FINAL REPORT

TASK 7: A TIDAL CREEK CONDITION INDEX

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TASK 8: EVALUATION OF THE TIDAL CREEK CONDITION INDEX

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EXECUTIVE SUMMARY

This report summarizes the final technical tasks associated with the development of a rapid-survey, ecologically based index of tidal creek condition. The index was developed in the tidal creeks of Sarasota County, Florida, for Sarasota County government, but the index can be used for tidal creeks throughout southwest Florida.

Previous project tasks in 2004 and 2005 determined that the tidal creeks of Sarasota County are situated centrally in a region of coastal homogeneity with respect to terrestrial, estuarine, and oceanic landscapes and environmental conditions; that Sarasota County's coastal watersheds differed widely with respect to land use, pollutant load, and other measures of watershed quality, and that ecological conditions in creeks formed by watersheds in poor and good condition themselves presented characteristics of impaired and unimpaired waterways.

In 2006 a prototype index was field-tested using dozens of potential biological indicators in both intertidal and subtidal settings of 15 of Sarasota County's 16 coastal creeks. The Myakka River and its associated creeks were not included in field tests owing to their different ecological setting. The 2006 field-test demonstrated that many potential index variables merited further testing, and that methods could be developed for the combination of varied data into a single Tidal Creek Condition Index. Reports on these antecedent tasks are listed in the References section of this report and are available at Sarasota County's Water Atlas website, http://www.sarasota.wateratlas.usf.edu/.

In 2007 a new effort was made to refine, test, and finalize the terms of a Tidal Creek Condition Index. All 16 county creeks were revisited to establish or modify sampling locations. Data from 2006 were analyzed in more detail to determine adequate sampling effort. Standard operating procedures were detailed for field crews, and a new set of field data sheets was produced. In May and June 2007 all 16 creeks were sampled in both intertidal and subtidal settings to collect data on 45 ecological variables.

The types of samples and measurements made in each creek included extent (frequency of occurrences), mollusk density, submerged aquatic vegetation, percent cover, oyster attributes, *Tagelus* (a razor clam) attributes, dipnet catches (of fishes, shrimps, crabs, etc.), and burrow density. Approximately 6,000 data were collected.

Data were analyzed in a stepwise manner to: 1. Assess data completeness and distribution by creek, 2. Identify correlations among variables, 3. Screen variables to achieve index objectives, 4. Select variables for the Tidal Creek Condition Index, 5. Establish a data rectification process, and 6. Aggregate rectified data into the index.

There was a threefold difference in the number of data available across creeks. Twenty-six variables accounted for 90% of all data; zero values dominated the data space, and subtidal data were twice as numerous as intertidal data. Similarities among creeks were examined by applying a hierarchical cluster analysis to presence/absence of index variables. Two groups were evident with one defining an affinity among Clower, Matheny, Whitaker, Hatchett, and Woodmere Creeks. The five creeks most distant in similarity from these five were Forked, Alligator, Ainger, North, and Gottfried Creeks.

Correlation coefficients were computed between individual variables using a pair-wise approach that employed all original data for every variable. There were 110 significant or highly significant variables pairs among the 1,317 comparisons, or approximately 8.3 percent. The variable most frequently correlated to others with significance was intertidal *Tagelus* extent, with

6 pairs. In descending order of their correlation frequency with other variables, the relative number of significant correlations of variables grouped by type were measurements of extent (10.7%), mollusk density, submerged aquatic vegetation, percent cover, oyster attributes, *Tagelus* attributes, net catches, and burrow density.

Once the size and characteristics of the creek database were known, variables were screened to achieve index objectives using these criteria: 1. Multiple levels of biological organization; 2. Relationship to creek and watershed management; 3. Multiple strata represented in the data set; 4. Scope for change, and 5. Logistical considerations. Variables selected for use in the creek index included two intertidal variables (percent live oyster, maximum height of live oysters), and seven subtidal variables (burrow density, live *Tagelus* density, number of live *Tagelus* cohorts, other mollusk density, bare dipnet catch (all species combined), percent cover of periphyton, and percent cover of filamentous algae. The algal measures are pollution indicators.

Before the nine variables could be combined into an index it was necessary to transform data from 5 different unit systems into unit-less values. Upon reviewing data distributions for the variables the following system was employed. Four bins were used to distribute original data for each variable. Bin 1 was used for data with zero value. The remaining non-zero data were divided into thirds relative to their maximum values. To account for yet-larger values than 2007 maxima the upper limits of the last bin were calculated using 2007 maxima plus an increment, usually about 10%, based on the nature of the variable.

Model environments were used to compare and contrast two methods for aggregating unit-less data for the 9 index variables. An additive approach was found deficient because variability in the data base available for each creek caused creek index scores and the relative ranks of creeks to vary. To improve the comparability of creek index scores between creeks and also improve the ability to compare a given creek's index score from one year to the next, an aggregation method based on geometric means was chosen. In this respect the computation of the Tidal Creek Condition Index is similar to the computation of the widely used Habitat Suitability Index. The 2007 Sarasota County Tidal Creek Index results are shown in Figure A.

No index score is presented for Matheny Creek because of poor bottom and water quality conditions, and the index's reliance on mostly subtidal data. Subtidal data were collected for several variables in Matheny Creek but no data were available for index variables. Alternative methods employed in 2007 for poor sampling conditions were unsuccessful but can be improved upon. Also, intertidal oysters are a component of the index but Matheny Creek supports an insufficient number of oysters to sample for the index.

Index values ranged from 1.03 to 2.08 or about 35% of the index's theoretical range (1.0 – 4.0). The mean creek score was 1.64, or 21% of the index's upper limit. Until subsequent fieldwork produces a larger database for the index variables, it is too early to tell whether the relatively low 2007 scores for creeks are typical. In 2007 at least one creek produced a score of 4.0 for every index variable except the two measures of longevity and persistence, *Tagelus* cohort number, and maximum oyster height. Because perfect scores occurred for most variables in at least one creek then it is reasonable to expect higher creek condition index scores than seen in 2007.

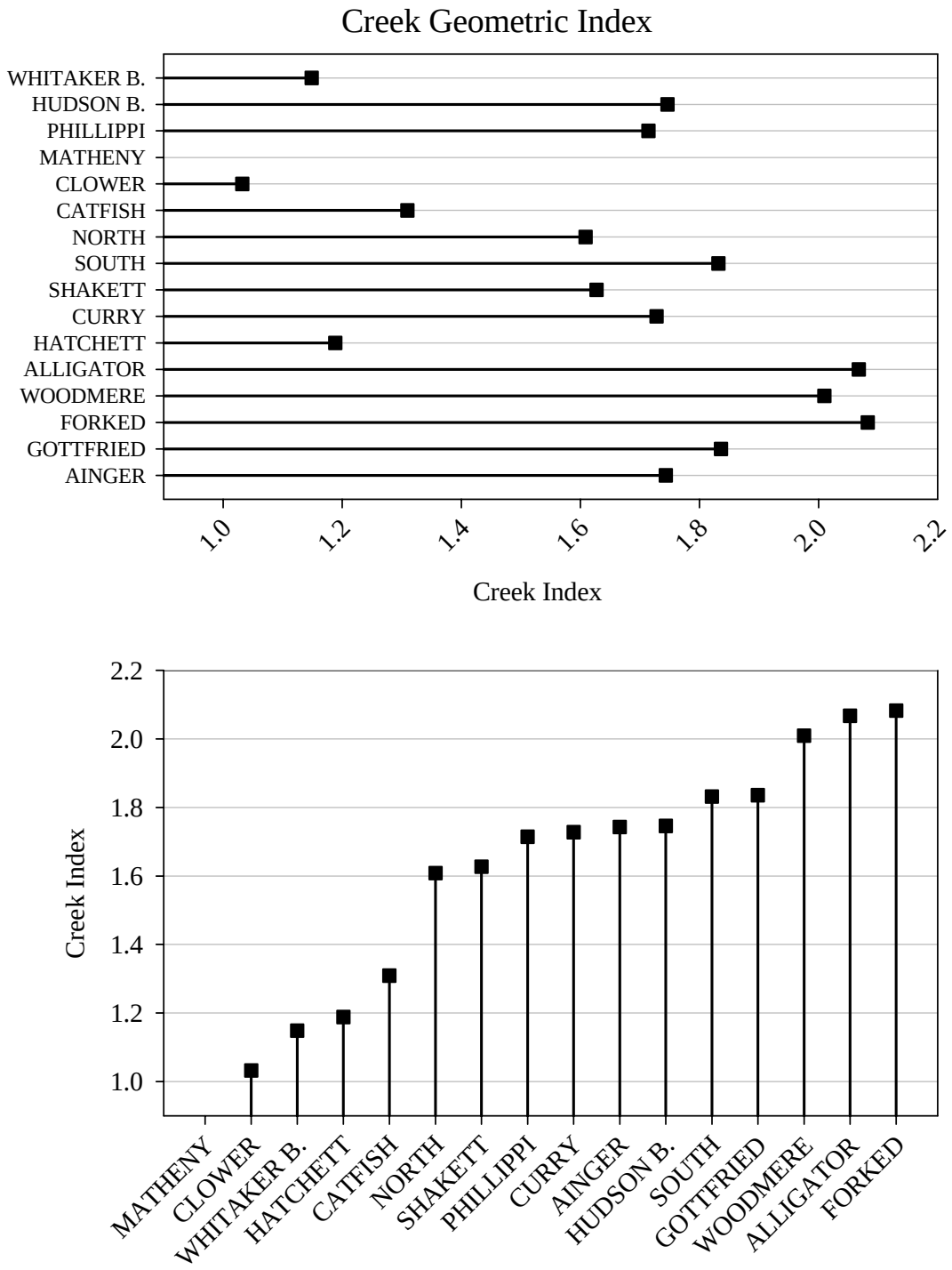


Figure A. 2007 Sarasota County Tidal Creek Index Scores. Creek scores are shown from north to south in the upper panel and from lowest to highest value in the lower panel.

Other measures of creek and watershed condition selected as bases for the assessment of the Tidal Creek Condition Index include the 2004 Landscape Development Intensity Index (LDII), Watershed Age of Development Index (WAD), 2006-2007 hydrological variability of county creeks, antecedent creek water quality, Pollution Load Model (PLM) outputs, and 2007 benthic infaunal community structure.

The Tidal Creek Condition Index was not significantly correlated with the 2004 LDII, WAD index, salinity as a proxy for hydrological variability, antecedent water quality, or normalized pollutant loads. The Tidal Creek Condition Index was significantly correlated with faunal density and the creek condition index was correlated at highly significant probability with species richness. Relative ranking of creeks between the index and benthic data was good but imperfect. The two systems shared 3 of 5 highest ranked creeks and 4 of 5 lowest ranked creeks.

In other words, a rapid-survey technique based on nine variables produced scores and, with lower fidelity, relative ranks of tidal creeks comparable to scores and ranks derived from traditional community-level studies of benthic infauna. On the one hand, this result can be explained by the fact that several creek condition variables are benthic in nature (burrow count, Tagelus and other mollusk densities). On the other hand, the creek index also employs intertidal variables (oyster data), abundances of fishes, crabs and shrimp, and the presence and extent of nuisance macroalgae, providing a wider range of ecosystem condition that infauna alone.

That the Tidal Creek Condition Index was significantly correlated with benthic fauna is noteworthy because the same benthic infaunal community measures were significantly correlated with the LDII and WAD characteristics of creek watersheds. If the objective of having a biologically based index of tidal creek condition reflect watershed development or age is paramount, benthic diversity and density will be useful. If having the creek index reflect specific or combined pollutant loads is paramount, neither method presented here will do so with fidelity. To evaluate the relationship of the two biological methods to measures of hydrological variability or water quality, additional data for these independent variables will be needed.

The Tidal Creek Condition Index has numerous applications, the most important being its use in producing a watershed and creek "report card." To enumerate decisions needed in producing a report card and to illustrate how the Tidal Creek Condition Index can be employed in one, county creeks *and* watersheds were ranked using 15 types of data including the creek condition index and data on watersheds, long-term and short-term water quality, pollutant loads, sediment quality, and benthic communities.

Creeks that consistently ranked in good condition using a mixture of watershed and creek indicators included South, Shakett, Curry, Forked, and Ainger Creeks. Creeks that consistently ranked in poor condition using a mixture of indicators included Hudson, Matheny, and Clower Creeks. Creeks that were sometimes ranked among the good creeks and sometimes among the poor creeks depending on variation among indicators were Whitaker, Catfish, North, Hatchett, and Woodmere (mostly poor), and Phillippi, Alligator, and Gottfried Creeks (mostly good).

There is little agreement between creek scores and ranks based solely on the creek condition index, and creek scores and ranks based on multiple sources of information including the creek condition index. The creek condition index is based solely on biological information from the tidal reaches of coastal creeks; it accords well with independent benthic community data taken at the same time, and adds a biological dimension to a creek and watershed report card. Neither the creek condition index nor any other single report card constituent can be used to describe the inherently complex condition of watersheds and creeks combined.

PART I: A TIDAL CREEK CONDITION INDEX (TASK 7)

INTRODUCTION

The importance of tidal creeks, including their headwater areas and the narrow reaches of coastal rivers, cannot be overstated. They are valuable environmental resources in that they are unique ecosystems that function as a link between uplands and estuaries. Two major roles that tidal creeks play as that link are 1) to deliver freshwater and nutrients to marsh and estuarine systems (the delicate balance between fresh and saltwater is critical to the estuarine health); and 2) to transport and deposit sediment, the most essential natural processes occurring in watersheds. Acre for acre, tidal creeks are the most productive piece of the coastal estuary, providing the food and shelter for many aquatic species in their breeding and juvenile stages. They are also the first point of entry of non-point source runoff from upland areas and their sensitivity to impacts from upstream activities such as agriculture and development allows them to function as an early indicator of anthropogenic stress. Other important attributes are that they serve as potential resources for public water supply, they offer opportunities for flood control, and they are extremely popular sites for residential developments, vacation resorts, and recreational businesses.

