# ANALYSIS OF BENTHIC COMMUNITY STRUCTURE IN TRIBUTARIES TO THE CHASSAHOWITZKA RIVER

**Purchase Order #07PO0001718**

**Prepared for:**
**Southwest Florida Water Management District**
**Brooksville, Florida**

**Prepared by:**
**Stephen A. Grabe and Anthony Janicki**
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Jeffery Winter, assisted by Tim Smith (PBS&J) collected the samples. Mote Marine Laboratory staff, under the direction of Jim Culter were responsible for the analysis of the samples. Michael Dema (Janicki Environmental, Inc.) prepared the maps and edited the final draft of this report.

Dr. Thomas Frazer and Sky Notestein (IFAS, University of Florida) provided us with information on the vegetation and water quality characteristics of the Chassahowitzka River.

Cover photograph courtesy of Chris and Bill Quick (www.kayakguy.com)

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# 1.0 INTRODUCTION

The Southwest Florida Water Management District (District) is one of five water management districts charged with protecting and managing the State of Florida's water resources. One of the District's legislatively-mandated responsibilities is to establish minimum flows and levels for surface water bodies including freshwater streams and the freshwater inflow to estuarine waters.

MFLs for the Chassahowitzka River and the Chassahowitzka springs system are scheduled to be set in 2008 (SWFWMD, 2008). In 2006 Janicki Environmental, Inc. (2006) analyzed benthic data collected in May 2005 along the main axis of the river. These data showed that salinity did not vary much along the ~9 km length of the river and that the benthos did not appear to vary with salinity.

To complement these data and better understand the structure of the benthos of the Chassahowitzka River a survey of six of the creeks and spring runs of the Upper Chassahowitzka River (above river kilometer [RKM] 2.7) was conducted during April 2008. The original design called for seven creeks to be sampled. Baird Creek, however, was obstructed by a fallen tree and could not be sampled (J. Winter, PBS&J, pers. comm.) The objectives, then, are to describe, compare, and contrast the benthic assemblages of six spring-fed tributaries to the Chassahowitzka River and those of the river itself.

## 1.1 Study Area

The Chassahowitzka River is a spring-fed river that originates in Citrus County and enters the Gulf of Mexico at Chassahowitzka Bay. The river is an "Outstanding Florida Water" and a major resource is the 30,000 acre Chassahowitzka National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service. For the purposes of this study, the Upper Chassahowitzka River is operationally defined as upstream of RKM 2.7 of the >9 RKM system.

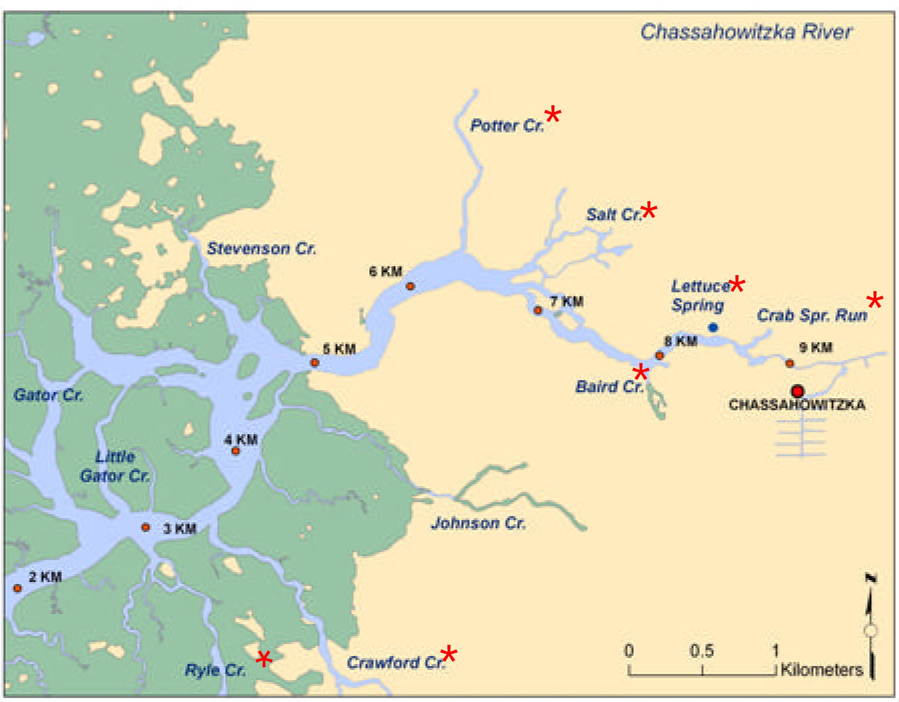


**Figure 1-1. The Chassahowitzka River and the tributary sampling sites, April 2008.**

The river is tidal to the headspring, ~9 kilometers upstream from the mouth. The salinity of the discharges from the spring complex ranges from freshwater to up to 16 ppt in Baird Spring Yobbi, 1992). Champion (2001) provided conductivity data for several springs in both the main springs complex as well as several of the tributary springs. Specific conductivities of these springs ranged from 821 (Beteejay Spring) to 10,900 $\mu$S $cm^{-1}$ (Blue Run) in 1999 (Champion, 2001).

Frazer *et al*. (2001) showed that the river headwaters are oligohaline year-round. Salinities at the river's mouth range widely, from <10 ppt (August and November) to almost 25 ppt (May).

The Chassahowitzka Main Spring is estimated to contribute ~50% of the flow to the river. Monthly mean flows at have ranged from 31.8 to 197 cfs (mean=140 cfs; data from 1930-1972 cited in Yobbi and Knochnemus, 1989). Frazer *et al*. (2001) reported a mean flow of approximately 140 cfs during their three year study. Monthly mean flows measured at Hommasassa (U.S.G.S. gage 02310650) from 1999 through 2007 ranged from 44 to 78 cfs, with a median of 59 cfs (U.S.G.S., 2008). Yobbi (1992) observed that there is a seasonal component to the springs discharge. Lowest flows occur during June and July and the greatest flows occur during early fall. Crab Spring is the second largest contributor (Table 1-1).

