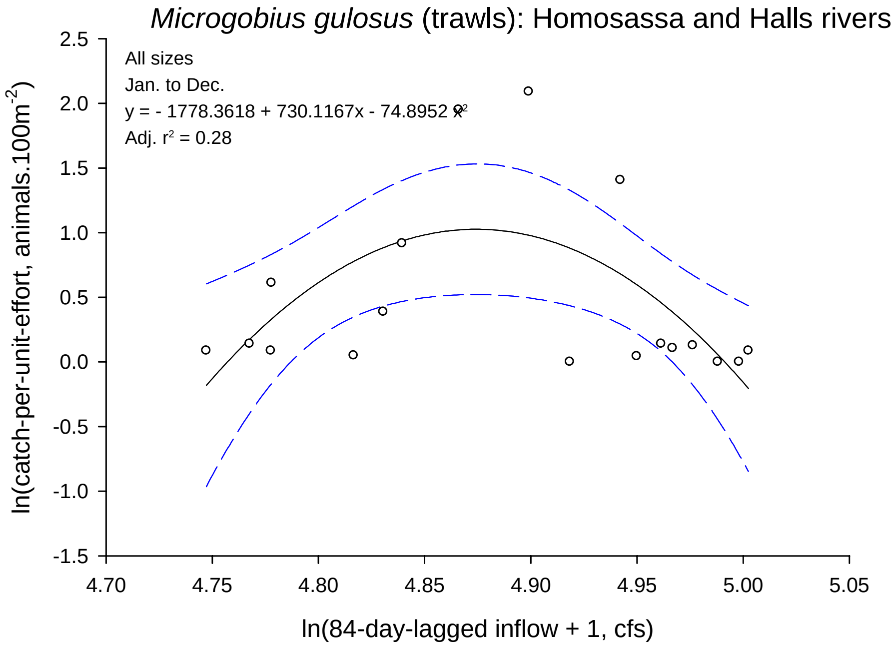


Fig. I39. Abundance response of clown goby (All sizes) in the channel habitat of the Homosassa River estuary to 84-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

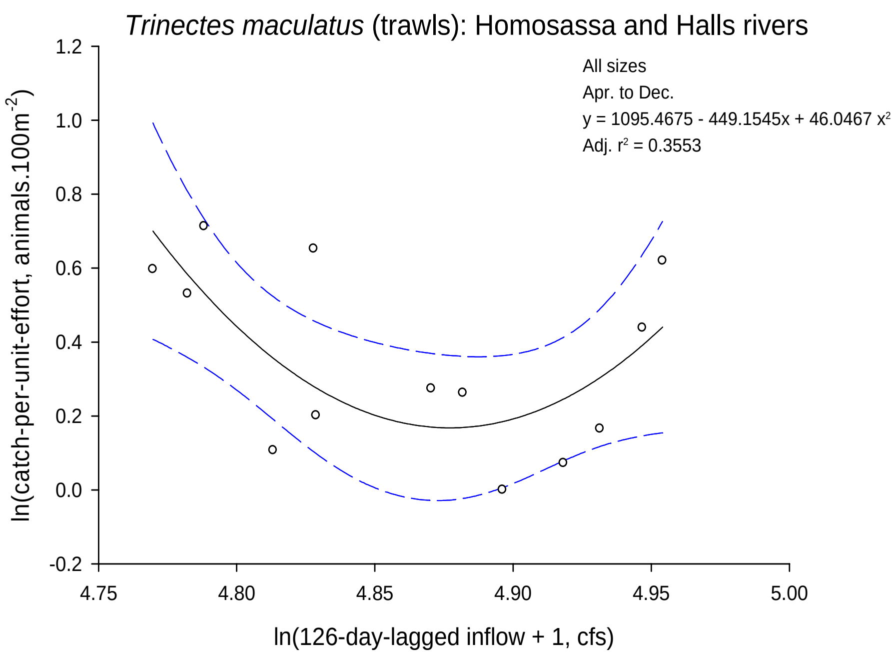


Fig. I40. Abundance response of hogchoker (All sizes) in the channel habitat of the Homosassa River estuary to 126-day-lagged inflow. Solid line: predicted values; dashed lines: 95% CI.

Appendix I

Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of plankton and nekton in the Homosassa and/or Halls River for the benchmark periods of 2007 and October 18, 1995 through May 13, 2009.

Table I-1. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Hargeria rapax* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for organisms collected with a plankton net (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Absolute Abundance (number/ channel)	Baseline Absolute Abundance Minus 15% (number/ channel)	Flow Associated with Baseline Absolute Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	359,492	305,568	148.8	1.4
	80%	145.0	228,327	194,078	142.9	1.4
	70%	140.0	154,151	131,028	138.0	1.4
	60%	136.0	111,432	94,717	134.0	1.4
	50%	130.0	67,242	57,155	128.1	1.4
	40%	126.0	47,390	40,282	124.2	1.4
	30%	121.0	30,128	25,609	119.3	1.4
	20%	117.0	20,672	17,571	115.3	1.4
	10%	110.8	11,223	9,539	109.2	1.4
1995 - 2009	90%	184.6	3,407,062	2,896,002	181.9	1.4
	80%	171.2	1,462,113	1,242,796	168.7	1.4
	70%	163.0	846,219	719,286	160.7	1.4
	60%	156.0	517,693	440,039	153.8	1.4
	50%	150.0	333,722	283,663	147.8	1.4
	40%	144.0	211,305	179,610	141.9	1.4
	30%	138.0	131,217	111,534	136.0	1.4
	20%	131.0	73,265	62,275	129.1	1.4
	10%	122.3	33,792	28,723	120.5	1.4

Table I-2. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Lucania parva postflexion larvae* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for organisms collected with a plankton net (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Absolute Abundance (number/ channel)	Baseline Absolute Abundance Minus 15% (number/ channel)	Flow Associated with Baseline Absolute Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	8,057	6,849	148.9	1.4
	80%	145.0	5,024	4,270	143.0	1.4
	70%	140.0	3,338	2,837	138.1	1.4
	60%	136.0	2,381	2,024	134.1	1.4
	50%	130.0	1,407	1,196	128.2	1.4
	40%	126.0	978	831	124.3	1.4
	30%	121.0	610	519	119.3	1.4
	20%	117.0	412	350	115.4	1.4
	10%	110.8	218	186	109.3	1.4
1995 - 2009	90%	184.6	83,706	71,150	182.0	1.4
	80%	171.2	34,702	29,497	168.8	1.4
	70%	163.0	19,641	16,695	160.7	1.4
	60%	156.0	11,777	10,011	153.8	1.4
	50%	150.0	7,457	6,339	147.9	1.4
	40%	144.0	4,634	3,939	142.0	1.4
	30%	138.0	2,822	2,399	136.1	1.4
	20%	131.0	1,539	1,308	129.2	1.4
	10%	122.3	688	585	120.6	1.4

Table I-3. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of podocopid *Ostracods,* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for organisms collected with a plankton net (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Absolute Abundance (number/ channel)	Baseline Absolute Abundance Minus (number/ channel)	Flow Associated with Baseline Absolute Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	186,873	158,842	149.0	1.3
	80%	145.0	114,925	97,686	143.0	1.3
	70%	140.0	75,455	64,137	138.1	1.3
	60%	136.0	53,302	45,307	134.2	1.3
	50%	130.0	31,031	26,376	128.3	1.3
	40%	126.0	21,333	18,133	124.3	1.3
	30%	121.0	13,133	11,163	119.4	1.3
	20%	117.0	8,773	7,457	115.4	1.3
	10%	110.8	4,561	3,877	109.3	1.3
1995 - 2009	90%	184.6	2,077,763	1,766,098	182.1	1.3
	80%	171.2	839,666	713,716	168.9	1.3
	70%	163.0	467,458	397,339	160.8	1.3
	60%	156.0	276,170	234,745	153.9	1.3
	50%	150.0	172,563	146,678	148.0	1.3
	40%	144.0	105,774	89,908	142.1	1.3
	30%	138.0	63,499	53,974	136.1	1.3
	20%	131.0	34,017	28,914	129.2	1.3
	10%	122.3	14,851	12,623	120.6	1.3

Table I-4. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Acartia tonsa,* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for organisms collected with a plankton net (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Absolute Abundance (number/ channel)	Baseline Absolute Abundance Minus 15% (number/ channel)	Flow Associated with Baseline Absolute Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	12,548,577	10,666,291	149.4	1.1
	80%	145.0	6,783,977	5,766,381	143.5	1.1
	70%	140.0	3,983,908	3,386,322	138.5	1.1
	60%	136.0	2,566,521	2,181,543	134.6	1.1
	50%	130.0	1,294,494	1,100,319	128.6	1.1
	40%	126.0	805,775	684,909	124.7	1.1
	30%	121.0	436,186	370,758	119.7	1.1
	20%	117.0	261,821	222,548	115.8	1.1
	10%	110.8	114,431	97,266	109.6	1.1
1995 - 2009	90%	184.6	264,235,083	224,599,821	182.6	1.1
	80%	171.2	83,979,314	71,382,417	169.3	1.1
	70%	163.0	40,028,281	34,024,039	161.3	1.1
	60%	156.0	20,568,386	17,483,128	154.3	1.1
	50%	150.0	11,345,444	9,643,627	148.4	1.1
	40%	144.0	6,107,927	5,191,738	142.5	1.1
	30%	138.0	3,202,720	2,722,312	136.5	1.1
	20%	131.0	1,454,057	1,235,949	129.6	1.1
	10%	122.3	509,570	433,134	121.0	1.1

Table I-5. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Eurytemora affinis,* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for organisms collected with a plankton net (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Absolute Abundance (number/ channel)	Baseline Absolute Abundance Minus 15% (number/ channel)	Flow Associated with Baseline Absolute Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	56,739	48,228	149.8	0.8
	80%	145.0	25,240	21,454	143.8	0.8
	70%	140.0	12,521	10,643	138.9	0.8
	60%	136.0	7,016	5,964	134.9	0.8
	50%	130.0	2,849	2,421	129.0	0.8
	40%	126.0	1,526	1,297	125.0	0.8
	30%	121.0	680	578	120.0	0.8
	20%	117.0	347	295	116.1	0.8
	10%	110.8	117	99	109.9	0.8
1995 - 2009	90%	184.6	3,139,289	2,668,395	183.1	0.8
	80%	171.2	693,730	589,671	169.8	0.8
	70%	163.0	261,435	222,220	161.7	0.8
	60%	156.0	108,774	92,458	154.7	0.8
	50%	150.0	49,686	42,233	148.8	0.8
	40%	144.0	21,981	18,684	142.8	0.8
	30%	138.0	9,393	7,984	136.9	0.8
	20%	131.0	3,320	2,822	129.9	0.8
	10%	122.3	834	709	121.3	0.8

Table I-6. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Palaemonetes intermedius* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	37.7	32.0	147.9	2.1
	80%	145.0	27.4	23.3	142.0	2.0
	70%	140.0	20.8	17.6	137.2	2.0
	60%	136.0	16.5	14.0	133.3	2.0
	50%	130.0	11.4	9.7	127.5	1.9
	40%	126.0	8.8	7.5	123.6	1.9
	30%	121.0	6.2	5.3	118.8	1.8
	20%	117.0	4.6	3.9	115.0	1.7
	10%	110.8	2.7	2.3	109.1	1.5
1995 - 2009	90%	184.6	177.2	150.6	180.7	2.1
	80%	171.2	99.3	84.4	167.6	2.1
	70%	163.0	68.1	57.9	159.6	2.1
	60%	156.0	48.5	41.2	152.8	2.1
	50%	150.0	35.8	30.4	146.9	2.1
	40%	144.0	25.9	22.1	141.1	2.0
	30%	138.0	18.5	15.7	135.2	2.0
	20%	131.0	12.1	10.3	128.5	1.9
	10%	122.3	6.8	5.8	120.0	1.8

Table I-7. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Callinectus sapidus* less than 30 mm in length in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	17.7	15.1	149.3	1.1
	80%	145.0	9.7	8.3	143.5	1.1
	70%	140.0	5.6	4.8	138.6	1.0
	60%	136.0	3.5	2.9	134.8	0.9
	50%	130.0	1.4	1.2	129.1	0.7
	40%	126.0	0.6	0.5	125.5	0.4
	30%	121.0	NA	NA	NA	NA
	20%	117.0	NA	NA	NA	NA
	10%	110.8	NA	NA	NA	NA
1995 - 2009	90%	184.6	294.1	250.0	182.4	1.2
	80%	171.2	103.5	88.0	169.2	1.2
	70%	163.0	52.5	44.6	161.1	1.2
	60%	156.0	28.3	24.0	154.2	1.1
	50%	150.0	16.1	13.7	148.3	1.1
	40%	144.0	8.8	7.4	142.5	1.0
	30%	138.0	4.4	3.8	136.7	0.9
	20%	131.0	1.7	1.4	130.1	0.7
	10%	122.3	0.0	0.0	122.2	0.0

NA = not applicable; predicted baseline abundance less than zero

Table I-8. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Callinectus sapidus* greater than 30 mm in length in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	1.6	1.3	146.8	2.8
	80%	145.0	1.2	1.1	141.4	2.5
	70%	140.0	1.0	0.8	136.9	2.2
	60%	136.0	0.8	0.7	133.3	2.0
	50%	130.0	0.5	0.5	128.0	1.6
	40%	126.0	0.4	0.3	124.5	1.2
	30%	121.0	0.20	0.17	120.1	0.7
	20%	117.0	0.07	0.06	116.7	0.3
	10%	110.8	NA	NA	NA	NA
1995 - 2009	90%	184.6	4.2	3.6	177.8	3.7
	80%	171.2	3.0	2.5	165.4	3.4
	70%	163.0	2.4	2.0	157.8	3.2
	60%	156.0	1.9	1.6	151.4	2.9
	50%	150.0	1.5	1.3	145.9	2.7
	40%	144.0	1.2	1.0	140.5	2.4
	30%	138.0	0.9	0.8	135.1	2.1
	20%	131.0	0.6	0.5	128.9	1.6
	10%	122.3	0.25	0.2	121.2	0.9

NA = not applicable; predicted baseline abundance less than zero

Table I-9. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Callinectus sapidus* greater than 30 mm in length in the Homosassa and Halls Rivers as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for trawl-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	0.9	0.8	147.9	2.1
	80%	145.0	0.6	0.6	142.5	1.7
	70%	140.0	0.5	0.4	138.1	1.3
	60%	136.0	0.3	0.3	134.6	1.0
	50%	130.0	0.1	0.1	129.4	0.5
	40%	126.0	0.0	0.0	126.0	0.0
	30%	121.0	NA	NA	NA	NA
	20%	117.0	NA	NA	NA	NA
	10%	110.8	NA	NA	NA	NA
1995 - 2009	90%	184.6	2.9	2.4	178.6	3.3
	80%	171.2	2.0	1.7	166.2	2.9
	70%	163.0	1.5	1.3	158.7	2.6
	60%	156.0	1.1	1.0	152.4	2.3
	50%	150.0	0.9	0.7	147.0	2.0
	40%	144.0	0.6	0.5	141.6	1.6
	30%	138.0	0.4	0.3	136.4	1.2
	20%	131.0	0.2	0.1	130.3	0.6
	10%	122.3	NA	NA	NA	NA

NA = not applicable; predicted baseline abundance less than zero

Table I-10. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Fundulus grandis* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	4.6	3.9	147.4	2.4
	80%	145.0	3.5	3.0	141.7	2.3
	70%	140.0	2.7	2.3	137.0	2.1
	60%	136.0	2.2	1.9	133.3	2.0
	50%	130.0	1.5	1.3	127.7	1.7
	40%	126.0	1.1	1.0	124.1	1.5
	30%	121.0	0.71	0.60	119.6	1.2
	20%	117.0	0.42	0.36	116.0	0.8
	10%	110.8	0.1	0.1	110.6	0.2
1995 - 2009	90%	184.6	15.7	13.3	179.5	2.8
	80%	171.2	10.1	8.6	166.6	2.7
	70%	163.0	7.5	6.4	158.8	2.6
	60%	156.0	5.7	4.9	152.1	2.5
	50%	150.0	4.4	3.8	146.4	2.4
	40%	144.0	3.4	2.9	140.8	2.3
	30%	138.0	2.5	2.1	135.1	2.1
	20%	131.0	1.6	1.4	128.7	1.8
	10%	122.3	0.80	0.7	120.7	1.3

Table I-11. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Lucania parva* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	255.2	216.9	148.9	1.4
	80%	145.0	158.5	134.7	143.0	1.4
	70%	140.0	104.9	89.1	138.1	1.4
	60%	136.0	74.5	63.3	134.1	1.4
	50%	130.0	43.6	37.0	128.2	1.3
	40%	126.0	29.9	25.4	124.3	1.3
	30%	121.0	18.29	15.55	119.4	1.3
	20%	117.0	12.03	10.22	115.5	1.3
	10%	110.8	5.9	5.0	109.5	1.2
1995 - 2009	90%	184.6	2683.6	2281.0	182.1	1.4
	80%	171.2	1108.0	941.8	168.8	1.4
	70%	163.0	625.4	531.6	160.8	1.4
	60%	156.0	373.9	317.8	153.9	1.4
	50%	150.0	236.1	200.6	147.9	1.4
	40%	144.0	146.1	124.2	142.0	1.4
	30%	138.0	88.5	75.2	136.1	1.4
	20%	131.0	47.7	40.6	129.2	1.4
	10%	122.3	20.74	17.6	120.6	1.3

Table I-12. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Gambusia holbrooki* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	61.6	52.3	149.5	1.0
	80%	145.0	32.1	27.3	143.6	1.0
	70%	140.0	18.0	15.3	138.6	1.0
	60%	136.0	11.1	9.4	134.7	0.9
	50%	130.0	4.9	4.2	128.9	0.8
	40%	126.0	2.6	2.2	125.1	0.7
	30%	121.0	0.93	0.79	120.4	0.5
	20%	117.0	0.14	0.12	116.9	0.1
	10%	110.8	NA	NA	NA	NA
1995 - 2009	90%	184.6	1475.0	1253.7	182.7	1.0
	80%	171.2	448.2	381.0	169.4	1.0
	70%	163.0	207.3	176.2	161.3	1.0
	60%	156.0	103.4	87.9	154.4	1.0
	50%	150.0	55.3	47.0	148.5	1.0
	40%	144.0	28.7	24.4	142.6	1.0
	30%	138.0	14.2	12.1	136.7	1.0
	20%	131.0	5.7	4.8	129.9	0.9
	10%	122.3	1.26	1.1	121.6	0.6

NA = not applicable; predicted baseline abundance less than zero

Table I-13. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Poecillia latipinna* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	1.2	1.1	146.8	2.8
	80%	145.0	1.0	0.8	141.4	2.5
	70%	140.0	0.8	0.7	136.9	2.2
	60%	136.0	0.6	0.5	133.4	1.9
	50%	130.0	0.4	0.4	128.1	1.5
	40%	126.0	0.3	0.2	124.6	1.1
	30%	121.0	0.14	0.12	120.3	0.6
	20%	117.0	0.03	0.02	116.9	0.1
	10%	110.8	NA	NA	NA	NA
1995 - 2009	90%	184.6	3.2	2.7	177.5	3.9
	80%	171.2	2.3	2.0	165.1	3.5
	70%	163.0	1.8	1.6	157.7	3.3
	60%	156.0	1.5	1.3	151.3	3.0
	50%	150.0	1.2	1.0	145.9	2.7
	40%	144.0	0.9	0.8	140.5	2.4
	30%	138.0	0.7	0.6	135.2	2.1
	20%	131.0	0.5	0.4	129.0	1.5
	10%	122.3	0.17	0.1	121.4	0.7

NA = not applicable; predicted baseline abundance less than zero

Table I-14. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Syngnathus scovelli* in the Homosassa and Halls Rivers as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for trawl-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	1.3	1.1	147.9	2.0
	80%	145.0	0.9	0.8	142.5	1.7
	70%	140.0	0.6	0.5	138.0	1.4
	60%	136.0	0.4	0.4	134.5	1.1
	50%	130.0	0.2	0.2	129.3	0.6
	40%	126.0	0.0	0.0	125.8	0.1
	30%	121.0	NA	NA	NA	NA
	20%	117.0	NA	NA	NA	NA
	10%	110.8	NA	NA	NA	NA
1995 - 2009	90%	184.6	4.3	3.7	179.1	3.0
	80%	171.2	2.9	2.4	166.5	2.7
	70%	163.0	2.1	1.8	158.9	2.5
	60%	156.0	1.6	1.4	152.5	2.2
	50%	150.0	1.2	1.0	147.0	2.0
	40%	144.0	0.8	0.7	141.6	1.6
	30%	138.0	0.5	0.5	136.3	1.3
	20%	131.0	0.2	0.2	130.1	0.7
	10%	122.3	NA	NA	NA	NA

NA = not applicable; predicted baseline abundance less than zero

Table I-15. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Syngnathus scovelli* in Halls River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	6.0	5.1	147.6	2.2
	80%	145.0	4.5	3.8	141.9	2.1
	70%	140.0	3.4	2.9	137.2	2.0
	60%	136.0	2.7	2.3	133.4	1.9
	50%	130.0	1.8	1.5	127.9	1.6
	40%	126.0	1.3	1.1	124.2	1.5
	30%	121.0	0.81	0.69	119.6	1.1
	20%	117.0	0.48	0.40	116.1	0.8
	10%	110.8	0.1	0.0	110.6	0.1
1995 - 2009	90%	184.6	22.9	19.5	180.0	2.5
	80%	171.2	14.1	11.9	167.0	2.4
	70%	163.0	10.2	8.6	159.1	2.4
	60%	156.0	7.5	6.4	152.4	2.3
	50%	150.0	5.7	4.9	146.7	2.2
	40%	144.0	4.2	3.6	141.0	2.1
	30%	138.0	3.0	2.6	135.3	1.9
	20%	131.0	1.9	1.6	128.8	1.7
	10%	122.3	0.93	0.8	120.8	1.2

Table I-16. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Lepomis punctatus* in Halls River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	17.0	14.4	148.6	1.6
	80%	145.0	11.2	9.5	142.8	1.5
	70%	140.0	7.7	6.6	137.9	1.5
	60%	136.0	5.6	4.8	134.1	1.4
	50%	130.0	3.3	2.8	128.3	1.3
	40%	126.0	2.2	1.9	124.6	1.1
	30%	121.0	1.17	1.00	119.9	0.9
	20%	117.0	0.58	0.49	116.3	0.6
	10%	110.8	NA	NA	NA	NA
1995 - 2009	90%	184.6	121.6	103.4	181.5	1.7
	80%	171.2	58.5	49.8	168.3	1.7
	70%	163.0	36.3	30.9	160.3	1.6
	60%	156.0	23.5	20.0	153.5	1.6
	50%	150.0	15.9	13.5	147.6	1.6
	40%	144.0	10.4	8.9	141.8	1.5
	30%	138.0	6.6	5.6	136.0	1.5
	20%	131.0	3.6	3.1	129.3	1.3
	10%	122.3	1.40	1.2	121.1	1.0

NA = not applicable; predicted baseline abundance less than zero

Table I-17. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Micropterus salmoides* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	87.5	74.4	149.4	1.1
	80%	145.0	47.4	40.3	143.5	1.1
	70%	140.0	27.7	23.5	138.5	1.0
	60%	136.0	17.6	15.0	134.6	1.0
	50%	130.0	8.5	7.2	128.7	1.0
	40%	126.0	5.0	4.2	124.9	0.9
	30%	121.0	2.28	1.94	120.1	0.7
	20%	117.0	0.99	0.84	116.4	0.5
	10%	110.8	NA	NA	NA	NA
1995 - 2009	90%	184.6	1764.9	1500.2	182.6	1.1
	80%	171.2	571.5	485.7	169.3	1.1
	70%	163.0	275.4	234.1	161.2	1.1
	60%	156.0	142.8	121.3	154.3	1.1
	50%	150.0	79.2	67.3	148.4	1.1
	40%	144.0	42.6	36.2	142.5	1.1
	30%	138.0	22.2	18.8	136.6	1.0
	20%	131.0	9.7	8.2	129.7	1.0
	10%	122.3	2.82	2.4	121.3	0.8

NA = not applicable; predicted baseline abundance less than zero

Table I-18. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Micropterus salmoides* in Halls River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	106.7	90.7	149.8	0.8
	80%	145.0	45.8	38.9	143.9	0.8
	70%	140.0	21.8	18.5	138.9	0.8
	60%	136.0	11.5	9.8	135.0	0.7
	50%	130.0	4.0	3.4	129.2	0.6
	40%	126.0	1.6	1.4	125.4	0.5
	30%	121.0	0.14	0.12	120.9	0.1
	20%	117.0	NA	NA	NA	NA
	10%	110.8	NA	NA	NA	NA
1995 - 2009	90%	184.6	6710.1	5703.6	183.1	0.8
	80%	171.2	1416.3	1203.8	169.8	0.8
	70%	163.0	517.9	440.2	161.7	0.8
	60%	156.0	209.4	178.0	154.8	0.8
	50%	150.0	92.9	79.0	148.8	0.8
	40%	144.0	39.6	33.7	142.9	0.8
	30%	138.0	15.9	13.5	137.0	0.7
	20%	131.0	4.8	4.1	130.2	0.6
	10%	122.3	0.41	0.3	122.0	0.2

NA = not applicable; predicted baseline abundance less than zero

Table I-19. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Lagadon rhomboides* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	57.5	48.9	149.0	1.3
	80%	145.0	35.2	29.9	143.1	1.3
	70%	140.0	22.8	19.4	138.2	1.3
	60%	136.0	15.9	13.5	134.3	1.3
	50%	130.0	8.9	7.6	128.4	1.2
	40%	126.0	5.8	5.0	124.6	1.1
	30%	121.0	3.23	2.74	119.8	1.0
	20%	117.0	1.84	1.56	116.0	0.9
	10%	110.8	0.5	0.4	110.3	0.4
1995 - 2009	90%	184.6	636.3	540.8	182.1	1.4
	80%	171.2	258.5	219.7	168.8	1.4
	70%	163.0	144.2	122.6	160.8	1.3
	60%	156.0	85.2	72.4	153.9	1.3
	50%	150.0	53.1	45.1	148.0	1.3
	40%	144.0	32.3	27.5	142.1	1.3
	30%	138.0	19.1	16.2	136.2	1.3
	20%	131.0	9.8	8.4	129.4	1.2
	10%	122.3	3.77	3.2	121.0	1.1

Table I-20. Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of *Leiostomus xanthurus* in the Homosassa River as compared to abundances for median baseline flows for two benchmark periods – 2007 and October 18, 1995 through May 13, 2009. Predicted abundances derived using baseline flow percentiles and regression developed by Peebles *et al.* (2009) for seine-collected organisms (see Chapter 3 of this report).

Benchmark Period	Flow Percentile	Baseline Flow (cfs)	Baseline Relative Abundance (number/ 100 m^2)	Baseline Relative Abundance Minus 15% (number/ 100 m^2)	Flow Associated with Baseline Relative Abundance Minus 15% (cfs)	Percent of Flow Reduction from Baseline Flow (%)
2007	90%	151.0	74.0	62.9	150.3	0.5
	80%	145.0	18.9	16.1	144.3	0.5
	70%	140.0	5.3	4.5	139.4	0.4
	60%	136.0	1.5	1.2	135.6	0.3
	50%	130.0	NA	NA	NA	NA
	40%	126.0	NA	NA	NA	NA
	30%	121.0	NA	NA	NA	NA
	20%	117.0	NA	NA	NA	NA
	10%	110.8	NA	NA	NA	NA
1995 - 2009	90%	184.6	53622.3	45579.0	183.7	0.5
	80%	171.2	4519.5	3841.6	170.3	0.5
	70%	163.0	913.2	776.3	162.2	0.5
	60%	156.0	216.5	184.0	155.2	0.5
	50%	150.0	59.3	50.4	149.3	0.5
	40%	144.0	14.9	12.6	143.3	0.5
	30%	138.0	3.0	2.5	137.5	0.4
	20%	131.0	NA	NA	NA	NA
	10%	122.3	NA	NA	NA	NA

NA = not applicable; predicted baseline abundance less than zero

Appendix J

Modeled isohaline river kilometer location percentiles for the Homosassa River as determined for the benchmark period of 2007 using the Homosassa River hydrodynamic model described in Chapter 2 of this report.

Table J-1. River kilometer location percentiles for bottom isohalines with a salinity of 2, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 2 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	11.3	11.3	0.0	11.3	0.0	11.3	0.0	11.3	0.1	11.4	0.2	11.5	0.2
20	11.3	11.4	0.1	11.4	0.1	11.5	0.2	11.6	0.3	11.7	0.4	12.0	0.7
30	11.5	11.6	0.1	11.7	0.1	11.8	0.3	12.1	0.6	12.3	0.8	>12.5	>1.0
40	11.8	12.0	0.2	12.3	0.5	12.3	0.5	>12.5	>0.7	>12.5	>0.7	>12.5	>0.7
50	12.3	>12.5	>0.2	>12.5	>0.2	>12.5	>0.2	>12.5	>0.2	>12.5	>0.2	>12.5	>0.2
60	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	>12.5	>12.5	NA
70	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	>12.5	>12.5	NA
80	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	>12.5	>12.5	NA
90	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	>12.5	>12.5	NA

NA = Not available; isohaline for baseline scenario located upstream of model domain
Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-2. River kilometer location percentiles for bottom isohalines with a salinity of 3, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 3 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	8.7	8.9	0.2	9.1	0.3	9.2	0.5	9.5	0.8	9.7	1.0	9.9	1.2
20	9.5	9.6	0.1	9.8	0.3	10.0	0.5	10.2	0.8	10.4	0.9	10.7	1.2
30	10.1	10.2	0.2	10.3	0.3	10.5	0.5	10.8	0.8	10.9	0.9	11.1	1.0
40	10.5	10.7	0.2	10.9	0.4	11.0	0.5	11.1	0.6	11.2	0.7	11.4	0.9
50	10.9	11.0	0.1	11.1	0.2	11.2	0.3	11.3	0.4	11.5	0.6	11.6	0.7
60	11.2	11.2	0.1	11.3	0.1	11.4	0.2	11.6	0.4	11.8	0.6	12.1	0.9
70	11.3	11.4	0.1	11.6	0.2	11.7	0.4	11.9	0.6	12.3	1.0	>12.5	>1.2
80	11.5	11.7	0.1	11.8	0.2	12.1	0.6	>12.5	>1.0	>12.5	>1.0	>12.5	>1.0
90	11.8	12.1	0.3	12.4	0.6	>12.5	>0.7	>12.5	>0.7	>12.5	>0.7	>12.5	>0.7

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-3. River kilometer location percentiles for bottom isohalines with a salinity of 5, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 5 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	7.1	7.2	0.1	7.3	0.2	7.5	0.4	7.7	0.6	7.9	0.8	8.1	1.0
20	7.7	7.9	0.1	8.0	0.3	8.2	0.5	8.4	0.7	8.6	0.9	8.8	1.1
30	8.3	8.5	0.2	8.6	0.3	8.8	0.5	9.0	0.7	9.2	0.8	9.4	1.0
40	8.8	8.9	0.1	9.1	0.3	9.2	0.5	9.4	0.6	9.6	0.8	9.8	1.0
50	9.1	9.2	0.1	9.4	0.3	9.6	0.5	9.7	0.6	10.0	0.9	10.3	1.2
60	9.4	9.6	0.2	9.7	0.3	9.9	0.5	10.2	0.8	10.3	0.9	10.6	1.2
70	9.7	10.0	0.2	10.2	0.4	10.3	0.6	10.5	0.8	10.9	1.2	11.0	1.3
80	10.2	10.3	0.1	10.5	0.3	10.8	0.6	10.9	0.8	11.0	0.8	11.1	1.0
90	10.7	10.9	0.2	11.0	0.3	11.0	0.3	11.2	0.5	11.3	0.6	11.5	0.8

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-4. River kilometer location percentiles for bottom isohalines with a salinity of 12, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 12 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	3.3	3.4	0.1	3.5	0.2	3.5	0.2	3.7	0.4	3.7	0.4	3.9	0.6
20	4.2	4.3	0.1	4.4	0.2	4.6	0.3	4.6	0.4	4.7	0.5	4.9	0.7
30	5.0	5.1	0.1	5.2	0.2	5.3	0.3	5.5	0.5	5.6	0.6	5.8	0.8
40	5.6	5.7	0.1	5.9	0.2	6.0	0.4	6.2	0.6	6.4	0.8	6.5	0.9
50	6.2	6.4	0.2	6.4	0.2	6.5	0.3	6.7	0.5	6.9	0.7	7.0	0.8
60	6.5	6.6	0.1	6.8	0.3	6.9	0.4	7.0	0.5	7.1	0.6	7.1	0.6
70	6.9	6.9	0.1	7.0	0.2	7.1	0.2	7.2	0.3	7.3	0.5	7.5	0.6
80	7.0	7.1	0.1	7.2	0.2	7.4	0.3	7.5	0.5	7.8	0.7	7.9	0.9
90	7.4	7.5	0.1	7.7	0.3	7.9	0.4	8.0	0.6	8.2	0.8	8.4	1.0

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-5. River kilometer location percentiles for surface isohalines with a salinity of 2, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 2 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	11.2	11.3	0.0	11.3	0.0	11.3	0.0	11.3	0.1	11.4	0.1	11.5	0.2
20	11.3	11.4	0.1	11.4	0.1	11.5	0.2	11.6	0.3	11.6	0.3	11.8	0.5
30	11.5	11.5	0.1	11.6	0.1	11.7	0.2	11.9	0.4	12.0	0.6	12.3	0.8
40	11.7	11.7	0.1	11.9	0.3	12.0	0.4	12.3	0.6	12.4	0.7	>12.5	>0.8
50	12.0	12.1	0.1	12.3	0.3	12.3	0.3	>12.5	>0.5	>12.5	>0.5	>12.5	>0.5
60	12.3	12.3	0.0	>12.5	>0.2	>12.5	>0.2	>12.5	>0.2	>12.5	>0.2	>12.5	>0.2
70	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA
80	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA
90	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA

NA = Not available; isohaline for flow reduction scenario located upstream of model domain
Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-6. River kilometer location percentiles for surface isohalines with a salinity of 3, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 3 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	8.6	8.8	0.2	9.0	0.4	9.2	0.6	9.5	0.8	9.7	1.0	9.9	1.3
20	9.4	9.5	0.1	9.7	0.3	9.9	0.6	10.2	0.8	10.3	0.9	10.5	1.1
30	10.0	10.2	0.2	10.3	0.3	10.4	0.5	10.7	0.7	10.9	0.9	11.0	1.0
40	10.4	10.5	0.1	10.8	0.4	10.9	0.5	11.0	0.6	11.2	0.8	11.3	0.9
50	10.9	11.0	0.1	11.0	0.2	11.2	0.3	11.3	0.4	11.4	0.5	11.6	0.7
60	11.1	11.2	0.1	11.3	0.2	11.4	0.3	11.5	0.4	11.6	0.6	11.8	0.8
70	11.3	11.3	0.1	11.4	0.2	11.6	0.3	11.7	0.5	12.0	0.7	12.3	1.0
80	11.4	11.5	0.1	11.6	0.2	11.8	0.4	12.1	0.7	12.4	1.0	>12.5	>1.1
90	11.7	11.8	0.1	12.0	0.4	12.3	0.7	>12.5	>0.8	>12.5	>0.8	>12.5	>0.8

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-7. River kilometer location percentiles for surface isohalines with a salinity of 5, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 5 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	7.0	7.1	0.1	7.3	0.2	7.4	0.4	7.6	0.6	7.8	0.8	8.0	1.0
20	7.6	7.8	0.2	7.9	0.3	8.1	0.5	8.3	0.6	8.4	0.8	8.7	1.1
30	8.1	8.2	0.1	8.4	0.3	8.6	0.5	8.8	0.7	9.0	0.9	9.2	1.1
40	8.5	8.7	0.2	8.9	0.3	9.1	0.5	9.2	0.7	9.4	0.9	9.7	1.1
50	8.9	9.1	0.2	9.2	0.3	9.4	0.5	9.6	0.7	9.7	0.8	10.0	1.1
60	9.2	9.4	0.1	9.5	0.3	9.7	0.5	9.9	0.7	10.2	0.9	10.3	1.1
70	9.6	9.7	0.1	9.9	0.3	10.1	0.5	10.3	0.7	10.4	0.9	10.6	1.1
80	9.9	10.1	0.2	10.2	0.3	10.4	0.4	10.6	0.6	10.9	0.9	11.0	1.1
90	10.3	10.4	0.1	10.6	0.3	10.9	0.6	11.0	0.7	11.1	0.8	11.3	1.0

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-8. River kilometer location percentiles for surface isohalines with a salinity of 12, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 12 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	2.7	2.8	0.1	3.0	0.3	3.2	0.5	3.3	0.6	3.4	0.8	3.7	1.0
20	3.8	3.9	0.1	4.0	0.2	4.2	0.4	4.3	0.5	4.4	0.6	4.6	0.8
30	4.5	4.6	0.1	4.8	0.3	5.0	0.4	5.1	0.5	5.2	0.7	5.4	0.9
40	5.1	5.2	0.1	5.3	0.2	5.5	0.4	5.7	0.6	5.8	0.7	6.0	0.9
50	5.5	5.7	0.1	5.8	0.2	5.9	0.4	6.2	0.7	6.3	0.8	6.5	1.0
60	5.9	6.1	0.2	6.3	0.4	6.4	0.5	6.5	0.6	6.7	0.8	6.9	1.0
70	6.4	6.4	0.1	6.5	0.2	6.7	0.3	6.9	0.5	7.0	0.6	7.1	0.7
80	6.7	6.8	0.2	6.9	0.3	7.0	0.4	7.2	0.5	7.4	0.7	7.6	0.9
90	7.1	7.2	0.1	7.3	0.3	7.5	0.4	7.7	0.7	7.9	0.8	8.1	1.0

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-9. River kilometer location percentiles for water-column average isohalines with a salinity of 2, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 2 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	11.2	11.3	0.0	11.3	0.0	11.3	0.0	11.3	0.1	11.4	0.1	11.5	0.2
20	11.3	11.4	0.1	11.4	0.1	11.5	0.2	11.6	0.3	11.7	0.4	11.9	0.6
30	11.5	11.6	0.1	11.6	0.1	11.7	0.2	12.0	0.5	12.3	0.8	12.4	0.9
40	11.7	11.8	0.1	12.0	0.3	12.3	0.6	12.3	0.6	>12.5	>0.8	>12.5	>0.8
50	12.2	12.3	0.1	12.4	0.2	>12.5	>0.3	>12.5	>0.3	>12.5	>0.3	>12.5	>0.3
60	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA
70	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA
80	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA
90	>12.5	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA	>12.5	NA

NA = Not available; isohaline for baseline scenario located upstream of model domain
Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-10. River kilometer location percentiles for water-column average isohalines with a salinity of 3, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 3 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	8.7	8.9	0.2	9.0	0.4	9.2	0.6	9.5	0.8	9.7	1.0	9.9	1.3
20	9.4	9.6	0.2	9.7	0.3	10.0	0.6	10.2	0.8	10.3	0.9	10.7	1.2
30	10.0	10.2	0.2	10.3	0.3	10.5	0.5	10.8	0.8	10.9	0.9	11.0	1.0
40	10.4	10.7	0.2	10.9	0.4	11.0	0.5	11.0	0.6	11.2	0.8	11.3	0.9
50	10.9	11.0	0.1	11.1	0.2	11.2	0.3	11.3	0.4	11.4	0.5	11.6	0.7
60	11.1	11.2	0.1	11.3	0.2	11.4	0.3	11.5	0.4	11.7	0.6	12.0	0.9
70	11.3	11.4	0.1	11.5	0.2	11.6	0.3	11.8	0.5	12.1	0.8	>12.5	>1.2
80	11.5	11.6	0.1	11.7	0.2	12.0	0.5	12.3	0.8	>12.5	>1.0	>12.5	>1.0
90	11.7	11.9	0.2	12.2	0.5	>12.5	>0.8	>12.5	>0.8	>12.5	>0.8	>12.5	>0.8

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-11. River kilometer location percentiles for water-column average isohalines with a salinity of 5, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 5 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	7.1	7.1	0.1	7.3	0.2	7.5	0.4	7.7	0.6	7.9	0.8	8.1	1.0
20	7.7	7.8	0.2	8.0	0.3	8.2	0.5	8.3	0.7	8.5	0.9	8.8	1.1
30	8.2	8.4	0.2	8.5	0.3	8.7	0.5	8.9	0.7	9.1	0.9	9.3	1.1
40	8.7	8.8	0.2	9.0	0.3	9.2	0.5	9.3	0.7	9.5	0.9	9.7	1.0
50	9.0	9.2	0.1	9.3	0.3	9.5	0.5	9.7	0.7	9.9	0.9	10.2	1.1
60	9.3	9.5	0.2	9.7	0.3	9.8	0.5	10.1	0.7	10.3	0.9	10.5	1.1
70	9.7	9.8	0.1	10.0	0.3	10.2	0.5	10.4	0.7	10.6	0.9	10.9	1.2
80	10.0	10.2	0.2	10.3	0.3	10.5	0.5	10.8	0.8	11.0	0.9	11.0	1.0
90	10.4	10.6	0.2	10.9	0.4	11.0	0.5	11.0	0.6	11.2	0.8	11.4	1.0

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table J-12. River kilometer location percentiles for water-column average isohalines with a salinity of 12, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model.

Isohaline Salinity 12 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	3.0	3.1	0.1	3.3	0.3	3.4	0.4	3.5	0.5	3.6	0.7	3.8	0.8
20	4.0	4.1	0.1	4.2	0.2	4.3	0.3	4.5	0.5	4.6	0.6	4.8	0.8
30	4.8	4.9	0.2	5.0	0.3	5.1	0.4	5.2	0.5	5.4	0.7	5.6	0.8
40	5.3	5.5	0.1	5.6	0.3	5.7	0.4	5.9	0.5	6.1	0.7	6.3	1.0
50	5.8	5.9	0.1	6.2	0.3	6.3	0.5	6.4	0.6	6.5	0.7	6.7	0.9
60	6.3	6.4	0.1	6.5	0.2	6.6	0.3	6.8	0.5	6.9	0.6	7.0	0.7
70	6.5	6.7	0.2	6.9	0.3	6.9	0.4	7.0	0.5	7.1	0.6	7.3	0.8
80	6.9	7.0	0.1	7.1	0.2	7.1	0.2	7.3	0.4	7.5	0.6	7.8	0.9
90	7.2	7.3	0.2	7.5	0.3	7.7	0.5	7.8	0.7	8.0	0.8	8.2	1.0

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Appendix K

Modeled isohaline river kilometer location percentiles for the Homosassa River as determined for the benchmark period of 2007 based on regression models 1 and 2 described in Chapter 2 of this report.

Table K-1. River kilometer location percentiles for bottom isohalines with a salinity of 3, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with empirical regression models.

Isohaline Salinity 3 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	9.3	9.9	0.6	10.5	1.2	10.7	1.5	10.9	1.7	11.1	1.8	11.3	2.0
20	9.9	10.4	0.6	10.7	0.9	10.9	1.1	11.1	1.3	11.3	1.5	11.5	1.6
30	10.3	10.7	0.4	10.9	0.6	11.1	0.8	11.3	1.0	11.5	1.2	11.6	1.4
40	10.7	10.9	0.3	11.1	0.4	11.3	0.6	11.4	0.8	11.6	1.0	11.8	1.1
50	10.9	11.1	0.2	11.3	0.3	11.5	0.5	11.6	0.7	11.8	0.9	12.0	1.0
60	11.1	11.3	0.2	11.4	0.3	11.6	0.5	11.8	0.7	11.9	0.8	12.1	1.0
70	11.3	11.4	0.2	11.6	0.3	11.7	0.5	11.9	0.6	12.0	0.8	12.2	0.9
80	11.4	11.6	0.1	11.7	0.3	11.9	0.5	12.0	0.6	12.2	0.8	12.3	0.9
90	11.6	11.7	0.1	11.9	0.3	12.0	0.4	12.2	0.6	12.3	0.7	>12.5	>0.9

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table K-2. River kilometer location percentiles for bottom isohalines with a salinity of 5, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with empirical regression models.

Isohaline Salinity 5 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	7.9	8.6	0.7	9.3	1.4	9.4	1.5	9.5	1.6	9.6	1.6	9.6	1.7
20	8.6	9.3	0.7	9.5	0.9	9.6	1.0	9.6	1.0	9.7	1.1	9.8	1.2
30	9.1	9.5	0.4	9.6	0.5	9.7	0.6	9.7	0.7	9.8	0.7	9.9	0.8
40	9.5	9.7	0.2	9.8	0.3	9.9	0.3	9.9	0.4	10.0	0.4	10.0	0.5
50	9.8	9.9	0.1	9.9	0.1	10.0	0.2	10.0	0.2	10.1	0.3	10.2	0.4
60	9.9	10.0	0.1	10.0	0.1	10.1	0.2	10.2	0.2	10.2	0.3	10.3	0.3
70	10.0	10.1	0.1	10.1	0.1	10.2	0.2	10.2	0.2	10.3	0.3	10.4	0.3
80	10.1	10.2	0.1	10.2	0.1	10.3	0.2	10.3	0.2	10.4	0.3	10.4	0.3
90	10.2	10.3	0.1	10.3	0.1	10.4	0.2	10.5	0.2	10.5	0.3	10.6	0.3

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table K-3. River kilometer location percentiles for bottom isohalines with a salinity of 12, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with empirical regression models.

Isohaline Salinity 12 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	3.6	4.3	0.7	4.9	1.3	5.4	1.8	5.6	2.1	5.9	2.3	6.1	2.5
20	4.3	5.0	0.6	5.5	1.2	5.8	1.4	6.0	1.7	6.2	1.9	6.4	2.1
30	4.9	5.5	0.6	5.8	0.9	6.0	1.1	6.2	1.3	6.4	1.5	6.6	1.7
40	5.5	5.9	0.4	6.1	0.6	6.3	0.8	6.5	1.0	6.7	1.2	6.9	1.4
50	6.0	6.2	0.2	6.4	0.4	6.6	0.6	6.8	0.8	7.0	1.0	7.2	1.1
60	6.3	6.5	0.2	6.7	0.4	6.9	0.6	7.0	0.7	7.2	0.9	7.4	1.1
70	6.5	6.7	0.2	6.8	0.3	7.0	0.5	7.2	0.7	7.4	0.9	7.6	1.1
80	6.7	6.9	0.2	7.1	0.3	7.2	0.5	7.4	0.7	7.6	0.8	7.8	1.0
90	7.0	7.2	0.2	7.3	0.3	7.5	0.5	7.7	0.7	7.8	0.8	8.0	1.0

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table K-4. River kilometer location percentiles for surface isohalines with a salinity of 3, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with empirical regression models.

Isohaline Salinity 3 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	8.5	8.9	0.3	9.2	0.7	9.6	1.0	9.7	1.2	9.8	1.3	10.0	1.4
20	8.9	9.2	0.3	9.5	0.7	9.7	0.8	9.8	1.0	10.0	1.1	10.1	1.2
30	9.1	9.5	0.3	9.7	0.6	9.8	0.7	10.0	0.8	10.1	0.9	10.2	1.1
40	9.4	9.7	0.3	9.9	0.5	10.0	0.6	10.1	0.7	10.2	0.8	10.3	0.9
50	9.7	9.9	0.2	10.0	0.3	10.1	0.4	10.2	0.5	10.4	0.6	10.5	0.8
60	9.9	10.0	0.1	10.1	0.2	10.2	0.3	10.4	0.4	10.5	0.5	10.6	0.7
70	10.0	10.1	0.1	10.2	0.2	10.3	0.3	10.4	0.4	10.5	0.5	10.6	0.6
80	10.1	10.2	0.1	10.3	0.2	10.4	0.3	10.5	0.4	10.6	0.5	10.7	0.6
90	10.3	10.4	0.1	10.5	0.2	10.6	0.3	10.6	0.4	10.7	0.5	10.8	0.6

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table K-5. River kilometer location percentiles for surface isohalines with a salinity of 5, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with empirical regression models.

Isohaline Salinity 5 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	7.3	7.6	0.4	8.0	0.8	8.2	0.9	8.4	1.1	8.5	1.2	8.7	1.4
20	7.7	8.0	0.4	8.2	0.6	8.4	0.7	8.5	0.9	8.7	1.0	8.8	1.1
30	8.0	8.2	0.3	8.4	0.4	8.5	0.6	8.7	0.7	8.8	0.8	8.9	1.0
40	8.2	8.4	0.2	8.6	0.3	8.7	0.5	8.8	0.6	9.0	0.7	9.1	0.9
50	8.5	8.6	0.1	8.7	0.3	8.9	0.4	9.0	0.5	9.1	0.6	9.3	0.8
60	8.6	8.8	0.1	8.9	0.3	9.0	0.4	9.1	0.5	9.3	0.6	9.4	0.8
70	8.7	8.9	0.1	9.0	0.2	9.1	0.4	9.2	0.5	9.4	0.6	9.5	0.7
80	8.9	9.0	0.1	9.1	0.2	9.2	0.4	9.4	0.5	9.5	0.6	9.6	0.7
90	9.0	9.1	0.1	9.3	0.2	9.4	0.3	9.5	0.5	9.6	0.6	9.7	0.7

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table K-6. River kilometer location percentiles for surface isohalines with a salinity of 12, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with empirical regression models.

Isohaline Salinity 12 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	3.0	3.6	0.5	4.1	1.1	4.6	1.6	5.0	2.0	5.0	2.0	5.0	2.0
20	3.7	4.2	0.5	4.7	1.0	5.1	1.5	5.2	1.6	5.2	1.6	5.2	1.6
30	4.2	4.7	0.5	5.1	0.9	5.4	1.2	5.4	1.3	5.4	1.2	5.4	1.2
40	4.7	5.2	0.5	5.5	0.8	5.6	0.9	5.6	0.9	5.6	0.9	5.6	0.9
50	5.2	5.6	0.4	5.8	0.5	5.8	0.6	5.8	0.6	5.8	0.6	5.8	0.5
60	5.7	5.9	0.2	5.9	0.2	5.9	0.2	5.9	0.2	5.9	0.2	5.9	0.2
70	5.9	6.0	0.1	6.1	0.1	6.1	0.1	6.0	0.1	6.0	0.1	6.0	0.1
80	6.1	6.2	0.0	6.2	0.1	6.2	0.0	6.2	0.0	6.2	0.0	6.2	0.0
90	6.3	6.4	0.0	6.4	0.0	6.3	0.0	6.3	0.0	6.3	0.0	6.3	0.0

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table K-7. River kilometer location percentiles for water-column average isohalines with a salinity of 3, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with empirical regression models.

Isohaline Salinity 3 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	8.9	9.4	0.5	9.8	1.0	10.1	1.2	10.3	1.4	10.5	1.6	10.6	1.7
20	9.4	9.8	0.5	10.1	0.8	10.3	1.0	10.5	1.1	10.6	1.3	10.8	1.4
30	9.7	10.1	0.4	10.3	0.6	10.5	0.8	10.6	0.9	10.8	1.1	10.9	1.2
40	10.0	10.3	0.3	10.5	0.4	10.6	0.6	10.8	0.7	10.9	0.9	11.1	1.0
50	10.3	10.5	0.2	10.7	0.3	10.8	0.5	10.9	0.6	11.1	0.8	11.2	0.9
60	10.5	10.7	0.1	10.8	0.3	10.9	0.4	11.1	0.6	11.2	0.7	11.3	0.8
70	10.6	10.8	0.1	10.9	0.3	11.0	0.4	11.2	0.5	11.3	0.7	11.4	0.8
80	10.8	10.9	0.1	11.0	0.3	11.2	0.4	11.3	0.5	11.4	0.6	11.5	0.8
90	10.9	11.1	0.1	11.2	0.2	11.3	0.4	11.4	0.5	11.5	0.6	11.7	0.7

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table K-8. River kilometer location percentiles for water-column average isohalines with a salinity of 5, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with empirical regression models.

Isohaline Salinity 5 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	7.6	8.1	0.5	8.7	1.1	8.8	1.2	8.9	1.3	9.0	1.4	9.1	1.5
20	8.1	8.6	0.5	8.9	0.7	9.0	0.8	9.1	1.0	9.2	1.1	9.3	1.2
30	8.5	8.9	0.4	9.0	0.5	9.1	0.6	9.2	0.7	9.3	0.8	9.4	0.9
40	8.9	9.1	0.2	9.2	0.3	9.3	0.4	9.4	0.5	9.5	0.6	9.6	0.7
50	9.1	9.2	0.1	9.3	0.2	9.4	0.3	9.5	0.4	9.6	0.5	9.7	0.6
60	9.3	9.4	0.1	9.5	0.2	9.6	0.3	9.6	0.4	9.7	0.5	9.8	0.5
70	9.4	9.5	0.1	9.6	0.2	9.6	0.3	9.7	0.4	9.8	0.4	9.9	0.5
80	9.5	9.6	0.1	9.7	0.2	9.8	0.3	9.8	0.3	9.9	0.4	10.0	0.5
90	9.6	9.7	0.1	9.8	0.2	9.9	0.2	10.0	0.3	10.1	0.4	10.1	0.5

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table K-9. River kilometer location percentiles for water-column average isohalines with a salinity of 12, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with empirical regression models.

Isohaline Salinity 12 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	3.3	3.9	0.6	4.5	1.2	5.0	1.7	5.3	2.0	5.5	2.1	5.6	2.2
20	4.0	4.6	0.6	5.1	1.1	5.5	1.5	5.6	1.6	5.7	1.7	5.8	1.8
30	4.5	5.1	0.5	5.4	0.9	5.7	1.2	5.8	1.3	5.9	1.4	6.0	1.5
40	5.1	5.5	0.5	5.8	0.7	6.0	0.9	6.1	1.0	6.2	1.1	6.3	1.2
50	5.6	5.9	0.3	6.1	0.5	6.2	0.6	6.3	0.7	6.4	0.7	6.5	0.8
60	6.0	6.2	0.2	6.3	0.3	6.4	0.4	6.5	0.5	6.6	0.6	6.7	0.6
70	6.2	6.4	0.1	6.5	0.2	6.6	0.3	6.6	0.4	6.7	0.5	6.8	0.6
80	6.5	6.5	0.1	6.6	0.2	6.7	0.3	6.8	0.3	6.9	0.4	6.9	0.5
90	6.7	6.8	0.1	6.8	0.2	6.9	0.2	7.0	0.3	7.1	0.4	7.1	0.5

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Appendix L

Modeled isohaline river kilometer location percentiles for the Homosassa River as determined for the benchmark period from October 18, 1995 through May13, 2009 based on regression models 1 and 2 described in Chapter 2 of this report.

Table L-1. River kilometer (Rkm) location percentiles for bottom isohalines with a salinity of 3, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models.

Isohaline Salinity 3 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	6.8	7.5	0.7	8.3	1.5	9.0	2.2	9.8	2.9	10.5	3.7	10.9	4.1
20	7.9	8.6	0.7	9.3	1.4	9.9	2.0	10.6	2.7	10.9	3.0	11.2	3.3
30	8.6	9.2	0.7	9.9	1.3	10.5	2.0	10.9	2.4	11.1	2.6	11.3	2.8
40	9.1	9.7	0.6	10.4	1.2	10.8	1.7	11.1	1.9	11.3	2.2	11.5	2.4
50	9.6	10.2	0.6	10.8	1.1	11.0	1.4	11.2	1.6	11.4	1.8	11.6	2.0
60	10.1	10.7	0.6	11.0	0.8	11.1	1.0	11.3	1.2	11.5	1.4	11.7	1.6
70	10.6	11.0	0.3	11.1	0.5	11.3	0.7	11.5	0.9	11.7	1.0	11.9	1.2
80	11.0	11.1	0.2	11.3	0.3	11.5	0.5	11.7	0.7	11.8	0.9	12.0	1.0
90	11.2	11.4	0.2	11.5	0.3	11.7	0.5	11.9	0.6	12.0	0.8	12.2	1.0

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table L-2. River kilometer location percentiles for bottom isohalines with a salinity of 5, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May13, 2009, based on modeling conducted with empirical regression models.

Isohaline Salinity 5 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	5.2	6.1	0.8	6.9	1.7	7.7	2.5	8.6	3.4	9.4	4.1	9.7	4.4
20	6.4	7.2	0.8	8.0	1.5	8.8	2.3	9.5	3.0	9.7	3.2	9.8	3.3
30	7.2	7.9	0.7	8.7	1.5	9.4	2.2	9.7	2.5	9.8	2.6	9.9	2.7
40	7.8	8.5	0.7	9.2	1.4	9.7	1.8	9.8	2.0	9.9	2.0	9.9	2.1
50	8.4	9.1	0.7	9.6	1.2	9.8	1.3	9.9	1.5	10.0	1.5	10.0	1.6
60	9.0	9.6	0.6	9.8	0.8	9.9	0.9	10.0	1.0	10.1	1.1	10.1	1.2
70	9.5	9.8	0.2	9.9	0.4	10.0	0.4	10.1	0.5	10.1	0.6	10.2	0.6
80	9.9	10.0	0.1	10.0	0.2	10.1	0.2	10.1	0.3	10.2	0.4	10.3	0.4
90	10.0	10.1	0.1	10.1	0.1	10.2	0.2	10.2	0.2	10.3	0.3	10.3	0.3

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table L-3. River kilometer location percentiles for bottom isohalines with a salinity of 12, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models.

Isohaline Salinity 12 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	1.2	2.0	0.8	2.8	1.6	3.6	2.5	4.4	3.3	5.3	4.1	5.9	4.7
20	2.3	3.1	0.8	3.9	1.5	4.6	2.3	5.4	3.0	5.9	3.5	6.2	3.8
30	3.1	3.8	0.7	4.6	1.5	5.3	2.2	5.8	2.8	6.1	3.1	6.4	3.3
40	3.8	4.4	0.7	5.1	1.4	5.8	2.0	6.1	2.3	6.4	2.6	6.6	2.8
50	4.3	5.0	0.7	5.6	1.3	6.0	1.7	6.3	2.0	6.5	2.2	6.7	2.4
60	4.9	5.5	0.6	6.0	1.1	6.3	1.4	6.5	1.6	6.7	1.8	6.9	2.1
70	5.5	6.0	0.5	6.3	0.8	6.5	1.0	6.7	1.2	6.9	1.4	7.1	1.6
80	6.0	6.3	0.3	6.5	0.5	6.7	0.7	6.9	0.9	7.1	1.1	7.3	1.2
90	6.4	6.6	0.2	6.8	0.4	7.0	0.5	7.2	0.7	7.3	0.9	7.5	1.1

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table L-4. River kilometer location percentiles for surface isohalines with a salinity of 3, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models.

Isohaline Salinity 3 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	7.2	7.6	0.4	8.0	0.8	8.5	1.3	8.9	1.7	9.3	2.1	9.7	2.5
20	7.8	8.2	0.4	8.6	0.8	9.0	1.2	9.4	1.6	9.7	1.9	9.9	2.1
30	8.2	8.6	0.4	8.9	0.8	9.3	1.1	9.7	1.5	9.9	1.7	10.0	1.8
40	8.5	8.9	0.4	9.2	0.7	9.6	1.1	9.8	1.3	10.0	1.5	10.1	1.6
50	8.8	9.2	0.3	9.5	0.7	9.8	1.0	10.0	1.1	10.1	1.3	10.2	1.4
60	9.1	9.4	0.3	9.7	0.6	9.9	0.8	10.0	1.0	10.2	1.1	10.3	1.2
70	9.4	9.7	0.3	9.9	0.5	10.0	0.6	10.2	0.8	10.3	0.9	10.4	1.0
80	9.7	9.9	0.2	10.1	0.3	10.2	0.4	10.3	0.5	10.4	0.7	10.5	0.8
90	10.0	10.1	0.1	10.2	0.2	10.3	0.3	10.4	0.4	10.5	0.5	10.6	0.6

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table L-5. River kilometer location percentiles for surface isohalines with a salinity of 5, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models.

Isohaline Salinity 5 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	5.9	6.3	0.5	6.8	0.9	7.2	1.4	7.7	1.8	8.2	2.3	8.4	2.6
20	6.5	6.9	0.4	7.4	0.9	7.8	1.3	8.2	1.7	8.4	1.9	8.6	2.1
30	6.9	7.3	0.4	7.7	0.8	8.2	1.2	8.4	1.5	8.6	1.7	8.7	1.8
40	7.3	7.7	0.4	8.1	0.8	8.4	1.1	8.6	1.3	8.7	1.4	8.9	1.6
50	7.6	8.0	0.4	8.3	0.7	8.5	0.9	8.7	1.0	8.8	1.2	9.0	1.3
60	7.9	8.3	0.3	8.5	0.6	8.6	0.7	8.8	0.8	8.9	1.0	9.1	1.1
70	8.3	8.5	0.2	8.6	0.4	8.8	0.5	8.9	0.6	9.0	0.8	9.2	0.9
80	8.5	8.6	0.1	8.8	0.3	8.9	0.4	9.0	0.5	9.2	0.7	9.3	0.8
90	8.7	8.8	0.1	9.0	0.2	9.1	0.4	9.2	0.5	9.3	0.6	9.4	0.7

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table L-6. River kilometer location percentiles for surface isohalines with a salinity of 12, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models.

Isohaline Salinity 12 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	1.3	2.0	0.6	2.6	1.3	3.2	1.9	3.9	2.6	4.6	3.2	5.1	3.8
20	2.2	2.8	0.6	3.4	1.2	4.0	1.8	4.6	2.4	5.2	3.0	5.4	3.2
30	2.9	3.4	0.6	4.0	1.1	4.6	1.7	5.1	2.3	5.4	2.5	5.5	2.6
40	3.4	3.9	0.5	4.5	1.1	5.0	1.6	5.4	2.0	5.5	2.2	5.6	2.2
50	3.8	4.4	0.5	4.9	1.1	5.4	1.6	5.6	1.7	5.7	1.9	5.7	1.9
60	4.3	4.8	0.5	5.3	1.0	5.6	1.3	5.7	1.5	5.9	1.6	6.0	1.7
70	4.8	5.3	0.5	5.6	0.8	5.8	1.0	6.0	1.2	6.0	1.2	6.0	1.2
80	5.3	5.7	0.4	5.9	0.6	6.0	0.7	6.1	0.7	6.1	0.7	6.1	0.7
90	5.9	6.0	0.2	6.1	0.2	6.1	0.2	6.2	0.3	6.2	0.3	6.2	0.3

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table L-7. River kilometer location percentiles for water-column average isohalines with a salinity of 3, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models.

Isohaline Salinity 3 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	7.0	7.6	0.6	8.2	1.2	8.7	1.7	9.3	2.3	9.9	2.9	10.3	3.3
20	7.8	8.4	0.5	8.9	1.1	9.5	1.6	10.0	2.1	10.3	2.5	10.5	2.7
30	8.4	8.9	0.5	9.4	1.0	9.9	1.5	10.3	1.9	10.5	2.1	10.7	2.3
40	8.8	9.3	0.5	9.8	1.0	10.2	1.4	10.5	1.6	10.6	1.8	10.8	2.0
50	9.2	9.7	0.5	10.1	0.9	10.4	1.2	10.6	1.4	10.7	1.5	10.9	1.7
60	9.6	10.1	0.5	10.3	0.7	10.5	0.9	10.7	1.1	10.9	1.3	11.0	1.4
70	10.0	10.3	0.3	10.5	0.5	10.7	0.7	10.8	0.8	11.0	1.0	11.1	1.1
80	10.4	10.5	0.2	10.7	0.3	10.8	0.5	11.0	0.6	11.1	0.7	11.2	0.9
90	10.6	10.7	0.1	10.9	0.3	11.0	0.4	11.1	0.5	11.3	0.7	11.4	0.8

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table L-8. River kilometer location percentiles for water-column average isohalines with a salinity of 5, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models.

Isohaline Salinity 5 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	5.5	6.2	0.7	6.9	1.3	7.5	1.9	8.1	2.6	8.8	3.2	9.1	3.5
20	6.5	7.1	0.6	7.7	1.2	8.3	1.8	8.8	2.4	9.1	2.6	9.2	2.7
30	7.1	7.6	0.6	8.2	1.1	8.8	1.7	9.0	2.0	9.2	2.1	9.3	2.3
40	7.6	8.1	0.6	8.7	1.1	9.0	1.5	9.2	1.6	9.3	1.7	9.4	1.8
50	8.0	8.5	0.5	9.0	0.9	9.2	1.1	9.3	1.2	9.4	1.4	9.5	1.5
60	8.4	8.9	0.5	9.1	0.7	9.3	0.8	9.4	0.9	9.5	1.0	9.6	1.1
70	8.9	9.1	0.2	9.3	0.4	9.4	0.5	9.5	0.6	9.6	0.7	9.7	0.8
80	9.2	9.3	0.1	9.4	0.2	9.5	0.3	9.6	0.4	9.7	0.5	9.8	0.6
90	9.4	9.4	0.1	9.5	0.2	9.6	0.3	9.7	0.4	9.8	0.4	9.9	0.5

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Table L-9. River kilometer location percentiles for water-column average isohalines with a salinity of 12, and relative change in location percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models.

Isohaline Salinity 12 Percen-tiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
10	1.2	2.0	0.7	2.7	1.5	3.5	2.2	4.2	2.9	4.9	3.6	5.5	4.3
20	2.3	3.0	0.7	3.6	1.3	4.3	2.0	5.0	2.7	5.5	3.2	5.8	3.5
30	3.0	3.6	0.6	4.3	1.3	4.9	1.9	5.5	2.5	5.8	2.8	6.0	3.0
40	3.6	4.2	0.6	4.8	1.2	5.4	1.8	5.8	2.2	6.0	2.4	6.1	2.5
50	4.1	4.7	0.6	5.3	1.2	5.7	1.6	5.9	1.9	6.1	2.0	6.3	2.2
60	4.6	5.1	0.6	5.6	1.1	5.9	1.4	6.1	1.6	6.3	1.7	6.4	1.9
70	5.1	5.6	0.5	6.0	0.8	6.2	1.0	6.3	1.2	6.4	1.3	6.5	1.4
80	5.7	6.0	0.3	6.2	0.6	6.4	0.7	6.5	0.8	6.6	0.9	6.7	1.0
90	6.2	6.3	0.2	6.4	0.3	6.5	0.4	6.6	0.5	6.7	0.5	6.8	0.6

Note: Rounding of values may account for differences between Relative Change values and results obtained by subtraction of Rkm values presented in the table

Appendix M

Modeled area, volume and shoreline length percentiles associated with specific isohalines in the Homosassa River as determined for 2007 using the Homosassa River hydrodynamic model described in Chapter 2 of this report.

Table M-1. Percentiles for daily bottom area upstream of bottom isohalines with a salinity of 2, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<2 Salinity Zone Percentiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
50	14,470	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
60	70,895	47,062	34	19,950	72	12,783	82	NA	NA	NA	NA	NA	NA
70	81,968	81,583	1	77,707	5	67,126	18	36,220	56	14,090	83	NA	NA
80	92,908	86,112	7	82,363	11	82,094	12	81,714	12	75,804	18	48,371	48
90	104,168	102,305	2	100,788	3	98,839	5	94,352	9	82,487	21	82,122	21

NA = Not available; isohaline for baseline or flow reduction scenario located upstream of model domain

Table M-2. Percentiles for daily bottom area upstream of water-column average isohalines with a salinity of 2, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<2 Salinity Zone Percentiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
50	30,504	18,201	40	10,175	67	NA	NA	NA	NA	NA	NA	NA	NA
60	76,340	69,379	9	46,822	39	21,162	72	15,705	79	NA	NA	NA	NA
70	82,116	81,826	<1	80,066	2	74,255	10	49,694	39	21,526	74	11,449	86
80	95,615	88,048	8	82,439	14	82,158	14	81,798	14	78,201	18	62,636	34
90	104,897	103,377	1	101,435	3	99,342	5	95,867	9	83,484	20	82,158	22

NA = Not available; isohaline for baseline or flow reduction scenario located upstream of model domain

Table M-3. Percentiles for daily bottom area upstream of bottom isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<3 Salinity Zone Percentiles	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	69,852	41,276	41	6,650	44	NA	NA	NA	NA	NA	NA	NA	NA
20	81,914	78,945	4	71,422	13	37,045	55	NA	NA	NA	NA	NA	NA
30	95,395	82,435	14	81,887	14	77,607	19	61,403	36	18,113	81	NA	NA
40	113,724	105,812	7	97,911	14	82,345	28	81,757	28	73,449	35	36,547	68
50	162,199	149,769	8	134,345	17	107,030	34	94,817	42	82,209	49	79,029	51
60	244,947	192,071	22	165,959	32	153,470	27	138,508	43	107,614	56	87,863	64
70	338,828	308,887	9	285,844	16	235,744	30	175,090	48	157,503	54	139,179	59
80	434,484	406,624	6	385,439	11	347,295	20	310,893	28	278,308	36	193,466	55
90	540,940	530,894	2	514,226	5	484,715	10	434,083	20	398,055	26	357,721	34

NA = Not available; isohaline for flow reduction scenario located upstream of model domain

Table M-4. Percentiles for daily bottom area upstream of water-column average isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<3 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	74,984	56,890	24	27,908	63	NA	NA	NA	NA	NA	NA	NA	NA
20	82,159	81,705	1	75,935	8	53,039	35	18,483	78	NA	NA	NA	NA
30	100,709	85,497	15	82,121	18	80,635	20	72,492	28	37,266	63	NA	NA
40	133,120	107,892	19	100,966	24	82,503	38	81,942	38	78,079	41	50,609	62
50	164,680	152,891	7	137,149	17	108,939	34	100,287	39	82,344	50	81,341	51
60	256,785	204,792	20	168,933	34	157,179	39	142,786	44	109,678	57	95,039	63
70	348,082	320,821	8	290,258	17	249,959	28	186,817	46	159,797	54	144,691	58
80	444,804	415,067	7	393,981	11	352,740	21	319,482	28	285,209	36	206,723	54
90	544,341	532,434	2	516,130	5	486,412	11	435,544	20	400,274	26	360,418	34

NA = Not available; isohaline for flow reduction scenario located upstream of model domain

Table M-5. Percentiles for daily bottom area upstream of bottom isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	197,406	165,029	16	155,096	21	144,825	27	114,690	42	90,583	54	82,158	58
20	323,465	291,211	10	250,593	23	185,646	43	160,595	50	149,400	54	125,100	61
30	393,714	356,145	10	326,438	17	292,835	26	243,427	38	167,547	57	154,844	61
40	450,013	417,105	7	394,689	12	358,216	20	325,525	28	284,582	37	212,544	53
50	508,851	488,602	4	450,710	11	415,959	18	393,589	23	347,073	32	304,949	40
60	538,361	528,731	2	513,866	5	491,671	9	450,179	16	411,125	24	385,696	28
70	587,832	558,775	5	546,991	7	535,369	19	524,405	11	500,980	15	460,246	22
80	692,260	666,952	4	634,123	8	604,959	13	572,973	17	548,691	21	533,518	23
90	840,193	818,506	3	775,858	8	738,344	12	699,674	17	663,159	21	619,984	26

Table M-6. Percentiles for daily bottom area upstream of water-column average isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	260,042	218,761	16	168,507	35	156,100	40	144,457	44	110,502	58	84,756	67
20	342,439	312,995	9	284,978	17	241,756	29	175,139	49	156,865	54	144,199	58
30	396,113	374,958	5	345,047	13	310,582	22	273,956	31	220,566	44	165,063	58
40	465,102	432,346	7	398,578	14	376,080	19	340,088	27	302,612	35	254,328	45
50	518,409	498,393	4	465,521	10	429,087	17	395,735	24	358,883	31	324,816	37
60	544,210	533,375	2	522,871	4	500,439	8	464,832	15	424,984	22	394,197	28
70	603,589	576,525	4	552,774	8	540,723	10	527,583	13	508,173	16	469,175	22
80	700,558	673,486	4	644,746	8	616,375	12	584,514	17	552,876	21	537,258	23
90	845,856	827,397	2	784,954	7	744,367	12	704,360	17	667,387	21	626,292	26

Table M-7. Percentiles for daily bottom area upstream of bottom isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the highest modeled flow reduction scenario resulted in less than a 15 percent reduction in baseline bottom area.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	754,796	724,140	4	693,082	8	668,191	11	638,050	15	607,293	20	574,976	24
20	849,795	835,832	2	805,036	5	763,275	10	723,609	15	687,175	19	653,163	23
30	897,192	875,822	2	857,792	4	842,726	6	821,699	8	776,778	13	733,136	18
40	993,463	955,827	4	911,604	8	883,185	11	863,671	13	845,428	15	827,157	17
50	1,047,360	1,017,990	3	1,004,548	4	989,253	6	935,873	11	890,436	15	866,732	17
60	1,171,046	1,145,681	2	1,114,443	5	1,076,425	8	1,041,625	11	1,008,828	14	990,211	15
70	1,285,631	1,266,212	2	1,253,217	3	1,230,086	4	1,204,860	6	1,170,753	9	1,132,889	12
80	1,382,258	1,371,468	1	1,354,740	2	1,334,554	3	1,326,962	4	1,315,489	5	1,296,704	6
90	1,560,391	1,541,560	1	1,525,323	2	1,512,962	3	1,487,166	5	1,471,033	6	1,444,011	7

Table M-8. Percentiles for daily bottom area upstream of water-column average isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the highest modeled flow reduction scenario resulted in less than a 15 percent reduction in baseline bottom area.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	813,510	773,972	5	739,820	9	699,196	14	670,776	18	638,592	22	607,417	25
20	889,209	865,291	3	845,511	5	824,530	7	778,406	12	733,591	18	687,146	23
30	985,912	945,972	4	900,915	9	877,400	11	855,209	13	835,305	15	788,889	20
40	1,032,417	1,011,645	2	998,571	3	966,481	6	917,821	11	882,615	15	856,497	17
50	1,127,570	1,098,010	3	1,053,619	7	1,024,120	9	1,004,918	11	984,638	13	929,789	18
60	1,229,132	1,205,473	2	1,171,308	5	1,144,058	7	1,112,613	10	1,066,208	13	1,023,696	17
70	1,313,626	1,295,664	1	1,286,531	2	1,266,804	4	1,249,621	5	1,214,675	8	1,179,513	10
80	1,420,793	1,409,909	1	1,391,151	2	1,369,353	4	1,345,396	5	1,329,334	6	1,312,826	8
90	1,638,225	1,603,180	2	1,570,475	4	1,545,313	6	1,518,602	7	1,491,284	9	1,468,116	10

Table M-9. Percentiles for daily water volume upstream of water-column average isohalines with a salinity of 2, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the lowest or highest modeled flow reduction scenarios resulted in more or less than a 15 percent reduction in baseline water volume.

<2 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
50	49,013	27,034	45	13,298	73	NA	NA	NA	NA	NA	NA	NA	NA
60	131,738	121,811	8	83,237	37	32,102	76	22,762	83	NA	NA	NA	NA
70	145,542	141,119	3	136,741	6	128,939	11	88,391	39	32,725	78	15,479	89
80	161,096	155,617	3	150,474	7	146,186	9	140,689	13	134,237	17	110,363	31
90	167,818	166,717	1	165,311	1	163,796	2	161,279	4	152,312	9	146,197	13

NA = Not available; isohaline for baseline or flow reduction scenario located upstream of model domain

Table M-10. Percentiles for daily water volume upstream of water-column average isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenarios resulted in more than a 15 percent reduction in baseline water volume.

<3 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
10	129,917	100,608	23	43,645	66	NA	NA	NA	NA	NA	NA	NA	NA
20	146,203	139,277	5	131,194	10	94,070	36	27,517	81	NA	NA	NA	NA
30	164,786	153,770	7	145,621	12	137,505	17	126,572	23	63,196	62	NA	NA
40	197,385	169,987	14	164,971	16	151,455	23	142,894	28	134,073	32	89,944	54
50	236,409	220,729	7	202,052	15	170,745	28	164,479	30	149,022	37	138,453	41
60	353,985	289,840	18	242,065	32	226,433	36	208,581	41	171,280	52	160,680	55
70	470,734	430,764	8	393,915	16	345,788	27	265,877	44	229,914	51	210,788	55
80	603,516	569,466	6	537,686	11	477,303	21	428,800	29	387,914	36	292,415	52
90	741,905	715,075	4	684,530	8	647,973	13	592,914	20	547,748	26	487,928	34

NA = Not available; isohaline for flow reduction scenario located upstream of model domain

Table M-11. Percentiles for daily water volume upstream of water-column average isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
10	357,897	308,319	14	241,499	33	224,998	37	210,517	41	171,877	52	153,233	57
20	462,460	420,937	9	387,640	16	335,935	27	250,320	46	226,014	51	210,218	55
30	541,095	508,049	6	466,284	14	418,070	23	374,541	31	310,487	43	236,918	56
40	625,393	589,251	6	545,036	13	509,602	19	459,013	27	408,597	35	351,034	44
50	687,505	661,379	4	625,837	9	585,520	15	540,490	21	485,803	29	436,621	36
60	741,610	717,195	3	693,526	6	664,050	10	625,107	16	580,822	22	538,031	27
70	826,164	793,048	4	760,906	8	733,753	11	704,144	15	674,145	18	629,709	24
80	947,229	912,972	4	876,607	7	841,809	11	802,823	15	761,135	20	725,945	23
90	1,137,221	1,112,863	2	1,056,857	7	1,003,301	12	952,039	16	905,255	20	853,943	25

Table M-12. Percentiles for daily water volume upstream of water-column average isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline bottom area. Orange shading indicates the highest modeled flow reduction scenarios resulted in less than a 15 percent reduction in baseline water volume.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
10	1,094,539	1,042,367	5	997,301	9	945,505	14	909,544	17	868,994	21	830,848	24
20	1,199,606	1,163,415	3	1,136,766	5	1,109,080	8	1,048,217	13	989,081	18	930,257	22
30	1,345,935	1,285,499	4	1,217,320	10	1,181,738	12	1,149,563	15	1,123,299	17	1,062,050	21
40	1,415,072	1,384,284	2	1,364,905	4	1,316,533	7	1,242,902	12	1,189,630	16	1,151,263	19
50	1,565,149	1,515,635	3	1,446,498	8	1,402,774	10	1,374,312	12	1,344,007	14	1,261,012	19
60	1,738,369	1,696,107	2	1,638,411	6	1,592,767	8	1,540,095	11	1,465,158	16	1,402,146	19
70	1,900,507	1,860,424	2	1,840,905	3	1,805,666	5	1,774,971	7	1,712,544	10	1,652,156	13
80	2,086,425	2,069,286	1	2,039,754	2	2,005,434	4	1,967,716	6	1,935,559	7	1,898,721	9
90	2,438,107	2,388,188	2	2,331,027	4	2,287,051	6	2,240,623	8	2,197,556	10	2,161,031	11

Table M-13. Percentiles for daily natural shoreline length upstream of surface isohalines with a salinity of 2, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline natural shoreline length.

<2 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
40	737	730	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
50	881	737	16	737	16	730	17	NA	NA	NA	NA	NA	NA
60	951	881	7	881	7	881	7	737	22	730	23	NA	NA
70	1,141	1,038	9	951	17	951	17	881	23	881	23	737	35
80	1,197	1,197	0	1,141	5	1,141	5	1,038	13	951	21	881	26
90	1,197	1,197	0	1,197	0	1,197	0	1,197	0	1,197	0	1,141	56

NA = Not available; isohaline for baseline or flow reduction scenario located upstream of model domain

Table M-14. Percentiles for daily natural shoreline length upstream of surface isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline natural shoreline length.

<3 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
10	951	881	7	881	7	730	23	NA	NA	NA	NA	NA	NA
20	1,141	1,038	9	951	17	881	23	881	23	611	46	NA	NA
30	1,197	1,197	0	1,141	5	1,038	13	881	26	881	26	737	38
40	1,276	1,197	6	1,197	6	1,197	6	1,141	11	951	25	881	33
50	1,538	1,372	11	1,276	17	1,197	22	1,197	22	1,197	22	1,038	31
60	1,846	1,839	0	1,735	6	1,372	26	1,276	31	1,206	35	1,197	35
70	2,157	1,925	11	1,846	14	1,846	14	1,735	20	1,372	36	1,276	41
80	2,753	2,556	7	2,463	11	2,157	22	1,925	30	1,846	33	1,839	33
90	2,874	2,834	1	2,834	1	2,834	1	2,660	7	2,463	14	2,157	25

NA = Not available; isohaline for reduction scenario located upstream of model domain

Table M-15. Percentiles for daily natural shoreline length upstream of surface isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline natural shoreline length. Orange shading indicates the highest modeled flow reduction scenario resulted in less than a 15 percent reduction in baseline natural shoreline length.

<5 Salinity Zone Pcntl.	Flow Scenario													
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
10	1,846	1,846	0	1,839	0	1,538	17	1,372	26	1,276	31	1,197	35
20	2,157	2,046	5	1,846	14	1,846	14	1,839	15	1,538	29	1,372	36
30	2,556	2,463	4	2,256	12	2,046	20	1,846	28	1,846	28	1,792	30
40	2,834	2,753	3	2,556	10	2,463	13	2,157	24	1,925	32	1,846	35
50	2,834	2,834	0	2,834	0	2,660	6	2,556	10	2,356	17	2,046	28
60	2,960	2,874	3	2,834	4	2,834	4	2,834	4	2,660	10	2,463	17
70	3,141	3,141	0	3,141	0	2,960	6	2,874	8	2,834	10	2,834	10
80	3,295	3,190	3	3,141	5	3,141	5	3,141	5	2,997	9	2,874	13
90	4,368	3,992	9	3,831	12	3,602	18	3,295	25	3,141	28	3,141	28

Table M-16. Percentiles for daily natural shoreline length upstream of surface isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007 based on modeling of three-hour increments conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline natural shoreline length.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
10	4,368	3,992	9	3,703	15	3,602	18	3,190	27	3,141	28	3,141	28
20	5,278	4,718	11	4,513	15	4,368	17	3,992	24	3,703	30	3,507	34
30	5,732	5,552	3	5,338	7	4,928	14	4,718	18	4,513	21	3,992	30
40	7,003	6,227	11	6,094	13	5,552	21	5,552	21	5,278	25	4,718	33
50	7,975	7,660	4	7,451	7	6,720	16	6,227	22	5,732	28	5,552	30
60	9,906	9,635	3	8,707	12	8,238	17	7,660	23	7,451	25	6,720	32
70	10,995	10,870	1	10,359	6	10,053	9	9,906	10	8,985	18	8,238	25
80	14,268	13,601	5	12,481	13	12,105	15	11,892	17	11,399	20	10,895	24
90	18,388	17,953	2	17,757	3	16,657	9	15,272	17	14,991	18	14,473	21

Appendix N

Modeled area, volume and shoreline length percentiles associated with specific isohalines in the Homosassa River as determined for the benchmark period of 2007 based on regression models 1 and 2 described in Chapter 2 of this report.

Table N-1. Percentiles for daily bottom area upstream of bottom isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reduction associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<3 Salinity Zone Pcntl.	Flow Scenario													
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	81,753	74,799	9	61,739	24	44,599	45	30,515	63	15,171	81	NA	NA
20	82,465	81,843	1	75,638	8	62,665	24	44,954	45	30,371	63	14,583	82
30	101,596	82,409	19	81,764	20	74,462	27	60,696	40	42,827	58	27,011	73
40	127,521	99,527	22	82,331	35	81,346	36	72,440	43	54,403	57	37,171	71
50	159,128	129,245	19	99,989	37	82,291	48	80,345	50	71,191	55	51,248	68
60	205,261	162,194	21	132,244	36	101,450	51	82,314	60	80,271	61	70,492	66
70	300,163	194,082	35	162,377	46	132,005	56	101,177	66	82,293	73	79,683	73
80	370,936	260,341	30	190,016	49	160,310	57	127,835	66	96,591	74	82,130	78
90	477,525	366,515	23	246,004	48	192,119	60	160,493	66	126,307	74	94,139	80

NA = Not available; isohaline for flow reduction scenario located upstream of model domain

Table N-2. Percentiles for daily bottom area upstream of water-column isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<3 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	160,190	140,514	12	117,607	27	98,967	38	82,486	49	81,982	49	78,941	51
20	183,519	163,940	11	144,687	21	121,139	34	100,788	45	82,486	55	81,961	55
30	209,371	185,026	12	164,469	21	143,526	31	118,224	44	98,065	53	82,405	61
40	239,856	206,748	14	179,904	25	159,703	33	137,908	43	112,631	53	92,229	62
50	286,890	240,324	16	207,447	28	180,052	37	159,403	44	135,286	53	109,057	62
60	344,228	289,623	16	247,036	28	211,464	39	183,250	47	161,236	53	137,031	60
70	394,169	335,428	15	290,667	26	251,593	36	214,325	46	185,377	46	162,289	59
80	456,394	374,913	18	327,639	28	288,140	37	248,950	45	211,417	54	180,971	60
90	529,388	455,288	14	371,359	30	327,634	38	290,232	45	249,260	53	210,387	60

Table N-3. Percentiles for daily bottom area upstream of bottom isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reduction associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest or highest modeled flow reduction scenarios resulted in more or less than a 15 percent reduction in baseline bottom area.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	308,522	295,466	4	281,952	9	268,357	13	254,101	18	240,302	22	227,994	26
20	330,281	321,741	3	310,208	6	297,374	10	284,419	14	270,941	18	257,997	22
30	345,966	337,548	2	329,186	5	320,609	7	307,201	11	292,583	15	279,333	19
40	359,509	351,524	2	342,957	5	334,558	7	326,157	9	316,254	12	301,693	16
50	378,197	369,390	2	360,703	5	352,111	7	343,432	9	334,609	12	325,786	14
60	422,674	390,430	8	379,953	10	371,017	12	362,254	14	353,413	16	344,229	19
70	510,048	423,276	17	407,162	20	397,106	22	386,965	24	376,998	26	367,764	28
80	548,241	480,060	12	426,432	22	413,804	25	402,770	27	392,659	28	382,628	30
90	654,859	548,274	16	473,810	28	445,798	32	432,779	34	419,147	36	406,842	38

Table N-4. Percentiles for daily bottom area upstream of water-column isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	402,840	389,297	3	376,524	7	365,232	9	353,717	12	341,553	15	328,917	18
20	428,464	412,574	4	398,641	7	384,952	10	371,697	13	359,338	16	347,315	19
30	452,626	435,437	4	418,878	7	403,042	11	388,287	14	374,712	17	361,542	20
40	476,196	452,997	5	435,288	9	418,618	12	403,136	15	388,415	18	374,417	21
50	503,809	486,083	4	463,881	8	443,819	12	426,316	15	409,129	19	394,403	22
60	529,684	512,115	3	498,938	6	478,397	10	455,909	14	436,129	18	417,526	21
70	554,269	530,094	4	522,321	6	508,186	8	494,195	11	470,250	15	447,476	19
80	617,503	545,884	12	530,591	14	523,470	15	509,710	17	495,231	20	471,176	24
90	713,992	620,087	13	545,477	24	535,314	25	528,165	26	519,315	27	504,588	29

Table N-5. Percentiles for daily bottom area upstream of bottom isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reduction associated with a 15 percent relative decrease in baseline bottom area.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	865,414	821,299	5	776,988	10	733,790	15	704,904	19	676,897	22	647,858	25
20	930,688	887,147	5	844,175	9	800,246	14	757,256	19	718,393	23	687,335	26
30	992,421	948,077	4	901,619	9	856,929	14	812,029	18	763,538	23	722,742	27
40	1,026,433	993,573	3	945,894	8	898,110	13	852,430	17	807,229	21	760,107	26
50	1,076,754	1,041,844	3	1,008,080	6	964,576	10	915,935	15	868,381	19	820,908	24
60	1,206,760	1,107,559	8	1,059,837	12	1,025,998	15	990,622	18	939,974	22	889,430	26
70	1,302,051	1,205,392	7	1,132,168	13	1,082,762	17	1,046,014	20	1,010,111	22	965,680	26
80	1,367,798	1,291,925	6	1,196,815	13	1,138,123	17	1,086,357	21	1,046,933	23	1,009,364	26
90	1,501,334	1,377,018	8	1,294,524	14	1,213,067	19	1,165,197	22	1,112,812	26	1,066,372	29

Table N-6. Percentiles for daily bottom area upstream of water-column isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the highest modeled flow reduction scenario resulted in less than a 15 percent reduction in baseline bottom area.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	949,745	926,480	2	904,507	5	884,804	7	865,803	9	846,063	11	825,681	13
20	1,000,374	981,280	2	959,651	4	938,956	6	919,454	8	899,844	10	878,697	12
30	1,040,311	1,014,338	2	997,211	4	978,018	6	957,455	8	936,900	10	916,344	12
40	1,079,844	1,043,598	3	1,026,319	5	1,011,055	6	995,742	8	975,140	10	952,953	12
50	1,170,686	1,100,269	6	1,061,060	9	1,045,83	11	1,030,616	12	1,015,393	13	1,000,171	15
60	1,274,121	1,192,347	6	1,127,173	12	1,086,027	15	1,067,487	16	1,051,379	17	1,035,246	19
70	1,338,480	1,279,251	4	1,210,059	10	1,153,058	14	1,129,553	16	1,105,873	17	1,083,385	19
80	1,420,237	1,332,587	6	1,272,221	10	1,209,721	15	1,171,743	17	1,148,659	19	1,125,138	21
90	1,557,412	1,435,679	8	1,337,467	14	1,281,557	18	1,229,866	21	1,208,288	22	1,186,083	24

Table N-7. Percentiles for daily volume upstream of water-column isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline water volume.

<3 Salinity Zone Pcntl.	Flow Scenario													
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction		
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
10	230,437	205,950	11	179,416	22	163,524	29	151,203	34	143,508	38	135,230	41
20	261,480	235,425	10	210,783	19	183,507	30	164,843	37	151,196	42	143,184	45
30	295,946	263,489	11	236,129	20	209,439	29	180,131	39	162,871	45	149,965	49
40	333,654	292,448	12	256,660	23	229,789	31	202,930	39	173,652	48	158,644	52
50	389,912	334,216	14	293,379	25	256,857	34	229,391	41	199,894	49	170,830	56
60	465,083	393,160	15	342,277	26	298,736	36	261,121	44	231,828	50	201,914	57
70	537,987	452,180	16	394,401	27	347,750	35	302,550	44	263,957	51	233,229	57
80	616,167	507,987	18	440,760	28	391,398	36	344,576	44	298,672	52	258,082	58
90	708,211	614,995	13	503,068	29	440,753	38	393,884	44	344,948	51	297,299	58

Table N-8. Percentiles for daily volume upstream of water-column isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a 15 percent relative decrease in baseline water volume.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
10	551,849	530,198	4	510,215	8	494,589	10	478,655	13	461,161	16	442,634	20
20	584,807	566,612	3	545,137	7	523,252	11	503,536	14	486,434	17	469,609	20
30	612,174	592,791	3	573,831	6	552,172	10	528,582	14	507,708	17	489,483	20
40	637,148	612,568	4	592,620	7	573,532	10	552,323	13	528,787	17	507,301	20
50	668,449	647,625	3	624,100	7	602,388	10	582,347	13	561,905	16	538,362	19
60	708,877	679,290	4	662,091	7	639,480	10	615,653	13	593,584	16	572,282	19
70	764,275	709,802	7	692,612	9	674,162	12	656,220	14	630,848	17	606,575	21
80	843,189	745,381	12	710,921	16	694,877	18	676,151	20	657,357	22	631,830	25
90	964,226	846,352	12	744,464	23	721,563	25	705,456	27	688,688	29	669,466	31

Table N-9. Percentiles for daily volume upstream of water-column isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the highest modeled flow reduction scenario resulted in less than a 15 percent reduction in baseline water volume.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
10	1,291,207	1,256,004	3	1,222,755	5	1,192,941	8	1,164,190	10	1,137,495	12	1,110,600	14
20	1,367,577	1,338,926	2	1,306,197	4	1,274,882	7	1,245,373	9	1,215,700	11	1,183,701	13
30	1,426,773	1,388,275	3	1,362,890	4	1,333,989	7	1,302,875	9	1,271,771	11	1,240,666	13
40	1,485,369	1,431,644	4	1,406,034	5	1,383,409	7	1,360,711	8	1,329,634	10	1,296,061	13
50	1,637,370	1,519,419	7	1,457,527	11	1,434,964	12	1,412,402	14	1,389,839	15	1,367,277	16
60	1,818,737	1,673,653	8	1,564,483	14	1,495,563	18	1,467,053	19	1,443,178	21	1,419,265	22
70	1,955,971	1,827,900	7	1,704,298	13	1,607,843	18	1,568,470	20	1,528,805	22	1,491,138	24
80	2,085,549	1,942,820	7	1,815,343	13	1,703,695	18	1,639,140	21	1,600,474	23	1,561,076	25
90	2,308,196	2,109,892	9	1,953,710	15	1,832,020	21	1,739,680	25	1,701,134	26	1,701,134	28

Table N-10. Percentiles for daily natural shoreline length upstream of surface isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline natural shoreline length. Orange shading indicates the highest modeled flow reduction scenario resulted in less than a 15 percent reduction in baseline natural shoreline length.

<3 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
10	1,846	1,846	0	1,846	0	1,839	0	1,792	3	1,735	6	1,538	17
20	1,925	1,846	4	1,846	4	1,846	4	1,839	4	1,792	7	1,735	10
30	2,046	1,925	6	1,846	10	1,846	10	1,846	10	1,839	10	1,792	12
40	2,157	2,046	5	1,925	11	1,846	14	1,846	14	1,846	14	1,839	15
50	2,356	2,157	8	2,046	13	1,925	18	1,846	22	1,846	22	1,846	22
60	2,660	2,356	11	2,256	15	2,157	19	1,925	28	1,846	31	1,846	31
70	2,834	2,660	6	2,356	17	2,256	20	2,157	24	2,046	28	1,925	32
80	2,834	2,834	0	2,556	10	2,356	17	2,256	20	2,157	24	2,046	28
90	2,960	2,834	4	2,834	4	2,556	141	2,421	18	2,256	24	2,157	27

Table N-11. Percentiles for daily natural shoreline length upstream of surface isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a 15 percent relative change (reduction) in baseline natural shoreline length. Orange shading indicates the highest modeled flow reduction scenario resulted in less than a 15 percent reduction in baseline natural shoreline length.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
10	2,834	2,834	0	2,834	0	2,753	3	2,660	6	2,501	12	2,356	17
20	2,834	2,834	0	2,834	0	2,834	0	2,753	3	2,660	6	2,556	10
30	2,874	2,834	1	2,834	1	2,834	1	2,834	1	2,753	4	2,660	7
40	2,874	2,874	0	2,834	1	2,834	1	2,834	1	2,834	1	2,753	4
50	2,997	2,874	4	2,874	4	2,834	5	2,834	5	2,834	5	2,834	5
60	3,141	2,997	5	2,960	6	2,874	8	2,834	10	2,834	10	2,834	10
70	3,141	3,141	0	3,141	0	2,960	6	2,874	8	2,874	10	2,834	10
80	3,295	3,141	5	3,141	5	3,141	5	2,960	10	2,874	13	2,834	14
90	3,831	3,295	14	3,141	18	3,141	18	3,141	18	2,982	22	2,874	25

Table N-12. Percentiles for daily natural shoreline length upstream of surface isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline natural shoreline length. Orange shading indicates the lowest or highest modeled flow reduction scenario resulted in more or less than a 15 percent reduction in baseline natural shoreline length.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
10	5,732	5,732	0	5,732	0	5,732	0	5,732	0	5,732	0	5,732	0
20	6,227	6,227	0	6,200	0	6,227	0	6,227	0	6,227	0	6,227	0
30	6,720	6,420	4	6,420	4	6,420	4	6,420	4	6,420	4	6,420	4
40	7,451	7,003	6	6,720	10	6,720	10	6,720	10	7,003	6	7,003	6
50	8,985	7,660	15	7,451	17	7,451	17	7,451	17	7,451	17	7,451	17
60	10,870	9,635	11	7,975	27	7,660	30	7,660	30	7,660	30	7,786	28
70	12,105	10,870	10	9,635	20	8,614	29	8,238	32	8,614	29	8,614	29
80	14,473	12,105	16	10,870	25	9,635	33	8,985	38	8,985	38	8,985	38
90	17,134	14,549	15	12,330	28	10,870	37	10,053	41	9,906	42	9,906	42

Appendix 0

Modeled area, volume and shoreline length percentiles associated with specific isohalines in the Homosassa River as determined for the benchmark period from October 18, 1995 through May13, 2009, based on regression models 1 and 2 described in Chapter 2 of this report.