Numerous studies have been conducted to understand how land development has impacted the environmental quality of small streams. Certain studies have used the amount of impervious surface to measure the degree of watershed development. There has been a correlation between human population densities and the physical and chemical changes in the tidal creek environment, as well as changes in a tidal creek's capacity to serve as valuable nursery habitat. Studies have shown that impervious surfaces exceeding 20% can result in major impacts, such as changes in the salinity regime, increased chemical accumulation in sediments, increased fecal coliform bacteria levels, changes in food web organism abundance and diversity, and changes in biological indicator abundance and diversity. In more urbanized areas, the abundance of pollution-sensitive individuals decreases as the abundance of pollution tolerant individuals increases. "Tidal creeks are sentinels that provide early warning of the degree to which land development affects coastal environmental quality." (Holland, et. al, 2005)

While comparative ecological health assessment indices have been developed for marine, estuarine, and freshwater ecosystems, none has been developed for tidal creeks, so none has been developed using rapid survey techniques. There is considerable interest in condition indices for coastal waters of all types, although next-generation indices will be challenging to produce (Niemi et al., 2004). Sarasota County and Mote Marine Laboratory have collaborated to develop biological indicators for tidal creeks. An ecologically-based index of tidal creek ecosystem health would be a valuable tool for comparing multiple systems, documenting the ecological condition of a system through time, having independent data for TMDL assessment, and tracking the success of watershed management plans. The ecological and water quality data could serve as a useful baseline to compare with future trends as watersheds are altered by development, restoration, or other processes and could allow a proactive approach in their protection, management, and maintenance. The data could also be useful in the development of Basin

Management Action Plans and strategies to meet Total Maximum Daily Loads (TMDLs) assigned to the watersheds. An ecological index is a measure that integrates health over time, but TMDLs are a series of snapshots that are assumed to correlate, as a more indirect measure, with biological health. The preliminary effort to develop a Tidal Creek Condition Index for County tidal creeks by Mote Marine Laboratory was divided into three phases.

Phase I

During the first phase of the project in 2004, County staff conducted research to collect existing data for the sub-basins of the following 20 tidal creeks: Whitaker Bayou/Walker Creek, Hudson Bayou, Phillippi, Matheny, Clower, Catfish, North, South, Cow Pen/Shakett, Curry, Hatchett, Alligator, Woodmere, Forked, Gottfried, and Ainger Creeks, the Myakka River, and its three tributaries - Deer Prairie, Little Salt, and Myakkahatchee Creeks. The data were compared to establish the ecological condition of those streams, characterize the condition of their sub-basins, and select 2 streams that could be deemed as opposites (best and worst) by the condition of their respective sub-basins. After analyzing the data, Mote recommended that Myakka River tributaries were inappropriate to compare to the coastal streams given their different ecological settings. Therefore, the Myakka River and its 3 tributaries were set apart for separate study. The data analysis from Phase I resulted in a preliminary rough grading of the remaining 16 watersheds and streams in order of best condition to worst condition, and the project team concluded that there were enough streams with very different major basin features to be able to move forward with the next phase of the project.

Phase II

During the second phase in 2005, Mote Marine Laboratory conducted field studies to characterize extremes among County coastal systems to determine the range of ecological conditions available for index development. Based on data obtained in Phase I, Gottfried Creek was designated as an example of a least impacted watershed and Whitaker Bayou/Walker Creek was designated as an example of a most impacted watershed. Both streams were assessed using identical metrics. The assessment resulted in two reports: “The Gottfried Creek Reconnaissance Report”, July 12, 2005 and “The Whitaker Bayou Reconnaissance Report”, August 17, 2005. These concluded that there were enough significant ecological differences between the two streams to affirm the characterization of the two as examples of “best” and “worst” streams, thus demonstrating at least a correlative relationship between watershed and creek condition. Following the data review in Phase I and *in situ* study of “best” and “worst” watersheds/streams in Phase II, Mote Marine Laboratory concluded that there were a sufficient number of county systems to develop a biologically-based stream condition index; their watersheds differed widely; and extremely different basins had widely different tidal creeks. These conclusions supported the decision to move forward with the third phase of the project.

Phase III

During the third project phase (2006), Mote Marine Laboratory developed and tested a prototypic creek index based on ecological attributes that could be measured using rapid survey techniques. The test was made in 15 County coastal creek systems.

Phase III assessments and data analysis were completed in August 2006. The draft report, "Biological Condition Index for Tidal Streams in Coastal Sarasota County, Florida", which provided methods and results of the test, and a recapitulation of previous planning efforts, was submitted on September 30, 2006. A 2007 plan of study was submitted in November 2006. The final report was submitted on February 1, 2007.

Phase III assessments resulted in the following conclusions and recommendations:

1) Representative index sites could be identified in most tidal creeks, with many sites at or near existing or proposed stations for other monitoring programs.
2) The assessment and data analysis resulted in a scoring methodology for each creek that allowed them to be ranked in order of best (highest-scoring) to worst (lowest-scoring).
3) Phase III identified lower, middle, and upper sets of creeks, and, except for one creek, identified both impacted and lesser impacted groups of creeks that are generally perceived by other standards.
4) Phase III index results should be interpreted as a test of its metrics rather than as an assessment of county creeks.
5) Further index refinement and testing can lead to a workable tidal creek index system for use in Sarasota County and southwest Florida.
6) The prototype index should be tested against independent standards of creek and watershed condition, such as the Landscape Development Intensity Index (LDI), water quality data, etc.
7) The prototype index should be refined and field-tested in the 2007 dry season and conserve all of the metrics tested in Phase III. It will add "density of crustaceans and mollusks from coarsely-sieved benthic samples" as a new metric, as well as other candidate metrics.

Phase IV Project Objective

The objective of Phase IV of the Tidal Creek Condition Index project is to implement and apply the prototype index metrics to 16 County tidal creeks assessed in the preliminary phases. The data collected within the index will apply a scientifically-based ranking of the streams with respect to their existing condition; identify healthy and impaired streams; prioritize streams for restoration and protection; and will provide an assessment tool for restoration success.

INDEX APPLICATION AND CREEK ASSESSMENT

To accomplish the project, Mote Marine Laboratory applied the prototype index to the following 16 tidal creeks in Sarasota County: Whitaker Bayou (aka Walker Creek), Hudson Bayou, Phillippi Creek, Matheny Creek, Clower Creek, Catfish Creek, North Creek, South Creek, Shakett Creek, Curry Creek, Hatchett Creek, Alligator Creek, Woodmere Creek, Forked Creek, Gottfried Creek, and Ainger Creek (Figure 1). The sites within each creek were to be chosen to ensure that samples will be representative of biological conditions and suitable for comparison among other creek sample sites. The sampling was to be conducted within each tidal creek and not adjacent bays.

In applying the prototype index Mote Marine Laboratory was responsible for the satisfactory completion of a number of tasks and this report describes progress made in the final two research tasks listed below:

Task 7. Report Preparation

Mote will prepare the Dry Season Tidal Creek condition Index Report. Part 1 of the report will present correlation and regression analyses of metrics to determine the effects of site characteristics on metric scores. Part 2 will present results of statistical analyses including assessments of rectification, aggregation, and normalization alternatives. Part 3 will contain the results of stepwise sensitivity analyses to determine whether a core group of metrics accounts for a significant proportion of index variation.

Deliverable: A Dry Season Tidal Creek Condition Index Report that, in addition to deliverables listed above, will: Report empirical measures of health for each tidal creek; Include a thorough explanation of how the ranking was achieved, with index development calculations; Include a comprehensive explanation of how the index could be used to develop a watershed report card; Include a detailed explanation outlining specific stream conditions or metrics that would preclude application of the tidal creek index to any of the 16 subject creeks; Include a thorough explanation of the methodology used to further refine the prototype Tidal Creek Condition Index; Include a concise discussion of seasonality of sampling; Include a brief discussion of management activities for each creek including protection, restoration, or data deficiency needs. These strategies should be consistent with addressing the TMDLs for those impaired waters included in the study. The report should include a short executive summary that states the objectives, the accomplishments, and the conclusions of the project.

Task 8. Index Evaluation

Mote will compare creek scores to land development intensity indexes, County oyster monitoring results, County TMDL data or other independent watershed and/or creek condition measures, and testing index techniques to improve goodness of fit.

Deliverable: A Separate report on the validation of 2007 creek index results. This will be included as either a chapter or an Appendix in the final report.

This report is comprised of two parts corresponding to Task 7 and Task 8 deliverables.

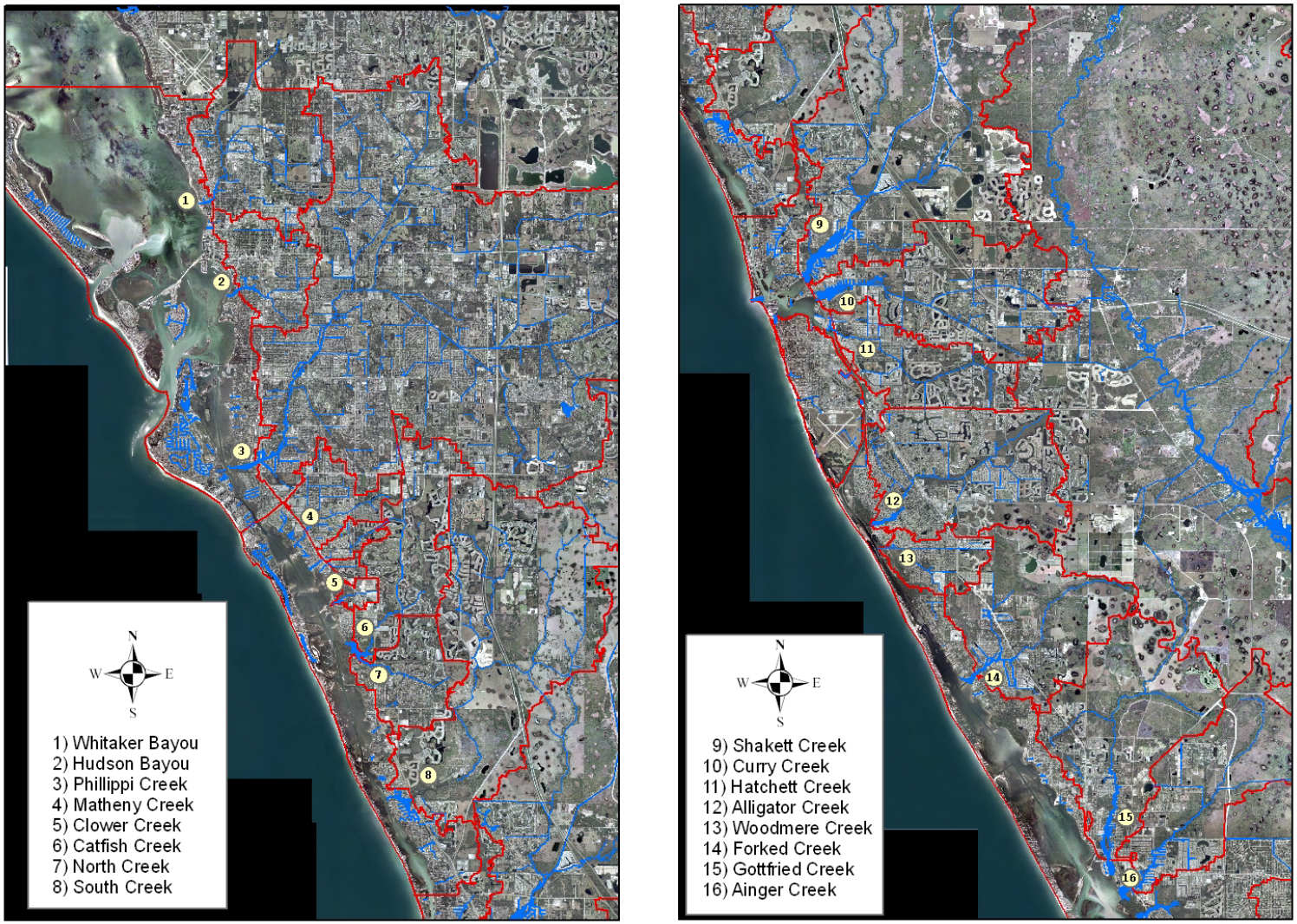


Figure 1. Location of tidal creeks in Sarasota County, Florida.

RATIONALE AND METHODS

Development of the tidal creek condition index entailed five steps:

1. Assessing Data Completeness and Distribution by Creek,
2. Analysis for correlations among variables,
3. Screening variables to achieve index objectives,
4. Selecting Variables for the Tidal Creek Condition Index,
5. Establishing a data rectification process, and
6. Aggregating Rectified Data into the Index.

Each is discussed in turn with explanations of methods and results. Supporting information is provided in corresponding appendices.

1. Data Completeness and Distribution by Creek.

Including two variables related to intertidal oysters (provided by Sarasota County as part of its oyster monitoring program in 11 creeks—Appendix 1), measurements were sought for 45 variables in both the intertidal and subtidal environments of each creek. In most creeks it was not possible to sample for every variable in each setting due to local conditions of habitat variety, size, or condition. The number of data for each variable in both intertidal and subtidal settings of all creeks combined is given in Table 1; details are provided in Appendix 2.

Some opportunistic data not required for the survey were collected, such as information on fungal mats or tunicate aggregations. Discounting these, 5,992 data were collected for the targeted variables. Data returns are presented by creek, below.

Creek	Intertidal	Subtidal	Combined
SOUTH	289	357	646
WOODMERE	207	396	603
GOTTFRIED	369	206	575
ALLIGATOR	279	276	555
AINGER	74	317	391
PHILLIPPI	47	327	374
CURRY	79	286	365
CATFISH	165	161	326
HATCHETT	171	151	322
WHITAKER	151	162	313
FORKED	70	237	307
MATHENY	196	80	276
SHAKETT	36	227	263
NORTH	3	232	235
CLOWER	120	112	232
HUDSON B.	3	206	209

Table 1. Data returns by variable for intertidal and subtidal settings combined.