**Table 1-1. Summary of discharge and conductivity measurements in eight springs and creeks in the Chassahowitzka River system (from Champion, 2001; U.S.G.S., 2008).**

| Spring | Flow (cfs) | Conductivity ($\mu$S $cm^{-1}$) |
|---|---|---|
| Chassohowitzka Main Spring | 59 | 1,040 |
| Chassahowitzka #1 | 30 | 851 |
| Crab Creek | 48.7 | 4,480 |
| Blue Run (Crawford Creek) | 6.6 | 10,900 |
| Beteejay Spring (Crawford Creek) | 6.4 | 821 |
| Ruth Spring (Potter Creek) | 13.3 | 2,200 |
| Baird Spring | 5.6 | 10,390 |
| Potter Creek | 18.6 | No Data |

Frazer *et al.* (2001) observed that there was little residential development along this river, with ~12 single family residences in the Lower Chassahowitzka reach. The upper reach of the Chassahowitzka is relatively narrow but broadens considerably (to 175 m) downstream. Wolfe (1990) describes the coastal vegetation as primarily hammock forest, which includes *Quercus virginiana*, *Juniperus silicicola*, and *Sabal palmetto. Taxodium distichum* is common along the spring runs that join with the river. *Typha* spp. and *Phragmites australis* are found at the lower salinities. There is an extensive marsh system (*Cladium jamaicense and Juncus roemerianus)* near the mouth of the river.

Submerged aquatic vegetation (SAV) occurs throughout most of the river, gradually declining downstream. Common freshwater macrophytes include *Vallisneria americana*, *Potamogeton pectinatus*, *Najas guadalupensis*, *Myriophyllum spicatum*, and *Hydrilla verticillata* (Frazer *et al.*, 2001; Clewell *et al.,* 2002). Filamentous macroalgae, including *Lyngbya* sp. and *Chaetomorpha* sp., are also abundant. Mote Marine Laboratory (2006) resurveyed the distribution of SAV in the river. *Myriophyllum spicatum* was the most widespread species (RKM 0.5-6.5 and RKM 9), followed by *Ruppia maritima* (RKM 1-6). Above RKM 6.5 *Vallisneria americana, Najas guadalupensis*, and *Potamogeton pectinatus* were the most common species.

In the coastal area, SAV beds are well-developed, and may cover as much as 90% of the substrate where water depths are $< 2$m (McNulty *et al.,* 1972; Wolfe, 1990). Species include *Thalassia testudinum, Syringodium filiforme, Halodule wrightii*, and, in lower salinity areas, *Ruppia maritima* (Iverson and Bittaker, 1986).

# 2.0 METHODS

In this section the field, laboratory, and data analysis methods are summarized.

## 2.1 Study Design

Six tributaries to the Upper Chassahowitzka River were surveyed in April 2008 (Table 2-1). Within each tributary, sample locations were approximately equidistant, from the mouth to its upstream extent. In Lettuce Creek, only the mouth could be sampled because the creek was too narrow and shallow. Baird Creek could not be sampled at all because a fallen tree obstructed the creek near the mouth (J. Winter, PBS&J, personal communication). A total of 35 samples were collected. Fourteen samples were collected in the river proper in May 2005 (Figure 2-1; Janicki Environmental, Inc., 2006).

**Table 2-1. Tributaries and river strata selected for the collection of benthic samples in the Chassahowitzka River and the number of samples collected, May 2005 and April 2008.**

| Tributary | Number of Samples Collected |
|---|---|
| Upper Chassahowitzka River (May 2005) | 11 |
| Crab Spring (April 2008) | 6 |
| Lettuce Spring (April 2008) | 1 |
| Crawford Creek (April 2008) | 8 |
| Baird Creek (April 2008) | 0 |
| Salt Creek (April 2008) | 8 |
| Potter Creek (April 2008) | 8 |
| Ryle's Creek (April 2008) | 4 |
| Lower Chassahowitzka River (May 2005) | 3 |
| **Total** | **49** |

## 2.2 Field Methods

Each benthic sample was initially collected with a 0.04 $m^2$ Young-modified Van Veen sampler. Then, a 7.62 cm diameter (3") (area = 45.6 $cm^2$) stainless steel pipe was inserted into the Young sampler to extract the actual benthic sample.

Each core sample was bagged with an internal label. Magnesium sulfate solution was added to relax the organisms and then the samples were stored on ice. Samples were sieved (0.5 mm mesh) to remove finer-grained particles of sediment and meiofauna. Samples were then fixed in a 10% solution of buffered formalin and Rose Bengal stain.

Other information/data collected at each sampling location included:

- sample depth;
- latitude and longitude;
- qualitative descriptions of land-use, including types of riparian vegetation, along the shoreline proximate to each sampling location; and
- field observations on habitat, ambient environmental conditions.