Table O-1. Percentiles for daily bottom area upstream of bottom isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reduction associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<3 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	109,316	85,404	22	81,952	25	76,648	30	64,910	41	46,453	58	30,855	72
20	153,547	122,820	20	95,412	38	82,148	46	78,481	49	67,202	56	47,518	69
30	210,958	155,978	26	123,886	41	94,799	55	82,125	61	77,913	63	65,007	69
40	332,823	203,352	39	156,352	53	122,023	63	92,343	72	81,999	75	75,592	77
50	405,494	311,957	23	186,320	54	148,878	63	111,884	72	82,922	80	81,714	80
60	507,380	389,099	23	278,217	45	173,066	66	138,467	73	102,227	80	82,214	84
70	552,447	494,863	10	370,724	33	241,287	56	164,376	70	127,503	77	92,728	83
80	661,133	550,307	17	479,333	27	357,187	46	214,256	68	159,835	76	120,015	82
90	911,996	724,866	21	593,334	35	520,045	43	385,779	58	245,486	73	160,982	82

Table O-2. Percentiles for daily bottom area upstream of water-column isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<3 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	216,938	191,826	12	169,713	22	150,622	31	125,098	42	102,093	53	82,512	62
20	278,734	231,975	17	200,672	28	174,928	37	154,949	44	129,455	54	105,117	62
30	347,595	286,748	18	236,381	32	202,750	42	175,209	50	153,544	56	127,063	63
40	410,981	341,736	17	281,584	31	233,433	43	198,858	52	171,662	58	149,520	64
50	489,079	394,129	19	328,534	33	269,681	45	223,104	54	191,044	61	164,737	66
60	534,946	471,391	12	379,331	29	313,152	41	253,743	53	211,290	61	178,796	67
70	578,288	530,488	8	450,961	22	363,719	37	296,256	49	242,342	58	202,810	65
80	670,517	576,436	14	527,703	21	437,376	35	351,757	48	285,768	57	234,102	65
90	865,303	720,157	17	616,128	29	540,122	38	465,711	46	361,480	58	290,090	66

Table O-3. Percentiles for daily bottom area upstream of bottom isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	348,385	339,796	2	330,991	5	322,530	7	310,867	11	296,629	15	282,399	19
20	371,011	355,327	4	346,381	7	337,089	9	327,880	12	318,320	14	303,483	19
30	421,772	380,480	10	361,092	14	350,651	17	340,511	19	330,536	22	320,857	24
40	525,528	418,929	20	383,464	27	363,379	31	352,066	33	341,844	35	331,825	37
50	566,623	507,782	10	408,937	28	383,252	32	365,293	36	**353,908**	**38**	343,711	39
60	673,026	553,556	18	486,553	28	402,397	40	381,235	43	368,060	45	357,096	47
70	811,294	656,030	19	545,507	33	453,302	44	398,926	51	382,538	53	369,082	55
80	1,002,350	804,617	20	645,001	36	538,537	46	431,946	57	398,926	60	382,491	62
90	1,249,780	1,070,314	14	889,997	29	689,436	45	550,361	56	456,225	63	399,926	68

Table O-4. Percentiles for daily bottom area upstream of water-column isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	459,754	440,239	5	423,073	8	406,281	12	392,075	15	378,119	18	364,963	21
20	496,835	472,233	5	450,025	9	431,435	13	413,567	17	397,488	20	382,041	23
30	529,320	502,826	5	477,439	10	454,731	14	434,400	18	415,007	22	397,900	25
40	566,285	528,531	7	504,248	11	479,205	15	455,102	20	433,868	23	413,567	27
50	637,346	552,737	13	525,058	18	502,149	21	476,917	25	451,617	29	429,912	33
60	720,612	621,765	14	544,018	25	520,048	28	497,998	31	473,264	34	447,532	38
70	847,742	710,294	16	609,566	28	538,449	36	516,060	39	496,419	41	469,636	45
80	996,201	841,655	16	701,281	30	596,535	40	532,609	47	515,061	48	495,639	50
90	1,191,121	1,045,434	12	901,301	24	735,277	38	619,475	48	538,016	48	515,368	57

Table O-5. Percentiles for daily bottom area upstream of bottom isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	1,002,819	961,731	4	915,838	9	868,350	13	821,097	18	774,701	23	730,251	27
20	1,073,481	1,023,284	5	986,924	8	936,565	13	886,581	17	836,894	22	788,342	27
30	1,205,914	1,087,013	10	1,031,437	14	994,404	18	942,181	22	891,372	26	838,600	30
40	1,303,774	1,201,975	8	1,087,996	17	1,032,966	21	994,412	24	940,999	28	886,197	32
50	1,369,157	1,290,431	6	1,165,769	15	1,077,869	21	1,027,324	25	986,503	28	929,843	32
60	1,469,349	1,348,482	8	1,265,175	14	1,140,840	22	1,063,887	28	1,018,281	31	972,609	34
70	1,605,842	1,455,027	9	1,334,386	17	1,239,953	23	1,120,428	30	1,054,367	30	1,012,228	37
80	1,988,662	1,603,241	19	1,449,774	27	1,328,554	33	1,225,902	38	1,112,242	44	1,052,798	47
90	2,456,944	2,112,411	14	1,747,444	29	1,495,411	39	1,348,043	45	1,243,436	49	1,114,908	55

Table O-6. Percentiles for daily bottom area upstream of water-column isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest or highest modeled flow reduction scenario resulted in more or less than a 15 percent reduction in baseline bottom area.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
10	1,052,512	1,020,960	3	1,002,322	5	983,991	7	962,688	9	940,077	11	918,079	13
20	1,157,166	1,079,346	7	1,038,137	10	1,015,039	12	997,260	14	975,874	16	952,210	18
30	1,266,777	1,171,701	8	1,090,273	14	1,052,130	17	1,023,152	19	1,003,056	21	982,219	22
40	1,332,816	1,263,411	5	1,170,507	12	1,096,821	18	1,056,815	21	1,026,453	23	1,005,488	25
50	1,406,014	1,322,300	6	1,244,244	12	1,154,915	18	1,092,838	22	1,056,988	25	1,031,303	27
60	1,506,590	1,390,045	8	1,308,548	13	1,221,208	19	1,136,178	25	1,088,021	28	1,062,812	29
70	1,636,453	1,496,996	9	1,376,065	16	1,296,324	21	1,203,040	26	1,127,750	31	1,090,840	33
80	2,001,812	1,648,639	18	1,493,844	25	1,369,452	32	1,289,455	36	1,195,070	40	1,127,404	44
90	2,416,621	2,109,278	13	1,794,930	26	1,528,317	37	1,391,680	42	1,298,986	46	1,198,486	50

Table O-7. Percentiles for daily volume upstream of water-column isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<3 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
10	306,033	272,554	11	243,103	21	217,712	29	188,093	39	165,788	46	151,592	50
20	380,219	324,189	15	284,348	25	250,040	34	223,466	41	193,139	49	167,977	56
30	470,020	389,743	17	329,480	30	287,117	39	250,413	47	221,597	53	190,369	59
40	564,788	461,429	18	383,606	32	325,940	42	281,930	50	245,694	56	216,381	62
50	650,799	537,923	17	442,073	32	369,460	43	313,535	52	271,511	58	236,485	64
60	720,734	632,057	12	514,264	29	421,124	29	350,332	51	298,504	59	255,183	65
70	795,205	710,690	11	610,410	23	492,495	38	401,043	50	336,640	58	287,198	64
80	909,215	792,940	13	704,414	23	595,011	35	475,943	48	388,579	57	326,744	64
90	1,163,433	972,028	16	841,506	28	732,399	37	626,039	46	489,397	58	393,716	66

Table O-8. Percentiles for daily volume upstream of water-column isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline bottom area.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
10	619,727	598,289	3	578,633	7	557,352	10	534,640	14	512,423	17	494,218	20
20	659,345	632,949	4	609,419	8	588,209	11	567,749	14	543,293	18	518,597	21
30	708,058	667,166	6	638,465	10	614,405	13	591,604	16	569,397	20	543,951	23
40	780,518	706,281	10	669,022	14	640,337	18	614,798	21	590,995	24	567,749	27
50	867,470	760,824	12	698,454	19	666,282	23	637,912	26	611,105	30	586,465	32
60	972,603	848,404	13	741,176	24	689,644	29	660,864	32	634,042	35	606,640	38
70	1,139,710	959,548	16	833,477	27	728,629	36	684,439	40	658,803	42	630,197	45
80	1,361,392	1,131,677	17	948,143	30	817,533	40	715,470	47	683,136	50	657,785	52
90	1,671,599	1,434,366	14	1,217,905	27	991,306	41	845,603	49	727,653	56	683,536	59

Table O-9. Percentiles for daily volume upstream of water-column isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative decrease in baseline bottom area. Orange shading indicates the highest modeled flow reduction scenario resulted in less than a 15 percent reduction in baseline bottom area.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
10	1,444,857	1,398,091	3	1,370,464	5	1,343,028	7	1,310,793	9	1,276,579	12	1,243,292	14
20	1,614,723	1,484,630	8	1,423,550	12	1,389,314	14	1,362,962	16	1,330,745	18	1,294,937	20
30	1,805,617	1,639,070	9	1,502,675	17	1,444,290	20	1,401,340	22	1,371,553	24	1,340,346	26
40	1,943,331	1,799,604	7	1,637,069	16	1,513,644	22	1,451,235	25	1,406,232	28	1,375,157	29
50	2,063,155	1,919,863	7	1,765,365	14	1,610,953	22	1,506,972	27	1,451,491	30	1,413,421	31
60	2,221,685	2,038,012	8	1,889,174	15	1,724,215	22	1,579,567	29	1,498,903	33	1,460,124	34
70	2,436,341	2,206,561	9	2,016,001	17	1,861,895	24	1,691,760	31	1,565,450	36	1,503,624	38
80	2,833,555	2,448,489	14	2,201,592	22	2,005,590	29	1,846,568	35	1,678,215	41	1,564,871	45
90	3,313,120	2,985,864	10	2,594,332	22	2,257,346	32	2,040,586	38	1,867,837	44	1,683,936	49

Table O-10. Percentiles for daily natural shoreline length upstream of surface isohalines with a salinity of 3, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline natural shoreline length. Orange shading indicates the lowest modeled flow reduction scenario resulted in more than a 15 percent reduction in baseline natural shoreline length.

<3 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
10	2,157	2,046	5	1,846	14	1,846	14	1,846	14	1,839	15	1,792	17
20	2,356	2,157	8	2,046	13	1,925	18	1,846	22	1,846	22	1,846	22
30	2,660	2,356	11	2,157	19	2,046	23	1,925	28	1,846	31	1,846	31
40	2,834	2,660	6	2,356	17	2,157	24	2,046	28	1,925	32	1,846	35
50	2,834	2,834	0	2,556	10	2,356	17	2,157	24	2,046	28	1,846	35
60	2,960	2,834	4	2,834	4	2,556	14	2,256	24	2,157	27	1,925	35
70	3,141	2,960	6	2,834	10	2,753	12	2,463	22	2,256	28	2,046	35
80	3,190	3,141	2	2,960	7	2,834	11	2,753	14	2,356	26	2,157	32
90	3,992	3,295	17	3,141	21	2,997	25	2,834	29	2,753	31	2,356	41

Table O-11. Percentiles for daily natural shoreline length upstream of surface isohalines with a salinity of 5, and relative change in bottom area percentiles for baseline and five to 30 percent flow for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline natural shoreline length. Orange shading indicates the lowest or highest modeled flow reduction scenarios resulted in more or less than a 15 percent reduction in baseline natural shoreline length.

<5 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
10	2,874	2,834	1	2,834	1	2,834	1	2,834	1	2,753	4	2,660	7
20	2,960	2,874	3	2,874	3	2,834	4	2,834	4	2,834	4	2,753	7
30	3,141	2,997	5	2,874	8	2,874	8	2,834	10	2,834	10	2,834	10
40	3,141	3,141	0	2,997	5	2,874	8	2,874	8	2,834	10	2,834	10
50	3,295	3,141	5	3,141	5	2,960	10	2,874	13	2,834	14	2,834	14
60	3,703	3,295	11	3,141	15	3,141	15	2,960	20	2,874	22	2,874	23
70	4,513	3,703	18	3,190	29	3,141	30	2,997	34	2,960	34	2,874	36
80	5,338	4,513	15	3,703	31	3,190	40	3,141	41	2,997	44	2,874	46
90	7,003	5,732	18	4,928	30	3,831	45	3,295	53	3,141	55	2,997	57

Table O-12. Percentiles for daily natural shoreline length upstream of surface isohalines with a salinity of 12, and relative change in bottom area percentiles for baseline and five to 30 percent flow reduction for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a 15 percent relative change (reduction) in baseline natural shoreline length. Orange shading indicates the lowest or highest modeled flow reduction scenarios resulted in more or less than a 15 percent reduction in baseline natural shoreline length.

<12 Salinity Zone Pcntl.	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
10	7,003	6,420	8	6,420	8	6,227	11	6,227	11	6,227	11	6,227	11
20	8,707	7,451	14	6,720	23	6,420	26	6,420	26	6,420	26	6,420	26
30	10,299	8,985	13	7,975	23	7,451	28	6,720	35	6,420	38	6,420	38
40	11,892	10,500	12	8,985	24	7,975	33	7,451	37	7,003	41	6,720	43
50	13,795	11,675	15	10,299	25	8,707	37	7,975	42	7,451	46	7,451	46
60	15,272	13,601	11	11,399	25	9,906	35	8,238	46	7,975	48	7,975	48
70	17,953	14,991	16	12,481	30	10,995	39	9,635	46	8,707	51	8,238	54
80	21,594	17,953	17	14,991	31	12,481	42	10,870	50	9,635	55	8,707	60
90	27,315	23,685	13	18,388	33	15,724	42	13,601	50	10,995	60	9,635	65

Appendix P

Leeper, D.A., Flannery, M.S. and Kelly, M.H. 2010. Recommended minimum flows for the Homosassa River system, July 12 2010 peer-review draft. Southwest Florida Water Management District. Brooksville, Florida.

Recommended Minimum Flows for the Homosassa River System

July 12, 2010 Peer-Review Draft

Southwest Florida Water Management District

Douglas A. Leeper
Michael S. Flannery
Martin H. Kelly

Ecologic Evaluation Section
Resource Projects Department
Southwest Florida Water Management District
Brooksville, Florida

with contributions by

HSW Engineering, Inc.
Tampa, Florida

Recommended Minimum Flows for the Homosassa River System

July 12, 2010 Peer-Review Draft

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On the Cover: Aerial photograph of the Homosassa Main Springs pool and upper portion of the Homosassa River in 2001 (Southwest Florida Water Management District files).

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Chapter 5 – Results and Recommended Minimum Flows

Chapter 6 – Cited Documents and Other Relevant Literature

Appendix A – HSW Engineering, Inc. 2010. A modeling study of the relationships of freshwater flow and thermal characteristics of the Homosassa River. Tampa, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Appendix B – Basso, R. 2010. Predicted groundwater withdrawal impacts to Homosassa Springs based on numerical model results. Technical memorandum dated February 15, 2010. Southwest Florida Water Management District. Brooksville, Florida.

Appendix C – Wang, P. 2007. Shoreline mapping and bathymetric survey for the Homosassa River systems. University of South Florida. Tampa, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Appendix D – Grabe, S.A. and Janicki, A. 2009. Draft - Characterization of macroinvertebrate communities of the Homosassa & Hall's Rivers. St. Petersburg, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Appendix E – PBS&J. 2009. Vegetation mapping of the Homosassa River in support of minimum flows and levels establishment; final – January 2009. Tampa, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Appendix F – Water & Air Research, Inc. 2010. Mollusc survey of the Homosassa River; Purchase Order #08POSOS1805. Gainesville, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Appendix G – Culter, J.K. 2009. Draft - An evaluation of the spatial extent and relative density of barnacles in Crystal, Homosassa and Withlacoochee Rivers, Florida. Mote Marine Laboratory. Sarasota, Florida. Prepare for the Southwest Florida Water Management District. Brooksville, Florida.

Appendix H – Peebles, E.B., MacDonald, T.C., Burghart, S.E., Guenther, C., Matheson, R.E., Jr., and McMichael, R.H., Jr. 2009. Freshwater inflow effects on fish and invertebrate use of the Homosassa River estuary. University of

South Florida College of Marine Science and Florida Fish and Wildlife Conservation Commission. St. Petersburg, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Appendix I – Summary information for percentage of flow reductions associated with 15 percent decreases in predicted relative abundances of plankton and nekton in the Homosassa and/or Halls River for the benchmark periods of 2007 and October 18, 1995 through May 13, 2009.

Appendix J – Modeled isohaline river kilometer location percentiles for the Homosassa River as determined for the benchmark period of 2007 using the Homosassa River hydrodynamic model.

Appendix K – Modeled isohaline river kilometer location percentiles for the Homosassa River as determined for the benchmark period of 2007 based on regression models 1 and 2 described in Chapter 2 of this report.

Appendix L – Modeled isohaline river kilometer location percentiles for the Homosassa River as determined for the benchmark period from October 18, 1995through May13, 2009 based on regression models 1 and 2 described in Chapter 2 of this report.

Appendix M – Modeled area, volume and shoreline length percentiles associated with specific isohalines in the Homosassa River as determined for 2007 using the Homosassa River hydrodynamic model 1 and 2 described in Chapter 2 of this Report.

Appendix N – Modeled area, volume and shoreline length percentiles associated with specific isohalines in the Homosassa River as determined for 2007 based on regression models 1 and 2 described in Chapter 2 of this report.

Appendix O – Modeled area, volume and shoreline length percentiles associated with specific isohalines in the Homosassa River as determined for the benchmark period from October 18, 1995 through May13, 2009,based on regression models 1 and 2 described in Chapter 2 of this report.

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Acknowledgements

We would like to thank several colleagues at the Southwest Florida Water Management District who assisted with development of the minimum flow recommendations presented in this report for the Homosassa River system. We thank Ron Basso for providing an assessment of the effects of regional water use on spring discharge in the Homosassa River system. We also indebted to Mike Heyl for advice and support regarding estuarine ecology, water chemistry and application of District methods for establishing minimum flows, and Richard Gant for reviewing this draft report. We thank Tammy Hinkle and Doug Pary for collection of water quality data on the river; Carol Kraft, Mark Rials and Jackie Robbins for assistance with database management for District water quality data; and Keith Schaniel for data entry of manatee count information provided by the United States Fish and Wildlife Service. Thanks are also extended to Phil Jackson for advice regarding processing of geographic information system data for the river system.

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Executive Summary

The Southwest Florida Water Management District is mandated by State law to establish minimum flows and levels for lakes, wetlands, rivers and aquifers. As currently defined by statute, "[t]he minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area" (Section 373.042(1)(b), Florida Statutes). Minimum flows and levels are established and used by the District for water resource planning, as one of the criteria used for evaluating water use permit applications, and for the design, construction and operation of surface water management systems.

This report summarizes development of recommended minimum flows for the Homosassa River system, which is located in the District's Coastal Rivers Basin on the west coast of Florida in Citrus County, and includes the Homosassa River, Southeast Fork of the Homosassa River, Halls River, Hidden River and springs associated with the rivers, including at least 19 named or identified springs or vents. The Homosassa River originates in the Homosassa Main Springs Pool in the Ellie Schiller Homosassa Springs State Wildlife Park west of the community of Homosassa and flows eight miles to the Gulf of Mexico. Halls River originates at Halls River Head Spring and flows three and a half miles to join the Homosassa River about seven miles upstream from the Gulf. Hidden River also originates from a spring pool and flows one and a third miles towards the Gulf before disappearing into a sink that probably contributes discharge to the Homosassa River. The Homosassa and Halls Rivers receive a small amount of surface runoff from their 56 square mile watershed, and similarly the Hidden River receives some runoff from its watershed. The majority of flow in the system arises, however, from the continuous spring discharge derived from the approximate 270 square mile springshed. Spring discharge to the system exhibits only moderate seasonal variation, with lower flows in summer when tidal stage is highest. Estimated combined discharge past United States Geological Survey (USGS) gages in the Homosassa Main Spring run and the Southeast Fork of the Homosassa River has averaged 152 cubic feet per second (cfs) for the period from 1995 through 2009.

To develop recommended minimum flows, a number of ecological resources were evaluated for sensitivity to reduced flows using both numeric and empirical regression models. Resources evaluated included the amount of salinity-based habitats, fish and invertebrates, and thermal-refuge habitat for manatees. Because spring discharge and consequently river flow in the system are relatively constant, minimum flow criteria were not evaluated on a seasonal basis. Declines in flow to the system associated with groundwater withdrawals were estimated to be approximately 2.3 cfs, including a 1 cfs decline in the springs contributing to flow past the USGS gages in the Homosassa Main Springs run and Southeast Fork. This 1 cfs change in flow was considered insignificant as compared to the estimated average flow of 152 cfs for the two sites, so available flow records for the sites were considered representative of baseline conditions for evaluation of minimum flow criteria. Because break-points in ecological responses were not observed, a fifteen percent loss of resource or habitat was adopted as representative of significant harm.

The most sensitive resource responses to modeled flow reductions were exhibited by fish and invertebrate plankton and nekton, *i.e.,* free-floating and actively swimming organisms. Flow reductions of 2.7 percent or less from median baseline conditions were associated with fifteen percent reductions in predicted abundances of individual pseudo-species or taxa. Similar or increased sensitivity to flow reductions was predicted for many taxa across the range of baseline flows, in particular for baseline flows less than the median flows. For some flow ranges, some nektonic taxa were predicted to not occur in the portions of the system for which the models were applicable, *e.g.,* in areas where organisms were sampled for construction of the predictive regression models.

It is possible that the apparent acute sensitivity of the evaluated plankton and nekton taxa to flow reductions in the Homosassa River system is an artifact of spurious relationships between the inflow values and organism count data used for development of the predictive regression models. Although all significant, positive linear models developed for planktonic and nektonic fish and invertebrates collected from the river system were used for the minimum flows analysis presented in this report, the amount of variation accounted for by individual models and sample sizes used for model construction varied considerably. Despite this variation in the quality of the regression models, predicted responses of all evaluated planktonic and nektonic pseudo-species or taxa exhibited similar sensitivity to flow reductions. It is possible that the very sensitive modeled responses of these organisms to flow reductions are a function of the relatively stable flow conditions of the spring-dominated system.

Modeled responses of a number of salinity-based habitats in the Homosassa River main channel were also relatively sensitive to flow reductions. Flow reductions of less than five percent were associated with more than fifteen percent reductions in selected salinity-based habitats determined from isohalines with salinities of 2, 3, 5 and 12. Other sensitive salinity-habitats were predicted to be reduced by fifteen percent when baseline flows were reduced by five to ten percent.

The volume of thermally-favorable habitat available to manatees during acute cold conditions was also found to be relatively sensitive to modeled flow reductions. Flow reductions between five and ten percent were predicted to reduce favorable manatee habitat by fifteen percent for a recent cold period. The absolute volume of thermally-favorable habitat available for critically-cold baseline and all flow-reduction scenarios examined suggests, however, that flow reductions up to thirty percent are not likely to be limiting for manatee use of the Homosassa River system as a thermal refuge.

Based on review of resource and habitat-based criteria, the recommended minimum flows for the Homosassa River system are defined as a five percent reduction from baseline flows. Given the minimal existing withdrawal impacts on flow, the recommended minimum flows are a five percent reduction from combined flows measured on a daily basis at the USGS gauge sites in the Homosassa Springs run and Southeast Fork of the Homosassa River.

Chapter 1

Minimum Flows and Levels and Purpose of this Report

Legal Directives and Use of Minimum Flows and Levels

State law (Section 373.042, Florida Statutes; hereafter F.S.) directs the Department of Environmental Protection or the water management districts to establish minimum flows and levels for lakes, wetlands, rivers and aquifers. As currently defined by statute, the minimum flow for a given watercourse "shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area", and the minimum level of an aquifer or surface water body is "the level of groundwater in the aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area". Minimum flows and levels are established and used by the Southwest Florida Water Management District for water resource planning, as one of the criteria used for evaluating water use permit applications, and for the design, construction and operation of surface water management systems.

Development of a minimum flow or level does not in itself protect a water body from significant harm; however, resource protection, recovery and regulatory compliance can be supported once the flow or level standards are established. State law governing implementation of minimum flows and levels (Section 373.0421, F.S.) requires development of a recovery or prevention strategy for water bodies if the " existing flow or level in a water body is below, or is projected to fall within 20 years below, the applicable minimum flow or level". Recovery or prevention strategies are developed to: "(a) achieve recovery to the established minimum flow or level as soon as practicable; or (b) prevent the existing flow or level from falling below the established minimum flow or level." Periodic re-evaluation and as necessary, revision of established minimum flows and levels are also required by state law.

Minimum flows and levels are to be established based upon the best available information with consideration given to "…changes and structural alterations to watersheds, surface waters and aquifers, and the effects such changes or alterations have had, and the constraints such changes or alterations have placed on the hydrology of the affected watershed, surface water, or aquifer…", with the caveat that these considerations shall not allow significant harm caused by withdrawals (Section 373.0421, F.S.). The Florida Water Resources Implementation Rule (Rule 62-40.473, Florida Administrative Code; hereafter F.A.C.) provides additional guidance for the establishment of minimum flows and levels, requiring that "consideration shall be given to the protection of water resources, natural seasonal fluctuations in water flows, and environmental values associated with coastal, estuarine, aquatic and wetland ecology, including: a) recreation in and on the water; b) fish and wildlife habitats and the passage of fish; c) estuarine resources; d) transfer of detrital material; e) maintenance of freshwater storage and supply; f) aesthetic and scenic attributes; g) filtration and absorption of nutrients and other pollutants; h) sediment loads; i) water quality; and j) navigation." The Water Resource Implementation Rule also indicates that "minimum flows and levels should be expressed as multiple flows or levels defining a minimum hydrologic regime, to the extent practical and necessary to establish the limit beyond which further withdrawals would be significantly harmful to the water resources or the ecology of the area".

Development of Minimum Flows and Levels in the Southwest Florida Water Management District

District Minimum Flows and Levels Rules and Documents

The Southwest Florida Water Management District has developed specific methodologies for establishing minimum flows or levels for lakes, wetlands, rivers, springs and aquifers, subjected the methodologies to independent, scientific peer-review, and in some cases, incorporated the methods into its Water Level and Rates of Flow Rule (Chapter 40D-8, F.A.C). In addition, regulatory components of recovery strategies necessary for restoration of minimum flows and levels that are not currently being met have been incorporated into the District's Recovery and Prevention Strategies for Minimum Flows and Levels Rule (Chapter 40D-80, F.A.C.). A recent summary of efforts completed for the District's Minimum Flows and Levels Program is provided by Hancock et al. (2010).

Using peer-reviewed methodologies, the District has established and codified into rule (Chapter 40D-8, F.A.C.) minimum flows for 15 river segments, including: the upper and lower Alafia River; the Anclote River; the lower Braden River; Cow Pen Slough/Shakett Creek; the upper and lower Hillsborough River; the upper Myakka River; the upper, and lower Peace River; three segments of the middle Peace River; the Tampa Bypass Canal; and the Weeki Wachee River. A total of 11 springs have been afforded the protection of minimum flows based on the adopted river segment minimum flows or minimum flows identified for individual springs. Information pertaining to the adoption of these minimum flows, peer-review or minimum flows and levels and other related issues is available from the District's Minimum Flows and Levels (Environmental Flows) Program web page at: *http://www.swfwmd.state. fl.us/ projects/mfl/* and the Minimum Flows and Levels (Environmental Flows) Documents and Reports page at*:* *http://www.swfwmd.state.fl.us/projects/mfl/mfl_reports.html*.

Conceptual Overview of Minimum Flows

Minimum flows that have been established by the District and other water management districts in the state (*e.g.,* South Florida Water Management District 2002, Water Resources Associates, Inc. *et al.* 2005, Mace 2007, Neubauer *et al.* 2008) have emphasized the maintenance of natural flow regimes, which include seasonal and interannual flow variations that reflect or integrate climatic and watershed characteristics. Consideration of hydrologic regimes when developing or managing for minimum or environmental flows is predicated on the concept that many important ecologic and hydrologic functions of streams and rivers are primarily dependant or supported by the range and pattern of flow conditions (Hill *et al.* 1991, Richter *et al.* 1996, Poff *et al.* 1997, Postel and Richter 2003, Annear *et al.* 2004, Olsen and Richter 2006).

Based on the importance of the flow regime to river system integrity, the District has employed a percent-of-flow method for determining minimum flows for freshwater and estuarine river segments and associated spring systems. The percent-of-flow method identifies flow reductions as percentages of daily mean flows that may be withdrawn directly from the system without causing significant harm. The percent-of-flow reductions similarly apply to flow reductions that may be caused by indirect flow impacts associated with groundwater withdrawals. In some cases, specific allowable percentage flow reductions may be developed for seasonally flow periods or flow ranges to reflect changes in system sensitivity to flows. By proportionally scaling water withdrawals to the rate of flow, the percent-of-flow method minimizes adverse impacts that could result from withdrawal of large volumes of water during low flow periods, when river systems may be especially vulnerable to flow reductions. Similarly, larger volumes may be available for withdrawal during periods of higher flows. A goal of the use of the percent-of-flow method for establishing minimum flows is that the natural flow regime of the river be maintained, albeit with some flow reduction for water supply.

The development minimum flows for coastal systems such as the Homosassa River necessarily involves the evaluation of flow effects on downstream estuaries. Estuaries account for approximately three-quarters of the Florida coastline (Kleppel *et al.* 1996a) and these habitats serve as spawning areas, nurseries or other habitat for more than 95 percent of Florida’s recreationally and commercially harvested fish, shellfish and crustaceans (Florida Fish and Wildlife Conservation Commission 2007).

To support early water-use regulation decisions for coastal river systems that preceded the establishment of minimum flows, the District funded a literature review of the effects of freshwater inflow on estuarine systems (Snedaker *et al.* 1977) and subsequently sponsored a workshop on the role of freshwater in Florida coastal areas (Seaman and McLean 1977). These Florida-specific efforts were followed by a national symposium on estuarine inflows in 1980 (Cross and Williams 1981) and more recently, the Estuarine research Federation published a special issue of the journal *Estuaries* containing papers presented at an estuarine inflow symposium held in St. Petersburg in 2001 (issue overview provided by Montagna *et al.* 2002). The special issue of Estuaries includes a paper by Alber (2002) outlining a conceptual model of estuarine inflow management, summaries of estuarine inflow programs being implemented in California (Kimmerer 2002) and Texas (Powell *et al.* 2002), and a review of methodological approaches using biological parameters (Estevez 2002). The special issue also includes a paper describing the development and application of the percent-of-flow approach for establishing minimum flows in the Southwest Florida Water Management District (Flannery *et al.* 2002). Numerous additional paper and reports have been devoted to the development and implementation of minimum flows for estuarine system, as exemplified by the publications of Wade (1992), Drinkwater and Frank (1994), Longley (1994), Kleppel *et al.* (1996a, b), Sklar and Browder (1998), Pierson *et al.* 2002, Postel and Richter (2003) and Olsen and Richter (2006).

Significant Harm

State law requires establishment of minimum flows and levels as limits at which further withdrawals would be significantly harmful to water resources or ecology of an area, but does not explicitly define what constitutes “significant harm”. In establishing minimum flows the District has identified flows associated with fish passage and maximization of stream bottom habitat with the least amount of flow and determined that loss of these threshold flows would be significantly harmful to river systems. The District has also used quantifiable reductions in potential habitat or resources to identify significant harm and develop minimum flow recommendations. This latter approach is complicated by the fact that many structural and functional components of river ecosystems vary incrementally with flow and do not exhibit clear thresholds or “break-points”.

Given the incremental nature of much environmental change in riverine ecosystems, the District has used a fifteen percent change criterion when evaluating flow-based changes in potential habitat or resource. The basis for this management decision lies, in part, with a recommendation put forth by the peer-review panel that considered the District’s proposed minimum flows for the upper Peace River. In their report, the panelists note that “[i]n general, instream flow analysts consider a loss of more than 15 percent habitat, as compared to undisturbed or current conditions, to be a significant impact on that population or assemblage” (Gore *et al.* 2002). The panel’s assertion was based on consideration of environmental flow studies employing the Physical Habitat Simulation Model (PHABSIM) for analyzing flow, water depth and substrate preferences that define aquatic species habitats. Use of a fifteen percent change in habitat or resources as constituting significant harm and therefore, for development of minimum flow recommendations has been extended by the District to evaluate changes in freshwater fish and invertebrate habitat, days of inundation of floodplains, snag habitat and woody debris in freshwater river segments, changes in abundances or population center-location tendencies of planktonic (free-floating) and nektonic (actively swimming) fish and invertebrates in estuarine river segments, spatial decreases in the availability of warm-water refuges for manatees during critically cold periods, and decreases in the volume, bottom area and shoreline length associated with specific salinity zones in estuarine river segments.

Peer-review panels convened to evaluate District recommendations subsequent to the findings put forth by Gore *et al.* (2002) for the upper Peace River have generally been supportive of the use of a fifteen percent change criterion for evaluating effects of potential flow reductions on habitats or resources when determining minimum flows (see peer-review reports at the District’s Minimum Flows and Levels Documents and Reports web page). However, the peer-review panel that recently considered the District’s recommended minimum flows for the upper Hillsborough River indicated that although use of the fifteen percent criterion was reasonable, "…the use of a de facto significant harm criterion based on a 15% reduction in habitat availability has not been rigorously demonstrated and will remain presumptive until such time as the District commits to the monitoring and assessment necessary to determine whether these criteria are truly protective of the resource" (Cichra *et al.* 2007). In response to this and other comments presented by Cichra *et al.* (2007), the District has sponsored a review of the percentage flow, habitat and resource changes documented in the environmental flows literature and has also initiated what is expected to be a long-term field study involving manipulation of flows in a natural stream segment to evaluate environmental changes associated with reduced flows.

Pending completion of the ongoing District-sponsored literature review of environmental flow studies, the recently initiated long-term flow manipulation study or findings from other environmental flow studies, the District plans to continue use of the fifteen percent habitat or resource change criteria for developing recommended minimum flows. In keeping with this policy, the District has used this approach for development of the minimum flow recommendations for the Homosassa River system outlined in this report. The District does, however, acknowledge that allowable percentage changes in habitat or resources other than fifteen percent have been used by others for environmental flow determinations. For example, Dunbar *et al.* (1998) in reference to the use of PHABSIM notes, "…an alternative approach is to select the flow giving 80 percent habitat exceedance percentile," which is equivalent to an allowable 20 percent decrease from baseline conditions. For another habitat-based environmental flow study, Jowett (1993) used a one-third loss of existing habitat associated with naturally occurring low flows as a guideline for determining flow recommendations. In Texas, the state established environmental flows for Matagorda Bay based on modeling that limited decreases of selected commercially important species to no more than 20 percent reductions from historical harvest levels (Powell *et al.* 2002).

Purpose of this Report

In accordance with Florida Statutes and rules pertaining to minimum flows and levels, recommended minimum flows were developed for the Homosassa River system using the best available information, including data that were obtained or developed specifically for the purpose of the minimum flows and levels determination. For this effort and implementation of the recommended minimum flows, the Homosassa River system is defined as the entire courses of the Homosassa River, Southeast Fork of the Homosassa River, Halls River, Hidden River and springs associated with these rivers.

The proposed minimum flows and the data, methodologies, models and assumptions used for their development are described in this draft technical report, which will be voluntarily subjected to independent scientific review and public comment. Based on this scientific and public review, the proposed minimum flows may be modified prior to presentation to the Southwest Florida Water Management District Governing Board for consideration as rule amendments to Rule 40D-8.041, F.A.C.

In this chapter, we have summarized the legal requirements and general approach used by the District for developing minimum flows. Subsequent chapters address the specific information and approaches used for development of minimum flow recommendations for the Homosassa River system. The physical setting and descriptive information for the river system are provided in Chapter two and biological resources associated with the system are described in Chapter three. In Chapter four, we identify the resources of concern and approaches used for evaluating changes in the resources that were considered for development of the minimum flow recommendations. Results for the resource-change assessments are described in Chapter five along with recommended minimum flows for the Homosassa River system. Documents cited in this report and other relevant publications used for the minimum flows assessment are listed in Chapter six. Appendices, which include summary data and reports for projects conducted to support development of the minimum flow recommendations, are bound as a separate volume of this report.

Chapter 2

Physical Setting and Description of the Homosassa River System

Location and General Description

The Homosassa River System is located in Citrus County, Florida, in the Coastal Rivers Basin of the Southwest Florida Water Management District (Figure 2-1). For the purpose of developing the minimum flows recommendations described in this report, the Homosassa River system includes the Homosassa River, Southeast Fork of the Homosassa River, Halls River, Hidden River and springs associated with these rivers (Figure 2-2). Named springs of the system include the Homosassa Main Springs, which includes three vents referred to as Main Spring Nos. 1, 2 and 3, Homosassa River No. 1 Spring (also referred to as Homosassa Unnamed Spring No. 1), Homosassa Unnamed Spring No. 2, Abdoney Spring, Alligator Spring, Banana Spring, Bear Spring, Belcher Spring, Blue Hole Spring, Bluebird Spring, McClain Spring, Pumphouse Spring, Trotter Main Spring, Trotter No. 1 Spring, Halls River Head Spring, Halls River No. 1 Spring, Halls River Spring No. 2, Hidden River Head Spring, Hidden River No. 2 Spring and Hidden River Spring No. 6 (Figure 2-3).

The Homosassa River originates at the Homosassa Main Springs complex and flows approximately 8 miles to its mouth near Shell Island in the Homosassa Bay region of the Gulf of Mexico. General hydrography of the Homosassa River and surrounding area depicted in United States Geological Survey topographic maps is shown in Figure 2-4. Yobbi and Knochemus (1989) report that the Homosassa River is approximately 200-700 feet wide and five feet deep in the upstream reach and about 1,000 feet wide and 15 to 20 feet deep at the mouth. Artificial channels associated with drainage and access improvement are common in the upper half of the river. The lower portion of the river is connected to a number of tidal creeks and bayous, including Price Creek, Salt River, Sams Bayou and False Channel to the north and Otter Creek, Battle Creek and Petty Creek to the south.

The Southeast Fork, which originates from several spring vents, extends about one quarter of a mile downstream to the bridge at West Fishbowl Drive and another 400 feet downstream to its confluence with the Homosassa River, about 0.15 miles downstream from the Homosassa Main Springs pool. The Southeast Fork is a shallow, narrow system, typically less than 100 feet in width in most areas. Halls River originates at Halls River Head Springs and flows approximately 3.2 miles to the bridge at Halls River Road and another 400 feet to join the Homosassa River approximately 0.2 miles downstream from the Homosassa Main Spring complex. The upper portion of Halls River includes several wide pools connected by narrow channels. The lower portion of the river is consistently broader, ranging between 200 and 750 feet in width. Hidden River is located about one and half miles south of the Homosassa River. The narrow river, with channel widths of 50 feet or less, originates at the Hidden River Head Springs and meanders westward for approximately one and a third miles before disappearing into a sink about 0.8 miles east of the headwaters of Mason Creek. Cherry *et al.* (1970) note that flow from Hidden River probably discharges to the Homosassa River.

The Homosassa Main Springs includes three large vents (Nos. 1-3) within a collapsed-cavern feature that has been explored to a depth of about 70 feet (Karst Environmental Services, Inc. 1992, Jones *et al.* 1997, Champion and Starks 2001). Waters discharged from the three vents differ chemically, but may be collectively characterized as brackish (total dissolved solids between 1,000 and 10,000 mg/l at low tide) with water chemistry that may vary with the tidal cycle (Jones *et al*. 1997).

Scott *et al.* (2004) identify three smaller springs that discharge to an approximate 900-foot long run which drains to the Homosassa River a few hundred feet downstream from the Homosassa Main Springs pool. The run originates at Bear Spring, in an approximate 20 by 60 foot pool with a depth of about five feet. Banana Spring discharges to the run from an excavated 40 by 60 foot pool. Downstream, Alligator Spring lies within a larger, 100 by 150 foot pool with an approximate depth between 5 and 8 feet. Blue Hole Spring is located adjacent to the south shore of the Homosassa River just upstream of the river's confluence with the Southeast Fork of the Homosassa River. Scott *et al.* (2004) estimate the spring vent lies under about 15 feet of water and discharges into a steep-sided pool approximately 25 by 75 feet in size.

Homosassa River No. 1 Spring, which may be the spring referred to as Homosassa Unnamed Spring No. 1 by Scott *et al.* (2004), is located along the east shore of the Southeast Fork of the Homosassa River, near the confluence of the Southeast Fork and the Homosassa River. Jones *et al.* (1997) report that the vent for this spring lies under about ten feet of water in an approximated 50-feet diameter depression, and note that water quality of the limited discharge from the vent is probably influenced by the tidal cycle. Homosassa Unnamed Spring No. 2 is located in a cove off the east shore of the Southeast Fork of the Homosassa River. Scott et *al.* (2004) note that the spring pool is approximately 25 feet in diameter with a depth of about 3.1 feet.

Springs in the upper portion of the Southeast Fork of the Homosassa River include Abdoney Spring, Belcher Spring, McClain Spring, Pumphouse Spring, Trotter Main Spring and Trotter No. 1 Spring. Collectively, the springs discharge fresh water with total dissolved solids < 1,000 mg/l (Jones *et al.* 1997) and their water quality is unaffected by tidal cycles (Yobbi 1992). Jones *et al.* (1997) note that some springs in the fork discharge tannin stained water derived from a nearby sunken spring-fed stream that is the likely source of discharge for at Trotter Main Spring, Trotter No. 1. Spring and possible Pumphouse Spring. Scott *et al.* (2004) report that Pumphouse Spring includes at least three vents in an approximate fifteen-foot deep pool. They also note that Trotter Main Spring includes an approximate five-foot long vent that lies under about ten feet of water.

Knochenmus and Yobbi (2001) describe the Halls River Head Spring as a sediment-filled vent in an approximate 200-foot wide pool. Jones *et al.* (1997) and Champion and Starks (2001) report that the pool contains a few sand boils, but not an obvious limestone vent. Yobbi (1992) notes that water discharged from the spring is brackish during low tide with variable water chemistry associated with the tidal cycle. Halls River Spring No. 2 lies about 900 feet downstream from the Head Spring, and discharges through an approximate 1.5-foot diameter vent into a 30 by 40 foot widened pool on the spring run. Approximately 0.7 miles downstream, Halls River No. 1 Spring discharges to the river.

Jones *et al.* (1997) note that Hidden River Head Springs and Hidden River Spring Number 2 consist of small, five-foot diameter circular depressions under about 4 feet of water. Knochenmus and Yobbi (2001) report that Hidden River Head Springs and another area spring referred to as Hidden River Spring Number 6 are small, sediment-filled vents under about five feet of water. The chemistry of water discharged from the Hidden River Head Spring varies with the tidal cycle (Champion and Starks 2001).

Bluebird Spring is located approximately 0.7 miles southeast of the Homosassa Main Springs Pool in a Bluebird Springs Park, which is maintained by Citrus County. The spring discharges through a limestone vent under about 15 feet of water in an approximate 120 by 225 foot pool (Scott *et al.* 2004).

The Homosassa River system lies to the west of the community of Homosassa Springs and the river itself bisects the community of Homosassa (Figure 2-2). Much of the land surrounding the Homosassa River and other components of the Homosassa River system is under public ownership. The Homosassa Main Springs are located in the Ellie Schiller Homosassa Springs State Wildlife Park and are used as a center for injured and orphaned Florida manatees (*Trichechus manatus latirostris*). An underwater observatory located in the Main Springs pool affords park visitors with the opportunity to view manatees and other aquatic organisms in their element (Figure 2-5). In addition to the Ellie Schiller state park lands, much of the land surrounding Halls River and portions of the Homosassa River are included in the Crystal River Preserve State Park. A smaller unit of the State Park system, the Yulee Sugar Mill Ruins Historic State Park, is located near the south shore of the Homosassa River, and portions of the Withlacoochee State Forest are also situated in the vicinity of the Homosassa River system. Hidden River, Hidden River Head Spring and Hidden River No. 2 Spring are all located within the District-owned Chassahowitzka Riverine Swamp Sanctuary. Portions of the Homosassa River are contained in the St. Martins Marsh Aquatic Preserve, the Homosassa River/Walker Tract, and the Chassahowtizka and Crystal River National Wildlife Refuges. The entire Homosassa River is classified as an Outstanding Florida Water (Florida Department of Environmental Protection 1996), a State designation associated with enhanced water quality protection criteria.

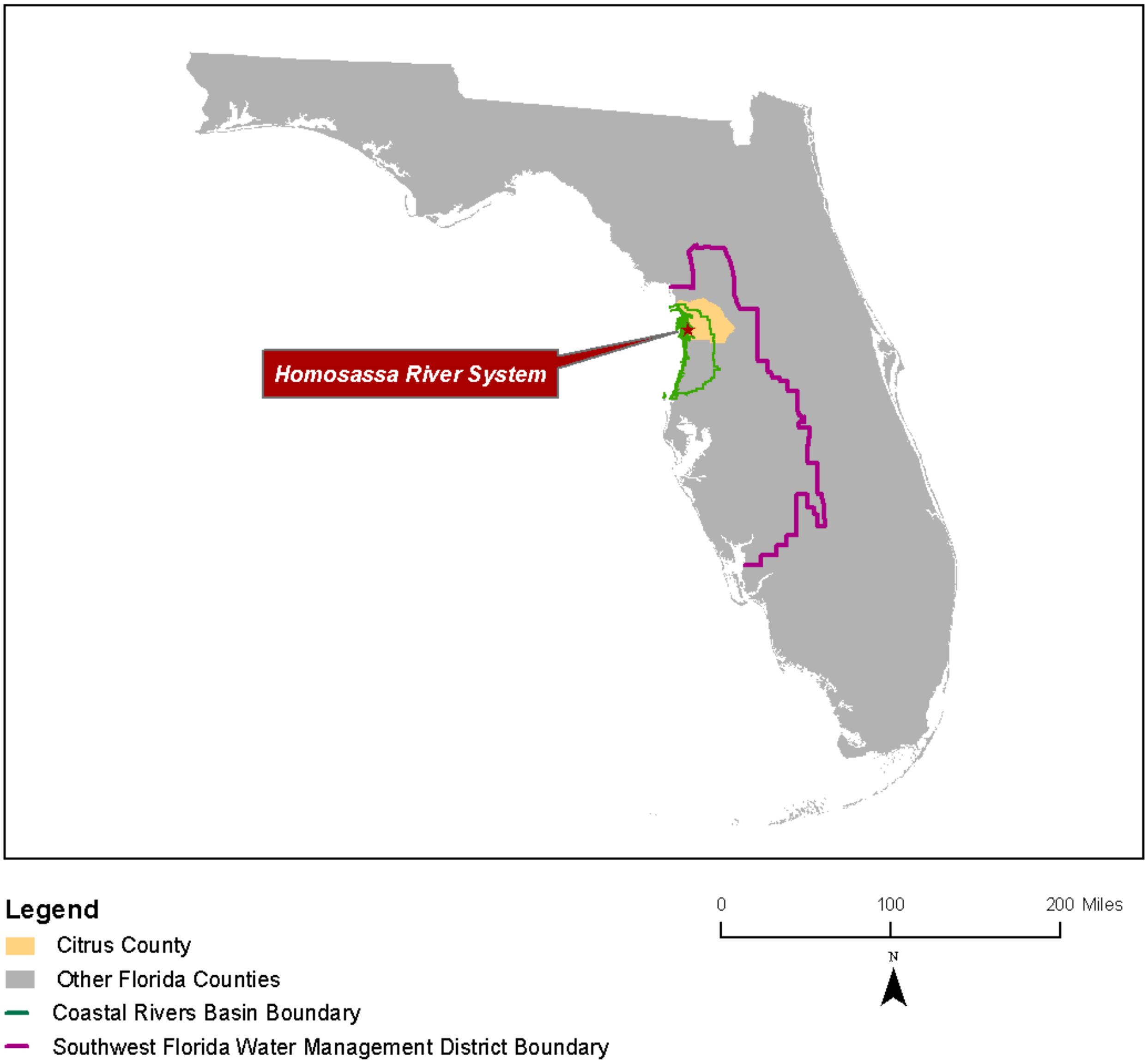


Figure 2-1. Location of the Homosassa River system in Citrus County, Florida. Boundaries of the Southwest Florida Water Management District and the Coastal Rivers Basin of the District are also shown (image data sources: Southwest Florida Water Management District 2003c, 2003d, 2009).

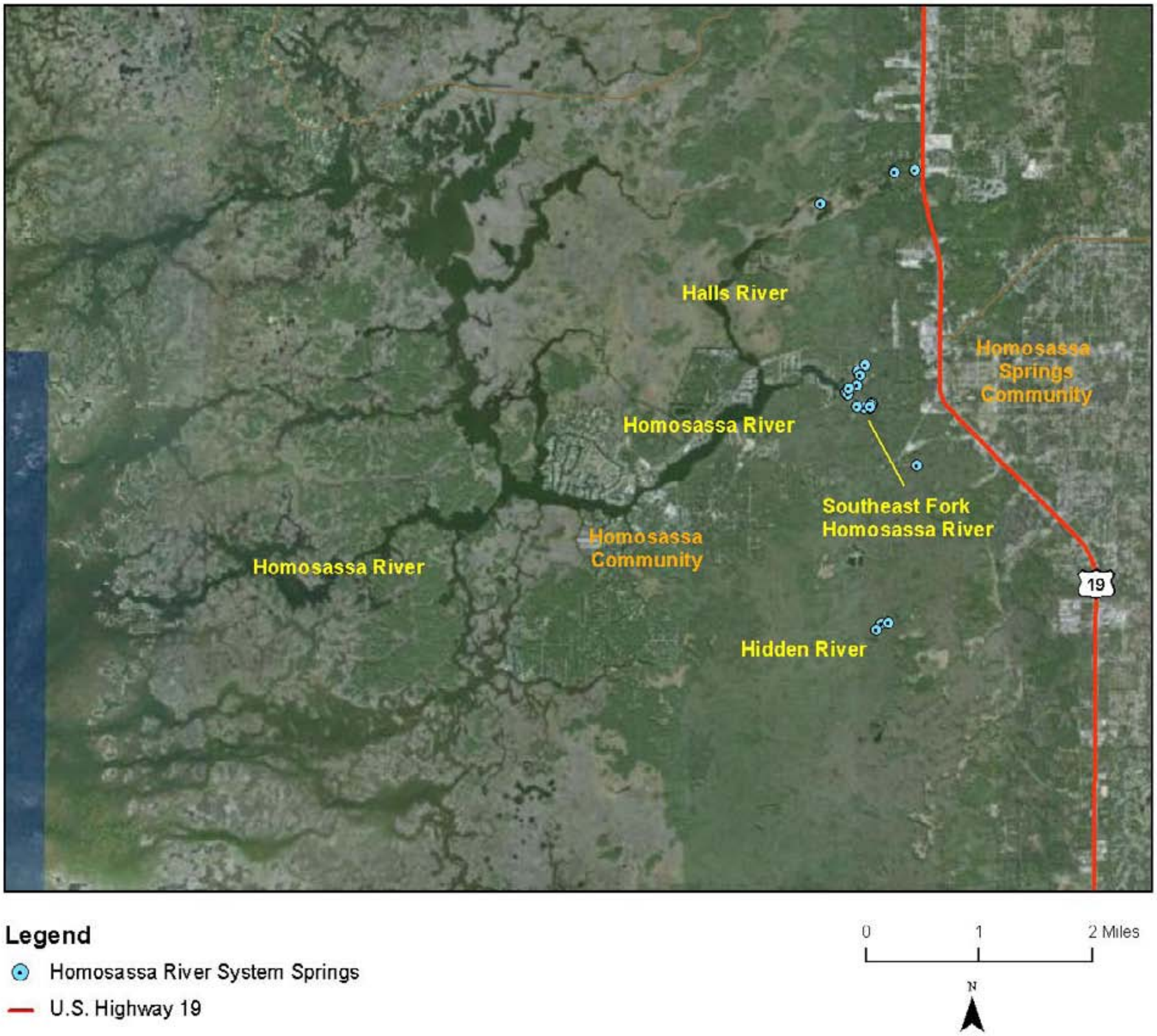


Figure 2-2. Aerial photograph showing the communities of Homosassa and Homosassa Springs and the Homosassa River system, which is defined for this report as the Halls River, Homosassa River, Southeast Fork of the Homosassa River, Hidden River and springs associated with these rivers (see Figure 2-3 for names of system springs)(photographic image source: Woolpert, Inc. 2009).

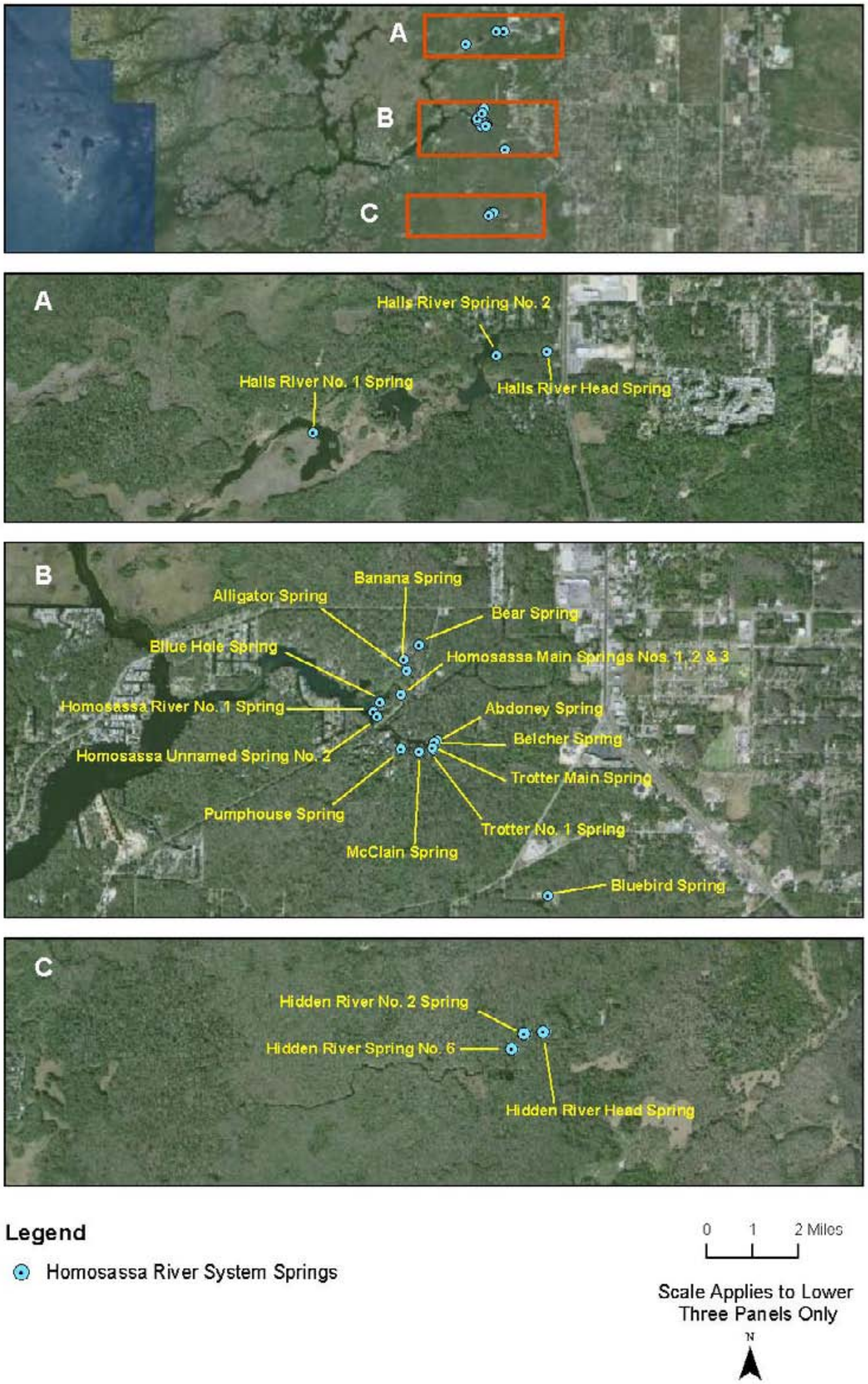


Figure 2-3. Named springs of the Homosassa River system. Upper panel shows relative location of areas shown in the lower three panels (image data sources: Southwest Florida Water Management District 2002a, Woolpert, Inc. 2009).

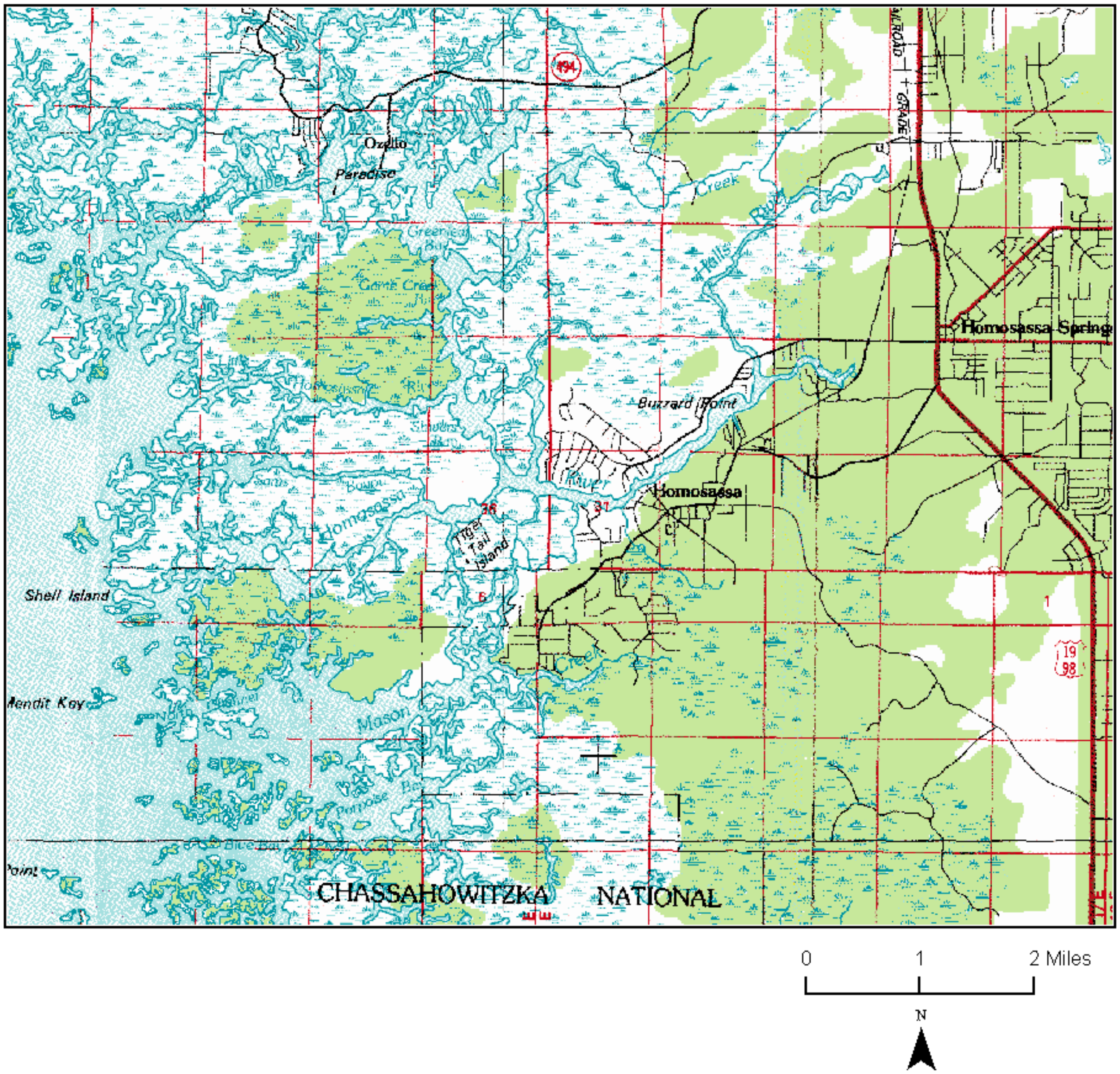


Figure 2-4. United States Geological Survey hydrography in the vicinity of the Homosassa River system (image source: Southwest Florida Water Management District 2002b).

Figure 2-5. The fish bowl observatory and manatees at the Homosassa Main Springs pool in the Ellie Schiller Homosassa Springs State Wildlife Park in 2003 (image source: Southwest Florida Water Management District files).

Physiography, Watershed and Springshed

The Homosassa River system extends across three of the state's physiographic regions described by White (1970). Springs at the system headwaters lie within the Northern Gulf Coastal Lowlands, which includes sand covered scarps and terraces that reflect former marine shorelines and which rise from sea level to about 100 feet above sea level. Downstream, the system courses through the Coastal Swamps region, an area where land surfaces are typically less than ten feet above mean sea level. The lower reach of the system is included in the Drowned Karst region, an area of karst topography that has been inundated by rising sea level. Brooks (1981) categorized the area in which the Homosassa River system lies as the Chassahowitzka Coastal Strip of the Big Bend Karst in the Ocala Uplift Physiographic District, and described the region as "[a] very low coastal strip of limestone rocklands mostly covered by hardwoods and swamps" with some flatwoods. Brooks also notes that the Big Bend Karst area is an erosional limestone plain, with low sandy hills and few beaches.

The Homosassa, Southeast Fork of the Homosassa and Halls rivers lie within the Homosassa River drainage basin of the Upper Coastal Areas watershed, as delineated in accordance with the United States Geological Survey Hydrologic Unit Classification system (Florida Department of Environmental Protection 2004a, b). The drainage basin or watershed extends over approximately 55.6 square miles in Citrus County (Figure 2-6). Hidden River occurs within the Direct Runoff to Gulf drainage basin, an area that includes 61.5 square miles of Citrus County. Few surface water courses occur within the karst landscape of this region, so it is likely that surface runoff from only a small portion of the Homosassa River and Direct runoff to Gulf drainage basins makes its way directly to the channels of the Homosassa, Southeast Fork, Halls and Hidden Rivers. Much of the flow in these rivers likely arises instead from spring discharge derived from the system's ground-water basin, or springshed. Knochenmus and Yobbi (2001) inferred ground-water flow patterns from potentiometric-surface maps of the Upper Floridan Aquifer system in the Springs Coast area and developed approximate ground-water basin boundaries for the region. The ground-water basin for the Homosassa River system depicted in Figure 2-6 was developed based on figures presented in Knochenmus and Yobbi (2001) and extends over approximately 270 square miles in Citrus and Hernando counties. Basso (2010) developed a similar estimate of 292 square miles for the ground-water basin based on approximation of the basin boundaries presented by Knochenmus and Yobbi.

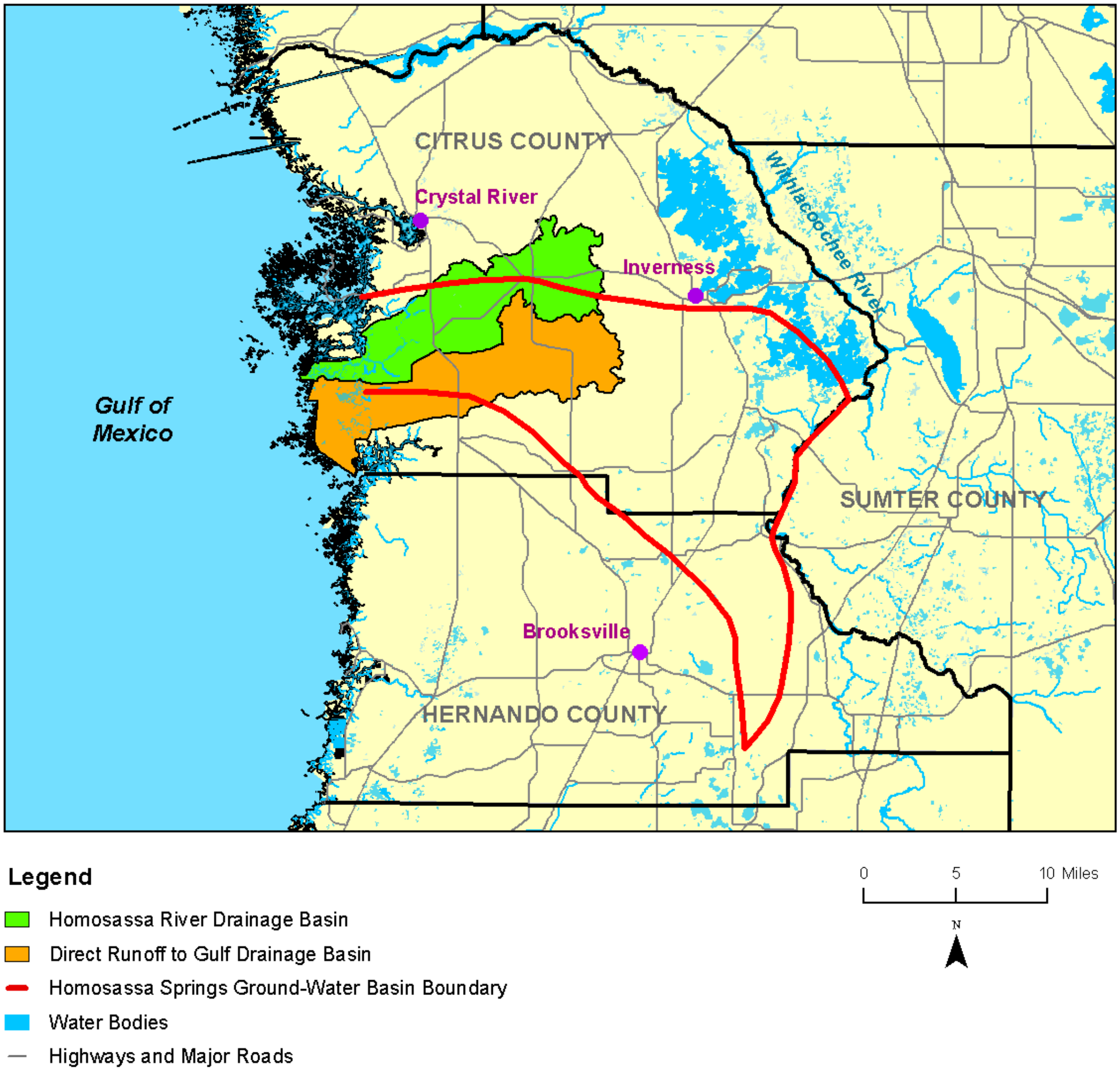


Figure 2-6. Homosassa River and Direct Runoff to Gulf drainage basins as delineated by the United States Geological Survey (Florida Department of Environmental Protection 2004a) and approximate location of the Homosassa Springs ground-water basin boundary as adapted from Knochenmus and Yobbi (2001). The Homosassa, Southeast Fork of the Homosassa and Halls rivers lie within the Homosassa River Drainage Basin. Hidden River is located in the Direct Runoff to Gulf drainage basin.

Watershed Land Use and Cover

Land use and cover in the Homosassa River basin of the Homosassa River system currently includes a mix of urbanized or developed lands, agricultural lands, forested uplands, wetlands and water (Figure 2-7). Based on the Florida Land Use, Cover and Forms Classification System (Florida Department of Transportation 1999), urban and built-up lands and those used for transportation, communication and utilities in 2008 accounted for thirty-six percent of the 35,637 acres within the Homosassa River Basin (Table 2-1). Lands classified as upland forest accounted for twenty-nine percent of the basin area and water and wetlands accounted for twenty-six percent of the landscape. Urbanized areas include the community of Homosassa and other areas adjacent to the Homosassa River, the communities of Homosassa Springs, which is located primarily east of U.S. Highway 19, and an area of Citrus County northwest of the City of Inverness.

Changes in land use and cover within the Homosassa River basin were evaluated using geographic information system layers representing land use/cover classifications for the area in 1990, 1995, 1999 and 2004 through 2008 (Southwest Florida Water Management District 2003a,b, 2004a, 2007a,b,c, 2008a, 2010). For the analyses, ESRI ArcMap software was used to clip land use/cover layers to the boundaries delineated by the Homosassa River Drainage Basin. With the exception of the Urban and Built-Up and Upland Forest land use/cover classes, land use/cover in the watershed exhibited little change in the years examined between 1990 and 2008 (Table 2-1). Increases in urbanized lands have been associated primarily with decreases in forested uplands.

Table 2-1. Land use/cover by acre in the Homosassa River Drainage Basin, *i.e.*, watershed, for selected years based on Land use/cover classes of the Florida Land Use, Cover and Forms Classification System.

Land Use/ Cover Class	1990 Acres	1995 Acres	1999 Acres	2004 Acres	2005 Acres	2006 Acres	2007 Acres	2008 Acres
Urban and Built-Up	10,533	10,909	11,295	11,854	11,904	12,094	12,160	12,329
Agriculture	3,399	3,095	2,859	2,984	2,579	2,679	2,650	2,609
Rangeland	14	86	81	421	421	421	421	421
Upland Forest	12,089	11,954	11,646	10,584	10,884	10,640	10,592	10,475
Water	1,270	1,300	1,298	1,297	1,297	1,302	1,307	1,307
Wetlands	7,804	7,795	7,797	7,832	7,828	7,824	7,826	7,823
Barren Land	218	198	189	196	254	208	208	197
Transportation, Communication and Utilities	309	299	472	469	469	469	473	475
Total Acres	**35,637**							

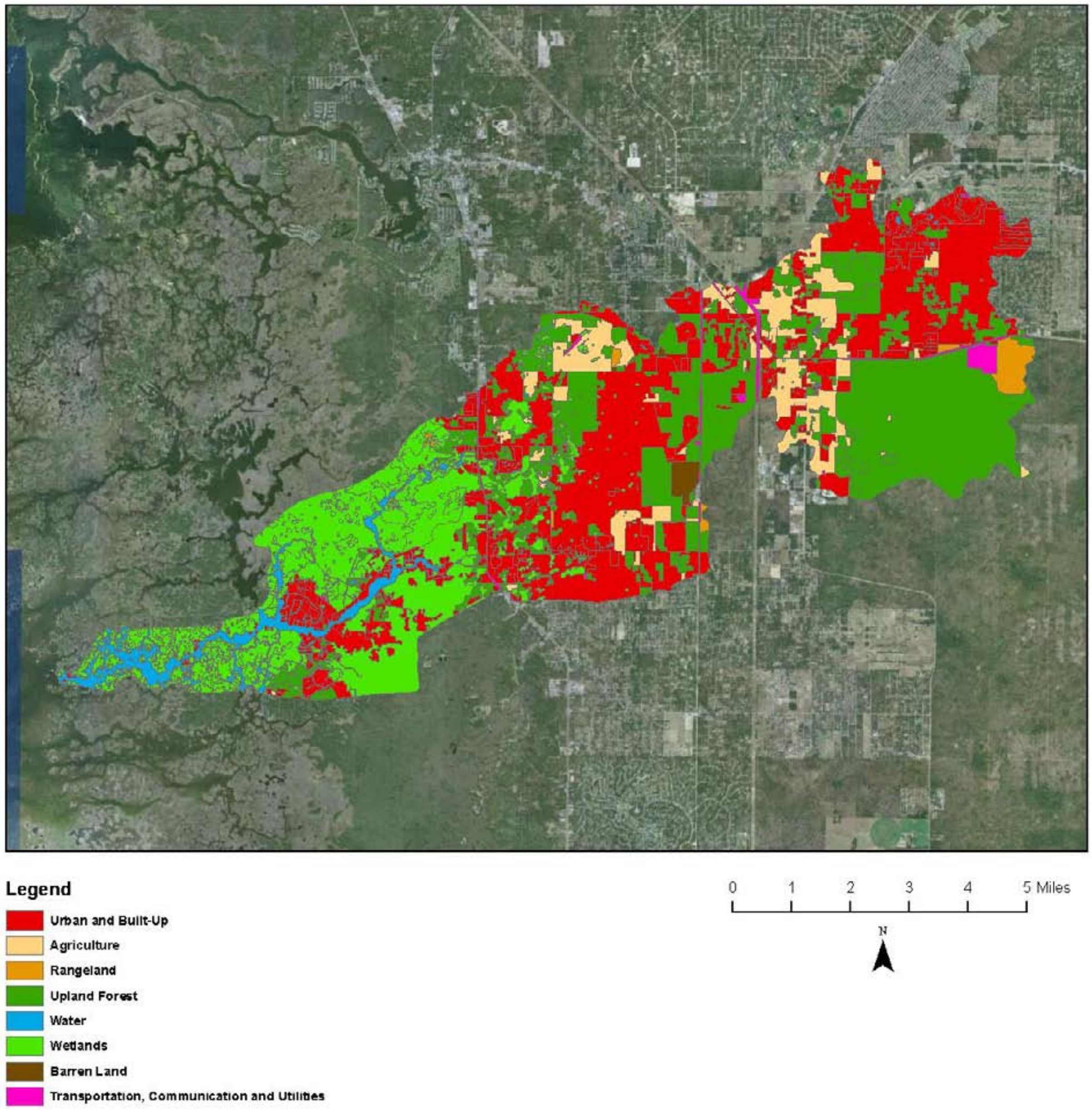


Figure 2-7. Land use–cover in the Homosassa River Drainage Basin in 2008, based on the Florida Land Use, Cover and Forms Classification System (image sources: Woolpert, Inc. 2009, Southwest Florida Water Management District 2010).

Hydrology

Data Sources for Hydrologic Information

Hydrologic information presented in this section is based on previously published reports and analyses completed specifically for development of minimum flow recommendations outlined in this report. Primary data sources for the analyses completed specifically for development of the recommend minimum flows included the District Water Management Information System, the United States Geological Survey National Water Information System, the National Weather Service and the Florida Automated Weather Network.

A number of agencies record and maintain rainfall and other meteorological records in the west-central Florida region. The Southwest Florida Water Management District currently tabulates rainfall summaries by specific geographic areas, including drainage basins and counties within the District, using NEXRAD (Next-Generation Radar) data obtained from the National Weather Service. Area-weighted monthly total rainfall values tabulated for Citrus County for the period from 1915 through 2009 were used for characterization of general rainfall patterns in the vicinity of the Homosassa River system. In addition, meteorological data used for modeling hydrologic conditions in the Homosassa River were obtained from the Florida Automated Weather Network (FAWN), which is maintained by the University of Florida Institute of Food and Agricultural Sciences (IFAS) and is supported, in part, by the District. Records used for the analyses included wind speed and direction information and air temperatures measured at the FAWN-IFAS Brooksville site, which is located at the United States Department of Agriculture Brooksville Subtropical Agricultural Station.

With support from the District and the Florida Department of Environmental Protection, the United States Geological Survey maintains six surface-water gage sites where surface water levels, discharge and various water quality parameters are currently or have recently been monitored in the Homosassa River system (Table 2-2, Figure 2-8). Daily stage or gage height, *i.e.,* water level, records are available for each of the six sites, which are named Homosassa Springs at Homosassa Springs FL, Southeast Fork Homosassa Spring at Homosassa Springs FL, Halls River near Homosassa, FL, Homosassa River at Homosassa FL, Homosassa River at Shell Island near Homosassa FL, and Hidden River near Homosassa FL. Daily discharge estimates are available for four of the sites, including the gages at Homosassa Springs, the Southeast Fork, Homosassa River and Hidden River. Water quality parameters are currently or up until recently have been measured at all of the sites. In addition to the records for daily stage, discharge and other parameters, measurements of stage, specific conductance and water temperature collected at fifteen-minute intervals are available for five of the sites. Discharge estimates are also available for fifteen-minute intervals for the Homosassa Springs, SE Fork and Homosassa River sites.

Period of record daily parameter values for each of the six surface water gage sites were obtained from the United States Geological Survey National Water Information System Web Interface in March 2010 and used to prepare much of the summary information presented in this minimum flows report. Some analyses and summary information presented in the report are based on fifteen-minute-interval data collected through September 30, 2008 that were obtained from the USGS by HSW Engineering, Inc.

Records or data available from the USGS include those that have been “approved” for publication, following agency processing and review, and those classified as “provisional” and subject to revision. Although both USGS approved and provisional data are presented in some portions or figures contained in this report, only approved data were used for data summaries and analyses associated with development of the recommended minimum flows for the Homosassa River system.

The USGS maintains two wells in the vicinity of the Homosassa River system that are used to monitor water levels in the Upper Floridan Aquifer and which are relevant to the information presented in this report. The Weeki Wachee Well near Weeki Wachee FL (Site Number 283201082315601) is used to estimate discharge at the Homosassa Springs at Homosassa Springs FL and Southeast Fork Homosassa Spring at Homosassa Springs FL gage sites. The well is located about 13 miles south of Homosassa Springs, near Weeki Wachee Springs in Hernando County. Water surface elevations are available for this well from June 15, 1966 through the current date, with USGS-approved data available through December 7, 2009. The Weeki Wachee Well Records for the well were obtained from the USGS by HSW Engineering, Inc. to support their hydrologic modeling efforts, which are described in later sections of this report. The second well of interest to the development of minimum flows for the Homosassa River system is the Homosassa Well 3 near Homosassa FL (Site Number 284551082345301). This well is used to estimate discharge at the Hidden River near Homosassa FL site and is located approximately 0.4 miles southeast of the Hidden River gage site. The period of record for water levels in the well extends from January 25, 1967 to the current date, with approved data available through December 9, 2009.

Table 2-2. Summary information for daily records available for United States Geological Survey surface-water gage sites in the Homosassa River system. Periods of record are identified for USGS "approved" and "provisional" data. Additional site records may be available from USGS "field measurement" or "field/lab samples" databases, but are not identified in this table. Information regarding availability of data collected for the sites at fifteen-minute intervals is provided in Appendix A of HSW Engineering, Inc. (2010).

Site Number and Name	Stage or Gage Height Periods of Record	Discharge Periods of Record	Specific Conductance or Salinity Periods of Record	Temperature Periods of Record	Comments
02310678 Homosassa Springs at Homosassa Spring FL	11/02/1988 – 03/16/2010 (provisional prior to 10/10/1996 and after 10/14/2009)	10/18/1995 – 03/16/2010 (provisional after 10/14/2009)	06/28/2004 – 03/16/2010 (provisional after 10/14/2009)	06/28/2004 – 03/16/2010 (provisional after 10/14/2009)	Gage height and discharge records sporadic prior to 01/09/1996. Gage height reported as mean, tidal high and tidal low. Discharge reported as mean. Specific conductance and temperature reported as bottom minimum and maximum.
02310688 SE Fork Homosassa Spring at Homosassa Springs FL	10/01/2002 – 12/28/2009 (provisional after 10/12/2009)	10/01/2000– 03/12/2010 (provisional after 10/12/2009)	05/03/2006 – 03/16/2010 (provisional after 10/12/2009)	05/03/2006 – 03/16/2010 (provisional after 10/12/2009)	Gage height reported as tidal high and tidal low. Discharge reported as mean. Specific conductance and temperature reported as near bottom minimum and maximum.
02310690 Halls River near Homosassa FL	10/27/2000 – 10/12/2009	NA	NA	NA	Gage height reported as mean, tidal high and tidal low.
02310700 Homosassa R at Homosassa FL	10/01/1970 – 01/03/2010 (provisional after 9/30/2009)	06/08/1984 – 03/12/2010 (not filtered for tide) (provisional after 12/12/2009) 05/20/2004 – 09/30/2009 (tidally filtered)	05/05/2006 – 03/16/2010 (top) (provisional after 12/12/2009) 05/18/2006 – 03/16/2010 (bottom) (provisional after 12/12/2009)	05/05/2004 – 03/16/2010 (top) (provisional after 12/12/2009) 05/18/2004 – 03/16/2010 (bottom) (provisional after 12/12/2009)	Gage height reported variously as mean, minimum, maximum and tidal high and low. Stage reported as tidal high and low. Discharge reported as mean. Specific conductance and temperature reported as top and bottom minimum and maximum.
02310712 Homosassa R at Shell Island near Homosassa FL	10/01/1984 – 10/06/2009	NA	09/15/2006 – 10/06/2009	09/15/2006 – 10/06/2009	Gage height reported variously as mean, tidal high and tidal low. Specific conductance and temperature reported as top, middle and bottom minimum and maximum.
02310675 Hidden River near Homosassa FL	NA	10/28/2003 – 03/16/2010 (provisional after 10/14/2009)	NA	NA	Discharge reported as mean.

NA = not available

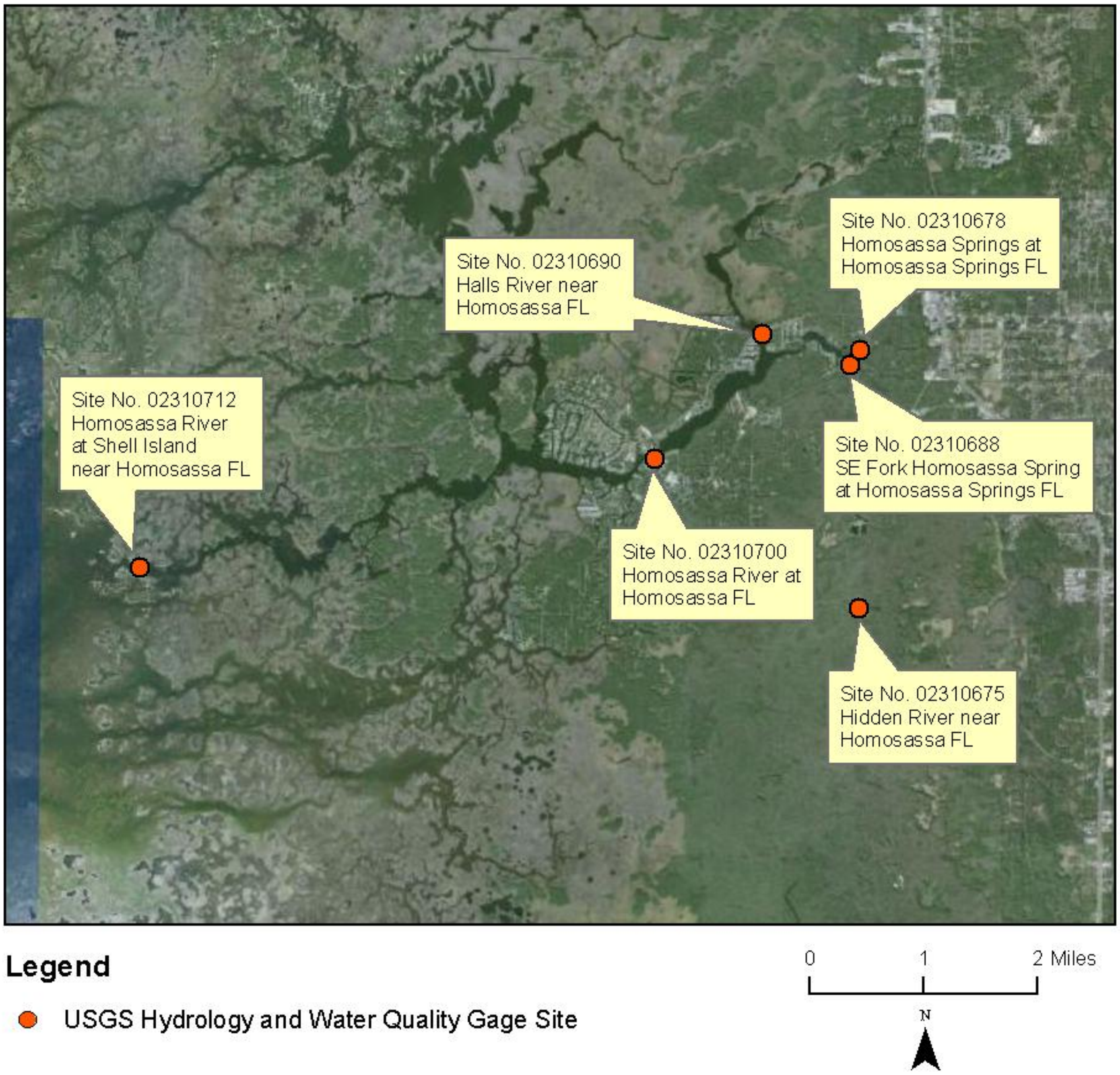


Figure 2-8. United States Geological Survey (USGS) surface-water gage sites in the Homosassa River system (photographic image source: Woolpert, Inc. 2009).

Climate and Rainfall

The climate of coastal Florida in the vicinity of the Homosassa Springs system may be characterized as humid subtropical. Local weather is strongly influenced by the Gulf of Mexico, which moderates winter and summer temperatures. Wolfe (1990b) notes that mean daily summer temperatures are typically in the low 80s (degrees Fahrenheit) along the Springs Coast, which includes coastal areas between the Pithlachascotee River in Pasco County and the Waccasassa River in Levy County. Wolfe also notes that daytime winter temperatures in the area often range into the upper 50s, although they may be considerably lower in response to passing cold fronts.

Based on area-weighted regional records, annual rainfall in Citrus County ranged from 32.1 to 84.6 inches and averaged 54.0 inches from 1915 through 2008 (Figure 2-9, upper panel). Rainfall within the county has typically been highest during the months of June through September (Figure 2-9, lower panel), likely as a result of the significant rainfall that may be associated with convective and tropical storms that occur during these wet-season months.

Knochenmus and Yobbi (2001) estimated an annual average evapotranspiration rate of 32 inches per year from the Homosassa Springs ground-water basin, based on a water budget developed for the two-year of 1997 and1998. Cherry *et al.* (1970) note that evaporation in the region is highest in May and June, prior to and during the early phase of the summer wet season.

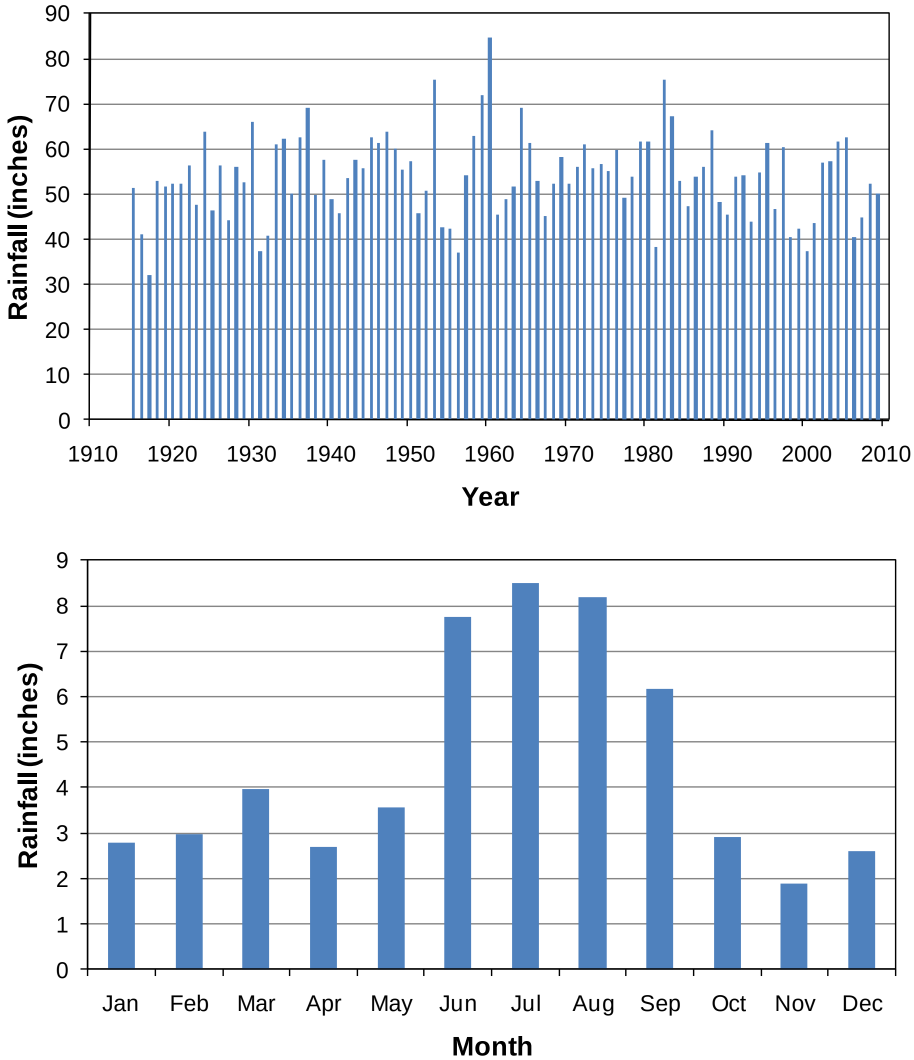


Figure 2-9. Area-weighted annual (upper panel) and monthly mean (lower panel) rainfall for Citrus County between 1915 and 2009 (data source: Southwest Florida Water Management District Rainfall Data Summaries web page at *http://www.swfwmd state.fl.us /data/ wmdbweb/rainfall_data_summaries. php*).

Stage and Tides

Tides in the vicinity of the Homosassa River system may be classified as mixed semidiurnal; higher and lower high tides and higher and lower low tides may occur in a single day. The diurnal tidal range is about two feet at the mouth of the Homosassa River near Shell Island (Yobbi and Knochenmus 1989) and tidal influence on stage or gage height is evident throughout the Homosassa River system (Figure 2-10). Daily high and low water levels at gage sites in the Homosassa River and Halls River are highly correlated (HSW Engineering, Inc. 2010; included in this report as Appendix A). Figure 2-11 provides an example of the relationship between gage heights at Shell Island and the upstream gage sites. These values are not converted to elevations relative to the North American Vertical Datum of 1988 (NAVD88) so that better separation can be seen between the gages for plotting purposes.

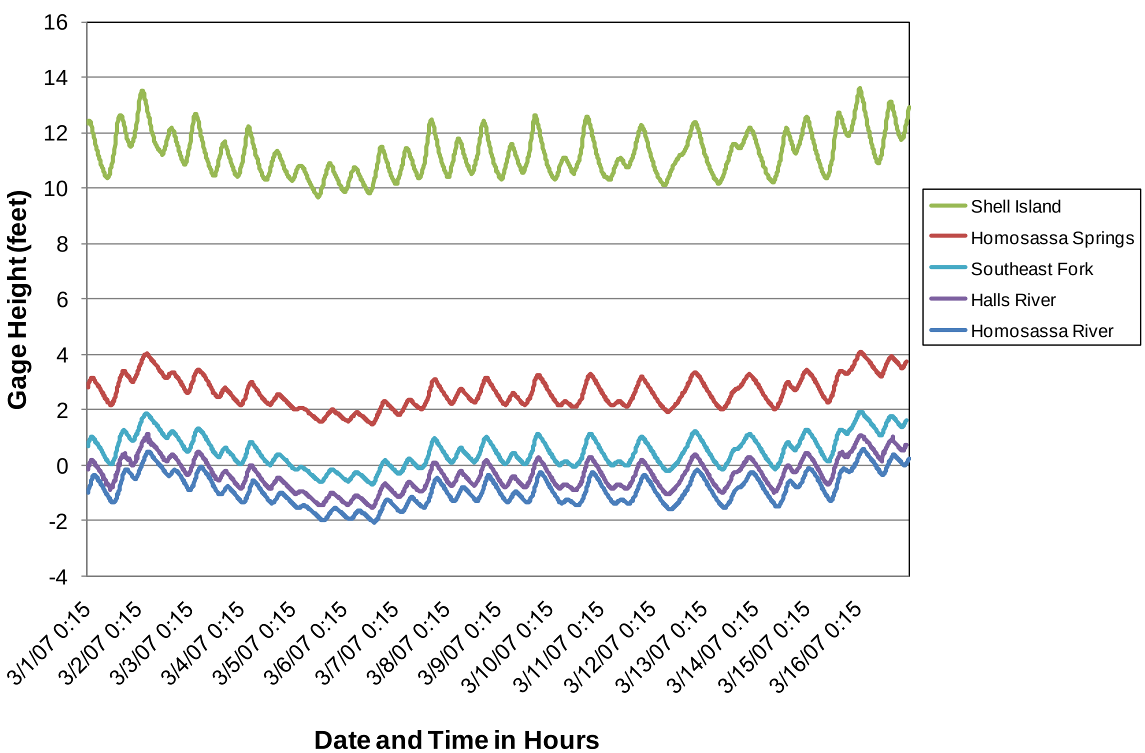
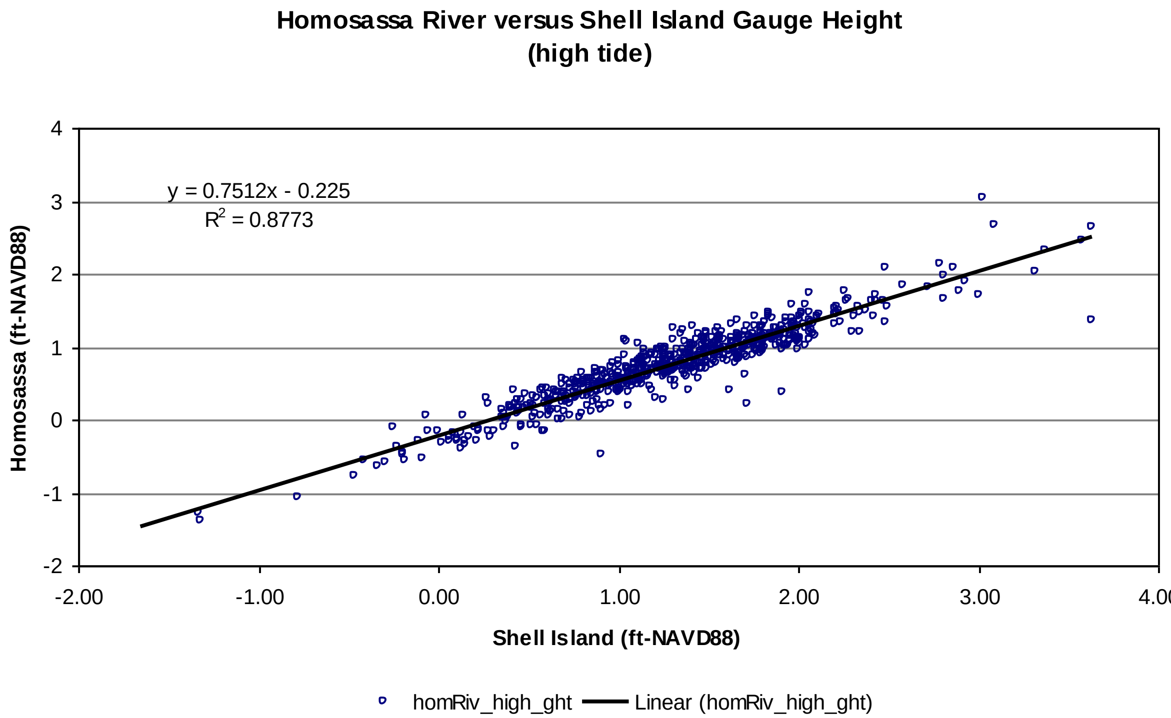


Figure 2-10. Time-series of fifteen-minute gage height records showing tidal influence at the United States Geological Survey Shell Island, Homosassa River, Halls River, Homosassa Springs and the Southeast Fork Homosassa Springs gage sites from March 1 through March 16, 2007. Gage datum values to convert gage heights to elevations relative to NAVD88 vary among sites.



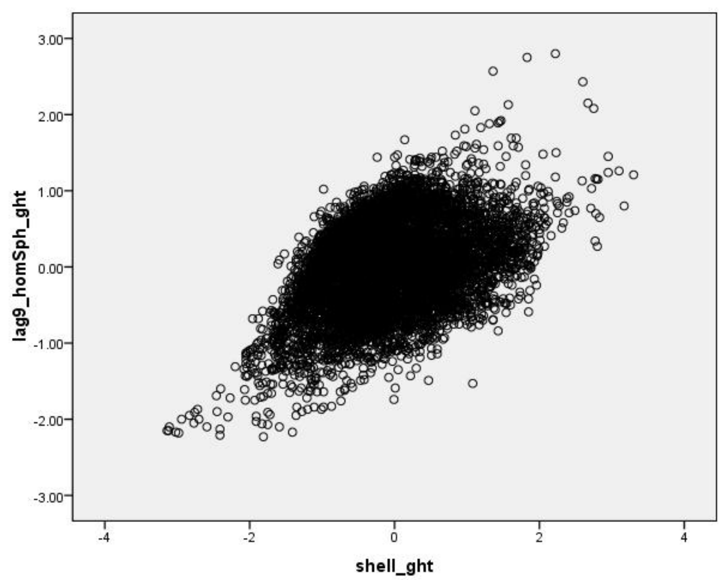


Figure 2-11. Relationship between gage heights for the Homosassa River at Shell Island near Homosassa FL, Homosassa Springs at Homosassa Springs FL, and Homosassa River at Shell Island near Homosassa FL gage sites. Upper panel shows the relationship for daily high tide gage heights; lower panel shows relationship for 15-minute gage heights with the springs gage height lagged 2.25 hours behind the Shell Island gage height. Panels reproduced from HSW Engineering, Inc. (2010).

Tidal fluctuations in the vicinity of the Homosassa River system vary seasonally, with higher low and median tides occurring during late spring and summer, and lower low and median tides occurring in the winter (Figure 2-12). This typical seasonal shift in tides contributes to seasonal discharge patterns in the spring/river system (see next section). Some of the highest recorded high tides, however, been observed during fall and winter months, likely due to wind driven tides due the passing of frontal systems

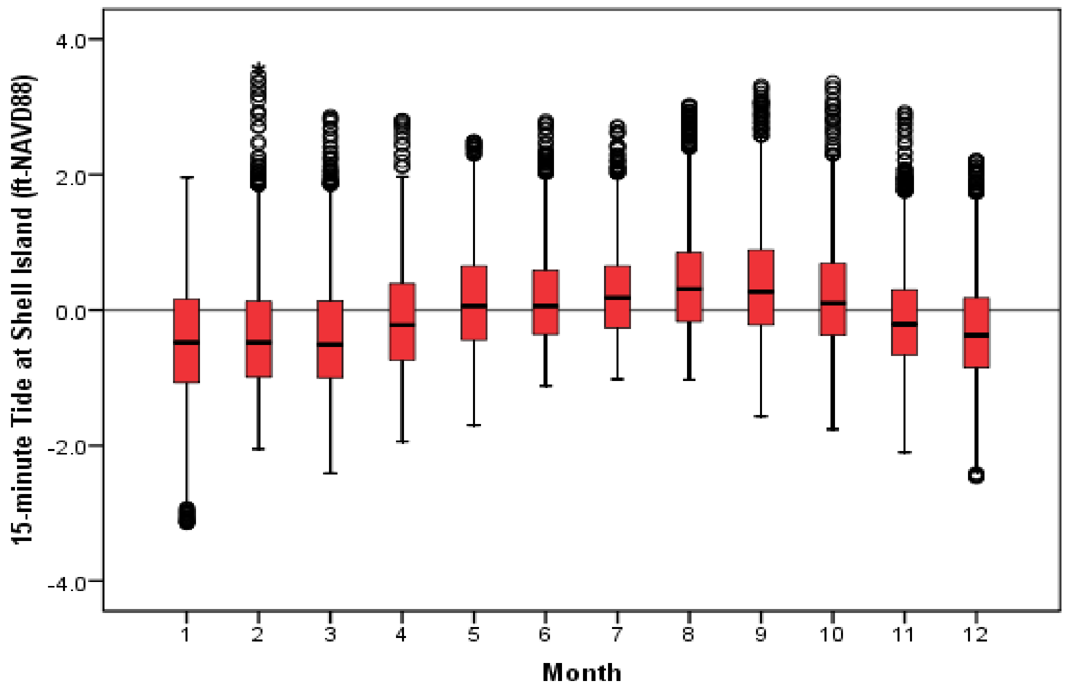


Figure 2-12. Box plot of fifteen-minute tidal stage at Shell Island summarized by month (1-12). Plot reproduced from HSW Engineering, Inc. (2010).

Discharge

Mean daily discharge reported by the USGS for the Homosassa Springs at Homosassa FL gage site is derived by averaging 96 daily discharge estimates based on fifteen-minute interval gage heights at the spring and hourly groundwater levels at the Weeki Wachee Well near Weeki Wachee FL site. Discharge at the Homosassa Springs gage site has varied only moderately during the period of record (Figure 2-13), with approved mean daily discharge values ranging from 34 to 141 cfs and average and median values of 89 and 88 cfs, respectively (Table 2-3).

Discharge from the spring tends to be lowest in late spring and early summer (Figure 2-14), likely as a result of the higher median and low tides during this period. Lower tides in the winter exert less hydraulic head pressure over the spring vents, thus allowing greater spring discharge relative to higher tide conditions. Simple linear regression of

USGS approved daily discharge values indicates a significant negative linear trend ($p<0.001$) over the relatively short period of record (regression information not shown in Figure 2-13). However, this trend appears to be influenced by low flows that were observed after the summer of 2006, when there was a period of deficit rainfall in the region (SWFWMD 2010b).

Using an approach similar to that used for the Homosassa Springs gage site, mean daily discharge at the Southeast Fork Homosassa Spring at Homosassa Springs FL gage site is calculated from fifteen-minute interval discharge estimates based on the gage height at the site and the water level in the Weeki Wachee well. Reported discharge at the Southeast For gage site has varied only moderately, ranging from 23 to 100 cfs, with average and median values of 61 and 60 cfs, respectively (Figure 2-15, Table 2-3). The seasonal pattern of flows from the Southeast Fork gage is similar to the Homosassa Springs gage with the highest flows in the winter and lowest flows in the late spring and early summer.