	Parameter	N	Cumulative Percent
1	BURROW COUNT	250	5.65
2	DEAD TAG COHORT NO	238	11.03
3	LIVE TAG COUNT	238	16.41
4	DEAD TAG COUNT	236	21.74
5	PERI PERCENT COVER	220	26.71
6	TAG PERCENT COVER	220	31.68
7	OTHER LIVE MOLL COUNT	208	36.38
8	DRIFT PERCENT COVER	199	40.88
9	BARE NET CRAB	180	44.95
10	BARE NET FISH	180	49.02
11	BARE NET SHRIMP	180	53.08
12	SAV PERCENT COVER	180	57.15
13	BARE NET OTHER	179	61.20
14	OYSTER PERCENT COVER	170	65.04
15	FILAM PERCENT COVER	160	68.66
16	LIVE COHORT NO.	138	71.77
17	DRIFT NET CRAB	97	73.97
18	DRIFT NET FISH	97	76.16
19	DRIFT NET OTHER	97	78.35
20	DRIFT NET SHRIMP	97	80.54
21	LIVE TAG COHORT NO.	90	82.58
22	PERI NET CRAB	70	84.16
23	PERI NET FISH	70	85.74
24	PERI NET OTHER	70	87.32
25	PERI NET SHRIMP	70	88.90
26	SAV EPI COVER	60	90.26
27	SAV EPI LUX	60	91.62
28	SAV NET CRAB	35	92.41
29	SAV NET FISH	35	93.20
30	SAV NET OTHER	35	93.99
31	SAV NET SHRIMP	35	94.78
32	TAG EXTENT	31	95.48
33	PERI EXTENT	22	95.98
34	DRIFT EXTENT	19	96.41
35	SAV EXTENT	18	96.81
36	OYSTER EXTENT	17	97.20
37	FILAM EXTENT	16	97.56
38	SAV SPECIES NUMBER	14	97.88
39	OYSTER SPAT	11	98.12
40	OYSTERS %	11	98.37
41	FILAM NET CRAB	10	98.60
42	FILAM NET FISH	10	98.82
43	FILAM NET OTHER	10	99.05
44	FILAM NET SHRIMP	10	99.28
45	FUNGUS PERCENT COVER	10	99.50
46	OYSTER HT.	10	99.73
47	TUNICATE PERCENT COVER	10	99.95
48	FUNGUS EXTENT	1	99.98
49	TUNICATE EXTENT COVER	1	100.0

Comprising 62.3% of all records, subtidal data were twice as numerous as intertidal data.

Zero values were common among data for most variables. Zero values result when a variable could be measured but a replicate effort produced no result. Zero values were employed in statistical analyses described in subsequent sections. Empty data sets were left empty (not populated with zero values).

Of all variables measured in the field (as opposed to "synthetic" variables discussed below), two-thirds of the returned records were zero values. Two factors are generally responsible for the large number of zero records, namely the impaired condition of particular creeks, and the intentional effort to measure indicators of pollution for which zero records are meaningful. A variable's zero value is not necessarily associated with undesirable ecological conditions. Some variables were chosen as indicators of eutrophication, for example the cover and extent of filamentous algae. In these cases, a zero value signifies that an indicator of ecosystem distress does not occur in a given creek.

Although no data have been presented thus far in the present report to support the claim that some county creeks are ecologically impaired, and thus responsible for zero values for some variables, sufficient groundwork was laid in earlier project reports, other independent sources of creek data, and the experience of field crews working in 2007 to support the general statement that some creeks are in poorer ecological condition than others. Zero values for variables of interest may be expected until such time as the conditions of these creeks improve.

The creek-wise distributions of data by variable, as well as instances where variables were measured but produced only zero values, are summarized for intertidal and subtidal settings in Figures 1 and 2. It is worth noting that Figures 1 and 2 depict a "synthetic" variable concerning net catches. In the field logs and in data analysis to this point, dipnet catches over different bottom types were kept separate as counts of crabs, shrimps, fishes, or other fauna. In order to assess the usefulness of the combined catch, data were summed across groups within replicates to produce, for example, the variable named "SAV Net Catch--All."

Data in Figures 2 and 3 are sorted by the number of records for creeks and variables, from top to bottom. Thus, variables in the upper half of each figure are those for which the most data were collected. For intertidal settings, variables with the most data and also the largest number of creek-wise occurrences include burrow count, oyster attributes, macroalgal records, *Tagelus* attributes, and SAV records, in descending order. For subtidal settings, variables with the most data and also the largest number of creek-wise occurrences include *Tagelus* and "other mollusk" attributes, burrow count, dip net catches over bare bottoms, and macroalgal records, also in descending order.

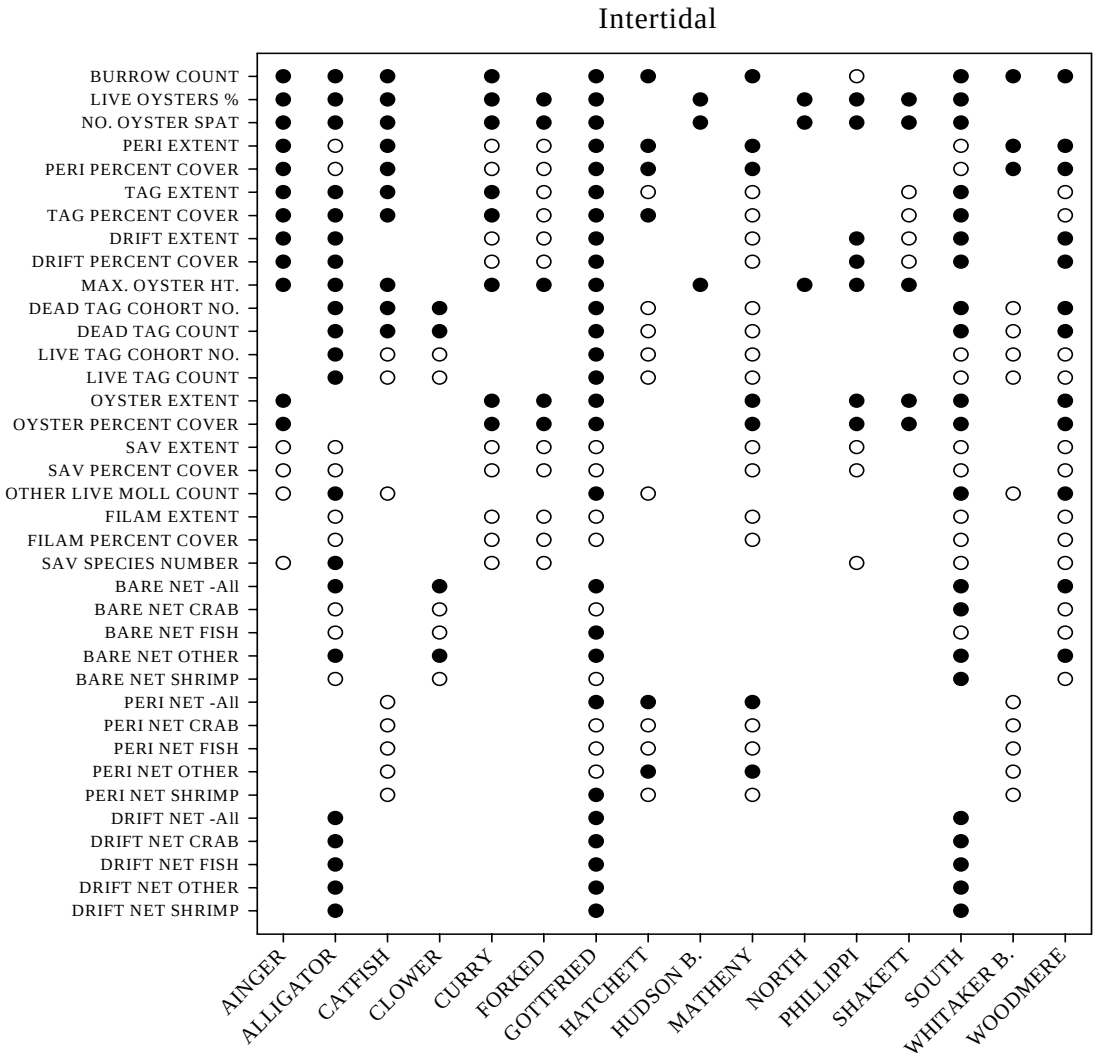


Figure 2. Creek-wise distribution of intertidal data by variable. Symbols mark the occurrence of data: open symbols are data sets comprised of zero-value records only and closed symbols represent data sets with non-zero records.

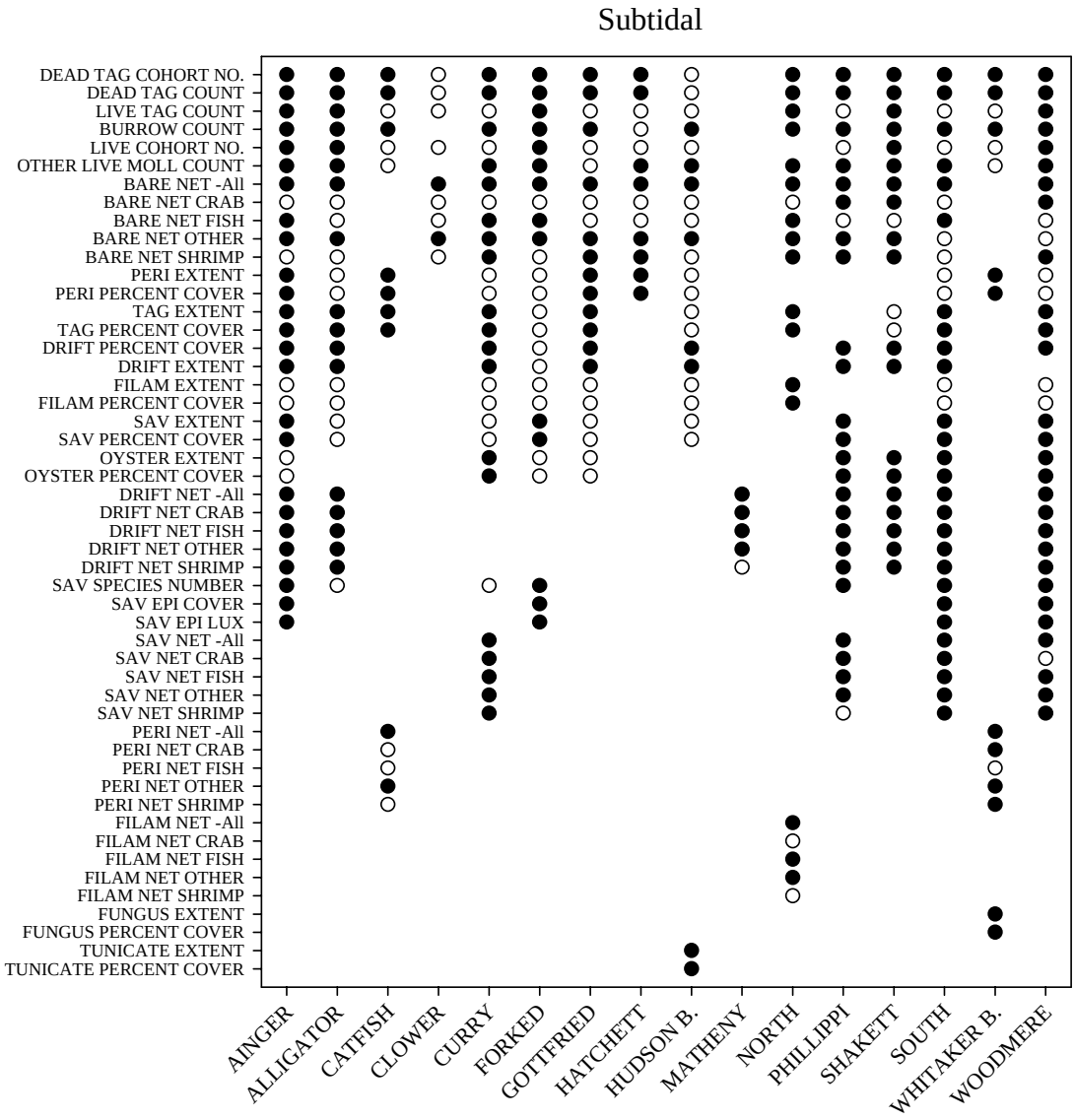


Figure 3. Creek-wise distribution of subtidal data by variable. Symbols mark the occurrence of data: open symbols are data sets comprised of zero-value records only and closed symbols represent data sets with non-zero records.

Although the purpose of the present project is to identify a smaller set of variables upon which a creek condition index may be calculated, it is worthwhile to examine the complete data set with respect to how creeks would group or be ordered in terms of their similarity using the original and entire data set. In order to anticipate problems that rare, large values can cause in similarity analysis, and to generalize the comparison of creeks as much as possible, all data were converted to a presence/absence basis.

Similarities among creeks were examined by applying a hierarchical cluster analysis (in SPSS) to presence/absence of chosen environmental variables (i.e., oysters, SAV, macroalgae) for each creek, using an average linkage clustering with a Euclidean distance matrix. The method yields a dendrogram which can then suggest similarities among subjects, in this case, creeks.

Results appear in Figure 4 in which leftward groupings are most similar and rightward branches signify the strength of group nesting. Two groups are evident with an upper set of five creeks and a lower set of eleven creeks. The upper group defines a strong to weak but distinctive affinity among Clower, Matheny, Whitaker, Hatchett, and Woodmere creeks. The five creeks most distant in similarity from these five are Forked, Alligator, Ainger, North and Gottfried creeks.

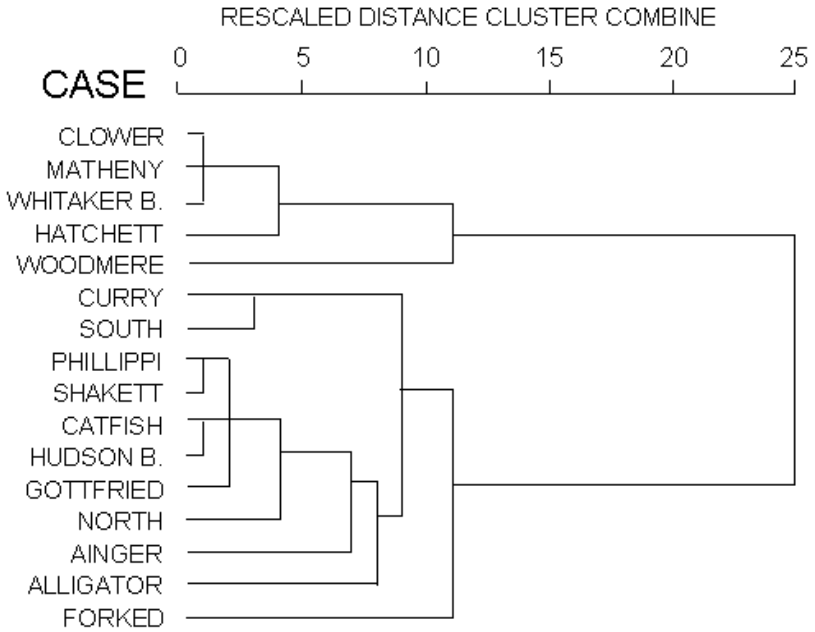


Figure 4. Cluster analysis dendrogram depicting similarity of creeks based on presence-absence transformation of original 2007 data.