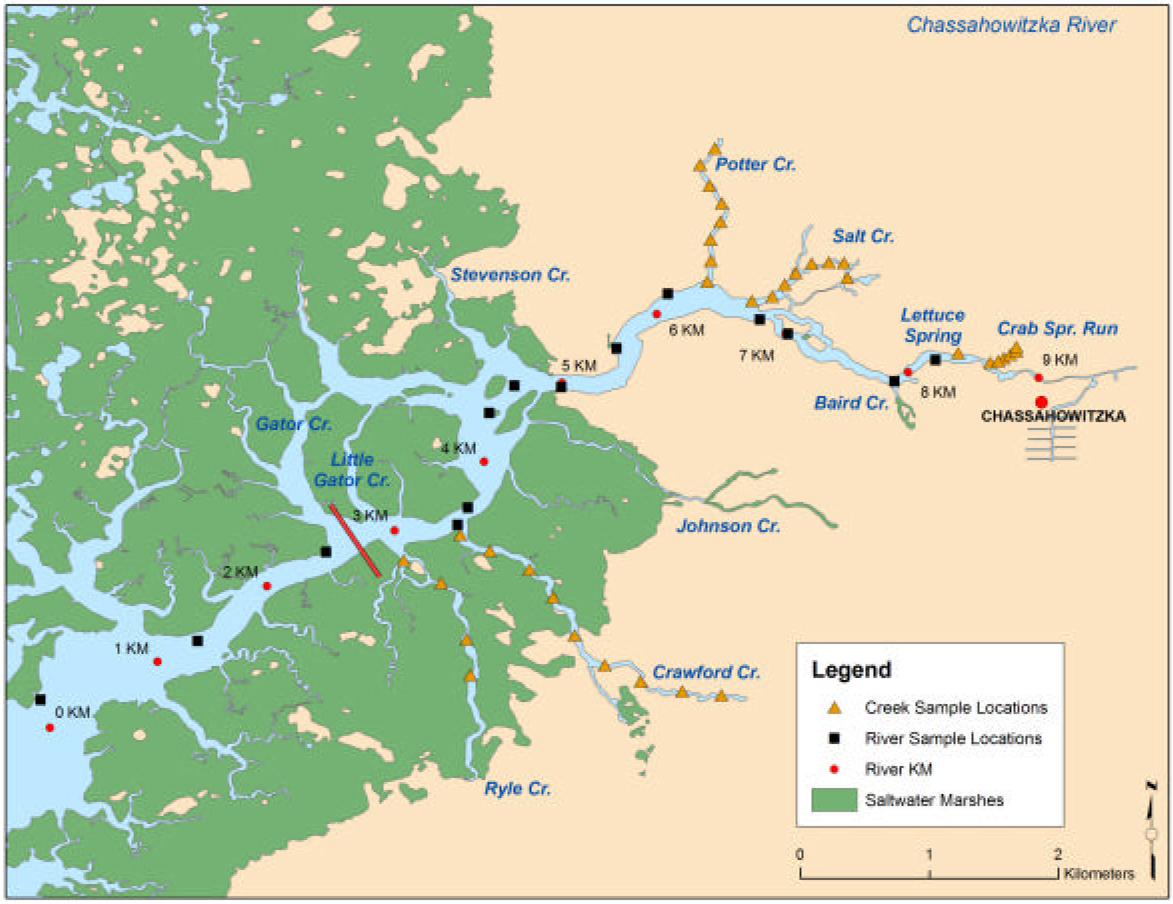


**Figure 2-1. Location of benthic sampling stations in the Chassahowitzka River (May 2005) and six of its tributaries (April 2008).**

## 2.3 Laboratory Methods

Macroinvertebrate samples were fixed in the formalin solution for at least 12 days, after which they were transferred to a preservative (a solution of 50% to 70% isopropanol or ethanol). All organisms were sorted from the samples, with at least 90% recovery, under a dissecting microscope. Macroinvertebrates were identified to the lowest practical identification level—typically genus or species. If an animal was a member of one of the "minor" taxonomic groups, such as the Nemertea, identifications might only be to that higher taxonomic level. Additionally, if an organism was damaged or a juvenile, identifications to the genus or species level could not always be made.

## 2.4 Data Analysis Approach

The primary focus of the study was to see if the tidal creek communities are statistically different from those of the Chassahowitzka River proper. Two generic approaches to analyzing the benthic data were used:

- univariate metrics; and
- a multivariate analysis, non-metric multidimensional scaling [MDS], was used to explore how the benthos assemblage as a whole was organized, particularly the resemblance of the creeks to the river.

### 2.4.1 Univariate Metrics

Three univariate metrics were calculated for each tributary and, for comparison, the May 2005 samples from the Upper and Lower strata in the Chassahowitzka River:

- Dominant taxa were identified. Dominance was calculated as the geometric mean of the frequency of occurrence (a measure of the distribution in the river) and relative abundance (a measure of a taxon's contribution to the river's standing crop).
- Species (taxa) richness is the number of distinct species (taxa) identifiable in a sample. Species or taxa richness is the simplest representation of "diversity".
- Total abundance (numbers of individuals $m^{-2}$) is an indicator of the standing crop of the benthic community. Extremely high or extremely low abundance can be indicative of a perturbed environment.

### 2.4.2 Univariate Tests

Analysis of Variance (ANOVA) was used to test for differences in mean numbers of taxa and mean abundance among creek systems and river strata. Where significant ($p < 0.05$) differences in means were found, the Bonferroni comparison (Neter *et al.*, 1985) was used to test for differences between pairs of creeks and strata. Both numbers of taxa and abundance were Ln transformed prior to analysis to normalize the data (Sokal and Rohlf, 1981).

### 2.4.3 Multivariate Analysis

Multivariate statistical routines in the PRIMER software package (Clarke and Warwick, 2001) used in this study included:

- non-metric multidimensional scaling (MDS) - MDS was used to explore spatial heterogeneity among the six creek systems surveyed in 2008 and the May 2005 Upper Chassahowitzka and Lower Chassahowitzka river samples. MDS is an ordination technique in which rank similarities of a large number of variables are expressed as a two-dimensional map.
- "Analysis of Similarities" (ANOSIM) - ANOSIM tests the statistical significance of the pair-wise comparisons of the *a priori* defined groups (creek system and river reach).
- "Similarity Percentage" (SIMPER) - SIMPER objectively identified those taxa that explained relatively large proportions of the similarity within a group.
- The association of abiotic variables with multivariate community structure was explored using the BIO-ENV test in PRIMER. *BIO-ENV is an exploratory analysis and should be not be interpreted as identifying "significant" or causative relationships.*

Abundance (numbers $m^{-2}$) was $4^{th}$ root transformed for all multivariate community analyses. The $4^{th}$ root transformation in multivariate analyses permits a greater number of taxa to influence the results (Clarke and Warwick, 2001). The use of untransformed data yields results strongly influenced by the most abundant taxa. Cao *et al.* (1998) argue that "rare" taxa may be more sensitive to environmental perturbation than common species. Therefore, an analytical approach that is more responsive to the "community" rather than to only a few, numerically abundant taxa was desirable. Thorne *et al.* (1999) have also demonstrated that the $4^{th}$ root transformation is preferred in multivariate community analyses because it represents a "good compromise between untransformed and binary data". Therefore, the $4^{th}$ root transformation was employed in the multivariate analyses.