Mean daily discharge at the Homosassa River at Homosassa FL gage site is calculated using fifteen-minute interval discharge estimates based on measured gage height and a rating curve for site. An Acoustic Doppler Current Profiler, which is effective at measuring downstream and upstream flow, is used to develop the streamflow rating relationships. Discharge estimates for the site are reported as unfiltered values and values that are filtered in an attempt to remove tidal influence (Figure 2-16). Filtered discharge at the site ranged from -636 to 2,090 cfs; mean and median values for the period of record were 272 and 251 cfs, respectively. Negative values in the record suggest that tidal influences are not completely accounted for in the method used to transform the unfiltered records. However, prolonged onshore prevailing winds can contribute to upstream tidal flow and negative discharge values.

Daily discharge values are not reported by the USGS for the Halls River near Homosassa FL gage site. However, discharge may be approximated for Halls River by subtracting combined discharge from the Homosassa Springs and Southeast Fork sites from the reported filtered discharge at the Homosassa River gage. Calculated in this manner, the resulting discharge estimates include ungaged spring and diffuse groundwater discharge to the river above the Homosassa River gage, surface runoff to the river, and error associated with incomplete filtering of tidal influences on the Homosassa River discharge records (HSW Engineering, Inc. 2010). Mean daily discharge for the Halls River was estimated to range from -765 to 1,195 cfs with mean and median values of 129 and 108 cfs, respectively (Figure 2-17, Table 2-3).

Mean daily discharge at the Hidden River near Homosassa FL gage site is calculated using the daily maximum water level and a rating curve for the site and water level in the USGS Homosassa Well 3 near Homosassa FL. Daily mean discharge at the site ranged from 1.3 to 25 cfs, with a mean and median value of eight cfs (Figure 2-18, Table 2-3).

Table 2-3. Summary statistics for mean daily discharge records approved by the United States Geological Survey for Homosassa River system gage sites. Values are expressed as cubic feet per second (cfs) unless specified. Periods of record for approved data are listed by gage site in Table 2-2.

Statistic (cfs or N)	Homosassa Springs at Homosassa Springs FL	SE Fork Homosassa Spring at Homosassa Springs FL	Combined Springs[a]	Halls River[b]	Homosassa River at Homosassa FL (tidally filtered)	Hidden River near Homosassa FL
Maximum	141	100	240	1,995	2,090	25.0
75th Percentile	98	68	165	200	350	11
Median	88	60	147	108	251	8.0
25th Percentile	79	53	131	28	167	4.6
Minimum	34	23	57	-765	-636	1.3
Mean	89	61	149	129	272	8.0
Standard Deviation	14	11	26	181	183	4.4
Number (N) of daily Records	4,975	3,123	3,102	1,662	1,774	2,063

[a] Combined Springs discharge determined as the sum of the Homosassa Springs at Homosassa FL and SE Fork Homosassa Spring at Homosassa Springs FL discharge for days when records were available for both sites.

[b] Halls River discharge estimated by subtracting combined springs discharge from tidally filtered Homosassa River at Homosassa FL discharge for days when records were available for the two spring sites and the Homosassa River site.

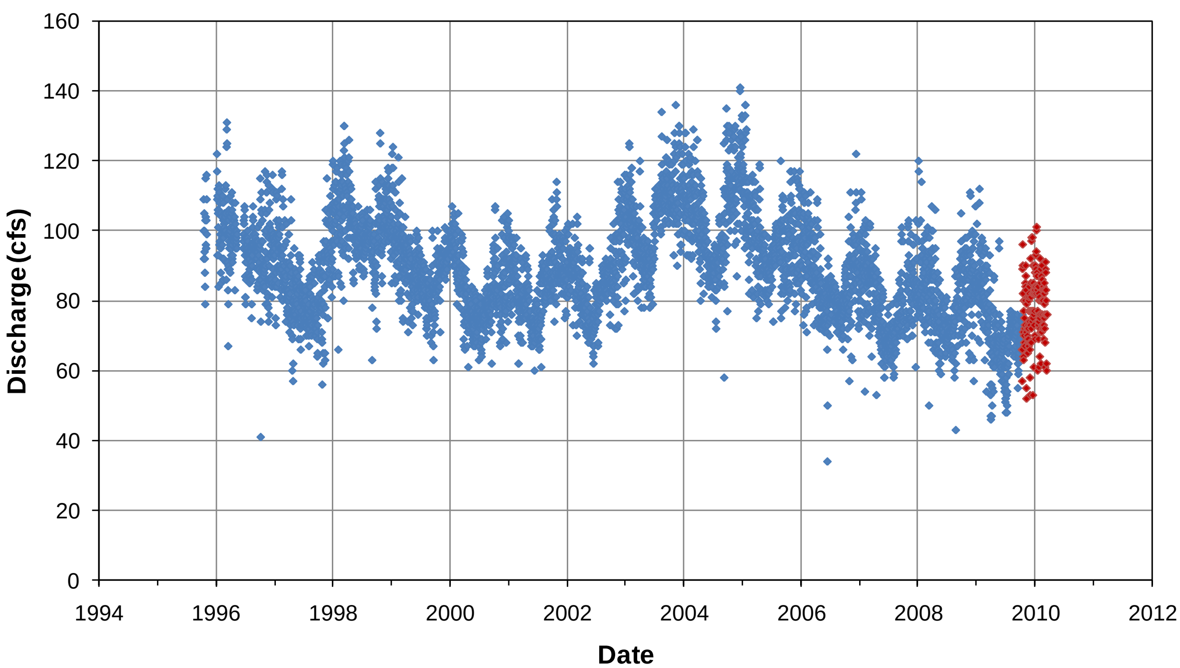


Figure 2-13. Period of record daily mean discharge time series for the United States Geological Survey Homosassa Springs at Homosassa Springs FL gage site (number 02310678). Values approved by the USGS are shown in blue; provisional values are shown in red.

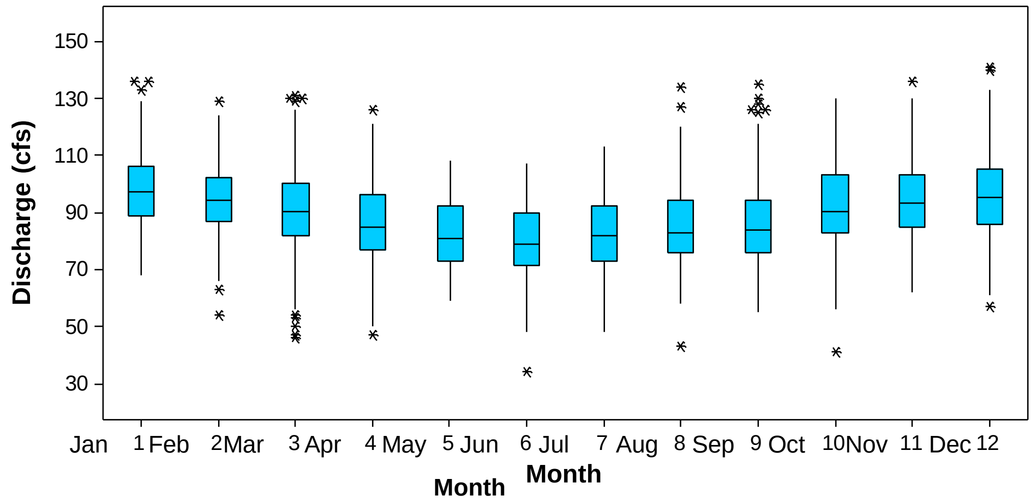


Figure 2-14. Box plot of monthly mean discharge values for the United States Geological Survey Homosassa Springs at Homosassa Springs FL gage site (number 02310678), based on compilation of USGS approved period of record daily values.

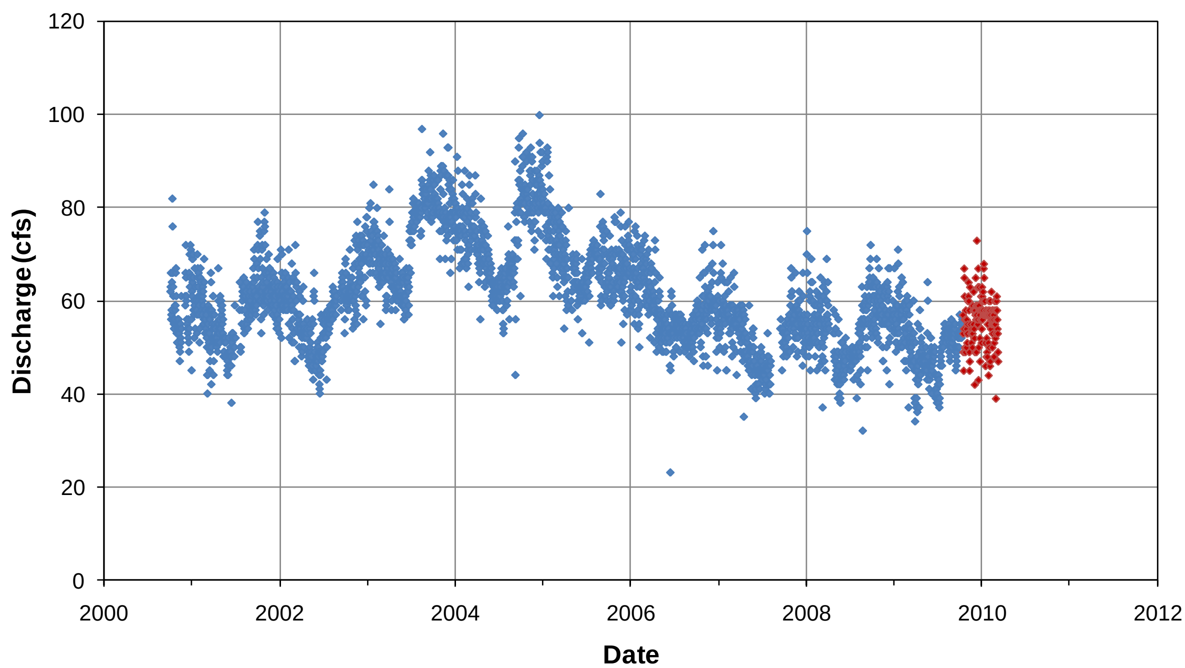


Figure 2-15. Period of record daily mean discharge time series for the United States Geological Survey SE Fork Homosassa Springs at Homosassa Springs FL gage site (number 02310688). Values approved by the USGS are shown in blue; provisional values are shown in red.

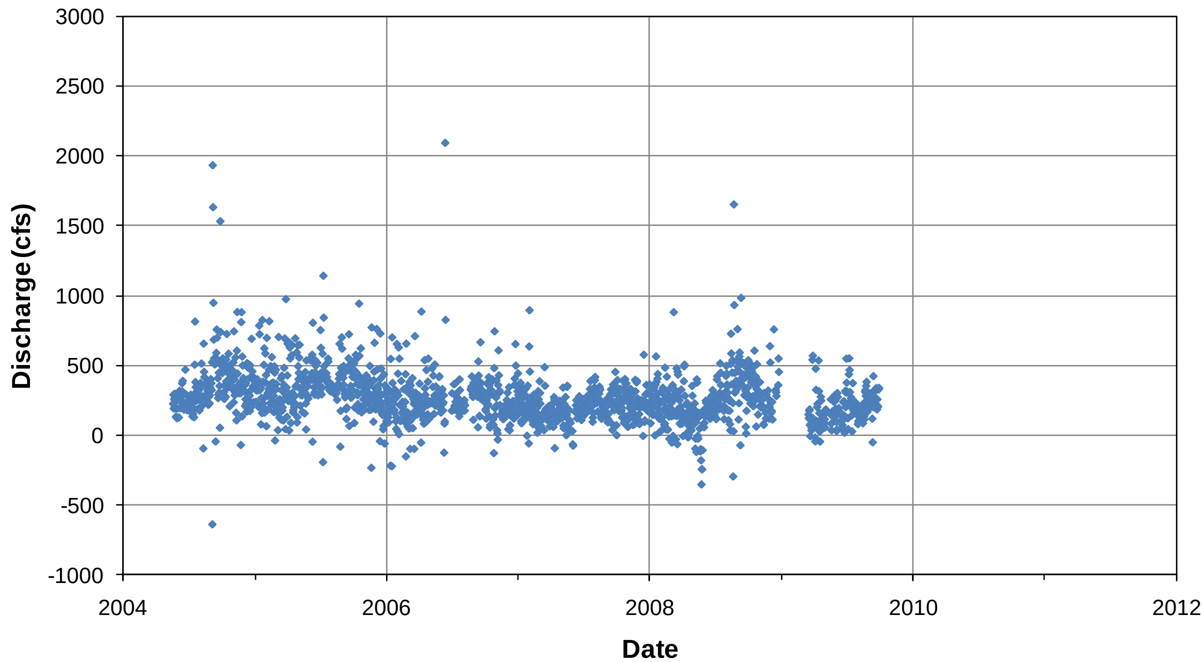


Figure 2-16. Period of record daily mean tidally-filtered discharge time series for the United States Geological Survey Homosassa River near Homosassa Springs FL gage site (number 02310690).

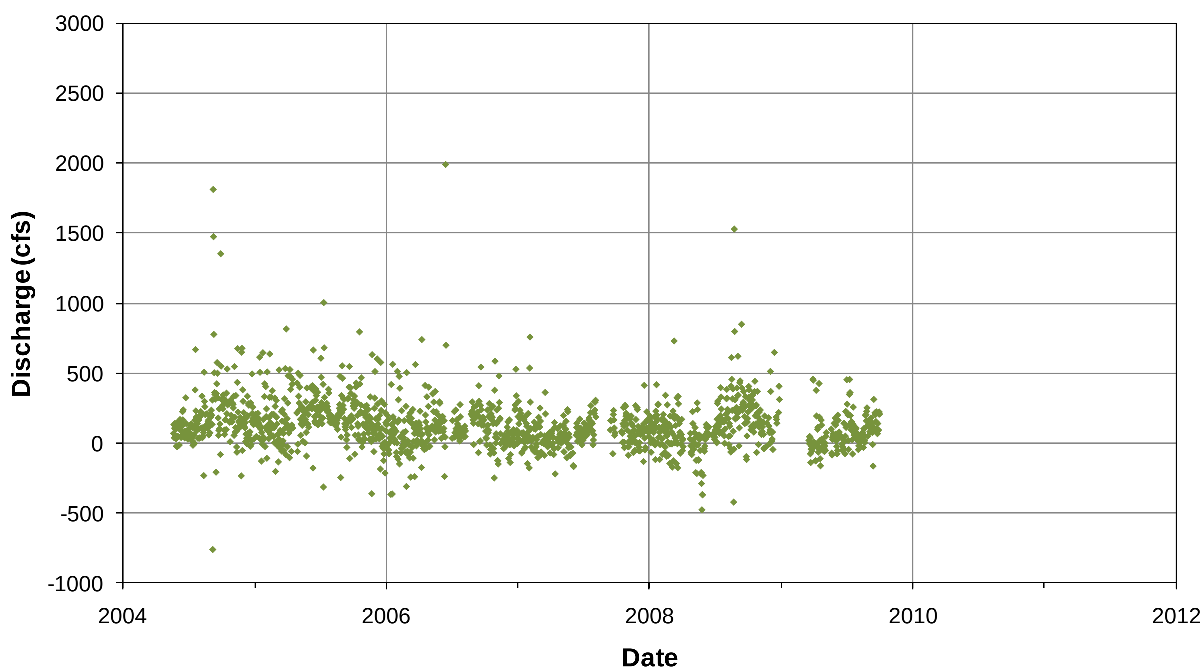


Figure 2-17. Estimated daily mean tidally-filtered discharge time series for Halls River. Values estimated by subtracting approved discharge records for the Homosassa Springs at Homosassa Springs FL and SE Fork Homosassa Springs at Homosassa Springs FL gage sites from the records for the Homosassa River near Homosassa Springs FL gage site.

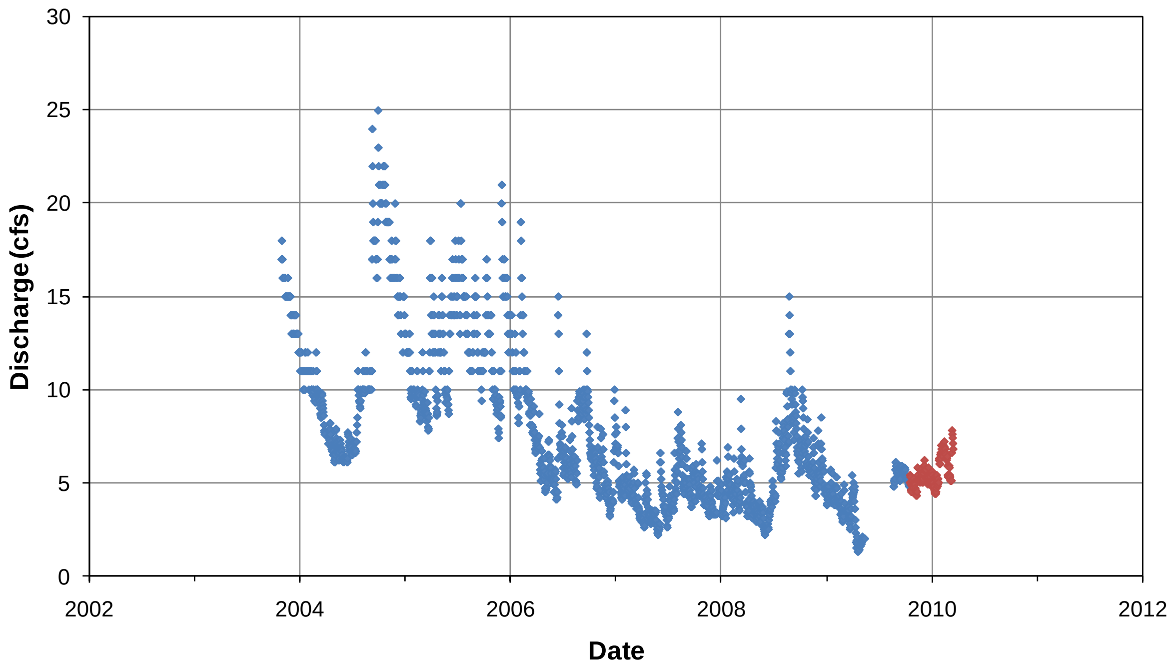


Figure 2-18. Period of record daily mean discharge time series for the United States Geological Survey Hidden River near Homosassa Springs FL gage site (number 02310690). Values approved by the USGS are shown in blue; provisional values are shown in red.

Water Use Impacts on Spring Discharge

Yobbi and Knochenmus (1989) developed a digital ground-water model of the Upper Floridan Aquifer system for the portion of west-central Florida that includes the Homosassa River system. The model was used to evaluate changes in spring discharge associated with hypothetical withdrawals totaling 116 cfs (75 million gallons per day or mgd) from five wellfields distributed from Crystal River to a point south of the border between Citrus and Hernando counties. The model was also used to evaluate potential effects associated with individual 62 cfs (40 mgd) withdrawals located within four-square-mile model grids in the vicinity of major area springs. Results for the Homosassa River system indicate that discharge from Hidden River Springs and combined discharge from Homosassa Springs, the Southeast Fork Homosassa Springs and Halls River Springs would be reduced by eight percent in response to the hypothetical withdrawal of 75 mgd from hypothetical regional wellfields. Local withdrawals of 40 mgd in the vicinity of Hidden River and Homosassa Springs resulted in respective fourteen and thirteen percent decreases in spring discharge. Yobbi and Knochenmus (1989) note that their reported results should be considered speculative, because at the time of their modeling effort, no appreciable ground-water withdrawals were occurring in the region and the modeled withdrawals in the proximity of individual springs would not likely be allowed under the then existing water-use regulations.

More recently, Knochenmus and Yobbi (2001) developed water budgets for a two-year period (January 1997 through December 1998) for ground-water basins associated with the Aripeka, Weeki Wachee, Chassahowitzka and Homosassa springs. Estimated ground-water withdrawals in the Homosassa Springs basin for the two year period totaled 0.6 inches per year and included permitted water-use in area counties and non-permitted use in Citrus County, where individual water-withdrawals less than the District's threshold requirement for issuance of a water-use permit are relatively common. Withdrawals accounted for 1.2 percent of the total combined outflow components of the water budget (evapotranspiration, spring discharge, ground-water flow and withdrawals). Knochenmus and Yobbi (2001) emphasize the minimal impact of water withdrawals on area water budgets, noting that "…little if any of the ground water pumped from the Coastal Springs Ground Water Basin is exported from the area, and a portion of the pumped volume is returned to the basin."

To support development of minimum flows for the Homosassa River system, Basso (2010; included as Appendix B to this report) evaluated rainfall, Upper Floridian Aquifer levels, area water withdrawals, and modeled withdrawal impacts on ground-water levels and spring discharge in the Homosassa River system. Basso reports a statistically significant downward trend in water levels in the Lecanto 2 Upper Floridan Aquifer well (which is about 9.5 miles southeast of the Homosassa Main Springs complex) for the period from 1965 through 2009, but notes that this trend is consistent with regional rainfall patterns. He also notes that in 2005, groundwater withdrawals within five miles of the Homosassa Main Springs averaged 1.3 mgd, and averaged 8.2 mgd within ten miles of the spring complex. On a broader regional scale, Basso reports that average annual groundwater withdrawals in the Northern District groundwater flow model domain, an area that includes all of Citrus, Hernando, Pasco and Sumter Counties and significant portions of adjacent counties, totaled 438.1 mgd in 2005.

To identify potential effects of water withdrawals in the Homosassa River system, the Northern District Model was used to simulate spring discharge and the potentiometric surface of the Upper Floridan Aquifer system for scenarios with and without regional groundwater pumping. The 2005 annual average groundwater withdrawal total (438.1 mgd) was used to simulate withdrawal effects for a five-year period, from 2001 through 2005, and results from this scenario were compared with a simulation that included no withdrawals during the same period. In the Homosassa River system area, drawdown in the poteniomitric surface of the Upper Floridan Aquifer system associated with the 438.1 mgd annual average withdrawal was less than 0.1 feet. The predicted decrease in combined discharge from springs in the Homosassa River system included as nodes in the Northern District Model was 2.3 cfs, a value that represented a 1.1% decrease from the total combined discharge of 210 cfs predicted for the springs in the modeled scenario without withdrawals. Predicted decreases associated with modeled withdrawals ranged from 0.9 to 4 percent, with the highest decrease predicted for Hidden River Head Spring. The predicted 4 percent decrease in discharge for Hidden River Head Spring, corresponded to a reduction of only 0.3 cfs. Given the relatively minor (1.1%) potential impact of withdrawals on spring discharge in the Homosassa River system that were identified by Basso (2010), measured and modeled flows used for the minimum flow analyses presented in the remainder of this report were not adjusted and were considered baseline or natural flows.

Table 2-4. Predicted discharge for selected springs in the Homosassa River system, based on the Northern District groundwater flow model for non-pumping and 2005 withdrawal scenarios (adapted from Basso 2010).

Spring	Discharge for Non-Pumping Scenario (cfs)	Discharge for 2005 Pumping Scenario (cfs)	Difference (cfs)	Percent Difference
Abdoney Spring	4.98	4.93	0.05	0.9
Belcher Spring	4.98	4.89	0.10	2.0
Halls River No. 1 Spring	5.00	4.95	0.05	0.9
Halls River Head Spring	102.11	101.06	1.05	1.0
Hidden River Head Spring	6.61	6.35	0.26	4.0
Homosassa Main Springs	71.65	70.98	0.67	0.9
McClain Spring	4.98	4.93	0.05	0.9
Pumphouse Spring	4.97	4.92	0.05	0.9
Trotter No. 1 Spring	4.97	4.93	0.05	0.9
Total	**210.2**	**207.9**	**2.31**	**1.1**

Bathymetry and River-Kilometer System

To support development of minimum flows for the Homosassa River system, the District contracted with the University of South Florida to map shoreline and complete a bathymetric survey of the system and surrounding areas. For the survey, bottom substrate elevations in the Homosassa River, Halls River and tributary channels off the Homosassa River were measured near the shoreline, along the centerline of main channels and across 257 channel cross-sections spaced approximately 500 feet apart using a boat-mounted real-time kinematics global positioning system and a survey-grade Odom echo sounder (Wang 2007; included as appendix C to this report). A survey of Hidden River was not included in this effort. The surveyed bottom elevation data were referenced to the North American Vertical Datum of 1988 (NAVD88). Data processing of the bathymetric data set with ESRI ArcGIS software included creation of a triangulated integrated network of the river segment ground and river bottom elevations (Figure 2-19).

Mapped shoreline and bathymetric survey data were provided to HSW Engineering, Inc. by the District for development of bathymetric data sets used to support much of the analyses described in the remainder of this report, including the salinity and thermal modeling conducted to support minimum flow recommendations. As part of this effort, a river kilometer system (Figure 2-20) was developed to describe distances along the Homosassa River from a point near Shell Island (Rkm 0) to a point near the upstream terminus of the South Fork of the Homosassa River (Rkm 13). A river-kilometer system was also developed for the Halls River, from the river's confluence with the Homosassa River (at Halls River Rkm 0) to the Halls River Head Spring at Rkm 5.6. Bathymetric data were processed by HSW Engineering, Inc. (2010) using ESRI ArcGIS 9.2 and SURFER to develop stage-area-volume relationships for the Halls River and the main channel of the Homosassa River from Rkm 0 to approximately Rkm 12.5, near the confluence of the Homosassa River and Southeast Fork of the Homosassa River. Area and volume information were also estimated for individual 500-m to 100-m segments of the main Homosassa River channel. Area and volume were not estimated for the Southeast Fork of the Homosassa River or the approximate 300-m reach of the Homosassa River downstream from the Main Homosassa Spring complex.

At a reference elevation of 0.0 feet NAVD88, the main channel of the Homosassa River extends over 2.76 million square meters, or approximately 682 acres and contains approximately 3.68 million cubic meters, or 972 million gallons or water (Figure 2-21). Cumulative upstream inundated area and volume in the main channel of the Homosassa River at this same elevation by river kilometer are shown in Figure 2-22. In terms of area and volume, Halls River is much smaller than the Homosassa River. At 0.0 feet NAVD88, Halls River extends over approximately 341,000 square meters (84 acres) and includes approximately 269,000 cubic meters (71 million gallons) of water (Figure 2-23).

Wetlands Solution, Inc. (2010), with support from the District and others, recently developed bathymetric information for the Homosassa Main Springs pool and upper portion of the Homosassa River as part of their ecosystem-level study of several Florida springs. Using a recording depth finder and global positioning system in November 2008, they determined that the spring pool and upper segment of the Homosassa River (approximately upstream from river kilometer 12.5) extends over 11,319 square meters or 2.8 acres and contains a volume of 12,352 cubic meters, or 3.3 million gallons of water.

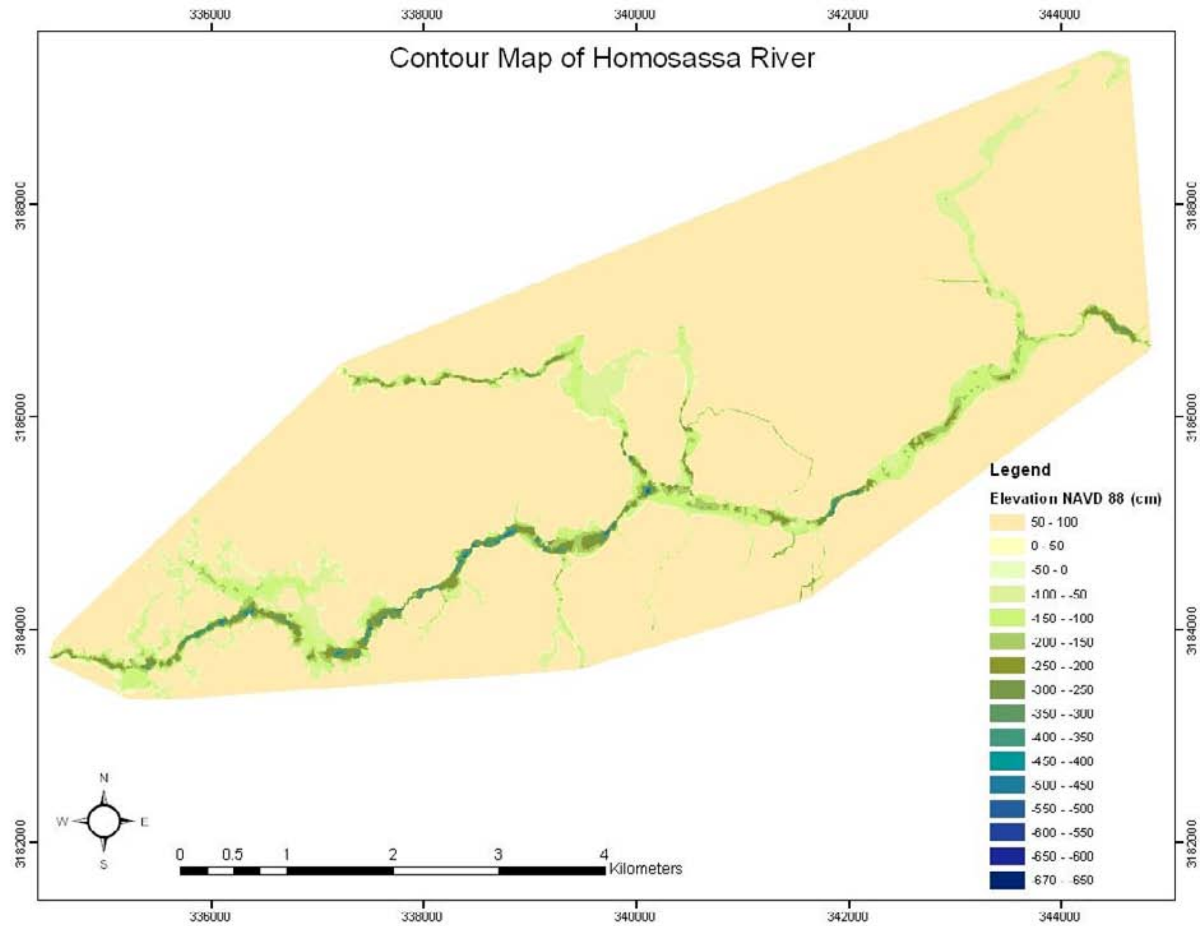


Figure 2-19. River bottom elevation contour map of the Homosassa and Halls Rivers and adjacent areas. Image provided by Ping Wang (University of South Florida).

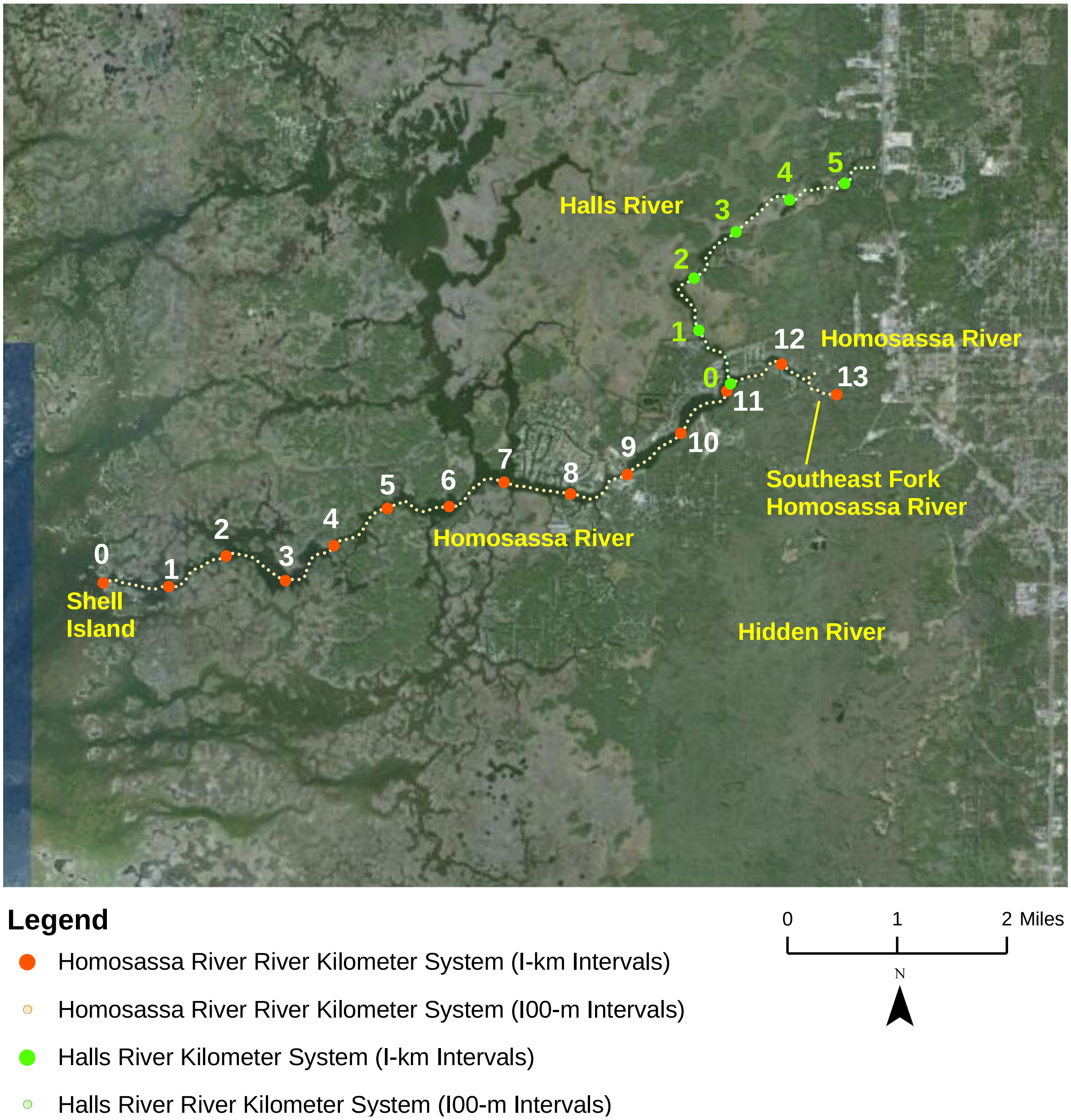


Figure 2-20. River-kilometer systems (with labeled 1-km locations) developed for the Homosassa River and Halls River to support minimum flows establishment. Note that a river-kilometer system was not developed for Hidden River (photographic image source: Woolpert, Inc. 2009).

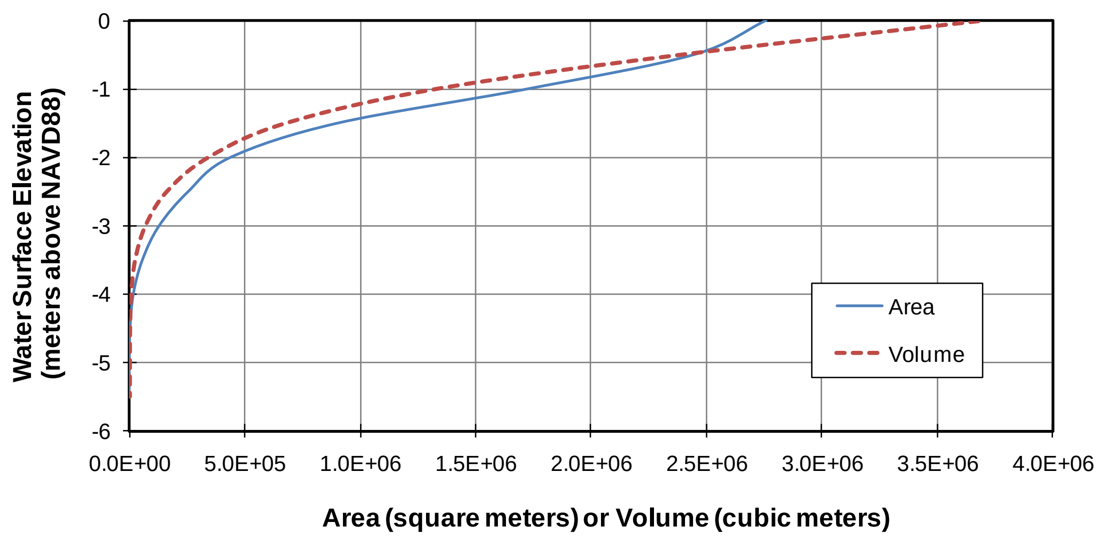


Figure 2-21. Stage-area-volume relationships for the main channel of the Homosassa River from river kilometer 0 to river kilometer 12.5.

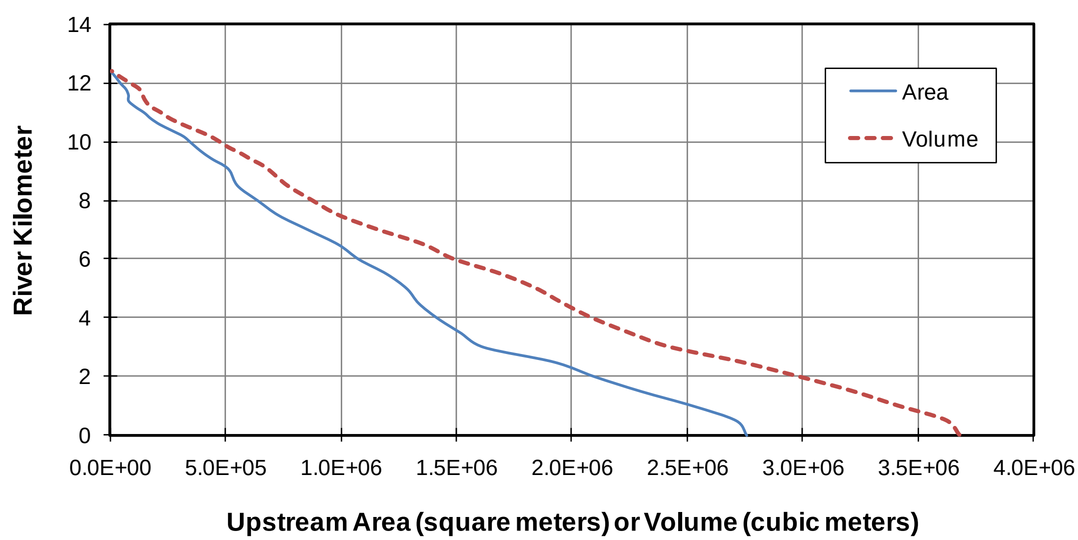


Figure 2-22. Upstream area and volume for the main channel of the Homosassa River by river kilometer from river kilometer 0 (near Shell Island) to river kilometer 12.5 (near the confluence of the Homosassa River and South Fork of the Homosassa River).

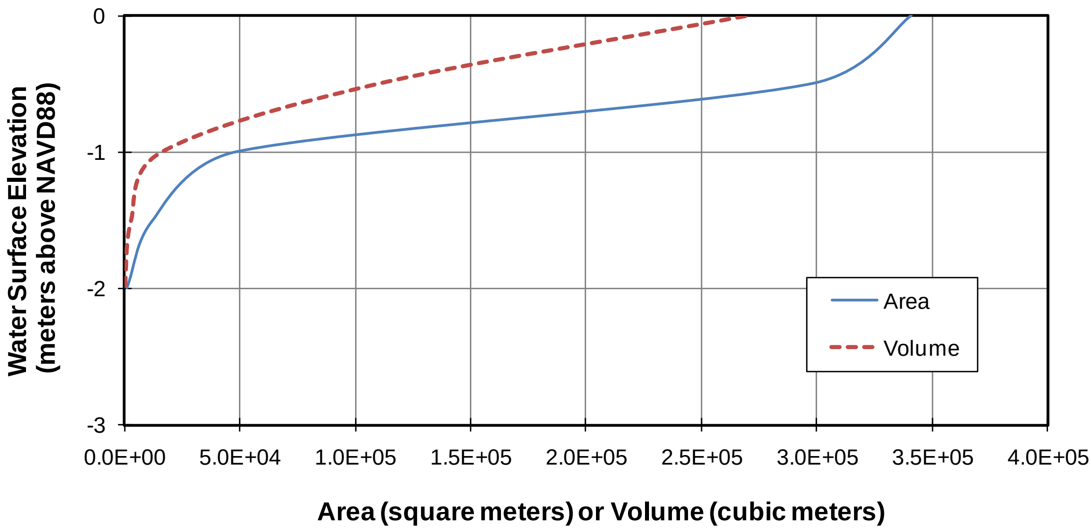


Figure 2-23. Stage-area-volume relationships for the Halls River from river kilometer 0 to river kilometer 5.6.

Bottom Substrates

Sloan (1956) provides an early report on the bottom substrates of the Homosassa River from the headwaters area downstream to approximately river kilometer three. Based on sampling that was conducted in the early 1950s, substrates in the Homosassa Main Spring pool were characterized as fine yellow sand. At a site 0.2 miles downstream, Sloan noted an accumulation of organic detritus atop the sand substrate. Further downstream at a site just upstream of the confluence of the Halls and Homosassa Rivers, sediments included sand and fine black silt. Downstream substrates were characterized as mixtures of black silt, organic detritus and “shellbar”.

As part of a District-funded study of several Gulf coastal rivers, Frazer *et al.* (2001a, b) report that mud is the most common bottom type in the Homosassa River, where it was the dominant substrate at 56.7 percent of the 100 sites sampled annually in 1998, 1999 and 2000 at 20 transects located between the community of Homosassa (approximately river kilometer 7.4) and the Main Springs area. Sand was the dominant substrate at 18.3 percent of the sampled sites and a mix of mud and sand was dominant at 15 percent of the sites. Although limestone outcrops are common along the entire river, rock was dominant at only three percent of the sampled sites and a mixture of rock and mud, sand or shell was dominant at about 6.3 percent of the samples sites. Similar results regarding substrate types were reported by Frazer *et al.* (2006) based on sampling of the river from 2003 through 2006 at the same sites surveyed between1998 and 2001.

For more recent District-funded studies of the macroinvertebrates of the Homosassa River system, Grabe and Janicki (2009; included as Appendix D in this report) and Water & Air Research, Inc. (2010; included as Appendix F in this report) qualitatively characterized substrates in the system. Sampling by Grabe and Janicki was conducted on May 12-14, 2008 at 75 sites in the Homosassa River and Southeast Fork of the Homosassa River between river kilometers 0 and 13, and 10 sites in Halls River, between river kilometers 0.4 and 2.2. Shell hash was common in the Homosassa River near Shell Island, and upstream substrates were typically characterized as mixtures of sand, silt, muck and silt. Sand-dominated substrate was observed at only a few sites; all were located in upstream reaches of the Homosassa and Halls rivers. Oyster bars are relatively uncommon in the Homosassa River. Although Grabe and Janicki (2009) collected oysters with a dredge between river kilometer 4 and 9, Water & Air Research, Inc. (2010) observed live oyster beds at only three sites in the river, all downstream from river kilometer 1.3, during a field survey completed over two days in the fall of 2008.

Shoreline

PBS&J (2009; included as Appendix E) recently evaluated shoreline vegetation and the extent of altered shoreline along the Homosassa, Halls and Southeast Fork of the Homosassa Rivers for the District to support development of minimum flows for the Homosassa River system. Shoreline alteration status and natural vegetation within five feet of the edge of water were characterized in October 2008 in the Homosassa River from Shell Island upstream to the bridge in the Homosassa Springs Wildlife Park, approximately 106 m (~350 feet) downstream from the Homosassa Main Springs pool, and in the Southeast Fork upstream to approximately river kilometer 12.95. Shorelines of Halls River were surveyed from the river’s confluence with the Homosassa upstream to approximately river kilometer 3.2. All surveyed shorelines were classified as natural, *i.e.,* naturally vegetated or altered, with altered shorelines including areas of rip-rap, seawall, a combination of rip-rap and seawall and maintained or modified lands. Maintained shorelines include lawns and maintained landscaping. Modified shorelines were those with relatively natural vegetation that has been previously modified.

Natural vegetation occurs along approximately 71 percent of the combined 62,529 m shoreline mapped for the Halls River, Homosassa River and Southeast Fork of the Homosassa Rivers (Figure 2-24, Table 2-5). Most of Halls River upstream from the Halls River Road bridge is naturally vegetated, including upstream areas that were not mapped or surveyed by PBS&J. Unaltered or natural shoreline is similarly dominant in the Homosassa River downstream from the Homosassa Community near river kilometer 7.2. Although not mapped by PBS&J, the shoreline of Hidden River may be considered unaltered. Additional information on the plant species and communities that occur within the vegetated shorelines of the Homosassa River system is provided in Chapter 3 of this report.

Upstream of approximately river kilometer 7.2, the shoreline of the Homosassa River is mostly altered with the exception of much of the left (south) bank between river kilometers 9.3 and 11.1. Seawalls are the dominant altered shoreline type, especially upstream from river kilometer 8, although rip-rap is the dominant altered shoreline (along the right bank only) between river kilometers 7 and 8. Nearly all altered areas downstream from river kilometer 7 were classified as modified shoreline.

Table 2-5. Summary information for shorelines of the Homosassa River, Halls River and Southeast Fork of the Homosassa River mapped by PBS&J (2010) in October 2008. Maintained shorelines include lawns and maintained landscaping. Modified shorelines were those with relatively natural vegetation that has been modified.

Shoreline Type	Shoreline Length (m)	Percentage of Total Shoreline	Percentage of Altered Shoreline
Natural	44,297	71	NA
Altered - Seawall	7,829	13	43
Altered - Modified	6,803	11	37
Altered - Maintained	410	<1	2
Altered - Rip-Rap	2,614	4	14
Altered - Rip-Rap and Seawall	576	<1	3
All (Total)	62,529	100	100

NA = not applicable

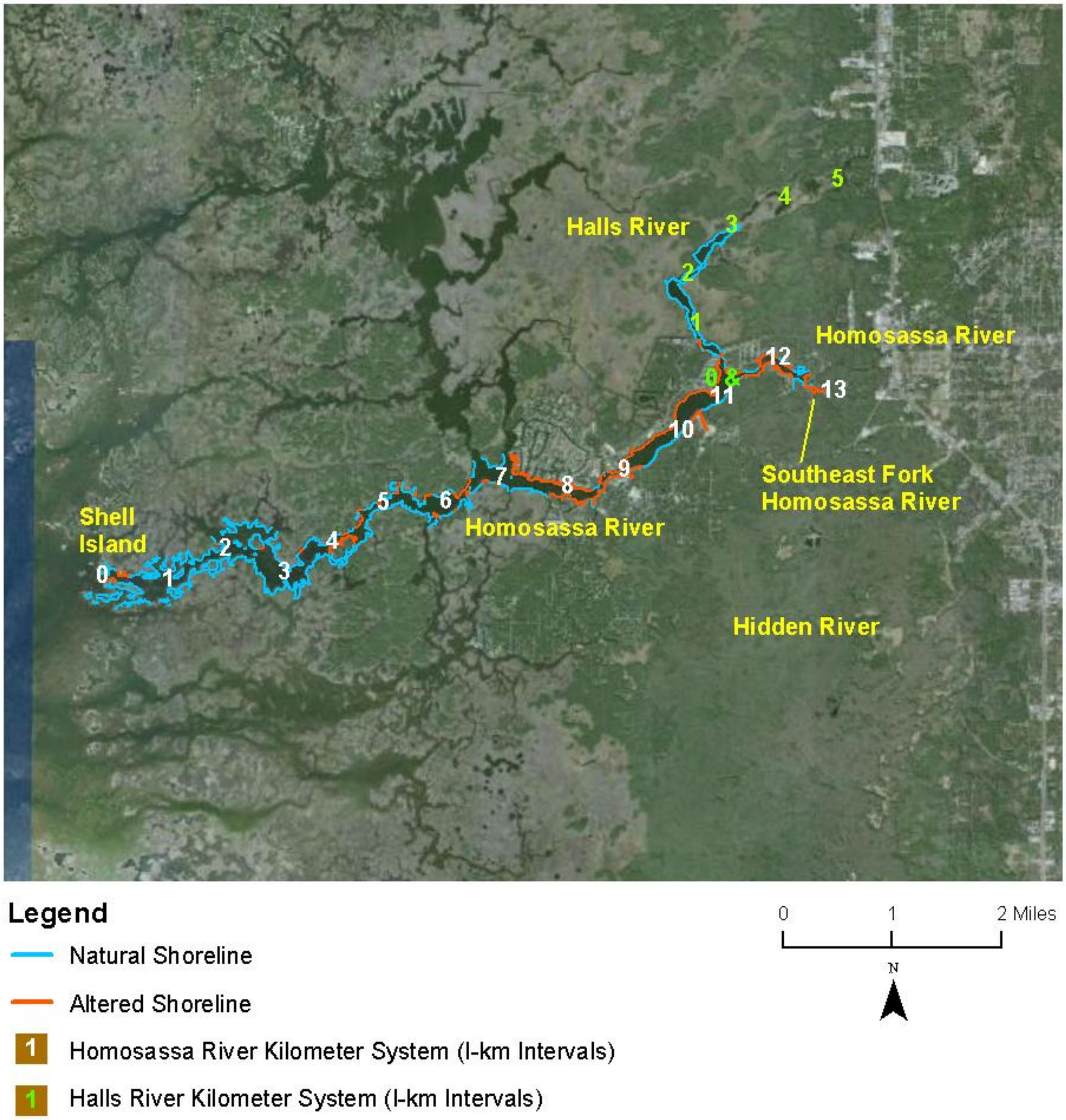


Figure 2-24. Natural and altered shoreline of the Homosassa River/Southeast Fork and the lower 3.2 kilometers of the Halls River in October 2008 as mapped by PBS&J (2010). The shoreline of Hidden River was not mapped, but may be classified as natural shoreline (photographic image source: Woolpert, Inc. 2009).

Water Quality

Water Body Classification Based on Water Quality

All surface waters in Florida are classified according to present and future most beneficial uses (Section 403.061(10), F.S.) and associated with class-specific water quality standards for selected physical and chemical parameters (Chapter 62-302, F.A.C.). Most coastal waters of Citrus County, including the Homosassa River upstream to about river kilometer 8.4 are classified as Class II waters, with a designated use of shellfish propagation or harvesting. The upper portion of the Homosassa River, Halls River, Hidden River and the springs associated with the Homosassa River system are all designated as Class III waters, with designated uses of recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. All water bodies in the Homosassa River system are also classified as Outstanding Florida Waters, a designation associated with enhanced water quality protection criteria (Rule 62-302.700, F.A.C.).

With regard to compliance with water quality standards, Section 303(d) of the Federal Clean Water Act requires each state to identify and list "impaired" waters where applicable water quality criteria are not being met after implementation of technology-based effluent limitations, and also requires development of Total Maximum Daily Loads (TMDLs) for the water bodies. Total Maximum Daily Loads are the amount of pollutant that a receiving water body can assimilate without causing violation of a pollutant-specific water quality standard. The TMDLs development process identifies allowable loadings of pollutants or other factors and supports implementation of management strategies for reducing pollutant loads and ensuring appropriate water quality standards are met.

The most recent 303(d) list for impaired Florida waters was approved by the United States Environmental Protection Agency in 1998. The 1998 list does not include any basins in the Homosassa River system, although Crystal River (WBID 1341I, i*.e.*, Water Basin Identification 134I) and Crystal River Bay (WBID 1345A), which extends to a point just north of the main channel of the Homosassa River system are classified as impaired, based on nutrient concentrations. The revised final “verified list” for impaired waters of the Springs Coast was approved by the FDEP in May 2009 and like the 1998 list, does not include any water bodies in the Homosassa River system.

Data Sources for Water Quality Summaries

Temperature, salinity and other water quality information summarized in this report are based on previously published reports, measurements made by the USGS and the District, and data collected for the District by the University of Florida, the University of South Florida and Florida Fish and Wildlife Conservation Commission’s Fish and Wildlife Research Institute. Although current standard practices in scientific oceanographic work include reporting salinity as a dimensionless number, some results summarized in this report are based on values reported in units of parts per thousand (ppt) or practical salinity units (psu), and original reported units have been retained in some instances.

In cooperation with the District and Florida Department of Environmental Protection, the USGS regularly monitors near-surface and bottom water temperature and specific conductance at fifteen-minute intervals at the gage sites at Shell Island, Homosassa River, Halls River, Homosassa Springs and the Southeast Fork of the Homosassa River. Data collected at 15-minute intervals and/or mean daily values for these sites for the period from May 17, 2004 through October 19, 2009 were obtained from the USGS and used for the summary analyses described in this report. Sub-sets of these data were used for some analyses, and where appropriate, these periods of record and data types are identified. The USGS also conducts periodic sampling of water quality constituents other than temperature and specific conductance at gage sites in the Homosassa River system. These data were not reviewed for the analyses presented in this report, but summary water quality information based on USGS sampling as reported by Yobbi and Knochenmus (1989), Yobbi (1992) and Knochenmus and Yobbi (2001) were evaluated.

To support development of minimum flows for the Homosassa River system, the District measured water temperature, salinity, specific conductance and dissolved oxygen concentrations throughout the water column at 14 stations in the Homosassa River system at approximately monthly intervals between February 2008 and February 2009. The stations included ten sites on the Homosassa River between Shell Island (river kilometer 0) and river kilometer 13.2; three sites on Halls River between river kilometers 0.25 and 2.2, and a single site on the Southeast Fork of the Homosassa River (Figure 2-24). Water samples were collected at five of the 14 stations for characterization of ion concentrations and other water quality constituents at the District Chemistry Laboratory. The stations where water samples were collected included three sites on the Homosassa River, and single sites in the Halls River and Southeast Fork of the Homosassa River. Results from these sampling events have not been previously published in report format.

As part of their District-funded studies of several Gulf coastal rivers, researchers from the University of Florida (Frazer *et al.* 2001a, b, 2006) measured near-surface water temperature, dissolved oxygen concentration and salinity at 20 transects located between the main Homosassa Springs complex and a point approximately 0.8 miles west of Shell Island (Figure 2-25). Sampling was conducted at a center-channel site and near each shore at the upper 15 transects and at a single center-channel site at the lower five transects. Water samples were also collected for laboratory analysis of various constituents during the quarterly sampling that was conducted at the Homosassa River from August 1998 through January 2001 and again from February 2003 through December 2005. Summary information presented in Frazer *et al.* (2001a, b, 2006) as well as *in-situ* measurements from center channel sites in the Homosassa River were used for the minimum flows analysis presented in this report.

The District-supported Project COAST, which is administered by the University of Florida, has involved water quality sampling along the west coast of Florida since 1997 (see Jacoby *et al.* 2008). As part of the project, water temperature, dissolved oxygen and salinity measurements and water samples for laboratory analysis of various constituents are collected at a station in the Homosassa River at river kilometer 9 (Figure 2-24). Data for this site were obtained and reviewed for the analyses described in this report.

For their District-funded survey of the fish and invertebrates in the Homosassa River system conducted to support development of minimum flow recommendations, the University of South Florida and Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute (Peebles *et al.* 2009) measured *in situ* water temperature, salinity, pH and dissolved oxygen concentration monthly or bi-monthly between December 2006 and November 2008. Sampling was conducted in the Homosassa River between Shell Island and river kilometer 13.4, downstream from the Homosassa Main Springs complex and also in Halls River (Figure 2-24). Summary information presented in (Peebles *et al.* 2009) as well as the data obtained for their study were used for the minimum flows analysis described in this report.

Field measurements of water temperature, salinity, specific conductance and dissolved oxygen concentration at five sites (Figure 2-25) in the Homosassa River collected between October 2005 and December 2008 in support of the District's Coastal Rivers Monitoring Network project (B121) were also included in the analyses presented in this report. Results from periodic water sampling conducted to support a variety of other District projects were also used to characterize water chemistry in the Homosassa River system (locations of these sites are not shown in Figurer 2-25). Summaries of spring water chemistry provided in District reports by Jones *et al.* (1997) and Champion and Starks (2001) were also reviewed.

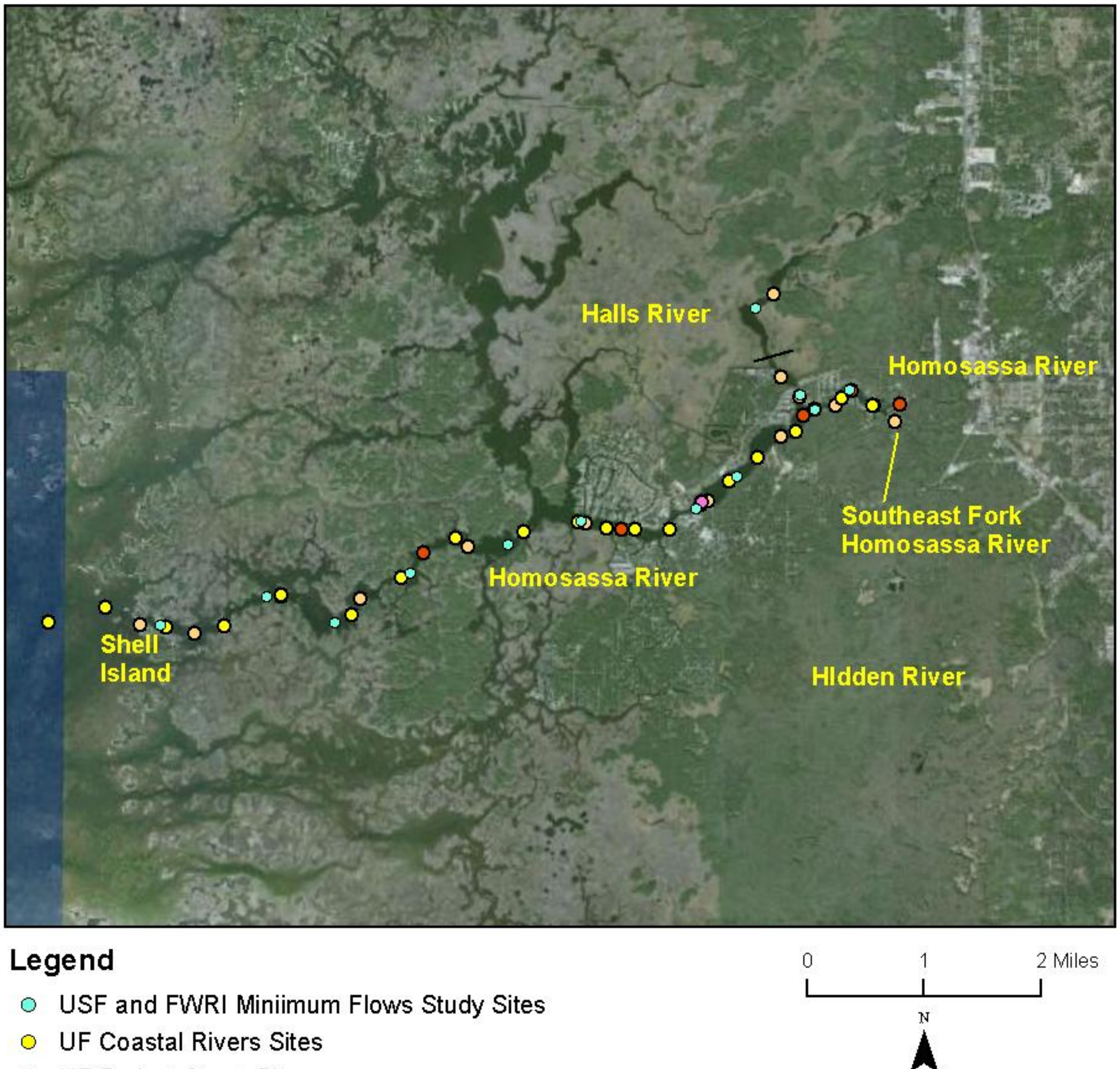


Figure 2-25. Locations of sites where *in situ* water quality sampling summarized in this report was completed by the University of South Florida (USF) and Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI), the University of Florida (UF) and the Southwest Florida Water Management District (SWFWMD) in the Homosassa River system (photographic image source: Woolpert, Inc. 2009).

Spring Water Quality

Considerable variation is evident in the chemical composition of water discharging from the springs of the Homosassa River system. Water quality/chemistry varies among springs, and diurnal fluctuations in water quality parameters in individual springs are common, and may be associated with tidal fluctuations (Yobbi 1992). Yobbi and Knochenmus (1989) describe the Homosassa Main Springs and Halls River springs as brackish systems and the springs of the Southeast Fork as freshwater systems. Knochenmus and Yobbi (2001) report that the Homosassa Main Springs, Halls River Head Spring, Hidden River Head Spring and Hidden River Spring Number 6 discharge sodium-chloride type water, based on relatively high concentrations of sodium, chloride and other dissolved ions. They also note that Trotter Spring is a mixed-ion type spring, with waters not dominated by any ions; a condition that typically reflects mixing of saltwater and freshwater.

Jones *et al.* (1997) and Champion and Starks (2001) provide recent summaries of water quality and hydrology of springs in the Southwest Florida Water Management District. Variation in the water quality of springs in the Homosassa River system is well described in the paragraphs below, which is excerpted from page 57 of Champion and Starks' report and includes references to Jones *et al.* noted as a superscripted, parenthetic number 12). Note also the addition of parenthetic descriptions of two acronyms presented in original text.

> *Ground water discharging the Homosassa Springs group may be fresh or brackish, depending on tides and water levels in the Floridan aquifer. At low tide, water quality varies across the spring group with TDS* [Total Dissolved Solids] *concentrations increasing from less than 250 mg/l along the southeastern fork of the Homosassa River to greater than 1,500 mg/l in springs at the head of Hall's River. Chloride concentrations across the group may range from less than 50 mg/l to greater than 500 mg/l, indicating that water quality at the spring group is strongly influenced by the coastal transition zone even at low tide*[(12)]*.*
>
> *Nitrate concentrations at the Homosassa Springs group are typically below 0.7 mg/l. The concentrations vary among the individual springs of the group, possibly in response to mixing in the coastal transition zone and variations in nitrate in Floridan aquifer ground water. Research conducted by the WQMP* [*i.e.*, the District's Water Quality Monitoring Program] *indicates that the nitrate discharging from the springs is most likely derived from an inorganic source of nitrate - inorganic fertilizers applied to residential and golf course turf grass near the springs*[(12)]*.*

Median concentrations of major ions and field-measured parameters based on records currently available from the District Water Management Information System illustrate the variability in most water quality constituents among springs noted by previous investigators (Table 2-6 and 2-7). Salinities estimated from median chloride concentrations based on the general relationship between salinity and chlorinity (salinity as parts per thousand or ppt = 1.80655 * chlorinity as ppt) published by Wooster *et al.*

(1969) illustrate the heterogeneity among the systems. Salinity for springs discharging to the Southeast Fork of the Homosassa River were estimated at 0.1, while springs in Halls River and the Homosassa Main Spring pool exhibited salinities ranging from 0.7 to 3.9 (Table 2-8). Some parameters, including water temperature and pH are, however, somewhat less variable among the springs. Median water temperature for the 15 Homosassa River system springs examined varied by only 1.3 degrees, ranging from 23.0 to 24.3°C. All the springs examined discharge slightly basic water, with median pH values from 7.30 to 7.85.

Dissolved oxygen concentrations were consistently low, with median concentrations for the springs ranging from 1.9 to 4.0 mg/L. Concentrations of dissolved oxygen often vary widely within an aquatic systems, based on variation in temperature, atmospheric pressure, photosynthesis, respiration and chemical oxidation/reduction reactions not associated with living organisms. The parameter is of importance to aquatic ecosystem management because many estuarine organisms cannot tolerate extended periods of concentrations less than about 2 mg/L (United States Environmental Protection Agency 2000, Diaz 2001).

The Florida criterion for dissolved oxygen in Class III-Fresh water bodies requires that dissolved oxygen concentrations shall not be less than 5.0 mg/L and that “[n]ormal daily and seasonal fluctuations above these levels shall be maintained” (Rule 62-302.530, F.A.C.). The criteria for dissolved oxygen in Class III-Marine and Class II water bodies similarly includes the daily and seasonal requirements, but requires that dissolved oxygen concentrations shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0 mg/L.

Low dissolved oxygen concentrations are not uncommon in Florida water bodies, particularly in spring pools. Odum (1957) found night-time dissolved oxygen concentrations averaged 2.8 mg/L at 11 Florida springs in July and August 1955 with a value of 4.3 mg/L reported for the Homosassa Springs pool. In an earlier study of the Homosassa River, Sloan (1956) recorded dissolved oxygen concentrations between 4.3 and ~5.5 mg/L at the spring pool between November 1952 and February 1954. McKinsey and Chapman (1998) report dissolved oxygen concentrations averaged 0.20 mg/L at the Singing Springs boil in north-central Florida and cited numerous earlier studies where low oxygen levels were reported for other springs of the state. In a more recent study, Wetlands Solutinons, Inc. (2010) report dissolved oxygen concentrations ranged from 0.1 to 3.7 mg/L at ten of the 12 Florida springs they evaluated in 2008 and 2009. At the Homosassa Main Springs pool, dissolved oxygen averaged 3.7 mg/L.

Table 2-6. Median water quality constituent/parameter concentrations for selected springs in the Homosassa Springs system, based on sampling conducted from March 24, 1992 through August 5, 2009 by the Southwest Florida Water Management District. Values are expressed as dissolved mg/L unless otherwise indicated.

Spring	Number of Dates Sampled (N)	Number of Samples (N)	Ca	Cl	F	Mg	K	Na	SO_4	NO_3 + NO_2	Ortho-PO_4	Total Dissolved Solids
Abdoney Spring	3	3	38	68	0.11	10	1.3	36	14	0.46	0.032	260
Belcher Spring	3	3	39	57	0.10	10	1.2	35	13	0.44	0.024	242
Bluebird Spring	3	3	63	289	0.10	21	3.9	147	41	0.64	0.021	658
Halls River Spring No. 1	1	1	107	2,164	0.11	149	43.0	1170	301	0.16	0.020	4,033
Halls River Main Head Spring	19	13-18	78	1,663	0.13	116	34.0	918	248	0.30	0.025	3,178
Hidden River Spring No. 2	61	58-61	63	703	0.11	51	13.0	367	101	0.67	0.025	1,404
Hidden River Head Spring	60	56-59	56	438	0.11	36	8.9	254	68	0.70	0.022	1,010
Homosassa Main Spring No. 1	60	66-69	64	1,115	0.14	77	22.8	590	167	0.51	0.015	2,085
Homosassa Main Spring No. 2	60	65-69	80	1,711	0.15	119	35.3	962	247	0.48	0.015	3,220
Homosassa Main Spring No. 3	57	63-66	45	380	0.12	32	7.8	214	58	0.52	0.014	822
Homosassa River Spring No. 1	4	4	67	1,141	0.14	78	22.5	613	166	0.41	0.027	2,045
McClain Spring	3	3	44	80	0.10	12	1.4	45	15	0.37	0.029	292
Pumphouse Spring	33	26-32	44	83	0.10	11	1.4	45	15	0.42	0.018	286
Trotter Spring No. 1.	3	3	39	58	0.11	10	1.2	35	13	0.45	0.024	244
Trotter Main Spring	62	54-60	41	63	0.10	11	1.3	36	13	0.54	0.020	254

Table 2-7. Median water quality constituent/parameter values for selected springs in the Homosassa Springs system, based on *in-situ* measurements made from March 24, 1992 through August 5, 2009 by the Southwest Florida Water Management District. Dashes indicated that data were not available.

Spring	Number of Dates Sampled (N)	Number of Samples (N)	Temperature (°C)	pH (standard units)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at 25 °C)
Abdoney Spring	3	3	24.3	7.80	–	496
Belcher Spring	3	3	23.1	7.77	–	441
Bluebird Spring	3	2-5	22.9	7.85	1.9	1,202
Halls River Spring No. 1	1	1	23.7	7.60	–	6,950
Halls River Main Head Spring	19	5-28	23.2	7.69	2.3	5,135
Hidden River Spring No. 2	61	34-103	23.3	7.64	3.4	2,700
Hidden River Head Spring	60	33-100	23.3	7.69	3.8	1904
Homosassa Main Spring No. 1	60	31-110	23.4	7.58	4.0	4,089
Homosassa Main Spring No. 2	60	32-109	23.4	7.56	4.0	5,961
Homosassa Main Spring No. 3	57	29-104	23.4	7.67	4.2	1,635
Homosassa River Spring No. 1	4	4	23.7	7.30	–	3,890
McClain Spring	3	3	23.9	7.67	–	533
Pumphouse Spring	33	10-46	23.0	7.65	3.7	521
Trotter Spring No. 1.	3	3	23.2	7.74	–	451
Trotter Main Spring	62	34-103	23.4	7.71	3.8	497

Table 2-8. Estimated salinity for selected springs in the Homosassa Springs system, based on median chloride concentrations presented in Table 2-6 and the general relationship between salinity and chlorinity (salinity as parts per thousand or ppt = 1.80655 * chlorinity as ppt) published by Wooster *et al. (1969)*.

Spring	Estimated Salinity
Abdoney Spring	0.1
Belcher Spring	0.1
Bluebird Spring	0.5
Halls River Spring No. 1	3.9
Halls River Main Head Spring	3.0
Hidden River Spring No. 2	1.3
Hidden River Head Spring	0.8
Homosassa Main Spring No. 1	2.0
Homosassa Main Spring No. 2	3.1
Homosassa Main Spring No. 3	0.7
Homosassa River Spring No. 1	2.1
McClain Spring	0.1
Pumphouse Spring	0.1
Trotter Spring No. 1.	0.1
Trotter Main Spring	0.1

River Temperature

Water temperatures in the Homosassa River system exhibit considerable seasonal variation. Monthly water temperatures for the system are typified by the values shown in Figure 2-26 for the combined Homosassa River and Southeast Fork, where median monthly temperatures based on records collected between 1997 and 2009 ranged from 17.2 °C in January to 30.1°C in July. Variation in water temperatures in the upper few kilometers of the Homosassa and Southeast Fork was relatively low during this 12-year period (Figure 2-27, Table 2-9), likely in response to the discharge of relatively constant-temperature water from the headwater springs. Water temperatures were similarly lower in the upstream portion of Halls River (Table 2-9), although they were more variable than in the upper Homosassa (variance information not shown). The relative constancy and magnitude of water temperatures in the upper reaches of the Homosassa River system are important factors associated with use of the system as a thermal refuge by manatees during periods when water temperatures in the Gulf of Mexico fall below critical physiological thresholds for these animals.

Depth-specific measurements of temperature indicate that the water column of the Homosassa River is relatively well mixed. At the USGS Homosassa River at Shell Island near Homosassa FL gage, maximum top and bottom water temperatures differed by no more than 0.5°C on a daily basis between September 2006 and October 2009 and minimum top and bottom temperatures differed by less than 0.7°C (data not shown). Slightly more variation in water column temperatures is evident at the Homosassa River at Homosassa FL gage, where daily maximum top and bottom water temperatures varied by up to 1.2°C between May 2006 and October 2009 and daily minima varied up to 2.6 in bottom waters (Figure 2-28). On most dates however, differences between top and bottom water temperatures at the Homosassa River at Homosassa gage were less than 1°C.

Modeling River Temperature

A calibrated hydrodynamic model for evaluating the effects of changes in flow on water temperature and salinity in the main channel of the Homosassa River was developed as part of the District effort to develop minimum flow recommendations for the river system. The model, which was developed for the District by HSW Engineering, Inc. (2010), is described in the next sub-section of this chapter and use of the model for evaluating thermal characteristics of the Homosassa River is discussed in Chapter 4.

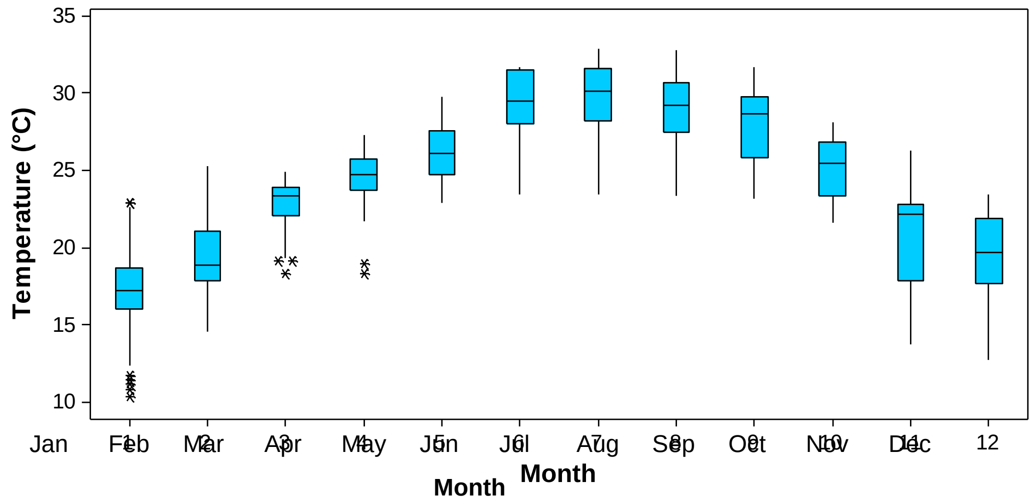


Figure 2-26. Box plot of monthly water temperatures in the Homosassa River and Southeast Fork, based on measurements made by the University of South Florida, the University of Florida, Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute and the Southwest Florida Water Management District between January 1997 and February 2009.

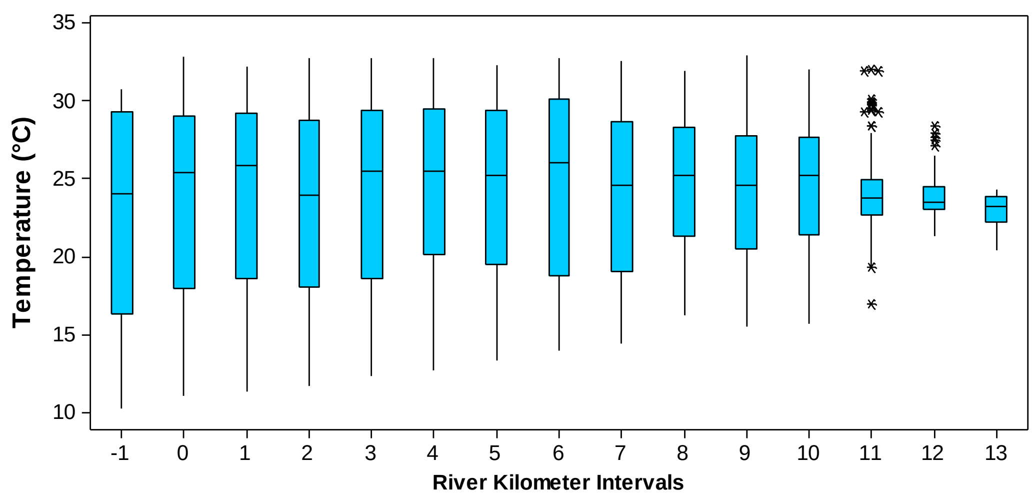


Figure 2-27. Box plot of water temperature in one kilometer segments of the Homosassa River (including the Southeast Fork of the Homosassa River), based on data sources and record identified in Figure 2-26.

Table 2-9. Median water temperature, pH, dissolved oxygen concentration and specific conductance for one-kilometer segments of Halls River and the Homosassa River (including the Southeast Fork), based on data sources and record identified in Figure 2-26.

Downstream River-Kilometer Segment Boundary	Number of Samples (N)	Temperature (°C)	pH (standard units	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm at25 °C)*
Halls River					
0	75-122	24.7	7.8	7.7	4,990
1	58-95	25.6	7.8	7.3	5,150
2	67	27.4	7.6	6.0	5,400
3	44	22.5	7.8	7.7	5,700
4	41	25.0	7.8	6.1	4,700
5	11	21.5	7.7	5.9	5,500
Homosassa River					
-1	40-42	24.0	8.2	7.6	30,880
0	103-187	25.4	7.9	7.0	32,950
1	58-59	25.9	7.9	6.2	26,700
2	87-163	24.0	7.9	7.3	27,600
3	91-178	25.5	7.9	6.6	24,730
4	71-162	25.5	7.8	6.3	21,000
5	108-109	25.2	7.8	6.0	18,490
6	68-141	26.1	7.8	6.6	15,300
7	146-203	24.6	7.8	7.0	13,000
8	85	25.2	7.9	7.5	6,620
9	129-368	24.6	7.9	7.3	5,130
10	127	25.2	7.9	6.9	3,970
11	143-263	23.8	7.8	6.0	3,000
12	171	23.5	7.8	6.0	2,800
13	17	23.2	7.6	6.5	950

* Specific conductance values approximated by multiplying reported values, which were expressed in units of mS/cm at 25 °C, by 1,000.

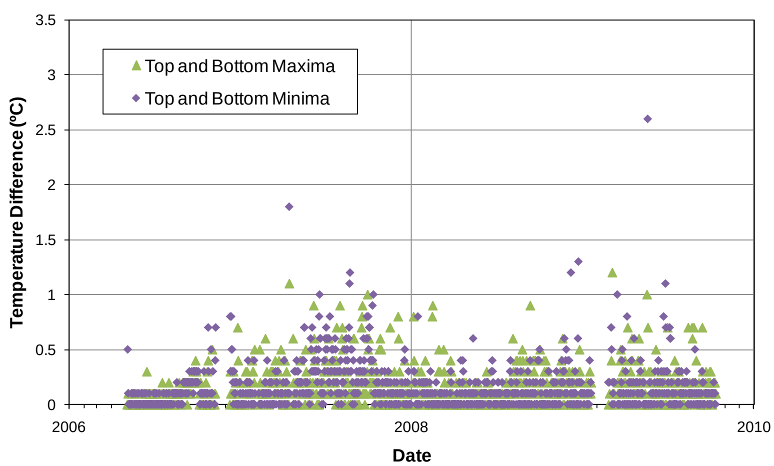


Figure 2-28. ... d minima near the top ... logical Survey Homo ... and October 2009, based ...

River Salinity

Box plots of synoptic salinity measurements made by the District, University of South Florida, University of Florida and the Florida Marine Research Institute between January 24, 1997 and February 17, 2009 illustrate the strong longitudinal salinity gradient that typifies the Homosassa River and Southeast Fork and the relatively low range of salinities in Halls River (Figure 2-29). Based on the Venice System used for classification of marine systems according to salinity (Anonymous 1958), waters in the Homosassa River typically range from oligohaline conditions (approximate salinity range from 0.5 to 5.0) in the headwaters to mesohaline conditions (approximate salinities between 5 and 18) through much of the length of the river and polyhaline conditions (approximate salinity range from 18 to 30) near and downstream from Shell Island at river kilometer zero. Oligohaline conditions are typical throughout the entire Halls River.

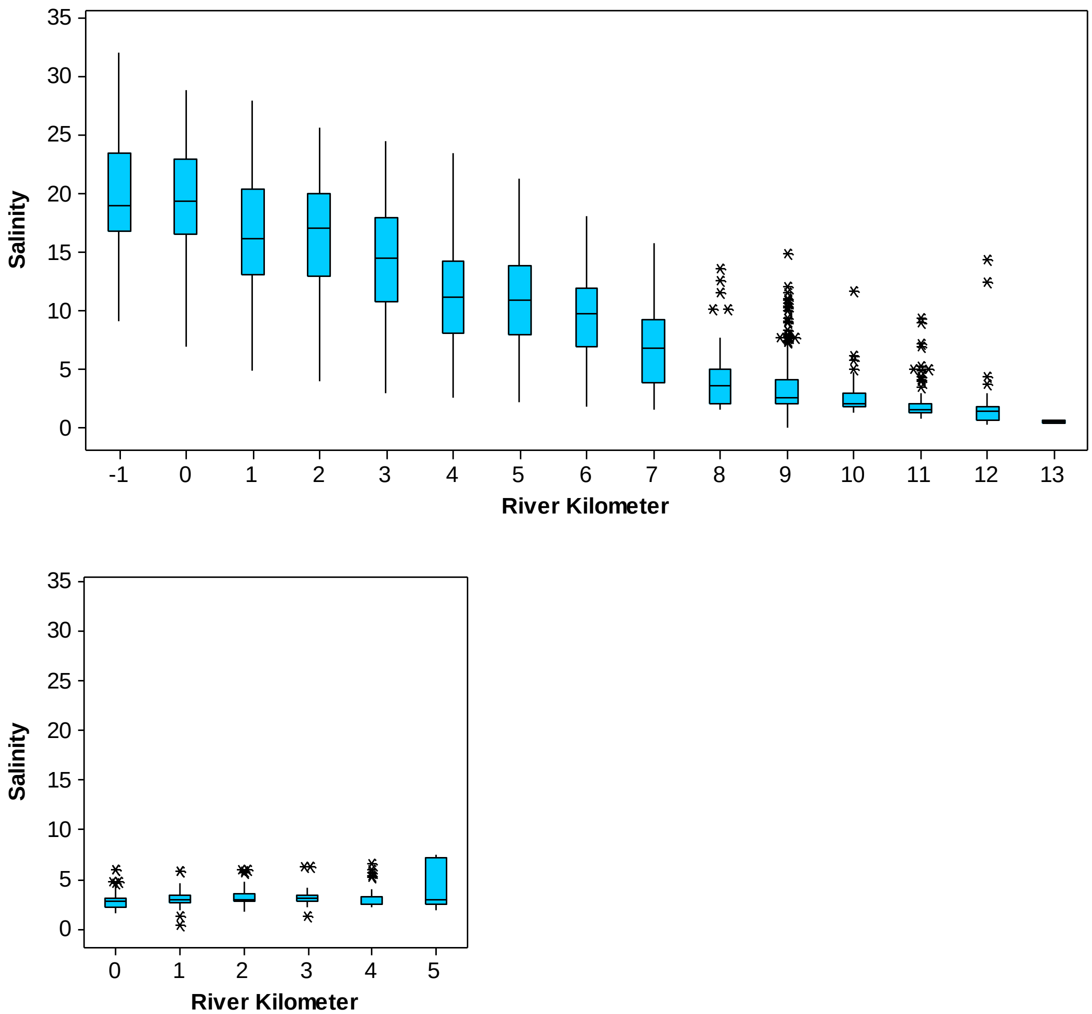


Figure 2-29. Box plots of salinity in one-kilometer segments of the Homosassa River, including the Southeast Fork of the Homosassa River (upper panel), and Halls River (lower panel) based on data sources and period of record identified in Figure 2-25.

Period of record mean daily bottom salinities at United States Geological Survey gage sites on the Homosassa River estimated from reported specific conductance values using the formulae of Cox *et al.* (1967) are consistent with the longitudinal variation of salinities in the river system demonstrated by the recent synoptic sampling (Figure 2-30). Lowest salinities have typically been recorded at the Southeast Fork of the Homosassa River gage, where the median daily minimum and maximum salinities were 0.4 and 1.4, respectively. Salinities at the Homosassa Springs and Halls River gages have been slightly higher; median daily minimum and maximum salinities at the Homosassa Springs site were 1.5 and 2.4, respectively, and median daily minimum and maximum salinities at the Halls River site were 1.7 and 3. Downstream at the Homosassa River gage, median daily minimum and maximum salinities for the period of record were 2.2 and 6.2, respectively. At the mouth of the river near Shell Island median daily minimum salinity has been 17.5 and median daily maximum salinity has been 24.7.

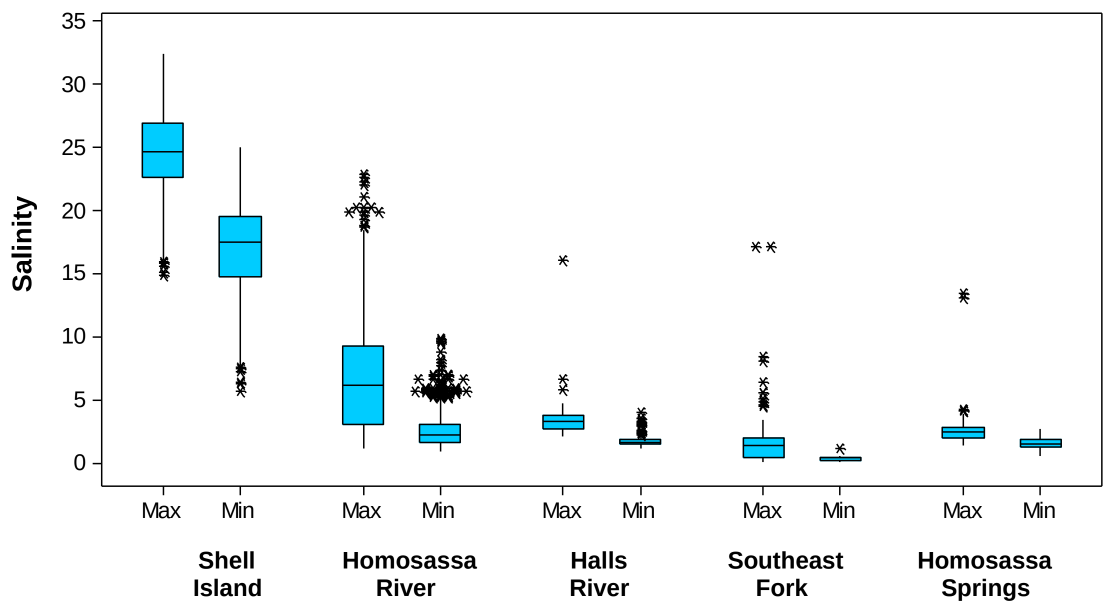


Figure 2-30. Box plot of maximum and minimum daily salinity in the Homosassa River system at United States Geological Survey gage sites. Salinities calculated from reported specific conductance; period of record varies by site (see Table 2-2).

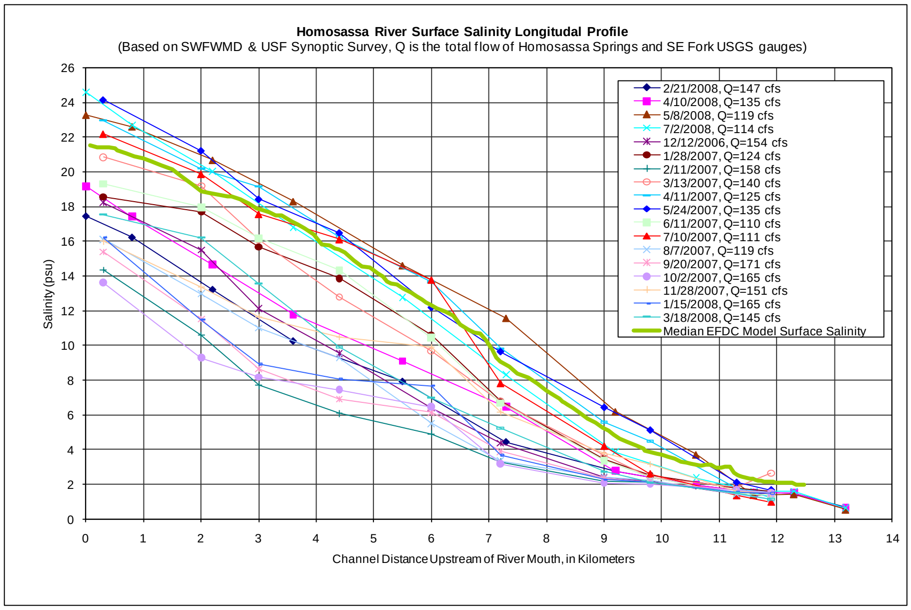
The Florida Department of Environmental Protection uses surface water chloride concentrations to classify surface waters of the State as predominately fresh or marine waters. Surface waters in which the chloride concentration is less than 1,500 milligrams per liter are classified as predominately fresh waters. Surface waters with chloride concentrations greater than or equal to 1,500 milligrams per liter are classified as predominately marine waters (Rules 62-301.200(22) and (23), F.A.C.). The 1,500 mg/L chloride threshold corresponds roughly to a salinity of 2.71, based on the general relationship between salinity and chlorinity (salinity as parts per thousand or ppt = 1.80655 * chlorinity as ppt) published by Wooster *et al.* (1969). Comparison of salinities shown in Figure 2-30 with this approximate threshold salinity indicates that the Homosassa River upstream of the Homosassa Springs gage and the Southeast Fork of the Homosassa River may be considered predominantly fresh water bodies. Maximum daily bottom salinities at the Halls River gage site often exceed the approximate 2.71 salinity criterion, suggesting that the portion of Halls River near the site may be classified as predominantly marine waters. Bottom salinities at the Homosassa River and Shell Island gage sites also suggest the segments of the Homosassa River near and downstream from the sites may be classified as predominately marine waters.

Yobbi and Knochenmus (1989) evaluated salinity, tide and spring discharge relationships in the Homosassa River during 1984 and 1985 using measurements from fixed gage stations in the Homosassa River and sporadic sampling at several additional sites. Vertical or depth-specific salinity profiles constructed for various isohalines indicated the water column was typically well-mixed during their two-year study period; ratios between top and bottom salinities were on the order of 0.85 to 1.0. Salinities during the two-year study period fluctuated between one to two ppt at river mile 6.5, just downstream of the confluence of the Homosassa and Halls rivers, and ranged between approximately 13 to 26 ppt at the river mouth. Longitudinal salinity profiles developed for the river under a range of flow conditions demonstrated how salinity variation in the upper portion of the river was relatively minor as compared to the variability observed in the lower river. Waters with a salinity of 2 ppt, the threshold used by Yobbi and Knochenmus to identify mixing of seawater and spring water discharged from the system headwaters, were observed during high tide conditions over a 1.7 mile stretch of the river, between miles 4.5 and 6.2 upstream from the river mouth. In contrast, salinities of 25 ppt were observed over a range of 5.4 miles, from a point 5 miles downstream from the river mouth to a point 0.4 miles upstream of the mouth.

More recent characterization of salinities in the Homosassa River has been completed for the District by HSW Engineering, Inc. (2010) in support of the development of minimum flow recommendations. The analyses involved: 1) summarization of synoptic salinity measurements in the Homosassa River completed by and for the District in recent years; 2) evaluation of salinity estimates derived from specific conductance measurements made at fifteen-minute intervals at USGS gage sites in the river system; 3) development of empirical models for predicting salinities in the main channel of the Homosassa River; and 4) hydrodynamic modeling of salinity (and water temperature) in the main channel of the Homosassa River.

Based on synoptic sampling completed by the University of South Florida and the District from December 2006 through July 2008, HSW Engineering, Inc. (2010) found nearly linear longitudinal salinity gradients along the center of the Homosassa River (Figure 2-31). Near surface and bottom salinities of 2.71 or less, the salinity corresponding to the chloride threshold used by the Florida Department of Environmental Protection for delineating predominately fresh and marine waters, were typically common only above river kilometers 9 or 10, and vertical salinity gradients were minor, indicating the water column was relatively well mixed. In contrast to the 2006 through 2008 period evaluated by HSW Engineering, Inc., near-surface salinities less than the “predominately fresh water” salinity threshold of 2.71 were common downstream as far as river kilometer 7 or 8 from February 2003 through December 2005, when the river was sampled by the University of Florida and combined spring discharge was consistently higher than the 2006-2008 period (Figure 2-32).

Based on salinity estimates derived from specific conductance measurements and reported discharge values for fifteen-minute intervals between 2004 or 2006 and September 2008, HSW Engineering, Inc. (2010) found that salinity in the Homosassa River at the Homosassa River and Shell Island USGS gages was inversely related to combined discharge past the Homosassa Springs and SE Fork gages (Figure 2-33). Salinities at the Halls River gage were not strongly related to discharge from springs in the upper Homosassa River. HSW Engineering, Inc. notes that apparent increased salinity at the Halls River gage during highest observed flows may have been associated with backwater effects of spring discharge at the confluence of the Halls River with the Homosassa River.



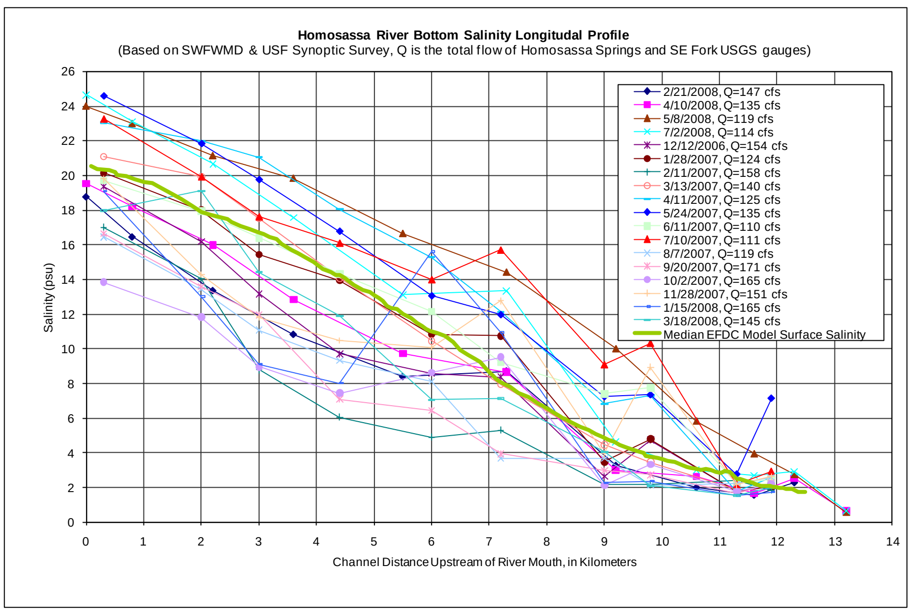


Figure 2-31. Longitudinal surface (upper panel) and bottom (lower panel) salinity profiles for the main channel of the Homosassa River based on synoptic sampling by the University of South Florida and the District during a variety of flow conditions between December 2006 and July 2008. Salinities are expressed as practical salinity units or psu. Flow values (Q) correspond to combined flow at the United States Geological Survey Homosassa Springs at Homosassa Springs, FL and Southeast Fork Homosassa Spring at Homosassa Springs, FL gage sites. Longitudinal surface and bottom salinity profiles for 2007 based on median centerline salinities simulated with the Homosassa River Environmental Fluid Dynamic Code (EFDC) hydrodynamic model are also shown. Panels reproduced from HSW Engineering, Inc. (2010).

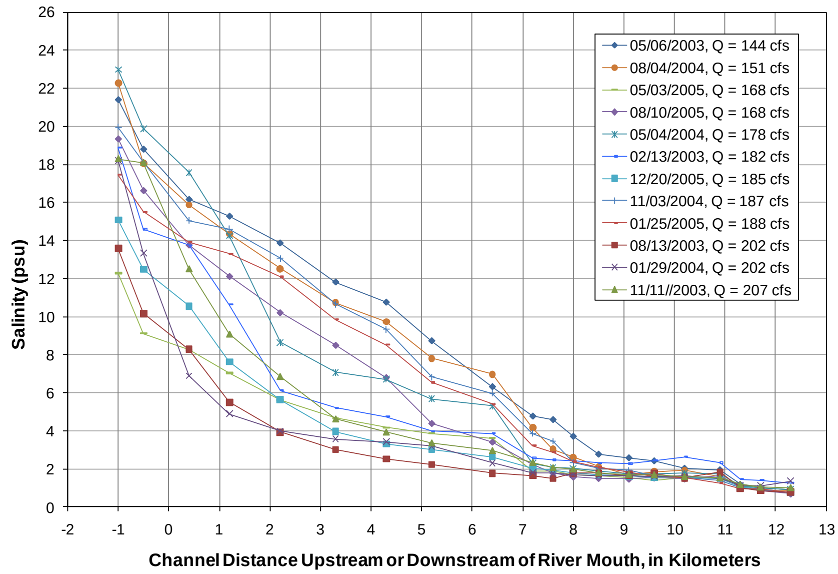


Figure 2-32. Longitudinal profiles of near-surface salinity for the Homosassa River channel center based on synoptic sampling by the University of Florida under a variety of flow conditions between February 2003 and December 2005. Flow (Q) and salinity values as described in Figure 2-30.

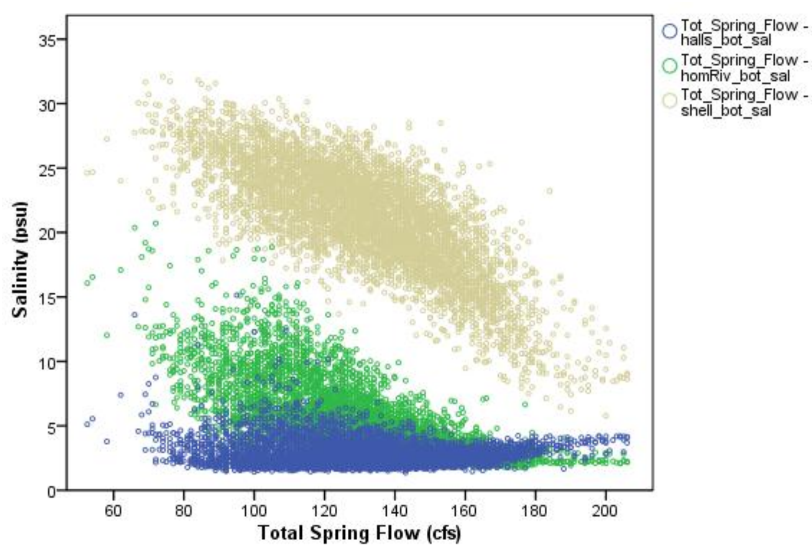


Figure 2-33. Bottom salinity (expressed in practical salinity units or psu) at the United States Geological Survey Homosassa River, Halls River and Shell Island gage sites based on total discharge (spring flow) from the Homosassa Springs and Southeast Fork gages. Plotted values represent a randomly-selected subset composed of ten percent of the fifteen-minute-interval values reported by the USGS for the period from 2004 or 2006 and 2008 (sample period start date is gage-specific). Figure reproduced from HSW Engineering, Inc. (2010).

Modeling River Salinity – Empirical Regression Models

Empirical regressions for modeling or predicting salinity in the main channel of the Homosassa River were developed by HSW Engineering, Inc. based on salinity, tide stage and discharge records for gage sites in the river and salinity measurements made by the USGS, the University of South Florida, the University of Florida, the Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute and the Southwest Florida Water Management District. Summary descriptions of the regression equations are presented in this section; details regarding regression model development are provided in HSW Engineering, Inc. (2010), which is included as Appendix A to this report.

The regression models include sets of equations for predicting the location of surface and bottom isohalines for salinities of 3, 5 and 12 in the Homosassa River based on the combined flow at the USGS Homosassa Springs and Southeast Fork Homosassa Spring gage sites and the tide stage at the USGS Homosassa River gage site. Synoptic salinity data collected from 2000 through 2009 were used for development of the regression equations. The equations account for 53-59 percent of the variance in the salinity measurements used to develop the predictive models and may be expressed as

$$RKM = a_0 + a_1 * Q + a_2 * (Q - knot_1) + a_3 * T, \text{ for } Q >= \text{knot}_1 \quad \text{(Equation 1)}$$

or

$$RKM = a_0 + a_1 * Q + a_3 * T \text{ for } Q < knot_1 \quad \text{(Equation 2),}$$

where: *RKM* is the isohaline location expressed as the river kilometer or distance upstream from the river mouth near Shell Island;

Q is the combined flow, in cubic feet per second, past the USGS Homosassa Springs at Homosassa Springs and SE Fork Homosassa Spring gages;

$knot_1$ is the inflection *Q* value used in the piecewise regression model (Equation 1); and

T is the tide stage at the USGS Homosassa River gage, in feet above NAVD88, at the time of the salinity measurement.