2. Analysis for Correlations among Variables.

In order to identify variables of potential use for the creek condition effort, an effort was made to learn the extent to which variables were correlated in order to identify redundant efforts and highlight variables that were relatively independent and also contributed unique insights to creek condition.

Pearson correlation coefficients were computed between individual variables using a pair-wise approach that employed all original data for every variable. Data from all 16 creeks were used, as available for each variable. One set of analyses was made for intertidal data and another was made for subtidal data sets because of differences in the size, evenness, and coverage of variables in the two settings, as previously described. Then correlations were determined among variables between intertidal and subtidal settings.

Significant relationships are denoted with an asterisk (for $p<0.05$) and highly significant relationships are denoted by two asterisks (for $p<0.01$). Except where the distinction is needed to notice a special condition, the convention is used in this report of referring to significant *and* highly significant relationships as "significant", irrespective of sign (negative correlations are indicated as such in accompanying tables and appendices). Complete results appear in Appendix 3.

There were 110 significant or highly significant variables pairs among the 1,317 comparisons, or approximately 8.3 percent. The variable most frequently correlated was intertidal *Tagelus* extent and it was correlated at 0.05 or 0.01 probability levels in 6 paired comparisons. In general, intertidal variables were correlated with other intertidal variables in 6.8% of pairs; subtidal variables were correlated with other subtidal variables in 9.2% of pairs, and 7.8% of intertidal and subtidal pairs were correlated at 0.05 or 0.01 levels.

The frequency of significant and highly significant correlations among variables can be summarized by the general types of data collected in the creeks:

Type of Effort	Percent of all Correlations at 0.05 or 0.01 Levels
Extent	10.7
Mollusk Density	9.3
SAV & Epiphytes	8.7
Percent Cover	8.5
Oyster Attributes	7.1
Tagelus Attributes	6.1
Net Catch	3.5
Burrow Density	2.8

As shown above, the frequencies of pair-wise correlations that were found to be significant or highly significant varied with intertidal and subtidal setting as well as by the type of effort. On balance, the extent of such correlations was generally low. It is also worth noting that

correlations were contagious or nested because of the contingent relationship of some variables. For example, epiphyte load on SAV is necessarily dependent upon the presence of SAV, and the dip net catch of fauna in macroalgae is contingent on the presence of macroalgae. There were 35 pairs of variables for which the potential existed of obtaining significant correlations as a consequence of their contingent relationship. Knowledge of such contingent nesting of correlations aids in the selection of variables for index use.

3. Screening Variables to Achieve Index Objectives.

The following criteria and considerations were used to guide the selection of specific ecosystem variables upon which a creek condition index could be established.

A. Multiple levels of biological organization. A robust index draws from biological and ecological attributes spanning a hierarchy of levels from the condition (health, disease) of single organisms, to ecosystem structure, function, and production. The Florida Department of Environmental Protection seeks to integrate bioassessment across multiple attribute groups depicted below.

INDIVIDUAL CONDITION	**TAXONOMIC COMPOSITION**	**COMMUNITY STRUCTURE**	**LIFE HISTORY ATTRIBUTES**	**SYSTEM PROCESSES**
Disease	*Identity*	*Taxa Richness*	*Feeding Groups*	*Trophic Dynamics*
Anomalies	*Tolerance*	*Relative Abundance*	*Habit*	*Productivity*
Contaminant Levels	*Rare or Endangered Key Taxa*	*Dominance*	*Voltinism*	*Material Cycles*
Longevity/ Death	*Indicator Species*	*Keystone Species*		*Predation*
Metabolic Rate				*Recruitment*

(Indicator and keystone species, and longevity have been added.) In practice, logistical limitations, scaling issues, and frequently the lack of baseline or reference conditions make it difficult to operate across several attribute groups simultaneously.

B. Relationship to creek and watershed condition and management. Useful metric variables are those with known responses to proximate stressors that are in turn be related to watershed influences. The longevity of oysters, for example, is known to be regulated by the frequency and duration of freshets that result either from natural rainfall and runoff or from the operation of

instream control structures. Other factors being equal, a creek with altered hydrology that experiences significantly greater oyster mortality than a comparable creek with natural hydrology may be considered impaired with respect to oyster resources (because of their mortality); an adverse salinity regime is the proximate stressor causing the mortality (because of lethally low salinities), and the operation of instream structures is the watershed management practice requiring modification. Where these causal relationships between the resource variable, proximate stressor, and watershed activity are imprecisely known the relationships can be transferred from better-studied settings, or discovered through new research.

C. Multiple strata. To the extent possible, variables should be chosen so as to work in each of the strata identified from prior work, study design, or companion studies of resource distribution, water quality, human activities, etc. Where spatial, physical, ecological or anthropogenic conditions such as urbanization prevent variables from universal use, but multiple strata are more or less evenly represented in creeks, variables should be included to provide some information on each to an index. For example, creeks present both intertidal and subtidal settings and an index that captures unique resource values in both settings will be more representative than otherwise.

D. Scope for change. Index variables should have scope to change as a creek's condition improves or worsens. Scope for change can be provided in terms of how samples and measurements are defined for a variable, as in gear, method, and replication decisions. A set of creeks held by other standards to be relatively unimpaired might employ one suite of variables whereas an impaired creek set might employ another. Consideration in selecting variables must be made when seeking to establish an index in a set of creeks with a range of ecological conditions. Another method for providing scope, especially in the latter case, is to consider variables that indicate impairment such as the presence of nuisance accumulations of macroalgae.

E. Logistics. The selection of index variables must necessarily be advised by logistical constraints such as access, time on station, the need to sample multiple creeks in a day, and crew safety.

4. Variables Selected for the Tidal Creek Condition Index

Taking the objectives described in Part 3 into consideration, nine variables were selected for further study and potential use in Sarasota County's Tidal Creek Condition Index:

<u>Intertidal: Percent live oyster; largest live oyster.</u>

Sarasota County's oyster monitoring program produced May-June 2007 data on intertidal oysters in a majority of county creeks. Live and dead oysters and the number of oyster spat were counted in quadrats, and the heights of the largest living oysters were recorded. Percentages of living oysters were computed from SCG field data. Results appear in Appendix 4. The mean percentage of live oysters in a creek ranged from 38 – 82%; maximum heights ranged from 5.6 –

9.2 cm. The percent of live oysters was not significantly correlated with other index variables; maximum oyster height was significantly correlated with live Tagelus density (Table 2).

Table 2. Pair-wise Pearson correlation coefficients for creek index variables. Significant and highly significant correlations are shown in bold.

VAR	SUB LIVE COHORT NO_	SUB LIVE TAG COUNT	SUB BARE NET -All	SUB BURROW COUNT	SUB OTHER LIVE MOLL COUNT	SUB FILAM PERCENT COVER	SUB PERI PERCENT COVER
LIVE OYSTERS %	0.263	0.4135	0.4365	0.3138	0.0959	0.3574	0.0467
MAX_ OYSTER HT_	0.374	**0.4558**	0.4312	0.2786	0.1337	0.3572	0.0952
SUB BARE NET –All	0.276	**0.8608**		0.2145	0.3814	**0.9649**	0.1603
SUB BURROW COUNT	0.201	0.1542	0.2145		0.2812	0.1953	0.3175
SUB FILAM PERCENT COVER	0.232	**0.8602**	**0.9649**	0.1953	0.3929		0.2066
SUB LIVE COHORT NO_		**0.6428**	0.2764	0.2011	**0.7133**	0.2319	0.1175
SUB LIVE TAG COUNT	**0.643**		**0.8608**	0.1542	**0.5697**	**0.8602**	0.1165
SUB PERI PERCENT COVER	0.118	0.1165	0.1603	0.3175	0.1981	0.2066	

<u>Subtidal: Burrow density; live *Tagelus* density; number of live *Tagelus* cohorts; other mollusk density; bare net catch (all species combined); percent cover of periphyton; percent cover of filamentous algae.</u>

Burrow density is a novel variable and refers to the number of burrows within a small area, which are visible to the naked eye. Burrow data were available from all creeks but Clower and Matheny, where subtidal measurements could not be made owing to poor bottom conditions. Burrow density ranged from near zero to 90 burrows per square meter. Burrow density was not significantly correlated with other index variables.

Live *Tagelus* occurred in six creeks. In selecting *Tagelus* as an index variable it is worth noting that recently dead *Tagelus* were found in 12 of the 16 creeks, indicating their ability to live in the majority of county creeks. Mean live *Tagelus* density ranged from less than 1.0 to 2.5 animals per square meter. Only a single cohort of live subtidal *Tagelus* was found in any creek, compared to a subtidal mean of 3 dead cohorts and, in the intertidal zone of Alligator Creek, a

maximum of 7 dead cohorts. Live *Tagelus* density was significantly correlated with seven index variables; live cohort number to three.

Other mollusk density refers to the combined catch of all mollusks in cores, other than *Tagelus*. Only live mollusks were counted; most were bivalves. Other mollusks were collected in 11 creeks and values ranged from near zero to 30 individuals per square meter. Other mollusk density was significantly correlated with *Tagelus* data.

Dip nets were used to collect epifauna and sedentary swarming and pelagic fauna over all bottom types. Abundances of fishes, shrimps, crabs, and other fauna were recorded separately but for index use the abundances were combined for total net catches. Mean abundances of combined catches were lowest over bare bottoms (compared to drift algae, SAV, etc.) but bare net catch data were collected from more creeks (9) than net samples over other bottom types. Bare net catch ranged from near zero to 10 animals per tow. Bare net catch was significantly correlated with 4 index variables.

The percent cover of two nuisance algal forms, filamentous algae and periphyton mats, contribute to creek condition by virtue of their absence. Filamentous forms include species of *Lyngbia*, *Cladophora*, *Chaetomorpha*, *Enteromorpha*, etc. and filamentous algae were especially abundant in 2006, notably in South Creek. Periphyton mats occurred in various forms. In 2007, filamentous algae and periphyton mats occurred in the same five creeks (Whitaker Bayou, Catfish, Hatchett, Gottfried, and Ainger) in ranges from near zero to 100 percent. Filamentous percent cover was significantly related to 4 index variables while periphyton percent cover was correlated with none.

Taken together, these variables selected for index use span both intertidal and subtidal settings and several levels of biological organization. Variables also have known stressors that in many cases can be mapped to watershed influences amenable to management (Table 3).

5. Establishing a Data Rectification Process.

The nine variables selected for use present five different unit systems. Before the variables can be combined into an index it is necessary to transform data into unit-less values. Upon reviewing data distributions for the variables the following system was employed. Four bins were used to distribute original data for each variable. Bin 1 was used for data with zero value. The remaining non-zero data were divided into thirds relative to their maximum values. To account for yet-larger values than 2007 maxima the upper limits of Bin 4 were calculated using 2007 maxima plus an increment, usually about 10%, based on the nature of the variable. The final system by which data were distributed is shown in Table 4.

Bin labels indicate the numeric value assigned to each original datum. Thus, a mean burrow count of zero would be transformed to a value of 1; this is necessary for aggregation methods described in the next section. Mean burrow counts of 3, 7, and 11 have rectified values of 2, 3, and 4, respectively.

Table 3. Relationship of Condition Index components to proximate stressors and watershed influences. Other abiotic and biotic stressors (weather; predation) affect these resources but are unrelated to watershed influence.

Level of Biological Organization	**Index Component**	**Proximate Stressors**	**Watershed Influences**
Longevity	Live *Tagelus* Cohorts	Salinity	Hydrological Modifications
		Chlorophyll *a*	Nutrients; Residence Time
	Largest Live Oyster	Salinity	Hydrological Modifications
		Dissolved Oxygen	Point and NPS Runoff
		Chlorophyll *a*	Nutrients; Residence Time
Indicator Species	Live *Tagelus* Density	Salinity	Hydrological Modifications
		Chlorophyll *a*	Nutrients; Residence Time
	Percent Live Oysters	Salinity	Hydrological Modifications
		Dissolved Oxygen	Point and NPS Runoff
		Chlorophyll *a*	Nutrients; Residence Time
		Parasites; Predators	Hydrological Modifications
Pelagic/Epibenthic Community	Bare Net Catch All	Sediment Structure	Sedimentation
		Salinity	Hydrological Modifications
		Dissolved Oxygen	Point and NPS Runoff
Benthic/Infaunal Community	Burrow Density	Sediment Structure	Sedimentation
		Salinity	Hydrological Modifications
		Dissolved Oxygen	Point and NPS Runoff
	Other Mollusk Density	Salinity	Hydrological Modifications
		Dissolved Oxygen	Point and NPS Runoff
		Chlorophyll *a*	Nutrients; Residence Time
		Parasites; Predators	Hydrological Modifications
Pollution Indicator Species	Periphyton Percent Cover	Light	Sediments, Turbidity, Color
		Nutrients	Point and NPS Runoff
		Salinity	Hydrological Modifications
	Filamentous Percent Cover	Light	Sediments, Turbidity, Color
		Nutrients	Point and NPS Runoff
		Salinity	Hydrological Modifications

Table 4. Bin definitions used to rectify index data, by variable. Note that original field data are used and that the direction of transformed scores for nuisance algae is reversed.

	Transformed Value			
Variable:	1	2	3	4
Burrow Count	0	1-4	5-8	≥9
Live *Tagelus* Density	0	1-2	3-4	≥5
Live *Tagelus* Cohort No.	0	1	2	≥3
Other Mollusk Density	0	1-3	4-9	≥10
% Live Oyster	0	1-50	51-74	≥75
Maximum Oyster Ht. (cm)	<6	6-8	>8-9	≥9
Bare Net Catch (All)	0	1-10	11-20	≥21
Filamentous Algae % Cover	≥66	65-34	33-1	0
Periphyton % Cover	≥66	65-34	33-1	0

Original field data (e.g. number of burrows per quadrat) were used to create values for the index rather than transformed data (e.g. number of burrows per square meter). This was done so that future field crews can compute the creek index while on station, if needed, using field sheets prepared for this purpose. As another measure to facilitate sampling and measurement, 2007 field experience determined that net catches greater than 20 total individuals are difficult to enumerate, but numbers greater than 20 can be visually estimated with confidence. Because bin 1 was used for undesirable conditions and bin 4 was used for desirable ones, the assignment of field data for nuisance algae has been reversed so that high percent cover values produce low index constituents.