# 3.0 RESULTS

## 3.1 Abiotic Characteristics

Water depths in the six creeks and spring runs were < 1 m, considerably shallower than the river proper (Table 3-1). Crab and Potter creeks had the highest mean near-bottom water temperatures of the six creeks. Near-bottom water temperatures were higher in the river, but these 2005 samples were collected a month later (May) than the 2008 samples. Mean near-bottom salinities were highest (> 7 ppt) in Ryle Creek and the Lower Chassahowitzka River. Salinities in the other study areas averaged < 4ppt (Table 3-1). Mean near-bottom dissolved oxygen concentrations were highest in Salt and Potter creeks and lowest in Crab Creek where one measurement was < 2 mg/L. Concentrations varied widely (> 8 mg/L) in Salt Creek, Potter Creek, and the Upper Chassahowitzka River. Sediments in the creeks and runs were mainly described as muds and silts; sandy-muds were the second most frequent category (Field observations).

**Table 3-1. Mean of sample depths and bottom water temperature, salinity, and DO for the Upper and Lower river strata (May 2005) and each tributary (April 2008).**

| Location | Sample Depth (m) | Temperature (°C) | Salinity (ppt) | Dissolved Oxygen (mg/L) |
|---|---|---|---|---|
| Lower River | 2.6 | 25.7 | 7.4 | 6.2 |
| Crab | 0.3 | 23.5 | 3.7 | 5.6 |
| Crawford | 0.5 | 20.8 | 2.8 | 8.8 |
| Lettuce | 0.0 | 20.1 | 1.1 | 7.8 |
| Potter | 0.3 | 23.6 | 3.0 | 15.3 |
| Ryle | 0.6 | 21.9 | 7.9 | 10.8 |
| Salt | 0.2 | 22.2 | 4.0 | 14.6 |
| Upper River | 1.7 | 26.2 | 3.3 | 11.3 |

## 3.2 Biota

### 3.2.1 Dominant Taxa

Dominant taxa were identified for each tributary and the Upper Chassahowitzka and Lower Chassahowitzka rivers. Dominants are identified by their dominance score, which is calculated as:

*Dominance Score = (% occurrence * % composition)*$^{-0.5}$.

The dominants of the eight study areas were generally segregated into an upstream and a downstream group. The four more upstream creek, northern shoreline systems, (upstream of RKM 6) and the Upper Chassahowitzka River had the estuarine amphipod *Grandidierella bonnieroides* (Janicki Environmental, Inc., 2007) as a Dominant; Oligochaete worms, which could represent either freshwater and/or estuarine species, were also Dominant in the upper river, Crab, Lettuce, and Salt creeks—but not in Potter Creek (Table 3-2). Freshwater insect larvae were rarely included among the dominants, except in the single Lettuce Creek sample. The dominants in the Lower Chassahowitzka River and Crawford and Ryle creeks (downstream and southern shore) included estuarine *Ampelisca* spp. amphipods (Janicki Environmental, Inc., 2007), and, in the two creeks, *Grandidierella* (Table 3-2).

| Table 3-2. The top ten highest Dominance scores for macroinvertebrate taxa identified from infaunal samples collected in the Chassahowitzka River and six selected tributaries. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TAXON** | **Lower River** | **Crab** | **Crawford** | **Lettuce** | **Potter** | **Ryle** | **Salt** | **Upper River** |
| Athenaria | 13 | | | | | | | 3 |
| **ANNELIDA** | | | | | | | | |
| Polychaeta | | | | | | | | |
| *Heteromastus filiformis* | | | | | | 14 | | |
| *Hobsonia florida* | | 6 | | 23 | | | | |
| *Laeonereis culveri* | 15 | 43 | 15 | 16 | 17 | | 12 | 22 |
| *Leitoscoloplos robustus* | | | | | | 12 | | |
| Oligochaeta | 30 | 42 | 24 | 45 | 37 | 15 | 51 | 49 |
| Hirudinea | | | | 23 | 5 | | | |
| **MOLLUSCA** | | | | | | | | |
| Gastropoda | | | | | | | | |
| *Acteocina canaliculata* | | | | | | 14 | | |
| Gastropoda | | | 10 | | | 14 | | |
| *Littoridinops palustris* | | | | | 12 | | | |
| Bivalvia | | | | | | | | |
| *Cyrenoida floridana* | | | 14 | | | | | |
| *Macoma tenta* | | | 10 | | | 12 | | |
| **CRUSTACEA** | | | | | | | | |
| Amphipoda | | | | | | | | |
| *Americorophium ellisi* | | | | | | | 6 | |
| *Ampelisca vadorum* | | | 40 | | | 61 | | |
| *Ampelisca sp.* | 76 | | | | | | | 9 |
| *Amphilochus sp.* | | 4 | | | | | | |
| Corophiidae | 18 | | | | | | | 33 |
| *Gammarus mucronatus* | 13 | 32 | 17 | 23 | 58 | 16 | 38 | 21 |
| *Grandidierella bonnieroides* | 17 | 44 | 44 | 48 | 47 | 46 | 46 | 38 |
| *Melita sp.* | 11 | | | | | | | |
| *Monocorophium sp.* | | | | | | | 6 | |
| Isopoda | | | | | | | | |
| *Cyathura polita* | 11 | 24 | 10 | 16 | 9 | | 8 | 16 |
| *Edotea montosa* | | 16 | | 16 | 13 | | 8 | |
| *Xenanthura brevitelson* | 10 | | | | | 21 | | |
| Tanaidacea | | | | | | | | |
| *Hargeria rapax/Leptochelia forresti* | 11 | 23 | | | | 26 | | 12 |
| Cumacea | | | | | | | | |
| *Almyracuma bacescui* | | | 12 | | 8 | | 17 | 3 |
| **INSECTA** | | | | | | | | |
| Trichoptera | | 4 | | | | | | |
| Diptera-Chironomidae | | | | | | | | |
| *Cladotanytarsus* | | | | 39 | | | | |
| *Polypedilum scalaenum* | | 16 | | 39 | 7 | | 7 | |
| *Procladius* | | | | 16 | | | | |

### 3.2.2 Numbers of Taxa

Mean numbers of taxa per sample were generally low (< 15) in all reaches and systems, except Ryle Creek (Figure 3-1). The six creeks generally had higher means than the two river reaches, although the absolute differences were small. ANOVA showed that the means differed among creeks and river strata ($F_{7,39} = 3.5$; $p = 0.005$). The mean numbers of taxa were similar ($p > 0.05$) in all comparisons except one. The mean numbers of taxa in Ryle Creek was higher ($p < 0.001$) than that of the Upper Chassahowitzka River (Figure 3-1).