Summary statistics and regression coefficients for the predictive surface and bottom isohaline models in the form of equations 1 and 2 are provided in Table 2-10. The coefficients a_1 and a_2 in association with the flow (Q) and knot_1 flow in the equations describe the longitudinal change in kilometers associated with a one cfs change in *Q*. For example, if *Q* is less than the knot_1 value of 135 cfs, a ten cfs reduction is predicted to result in a 0.09 km upstream movement of the bottom isohaline with a salinity of 5 based on equation 1. For flows exceeding the $knot_1$ value of 135 cfs, a ten cfs reduction in flow would be expected to result in an approximate 0.9 km upstream movement of the bottom isohaline with a salinity of 5.

Table 2.10. Summary information for regression equations used to predict surface and bottom isohaline locations for selected salinities in the main channel of the Homosassa River based on data collected from 2000 through 2009 (adapted from HSW Engineering, Inc. 2010).

Salinity Isohaline	Isohaline Type	Regression Coefficients					R^2	Number of Observations
		a_0	a_1	a_2	a_3	$knot_1$		
3	Surface	11.936	-0.017	-0.029	0.427	128.0	0.54	59
	Bottom	14.259	-0.026	-0.054	0.443	135.0	0.57	61
5	Surface	10.991	-0.020	-0.030	0.511	135.0	0.59	69
	Bottom	10.874	-0.009	-0.081	0.664	135.0	0.53	65
12	Surface	5.397	0.002	-0.072	1.250	121.6	0.59	70
	Bottom	9.630	-0.029	-0.060	1.070	131.2	0.54	49

Equation forms:

$RKM = a_0 + a_1 * Q + a_2 * (Q - knot_1) + a_3 * T$ for $Q >= knot_1$ or

$RKM = a_0 + a_1 * Q + a_3 * T$ for $Q < knot_1$

in which

RKM = the isohaline location expressed as the river kilometer or distance upstream from the river mouth near Shell Island;

Q = the combined flow, in cfs, past the USGS Homosassa Springs at Homosassa Springs and SE Fork Homosassa Spring at Homosassa Spring gages;

$knot_1$ = the inflection Q value used in the piecewise regression model; and

T = the tide stage at the USGS Homosassa River gage, in feet above NAVD88, at the time of the salinity measurement.

Modeling River Salinity – Hydrodynamic Model

In addition to the regression models developed for prediction longitudinal salinity in the Homosassa River, a calibrated hydrodynamic model of the system was developed for the District by HSW Engineering, Inc. (2010) to support minimum flows evaluations. The model, which was developed using Environmental Fluid Dynamic Code was used to evaluate salinity and thermal characteristics of the Homosassa River main channel for baseline and selected flow-reduction scenarios. The District has previously used the Environmental Fluid Dynamics Code to evaluate salinity and thermal characteristics and develop minimum flow recommendations for other estuarine river systems, including the Chassahowitzka River system (Dynamic Solutions, LLC 2009), the Little Manatee River system (Huang and Liu 2007) and the Weeki Wachee River system (Janicki Environmental, Inc. and Applied Technology and Management 2007).

The Homosassa River hydrodynamic model includes a three dimensional orthogonal grid system with up to three vertical layers, depending on water depth in individual grid-cells (Figure 2-34). Boundary conditions for the model were established west of Shell Island and at the headwaters of Halls River and the Homosassa River. Downstream boundary conditions included measured stage, salinity and temperature at the USGS Shell Island gage and modified salinity values developed during the model calibration process. Upstream conditions included discharge, salinity and temperature at the USGS Homosassa Springs and SE Fork gage sites. Boundary conditions for Halls River included statistically modeled values based on the combined discharge past the USGS Homosassa Springs, SE Fork and Homosassa River gages; salinity conditions measured in Halls River and at the Homosassa Springs gage; and a temperature constant of 23.2°C. Meteorological inputs included wind speed and direction and air temperature measured at the FAWN-IFAS Station at Brooksville.

The model was calibrated and validated to achieve optimal concordance with measured water surface elevation and surface, middle water-column and bottom salinity and water temperature. The model was calibrated for the period from September 15, 2006 through December 31, 2006, and model validation and sensitivity analysis were conducted for the period from January 1, 2007 through June 30, 2007. The modeled period used for analysis of flow variation on thermal characteristics of the river extended from October 1, 2007 through March 31, 2008, and the period modeled for evaluation of salinity changes associated with flow reductions extended from January 1, 2007 through December 31, 2007. Flow duration curves generated for the Homosassa Springs and SE Fork Homosassa Spring gages indicate that the timeframes chosen for modeling thermal and salinity characteristics of the river represented relatively low flow conditions (Figure 2-35).

HSW Engineering, Inc. (2010) report that modeling tidal stage at the USGS gage sites with the Environmental Fluid Dynamic Code was somewhat problematic. They indicate that model accuracy for this parameter could be improved by inclusion of additional downstream side channels within the model domain. Mean salinity was modeled adequately at the three gages, but maximum salinities observed at the Halls River and Homosassa River gage sites were underestimated by the calibration and validation periods. Water temperatures were modeled well for the Shell Island sites and reasonably well for the Homosassa River and Halls River sites. Water temperatures were slightly under- predicted for warm months and over-predicted for cold months, suggesting that the thermal effect of spring discharge may be underestimated by the model. Observed and modeled stage, surface water salinity and temperature for the Homosassa River gage site for the model calibration period are shown in Figure 2-36.

Centerline surface and bottom salinities in the Homosassa River were modeled for three-hour increments in calendar year 2007 using the calibrated hydrodynamic model. Median centerline salinities compare favorably with longitudinal salinity profiles for the river channel that were developed based on synoptic sampling completed by the District and others (see Figure 2-31). Use of these baseline modeling results and modeled results associated with various flow reduction scenarios was an important component of the District's minimum flow recommendations for the Homosassa River system and is discussed further in Chapters 4 and 5 of this report.

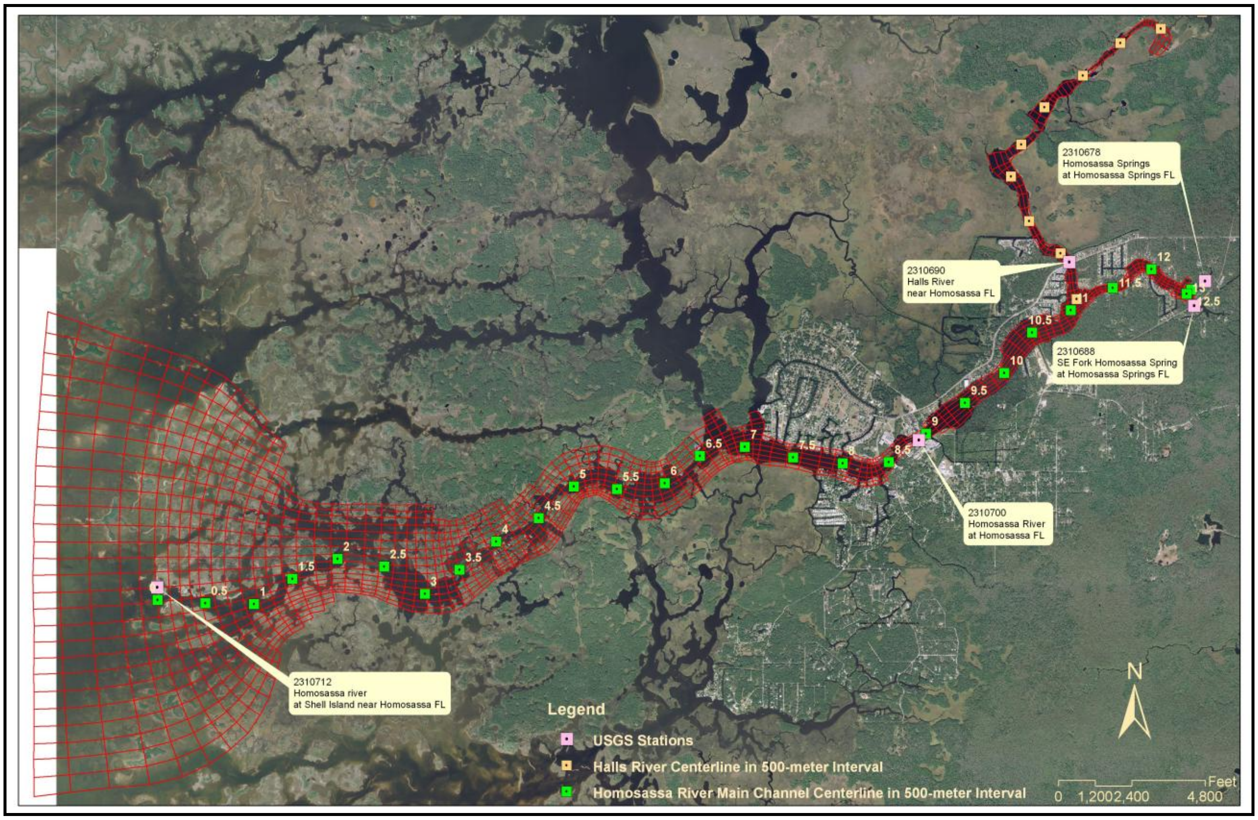
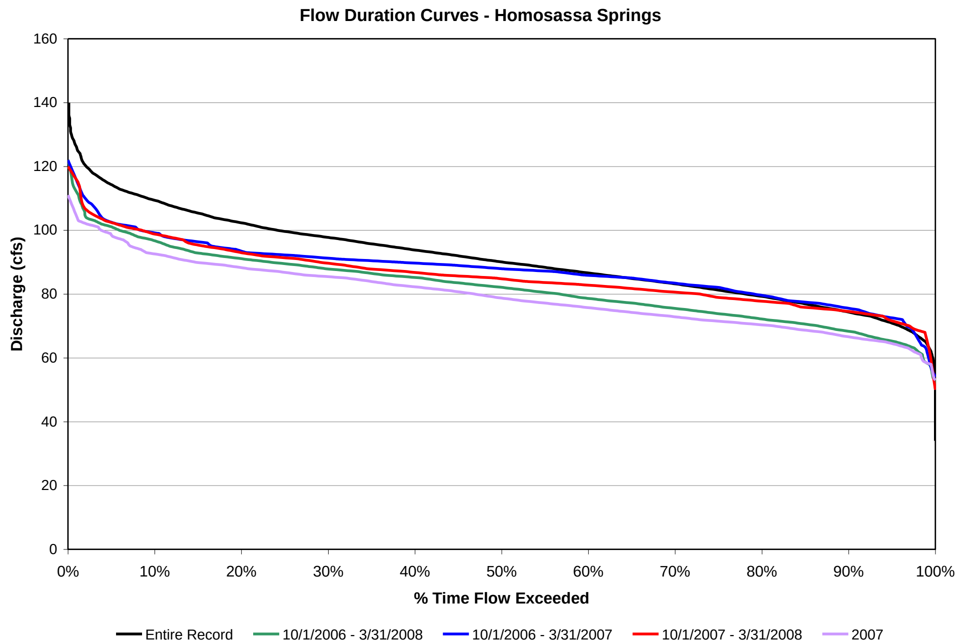


Figure 2-34. Curvilinear-orthogonal grid system for the Homosassa River Environmental Fluid Dynamics Code model (map reproduced from HSW Engineering, Inc. 2010).



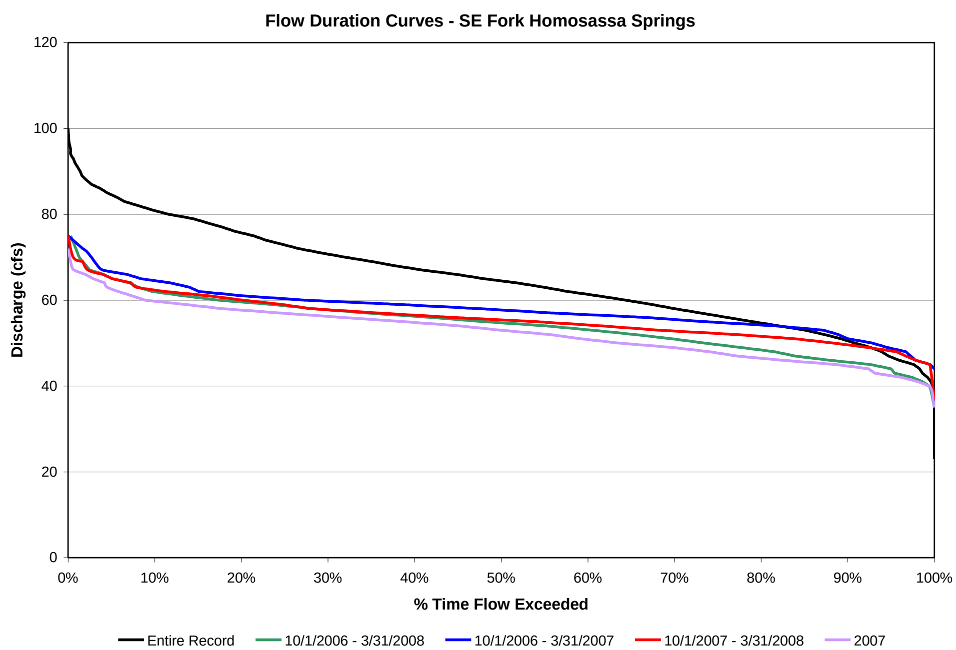


Figure 2-35. Flow duration curves for the United States Geological Survey Homosassa Springs at Homosassa, FL (upper panel) and Southeast Fork Homosassa Spring at Homosassa Springs, FL (lower panel) gage sites for selected periods, including the site-specific periods of record and two periods (calendar year 2007 and the period from October 1, 2007 through March 31, 2008) that were used for modeling salinity and thermal characteristics of the Homosassa River. Panels reproduced from HSW Engineering, Inc. (2010).

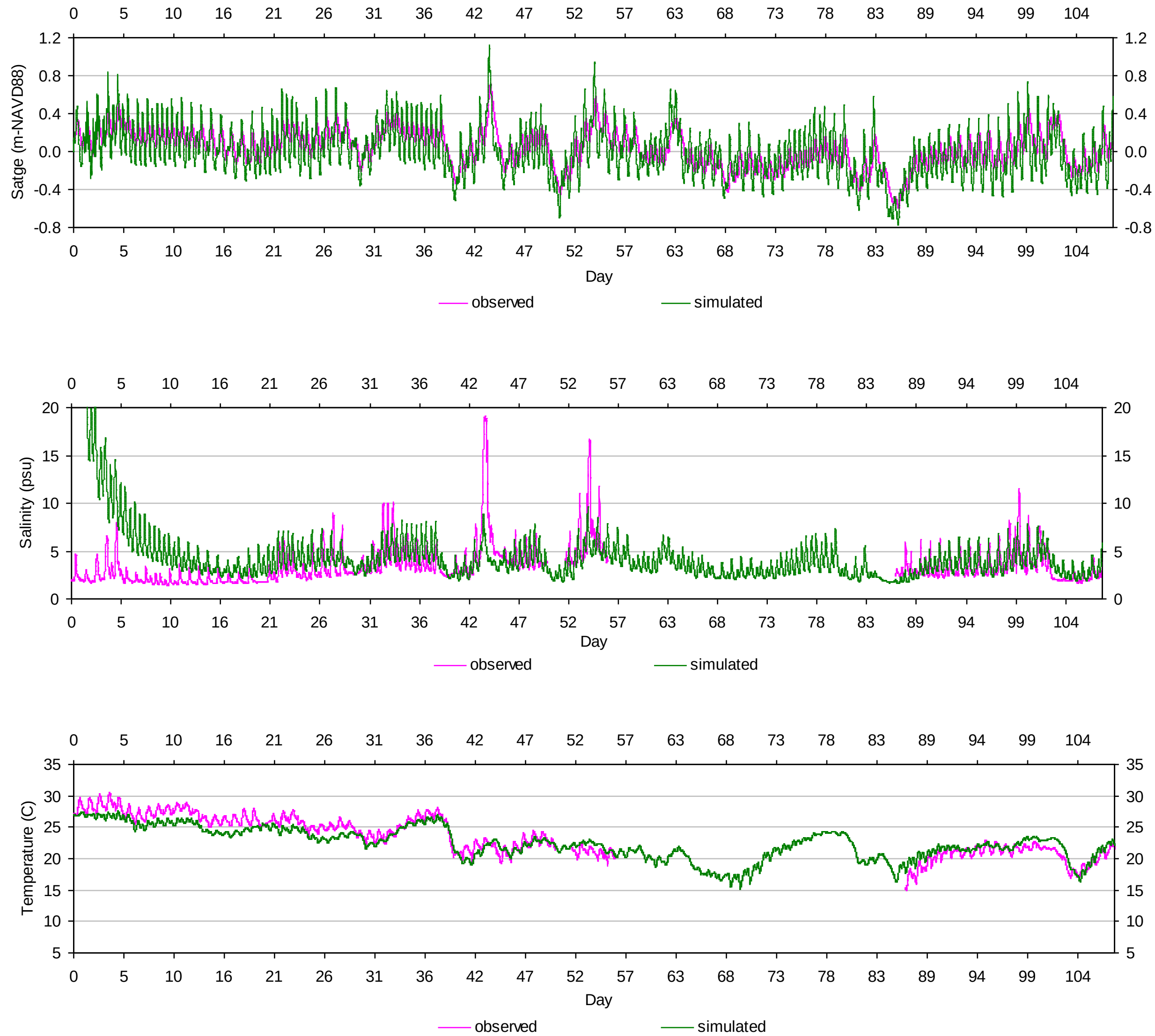


Figure 2-36. Observed and modeled stage (upper panel), surface water salinity (middle panel, expressed as practical salinity units or psu) and water temperature (lower panel) for the United States Geological Survey Homosassa River at Homosassa, FL gage site for the September 15. 2006 through December 31, 2006 model calibration period. Modeled values derived using the Environmental Fluid Dynamic Code Homosassa River model. Plots reproduced from HSW Engineering, Inc. (2010).

Modeling River Salinity – Comparison of Hydrodynamic and Empirical Regression Models

Predicted salinities for the Homosassa River in 2007 developed using the Homosassa river hydrodynamic model and the empirical regression modeling approaches were similar. Coefficients of determination for regressions of predicted surface, bottom and depth-average isohalines with salinities of 3,5 and 12 for the two sets of modeled results ranged from 0.63 to 0.73 (HSW Engineering, Inc. 2010). Modeled isohaline locations associated with the combined discharge past the USGS Homosassa Springs and SE Fork Homosassa Springs gages developed with the hydrodynamic model tended to occur further upstream as compared to the locations predicted using the empirical regression models (equations 1 and 2 presented in this chapter). Difference in model-predicted isohaline locations were most apparent for surface salinities, as illustrated in Figure 2-37, which includes modeled results for daily surface, bottom and depth-averaged isohalines with a salinity of 3. Similar graphics for the 5 and 12 psu isohalines prepared by HSW Engineering, Inc. (2010) are included in Appendix A of this report.

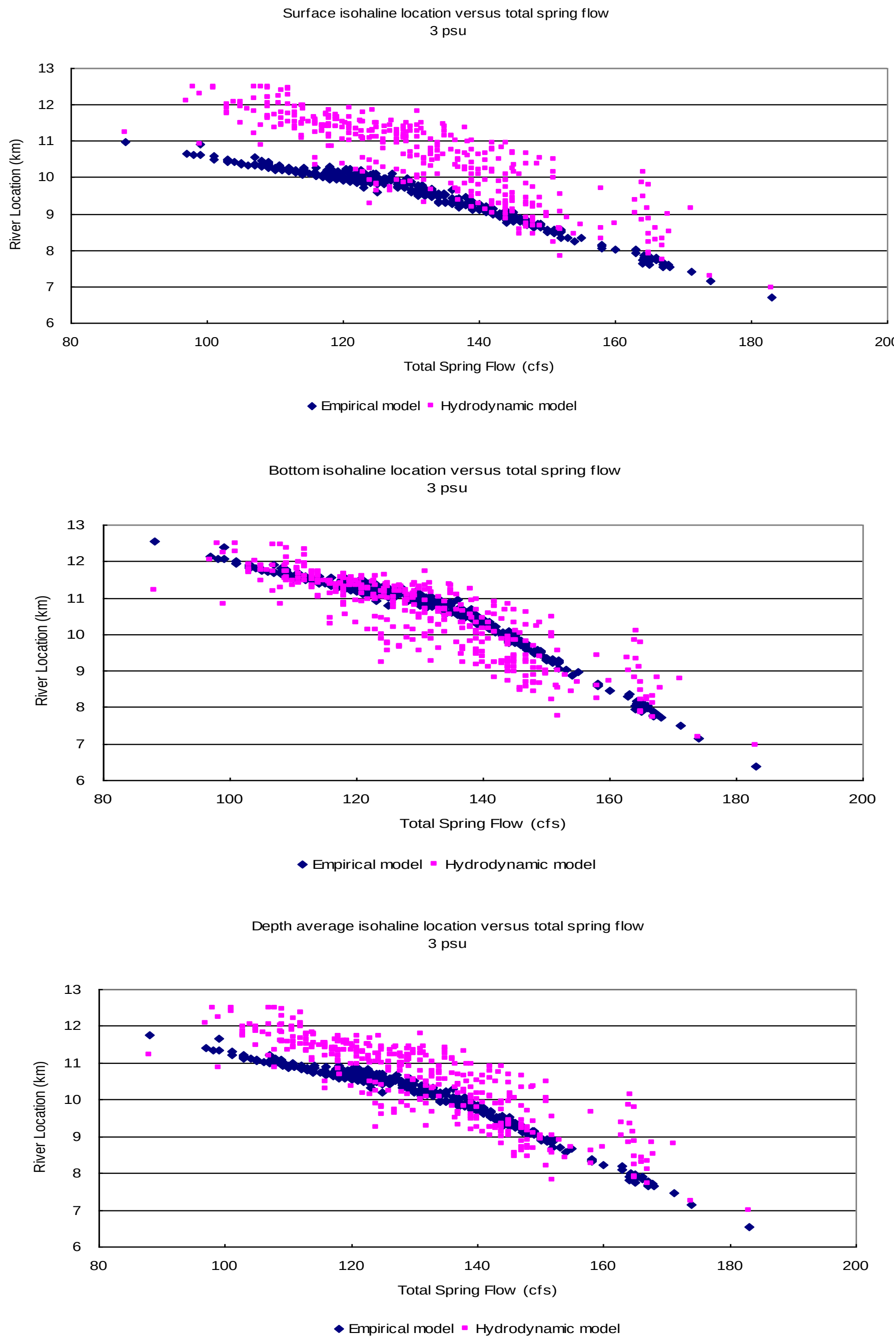


Figure 2-37. Predicted location of the surface, bottom and depth-averaged 3 psu (practical salinity unit) isohaline as a function of total spring flow (combined discharge past the United States Geological Survey Homosassa Springs and SE Fork Homosassa Springs gages) for 2007 based on model results derived using empirical regression models and the Homosassa River Environmental Fluid Dynamic Code hydrodynamic model. Depth-average isohaline location for the regression-based results derived through interpolation of bottom and surface isohaline locations.

<u>Other River Water Quality Characteristics</u>

In addition to water temperature and salinity, which were discussed in previous sub-sections of this report, several other water quality parameters were evaluated for this report on recommended minimum flows for the Homosassa River system. For this review, records available from the District Water Management Information system and synoptic sampling completed by and for the District during recent decades were evaluated, along with previously published water quality summaries for the system.

Water in the river channels of the Homosassa River system can be characterized as basic. Median pH values in 1-km segments of the Homosassa River between river kilometers 0 and 13 ranged from 7.6 to 7.9, based on synoptic sampling completed from January 1997 through February 2009 (Figure 2-38, upper panel; also Table 2-9). Median pH values ranged from 7.7 to 7.8 for 1-km segments of Halls River (see Table 2-8). Median pH values for Hidden River Head Spring and Hidden River Spring No. 2 (see Table 2-7) suggest that the Hidden River is also a basic system. The range of pH values observed in the Homosassa River system likely reflects the substantial groundwater from springs and diffuse groundwater discharges in the headwater areas and the basic nature of seawater in the lower portions of the system.

The Florida criterion for dissolved oxygen in Class II and Class III-Marine water bodies requires that dissolved oxygen concentrations shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0 mg/L. The standards also require that "[n]ormal daily and seasonal fluctuations above these levels shall be maintained" (Rule 62-302.530, F.A.C.). Criteria are similar for Class III-Fresh water bodies although dissolved oxygen concentrations are required to equal or exceed 5.0 mg/L at all times. Median dissolved oxygen concentrations in 1-km segments of the Homosassa River and Halls River ranged from 5.9 to 7.7mg/L (see Table 2-9), but concentrations less than 5.0 mg/L were measured in all segments. The distribution of oxygen concentrations in one-kilometer segments of the Homosassa River is shown in the lower panel of Figure 2-38.

Nitrogen is an essential element for the growth of algae and aquatic plants, and is frequently a limiting nutrient in estuarine systems (Ryther and Dunstan 1971, Nixon 1986, National Research Council 2000). It occurs in a wide variety of organic or inorganic forms in water and different forms of the element are often measured for assessments of water quality. Total nitrogen, which is the sum of nitrate, nitrite, ammonia and organic nitrogen, is commonly used for trophic-state evaluations. Median total nitrogen concentrations for most of the sites sampled in the Homosassa River system ranged from 0.42 to 0.63 mg/L (Table 2-11). The high end of this range is less than 60 to 70% of the total nitrogen levels reported for estuarine sites and less than the levels reported for 80 to 90% of the stream sites evaluated by Friedemann and Hand (1989) in their now historical compilation of statewide water quality information. The median observed total nitrogen values are lower than the 1.205 mg/L numeric criterion currently proposed by the United States Environmental Protection Agency for free-flowing surface waters in the peninsular region of Florida.

Phosphorus is also often identified as a limiting nutrient for the growth of algae and aquatic plants. This element occurs in dissolved and particulate forms in aquatic systems and often cycles rapidly between these two states. Total phosphorus, the sum of dissolved and particulate forms, is often used to characterize the trophic state, or level of biological productivity, of water bodies. Median total phosphorus concentrations for most of the sites sampled in the Homosassa River system were typically between 0.02 and 0.03 mg/L (Table 2-11), a range that is less than 80 to 90% of the levels reported for the estuarine sites and less than the levels reported for 80 to 95% of the stream sites evaluated by Friedemann and Hand (1989) in their now historical compilation of statewide water quality information. Concentrations of dissolved orthophosphate, a common form of dissolved phosphorus, ranged from 0.01 to approximately 0.02 mg/L at river sites in the Homosassa River system. These concentrations correspond to a “good” condition of level for this nutrient, based on a recent assessment of the condition of coastal estuaries of the United States (United States Environmental Protection Agency 2004) and are lower than the 0.107 mg/L numeric criterion currently proposed by the United States Environmental Protection Agency for free-flowing surface waters in the peninsular region of Florida.

Chlorophyll, a primary pigment involved in plant photosynthesis, is another water quality parameter that is typically assessed when evaluating or describing trophic-state conditions in a water body. Median total chlorophyll values at sites in the Homosassa and Halls Rivers ranged from 1 to19.9 µg/L, with highest medians reported for Halls River and the Homosassa River near the confluence of the two rivers (Table 2-11).

Table 2-11. Median water quality parameter values for sites in the Homosassa River, Southeast Fork and Halls Rivers, based on data collected between March 24, 1992 and December 15, 2009 by or for the Southwest Florida Water Management District. Values are expressed as dissolved mg/L unless otherwise indicated and "x" denotes measurements are not available.

Site Name	River Kilo-meter	Number of Dates Sampled (N)	Ca	Cl	Mg	K	Na	SO_4	Total N (µg/L)	Total P	Ortho-PO_4	Total Suspen-ded Solids	Total Chloro-phyll (µg/L)	Color (PCU)
Halls River														
Halls River Bridge	0.4	12	82	1,615	111	31	874	223		0.02	0.01	3.3	x	18
HALLS River AB Homosassa	1.4	27	109	1,877	102	x	x	283	x	x	x	x	8.4	20
Homosassa River WQ HL6	2.2	6	93	1,189	111	31	895	238	0.59	0.055	x	3.3	9.1	25
Homosassa River														
Homosassa River WQ H10	0	7	310	12,700	851	279	7,020	1,820	0.39	0.015	x	5.4	1.3	20
Homosassa River WQ H7	3.6	7	248	8,240	572	192	4,740	1,360	0.45	0.022	x	5.3	1.9	21
Homosassa River HV5	4.8	26	x	x	x	x	x	x	0.43	0.023	0.01	5.5	2.7	20
Homosassa River HV3	7.8	26	x	x	x	x	x	x	0.42	0.024	0.01	3.0	5.9	15
Homosassa River AB Gulf	8.4	29	96	2,311	287	x	x	337	x	x	x	x	7.1	20
Homosassa River at Homosassa	8.9	40	71	1,320	68	20	531	183	x	0.025	0.01	3.5	x	5
Homosassa River HV1	11.1	26	x	x	x	x	x	x	0.50	0.023	0.01	1.7	2.7	10
Homosassa River AB Halls River	11.4	29	65	670	65	x	x	101	x	x	x	x	19.9	5
Homosassa River HV0.5	11.9	26	x	x	x	x	x	x	0.59	0.022	0.02	0.7	1	5
Homosassa River WQ H1	12.3	7	57	673	48	13	312	100	0.63	0.022	x	0.3	1	10
Homosassa Wildlife Park	12.6	2	80	601	x	x	x	91	x	0.026	0.02	x	x	x
Homosassa River HV0 (pool)	12.9	26	x	x	x	x	x	x	0.60	0.026	0.02	0.7	1	5
Southeast Fork														
Southeast Fork of Homosassa Spring	12.6	7	41	50	11	1.2	29.4	12	x	0.016	0.02	0.5	x	5
Homosassa River WQ SE1	12.7	7	52	194	18	3.7	103	37	0.62	0.021	x	0.4	1	10

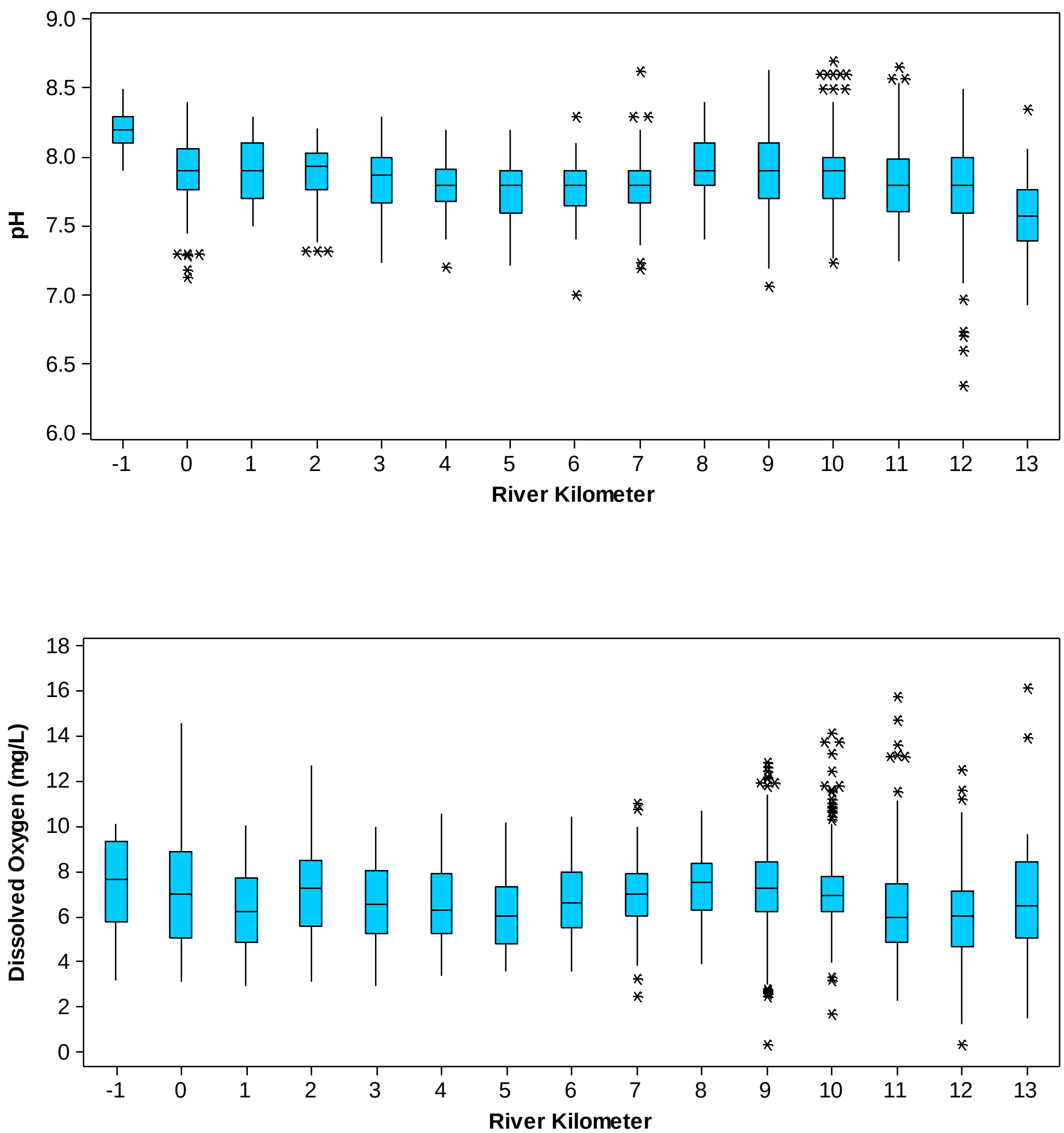


Figure 2-38. Box plots of pH (upper panel) and dissolved oxygen concentrations (lower panel) in one-kilometer segments of the Homosassa River, including the Southeast Fork of the Homosassa River, based on data sources and period of record identified in Figure 2-25.

Chapter 3

Biological Characteristics of the Homosassa River System

Vegetation

Description

The Homosassa River and Southeast Fork of the Homosassa River originate in an extensive wetland system that transitions from hydric hammock and seasonally or temporarily flooded brackish, forested wetlands to irregularly flooded estuarine salt marsh approximately 3.1 miles (five km) downstream from the river's headwaters near the community of Homosassa (see Figure 2-23). Downstream, the river courses through a complex of irregularly flooded emergent and forested estuarine wetlands and subtidal aquatic beds. Halls River and Hidden River are surrounded by seasonally flooded or tidal brackish, forested and emergent wetlands over their entire lengths.

Descriptions of these and similar coastal wetlands of the region are included in a number of reports published during recent decades. Simons (1990) and Wolfe *et al.* (1990) provide general overviews of wetland and upland vegetation for the Springs Coast, which is the extensive portion of the west coast of Florida ranging from the Pithlachascotee River basin in Pasco County northward to the Waccasassa River basin in Levy County. Simons *et al.* (1989), Vince *et al.* (1989) and Williams *et al.* (2007) focus on hydric hammocks, which are a unique forested wetland type that is most widely distributed in Florida along the Springs Coast and beyond to the St. Marks River area. Comprehensive reviews of seagrass communities in the area include those by Zieman and Zieman (1989), Frazer and Hale (2001), Mattson *et al.* (2007) and Dawes *et al.* (2004). Other studies, including those by Blackburn and Weldon (1967), Gates (1967), the Southwest Florida Water Management District (1989), Kelly (1994), Frazer (1999), Frazer *et al.* (2001a, b), Hoyer *et al.* (2004), Southwest Florida Water Management District (2005), Frazer *et al.* (2006) and PBS&J (2009) provide specific information on the vegetation of the Homosassa River system.

Submersed aquatic vegetation was reportedly quite dense in the Homosassa River in the 1960s (Blackburn and Weldon 1967, Gates 1967), but is currently relatively sparse (Frazer *et al.* 2001a,b. Frazer *et al.* 2006, PBS&J 2009). Freshwater species of submersed aquatic vegetation extend down the Homosassa River to approximately river kilometer six and are most abundant in Halls River. The most common submersed plants populating the river in recent years include parrot feather (*Myriophyllum aquaticum),* Eurasian water milfoil *(Myriophyllum spicatum),* southern naiad (*Najas guadalupensis*) and small pondweed (*Potamogeton pusillus*). Although less abundant, hydrilla (*Hydrilla verticillata*), American eelgrass (*Vallisneria americana*), coontail

(*Ceratophyllum dermersum*), pondweed (*Potamogeton pectinatus*) and widgeon grass (*Ruppia maritima*) have also been observed. *Sargassum* occurred at a number of sites in the lower Homosassa River, up to about river kilometer 4.4. Marine and freshwater algae, including *Chaetomorpha* and *Lyngbya* are commonly found in the upper and lower portions of the river, respectively. Less common macroalaga include *Chara*, *Gracilaria* and *Entermorpha*.

The shorelines of the Homosassa River downstream from the Homosassa Community and most of the Halls River are dominated by natural vegetative cover. Black needlerush (*Juncus roemerianus*) is the dominant emergent plant along the shore of the Homosassa River, where it extends upstream to river kilometer 7.4 (PBS&J 2009). The species is also relatively common in Halls River, where cattail (*Typha* sp.) is the dominant emergent plant. Sawgrass (*Cladium jamaicense*) is relatively abundant in Halls River and the Homosassa River. Leather fern (*Achrostichum* spp.) also occurs in both rivers, but is more common in the Homosassa River.

Common trees in the forested wetlands of the Homosassa River system include red maple (*Acer rubrum*), ash (*Fraxinus* spp.), swamp bay (*Persea palustris*), cabbage palm (*Sabal palmetto*), southern red cedar (*Juniperus virginiana* var. *silicicola*) and sweetbay (*Magnolia virginiana*). More salt tolerant trees, including red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*) and buttonwood (*Conocarpus erectus*) are sparsely distributed along the lower segment of the river. Common shrubs include saltbush (*Baccharis* spp.) and wax myrtle (*Myrica cerifera*).

Relationships Between Vegetation, Salinity and Other Physiochemcial Variables

Tidal wetlands associated with coastal rivers of the southeastern United States and elsewhere are susceptible to degradation associated with droughts, anthropogenic alteration of natural freshwater inflows or groundwater discharge, land-use changes, hurricanes and other storms, climate change, sea-level trends and sediment or substrate subsidence (*e.g.,* see Boesch *et al.* 1994, Brinson and Malvarez 2002, Kennish 2004, Doyle *et al.* 2007, Stedman and Dahl 2008). Studies addressing effects of salinity increases associated with these factors are particularly relevant to the development of minimum flow requirements for the Homosassa River system and other coastal rivers in the District, where flow reductions may alter salinity patterns within river channels and associated wetlands.

Effects of salinity on changes in cypress-dominated and mixed bottomland swamps in tidal segments of southeastern coastal rivers have been considered by numerous investigators. In a review of sea-level rise and coastal forests of the Gulf of Mexico, Williams *et al.* (1999) describe changes associated with sea level variation during the Holocene and summarize recent changes that have been attributed to increased salinity in the Mississippi River delta and south Florida. More recent summaries of saltwater induced changes in southeastern tidal swamps are provided by Conner *et al.* (2007) and Krauss *et al.* (2007). As part of a comprehensive review of tidal floodplain forests of the Suwannee River, Light *et al.* (2002) discuss potential increases in the abundance of salt-tolerant species under various flow-reduction scenarios. In the Northwest Fork of the Loxahatchee River in southeast Florida, recent decline of floodplain swamp vegetation, including bald cypress, has been associated with increased salinity (South Florida Water Management District 2002). In response to this environmental degradation and to preserve existing and stressed floodplain swamp communities, a minimum flow for the Loxahatchee River was established to maintain salinities less than 2 at selected sites along the river corridor. Based on review of published salinity tolerance information for common tree species within tidal forested wetlands, including bald cypress and various hardwood species, the Suwannee River Water Management District (Water Resources Associates Inc*. et al.* 2005) also identified a salinity criterion of 2 for consideration in their development of minimum flows for the lower segment of the Suwannee River.

The effects of sea-level rise and increasing salinity have also been evaluated for hydric hammocks, a common forested wetland type extending along the west coast of Florida from the southern Hernando County line north to the vicinity of the St. Marks River. Reduction in the aerial coverage of hydric hammocks, which are typically dominated by cabbage palm, southern red cedar, a mixture of hardwood trees and loblolly pine (*Pinus taeda*), has been extensive during the past century (see review by Williams *et al.* 2007). DeSantis *et al.* (2007) attributed recent declines in populations of cabbage palm and southern red cedar at Waccasassa Bay State Preserve to sea-level increase and drought, noting that recent rates of decline have exceeded predictions derived from previous studies of the area. Castaneda and Putz (2007) documented more than a seventeen percent decline in coastal forest in the Waccasassa Bay State Preserve between 1973 and 2003 as a result of forest replacement with salt marsh species. Modeled wetland changes associated with various sea level increase scenarios for the St. Marks National Wildlife Refuge area also demonstrate potential increases in salt marsh habitat and losses in forested habitat with increased sea levels (Doyle *et al.* 2003). According to analyses conducted by Raabe *et al.* (2004), as cited by Williams *et al.* (2007), decline of hydric hammock vegetation along the Big Bend coastline of Florida since the mid-1800s has been less pronounced in areas with high freshwater discharge, *e.g.,* near the Suwannee and Weeki Wachee Rivers. Field investigations of the survival of transplanted cabbage palm seedlings at Waccasassa Bay and at the Chassahowitzka National Wildlife Refuge (an area of relatively low salinity), provide some support for the mitigation of adverse salinity-effects in areas of higher freshwater discharge (Perry and Williams 1996). However, Williams *et al.* (2007) caution that *"[g]ood quantification of the effect of freshwater discharge on the rates of forest canopy loss and coastal forest retreat requires further study"*.

A number of recent District-funded studies have addressed factors influencing temporal and spatial variation in submersed aquatic, emergent and woody wetland vegetation of the Homosassa River system. Frazer *et al*. (2001a, b), Hoyer *et al.* (2004) and Frazer *et al.* (2006) evaluated factors such as salinity, freshwater flow, substrate, light and nutrient concentrations on submersed aquatic vegetation in the Homosassa River. PBS&J (2009) recently mapped and described submersed and emergent aquatic vegetation and woody vegetation of the Homosassa River, Halls River and Southeast

Fork of the Homosassa River to support development of minimum flows for the system. Results from these studies are highlighted in this section.

Hoyer *et al*. (2004) investigated submersed aquatic vegetation in the Homosassa, Chassahowitzka and Crystal rivers between 1998 and 2000 as part of a District-funded study designed to evaluate factors controlling plant abundance and distribution in these systems. At the Homosassa River, five main-channel sites were sampled during summer months along 20 regularly spaced transects between the Homosassa Main Spring pool and the landward margin of the salt marsh. Plant distributions in all three rivers were associated with flow rate. At sites where discharge exceeded 0.25 m s^{-1} (0.82 feet s^{-1}), substrates typically consisted of rock and were devoid of vegetation. Similarly, sites where bottom light intensity was less than ten percent of that at the water surface exhibited low plant abundance and biomass. Submersed aquatic vegetation biomass in all three sampled rivers was also nearly zero at sites where annual average salinity exceeded 3.5 ppt. Distributions of individual taxa were associated with average salinity values, with *Hydrilla* and *Gracilaria* found at sites with the lowest (1.5 ppt) and highest (2.6 ppt) mean salinities, respectively. Plant nutrients were found to affect submersed aquatic vegetation biomass much less than the other factors examined, leading Hoyer and his co-authors to assert that flow, substrate type, light intensity and salinity control the distribution and abundance of submersed aquatic vegetation in the Homosassa, Chassahowitzka and Crystal rivers.

Between 1998 and 2000 the University of Florida (Frazer *et al.* 2001a, b) sampled the submersed aquatic vegetation and characterized physical and chemical attributes of five rivers in the Springs Coast, including the Homosassa River. Three of the systems, the Homosassa, Chassahowitzka and Weeki Wachee Rivers, were again sampled by the University between 2003 and 2005 and results from the two study periods, *i.e.,* 1998-2000 and 2003-2005, are described and contrasted by Frazer *et al.* (2006). For both sampled periods, submersed aquatic macrophytes and macroalga were evaluated at a total of 100 sites located along 20 transects in each river between the headwater spring boils and the landward extent of salt marsh (the lowest sampled site on the Homosassa River was located near river kilometer 7.6). Water chemistry and periphtyon associated with macrophytes were sampled at 10 transects in each river.

The number of sites where submersed aquatic vegetation was absent in the Homosassa River and the other systems was substantially higher in the more recent sampling period; in the Homosassa River the mean number of sampled sites without vegetation increased 104% between the 1998-2000 and 2003-2005 periods. Submersed aquatic vegetation was, however, relatively sparse in the Homosassa River during both sampled periods, as compared to abundances observed on the other rivers. Filamentous algae (primarily *Lyngbya* sp.) and most macrophytes were less abundant in the Homosassa during the more recent period, with mean biomass values for the two periods differing by approximately 67 percent. Exceptions included small pondweed (*Potamogeton pusillus)* and widgeongrass (*Ruppia maritima)*, which both increased in abundance. Biomass of macroalga in the Homosassa River was 62 percent lower in the more recent sampling period. In contrast, biomass of periphyton on submersed aquatic vegetation in the river increased by 85 percent between the two periods.

Interestingly, mean salinity values in the Homosassa River for the more recently sampled period were lower than those for the earlier period, prompting Frazer and his collaborators to note that "… factors other than an increase in salinity underlie the observed declines in the frequency of occurrence and general downstream decline of submersed aquatic vegetation." Given that nitrate and soluble reactive phosphorus concentrations were substantially higher during the more recent period, they note that the observed changes in the Homosassa and other studied rivers could be indicative of increasing eutrophication associated with increased nutrient loading.

PBS&J (2009) recently evaluated submersed, emergent and woody shoreline plants along the Homosassa, Halls and Southeast Fork of the Homosassa Rivers. Based on field surveys completed in October 2008 and additional sampling by the District, the University of Florida and others, they delineated salinity zones in each river and characterized plant distributions in the river channels and within five feet of the shorelines. Shorelines of the Homosassa River between Shell Island and the bridge in the Homosassa Springs Wildlife Park near river kilometer 12.6 were evaluated. Southeast Fork shorelines were surveyed upstream to river kilometer 12.95 and Halls River shorelines were characterized from the river's confluence with the Homosassa upstream to approximately river kilometer 3.2. Shorelines were classified as natural or altered, with altered shorelines identified as rip-rap, seawall, maintained or modified. Maintained shorelines include lawns and maintained landscaping. Modified shorelines were those with relatively natural vegetation that have been obviously modified. Natural shoreline vegetation was mapped using a Braun-Blanquet approach and density-weighted cover classes were developed for individual plant species.

Based on salinity data collected by the District and other sources and the Venice Salinity Classification system, PBS&J classified only the most upstream few hundred meters of the Southeast Fork of the Homosassa River as freshwater habitat. Halls River and the Homosassa River segment between river kilometers 10 and 12.6 were classified as an oligohaline zone; the Homosassa River between river kilometers 3 and 10 may be classified as mesohaline zone; and the lower portion of the river between river kilometers 1 and 3 were classified as a polyhaline zone.

PBS&J notes that observed distributions of submersed and emergent aquatic vegetation are consistent with the delineated salinity zones and known salinity tolerances for individual plant taxa (Figures 3-1 through 3-3). Freshwater species of submersed aquatic vegetation were most abundant in Halls River and extended down the Homosassa River to approximately river kilometer 8. Freshwater species of emergent aquatic vegetation were limited to the Homosassa River upstream of its confluence with the Halls River at approximately RK11. Oligohaline emergent species were common throughout Halls River and were typically not distributed below river kilometer 6.6 in the Homosassa River, although leather fen was found as far downstream as river kilometer 2.2. Freshwater tree species were common along the

Homosassa River shoreline upstream from river kilometer 9. Oligohaline to mesohaline trees, including cabbage palm and red cedar were the dominant trees in the middle reach of the Homosassa River and were present throughout most of the Homosassa and Halls Rivers. Polyhaline species, including mangroves and buttonwood were dominant in the lowest segment of the Homosassa River.

Although submersed aquatic vegetation has been used to establish minimum flow requirements, PBS&J (2009) note that "...it is not an adequate indicator of increasing salinities in the Homosassa River due to its limited and declining distribution." They further suggest that "EAV [emergent aquatic vegetation] distributions may provide a good indicator for establishing MFLs along the Homosassa River" noting that "EAV species distributions generally correspond to mean high salinities along tidally influenced rivers and freshwater species respond relatively quickly to changes in salinities." In contrast, Clewell *et al.* (2002) report that apparent transitions in shoreline vegetation observed at several other west-Florida coastal rivers sampled for the District "…*may be indicative of general salinity conditions but are not reliable as predictors of specific salinity regimes."* Factors cited by Clewell and his collaborators as contributing to a lack of good correlation between shoreline plant occurrences and salinity included the narrow nature and relatively high frequency of disturbance of riverbank habitat with as compared to adjacent marsh or forested habitats.

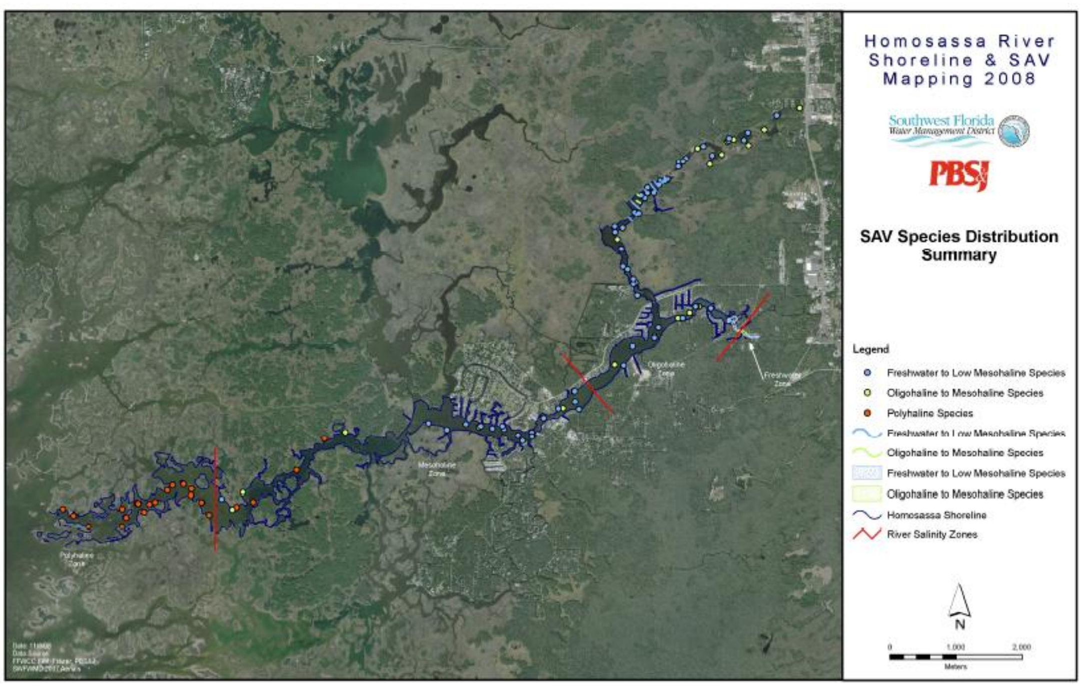


Figure 3-1. River salinity zones and submersed aquatic vegetation distributions in the Homosassa River, Southeast Fork of the Homosassa River and Halls River. Figure reproduced from PBS&J (2009).

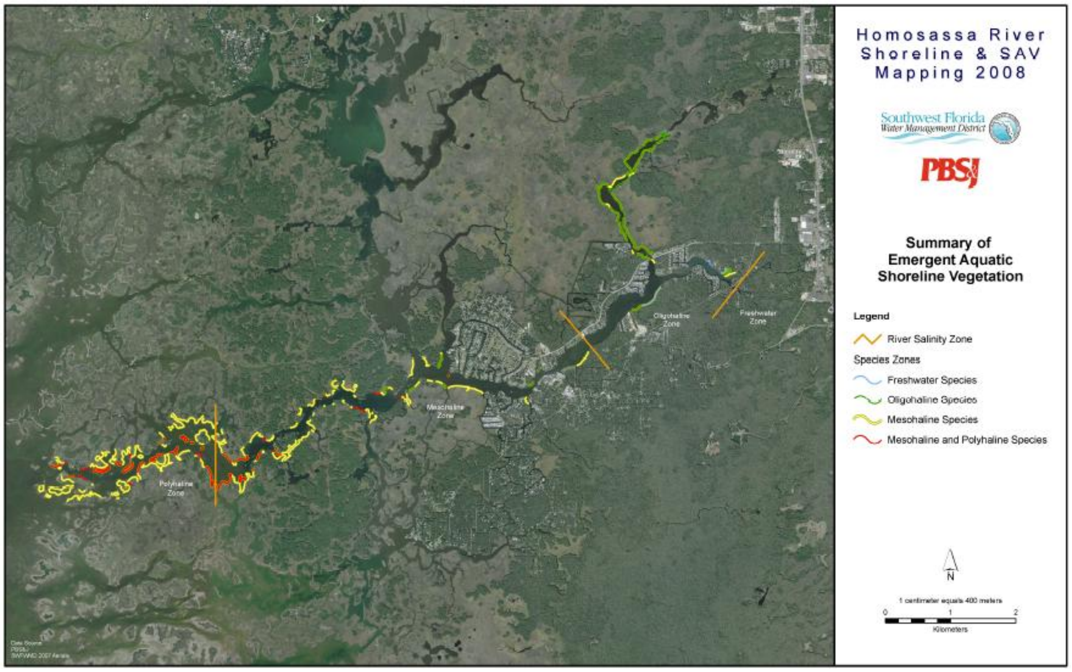


Figure 3-2. River salinity zones and emergent aquatic vegetation distributions in the Homosassa River, Southeast Fork of the Homosassa River and Halls River. Figure reproduced from PBS&J (2009).

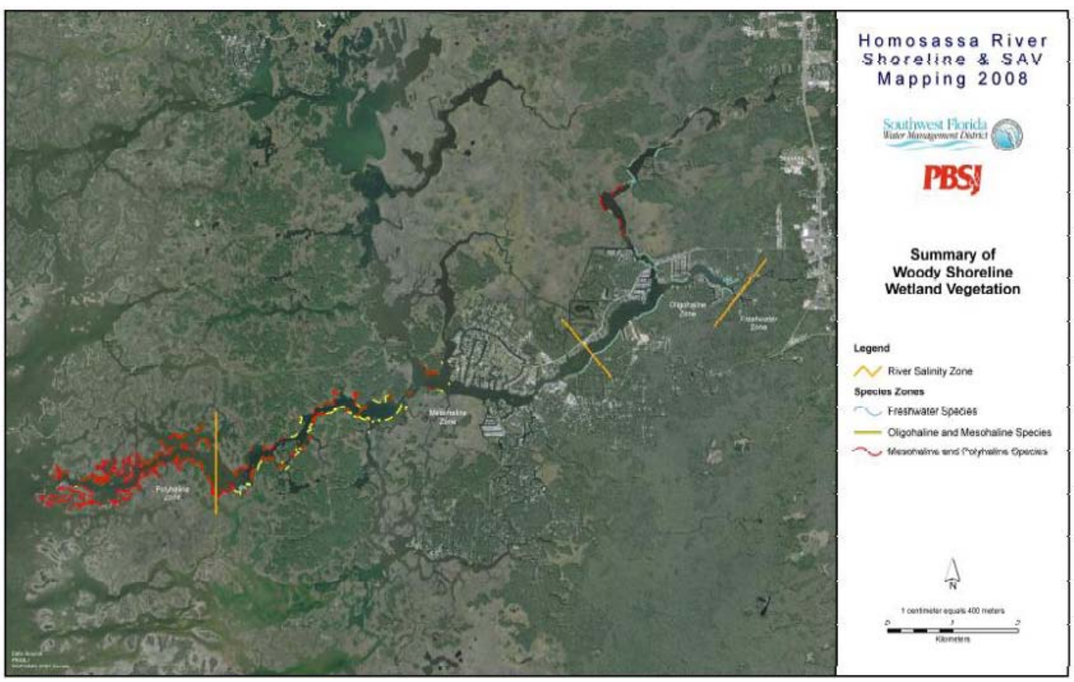


Figure 3-3. River salinity zones and woody plant species distributions in the Homosassa River, Southeast Fork of the Homosassa River and Halls River. Figure reproduced from PBS&J (2009).

Benthic Macroinvertebrates

Description

Benthic macroinvertebrates, *i.e.,* invertebrates larger than about 0.5 mm that live in, on or near bottom substrates of aquatic systems, are ecologically and recreationally important components of the Homosassa River system fauna. Some species, such as oysters, are relatively sessile, while others, including amphipods or scuds, are highly mobile. The life cycle of many benthic invertebrates include planktonic larvae or eggs that utlimately settle on bottom substrates. Longitudinal gradations in salinity and other phyiochemical factors likely contribute to the occurrence, persistence and distribution of benthic invertebrate species in the Homosassa River system.

Sloan (1956) and Wetland Solutions, Inc. (2010) provide descriptions of the aquatic insect component of the Homosassa River benthic macroinvertebrate assemblage. Based on sampling completed in the Homosassa and Weekiwachee Rivers between November 1952 and February 1954, Sloan found the number of insect species and abundances were lower in the spring pools and downstream estuarine areas as compared to the relatively fresh upstream or middle segments of the rivers. Sloan hypothsizes that the distribution of insect species in the Homosassa River (and the Weekiwachee River) may be related to low dissolved oxygen concentrations in spring pools and increased chloride concentrations in downstream areas. In the more recent study funded in part by the District, Wetland Solutions, Inc. report that the number of insects emerging from the Homosassa Main Spring run was four times greater than the number emerging from the spring pool, based on a three-day sampling event in November 2008. Although limited in scope, this sampling effort seems to support Sloan’s characterization of the distribution of insects in the upper Homosassa River and spring pool.

To support development of minimum levels for the Homosassa River system, the District recently funded a study by Janicki Environmental, Inc. designed to characterize the soft-sediment benthic macroinvertebrates in the Homosassa River, Southeast Fork of the Homosassa River and the lower portion of Halls River. The study included evaluation of relationships between macroinvertebrates, salinity and other environmental variables for development of predictive regression equations that describe variation in benthic macroinvertebrate taxa richness, diversity and total abundances. A report (Grabe and Janicki 2009) for the project is near finalization and is included in draft form as Appendix D to this report.

For the study, single three-inch diameter core samples were extracted from 0.43 ft^2 dredge samples collected at 114 sites with a Young-modified Van Veen sampler between May 12 and 14, 2008. Core samples were sieved in the field through a 0.5 mm mesh, preserved and sorted by the Mote Marine Laboratory. Sampled sites included 104 sites in the Homosassa River, five sites in the “spring run” or upper 250 meters of the Homosassa River, ten sites in the Southeast Fork and ten sites in the lower half of Halls River (Figure 3-4). Samples were collected at transects located throughout the river and at haphazardly selected sites in the spring run and Southeast Fork. Four samples were collected at transects in the Homosassa and two were collected at the Halls River transects. Water depth and near-surface and near-bottom water temperature, salinity, conductivity, dissolved oxygen concentration and pH were measured at each sampled site.

Abundance (numbers per square meter) and dominance (the geometric mean of the frequency of occurrence) were determined for the top fifty taxa in the Homosassa River/spring run/Southeast Fork and Halls River (Table 3-1). These taxa accounted for more than 91% of the mean total number of individuals collected from the core samples. The number of taxa was highest in the downstream portion of the Homosassa River and lowest between river kilometers 10 and 11 (Figure 3-5).

Abundant/dominant taxa in the Homosassa River and Southeast Fork included the amphipods *Grandidierella bonnieroides* and *Ampelisca* sp., the tanaid crustacean *Halmyrapseudes cf. cubensis*, the polychaete worm, *Mediomastus* sp. and unidentified olgiochaete worms. Amphipods were also abundant and dominant in Halls River, where *G. bonnierodes*, *Cerapus bethophilus* and *Gammarus mucronatus* were common. The isopod *Cassidinidea ovalis*, the Carolina marsh clam, *Polymedosa caroliniana*, and unidentified oligochaetes were also abundant in Halls River. Insect larvae, including midges and mayflies were encountered primarily in the Southeast Fork and the upper portion of the Homosassa River and Halls River.

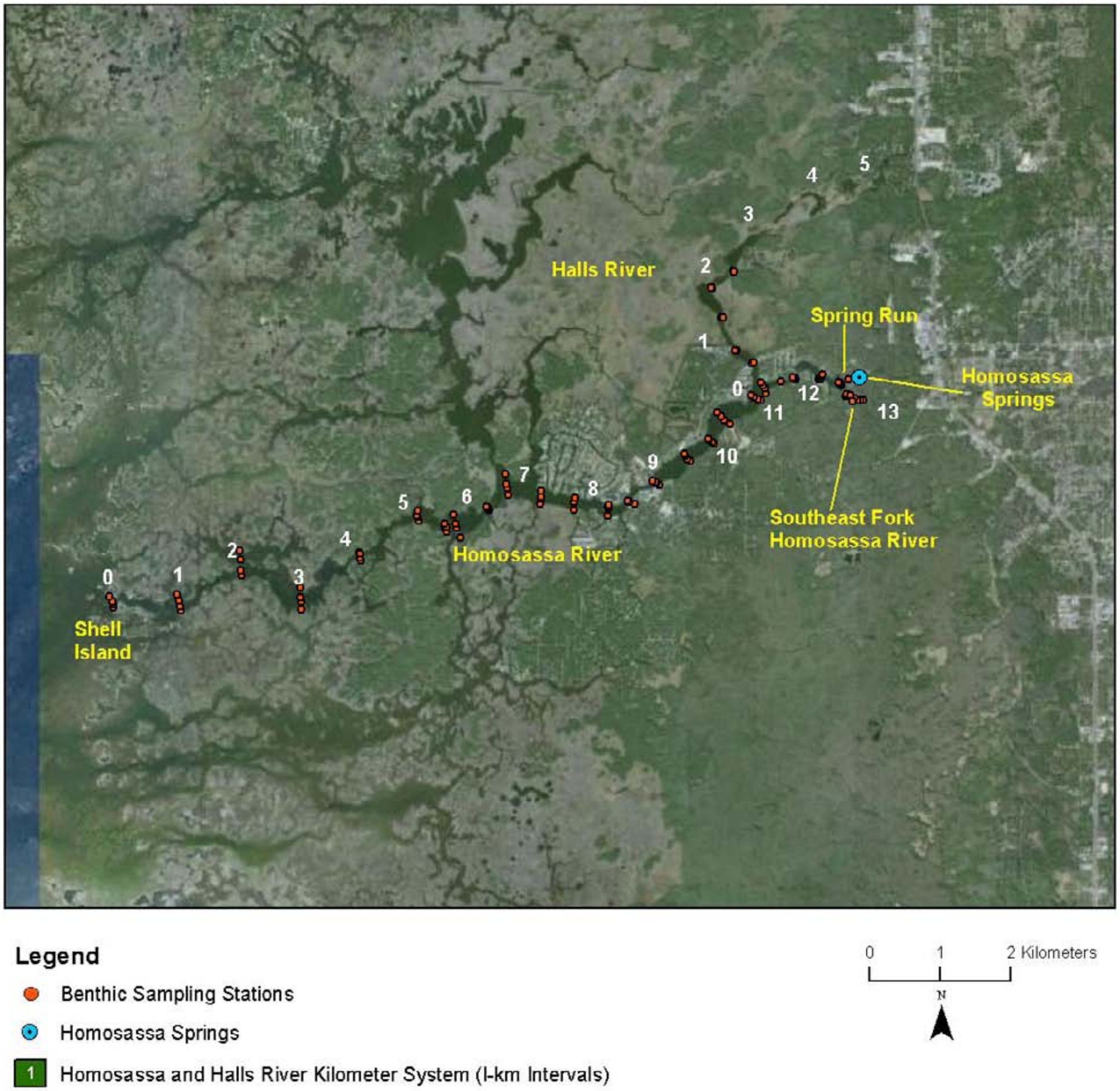


Figure 3-4. Location of stations where benthic macroinvertebrates were sampled by Grabe and Janicki (2009) on May 12-14, 2008 in the Homosassa River (including the spring run), Southeast Fork of the Homosassa River and the lower Halls River (photographic image source: Woolpert, Inc. 2009).

Table 3-1. Mean densities and dominance scores (Dom.) for soft-sediment benthic invertebrate taxa with the top 50 highest dominance scores based on core samples collected from the Homosassa River, Southeast Fork of the Homosassa River and lower Halls River between May 12 and 14, 2008. Center of abundance expressed as river kilometer and mean salinity at capture are also listed for Homosassa River dominants. The symbol "x" indicates absence in core samples. Adapted from Grabe and Janicki (2009).

Taxon	Common Name	Homosassa River				Halls River	
		Mean No./ m^2	Dom.	Center of Abund-ance (RKM)	Mean Salinity at Capture (ppt)	Mean No./ m^2	Dom.
Actiniaria	Sea anemones						
Genera undetermined		274	3.4	3.8	17.9	x	x
Nemertea	Probiscis worms						
Genera undetermined		118	2.3	3.8	17.0	22	0.8
Platyhelminthes	Flatworms	322	2.6	11.9	1.3	x	x
Genera undetermined		322	2.6	11.9	1.3	x	x
Annelida - Polychaeta	Worms						
Amphicteis gunneri		158	3.0	6.1	13.1	66	2.5
Apomatus sp.		310	1.9	7.1	13.7	x	x
Aricidea philbinae		518	5.4	2.2	19.6	x	x
Brania sp.		126	1.8	2.7	18.2	x	x
Capitella capitata complex		110	2.0	5.3	15.2	x	x
Cirrophorus sp.		320	2.3	0.3	22.6	x	x
Fabriciola sp.		598	4.9	3.3	17.5	x	x
Laeonereis culveri						175	5.2
Leitoscoloplos sp.		173	3.0	4.1	15.9	x	x
Lysilla sp.		101	1.6	1.2	21.0	x	x
Mediomastus sp.		3,573	18.7	6.7	13.1	x	x
Parandalia tricuspis		335	4.9	7.3	11.9	x	x
Polydora socialis		x	x	x	x	22	0.8
Streblospio gynobranchiata		680	6.5	7.5	12.5	22	0.8
Typosyllis alosae		1,004	4.6	0.4	22.1	x	x
Annelida - Oligochaeta	Worms						
Genera undet.		2,156	14.9	10.6	3.4	1,621	18.6
Annelida - Hirudinea	Leeches						
Genera undet.		x	x	x	x	22	0.8

Table 3-1. Continued.

Taxon	Common Name	Homosassa River				Halls River	
		Mean No./ m^2	Dom.	Center of Abund-ance (RKM)	Mean Salinity at Capture (ppt)	Mean No./ m^2	Dom.
Mollusca - Bivalvia	Clams, Mussels						
Angulus versicolor	Many-colored tellin	152	2.9	6.1	13.9	x	x
Branchidontes exustus	Scorched mussel	2,318	6.9	6.4	12.9	22	0.8
Parastarte triquetra	Brown gemclam	331	3.3	4.3	16.2	x	x
Polymesoda caroliniana	Carolina marsh clam	x	x	x	x	1,643	17.4
Mollusca - Gastropoda	Snails						
Acteocina canaliculata	Channeled barrel-bubble	76	1.6	5.6	13.5	x	x
Crepidula sp.	Slipper snail	457	3.3	0.7	21.6	x	x
Hydrobiidea-Genera undetermined	Mud snails	440	4.4	8.4	11.0	482	8.6
Crustacea - Cumacea	Hooded shrimps						
Cyclaspis varians		82	1.8	4.1	15.9	x	x
Crustacea - Isopoda	Isopods						
Cassidinidea ovalis		535	4.8	3.1	17.2		
Cyathura polita		625	6.5	9.3	3.7	1,029	16.8
Valvifera-Genera undet.		213	3.3	10.7	4.9	x	x
Xenanthura brevitelson		467	5.7	5.1	14.4	x	x
Crustacea - Tanaidacea	Tanaids						
Halmyrapseudes cf. Cubensis		1,685	9.6	4.0	16.0	x	x
Hargeria/Letochelia sp. complex		461	5.3	6.3	12.4	44	1.2
Kalliapseudes macsweenyi		1,186	3.3	0.3	22.7	x	x
Crustacea - Amphipoda	Scuds						
Americorophium ellisi		457	4.3	10.2	10.6	x	x
Ampelisca sp.		5,848	23.7	6.0	13.4		
Amphipoda-Genera undetermined		1,504	9.8	7.9	8.3	1,029	13.7
Aoridae-Genera undetermined		937	4.6	11.4	1.7	x	x
Cerapus benthophilus		204	2.8	2.8	5.2	7,118	33.0

Table 3-1. Continued.

Taxon	Common Name	Homosassa River				Halls River	
		Mean No./ m^2	Dom.	Center of Abund-ance (RKM)	Mean Salinity at Capture (ppt)	Mean No./ m^2	Dom.
Corophiidae-Genera undetermined		474	3.7	4.5	10.6	2,256	23.5
Elasmopus sp.		1,154	3.6	0.1	22.6		
Gammarus mucronatus		903	8.2	5.9	3.9	11,388	49.4
Grandidierella bonnieroides		5,208	25.6	10.4	4.3	4,271	32.3
Hourstonius laguna		598	4.4	5.5	14.0	x	x
Hyalella sp. C		2,453	8.0	12.0	0.7	x	x
Melitidae-Genera undetermined		383	7.4	5.6	13.2	x	x
Caprellidae-Genera undetermined		211	2.0	0.6	21.9	x	x
Crustacea - Decapoda	Crabs, Shrimp, Lobsters						
Panopeidae-Genera undetermined	Mud crab	259	3.8	5.3	12.1	460	9.2
Insecta - Diptera	Flies						
Chironomidae sp. - Genera undetermined.		898	6.7	11.4	2.1	285	8.3
Chironomus sp.		230	2.5	10.9	8.4	22	0.8
Cryptochironomus sp.		x	x	x	x	66	2.5
Dicrotendipes sp.		758	5.3	11.8	1.3	66	1.4
Polypedilum halterale Group		x	x	x	x	131	2.8
Procladius sp.		128	2.1	9.2	3.7	416	8.7
Pseudochironomus sp.		246	1.9	11.9	0.5	22	0.8
Insecta - Ephemeroptera	Mayflies						
Stenonema sp. and Genera undetermined		x	x	x	x	22	0.8

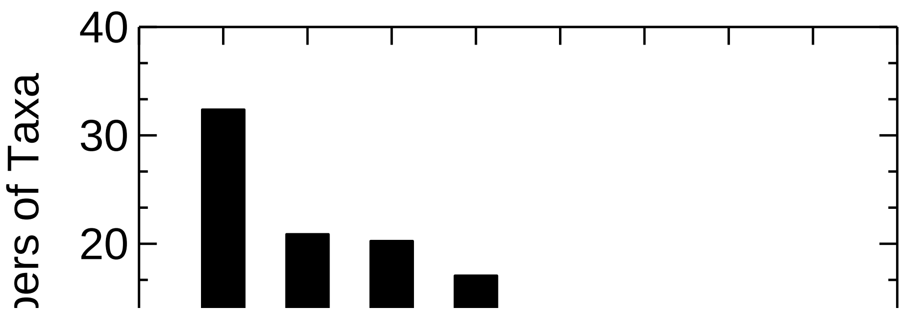


Figure 3-5. Mean number of benthic macroinvertebrate taxa in the Homosassa River (including the spring run and Southeast Fork of the Homosassa River) by river kilometer and in the lower Halls River based on 114 core samples collected between May 12 and 14, 2010. Figure reproduced from Grabe and Janicki (2009).

To further characterize the molluscs of the Homosassa River, the District contracted with Water & Air Research, Inc. (2010; included as Appendix F to this report) to complete a two-day survey of the assemblage on two dates in the fall of 2008. Quantitative sampling of ~0.25 ft^2 of substrate area was conducted using a Petite Ponar dredge or spade at a six transects in the Homosassa River upstream of river kilometer 7.5 and at a single transect in the Southeast Fork of the Homosassa River. Qualitative samples were collected by hand or dip net in the lower portion of the river and the entire river was surveyed to map the locations of live oyster bars (see Figure 3-6 for all sampling locations).

A total of 18 taxa were identified, with live individuals of eight bivalve species and 10 gastropods observed or collected (Table 3-2). Living bivalves included the Eastern oyster (*Crassostrea virginica), ribbed mussel (Guekensia demissa*), brackish water mussel (*Mytilopsis leucophaeta*) and Carolina marsh clam (*Polymesoda caroliniana*). Oyster beds with living individuals were found at only three sites in the river, with the most upstream bed located near river kilometer 1.3 (Figure 3-6). This distribution for live oysters differs from that reported by Grabe and Janicki (2009), who found oysters in dredge samples collected between river kilometers 4 and 9 during their May 2008 sampling events. Live snails observed by Water & Air Research, Inc. included the ladder hornsnail (*Cerithidea scalariformis*), marsh periwinkle (*Littorina irrorata*), coffee bean snail (*Melampus coffeus*), Malaysian trumpet snail (*Melanoides tuberculata*), Florida crown conch (*Melongena corona*) and unidentified hydrobiid mud snails.

The District is also currently funding a study of barnacle distributions in the Homosassa, Crystal and lower Withlacoochee Rivers. The project, which is being completed by Mote Marine Laboratory, includes field surveys and deployment of artificial substrates for evaluation of barnacle colonization, abundance and biomass within the rivers. In a draft project report that is currently being revised, Culter (2009; included as Appendix G in this report) notes that *Balanus subalbidus* is the dominant barnacle in the Homosassa River. Specimens of the exotic species, *Balanus amphitrite,* have also been collected from the river and other species may be present. Based on project sampling, which was completed from mid-March through July 2009, barnacles occur in the Homosassa River upstream to where the Main Spring run interfaces with the river. In this region of the upper river, barnacles are restricted to deeper areas and are not found in the intertidal zone. Results from the study indicate that salinities less than about two may be inhibitory to barnacle settlement in the rivers examined, although barnacles were observed on substrates in areas where salinities were less than 2. It may be that during some high tides, incursion of higher salinity water in low-salinity zones supports persistence of barnacles in areas where salinities are typically low.

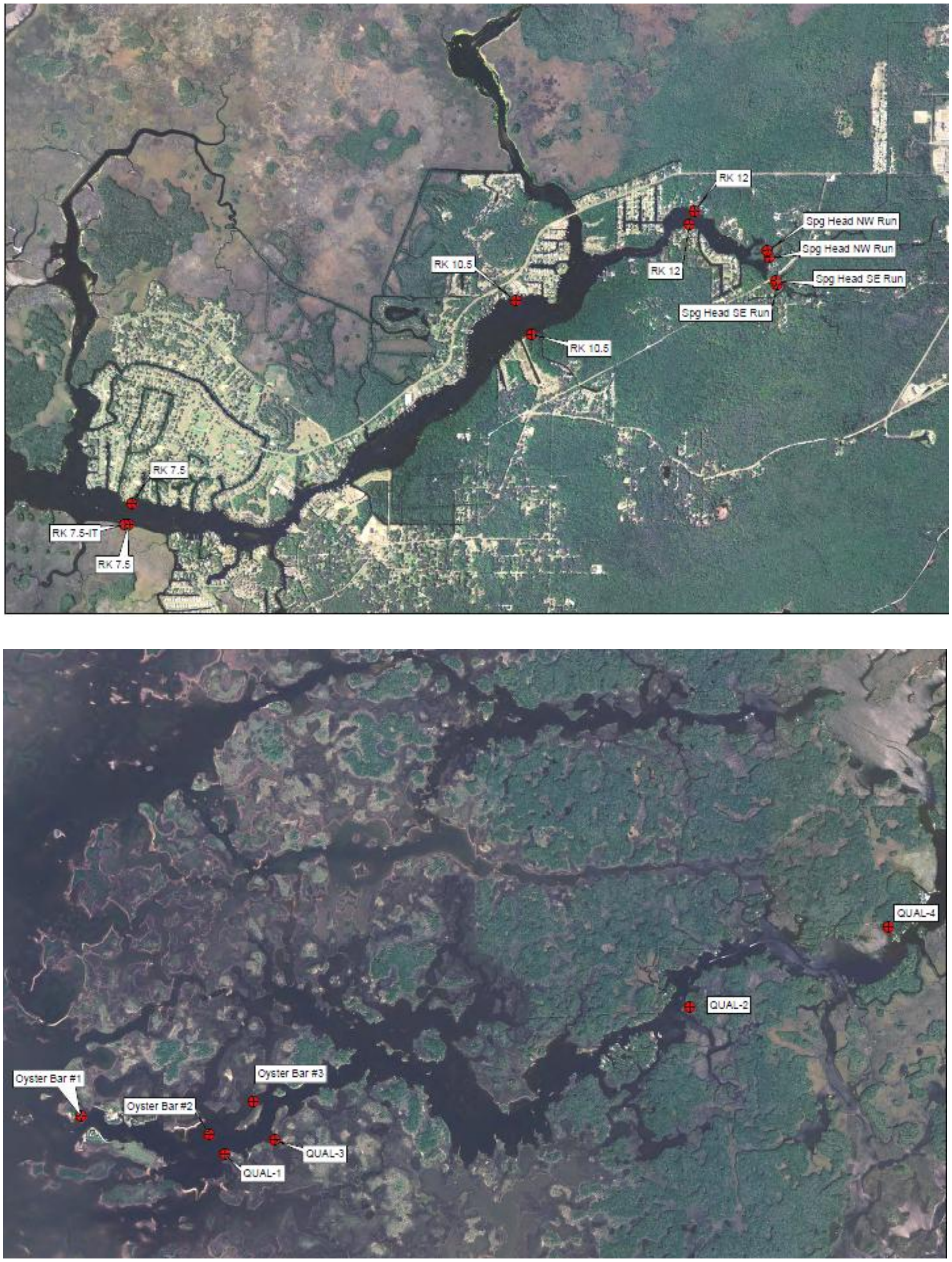


Figure 3-6. Locations where molluscs were quantitatively (upper panel) and qualitatively (lower panel) sampled in the Homosassa River in September and October 2008 and location of oyster bars (lower panel). Panels reproduced from Water & Air Research, Inc. (2010).

Table 3-2. Molluscs (living and dead) observed or collected from the Homosassa River and Southeast Fork of the Homoasassa River in September and/or October 2008 by Water & Air Research, Inc. (2010).

Taxon	Common Name	Live or Dead
Mollusca - Bivalvia	Clams, mussels	
Corbicula fluminea	Asian clam	Dead
Crassostrea virginica	Eastern oyster, American oyster	Live
Guekensia demissa	Ribbed mussel	Live
Ischadium recurvum	Hooked mussel	Dead
Mytilopsis leucophaeta	Brackish water mussel; false dark mussel	Live
cf. *Mytilidae*	Sea mussels	Dead
Polymesoda caroliniana	Carolina marsh clam	Live
Tellinidae	Tellin clams	Dead
Mollusca - Gastropoda	Snails	
Cerithidea scalariformis	Ladder hornsnail	Live
Elimia cf. floridensis	Rasp elimia	Dead
Haitia cubensis	Carib physa	Dead
Hydrobiidae	Mud snails	Live
Littorina irrorata	Marsh periwinkle	Live
Melampus coffeus	Coffee bean snail	Live
Melanoides tuberculata	Malaysian trumpet snail	Dead
Melongena corona	Florida crown conch	Live
Micromenetus floridensis	Penny spring	Dead
Planorbella scalaris	Mesa-rams horn	Dead

Relationships Between Benthic Invertebrates, Salinity and Other Physiochemcial Variables

Numerous studies have addressed relationships between benthic invertebrates, salinity and other physiochemical parameters in southwestern Florida tidal rivers. In their recent meta-analyis involving mollusc distribution in six southwest Florida tidal rivers, Montagna *et al.* (2008) report that salinity is the most important variable correlated with mollusc community attributes. In another regional study, Janicki Environmental, Inc. (2007) identified biologically-based salinity classes for benthic invertebrates using data collected at 12 tidal southwest Florida tidal rivers. Four salinity classes (0-7; 7-18; 18-29 and >29) were derived and were referred to as “oligohaline”, “mesohaline”, “polyhaline” and “euhaline” classes. Analysis of a subset of four of the 12 rivers that discharge along the Spings Coast yielded slightly different salinity class ranges as follows: 0-16; 17-24; 24-30 and >30 (Janicki Environmental, Inc. 2007).

Evaluation of mean salinity-at-capture information reported by Grabe and Janicki (2009) for invertebrates collected from core sampes from the Homosassa River, spring run and Southeast Fork of the river (*e.g.,* see Table 3-1) illustrates the potential effect of salinity on the distribution of benthic invertebrates in the system. Some taxa, including unidentified oligochaete worms, larval insects and the dominant amphipod*, G. bonnieroides* were most strongly associated with relatively low salinities (mostly < 7) in the "oligohaline" range for Springs Coast rivers identified by Janicki Environmental, Inc. (2007). Others dominants, including the polychaete worm, *Mediomastus* sp., the tanaid crustacean *Halmyrapseudes* c.f. *cubensis* and the amphipod *Ampelisca* sp. were associated with mean capture-salinities at the higher end of the "oligohaline" range (13.1 to 16). When examined as a whole, the benthic invertebrate assemblage in the core samples collected by Grabe and Janicki demonstrated significant positive relationships between salinity-at-capture and taxa richness, diversity and total abundance; negative associations were noted for water temperature and the benthic metrics.

Other studies provide supporting information regarding the effect of salinity on benthic macroinvertebrates in the Homosassa River system. As noted in the previous section of this chapter, Sloan (1956) reported associations between the distributions of aquatic insects in the Homosassa River and chloride and dissolved oxygen concentrations, although he considered these associations speculative based on limited knowledge regarding the oxygen and chloride requirements of the insects observed in the river. Also, as noted in the above, Culter (2009) suggest that barnacle distribution in the Homosassa River system and other area rivers may be associated with the distribution of zones or boundaries where salinities less than and greater than 2 are common.

Fish and Invertebrate Plankton and Nekton

Description

Planktonic (weakly swimming) and nektonic (actively swimming) fish and invertebrates are conspicuous and recreationally and ecologically important components of the Homosassa River system fauna. Some organisms found in the river system exist thoughout their life cyle as either plankton or nekton. Many species shift between planktonic and nektonic forms as they develop and some spend only portions of their lives as plankton and/or nekton after which they settle on bottom substrates to become part of the benthos. Longitudinal gradations in salinity and other physiochemical factors likely contribute to the occurrence and persistence of planktonic and nektonic fish and invertebrates.

Herald and Strickland (1949) provide an early account of the fishes of Homosassa Springs, reporting provisional observation of 34 species. In their historical account, they note with interest the co-occurrence of both marine and freshwater species in the Main Spring pool. In a more recent assessment partially funded by the District, Wetland Solutions, Inc. (2010) found that marine species, including gray snapper (*Lutjanus griseus)* and snook (*Centropomus undecimalis)* accounted for much of the fish biomass in the Homosassa Main Springs pool and upper Homosassa River. During their surveys of the spring and river, which were conducted in November 2008, a total of 22 fish species were observed (Table 3-3).

Table 3-3. Fishes in the Homosassa Main Spring pool and upper portion of the Homosassa River in November 2008 as reported by Wetland Solutions, Inc. (2010) and primary habitat information or classification.

Taxon	Common Name	Primary Habitat(s)
Amia calva	Bowfin	Freshwater[a]
Archosargus probatocephalus	Sheepshead	Marine, Brackish[a]
Bagre marinus	Gafftop sail sea catfish	Marine, Brackish[b]
Caranx hippos	Crevalle jack	Marine, Brackish[c]
Centropomus undecimalis	Common snook	Marine, Brackish[a]
Echeneis naucrates	Sharksucker	Marine[d]
Elops saurus	Ladyfish	Marine, Brackish, Freshwater[a]
Eucinostomus harengulus	Tidewater mojarra	Marine, Brackish[a]
Eugerres [Diapterus] plumieri	Striped mojarra	Marine, Brackish[a]
Gambusia holbrooki	Eastern mosquitofish	Freshwater[a]
Lepisosteus platyrhincus	Florida gar	Freshwater[a]
Lepomis auritus	Redbreast sunfish	Freshwater[a]
Lepomis macrochirus	Bluegill	Freshwater[a]
Lucania parva	Rainwater killifish	Brackish[a]
Lutjanus griseus	Gray snapper	Marine, Brackish[a]
Menidia beryllina	Inland silverside	Brackish, Freshwater[a]
Microgobius gulosus	Clown goby	Marine, Brackish[a]
Micropterus salmoides	Largemouth bass	Freshwater[a]
Mugil cephalus	Striped mullet	Marine, Brackish, Freshwater[a]
Pogonias cromis	Black drum	Marine, Brackish[c]
Sciaenops ocellatus	Red drum	Marine, Brackish[a]
Strongylura marina	Atlantic needlefish	Marine, Brackish, Freshwater[a]

[a] Source: A check list of Florida's freshwater fishes, with photos compiled by Gray Bass, P. Shafland and B. Wattendord, accessed at *name.htm* on April 23, 2010.
[b] Source: Muncy and Wingo (1983).
[c] Source: Florida Fish and Wildlife Conservation Commission Fish Identification – Saltwater web page at *http://www.myfwc.com/WILDLIFEHABITATS/SaltFishID.htm* accessed on April *23*, 2010.
[d] Source: Ichthyology at the Florida Museum of Natural History web page *at http://www.flmnh. ufl.edu/fish/Gallery/Descript/LiveSharksucker/LiveSharksucker/html,* accessed on April 23, 2010.

To further support development of minimum flows for the Homosassa River system, the District funded a recent, two-year study of freshwater inflow effects on habitat use by planktonic and nektonic fish and invertebrates in the Homosassa River and Halls River. The study, completed by the University of South Florida College of Marine Science and Florida Fish and Wildlife Conservation Commission (Peebles *et al.* 2009; included as Appendix H to this report), included identification of patterns and responses of estuarine fish and invertebrate and abundances and habitat use under variable freshwater inflow conditions, based on sampling completed between December 2006 and November 2008.

Sampling for the plankton-nekton evaluation was conducted on a monthly basis during the first year of the study and every other month during year two, for a total of 18 sampling dates. For sampling purposes, seven zones from which plankton net, seine net and trawl samples were taken, were identified in the Homosassa and Halls Rivers (Figure 3-7). Two plankton net collections were made at fixed stations in zones 1 through 6 on each sampling date; zone 7 in the upper Halls River could not be sampled with the plankton net due to shallow water depths and obstructions. The plankton net had a 500 µm mesh-size and was deployed during nighttime flood tides. Three seine collections were made in each zone at randomly selected stations on each sampling date and three trawl-net deployments were similarly deployed on each date, but only in zones 3, 4 and 6. Rock substrates prevented use of the trawl net in zones 1, 2, 5 and 7. The bag seine had a mesh size of 3.2 mm (0.125 in) and the otter trawl had a 3.2 mm (0.125 in) mesh size; both were deployed during the day under variable tide stages. The seines and trawls were used to sample larger fish and invertebrates that were capable of evading the plankton net. Seines hauls were generally conducted in shallow habitats where water depths were less than five feet and the trawl net was used to sample deeper areas. Salinity, water temperature, dissolved oxygen and pH measurements were measured at the surface and at 1-meter (3.3-feet) intervals to the bottom in association with each net or trawl deployment.

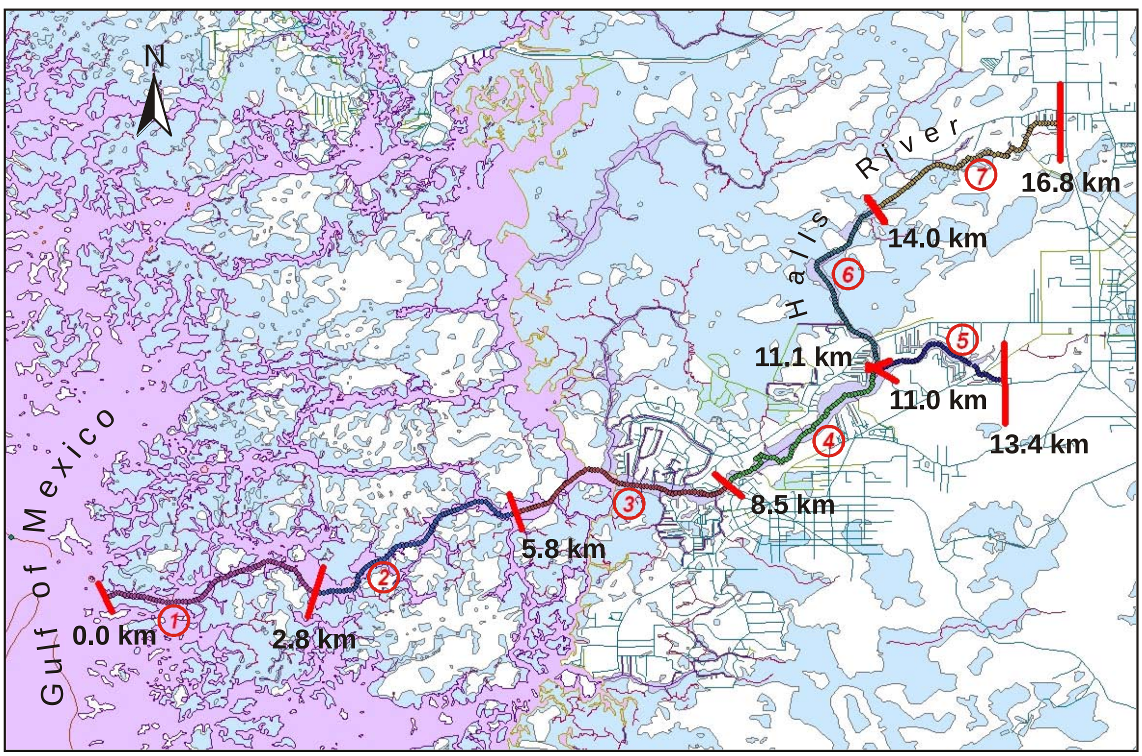


Figure 3-7. Seven zones (delineated by red bars and circled numbers) where plankton, seine and trawl nets were deployed in the Homosassa and Halls Rivers between December 2006 and November 2008. Figure reproduced from Peebles *et al.* (2009).

Fish eggs, including those of gobies and anchovies, numerically dominated the fish catch in the plankton net collections. Larval gobies of the genus *Gobiosoma* and the bay anchovy (*Anchoa mitchilli*) were also common. Other abundant larval fishes included rainwater killifish (*Lucania parva*), silversides (*Menidia* spp.), blennies, including the Florida blenny (*Chasmodes saburrae*), skilletfish (*Gobiesox strumosus*) and mojorras (*Eucinostomus* spp.).

Nearly 70 percent of the seine catch was comprised of rainwater killifish, silversides and mojarras. Freshwater taxa, including shiners (*Notropis petersoni, Notropis harperi,* and *Notemigonus crysoleucas)*, bluefin killifish (*Lucania goodei*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus)*, redear sunfish (*Lepomis microlophus*) and spotted sunfish (*Lepomis punctatus*) were commonly encountered in both Halls River and the Homosassa River upstream of the confluence of the two rivers, but were much less abundant than marine-oriented species. Fishes caught in the trawl net were dominated by small (< 40 mm in length) and large (>40 mm in length) mojarra, rainwater killifish and bay anchovy, which in combination accounted for 77 percent of the total catch.

The invertebrates caught with the plankton net were dominated by larval crabs (decapod zoeae and megalopae), larval shrimps, gammaridean amphipods, the mysid shrimp *Americamysis almyra*, cumacean crustaceans, and the copepod *Acartia tonsa*. Larval crabs and shrimps, amphipods, *A. almyra* and *A. tonsa* were common in all sampled zones. Cumaceans were most abundant the lower portion of the river system. Invertebrates collected with the seine were dominated by brackish grass shrimp (*Palaemonetes intermedius*), daggerblade grass shrimp (*Palaemonetes pugio*), riverine grass shrimp (*Palaemonetes* paludosus) and blue crab (*Callinectes sapidus*). Collectively, these crustaceans accounted for over 96 percent of the total number of invertebrates caught with the seine. Invertebrates in the trawl samples were dominated by blue crab and brackish grass shrimp, which in combination accounted for 90% of the total invertebrate trawl catch.

Peebles *et al.* (2009) note that relatively few fish species used the sampled area for spawning. As compared to other area estuaries, the Homosassa River system contained "… relatively few eggs and larvae of broadcast-spawning, estuarine-dependent or coastal species, but instead was dominated by the larvae of small, resident species that have adhesive eggs which hatch into planktonic larvae." Estuary-dependent taxa, which spawn in the Gulf and migrate into the river system, were common and included the recreationally and commercially important blue crab and forage fish such as pinfish and mojarras.

Relationships Between Fish and Invertebrate Nekton and Plankton and Inflow

As part of their recent study of the Homosassa River system, Peebles *et al.* (2009) evaluated responses of planktonic and nektonic taxa to inflow in terms of changes in absolute or relative abundances of organisms within the study area and in terms of organism distribution or location of maximum occurrence. Responses were evaluated for common taxa collected with a plankton net, seine and trawl as described in the previous section of this report and measured or estimated daily flow records for the USGS Homosassa Springs at Homosassa Springs, FL and SE Fork Homosassa Spring at Homosassa Springs, FL gages. Daily mean combined flows on the dates plankton and nekton were sampled ranged from 103 to 163 cfs and averaged 132 cfs. Note that location responses are not discussed further in this report, as they were determined not to be useful for development of minimum flows.

For evaluation of abundance responses to inflow, planktonic and nektonic organisms collected from the Homosassa River system were classified as pseudo-species, based on life-history stage, size class, taxonomic resolution and capture with the differing sampling gear. Absolute abundances of pseudo-species collected with the plankton net were based on samples collected only from the Homosassa River and Southeast Fork. Samples from Halls River were excluded from these analyses because flow estimates for Halls River were not available for evaluation of flow-abundance relationships for the planktonic taxa. Relative abundances were determined for the pseudo-species collected with the seine and trawl for the combined Homosassa River and Southeast Fork, the combined Homosassa River/Southeast Fork/Halls River or Halls River.

For organisms captured with the plankton net, absolute abundance (N) in the combined Homosassa River/Southeast Fork for each one or two month sampling interval was estimated by summing the product of mean organism density and tide-corrected water volume for each study zone according to the equation

$$N = \sum (\bar{U} * V) \qquad \text{(Equation 3)},$$

where: N is the total number of organisms in the Homosassa River and Southeast Fork based on plankton net samples and river volume;

$\bar{U}$ is the zone-specific mean organism density, expressed as number of organisms per cubic meter;

V is the tide-corrected zone specific volume; and

$\sum$ indicates summation of values for all sampled zones.

For the seine and trawl data, relative abundance ($\bar{N}$) was calculated for each one or two month sampling interval or selected intervals based on recruitment periods identified using organism length-frequency distributions (see Peebles et al. 2009 which is included as Appendix H) according to the equation

$$\bar{N} = 100 * N_{total} / A_{total} \qquad \text{(Equation 4)},$$

where: $\bar{N}$ is the relative abundance or mean number of organisms per 100 square meters in the Halls River, Homosassa River/Southeast Fork (seine-collected organisms) or sampled zones for the Halls River/Homosassa River (trawl-collected organisms);

N_{total} is the total number of organisms captured during the sampling interval in the Halls River or Homosassa River/Southeast Fork; and

A_{total} is the total area or the Halls River or Homosassa River sampled during the sampling interval.

Daily mean combined inflows for the USGS Homosassa Springs and Southeast Fork gages were used for model development. For the regressions based on samples collected with the plankton net, inflow (*F*) values for the sampling date and mean inflows for periods up to 120 days including and prior to the sampling date were evaluated. For regressions based on seine and trawl samples, mean flows from the date of sampling were evaluated, as were continuously-lagged weekly mean flows from the day of sampling up to 203 days before sampling (*e.g.*, mean flow for the sampling day and preceding six days; mean flow for sampling day and preceding thirteen days, *etc.)*.

Absolute abundances of 28 of the 64 plankton-net taxa that were evaluated exhibited significant responses to inflow (Table 3-4) (Peebles *et al.* 2009). Negative responses, *i.e*., lower absolute abundances associated with higher flows, were most common and likely reflected organisms being swept from the sampled area during periods of higher inflows. Five taxa, including: the estuarine tanaid crustacean *Hargeria rapax*; postflexion larvae of the oligohaline rainwater killifish (*Lucania parva)*; ostracods of the order Podocopida, which is an exclusively freshwater order; the estuarine copepod *Acartia tonsa*; and the oligohaline copepod *Eurytemora affinis* exhibited positive responses to flow, *i.e.,* their abundances increased with increased flow. Absolute abundances of these planktonic taxa were associated with lagged flows from periods ranging from 36 to 120 days, with 29 to 62 percent of the variance in their abundances associated with inflow (Table 3-4).

Relative abundances of 40 of the 53 pseudo-species evaluated from the seine and trawl catches were significantly related to inflow (Table 3-5) (Peebles *et al.* 2009). Thirteen pseudo-species exhibited quadratic responses in relative abundance as a function of inflow and 27 exhibited linear responses to inflow. Quadratic responses could be characterized as “intermediate-maximum” or “intermediate-minimum” responses to inflow, with maximum or minimum relative abundances associated at intermediate flows and lower or higher abundances occurring during periods of lower and higher flows.

Linear relationships were split between 12 negative responses and 15 positive responses. Negative linear responses, *i.e*., an inverse relationship between relative abundance and inflow, likely reflected organisms being swept from the sampled area during periods of higher inflows or movement of organisms into higher salinity zones during low flow periods. Positive linear responses were observed for brackish grass shrimp (*Palaemonetes intermedius*), blue crabs (*Callinectus sapidus*) less than and greater than 30 mm in size, Seminole killifish (*Fundulus grandis*), rainwater killifish

(*Lucania parva*), mosquitofish (*Gambusia holbrooki*), sailfin mollies (*Poecilia latipinna*), largemouth bass (*Micropterus salmoides*), pinfish (*Lagodon rhomboides*), and spot (*Leiostomus xanthurus*) collected with the seine from shallow areas of the Homosassa River. In addition, abundances of Gulf pipefish (*Syngnathus scovelli*), spotted sunfish (*Lepomis punctatus*) and largemouth bass collected by seine from Halls River and blue crabs and Gulf pipefish collected by trawl net in the Homosassa and Halls Rivers also exhibit significant, positive response to flow. Relative abundances of pseudo-species exhibiting a positive response to flow were associated with lagged flows for periods ranging from 1 to 203 days. Twenty to 78 percent of the variance in abundances of these taxa was explained by the inflow values (Table 3-5). Most regressions were based on occurrence of organisms in samples collected during the entire year, although regressions for Gulf killifish, largemouth bass and spot were based on seasonal occurrences with correspondingly low numbers of dates sampled (see degrees of freedom listed in Table 3-5).