Use of the system is illustrated below for hypothetical field data for mollusk density data and their transformation.

Replicate	1	2	3	4	5	6	7	8	9	10
Field Value	2	0	0	7	1	0	16	10	5	3
Binned Value	2	1	1	3	2	1	4	4	3	2

6. Aggregating Rectified Data into the Index

Two methods were tested. In 2006 a prototypic index was developed using summed values. As explained below, this method was found deficient given the nature of the data at hand, so a second approach was evaluated.

When a creek index is aggregated of multiple values two objectives are desirable: that the index scores be comparable between different creeks, and that one creek's index scores be comparable through time. In order to test whether summation or other aggregation methods differed in their ability to fulfill these objectives, a model system was developed. The model was comprised of 5 hypothetical data sets. Each set contained 8 replicate values for each of 10 index variables, and values were assigned to each set so as to represent a predetermined creek condition thusly.

Set A: Very Good-- mostly maximum values in the ranges of all variables
Set B: Good-- a mixture of high and maximum values
Set C: Average-- mostly mid-range values for each variable
Set D: Poor-- a mixture of low and minimum values
Set E: Very Poor – mostly minimum values in the ranges of all variables.

In each case only data represented as bins (1,2,3,4) described in the previous section were used.

When all variables and all replicates are available for use, summing values and computing arithmetic means produces the results in column 1 below. When data are removed (in this case by the deletion of 3 variables per set, summing and arithmetic means produces the results in column 2.

	Column 1	Column 2
Set A: Very Good	4.0	2.8
Set B: Good	3.1	2.1
Set C: Average	2.2	1.7
Set D: Poor	1.8	1.4
Set E: Very Poor	1.0	0.7

It appears that a loss of data affects the value of the creek index but in this case where the same data loss was applied to each set, there was no change in the *relative ranking* of the sets (creeks).

As it happens, Sarasota County creeks present a variety of conditions with respect to the number of index variables in each, and also the number of replicates that can be taken for individual variables. Specifically, in 2007 no creek had data for every one of the nine index variables. Two creeks are missing one variable and two creeks are missing two variables. Another two creeks are missing 5 and 7 variables although two of the variables are pollution indicators. Stated otherwise, in 2007 a typical variable was absent in three creeks on average. Depending on antecedent creek conditions, locally episodic events, logistical problems and other factors, a given creek may present fewer or more variables in one year than others. Using the examples above, if Set A (Very Good Creek) presented three fewer variables than last year, but was otherwise in excellent condition, its score with summation and arithmetic averaging would fall from 4.0 to 2.8, thus changing its condition relative to other creeks unaffected by a data loss.

To remedy this problem an alternative aggregation method was evaluated, that of computing geometric means. A geometric mean is the nth root of a series of products. For example, if a creek had 8 mean rectified constituents 1, 3, 2, 1, 4, 4, 3, and 2 the geometric mean will be the 8th root of 1x3x2x1x4x4x3x2, or the 8th root of 576, or 2.213…. .

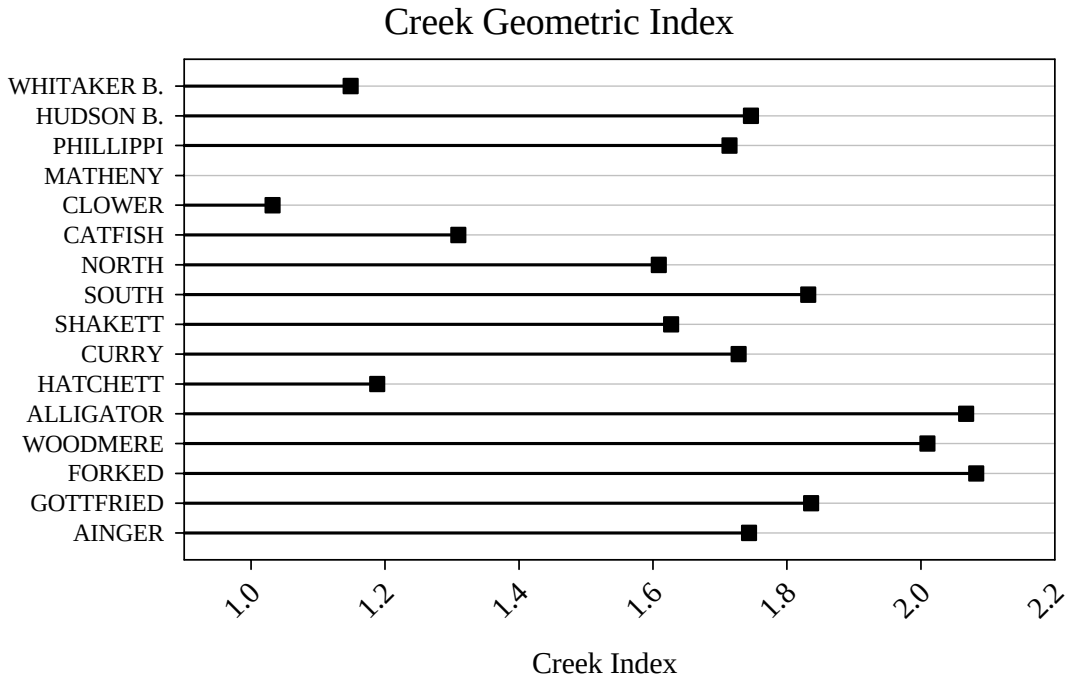
Using the same approach for arithmetic means to evaluate the results of data loss on geometric means produces these results. In column two the removal of data is the same as in the first test.

	Column 1	Column 2
Set A: Very Good	4.00	4.00
Set B: Good	3.03	2.87
Set C: Average	2.12	2.56
Set D: Poor	1.68	1.95
Set E: Very Poor	1.00	1.00

When data sets are uneven the index scores based on geometric means differ from those based on arithmetic means in two significant ways. First, a reduction in the number of variables does not necessarily reduce all creek scores uniformly; in fact, some scores improve. More importantly, however, is the preservation of relative rank or order of creeks affected by data loss. While this does not obtain in every possible case the present example illustrates that Good Creek's score of 2.87 (with data loss) does not rank it below Average Creek's score of 2.12 (with all data at work).

The use of rectified data aggregated by geometric means is the system employed in habitat suitability index (HSI) models. Originally developed by the U.S. Fish and Wildlife Service (1981), the HSI modeling method employs information on a variety of physical, chemical, and biological attributes of a species' habitat. The fitness of the species is defined as unit-less values ranging from 0.0 (completely unfit) to 1.0 (ideally fit) across the range of natural values for each HSI variable, and these are combined as a geometric mean. Data for every variable comprising an HSI index score are not always available so the HSI is similar in this respect to the tidal creek condition index. Even with uneven numbers of variables, the suitability of multiple habitats can be quantified and ranked.

The 2007 Sarasota County tidal creek condition index is illustrated in Figure 5.



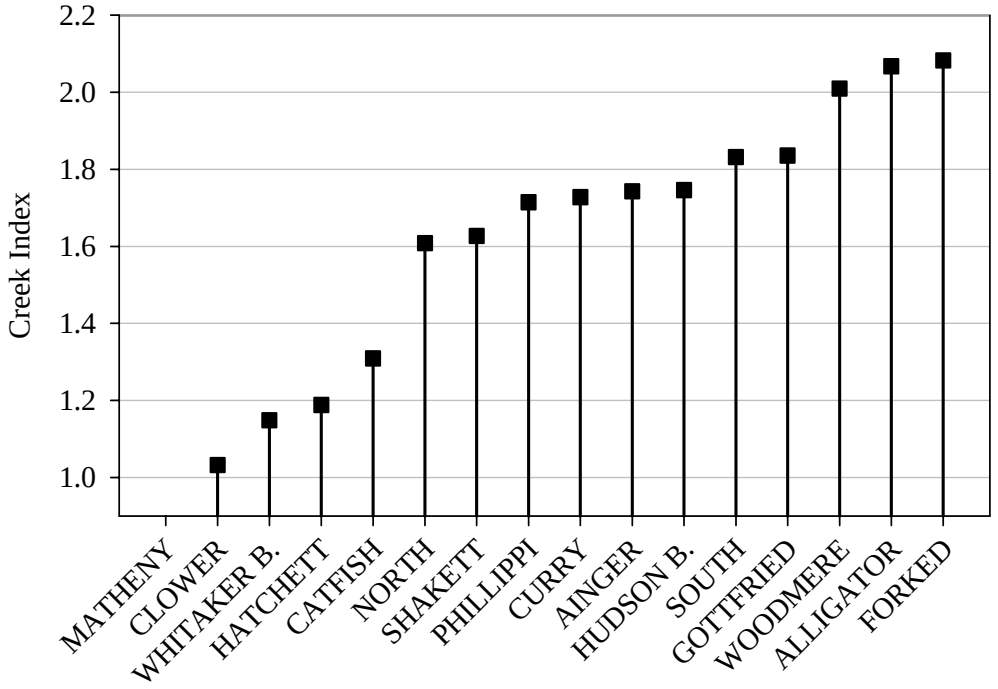


Figure 5. 2007 Tidal Creek Condition Index Scores.

As shown in Figure 5, no index score is presented for Matheny Creek. Reasons include poor bottom and water quality conditions, and the index's reliance on mostly subtidal data. Subtidal data were collected for some variables in Matheny Creek but no data were available for the variables that would come to comprise the index. Alternative methods employed in 2007 for poor sampling conditions were unsuccessful but can be improved upon. Also, intertidal oysters are a component of the index but Matheny Creek supports an insufficient number of oysters to sample for the index.

Creek index scores fell into small groups having relatively low and high values and a larger group with intermediate values. Compared to the cluster analysis dendrogram based on all data for all variables (Figure 4), the sorting of creeks by index scores was conservative. Both approaches identified Clower, Matheny, Whitaker and Hatchett Creeks as a group with similar low resource values, and the two approaches agreed in placing Alligator and Forked Creeks among the group with similar high resource values. This result demonstrates the ability of the index to capture like creek groups and their relative order as identified through the use of the entire database.

Index values ranged from 1.03 to 2.08 or about 35% of the index's theoretical range (1.0 – 4.0). The mean creek score was 1.64, or 21% of the index's upper limit. Until subsequent fieldwork produces a larger data base for the index variables, it is too early to tell whether the relatively low 2007 scores for creeks are typical. However it should be noted that in 2007 at least one creek produced a score of 4.0 for every index variable except the two measures of longevity and persistence, *Tagelus* cohort number, and maximum oyster height. If perfect scores occurred for most variables in at least one creek then it is reasonable to expect higher creek condition index scores than seen in 2007.

PART II: COMPARING AND COMBINING THE CREEK INDEX WITH OTHER INDICATORS OF WATERSHED AND CREEK CONDITION (TASK 8)

INTRODUCTION

(NEED)

The Tidal Creek Condition Index brings to bear a set of variables uniquely based in biological attributes. The insight the index provides is therefore ecological in nature and, at present, is the only ecological reference system available for tidal creeks. On the one hand, there are valid reasons why the biology of a creek is not necessarily tied to its water quality, or the condition of the creek's watershed. This is because numerous factors that are strictly biological in nature, and independent of water quality or watershed condition, are in operation with the creek ecosystem. Examples include recruitment, extirpation, competition, predator-prey cycles, symbioses, and epizootics. Human influences such as harvesting, unintended vessel traffic impacts, and channel maintenance also exert ecological effects independent of creek water quality or watershed condition.

On the other hand, it is reasonable to expect that the condition of a creek and its watershed be tangibly linked in some observable way to the creek's dominant water quality conditions, or the watershed's dominant landscape and use characteristics. It was that expectation that led to the early project effort to visit two creeks representing greatly different watershed qualities and the subsequent finding that the two creeks themselves varied considerably with respect to biological resources.

Accordingly, an effort was made to compare the 2007 tidal creek condition index to a variety of other creek and watershed condition descriptions. Benefits of such comparisons are several. First, the comparison reveals the extent to which the condition index conforms to valuations and rankings of creeks based on non-biological data. Knowledge of such conformance corroborates the utility of both data sets and also provides valuable hypotheses that can be tested to discover the particular causal mechanisms responsible for the agreement. Second, the comparison opens the possibility for serendipitous associations that may add deeper insight to watershed, creek, and ecosystem linkages. Third, if an accepted standard of biological integrity exists, other than those employed in the creek index, then an opportunity exists to gauge their correspondence and the efficiencies and economies that the creek index presents relative to traditional methods.

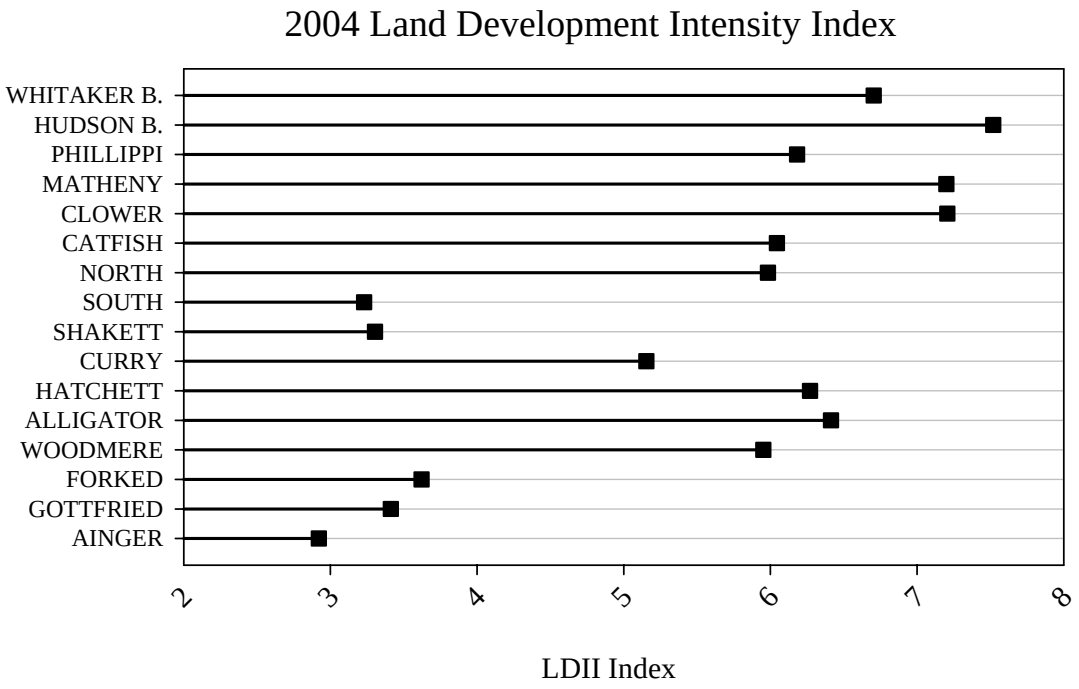
Other measures of creek and watershed condition selected as bases for the assessment of the tidal creek condition index include:

1. 2004 Landscape Development Intensity Index
2. Watershed Age of Development
3. 2006-2007 Hydrological Variability
4. Antecedent Water Quality
5. Pollution Load Model Outputs
6. 2007 Benthic Infaunal Community

1. Landscape Development Intensity Index

With support from the Florida Department of Environmental Protection, the University of Florida Center for Wetlands developed an index that combines the areal extent of dominant land covers and land uses with their respective ecosystem impact, using embodied energy (emergy) as the algorithm for weighting each area appropriately (Brown and Vivas 2005). Using GIS, Sarasota County determined the percent of each tidal creek's watershed given to dominant land covers and land uses; applied the emergy coefficients to each, and summed the constituents into a single Landscape Development Intensity Index (LDII) for 2004. A low LDII score indicates a less-intensely developed watershed.