Taxa unique to the Ryle Creek samples included estuarine species such as the cumacean *Cyclaspis cf. varians* and the polychaetes *Heteromastus filiformis* and *Streptosyllis pettiboneae*. Ryle Creek also had the highest mean salinity of any of the creek systems sampled (Table 3-1). *However, because the number of samples within each creek system is small (< 10), and the patchy distributions of benthic organisms, the presence or absence of a particular taxon is not particularly meaningful.*

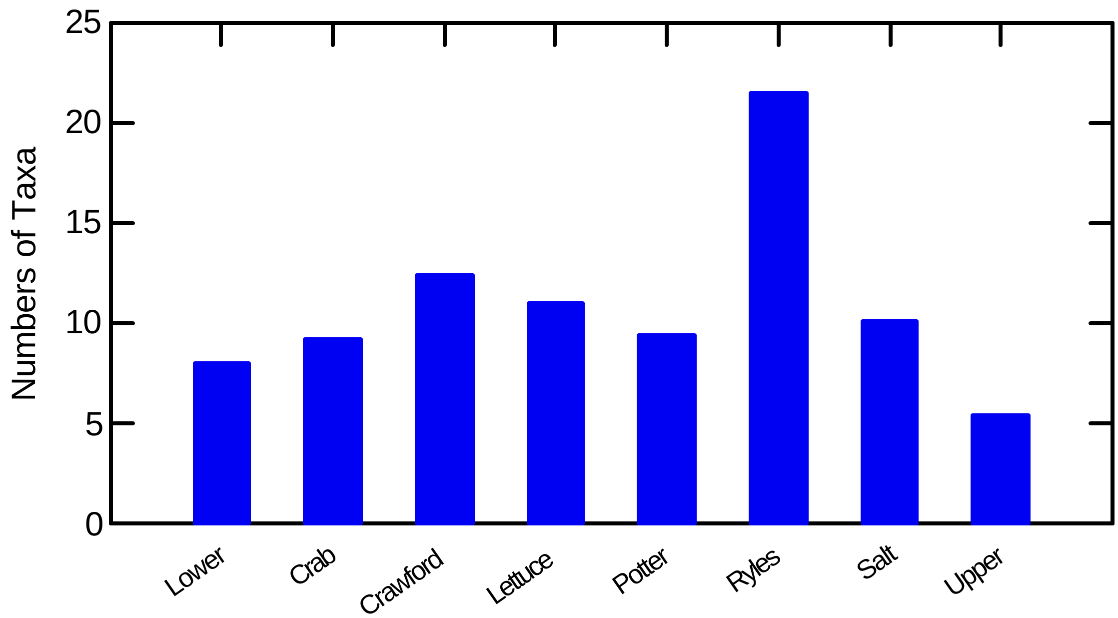


**Figure 3-1. Mean numbers of taxa, by river reach (May 2005) and creek system (April 2008).**

### 3.2.3 Abundance

Mean abundance per sample was highest in Ryle Creek and lowest in the river samples and in the single Lettuce Creek sample (Figure 3-2). ANOVA, however, showed that the mean abundances in each creek and the upper and lower rivers were similar ($F_{7,39} = 1.6$; $p = 0.17$). Some estuarine taxa that were particularly abundant in Ryle Creek, although not elsewhere (Appendix A), included:

- the polychaetes *Capitella capitata* complex, *Leitoscoloplos robustus*, and *Heteromastus filiformis*;
- the bivalve *Macoma tenta*;
- the gastropod *Acteocina canaliculata*;
- the amphipods *Grandidierella bonnieroides* and *Ampelisca spp*;
- the isopod *Xenanthura brevitelson*; and
- the tanaids *Leptochelia/Hargeria* (Janicki Environmental, Inc., 2007).

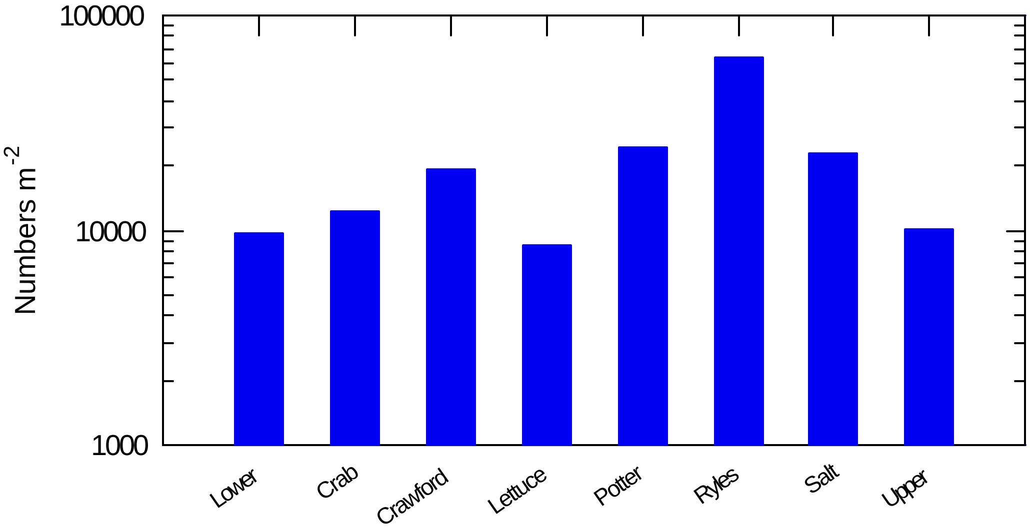


**Figure 3-2. Mean abundance, by river reach (May 2005) and creek system (April 2008).**

### 3.2.4 Multivariate Community Structure

To examine the similarities and differences in benthic community structure among the two river strata and six creeks, MDS and two related tests were used. Ryle Creek, and to a lesser extent, Crawford Creek, appeared to differ from the other creek systems and the two river reaches in the MDS plot (Figure 3-3).