Table 3-4. Regression statistics for plankton-net organism absolute abundance responses (N expressed as number / m^3) to mean freshwater inflow (F expressed as cfs) in the Homosassa River system (adapted from Table 3.8.1.1. in Peebles *et al.* 2009). Statistics listed for the linear equation *ln N = Intercept + Slope * ln F* include sample size (n), intercept, slope, slope probability (P) and adjusted coefficient of determination (r^2_{adj}). The number of daily inflow values (D) used to calculate mean freshwater inflow is also shown. Possible serial correlation based on a Durbin-Watson (DW) statistic with p<0.05 indicated by "x".

Taxon	Common Name	Linear Regression Statistics						
		n	*Intercept*	*Slope*	*P*	r^2_{adj}	*DW*	*D*
Crustacea - Maxillipoda	Fish lice							
Branchiurans, *Argulus* spp.	Fish lice	11	35.263	-5.414	0.0014	0.70		42
Crustacea - Copepoda	Copepods							
Acartia tonsa	Copepod	18	-59.762	15.169	0.0183	0.30	x	120
Eurytemora affinis	Copepod	12	-89.289	19.978	0.0482	0.34		36
Crustacea - Decapoda	Amphipods, scuds							
Amphipods, caprellid	Skeleton shrimps	17	43.526	-6.681	0.0007	0.55		20
Crustacea - Decapoda	Crabs, shrimp, lobsters							
Americamysis almyra	Opossum shrimp, mysid	18	50.709	-7.093	0.0000	0.69		1
Decapod megalopae	Post-zoea crab larvae	18	63.694	-10.343	0.0355	0.25		1
Decapod zoeae	Crab larvae	18	134.592	-24.143	0.0004	0.56		16
Decapod mysis	Shrimp larvae	18	122.821	-22.172	0.0000	0.72		16
Bowmaniella dissimilis	Opossum shrimp, mysid	18	76.013	-12.591	0.0039	0.41		113
Palaemonetes pugio juveniles	Daggerblade grass shrimp	12	61.161	-10.466	0.0182	0.44		17
Taphromysis bowmani	Opossum shrimp, mysid	13	55.436	-9.126	0.0084	0.48		1
Unidentified *Americamysis* juveniles	Opossum shrimps, mysids	18	46.748	-6.252	0.0008	0.52		1
Crustacea - Isopoda	Isopods							
Cassidinidea ovalis	Isopod	18	93.659	-16.865	0.0001	0.61		17
Cyathura polita	Isopod	10	48.087	-8.040	0.0092	0.59	x	7
Cymothoid sp. a (*Lironeca*) juveniles	Isopod	18	64.261	-11.212	0.0004	0.56		47
Edotea triloba	Isopod	18	71.411	-12.124	0.0039	0.41		20
Anopsilana jonesi	Isopod	10	58.417	-10.129	0.0018	0.72	x	43
Crustacea - Ostracoda	Isopods							
Ostracods, podocopid	Ostracods, seed shrimps	16	-48.019	11.990	0.0331	0.29		58
Parasterope pollex	Ostracod, seed shrimp	16	47.079	-7.258	0.0238	0.31		16
Crustacea - Tanaidacea	Tanaids							
Hargeria rapax	Tanaid	18	-43.376	11.195	0.0183	0.30		117

Table 3-4. Continued.

Taxon	Common Name	Linear Regression Statistics						
		n	***Intercept***	***Slope***	***p***	r^2_{adj}	***DW***	***D***
Insecta - Diptera	Flies							
Dipterans, pupae	Flies, mosquitoes	18	42.402	-6.331	0.0075	0.37	x	1
Osteicthyes	Bony fishes							
Anchoa mitchilli juveniles	Bay anchovy	17	84.624	-14.977	0.0178	0.32	x	120
Anchoa spp. preflexion larvae	Anchovies	10	38.964	-5.862	0.0467	0.41		1
Gobiid flexion larvae	Gobies	15	111.054	-20.112	0.0001	0.72	x	20
Gobiid preflexion larvae	Gobies	17	111.229	-20.093	0.0011	0.52	x	13
Gobiosoma spp. postflexion larvae	Gobies	16	145.423	-27.173	0.0001	0.66		32
Lucania parva postflexion larvae	Rainwater killifish	12	-49.467	11.652	0.0023	0.62		120
Microgobius spp. postflexion larvae	Gobies	16	81.404	-14.401	0.0070	0.42	x	14

Table 3-5. Summary information for modeled relative abundance ($\bar{N}$) response of seine and trawl-net captured pseudo-species to mean freshwater inflow (*F* expressed as cfs) in the Homosassa River/Southeast Fore and/or Halls River. The type of response (Resp.) is either linear (L) or quadratic (Q). Linear regressions expressed as *ln ($\bar{N}$ + 1) = Intercept + Linear Coefficient * ln (F +1)*. Quadratic regressions expressed as *ln ($\bar{N}$ + 1) = Intercept + Linear Coefficient * ln (F +1) + Quadratic Coefficient * [ln (F + 1)]^2*. Listed statistics include degrees of freedom (*df*), intercept (*Int.*), slope (*Linear Coeff.*), slope probability (Linear *P*), quadratic coefficient (*Quad Coeff.),* quadratic coefficient probability (*Quad P*) and adjusted coefficient of determination (r^2_{adj}). Modeled responses are identified by: River segment (Riv Seg.) for the Homosassa River (HR) or Halls River (HA); pseudo-species Life History type, including Estuarine Spawners (ES), Tidal River Residents (TRR), nearshore spawners (NS) and Offshore Spawners (OS); sampling gear, either seine (S) or trawl (T); taxon size class (range in mm or "All") and identified recruitment Period. An "x" in column labeled DW (Durbin-Watson) indicates that the Durbin-Watson statistic was significant (p<0.05), a possible indication of serial correlation. The number of daily inflow values (*D*) used to calculate continuously-lagged mean freshwater inflow is also shown. Table is adapted from Table 3.8.2.1 in Peebles *et al.* (2009).

Species	Common name	Life History	Gear	River Seg.	Size	Period	Resp.	*df*	*Int.*	*Linear*		*Quadratic*		r^2_{adj}	DW	D
										Coeff.	*P*	*Coeff.*	*P*			
Palaemonetes intermedius	Brackish grass shrimp	ES	S	HR	All	Jan. to Dec.	L	16	-34.788	7.652	0.013	.	.	0.289		63
Palaemonetes paludosus	Riverine grass shrimp	ES	S	HA	All	Jan. to Dec.	Q	15	5552.469	-2266.036	0.045	231.271	0.048	0.160	x	175
Palaemonetes intermedius	Brackish grass shrimp	ES	T	HR/HA	All	Jan. to Dec.	Q	15	-646.181	264.851	0.047	-27.120	0.047	0.139		84
Callinectes sapidus	Blue crab	NS	S	HR	≤30	Jan. to Dec.	L	16	-66.445	13.809	0.001	.	.	0.560		182
Callinectes sapidus	Blue crab	NS	T	HR/HA	≤30	Jan. to Dec.	L	16	-17.272	3.566	0.002	.	.	0.438		182
Callinectes sapidus	Blue crab	NS	S	HR	>30	Jan. to Dec.	L	16	-16.522	3.479	0.009	.	.	0.320	x	70
Callinectes sapidus	Blue crab	NS	T	HR/HA	>50	Jan. to Dec.	L	16	18.754	-3.687	0.005	.	.	0.363	x	7
Notemigonus crysoleucas	Golden shiner	TRR	S	HA	All	Apr. to Oct.	L	8	28.142	-5.449	0.004	.	.	0.636	x	1
Notropis petersoni	Coastal shiner	TRR	S	HA	All	Jan. to Dec.	L	16	62.221	-12.149	0.001	.	.	0.521		98
Strongylura notata	Redfin needlefish	ES	S	HR	All	Jan. to Dec.	Q	15	-3031.948	1242.757	0.009	-127.302	0.008	0.420	x	203
Strongylura timucu	Timucu	ES	S	HR	All	Jan. to Dec.	Q	15	547.748	-227.051	0.039	23.537	0.037	0.338	x	7
Cyprinodon variegatus	Sheepshead minnow	TRR	S	HA	All	Jan. to Dec.	Q	15	3278.856	-1342.938	0.022	137.526	0.022	0.240		175
Fundulus grandis	Gulf killifish	TRR	S	HR	All	Jan. to May	L	6	-25.551	5.430	0.012	.	.	0.628		1
Fundulus seminolis	Seminole killifish	TRR	S	HA	All	Jan. to Dec.	L	16	26.326	-5.090	0.006	.	.	0.349	x	63
Lucania parva	Rainwater killifish	TRR	S	HR	All	Jan. to Dec.	L	16	-53.560	11.765	0.025	.	.	0.232	x	203

Table 3-5. Continued

Species	Common name	Life History	Gear	River Seg.	Size	Period	Resp.	*df*	*Int.*	*Linear*		*Quadratic*		r^2_{adj}	DW	D
										Coeff.	*P*	*Coeff.*	*P*			
Lucania parva	Rainwater killifish	TRR	S	HR	All	Jan. to Dec.	L	16	-53.560	11.765	0.025	.	.	0.232	x	203
Lucania parva	Rainwater killifish	TRR	S	HA	All	Jan. to Dec.	L	16	38.322	-6.731	0.001	.	.	0.495		7
Lucania parva	Rainwater killifish	TRR	T	HR/HA	All	Jan. to Dec.	Q	15	-2243.555	918.378	0.036	-93.919	0.037	0.187		105
Lucania goodei	Bluefin killifish	TRR	S	HA	All	Jan. to Dec.	L	16	25.199	-4.539	0.028	.	.	0.222		14
Floridichthys carpio	Goldspotted killifish	ES	S	HR	All	Jan. to Dec.	Q	15	2932.867	-1206.984	0.025	124.186	0.025	0.357		140
Gambusia holbrooki	Eastern mosquitofish	TRR	S	HR	All	Jan. to Dec.	L	16	-75.932	15.830	0.004	.	.	0.387		126
Gambusia holbrooki	Eastern mosquitofish	TRR	S	HA	All	Jan. to Dec.	L	16	47.285	-9.388	0.006	.	.	0.348		7
Poecilia latipinna	Sailfin molly	TRR	S	HR	All	Jan. to Dec.	L	16	-14.725	3.092	0.009	.	.	0.313		14
Poecilia latipinna	Sailfin molly	TRR	S	HA	All	Jan. to Dec.	Q	15	-3310.424	1359.001	0.013	-139.371	0.013	0.261	x	98
Heterandria formosa	Least killifish	TRR	S	HA	All	Jan. to Dec.	Q	15	-1480.200	614.829	0.005	-63.724	0.005	0.543		7
Syngnathus scovelli	Gulf pipefish	ES	S	HA	All	Jan. to Dec.	L	16	-28.946	6.149	0.033	.	.	0.207		203
Syngnathus scovelli	Gulf pipefish	ES	T	HR/HA	All	Jan. to Dec.	L	16	-20.789	4.300	0.017	.	.	0.265	x	203
Lepomis macrochirus	Bluegill	TRR	S	HR	≥20	Jan. to Dec.	Q	15	1302.098	-531.893	0.002	54.324	0.002	0.538		42
Lepomis macrochirus	Bluegill	TRR	S	HA	≥20	Jan. to Dec.	L	16	28.295	-5.541	0.020	.	.	0.249	x	7
Lepomis punctatus	Spotted sunfish	TRR	S	HA	≥20	Jan. to Dec.	L	16	-45.400	9.612	0.025	.	.	0.231		203
Micropterus salmoides	Largemouth bass	TRR	S	HR	All	Apr. to Aug.	L	5	-70.8301	14.991	0.005	.	.	0.779		98
Micropterus salmoides	Largemouth bass	TRR	S	HA	All	Apr. to Aug.	L	5	-99.285	20.694	0.021	.	.	0.625	x	203
Eucinostomus harengulus	Tidewater mojarra	OS	T	HR/HA	>40	Jan. to Dec.	L	16	40.798	-8.194	0.0001	.	.	0.619	x	168
Lagodon rhomboides	Pinfish	OS	S	HR	All	Jan. to Oct.	L	13	-56.001	11.957	0.001	.	.	0.541	x	182
Lagodon rhomboides	Pinfish	OS	T	HR/HA	>45	Mar. to Nov.	L	12	6.219	-1.228	0.005	.	.	0.446		1
Leiostomus xanthurus	Spot	OS	S	HR	All	Jan. to May	L	6	-161.044	32.915	0.011	.	.	0.639		147
Gobiosoma bosc	Naked goby	TRR	S	HR	All	Jan. to Dec.	Q	15	-2088.045	851.897	0.043	-86.847	0.044	0.202		182
Microgobius gulosus	Clown goby	TRR	S	HR	All	Jan. to Dec.	L	16	39.109	-7.695	0.002	.	.	0.430		21
Microgobius gulosus	Clown goby	TRR	S	HA	All	Jan. to Dec.	L	16	49.670	-9.640	0.000	.	.	0.747		28
Microgobius gulosus	Clown goby	TRR	T	HR/HA	All	Jan. to Dec.	Q	15	-1778.362	730.117	0.011	-74.895	0.011	0.280	x	84
Trinectes maculatus	Hogchoker	ES	T	HR/HA	All	Apr. to Dec.	Q	10	1095.468	-449.155	0.031	46.047	0.031	0.355	x	126

Manatees

Description

The Florida manatee (*Trichechus manatus latirostris*), a subspecies of the West Indian manatee, is found primarily in the waters of Florida. This marine mammal is protected by the State of Florida in accordance with the Florida Manatee Sanctuary Act and is a federally listed endangered species. The most recent United States Fish and Wildlife Service (2009) stock estimate for the Florida population indicates around 3,802 animals occur in state waters, based on a synoptic survey completed by the Florida Fish and Wildlife Conservation Commission in January 2009. The U.S. Fish and Wildlife Service stock estimate also indicates that a sub-population of about 400 animals occurs along the northwest Florida coast, from the panhandle to the border between Hernando and Pasco counties. Recent synoptic aerial survey data for 2010 indicates that the Florida manatee population is larger than reported in 2009. A total of 5,076 animals were counted in state waters in January 2010, with 2,296 observed along the west coast (Florida Fish and Wildlife Conservation Commission 2010a, b).

Since the early 1980s, the United States Fish and Wildlife Service has conducted routine aerial surveys of manatees on an approximate biweekly basis in up to 13 river/canal/bay segments along the west coast of Florida, including Kings Bay; Crystal River, the upper Homosassa River, the lower Homosassa River, Salt River, Crystal River Power Plant; Barge Canal, Waccasassa River, Withlacoochee River, Suwannee River, Suwannee River Estuary, Chassahowitzka River, and Weeki Wachee River. Total manatee counts based on surveys of all or some of these sites between January 11, 1985 through May 12, 2010 averaged 154.8 (n = 629 surveys), with a maximum of 650 animals observed on one survey date. Although all sites were not sampled on many of the survey dates, available information indicates that among the sampled sites, manatee abundances are typically highest in King's Bay/Crystal River system. Counts in this system averaged 107.7 animals per survey and ranged up to 565 animals on a single date.

Manatee abundances are also relatively high in the Homosassa River. The United States Fish and Wildlife Service counts manatees in two segments of the Homosassa River; upstream and downstream from Buzzard Point, which is located just downstream from the confluence of the Halls and Homosassa Rivers (Figure 2-4). Combined counts for both segments averaged 31.2 per survey with a maximum of 156 animals observed (all in the upper segment) during a single survey on January 21, 2009 (Figure 3-8). Manatee use of the Homosassa River is typically highest from the late fall through early spring and lower during summer (Figure 3-9). From January 1985 through May 2010 median abundances in the river ranged from 23 to 40 animals per survey for the months of November through March and 4 to 5 animals per survey for the months of July through September.

Throughout the state, many manatees succumb annually to collisions with boats and to a lesser degree from the effects of neurotoxins produced by the dinoflagellate, *Karenia* *brevis,* during “red tides”. Because manatees are poor thermal regulators, they are also negatively impacted when water temperatures drop below 20°C, although some individuals can survive chronic exposure to temperatures a few degrees lower (references cited in Laist and Reynolds 2005). To survive through periods of extremely cold weather, manatees often congregate in warm-water natural springs or in the warm cooling-water discharge plumes of power plants located along the coast of Florida. The potential loss of the artificial sources of warm water through plant closing and reduction of natural spring flow due to groundwater withdrawals is identified as a significant concern for management of this endangered species (United States Fish and Wildlife Service 2001, Laist and Reynolds 2005).

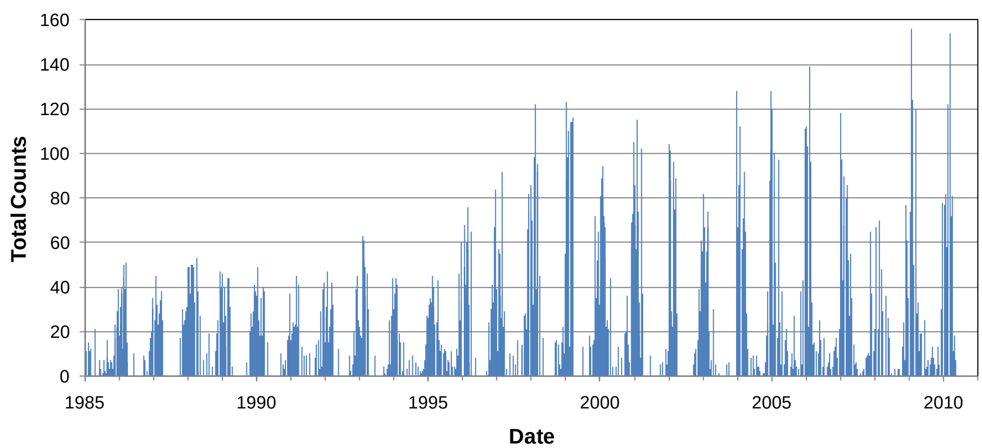


Figure 3-8. Abundance (total counts) of manatees in the Homosassa River from January 11, 1985 through May 12, 2010, based on aerial survey data provided by United States Fish and Wildlife Service.

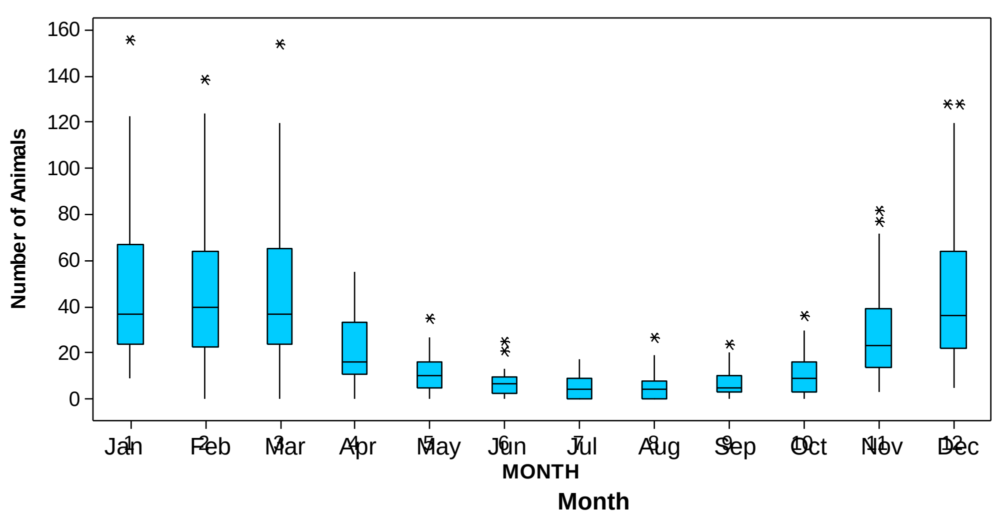


Figure 3-9. Box plot of the number of manatees per survey in the Homosassa River by month from January 11, 1985 through May 12, 2010, based on aerial survey data provided by the United States Fish and Wildlife Service.

Relationships Between Manatees and Inflow

Relatively warm spring water discharged into the Homosassa River system and other spring-fed Florida river systems provides thermal refuge for manatees during extreme cold events. Relationships between spring discharge, river stage and thermal characteristics of river segments or spring runs have been evaluated for numerous minimum flow studies in Florida, beginning with the investigation of Blue Springs in Volusia County by the St. Johns River Water Management District. In support of the development of minimum flows for Blue Springs, Rouhani *et al.* (2007) notes that prolonged exposure to water at 66-68^{o} F (19-20^{o} C) may be extremely detrimental to Florida manatee populations. Based on a 50-year lifespan for the animals, cold-associated "catastrophic conditions" for manatee populations were defined as "extreme hydrologic events lasting three of more days" with a return frequency of 50 years. The return interval for the extreme hydrologic events that could detrimentally affect the manatee population of Blue Springs was estimated as the joint probability product of probabilities associated with spring discharge, river water temperature, and river stage.

An approach similar to that used by the St. Johns River Water Management District for Blue Springs has been used by the Southwest Florida Water Management District for establishing minimum flows for the Weeki Wachee River system and proposed minimum flows for the Chassahowitzka River system (see Heyl 2008 and Heyl *et al.*, 2010). Evaluation of flow effects on thermal characteristics has also been used by for development of minimum flows for Sulphur Springs (Southwest Florida Water Management District 2004b) and by the Suwannee River Water Management District (Water Resources Associates, Inc. *et al.* 2005) for establishment of minimum flows for the lower Suwannee River and associated springs.

To support development of minimum flows for the Homosassa River system, volumetric change in thermal-based habitat suitable for preventing or minimizing cold-related adverse impacts to manatees was investigated for the District by HSW Engineering, Inc. (2010) using the hydrodynamic model of the Homosassa River main channel that was also used to characterize salinity in the river. The model was used to evaluate thermal characteristics of the Homosassa River for baseline and various flow-reduction scenarios. Development and application of the model is discussed further in Chapters 4 and 5 of this report.

Chapter 4

Resources of Concern and Technical Approach for Developing Recommended Minimum Flows

Resources of Concern

Based on the summary information described in preceding chapters of this report, several resources of concern were identified for development of criteria that could be used to establish minimum flows for the Homosassa River system. The identified resources included submersed and emergent aquatic and wetland vegetation, benthic macroinvertebrates, fish and invertebrate nekton and plankton, and manatees. Based on data limitations and current understanding of the Homosassa River system, specific criteria were developed only for fish and invertebrate nekton and plankton and manatees. Generalized criteria based on preservation of salinity-based habitats, expressed as riverine areas, volumes or shoreline lengths associated with selected salinity zones were, however, evaluated based on the assumption that the salinity-based habitats may be associated with the occurrence and persistence of all identified resources of concern. Protection of salinity-based habitats was also viewed as a means to afford protection to many physical, chemical and biological processes and system components that were not specifically quantified or described by the data compiled for this minimum flows study.

Significant harm criteria associated with the resources of concern in the Homosassa River system were developed to prevent more than a fifteen percent decrease in the resources from baseline conditions. Baseline conditions were identified using information from benchmark periods developed using available data and models developed as part of this minimum flows study. Criteria for the identified resources of concern are described in subsequent section of this chapter.

Fish and Invertebrate Plankton and Nekton Criteria and Technical Approach

Development of specific criteria for preventing significant harm to the fish and invertebrate planktonic and nektonic communities of the Homosassa River system was investigated based on identifying flow reductions associated with predicted fifteen percent reductions in abundances of several taxa or pseudo-species that were collected from the system using plankton, seine or trawl nets. Baseline and significant harm threshold values for these metrics were evaluated using regression equations developed by Peebles *et al.* (2009) that relate organism abundances to the combined flow past the USGS Homosassa Springs and SE Fork gages. The analysis included identification of flow reductions for pseudo-species that exhibited positive, linear responses to inflow that were developed based on organisms collected from the

Homosassa and/or Halls Rivers. Pseudo-species exhibiting positive, linear responses to inflow were evaluated based on the assumption that modeled or actual flow reductions would be associated with reduced organism abundances.

Responses of fish and invertebrates captured from the system with a plankton net were evaluated using predicted absolute abundances of the tanaid crustacean *Hargeria rapax*, postflexion larvae of the rainwater killifish (*Luciana parva*), freshwater podocopid ostracods, and the copepods *Acartia tonsa* and *Eurytemora affinis*. Responses of psuedo-species collected with the seine nets from the Homosassa River were evaluated using predicted relative abundances of ten pseudo-species, including: brackish grass shrimp (*Palaemonetes intermedius*); blue crab (*Callinectus sapidus*) greater than and less than 30 mm in size; Seminole killifish (*Fundulus grandis*); rainwater killifish (*Lucania parva*); mosquitofish (*Gambusia holbrooki*); sailfin mollies (*Poecilia latipinna*); largemouth bass (*Micropterus salmoides*), pinfish (*Lagodon rhomboides*), and spot (*Leiostomus xanthurus*). Responses based on predicted relative abundances of Gulf pipefish (*Syngnathus scovelli*), spotted sunfish (*Lepomis punctatus*) and largemouth bass collected by seine from Halls River and blue crabs and Gulf pipefish collected by trawl net in the Homosassa and Halls Rivers also evaluated.

For the initial step in these analyses, baseline absolute (plankton-net captured) or relative (seine or trawl-net captured) abundances were estimated for each pseudo-species for two benchmark periods, 2007 and the period from October 18, 1995 through May 13, 2009, using taxon-specific regressions. The single-year benchmark period was used for the analysis to evaluate organism responses to flow variation for the same period used to evaluate salinity-based habitat responses (see the next section of this report). The longer benchmark period was similarly selected based on availability of flow records for the upper river. The record for this longer period included some estimates for dates when flows at either the USGS Homosassa Springs or SE Fork gage were unavailable. Flows used for estimation of plankton and nekton abundances for both benchmark periods included the fiftieth and other (tenth, twentieth, thirtieth, fortieth, sixtieth, seventieth, eightieth and ninetieth) percentile flows. Use of these flows, rather than time-lagged inflow values, was considered appropriate for characterizing abundance responses of individual pseudo-species over the majority of the flows that the organisms would be expected to encounter in the Homosassa River system. Predicted baseline absolute or relative abundances associated with the benchmark flows were then reduced by fifteen percent and flows associated with the reduced abundances were calculated using the taxon-specific regression equations. Flows associated with the reduced abundance values were then compared with the benchmark flows associated with the baseline abundances to determine percent-of-flow reductions associated with the fifteen percent changes in abundance.

Salinity-Based Habitat Criteria and Technical Approach

Generalized criteria for preventing significant harm to submersed aquatic and emergent vegetation, benthic invertebrates, fish and invertebrate plankton and nekton in the Homosassa River system were developed based on modeling of selected salinity-based habitats for baseline conditions in the Homosassa River and determination of percent of flow reductions associated with maintaining at least 85 percent of selected salinity-based habitats expected under baseline conditions. The generalized salinity-habitat criteria were also developed to afford protection to the myriad physical, chemical and biological processes and system components not specifically quantified or described as resources of concern for this minimum flows study. The criteria were based on identifying the volume of water at or below selected salinities and the linear extent of shoreline and area of bottom substrate in contact with water of selected salinities using results from the hydrodynamic model and empirical regression models for the Homosassa River developed for the District by HSW Engineers, Inc. (2010), bathymetric information collected for the District by the University of South Florida (2007) and shoreline information collected for the District by PBS&J (2009).

For analyses using the Homosassa River hydrodynamic model, baseline or reference salinity habitats and those associated with percent of flow reductions used to identify significant change criteria were evaluated using model output for calendar year 2007. Use of this single year as a benchmark period for identifying salinity-based habitats and development of significant change criteria was not considered optimal, although data limitations precluded use of a longer period for evaluation of salinity-habitats with the hydrodynamic model. Fortunately, spring discharge and flow in the Homosassa River system were relatively low in 2007 and may, therefore, be considered appropriate for evaluation of minimum flow criteria.

The hydrodynamic modeling involved identification of 2, 3, 5 and 12 salinity isohaline locations based on near surface, near bottom and water-column average salinity estimates for model centerline cells in three-hour increments for 2007. Modeled isohaline locations for the three-hour increments during the one-year benchmark period were used to calculate upstream area, volume or shoreline length values using the bathymetric data for the Homosassa River main channel and shoreline information described in Chapter 2 of this report. For these analyses, the shoreline data were truncated to exclude Halls River and Southeast Fork shorelines and the Homosassa River shoreline upstream of river kilometer 12.5. Modifications to the shoreline data set were made using ESRI ArcGIS, and were based on domain limits for the hydrodynamic model.

Areas upstream of the selected isohalines were considered representative of salinity-based habitats for benthic organisms in the Homosassa River and were calculated using bottom salinity isohaline and water-column average isohaline locations. Results based on use of bottom salinity isohalines were considered appropriate for deeper bottom habitats since the hydrodynamic model results for bottom salinities were based on salinities for the relatively deep river channel centerline. Use of water-column average isohalines for calculation of bottom area upstream of selected isohalines was considered to be representative of bottom-salinity conditions across the width of the river-channel bottom, including regions of shallower bottom habitats. Volumes for salinity habitats were calculated using water-column average isohaline locations and shoreline-based salinity habitats were characterized using surface isohaline locations.

Modeled habitat area, volume and natural shoreline lengths upstream of each respective isohaline for each three-hour increment in the 2007 benchmark period were considered representative of baseline conditions for the system. Median habitat values for the three-hour increment results, as well as other percentiles (the tenth through ninetieth percentiles in ten percent increments) were used to characterize baseline salinity-habitat conditions in the Homosassa River main channel.

Response of modeled salinity-based habitats to hypothetical flow reductions in the Homosassa River were then evaluated for the 2007 benchmark period in a manner analogous to that used for identification of baseline habitats. For these hydrodynamic model runs, daily flows during the benchmark period were reduced by five, ten, fifteen, twenty, twenty-five or thirty percent. Potential significant harm criteria were identified as percent of flow reductions associated with fifteen percent or greater reductions in the water volume, shoreline or bottom area upstream of each isohaline as compared to the respective habitat values for the baseline condition. Similarly to the approach used for baseline conditions, tenth through ninetieth percentiles were calculated for salinity habitats for each flow reduction scenario to characterize effects over the full range of flow conditions during the 2007 benchmark period.

Empirical regression models were also used to evaluate salinity habitats for baseline and flow reduction scenarios. Two benchmark periods – calendar year 2007 and the longer period from October 18, 1995 through May 13, 2009 – were used for these analyses. Salinity habitats during the 2007 benchmark period were evaluated with the regression models for comparison with and to support results obtained from the hydrodynamic modeling effort. The extent of salinity-based habitats for the longer benchmark period (1995 through 2009) were examined to supplement the modeling results for the one-year benchmark period, assuming that the observed responses would better integrate longer-term effects of a relatively wider range of spring discharge and river flow conditions. The period used for the longer benchmark period was limited based on availability of records for the combined discharge past the USGS Homosassa Springs and Southeast Fork gages.

For the regression analyses, equations 1 and 2 described in Chapter 2 of this report were used to predict daily locations of near surface and bottom isohalines corresponding to salinities of 3, 5 and 12 in the Homosassa River. Isohalines associated with a salinity of 2 were not included in the empirical regression analyses, because predictive regression equations for locating surface and bottom salinities of 2 could not be developed for the Homosassa River. The daily mean combined flow records for USGS Homosassa Springs and Southeast Fork used for the regression analyses included estimates derived for days when flow records were missing for either gage site. Daily mean tide values were used for evaluation of salinity habitats for the 2007 benchmark period; monthly mean values were used for evaluation of salinity habitats for the longer 1995-2009 period. Monthly values were used for the longer benchmark period because daily tide values at the Homosassa gage were unavailable for much of the longer time span.

Daily isohaline locations were used to calculate daily upstream areas, volumes and shoreline lengths associated with specific salinities. Median and tenth through ninetieth percentile habitat areas, volumes and shoreline lengths based on the daily values were calculated for the 2007 and 1995-2009 benchmark periods and considered representative of baseline conditions. Salinity-based habitats associated with baseline conditions were then contrasted with habitats modeled using daily spring flow records that were reduced by five, ten, fifteen, twenty, twenty-five or thirty percent. Using an approach analogous to that used for the Homosassa River hydrodynamic model output, potential significant harm criteria were identified as percent of flow reductions associated with fifteen percent or greater reductions in the bottom area, water volume or natural shoreline length upstream of each isohaline as compared to the respective habitat values for the baseline conditions.

Isohalines used for modeling salinity in the Homosassa River were selected based on salinities of spring water discharged to the system and biologically-relevant salinity preferences or tolerances. Given that estimated median salinities were less than 1 for springs in the Southeast Fork, and ranged from 1 to 3 for the Homosassa Main Spring pool vents (see Table 2-8), it was considered reasonable to evaluate habitats associated with salinities of less than 2 or 3. Analysis of isohalines associated with these two similar salinities was expected to provide useful information on potential flow-related changes in low salinity habitats within the system.

Evaluation of changes in low salinity habitats, *i.e.,* zones where salinities are less than 2 or 3, for development of minimum flow recommendations for the Homosassa River system was also supported by site-specific biological information and by approaches used for environmental flow studies of other estuarine systems. Freshwater insects, oligochaetes, and certain other invertebrate taxa are most abundant in low-salinity areas near the headwater springs of the Homosassa River system (Sloan 1956, Grabe and Janicki 2009, Wetland Solutions, Inc. 2010), suggesting that maintenance of low salinity zones in these areas is important for preservation of these components of the river's biological community. Also, based on recent sampling of the Homosassa and other area rivers, Culter (2009) notes that barnacle distributions in these systems may be limited in areas where salinities less than 2 are common, a finding that lends support to maintenance of low salinity zones for limiting upstream biofouling associated with barnacle attachment. Elsewhere in the state, the South Florida Water Management District (2002) and Suwannee River Water Management District (Water Resources Associates, Inc. *et al.* 2005) have established minimum flows based on maintaining zones with salinities less than 2 for preventing significant harm to river floodplain forests. In the Sacramento-San Joaquin estuary system in California, the position of the 2 psu bottom isohaline has been associated with phytoplankton productivity, fish abundances, and survivorship of molluscs, crustaceans and larval fish (Jassby *et al.* 1995) and used for management of inflows to the estuary (Kimmerer *et al.* 2002).

Evaluation of habitats in the Homosassa River with salinities less than 5 and 12 is also supported based on the extent of these zones within the river and the biological communities occurring in these salinity zones. Salinities up to 5 occur routinely upstream from river kilometers 7-8 and zones with salinities up to 12 are common upstream from river kilometer 4, based on median salinity values for the period from January 1997 and February 2009 (see Figure 2-29). Salinity tolerances of black needlerush (*Juncus roemerianus*), the dominant emergent plant along the Homosassa River shoreline, exemplify the biological relevance of evaluating changes in zones where salinities are less than 5 or 12. Clewell *et al.* (2002) report twenty-fifth exceedance and median salinities of 3 and 7, respectively, at sites where black needlerush (*Juncus roemerianus*) occurred in seven southwest Florida coastal rivers. The ninetieth percentile exceedance salinity for the sites populated by this important marsh plant was 12. Two common coastal tree species, cabbage palm (*Sabal palmetto*) and southern red cedar (*Juniperus virginiana* var. *silicicola*), are relatively tolerant of salinities of about 10 (references cited in PBS&J 2009), and their abundance in the Homosassa River system provides further support for the evaluation of habitats with salinities up to 12. On a regional scale, the Nature Conservancy has identified oligohaline saltmarsh (with salinities less than 5) as a priority habitat for conservation along the northern Gulf coast (Beck *et al.* 2000). Restoration of oligohaline habitats is also a top priority of the Tampa Bay National Estuary Program (2006), and based on the ecological importance of this low-salinity habitat, the District has established minimum flows for the lower Hillsborough River and Sulphur Springs to maintain salinities less than 5 in portions of the lower river.

Manatee Thermal Refuge Criteria and Technical Approach

Specific criteria for preventing significant harm to the Florida manatee population that uses the Homosassa River were based on maintaining adequate thermally-based habitat for preventing or minimizing adverse effects associated with exposure to cold water during a six-month “manatee season”, between October 1 and March 31. Thermally-favorable habitat was defined as water with a temperature at or above 20^{o}C (68^{o}F) for the duration of a critically cold, three-day chronic period during the manatee season, or water with a temperature above 15^{o}C (59^{o}F) for the duration of a critically cold, four-hour acute period during the manatee season. Because low tides may be associated with water depths that are insufficient for allowing manatees to access warm-water areas of the river, tide stage was also used to define thermally-favorable manatee habitat. A minimum depth of 1.16 m (3.8 ft) was considered necessary for characterization of areas of the river as thermally-favorable habitat. The six-month manatee season was selected for the habitat evaluation, assuming that this period corresponds to the primary period during which manatees would be expected to seek refuge from cold Gulf of Mexico waters in warm water areas such as the upper reach of the Homosassa River (see Figure 3-9 for actual manatee use data for the river). The significant harm criteria were developed to limit volumetric changes in thermally favorable habitat to no more than a fifteen percent reduction in the extent of habitat available during baseline chronic and acute cold conditions.

The extent of thermally-favorable habitat for manatees in the Homosassa River during critical cold periods under existing baseline flow conditions and hypothetical flow-reduction scenarios was evaluated for the District by HSW Engineering, Inc. (2010), using the Homosassa River hydrodynamic model and bathymetric information developed for the District by the University of South Florida (Wang 2007). For the analysis, a critically cold three-day period for evaluating thermally-favorable habitat was identified using a method similar to the approach used previously by the District for investigation of manatee habitat in the Chassahowitzka and Weeki Wachee River systems (see Janicki Environmental, Inc. and Applied Technology & Management 2007, Dynamic Solutions, Inc. 2008, Heyl 2008, Heyl *et al.* 2010). First, Cunnanae probabilities of non-exceedance for air temperature as measured at the Brooksville FAWN-IFAS station, discharge past the USGS Homosassa Springs gage, and tide stage at the USGS Homosassa River gage was calculated for each day during the 2007-2008 manatee season. The daily joint probability of non-exceedance was calculated as the product of the three probabilities, and three-day moving averages of the joint probabilities were developed to identify three-day periods with low air temperature, discharge and tide stage. Three-day joint probabilities were also calculated using daily non-exceedance probabilities for air temperature and discharge only, because missing tide stage values precluded calculation of three-day joint probabilities for all three factors for some dates during the 2007-2008 manatee season. Review of calculated three-day joint probabilities indicated that two time periods, December 16 through 18, 2007 and January 2 through 4, 2008, could potentially be used to evaluate thermally-favorable manatee habitat in the river (Figure 4-1). Review of three-day moving average air temperature and daily mean high tide values indicated that the January 2-4, 2008 time period was a more appropriate critically cold period for evaluating thermally-favored manatee habitat. Use of this period was also supported through review of two-factor (air temperature and discharge) and three-factor (air temperature, discharge, tide stage) joint probabilities estimated for the 1997-1998 through 2007-2008 manatee seasons (see technical memorandum included as Appendix J in HSW Engineering Inc. 2010). The three-factor joint probability for the January 2-4, 2008 critically cold period was the second lowest among all three-day periods evaluated, and the two-factor probability was ranked in the top five percent of the 1,708 three-day periods occurring during the combined 1997 through 2008 manatee seasons.

The Homosassa River hydrodynamic model was then used to estimate depth-average water temperatures for model domain cells for baseline conditions and for various flow-reduction scenarios during the three-day (January 2-4, 2008) critically cold period based on combined discharge measurements for the USGS Homosassa Springs and Southeast Fork gages. The extent (volume) of thermally favorable manatee habitat during the baseline critically cold three-day chronic and four-hour acute conditions during the three-day period were quantified using the modeled depth-averaged water temperatures and bathymetric data to identify portions of the river that met the thermal and water depth requirements of the animals. Changes in the volume of thermally-favored manatee habitat available associated with five, ten, fifteen, twenty, twenty-five and thirty percent reductions in flow from baseline conditions were also modeled and evaluated to identify flow reductions associated with more than a fifteen percent decrease in the volume of thermally-favorable habitat available under baseline conditions.

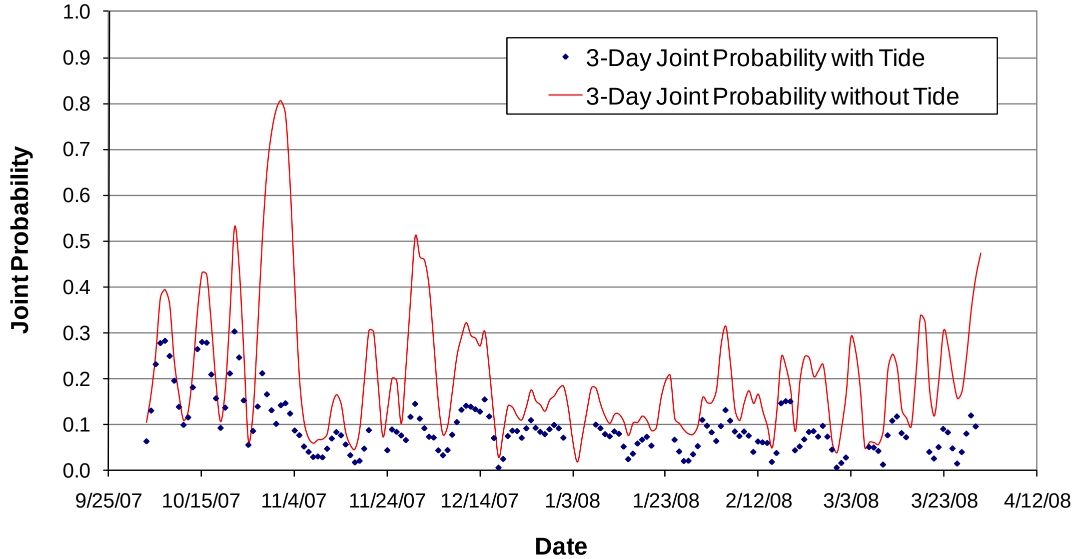


Figure 4-1. Three-day average joint non-exceedance probabilities for air temperature, spring discharge and tide stage (3-day Joint Prob. with Tide) and air temperature and spring discharge (3-day Joint Probability without Tide) during the 2007-2008 manatee season.

Chapter 5

Results and Recommended Minimum Flows

Introduction

Results from application of the technical approaches described in Chapter 4 are summarized in this chapter and were used to develop recommended minimum flows for the Homosassa River system. Results are grouped based on methods used to investigate flow-reduction responses of planktonic and nektonic fish and invertebrates, salinity-based habitats and extent of thermal refuge for the Florida manatee.

Results for Fish and Invertebrate Plankton and Nekton Analyses

All taxa or pseudo-species that were evaluated exhibited sensitive modeled responses to flow reductions for both the 2007 and the longer 1995 through 2010 benchmark periods. The five fish and invertebrate taxa evaluated with regressions based on organisms collected from the Homosassa River using a plankton net exhibited fifteen percent decreases from median baseline abundances with flow reductions ranging from less than one up to 1.4 percent (Table 5-1). Use of natural logarithmic transformed lagged flow and abundance values for development of the regression equations for the planktonic taxa (see Table 3-4) resulted in a constant response in predicted relative abundances as a function of flow across the range of evaluated benchmark inflow values; *i.e*., flow reductions associated with fifteen percent decreases from all benchmark percentile flows were the same as those associated with the median benchmark flows. Summary information regarding baseline and flow reduction scenario abundances associated with tenth to ninetieth baseline flows for the 2007 and 1995 through 2009 benchmark periods are included in Tables I1 through I5 in Appendix I.

Responses of pseudo-species evaluated using regressions based on organisms captured from shallow and deeper areas of the Homosassa and/or Halls Rivers with seine and trawl nets were similar to those for taxa collected with the plankton net. Flow reductions ranging from less than one to 2.7 percent were associated with fifteen percent reductions in relative abundances associated with median flows for the 2007 and 1995 through 2010 benchmark periods (Table 5-1). Responses of all pseudo-species were more sensitive for the 2007 benchmark period flows as compared to the 1995 through 2010 flows and likely reflected the relatively low flow conditions that occurred during 2007.

Responses to flow reductions associated with median benchmark flows were generally similar to the responses predicted across the range of benchmark flows examined (see Tables I6 through I20 in Appendix I), although variable responses were noted for some taxa. Some pseudo-species, *e.g.,* blue crabs (*Callinectus sapidus)* greater than 30 mm in length, exhibited increasingly sensitive responses to flow reductions from progressively lower baseline flow percentiles (Table I-8 in Appendix I). The regression equation used to predict baseline abundance for one pseudo-species, spot (*Leiostomus xanthurus*), indicated that for at least half the time, the sampled size-class for this fish would not be expected to occur in the shallow portions of the Homosassa River that were sampled with the seine net – predicted baseline abundance at the median flow for the 2007 benchmark periods was less than zero (Table 5-2). Lack of occurrence of the fish from shallow regions of the river was similarly predicted for the longer 1995 through 2010 benchmark period, based on the twentieth percentile flow for the period (Table I-20, Appendix I). Baseline relative abundances less than zero were predicted for nine additional pseudo-species based on lower (tenth to thirtieth percentile) baseline flows for the 2007 benchmark period and a single pseudo-species for the tenth percentile baseline flow for the 1995 through 2009 benchmark period.

Table 5-1. Summary information pertaining to identification of percentage of flow reductions associated with fifteen percent decreases in absolute (plankton net captured) or relative (seine or trawl-net captured) abundances of planktonic and nektonic fish and invertebrates in the Homosassa River and/or Halls River as compared to abundances for median baseline flows in the Homosassa River for the benchmark periods of 2007 and October 18, 1995 through May 13, 2009 (1995-2009).

Taxon or Pseudo-Species	Benchmark Period	Baseline Flow[a] (cfs)	Baseline Abundance (number/ channel or number/ 100m^2)	85% of Baseline Abundance (number/ channel or number/ 100m^2)	Flow Associated with 85% of Baseline Abundance (cfs)	Percent of Flow Reduction Associated with 85% of Baseline Abundance (%)
Plankton-Net Captured			**(number/ channel)**	**(number/ channel)**		
Hargeria rapax[b]	2007	130	67,242	57,155	128.1	1.4
	1995-2009	150	333,722	283,663	147.8	1.4
Lucania parva postflexion larvae[b]	2007	130	1,407	1,196	128.2	1.4
	1995-2009	150	7,457	6,339	147.9	1.4
Ostracods, podocopid[b]	2007	130	31,031	26,376	128.2	1.3
	1995-2009	150	172,563	146,678	148.0	1.3
Acartia tonsa[b]	2007	130	1,294,494	1,100,319	128.6	1.1
	1995-2009	150	11,345,444	9,643,627	148.40	1.1
Eurytemora affinis[b]	2007	130	2,849	2,421	128.9	0.8
	1995-2009	150	49,686	42,233	148.8	0.8
Seine-Net Captured			**(number/ 100m^2)**	**(number/ 100m^2)**		
Palaemonetes intermedius[c]	2007	130	11.4	9.7	127.5	1.9
	1995-2009	150	35.8	30.4	146.9	2.1
Callinectus sapidus; <30 mm in length[c]	2007	130	1.4	1.2	129.1	0.7
	1995-2009	150	16.1	13.7	148.3	1.1

Table 5-1. Continued.

Taxon or Pseudo-Species	Benchmark Period	Baseline Flow[a] (cfs)	Baseline Abundance	15% Decrease from Baseline Abundance	Flow Associated with 85% of Baseline Abundance (cfs)	Percent of Flow Reduction Associated with 85% of Baseline Abundance (%)
Callinectus sapidus; >30mm in length[c]	2007	130	0.5	0.5	128.0	1.6
	1995-2009	150	1.5	1.3	145.9	2.7
Fundulus grandis[c]	2007	130	1.5	1.3	127.7	1.7
	1995-2009	150	4.4	3.8	146.4	2.4
Lucania parva[c]	2007	130	43.6	37.0	128.3	1.3
	1995-2009	150	236.1	200.6	147.9	1.4
Gambusia holbrooki[c]	2007	130	4.9	4.2	128.9	0.8
	1995-2009	150	55.3	47.0	148.5	1.0
Poecilia latipinna[c]	2007	130	0.4	0.4	128.1	1.5
	1995-2009	150	1.2	1.0	145.9	2.7
Syngnathus scovelli[d]	2007	130	1.8	1.5	127.9	1.6
	1995-2009	150	5.7	4.9	146.7	2.2
Lepomis punctatusi[d]	2007	130	3.3	2.8	128.3	1.3
	1995-2009	150	15.9	13.5	147.6	1.6
Micropterus salmoides[c]	2007	130	8.5	7.2	128.8	1.0
	1995-2009	150	79.2	67.3	148.4	1.1
Micropterus salmoidesi[d]	2007	130	4.0	3.4	129.2	0.6
	1995-2009	150	92.9	79.0	148.8	0.8
Lagadon rhomboides[c]	2007	130	8.9	7.6	128.4	1.2
	1995-2009	150	53.1	45.1	148.0	1.3
Leiostomus xanthurus[c]	2007	130	<0	NA	NA	NA
	1995-2009	150	59.3	50.4	149.3	0.5
Trawl-Net Captured			**(number/ 100m^2)**	**(number/ 100m^2)**		
Callinectus sapidus[e]	2007	130	0.1	0.1	129.4	0.5
	1995-2009	150	0.9	0.7	147.0	2.0
Syngnathus scovelli[e]	2007	130	0.2	0.2	129.3	0.6
	1995-2009	150	1.2	1.0	147.0	2.0

[a] Daily flow records used to calculate median baseline flows include a small number of estimated flow values derived for days when flows were unavailable for either the Homosassa Springs or Southeast Fork Homosassa River gage sites maintained by the United States Geological Survey
[b] Abundances reported for Homosassa River between river kilometers 0 and 11
[c] Relative abundances reported for Homosassa River between river kilometers 0 and 13
[d] Relative abundances reported for Halls River between river kilometers 0 and ~5.8
[e] Relative abundances reported for Homosassa River between river kilometer 5.8 and 11 and Halls River between river kilometers 0 and ~3

Results for Salinity-Based Habitat Analyses

General Overview

Salinity-based habitats characterized using the Homosassa River hydrodynamic model and predictive regression models exhibited expected declines in response to modeled flow reductions. Results are summarized here for modeled responses for the benchmark period of 2007 based on hydrodynamic and regression modeling approaches and for the longer benchmark period, from October 18, 1995 through May 13, 2009 based on the regression models. For both the hydrodynamic and regression-model analyses, tenth to ninetieth percentiles for isohaline location and salinity-based habitat values were derived for baseline (*i.e.,* no flow reduction) and five, ten, fifteen, twenty, twenty-five and thirty percent flow-reduction scenarios. Flow-reduction effects on habitat were characterized primarily with median isohaline and salinity-based habitat values, although effects of flow reductions on other isohaline locations and habitat percentiles were also reviewed.

Isohaline Locations

Isohaline locations for median baseline conditions for the modeled 2007 and 1995-2009 benchmark periods are listed in Tables 5-2 through 5-7 and isohaline location percentiles for the modeled scenarios are provided in Appendices J through L.

In 2007, which was a relatively dry or low-flow year, model results indicated low salinity waters, *i.e*., with salinities less than 2 or 3, were typically limited to the portion of the Homosassa River upstream from or near the confluence of the Homosassa and Halls Rivers (Table 5-2 through 5-7). Median baseline bottom, surface and water-column isohalines with a salinity of 2 were located upstream of river kilometer 11.3, based on hydrodynamic modeling results. Review of modeled three-hour increment results indicated waters with salinities less than 2 were restricted to the uppermost portion of the river, upstream from the model domain boundary at river kilometer 12.5 for 28 to 39 percent of the time, based on locations of the bottom, surface or depth-average isohalines (see Tables J-1, J-5 and J-8 in Appendix J). Median locations of modeled isohalines with a salinity of 3 ranged between river kilometers 9.7 and 10.9, based on both the hydrodynamic and regression model results. The median lower extent of the oligohaline zone, *i.e.,* waters with salinities less than 5, was located between river kilometers 7.6 and 9.8 in 2007. Modeled median locations of the isohalines associates with a salinity of 12 occurred between river kilometers 3.8 and 6.0.

Flow reduction scenarios for 2007 evaluated with the hydrodynamic and regression models indicated median locations of the isohalines evaluated would be located between 0.1 and 1.2 km upstream of the locations associated with baseline, *i.e*., no flow reduction, conditions (Table 5-2 through 5-7). As expected, the greatest upstream displacement of isohalines was associated with the thirty percent, or highest modeled flow reduction scenario. Flow reductions of up to ten percent were typically associated with less than a 0.5 km upstream displacement of salinity isohalines, although based on hydrodynamic modeling results, the surface isohaline with a salinity of 2 was predicted to occur more than 1.2 km upstream from the baseline condition in response to as little as a five percent flow reduction.

Median locations of salinity isohalines for the 1995-2009 benchmark period developed using the regression approach typically occurred approximately one kilometer downstream of the isohaline locations modeled for the 2007 benchmark period (Tables 5-8 through 5-10). Relative upstream displacement of median isohaline locations from baseline conditions for the 1995-2009 benchmark period ranged from 0.3 and 0.7 kilometers for the five-percent flow reduction scenario from 1.3 to 2.4 km for the thirty percent flow reduction scenario.

Table 5-2. Median river kilometer (Rkm) location and relative change of bottom isohalines with salinities of 2, 3, 5 and 12 for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with the Homosassa River hydrodynamic model. Isohaline locations upstream of river kilometer 12.5 were outside the model domain and could not be determined. Table adapted from HSW Engineering, Inc. (2010).

Salinity Isohaline	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
2	12.0	12.1	0.1	12.3	0.3	12.3	0.3	>12.5	>0.5	>12.5	>0.5	>12.5	>0.5
3	10.9	11.0	0.1	11.0	0.2	11.2	0.3	11.3	0.4	11.4	0.5	11.6	0.7
5	8.9	9.1	0.2	9.2	0.3	9.4	0.5	9.6	0.7	9.7	0.8	10.0	1.1
12	5.5	5.7	0.1	5.8	0.3	5.9	0.4	6.2	0.7	6.3	0.8	6.5	1.0

Table 5-3. Median river kilometer (Rkm) location of surface isohalines with salinities of 2, 3, 5 and 12 for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with the Homosassa River hydrodynamic model. Isohaline locations upstream of river kilometer 12.5 were outside the model domain and could not be determined. In addition, flow reduction scenario results were not calculated for the isohaline with a salinity of 12.

Salinity Isohaline	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
2	11.4	>12.5	>1.1	>12.5	>1.1	>12.5	>1.1	>12.5	>1.1	>12.5	>1.1	>12.5	>1.1
3	10.9	11.0	0.1	11.1	0.2	11.2	0.3	11.3	0.4	11.5	0.6	11.6	0.7
5	9.1	9.2	0.1	9.4	0.3	9.6	0.5	9.7	0.6	10.0	0.9	10.3	1.2
12	6.2	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated

Table 5-4. Median river kilometer (Rkm) location of water-column average isohalines with salinities of 2, 3, 5 and 12 for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with the Homosassa River hydrodynamic model. Isohaline locations upstream of river kilometer 12.5 were outside the model domain and could not be determined. Table adapted from HSW Engineering, Inc. (2010).

Salinity Isohaline	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
2	12.2	12.3	0.1	12.4	0.2	>12.5	>0.3	>12.5	>0.3	>12.5	>0.3	>12.5	>0.3
3	10.9	11.0	0.1	11.1	0.2	11.2	0.3	11.3	0.4	11.4	0.5	11.6	0.7
5	9.0	9.2	0.2*	9.3	0.3	9.5	0.5	9.7	0.7	9.9	0.9	10.2	1.1
12	5.8	5.9	0.1	6.2	0.35	6.3	0.5	6.4	0.6	6.5	0.7	6.7	0.9

Table 5-5. Median river kilometer (Rkm) location of bottom isohalines with salinities of 3, 5 and 12 for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007, based on modeling of daily values conducted with empirical regression models. Isohalines with a salinity of 2 were not modeled because appropriate regressions could not be developed based on available data.

Salinity Isohaline	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
3	10.9	11.1	0.2	11.3	0.3*	11.5	0.5*	11.6	0.7	11.8	0.9	12.0	1.0
5	9.8	9.9	0.1	9.9	0.1	10.0	0.2	10.4	0.2	10.1	0.2*	10.2	0.4
12	6.0	6.2	0.2	6.4	0.4	6.6	0.6	6.8	0.8	7.0	1.0	7.2	1.1*

Table 5-6. Median river kilometer (Rkm) location of surface isohalines with salinities of 3, 5 and 12 for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007, based on modeling of daily values conducted with empirical regression models. Isohalines with a salinity of 2 were not modeled because appropriate regressions could not be developed based on available data.

Salinity Isohaline	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
3	9.7	9.9	0.2	10.0	0.3	10.1	0.4	10.2	0.5	10.4	0.6*	10.5	0.8
5	8.5	8.6	0.1	8.7	0.3	8.9	0.4	9.0	0.5	9.1	0.6	9.3	0.8
12	5.2	5.6	0.4	5.8	0.5	5.8	0.6	5.8	0.6	5.8	0.6	5.8	0.5*

Table 5-7. Median river kilometer (Rkm) location of water-column average isohalines with salinities of 3, 5 and 12 for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007, based on modeling of daily values conducted with empirical regression models. Isohalines with a salinity of 2 were not modeled because appropriate regressions could not be developed based on available data.

Salinity Isohaline	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
3	10.3	10.5	0.2	10.7	0.3*	10.8	0.5	10.9	0.6	11.1	0.8	11.2	0.9
5	9.1	9.2	0.1	9.3	0.2	9.4	0.3	9.5	0.4	9.6	0.5	9.7	0.6
12	5.6	5.9	0.3	6.1	0.5	6.2	0.6	6.3	0.7	6.4	0.7	6.5	0.8

Table 5-8. Median river kilometer (Rkm) location of bottom isohalines with salinities of 3, 5 and 12 for baseline and five to thirty percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling of daily values conducted with empirical regression models. Isohalines with a salinity of 2 were not modeled because appropriate regressions could not be developed based on available data.

Salinity Isohaline	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
3	9.6	10.2	0.6	10.8	1.1	11.0	1.4	11.2	1.6	11.4	1.8	11.6	2.0
5	8.4	9.1	0.7	9.6	1.2	9.8	1.3	9.9	1.5	10.0	1.5	10.0	1.6
12	4.3	5.0	0.7	5.6	1.3	6.0	1.7	6.3	2.0	6.5	2.2	6.7	2.4

Table 5-9. Median river kilometer (Rkm) location of surface isohalines with salinities of 3, 5 and 12 for baseline and five to thirty percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling of daily values conducted with empirical regression models. Isohalines with a salinity of 2 were not modeled because appropriate regressions could not be developed based on available data.

Salinity Isohaline	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
3	8.8	9.2	0.3	9.5	0.7	9.8	1.0	10.0	1.1	10.1	1.3	10.2	1.4
5	7.6	8.0	0.4	8.3	0.7	8.5	0.9	8.7	1.0	8.8	1.2	9.0	1.3
12	3.8	4.4	0.53	4.9	1.1	5.4	1.6	5.6	1.7	5.7	1.9	5.7	1.9

Table 5-10. Median river kilometer (Rkm) location of water-column average isohalines with salinities of 3, 5 and 12 for baseline and five to thirty percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling of daily values conducted with empirical regression models. Isohalines with a salinity of 2 were not modeled because appropriate regressions could not be developed based on available data.

Salinity Isohaline	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Rkm	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)	Rkm	Relative Change (km)
3	9.2	9.7	0.5	10.1	0.9	10.4	1.2	10.6	1.4	10.7	1.5	10.9	1.7
5	8.0	8.5	0.5	9.0	0.9*	9.2	1.1	9.3	1.3	9.4	1.4	9.5	1.5
12	4.09	4.67	0.58	5.25	1.17	5.69	1.61	5.95	1.86	6.13	2.05	6.28	2.19

Salinity-Based Bottom Habitats

Modeled baseline and flow-reduction scenario bottom areas associated with specific salinity zones were evaluated using both bottom and water-column average isohaline locations. In some cases, modeled bottom areas associated with specific salinity zones differed considerably, depending upon whether bottom or water-column average isohalines were used for calculating areas for the salinity habitats. Flow reductions associated with fifteen percent decreases in bottom area from baseline conditions were not, however, in most cases strongly influenced by the choice of isohaline for calculation of bottom area.

Model results for median baseline and flow-reduction scenarios are summarized in Tables 5-11 through 5-15. The scenarios evaluated suggest that the areal extent of river bottom in the Homosassa River exposed to salinities up to 2 or 3 was relatively sensitive to flow reductions. Hydrodynamic modeling output indicated that flow reductions of less than five percent, the lowest modeled flow scenario, were predicted to result in more than a fifteen percent decrease in median baseline bottom area exposed to salinities of 2 or less during the 2007 benchmark period. Hydrodynamic model results for 2007 also indicate that flow reductions between five and ten percent would result in more than a fifteen percent reduction in median baseline habitat where salinities were less than or equal to 3. Predictions for bottom area with salinities of 3 or less based on the regression modeling approach were more sensitive than the responses predicted for the same salinity zone with the hydrodynamic model. Regression models predicted that flow reductions of less than five percent would cause more than fifteen percent reductions in habitat area with salinities less than 3 for both the 2007 and 1995-2009 benchmark periods.

Fifteen percent reductions in median bottom area exposed to salinities up to 5 were associated with ten to greater than thirty percent flow reductions, based on hydrodynamic and regression model output for the 2007 benchmark period. Similar to the results for median bottom area associated with a salinity of 3 or less, the regression modeling for the 1995-2009 benchmark period yielded more sensitive responses to flow reductions for bottom area with salinities of 5 or less. Flow reductions between five and ten percent for the 1995-2009 benchmark period resulted in a fifteen percent decrease in the median bottom habitat area associated with salinities of 5 or less.

Among the bottom-habitat salinity zones examined, bottom areas associated with salinities less than or equal to 12 were the least sensitive to flow alterations. Modeled flow reductions between ten and thirty percent were associated with fifteen percent reductions in habitat area from median baseline conditions. The most sensitive responses for this salinity-habitat were predicted for the 1995-2009 benchmark period using the regression modeling approach.

The sensitivity of changes in salinity-based bottom habitats to flow reductions was not limited to changes associated with median baseline conditions. For example, hydrodynamic modeling for the 2007 benchmark period indicated that bottom area associated with the fortieth percentile baseline conditions, *i.e.,* approximately associated with forty percent exceedance flows, were reduced by more than fifteen percent when flows were reduced by five percent (see Tables M-3 and M-4 in Appendix M). Changes in bottom area associated with all modeled salinity zones across the range of baseline conditions, from tenth to ninetieth percentiles, are presented in Appendices M, N and O.

Table 5-11. Median daily bottom area upstream of bottom isohalines with salinities of 2, 3, 5 and 12 and relative change in bottom area percentiles for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline bottom area. Orange shaded cells indicate lowest or highest modeled flow reduction scenarios resulted in more or less than a fifteen percent reduction in baseline bottom area. Table adapted from HSW Engineering, Inc. (2010).

Salinity Zone	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
<2	47,583	37,364	21	18,925	60	12,444	74	NA	NA	NA	NA	NA	NA
<3	168,987	156,321	7	141,811	16	111,043	34	103,375	39	83,048	51	81,841	52
<5	528,676	512,968	3	488,488	8	448,803	15	413,383	22	392,802	26	344,980	35
<12	1,196,570	1,163,602	3	1,136,924	5	1,099,905	8	1,049,144	12	1,020,670	15	997,500	17

NA = isohaline for salinity zone boundary located upstream of model domain

Table 5-12. Median daily bottom area upstream of water-column average isohalines with salinities of 2, 3, 5 and 12 and relative change in bottom area percentiles for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a 1 fifteen percent relative change (reduction) in baseline bottom area. Orange shaded cell indicates lowest modeled flow reduction scenarios resulted in more than a fifteen percent reduction in baseline bottom area. Table adapted from HSW Engineering, Inc. (2010).

Salinity Zone	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
<2	28,855	18,035	37	9,775	66	NA	NA	NA	NA	NA	NA	NA	NA
<3	164,628	152,814	7	137,077	17	108,922	34	100,170	39	82,342	50	81,329	51
<5	518,123	498,285	4	465,359	10	428,729	17	395,652	24	358,650	31	324,629	37
<12	1,126,019	1,095,540	3	1,051,797	7	1,023,141	9	1,004,374	11	982,838	13	927,962	18

NA = isohaline for salinity zone boundary located upstream of model domain

Table 5-13. Median daily bottom area upstream of bottom isohalines with salinities of 3, 5 and 12 and relative change in bottom area percentiles for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline bottom area. Orange shaded cell indicates the lowest modeled flow reduction scenario resulted in more than a fifteen percent reduction in baseline bottom area.

Salinity Zone	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
2	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
3	159,128	129,245	19	99,989	37	82,291	48	80,345	50	71,191	55	51,248	68
5	378,197	369,390	2	360,703	5	352,111	7	343,432	9	334,609	12	325,786	14
12	1,076,754	1,041,844	3	1,008,080	6	964,576	10	915,935	15	868,381	19	820,908	24

NM = not modeled

Table 5-14. Median daily bottom area upstream of water-column average isohalines with salinities of 3, 5 and 12 and relative change in bottom area percentiles for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline bottom area. Orange shaded cell indicates the lowest modeled flow reduction scenario resulted in more than a fifteen percent reduction in baseline bottom area.

Salinity Zone	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)
2	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
3	286,890	240,324	16	207,447	28	180,052	37	159,403	44	135,286	53	109,057	62
5	503,809	486,083	4	463,881	8	443,819	12	426,316	15	409,129	19	394,403	22
12	1,170,686	1,100,269	6	1,061,060	9	1,045,838	11	1,030,616	12	1,015,393	13	1,000,171	15

NM = not modeled

Table 5-15. Median daily bottom area upstream of bottom isohalines with salinities of 3, 5 and 12 and relative change in bottom area percentiles for baseline and five to thirty percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline natural shoreline length. Orange shaded cell indicates the lowest modeled flow reduction scenario resulted in more than a fifteen percent reduction in baseline bottom area.

Salinity Zone	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)
2	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
3	405,494	311,957	23	186,320	54	148,878	63	111,884	72	82,922	80	81,714	80
5	566,623	507,782	10	408,937	28	383,252	32	365,293	36	353,908	38	343,711	39
12	1,369,157	1,290,431	6	1,165,769	15	1,077,869	21	1,027,324	25	986,503	28	929,843	32

NM = not modeled

Table 5-16. Median daily bottom area upstream of water-column average isohalines with salinities of 3, 5 and 12 and relative change in bottom area percentiles for baseline and five to thirty percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline natural shoreline length. Orange shaded cell indicates the lowest modeled flow reduction scenario resulted in more than a fifteen percent reduction in baseline bottom area.

Salinity Zone	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)	Area (m^2)	Relative Change (%)	Area (m^2)	Relative Change (%)	Area (m^2)
2	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
3	489,079	394,129	19	328,534	33	269,681	45	223,104	54	191,044	61	164,737	66
5	637,346	552,737	13	525,058	18	502,149	21	476,917	25	451,617	29	429,912	33
12	1,406,014	1,322,300	6	1,244,244	12	1,154,915	18	1,092,838	22	1,056,988	25	1,031,303	27

NM = not modeled

Salinity-Based Volumetric Habitats

Baseline and flow reduction scenario water volumes associated with specific salinity zones in the Homosassa River were evaluated using water-column average isohaline locations derived using both the hydrodynamic and regression modeling approaches. Summary output on salinity-zone volumes from the modeled scenarios for median baseline conditions is presented in Tables 5-17 through 5-19. Changes in water volumes associated with modeled salinity zones across the range of baseline conditions, from tenth to ninetieth percentiles, are presented in Appendix M for the hydrodynamic modeling of the 2007 benchmark period and in Appendices N and O for the modeling of the 2007 and 1995-2010 benchmark periods using the regression approach.

Responses of salinity-based water volumes to modeled flow reductions were similar to the changes observed for modeled salinity-based bottom area. Flow reductions of five percent were associated with more than fifteen percent reductions in baseline median water volumes with salinities of up to 2 or 3, based respectively on results from the hydrodynamic modeling of the 2007 benchmark period and use of the regression approach for the 1995 through 2010 benchmark period. Sensitive responses to flow reductions, *i.e.,* habitat volume changes between five and ten percent, were also predicted for baseline median water volumes with salinities less than or equal to 3 for the 2007 benchmark period and for the zone of salinity less than or equal to five for the 1995-2010 benchmark period, based on regression modeling results. The median baseline volume of water with salinities up to 12 was less affected by flow reductions, with the most sensitive result indicating that a ten to fifteen percent flow reduction for the 1995 through 2010 benchmark period would lead to a fifteen percent reduction in the salinity-based habitat.

Table 5-17. Median daily water volume upstream of selected water-column average isohalines with salinities of 2, 3, 5 and 12 and relative change in bottom area percentiles for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline volume. Orange shaded cells indicate lowest or highest modeled flow reduction scenarios resulted in more or less than a fifteen percent reduction in baseline water volume. Table adapted from HSW Engineering, Inc. (2010).

Salinity Zone	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
<2	45,554	26,750	41	12,614	72	NA	NA	NA	NA	NA	NA	NA	NA
<3	236,340	220,627	7	201,968	15	170,733	28	164,395	30	149,003	37	138,437	41
<5	687,132	661,238	4	625,666	9	585,110	15	540,357	21	485,481	29	436,346	36
<12	1,562,551	1,511,497	3	1,443,7975	8	1,401,322	10	1,373,507	12	1,341,283	14	1,258,247	19

NA = isohaline for salinity zone boundary located upstream of model domain

Table 5-18. Median daily water volume upstream of water-column average isohalines with salinities of 3, 5 and 12 and relative change in volume percentiles for baseline and five to thirty percent flow reduction for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline volume. Isohalines with a salinity of 2 were not modeled because appropriate regressions could not be developed from available data.

Salinity Zone	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
2	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
3	389,912	334,216	14	293,379	25	256,857	34	229,391	41	199,894	49	170,830	56
5	668,449	647,625	3	624,100	7	602,388	10	582,347	13	561,905	16	538,362	19
12	1,637,370	1,519,419	7	1,457,527	11	1,434,964	12	1,412,402	14	1,389,839	15	1,367,277	16

NM = not modeled

Table 5-19. Median daily water volume upstream of water-column average isohalines with salinities of 3, 5 and 12 and relative change in volume percentiles for baseline and five to thirty percent flow reduction for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline natural shoreline length. Orange shaded cell indicates the lowest modeled flow reduction scenario resulted in more than a fifteen percent reduction in baseline volume. Isohalines with a salinity of 2 were not modeled because appropriate regressions could not be developed from available data.

Salinity Zone	Flow Scenario												
	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Volume (m^3)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)	Volume (m^3)	Relative Change (%)
2	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
3	650,799	537,923	17	442,073	32	369,460	43	313,535	52	271,511	58	236,485	64
5	867,470	760,824	12	698,454	19	666,282	23	637,912	26	611,105	30	586,465	32
12	2,063,155	1,919,863	7	1,765,365	14	1,610,953	22	1,506,972	27	1,451,491	30	1,413,421	31

NM = not modeled

Salinity-Based Shoreline Habitats

Baseline and flow reduction scenario shoreline lengths associated with specific salinity zones were evaluated using surface isohaline locations for both the hydrodynamic and regression modeling approaches. Regions of the Homosassa River classified as "natural" shoreline, *i.e*., non-hardened shoreline with natural vegetation, were examined to evaluate potential changes in flow that may affect these relatively natural components of the Homosassa River system. Summary output from the modeled scenarios for median baseline conditions is presented in Tables 5-20 through 5-22. Changes in natural shoreline lengths associated with modeled salinity zones across the range of baseline conditions, from tenth to ninetieth percentiles, are presented in Appendix M for the hydrodynamic modeling of the 2007 benchmark period and in Appendices N and O for the modeling of the 2007 and1995-2010 benchmark periods using the regression approach.

Flow reduction scenarios for evaluating natural shoreline lengths exposed to salinities of 2 or less under median baseline conditions could not be evaluated for the 2007 benchmark period with the Homosassa River hydrodynamic model. Even the lowest flow reduction scenario results indicated that the surface isohaline with a salinity of 2 used to define this low-salinity shoreline habitat was located upstream of the model domain more than half the time (Table 5-20). However, flow reductions from baseline conditions associated under higher flows indicated that a five percent reduction in flows would result in more than a fifteen percent reduction in natural shoreline length in the zone where salinities were 2 or less (see Table M-13 in Appendix M). Similar sensitivity to flow reductions was evident for shoreline lengths exposed to salinities up to 12, based on regression model output for the 2007 and 1995-2009 benchmark periods. Regression model results for these benchmark periods indicated that median shoreline habitat associated with salinities of 12 or less would be decreased by fifteen percent when flows were reduced by five percent (Tables 5-21 and 5-22). Natural shoreline lengths exposed to waters with salinities of up to 3 and 5 were less sensitive to changes in flows. Fifteen percent decreases in median shoreline habitat length exposed to these salinity zones were associated with flow reductions ranging from between ten and fifteen percent to more than thirty percent.

Table 5-20. Median daily natural shoreline length upstream of selected surface isohalines with salinities of 2, 3 and 5, and relative change in bottom area percentiles for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007 based on modeling conducted with the Homosassa River hydrodynamic model. Yellow shaded cells correspond with or bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline natural shoreline length.

Salinity Zone	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
<2	1,197	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
<3	1,372	1,276	7	1,276	7	1,197	13	1,17	13	1,141	17	951	31
<5	2,834	2,834	0	2,753	3	2,556	10	2,357	17	2,046	28	1,846	35
<12	6,227	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NA = isohaline for salinity zone boundary located upstream of model domain
NC = not calculated

Table 5-21. Median daily natural shoreline length upstream of selected surface isohalines with salinities of 3, 5 and 12 and relative change in bottom area percentiles for baseline and five to thirty percent flow reduction scenarios for the benchmark period of 2007, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline natural shoreline length. Orange shaded cell indicates the highest modeled flow reduction scenario resulted in less than a fifteen percent reduction in baseline natural shoreline length.

Salinity Zone	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
<2	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
<3	2,356	2,157	8	2,046	13	1,925	18	1,846	22	1,846	22	1,846	22
<5	2,997	2,874	4	2,874	4	2,834	5	2,834	5	2,834	5	2,834	5
<12	8,985	7,660	15	7,451	17	7,451	17	7,451	17	7,451	17	7,451	17

NM = not modeled

Table 5-22. Median daily natural shoreline length upstream of selected surface isohalines with salinities of 3, 5 and 12 and relative change in bottom area percentiles for baseline and five to thirty percent flow reduction scenarios for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with empirical regression models. Yellow shaded cells correspond with or bracket flow reductions associated with a fifteen percent relative change (reduction) in baseline natural shoreline length. Orange shaded cell indicates the highest modeled flow reduction scenario resulted in less than a fifteen percent reduction in baseline natural shoreline length.

Salinity Zone	Baseline	5% Reduction		10% Reduction		15% Reduction		20% Reduction		25% Reduction		30% Reduction	
	Length (m)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)	Length (m)	Relative Change (%)
<2	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
<3	2,356	2,157	9	2,046	13	1,925	18	1,846	22	1,846	22	1,846	22
<5	2,997	2,874	4	2,874	5	2,834	5	2,834	5	2,834	5	2,834	5
<12	8,985	7,660	15	7,451	17	7,451	17	7,451	17	7,451	17	7,451	17

NM = not modeled

Summary of Salinity-Based Habitat Results

Percentage-of-flow reductions associated with modeled fifteen percent reductions in median baseline salinity habitats in the Homosassa River are compiled in Table 5-23. Results are shown for model runs for the 2007 and 1995 through 2009 benchmark periods based on output from the hydrodynamic and regression modeling approaches. For both benchmark periods, flow reductions of five percent were predicted to result in greater than 15 percent reductions in bottom area and water volume associated with salinities of up to 2 or 3. The most sensitive model responses for bottom and volumetric habitats associated with salinities up to 5 indicated that flow reductions of five to ten percent would result in 15 percent reductions in habitat from baseline conditions. Linear interpolation of based on modeled habitat reductions associated with five and ten percent flow reductions for these habitats indicated that the 15 percent habitat reductions would result from flow reductions ranging from 6.3 to 7 percent. Among the habitats associated with salinities up to 12, natural shoreline length exhibited the most sensitive response to flow reductions. Flow reductions of less than five percent were predicted to result in more than a fifteen percent loss of natural shoreline in contact with salinities of 12 or less for both the 2007 and the 1995-2009 benchmark periods.

Table 5-23. Modeled percent-of-flow reductions associated with fifteen percent decreases in median baseline salinity-based habits for the benchmark period of 2007 evaluated with the Homosassa River hydrodynamic model and empirical regression models and for the benchmark period from October 18, 1995 through May 13, 2009, based on modeling conducted with the empirical regression models. Linearly-interpolated values for percent-of-flow reductions between five and ten percent are indicated in parentheses.

Salinity-Based Habitat	Percent-of-Flow Reduction Associated with 15% Reductions in Habitat from Median Baseline Conditions		
	Hydrodynamic Model 2007 Benchmark Period	***Regression Model 2007 Benchmark Period***	***Regression Model 1995-2009 Benchmark Period***
Bottom Area			
Salinity ≤ 2 Based on Bottom Isohaline Location	< 5	NM	NM
Salinity ≤ 2 Based on Water-Column Average Isohaline Location	< 5	NM	NM
Salinity ≤ 3 Based on Bottom Isohaline Location	5 – 10 (9.4)	< 5	< 5
Salinity ≤ 3 Based on Water-Column Average Isohaline Location	5 – 10 (9.1)	< 5	< 5
Salinity ≤ 5 Based on Bottom Isohaline Location	15	> 30	5 – 10 (6.3)
Salinity ≤ 5 Based on Water-Column Average Isohaline Location	10 – 15	20	5 – 10 (7.0)
Salinity ≤ 12 Based on Bottom Isohaline Location	25	20	10
Salinity ≤ 12 Based on Water-Column Average Isohaline Location	25 – 30	30	10 – 15
Water Volume			
Salinity ≤ 2	< 5	NM	NM
Salinity ≤ 3	10	5 – 10 (5.3)	< 5
Salinity ≤ 5	15	20 – 25	5 – 10 (6.9)
Salinity ≤ 12	20 – 25	25	10 – 15
Natural Shoreline Length			
Salinity ≤ 2	NA	NM	NM
Salinity ≤ 3	20 – 25	10 – 15	10 – 15
Salinity ≤ 5	15 – 20	> 30	> 30
Salinity ≤ 12	NA	5	5

NA = not available
NM = not modeled

Results for Manatee Thermal Refuge Analyses

Modeled thermally-favorable manatee habitat, *i.e*., regions meeting minimum temperature and water-depth requirements, in the Homosassa River for the critically cold three-day period in 2008 are shown in Figures 5-1 and 5-2. Areas of the river meeting the manatee thermal requirements, but not the minimum water-depth requirement are also shown, and identify additional regions of the Homosassa River where manatees could potentially seek refuge from cold waters.

Modeled baseline volume of thermally-favorable manatee habitat during the three-day, chronic cold period in January 2008 was 64,566 m^3 (Table 5-24). Baseline volume of thermally-favorable habitat during acute cold conditions within the three-day period was nearly twice as large, at 112,288 m^3. Modeled scenarios indicate that flows could be reduced between 25 and 30 percent before thermally-favorable habitat of sufficient depth was reduced by fifteen percent during the three-day, chronic period. Thermally-favorable habitat for acute cold conditions, was, however, more sensitive to modeled flow reductions. A modeled flow reduction between five and ten percent would be associated with more than a fifteen percent reduction in water volume meeting the defined manatee needs during acute cold conditions. Linear interpolation of percent change values for the five and ten percent flow reduction scenarios indicated that a flow reduction of 7.5 percent would be associated with a fifteen percent reduction in thermally-favorable habitat for the acute cold period.

Available abundance estimates for Florida manatees, information on their usage of another state spring system as a thermal refuge, and modeled volumes of thermally-favorable habitat in the Homosassa River suggest, however, that the volume of available thermal refuge in the Homosassa River may not be a limiting factor for the local manatee population. The Florida Fish and Wildlife Conservation Commission (2010a, b) recently estimated the Florida and west coast of Florida manatee population sizes at 5,976 and 2,296 animals, respectively. At the Homosassa River, a maximum of 156 manatees has recently been observed during aerial surveys conducted over the past 25 years (unpublished data provided by the United States Fish and Wildlife Service. Based on information on adult manatee size and observed manatee use of Blue Springs in Volusia County, Rouhani *et al.* (2007) identified a volumetric constraint of 3.1 m^3 for individual manatees as part of their development of minimum flows for the spring system. Assuming that an individual manatee occupies 3.1 m^3 of refuge volume in the Homosassa River during critical cold periods, volumes associated with thermally-favorable habitat for the modeled scenarios with 30 percent flow reductions could be expected to accommodate 9,968 and 23,833 animals, respectively, during the critically cold chronic and acute conditions modeled for 2008. These estimates greatly exceed reported manatee population sizes for the Homosassa River, west coast and the entire state. Given that the estimated numbers of manatees that could be accommodated in the Homosassa River may be high, based on social behaviors or other factors that could limit manatee distributions within the system, the magnitude of the estimates still suggests that the flow reductions evaluated are not likely to be limiting for manatee use of the river system as a thermal refuge.

Table 5-24. Summary of thermally-favorable manatee habitat in the Homosassa River for baseline and five to thirty percent flow reduction scenarios for chronic and acute cold conditions based on modeling conducted with the Homosassa River hydrodynamic model. Yellow shaded cells bracket flow reductions associated with a fifteen percent decrease in thermally-favorable baseline volume (adapted from HSW Engineering, Inc. 2010).

Cold Condition	Flow Scenario	River Kilometer	Volume (m^3)	Volumetric Change (m^3)	Relative Change (%)
Chronic	Baseline	11.46	64,566	NA	NA
	5% Reduction	11.53	64,153	412	1
	10% Reduction	11.58	63,859	707	1
	15% Reduction	11.67	63,144	1,422	2
	20% Reduction	11.73	62,632	1,934	3
	25% Reduction	11.84	58,191	6,375	10
	30% Reduction	12.10	30,901	33,665	52
Acute	Baseline	9.56	112,288	NA	NA
	5% Reduction	9.69	103,212	9,075	8
	10% Reduction	10.00	87,749	24,539	22
	15% Reduction	10.34	73,881	38,407	34

NA = not applicable

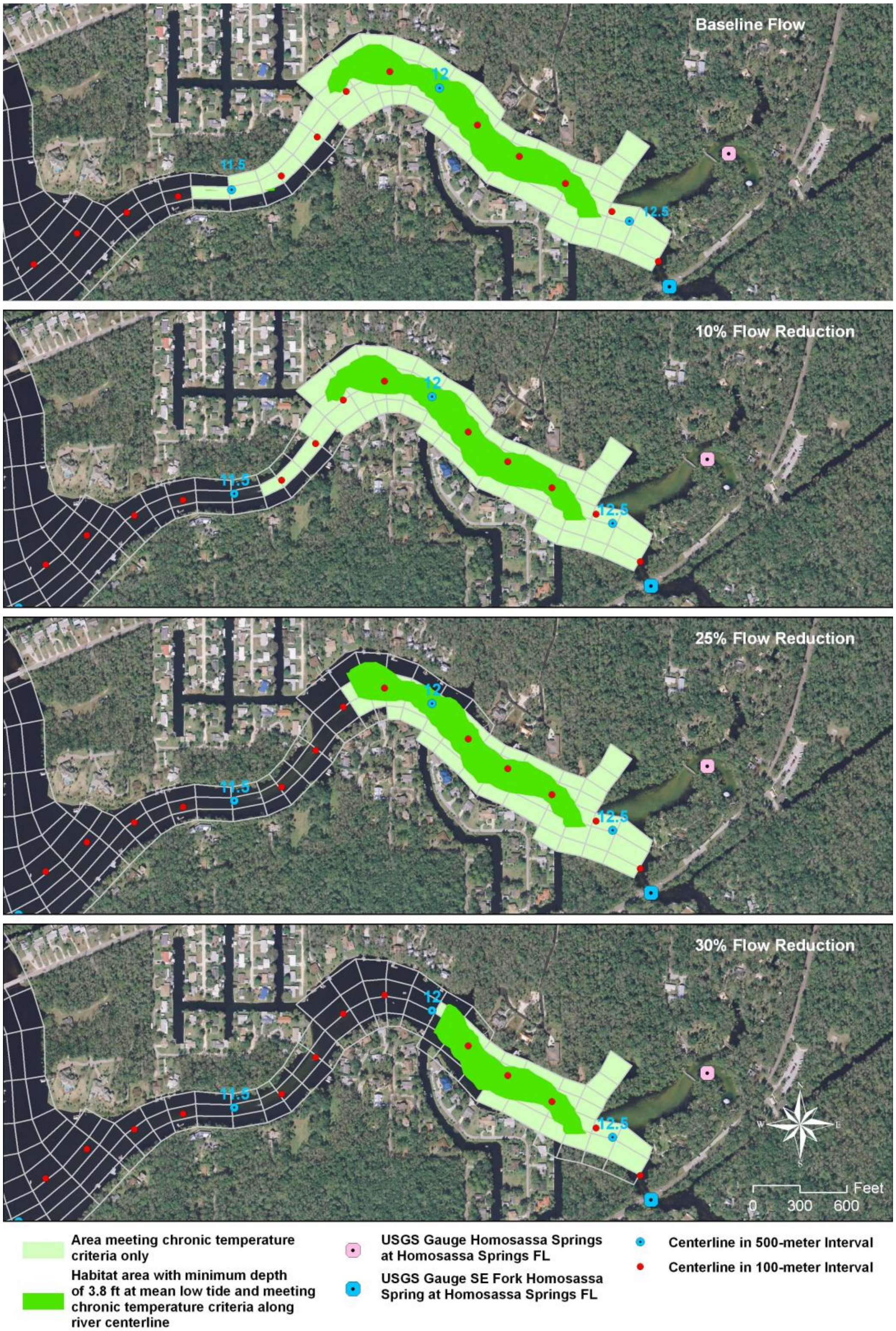


Figure 5-1. Thermally-favorable manatee habitat modeled for chronic cold conditions in 2007. Figure reproduced from HSW Engineering, Inc. (2010).

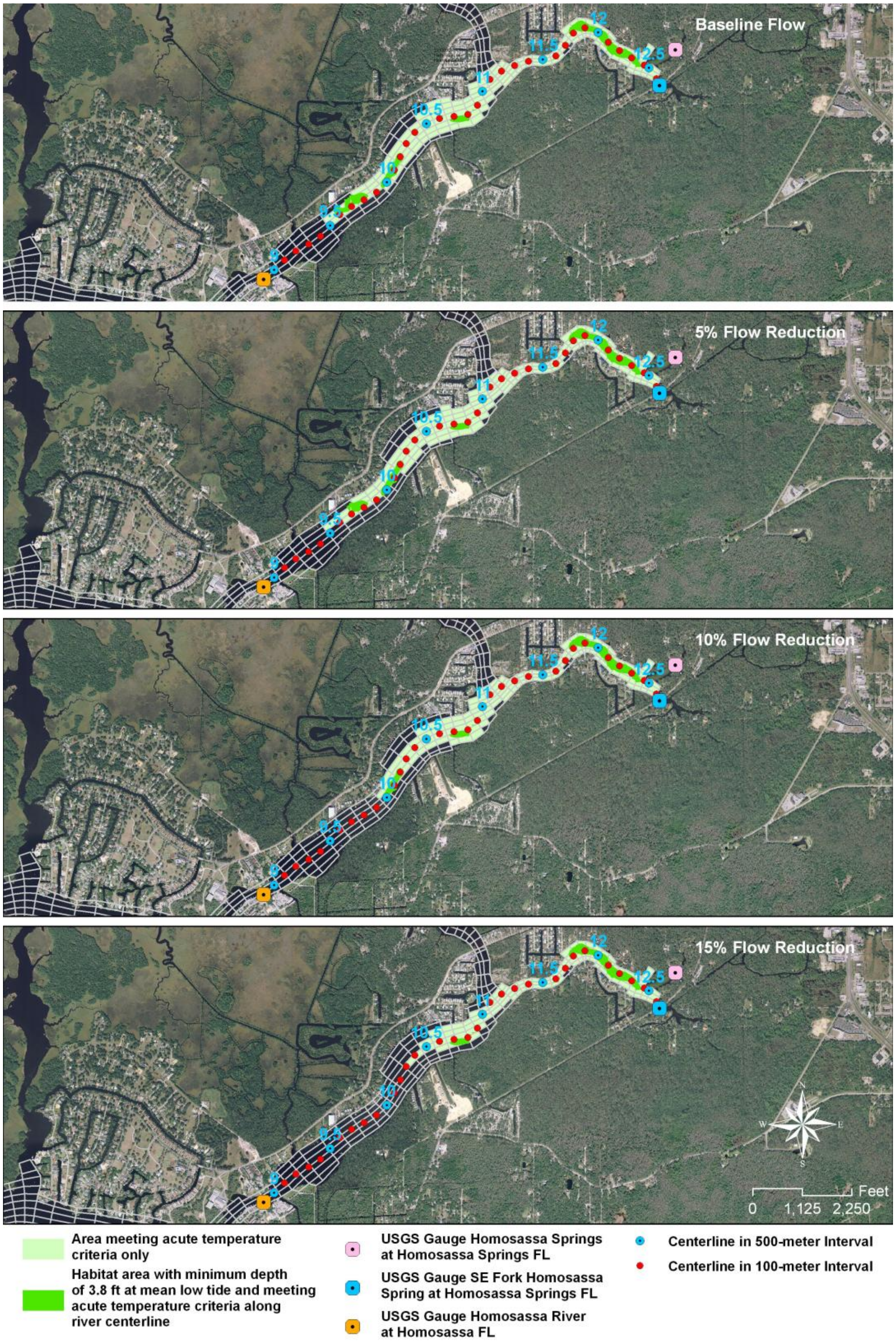


Figure 5-2. Thermally-favorable manatee habitat modeled for acute cold conditions in 2007. Figure reproduced from HSW Engineering, Inc. (2010).

Recommended Minimum Flows

Results from modeling approaches used to identify percent-of-flow reductions associated with fifteen percent changes in planktonic and nektonic fish and invertebrates, salinity-based habits and thermally-favorable habitat for manatees during critical cold periods were presented for the Homosassa River or larger extent of the Homosassa River system in the preceding sub-sections of this chapter.

The most sensitive resource responses to modeled flow reductions were exhibited by fish and invertebrate plankton and nekton. Flow reductions of 0.6 to 2.7 percent from median baseline conditions were associated with fifteen percent reductions in predicted abundances of individual pseudo-species or taxa. Similar or increased sensitivity to flow reductions was predicted for many taxa across the range of baseline flows, in particular for baseline flows less than the median flows. For some flow ranges, some nektonic taxa were predicted to not occur in the portions of the system for which the models were applicable, *e.g.,* in shallow areas for which empirical regression were constructed based on animals collected with a seine net.

It is possible that the apparent acute sensitivity of the evaluated plankton and nekton taxa to flow reductions in the Homosassa River system is an artifact of spurious relationships between the inflow values and organism count data used for development of the predictive regression models. Although all significant, positive linear models developed by Peebles *et al.* (2009) for planktonic and nektonic fish and invertebrates collected from the river system were retained for the minimum flows analysis presented in this report, the amount of variation accounted for by individual models and sample sizes used for model construction varied considerably. Despite this variation in the quality of the regression models, predicted responses of all evaluated planktonic and nektonic pseudo-species or taxa exhibited similar sensitivity to flow reductions. It is possible that the very sensitive modeled responses of these organisms to flow reductions are a function of the relatively stable flow conditions of the spring-dominated system.

Modeled responses of some salinity-based habitats in the Homosassa River main channel were also relatively sensitive to flow reductions. Flow reduction of less than five percent were associated with more than fifteen percent reductions in selected salinity-based habitats determined from isohalines with salinities of 2, 3, 5 and 12. Others sensitive salinity-habitats were predicted to be reduced by fifteen percent when baseline flows were reduced by five to ten percent.

The volume of thermally favorable habitat available to manatees during acute cold conditions was also relatively sensitive to modeled flow reductions. Flow reductions between five and ten percent were predicted to reduce favorable manatee habitat by fifteen percent during a recent critically cold period. The absolute volume of thermally-favorable habitat available for critically-cold baseline and all flow-reduction scenarios examined suggests, however, that flow reductions up to thirty percent are not likely to be limiting for manatee use of the Homosassa River system as a thermal refuge.

Based on the sensitive resource responses demonstrated by the modeling approaches used to evaluate the Homosassa River system, a five percent-of-flow reduction is considered appropriate for the minimum flow recommendation for the system. Based on the minimal existing withdrawal impacts on flow, the recommended minimum flow can be expressed for regulatory purposes as an allowable five percent reduction in mean daily flows in the Homosassa River calculated as the combined discharge or flow at the USGS Homosassa Springs at Homosassa Springs FL and Southeast Fork Homosassa Spring at Homosassa Springs FL gages. Long-term hydrologic statistics based on reductions from baseline conditions associated with the percent-of-flow reductions defined by recommended minimum flows are typically calculated for District minimum flows determinations. These statistics were not, however, calculated for the Homosassa River system, due to the limited period of record for available flow records at the Homosassa Springs and Southeast Fork gage sites. Given the magnitude of the percent-of-flow reduction recommended for the Homosassa River system minimum flows and the relatively short period of available flow records for gage sites in the system, the District strongly recommends future review and if necessary, revision of minimum flows that are adopted for the system.

Chapter 6

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Appendix Q

Excerpt from the July 27, 2010 Southwest Florida Water Management District Governing Board Meeting Agenda and Meeting Information document concerning draft report on proposed minimum flows for the Homosassa River system and submission of the report to the peer-review process.

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

Governing Board Meeting

Agenda and Meeting Information

July 27, 2010

9:00 a.m.

District Headquarters

2379 Broad Street • Brooksville, Florida
(352) 796-7211 • 1-800-423-1476

Weeki Wachee River

Southwest Florida
Water Management District

WATERMATTERS.ORG • 1-800-423-1476

Southwest Florida Water Management District

2379 Broad Street, Brooksville, Florida 34604-6899
(352) 796-7211 or 1-800-423-1476 (FL only)
TDD only 1-800-231-6103 (FL only)
On the Internet at: WaterMatters.org

An Equal Opportunity Employer

The Southwest Florida Water Management District (District) does not discriminate on the basis of disability. This nondiscrimination policy involves every aspect of the District's functions, including access to and participation in the District's programs and activities. Anyone requiring reasonable accommodation as provided for in the Americans with Disabilities Act should contact the District's Human Resources Director at 2379 Broad Street, Brooksville, FL 34604-6899; telephone (352) 796-7211, ext. 4702, or 1-800-423-1476 (FL only), ext. 4702; TDD (FL only) 1-800-231-6103; or email to ADACoordinator@swfwmd.state.fl.us.

MEETING NOTICE

AGENDA

GOVERNING BOARD MEETING

JULY 27, 2010

9:00 a.m.

All meetings are open to the public.

- Viewing of the Board meeting will be available at each of the District offices and through the District's web site (www.watermatters.org) -- follow directions to use internet streaming.
- Public input will be taken only at the meeting location.
- Public input for issues not listed on the published agenda will be heard shortly after the meeting begins.

Unless specifically stated, scheduled items will not be heard at a time certain.

At the discretion of the Board, items may be taken out of order to accommodate the needs of the Board and the public.

The meeting will recess for lunch at a time to be announced.

The current Governing Board agenda and minutes of previous meetings are on the District's web site: www.WaterMatters.org

9:00 A.M. CONVENE PUBLIC HEARING AND MEETING *(TAB A)*

1. Call to Order
2. Pledge of Allegiance and Invocation
3. Additions/Deletions to Agenda
4. District Recognition – Florida Nursery, Growers and Landscape Association for Landscape Challenge
5. Employee Recognition
6. Public Input for Issues Not Listed on the Published Agenda

CONSENT AGENDA *(TAB B)*

All matters listed under the Consent Agenda are considered routine and action will be taken by one motion, second of the motion and approval by the Board. If discussion is requested by a Board member, that item(s) will be deleted from the Consent Agenda and moved to the appropriate Committee or Report for consideration.

Finance & Administration Committee

7. Budget Transfer Report
8. Board Policy No. 190-2, Information Security

Executive Director's Report

9. Approve Governing Board June 29, 2010 Meeting Minutes

FINANCE & ADMINISTRATION COMMITTEE *(TAB C)*

Discussion Items

10. Consent Item(s) Moved for Discussion
11. Fiscal Year 2011 Budget Update and Adoption of Proposed District and Basin Millage Rates *(45 minutes)*

Submit & File Report

12. Fiscal Year 2010 Third Quarter Financial Report

Routine Reports

13. Treasurer's Report, Payment Register, and Contingency Reserves
14. Management Services Significant Activities

REGULATION COMMITTEE *(TAB D)*

Discussion Items

15. January 2010 Freeze Event
    a. Update on Rulemaking Amending 40D-3.600, Florida Administrative Code (F.A.C.), to Expand North and South Dover Areas Having Special Well Construction Standards *(10 minutes)*
    b. Status of Voluntary Payments by Agricultural Industry Representatives of Well Repairs Outside Permittee Mitigation Areas, Discussion of Litigation Options on District-Paid Repairs and of Outstanding Well Liability Cases in Legal *(20 minutes)*
    c. Initiate Rulemaking to Amend 40D-2, 40D-8 and 40D-80, F.A.C., to Establish a Water Use Caution Area in the Dover/Plant City Area and Associated Water Use Permitting Requirements, Minimum Level and Recovery Strategy *(30 minutes)*
16. Denials Referred to the Governing Board *(0 minutes)*

Submit & File Report

17. Individual Permits Issued by District Staff

Routine Reports

18. Southern Water Use Caution Area Quantities
19. Overpumpage Report
20. E-Permitting Metrics: Online vs. Paper Applications
21. Resource Regulation Significant Initiatives

RESOURCE MANAGEMENT COMMITTEE *(TAB E)*

Discussion Items

22. Hydrologic Conditions Status Report *(15 minutes)*
23. Utility Outreach Program *(15 minutes)*

Submit & File Reports

24. Proposed Minimum Flows Update for the Homosassa River Prior to Independent Scientific Peer Review
25. Proposed Minimum Flows Update for the Upper and Middle Withlacoochee River Prior to Independent Scientific Peer Review

Routine Reports

26. Florida Forever Funding
27. Minimum Flows and Levels
28. Structure Operations

29. Watershed Management Program and Federal Emergency Management Agency Map Modernization
30. Significant Water Supply and Resource Development Projects

OUTREACH & PLANNING COMMITTEE *(TAB F)*

Discussion Items – None
Submit & File Reports – None
Routine Reports

31. Comprehensive Plan Amendment and Related Reviews
32. Development of Regional Impact Activity Report
33. Speakers Bureau
34. Significant Activities

GENERAL COUNSEL'S REPORT *(TAB G)*

Discussion Item

35. Initiation of Litigation – WUP No. 20010392.005 – Milmack, Inc. (Oakwood Golf Club) – Polk County *(15 minutes)*

Submit & File Reports – None
Routine Reports

36. Litigation Report
37. Rulemaking Update

COMMITTEE/LIAISON REPORTS (*TAB H)*

38. Basin Board Education Committee Meeting
39. Basin Board Land Resources Committee Meeting
40. Industrial Advisory Committee Meeting
41. Public Supply Advisory Committee Meeting
42. Well Drillers Advisory Committee Meeting

EXECUTIVE DIRECTOR'S REPORT (*TAB H)*

43. Executive Director's Report

CHAIR'S REPORT *(TAB H)*

44. Chair's Report

✶ ✶ ✶ *RECESS PUBLIC HEARING* ✶ ✶ ✶

ANNOUNCEMENTS

- <u>Governing Board Meeting and Hearing Schedule</u>:
  Meeting – Wauchula .... August 24, 2010
  Tentative Budget Hearing – Tampa .... September 14, 2010
  Meeting – Brooksville .... September 28, 2010
  Final Budget Hearing – Brooksville .... September 28, 2010
  Meeting – St. Petersburg .... October 26, 2010

- <u>Basin Board Meeting Schedule</u>:
  Pinellas-Anclote River – St. Petersburg .... August 4, 2010
  Alafia River – Tampa .... August 5, 2010
  Hillsborough River – Tampa .... August 5, 2010
  Peace River – Bartow .... August 6, 2010
  Manasota – Sarasota .... August 11, 2010
  Coastal Rivers – Brooksville .... August 12, 2010
  Withlacoochee River – Brooksville .... August 12, 2010

- Advisory Committee Meeting Schedule:
  Industrial – Tampa .... July 20, 2010
  Public Supply – Tampa .... July 20, 2010
  Well Drillers – Tampa .... July 21, 2010
  Green Industry – Tampa .... August 26, 2010
  Agricultural – Tampa .... August 26, 2010
  Environmental – Sarasota .... September 13, 2010
- January 2010 Freeze Event Public Meeting – Plant City ....September 14, 2010

ADJOURNMENT

The Governing Board may take action on any matter on the printed agenda including such items listed as reports, discussions, or program presentations. The Governing Board may make changes to the printed agenda only for good cause as determined by the Chair, and stated in the record.