The 2004 LDII data are presented by watershed in Figure 6. Ainger, South, Shakett, Gottfried and Forked Creeks have relatively low LDII index values signifying low extent and intensity of watershed development. The 2004 LDII index was not significantly correlated with the tidal creek condition index. In general, the LDII index had significant or highly significant correlations with watershed age, a few pollutant loads and benthic faunal measures, and several 2007 creek sediment characteristics. (Appendix 5 contains correlation coefficients for all pairs of creek and watershed attributes discussed in this section.)



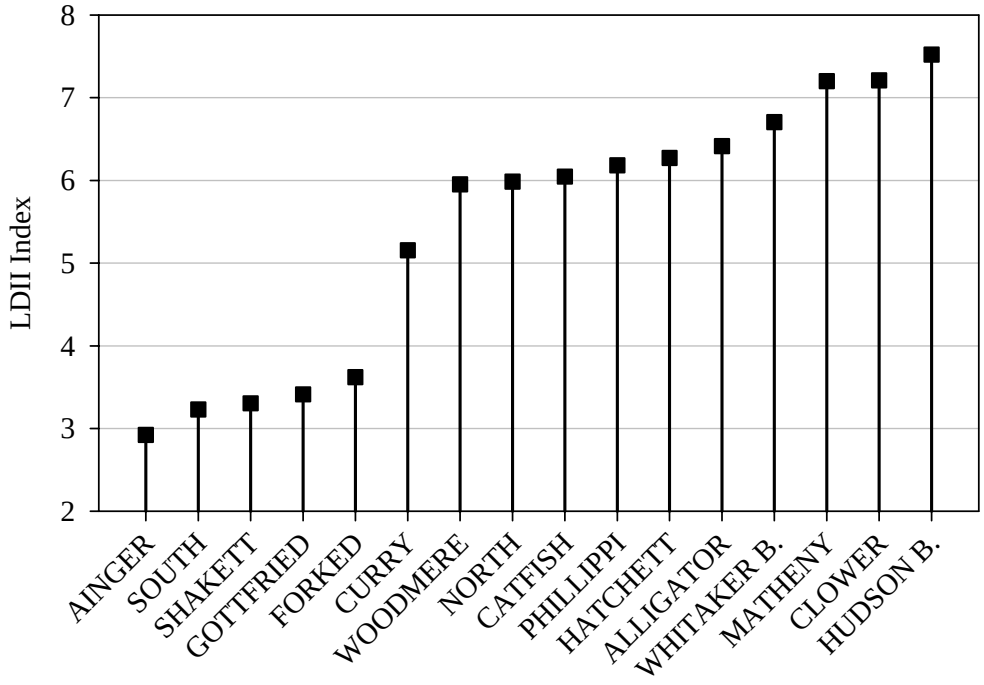


Figure 6. 2004 Land Development Intensity Index for watersheds of 16 tidal creeks. Data provided by Sarasota County.

2. Watershed Age of Development

Sarasota County has developed a novel watershed descriptor, the average age of development. The method employs county records analyzed in GIS to produce an area-weighted mean age of development for each watershed.

Instead of Plat boundaries that summarize "neighborhoods", the new method used the actual parcels as the bounding feature, and the year the property was built. The parcel layer was joined to the basin layer using the union tool so that the attributes of both features were assigned to all the joined features. Since parcels have the potential to being clipped by basin boundaries, new acreages were calculated for these parcels and a percent of the total basin acreage was calculated for each. The age was calculated as the time prior to 2004 that each property was built. This value was then multiplied by the % basin calculated earlier to get a value % area age from 2004. These values were then summed to get a basin total. Parcels with a year built = 0 were assigned a zero rather than 2004. Parcels not included in the analysis where those in the Braden River Basin and the Peace River Basin. Also, lack of information regarding those parcels in both Charlotte County (Ainger and Gottfried Creeks) and Manatee County (Whitaker, Phillippi, Cow Pen Slough, Upper Myakka River and Big Slough) were not included. In total, 222,001 of the 224,294 union polygons were used in this analysis (Jon Perry, Sarasota County, personal communication).

The watershed age of development (WAD) index is presented in Figure 7. Half of the county's coastal watersheds have area-weighted composite ages of 10 years or less. Whitaker Bayou and Matheny Creek have composite ages of about 20 years and the eldest watersheds (25 – 30 years) are Hudson Bayou and Clower Creek. The WAD index was not significantly correlated with the tidal creek condition index. In general, the WAD index had significant or highly significant correlations with land development intensity, a few pollutant loads and benthic faunal measures, and several 2007 creek sediment characteristics.

As an aside, the LDII and WAD were examined in greater detail to see whether other approaches might reveal latent significant correlations with the creek condition index. The LDII reflects development intensity but not development age, whereas WAD reflects age of development irrespective of type. The product of the two indices was computed for each creek and compared to the tidal creek condition index but the correlation was not significant. As will be described below, the composite development index was found to be significantly correlated with a new definition of watershed loading.

3. 2006-2007 Hydrological Variability

There are at present no direct measurements of flow or flow variability for all county creeks, amenable for use as direct indicators of stable or erratic flows that would affect the ecology of tidal reaches. Mean salinity and the salinity coefficient of variation (CV) were used as proxies for hydrological variability in county creeks. Data were provided by Sarasota County's monthly TMDL sampling program for the water quality stations closest to each condition index site.

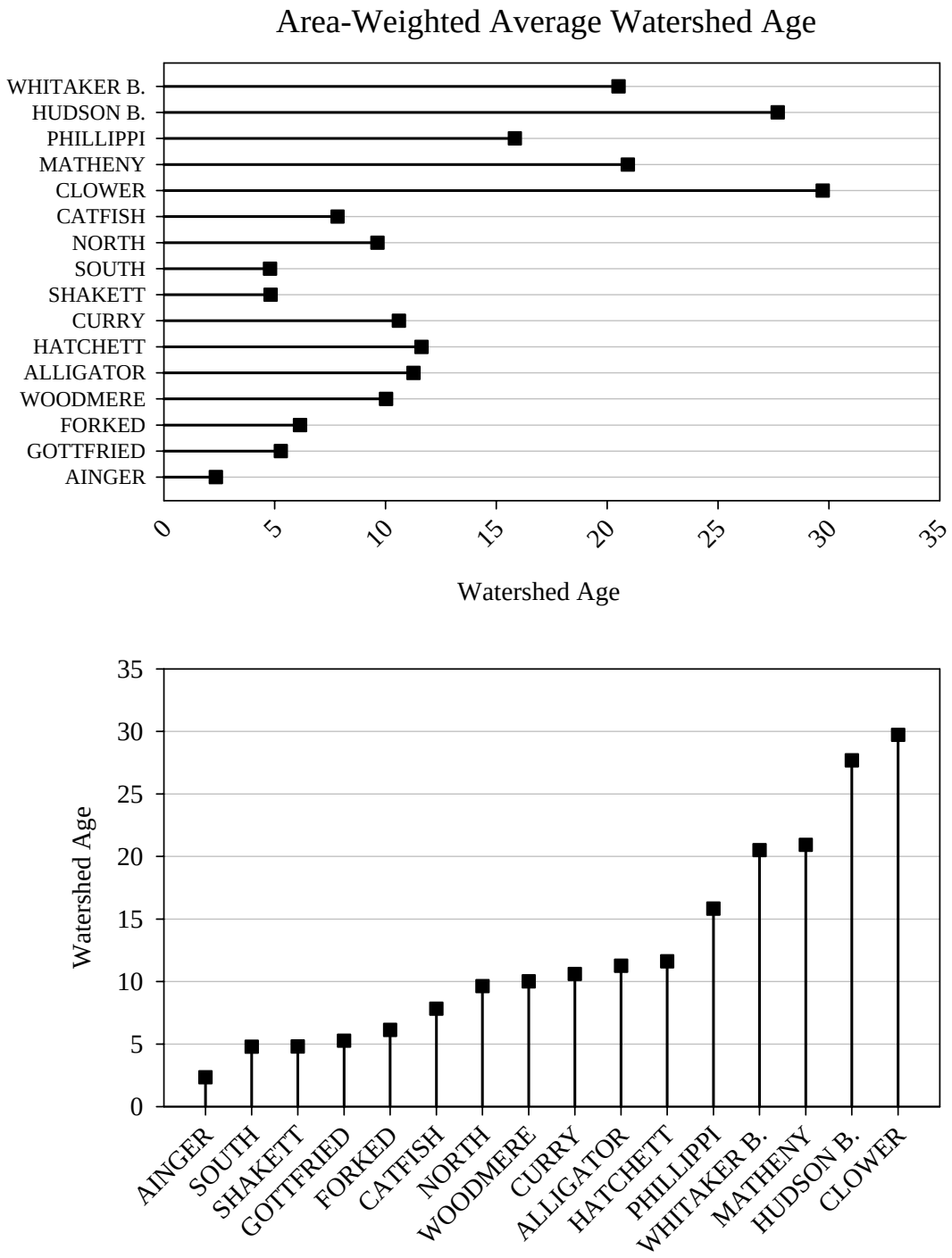


Figure 7. Area-weighted average age of watershed development prior to 2004. Data provided by Sarasota County.

Mean salinity and salinity CV varied widely across 12 county creeks during the 8 month period of record (Figures 8,9). Mean salinity ranged from 5 psu in Catfish Creek to 35 psu in Whitaker Bayou, and averaged about 20 psu. Creeks with high mean salinity had low salinity variances. Neither salinity nor salinity CV was correlated significantly with any variable other than reciprocally. The period of record is short and spanned a relatively drought-dominated time during which salinities would be expected to be higher than during typical years. Additional data for a longer and more representative period of time will be needed to re-visit the relationship of the creek condition index to proxies of hydrological variability.

4. Antecedent Water Quality

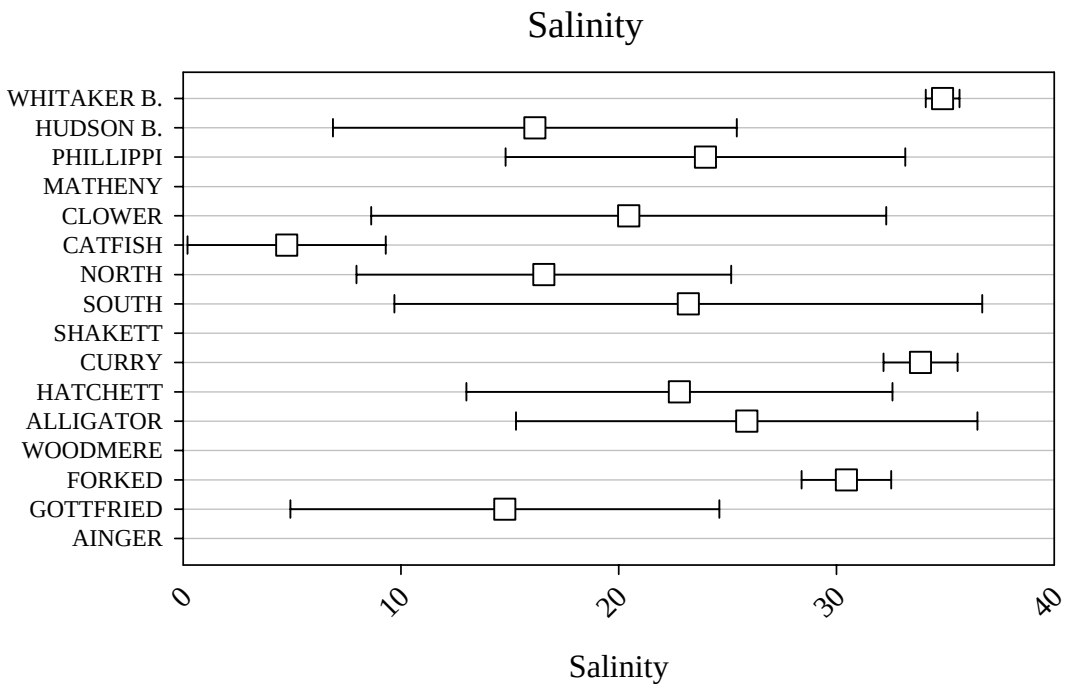
Water quality is comprised of numerous parameters known to affect the ecological condition of aquatic and estuarine biota. To assess whether water quality was related to the tidal creek condition index, data from Sarasota County's monthly TMDL sampling program were used for the water quality stations closest to each creek condition index site. Water quality data for May 8 – 24, 2007 were used to describe the conditions immediately antecedent to sampling for the tidal creek condition index (May 20 – June 8, 2007). Parameters of interest included conductivity, dissolved oxygen, chlorophyll a, total suspended solids, turbidity, and macronutrient series. Results are presented in Appendix 6. The creek condition index was not significantly correlated with any antecedent water quality variable. Forms of phosphorus had more significant correlations with other variables than any other.