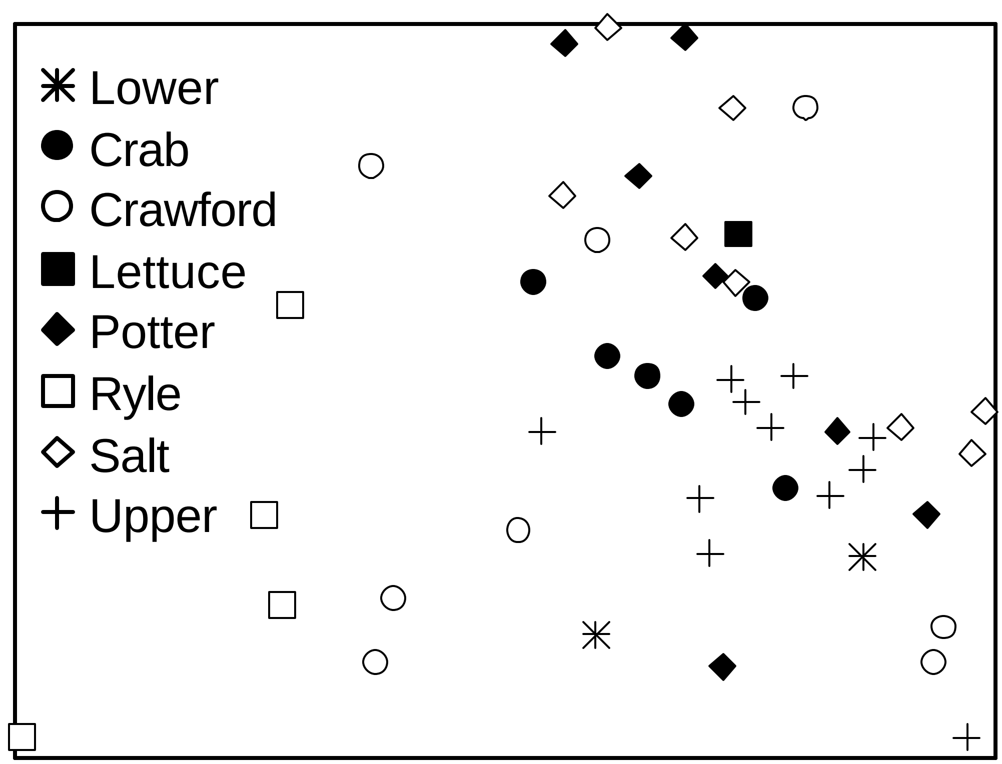


**Figure 3-3. MDS plot showing the resemblance of the benthos of the Upper Chassahowitzka and Lower Chassahowitzka River (May 2005) and six tributaries (April 2008).**

The fauna of the Upper Chassahowitzka River differed from the five creek systems and Ryle Creek differed from four of the study areas (Table 3-3). Crawford Creek and Potter Creek differed from two of the other five study areas.

**Table 3-3. Comparison of benthic community structure among five creeks (April 2008) and the Upper Chassahowitzka River (May 2005) by ANOSIM. Lettuce Creek and the Lower Chassahowitzka River were excluded because sample sizes` were < 3. Probability of significance for group comparisons: NS = $p > 0.05$; * = $p < 0.05$ ** = $p < 0.01$; *** = $p < 0.001$**

| | Upper | Crab Creek | Crawford Creek | Potter Creek | Salt Creek |
|---|---|---|---|---|---|
| **Upper** | | | | | |
| **Crab Creek** | ** | | | | |
| **Crawford Creek** | ** | NS | | | |
| **Potter Creek** | ** | NS | NS | | |
| **Salt Creek** | ** | * | * | NS | |
| **Ryle Creek** | *** | ** | NS | ** | ** |

The benthos the Upper Chassahowitzka River differed from that of the five creeks (Table 3-3). The densities of *Grandidierella bonnieroides* and *Gammarus mucronatus* were higher in the creeks than in the river and the isopod *Edotea montosa* was abundant in the creeks but absent from the upper river samples (Table 3-4).

Crab Creek differed from Salt Creek because *Laeonereis* and *Cyathura* abundances were higher and that of oligochaetes, lower (Table 3-4). Ryle Creek differed from Crab Creek because *Ampelisca* abundances were lower and both *Cyathura* and *Gammarus mucronatus* abundances were higher in Ryle Creek (Table 3-4). Crawford Creek had lower oligochaete and *Gammarus mucronatus* abundance and higher *Edotea* abundance than Salt Creek (Table 3-4).

Lower oligochaete abundances and higher *Ampelisca* abundances differentiated Ryle Creek from Potter Creek (Table 3-4). Polychaetes, *Ampelisca*, and *Grandidierella* abundances were higher in Ryle Creek than in Salt Creek (Table 3-4).

General trends differentiating these creek systems include:

- generally higher abundances of oligochaetes and *Gammarus mucronatus* in the Potter-Salt Creek system and in the Upper river; and
- highest abundances of *Ampelisca* in the two most downstream creeks.