If a party decides to appeal any decision made by the Board with respect to any matter considered at a hearing or these meetings, that party will need a record of the proceedings, and for such purpose that party may need to ensure that a verbatim record of the proceedings is made, which record includes the testimony and evidence upon which the appeal is to be based.

If you wish to address the Board concerning any item listed on the agenda or an issue that does not appear on the agenda, please fill out a speaker's card at the reception desk in the lobby and give it to the recording secretary. Your card will be provided to the Chair who will call on you at the appropriate time during the meeting. When addressing the Board, please step to the podium, adjust the microphone for your comfort, and state your name for the record. Comments will be limited to three minutes per speaker. In appropriate circumstances, the Chair may grant exceptions to the three-minute limit.

The Board will accept and consider written comments from any person if those comments are submitted to the District at Southwest Florida Water Management District, 2379 Broad Street, Brooksville, Florida 34604-6899.

The comments should identify the number of the item on the agenda and the date of the meeting. Any written comments received after the Board meeting will be retained in the file as a public record.

Item 24

Resource Management Committee
July 27, 2010

Submit & File Report

<u>Proposed Minimum Flows Update for the Homosassa River Prior to Independent Scientific Peer Review</u> (B222)

Purpose
To present, for information only, the recommended minimum flows for the Homosassa River system and summarize the methodologies used to develop the recommendation.

Background/History
The Homosassa River system is located on the west coast of Florida in Citrus County, and for purposes of establishing minimum flows, consists of the Homosassa River (including the southeast fork of the Homosassa River), Halls River, Hidden River and springs associated with the rivers, including at least 19 named or identified springs or vents. The Homosassa River is designated an "Outstanding Florida Water," and much of the land and waters within the greater Homosassa River system are contained in state or federal preserves or refuges. The Homosassa River originates in the Homosassa main springs pool in the Ellie Schiller Homosassa Springs State Wildlife Park west of the community of Homosassa and flows eight miles to the Gulf of Mexico, bisecting the community of Homosassa Springs along its course. Halls River originates at Halls River head spring and flows three and one half miles to join the Homosassa River about seven miles upstream from the gulf. Hidden River also originates from a spring pool and flows one and one third miles toward the gulf before disappearing into a sink that probably contributes discharge to the Homosassa River. The Homosassa and Halls rivers receive a small amount of surface runoff from their 56-square mile watershed, and similarly the Hidden River receives some runoff from its watershed. The majority of flow in the system arises, however, from the continuous spring discharge derived from the approximate 270-square mile springshed. Spring discharge to the system exhibits only moderate seasonal variation, with lower flows in summer when tidal stage is highest. Estimated combined discharge past United States Geological Survey (USGS) gages in the Homosassa main springs run and the southeast fork of the Homosassa River has averaged 152 cubic feet per second (cfs) for the period from 1995 through 2009.

Purpose/Approach
The purpose for establishing minimum flows for the Homosassa River system is to ensure that flow of freshwater is sufficient to prevent significant harm to natural and human-use resource values associated with the system, in accordance with state law. To develop recommended minimum flows, a number of ecological resources were evaluated for sensitivity to reduced flows using both numeric models and empirical regressions. Resources evaluated included the amount of salinity-based habitats, fish and invertebrates, shoreline vegetation and thermal-refuge habitat for the West Indian manatee. Because spring discharge and consequently river flow in the system are relatively constant, minimum flow criteria were not evaluated on a seasonal basis. Declines in flow to the system associated with groundwater withdrawals were estimated to be approximately 2.3 cfs, including a 1 cfs decline in the springs contributing to flow past the USGS gages in the Homosassa main springs run and southeast fork. This 1 cfs change in flow was considered insignificant as compared to the estimated average flow of 152 cfs for the two sites, so available flow records for the sites were considered representative of baseline conditions for evaluation of minimum flow criteria. Because break-points in

ecological responses were not observed, a 15 percent loss of resource or habitat was adopted as representative of significant harm.

Based on review of resource and habitat-based criteria, the recommended minimum flows for the Homosassa River system are defined as a five percent reduction from baseline flows. Given the minimal existing withdrawal impacts on flow, the recommended minimum flows are a five percent reduction from combined flows measured on a daily basis at the USGS gage sites in the Homosassa springs run and southeast fork of the Homosassa River.

The data, methodologies and models used to develop the recommended minimum flows are summarized in the report "*Recommended Minimum Flows for the Homosassa River System,"* which is attached as an exhibit to this recap.

Benefits/Costs
The recommended minimum flows were developed to ensure that natural and human-use resource values associated with the Homosassa River system are protected from significant harm that could result from consumptive water use.

The next step toward establishing the minimum flows involves peer review of the recommended minimum flows by an independent scientific panel. The panel will conduct their review and report to the Governing Board at a future meeting. Following a favorable peer review report, staff will return to the Board with proposed rule language to establish minimum flows for the Homosassa River system.

Staff Recommendation: See Report

This item is submitted for the Committee's information, and no action is required.

Presenter: Doug Leeper, Chief Environmental Scientist, Resource Projects Department

Appendix R

Approved minutes for the July 27, 2010 Southwest Florida Water Management District Governing Board meeting. Minutes associated with the peer-review of proposed minimum flows for the Homosassa River system highlighted in yellow.

APPROVED

MINUTES OF THE MEETING

GOVERNING BOARD
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

BROOKSVILLE, FLORIDA JULY 27, 2010

The Governing Board of the Southwest Florida Water Management District (SWFWMD) met for its regular meeting at 9:02 a.m. on July 27, 2010, at the District's headquarters in Brooksville. The following persons were present:

Board Members Present
Ronald E. Oakley, Chair
Hugh Gramling, Vice Chair
H. Paul Senft, Secretary
Douglas B. Tharp, Treasurer
Jeffrey M. Adams, Member
Carlos Beruff, Member
Jennifer E. Closshey, Member
Neil Combee, Member
Albert G. Joerger, Member
Todd Pressman, Member
Maritza Rovira-Forino, Member
Judith C. Whitehead, Member

Board Member(s) Absent
Bryan K. Beswick, Member

Staff Members
David L. Moore, Executive Director
William S. Bilenky, General Counsel
Lou Kavouras, Deputy Executive Director
Richard S. Owen, Deputy Executive Director
Eugene A. Schiller, Deputy Executive Director
Bruce C. Wirth, Deputy Executive Director

Board's Administrative Support
LuAnne Stout, Administrative Coordinator
Tahla Paige, Senior Administrative Assistant

A list of others present who signed the attendance roster is filed in the permanent records of the District. This meeting was available for viewing through internet streaming. Approved minutes from previous meetings can be found on the District's Web site (www.WaterMatters.org).

Public Hearing

1. **Call to Order**
   Chair Oakley called the meeting to order and opened the public hearing. Mr. Senft noted a quorum was present.

2. **Pledge of Allegiance and Invocation**
   Chair Oakley led the Pledge of Allegiance to the Flag of the United States of America. Mr. Bilenky offered the invocation.

Public Hearing
Chair Oakley introduced each member of the Governing Board. He noted that the Board's meeting was recorded for broadcast on government access channels, and public input was only taken during the meeting onsite.

Chair Oakley stated that anyone wishing to address the Governing Board concerning any item listed on the agenda or any item that does not appear on the agenda should fill out and submit a speaker's card. To assure that all participants have an opportunity to speak, a member of the public may submit a speaker's card to comment on agenda items only during today's meeting. If the speaker wishes to address the Board on an issue not on today's agenda, a speaker's card may be submitted for comment during "Public Input." Chair Oakley stated that comments would be limited to three minutes per speaker, and, when appropriate, exceptions to the three-minute limit may be granted by the Chair. He also requested that several individuals wishing to speak on the same issue/topic designate a spokesperson.

3. **Additions/Deletions to Agenda**
Chair Oakley noted for the record that there are no changes to the agenda. (Track 1 – 00:00/04:40)

4. **District Recognition – Florida Nursery, Growers and Landscape Association Recognizes District for Landscape Challenge**
Mr. Michael Molligan, Director, Communications Department, said the Florida Nursery, Growers and Landscape Association (FNGLA) recognized the District for its support of the Landscape Challenge, an event that encourages landscape best management practices that protect water resources. On April 16, the District's first Landscape Challenge event was held at the Pay it Forward Farm (PIFF) in Pasco County. Ms. Merry Mott, FNGLA Director of Industry Certifications, addressed the Board and noted that also here today was Ms. Christine Collins of PIFF. Ms. Mott said that Ms. Collins and the District's Senior Communications Coordinator Sylvia Durell were hosts of the April 2010 landscape challenge in Spring Hill. The Landscape Challenge is unique among the industries' professional programs in providing hands-on instruction in a competitive format that allows participating teams from professional landscape maintenance companies and government facilities departments to demonstrate their real-world application of skills learned. Messrs. Kris Miller, Steve Noble, Silas Rooker and Jesse Stephens from the District's Facilities & Construction Services Section represented the District in the Challenge and won third place out of seven teams. Ms. Mott presented a plaque to the District. Mr. Gramling complimented District staff, FNGLA and other industry entities for the tremendous partnership forged for conservation and water quality in the landscaping industry. (Track 1 – 04:40/11:00)

This item was presented for the Board's information, and no action was required.

5. **Employee Recognition**
Mr. Moore recognized staff members who have achieved milestones of 20 years or greater.

Milestone	Employee Name	Title	Department	Office Location
Retirement	Tim Bailey	Field Operations Supervisor	Operations	Tampa
25 Years	Rick Judd	Lead Tradesworker	Operations	Brooksville
	Dan Roche	Senior Heavy Equipment Operator	Operations	Tampa
20 Years	Joe Oros	Senior Prof Geologist/Engineer	Bartow Regulation	Bartow

Mr. Mike Holtkamp, Director, Operations Department, provided a brief history of Mr. Tim Bailey's 37 years of service and presented him a plaque in honor of his retirement. (Track /1 – 11:00/22:23)

This item was presented for the Board's information, and no action was required.

Consent Agenda

Finance & Administration Committee

7. **<u>Budget Transfer Report</u>**
   Staff recommended to approve the Budget Transfer Report covering all budget transfers for June 2010.
8. **<u>Board Policy No. 190-2, Information Security</u>**
   Staff recommended to approve Board Policy 190-2, Information Security.

Executive Director's Report

9. **<u>Approve Governing Board June 29, 2010 Meeting Minutes</u>**
   Staff recommended to approve the minutes.

Following consideration, **Ms. Closshey moved, seconded by Ms. Rovira-Forino, to approve the Consent Agenda as presented. Motion carried unanimously.** (Track 2 – 00:00/00:40)

6. **<u>Public Input for Issues Not Listed on the Published Agenda</u>**
   Chair Oakley noted that no requests to speak were submitted. (Track 2 – 00:40/00:57)

Chair Oakley relinquished the gavel to Finance and Administration Committee Chair Tharp.

Finance and Administration Committee

Discussion Items

10. **<u>Consent Item(s) Moved for Discussion</u>** – None

11. **<u>Fiscal Year 2011 Budget Update and Adoption of Proposed District and Basin Millage Rates</u>**
    Committee Chair Tharp said today the Governing Board needs to adopt proposed millage rates for the General Fund and the Basins. The Basin Boards met in June and adopted proposed millage rates for recommendation to the Governing Board. These millage rates will be used by the property appraisers to develop the Notices of Proposed Property Taxes that will be mailed to homeowners in August. After the proposed millage rates are adopted, the millage rates can be lowered but not raised. Before adopting the proposed millage rates, staff will present an update of the recommended fiscal year (FY) 2011 budget, focusing on proposed changes since the last meeting on June 29, 2010. Staff will also provide an overview of the Program Budget that was postponed from the June meeting.

    Committee Chair Tharp said the update will highlight the July 1, 2010 Certifications of Taxable Value that were received from the District's 16-county property appraisers, and the revised estimate of ad valorem revenue for FY2011; along with other revenue and expenditure adjustments in the General Fund and changes to Basin budgets. Last month, the Board requested further discussion of District staffing and staff will be prepared at the August Board meeting to provide a presentation. Staff will also provide an update in August of the District's Long-Range Water Supply and Water Resource Development Funding Plan through 2030, along with any other topics of interest requested today.

    Committee Chair Tharp urged Board members to contact Mr. Schiller or Ms. Linda Pilcher, Assistant Director of the Finance Department, to discuss any budget matters between meetings. He pointed out that, by July 21, the District had received 100.2 percent of the proposed budget meaning the funds are already available to fulfill the FY2010 budget. (Track 3 – 00:00/02:42)

Mr. Schiller provided an overview of the proposed fiscal year budget. He said staff is recommending approval of the required resolution for the adoption of proposed millage rates for FY2011. He noted that budget updates will be provided monthly for the Governing Board's consideration through adoption in September. The budget calendar shows the next action is the August 1 Budget report to the Governor. This report will reflect the budget as presented to the Board today. Although not shown on calendar for August 5, he and Ms. Pilcher, along with Mr. David Rathke and Ms. Colleen Thayer of the District's Community and Legislative Affairs Department, will meet in Tallahassee with the Governor's staff and staff from the Senate and House to review the District's tentative budget. In August, the Basin Boards will adopt final millage rates and budgets for recommendation to the Governing Board. At the August 24 Governing Board meeting, staff will provide an update of the District's Long-Range Water Supply and Water Resource Development Funding Plan through 2030, and present additional information regarding staffing. Based upon the Long-Range Funding Plan, the Governing Board may wish to consider any adjustments in the General Fund millage at the August 24 meeting.

Mr. Schiller summarized the impact of the July 1 Certifications of Taxable Values the District received from the 16-county property appraisers. For the District's General Fund, based on declining property values and assuming the same millage rate as FY2010, ad valorem revenue will be $12.9 million (10.8 percent) less than FY2010; in comparison, last year the tax base declined by 11.6 percent. For the Basins, based on declining property values and a reduction in the millage rate for the Hillsborough River and Pinellas-Anclote River Basins, ad valorem revenue will be $9.7 million (14.2 percent) less than FY2010; combined ad valorem revenue will be $22.6 million or 12 percent less than FY2010 at this point in time, subject to final decisions.

Mr. Schiller then provided a brief update on the recommended changes to the budget since the Board's last meeting. Except for the Basins, there are few changes at this point, and he identified the changes that have been made to the Budget, by Fund, since June 29. The District-wide budget as of this date is $282.9 million, an increase of $7.0 million since June 29. This is primarily due to $6.1 million in additional balances from prior year for the Basins related to canceled projects, projects completed under budget and interest earnings in excess of budget. The General Fund budget has increased by $597,000. This primarily relates to the re-allocation of $791,000 in prior year state trust funds for water supply resource development projects. These increases are offset by $194,000 in expenditure reductions. (Track 3 – 02:42/08:55)

In summary at this point in time, Mr. Schiller said the District's budget is down $16 million from FY2010. This is primarily due to (1) $22 reduction in ad valorem revenue compared to FY2010; and (2) $9 million reduction in state ($8 million) and federal ($1 million) funding. The impact of these decreases in revenue is lessened by a $15 million increase in balances available from prior years mainly due to the cancellation of the City of Tampa projects. Finally, this budget includes $166 million (59 percent of total budget), including the District's cooperative funding programs, that will be contracted out and directly benefit private industry, in these difficult times. These funds will be leveraged with an estimated match of $84 million by cooperator partners for a total potential investment of $250 million (Water Supply and Resource Development (WSRD)/Cooperative Funding – $95.3 million plus Outsourcing – $85.8 million, less WSRD/Cooperative Funding/Surface Water Improvement and Management (SWIM) in outsourcing – $14.9 million equals $166.2 million). (Track 3 – 08:55/10:30)

Mr. Schiller said at the last meeting there was discussion regarding the District's encumbrance balances which are starting to decline over the last couple of years and staff expects this trend to continue. As staff has previously discussed with the Governing and Basin Boards, the District enters into legal contracts to fund operations, Cooperative Funding and other projects, and the funds are encumbered or set aside at that time. Encumbered funds cannot be utilized for other purposes until the project is cancelled, the contract scope is reduced, or the project is completed under budget. The District requires the cooperators to set aside their funding within their annual budgets. In governmental accounting, encumbered funds cannot be used for other purposes. If the funds become available, they can be added to fund balance and used for other projects. Alternatively, the Governing and Basin Boards could consider reductions in millage depending upon long-range funding requirements. Reserves are funds encumbered for future projects and constitute funds set aside consistent with the District's successful pay-as-you-go philosophy. The District's approach of setting aside any revenue from increases in taxable value has worked well in good times to ramp up for projects, as well as to provide adequate funds to address District priorities in a time of declining revenues. The District is well positioned to finance core priorities until the economic climate improves.

Mr. Schiller said that, as of June 15, the District has $614 million in encumbrances ($479 million for ongoing projects (General Fund $313 million and Basins $166 million) and $135 million in WSRD Reserves (General Fund $108 million and Basins $27 million). Basin encumbrances are approximately equal to the 2005/2006 levels. General Fund encumbrances are $166 million. This includes major projects such as $50 million for the Lake Hancock land acquisitions; $20 million for Tampa Bay Water System Configuration II; $14 million for the Southwest Polk County-Tampa Electric Company project; and $11 million for Peace River Manasota Regional Water Supply Authority Regional Loop System. (Track 3 – 10:30/14:08)

Mr. Schiller said the Balances from Prior Years are used as a source of funding for new projects. All balance forward dollars are re-budgeted by the Governing and Basin Boards, in a pay-as-you-go system. Fiscal years 2003, 2004, 2005, 2006 and 2007 are more typical of the District's traditional levels of balance forward. The significant increases since FY2008 are unprecedented and relate to the cancellation of major projects that had been funded at least in part over multiple years, and to project bids below estimates in these weak economic times. For example, of the $40 million in Basin Balances for FY2009, $13.3 million is due to the cancellation of the Tampa Bay Regional Reclaimed Water Project which impacted six basins. This allowed them to re-budget the funds for other purposes. Another example of the $55.1 million in Basin Balances for FY2011 is $25 million due to the cancellation of three Hillsborough River Basin cooperative funding projects by the City of Tampa. These funds have been re-purposed for other current projects and reserves for future projects. Finally, due to fewer requests for funding combined with higher than normal balance forwards and an extension in the timeline for new water supply and other long-range funding requirements through 2030, both the Hillsborough and Pinellas-Anclote River Basins are recommending reducing their millage rates for FY2011. While there will be a lag time over the next couple of years as the economy and cooperator budgets stabilize, these higher levels of balances from prior years are not expected to continue long-term. (Track 3 – 14:08/18:30)

Discussion ensued regarding outsourced dollar details, operating expenses, reserve and revenue dollars, balance forward funds, cash flow, balance between the growth of capital and expenses, projects declining, millage reduction, cooperative funding percentages, ad valorem valuations, ecosystem acquisitions, future impacts such as numeric criteria standards, and regional funding. Mr. Moore said staff will address the Board's concerns at the August meeting. (Track 3 – 00:18:30/01:11:40)

Mr. Schiller noted that the District's revenue budget's peak years were FY2007 and FY2008. In FY2009, FY2010 and continuing into FY2011, ad valorem revenue reflects the fall of the real estate market, with declining property values and limited new construction. Property values are expected to stabilize and bottom-out by FY2012. Total District revenues are now at the FY2005 through FY2006 levels. Finally, as ad valorem revenues have decreased and the District has held the line or reduced operating expenses, combined with higher than normal balance forwards, the District has been able to create a stable financial climate while continuing to meet its highest priorities, without bonded debt. (Track 3 – 01:11:40/01:14:46)

Mr. Beruff requested a chart showing the capital amounts on June 30 from FY2001 through FY2010 and outsourcing dollars annualized for that same ten-year period. Mr. Schiller said the best representative date is fiscal year end which is September 30. Mr. Beruff agreed. Mr. Schiller then introduced Mr. Mazur. (Track 3 – 01:14:46/01:20:03)

Mr. Roy Mazur, Director, Planning Department, presented the FY2011 budget by statutorily defined program categories which are how the budget is submitted by all the water management districts to the Office of the Governor. The information was prepared by allocating each activity among Areas of Responsibility (AOR) using the best estimates. (Track 4 – 00:00/07:26)

Mr. Schiller said staff is recommending to approve Resolution No. 10-11, Adoption of Proposed District and Watershed Basin Millage Rates for Fiscal Year 2011.

Proposed District Millage Rate	0.3866 mill
Proposed Watershed Basin Millage Rates	
Alafia River Basin	0.2163 mill
Hillsborough River Basin	0.2300 mill
Coastal Rivers Basin	0.1885 mill
Pinellas-Anclote River Basin	0.2900 mill
Withlacoochee River Basin	0.2308 mill
Peace River Basin	0.1827 mill
Manasota Basin	0.1484 mill

Following consideration, **Mr. Gramling moved, seconded by Ms. Closshey, to approve Resolution 10-11, Adoption of Proposed District and Watershed Basin Millage Rates for Fiscal Year 2011, as presented. Motion carried unanimously.** (Track 4 – 07:26/09:37)

Committee Chair Tharp thanked staff for their work since the budget is an arduous task. He said the discussion today was extremely beneficial, and he thanked the Board members for their input.

Submit & File Report

The following item was submitted for the Committee's information, and no action was required.

12. **Fiscal Year 2010 Third Quarter Financial Report**

Routine Reports

The following items were provided for the Committee's information, and no action was required.

13. **Treasurer's Report, Payment Register, and Contingency Reserves**
14. **Management Services Significant Activities**

Finance and Administration Committee Chair Tharp relinquished the gavel to Chair Oakley since the order of consideration was altered to hear Item 35. (Track 4 – 07:26/09:59)

General Counsel's Report

Discussion Item

35. **Initiation of Litigation – WUP No. 20010392.005 – Milmack, Inc. (Oakwood Golf Club) – Polk County**

Ms. Amy C. Wells, Staff Attorney, Office of General Counsel, said on June 29, 2010, District staff presented this matter to the Governing Board and requested authorization to initiate litigation against Milmack, Inc. (permittee) and any other appropriate parties to obtain compliance, a monetary penalty, and recovery of District enforcement costs, court costs, and attorney's fees. Representatives from the permittee and the owners of the surrounding development, Oakwood Land Company, also provided public comment. The Governing Board requested that this item be deferred to its July 27, 2010 meeting to allow the permittee an additional opportunity to work with District staff. Governing Board members also expressed an expectation that the permittee make substantial progress toward resolving this matter by the July Board meeting.

Ms. Wells said there is no additional information to indicate that staff should change its original recommendation. Staff is recommending that the Board authorize initiation of litigation against the permittee and any other appropriate parties to obtain compliance, a monetary penalty, and recovery of District enforcement costs, court costs and attorneys' fees.

Mr. Brian S. Starford, P.G., Director, Bartow Regulation Department, provided an overview of staff's actions since the Board's last meeting. On June 30, 2010, District staff met with the permittee and its representatives to discuss what items need to be completed prior to the next Governing Board meeting. Those items were outlined in a letter dated July 1, 2010, and included the following: installation of a meter on the surface water withdrawal and submittal of meter reading data, in accordance with Special Condition 7 of the permit; establishment of appropriate acreages for fairways, tees, and greens for each of the permittee's 18 golf course holes; and submittal of an application for permit modification, if the permittee can demonstrate justification for an increased quantity. District staff also committed to providing staff to perform leak detection and to perform an irrigation audit on the permittee's irrigation system, and to provide recommendations the permittee could employ to improve the system's efficiency. No leaks were detected, the irrigation audit was done, and the acreages calculated approximately.

Following consideration, **Ms. Rovira-Forino moved, seconded by Mr. Beruff, to authorize initiation of litigation against the permittee and any other appropriate parties to obtain compliance, a monetary penalty, and recovery of District enforcement costs, court costs and attorneys' fees.** (Track 5 – 00:00/17:36)

In response to Mr. Senft's question, Mr. Starford said he could not confirm whether the District had received information that the meter was ordered/installed. Mr. Adams said the irrigation appears outdated and questioned what is the District's ultimate goal: to win the litigation or work with someone who is trying to work with staff. (Track 5 – 17:25/20:50)

Mr. Dan O'Neal, golf professional and general manager of Oakwood Golf Club, said he has renovated and built six different golf courses. He said he has over 40 years experience as a golf pro and superintendent. Mr. O'Neal said the meter was installed yesterday and the Club has done everything requested by the District. The Club is not being given credit for 116.8 acres – not allotted enough water. Mr. O'Neal claimed that the Bartow Service Office mandated in 2004 to allow a developer to remove dirt to allow his property to drain onto the Club property. He believed this created a situation where seven holes were under water for over a year and these areas had to be rebuilt. Now the Club is facing a fine and the fairways are brown due to the reduction of water. The Club is doing what it can to stay in business and comply with the permit. Mr. O'Neal said he is requesting water usage for 116.8 acres. (Track 5 – 20:50/25:55)

Mr. Ron Mackail, representing Oakwood Golf Club, said the meter was installed late yesterday. Regarding establishing appropriate acreage for fairways, tees and greens, Mr. MacKail said he called the Bartow Service Office to ask how staff establishes acreage but did not receive that information until today when Mr. Starford provided his overview. He read from the July 21, 2010, letter sent by staff which stated that the method to calculate acreages was not appropriate. He claimed the Club has received a letter stating that the course's management was very good. He said the amount of pumpage from December 31, 2008, was 337,500 gallons per day (gpd). He said he calculates the amount to be 238,500 gpd. He said the permit goes back to 2003 when the course was built which comes to 164.53 acres. He asked how the permit went from 164.53 acres to 97 acres. The number of gallons reported from 1994 through 2000 shows historically the consistency of pumpage since the beginning. Mr. MacKail said he does not understand what changed. (Track 5 – 25:55/34:15)

In response to Ms. Closshey's inquiry, Mr. Bilenky said the Board is a policy-setting body. In response to Mr. Senft's question, Mr. Starford said the original permit was evaluated in 1993 and subsequent modifications were made in 2003 when Southern Water Use Caution rules went into effect.

Mr. Bilenky said the District pursues litigation when there may not be recovery of the penalties because, once the District has a judgment for a permit, it places the District in a higher category for recovery as a judgment creditor. Penalties are not based upon staff's efforts or duration of working with the permittee but upon the quantity of overpumping versus quantity of the permit. Penalties are based not on what the applicant is doing but what he should be doing under rules that are applied to all permittees of like consideration. Ms. Wells said the District's proposed penalty to the permittee was calculated based upon four months of overpumpage for the months of April through August, 2009, but that the permittee had been overpumping for at least five years. Mr. Bilenky said technical staff was first involved to bring permittee into compliance before sending the file to his office in the beginning of 2009. (Track 5 – 34:15/41:23)

Mr. Pressman asked to see Mr. McKail's permit. Ms. Rovira-Forino noted that, in her records, the first report of overpumpage was in 2008. Ms. Closshey said the Board is setting a precedence and policy about staff handling permittees that are not in compliance. She said there are permits on the overpumpage report showing two or four months, not five years. Mr. Senft noted that staff has been working with the permittee for several years and staff has not been given proof the meter was installed. He noted there needs to be attention to detail. Mr. Adams said he appreciated the additional information provided today.

In response to Mr. Pressman's question, Mr. Owen said the first permit was probably based upon the owner's calculation of acres. He said the first Southern Water Use Caution Area rules altered all permits for efficiencies. Mr. Owen said the golf course superintendents were vetted for over a year and involved in the public meetings. He said all permittees were notified of modifications. Mr. Gramling said the Board is giving the General Counsel the authority to begin the process.

Mr. Gramling called the question and the motion carried unanimously. (Track 5 – 41:23/47:17)

Chair Oakley then asked the Board to vote on the motion approving the staff recommendation. Motion carried unanimously. (Track 5 – 47:17/48:17)

At this time, the Board meeting recessed to provide a lunch break and reconvened at 12:33 p.m.

Chair Oakley relinquished the gavel to Regulation Committee Chair Beruff.

Regulation Committee

Discussion Items

15. **January 2010 Freeze Event**

a. **Update on Rulemaking Amending 40D-3.600, Florida Administrative Code (F.A.C.), to Expand North and South Dover Areas Having Special Well Construction Standards**

Mr. Owen said, in 2002, the District adopted Rule 40D-3.600, F.A.C., which sets forth special well construction standards for potable wells in and around the Dover-Plant City area, to address potential impacts to such wells as a result of significant groundwater use by the surrounding agricultural community during frost/freeze events. At the May 2010 Governing Board meeting, the Board authorized the initiation of rulemaking and approved proposed amendments to Rule 40D-3.600, F.A.C., to expand the North and South Dover Areas. This expansion is based on the effectiveness of the required casing depths in preventing well impacts, as demonstrated during the extensive freeze events of January 2010. The amendments also clarify that the well construction standards required by the rule extend to both new and modified or repaired wells.

A notice of rule development was published in the Florida Administrative Weekly on June 4, 2010, and the proposed rule amendments were published on June 11, 2010. Interested persons had 21 days, or until July 2, 2010, to submit comments or objections, request a public hearing or provide a proposal for a lower cost alternative to the proposed amendments. No public comments or request for a public hearing have been received, nor has any proposal for a lower cost alternative been submitted. The rule amendments were also provided to the Joint Administrative Procedures Committee (JAPC) for review and comment on June 11, 2010. To date, no comments or objections have been received from JAPC. Staff intends to file the amendments with the Department of State following the July Board meeting, and anticipates that the expanded North and South Dover areas will be effective in August 2010. (Track 6 – 00:00/02:45)

This item was presented for the Committee's information, and no action was required.

b. **<u>Status of Voluntary Payments by Agricultural Industry Representatives of Well Repairs Outside Permittee Mitigation Areas, Discussion of Litigation Options on District-Paid Repairs and of Outstanding Well Liability Cases in Legal</u>**

Mr. Bilenky noted there remain three distinct groups of impacted citizens. Of the three, only the first group of impacted citizens, those for which the District expended funds pursuant to its Executive Director's Emergency Order of January 27, 2010, will require a Board vote seeking authority on how to proceed. Ms. Adrienne Vining, Staff Attorney, Office of General Counsel, provided a status report of all claims.

Class II Homeowners – There were a number of wells that were outside any mitigation circle and as a result, there were no identifiable responsible permittees. Repairs were undertaken by the homeowners who incurred expenses in the aggregate amount of $41,953.72. Thirty-eight homeowners accounted for the expenditures or an average of approximately $1,100.00. Only two of the expenditures exceeded $2,000. Voluntary contributions to reimburse the costs of remediation have been made by the Department of Agriculture and Consumer Services; Florida Strawberry Growers Association; Florida Citrus Mutual, Inc.; Tampa Bay Wholesale Growers, LLA; Florida Blueberry Growers' Association; and the Florida Tropical Fish Farms Association, Inc.

Class III Homeowners – Those homeowners within an identified mitigation area of a permittee who self mitigated. Sixty-five litigation files were sent to legal and nine were resolved without recourse to any formal proceeding, leaving 56 remaining that have not been resolved. These cases constitute a total liability of $114,950.00 of which $26,258.00 was paid by the District to drill three new wells using funds authorized by the Governing Board under the Emergency Order.

Class I Homeowners (Emergency Order Citizens) – There was a group of citizens who were outside a mitigation area of any permittee or who had adversely impacted wells where the permittee was refusing (for whatever reason) to remediate a well, and by the date of the Board meeting, the homeowners were still without potable water. The Board authorized the Executive Director to execute an emergency order to meet an immediate risk to public health safety or welfare as a result of the impacts to individual wells caused by the pumping of ground water for frost freeze protection in the vicinity of Dover, Florida. The Emergency Order was issued on January 27, 2010. The District incurred emergency expenditures of $78,300.10 for remediation of homeowner wells for which there is no responsible permittee. District staff has requested each homeowner repay the District in the event of receipt of insurance coverage or other recovery. Based upon the fact that public funds were expended pursuant to an emergency order for health safety and welfare and the staff has made a reasonable effort to obtain reimbursement from the affected homeowners without success, the only method remaining is for the District to seek recovery through litigation. In light of the facts that these homeowners were unable to remediate on their own accord and the cost of pursuing 20 individual recoveries through county and circuit court would probably cost more than would be recovered, District staff recommends that the Board direct the staff that it would not be in the public interest to expend additional public funds to seek recovery through litigation of these claims.

Staff recommended the District-incurred emergency expenditures of $78,300.10 for remediation of homeowner wells for which there is no responsible permittee; and that, as to those claims arising under "class I homeowners," the Board direct staff that it would not be in the public interest to expend additional public funds to seek recovery through litigation of these claims. Following consideration, **Mr. Tharp moved,**

seconded by Ms. Rovira-Forino, to approve the staff recommendation as presented. Motion carried unanimously. (Track 6 – 02:45/19:38)

Mr. Moore said he thanks staff for their hard work in following up with each homeowner. Mr. Owen said staff will provide a status report at the next meeting.

c. **Initiate Rulemaking to Amend 40D-2, 40D-8 and 40D-80, F.A.C., to Establish a Water Use Caution Area in the Dover/Plant City Area and Associated Water Use Permitting Requirements, Minimum Level and Recovery Strategy**

Ms. Alba E. Más, P.E., Director, Tampa Regulation Department, said in June District staff completed its sessions with the Technical Work Group and provided the Governing Board with an overview of staff's resulting Management Strategy for freeze protection in the Dover/Plant City area. The Board concurred with each of the elements of the Management Strategy as recommended by staff, either at the June meeting or in previous meetings, including seeking state and federal funding, expansion of the area subject to special well construction standards, a revised process for allocating investigation and remediation of well complaints, enhanced communications, local government planning and coordination, optimizing water use for freeze protection, enhanced data collection, and alternative freeze protection methods. The Board also concurred with implementation of an incentive-based, cooperatively funded program to reduce freeze protection quantities (tailwater recovery ponds, covers and foam; including use of the District's Facilitating Agricultural Resource Management Systems (FARMS) program to provide up to 75 percent of the costs).

One component of the Management Strategy that staff did not seek concurrence with at the June meeting is the development of regulatory strategies to limit and reduce groundwater pumpage in the Dover/Plant City area for freeze protection. Although several approaches have been evaluated and discussed with the Technical Work Group, a final recommendation had not been developed by staff. The next steps in implementing the Management Strategy are outreach/stakeholder meetings in July and August; initiation of rulemaking at the July Governing Board meeting and rule adoption scheduled for the November Governing Board meeting.

The actions taken were to reduce significantly the risk of sinkhole development and well problems that occurred during the January 2010 frost-freeze event in eastern Hillsborough County. The goal is to limit additional groundwater withdrawals in an area that experiences the greatest aquifer drawdown resulting from pumping during a freeze event and to reduce the use of groundwater currently permitted by 20 percent over the next ten years through incentive-based programs.

The draft action plan includes reduce the risk of sinkhole development and well problems, 20-percent reduction in withdrawals to keep aquifer levels 10 feet above sea level during freeze events, use an incentive based approach with a 10-year implementation, protect existing investments to the greatest extent practical, stabilize and reverse long-term aquifer level declines, enhance data collection networks to monitor progress, enhance outreach as an event approaches, during and after, and revise well mitigation allocation procedure. Required rule amendments to accomplish the action plan include declaring a water use caution area (256-square-mile area for FARMS and model, 30-foot drawdown contour for annual average and crop protection quantities), establishing minimum aquifer level for frost/ freeze event (10 feet above sea level at DV-1), developing a recovery strategy, and revising permitting criteria.

The new rules will require meters on Small General Water Use Permits and automated meter reading devices on all permits with frost-freeze protections, significantly constrain new groundwater quantities, require investigation of alternative methods of protection, modify complaint investigation criteria, use of the Florida Automated Weather Network (FAWN), and enhance use of tools like the FARMS program to address recovery in the area.

Rulemaking is necessary to implement the regulatory components of the Management Strategy, including the limitations on groundwater for freeze protection to be discussed at the July meeting, the complaint allocation process, and those aspects of alternative freeze protection methods and data collection that will be requirements for permittees. Staff will prepare draft rules for discussion at public workshops in August and September. Draft final rules will be presented to the Board for review and discussion at its October Board meeting with a request for approval planned for the November Governing Board. If there are no requests for hearings or objections from the Joint Administrative Procedures Committee, this will allow the rules to be effective at the beginning of January 2011.

Staff recommended to concur with the establishment of a Water Use Caution Area and minimum flows and levels in the Dover/Plant City area; and approve initiation of rulemaking to amend 40D-1, 40D-2, 40D-8 and 40D-80, F.A.C., to establish a Water Use Caution Area in the Dover/Plant City area and associated water use permitting requirements, a minimum aquifer level and associated recovery strategy.

Following consideration, **Ms. Closshey moved, seconded by Mr. Senft, to approve the staff recommendation as presented.** (Track 7 – 00:00/24:32)

Mr. Gramling said that, under the FARMS Program to receive cooperative funding, the District is only paying for capital expense items. He said that, as the variations are developed, the District continues to stay engaged and only do capital items. Ms. Closshey voiced her agreement. Mr. Bilenky noted that one of the enhancements is the length of time permittees have to respond. He said, if unable to have rules adopted in time, staff is considering emergency rules should another frost-freeze event occur. Mr. Gramling said a reasonableness clause is needed if due diligence has been done by the permittee. Mr. Owen said staff is considering a number of improved procedures for incorporation. Mr. Gramling said it needs to be in an enforceable format.

Motion carried unanimously. (Track 7 – 24:32/28:26)

16. **Denials Referred to the Governing Board**
There were no requests for applications or petitions referred to the Governing Board for final action.

Submit & File Report
The following item was submitted for the Committee's information, and no action was required.
17. **Individual Permits Issued by District Staff**

Routine Reports
The following items were provided for the Committee's information, and no action was required.
18. **Southern Water Use Caution Area Quantities**
19. **Overpumpage Report**

20. **E-Permitting Metrics: Online vs. Paper Applications**
Mr. Owen noted a new report was included to inform the Board of staff's goals for online permitting. By the end of FY2012, staff's goal is to have achieved a minimum of 85 percent application rate for electronic permitting.

21. **Resource Regulation Significant Initiatives**
(Track 7 – 28:26/30:06)

Regulation Committee Chair Beruff relinquished the gavel to Resource Management Committee Chair Joerger.

Resource Management Committee

Discussion Items

22. **Hydrologic Conditions Status Report**
Mr. Granville Kinsman, Manager, Hydrologic Data Section, said although June marks the start of the official four-month rainy season (June through September), rainfall during the month consisted of widely scattered showers, resulting in generally drier-than-average conditions. Drier conditions were especially evident in the northern region of the District. Storms that developed during the month generally tended to be stationary, and often delivered extreme amounts of rainfall in a short period of time in localized areas. The provisional District-wide 12-month rainfall accumulation shows a surplus of approximately 0.78 inch above the long-term average. The 24- and 36-month cumulative rainfall deficits improved during June, ending the month approximately 4.0 and 8.27 inches, respectively, below the historic average. The regionally inconsistent character of June rainfall resulted in locally different responses in hydrologic indicators. Groundwater levels and streamflow conditions posted declines in many areas, but all ended the month within statistical normal ranges. Regional lake levels ended the month at the low-end of the annual normal range in the Tampa Bay region, while remaining at below-normal levels in the Northern, Polk Uplands and Lake Wales Ridge regions. NOAA climate forecasts continue to indicate above-normal rainfall during the wet season (June through September) based on a predicted above-average Hurricane Season. Staff will continue to closely monitor conditions in accordance with the District's updated Water Shortage Plan, including any necessary supplemental analysis of pertinent data. (Track 8 – 00:00/13:02)

This item was presented for the Committee's information, and no action was required.

23. **Utility Outreach Program**
Kenneth R. Herd, P.E., Water Supply Program Director, Resource Projects Department, provided an overview of the District's Utility Outreach Program. The District initiated a Utility Outreach Program to help accomplish the goals and objectives of the District's public water supply related strategic initiatives. The Outreach Program involves proactively working with the 193 water supply utilities within the District on water supply planning and management to assist local governments and utilities in developing and implementing programs to reduce their per capita water use and expand their use of reclaimed water and other alternative sources. Through this collaborative process, the District will inform utilities of key programs and resources, assist in identifying and developing water conservation related programs, and enable the District to better understand specific challenges the utilities face. A Utility Reference Manual was completed in June 2010 that concisely describes key District programs, the benefits to utilities, and where to obtain more information. Outreach teams for the Northern Region, Heartland Region, Tampa Bay Region, and the Southern Region were developed to be

consistent with the updated District's regional water supply planning process. (Track 9 – 00:00/19:30)

This item was presented for the Committee's information, and no action was required.

Submit & File Reports
The following items were submitted for the Committee's information, and no action was required.

24. **Proposed Minimum Flows Update for the Homosassa River Prior to Independent Scientific Peer Review**
25. **Proposed Minimum Flows Update for the Upper and Middle Withlacoochee River Prior to Independent Scientific Peer Review**

Routine Reports
The following items were provided for the Committee's information, and no action was required.

26. **Florida Forever Funding**
27. **Minimum Flows and Levels**
28. **Structure Operations**
29. **Watershed Management Program and Federal Emergency Management Agency Map Modernization**
30. **Significant Water Supply and Resource Development Projects**
    (Track 9 – 19:30/19:39)

Resource Management Committee Chair Joerger relinquished the gavel to Outreach and Planning Committee Vice Chair Closshey.

Outreach and Planning Committee

Discussion Items – None

Submit & File Reports – None

Routine Reports
The following items were provided for the Committee's information, and no action was required.

31. **Comprehensive Plan Amendment and Related Reviews**
32. **Development of Regional Impact Reviews**
33. **Speakers Bureau**
34. **Significant Activities**
    - Ms. Kavouras said the 2012 Strategic Plan update began last month. In July, the strategic team held its first meeting. The focus of this year's update will be natural systems and water quality strategic initiatives.
    - Ms. Kavouras said it is never too early to teach water conservation to children. The District received the Community Partners of Excellence Award at the June 24, 2010 Headstart/Early Headstart Volunteer Appreciation Banquet. Staff has been working with the Hillsborough County Headstart Schools providing education grants, everything from water conservation curriculum which helps with science and math scores to water wise landscaping.
    - Ms. Kavouras said the District has been certifying several Florida Water Star℠ Gold homes. Three homes have received Aurora Awards from the Southeast Builders Conference. This is a prestigious award presented to home builders and granted in areas of water wise home, green construction and go green categories.

- Ms. Kavouras noted that each Board member received an outreach card for the Water PRO program for restaurants. When visiting a restaurant that does not participate, she asked that they leave the card with a manager who can visit the website to learn more.

(Track 10 – 00:00/03:10)

Outreach & Planning Committee Vice Chair Closshey relinquished the gavel to Chair Oakley.

General Counsel's Report

Submit & File Reports – None

Routine Reports

The following items were provided for the Committee's information, and no action was required.

36. **Litigation Report**
37. **Rulemaking Update**

(Track 11 – 00:00/00:17)

Committee Reports

38. **Basin Board Education Committee Meeting**

Ms. Rovira-Forino said the meeting was held on July 14, 2010, and included updates on the "Get Outside" campaign, water conservation month (April), bus wraps and the airport promotion; Starkey exhibits ribbon-cutting report; "Skip a Week" campaign results; Tampa Bay Estuary Program education efforts; and Water PRO outreach cards. The workshop for an overview of District education programs will be Thursday, September 16, 2010 at the Tampa Service Office.

39. **Basin Board Land Resources Committee Meeting**

Mr. Joerger said the Committee met jointly for the second time with the Land Use Stakeholders at the Lecanto Government Center on July 14, 2010. Topics discussed included FY2011 meeting dates, land use and management plans, hunting, recreation monitoring, and multiple use/revenue generation analysis.

40. **Industrial Advisory Committee Meeting**

Ms. Closshey said the meeting was held on July 20, 2010. Topics discussed included updates on South Pasture Mine Extension Project in Hardee County, integrated water use permitting, rulemaking, Plant City/Dover frost/freeze protection status, hydrologic conditions/drought and water shortage plan, numeric nutrient criteria, and Water Use Condition Data – Permit Information Center.

41. **Public Supply Advisory Committee Meeting**

Mr. Senft said the meeting was held on July 20, 2010. Topics discussed included the Central Florida Coordination Area, hydrologic conditions/drought, water shortage restrictions and water shortage plan, frost/freeze protection status, hydrologic conditions/drought and water shortage plan, numeric nutrient criteria, Water Use Condition Data – Permit Information Center, and rulemaking.

42. **Well Drillers Industry Advisory Committee Meeting**

Mr. Oakley said the meeting was held on July 21, 2010. Topics discussed included Hillsborough County pump inspections, limiting groundwater quantities and consideration of a more equitable approach for assigning well mitigation responsibility in the Dover Area, changes to the Department of Environmental Protection Minimum Construction Requirement per Chapter 62-532, F.A.C.; introduction to the new State of Florida Well Construction Permit and Well Completion Report forms and modifications/enhancements to the WMIS Well Construction Portal, and how to use the District's Permit Map Viewer.

(Track 11 – 00:17/08:20)

Executive Director's Report

43. **Executive Director's Report**
   - Mr. Moore said one of the Permitting Summer School panel discussions was water management—where it has come from and where it is heading—and emphasis was on the needs for legislative change. He and Mr. Senft attended a two-day workshop in the MyRegion.org area with experts from around the country to develop a work plan relative to the Orlando general area. He said the two common threads in discussions were conservation (consistent approaches by the five districts, per capita calculations, permit renewal quantity reductions remove incentive) and funding (eligible for state or district alternative supply funding dollars, restoration of funding state wide). Legislative change to further encourage the development of multi-jurisdictional entities to address issues. Other concerns discussed included permit durations, conjunctive uses, districts wear too many hats creating conflicts of interest and should either be a regulatory or a funding entity, collaborative efforts creating stakeholder teams, and clarity of mission for each district. Mr. Moore noted that, if Board members want to receive the presentation, they should send their request by email to Ms. Kavouras. Mr. Senft said the MyRegion.org workshop stressed thinking regionally across district lines and water plans for regions such as Tampa to Daytona area as a super region. He said a topic of concern was the statewide stormwater rule and the fact that it does not deal directly with stormwater draining into wetlands. Mr. Senft said harvesting stormwater and using it as a source was discussed as well. He noted that, at both events, this District is recognized and complimented for its method of funding, basins, advisory committees and other ways issues are handled. Mr. Tharp said he attended a session at the Permitting Summer School on conservation and there are many opportunities to think out of the box to introduce new innovative ideas. He said he felt the sessions were valuable and it should be mandatory for new Board members. (Track 11 – 08:20/20:25)

In response to Ms. Closshey's questions, Mr. Wirth said the desalination plant is on standby since water is available from surface water sources. Mr. Moore said the plant is not idle and water is circulating. Ms. Closshey requested a status report at next month's meeting.

Chair's Report

44. **Chair's Report**
   - Chair Oakley thanked staff for their work in dealing with the items presented today.
   - Chair Oakley noted the announcements listed on the agenda and that next month's meeting is in Wauchula.

There being no further business to come before the Board, Chair Oakley adjourned the meeting until the next regularly scheduled meeting. (Track 11 – 20:25/23:25)

The meeting was adjourned at 2:18 p.m.

Appendix S

Hackney, C.T., Peterson, M.S. and Motz, L.H. 2010. Scientific review of the recommended minimum flows for the Homosassa River system scientific peer review report, October 17, 2010. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

SCIENTIFIC REVIEW OF THE RECOMMENDED MINIMUM FLOWS FOR THE HOMOSASSA RIVER SYSTEM

Scientific Peer Review Report

October 17, 2010

Prepared For:
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34609-6899

Prepared By: Scientific Peer Review Panel

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Scientific Peer Review of Proposed Minimum Flows and Levels for the Homosassa River System

EXECUTIVE SUMMARY

The Review Panel visited the Homosassa River system via boat and portions of the Hidden River by land. We accepted the District‟s charge to the panel and formulated eight questions that we felt must be answered before accepting the minimum flows proposed for this river system. The Panel agrees that the Homosassa River System‟s flow is dominated by spring discharge and minimum flow criteria do not need to be evaluated seasonally. The District‟s approach of using a threshold of acceptable change, 15%, is reasonable and defensible. The District has amassed an adequate database for purposes of the MFL (Minimum Flows and Levels) evaluation, although there was a lack of historical data for some biological components and some additional analyses of some biological data might be useful. The District has followed a credible and defensible approach in determining that current groundwater pumping in the Northern District has not affected the quantities of base flows in the Homosassa River system. However, the impact that groundwater pumping in the Northern District has had and will have on salinity and other water-quality parameters in spring discharges and base flows in the river is not well understood. The current assumption that salinities in the Homosassa River system today represent base flow conditions needs further evaluation. Changes in the quality of water exiting springs are as critical to future biological resources as changes in overall flow. Traditionally, reductions in downstream flow result in the upstream migration of the freshwater-saltwater boundary. In the Homosassa System, however, there is the additional impact of saline water flowing from springs. Evidence presented by Leeper et al (2010) is adequate to conclude that the proposed maximum 5% reduction in Minimum Flow satisfies the language and intent of the Statute and will result in "no significant harm" to the flora and fauna of the Homosassa River System. The use of the Homosassa River by Manatees as a thermal refuge in winter will not be impacted by this reduction. Suggestions for additional data collection and analyses are made in this review.

INTRODUCTION

The Florida Legislature requires that Water Management Districts establish minimum flows and levels (MFLs) for state surface waters and aquifers within its boundaries. The purpose of the statute is to protect Florida‟s water resources for the future. This protection extends to the fauna and flora within the water body through the requirement that the ecology of the area be protected from "significant harm" (Florida Statutes, 1972 as amended, Chapter 373, Section 373.0421). Once Water Management Districts have determined an MFL for a watershed, maintenance of the MFL becomes part of the planning process for future withdrawals. The same Florida statute requires that Districts develop strategies that will achieve recovery to the MFL within 20 years or to prevent withdrawals from decreasing flows below the determined MFL.

Water management districts are required to use the best information available in establishing the MFL for a watershed and to plan for low water flow conditions associated with season. A minimum flow is the point below which further water withdrawals will cause significant harm to the water resources or ecology of the area or significant harm to the water resources of the watershed. Thus, Water Management Districts must consider a wide array of impacts in the development of their MFL levels based on a variety of different information, which may be more robust for some resources than others.

The Southwest Florida Water Management District (SWFWMD) has begun the process of developing MFLs for watersheds within their district. Using guidance provided through Florida Statutes, SWFWMD has used a data collection/data review process to develop a recommended MFL for 15 of its watershed segments. Each of these recommended MFL levels was evaluated by a panel of independent reviewers. The Panel examines documents and data provided by SWFWMD staff and makes a recommendation with respect to the proposed MFL. Once the Panel recommendations are reviewed by SWFWMD, minimum flows are codified by rule and used in future decision making within the specified watershed segment.

Because many of the watersheds have been structurally altered by canals, dams, etc, identifying a baseline condition that incorporates structural and hydrological

alterations within the hydrologic system is not straightforward. Determining MFLs for a watershed must incorporate current conditions and often uses data which may or may not have been affected by these structural alterations.

A number of the SWFWMD watersheds, including the Homosassa River, are dominated by artesian spring flows from the Floridan aquifer. How water moves through the Floridan aquifer is not as easy to understand as surface-water flows. While this adds a level of complexity not found with watersheds dominated by surface-water flow, it does simplify the development of an MFL since most of the annual variation resulting from seasonal variations in rainfall is eliminated.

The development of MFL‟s must consider protection of not just water resources, i.e., freshwater flow, storage, etc, but attributes of the natural world associated with flows or water levels that are valuable to people (State Water Resources Implementation Rule, Chapter 62-40.473, Florida Administrative Code). Recreational values inherent in fishing and hunting are important considerations in setting MFL and dependent on the aerial extent of freshwater, marine, and estuarine habitats associated with a river. Navigation and aesthetic values should be considered as well as the function of a river system in absorbing and transporting nutrients and sediment. The development of a**n** MFL for any system is a complex undertaking.

The Panel for the review of the MFL for the Homosassa River system was provided a draft copy of the report prior to an on-site visit on August 10, 2010. During that visit, we observed by boat almost the entire system, with special emphasis on springs, which are the primary sources of river flow. We also visited, via vehicle, the Hidden River and its watershed. The Panel met the evening of 10 August 2010 and discussed our initial impressions of the Homosassa River system and what we felt were key questions which needed to be answered in the MFL recommendation and supporting documents. These questions became the focus of our review process. Central questions were:

1. Is the District‟s threshold of a maximum 15% change of resource within the system a reasonable approach?
2. Was there an adequate data base for development of the regression model?

3. Was there an adequate data base for development of the hydrodynamic model?
4. Were the models used by the SWFWMD the best models for determining the MFL for the Homosassa River system?
5. Was the data collection approach adequate to determine the past and present natural resources on the river system?
6. Were appropriate assumptions and analyses made in the use and extrapolation of these data?
7. Was the weight of evidence enough to convince the panel that the recommended MFL satisfied the Florida Statute establishing the MFL requirement?
8. Are there additional data that should be collected in the future that would add confidence to the MFL SWFWMD recommendations?

The following sections are arranged as follows: Critical Questions, General Comments and Recommendations related to the eight questions above. Specific Comments follow and are aspects of the document or appendices we found confusing or that appear inaccurate. These should be corrected or explained to eliminate the confusion. Finally, there is an Errata Section.

Critical Questions

Question #1 - Is the District‟s threshold of a maximum 15% change of resource within the system a reasonable approach? **Yes**, while it may be somewhat arbitrary, setting a quantifiable threshold provides a means to evaluate the impact that reductions in discharge would have on fish and invertebrates, salinity-based habitats, and the extent of thermal refuge for the Florida manatee. While reasonable, many of the r^2 values were low (but significant) and only positive relationships were examined. Both positive and negatives ones should be examined if the goal is to not dramatically change the community structure of the entire system.

Question 2 - Was there an adequate data base for development of the regression model? **Yes**, the salinity, tide stage, and discharge records for gage sites in the river and the salinity measurements made by SWFWMD and other agencies provided an adequate data base for the empirical regression models developed to describe salinity in the main channel of the Homosassa River. **Yes**, for most of the biological response measures (plankton, fishes, and manatees). The benthic analysis was incomplete, however. There were also considerable data sets for SAV and EAV that seemed to contradict each other.

Question 3 - Was there an adequate data base for development of the hydrodynamic model? **Yes**, the stage, salinity, and temperature data at the USGS Shell Island gage, the salinity and temperature data at the USGS Homosassa Springs and SE Fork gage sites, the discharge data at the USGS Homosassa Springs, SE Fork, and Homosassa Springs gages used to model the discharge at Halls River, the salinity data in Halls River and at the Homosassa Springs gage, and meteorological data measured at the FAWN-IFAS station at Brooksville in general provided an adequate data base for development of the hydrodynamic model.

Question 4 - Were the models used by the SWFWMD the best models for determining the MFL for the Homosassa River system? **Yes,** the EFDC hydrodynamic model is well documented in the literature, and it has been widely used to simulate flows and water-quality parameters in estuarine and coastal applications. Also, the use of regression models to empirically relate river discharge and salinities is acceptable. The assessment of the impacts of pumping on spring discharges (Basso 2010) is based on a proprietary version of MODFLOW, which also is well documented and widely used to simulate groundwater flow systems. Additional study of the relationship between withdrawals and spring flow at different springs should be done with the goal of understanding any potential increases in salinity at saline springs or decreases in flow at freshwater springs that might be caused by withdrawals.

Question 5 - Was the data collection approach adequate to determine the past and present natural resources on the river system? **Yes**, with respect to flow, this approach is quite adequate to conclude that present-day spring and river discharges can be considered baseline or natural flows [also, please see response to the next question concerning water quality]. The approach assumed that present-day flow records were representative of past, or baseline, conditions based largely on the determination using a numerical groundwater flow (Basso 2010) that groundwater pumping in the Northern District of SWFWMD has reduced historical spring flows in the Homosassa River system by an insignificant amount (approximately 1 percent). With respect to many natural components, the answer was **no**. There were some data for SAV/EAV and water quality from earlier reports, but not much else besides those. Obtaining data on past resources that are not considered of economic value is often difficult. Data collected as part of the current MFL document will serve as a baseline for future modification of MFL evaluations.

Question 6 - Were appropriate assumptions and analyses made in the use and extrapolation of these data? In response 5 above, **yes** it is reasonable to assume that present-day spring and river discharges represent baseline or natural flows. However, it can only be inferred that present-day salinities discharging from the springs into the river system are still at natural levels. Based on the lack of a calibrated numerical groundwater transport model for the Northern District or other means to address this issue currently, this is the best that can be done at this time. Addressing the need for data that can be used to calibrate such a model should be a priority for future research and monitoring.

There were also some questions of providing additional information with respect to assumptions used in the detailed analyses provided. For example, low r or R values in many analyses were not compared to the „norms" of statistical procedures. These should be provided.

Question 7 - Was the weight of evidence enough to convince the panel that the recommended MFL satisfied the Florida Statute establishing the MFL requirement? Generally, **yes**, it would satisfy the statute, but because of the variability and low predictability of input data, there could be problems with the accuracy of the predictions.

Question 8 - Are there additional data that should be collected in the future that would add confidence to the MFL SWFWMD recommendations? Yes, as noted in previous questions, priority should be given to collecting additional data as part of an investigation intended to resolve some of the salinity and temperature results obtained using the hydrodynamic model. Also, additional groundwater quality data should be collected as part of an investigation to better understand the flow and water-quality aspects of the springs in the Homosassa springshed and to determine whether spring salinities will increase in response to increased groundwater pumping in the Northern District of SWFWMD.

We feel the District should take a multivariate approach as illustrated in their analyses in the appendices using Primer statistics. The goal of the MFL process is to do no „significant harm", which in many cases is a professional judgment call. The suggested multivariate approach outlined at the end of this document (The sections on Chapters 4 & 5) would improve the ability to make predictions of potential outcomes based on flow reductions. These outcomes would be more holistic and at the heart of the MFL process.

General Comments and Recommendations

Water Quality in the Springs

The water quality in the springs that discharge into the Homosassa River system varies from fresh to brackish. The Homosassa Main Springs and Halls River springs discharge brackish water, and the springs of the Southeast Fork discharge relatively freshwater, based on Yobbi and Knochenmus (1989). Halls River Head Spring, Homosassa Springs, and Hidden River Head Spring discharge sodium-chloride water, which indicates a seawater origin, and Trotter Spring in the Southeast Fork discharges mixed-ion water, which is the result of freshwater and saltwater mixing (Knochenmus and Yobbi 2001). The variability of the quality of the water discharging from the springs of the Homosassa River system is explained in terms of the existence of a coastal transition zone between freshwater and saltwater in the groundwater system (Leeper et al. 2010). Differences in water quality among springs are attributed to the depth of individual spring vents, the proximity of a spring to the Gulf of Mexico, and the transient location of the saltwater-freshwater interface, which creates a zone of mixing that changes seasonally and diurnally (Knochenmus and Yobbi 2001). The transition zone moves horizontally and vertically in the Floridan aquifer in response to tidal fluctuations in the Gulf of Mexico and changes in water levels in the aquifer (Champion and Starks 2001). The age and residence time of groundwater discharging to springs in the Homosassa River system apparently have not been determined. However, in a somewhat similar hydrogeologic setting in the Suwannee River basin, relatively young ages and residence times of spring discharges ranging from 5 to 50 years were estimated by Katz et al. (1999). In general, these description and explanations of water-quality variations among the springs can be summarized in terms of the hypothesis that present-day seawater intrusion and recirculation in an active groundwater flow system result in a saltwater-freshwater interface that moves horizontally and vertically in response to tides and changes in regional groundwater levels, causing spatial and temporal variations in salinities in the springs. In this context, it can be expected that future withdrawals of freshwater from the groundwater system in the Northern District that affect groundwater

levels also may affect spring flows and water quality in the Homosassa River system. Potentially, withdrawals of fresh groundwater in inland areas will reduce freshwater spring discharges and also cause the saltwater-freshwater interface to move farther inland, thus resulting in a disproportionate increase in salinity in the spring discharges into the river system. Accordingly, the Panel recommends that SWFWMD conduct future investigations to better quantify the relation between the salinities of the springs discharging into the Homosassa River and saltwater intrusion in the Floridan aquifer. Also, the Panel recommends that SWFWMD investigate the impacts that groundwater pumping in the Northern District potentially has had and will have on salinities and other water-quality parameters in the springs and base flows in the Homosassa River system.

Groundwater Modeling

For the purpose of developing minimum flow recommendations, the Homosassa River system is considered by SWFWMD to consist of the Homosassa River, Southeast Fork of the Homosassa River, Halls River, Hidden River, and springs associated with these rivers (Leeper et al., 2010). As described by Leeper et al. (2010) and in more detail by Basso (2010), it was determined that current groundwater use in Citrus, Hernando, Pasco, and Sumter counties has not had any significant impact on spring discharge in the Homosassa River system. This was accomplished by running the Northern District groundwater model (HydroGeoLogic, Inc., 2008) for two scenarios, i.e., one scenario representing 2005 conditions and the other with no pumping representing pre-development conditions. It was concluded that the resulting decrease in spring discharge in the Homosassa River system represents an insignificant decrease of 1.1 percent. Based on this result, the measured and modeled flows used in the minimum flow analyses were considered baseline or natural flows. The Northern District groundwater model is a fully three-dimensional groundwater flow and saltwater intrusion model developed by HydroGeoLogic, Inc. (2008) for the northern part of SWFWMD consisting of Hernando, Sumter, and Citrus counties and parts of Pasco, Polk, Lake, Marion, and Levy counties. The groundwater flow and solute transport code MODFLOW-SURFACT was used to develop a numerical groundwater flow model of the Northern District and to develop a saltwater-intrusion model for the coastal areas of the Northern District. The groundwater

flow model was calibrated to steady-state conditions representing 1995 and to transient conditions representing 1996 to 2002. However, as pointed out by HydroGeoLogic, Inc. (2008), the saltwater intrusion model was not calibrated; instead, a qualitative evaluation was conducted to assess whether the saltwater intrusion model produced the general distribution of chlorides observed from monitoring wells.

SWFWMD has followed a credible and defensible approach in determining that current groundwater pumping in the Northern District has not affected the quantities of base flows in the Homosassa River system and thus that recently measured flows in the Homosassa River system can be treated as base flows without adjustment in this study. The impacts that future increased groundwater pumping will have on the quantities of spring discharges and base flows in the Homosassa River system were not addressed in Appendix B (Basso 2010), but it is certainly reasonable to conclude that the Northern District groundwater model also could be used to assess such impacts. Thus, the impact that groundwater pumping has had and will have on the quantities of the spring discharges and base flows in the Homosassa River system appears to be well defined. By contrast, the impact that groundwater pumping in the Northern District has had and will have on salinity and other water-quality parameters in spring discharges and base flows in the river is not well defined. It can only be inferred that recently measured salinities in the Homosassa River system represent base flow conditions, because the lack of a calibrated saltwater intrusion component in the Northern District groundwater model precludes a quantitative assessment of salinity changes in the spring discharges using this model. The assessment of groundwater conditions and impacts described by Basso (2010) and summarized by Leeper et al. (2010) is quite adequate based on the criterion of using the "best available information" concerning the quantities of the spring discharges and base flows in the Homosassa River system. However, determining how salinity and other water-quality parameters in the springs that discharge into the Homosassa River system will change in response to changes in groundwater pumping in the Northern District cannot be accomplished currently using the existing Northern District groundwater model. Accordingly, the Panel recommends that SWFWMD add a calibrated saltwater intrusion component to the Northern District groundwater model in a

future investigation (or otherwise quantify the relation between changes in groundwater pumping and the water quality of spring discharges) to address this issue.

Detailed Comments

Chapter 1

The explanation regarding the adoption of the 15% loss standard was useful in reviewing the remaining chapters and sections. There is the potential, however, that this standard might over-emphasize what are essentially very small changes when the initial habitat or resource is small. Caution should also be exercised in assuming that high volumes may be withdrawn during high flow events (page 24). High flow events can be extremely important in resetting systems, e.g. removing accumulated fine organics from sandy bottoms. This may not be an issue for the Homosassa given that the primary discharge is from springs, but should not be universally applied when developing regulations regarding water removal.

Chapter 2

On pages 38-39, land use in the Homosassa River drainage basin was mapped and delineated for 1990, 1995, 1999, 2004, 2005, 2006, 2007, and 2008 (Table 2-1). The point is made that generally little change occurred in land use/cover in the watershed in the years between 1990 and 2008 (Table 2-1). This observation is somewhat limited in value, however, because the Homosassa River *surface-water* drainage basin, which consists of approximately 55.6 square miles, overlies only part of the Homosassa Springs *groundwater* basin, which consists of approximately 270 square miles (Knochenmus and Yobbi 2001). This is clearly indicated in Figure 2-6, on page 37. The observation that land use has not changed significantly would be better made if land use from 1990 to 2008 in the groundwater basin, or springshed, could be compared. Apparently this section was written to point out that land-use has not changed from 1990 to 2008 and, thus, that the springs have not been affected during this period. If so, this point should be made explicitly.

Box plots are used in figure 2-12 (page 48) and in many others throughout the report to indicate the range of data for tides and other parameters. Are the box plots standardized; do all of the box plots show the same range of information? It is suggested

that the information shown in the box plots (minimum, maximum, median, and lower and upper quartile) be specified the first time this type of plot is used.

The variability of the quality of the water discharging from the springs of the Homosassa River system is described (Page 68, 1st-3rd paragraph) and explained in terms of the coastal transition zone between freshwater and saltwater in the groundwater system. It is noted that the Homosassa Main Springs and Halls River springs have been described as brackish systems and that the springs of the Southeast Fork have been described as freshwater systems (Knochenmus and Yobbi 2001). Differences in water quality of the springs are explained in terms of the differences in the vertical and horizontal location of the transition zone and its spatial and temporal variability. Is it possible to illustrate the relation of the springs to the saltwater-freshwater transition zone by constructing a vertical hydrogeologic cross-section aligned with the direction of groundwater flow based on existing water-quality data and/or the numerical modeling results (Hydrogeologic, Inc. 2008) described by Basso (2010) in Appendix B?

Ratios between top and bottom salinities in the Homosassa River during 1984 and 1985 (page 78) were on the order of 0.85 to 1.0 (Yobbi and Knochenmus 1989), i.e., top salinities generally were equal to or less than bottom salinities. In Figure 2-31 (page 80), synoptic salinity profiles for the river surface in 2007 and 2008 are shown in the top panel, and salinity profiles for the river bottom are shown in the bottom panel. The surface salinities generally appear to be less than corresponding bottom salinities for these measured data. However, the median values for the EFDC model in the top panel of Figure 2-31 for surface salinity appear to be greater than the corresponding bottom salinities for the EFDC model in the bottom panel of Figure 2-31. Is there a contradiction between the observed salinity data and the EFDC model results shown in Figure 2-31? If so, an explanation needs to be provided. [Please see further comments below pertaining to Appendix A (HSW Engineering, Inc. 2010) in which salinity profiles shown in Figure F-3 along with the salinity profiles shown in Figures F-1 and F-2, which correspond to Figure 2-31 in Leeper et al. (2010), also indicate that top salinities generally are less than bottom salinities.]

The legend for Figure 2-31 (page 80) indicates that the solid green line shows the median EFDC model salinity for the river surface. Figure F-2 in Appendix F (HSW

Engineering, Inc. 2010), which is included in Appendix A of Leeper et al. (2010), indicates that this line is the median EFDC model salinity for the river *bottom*.

Salinity, tide stage, and discharge records were used to develop empirical regressions for modeling or predicting salinity in the main channel of the Homosassa River (Pages 82-83). Summary descriptions of the regression equations are presented by Leeper et al. (2010), and details regarding development of the regression models are provided in Appendix A (HSW Engineering, Inc. 2010). The regression models consist of sets of equations for predicting the locations of surface and bottom isohalines for salinities of 3, 5, and 12 in the Homosassa River based on the combined flow at the USGS Homosassa Springs and Southeast Fork Homosassa Spring gage sites and the tide stage at the USGS Homosassa River stage gage. The equations account for 53 to 59% of the variability in the salinity measurements, based on r^2 values presented in Table 2.10. Are these results acceptable for empirical models, i.e., are there any generally accepted standards or guidelines to which these regression results could be compared?

One main concern is the weakness of the hydrodynamic model results. The authors state and illustrate (Figure 2-37) in Leeper et al. (2010) that the model overestimates and underestimates the empirical regressions at a number of flow rates and locations. In particular, it appears from Figure 2-37 in Leeper et al. (2010) that modeled 3 psu (practical salinity unit) isohaline locations versus flows for all 3 locations (surface, bottom, depth-averaged) between 160-170 cfs are always high (upriver) compared to the empirical model results and those from 120-150 cfs are mainly low in bottom isohaline locations (mid river), but high in surface and depth-averaged locations (mid-river). This is disconcerting as these relate to where the 3 psu isohaline should be for 2007 baseline period, but the hydrodynamic model does not do a good job and thus predictions may also not be accurate. In contrast, the empirical regression r^2 values ranged from 0.63-0.73 and suggest these may do a better job in predicting impact with future water withdrawals.

The predicted locations of the surface, bottom, and depth-averaged 3 psu isohalines as a function of total spring flow for the Homosassa River in 2007 are shown in Figure 2-37 (pages 88-89). Leeper et al. 2010 notes [and it is quite apparent in the top panel in Figure 2-37] that there are significant differences in the model-predicted isohaline locations for surface salinities, i.e., the surface salinities predicted by the EFDC

hydrodynamic model occur farther upstream than locations predicted using the empirical regression models. In the empirical model results, bottom salinities extend farther upriver than the surface salinities, which is consistent with the results of Yobbi and Knochenmus (1989), in which top salinities in the Homosassa River during 1984 and 1985 generally were equal to or less than bottom salinities (see comment above relative to Page 78). However, in the EFDC hydrodynamic model results in Figure 2-37, there is no distinct difference between the surface and bottom isohaline locations. What is the significance of this result? Should it be concluded that the EFDC model over-predicts surface salinities? If so, how does this affect the determination of salinity and temperature changes used to predict the impact of reduced flows in setting minimum flows for the Homosassa River? [Please see further comments below pertaining to Appendix A (HSW Engineering, Inc. 2010) in which the predicted locations for the 5 and 12 psu isohalines in Appendix J are discussed.]

In Appendix F in HSW Engineering, Inc. (2010), synoptic salinity profiles for the river surface between December 2006 and July 2008 are shown in Figure F-1, and salinity profiles for the river bottom between December 2006 and July 2008 are shown in Figure F-2. The surface salinities generally appear to be less than corresponding bottom salinities for these measured data. However, the median values for surface salinity for the EFDC model for 2007 in Figure F-1 appear to be greater than the corresponding bottom salinities for the EFDC model for 2007 in Figure F-2. Longitudinal profiles of surface and bottom salinity measured on individual dates illustrate water that is generally well mixed or *weakly stratified with bottom salinity several psu higher than the surface salinity* (Figure F-3) [page 2-21, 1st paragraph, italics added]. The measured surface and bottom salinity profiles in Figures F-1 through F-3 apparently contradict the results that were calculated using the EFDC model shown in Figures F-1 and F-2. Is there a contradiction between the observed salinity data and the EFDC model results? If so, an explanation needs to be provided. A similar comment was noted for page 78, line17 (Leeper et al. 2010).

Three isohaline models (3, 5, and 12 psu) were developed for predicting the location of surface and bottom water-column salinity isohalines using synoptic data for 2005 through 2009 (p. 2-29, last paragraph and p. 2-30, Table 2-4). The isohaline models

explain about 50% to 60% of the variation in the measurements used to develop the models (Table 2-4 and Appendix I-3). R^2 in Table 2-4 needs to be defined. This parameter is often used to indicate a correlation coefficient, but is that the case here? It is defined in Appendix I-3 in HSW Engineering, Inc. (2010) as R squared = 1 – (Residual Sum of Squares)/ (Corrected Sum of Squares); this definition should be added to Table 2-4. Six values of the standard deviation of the residuals between observed and calculated surface and bottom salinities for 3, 5, and 12 psu can be extracted from the histograms in Appendix I-3 in HSW Engineering, Inc. (2010). Including these values, which range from 0.719 to 1.85, in Table 2-4 would provide an additional means to assess how well the regression models predict salinities.

The maximum observed surface and bottom salinities at the Homosassa River gage and the maximum observed bottom salinity at the Halls River gage (p. 3-11, Table 3-4**)** are significantly greater than the respective simulated salinities at these gages (i.e., 19.13 > 9.60, 18.79 > 9.70, and 16.07 > 4.12 psu). Also, the root mean square errors at these gauges (2.08, 2.02, and 1.15 psu) appear to be relatively large. Are there recommended calibration guidelines for estuarine models to which these results could be compared? For example, the Pearson Coefficient R values in Table 3-4 for the Shell Island gage are relatively large (0.91, 0.90, and 0.90), but the values for the Homosassa River and Halls River gages are relatively small (0.50, 0.55, and 0.35). The values for the Homosassa and Halls River gages, particularly the Halls River value of 0.35, are less than the minimum correlation coefficient of 0.60 preliminarily recommended by EPA (1990) for estuarine water quality models. Does this indicate that the Homosassa River model is not well calibrated?

Appendix B in Leeper et al. (2010), in the second paragraph of the Introduction**:** Hidden River should be included in this paragraph to be consistent with Leeper et al. (2010) and Table 2 (p. 12). On page 4 of the first line, it states that the "ground-water basin …is approximately 292 square miles…." This is different from the value of 270 square miles in Leeper et al. (2010) (p. 36) that was determined by Knochenmus and Yobbi (2001). However, these values are considered "similar" (Leeper et al. 2010, p. 36), which seems to be a reasonable way of reconciling the difference.

On page 10, 3.2 2005 Scenario: To determine drawdown in the UFA and potential impacts to spring flow in the Homosassa River system, average annual groundwater withdrawals in 2005 (438.1 mgd) were simulated in the NDM…and compared to non-pumping conditions (zero withdrawals). Please clarify who did this analysis, i.e., did HydroGeoLogic, Inc., or SWFWMD do this analysis? Is the 438.1 mgd scenario the same as scenario 1 in the HydroGeoLogic, Inc. (2008) report? It appears to be, but this pumping rate does not seem to be listed explicitly in HydroGeoLogic‟s report. Please indicate if the 2005 condition in Basso (2010) is the same as scenario 1 in HydroGeoLogic, Inc. (2008). Also, please indicate the source of the discharge values for the 2005 pumping scenario in Table 2 (p. 12) (apparently they are from Table 5.2 in the HydroGeoLogic, Inc. report).

On page 11, Table 2 states that the discharge at Hidden River Spring Head is reduced 4.0 percent, while all of the other spring discharges are reduced by approximately 1.0 percent, except for Belcher Spring, which is reduced by 2.0 percent. Is the result for Hidden River Spring Head correct? If so, is there a reason why it is so much larger than the other results?

Table 2.8 in Leeper et al. (2010) indicated that the estimated salinity of water coming from different springs varies from 0.1-3.9 ppt, even though they are spatially close. This is perplexing. How can this happen if they are using the same groundwater sources, and we could not find sufficient evidence suggesting why this is occurring nor how this may be influenced differentially by water withdrawals. Is it possible that water withdrawal in one location could only influence the very low salinity springs and thus, elevate the contribution of the high salinity spring water into the system? Ratios of ions in the saline springs (Table 2.6) argues that this is dilute seawater and not just water with high solids derived from minerals in the rock strata through which the springs flow. The oceanic ratio of Na to Mg is 8.213 (Sverdrup et al. 1942), while the ratio in Hall‟s River Spring #1 was 7.8, 7.9 for Hall‟s River Main Spring and 8.08 for Homosassa Main Spring #2. Analyses of any inert sea water derived ions from Table 2.6 found similar sea water-like ratios, arguing that the spring discharged dilute seawater. Is this fossil seawater as has been proposed for other similar Florida springs (Scott et al. 2004)? It appears more data are needed to substantiate and verify why this is occurring as it may have some indirect impacts on the contribution of saline waters to the Homosassa River from springs with high salinity compared to other springs. Additional pumping from the spring shed could have very different impacts if flow was reduced from one of the saline or non-saline springs.

It is not clear that there is an adequate understanding of the aquifer itself, residence time for water in the aquifer, or the ultimate source of salt (fossil or modern source) in the saline springs.

In Leeper et al. (2010, page 84) – the hydrodynamic model is "… somewhat problematic" and suggested model accuracy could be improved by adding data from downstream side channels. They also note water temperatures are slightly under-predicted in warm month and over-predicted in cold months (page 84) suggesting the thermal effect of spring discharge may be underestimated. Also, maximum salinity at the Halls and Homosassa Rivers gage sites were underestimated by the calibration and validation periods.

Finally, in Appendix A, page 2-20, paragraph 2, lines 13-15, the authors state „… river stage as measured at the springs is a variable used in calculating spring flow and therefore the independent variables spring flow and tide are related." This is of concern as this interdependence may influence (increase) the models predictability and thus this autocorrelation is problematic from a statistical point of view. How this influences the model outcome and thus prediction is not explained or considered.

Chapter 3 - Vegetation

The narrative in the vegetation section of Chapter 3 (Leeper et al. 2010) is based on a variety of historical and more recent reports (Hoyer et al. 1984, Fraser et al. 2001a,b, Fraser et al. 2006, PBS&J 2009), which indicate some contrasting findings in terms of submerged aquatic vegetation (SAV) and emergent aquatic vegetation (EAV) relative to environmental factors in the Homosassa River. Hoyer et al. (1984) noted significant relationships between SAV distribution and abundance and flow, salinity and light levels in the Homosassa River.

However, more recent research (Frazer et al. 2001a,b; Fraser et al. 2006) indicates significant changes in SAV in the river in terms of number of sites without SAV (104%

decrease) between 1998-00 and 2003-05. There was also a mean reduction in biomass of filamentous algae and most macrophytes (~ 67%) and macroalga biomass (62%), but an increase (85%) in periphyton biomass on SAV between time periods. Because the more recent survey period had lower salinity, they suggested salinity was not as influential as elevated nutrient loadings and possible eutrophication in the Homosassa River. In contrast, the most recent survey (PBS&J 2009) suggested distribution and abundance of SAV and EAV was clearly delineated across salinity zones based on known species tolerances, but that SAV, because of the marked decline, was not a good indicator of increasing salinity and thus, changes in flow. In fact, they believe EAV is a much more predictable indicator of mean salinity along the river and that freshwater species respond quickly to reduced salinities.

Finally, Appendix E (page 3-11) PBS&J (2009) indicates that the relationships between nutrient loads and SAV have not been clearly defined or quantified and thus, predicting impacts due to epiphyte growth and SAV loss are not possible presently. They also note until these relationships are quantified, restoration is not possible. Somehow, the District needs to decouple nutrient load issues from salinity changes in the system before they can accurately decide on which is driving these relationships.

It is clear more research is required to clarify the relationship between SAV and EAV distribution and abundance relative to nutrient loads, salinity changes, and light level modifications along the Homosassa River relative to proposed flow reductions. This must include examining groundwater sources of nutrients into the system and these sources may be influenced by water withdrawals based on the proposed MFL scenarios.

Forested tidal wetlands were noted in the report, but little information reported on the extent of the freshwater tidal swamp within the Homosassa River system. Impacts to this important part of the ecosystem will be hard to calculate because the Homosassa is on the Tropical-Temperate boundary where saline-tolerant mangroves can easily displace salinity intolerant species such as Ash (*Fraxinus* spp.) and red maple (*Acer rubrum*). In a typical transition from freshwater to saltwater within an estuary, a potential reduction of flow would result in an upstream migration of the freshwater to saltwater boundary that could be easily modeled. With the source of flow in the Homosassa system consisting of multiple springs, some of which release saline water, impacts of the freshwater-saltwater boundary are difficult to predict without a better understanding of the aquifer system from which the springs emerge. It would be prudent to develop a map of the tidal, forested wetlands for future comparisons. There is some suggestion that changes have already occurred (See pages 3-14, Appendix E). Freshwater tidal swamp species extended further downstream than their aquatic counterparts (See Appendix E). Woody species can often persist even after salinity has increased. Alternatively, these tidal swamp species may be holding on because they are at an elevation slightly above the tides.

Sea level rise on this flat landscape also has the potential to greatly increase the extent of tidal marsh and swamp and should be modeled to understand the long-term changes that may impact the Homosassa even without flow modification. This may be critical if some of the forested wetlands are just above the current high tide level as noted above.

If saline water is currently intruding into the aquifer and is the source of the salt in some of the springs feeding the Homosassa River, even a slight change in sea level could increase the salinity of these springs. Even a small change in salinity and/or sea level could greatly alter the extent of freshwater wetlands in the upper reaches of the Homosassa River system. Tidal forested wetlands are an obvious component of the landscape and a sudden loss of this vegetation could appear to be the result of some change in management, when it may just be the result of crossing a critical threshold caused by sea level rise.

Benthic Macroinvertebrates

Results from Grabe and Janicki (2009; Appendix D) did not note any eastern oysters collected in the top 50 species they reported on in Chapter 3, nor are they listed in Tables 3-3 and 3-4 in Appendix D. In contrast, Water and Air Research (2010; Appendix F) found live eastern oysters in their study and Chapter 3 noted “The distribution for live oysters differs from that reported by Grabe and Janicki (2009) who found oysters in dredge samples collected between river kilometers 4 and 9 during their May 2008 sampling events” but no explanation for this difference is provided. Oyster data can be found in Table 3-7 in Appendix D, but this species was not mentioned directly in the text.

In terms of the barnacle study (Culter 1900; Appendix G) noted in Chapter 3, it would be interesting to note if there were any patterns in the distribution of the presumed exotic species, *Balanus amphitrite*, in relation to salinity along the Homosassa River, which might suggest that water withdrawals might enhance their distribution and abundance in areas along the river compared to baseline.

One of the potential problems in the analysis of benthic data is using both RKM and salinity in their forward stepwise multiple regression (Appendix D; Table 3-5). If I am correct, aren‟t RKM (position in river) and salinity potentially correlated and thus if both are included in model (as in the Shannon Diversity regression in Table 3-5) it should inflate the adjusted R^2 values? This can easily be examined in regression in a number of ways and should be examined in all models. Also, the adjusted R^2 values for density and Shannon diversity are low (< 0.40) and thus, do not explain much of the variation in the models. They may be lower if you exclude either RKM or salinity if they are highly correlated.

Another potential problem is the interpretation of the results from the ANOSIM procedure listed in Table 3-6 (Appendix D). One caution with Primer statistics illustrated in Appendix D is that the MDS plot stress levels are not reported in Figure 3-10; these should be reported in all such plots. Also, with ANOSIM, Clark and Warwick (2001, page 6-4) note R-values are as important as p-values in determining significance and 5 of the 7 significant pairwise comparisons have R values < 0.5 While significant, having high p-values with low R-values suggest a re-evaluation of how these plots are interpreted.

In the executive summary section of Leeper et al. (2010) and in Chapter 4 (paragraph 1, lines 5-8), point out only the fish and invertebrate plankton, nekton, salinity-based habitats, and manatee data are used to set MFL levels, as those appear to be the most-sensitive to water withdrawals. Thus, the issues with the benthic data noted above may be less problematic in reference to setting the MFL, but the issues need to be examined and re-evaluated (if necessary) for the final document such that no spurious interpretations are made.

Plankton and Seine & Trawl Data Sets

The authors indicate in Appendix H (page 72) that “Some characteristics of the plankton community in the Homosassa River estuary suggest that the area has become more eutrophic.” The authors suggest that reduced abundance patterns of presumed indicator species (a copepod, mysid and the bay anchovy) compared to other non-spring-fed systems and regular occurrences of large shifts in dissolved oxygen (DO) concentration (Appendix H, page 72, parag. 2, line 5) is evidence of increased eutrophication. The data presented in Table 3.2.1 and Figure 3.2.1 in Appendix H (pages 26-27) illustrate high and low DO values based on depth and location strata, but the text states that dissolved oxygen “occasionally reached strong supersaturation levels during winter and spring months, …”. This seems to contradict the statements above about regular occurrences of supersaturation. Also, both of the presumed indictor species are very common across their range and are found in non-eutrophic and eutrophic systems as well, so it may be useful for authors to cite some literature on them being an indicator species relative to the potential eutrophication issues they note. There is also no mention of these concerns in water quality section of Chapter 2 in Leeper et al. (2010, page 90), although they do note some low DO (< 5.0 mg/L) were observed in all sections. However, data presented in Chapter 3 (pages 97-98), based on Fraser et al. (2001a,b; 2006) suggested increases in nutrient loads in the system over time and noted for SAV and EAV that nutrients may be more influential on distribution and abundance compared to salinity changes. It is sometimes hard to glean important data from Leeper et al. (2010) because it may not be in the section you expect and in this case, we expected it to be in water quality, not in the SAV/EAV section. There is clearly some inconsistency in how different authors view presumably the same data sets or how data are logically provided in Leeper et al. (2010).

The authors in Appendix H (page 73) indicate “…has a relatively deep channel throughout much of it length (Fog. 2.7.4.1), and this channel may facilitate two-layered estuarine circulation …” but really provide no data illustrating two-layered flow patterns. In contract, in Chapter 2 of Leeper et al. (2010) these authors indicate vertical water temperature data (page 72, paragraph 2, line 2) and vertical salinity data (page 78, paragraph 2, line 5) suggests a relatively well-mixed system. There are clearly some inconsistencies in how different authors view this system and there should not be these inconsistencies in a single document.

One of our main concerns in Chapter 3 of Leeper et al. (2010) is the quality of the regressions (linear and quadratic) in terms of their explanatory power relative to flow issues. For example, in the plankton section (pages 116-117; Table 3-4) the authors note that only 28 of 64 plankton-net taxa showed some significant response to the range of flow encountered. Of the 28 noted, only 5 had significant positive relationships (abundances increased with increased flow) and the remaining 23 had negative relationships (decrease in abundance with increased flow). The authors then focused on those five taxa with positive relationships. The authors also note that the coefficients of variation (adjusted r^2) ranged from 0.29-0.62 for time lags of 36-120 days; however, careful examination of Table 3-4 shows these values ranged from 0.25-0.72 and 50% (n = 14) had r^2 values < 0.50. Also, eight taxa (29%) had issues of possible serial correlations (significant DW values). The authors justify these r^2 values for both plankton-net and seine and trawl collections by stating "Some of these relationships had very good fit, suggesting that these relationships are not spurious" (Appendix H; pages 40 and 68). We are not sure if those fourteen taxa are really relevant to the discussion as only up to 50% of the response appears to be explained by flow. In most biological responses, 50% may be statistically significant, but not be biologically meaningful. The summary (page 160) in Leeper et al. (2010) makes note of this low accounting of variation of individual regressions.

Similar patterns in these regression coefficients can be noted for the seine and trawl data sets. For example, the authors noted that 40 (41?) of the 53 pseudo-species had significant relationships to flow while 13 had quadratic and 27 (28?) had linear relationships (page 116). Of the linear relationships, 12 had negative responses and 15 (16?) had positive ones with time lags from 1-203 d. The reported r^2 values ranged from 0.20-0.78 for those positive responses; however, 37% (n = 10) of these had r^2 values < 0.50. Also, seventeen pseudo-species (32%) also had issues of possible serial correlations (significant DW values). The authors justify these r^2 values for both plankton-net and seine and trawl collections by stating "Some of these relationships had very good fit, suggesting that these relationships are not spurious" (Appendix H; pages 40 and 68). As noted above, we are not sure these 10 pseudo-species add much to the discussion of altered flow, since as explained < 50% of the variance is probably not very biologically meaningful. The summary (page 160) in Leeper et al. (2010) makes note of this low accounting of variation of individual regressions.

We also question not discussing the negative relationships (most of the taxa and pseudo-species collected) as the regressions suggest that as flow is reduced, abundances of many of these taxa or pseudo-species would increase and presumable expand into upriver locations as salinity changes with flow. This should have consequences relative to community structure patterns over some time frame, which may ultimately modify community structure in the system overall. This may be more relevant if some exotic species are present (i.e., striped barnacle; Culter 2009).

One caution with Primer statistics illustrated in Appendix H is that the MDS plot stress levels are approaching values that are of concern in interpretation (stress = 0.20 and above; See Clarke and Warwick 2001); thus, the 2-D fit of a 3-D plot may not be very good. Also, with ANOSIM and tests that generate R-values and p-values, Clark and Warwick (2001, page 6-4) note R-values are as important as p-values in determining significance and some in Appendix H have high p-values with low R-values. These need to be re-evaluated and they may not be as strong a relationship as suggested.

Chapters 4 and 5

The approaches used for individual responses to flow changes are reasonable, but a more holistic approach is really required. Below is a suggestion of a way (there may be others) to examine plankton, nekton and benthic responses with Primer statistics and couple those results with salinity-based habitats and manatee thermal habitats data currently in place. In Appendix H (pages 54-72), the authors conducted some very interesting multivariate community analyses, but these were not discussed in Leeper et al. (2010), and, in part, they support our concern about community structure change given the individual empirical relationship for plankton, seine and trawl data sets outlined above. It might be very useful to examine carefully the community structure changes using Primer statistics (MDS, ANOSIM, SIMPER, etc.) of the taxa and pseudo-species relative to flow reduction scenarios. We believe one could use the individual empirical relationships (both positive and negative ones) to estimate abundances at particular flows coupled with predicted changes in salinity, etc. These calculated abundance values could be used to create a new data matrix and run some of the appropriate Primer statistics to see if overall assemblage structure would change under different flow scenarios. One could do this at some estimate above and below the linear (mean) values (i.e., ± 10, 15, 20 %) based on the empirical relationships. This may provide some indication of how much the assemblage as a whole could change given the scenarios of interest (change in water flow) and would be a more holistic approach than the standard individual responses documented in Leeper et al. (2010). Given Leeper et al. (2010) currently lists 20 total individual responses used for 2007 and 1996-2009 baseline estimates of non-lagged data, these could be used for the suggested analysis and when the final report is completed on the benthic surveys, they may be able to be incorporated as well. In Primer, we could see rows of species, taxa and pseudo-species with columns being baseline abundances for 2007 and 1995-2009 and then have other columns based on generated abundances given reduced flows (as done individually already). These could be ordinated in MDS, compared with ANOSIM among flow scenarios, and, if you used SIMPER, you could show which flow rates produced significantly lower abundances estimates by species and how many species responded holistically instead of individually. It could be that some taxa do worse or better in different flow scenarios, thus impacting the overall assemblage composition.

Can figures be generated using tables 5-20 through 5-22 that would show salinity-based shoreline changes using data from both the hydrodynamic model and the empirical regression models? It might help visualize how the potential change would look in the Homosassa system.

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Page	¶ #	Line #	Figure (F) **Table (T)**	Comment
5	6	3		Change “model” to “models”
19	Title			Change “Acknowledgements” to “ Acknowledgments” (no “e”)
20	2	5		“…at least 19 named or identified springs or vents.” There appear to be 20 named springs in Figure 2-3, page 33. Should these numbers be the same?
30	3	2		Delete the “a” before Bluebird Springs Park.
49	2	5		Add “k” to Southeast For (k) gage site.
52			F. 2-16	The discharge data in this figure appear to match the discharge data for gage site USGS 02310700 Homosassa R at Homosassa FL; apparently, this gage site number should be in the figure caption, instead of the gage site number that is listed in the caption (02310690), which is the number for Halls River.
53			F. 2-18	The gage site number for Hidden River should be number 02310675, instead of 02310690, which is the number for the Halls River gage.
54	3	8		“poteniomitric” should be “*potentiometric*”.
54	3	10		It is suggested that **nodes** be replaced with *“drain cells”*.
55			T. 2-4	It is suggested that Abdoney, Belcher, McCain, Pumphouse, and Trotter No. 1 springs be identified as comprising the Southeast Fork springs complex.
61	1	9		“sand, silt, muck and silt”
65	3	5-8		The text says 14 stations (10 in Homosassa River and 3 in Halls River and 1 in SE Fork). However Figure 2-24 has 19 stations (13 in Homosassa River and 6 in Halls River). Hard to rectify stations plotted on 2-24 and data on 2-25??
66	1&2			The text cited Figure 2-24 in both paragraphs and it appears it should be Figure 2-25?
66	3	4		What is “B121”?
66	3	7		“figurer” should be “figure”
66	3	7		Is the part of this sentence that states “locations of these sites are not shown in Figure [sic.] 2-25” written correctly? If so, is it possible to include a reference that does show the locations of the sites?
75			F.2-28	This figure is real hard to interpret because of small size and overlap of the symbols.
75			F. 2-28	It is suggested that the gage number be included in the caption.
77	1	3		Can the formulas of Cox et al. (1967) be included in the text?
80			F. 2-31	It is indicated that the solid green line shows the median EFDC model salinity for the river **surface**; Figure F-2 in Appendix F (HSW Engineering, Inc. 2010), which is included in Appendix A of Leeper et al. (2010), indicates that this line is the median EFDC model salinity for the river *bottom*.
81			F. 2-33	It is very difficult to read the legend and understand what data are presented in this figure.
83	2	1		Change “prediction” to “predicting”

Page	¶ #	Line #	Figure (F) Table (T)	Comment
84	1	11-12		How was a **temperature constant of 23.2ºC** used? Should this be "*constant temperature* of 23.2ºC"?
84	1	14		It is suggested that **concordance** be replaced with *"agreement"*.
87			F.2-36	The upper 2 panels are almost impossible to separate observed from simulated signals. I would attempt to make larger as these tell a great deal about model simulation patterns compared to the observed. I suggest you change the two colors so that they do not produce black when overlapped.
88	1			Paragraph describing predicted salinities: Coefficients of determination …ranged from 0.63 to 0.73 (HSW Engineering, Inc. 2010). It is suggested that the specific location for these results, i.e., the table number in Appendix A, be included in the text on page 88.
94	1	6		Looks like this should be Figure 2-20, not 2-23??
97	2	7		Earlier "discharge" was measured as cfs, here it is m/s
99-100			F.3-1 to 3-3	These are very small and hard to read. Color patterns are reasonable but dots are almost impossible to see clearly.
101	1	4		Delete "relatively"
101	1	7		Should be "physiochemical"
107	1	5		Delete "a" before size transects in the …
107	2	3		*Guekensis* is spelled *Geukensis*
110			F.3-2	*Guekensis* is spelled *Geukensis*
110	1	3		Should read "meta-analysis"
110	1	7		The word "tidal" appears redundantly
110	2	2		"sampes" should read "samples"
111	2	7		Should read "suggests" plural
114	3	8		"paludosus" should be in italics
116	3	1-4		I count 41 of the 53 pseudo-species having significant relationships, 13 with quadratic but 28 (not 27) with linear. Also, the authors list 12 negative and 15 positive linear responses but Table 3-5 has 16 positive linear responses. This may explain the 1 difference noted. Needs correction in text.
116	4	7		Seminole killifish (*Fundulus grandis*) is actually Gulf killifish.
123	1	1		Should read "red tides." The period inside the quotes.
124	1	11-14		Redundant "probabilities"
126	2	8		Again, Seminole should be Gulf killifish.
126	2	9		"mollies" should be "molly."
134-135			T. 5-1	Callinectus sapidus in this Table is mis-spelled and should be in italics. It is spelled *Callinectes sapidus* in the seine-net, taxon or pseudo-species and trawl-net sections. All should be in italics. Also, *Lepomis punctatusi* and *Micropterus salmoidesi* are mis-spelled and the "i" on the end of both species name should be deleted.
134	1	6		Looks like Table 5-2 should be Table 5-1.
154	1	10		Delete "of"

Page	¶ #	Line #	Figure (F) Table (T)	Comment
154				No page number
Appendix A Edits and Typos				
xiii				**Table of contents, p. xiii:** Consistent with the information presented in the table of contents for Appendices A-I in HSW Engineering, Inc. (2010), the figures contained in Appendix J in HSW Engineering, Inc. (2010) should be listed in the table of contents.
2-19	2	4-7		Something is missing in this sentence. It makes no sense to me.
2-19	2			Figures 2-25 through 2-33 should immediately follow p. 2-19 if possible.
3-10	2	3		Table 3-3 cited should be Table 3-4.
3-11		3	T. 3-4	Headings in line 3, columns 3 and 4 for the Shell Island gauge are both labeled "Middle". Should the heading in column 4 be labeled "Bottom" instead? Are the data correctly entered in these columns? Also, it is noted at the bottom of Table 3-4 that "**R is the Pearson Coefficient...."** Is this coefficient defined or referenced somewhere in the report?
4-4	1		F. 4-3 & 4-4	Printed off the page and you can not see legends or captions.
Appendix B Edits and Typos				
				Second paragraph in Introduction: To be consistent with Leeper et al. (2010) and Table 2 (p. 12), Hidden River should be included in this paragraph.
Appendix C Edits and Typos				
Appendix D Edits and Typos				
3-16	1	2		Delete "s" from compares.
3-18	4	5		Peebles 2005 not cited in literature cited section (note to add it if found in red).
Appendix E Edits and Typos				
3-7	6	4-6		Figs 5 & 6 are printed off the page (can not read scales, etc.) and have no figures legends. Same for appendices A-C.
3-8	1	1		Ruppia must be in italics.
3-13			F. 7	Figures 7 & 8 are not cited in the text.
3-14			F.8	Figures 7 & 8 are not cited in the text.
3-16			T.2	Plant names must be in italics like all other tables.
Appendix F Edits and Typos				
			T. 6	Table 6 – *Geukensia* also misspelled as noted above.
Appendix G Edits and Typos				
Appendix H Edits and Typos				
17			F. 2.7.4.2	TIN is upper case is in upper panel but lower case in lower panel.
29	3	2-3		Names need to be in italics.
30	1	3		"fro" should be "from".
30	1	13		Peebles & Flannery 1992 is not cited in literature cited section.