5. Pollution Load Model Outputs

In 2005 Sarasota County developed a county-wide non-point source pollutant loading model as part of the county's NPDES Phase 1 permitting requirements (Jones, Edmunds and Associates. 2005). Previous estimates made in 1993 were improved upon with contemporary data evaluated in a GIS framework. Total watershed and normalized watershed loading rates (pounds per year, and pounds per acre per year) were calculated for 16 pollutants. Methods and results are available at http://www.sarasota.wateratlas.usf.edu/upload/documents/SaraCoCo-WideNonPtPollLoadModel2005.pdf

For purposes of assessing the relation of pollution loading rates to the Tidal Creek Condition Index, normalized watershed loading rates were employed. This choice was made because total watershed loading is driven by watershed area, which is unchangeable, whereas per-acre loading rates are subject to management. Data for 8 pollutants of interest are provided in Appendix 7. For analysis purposes, TN and TP are used to represent nutrients, and all metal species were combined as "total metals." Creeks with the highest specific pollutant loads included Alligator, Hudson, Catfish, and Woodmere Creeks.

No significant or highly significant correlations of the tidal creek index with specific pollutant loads were calculated. Moreover, there was no significant correlation of the tidal creek index with the sum of specific pollutant loads per creek. However, a significant correlation (R^2=0.528; $p<.05$) was calculated between the sum of specific pollutant loads per creek *and* the product LDII*WAD described previously. Total metals drove the correlation.



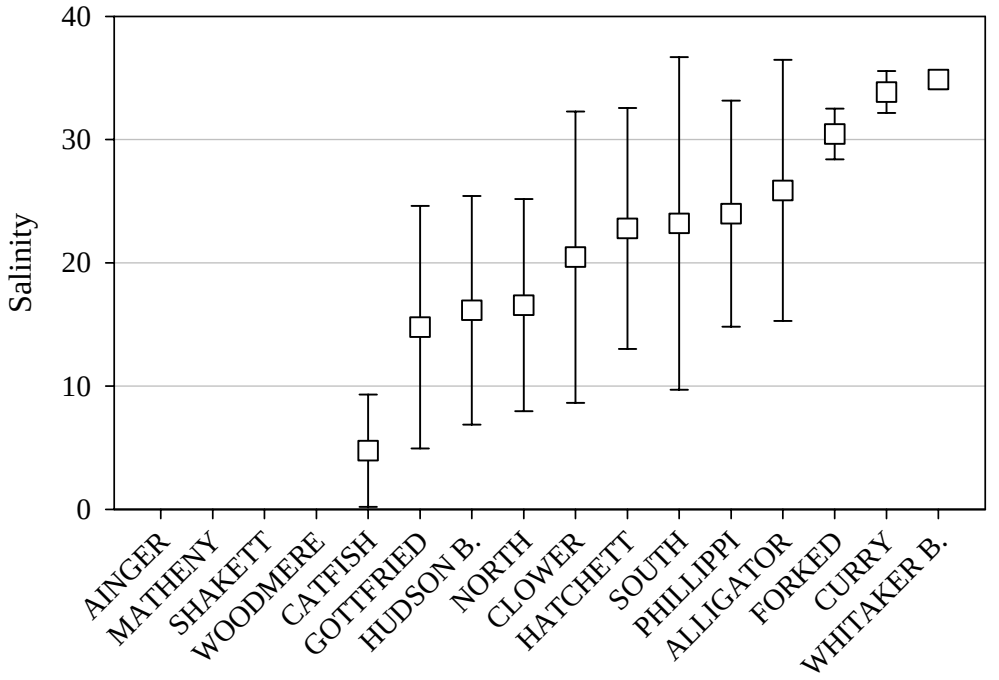


Figure 8. Mean surface salinity (psu) for TMDL stations closest to creek condition survey sites, October 2006-May 2007. Data provided by Sarasota County.

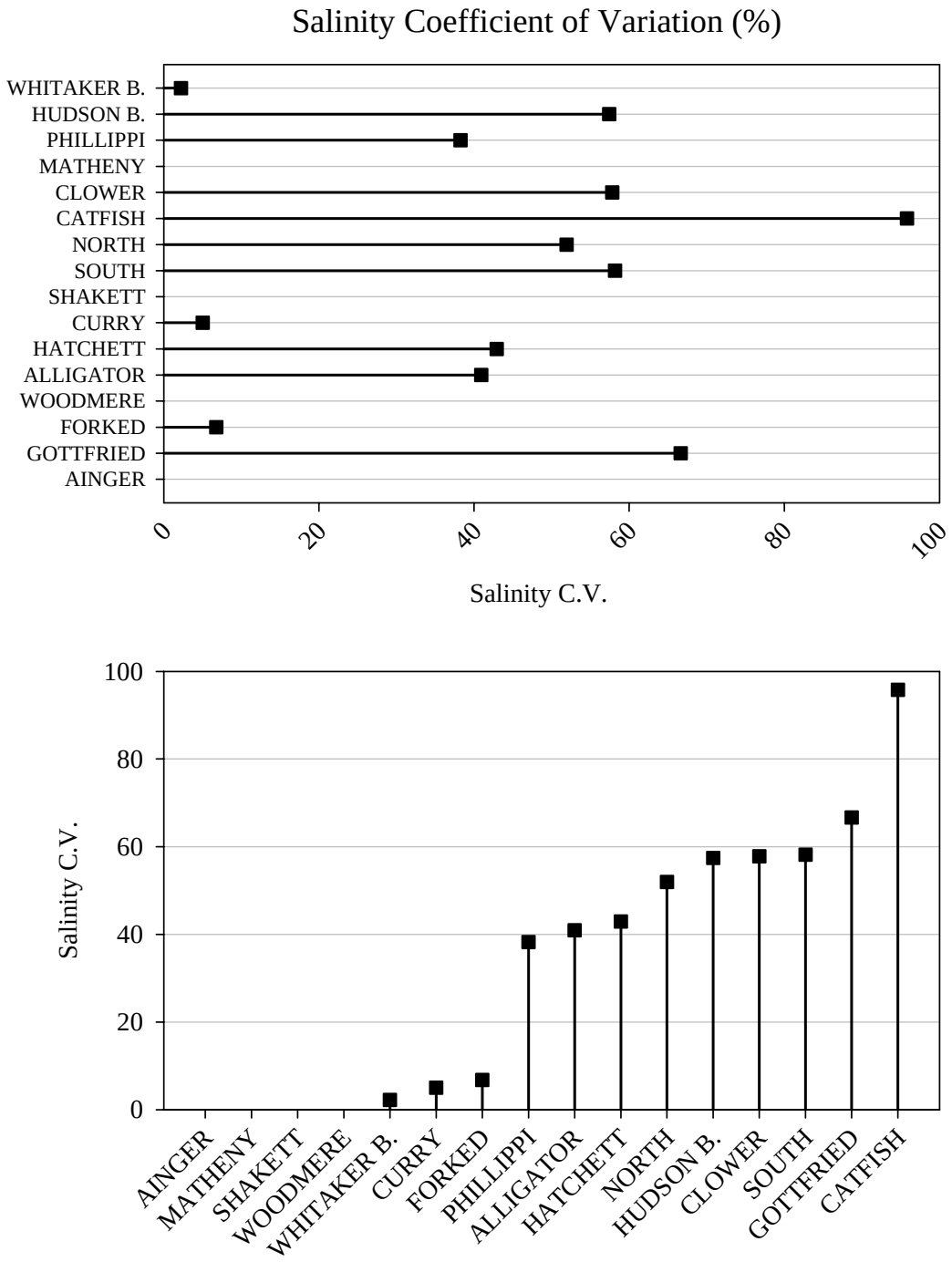


Figure 9. Salinity coefficient of variation CV) for TMDL stations closest to creek condition survey sites, October 2006-May 2007. Data provided by Sarasota County.

6. 2007 Benthic Infaunal Community

Numerous studies have demonstrated the relationship of benthic infaunal communities to habitat integrity, and benthic infauna are used in indices of biological integrity for aquatic, estuarine and marine systems. In order to have an independent biological standard against which the performance of the tidal creek index could be evaluated, benthic infaunal samples were collected and processed during the 2007 tidal creek condition index effort. Methods and results appear in Mote Marine Laboratory Technical Report No. 1211 (Estevez, 2007x).

To compare the creek index scores to benthic community attributes, correlations were sought between the index and species richness, faunal density, and four computed indices: Margalef's (species richness normalized for sample size); Shannon's (diversity); Pielou's (evenness), and Gini's (inequality or dominance).

The Tidal Creek Condition Index was significantly correlated with faunal density and with Margalef's index, and the creek condition index was correlated at highly significant probability with species richness (number of taxa). Relative ranking of creeks between the two systems was good but imperfect. The two systems shared 3 of 5 highest ranked creeks and 4 of 5 lowest ranked creeks. In other words, a rapid-survey technique based on nine variables produced scores and, with lower fidelity, relative ranks of tidal creeks comparable to scores and ranks derived from traditional community-level studies of benthic infauna. On the one hand, this result can be explained by the fact that several creek condition variables are benthic in nature (burrow count, Tagelus and other mollusk densities). On the other hand, the creek index also employs intertidal variables (oyster data), abundances of fishes, crabs and shrimp, and the presence and extent of nuisance macroalgae, providing a wider range of ecosystem condition that infauna alone.

To recapitulate, a comparison of the Tidal Creek Condition Index to external reference systems found that creek condition was not significantly correlated with the 2004 LDI, WAD index, salinity as a proxy for hydrological variability, antecedent water quality, or normalized pollutant loads. That the Tidal Creek Condition Index was significantly correlated with faunal density, and correlated at highly significant probability with species richness, is noteworthy because the same benthic infaunal community measures were significantly correlated with the LDII and WAD characteristics of creek watersheds. If the objective of having a biologically based index of tidal creek condition reflect watershed development or age is paramount, benthic diversity and density will be useful. If having the creek index reflect specific or combined pollutant loads is paramount, neither method presented here will do so with fidelity. To evaluate the relationship of the two biological methods to measures of hydrological variability or water quality, additional data for these independent variables will be needed.

USING THE TIDAL CREEK CONDITION INDEX

Future use of the tidal creek condition index is simplified by the reduction of index variable variables from the 45 variables evaluated in both intertidal and subtidal settings in 2007, to 2 intertidal and 7 subtidal variables. At the 2007 levels of effort employed for these variables a station time of 140 minutes is reasonable. Depending on travel and local conditions, two or three creeks could be sampled in a day.

On balance, now that the index variables have been identified it would be worthwhile to revisit the effects of sample size and replication on the precision and accuracy of their measurement. An earlier project report (Mote Technical Report 1189) examined these questions using 2006 reconnaissance and supplementary data available for subtidal burrow density subtidal other mollusk density. Other variables that were evaluated were not chosen as index variables, although some preliminary analysis of data on maximum oyster height has been performed (Estevez, unpublished data) suggesting that additional replication would improve estimates of maximum oyster height. In conducting future efforts to optimize sampling effort it will be important to consider that original field data will be binned during data rectification and aggregation. One focus of future effort analyses should be on the sensitivity of binned results to varied combinations of sample size and replication.

Some creeks present difficult sampling conditions. Two principal difficulties are stream sanitation challenges to crew safety, and poor creek-bottom conditions. Alternative methods employed in 2007 were only partly successful. Now that 9 specific creek variables have been identified it will be easier to develop and test alternative methods. For example, it may be possible to employ bottom grabs instead of visual surveys and dipnet sweeps, but some assessment must be made of effort equivalency. Also, Matheny Creek was dredged in 2007 (after index sampling) and its post-dredging condition may improve sampling and measurement there.

After these tasks have been completed and as part of the mobilization effort for subsequent field sampling, the index field sheets can be configured for the proper gear types and sampling effort for each of the 9 index variables. These sheets will comprise Version 8.0 of the field logs.

The Tidal Creek Condition Index has been developed and used for spring, dry-season conditions. Future index sampling should employ the same seasonal timing in order to track changes in the condition of a specific creek through time, or to compare creeks. The behavior of the index to wet season conditions is presently unknown. Some consideration should be given to assessing index response to seasonal and other variability. The power of the index to detect ecosystem condition may be better or worse during wet seasons. Knowing the scope or range of index sensitivity to season would also improve its usefulness as an incident-response tool, for example to document creek changes following a pollution accident or extensive algae bloom.

The creek condition index is based on the abundances of oysters, clams, fish and invertebrates, and problematic algae. The gear and methods used in the index were chosen for reasons of

logistics, economy, and understandability, but the gear and methods are not those needed to provide data for other valued biota that utilize creeks as habitat. The common snook *Centropomis undecimalis* for example is a highly prized game fish that relies on tidal creeks for nursery and juvenile habitat. Their numbers, growth, and health would be valuable indicators of creek condition but such data require much different sampling and measurement protocols that could not be employed in a rapid-survey program.

APPLICATIONS OF THE TIDAL CREEK CONDITION INDEX

The Tidal Creek Condition Index has three principal uses. In the first instance, the index serves to guide focused analysis of particular watershed and creek conditions as each affects specific index variables. For example, when sufficient data exist to develop an index of hydrological variability for each creek the relationship of it to the creek condition index can inform management actions targeted at reducing adverse hydrological impacts on downstream ecological resources.

The second application of the index to management is serendipitous. An unexpected outcome of the 2007 index project has been the conclusion that historical events that cannot be defined today may play important roles in the contemporary condition of the County's tidal creeks. The low values and especially the absence of some index variables in creeks suggest that the creek index might guide active creek restoration actions such as intervention. Oysters and the razor clam *Tagelus*, for examples, do not presently occur in all county creeks. In 2007, live *Tagelus* was found in only 6 creeks but recently dead *Tagelus* was found in 12 creeks, suggesting that the recruitment and/or persistence of the species is regulated by extirpation events. Active stocking of oysters and *Tagelus* into creeks where they do not occur could improve the creek condition index effort but also provide novel insights to the ecology of the species and creeks.

The third and most important application of the creek condition index may very well be its use in the development of creek or watershed "report cards." As it has come to be used for rivers, lakes, and estuaries, the report card tends to have these characteristics:

-- It is based on a few too many variables relevant to the waterway in question
-- Its variables depend on local management objectives (recreation, sanitation, fishing, etc)
-- The variables are each self explanatory or understandable to a wide audience
-- Variables may be combined by type or management end-point, and
-- Like scholastic report cards, a simple numeric score or letter grade may be the final product.