| **Table 3-4. Mean abundance (numbers m$^{-2}$) of taxa explaining at least 25% of the similarity within five creeks and the Upper Chassahowitzka River in SIMPER analysis. Samples from the Lower Chassahowitzka River and Lettuce Creek are excluded.** | | | | | | |
|---|---|---|---|---|---|---|
| **Taxa** | **Crab** | **Crawford** | **Potter** | **Ryle** | **Salt** | **Upper** |
| **ANNELIDA** | | | | | | |
| **Polychaeta** | | | | | | |
| *Heteromastus filiformis* | 0 | 0 | 0 | | 0 | 0 |
| *Laeonereis culveri* | 2,227 | 548 | 1,001 | 1,040 | 411 | 657 |
| | | | | | | |
| **Oligochaeta** | | | | | | |
| *Oligochaeta* | 2,628 | 1,259 | 4,693 | 1,807 | 8,048 | 2,907 |
| | | | | | | |
| ***MOLLUSCA*** | | | | | | |
| **Gastropoda** | | | | | | |
| Gastropoda | 37 | 329 | 125 | 1,752 | 0 | 0 |
| | | | | | | |
| **CRUSTACEA** | | | | | | |
| **Isopoda** | | | | | | |
| *Cyathura polita* | 730 | 301 | 282 | 438 | 329 | 398 |
| *Edotea montosa* | 475 | 219 | 720 | 383 | 219 | 0 |
| | | | | | | |
| **Tanaidacea** | | | | | | |
| *Leptochelia/Hargeria* | 949 | 301 | 63 | 4,599 | 82 | 518 |
| | | | | | | |
| **Amphipoda** | | | | | | |
| *Ampelisca spp.* | 0 | 6,242 | 0 | 23,816 | 0 | 279 |
| Corophiidae | 0 | 192 | 188 | 767 | 493 | 2,369 |
| *Gammarus mucronatus* | 1,241 | 1,150 | 8,103 | 2,135 | 3,230 | 836 |
| *Grandidierella bonnieroides* | 2,884 | 4,873 | 6,163 | 13,523 | 6,433 | 1,792 |

In order to explore the relationship of four abiotic variables (salinity, depth, pH, and dissolved oxygen) to multivariate community structure, BIO-ENV analysis was used. This showed that salinity was the variable with the highest Spearman rank correlation ($\rho_s$) to community structure and that the addition of other variables reduced $\rho_s$ (Table 3-5). *This analysis is purely exploratory and no statistical significance should be inferred from* $r_s$ values (Clarke and Warwick, 2001).

| **Table 35. Association (Spearman rank correlations, $r_s$) between benthic community structure in the Chassahowitzka River and six tributaries and four abiotic variables.** | | | | | |
|---|---|---|---|---|---|
| **Number of Variables** | $r_s$ | **Salinity** | **Dissolved Oxygen** | **Depth** | **pH** |
| 1 | 0.29 | | | | |
| 2 | 0.27 | | | | |
| 3 | 0.26 | | | | |
| 4 | 0.22 | | | | |

# 4.0 CONCLUSIONS

The following conclusions can be drawn from the analysis of the benthic macroinvertebrate data:

- Ryle Creek had a greater number of taxa per sample than did the Upper Chassahowitzka River; all other paired comparisons of creeks showed that there were no differences in taxa richness;
- Total abundance of benthic macroinvertebrates was similar in each of the areas studied;
- Pair-wise comparisons showed that the benthic assemblage of the Upper Chassahowitzka River differed from the five creeks and Ryle Creek differed from the upper river and four of the creek systems;
- greater abundances of oligochaetes and *Gammarus mucronatus* were generally found in the Potter-Salt Creek system and in the Upper river; and
- greatest abundances of *Ampelisca* occurred in Crawford and Ryle creeks, the two most downstream creeks;
- the higher densities of estuarine amphipods and some polychaetes in Ryle Creek appeared to be related to the somewhat higher salinities in this creek; and
- freshwater insect larvae were not particularly abundant in any of the creeks.

Therefore, any reductions in discharge from the springs are unlikely to impact the benthos of the tributary creeks, which are dominated by estuarine species.

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# APPENDIX A

## MEAN ABUNDANCE OF BENTHIC TAXA

## BY CREEK SYSTEM (APRIL 2008) AND RIVER STRATUM (MAY 2005)

| Taxa | Lower River | Crab | Crawford | Lettuce | Potter | Ryle | Salt | Upper River |
|---|---|---|---|---|---|---|---|---|
| **CNIDARIA** | | | | | | | | |
| Actiniaria | 0 | 0 | 82 | 0 | 0 | 55 | 0 | 0 |
| Athenaria | 329 | 0 | 0 | 0 | 0 | 0 | 0 | 60 |
| | | | | | | | | |
| **Platyhelminthes** | | | | | | | | |
| Platyhelminthes | 0 | 0 | 27 | 0 | 94 | 0 | 0 | 0 |
| | | | | | | | | |
| **Nemertea** | | | | | | | | |
| Nemertea | 0 | 37 | 27 | 0 | 0 | 55 | 0 | 0 |
| | | | | | | | | |
| **ANNELIDA** | | | | | | | | |
| **Polychaeta** | | | | | | | | |
| *Aricidea philbinae* | 0 | 0 | 0 | 0 | 0 | 438 | 0 | 0 |
| *Boccardia* | 0 | 0 | 0 | 0 | 31 | 0 | 0 | 0 |
| *Brania* | 0 | 0 | 0 | 0 | 0 | 55 | 0 | 0 |
| *Capitella complex* | 0 | 0 | 27 | 0 | 0 | 821 | 0 | 0 |
| *Eteone heteropoda* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40 |
| Fabricinae | 0 | 0 | 0 | 0 | 0 | 438 | 0 | 0 |
| *Heteromastus filiformis* | 0 | 0 | 0 | 0 | 0 | 1,150 | 0 | 0 |
| *Hobsonia florida* | 0 | 110 | 110 | 438 | 0 | 219 | 137 | 0 |
| *Laeonereis culveri* | 219 | 2,227 | 548 | 219 | 1,001 | 1,040 | 411 | 657 |
| *Leitoscoloplos robustus* | 0 | 0 | 55 | 0 | 0 | 931 | 0 | 40 |
| *Mediomastus* | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 |
| *Melinna maculata* | 0 | 0 | 0 | 0 | 0 | 55 | 0 | 0 |
| *Polydora socialis* | 0 | 110 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stenonineris martini* | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 |
| *Streblospio* | 0 | 0 | 82 | 0 | 0 | 55 | 0 | 0 |
| *Streptosyllis pettiboneae* | 0 | 0 | 0 | 0 | 0 | 110 | 0 | 0 |
| | | | | | | | | |
| **Oligochaeta** | | | | | | | | |
| Oligochaeta | 876 | 2,628 | 1,259 | 1,752 | 4,693 | 1,807 | 8,048 | 2,907 |
| | | | | | | | | |
| **Hirudinea.** | | | | | | | | |
| Hirudinea. | 0 | 0 | 0 | 438 | 250 | 0 | 219 | 0 |