Page	¶ #	Line #	Figure (F) Table (T)	Comment
31	3	4		Merriner et al. 1976 also not cited in literature cited section.
31	4	6		Peebles 2002 also not cited in literature cited section.
73	5	7		"appeanace" misspelled.
74	2	5		"esutuary" misspelled.
Appendix I Edits and Typos				
Appendix J Edits and Typos				
Appendix K Edits and Typos				
Appendix L Edits and Typos				
Appendix M Edits and Typos				
Appendix N Edits and Typos				
Appendix O Edits and Typos				

Errata, Leeper et al. 2010 (12 July Peer-reviewed Draft)

Appendix T

Excerpt from the November 16, 2010 Southwest Florida Water Management District Governing Board Meeting Agenda and Meeting Information document concerning peer-review of proposed minimum flows for the Homosassa River system.

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

Governing Board Meeting

Agenda and Meeting Information

November 16, 2010

9:00 a.m.

District Headquarters

2379 Broad Street • Brooksville, Florida
(352) 796-7211 • 1-800-423-1476

Weeki Wachee River

Southwest Florida Water Management District

WATERMATTERS.ORG • 1-800-423-1476

2379 Broad Street, Brooksville, Florida 34604-6899
(352) 796-7211 or 1-800-423-1476 (FL only)
TDD only 1-800-231-6103 (FL only)
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Southwest Florida Water Management District

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MEETING NOTICE

AGENDA

GOVERNING BOARD MEETING

NOVEMBER 16, 2010

9:00 a.m.

All meetings are open to the public.

- Viewing of the Board meeting will be available at each of the District offices and through the District's web site (www.watermatters.org) -- follow directions to use internet streaming.
- Public input will be taken only at the meeting location.
- Public input for issues not listed on the published agenda will be heard shortly after the meeting begins.

Unless specifically stated, scheduled items will not be heard at a time certain.

At the discretion of the Board, items may be taken out of order to accommodate the needs of the Board and the public.

The meeting will recess for lunch at a time to be announced.

The current Governing Board agenda and minutes of previous meetings are on the District's web site: www.WaterMatters.org

9:00 A.M. CONVENE PUBLIC HEARING AND MEETING *(TAB A)*

1. Call to Order
2. Pledge of Allegiance and Invocation
3. Additions/Deletions to Agenda
4. District Recognition – Florida's Heartland Rural Economic Development Initiative, Inc.
5. Employee Recognition
6. Public Input for Issues Not Listed on the Published Agenda

CONSENT AGENDA *(TAB B)*

All matters listed under the Consent Agenda are considered routine and action will be taken by one motion, second of the motion and approval by the Board. If discussion is requested by a Board member, that item(s) will be deleted from the Consent Agenda and moved to the appropriate Committee or Report for consideration.

Regulation Committee

7. Individual Water Use Permits Referred to the Governing Board
    a. WUP No. 20002486.004 - Circle G Farm and Ranch LLC (Hillsborough County)
    b. WUP No. 20000742.010 - City of Tarpon Springs (Pinellas County)

Resource Management Committee

8. Initiate Rulemaking and Approve Amendment to Rule 40D-8.041, Florida Administrative Code (F.A.C.), to Establish Minimum Flows for the Chassahowitzka River System and Accept Report
9. Facilitating Agricultural Resource Management Systems (FARMS) – Polkdale Farms, L.L.C. Wind Machine – Polk County

Finance & Administration Committee

10. Budget Transfer Report

General Counsel's Report

11. Settlement Agreement – SWFWMD v. Matthew Smith, et al, Case No. 53-2010-CA-004082, 10th Judicial Circuit – Lake Hancock Project, SWF Parcel No. 20-503-110P – Polk County
12. Settlement Agreement – SWFWMD v. Sharon E. Pitz & Charles R. Connolly, et al, Case No. 2009-CA-010078, 10th Judicial Circuit – Lake Hancock Project, SWF Parcel No. 20-503-198P – Polk County
13. Initiation of Litigation – Well Construction - License No. 9021 - Brett Roth – Levy and Citrus Counties

Executive Director's Report

14. Approve Governing Board Minutes
    a. October 22, 2010 Finance and Administration Screening Committee Meeting
    b. October 26, 2010 Meeting

REGULATION COMMITTEE *(TAB C)*

Discussion Items

15. Consent Item(s) Moved for Discussion
16. Hydrologic Conditions Status Report
17. Consider Water Shortage Declaration
18. Approve Amendments to Chapters 40D-1, 40D-2, 40D-8 and 40D-80, F.A.C., including the Water Use Permit Basis of Review, to Establish a Water Use Caution Area in the Dover/Plant City Area and Associated Water Use Permitting Requirements, Minimum Level and Recovery Strategy
19. Mitigation Issues
    a. District Conservation Easements and Mitigation Banking
    b. Florida Department of Transportation Mitigation Program
20. Denials Referred to the Governing Board

Submit & File Reports – None

Routine Reports

21. Public Supply Production Report
22. Southern Water Use Caution Area Quantities
23. Overpumpage Report
24. E-Permitting Metrics: Online vs. Paper Applications
25. Individual Permits Issued by District Staff
26. Resource Regulation Significant Initiatives

OUTREACH & PLANNING COMMITTEE *(TAB D)*

Discussion Items

27. 2012-2016 Strategic Plan Update
28. Surface Water Permitting for Projects in Urban Redevelopment Areas

Submit & File Reports – None

Routine Reports
29. Comprehensive Plan Amendment and Related Reviews
30. Development of Regional Impact Activity Report
31. Speakers Bureau
32. Significant Activities

RESOURCE MANAGEMENT COMMITTEE *(TAB E)*

Discussion Items
33. Consent Item(s) Moved for Discussion
34. Memorandum of Understanding for the District's Maintenance of the Peace Creek Canal and Report of Progress in Acquiring Access Rights Necessary for Long-Term Canal Maintenance
35. Memorandum of Understanding with Mosaic Fertilizer, LLC for Consideration of a Public/Private Partnership for the Restoration of Flatford Swamp
36. District-Funded Agricultural and Urban Landscape Research Program
37. Surface Water Improvement and Management Program Overview

Submit & File Reports
38. Scientific Peer Review of Recommended Minimum Flows for the Homosassa River System and Staff Response
39. Scientific Peer Review for Upper and Middle Withlacoochee River and Staff Response

Routine Reports
40. Florida Forever Funding
41. Minimum Flows and Levels
42. Structure Operations
43. Watershed Management Program and Federal Emergency Management Agency Map Modernization
44. Significant Water Supply and Resource Development Projects

FINANCE & ADMINISTRATION COMMITTEE *(TAB F)*

Discussion Items
45. Consent Item(s) Moved for Discussion
46. Office of Inspector General – Proposed Annual Audit Plan for Fiscal Year 2011
47. Request for Proposals for Total Compensation (Salary and Benefits) Review

Submit & File Report
48. October 2010 Interim Report on Workforce and Vendor Diversity

Routine Reports
49. Treasurer's Report, Payment Register, and Contingency Reserves
50. Management Services Significant Activities

GENERAL COUNSEL'S REPORT *(TAB G)*

Discussion Items
51. Consent Item(s) Moved for Discussion
52. District's Authority to Lend Matching Funds to Cooperators

Submit & File Reports – None

Routine Reports
53. Litigation Report
54. Rulemaking Update

COMMITTEE/LIAISON REPORTS (*TAB H)*

55. Joint Green Industry/Agricultural Advisory Committee Meeting

EXECUTIVE DIRECTOR'S REPORT (*TAB H)*

56. Executive Director's Report

Item 38

Resource Management Committee
November 16, 2010

Submit & File Report

<u>Scientific Peer Review of Recommended Minimum Flows for the Homosassa River System and Staff Response</u>

Purpose
To present an independent, scientific peer review of the District's draft report on recommended minimum flows for the Homosassa River system and provide staff response to the peer review.

Background/History
Staff submitted a draft report on recommended minimum flows for the Homosassa River system in Citrus County to the Governing Board on July 27, 2010. For the purpose of establishing minimum flows, the river system consists of the Homosassa River, including the southeast fork of the Homosassa River, Halls River, Hidden River and all named and unnamed springs that discharge to these rivers. The recommended minimum flows are 95 percent of the system's natural flows. Natural flows are defined as flows that would exist in the absence of withdrawals and may be estimated based on the combined mean daily flows measured at the United States Geological Survey Homosassa Springs at Homosassa Springs, FL and Southeast Fork Homosassa Spring at Homosassa Springs, FL gages, other appropriate gage sites, or modeled through application of numerical or statistical models.

Following the July Board meeting, the draft report outlining the recommended minimum flows was submitted to an independent, scientific peer review panel (Panel) for voluntary review. The Panel was composed of three scientists who have extensive experience in ecology, hydrology and freshwater inflow relationships. In support of the peer review, staff accompanied the Panel on a field reconnaissance of the Homosassa River system on August 10, 2010. On October 20, 2010, the Panel provided the District with a report titled "Scientific Review of the Recommended Minimum Flows for the Homosassa River System" (report attached).

Purpose/Approach
The District subjected the Homosassa River minimum flows report to peer review to obtain an independent, scientific assessment of the data and methods that were used to develop the minimum flows. In accordance with Florida Statutes, the Board shall give significant weight to the peer review Panel's report when establishing minimum flows for the river system.

The Panel's report was supportive of the District's recommended minimum flows, but suggested additional monitoring to enhance understanding of the impacts of groundwater withdrawals on flows and salinity of the system. In reference to the District's report on the recommended minimum flows, identified as "Leeper et al (2010), the Panel concluded that *"[e]vidence presented by Leeper et al (2010) is adequate to conclude that the proposed maximum 5% reduction in Minimum Flow satisfies the language and intent of the Statute and will result in "no significant harm" to the flora and fauna of the Homosassa River System.*" The Panel identified eight central questions that served as the primary basis for their evaluation of the District's report. The questions, reproduced from the Panel's peer review report, are:

1. *Is the District's threshold of a maximum 15% change of resource within the system a reasonable approach?*
2. *Was there an adequate data base for development of the regression model?*

3. *Was there an adequate data base for development of the hydrodynamic model?*
4. *Were the models used by the SWFWMD the best models for determining the MFL for the Homosassa River system?*
5. *Was the data collection approach adequate to determine the past and present natural resources on the river system?*
6. *Were appropriate assumptions and analyses made in the use and extrapolation of these data?*
7. *Was the weight of evidence enough to convince the panel that the recommended MFL satisfied the Florida Statute establishing the MFL requirement?*
8. *Are there additional data that should be collected in the future that would add confidence to the MFL SWFWMD recommendations?*

In their report, the Panel notes that the answer to each of these questions is “yes”, although an answer of “yes” and “no” was developed for question five. With regard to their response to question five, the Panel indicates that data are adequate for evaluating past and present flow conditions, but data addressing historical changes in salinity conditions and some biological components of the system are sparse. Specifically, the Panel notes that *“…it can only be inferred that present-day salinities discharging from the springs into the river system are still at natural levels*, but acknowledge that the District’s approach “…*is the best that can be done at this time.”* With regard to characterization of changes in biological components of the river system, the Panel notes that this type of information is often not available, and suggests that the biological information collected in support of the District’s minimum flow study may serve as a baseline for future minimum flow evaluations. In answering “yes” to question eight, the Panel suggests that the District should collect additional data on the salinity, temperature and flow in the river system, and continue to evaluate physical and chemical properties of the contributing groundwater systems. Goals for these efforts include improved understanding of and ability to model impacts of regional groundwater withdrawals on salinity, other water quality characteristics, and flows. In addressing their eight central questions, the Panel also provided a number of specific comments and recommendations concerning various sections of the report, and identified a number of editorial comments.

Staff supports the Panel’s major recommendation that the District continue to collect data to improve understanding of water quality and flow in the Homosassa River system and contributing groundwater basin. Continued data collection is considered essential for future re-evaluation of the minimum flows that are to be established for the river system and other nearby spring-dominated systems. Staff will continue to evaluate the Panel’s recommendations, and expects to incorporate a number of the Panel’s suggestions into a revised version of the District report on proposed minimum flows for the Homosassa River system. Staff also plans to include the Panel’s report and comments received from other interested parties as appendices to the revised minimum flows report.

Staff will return to the Board in the near future with proposed rule language necessary to establish minimum flows for the Homosassa River system.

<u>Staff Recommendation</u>: <u>See Exhibit</u>

This item is submitted for the Committee's information, and no action is required.

<u>Presenter</u>: Doug Leeper, Chief Environmental Scientist, Resource Projects Department

SCIENTIFIC REVIEW OF THE RECOMMENDED MINIMUM FLOWS FOR THE HOMOSASSA RIVER SYSTEM

Scientific Peer Review Report

October 17, 2010

Prepared For:
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34609-6899

Prepared By: Scientific Peer Review Panel

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Scientific Peer Review of Proposed Minimum Flows and Levels for the Homosassa River System

EXECUTIVE SUMMARY

The Review Panel visited the Homosassa River system via boat and portions of the Hidden River by land. We accepted the District's charge to the panel and formulated eight questions that we felt must be answered before accepting the minimum flows proposed for this river system. The Panel agrees that the Homosassa River System's flow is dominated by spring discharge and minimum flow criteria do not need to be evaluated seasonally. The District's approach of using a threshold of acceptable change, 15%, is reasonable and defensible. The District has amassed an adequate database for purposes of the MFL (Minimum Flows and Levels) evaluation, although there was a lack of historical data for some biological components and some additional analyses of some biological data might be useful. The District has followed a credible and defensible approach in determining that current groundwater pumping in the Northern District has not affected the quantities of base flows in the Homosassa River system. However, the impact that groundwater pumping in the Northern District has had and will have on salinity and other water-quality parameters in spring discharges and base flows in the river is not well understood. The current assumption that salinities in the Homosassa River system today represent base flow conditions needs further evaluation. Changes in the quality of water exiting springs are as critical to future biological resources as changes in overall flow. Traditionally, reductions in downstream flow result in the upstream migration of the freshwater-saltwater boundary. In the Homosassa System, however, there is the additional impact of saline water flowing from springs. Evidence presented by Leeper et al (2010) is adequate to conclude that the proposed maximum 5% reduction in Minimum Flow satisfies the language and intent of the Statute and will result in "no significant harm" to the flora and fauna of the Homosassa River System. The use of the Homosassa River by Manatees as a thermal refuge in winter will not be impacted by this reduction. Suggestions for additional data collection and analyses are made in this review.

INTRODUCTION

The Florida Legislature requires that Water Management Districts establish minimum flows and levels (MFLs) for state surface waters and aquifers within its boundaries. The purpose of the statute is to protect Florida's water resources for the future. This protection extends to the fauna and flora within the water body through the requirement that the ecology of the area be protected from "significant harm" (Florida Statutes, 1972 as amended, Chapter 373, Section 373.0421). Once Water Management Districts have determined an MFL for a watershed, maintenance of the MFL becomes part of the planning process for future withdrawals. The same Florida statute requires that Districts develop strategies that will achieve recovery to the MFL within 20 years or to prevent withdrawals from decreasing flows below the determined MFL.

Water management districts are required to use the best information available in establishing the MFL for a watershed and to plan for low water flow conditions associated with season. A minimum flow is the point below which further water withdrawals will cause significant harm to the water resources or ecology of the area or significant harm to the water resources of the watershed. Thus, Water Management Districts must consider a wide array of impacts in the development of their MFL levels based on a variety of different information, which may be more robust for some resources than others.

The Southwest Florida Water Management District (SWFWMD) has begun the process of developing MFLs for watersheds within their district. Using guidance provided through Florida Statutes, SWFWMD has used a data collection/data review process to develop a recommended MFL for 15 of its watershed segments. Each of these recommended MFL levels was evaluated by a panel of independent reviewers. The Panel examines documents and data provided by SWFWMD staff and makes a recommendation with respect to the proposed MFL. Once the Panel recommendations are reviewed by SWFWMD, minimum flows are codified by rule and used in future decision making within the specified watershed segment.

Because many of the watersheds have been structurally altered by canals, dams, etc, identifying a baseline condition that incorporates structural and hydrological

alterations within the hydrologic system is not straightforward. Determining MFLs for a watershed must incorporate current conditions and often uses data which may or may not have been affected by these structural alterations.

A number of the SWFWMD watersheds, including the Homosassa River, are dominated by artesian spring flows from the Floridan aquifer. How water moves through the Floridan aquifer is not as easy to understand as surface-water flows. While this adds a level of complexity not found with watersheds dominated by surface-water flow, it does simplify the development of an MFL since most of the annual variation resulting from seasonal variations in rainfall is eliminated.

The development of MFL's must consider protection of not just water resources, i.e., freshwater flow, storage, etc, but attributes of the natural world associated with flows or water levels that are valuable to people (State Water Resources Implementation Rule, Chapter 62-40.473, Florida Administrative Code). Recreational values inherent in fishing and hunting are important considerations in setting MFL and dependent on the aerial extent of freshwater, marine, and estuarine habitats associated with a river. Navigation and aesthetic values should be considered as well as the function of a river system in absorbing and transporting nutrients and sediment. The development of an MFL for any system is a complex undertaking.

The Panel for the review of the MFL for the Homosassa River system was provided a draft copy of the report prior to an on-site visit on August 10, 2010. During that visit, we observed by boat almost the entire system, with special emphasis on springs, which are the primary sources of river flow. We also visited, via vehicle, the Hidden River and its watershed. The Panel met the evening of 10 August 2010 and discussed our initial impressions of the Homosassa River system and what we felt were key questions which needed to be answered in the MFL recommendation and supporting documents. These questions became the focus of our review process. Central questions were:

1. Is the District's threshold of a maximum 15% change of resource within the system a reasonable approach?
2. Was there an adequate data base for development of the regression model?

3. Was there an adequate data base for development of the hydrodynamic model?
4. Were the models used by the SWFWMD the best models for determining the MFL for the Homosassa River system?
5. Was the data collection approach adequate to determine the past and present natural resources on the river system?
6. Were appropriate assumptions and analyses made in the use and extrapolation of these data?
7. Was the weight of evidence enough to convince the panel that the recommended MFL satisfied the Florida Statute establishing the MFL requirement?
8. Are there additional data that should be collected in the future that would add confidence to the MFL SWFWMD recommendations?

The following sections are arranged as follows: Critical Questions, General Comments and Recommendations related to the eight questions above. Specific Comments follow and are aspects of the document or appendices we found confusing or that appear inaccurate. These should be corrected or explained to eliminate the confusion. Finally, there is an Errata Section.

Critical Questions

Question #1 - Is the District's threshold of a maximum 15% change of resource within the system a reasonable approach? **Yes**, while it may be somewhat arbitrary, setting a quantifiable threshold provides a means to evaluate the impact that reductions in discharge would have on fish and invertebrates, salinity-based habitats, and the extent of thermal refuge for the Florida manatee. While reasonable, many of the r^2 values were low (but significant) and only positive relationships were examined. Both positive and negatives ones should be examined if the goal is to not dramatically change the community structure of the entire system.

Question 2 - Was there an adequate data base for development of the regression model? **Yes**, the salinity, tide stage, and discharge records for gage sites in the river and the salinity measurements made by SWFWMD and other agencies provided an adequate data base for the empirical regression models developed to describe salinity in the main channel of the Homosassa River. **Yes**, for most of the biological response measures (plankton, fishes, and manatees). The benthic analysis was incomplete, however. There were also considerable data sets for SAV and EAV that seemed to contradict each other.

Question 3 - Was there an adequate data base for development of the hydrodynamic model? **Yes**, the stage, salinity, and temperature data at the USGS Shell Island gage, the salinity and temperature data at the USGS Homosassa Springs and SE Fork gage sites, the discharge data at the USGS Homosassa Springs, SE Fork, and Homosassa Springs gages used to model the discharge at Halls River, the salinity data in Halls River and at the Homosassa Springs gage, and meteorological data measured at the FAWN-IFAS station at Brooksville in general provided an adequate data base for development of the hydrodynamic model.

Question 4 - Were the models used by the SWFWMD the best models for determining the MFL for the Homosassa River system? **Yes,** the EFDC hydrodynamic model is well documented in the literature, and it has been widely used to simulate flows and water-quality parameters in estuarine and coastal applications. Also, the use of regression models to empirically relate river discharge and salinities is acceptable. The assessment of the impacts of pumping on spring discharges (Basso 2010) is based on a proprietary version of MODFLOW, which also is well documented and widely used to simulate groundwater flow systems. Additional study of the relationship between withdrawals and spring flow at different springs should be done with the goal of understanding any potential increases in salinity at saline springs or decreases in flow at freshwater springs that might be caused by withdrawals.

Question 5 - Was the data collection approach adequate to determine the past and present natural resources on the river system? **Yes**, with respect to flow, this approach is quite adequate to conclude that present-day spring and river discharges can be considered baseline or natural flows [also, please see response to the next question concerning water quality]. The approach assumed that present-day flow records were representative of past, or baseline, conditions based largely on the determination using a numerical groundwater flow (Basso 2010) that groundwater pumping in the Northern District of SWFWMD has reduced historical spring flows in the Homosassa River system by an insignificant amount (approximately 1 percent). With respect to many natural components, the answer was **no**. There were some data for SAV/EAV and water quality from earlier reports, but not much else besides those. Obtaining data on past resources that are not considered of economic value is often difficult. Data collected as part of the current MFL document will serve as a baseline for future modification of MFL evaluations.

Question 6 - Were appropriate assumptions and analyses made in the use and extrapolation of these data? In response 5 above, **yes** it is reasonable to assume that present-day spring and river discharges represent baseline or natural flows. However, it can only be inferred that present-day salinities discharging from the springs into the river system are still at natural levels. Based on the lack of a calibrated numerical groundwater transport model for the Northern District or other means to address this issue currently, this is the best that can be done at this time. Addressing the need for data that can be used to calibrate such a model should be a priority for future research and monitoring.

There were also some questions of providing additional information with respect to assumptions used in the detailed analyses provided. For example, low r or R values in many analyses were not compared to the 'norms' of statistical procedures. These should be provided.

Question 7 - Was the weight of evidence enough to convince the panel that the recommended MFL satisfied the Florida Statute establishing the MFL requirement? Generally, **yes**, it would satisfy the statute, but because of the variability and low predictability of input data, there could be problems with the accuracy of the predictions.

Question 8 - Are there additional data that should be collected in the future that would add confidence to the MFL SWFWMD recommendations? Yes, as noted in previous questions, priority should be given to collecting additional data as part of an investigation intended to resolve some of the salinity and temperature results obtained using the hydrodynamic model. Also, additional groundwater quality data should be collected as part of an investigation to better understand the flow and water-quality aspects of the springs in the Homosassa springshed and to determine whether spring salinities will increase in response to increased groundwater pumping in the Northern District of SWFWMD.

We feel the District should take a multivariate approach as illustrated in their analyses in the appendices using Primer statistics. The goal of the MFL process is to do no 'significant harm', which in many cases is a professional judgment call. The suggested multivariate approach outlined at the end of this document (The sections on Chapters 4 & 5) would improve the ability to make predictions of potential outcomes based on flow reductions. These outcomes would be more holistic and at the heart of the MFL process.

General Comments and Recommendations

Water Quality in the Springs

The water quality in the springs that discharge into the Homosassa River system varies from fresh to brackish. The Homosassa Main Springs and Halls River springs discharge brackish water, and the springs of the Southeast Fork discharge relatively freshwater, based on Yobbi and Knochenmus (1989). Halls River Head Spring, Homosassa Springs, and Hidden River Head Spring discharge sodium-chloride water, which indicates a seawater origin, and Trotter Spring in the Southeast Fork discharges mixed-ion water, which is the result of freshwater and saltwater mixing (Knochenmus and Yobbi 2001). The variability of the quality of the water discharging from the springs of the Homosassa River system is explained in terms of the existence of a coastal transition zone between freshwater and saltwater in the groundwater system (Leeper et al. 2010). Differences in water quality among springs are attributed to the depth of individual spring vents, the proximity of a spring to the Gulf of Mexico, and the transient location of the saltwater-freshwater interface, which creates a zone of mixing that changes seasonally and diurnally (Knochenmus and Yobbi 2001). The transition zone moves horizontally and vertically in the Floridan aquifer in response to tidal fluctuations in the Gulf of Mexico and changes in water levels in the aquifer (Champion and Starks 2001). The age and residence time of groundwater discharging to springs in the Homosassa River system apparently have not been determined. However, in a somewhat similar hydrogeologic setting in the Suwannee River basin, relatively young ages and residence times of spring discharges ranging from 5 to 50 years were estimated by Katz et al. (1999). In general, these description and explanations of water-quality variations among the springs can be summarized in terms of the hypothesis that present-day seawater intrusion and recirculation in an active groundwater flow system result in a saltwater-freshwater interface that moves horizontally and vertically in response to tides and changes in regional groundwater levels, causing spatial and temporal variations in salinities in the springs. In this context, it can be expected that future withdrawals of freshwater from the groundwater system in the Northern District that affect groundwater

levels also may affect spring flows and water quality in the Homosassa River system. Potentially, withdrawals of fresh groundwater in inland areas will reduce freshwater spring discharges and also cause the saltwater-freshwater interface to move farther inland, thus resulting in a disproportionate increase in salinity in the spring discharges into the river system. Accordingly, the Panel recommends that SWFWMD conduct future investigations to better quantify the relation between the salinities of the springs discharging into the Homosassa River and saltwater intrusion in the Floridan aquifer. Also, the Panel recommends that SWFWMD investigate the impacts that groundwater pumping in the Northern District potentially has had and will have on salinities and other water-quality parameters in the springs and base flows in the Homosassa River system.

Groundwater Modeling

For the purpose of developing minimum flow recommendations, the Homosassa River system is considered by SWFWMD to consist of the Homosassa River, Southeast Fork of the Homosassa River, Halls River, Hidden River, and springs associated with these rivers (Leeper et al., 2010). As described by Leeper et al. (2010) and in more detail by Basso (2010), it was determined that current groundwater use in Citrus, Hernando, Pasco, and Sumter counties has not had any significant impact on spring discharge in the Homosassa River system. This was accomplished by running the Northern District groundwater model (HydroGeoLogic, Inc., 2008) for two scenarios, i.e., one scenario representing 2005 conditions and the other with no pumping representing pre-development conditions. It was concluded that the resulting decrease in spring discharge in the Homosassa River system represents an insignificant decrease of 1.1 percent. Based on this result, the measured and modeled flows used in the minimum flow analyses were considered baseline or natural flows. The Northern District groundwater model is a fully three-dimensional groundwater flow and saltwater intrusion model developed by HydroGeoLogic, Inc. (2008) for the northern part of SWFWMD consisting of Hernando, Sumter, and Citrus counties and parts of Pasco, Polk, Lake, Marion, and Levy counties. The groundwater flow and solute transport code MODFLOW-SURFACT was used to develop a numerical groundwater flow model of the Northern District and to develop a saltwater-intrusion model for the coastal areas of the Northern District. The groundwater

flow model was calibrated to steady-state conditions representing 1995 and to transient conditions representing 1996 to 2002. However, as pointed out by HydroGeoLogic, Inc. (2008), the saltwater intrusion model was not calibrated; instead, a qualitative evaluation was conducted to assess whether the saltwater intrusion model produced the general distribution of chlorides observed from monitoring wells.

SWFWMD has followed a credible and defensible approach in determining that current groundwater pumping in the Northern District has not affected the quantities of base flows in the Homosassa River system and thus that recently measured flows in the Homosassa River system can be treated as base flows without adjustment in this study. The impacts that future increased groundwater pumping will have on the quantities of spring discharges and base flows in the Homosassa River system were not addressed in Appendix B (Basso 2010), but it is certainly reasonable to conclude that the Northern District groundwater model also could be used to assess such impacts. Thus, the impact that groundwater pumping has had and will have on the quantities of the spring discharges and base flows in the Homosassa River system appears to be well defined. By contrast, the impact that groundwater pumping in the Northern District has had and will have on salinity and other water-quality parameters in spring discharges and base flows in the river is not well defined. It can only be inferred that recently measured salinities in the Homosassa River system represent base flow conditions, because the lack of a calibrated saltwater intrusion component in the Northern District groundwater model precludes a quantitative assessment of salinity changes in the spring discharges using this model. The assessment of groundwater conditions and impacts described by Basso (2010) and summarized by Leeper et al. (2010) is quite adequate based on the criterion of using the "best available information" concerning the quantities of the spring discharges and base flows in the Homosassa River system. However, determining how salinity and other water-quality parameters in the springs that discharge into the Homosassa River system will change in response to changes in groundwater pumping in the Northern District cannot be accomplished currently using the existing Northern District groundwater model. Accordingly, the Panel recommends that SWFWMD add a calibrated saltwater intrusion component to the Northern District groundwater model in a

future investigation (or otherwise quantify the relation between changes in groundwater pumping and the water quality of spring discharges) to address this issue.

Detailed Comments

Chapter 1

The explanation regarding the adoption of the 15% loss standard was useful in reviewing the remaining chapters and sections. There is the potential, however, that this standard might over-emphasize what are essentially very small changes when the initial habitat or resource is small. Caution should also be exercised in assuming that high volumes may be withdrawn during high flow events (page 24). High flow events can be extremely important in resetting systems, e.g. removing accumulated fine organics from sandy bottoms. This may not be an issue for the Homosassa given that the primary discharge is from springs, but should not be universally applied when developing regulations regarding water removal.

Chapter 2

On pages 38-39, land use in the Homosassa River drainage basin was mapped and delineated for 1990, 1995, 1999, 2004, 2005, 2006, 2007, and 2008 (Table 2-1). The point is made that generally little change occurred in land use/cover in the watershed in the years between 1990 and 2008 (Table 2-1). This observation is somewhat limited in value, however, because the Homosassa River *surface-water* drainage basin, which consists of approximately 55.6 square miles, overlies only part of the Homosassa Springs *groundwater* basin, which consists of approximately 270 square miles (Knochenmus and Yobbi 2001). This is clearly indicated in Figure 2-6, on page 37. The observation that land use has not changed significantly would be better made if land use from 1990 to 2008 in the groundwater basin, or springshed, could be compared. Apparently this section was written to point out that land-use has not changed from 1990 to 2008 and, thus, that the springs have not been affected during this period. If so, this point should be made explicitly.

Box plots are used in figure 2-12 (page 48) and in many others throughout the report to indicate the range of data for tides and other parameters. Are the box plots standardized; do all of the box plots show the same range of information? It is suggested

that the information shown in the box plots (minimum, maximum, median, and lower and upper quartile) be specified the first time this type of plot is used.

The variability of the quality of the water discharging from the springs of the Homosassa River system is described (Page 68, 1st-3rd paragraph) and explained in terms of the coastal transition zone between freshwater and saltwater in the groundwater system. It is noted that the Homosassa Main Springs and Halls River springs have been described as brackish systems and that the springs of the Southeast Fork have been described as freshwater systems (Knochenmus and Yobbi 2001). Differences in water quality of the springs are explained in terms of the differences in the vertical and horizontal location of the transition zone and its spatial and temporal variability. Is it possible to illustrate the relation of the springs to the saltwater-freshwater transition zone by constructing a vertical hydrogeologic cross-section aligned with the direction of groundwater flow based on existing water-quality data and/or the numerical modeling results (Hydrogeologic, Inc. 2008) described by Basso (2010) in Appendix B?

Ratios between top and bottom salinities in the Homosassa River during 1984 and 1985 (page 78) were on the order of 0.85 to 1.0 (Yobbi and Knochenmus 1989), i.e., top salinities generally were equal to or less than bottom salinities. In Figure 2-31 (page 80), synoptic salinity profiles for the river surface in 2007 and 2008 are shown in the top panel, and salinity profiles for the river bottom are shown in the bottom panel. The surface salinities generally appear to be less than corresponding bottom salinities for these measured data. However, the median values for the EFDC model in the top panel of Figure 2-31 for surface salinity appear to be greater than the corresponding bottom salinities for the EFDC model in the bottom panel of Figure 2-31. Is there a contradiction between the observed salinity data and the EFDC model results shown in Figure 2-31? If so, an explanation needs to be provided. [Please see further comments below pertaining to Appendix A (HSW Engineering, Inc. 2010) in which salinity profiles shown in Figure F-3 along with the salinity profiles shown in Figures F-1 and F-2, which correspond to Figure 2-31 in Leeper et al. (2010), also indicate that top salinities generally are less than bottom salinities.]

The legend for Figure 2-31 (page 80) indicates that the solid green line shows the median EFDC model salinity for the river surface. Figure F-2 in Appendix F (HSW

Engineering, Inc. 2010), which is included in Appendix A of Leeper et al. (2010), indicates that this line is the median EFDC model salinity for the river *bottom*.

Salinity, tide stage, and discharge records were used to develop empirical regressions for modeling or predicting salinity in the main channel of the Homosassa River (Pages 82-83). Summary descriptions of the regression equations are presented by Leeper et al. (2010), and details regarding development of the regression models are provided in Appendix A (HSW Engineering, Inc. 2010). The regression models consist of sets of equations for predicting the locations of surface and bottom isohalines for salinities of 3, 5, and 12 in the Homosassa River based on the combined flow at the USGS Homosassa Springs and Southeast Fork Homosassa Spring gage sites and the tide stage at the USGS Homosassa River stage gage. The equations account for 53 to 59% of the variability in the salinity measurements, based on r^2 values presented in Table 2.10. Are these results acceptable for empirical models, i.e., are there any generally accepted standards or guidelines to which these regression results could be compared?

One main concern is the weakness of the hydrodynamic model results. The authors state and illustrate (Figure 2-37) in Leeper et al. (2010) that the model overestimates and underestimates the empirical regressions at a number of flow rates and locations. In particular, it appears from Figure 2-37 in Leeper et al. (2010) that modeled 3 psu (practical salinity unit) isohaline locations versus flows for all 3 locations (surface, bottom, depth-averaged) between 160-170 cfs are always high (upriver) compared to the empirical model results and those from 120-150 cfs are mainly low in bottom isohaline locations (mid river), but high in surface and depth-averaged locations (mid-river). This is disconcerting as these relate to where the 3 psu isohaline should be for 2007 baseline period, but the hydrodynamic model does not do a good job and thus predictions may also not be accurate. In contrast, the empirical regression r^2 values ranged from 0.63-0.73 and suggest these may do a better job in predicting impact with future water withdrawals.

The predicted locations of the surface, bottom, and depth-averaged 3 psu isohalines as a function of total spring flow for the Homosassa River in 2007 are shown in Figure 2-37 (pages 88-89). Leeper et al. 2010 notes [and it is quite apparent in the top panel in Figure 2-37] that there are significant differences in the model-predicted isohaline locations for surface salinities, i.e., the surface salinities predicted by the EFDC

hydrodynamic model occur farther upstream than locations predicted using the empirical regression models. In the empirical model results, bottom salinities extend farther upriver than the surface salinities, which is consistent with the results of Yobbi and Knochenmus (1989), in which top salinities in the Homosassa River during 1984 and 1985 generally were equal to or less than bottom salinities (see comment above relative to Page 78). However, in the EFDC hydrodynamic model results in Figure 2-37, there is no distinct difference between the surface and bottom isohaline locations. What is the significance of this result? Should it be concluded that the EFDC model over-predicts surface salinities? If so, how does this affect the determination of salinity and temperature changes used to predict the impact of reduced flows in setting minimum flows for the Homosassa River? [Please see further comments below pertaining to Appendix A (HSW Engineering, Inc. 2010) in which the predicted locations for the 5 and 12 psu isohalines in Appendix J are discussed.]

In Appendix F in HSW Engineering, Inc. (2010), synoptic salinity profiles for the river surface between December 2006 and July 2008 are shown in Figure F-1, and salinity profiles for the river bottom between December 2006 and July 2008 are shown in Figure F-2. The surface salinities generally appear to be less than corresponding bottom salinities for these measured data. However, the median values for surface salinity for the EFDC model for 2007 in Figure F-1 appear to be greater than the corresponding bottom salinities for the EFDC model for 2007 in Figure F-2. Longitudinal profiles of surface and bottom salinity measured on individual dates illustrate water that is generally well mixed or *weakly stratified with bottom salinity several psu higher than the surface salinity* (Figure F-3) [page 2-21, 1st paragraph, italics added]. The measured surface and bottom salinity profiles in Figures F-1 through F-3 apparently contradict the results that were calculated using the EFDC model shown in Figures F-1 and F-2. Is there a contradiction between the observed salinity data and the EFDC model results? If so, an explanation needs to be provided. A similar comment was noted for page 78, line17 (Leeper et al. 2010).

Three isohaline models (3, 5, and 12 psu) were developed for predicting the location of surface and bottom water-column salinity isohalines using synoptic data for 2005 through 2009 (p. 2-29, last paragraph and p. 2-30, Table 2-4). The isohaline models

explain about 50% to 60% of the variation in the measurements used to develop the models (Table 2-4 and Appendix I-3). R^2 in Table 2-4 needs to be defined. This parameter is often used to indicate a correlation coefficient, but is that the case here? It is defined in Appendix I-3 in HSW Engineering, Inc. (2010) as R squared = 1 – (Residual Sum of Squares)/ (Corrected Sum of Squares); this definition should be added to Table 2-4. Six values of the standard deviation of the residuals between observed and calculated surface and bottom salinities for 3, 5, and 12 psu can be extracted from the histograms in Appendix I-3 in HSW Engineering, Inc. (2010). Including these values, which range from 0.719 to 1.85, in Table 2-4 would provide an additional means to assess how well the regression models predict salinities.

The maximum observed surface and bottom salinities at the Homosassa River gage and the maximum observed bottom salinity at the Halls River gage (p. 3-11, Table 3-4**)** are significantly greater than the respective simulated salinities at these gages (i.e., 19.13 > 9.60, 18.79 > 9.70, and 16.07 > 4.12 psu). Also, the root mean square errors at these gauges (2.08, 2.02, and 1.15 psu) appear to be relatively large. Are there recommended calibration guidelines for estuarine models to which these results could be compared? For example, the Pearson Coefficient R values in Table 3-4 for the Shell Island gage are relatively large (0.91, 0.90, and 0.90), but the values for the Homosassa River and Halls River gages are relatively small (0.50, 0.55, and 0.35). The values for the Homosassa and Halls River gages, particularly the Halls River value of 0.35, are less than the minimum correlation coefficient of 0.60 preliminarily recommended by EPA (1990) for estuarine water quality models. Does this indicate that the Homosassa River model is not well calibrated?

Appendix B in Leeper et al. (2010), in the second paragraph of the Introduction**:** Hidden River should be included in this paragraph to be consistent with Leeper et al. (2010) and Table 2 (p. 12). On page 4 of the first line, it states that the "ground-water basin …is approximately 292 square miles…." This is different from the value of 270 square miles in Leeper et al. (2010) (p. 36) that was determined by Knochenmus and Yobbi (2001). However, these values are considered "similar" (Leeper et al. 2010, p. 36), which seems to be a reasonable way of reconciling the difference.

On page 10, 3.2 2005 Scenario: To determine drawdown in the UFA and potential impacts to spring flow in the Homosassa River system, average annual groundwater withdrawals in 2005 (438.1 mgd) were simulated in the NDM…and compared to non-pumping conditions (zero withdrawals). Please clarify who did this analysis, i.e., did HydroGeoLogic, Inc., or SWFWMD do this analysis? Is the 438.1 mgd scenario the same as scenario 1 in the HydroGeoLogic, Inc. (2008) report? It appears to be, but this pumping rate does not seem to be listed explicitly in HydroGeoLogic's report. Please indicate if the 2005 condition in Basso (2010) is the same as scenario 1 in HydroGeoLogic, Inc. (2008). Also, please indicate the source of the discharge values for the 2005 pumping scenario in Table 2 (p. 12) (apparently they are from Table 5.2 in the HydroGeoLogic, Inc. report).

On page 11, Table 2 states that the discharge at Hidden River Spring Head is reduced 4.0 percent, while all of the other spring discharges are reduced by approximately 1.0 percent, except for Belcher Spring, which is reduced by 2.0 percent. Is the result for Hidden River Spring Head correct? If so, is there a reason why it is so much larger than the other results?

Table 2.8 in Leeper et al. (2010) indicated that the estimated salinity of water coming from different springs varies from 0.1-3.9 ppt, even though they are spatially close. This is perplexing. How can this happen if they are using the same groundwater sources, and we could not find sufficient evidence suggesting why this is occurring nor how this may be influenced differentially by water withdrawals. Is it possible that water withdrawal in one location could only influence the very low salinity springs and thus, elevate the contribution of the high salinity spring water into the system? Ratios of ions in the saline springs (Table 2.6) argues that this is dilute seawater and not just water with high solids derived from minerals in the rock strata through which the springs flow. The oceanic ratio of Na to Mg is 8.213 (Sverdrup et al. 1942), while the ratio in Hall's River Spring #1 was 7.8, 7.9 for Hall's River Main Spring and 8.08 for Homosassa Main Spring #2. Analyses of any inert sea water derived ions from Table 2.6 found similar sea water-like ratios, arguing that the spring discharged dilute seawater. Is this fossil seawater as has been proposed for other similar Florida springs (Scott et al. 2004)? It appears more data are needed to substantiate and verify why this is occurring as it may have some indirect impacts on the contribution of saline waters to the Homosassa River from springs with high salinity compared to other springs. Additional pumping from the spring shed could have very different impacts if flow was reduced from one of the saline or non-saline springs.

It is not clear that there is an adequate understanding of the aquifer itself, residence time for water in the aquifer, or the ultimate source of salt (fossil or modern source) in the saline springs.

In Leeper et al. (2010, page 84) – the hydrodynamic model is "… somewhat problematic" and suggested model accuracy could be improved by adding data from downstream side channels. They also note water temperatures are slightly under-predicted in warm month and over-predicted in cold months (page 84) suggesting the thermal effect of spring discharge may be underestimated. Also, maximum salinity at the Halls and Homosassa Rivers gage sites were underestimated by the calibration and validation periods.

Finally, in Appendix A, page 2-20, paragraph 2, lines 13-15, the authors state '... river stage as measured at the springs is a variable used in calculating spring flow and therefore the independent variables spring flow and tide are related." This is of concern as this interdependence may influence (increase) the models predictability and thus this autocorrelation is problematic from a statistical point of view. How this influences the model outcome and thus prediction is not explained or considered.

Chapter 3 - Vegetation

The narrative in the vegetation section of Chapter 3 (Leeper et al. 2010) is based on a variety of historical and more recent reports (Hoyer et al. 1984, Fraser et al. 2001a,b, Fraser et al. 2006, PBS&J 2009), which indicate some contrasting findings in terms of submerged aquatic vegetation (SAV) and emergent aquatic vegetation (EAV) relative to environmental factors in the Homosassa River. Hoyer et al. (1984) noted significant relationships between SAV distribution and abundance and flow, salinity and light levels in the Homosassa River.

However, more recent research (Frazer et al. 2001a,b; Fraser et al. 2006) indicates significant changes in SAV in the river in terms of number of sites without SAV (104%

decrease) between 1998-00 and 2003-05. There was also a mean reduction in biomass of filamentous algae and most macrophytes (~ 67%) and macroalga biomass (62%), but an increase (85%) in periphyton biomass on SAV between time periods. Because the more recent survey period had lower salinity, they suggested salinity was not as influential as elevated nutrient loadings and possible eutrophication in the Homosassa River. In contrast, the most recent survey (PBS&J 2009) suggested distribution and abundance of SAV and EAV was clearly delineated across salinity zones based on known species tolerances, but that SAV, because of the marked decline, was not a good indicator of increasing salinity and thus, changes in flow. In fact, they believe EAV is a much more predictable indicator of mean salinity along the river and that freshwater species respond quickly to reduced salinities.

Finally, Appendix E (page 3-11) PBS&J (2009) indicates that the relationships between nutrient loads and SAV have not been clearly defined or quantified and thus, predicting impacts due to epiphyte growth and SAV loss are not possible presently. They also note until these relationships are quantified, restoration is not possible. Somehow, the District needs to decouple nutrient load issues from salinity changes in the system before they can accurately decide on which is driving these relationships.

It is clear more research is required to clarify the relationship between SAV and EAV distribution and abundance relative to nutrient loads, salinity changes, and light level modifications along the Homosassa River relative to proposed flow reductions. This must include examining groundwater sources of nutrients into the system and these sources may be influenced by water withdrawals based on the proposed MFL scenarios.

Forested tidal wetlands were noted in the report, but little information reported on the extent of the freshwater tidal swamp within the Homosassa River system. Impacts to this important part of the ecosystem will be hard to calculate because the Homosassa is on the Tropical-Temperate boundary where saline-tolerant mangroves can easily displace salinity intolerant species such as Ash (*Fraxinus* spp.) and red maple (*Acer rubrum*). In a typical transition from freshwater to saltwater within an estuary, a potential reduction of flow would result in an upstream migration of the freshwater to saltwater boundary that could be easily modeled. With the source of flow in the Homosassa system consisting of multiple springs, some of which release saline water, impacts of the freshwater-saltwater boundary are difficult to predict without a better understanding of the aquifer system from which the springs emerge. It would be prudent to develop a map of the tidal, forested wetlands for future comparisons. There is some suggestion that changes have already occurred (See pages 3-14, Appendix E). Freshwater tidal swamp species extended further downstream than their aquatic counterparts (See Appendix E). Woody species can often persist even after salinity has increased. Alternatively, these tidal swamp species may be holding on because they are at an elevation slightly above the tides.

Sea level rise on this flat landscape also has the potential to greatly increase the extent of tidal marsh and swamp and should be modeled to understand the long-term changes that may impact the Homosassa even without flow modification. This may be critical if some of the forested wetlands are just above the current high tide level as noted above.

If saline water is currently intruding into the aquifer and is the source of the salt in some of the springs feeding the Homosassa River, even a slight change in sea level could increase the salinity of these springs. Even a small change in salinity and/or sea level could greatly alter the extent of freshwater wetlands in the upper reaches of the Homosassa River system. Tidal forested wetlands are an obvious component of the landscape and a sudden loss of this vegetation could appear to be the result of some change in management, when it may just be the result of crossing a critical threshold caused by sea level rise.

Benthic Macroinvertebrates

Results from Grabe and Janicki (2009; Appendix D) did not note any eastern oysters collected in the top 50 species they reported on in Chapter 3, nor are they listed in Tables 3-3 and 3-4 in Appendix D. In contrast, Water and Air Research (2010; Appendix F) found live eastern oysters in their study and Chapter 3 noted “The distribution for live oysters differs from that reported by Grabe and Janicki (2009) who found oysters in dredge samples collected between river kilometers 4 and 9 during their May 2008 sampling events” but no explanation for this difference is provided. Oyster data can be found in Table 3-7 in Appendix D, but this species was not mentioned directly in the text.

In terms of the barnacle study (Culter 1900; Appendix G) noted in Chapter 3, it would be interesting to note if there were any patterns in the distribution of the presumed exotic species, *Balanus amphitrite*, in relation to salinity along the Homosassa River, which might suggest that water withdrawals might enhance their distribution and abundance in areas along the river compared to baseline.

One of the potential problems in the analysis of benthic data is using both RKM and salinity in their forward stepwise multiple regression (Appendix D; Table 3-5). If I am correct, aren't RKM (position in river) and salinity potentially correlated and thus if both are included in model (as in the Shannon Diversity regression in Table 3-5) it should inflate the adjusted R^2 values? This can easily be examined in regression in a number of ways and should be examined in all models. Also, the adjusted R^2 values for density and Shannon diversity are low (< 0.40) and thus, do not explain much of the variation in the models. They may be lower if you exclude either RKM or salinity if they are highly correlated.

Another potential problem is the interpretation of the results from the ANOSIM procedure listed in Table 3-6 (Appendix D). One caution with Primer statistics illustrated in Appendix D is that the MDS plot stress levels are not reported in Figure 3-10; these should be reported in all such plots. Also, with ANOSIM, Clark and Warwick (2001, page 6-4) note R-values are as important as p-values in determining significance and 5 of the 7 significant pairwise comparisons have R values < 0.5 While significant, having high p-values with low R-values suggest a re-evaluation of how these plots are interpreted.

In the executive summary section of Leeper et al. (2010) and in Chapter 4 (paragraph 1, lines 5-8), point out only the fish and invertebrate plankton, nekton, salinity-based habitats, and manatee data are used to set MFL levels, as those appear to be the most-sensitive to water withdrawals. Thus, the issues with the benthic data noted above may be less problematic in reference to setting the MFL, but the issues need to be examined and re-evaluated (if necessary) for the final document such that no spurious interpretations are made.

Plankton and Seine & Trawl Data Sets

The authors indicate in Appendix H (page 72) that "Some characteristics of the plankton community in the Homosassa River estuary suggest that the area has become more eutrophic." The authors suggest that reduced abundance patterns of presumed indicator species (a copepod, mysid and the bay anchovy) compared to other non-spring-fed systems and regular occurrences of large shifts in dissolved oxygen (DO) concentration (Appendix H, page 72, parag. 2, line 5) is evidence of increased eutrophication. The data presented in Table 3.2.1 and Figure 3.2.1 in Appendix H (pages 26-27) illustrate high and low DO values based on depth and location strata, but the text states that dissolved oxygen "occasionally reached strong supersaturation levels during winter and spring months, …". This seems to contradict the statements above about regular occurrences of supersaturation. Also, both of the presumed indictor species are very common across their range and are found in non-eutrophic and eutrophic systems as well, so it may be useful for authors to cite some literature on them being an indicator species relative to the potential eutrophication issues they note. There is also no mention of these concerns in water quality section of Chapter 2 in Leeper et al. (2010, page 90), although they do note some low DO (< 5.0 mg/L) were observed in all sections. However, data presented in Chapter 3 (pages 97-98), based on Fraser et al. (2001a,b; 2006) suggested increases in nutrient loads in the system over time and noted for SAV and EAV that nutrients may be more influential on distribution and abundance compared to salinity changes. It is sometimes hard to glean important data from Leeper et al. (2010) because it may not be in the section you expect and in this case, we expected it to be in water quality, not in the SAV/EAV section. There is clearly some inconsistency in how different authors view presumably the same data sets or how data are logically provided in Leeper et al. (2010).

The authors in Appendix H (page 73) indicate "…has a relatively deep channel throughout much of it length (Fog. 2.7.4.1), and this channel may facilitate two-layered estuarine circulation …" but really provide no data illustrating two-layered flow patterns. In contract, in Chapter 2 of Leeper et al. (2010) these authors indicate vertical water temperature data (page 72, paragraph 2, line 2) and vertical salinity data (page 78, paragraph 2, line 5) suggests a relatively well-mixed system. There are clearly some inconsistencies in how different authors view this system and there should not be these inconsistencies in a single document.

One of our main concerns in Chapter 3 of Leeper et al. (2010) is the quality of the regressions (linear and quadratic) in terms of their explanatory power relative to flow issues. For example, in the plankton section (pages 116-117; Table 3-4) the authors note that only 28 of 64 plankton-net taxa showed some significant response to the range of flow encountered. Of the 28 noted, only 5 had significant positive relationships (abundances increased with increased flow) and the remaining 23 had negative relationships (decrease in abundance with increased flow). The authors then focused on those five taxa with positive relationships. The authors also note that the coefficients of variation (adjusted r^2) ranged from 0.29-0.62 for time lags of 36-120 days; however, careful examination of Table 3-4 shows these values ranged from 0.25-0.72 and 50% (n = 14) had r^2 values < 0.50. Also, eight taxa (29%) had issues of possible serial correlations (significant DW values). The authors justify these r^2 values for both plankton-net and seine and trawl collections by stating "Some of these relationships had very good fit, suggesting that these relationships are not spurious" (Appendix H; pages 40 and 68). We are not sure if those fourteen taxa are really relevant to the discussion as only up to 50% of the response appears to be explained by flow. In most biological responses, 50% may be statistically significant, but not be biologically meaningful. The summary (page 160) in Leeper et al. (2010) makes note of this low accounting of variation of individual regressions.

Similar patterns in these regression coefficients can be noted for the seine and trawl data sets. For example, the authors noted that 40 (41?) of the 53 pseudo-species had significant relationships to flow while 13 had quadratic and 27 (28?) had linear relationships (page 116). Of the linear relationships, 12 had negative responses and 15 (16?) had positive ones with time lags from 1-203 d. The reported r^2 values ranged from 0.20-0.78 for those positive responses; however, 37% (n = 10) of these had r^2 values < 0.50. Also, seventeen pseudo-species (32%) also had issues of possible serial correlations (significant DW values). The authors justify these r^2 values for both plankton-net and seine and trawl collections by stating "Some of these relationships had very good fit, suggesting that these relationships are not spurious" (Appendix H; pages 40 and 68). As noted above, we are not sure these 10 pseudo-species add much to the discussion of altered flow, since as explained < 50% of the variance is probably not very biologically meaningful. The summary (page 160) in Leeper et al. (2010) makes note of this low accounting of variation of individual regressions.

We also question not discussing the negative relationships (most of the taxa and pseudo-species collected) as the regressions suggest that as flow is reduced, abundances of many of these taxa or pseudo-species would increase and presumable expand into upriver locations as salinity changes with flow. This should have consequences relative to community structure patterns over some time frame, which may ultimately modify community structure in the system overall. This may be more relevant if some exotic species are present (i.e., striped barnacle; Culter 2009).

One caution with Primer statistics illustrated in Appendix H is that the MDS plot stress levels are approaching values that are of concern in interpretation (stress = 0.20 and above; See Clarke and Warwick 2001); thus, the 2-D fit of a 3-D plot may not be very good. Also, with ANOSIM and tests that generate R-values and p-values, Clark and Warwick (2001, page 6-4) note R-values are as important as p-values in determining significance and some in Appendix H have high p-values with low R-values. These need to be re-evaluated and they may not be as strong a relationship as suggested.

Chapters 4 and 5

The approaches used for individual responses to flow changes are reasonable, but a more holistic approach is really required. Below is a suggestion of a way (there may be others) to examine plankton, nekton and benthic responses with Primer statistics and couple those results with salinity-based habitats and manatee thermal habitats data currently in place. In Appendix H (pages 54-72), the authors conducted some very interesting multivariate community analyses, but these were not discussed in Leeper et al. (2010), and, in part, they support our concern about community structure change given the individual empirical relationship for plankton, seine and trawl data sets outlined above. It might be very useful to examine carefully the community structure changes using Primer statistics (MDS, ANOSIM, SIMPER, etc.) of the taxa and pseudo-species relative to flow reduction scenarios. We believe one could use the individual empirical relationships (both positive and negative ones) to estimate abundances at particular flows coupled with predicted changes in salinity, etc. These calculated abundance values could be used to create a new data matrix and run some of the appropriate Primer statistics to see if overall assemblage structure would change under different flow scenarios. One could do this at some estimate above and below the linear (mean) values (i.e., ± 10, 15, 20 %) based on the empirical relationships. This may provide some indication of how much the assemblage as a whole could change given the scenarios of interest (change in water flow) and would be a more holistic approach than the standard individual responses documented in Leeper et al. (2010). Given Leeper et al. (2010) currently lists 20 total individual responses used for 2007 and 1996-2009 baseline estimates of non-lagged data, these could be used for the suggested analysis and when the final report is completed on the benthic surveys, they may be able to be incorporated as well. In Primer, we could see rows of species, taxa and pseudo-species with columns being baseline abundances for 2007 and 1995-2009 and then have other columns based on generated abundances given reduced flows (as done individually already). These could be ordinated in MDS, compared with ANOSIM among flow scenarios, and, if you used SIMPER, you could show which flow rates produced significantly lower abundances estimates by species and how many species responded holistically instead of individually. It could be that some taxa do worse or better in different flow scenarios, thus impacting the overall assemblage composition.

Can figures be generated using tables 5-20 through 5-22 that would show salinity-based shoreline changes using data from both the hydrodynamic model and the empirical regression models? It might help visualize how the potential change would look in the Homosassa system.

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Page	¶ #	Line #	Figure (F) **Table (T)**	Comment
5	6	3		Change "model" to "models"
19	Title			Change "Acknowledgements" to " Acknowledgments" (no "e")
20	2	5		"…at least 19 named or identified springs or vents." There appear to be 20 named springs in Figure 2-3, page 33. Should these numbers be the same?
30	3	2		Delete the "a" before Bluebird Springs Park.
49	2	5		Add "k" to Southeast For (k) gage site.
52			F. 2-16	The discharge data in this figure appear to match the discharge data for gage site USGS 02310700 Homosassa R at Homosassa FL; apparently, this gage site number should be in the figure caption, instead of the gage site number that is listed in the caption (02310690), which is the number for Halls River.
53			F. 2-18	The gage site number for Hidden River should be number 02310675, instead of 02310690, which is the number for the Halls River gage.
54	3	8		"poteniomitric" should be "*potentiometric*".
54	3	10		It is suggested that **nodes** be replaced with *"drain cells"*.
55			T. 2-4	It is suggested that Abdoney, Belcher, McCain, Pumphouse, and Trotter No. 1 springs be identified as comprising the Southeast Fork springs complex.
61	1	9		"sand, silt, muck and silt"
65	3	5-8		The text says 14 stations (10 in Homosassa River and 3 in Halls River and 1 in SE Fork). However Figure 2-24 has 19 stations (13 in Homosassa River and 6 in Halls River). Hard to rectify stations plotted on 2-24 and data on 2-25??
66	1&2			The text cited Figure 2-24 in both paragraphs and it appears it should be Figure 2-25?
66	3	4		What is "B121"?
66	3	7		"figurer" should be "figure"
66	3	7		Is the part of this sentence that states "locations of these sites are not shown in Figure [sic.] 2-25" written correctly? If so, is it possible to include a reference that does show the locations of the sites?
75			F.2-28	This figure is real hard to interpret because of small size and overlap of the symbols.
75			F. 2-28	It is suggested that the gage number be included in the caption.
77	1	3		Can the formulas of Cox et al. (1967) be included in the text?
80			F. 2-31	It is indicated that the solid green line shows the median EFDC model salinity for the river **surface**; Figure F-2 in Appendix F (HSW Engineering, Inc. 2010), which is included in Appendix A of Leeper et al. (2010), indicates that this line is the median EFDC model salinity for the river *bottom*.
81			F. 2-33	It is very difficult to read the legend and understand what data are presented in this figure.
83	2	1		Change "prediction" to "predicting"

Page	¶ #	Line #	Figure (F) Table (T)	Comment
84	1	11-12		How was a **temperature constant of 23.2ºC** used? Should this be "*constant temperature* of 23.2ºC"?
84	1	14		It is suggested that **concordance** be replaced with *"agreement"*.
87			F.2-36	The upper 2 panels are almost impossible to separate observed from simulated signals. I would attempt to make larger as these tell a great deal about model simulation patterns compared to the observed. I suggest you change the two colors so that they do not produce black when overlapped.
88	1			Paragraph describing predicted salinities: Coefficients of determination …ranged from 0.63 to 0.73 (HSW Engineering, Inc. 2010). It is suggested that the specific location for these results, i.e., the table number in Appendix A, be included in the text on page 88.
94	1	6		Looks like this should be Figure 2-20, not 2-23??
97	2	7		Earlier "discharge" was measured as cfs, here it is m/s
99-100			F.3-1 to 3-3	These are very small and hard to read. Color patterns are reasonable but dots are almost impossible to see clearly.
101	1	4		Delete "relatively"
101	1	7		Should be "physiochemical"
107	1	5		Delete "a" before size transects in the …
107	2	3		*Guekensis* is spelled *Geukensis*
110			F.3-2	*Guekensis* is spelled *Geukensis*
110	1	3		Should read "meta-analysis"
110	1	7		The word "tidal" appears redundantly
110	2	2		"sampes" should read "samples"
111	2	7		Should read "suggests" plural
114	3	8		"paludosus" should be in italics
116	3	1-4		I count 41 of the 53 pseudo-species having significant relationships, 13 with quadratic but 28 (not 27) with linear. Also, the authors list 12 negative and 15 positive linear responses but Table 3-5 has 16 positive linear responses. This may explain the 1 difference noted. Needs correction in text.
116	4	7		Seminole killifish (*Fundulus grandis*) is actually Gulf killifish.
123	1	1		Should read "red tides." The period inside the quotes.
124	1	11-14		Redundant "probabilities"
126	2	8		Again, Seminole should be Gulf killifish.
126	2	9		"mollies" should be "molly."
134-135			T. 5-1	Callinectus sapidus in this Table is mis-spelled and should be in italics. It is spelled *Callinectes sapidus* in the seine-net, taxon or pseudo-species and trawl-net sections. All should be in italics. Also, *Lepomis punctatusi* and *Micropterus salmoidesi* are mis-spelled and the "i" on the end of both species name should be deleted.
134	1	6		Looks like Table 5-2 should be Table 5-1.
154	1	10		Delete "of"

Page	¶ #	Line #	Figure (F) Table (T)	Comment
154				No page number
Appendix A Edits and Typos				
xiii				**Table of contents, p. xiii:** Consistent with the information presented in the table of contents for Appendices A-I in HSW Engineering, Inc. (2010), the figures contained in Appendix J in HSW Engineering, Inc. (2010) should be listed in the table of contents.
2-19	2	4-7		Something is missing in this sentence. It makes no sense to me.
2-19	2			Figures 2-25 through 2-33 should immediately follow p. 2-19 if possible.
3-10	2	3		Table 3-3 cited should be Table 3-4.
3-11		3	T. 3-4	Headings in line 3, columns 3 and 4 for the Shell Island gauge are both labeled “Middle”. Should the heading in column 4 be labeled “Bottom” instead? Are the data correctly entered in these columns? Also, it is noted at the bottom of Table 3-4 that “**R is the Pearson Coefficient....”** Is this coefficient defined or referenced somewhere in the report?
4-4	1		F. 4-3 & 4-4	Printed off the page and you can not see legends or captions.
Appendix B Edits and Typos				
				Second paragraph in Introduction: To be consistent with Leeper et al. (2010) and Table 2 (p. 12), Hidden River should be included in this paragraph.
Appendix C Edits and Typos				
Appendix D Edits and Typos				
3-16	1	2		Delete “s” from compares.
3-18	4	5		Peebles 2005 not cited in literature cited section (note to add it if found in red).
Appendix E Edits and Typos				
3-7	6	4-6		Figs 5 & 6 are printed off the page (can not read scales, etc.) and have no figures legends. Same for appendices A-C.
3-8	1	1		Ruppia must be in italics.
3-13			F. 7	Figures 7 & 8 are not cited in the text.
3-14			F.8	Figures 7 & 8 are not cited in the text.
3-16			T.2	Plant names must be in italics like all other tables.
Appendix F Edits and Typos				
			T. 6	Table 6 – *Geukensia* also misspelled as noted above.
Appendix G Edits and Typos				
Appendix H Edits and Typos				
17			F. 2.7.4.2	TIN is upper case is in upper panel but lower case in lower panel.
29	3	2-3		Names need to be in italics.
30	1	3		“fro” should be “from”.
30	1	13		Peebles & Flannery 1992 is not cited in literature cited section.

Page	¶ #	Line #	Figure (F) Table (T)	Comment
31	3	4		Merriner et al. 1976 also not cited in literature cited section.
31	4	6		Peebles 2002 also not cited in literature cited section.
73	5	7		“appeanace” misspelled.
74	2	5		“esutuary” misspelled.
Appendix I Edits and Typos				
Appendix J Edits and Typos				
Appendix K Edits and Typos				
Appendix L Edits and Typos				
Appendix M Edits and Typos				
Appendix N Edits and Typos				
Appendix O Edits and Typos				

Appendix U

Approved minutes for the November 16, 2010 Southwest Florida Water Management District Governing Board meeting, including minutes associated with the peer-review of proposed minimum flows for the Homosassa River system (highlighted in yellow).

APPROVED

MINUTES OF THE MEETING

GOVERNING BOARD
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

BROOKSVILLE, FLORIDA NOVEMBER 16, 2010

The Governing Board of the Southwest Florida Water Management District (SWFWMD) met for its regular meeting at 9:00 a.m. on November 16, 2010, at the District's headquarters in Brooksville. The following persons were present:

Board Members Present
Ronald E. Oakley, Chair
Hugh Gramling, Vice Chair
H. Paul Senft, Secretary
Douglas B. Tharp, Treasurer
Jeffrey M. Adams, Member
Bryan K. Beswick, Member
Jennifer E. Closshey, Member
Neil Combee, Member
Albert G. Joerger, Member
Todd Pressman, Member
Judith C. Whitehead, Member

Board Member(s) Absent
Carlos Beruff, Member

Staff Members
David L. Moore, Executive Director
William S. Bilenky, General Counsel
Lou Kavouras, Deputy Executive Director
Richard S. Owen, Deputy Executive Director
Eugene A. Schiller, Deputy Executive Director
Bruce C. Wirth, Deputy Executive Director

Board's Administrative Support
LuAnne Stout, Administrative Coordinator
Tahla Paige, Sr. Administrative Assistant

A list of others present who signed the attendance roster is filed in the permanent records of the District. This meeting was available for viewing through internet streaming. Approved minutes from previous meetings can be found on the District's Web site (www.WaterMatters.org).

Public Hearing

1. **Call to Order**
   Chair Oakley called the meeting to order and opened the public hearing. Mr. Senft noted a quorum was present.

2. **Pledge of Allegiance and Invocation**
   Chair Oakley led the Pledge of Allegiance to the Flag of the United States of America. Mr. Bilenky offered the invocation.

Public Hearing
Chair Oakley introduced each member of the Governing Board. He noted that the Board's meeting was recorded for broadcast on government access channels, and public input was only taken during the meeting onsite.

Chair Oakley stated that anyone wishing to address the Governing Board concerning any item listed on the agenda or any item that does not appear on the agenda should fill out and submit a speaker's card. To assure that all participants have an opportunity to speak, a member of the public may submit a speaker's card to comment on agenda items only during today's meeting. If the speaker wishes to address the Board on an issue not on today's agenda, a speaker's card may be submitted for comment during "Public Input." Chair Oakley stated that comments would be limited to three minutes per speaker, and, when appropriate, exceptions to the three-minute limit may be granted by the Chair. He also requested that several individuals wishing to speak on the same issue/topic designate a spokesperson.

3. **Additions/Deletions to Agenda**
Mr. Moore said there was one deletion to the agenda.

Consent Agenda
The following items were deleted from consideration:
7. Individual Water Use Permits Referred to the Governing Board
   b. WUP No. 20000742.010 - City of Tarpon Springs (Pinellas County)
8. Initiate Rulemaking and Approve Amendment to Rule 40D-8.041, Florida Administrative Code (F.A.C.), to Establish Minimum Flows for the Chassahowitzka River System and Accept Report

Chair Oakley noted for the record that the deletions were accepted for today's agenda. (Track 1 – 00:00/05:24)

4. **District Recognition – Florida's Heartland Rural Economic Development Initiative (FHREDI), Inc.**
Mr. Roy Mazur, Director, Planning Department, introduced Ms. Lynn Topel, Executive Director of the Florida's Heartland Rural Economic Development Initiative (FHREDI), who provided information regarding the FHREDI organization. She presented an award and plaque to the Governing Board in appreciation for its support in creating economic stability in the FHREDI region. (Track 1 – 05:24/07:10)

This item was presented for the Board's information, and no action was required.

5. **Employee Recognition**
Mr. Moore recognized staff members who have achieved milestones of 20 years or greater.

MILESTONE	EMPLOYEE NAME	TITLE	DEPARTMENT	OFFICE LOCATION
30 Years	Margie Hagin	Water Resource Permit Evaluator	Tampa Regulation	Tampa
25 Years	Cheryl Glenn	GIS Analyst 3	Operations	Brooksville

Mr. Moore recognized Mr. Don Wood who is the new Manager in the Human Resources Department and welcomed him to the District's management team. He then introduced Mr. Eric DeHaven, Director, Resource Development and Restoration Department, to recognize staff through the District's Employee Suggestion Program (ESP) for Meritorious Service Award Recognition.

Mr. DeHaven said an ESP form was received from Mr. Jason Hust, Field Technician Supervisor, Water Quality Monitoring Program (WQMP) Section, on behalf of his employees: Bob Brady, Senior Field Technician; Tim Crosby, Staff Field Technician; Stacy Joyner, Field Technician; Joel Durkee, Field Technician; Rik Mathias, Field Technician; Kendale Antoine, Assistant Field Technician (currently an Assistant Well Driller); and Josh Kraft, Assistant Field Technician (no longer a District employee). WQMP has 12 multi-probe YSI meters, which are used on a daily basis to measure field parameters at ground and surface water monitoring sites. The accuracy of data collected depends on the appropriate calibration and maintenance of these meters. The District was sending the meters to the manufacturer for repair but now the WQMP staff has obtained the technical skills to perform these tasks in-house. In addition, the WQMP are making repairs to groundwater sampling pumps and water level monitoring equipment when possible to save down-time and repair costs. As a result, the District has realized a substantial decrease in the associated cost related to YSI meter repairs. Costs reduction has been realized in reduced down-time and lower equipment repair cost. A breakdown of cost savings for Fiscal Year (FY) 2009 totaled $16,094.00. A $1,609.40 Meritorious Service Award was equally split between the employees listed above.

Mr. DeHaven said an ESP form was received from Mr. Jerry Mallams, P.G., Manager, Geohydrologic Data Section, on behalf of his employee, George DeGroot, Senior Well Driller. Mr. DeGroot improved the efficiency of the Geohydrologic Data Section's wire-line operations by reducing the time required to clear obstructions when coring through fractured dolostone formations. Mr. DeGroot did this through developing a process and tools that allow removal of obstructions from the core rods. This has been termed the Rock Bailer. The Rock Bailer method uses the wire-line cable on the drill rig to remove the core rod obstruction in-situ, thereby negating the need to remove and reinstall the entire drill string, saving hours of drill rig and staff time. As a result, the District has realized a substantial decrease in the associated cost related to core drilling. Costs reduction has been realized in equipment and salary. A breakdown of cost savings for FY2009 totaled $34,448.63. Mr. DeGroot received a $2,000 Meritorious Service Award in appreciation for his cost-saving suggestion.

Chair Oakley thanked these staff members and said he appreciated their outstanding work for the District. (Track 1 – 07:10/16:15)

This item was presented for the Board's information, and no action was required.

6. **Public Input for Issues Not Listed on the Published Agenda**
Chair Oakley noted that no requests to speak were submitted. (Track 1 – 16:15/16:27)

Consent Agenda

Items 7.b. and 8 were deleted from consideration.

Regulation Committee

7. **Individual Water Use Permits Referred to the Governing Board**
   a. **WUP No. 20002486.004 - Circle G Farm and Ranch LLC (Hillsborough County)**
   Staff recommended to approve the proposed permit.
   b. **WUP No. 20000742.010 - City of Tarpon Springs (Pinellas County)** – This item was deleted from consideration.

Resource Management Committee

8. **Initiate Rulemaking and Approve Amendment to Rule 40D-8.041, Florida Administrative Code (F.A.C.), to Establish Minimum Flows for the Chassahowitzka River System and Accept Report** – This item was deleted from consideration.
9. **Facilitating Agricultural Resource Management Systems (FARMS) – Polkdale Farms, L.L.C. Wind Machine – Polk County**
Staff recommended to (1) approve the Polkdale Farms, L.L.C. Wind Machine project for a not-to-exceed project reimbursement of $40,000 with the entire reimbursement provided by the Governing Board; (2) authorize the transfer of $40,000 from fund 010 H017 Governing Board FARMS funds to H618, Polkdale Farms, L.L.C. Wind Machine project fund; and (3) authorize the Executive Director to execute the agreement.

Finance & Administration Committee

10. **Budget Transfer Report**
Staff recommended to approve the Budget Transfer Report covering all budget transfers for October 2010.

General Counsel's Report

11. **Settlement Agreement – SWFWMD v. Matthew Smith, et al, Case No. 53-2010-CA-004082, 10th Judicial Circuit – Lake Hancock Project, SWF Parcel No. 20-503-110P – Polk County**
Staff recommended to approve the Settlement Agreement in the total amount of $157,000.

12. **Settlement Agreement – SWFWMD v. Sharon E. Pitz & Charles R. Connolly, et al, Case No. 2009-CA-010078, 10th Judicial Circuit – Lake Hancock Project, SWF Parcel No. 20-503-198P – Polk County**
Staff recommended to approve the settlement of this matter for a total of $132,350.70 by entry of a Stipulated Amended Order of Taking and Final Judgment.
13. **Initiation of Litigation – Well Construction - License No. 9021 - Brett Roth – Levy and Citrus Counties**
Staff recommended to authorize the initiation of litigation against Mr. Roth to take disciplinary action against his license, recover an administrative fine/civil penalty, and recover District enforcement costs, court costs and attorney's fees.

Executive Director's Report

14. **Approve Governing Board Minutes**
    a. **October 22, 2010 Finance and Administration Screening Committee Meeting**
    b. **October 26, 2010 Meeting**
Staff recommended to approve the minutes.

Mr. Tharp moved, seconded by Mr. Gramling, to approve the Consent Agenda as amended. Motion carried unanimously. (Track 1 – 16:27/16:55)

Chair Oakley relinquished the gavel to Regulation Committee Vice Chair Pressman. (Track 1 – 16:55/17:19)

Regulation Committee

Discussion Items

15. **Consent Item(s) Moved for Discussion** – None

16. **Hydrologic Conditions Status Report**
Mr. Granville Kinsman, Manager, Hydrologic Data Section, said October historically marks the first month of the eight-month dry season (October-May) and provisional rainfall totals for the month have been at record low amounts. Rainfall during the four-month wet season (June-September) was lower than expected. Provisional rainfall data for the District indicate that October 2010 is the driest October since records began in 1915. Provisional data indicate that the District-wide 12-month rainfall accumulation has declined into deficit conditions, now showing a deficit of approximately 0.91 inch below the long-term average. The 24- and 36-month cumulative rainfall deficits also increased during the month and are approximately 7.8 and 11.9 inches, respectively, below the historic average. As a result of the low rainfall, all hydrologic indicators declined during October. Regional groundwater levels, lake levels and streamflow have now fallen below-normal in most of the District, with the Central region holding out with low-normal conditions. The U.S. Drought Monitor (as of October 26) indicates that abnormally dry conditions have returned throughout the District, and are expanding and intensifying. National weather forecasts for the three-month period from November through January, as well as the coming winter and spring, continue to predict below-normal rainfall due to La Niña conditions in the Pacific Ocean. Further declines in hydrologic conditions are likely should below-normal rainfall conditions occur during the coming winter and spring. (Track 2 – 00:00/06:59)

This item was presented for the Committee's information, and no action was required.

17. **Consider Water Shortage Declaration**
Ms. Lois Sorensen, Demand Management Program Manager, Tampa Regulation Department, noted that staff routinely monitors hydrologic conditions and other pertinent factors in accordance with the District's Water Shortage Plan (Rule 40D-21, Florida Administrative Code) to determine when a water shortage may need to be declared. As of October 27, below-normal rainfall was already contributing to unseasonably early ground and surface water declines, especially in a region that encompasses Citrus, Hernando,

Levy and Sumter counties. Conditions have continued to decline since then; however, public supply storage is in good shape, for now. As such, instead of taking more aggressive action at this time, staff's recommendation is to declare a Phase I (Moderate Water Shortage) order District wide, effective December 1, 2010; continue monitoring conditions; and, in the absence of a supply emergency, reassess the situation in January.

Ms. Sorensen said Phase I is primarily an alert intended to raise the public's awareness of dry conditions, and also intended to direct water utilities and their local governments to prepare for worsening conditions. Under Phase I, residents are asked to check their irrigation systems to ensure they are working properly. In addition to making any necessary repairs, residents should check their irrigation timer to ensure the settings are correct and verify the rain sensor or soil moisture sensor is working properly in accordance with state law. There are no changes to watering days or times in a Phase 1 water shortage therefore the District's year-round water conservation measures remain in effect. Under Phase I, water utilities and their local governments are expected to review and revise water restriction enforcement procedures, begin monthly enforcement reporting and communicate with customers about water restrictions and water conservation.

Mr. Gramling moved, seconded by Chair Oakley, to approve staff's recommendation to declare a Phase I water shortage order Districtwide effective December 1, 2010; continue monitoring conditions; and, in the absence of a supply emergency, reassess the situation in January. Motion carried unanimously. (Track 3 – 00:00/08:07)

18. **<u>Approve Amendments to Chapters 40D-1, 40D-2, 40D-8 and 40D-80, F.A.C., including the Water Use Permit Basis of Review, to Establish a Water Use Caution Area in the Dover/Plant City Area and Associated Water Use Permitting Requirements, Minimum Level and Recovery Strategy</u>**

Mr. Owen said the Board members have received a copy of comments provided by Mr. Doug Manson, an attorney representing the Strawberry Growers Association, on the rules the Board is considering at this meeting. He said staff has identified a number of issues that warrant additional changes for clarity purposes and concerns of the industry that possibly can be resolved. Mr. Owen said staff has strived to engage those parties who will be affected by these additional regulations. He said the District's goal has been to have these rules in place for the coming winter.

Mr. Owen said the staff recommendation is to postpone this presentation until the December Board meeting when staff will be prepared to review the rules in detail, explain how the Board's direction is being accomplished, and resolve the issues brought to staff's attention by Mr. Manson.

Mr. Gramling moved to accept the staff recommendation to postpone consideration of this item until the December meeting. (Track 4 – 00:00/02:45)

Mr. Gramling said he has three areas he would like addressed: (1) when a permit holder is given a well complaint, it be investigated and the cost of inspection passed to the well owner; (2) language is not clear regarding the frost-freeze average annual figure; and (3) whether modeling for frost-freeze quantities is per event or an annual average.

Chair Oakley seconded the motion. (Track 4 – 02:45/05:20)

Ms. Closshey said she would like to see the language made as simple and direct as possible, and addressing confusion regarding transfer of property and well use, as well as modeling in place so each farmer understands the rules. She said the District needs an aggressive messaging plan to ensure stakeholders are aware of these rule changes. She said she would like the Board to have a policy discussion regarding the simplicity of rule language. Discussion ensued. (Track 4 – 05:20/21:50)

Committee Vice Chair Pressman said two speaker cards had been submitted.

Mr. Doug Manson, representing the Strawberry Growers Association, said his client would like to have a delay from the standpoint that the rule be correct when it becomes effective. He said the Association wants the rule to be in place because it is an improvement over the existing policies being utilized and wants to work with staff to resolve issues. He noted a provision exists for emergency rules should a freeze event occur before the rule is adopted. (Track 4 – 21:50/24:50)

Mr. Ted Campbell, representing the Florida Strawberry Growers Association, said the industry is aware of this issue due to the unprecedented event last year and agriculture has agreed to seek alternative freeze methodologies. He said the rulemaking process is to find alternatives to freeze water mitigation, and the industry understands its responsibility to protect the water resources and neighbors. He then provided his comments on the proposed rules. (Track 4 – 24:50/32:10)

Discussion ensued regarding wells affected, aquifer rebound, sinkholes, litigation due to rule challenges and emergency rule process.

Mr. Gramling called the question. **Motion carried unanimously.** (Track 4 – 32:10/44:52)

Committee Vice Chair Pressman thanked industry representatives for attending today's meeting and noted staff exemplary work on this issue. (Track 4 – 44:52/45:18)

19. **Mitigation Issues**

a. **District Conservation Easements and Mitigation Banking**
Mr. Eric Sutton, Director, Land Resources Department, provided an overview of conservation easements. The District purchases conservation lands through the purchase of fee and less than fee interests (conservation easements). To date, the District has acquired approximately 343,300 acres in fee title and 104,100 acres in less than fee interests. Conservation easements were viewed as a mechanism to keep the lands from being more intensely developed, would keep the lands productive through low intensity agriculture and ranching, would not require public agencies to manage the land, and would allow more land to be protected since the costs of an easement were substantially below the cost to purchase in fee. In the mid 1990s, legislation was passed that required state agencies and the water management districts to identify and implement creative techniques and alternatives to acquiring land in fee. This included a statutory requirement for state agencies and water management districts to identify in their 1997 land acquisition plans specifically which lands were appropriate for fee acquisition and those where alternative techniques would meet the desired conservation objectives. The statutes further presumed that a private landowner retains the full range of uses for all the rights or interests in the landowner's land which are not specifically acquired by the public agency. Similar language encouraging the use of alternatives to fee acquisition was later included in the Florida Forever Act. Beginning with the 1997 Five-Year Land Acquisition Plan, the District distinguished which lands identified for acquisition in the Plan were more suitable for fee acquisition and those that were more suitable for the purchase of a conservation easement. In 2009, the District completed another comprehensive review of lands identified for protection in the Plan, which also distinguished whether the lands were more suitable for fee or less than fee acquisition and this updated plan was adopted by the Board as part of the 2010 Consolidated Annual Report. (Track 5 – 00:00/08:50)

Discussion ensued regarding restoration versus enhancement, purchase of mineral rights, commercial operations cease, appraisals based on best use, best management practices, concept of conservation easements, and policy procedure since a statewide issue. (Track 5 – 08:50/33:32)

Committee Vice Chair Pressman said two speaker cards had been submitted.

Mr. Doug Manson, representing W.R.B. Enterprises, said his client's property is known as Boar's Head Ranch and there is a conservation easement. He said it was contemplated there would be mitigation in the future and is stated in the conservation easement. He said there should not be double dipping on a conservation easement. He said the mitigation permit should never be given credit to preservation that has already been purchased by the District. Mr. Manson said the property has a pristine wetland yet allows other parts of the property to be used for cattle, homes, etc. He said each property's consideration is a case-by-case analysis, and staff is addressing issues. (Track 5 – 33:32/36:26)

Mr. Chet Bradshaw, a resident of Citrus County, said he is a volunteer environmentalist working in the Withlacoochee watershed. He said one of the topics of discussion is the Florida Department of Environmental Protection's Regional Offsite Mitigation Areas (ROMA) program which are environmental enhancement projects conducted by the department, a water management district, or a local government that serve as mitigation for multiple impact projects. Mr. Bradshaw said the landowner is restoring the land and the District should not have to pay for something that has already been done. (Track 5 – 36:26/38:25)

Mr. Owen noted there is a second presentation as part of this discussion. (Track 5 – 38:25/38:45)

Mr. H. Clark Hull, Jr., Environmental Regulation Program Director, Resource Regulation, provided an overview of mitigation banking and to specifically address the issue of establishing mitigation banks on lands already under a conservation easement. Mitigation as a regulatory concept is authorized in Section 373.414(1)(b), Florida Statues (F.S.) which states: "If the applicant is unable to otherwise meet the criteria set forth in this subsection, the governing board or the department, in deciding to grant or deny a permit, shall consider measures proposed by or acceptable to the applicant to mitigate adverse effects that may be caused by the regulated activity." Although the statutory concept of mitigation encompasses a broad scope of permitting requirements, it is most commonly applied to activities in wetlands and other surface waters which adversely impact fish and wildlife. Mitigation is addressed in the Environmental Resource Permitting (ERP) Basis of Review which states: "Mitigation (for wetland impacts) usually consists of restoration, enhancement, creation or preservation of wetlands, other surface waters or uplands." Florida Statutes anticipate the establishment of mitigation banks on both private and public lands. Section 373.4135(1) directs the water management districts "to participate in and encourage the establishment of private and public mitigation banks." If a mitigation bank is proposed on publicly owned lands or on privately owned lands which are encumbered by a conservation easement, mitigation credit is not granted for preservation of the site since it is already preserved through public ownership or the existing conservation easement. Only the ecological "value added" beyond the existing preservation is credited as mitigation. Mitigation banks receive credits only for environmental improvements to those values already protected by the conservation easement. An entity wishing to establish a mitigation bank must obtain a mitigation bank permit from the District and may also obtain a Mitigation Banking Instrument (MBI) from the U.S. Army Corps of Engineers (ACOE) in coordination with other Federal resource agencies. Some mitigation banks are unable or unwilling to obtain a Federal MBI and can only use their credits for impacts outside the jurisdiction of the ACOE. At present, there are approximately 50 mitigation banks in Florida, eight of which are located District. (Track 6 – 00:00/14:16)

This item was presented for the Committee's information, and no action was required.

b. **Florida Department of Transportation Mitigation Program**
Mr. H. Clark Hull, Jr., ERP Program Director, Resource Regulation, provided an overview of the District's Florida Department of Transportation (FDOT) Mitigation Program. This presentation examined the state's Department of Transportation Mitigation Program and how recent changes to Federal mitigation rules by the U.S. Environmental Protection Agency and the Army Corps of Engineers (ACOE) affect that state program. Additionally, Mr. Don Ross with EarthBalance has requested to share his perspective relative to the FDOT Program based on his experience as a mitigation banker.

Several factors have changed since the Legislature created the FDOT Mitigation Program; therefore, staff is seeking direction on several policy level issues. One policy issue involves use of the statutory exclusion provision referenced above. FDOT District One (Bartow) has expressed a desire to exclude roadway projects from the FDOT Mitigation Program if they can purchase credits directly from a mitigation bank for those projects. In staff's opinion, this approach would require that FDOT seek the necessary statutory changes to allow these projects to be excluded. It should be recognized that allowing FDOT to exclude projects because mitigation bank credits are available for less than the statutory amount (currently $102,959 per impact acre) could result in the District excluding road projects in urban basins where mitigation costs exceed the statutory amount.

Another substantive change since the inception of the FDOT Mitigation Program is the adoption of Federal mitigation rules by U. S. Environmental Protection Agency and the ACOE. FDOT road projects often require federal permits as well as ERPs. Florida statutes specifically require that the FDOT Mitigation Plan also meet the Federal mitigation requirements and so FDOT mitigation projects are developed to be consistent with State and Federal requirements. Federal mitigation rules recognize three types of mitigation: (1) mitigation banks, (2) in-lieu fee mitigation projects, and (3) permittee responsible mitigation. The District has not obtained a mitigation banking instrument or in-lieu fee agreement from the ACOE for any of the FDOT mitigation projects developed thus far and so the ACOE has categorized these projects as permittee responsible mitigation. As a consequence of this decision, the ACOE has recently begun to condition FDOT road permits with a requirement that FDOT be responsible for the mitigation projects developed by the District and liable for the mitigation if those projects should fail. This consequence seems to be inconsistent with statutory intent and could be remedied by seeking a mitigation banking instrument or in-lieu fee agreement with the ACOE for those projects.

Mr. Owen noted that correspondence has been received on this issue and copies have been provided to the Board. (Track 7 – 00:00/21:42)

At the August 2010 Governing Board meeting, Mr. Don Ross spoke to the Board and raised concerns regarding the District's FDOT Mitigation Program. Subsequently, in a letter dated September 27, 2010, Mr. Ross requested the Board approve a policy to allow FDOT to buy credits directly from fully permitted mitigation banks serving the basins in which impacts occur.

Mr. Don Ross, representing EarthBalance, thanked the Board for its interest in this issue. He said, after consulting with agencies and mitigation bankers, the District's staff will present a recommendation at the Board's January 2011 meeting. He said the Board is not being asked for a decision today but only for policy guidance. Mr. Ross said mitigation started about 1994 and it represents a private-public partnership since most of it occurs on private land but the purpose is conservation and preservation. He said the land is enhanced or restored as appropriate for that property at no cost to the public and is perpetually maintained through a trust fund. He said the mitigation plan is at a crossroads since the District DOT has requested to withdraw from a specific project to save a considerable amount of money which was denied. Mr. Ross said more is being spent on road projects that need to be done and changes have occurred with the ACOE regarding grandfathering. He said the program currently is not meeting the FDOT's needs. Mr. Ross said that Mr. B.T. Longino is here today and his property was mentioned earlier. He said Mr. Longino is a legacy landowner and asks that he speak briefly. He noted that another group represented here are the private investors who are looking for a return on investment for perhaps a pension fund. He noted they are driving this process forward looking for long-term investment with a return on capital.

Mr. Ross introduced Mr. Longino who is a former Governing Board and Basin Board member, Agriculture Hall of Fame Inductee and partner in the Myakka Mitigation Bank. He also introduced Mr. Grey Stevens who has a banking background, works with private land groups and has negotiated directly on behalf of Florida mitigation banks with institutional investors. (Track 8 – 00:00/07:01)

Mr. Longino thanked the Board for allowing him to speak. He said it was a pleasure to see faces he hasn't seen for some time and it speaks well for the District that there are so many loyal employees. He briefly provided history of his family's ranch. Mr. Longino noted that the property has always been a cattle and timber operation. He said it was a unanimous decision of the family to maintain the ranch as a sustainable agricultural enterprise in perpetuity. He said the family has in place a corporate structure which should ensure the continuity of the family's business. Mr. Longino said the land is in several conservation easements to restrict development of the land. He said sources of income are required to maintain the ranch as a provider of food, fiber, recreation, wildlife habitat, air and water purification, and all the amenities that come with forested natural and open pasture lands. He said the ranch is depending on its natural capital which is applicable due to the mitigation bank. Mr. Longino said the District encouraged the family ten years ago to develop a mitigation bank and they took Mr. Ross as a partner. He said the District instructed, approved, allocated credits and now regulates the bank. He said today there is a very successful restoration of a large wetland that was drained and degraded many years ago by a previous landowner. Mr. Longino said this required a lot of expense, time and effort to get all the permits needed. He said the credits allocated are limited to the Myakka River basin which is largely in public ownership or in private conservation lands which limits the opportunity to sell credits. He said, if the FDOT is not allowed to buy the credits, then the whole project may not be viable which affects the sustainability of the ranch. Mr. Longino said he is urging the Board to consider carefully the ramifications. (Track 9 – 00:00/09:38)

Mr. Grey Stevens then addressed the Board and said he represents Sandy Creek Partners which invests in wetlands restoration and preservation via investing in mitigation banks. He said investors look for opportunities to invest and there is ample capital available. He said the capital is not only individual, private money but it is also institutional money. Mr. Stevens said that, given the state of the economy, it is actually an attractive opportunity due to low interest rates and other investment opportunities difficult in terms of risk profile. He noted there is a big interest in green investing right now by the public and private sectors. He said that capital is typically specialized because, with mitigation banks, the process to invest, ultimately sell credits and receive a return on the investment takes quite a while. Mr. Stevens said there are about 48 private banks covering 115,000 acres and this growth will continue. He said investors are looking for a reasonable return on investment particularly given the timeframes required with mitigation banking. He said a level playing field is needed also which is the way the private sector can provide the efficient outcomes to users of the mitigation so competition is expected which is part of the game. Mr. Stevens said having rules which are applied consistently are expected for a level playing field. He said the capital is sensitive to any notion of competing with governmental agencies which regulate mitigation banking. He said the level of interest is high. (Track 10 – 00:00/04:00)

Mr. Ross said he asks the Board consider providing guidance on using private banking, the District continue to mitigate on its own land bought with Florida Forever money, and whether FDOT should be required to buy credits at a higher price than available in the private market. He thanked the Board for its attention to this matter. (Track 10 – 04:00/04:50)

Discussion ensued regarding land prices affected by the economy, public-private partnerships, FDOT pricing and one division requesting to be exempt from participation, Attorney General opinion regarding legislation, whether all districts are consistent with state statutes, staff examining to ensure District's interpretation meets the statutes, and moot point to continue discussion until the District's legal department determines a policy change is needed. (Track 10 – 04:50/20:10)

Committee Vice Chair Pressman said there are five requests to speak.

Ms. Sheri Lewin with Environmental Resource Marketing represents eight mitigiation banks around the state. She noted the North Tampa Mitigation Bank was approved in 2009 so this is the first year of selling credits. She said she has statewide experience mitigation both to public and private users. She provided a brief history of mitigation banks in Florida. She noted the districts do the mitigations, but FDOT is ultimately responsible. She said multiple, competing banks can bid for combined projects to receive a volume discount on credits and, in a recent case, a large discount was provided which saved substantial funds. (Track 10 – 20:10/24:30)

Mr. James Brearley said he is a stakeholder as a small mitigation banker in Hillsborough County. He said it is a pleasure to work with Mr. Hull and noted he is an asset to the District. He provided his perspective as a small banker. (Track 10 – 24:30/29:02)

Ms. Marian Ryan, a resident of Winter Haven, said the FDOT mitigation program has done great things environmentally. She noted that there are currently no mitigation banks for the Peace River Basin in Polk County although there are thousands of wetland acres suitable for this purpose. Ms. Ryan said any projects to improve water quality and quantity will benefit the users downstream. She said that, while the FDOT program liability issues can be resolved, incentivizing the use of mitigation would prove to be detrimental to the public interest especially when creating buffers and linkages or the ability to take advantage of new opportunities for restoration as they arise. (Track 10 – 29:02/30:12)

Mr. Mike Britt, Natural Resources Director for the City of Winter Haven, said he was in attendance for the City Manager. He said the City has been taking a holistic look at water resources and how the City fits into the Peace Creek watershed. He said the City has completed a two-year effort to develop a sustainable water resource plan which identifies the need for about 7,000 acres of wetland which should be restored to improve the watershed area and makes an opportunity for mitigation banks. Mr. Britt said there are many partnerships with the District but, for every benefit traded off downstream, eventually the public will have to pay those restoration dollars in future projects. He said the City recommends the District look for opportunities in the future and provide those benefits. In response to Mr. Combee's queries, Mr. Britt said the City is working on two large projects where the private development interests are investigating restoration of the land to create a mitigation bank or applying for cooperative funding. He said private interests may be more successful at working out an arrangement. In response to Mr. Senft's request, Mr. Britt said the City decided to incorporate the entire Peace Creek Watershed in its planning efforts and explained the watershed approach to involve the other local governments. (Track 10 – 30:12/37:40)

Mr. Stan Cann, representing the FDOT, noted District I incorporates 12 counties from Polk to Collier Counties. He said he appreciates the professional relationship of the District's staff. He said the program has been beneficial and provides the ability for mitigation. He noted Mr. Moore, he and his counterpart in District VII, Mr. Don Skelton, met a couple of months ago and said he appreciates the District's openness to consider private mitigation banks. Mr. Cann said the FDOT has had to defer $10 billion of projects in its five-year work program over the past four years and is looking for cost-effective options. He said $3.8 million is budgeted for mitigation based on Senate bill figures. He said the FDOT estimates that $1.5 million can be saved and remain in the transportation trust fund. He noted that the South Florida Water Management District does not require the FDOT to go through the Senate bill and the mitigation credits are bid out on the projects. He said the St. Johns River Water Management District recently gave an exception to some projects there. Mr. Cann said there is some inconsistency in application of the statutes which needs to be corrected. He said the FDOT remains committed to providing mitigation for these projects which the districts deem necessary. He said the FDOT is asking for consideration in saving funds in the transportation trust fund and will continue discussions with staff. (Track 10 – 37:40/41:10)

Ms. Closshey requested staff provide a financial overview of this program so the Board understands the costs, implications, future commitments that are outstanding, benefits provided, and whether the District may need to consider withdrawal. In response to Mr. Senft's question, Mr. Cann said the FDOT is requesting the option of participating or not.

Committee Vice Chair Pressman thanked Mr. Cann for attending this meeting. He noted the Board has clearly heard that the competition drives the price down. He urged staff to work to open those opportunities to reach a positive result. (Track 10 – 41:10/44:20)

This item was presented for the Committee's information, and no action was required.

20. **Denials Referred to the Governing Board**

Submit & File Reports – None

Routine Reports

The following items were provided for the Committee's information, and no action was required.

21. **Public Supply Production Report**
22. **Southern Water Use Caution Area Quantities**
23. **Overpumpage Report**
24. **E-Permitting Metrics: Online vs. Paper Applications**
25. **Individual Permits Issued by District Staff**
26. **Resource Regulation Significant Initiatives**
    (Track 10 – 44:20/44:54)

At this time, the meeting was recessed for lunch and reconvened at 1:15 p.m.

Regulation Committee Vice Chair Pressman relinquished the gavel to Committee Chair Beswick.

Outreach and Planning Committee

Discussion Items

27. **2012 – 2016 Strategic Plan Update**
Mr. Roy A. Mazur, Director, Planning Department, informed the Board of the completion of the fiscal year 2012 – 2016 Strategic Plan Update and communicated staff ideas to adjust the strategic planning process moving forward. Staff recommended to approve the 2012 – 2016 Strategic Plan for publication. Once approved, copies will be sent to all Regional Planning Councils, Water Supply Authorities, the Florida Department of Environmental Protection, the Florida Department of Community Affairs, all Advisory Committee members and Basin Board members, as well as all District legislative delegation members.

Mr. Tharp moved, seconded by Mr. Gramling, to approve the 2012 – 2016 Strategic Plan. Motion carried unanimously. (Track 11 – 00:00/04:24)

Mr. Mazur discussed ideas to modify the Strategic Plan update process to (1) ensure additional Governing Board and executive staff input, (2) improve the utility of the Strategic Plan as a communication tool to facilitate policy discussions at the Governing Board meetings, and (3) enhance accountability with Governing and Basin Board members relative to the District's strategic initiative. (Track 11 – 04:24/13:37)

28. **Surface Water Permitting for Projects in Urban Redevelopment Areas**
Mr. David Rathke, Director, Community and Legislative Affairs Department, provided a brief update on the upcoming 2011 legislation session that will begin in March with a focus on a potential legislation relating to surface water permitting for projects in urban redevelopment areas. Staff will be working with the Florida League of Cities, Florida Association of Counties, Department of Environmental Protection and the other water management districts to further this proposal moving into 2011. (Track 12 – 00:00/13:20)

This item was presented for the Committee's information, and no action was required.

Submit & File Reports – None

Routine Reports
The following items were provided for the Committee's information, and no action was required.
29. **Comprehensive Plan Amendment and Related Reviews**
30. **Development of Regional Impact Reviews**
31. **Speakers Bureau**
32. **Significant Activities**
(Track 12 – 13:20/13:41)

Committee Chair Beswick relinquished the gavel to Resource Management Committee Chair Joerger.

Resource Management Committee

Discussion Items

33. **Consent Item(s) Moved for Discussion** – None

34. **Memorandum of Understanding for the District's Maintenance of the Peace Creek Canal and Report of Progress in Acquiring Access Rights Necessary for Long-Term Canal Maintenance**
Mr. Chuck Lane, Senior Land Use Specialist, Land Resources Department, said at the request of local governmental entities along the Canal, District staff have been conducting

Canal maintenance activities since 2005. Local governments include Polk County, the City of Bartow, the City of Lake Wales, the Town of Lake Hamilton and the Town of Dundee. The District is in the process of developing a Peace Creek Watershed Management Plan which is intended to identify projects that will restore lost basin storage, improve water quality, provide flood protection benefits and improve natural systems in the watershed. While the Memorandum of Understanding (MOU) specifically addresses the Canal's function with respect to flood protection, it will not preclude the development of other beneficial water resource projects in the area. According to the MOU, local governments will discuss opportunities for no-cost conveyances of easements for access and Canal maintenance from developers through the land development review process. The proposed MOU is intended to establish a consistent coordination process between the District and all local governments with jurisdiction along the Canal. In addition to pursuing opportunities through the land development process, the MOU recognizes that the District and each local government agree to seek voluntary conveyances of easements from private property owners.