| Taxa | Lower River | Crab | Crawford | Lettuce | Potter | Ryle | Salt | Upper River |
|---|---|---|---|---|---|---|---|---|
| **MOLLUSCA** | | | | | | | | |
| **Bivalvia** | | | | | | | | |
| Bivalvia | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 |
| *Macoma tenta* | 0 | 0 | 493 | 0 | 0 | 931 | 0 | 0 |
| *Polymesoda caroliniana* | 0 | 37 | 27 | 0 | 0 | 110 | 27 | 0 |
| *Tagelus plebeius* | 0 | 0 | 27 | 0 | 0 | 274 | 0 | 0 |
| | | | | | | | | |
| **Gastropoda** | | | | | | | | |
| *Acteocina canaliculata* | 0 | 0 | 55 | 0 | 0 | 1,259 | 0 | 0 |
| *Cyrenoida floridana* | 0 | 0 | 575 | 0 | 219 | 0 | 110 | 0 |
| Gastropoda | 0 | 37 | 329 | 0 | 125 | 1,752 | 0 | 0 |
| *Littoridinops palustris* | 0 | 0 | 0 | 0 | 626 | 0 | 82 | 0 |
| | | | | | | | | |
| **CRUSTACEA** | | | | | | | | |
| **Cumacea** | | | | | | | | |
| *Almyracuma bacescui* | 0 | 0 | 520 | 0 | 344 | 383 | 1,834 | 100 |
| *Cyclaspis varians* | 0 | 0 | 0 | 0 | 0 | 164 | 0 | 0 |
| | | | | | | | | |
| **Tanaidacea** | | | | | | | | |
| *Halmyrapseudes bahamensis* | 0 | 0 | 110 | 0 | 0 | 274 | 0 | 0 |
| *Leptochelia/Hargeria* | 219 | 949 | 301 | 0 | 63 | 4,599 | 82 | 518 |
| | | | | | | | | |
| **Isopoda** | | | | | | | | |
| *Cassidinidea ovalis* | 0 | 73 | 137 | 0 | 63 | 0 | 27 | 0 |
| *Cyathura polita* | 219 | 730 | 301 | 219 | 282 | 438 | 329 | 398 |
| *Ericsonella attenuata* | 0 | 0 | 27 | 0 | 0 | 110 | 0 | 0 |
| *Ericsonella filiformis* | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 40 |
| *Edotea montosa* | 0 | 475 | 219 | 219 | 720 | 383 | 219 | 0 |
| *Xenanthura brevitelson* | 219 | 0 | 82 | 0 | 0 | 3,723 | 0 | 20 |
| | | | | | | | | |
| **Mysidacea** | | | | | | | | |
| Mysidacea | 0 | 0 | 27 | 0 | 63 | 55 | 0 | 0 |
| *Taphromysis bowmani* | 0 | 0 | 0 | 0 | 0 | 0 | 164 | 0 |
| | | | | | | | | |
| **Amphipoda** | | | | | | | | |
| *Ameroculodes A* | 0 | 0 | 110 | 0 | 0 | 274 | 0 | 0 |
| *Ampelisca spp.* | 5,694 | 0 | 6,242 | 0 | 0 | 23,816 | 0 | 279 |
| *Amphilochus* | 0 | 73 | 0 | 0 | 0 | 0 | 55 | 0 |
| Amphipoda | 0 | 0 | 0 | 0 | 156 | 0 | 164 | 0 |
| Corophiidae | 657 | 0 | 192 | 0 | 188 | 767 | 493 | 2,369 |
| *Cymadusa compta* | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ericthonius brasiliensis* | 0 | 0 | 192 | 0 | 0 | 602 | 0 | 0 |
| *Gammarus mucronatus* | 329 | 1,241 | 1,150 | 438 | 8,103 | 2,135 | 3,230 | 836 |
| *Grandidierella bonnieroides* | 548 | 2,884 | 4,873 | 1,971 | 6,163 | 13,523 | 6,433 | 1,792 |
| *Melita* | 219 | 0 | 0 | 0 | 0 | 0 | 27 | 0 |

| Taxa | Lower River | Crab | Crawford | Lettuce | Potter | Ryle | Salt | Upper River |
|---|---|---|---|---|---|---|---|---|
| **Decapoda** | | | | | | | | |
| *Rhithropanapeus harrisii* | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | |
| **INSECTA** | | | | | | | | |
| Chironominae | 0 | 37 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chironomus* | 0 | 0 | 0 | 0 | 94 | 0 | 0 | 0 |
| *Cladotanytarsus* | 0 | 0 | 219 | 1,314 | 0 | 0 | 137 | 0 |
| *Clinotanypus* | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 0 |
| Coenagrionidae | 0 | 37 | 0 | 0 | 0 | 0 | 27 | 0 |
| *Cryptochironomus* | 0 | 0 | 137 | 0 | 0 | 0 | 110 | 0 |
| Diptera pupae | 0 | 0 | 0 | 0 | 63 | 0 | 27 | 0 |
| *Labrundinia* | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 0 |
| Libellulidae | 0 | 0 | 0 | 0 | 31 | 0 | 0 | 0 |
| Orthocladius | 0 | 0 | 0 | 0 | 219 | 0 | 0 | 0 |
| *Paramerina* | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 |
| *Polypedilum scalaenum* | 0 | 365 | 411 | 1,314 | 250 | 383 | 219 | 0 |
| *Procladius* | 0 | 37 | 0 | 219 | 188 | 0 | 110 | 0 |
| Tanypodinae | 0 | 0 | 55 | 0 | 0 | 0 | 27 | 0 |
| *Tanytarsus* | 0 | 0 | 0 | 0 | 94 | 55 | 0 | 0 |
| Trichoptera | 0 | 73 | 0 | 0 | 0 | 0 | 0 | 0 |