Staff recommended to (1) approve the Memorandum of Understanding for the District's Maintenance of the Peace Creek Canal between the District and local governments consisting of Polk County, the City of Bartow, the City of Lake Wales, the Town of Lake Hamilton and the Town of Dundee; and (2) authorize the Land Resources Director to execute the Memorandum of Understanding with the above-mentioned local governmental entities. **Ms. Closshey moved, seconded by Mr. Senft, to approve the staff recommendation. Motion carried unanimously.** (Track 13 – 00:00/07:00)

35. **Memorandum of Understanding with Mosaic Fertilizer, LLC for Consideration of a Public/Private Partnership for the Restoration of Flatford Swamp**

Ms. Lisann Morris, Senior Professional Engineer, Resource Projects Department, provided an overview of the Memorandum of Understanding (MOU) between the District and Mosaic Fertilizer (Mosaic) agreeing to move forward with the development of a feasibility study scope of services for restoration of Flatford Swamp located in the Myakka River Watershed. The MOU outlines important topics to be discussed during the development of scoping documents to further evaluate a potential project with Mosaic. The discussion is divided into two phases: the first is to develop a feasibility study scope of services to gain a better understanding of how and when the excess water from Flatford Swamp could be beneficially utilized in Mosaic's operations; the second, if all parties agree to move forward, is to discuss operational, financial, and environmental issues and develop a scope of services for design, permitting and construction of the proposed project. Once agreement on the scope of services is reached, a contract will be executed under the Flatford Swamp Restoration (H089) project.

Staff recommended to authorize the Executive Director to execute the MOU so that staff can move forward with developing a scope of services for a feasibility study to determine if a joint project with Mosaic for removing excess water from Flatford Swamp is practicable. **Mr. Combee moved, seconded by Mr. Gramling, to approve the staff recommendation. Motion carried unanimously.** (Track 14 – 00:00/05:44)

36. **District-Funded Agricultural and Urban Landscape Research Program**

Mr. Ron Cohen, Senior Professional Engineer, Resource Projects Department, provided an overview of the District's Agricultural and Urban Landscape Research Program with the University of Florida Institute of Food and Agricultural Sciences (IFAS). He presented an overview of the program's accomplishments and current objectives along with a review of District staffing required for support of the program. The District's IFAS research program is one of the District's longest ongoing initiatives. Since the program's start in 1979, the District Governing and Basin Boards have funded over 200 projects costing $12,698,300. The District's funding share of the projects is $11,895,245. These projects provide the science that supports many aspects of the District's regulatory, conservation, communications, planning and FARMS programs. The District works primarily with three of the 29 units of IFAS, although the interdependent units work collaboratively as needed to respond to specific research objectives. The three units are: Agricultural and Biological Engineering, the Gulf Coast Research and Education Center, and Soil and Water Science.

Mr. Cohen noted that currently the District is funding over 30 ongoing research projects and six new projects will start in fiscal year (FY) 2011. The ongoing projects include determining water use for biofuel crops, water requirements for strawberry crop establishment, landscape water needs, and agricultural and urban irrigation controllers. New FY2011 IFAS projects include non-water alternatives for strawberry cold protection, improving current recommendations for strawberry cold protection, irrigation for turfgrass establishment, acceptable irrigation deficits for turf irrigation, and the Florida Automated Weather Network (FAWN). FAWN is a successful ongoing District-funded IFAS project in partnership with the South Florida and St. Johns River Water Management Districts and the agricultural community. In FY2011, FAWN will expand its educational efforts, enhance the urban irrigation scheduling tool and provide new tools to assist growers with irrigation management for cold protection.

Mr. Gramling complimented Mr. Cohen for his efforts in keeping the District ahead of the curve and thanked him for many years of service. Mr. Moore thanked Mr. Cohen for the outstanding job he has done over the years. Mr. Gramling noted that Mr. Cohen developed the AGMOD program. (Track 15 – 00:00/21:04)

This item was presented for the Committee's information, and no action was required.

Since Committee Chair Joerger needed to leave the meeting, he relinquished the gavel to Committee Vice Chair Gramling.

37. **<u>Surface Water Improvement and Management Program Overview</u>**
Ms. Jennette M. Seachrist, SWIM Program Manager, Resource Data & Restoration Department, provided an update on the staffing, completed and ongoing projects, funding and trends associated with the District's Surface Water Improvement and Management (SWIM) Program. For 23 years, the District's SWIM Program has improved water quality and restored habitats in these ten priority water bodies: Tampa Bay, Rainbow River, Banana Lake, Crystal River/Kings Bay, Lake Panasoffkee, Charlotte Harbor, Lake Tarpon, Lake Thonotosassa, Winter Haven Chain of Lakes, and Sarasota Bay. Since 1987, the SWIM Program has completed more than 250 water quality improvement and habitat restoration projects, which are providing treatment to over 50,000 acres of watershed and improvement to more than 6,000 acres of impacted habitat. The SWIM Program and these projects have received 49 environmental excellence awards.

Ms. Seachrist noted that one of the keys to the success of the SWIM Program has been the District's Basin Boards and many partnerships with local governments. State and federal agencies have also been key partners with funding or with in-kind services. Since 1998, approximately $245 million has been budgeted for SWIM projects, which include several large District initiatives such as Lake Panasoffkee Restoration, Lake Hancock Outfall Treatment System, and the Sawgrass Lake Restoration projects. The State has provided approximately 50 percent of the funding for SWIM projects through fiscal year 2009. Each year the District's SWIM Section produces an annual report of the program accomplishments. The 2009 Annual Report was updated in June 2010 and was included in the Board's meeting materials. (Track 16 – 00:00/31:23)

This item was presented for the Committee's information, and no action was required.

At Committee Vice Chair Gramling's request, Ms. Veronica Craw, Environmental Manager, Resource Projects Department, noted that the Environmental Protection Agency (EPA) has released a pre-publication of the final Water Quality Standards for Flowing Waters and Lakes within the state. She said it is important to note that the final rule that was pre-published is for freshwaters only and does not cover estuarine or coastal systems. Ms. Craw said the rule has not been published in the Federal Register which is expected this week. She said staff is reviewing the technical aspects of this rule and an update will be provided at the December Board meeting. In response to Committee Vice Chair Gramling's question, Ms. Craw said the EPA has delayed implementation or enforcement of the rule for 15 months; however, there is a portion of the rule which is effective immediately regarding the site specific alternative criteria process. (Track 17 – 00:00/03:00)

Submit & File Reports

The following items were submitted for the Committee's information, and no action was required.

38. **Scientific Peer Review of Recommended Minimum Flows for the Homosassa River System and Staff Response**
39. **Scientific Peer Review for Upper and Middle Withlacoochee River and Staff Response**

Committee Vice Chair Gramling said two speaker cards have been submitted.

Mr. Ron Miller, representing the Homosassa River Alliance, said District staff has presented the information to the Alliance which takes exception to the minimum flows and levels (MFLs) projected, and investments made in the area to protect the coastal springs and rivers. He requested that the Homosassa River be protected now by allowing any additional major wellheads to take water and keep the MFLs at current levels. (Track 17 – 03:00/08:10)

Mr. Al Grubman, representing TOOFAR, had to leave but left a handout for the Board which was distributed.

Routine Reports

The following items were provided for the Committee's information, and no action was required.

40. **Florida Forever Funding**
41. **Minimum Flows and Levels**
42. **Structure Operations**
43. **Watershed Management Program and Federal Emergency Management Agency Map Modernization**
44. **Significant Water Supply and Resource Development Projects**
    - Mr. Wirth provided an update on Lake Henry in the Winter Haven Chain of Lakes. This issue involved a structure which is one of four that was turned over to the Lakes Region Lakes Management District (LRLMD). There was a subdivision built that has several properties built historically too low. The golf course had to be shut down off and on for several weeks due to high water. Staff held a workshop for residents and Mr. Senft was in attendance. At the end of September, high water was being experienced and the District requested the LRLMD to lower Lake Henry which was done. (Track 17 – 08:10/12:25)

Ms. Closshey requested an update on the arsenic issue at a future meeting and whether there are any opportunities which may be beneficial to the District.

Resource Management Committee Vice Chair Gramling relinquished the gavel to Finance and Administration Committee Chair Tharp. (Track 17 – 12:25/13:05)

Finance and Administration Committee

Discussion Items

45. **Consent Item(s) Moved for Discussion** – None

46. **Office of Inspector General – Proposed Annual Audit Plan for Fiscal Year 2011**

Mr. Kurt P. Fritsch, Inspector General, said in accordance with Chapter 373 and Section 20.055, Florida Statutes, the Office of Inspector General develops an annual audit plan for approval by the Governing Board. The plan shows the Office's proposed work schedule and presents specific cost estimates for the provision of services. In accordance with Board Policy 140-3, the Inspector General will provide a semi-annual progress report at the April 2011 meeting. In addition, the Inspector General provides a final accounting of the projects in an annual report submitted each October.

Staff recommended to approve the Office of Inspector General's proposed Annual Audit Plan for Fiscal Year 2011. **Ms. Closshey moved, seconded by Mr. Senft, to approve the staff recommendation. Motion carried unanimously.** (Track 18 – 00:00/02:49)

47. **Request for Proposals for Total Compensation (Salary and Benefits) Review**

Committee Chair Tharp thanked staff for their effort in preparing this information. Staff was requested to prepare a Request of Proposals (RFP) to seek a consultant to perform a comprehensive review of the District's salary and benefits, and to ensure continued competitiveness in the District's total compensation package. A copy of the RFP was provided to each Board member for their review and the timeframe for completion was written to run concurrently with the prior RFP for workload and staffing review with a target date of July 1, 2011. The primary factor impacting both of these RFPs is the scope of review with respect to how many of the District's position titles will be benchmarked by the selected consultant. Staff has written the draft to provide for three possible scenarios: (1) performance of a benchmark review for 85 position titles, representing approximately 30 percent of the District's total position titles; (2) performance of a benchmark review for 150 position titles, representing approximately 50 percent of the District's total position titles; and (3) performance of a benchmark review for all District position titles. The draft RFP requests each consultant to provide a recommendation and estimate as to the amount of time and costs associated with each option—performing an 85-position review, 150-position review and a review of all 282 District position titles. (Track 19 – 00:00/03:45)

Committee Chair Tharp requested a motion or Board discussion on the draft RFP and staff's recommendation. Ms. Elaine M. Kuligofski, Director, Human Resources & Risk Management Department, noted there is an option for oral presentations before the Board.

Board members voiced their opposition to the salary and benefits review which included salary raises not occurring, low employee turnover, first completing the workload and staffing review, low morale at a number of agencies due to salary freeze, and staff treated fairly and properly relative to the private sector. (Track 19 – 03:45/09:30)

Committee Chair Tharp said one speaker card has been submitted.

Ms. Janet Dougherty, former Governing Board member and a resident of Riverview, said the District is a great oversight for citizens' tax dollars and the SWIM projects reviewed earlier are indicative. She said the District is run like a business and tax dollars are well spent. She spoke in support of District staff, and the great work being done. (Track 19 – 09:30/12:50)

Board comments ensued regarding not spending money at this time for a study, issues with morale not because of salary and benefits, staff motivated by ways of doing their jobs better, needing recent information when salary raises can occur, not appropriate during the current economic climate, and employees being fairly compensated.

Ms. Closshey moved, seconded by Mr. Pressman, to reject the RFP on salary and benefits, and not conduct the study. (Track 19 – 12:50/19:35)

Discussion ensued regarding a past study (KPMG) showing that additional staff was needed and having information that is current so staff knows they are being compensated fairly.

Motion carried with Messrs. Adams, Combee, Senft and Tharp voting in opposition. (Track 19 – 19:35/23:48)

Ms. Closshey requested that, at the time salary raises are contemplated, staff include in the work plan a study prepared so the Board has current information to act on. Board members were in agreement with Ms. Closshey. (Track 19 – 23:48/26:45)

Submit & File Report

The following item was submitted for the Committee's information, and no action was required.

48. **October 2010 Interim Report on Workforce and Vendor Diversity**

Routine Reports

The following items were provided for the Committee's information, and no action was required.

49. **Treasurer's Report, Payment Register, and Contingency Reserves**
50. **Management Services Significant Activities**
(Track 19 – 26:45/27:34)

Finance and Administration Committee Chair Tharp relinquished the gavel to Chair Oakley.

General Counsel's Report

Discussion Items

51. **Consent Item(s) Moved for Discussion** – None

52. **District's Authority to Lend Matching Funds to Cooperators**
Ms. Lori Tetreault, Senior Attorney, noted that, at the September 2010 Governing Board meeting, staff was asked whether the District could loan money to local governments to assist those governments in making up their percentage contribution within the cooperative funding process. Included in the Board's meeting materials was a Memorandum of Law explaining that the District may clearly establish a revolving loan program for Alternative Water Supply (AWS) projects for both public and private entities. It may be possible to establish a revolving loan fund for other kinds of projects, such as traditional water supply or water resource developments, although the legal authority for projects other than AWS is somewhat less clear. The Governing Board may wish to seek clarification on this issue from the Legislature. Before establishing any District loan fund, the Board may wish to consider the need, if any, by local cooperators, whether there are legal constraints on local governments concerning a new loan fund, the source or sources of District capitalization, and the administrative and operational resources required to establish and maintain such a loan fund.

This item was presented for the Board's information, and no action was required.

Submit & File Report

Routine Reports

The following items were provided for the Committee's information, and no action was required.

53. **Litigation Report**
54. **Rulemaking Update**
(Track 20 – 00:00/05:44)

Committee/Liaison Reports

55. **Joint Green Industry/Agricultural Advisory Committee Meeting**
Mr. Tharp said the joint meeting was held on November 4, 2010. Topics discussed included updates on the January 2010 freeze event management plan, staff delegation and Governing Board action on Individual Permits, hydrologic conditions and water shortage plan, MFL Priority List and Schedule, SWUCA Recovery, public service advertising for appropriate fertilizer use, and economic feasibility of reclaimed water use by non-utility end users.

Mr. Pressman provided an update on the November Tampa Bay Regional Planning Council meeting which included a presentation on Florida's Broadband Initiative. (Track 21 – 00:00/01:40)

Executive Director's Report

56. **Executive Director's Report**
- Mr. Moore said the Board was given a handout about the Strategic Plan for the members to provide feedback. He noted that this handout shows the plethora of tools available under Water Supply. He said, over the next year, staff will bring to the Board the major programs being undertaken and provide a presentation showing where dollars and staff resources are allocated. He said staff is looking for feedback from the Board about whether it is comfortable with the strategic initiatives or should new initiatives or programs be identified. Board discussion ensued. (Track 21 – 01:40/05:30)

Chair's Report

57. **Chair's Report**
- Chair Oakley said that the Board was provided a list of items discussed at the workshop held in September. He noted that several items were presented at today's meeting.
- Chair Oakley noted that two new members of the Basin Boards—Messrs. Al Grubman and Mac Martin—attended a portion of today's meeting.
- Chair Oakley said Board members and staff attended a tour of Highlands Hammock State Park to view lands which had been restored. They also visited the City of Lake Placid to view a cooperative funding project for stormwater cleanup and then traveled to the Archibold Research Station to see progress on the new education center.

There being no further business to come before the Board, Chair Oakley adjourned the meeting. (Track 21 – 05:30/11:35)

The meeting was adjourned at 3:48 p.m.

Appendix V

District staff response (shown in red font or within comment balloons) to:

Hackney, C.T., Peterson, M.S. and Motz, L.H. 2010. Scientific review of the recommended minimum flows for the Homosassa River system scientific peer review report, October 17, 2010. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

SCIENTIFIC REVIEW OF THE RECOMMENDED MINIMUM FLOWS FOR THE HOMOSASSA RIVER SYSTEM

Scientific Peer Review Report

October 17, 2010

Prepared For:
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34609-6899

Prepared By: Scientific Peer Review Panel

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Scientific Peer Review of Proposed Minimum Flows and Levels for the Homosassa River System

EXECUTIVE SUMMARY

The Review Panel visited the Homosassa River system via boat and portions of the Hidden River by land. We accepted the District‟s charge to the panel and formulated eight questions that we felt must be answered before accepting the minimum flows proposed for this river system. The Panel agrees that the Homosassa River System‟s flow is dominated by spring discharge and minimum flow criteria do not need to be evaluated seasonally. The District‟s approach of using a threshold of acceptable change, 15%, is reasonable and defensible. The District has amassed an adequate database for purposes of the MFL (Minimum Flows and Levels) evaluation, although there was a lack of historical data for some biological components and some additional analyses of some biological data might be useful. The District has followed a credible and defensible approach in determining that current groundwater pumping in the Northern District has not affected the quantities of base flows in the Homosassa River system. However, the impact that groundwater pumping in the Northern District has had and will have on salinity and other water-quality parameters in spring discharges and base flows in the river is not well understood. The current assumption that salinities in the Homosassa River system today represent base flow conditions needs further evaluation. Changes in the quality of water exiting springs are as critical to future biological resources as changes in overall flow. Traditionally, reductions in downstream flow result in the upstream migration of the freshwater-saltwater boundary. In the Homosassa System, however, there is the additional impact of saline water flowing from springs. Evidence presented by Leeper et al (2010) is adequate to conclude that the proposed maximum 5% reduction in Minimum Flow satisfies the language and intent of the Statute and will result in "no significant harm" to the flora and fauna of the Homosassa River System. The use of the Homosassa River by Manatees as a thermal refuge in winter will not be impacted by this reduction. Suggestions for additional data collection and analyses are made in this review.

Comment [dl1]: District staff agrees with the Peer-Review Panel‟s (the Panel‟s) assertion that historical data for many biological components of the Homosassa River system is rather limited, but notes as the Panel does in their report, that comprehensive biological data sets are rare for most ecosystems.

The Panel‟s recommendation regarding alternative approaches for evaluating biological responses to changes in flow at the community or assemblage level is acknowledged, although staff are not prepared to implement this type of analysis using the data that are currently available for the Homosassa River system.

Comment [dl2]: Staff agrees that withdrawal impacts on salinity and other physiochemical characteristics of waters discharged from individual springs or spring vents in the Homosassa River system is not well understood. Staff note, however, the Panel has acknowledged that current groundwater pumping has not substantially affected the quantities of base flows in the Homosassa River System. If this is so, then any potential salinity increases in the system must be related to something other than withdrawals. There have been well-documented long-term declines in rainfall since 1970, especially pronounced since 1989. Water budget information developed using the Northern District Model indicates that the increase in groundwater withdrawals (+0.1 inches/yr) during a very dry year (2000) within the groundwater basin was very small compared to the reduction in recharge (-7.2 inches/yr). Therefore, the vast majority of impact on spring discharge is related to drought conditions. Any salinity changes must be mostly attributed to this condition.

INTRODUCTION

The Florida Legislature requires that Water Management Districts establish minimum flows and levels (MFLs) for state surface waters and aquifers within its boundaries. The purpose of the statute is to protect Florida‟s water resources for the future. This protection extends to the fauna and flora within the water body through the requirement that the ecology of the area be protected from "significant harm" (Florida Statutes, 1972 as amended, Chapter 373, Section 373.0421). Once Water Management Districts have determined an MFL for a watershed, maintenance of the MFL becomes part of the planning process for future withdrawals. The same Florida statute requires that Districts develop strategies that will achieve recovery to the MFL within 20 years or to prevent withdrawals from decreasing flows below the determined MFL.

Water management districts are required to use the best information available in establishing the MFL for a watershed and to plan for low water flow conditions associated with season. A minimum flow is the point below which further water withdrawals will cause significant harm to the water resources or ecology of the area or significant harm to the water resources of the watershed. Thus, Water Management Districts must consider a wide array of impacts in the development of their MFL levels based on a variety of different information, which may be more robust for some resources than others.

The Southwest Florida Water Management District (SWFWMD) has begun the process of developing MFLs for watersheds within their district. Using guidance provided through Florida Statutes, SWFWMD has used a data collection/data review process to develop a recommended MFL for 15 of its watershed segments. Each of these recommended MFL levels was evaluated by a panel of independent reviewers. The Panel examines documents and data provided by SWFWMD staff and makes a recommendation with respect to the proposed MFL. Once the Panel recommendations are reviewed by SWFWMD, minimum flows are codified by rule and used in future decision making within the specified watershed segment.

Because many of the watersheds have been structurally altered by canals, dams, etc, identifying a baseline condition that incorporates structural and hydrological

alterations within the hydrologic system is not straightforward. Determining MFLs for a watershed must incorporate current conditions and often uses data which may or may not have been affected by these structural alterations.

A number of the SWFWMD watersheds, including the Homosassa River, are dominated by artesian spring flows from the Floridan aquifer. How water moves through the Floridan aquifer is not as easy to understand as surface-water flows. While this adds a level of complexity not found with watersheds dominated by surface-water flow, it does simplify the development of an MFL since most of the annual variation resulting from seasonal variations in rainfall is eliminated.

The development of MFL"s must consider protection of not just water resources, i.e., freshwater flow, storage, etc, but attributes of the natural world associated with flows or water levels that are valuable to people (State Water Resources Implementation Rule, Chapter 62-40.473, Florida Administrative Code). Recreational values inherent in fishing and hunting are important considerations in setting MFL and dependent on the aerial extent of freshwater, marine, and estuarine habitats associated with a river. Navigation and aesthetic values should be considered as well as the function of a river system in absorbing and transporting nutrients and sediment. The development of a**n** MFL for any system is a complex undertaking.

The Panel for the review of the MFL for the Homosassa River system was provided a draft copy of the report prior to an on-site visit on August 10, 2010. During that visit, we observed by boat almost the entire system, with special emphasis on springs, which are the primary sources of river flow. We also visited, via vehicle, the Hidden River and its watershed. The Panel met the evening of 10 August 2010 and discussed our initial impressions of the Homosassa River system and what we felt were key questions which needed to be answered in the MFL recommendation and supporting documents. These questions became the focus of our review process. Central questions were:

1. Is the District"s threshold of a maximum 15% change of resource within the system a reasonable approach?
2. Was there an adequate data base for development of the regression model?

3. Was there an adequate data base for development of the hydrodynamic model?
4. Were the models used by the SWFWMD the best models for determining the MFL for the Homosassa River system?
5. Was the data collection approach adequate to determine the past and present natural resources on the river system?
6. Were appropriate assumptions and analyses made in the use and extrapolation of these data?
7. Was the weight of evidence enough to convince the panel that the recommended MFL satisfied the Florida Statute establishing the MFL requirement?
8. Are there additional data that should be collected in the future that would add confidence to the MFL SWFWMD recommendations?

The following sections are arranged as follows: Critical Questions, General Comments and Recommendations related to the eight questions above. Specific Comments follow and are aspects of the document or appendices we found confusing or that appear inaccurate. These should be corrected or explained to eliminate the confusion. Finally, there is an Errata Section.

Critical Questions

Question #1 - Is the District"s threshold of a maximum 15% change of resource within the system a reasonable approach? **Yes**, while it may be somewhat arbitrary, setting a quantifiable threshold provides a means to evaluate the impact that reductions in discharge would have on fish and invertebrates, salinity-based habitats, and the extent of thermal refuge for the Florida manatee. While reasonable, many of the r^2 values were low (but significant) and only positive relationships were examined. Both positive and negatives ones should be examined if the goal is to not dramatically change the community structure of the entire system.

Comment [dl3]: Staff does not support use of negative or inverse relationships between flows and predicted abundances of plankton and nekton for development of minimum flow recommendations for the Homosassa River system. When attempting to identify allowable percentage of flow reductions that could be used to establish minimum flows, it seems reasonable to consider competent, direct relationships for predicting declines in freshwater and estuarine taxa that may be associated with flow reductions. In contrast, it is not clear how competent, inverse relationships, which if available would predict increased abundances with decreased flows, could be used for minimum flows development. In many instances, increases in individual estuarine-dependent taxa that are associated with lower flows could be viewed as beneficial. With regard to addressing changes in community structure through use of direct and indirect relationships between flows and organism abundances, staff has not identified a practical approach that could be used for minimum flows purposes.

Question 2 - Was there an adequate data base for development of the regression model? **Yes**, the salinity, tide stage, and discharge records for gage sites in the river and the salinity measurements made by SWFWMD and other agencies provided an adequate data base for the empirical regression models developed to describe salinity in the main channel of the Homosassa River. **Yes**, for most of the biological response measures (plankton, fishes, and manatees). The benthic analysis was incomplete, however. There were also considerable data sets for SAV and EAV that seemed to contradict each other.

Comment [dl4]: Staff notes that subsequent to the Panel"s review of the draft minimum flows report for the Homosassa River system, the September 2010 report by Grabe and Janicki titled "Characterization of Macroinvertebrate Communties of the Homosassa & Hall"s Rivers" was finalized. The finalized version of the Grabe and Janicki report was used to update appropriate sections of the minimum flows and levels report and was added to the updated report as Appendix D.

With regard to the Panel"s comments regarding information presented on submersed and emergent aquatic vegetation, staff note that information included in the draft minimum flows and levels report was representative of results presented in published studies. Staff does not agree that the information presented is contradictory, but does acknowledge that available information on the vegetative communities of the system is insufficient for development of quantitative tools that may be used to predict responses to changes in flows and salinities.

Question 3 - Was there an adequate data base for development of the hydrodynamic model? **Yes**, the stage, salinity, and temperature data at the USGS Shell Island gage, the salinity and temperature data at the USGS Homosassa Springs and SE Fork gage sites, the discharge data at the USGS Homosassa Springs, SE Fork, and Homosassa Springs gages used to model the discharge at Halls River, the salinity data in Halls River and at the Homosassa Springs gage, and meteorological data measured at the FAWN-IFAS station at Brooksville in general provided an adequate data base for development of the hydrodynamic model.

Question 4 - Were the models used by the SWFWMD the best models for determining the MFL for the Homosassa River system? **Yes,** the EFDC hydrodynamic model is well documented in the literature, and it has been widely used to simulate flows and water-quality parameters in estuarine and coastal applications. Also, the use of regression models to empirically relate river discharge and salinities is acceptable. The assessment of the impacts of pumping on spring discharges (Basso 2010) is based on a proprietary version of MODFLOW, which also is well documented and widely used to simulate groundwater flow systems. Additional study of the relationship between withdrawals and spring flow at different springs should be done with the goal of understanding any potential increases in salinity at saline springs or decreases in flow at freshwater springs that might be caused by withdrawals.

Comment [dl5]: Staff agrees that increased data collection and monitoring will increase our understanding of salinity changes in springs of the Homosassa River system. However, numerical modeling results have indicated little, if any potential salinity changes are related to baseflow reductions or decreased coastal discharge related to withdrawals.

Staff notes that any future requests for withdrawals in the region will likely be associated with permit conditions that require sampling and/or evaluation of spring water quality and discharge, and this information, in combination with modeled and measured/reported water use would be expected to provide an initial means for evaluating withdrawal effects on site-specific water quality.

Question 5 - Was the data collection approach adequate to determine the past and present natural resources on the river system? **Yes**, with respect to flow, this approach is quite adequate to conclude that present-day spring and river discharges can be considered baseline or natural flows [also, please see response to the next question concerning water quality]. The approach assumed that present-day flow records were representative of past, or baseline, conditions based largely on the determination using a numerical groundwater flow (Basso 2010) that groundwater pumping in the Northern District of SWFWMD has reduced historical spring flows in the Homosassa River system by an insignificant amount (approximately 1 percent). With respect to many natural components, the answer was **no**. There were some data for SAV/EAV and water quality from earlier reports, but not much else besides those. Obtaining data on past resources that are not considered of economic value is often difficult. Data collected as part of the current MFL document will serve as a baseline for future modification of MFL evaluations.

Comment [dl6]: Staff appreciates the reviewers comments regarding the availability of information that may be used to characterize existing and historical natural resources of the Homosassa River system. Staff notes that the District has invested substantial funds for the acquisition and analysis of biological data for the Homosassa River system, including information on the distribution and abundance of fish and invertebrate plankton and nekton, barnacles, mollusks, benthic macroinvetebrate assemblages, and aquatic and semi-aquatic vegetation. In addition, historical data associated with plant and animal assemblages of the river system was reviewed and summarized for the minimum flows report. Staff agrees that in sum, this information will serve as a baseline for future research and management activities in the region.

Question 6 - Were appropriate assumptions and analyses made in the use and extrapolation of these data? In response 5 above, **yes** it is reasonable to assume that present-day spring and river discharges represent baseline or natural flows. However, it can only be inferred that present-day salinities discharging from the springs into the river system are still at natural levels. Based on the lack of a calibrated numerical groundwater transport model for the Northern District or other means to address this issue currently, this is the best that can be done at this time. Addressing the need for data that can be used to calibrate such a model should be a priority for future research and monitoring.

There were also some questions of providing additional information with respect to assumptions used in the detailed analyses provided. For example, low r or R values in many analyses were not compared to the „norms" of statistical procedures. These should be provided.

Question 7 - Was the weight of evidence enough to convince the panel that the recommended MFL satisfied the Florida Statute establishing the MFL requirement? Generally, **yes**, it would satisfy the statute, but because of the variability and low predictability of input data, there could be problems with the accuracy of the predictions.

Question 8 - Are there additional data that should be collected in the future that would add confidence to the MFL SWFWMD recommendations? Yes, as noted in previous questions, priority should be given to collecting additional data as part of an investigation intended to resolve some of the salinity and temperature results obtained using the hydrodynamic model. Also, additional groundwater quality data should be collected as part of an investigation to better understand the flow and water-quality aspects of the springs in the Homosassa springshed and to determine whether spring salinities will increase in response to increased groundwater pumping in the Northern District of SWFWMD.

Comment [dl7]: Data is currently limited to calibrate a sub-regional saltwater intrusion model of the area. The District has an aggressive 10-year data collection program consisting of monitor well installation, exploratory drilling, water quality sampling, and aquifer testing that has been underway since 2005 as part of the Northern District Water Resource Assessment Project. The District also maintains a coastal saltwater intrusion network of monitor wells that have been sampled quarterly since the early-1990s. Monitoring data does not currently indicate a threat of regional saltwater intrusion. Numerical modeling does not indicate that significant reductions in spring discharge or coastal discharge are occurring due to groundwater withdrawn in the basin.

Comment [dl8]: District staff and HSW Engineering, Inc. generally agree with the Panel"s comments regarding collection of additional data to support modeling of salinity and temperature in the Homosassa River system. However, given the similarity between results obtained with the statistical and hydrodynamic models, we do not expect that the predicted relationships between changes in area or volume as a function of flow reductions would change substantially as a result of additional data collection. Also, given the uncertainty associated with the freshwater flow data input to the model, including magnitude and location of flows in the river corridor, it may be that some data enhancements (e.g., collection of additional bathymetric data) will not contribute much to resolution of the uncertainty associated with model predictions. Staff has attempted to address issues related to modeling domains for the river system by incorporating area and volume estimates for upper portions of the system into additional evaluations of flow-related changes in salinity-based habitats that were included in a revised minimum flows report. In addition, the District is funding additional streamflow and water quality data collection by the United States Geological Survey at the Southeast Fork Homosassa River gage site and at a new gage site in Halls River.

Comment [dl9]: As noted in the response to the Panel"s Question 6, additional water quality collection sites are planned in the Homosassa Springs contributing area.

We feel the District should take a multivariate approach as illustrated in their analyses in the appendices using Primer statistics. The goal of the MFL process is to do no „significant harm", which in many cases is a professional judgment call. The suggested multivariate approach outlined at the end of this document (The sections on Chapters 4 & 5) would improve the ability to make predictions of potential outcomes based on flow reductions. These outcomes would be more holistic and at the heart of the MFL process.

Comment [dl10]: Staff appreciates the appeal of a multivariate approach, but is unsure how results from such an analyses could be used for development of minimum flow recommendations. Staff also notes that development and use of an appropriate multivariate approach would be predicated on development of multiple, competent univariate relationships, and is not confident that such relationships exist for the Homosassa River system.

General Comments and Recommendations

Water Quality in the Springs

The water quality in the springs that discharge into the Homosassa River system varies from fresh to brackish. The Homosassa Main Springs and Halls River springs discharge brackish water, and the springs of the Southeast Fork discharge relatively freshwater, based on Yobbi and Knochenmus (1989). Halls River Head Spring, Homosassa Springs, and Hidden River Head Spring discharge sodium-chloride water, which indicates a seawater origin, and Trotter Spring in the Southeast Fork discharges mixed-ion water, which is the result of freshwater and saltwater mixing (Knochenmus and Yobbi 2001). The variability of the quality of the water discharging from the springs of the Homosassa River system is explained in terms of the existence of a coastal transition zone between freshwater and saltwater in the groundwater system (Leeper et al. 2010). Differences in water quality among springs are attributed to the depth of individual spring vents, the proximity of a spring to the Gulf of Mexico, and the transient location of the saltwater-freshwater interface, which creates a zone of mixing that changes seasonally and diurnally (Knochenmus and Yobbi 2001). The transition zone moves horizontally and vertically in the Floridan aquifer in response to tidal fluctuations in the Gulf of Mexico and changes in water levels in the aquifer (Champion and Starks 2001). The age and residence time of groundwater discharging to springs in the Homosassa River system apparently have not been determined. However, in a somewhat similar hydrogeologic setting in the Suwannee River basin, relatively young ages and residence times of spring discharges ranging from 5 to 50 years were estimated by Katz et al. (1999). In general, these description and explanations of water-quality variations among the springs can be summarized in terms of the hypothesis that present-day seawater intrusion and recirculation in an active groundwater flow system result in a saltwater-freshwater interface that moves horizontally and vertically in response to tides and changes in regional groundwater levels, causing spatial and temporal variations in salinities in the springs. In this context, it can be expected that future withdrawals of freshwater from the groundwater system in the Northern District that affect groundwater

levels also may affect spring flows and water quality in the Homosassa River system. Potentially, withdrawals of fresh groundwater in inland areas will reduce freshwater spring discharges and also cause the saltwater-freshwater interface to move farther inland, thus resulting in a disproportionate increase in salinity in the spring discharges into the river system. Accordingly, the Panel recommends that SWFWMD conduct future investigations to better quantify the relation between the salinities of the springs discharging into the Homosassa River and saltwater intrusion in the Floridan aquifer. Also, the Panel recommends that SWFWMD investigate the impacts that groundwater pumping in the Northern District potentially has had and will have on salinities and other water-quality parameters in the springs and base flows in the Homosassa River system.

Comment [dl11]: Staff acknowledges the Panel"s comments and notes that this issue has been addressed in responses to comments identified earlier in this peer-review document.

Groundwater Modeling

For the purpose of developing minimum flow recommendations, the Homosassa River system is considered by SWFWMD to consist of the Homosassa River, Southeast Fork of the Homosassa River, Halls River, Hidden River, and springs associated with these rivers (Leeper et al., 2010). As described by Leeper et al. (2010) and in more detail by Basso (2010), it was determined that current groundwater use in Citrus, Hernando, Pasco, and Sumter counties has not had any significant impact on spring discharge in the Homosassa River system. This was accomplished by running the Northern District groundwater model (HydroGeoLogic, Inc., 2008) for two scenarios, i.e., one scenario representing 2005 conditions and the other with no pumping representing pre-development conditions. It was concluded that the resulting decrease in spring discharge in the Homosassa River system represents an insignificant decrease of 1.1 percent. Based on this result, the measured and modeled flows used in the minimum flow analyses were considered baseline or natural flows. The Northern District groundwater model is a fully three-dimensional groundwater flow and saltwater intrusion model developed by HydroGeoLogic, Inc. (2008) for the northern part of SWFWMD consisting of Hernando, Sumter, and Citrus counties and parts of Pasco, Polk, Lake, Marion, and Levy counties. The groundwater flow and solute transport code MODFLOW-SURFACT was used to develop a numerical groundwater flow model of the Northern District and to develop a saltwater-intrusion model for the coastal areas of the Northern District. The groundwater

flow model was calibrated to steady-state conditions representing 1995 and to transient conditions representing 1996 to 2002. However, as pointed out by HydroGeoLogic, Inc. (2008), the saltwater intrusion model was not calibrated; instead, a qualitative evaluation was conducted to assess whether the saltwater intrusion model produced the general distribution of chlorides observed from monitoring wells.

SWFWMD has followed a credible and defensible approach in determining that current groundwater pumping in the Northern District has not affected the quantities of base flows in the Homosassa River system and thus that recently measured flows in the Homosassa River system can be treated as base flows without adjustment in this study. The impacts that future increased groundwater pumping will have on the quantities of spring discharges and base flows in the Homosassa River system were not addressed in Appendix B (Basso 2010), but it is certainly reasonable to conclude that the Northern District groundwater model also could be used to assess such impacts. Thus, the impact that groundwater pumping has had and will have on the quantities of the spring discharges and base flows in the Homosassa River system appears to be well defined. By contrast, the impact that groundwater pumping in the Northern District has had and will have on salinity and other water-quality parameters in spring discharges and base flows in the river is not well defined. It can only be inferred that recently measured salinities in the Homosassa River system represent base flow conditions, because the lack of a calibrated saltwater intrusion component in the Northern District groundwater model precludes a quantitative assessment of salinity changes in the spring discharges using this model. The assessment of groundwater conditions and impacts described by Basso (2010) and summarized by Leeper et al. (2010) is quite adequate based on the criterion of using the "best available information" concerning the quantities of the spring discharges and base flows in the Homosassa River system. However, determining how salinity and other water-quality parameters in the springs that discharge into the Homosassa River system will change in response to changes in groundwater pumping in the Northern District cannot be accomplished currently using the existing Northern District groundwater model. Accordingly, the Panel recommends that SWFWMD add a calibrated saltwater intrusion component to the Northern District groundwater model in a

Comment [dl12]: Data are currently limited for calibration of a saltwater intrusion model of the area. The saltwater intrusion model developed by HydroGeoLogic, Inc. was adequately conceptualized based on existing data. Staff believes the saltwater intrusion modeling conducted by HydroGeoLogic, Inc still provides important information on the role of groundwater withdrawal impacts on regional movement of the interface. Groundwater flow modeling and water budget analyses indicate that current groundwater use in the basin has little impact on spring discharge or coastal groundwater discharge and that variations in recharge due to climatic conditions have directly contributed to recent changes in spring and coastal discharge.

Comment [dl13]: The Panel is correct in noting that the Northern District Model can be used to evaluate the effects of future groundwater pumping on spring discharge in the Homosassa River system. This type of analyses has, in fact, been completed for projected water demand in 2030 and results from these analyses have been included in the revised minimum flows report.

With regard to baseline salinities in the river system, staff asks that if the groundwater flow model correctly predicts that groundwater withdrawals have negligible impact on spring discharge and river base flows, then is it not reasonable to assume that if there are changes in salinity, it is due to some other factor? It is not clear to staff how much additional understanding would be gained by the addition of a calibrated saltwater intrusion model to the minimum flow analyses. However, as additional data are collected over the next five to ten years, the District plans to revisit this issue.

future investigation (or otherwise quantify the relation between changes in groundwater pumping and the water quality of spring discharges) to address this issue.

Comment [dl14]: Staff acknowledges the Panel"s comments and recommendation, and considers these issues addressed in previous responses within this document.

Detailed Comments

Chapter 1

The explanation regarding the adoption of the 15% loss standard was useful in reviewing the remaining chapters and sections. There is the potential, however, that this standard might over-emphasize what are essentially very small changes when the initial habitat or resource is small. Caution should also be exercised in assuming that high volumes may be withdrawn during high flow events (page 24). High flow events can be extremely important in resetting systems, e.g. removing accumulated fine organics from sandy bottoms. This may not be an issue for the Homosassa given that the primary discharge is from springs, but should not be universally applied when developing regulations regarding water removal.

Comment [dl15]: Staff agrees with the Panel"s recommendation that use of a fifteen percent limit for evaluating significant harm associated with water withdrawals may be overly conservative when the extent or amount of baseline habitat or resource is relatively small.

Comment [dl16]: Staff appreciates the Panel"s concerns regarding the potential need for careful consideration of withdrawal limits during periods of high flows. Staff agrees with the Panel that this issue is not particularly applicable to the Homosassa River system, given the dominance of relatively stable spring discharge to the system. Staff also notes that it is confident that surface water withdrawals will not be permitted from the springs or flowing water bodies that comprise the system.

Chapter 2

On pages 38-39, land use in the Homosassa River drainage basin was mapped and delineated for 1990, 1995, 1999, 2004, 2005, 2006, 2007, and 2008 (Table 2-1). The point is made that generally little change occurred in land use/cover in the watershed in the years between 1990 and 2008 (Table 2-1). This observation is somewhat limited in value, however, because the Homosassa River *surface-water* drainage basin, which consists of approximately 55.6 square miles, overlies only part of the Homosassa Springs *groundwater* basin, which consists of approximately 270 square miles (Knochenmus and Yobbi 2001). This is clearly indicated in Figure 2-6, on page 37. The observation that land use has not changed significantly would be better made if land use from 1990 to 2008 in the groundwater basin, or springshed, could be compared. Apparently this section was written to point out that land-use has not changed from 1990 to 2008 and, thus, that the springs have not been affected during this period. If so, this point should be made explicitly.

Comment [dl17]: Staff agrees that it could be useful to develop land-use information based on springshed boundaries as well as watershed boundaries. This information is not considered critical to the development of minimum flow recommendations for the system, and as such, has not yet been developed. Staff will evaluate the need for development of ground-water basin land-use data for future minimum flow evaluations.

Box plots are used in figure 2-12 (page 48) and in many others throughout the report to indicate the range of data for tides and other parameters. Are the box plots standardized; do all of the box plots show the same range of information? It is suggested

that the information shown in the box plots (minimum, maximum, median, and lower and upper quartile) be specified the first time this type of plot is used.

Comment [dl18]: Descriptive information for the data represented in the box plot shown in Figure 2-12 has been added to the figure legend in the revised minimum flows report. Similar information was provided for Figure 2-14 in the updated document, and legends for other figures that included box plots were also modified to indicate that the formatting described in the legend for Figure 2-12 is applicable to the data presented in the figures.

The variability of the quality of the water discharging from the springs of the Homosassa River system is described (Page 68, 1st-3rd paragraph) and explained in terms of the coastal transition zone between freshwater and saltwater in the groundwater system. It is noted that the Homosassa Main Springs and Halls River springs have been described as brackish systems and that the springs of the Southeast Fork have been described as freshwater systems (Knochenmus and Yobbi 2001). Differences in water quality of the springs are explained in terms of the differences in the vertical and horizontal location of the transition zone and its spatial and temporal variability. Is it possible to illustrate the relation of the springs to the saltwater-freshwater transition zone by constructing a vertical hydrogeologic cross-section aligned with the direction of groundwater flow based on existing water-quality data and/or the numerical modeling results (Hydrogeologic, Inc. 2008) described by Basso (2010) in Appendix B?

Comment [dl19]: It is possible to construct a hydrogeologic cross-section for the Homosassa River system area, but data are currently unavailable at the scale and precision needed to infer more than a generalized conceptual model of subsurface flow. The orientation and geometry of relict karst activity, which provides the conduit flow for many of the springs, is largely unknown.

Ratios between top and bottom salinities in the Homosassa River during 1984 and 1985 (page 78) were on the order of 0.85 to 1.0 (Yobbi and Knochenmus 1989), i.e., top salinities generally were equal to or less than bottom salinities. In Figure 2-31 (page 80), synoptic salinity profiles for the river surface in 2007 and 2008 are shown in the top panel, and salinity profiles for the river bottom are shown in the bottom panel. The surface salinities generally appear to be less than corresponding bottom salinities for these measured data. However, the median values for the EFDC model in the top panel of Figure 2-31 for surface salinity appear to be greater than the corresponding bottom salinities for the EFDC model in the bottom panel of Figure 2-31. Is there a contradiction between the observed salinity data and the EFDC model results shown in Figure 2-31? If so, an explanation needs to be provided. [Please see further comments below pertaining to Appendix A (HSW Engineering, Inc. 2010) in which salinity profiles shown in Figure F-3 along with the salinity profiles shown in Figures F-1 and F-2, which correspond to Figure 2-31 in Leeper et al. (2010), also indicate that top salinities generally are less than bottom salinities.]

Comment [dl20]: HSW Engineering, Inc. identified some issues regarding the presentation of median modeled top and bottom longitudinal salinity data in Figure 2-31 and Appendix A in the draft minimum flows report. These issues were resolved in the updated 2011 report titled "A Modeling Study of the Relationships of Freshwater Flow with the Salinity and Thermal Characteristics of the Homosassa River", and this document replaced the original Appendix A included in the draft minimum flows report. Figure 2-31 was also revised for the updated minimum flows report.

The legend for Figure 2-31 (page 80) indicates that the solid green line shows the median EFDC model salinity for the river surface. Figure F-2 in Appendix F (HSW

Engineering, Inc. 2010), which is included in Appendix A of Leeper et al. (2010), indicates that this line is the median EFDC model salinity for the river *bottom*.

Salinity, tide stage, and discharge records were used to develop empirical regressions for modeling or predicting salinity in the main channel of the Homosassa River (Pages 82-83). Summary descriptions of the regression equations are presented by Leeper et al. (2010), and details regarding development of the regression models are provided in Appendix A (HSW Engineering, Inc. 2010). The regression models consist of sets of equations for predicting the locations of surface and bottom isohalines for salinities of 3, 5, and 12 in the Homosassa River based on the combined flow at the USGS Homosassa Springs and Southeast Fork Homosassa Spring gage sites and the tide stage at the USGS Homosassa River stage gage. The equations account for 53 to 59% of the variability in the salinity measurements, based on r^2 values presented in Table 2.10. Are these results acceptable for empirical models, i.e., are there any generally accepted standards or guidelines to which these regression results could be compared?

One main concern is the weakness of the hydrodynamic model results. The authors state and illustrate (Figure 2-37) in Leeper et al. (2010) that the model overestimates and underestimates the empirical regressions at a number of flow rates and locations. In particular, it appears from Figure 2-37 in Leeper et al. (2010) that modeled 3 psu (practical salinity unit) isohaline locations versus flows for all 3 locations (surface, bottom, depth-averaged) between 160-170 cfs are always high (upriver) compared to the empirical model results and those from 120-150 cfs are mainly low in bottom isohaline locations (mid river), but high in surface and depth-averaged locations (mid-river). This is disconcerting as these relate to where the 3 psu isohaline should be for 2007 baseline period, but the hydrodynamic model does not do a good job and thus predictions may also not be accurate. In contrast, the empirical regression r^2 values ranged from 0.63-0.73 and suggest these may do a better job in predicting impact with future water withdrawals.

The predicted locations of the surface, bottom, and depth-averaged 3 psu isohalines as a function of total spring flow for the Homosassa River in 2007 are shown in Figure 2-37 (pages 88-89). Leeper et al. 2010 notes [and it is quite apparent in the top panel in Figure 2-37] that there are significant differences in the model-predicted isohaline locations for surface salinities, i.e., the surface salinities predicted by the EFDC

Comment [dl21]: The inset legend associated with the lower panel of Figure 2-31 was revised. Staff note, however, that the median longitudinal top and bottom salinity data included in the original figure were incorrect. The modeled values in the two panels should have been switched. This figure and correspondeing information were corrected in the revised minimum flows and levels report.

Comment [dl22]: Staff is not aware of any generally accepted standards or guidelines that may be used for evaluation of the regression models used to predict isohaline locations in the main channel of the Homosassa River based on inflow and tide stage.

The range of coefficients of determination (0.53 to 0.59) is lower than the coefficient of determination (r^2) values of 0.88 and 0.85 reported for regressions developed by Yobbi and Knochenmus (1989) using flow and tide-stage data collected in 1984-1985 to predict the location of vertically-averaged salinities of 5 and 2 ppt.

For development of minimum flows for the Weeki Wachee River system, a spring-dominated system near the Homosassa River system, the District developed regressions for predicting locations of isohalines associated with salinities between 0.5 and 20 based on inflow (spring discharge) (Heyl 2008). Coefficients of determination for the regressions were comparable to those derived for the Homosassa River system, and ranged from 0.32 to 0.67.

Larger coefficients of determination, ranging from 0.77 to 0.91 were reported for regression models developed to predict locations of isohalines associated with salinities between 2 and 18 based on inflow and tide stage data for the Anclote River (Heyl et al. 2009). It maybe that the increased ability to predict isohaline location as a function of inflow for this river system, as compared to the Homosassa and Weeki Wachee River systems, is related to the fact that the Anclote River system is not a spring-dominated system and exhibits greater variability in discharge than that in the Homosassa and Weeki Wachee River systems.

Comment [dl23]: Staff notes that issue have been identified with the information that was presented in Figure 2-37. Surface and bottom isohaline locations predicted using the hydrodynamic model that were shown in the upper two panels should have been switched. The depth-average isohaline locations shown in the bottom panel of the figure, are, however, correct.

Staff acknowledges the differences in isohaline locations predicted using the regression and hydrodynamic models, and agrees with the Panel"s suggestion that the empirical-model results may better approximate salinity conditions in the river with respect to inflows.

hydrodynamic model occur farther upstream than locations predicted using the empirical regression models. In the empirical model results, bottom salinities extend farther upriver than the surface salinities, which is consistent with the results of Yobbi and Knochenmus (1989), in which top salinities in the Homosassa River during 1984 and 1985 generally were equal to or less than bottom salinities (see comment above relative to Page 78). However, in the EFDC hydrodynamic model results in Figure 2-37, there is no distinct difference between the surface and bottom isohaline locations. What is the significance of this result? Should it be concluded that the EFDC model over-predicts surface salinities? If so, how does this affect the determination of salinity and temperature changes used to predict the impact of reduced flows in setting minimum flows for the Homosassa River? [Please see further comments below pertaining to Appendix A (HSW Engineering, Inc. 2010) in which the predicted locations for the 5 and 12 psu isohalines in Appendix J are discussed.]

Comment [dl24]: Staff notes the surface and bottom isohaline locations predicted using the hydrodynamic model were erroneously presented in the draft minimum flows report, including Appendix A to the draft document. This error was corrected in the revised report and resulted in improved consistency between hydrodynamic-model predictions and results from application of the regression models, observed salinities, and salinity information presented by Yobbi and Knochenmus for 1984 and 1985.

In Appendix F in HSW Engineering, Inc. (2010), synoptic salinity profiles for the river surface between December 2006 and July 2008 are shown in Figure F-1, and salinity profiles for the river bottom between December 2006 and July 2008 are shown in Figure F-2. The surface salinities generally appear to be less than corresponding bottom salinities for these measured data. However, the median values for surface salinity for the EFDC model for 2007 in Figure F-1 appear to be greater than the corresponding bottom salinities for the EFDC model for 2007 in Figure F-2. Longitudinal profiles of surface and bottom salinity measured on individual dates illustrate water that is generally well mixed or *weakly stratified with bottom salinity several psu higher than the surface salinity* (Figure F-3) [page 2-21, 1st paragraph, italics added]. The measured surface and bottom salinity profiles in Figures F-1 through F-3 apparently contradict the results that were calculated using the EFDC model shown in Figures F-1 and F-2. Is there a contradiction between the observed salinity data and the EFDC model results? If so, an explanation needs to be provided. A similar comment was noted for page 78, line17 (Leeper et al. 2010).

Comment [dl25]: Staff notes the surface and bottom isohaline locations predicted using the hydrodynamic model were erroneously presented in the draft minimum flows report, including Appendix A to the draft document. This error was corrected in the revised report and improved consistency between hydrodynamic-model predictions and results from application of the regression models and observed longitudinal salinity profile data.

Three isohaline models (3, 5, and 12 psu) were developed for predicting the location of surface and bottom water-column salinity isohalines using synoptic data for 2005 through 2009 (p. 2-29, last paragraph and p. 2-30, Table 2-4). The isohaline models

explain about 50% to 60% of the variation in the measurements used to develop the models (Table 2-4 and Appendix I-3). R^2 in Table 2-4 needs to be defined. This parameter is often used to indicate a correlation coefficient, but is that the case here? It is defined in Appendix I-3 in HSW Engineering, Inc. (2010) as R squared = 1 – (Residual Sum of Squares)/ (Corrected Sum of Squares); this definition should be added to Table 2-4. Six values of the standard deviation of the residuals between observed and calculated surface and bottom salinities for 3, 5, and 12 psu can be extracted from the histograms in Appendix I-3 in HSW Engineering, Inc. (2010). Including these values, which range from 0.719 to 1.85, in Table 2-4 would provide an additional means to assess how well the regression models predict salinities.

The maximum observed surface and bottom salinities at the Homosassa River gage and the maximum observed bottom salinity at the Halls River gage (p. 3-11, Table 3-4**)** are significantly greater than the respective simulated salinities at these gages (i.e., 19.13 > 9.60, 18.79 > 9.70, and 16.07 > 4.12 psu). Also, the root mean square errors at these gauges (2.08, 2.02, and 1.15 psu) appear to be relatively large. Are there recommended calibration guidelines for estuarine models to which these results could be compared? For example, the Pearson Coefficient R values in Table 3-4 for the Shell Island gage are relatively large (0.91, 0.90, and 0.90), but the values for the Homosassa River and Halls River gages are relatively small (0.50, 0.55, and 0.35). The values for the Homosassa and Halls River gages, particularly the Halls River value of 0.35, are less than the minimum correlation coefficient of 0.60 preliminarily recommended by EPA (1990) for estuarine water quality models. Does this indicate that the Homosassa River model is not well calibrated?

Comment [dl26]: A definition for R^2 values was not added to Table 2-4 in the updated Appendix A (HSW Engineering, Inc., 2011, A Modeling Study of the Relationship s of Freshwater Flow with Salinity and Thermal Characteristics of the Homosassa River), but was added to the table corresponding to Table 2-10 in the main body of the revised minimum flows report.

Comment [dl27]: Standard deviation of the residuals between observed and calculated isohalines were not added to Table 2-4 in the updated Appendix A (HSW Engineering, Inc., 2011, A Modeling Study of the Relationship s of Freshwater Flow with Salinity and Thermal Characteristics of the Homosassa River), but were added to the table corresponding to Table 2-10 in the main body of the revised minimum flows report.

Comment [dl28]: District staff and HSW Engineering, Inc. are not aware of any standard calibration guidelines for estuarine hydrodynamic models that may be used to evaluate errors associated with predicted salinities for the gage sites in the Homosassa River system.

With regard to the Panel‟s question about the hydrodynamic model calibration, HSW Engineering, Inc. notes that the hydrodynamic model is not well calibrated for 15-minute input data, in particular for the Halls River gage, which is not in the study area (i.e., area and volume estimates associated with Halls River were not used for evaluations of salinity and thermal-based habitats). Lack of good calibration with the 15-minute data is associated, in part, with boundary condition uncertainties. Halls River contributes about 47% (estimated) of the total flow at the Homosassa River gauge. However, no recorded data are available (salinity, flow, and temperature) at that boundary. Estimated data, were used as the upstream boundary condition for Halls River, which introduces uncertainty to the model and increased the difficulty of model calibration at the Halls River gauge.

In addition, as discussed in the revised salinity/thermal modeling report (HSW 2011) included as Appendix A to the updated minimum flows report, there are many downstream side channel tributary interactions with the Homosassa River. Their effects certainly are reflected in the observed salinity data that were used for model calibration. However, due to lack of available data or documents to incorporate such interactions, additional uncertainties have been introduced into the model.

The model does estimate the mean daily salinity reasonably well with correlation coefficients > 0.6.

Appendix B in Leeper et al. (2010), in the second paragraph of the Introduction: Hidden River should be included in this paragraph to be consistent with Leeper et al. (2010) and Table 2 (p. 12). On page 4 of the first line, it states that the "ground-water basin …is approximately 292 square miles…." This is different from the value of 270 square miles in Leeper et al. (2010) (p. 36) that was determined by Knochenmus and Yobbi (2001). However, these values are considered "similar" (Leeper et al. 2010, p. 36), which seems to be a reasonable way of reconciling the difference.

On page 10, 3.2 2005 Scenario: To determine drawdown in the UFA and potential impacts to spring flow in the Homosassa River system, average annual groundwater withdrawals in 2005 (438.1 mgd) were simulated in the NDM…and compared to non-pumping conditions (zero withdrawals). Please clarify who did this analysis, i.e., did HydroGeoLogic, Inc., or SWFWMD do this analysis? Is the 438.1 mgd scenario the same as scenario 1 in the HydroGeoLogic, Inc. (2008) report? It appears to be, but this pumping rate does not seem to be listed explicitly in HydroGeoLogic"s report. Please indicate if the 2005 condition in Basso (2010) is the same as scenario 1 in HydroGeoLogic, Inc. (2008). Also, please indicate the source of the discharge values for the 2005 pumping scenario in Table 2 (p. 12) (apparently they are from Table 5.2 in the HydroGeoLogic, Inc. report).

On page 11, Table 2 states that the discharge at Hidden River Spring Head is reduced 4.0 percent, while all of the other spring discharges are reduced by approximately 1.0 percent, except for Belcher Spring, which is reduced by 2.0 percent. Is the result for Hidden River Spring Head correct? If so, is there a reason why it is so much larger than the other results?

Table 2.8 in Leeper et al. (2010) indicated that the estimated salinity of water coming from different springs varies from 0.1-3.9 ppt, even though they are spatially close. This is perplexing. How can this happen if they are using the same groundwater sources, and we could not find sufficient evidence suggesting why this is occurring nor how this may be influenced differentially by water withdrawals. Is it possible that water withdrawal in one location could only influence the very low salinity springs and thus, elevate the contribution of the high salinity spring water into the system? Ratios of ions in the saline springs (Table 2.6) argues that this is dilute seawater and not just water with

Comment [dl29]: The memorandum by Basso included as Appendix B was not revised for the updated minimum flows report. This document was used to support or serve as ancillary information for the positions outlined in the original and updated versions of the minimum flows report.

Comment [dl30]: Knochenmus and Yobbi did not include an area estimate for the Homosassa river ground-water basin in their 2001 report. For development of the ground-water sub-basin area estimate included in the body of the draft minimum flows report, District staff created a basin boundary from information presented by Knochenmus and Yobbi and then used ESRI ArcGIS software to calculated the basin area. The basin area estimate presented in Appendix B by Basson was determined in a similar manner, and not surprisingly yielded a similar areal value.

Comment [dl31]: Staff ran the non-pumping and 2005 pumping scenarios using the Northern District Model. This is not the same run as scenario 1 which was a comparison of 1995 to 2005 pumping in the referenced HydroGeoLogic Report. The 438.1 mgd is approximately the same as the 2005 pumpage in the HydroGeoLogic report but is slightly different due to variations of historic groundwater use for 2005 that were generated at the time of each simulation. The District updates historic water use as corrections to metered use or changes in estimated use occur. These changes are usually small when considered over the entire area of the model domain. The source of discharge values in Table 2 are from the output of the Northern District Model from District staff"s run. They are the same or closely approximate HydroGeoLogic"s spring discharge numbers in 2005.

Comment [dl32]: While simulated as a four percent reduction, the actual change in simulated springflow is only 0.26 cfs at the Hidden River Head Spring. This is a very small magnitude change in flows. There are a number of parameters that could be related to the slight variance in simulated springflow reduction at this spring as compared to the other springs that were evaluated. Differences in spring pool stage elevation, conductance, local pumping effects or model parameter changes could have contributed to the higher relative change in flows at the Hidden River Head Spring.

high solids derived from minerals in the rock strata through which the springs flow. The oceanic ratio of Na to Mg is 8.213 (Sverdrup et al. 1942), while the ratio in Hall‟s River Spring #1 was 7.8, 7.9 for Hall‟s River Main Spring and 8.08 for Homosassa Main Spring #2. Analyses of any inert sea water derived ions from Table 2.6 found similar sea water-like ratios, arguing that the spring discharged dilute seawater. Is this fossil seawater as has been proposed for other similar Florida springs (Scott et al. 2004)? It appears more data are needed to substantiate and verify why this is occurring as it may have some indirect impacts on the contribution of saline waters to the Homosassa River from springs with high salinity compared to other springs. Additional pumping from the spring shed could have very different impacts if flow was reduced from one of the saline or non-saline springs.

It is not clear that there is an adequate understanding of the aquifer itself, residence time for water in the aquifer, or the ultimate source of salt (fossil or modern source) in the saline springs.

In Leeper et al. (2010, page 84) – the hydrodynamic model is "… somewhat problematic" and suggested model accuracy could be improved by adding data from downstream side channels. They also note water temperatures are slightly under-predicted in warm month and over-predicted in cold months (page 84) suggesting the thermal effect of spring discharge may be underestimated. Also, maximum salinity at the Halls and Homosassa Rivers gage sites were underestimated by the calibration and validation periods.

Finally, in Appendix A, page 2-20, paragraph 2, lines 13-15, the authors state „„.. river stage as measured at the springs is a variable used in calculating spring flow and therefore the independent variables spring flow and tide are related." This is of concern as this interdependence may influence (increase) the models predictability and thus this autocorrelation is problematic from a statistical point of view. How this influences the model outcome and thus prediction is not explained or considered.

Chapter 3 - Vegetation

The narrative in the vegetation section of Chapter 3 (Leeper et al. 2010) is based on a variety of historical and more recent reports (Hoyer et al. 1984, Fraser et al. 2001a,b,

Comment [dl33]: As noted on page 68 of the draft minimum levels report for the Homosassa River system, the District and the United States Geological Survey have previously documented significant variability in water quality parameters for springs of the system. This complexity in water quality is likely the result of diverse flow paths for water moving through bedrock, tidal effects and the mixing of saltwater with freshwater. The peer review document also references the same USGS report (Knochenmus and Yobbi 2001) for the causes attributed to the variability in water quality from mixing of fresh and saline groundwater along the coastal transition zone. We agree with the statement that the observed slightly brackish water discharging from the springs is very dilute seawater, but there is no indication that "fossil" seawater is responsible for the brackish water conditions observed in the Homosassa Springs group. The brackish spring discharge is a result of mixing of saline groundwater with fresh water within the dynamic subsurface mixing zone known as the fresh/saltwater interface. Karst formations in the carbonate rocks, and preferential flow though subsurface conduits developed along fractures in the bedrock, results in the heterogeneity of observed water chemistry in the coastal springs.

It may be possible that a groundwater withdrawal at one location nearby an individual spring could affect that spring and reduce the percentage of freshwater flow, but it would take a sizeable localized withdrawal to effect the relative contribution of fresh to saline water from a group of springs and cause salinity changes to the system overall, which is not likely.

District staff agrees that a better understanding of groundwater hydraulics and more data collection is needed to further assess future potential impacts to springs of the Homosassa River system, although the source of saline water in the coastal margin of the Upper Floridan aquifer is understood to be from the occurrence of modern saline groundwater in the coastal transitional mixing zone or subsurface interface, and not connate or fossil water.

Comment [dl34]: Staff notes that the work "underestimated" in the report was replaced in the revised report with the word "overestimated" in reference to the predicted and observed thermal effects of spring discharge.

Comment [dl35]: District staff and HWS Engineering, Inc. note that the issue of collinearity probably is not so important in this instance as the tide variable is mean daily tide. A collinearity statistic was generated for the linear model (at Shell Island) and did not indicate that this is a problem for mean daily salinity regression equation.

Fraser et al. 2006, PBS&J 2009), which indicate some contrasting findings in terms of submerged aquatic vegetation (SAV) and emergent aquatic vegetation (EAV) relative to environmental factors in the Homosassa River. Hoyer et al. (1984) noted significant relationships between SAV distribution and abundance and flow, salinity and light levels in the Homosassa River.

However, more recent research (Frazer et al. 2001a,b; Fraser et al. 2006) indicates significant changes in SAV in the river in terms of number of sites without SAV (104% decrease) between 1998-00 and 2003-05. There was also a mean reduction in biomass of filamentous algae and most macrophytes (~ 67%) and macroalga biomass (62%), but an increase (85%) in periphyton biomass on SAV between time periods. Because the more recent survey period had lower salinity, they suggested salinity was not as influential as elevated nutrient loadings and possible eutrophication in the Homosassa River. In contrast, the most recent survey (PBS&J 2009) suggested distribution and abundance of SAV and EAV was clearly delineated across salinity zones based on known species tolerances, but that SAV, because of the marked decline, was not a good indicator of increasing salinity and thus, changes in flow. In fact, they believe EAV is a much more predictable indicator of mean salinity along the river and that freshwater species respond quickly to reduced salinities.

Finally, Appendix E (page 3-11) PBS&J (2009) indicates that the relationships between nutrient loads and SAV have not been clearly defined or quantified and thus, predicting impacts due to epiphyte growth and SAV loss are not possible presently. They also note until these relationships are quantified, restoration is not possible. Somehow, the District needs to decouple nutrient load issues from salinity changes in the system before they can accurately decide on which is driving these relationships.

Comment [dl36]: Staff agrees that confounding relationships between nutrient loading and salinity changes hinder development of reliable predictions between inflow (spring discharge) and the distribution and abundance of aquatic and semi-aquatic vegetation in the Homosassa River system. Staff also entertains the hypothesis that anthropogenic disturbance associated with boat-use may affect vegetation in the river system.

It is clear more research is required to clarify the relationship between SAV and EAV distribution and abundance relative to nutrient loads, salinity changes, and light level modifications along the Homosassa River relative to proposed flow reductions. This must include examining groundwater sources of nutrients into the system and these sources may be influenced by water withdrawals based on the proposed MFL scenarios.

Forested tidal wetlands were noted in the report, but little information reported on the extent of the freshwater tidal swamp within the Homosassa River system. Impacts to this important part of the ecosystem will be hard to calculate because the Homosassa is on the Tropical-Temperate boundary where saline-tolerant mangroves can easily displace salinity intolerant species such as Ash (*Fraxinus* spp.) and red maple (*Acer rubrum*). In a typical transition from freshwater to saltwater within an estuary, a potential reduction of flow would result in an upstream migration of the freshwater to saltwater boundary that could be easily modeled. With the source of flow in the Homosassa system consisting of multiple springs, some of which release saline water, impacts of the freshwater-saltwater boundary are difficult to predict without a better understanding of the aquifer system from which the springs emerge. It would be prudent to develop a map of the tidal, forested wetlands for future comparisons. There is some suggestion that changes have already occurred (See pages 3-14, Appendix E). Freshwater tidal swamp species extended further downstream than their aquatic counterparts (See Appendix E). Woody species can often persist even after salinity has increased. Alternatively, these tidal swamp species may be holding on because they are at an elevation slightly above the tides.

Sea level rise on this flat landscape also has the potential to greatly increase the extent of tidal marsh and swamp and should be modeled to understand the long-term changes that may impact the Homosassa even without flow modification. This may be critical if some of the forested wetlands are just above the current high tide level as noted above.

If saline water is currently intruding into the aquifer and is the source of the salt in some of the springs feeding the Homosassa River, even a slight change in sea level could increase the salinity of these springs. Even a small change in salinity and/or sea level could greatly alter the extent of freshwater wetlands in the upper reaches of the Homosassa River system. Tidal forested wetlands are an obvious component of the landscape and a sudden loss of this vegetation could appear to be the result of some change in management, when it may just be the result of crossing a critical threshold caused by sea level rise.

Comment [dl37]: Staff agrees with the Panel's comment regarding the mapping of tidal, forested wetlands, and will consider more detailed examination of these vegetative assemblages in future re-evaluations of minimum flows for the Homosassa River system.

Comment [dl38]: Staff agrees with these comments from the Panel and notes that evaluation of the effects of sea level rise was incorporated into the revised minimum flows report for the river system.

Benthic Macroinvertebrates

Results from Grabe and Janicki (2009; Appendix D) did not note any eastern oysters collected in the top 50 species they reported on in Chapter 3, nor are they listed in Tables 3-3 and 3-4 in Appendix D. In contrast, Water and Air Research (2010; Appendix F) found live eastern oysters in their study and Chapter 3 noted "The distribution for live oysters differs from that reported by Grabe and Janicki (2009) who found oysters in dredge samples collected between river kilometers 4 and 9 during their May 2008 sampling events" but no explanation for this difference is provided. Oyster data can be found in Table 3-7 in Appendix D, but this species was not mentioned directly in the text.

In terms of the barnacle study (Culter 1900; Appendix G) noted in Chapter 3, it would be interesting to note if there were any patterns in the distribution of the presumed exotic species, *Balanus amphitrite*, in relation to salinity along the Homosassa River, which might suggest that water withdrawals might enhance their distribution and abundance in areas along the river compared to baseline.

One of the potential problems in the analysis of benthic data is using both RKM and salinity in their forward stepwise multiple regression (Appendix D; Table 3-5). If I am correct, aren"t RKM (position in river) and salinity potentially correlated and thus if both are included in model (as in the Shannon Diversity regression in Table 3-5) it should inflate the adjusted R^2 values? This can easily be examined in regression in a number of ways and should be examined in all models. Also, the adjusted R^2 values for density and Shannon diversity are low (< 0.40) and thus, do not explain much of the variation in the models. They may be lower if you exclude either RKM or salinity if they are highly correlated.

Another potential problem is the interpretation of the results from the ANOSIM procedure listed in Table 3-6 (Appendix D). One caution with Primer statistics illustrated in Appendix D is that the MDS plot stress levels are not reported in Figure 3-10; these should be reported in all such plots. Also, with ANOSIM, Clark and Warwick (2001, page 6-4) note R-values are as important as p-values in determining significance and 5 of the 7 significant pairwise comparisons have R values < 0.5 While significant, having high p-values with low R-values suggest a re-evaluation of how these plots are interpreted.

Comment [dl39]: Staff has no explanation for the differences in oyster occurrences reported by Grabe and Janicki (2009) and Water and Air Research (2010). Similarly staff do not have an explanation as to why oysters are not discussed in the text included in Grabe and Janicki (2009). Finally, staff note that the draft report by Grabe and Janicki that was included as Appendix D to the draft minimum flows report was replaced by a revised, 2010 version of the document in the updated minimum flows report.

Comment [dl40]: Staff notes that *Balanus amphitrite* appear to be relatively rare in the Homosassa River system. In the final version of the barnacle survey report, Cutler (2010) notes at most 1 individual per 100 cm^2 was observed in field-scrape samples collected from fixed hard substrates in the river. Given the existing low densities of this organism in the river, and the limited information on this taxa reported by Culter, staff suggests that it is not currently possible to test any hypotheses regarding withdrawal effects on *B. amprhitite* distribution in the Homosassa River system.

Comment [dl41]: Staff agrees with the Panel"s comments regarding development of multiple regression models for relationships between benthic community parameters and abiotic variables in the Homosassa River. Staff notes that the regression equations presented by Grabe and Janicki were not utilized for development of minimum flow recommendations for the river system.

Comment [dl42]: Staff appreciates the panel"s comments regarding use of the ANOSIM procedure and notes that these analyses were not used for development of flow recommendations for the Homosassa River system.

In the executive summary section of Leeper et al. (2010) and in Chapter 4 (paragraph 1, lines 5-8), point out only the fish and invertebrate plankton, nekton, salinity-based habitats, and manatee data are used to set MFL levels, as those appear to be the most-sensitive to water withdrawals. Thus, the issues with the benthic data noted above may be less problematic in reference to setting the MFL, but the issues need to be examined and re-evaluated (if necessary) for the final document such that no spurious interpretations are made.

Comment [dl43]: Staff notes that the Panel acknowledges that results from analysis of benthic data reported by Grabe and Janicki were not used for development of flow recommendations for the Homosassa River system. Staff also notes that subsequent to initiation of the peer-review for the proposed minimum flows, Grabe and Janicki finalized their report and that this final report was included in the updated minimum flows report. Finally staff notes that reports prepared by consultants in support of minimum flows development may be considered final products and may include recommendations or data interpretations that are not endorsed by staff.

Plankton and Seine & Trawl Data Sets

The authors indicate in Appendix H (page 72) that "Some characteristics of the plankton community in the Homosassa River estuary suggest that the area has become more eutrophic." The authors suggest that reduced abundance patterns of presumed indicator species (a copepod, mysid and the bay anchovy) compared to other non-spring-fed systems and regular occurrences of large shifts in dissolved oxygen (DO) concentration (Appendix H, page 72, parag. 2, line 5) is evidence of increased eutrophication. The data presented in Table 3.2.1 and Figure 3.2.1 in Appendix H (pages 26-27) illustrate high and low DO values based on depth and location strata, but the text states that dissolved oxygen "occasionally reached strong supersaturation levels during winter and spring months, …". This seems to contradict the statements above about regular occurrences of supersaturation. Also, both of the presumed indictor species are very common across their range and are found in non-eutrophic and eutrophic systems as well, so it may be useful for authors to cite some literature on them being an indicator species relative to the potential eutrophication issues they note. There is also no mention of these concerns in water quality section of Chapter 2 in Leeper et al. (2010, page 90), although they do note some low DO (< 5.0 mg/L) were observed in all sections. However, data presented in Chapter 3 (pages 97-98), based on Fraser et al. (2001a,b; 2006) suggested increases in nutrient loads in the system over time and noted for SAV and EAV that nutrients may be more influential on distribution and abundance compared to salinity changes. It is sometimes hard to glean important data from Leeper et al. (2010) because it may not be in the section you expect and in this case, we expected it to be in

Comment [dl44]: Staff appreciates the Panel"s comments regarding potential modification of the 2009 report by Peebles and others. However, staff notes that reports prepared by consultants and included as appendices to the District report are typically considered to be final documents, even though they may contain interpretations of data that are not endorsed by staff or include shortcomings that may be addressed by simple text revisions.

water quality, not in the SAV/EAV section. There is clearly some inconsistency in how different authors view presumably the same data sets or how data are logically provided in Leeper et al. (2010).

The authors in Appendix H (page 73) indicate "…has a relatively deep channel throughout much of it length (Fog. 2.7.4.1), and this channel may facilitate two-layered estuarine circulation …" but really provide no data illustrating two-layered flow patterns. In contract, in Chapter 2 of Leeper et al. (2010) these authors indicate vertical water temperature data (page 72, paragraph 2, line 2) and vertical salinity data (page 78, paragraph 2, line 5) suggests a relatively well-mixed system. There are clearly some inconsistencies in how different authors view this system and there should not be these inconsistencies in a single document.

One of our main concerns in Chapter 3 of Leeper et al. (2010) is the quality of the regressions (linear and quadratic) in terms of their explanatory power relative to flow issues. For example, in the plankton section (pages 116-117; Table 3-4) the authors note that only 28 of 64 plankton-net taxa showed some significant response to the range of flow encountered. Of the 28 noted, only 5 had significant positive relationships (abundances increased with increased flow) and the remaining 23 had negative relationships (decrease in abundance with increased flow). The authors then focused on those five taxa with positive relationships. The authors also note that the coefficients of variation (adjusted r^2) ranged from 0.29-0.62 for time lags of 36-120 days; however, careful examination of Table 3-4 shows these values ranged from 0.25-0.72 and 50% (n = 14) had r^2 values < 0.50. Also, eight taxa (29%) had issues of possible serial correlations (significant DW values). The authors justify these r^2 values for both plankton-net and seine and trawl collections by stating "Some of these relationships had very good fit, suggesting that these relationships are not spurious" (Appendix H; pages 40 and 68). We are not sure if those fourteen taxa are really relevant to the discussion as only up to 50% of the response appears to be explained by flow. In most biological responses, 50% may be statistically significant, but not be biologically meaningful. The summary (page 160) in Leeper et al. (2010) makes note of this low accounting of variation of individual regressions.

Comment [dl45]: Staff acknowledge the Panel"s comments regarding shortcomings and organization of the report, and have hopefully improved clarity in the updated minimum flows report.

Comment [dl46]: Staff notes that consultant reports included as appendices to the District report may contain data interpretations of other information that are not endorsed by staff.

Comment [dl47]: Staff concurs with the Panel"s concerns regarding the explanatory power of the regressions developed to relate plankton and nekton abundance with inflows and chose not to emphasize results based on these regression as being supportive of particular flow reductions that could be associated with minimum flow recommendations.

Comment [dl48]: Staff notes that the reference to regressions that explain 29 to 62 percent of the variation in abundances in response to inflows included in the District report are for the five pseudo-species that exhibited positive responses to flow.

Comment [dl49]: Staff notes that data interpretations presented in consultant reports included as appendices to the District report may differ from those expressed by staff. In addition, staff concurs with the Panel"s concerns regarding the explanatory power of the regressions developed to relate plankton and nekton abundance with inflows, and chose not to emphasize results based on these regression as being supportive of particular flow reductions that could be associated with minimum flow recommendations.

Similar patterns in these regression coefficients can be noted for the seine and trawl data sets. For example, the authors noted that 40 (41?) of the 53 pseudo-species had significant relationships to flow while 13 had quadratic and 27 (28?) had linear relationships (page 116). Of the linear relationships, 12 had negative responses and 15 (16?) had positive ones with time lags from 1-203 d. The reported r^2 values ranged from 0.20-0.78 for those positive responses; however, 37% (n = 10) of these had r^2 values < 0.50. Also, seventeen pseudo-species (32%) also had issues of possible serial correlations (significant DW values). The authors justify these r^2 values for both plankton-net and seine and trawl collections by stating "Some of these relationships had very good fit, suggesting that these relationships are not spurious" (Appendix H; pages 40 and 68). As noted above, we are not sure these 10 pseudo-species add much to the discussion of altered flow, since as explained < 50% of the variance is probably not very biologically meaningful. The summary (page 160) in Leeper et al. (2010) makes note of this low accounting of variation of individual regressions.

We also question not discussing the negative relationships (most of the taxa and pseudo-species collected) as the regressions suggest that as flow is reduced, abundances of many of these taxa or pseudo-species would increase and presumable expand into upriver locations as salinity changes with flow. This should have consequences relative to community structure patterns over some time frame, which may ultimately modify community structure in the system overall. This may be more relevant if some exotic species are present (i.e., striped barnacle; Culter 2009).

One caution with Primer statistics illustrated in Appendix H is that the MDS plot stress levels are approaching values that are of concern in interpretation (stress = 0.20 and above; See Clarke and Warwick 2001); thus, the 2-D fit of a 3-D plot may not be very good. Also, with ANOSIM and tests that generate R-values and p-values, Clark and Warwick (2001, page 6-4) note R-values are as important as p-values in determining significance and some in Appendix H have high p-values with low R-values. These need to be re-evaluated and they may not be as strong a relationship as suggested.

Chapters 4 and 5

Comment [dl50]: Staff notes that "40" is the correct number of pseudo-species. Table 3-5 of the draft minimum flows report erroneously included a duplicate listing for one pseudo-species, so staff understands the Panel"s confusion regarding this tallying of data. This error was corrected in the updated minimum flows report.

Comment [dl51]: Staff notes "27" is the correct number of pseudo-species exhibiting linear responses in abundance as a function of flow.

Comment [dl52]: Staff notes that "15" pseudo-species collected with the seine or trawl nets exhibited positive, linear responses in abundance as a function of flow.

Comment [dl53]: As indicated in previous responses included in this document, staff notes that data interpretations presented in consultant reports included as appendices to the District report may differ from those expressed by staff. In addition staff concurs with the panel"s concerns regarding the explanatory power of the regressions developed to relate plankton and nekton abundance with inflows, and chose not to emphasize results based on these regression as being supportive of particular flow reductions that could be associated with minimum flow recommendations.

Comment [dl54]: Staff does not support use of negative or inverse relationships between flows and abundances for development of minimum flow recommendations. When attempting to identify allowable percentage of flow reductions that could be used to establish minimum flows, it seems reasonable to consider competent, direct relationships for predicting declines in freshwater and estuarine taxa that may be associated with flow reductions. In contrast, it is not clear how competent, inverse relationships, which would predict increased abundances with decreased flows, could be used for minimum flows development. Using the striped barnacle as an example, it would be difficult to define population changes that could be used to identify allowable percentage of flow reductions. Staff notes that evaluating changes in salinity-based habitats may be a powerful tool for evaluating indirect, flow related changes in the distribution of the myriad exotic and native species populating the Homosassa River system.

Comment [dl55]: Staff acknowledges the Panel"s comments and notes that results from the Primer analyses were not used for development of minimum flow recommendations for the river system.

The approaches used for individual responses to flow changes are reasonable, but a more holistic approach is really required. Below is a suggestion of a way (there may be others) to examine plankton, nekton and benthic responses with Primer statistics and couple those results with salinity-based habitats and manatee thermal habitats data currently in place. In Appendix H (pages 54-72), the authors conducted some very interesting multivariate community analyses, but these were not discussed in Leeper et al. (2010), and, in part, they support our concern about community structure change given the individual empirical relationship for plankton, seine and trawl data sets outlined above. It might be very useful to examine carefully the community structure changes using Primer statistics (MDS, ANOSIM, SIMPER, etc.) of the taxa and pseudo-species relative to flow reduction scenarios. We believe one could use the individual empirical relationships (both positive and negative ones) to estimate abundances at particular flows coupled with predicted changes in salinity, etc. These calculated abundance values could be used to create a new data matrix and run some of the appropriate Primer statistics to see if overall assemblage structure would change under different flow scenarios. One could do this at some estimate above and below the linear (mean) values (i.e., ± 10, 15, 20 %) based on the empirical relationships. This may provide some indication of how much the assemblage as a whole could change given the scenarios of interest (change in water flow) and would be a more holistic approach than the standard individual responses documented in Leeper et al. (2010). Given Leeper et al. (2010) currently lists 20 total individual responses used for 2007 and 1996-2009 baseline estimates of non-lagged data, these could be used for the suggested analysis and when the final report is completed on the benthic surveys, they may be able to be incorporated as well. In Primer, we could see rows of species, taxa and pseudo-species with columns being baseline abundances for 2007 and 1995-2009 and then have other columns based on generated abundances given reduced flows (as done individually already). These could be ordinated in MDS, compared with ANOSIM among flow scenarios, and, if you used SIMPER, you could show which flow rates produced significantly lower abundances estimates by species and how many species responded holistically instead of individually. It could be that some taxa do worse or better in different flow scenarios, thus impacting the overall assemblage composition.

Comment [dl56]: Staff appreciates this recommendation of the Panel, but asserts that the current approach involving examination of multiple indicators and development of minimum flow recommendations based on sensitive response variables is a conservative and defensible approach for resource protection.

Comment [dl57]: Staff appreciate the Panel's comments regarding use of a "community response" approach for evaluating biological effects of flow reductions, but is not sure how this approach may be implemented. Staff also notes that the panel offered warnings regarding use or interpretation of some of the multivariate approaches presented in reports included as appendices to the District's original minimum flows report.

Comment [dl58]: Staff does not agree with the Panel's recommendation regarding use of both inverse and direct empirical relationships between flows and abundances of plankton and nekton.

Can figures be generated using tables 5-20 through 5-22 that would show salinity-based shoreline changes using data from both the hydrodynamic model and the empirical regression models?   It might help visualize how the potential change would look in the Homosassa system.

Comment [dl59]: Staff notes that graphics depicting changes in shoreline length exposed various salinities could be developed, but note that changes in isohaline location for the flow reduction scenarios are relative minor, as presented in Table 5-3 of the report.

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Sverdrup, H.U., M.W. Johnson and R.H. Fleming. 1942. The Oceans. Prentice-Hall, Englewood Cliffs, NJ. 1087 pp.

Yobbi, D.K., and Knochenmus, L.A. 1989. Salinity and Flow Relations and Effects of Reduced Flow in the Chassahowitzka River and Homosassa River Estuaries, Southwest Florida. Water-Resources Investigations Report 88-4044. U.S. Geological Survey, Tallahassee, Florida, 38pp.

Page	¶ #	Line #	Figure (F) **Table (T)**	Comment
5	6	3		Change “model” to “models” *This change was ultimately not necessary in the revised version of the report. The phrase, “1 and 2” that followed “model” was incorrectly included and was deleted. Also, corrections were made to appendix title sheets and listings in the table of contents in the revised report.*
19	Title			Change “Acknowledgements” to “ Acknowledgments” (no “e”) *This change was made in the revised version of the report.*
20	2	5		“…at least 19 named or identified springs or vents.” There appear to be 20 named springs in Figure 2-3, page 33. Should these numbers be the same? *The term “19” was changed to “20” and additional text was modified in the revised report.*
30	3	2		Delete the “a” before Bluebird Springs Park. *This suggestion was incorporated into the revised report.*
49	2	5		Add “k” to Southeast For (k) gage site. *This typographical error was corrected in the revised report.*
52			F. 2-16	The discharge data in this figure appear to match the discharge data for gage site USGS 02310700 Homosassa R at Homosassa FL; apparently, this gage site number should be in the figure caption, instead of the gage site number that is listed in the caption (02310690), which is the number for Halls River. *These suggestions were incorporated into the revised report.*
53			F. 2-18	The gage site number for Hidden River should be number 02310675, instead of 02310690, which is the number for the Halls River gage. *This error was corrected in the revised report.*
54	3	8		“poteniomitric” should be “*potentiometric*”. *This error was corrected in the revised report.*
54	3	10		It is suggested that **nodes** be replaced with *“drain cells”*. *This suggestion was incorporated into the revised report.*
55			T. 2-4	It is suggested that Abdoney, Belcher, McCain, Pumphouse, and Trotter No. 1 springs be identified as comprising the Southeast Fork springs complex. *In the revised report, listings for spring in Table 2-4 (and Tables 2-6, 2-7 and 2-8) were grouped according to location (Homosassa River, Southeast Fork, Halls River, Hidden River) and location information was added to the tables. Also, a reference to Table 2-4 was added to the third paragraph on the page preceding the table.*
61	1	9		“sand, silt, muck and silt” *This suggested text was incorporated into the revised report.*
65	3	5-8		The text says 14 stations (10 in Homosassa River and 3 in Halls River and 1 in SE Fork). However Figure 2-24 has 19 stations (13 in Homosassa River and 6 in Halls River). Hard to rectify stations plotted on 2-24 and data on 2-25?? *Water quality sampling sites shown in Figure 2-25 are correctly*

				described on pages 65 and 66 of the report. Although the size of the map image in Figure 2-25 was increased slightly in the revised report, the figure was not substantially revised as it was intended to provide only a rough approximation of the distribution of water quality sampling sites.
66	1&2			The text cited Figure 2-24 in both paragraphs and it appears it should be Figure 2-25? *This assumption is correct and the citation was corrected in the revised version of the report.*
66	3	4		What is “B121”? *This is a District project number. The phrase “Project Number” was added for clarification to the text in the revised report.*
66	3	7		“figurer” should be “figure” *This error was corrected in the revised report.*
66	3	7		Is the part of this sentence that states “locations of these sites are not shown in Figure [sic.] 2-25” written correctly? If so, is it possible to include a reference that does show the locations of the sites? *The sentence from the report is correct; only the sites associated with the projects described in some detail on pages 65 and 66 are shown in Figure 2-25. Locations of other sites used for summarizing water quality information for the Homosassa River system may be found in a geographic information system layer available from the District web site, and a reference to this data set was added to the revised version of the report.*
75			F.2-28	This figure is real hard to interpret because of small size and overlap of the symbols. *Staff did not modify this figure for the revised minimum flows report. The figure was presented to show that most differences between top and bottom minima and maxima were relatively small (< 1 degree Celsius) and staff believes that this information is conveyed by the original figure.*
75			F. 2-28	It is suggested that the gage number be included in the caption. *The gage number was added to the caption in the revised report.*
77	1	3		Can the formulas of Cox et al. (1967) be included in the text? *Formulae of Cox et al. (1967) used for conversion of specific conductance values to salinities were included in the revised version of the minimum flows report.*
80			F. 2-31	It is indicated that the solid green line shows the median EFDC model salinity for the river **surface**; Figure F-2 in Appendix F (HSW Engineering, Inc. 2010), which is included in Appendix A of Leeper et al. (2010), indicates that this line is the median EFDC model salinity for the river *bottom*. *The data series was mislabeled in the original Excel file used to prepare the figure. In addition, the data for median surface and bottom EFDC modeling results were switched in files that were provided to the District. This error was corrected as was presentation of the relevant data in a revised version of the report*

				contained in Appendix A that was prepared by HSW Engineering, Inc. in February 2011. Figure 2-31 was also corrected in the revised version of the minimum flows report.
81			F. 2-33	It is very difficult to read the legend and understand what data are presented in this figure. *The figure is a reproduction from a consultant's report, so it was not modified. The figure legend was, however, modified to improve clarity in the revised minimum flows report.*
83	2	1		Change "prediction" to "predicting" *This suggested text was incorporated into the revised report.*
Page	**¶ #**	**Line #**	**Figure (F) Table (T)**	**Comment**
84	1	11-12		How was a **temperature constant of 23.2ºC** used? Should this be "*constant temperature* of 23.2ºC"? *This suggested text was incorporated into the revised report.*
84	1	14		It is suggested that **concordance** be replaced with *"agreement"*. *This suggested text was incorporated into the revised report.*
87			F.2-36	The upper 2 panels are almost impossible to separate observed from simulated signals. I would attempt to make larger as these tell a great deal about model simulation patterns compared to the observed. I suggest you change the two colors so that they do not produce black when overlapped. *The figures are reproductions from a consultant's report. Staff note that the figures printed poorly in the Adobe PDF version of the draft report, as compared to the electronic versions (Microsoft Word and Adobe PDF) of the report. In an attempt to rectify this issue, the vertical extent of each panel in the figure was slightly increased in the revised version of the minimum flows report.*
88	1			Paragraph describing predicted salinities: Coefficients of determination …ranged from 0.63 to 0.73 (HSW Engineering, Inc. 2010). It is suggested that the specific location for these results, i.e., the table number in Appendix A, be included in the text on page 88. *A parenthetic reference that indicates that the regression plots/information are included in Figures J-5 of Appendix J to HSW Engineering, Inc. 2011 (a revised version of the original 2010 HSW report), which is included as Appendix A to the revised version of the minimum flows report*
94	1	6		Looks like this should be Figure 2-20, not 2-23?? *This error was corrected in the revised minimum flows report.*
97	2	7		Earlier "discharge" was measured as cfs, here it is m/s *In the revised version of the report, "discharge" was changed to "flow rates". Note also that the original citation included flows expressed as meters per second, so this unit of presentation was retained and a parenthetic reference to flow rate in feet per second was included in the revised report.*

99-100			F.3-1 to 3-3	These are very small and hard to read. Color patterns are reasonable but dots are almost impossible to see clearly. *The figures are reproductions from consultant's report, so they were not substantially modified. The size of each figure was, however, increased in the revised minimum flows report to improve clarity.*
101	1	4		Delete "relatively" *This suggestion was incorporated into the revised minimum flows report.*
101	1	7		Should be "physiochemical" *This suggestion was incorporated into the revised minimum flows report.*
107	1	5		Delete "a" before size transects in the … *Revised as suggested*
107	2	3		*Guekensis* is spelled *Geukensis* *This error was corrected in the revised minimum flows report.*
110			F.3-2	*Guekensis* is spelled *Geukensis* *"This error was corrected in the revised minimum flows report.*
110	1	3		Should read "meta-analysis" *This suggestion was incorporated into the revised minimum flows report.*
110	1	7		The word "tidal" appears redundantly *The second use of the word "tidal" was eliminated from text in the revised minimum flows report.*
110	2	2		"sampes" should read "samples" *This error was corrected in the revised minimum flows report.*
111	2	7		Should read "suggests" plural
114	3	8		"paludosus" should be in italics *This suggestion was incorporated into the revised minimum flows report.*
116	3	1-4		I count 41 of the 53 pseudo-species having significant relationships, 13 with quadratic but 28 (not 27) with linear. Also, the authors list 12 negative and 15 positive linear responses but Table 3-5 has 16 positive linear responses. This may explain the 1 difference noted. Needs correction in text. *The discrepancies between the report text and tabular information related to the number of pseudo-species exhibiting significant relationships between abundance and flow is due to a duplicate listing for Lucania parva in Table 3-5. This duplication error was corrected in the revised minimum flows report.*
116	4	7		Seminole killifish (*Fundulus grandis*) is actually Gulf killifish. *This error was corrected in the revised minimum flows report.*
123	1	1		Should read "red tides." The period inside the quotes. *This suggestion was incorporated into the revised minimum flows report.*
124	1	11-14		Redundant "probabilities" *The identified sentence was revised to improve clarity in the revised minimum flows report. The word "probabilities" was, however,*

Page	¶ #	Line #	Figure (F) Table (T)	Comment
				retained in the revised sentence.
126	2	8		Again, Seminole should be Gulf killifish. *This error was corrected in the revised minimum flows report.*
126	2	9		"mollies" should be "molly." *This error was corrected in the revised minimum flows report.*
134-135			T. 5-1	Callinectus sapidus in this Table is mis-spelled and should be in italics. It is spelled *Callinectes sapidus* in the seine-net, taxon or pseudo-species and trawl-net sections. All should be in italics. Also, *Lepomis punctatusi* and *Micropterus salmoidesi* are mis-spelled and the "i" on the end of both species name should be deleted. *These errors were corrected in the revised minimum flows report.*
134	1	6		Looks like Table 5-2 should be Table 5-1. *This error was corrected in the revised minimum flows report.*
154	1	10		Delete "of" *This suggestion was incorporated into the revised minimum flows report.*
Page	**¶ #**	**Line #**	**Figure (F) Table (T)**	**Comment**
154				No page number *A page number was added to the appropriate page in the revised minimum flows report.*
Appendix A Edits and Typos				
xiii				**Table of contents, p. xiii:** Consistent with the information presented in the table of contents for Appendices A-I in HSW Engineering, Inc. (2010), the figures contained in Appendix J in HSW Engineering, Inc. (2010) should be listed in the table of contents. *Staff appreciates this suggestion but did not modify the appendix by adding figure legends to each figure within the appendix. Staff notes, however, that an updated 2011 version of the HSW Engineering, Inc. report has been appended to the revised minimum flows report, and further notes that the 2011 HSW report includes table of content listings for each group of figures contained within Appendix J.*
2-19	2	4-7		Something is missing in this sentence. It makes no sense to me. *The identified sentence was clarified in a revised version of the HSW Engineering, Inc. report that was prepared in February 2011 by adding the phrase "…is less clear" to the end of the sentence.*
2-19	2			Figures 2-25 through 2-33 should immediately follow p. 2-19 if possible. *Staff appreciates this suggestion, but did not require this revision for the February 2011 updated version of the HSW Engineering, Inc. report.*
3-10	2	3		Table 3-3 cited should be Table 3-4. *This error was corrected in a revised version of the HSW Engineering, Inc. report that was prepared in February 2011.*

3-11		3	T. 3-4	Headings in line 3, columns 3 and 4 for the Shell Island gauge are both labeled "Middle". Should the heading in column 4 be labeled "Bottom" instead? Are the data correctly entered in these columns? Also, it is noted at the bottom of Table 3-4 that "**R is the Pearson Coefficient....**" Is this coefficient defined or referenced somewhere in the report? *The heading in line three, column four for the Shell Island Gauge in Table 3-4 on page 3-11 should have been labeled "Bottom". This error was corrected in a revised version of the HSW Engineering, Inc. report that was prepared in February 2011. Staff notes that the Pearson's Coefficients included in Table 3-5 are standard correlation coefficients for a linear regression between Observed and Simulated water temperatures. Because the coefficient is commonly used for comparing the relationship between two sets of data, a definition was not provided in the table footnotes.*
4-4	1		F. 4-3 & 4-4	Printed off the page and you can not see legends or captions. *Staff note that Figures 4-3 and 4-4 in the Adobe PDF electronic version of the report are appropriately displayed – it appears that the printed version of the report provided to the peer review panel may have been incorrectly printed.*
Appendix B Edits and Typos				
				Second paragraph in Introduction: To be consistent with Leeper et al. (2010) and Table 2 (p. 12), Hidden River should be included in this paragraph. *This suggested revision was not made to the revised minimum flows report. Staff typically considers supporting documents such as Appendix B to be finished products that may not necessarily reflect organization and content of the District's report on recommended minimum flows.*
Appendix C Edits and Typos				
Appendix D Edits and Typos				
3-16	1	2		Delete "s" from compares. *The draft report by Grabe and Janicki that was included as Appendix D to the original minimum flows report was replaced by a final version of the report.*
3-18	4	5		Peebles 2005 not cited in literature cited section (note to add it if found in red). *Citation information for Peebles (2005) was added to the final version of the report that was included as an appendix to the revised minimum flows report.*
Appendix E Edits and Typos				
3-7	6	4-6		Figs 5 & 6 are printed off the page (can not read scales, etc.) and have no figures legends. Same for appendices A-C. *The figures are appropriately represented in the Microsoft Word and Adobe PDF electronic versions of the 2009 report by PBS&J included as Appendix E to the draft minimum flows report. Staff note that the printed versions of the report supplied to the peer-*

Page	¶ #	Line #	Figure (F) Table (T)	Comment
				review panel may have been misprinted.
3-8	1	1		Ruppia must be in italics. *This error was noted in the errata on the appendix cover sheet included in the revised version of the minimum flows report.*
3-13			F. 7	Figures 7 & 8 are not cited in the text. *These omissions were considered insignificant and not included in the errata on the appendix cover sheet included in the revised minimum flows report.*
3-14			F.8	Figures 7 & 8 are not cited in the text. *These errors were considered insignificant and not noted in the erratum on the appendix cover sheet included in the revised minimum flows report.*
3-16			T.2	Plant names must be in italics like all other tables. *This error was noted in the errata on the appendix cover sheet included in the revised minimum flows report.*
Appendix F Edits and Typos				
			T. 6	Table 6 – *Geukensia* also misspelled as noted above. *This error was noted as an erratum on the appendix cover sheet included in the revised minimum flows report.*
Appendix G Edits and Typos				
Appendix H Edits and Typos				
17			F. 2.7.4.2	TIN is upper case is in upper panel but lower case in lower panel. *This error was considered insignificant and not noted in the errata on the appendix cover sheet included in the revised minimum flows report.*
29	3	2-3		Names need to be in italics. *This error was noted in the errata on the appendix cover sheet included in the revised minimum flows report.*
30	1	3		"fro" should be "from". *This error was noted in the errata on the appendix cover sheet included in the revised minimum flows report.*
30	1	13		Peebles & Flannery 1992 is not cited in literature cited section. *This error was noted in the errata on the appendix cover sheet included in the revised minimum flows report.*
Page	**¶ #**	**Line #**	**Figure (F) Table (T)**	**Comment**
31	3	4		Merriner et al. 1976 also not cited in literature cited section. *This error was noted in the errata on the appendix cover sheet included in the revised minimum flows report.*
31	4	6		Peebles 2002 also not cited in literature cited section. *This error was noted in the errata on the appendix cover sheet included in the revised minimum flows report.*
73	5	7		"appeanace" misspelled. *This error was noted in the errata on the appendix cover sheet included in the revised minimum flows report.*
74	2	5		"esutuary" misspelled. *This error was noted in the errata on the appendix cover sheet*

	included in the revised minimum flows report.
Appendix I Edits and Typos	
Appendix J Edits and Typos	
Appendix K Edits and Typos	
Appendix L Edits and Typos	
Appendix M Edits and Typos	
Appendix N Edits and Typos	
Appendix O Edits and Typos	

Errata, Leeper et al. 2010 (12 July Peer-reviewed Draft)