In considering the use of the Tidal Creek Condition Index as all or part of a report card it will be necessary for Sarasota County to decide whether the County seeks one report for watersheds and another for creeks, or a report card for creeks and watersheds combined. How the tidal creek condition index might be used will vary accordingly.

It is beyond the scope of the present project to develop a report card system for County watersheds or creeks, but some discussion can be presented to frame the tasks needed to create a report card. Allowing that Sarasota County seeks one report card for its watersheds, including

their creeks, two questions arise: first, how should the creek condition index contribute to the report card; and second, what other elements should the report card include?

A report card comprised of multiple elements including the creek condition index could make direct use of the index scores computed for each creek each year. Alternately, the index scores could be expressed as a percentage of the maximum possible score, or described as grades. In other words, the form of the creek condition index's use depends on what other features are included in the report card.

For the sake of discussing this latter point further, county creeks and watersheds have been ranked using 15 types of data including the creek condition index. Data on watersheds, long-term and short-term water quality, pollutant loads, sediment quality, and benthic communities were considered. The following method was used. For each variable the four creeks with the highest or best resource values were identified and ranked 1 through 4. The four creeks with the lowest or worst resource values were identified and ranked, usually from 16 through 13 if data for all 16 creeks were available. In this way, half of the county's creeks were ranked as among the best or worst creeks relative to each variable, and the frequency of high and low ranks was tabulated. (Table 5).

Creeks that consistently ranked in good condition using a mixture of watershed and creek indicators included South, Shakett, Curry, Forked, and Ainger Creeks.

Creeks that consistently ranked in poor condition using a mixture of indicators included Hudson, Matheny, and Clower Creeks.

Creeks that were sometimes ranked among the good creeks and sometimes among the poor creeks depending on variation among indicators were Whitaker, Catfish, North, Hatchett, and Woodmere (mostly poor), and Phillippi, Alligator, and Gottfried Creeks (mostly good).

It should be emphasized that these ratings include the creek condition index and also several landscape, in-situ, modeled, or otherwise unique types of data. When all of these watershed and creek data are combined and sorted by scores, the relative ranks of creeks as shown in Table 5 result. It must be noted that there is little agreement between creek scores and ranks based solely on the creek condition index, and creek scores and ranks based on multiple sources of information including the creek condition index. The creek condition index is based solely on biological information from the tidal reaches of coastal creeks; it accords well with independent benthic community data taken at the same time, and adds a biological dimension to a creek and watershed report card. Neither the creek condition index nor any other single report card constituent can be used to describe the inherently complex condition of watersheds and creeks combined.

The method summarized in Table 5 is not recommended as Sarasota County's watershed and creek report card. The method is instructive, however, for illustrating that multiple sources of existing information can be combined to produce overall scores and ranks between systems; that the selection of data types for use in a report card can be made using objective and empirical as

well as social criteria; that computational methods need not be complex, and that meaningful results can be produced.

Table 5. Assessment of creek condition using multiple indicators. Columns show the number of times each creek ranked among the top (best) or bottom (worst) four of all creeks relative to Tidal Creek Condition Index, Land Development Intensity Index, Watershed Age of Development Index, mean dissolved oxygen for 8 months, chlorophyll a for May 2007, total nitrogen for May 2007, total phosphorus for May 2007, total nitrogen pollutant load, total phosphorus pollutant load, total suspended solids pollutant load, total metals pollutant load, 2007 benthic species richness, 2007 benthic species density, 2007 percent sediment as silt, and 2007 percent sediment moisture. Note ties (*).

	Frequency of Occurrence in Four			
CREEK	Worst Creeks	Best Creeks	Net	Rank
South	0	9	9	1
Ainger	0	8	8	2
Phillippi	2	7	5	3*
Shakett	0	5	5	3*
Curry	0	4	4	5
Alligator	3	6	3	6
Gottfried	4	6	2	7
Forked	0	1	1	8
Woodmere	2	1	-1	9
Hatchett	3	1	-2	10
Whitaker	6	3	-3	11
North	6	2	-4	12
Matheny	5	0	-5	13*
Catfish	6	1	-5	13*
Clower	9	0	-9	15
Hudson	11	0	-11	16

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APPENDICES

APPENDIX 1. 2007 Sarasota County oyster data employed in the tidal creek condition index. Data are means of three replicates per site. Max Ht, maximum height of largest live oysters (cm); Spat Count, number of spat per 0.25 m^2.

APPENDIX 2. Data density by variable for the 2007 tidal creek condition index.

APPENDIX 3. Pair-wise Pearson correlation coefficients for 2007 tidal creek condition index variables. Significant ($p < 0.05$) positive and negative correlations are red and signified by (*); highly significant ($p < 0.01$) positive and negative correlations are red and signified by (**).

APPENDIX 4. 2007 data depicted by creek from north to south (upper panel) and from low to high values (lower panel) for the nine variables comprising the tidal creek condition index.

APPENDIX 5. Master table of Pearson correlation coefficients for all pairs of creek and watershed attributes. Significant ($p < 0.05$) positive and negative correlations are red and signified by (*); highly significant ($p < 0.01$) positive and negative correlations are red and signified by (**).

APPENDIX 6. Master table of Pearson correlation coefficients for the tidal creek condition index and May 2007 water quality data. Significant ($p < 0.05$) positive and negative correlations are red and signified by (*); highly significant ($p < 0.01$) positive and negative correlations are red and signified by (**).

APPENDIX 7. 2004 pollutant load model outputs. All values are pounds/acre/year.

APPENDIX 1. 2007 Sarasota County oyster data employed in the tidal creek condition index. Data are means of three replicates per site. Max Ht, maximum height of largest live oysters (cm); Spat Count, number of spat per 0.25 m^2.

Creek	SCG Site No.	Percent Live	Max Ht.	Spat Count
Hudson	2	65.0	6.9	2.0
Phillippi	2	83.8	7.1	4.7
Catfish	1	73.3	6.4	1.0
North	1	84.9	7.1	26.3
South	1	41.8	---	1.3
Shakett	2	76.2	7.0	10.3
Curry	2	38.3	5.5	0.7
Alligator	2	78.4	9.0	11.0
Forked	2	84.6	7.6	31.3
Gottfried	2	78.1	6.1	13.0
Ainger	2	77.5	7.6	11.0

APPENDIX 2. Data density by variable for the 2007 tidal creek condition index.

A. Intertidal plus subtidal records.

	Parameter	N	Cumulative Percent
1	BURROW COUNT	250	5.65
2	DEAD TAG COHORT NO	238	11.03
3	LIVE TAG COUNT	238	16.41
4	DEAD TAG COUNT	236	21.74
5	PERI PERCENT COVER	220	26.71
6	TAG PERCENT COVER	220	31.68
7	OTHER LIVE MOLL COUNT	208	36.38
8	DRIFT PERCENT COVER	199	40.88
9	BARE NET CRAB	180	44.95
10	BARE NET FISH	180	49.02
11	BARE NET SHRIMP	180	53.08
12	SAV PERCENT COVER	180	57.15
13	BARE NET OTHER	179	61.20
14	OYSTER PERCENT COVER	170	65.04
15	FILAM PERCENT COVER	160	68.66
16	LIVE COHORT NO.	138	71.77
17	DRIFT NET CRAB	97	73.97
18	DRIFT NET FISH	97	76.16
19	DRIFT NET OTHER	97	78.35
20	DRIFT NET SHRIMP	97	80.54
21	LIVE TAG COHORT NO.	90	82.58
22	PERI NET CRAB	70	84.16
23	PERI NET FISH	70	85.74
24	PERI NET OTHER	70	87.32
25	PERI NET SHRIMP	70	88.90
26	SAV EPI COVER	60	90.26
27	SAV EPI LUX	60	91.62
28	SAV NET CRAB	35	92.41
29	SAV NET FISH	35	93.20
30	SAV NET OTHER	35	93.99
31	SAV NET SHRIMP	35	94.78
32	TAG EXTENT	31	95.48
33	PERI EXTENT	22	95.98
34	DRIFT EXTENT	19	96.41
35	SAV EXTENT	18	96.81
36	OYSTER EXTENT	17	97.20
37	FILAM EXTENT	16	97.56
38	SAV SPECIES NUMBER	14	97.88
39	OYSTER SPAT	11	98.12
40	OYSTERS %	11	98.37

41	FILAM NET CRAB	10	98.60
42	FILAM NET FISH	10	98.82
43	FILAM NET OTHER	10	99.05
44	FILAM NET SHRIMP	10	99.28
45	FUNGUS PERCENT COVER	10	99.50
46	OYSTER HT.	10	99.73
47	TUNICATE PERCENT COVER	10	99.95
48	FUNGUS EXTENT	1	99.98
49	TUNICATE EXTENT COVER	1	100.00

B. Intertidal Records

	Parameter	N	Cumulative Percent
1	BURROW COUNT	110	6.33
2	PERI PERCENT COVER	110	12.65
3	TAG PERCENT COVER	110	18.98
4	DRIFT PERCENT COVER	99	24.67
5	DEAD TAG COHORT NO.	90	29.84
6	DEAD TAG COUNT	90	35.02
7	LIVE TAG COHORT NO.	90	40.20
8	LIVE TAG COUNT	90	45.37
9	OYSTER PERCENT COVER	90	50.55
10	SAV PERCENT COVER	90	55.72
11	OTHER LIVE MOLL COUNT	75	60.03
12	FILAM PERCENT COVER	70	64.06
13	BARE NET CRAB	50	66.94
14	BARE NET FISH	50	69.81
15	BARE NET OTHER	50	72.69
16	BARE NET SHRIMP	50	75.56
17	PERI NET CRAB	50	78.44
18	PERI NET FISH	50	81.31
19	PERI NET OTHER	50	84.19
20	PERI NET SHRIMP	50	87.06
21	DRIFT NET CRAB	30	88.79
22	DRIFT NET FISH	30	90.51
23	DRIFT NET OTHER	30	92.24
24	DRIFT NET SHRIMP	30	93.96
25	TAG EXTENT	20	95.11
26	OYSTER SPAT	11	95.74
27	OYSTERS %	11	96.38
28	PERI EXTENT	11	97.01
29	DRIFT EXTENT	10	97.58
30	OYSTER HT.	10	98.16
31	OYSTER EXTENT	9	98.68
32	SAV EXTENT	9	99.19

33	FILAM EXTENT	7	99.60
34	SAV SPECIES NUMBER	7	100.0
35	FILAM NET CRAB	0	100.0
36	FILAM NET FISH	0	100.0
37	FILAM NET OTHER	0	100.0
38	FILAM NET SHRIMP	0	100.0
39	FUNGUS EXTENT	0	100.0
40	FUNGUS PERCENT COVER	0	100.0
41	LIVE COHORT NO.	0	100.0
42	SAV EPI COVER	0	100.0
43	SAV EPI LUX	0	100.0
44	SAV NET CRAB	0	100.0
45	SAV NET FISH	0	100.0
46	SAV NET OTHER	0	100.0
47	SAV NET SHRIMP	0	100.0
48	TUNICATE EXTENT COVER	0	100.0
49	TUNICATE PERCENT COVER	0	100.0

C. Subtidal Records

	Parameter	N	Cumulative Percent
1	DEAD TAG COHORT NO.	148	5.51
2	LIVE TAG COUNT	148	11.02
3	DEAD TAG COUNT	146	16.46
4	BURROW COUNT	140	21.67
5	LIVE COHORT NO.	138	26.81
6	OTHER LIVE MOLL COUNT	133	31.76
7	BARE NET CRAB	130	36.60
8	BARE NET FISH	130	41.44
9	BARE NET SHRIMP	130	46.28
10	BARE NET OTHER	129	51.08
11	PERI PERCENT COVER	110	55.17
12	TAG PERCENT COVER	110	59.27
13	DRIFT PERCENT COVER	100	62.99
14	FILAM PERCENT COVER	90	66.34
15	SAV PERCENT COVER	90	69.69
16	OYSTER PERCENT COVER	80	72.67
17	DRIFT NET CRAB	67	75.17
18	DRIFT NET FISH	67	77.66
19	DRIFT NET OTHER	67	80.16
20	DRIFT NET SHRIMP	67	82.65
21	SAV EPI COVER	60	84.88
22	SAV EPI LUX	60	87.12
23	SAV NET CRAB	35	88.42
24	SAV NET FISH	35	89.72

25	SAV NET OTHER	35	91.03
26	SAV NET SHRIMP	35	92.33
27	PERI NET CRAB	20	93.08
28	PERI NET FISH	20	93.82
29	PERI NET OTHER	20	94.56
30	PERI NET SHRIMP	20	95.31
31	PERI EXTENT	11	95.72
32	TAG EXTENT	11	96.13
33	FILAM NET CRAB	10	96.50
34	FILAM NET FISH	10	96.87
35	FILAM NET OTHER	10	97.24
36	FILAM NET SHRIMP	10	97.62
37	FUNGUS PERCENT COVER	10	97.99
38	TUNICATE PERCENT COVER	10	98.36
39	DRIFT EXTENT	9	98.70
40	FILAM EXTENT	9	99.03
41	SAV EXTENT	9	99.37
42	OYSTER EXTENT	8	99.66
43	SAV SPECIES NUMBER	7	99.93
44	FUNGUS EXTENT	1	99.96
45	TUNICATE EXTENT COVER	1	100.00
46	LIVE TAG COHORT NO.	0	100.00
47	OYSTER HT.	0	100.00
48	OYSTER SPAT	0	100.00
49	OYSTERS %	0	100.00

D. Number of data points per creek.

Creek	INT	SUB	Both
SOUTH	289	357	646
WOODMERE	207	396	603
GOTTFRIED	369	206	575
ALLIGATOR	279	276	555
AINGER	74	317	391
PHILLIPPI	47	327	374
CURRY	79	286	365
CATFISH	165	161	326
HATCHETT	171	151	322
WHITAKER	151	162	313
FORKED	70	237	307
MATHENY	196	80	276
SHAKETT	36	227	263
NORTH	3	232	235
CLOWER	120	112	232
HUDSON B.	3	206	209

APPENDIX 3. Pair-wise Pearson correlation coefficients for 2007 Tidal Creek Condition Index variables. Significant ($p < 0.05$) positive and negative correlations are red and signified by (*); highly significant ($p < 0.01$) positive and negative correlations are red and signified by (**).

1A	INT BARE NET -All	INT BURROW COUNT	INT DEAD TAG COHORT NO_	INT DRIFT PERCENT COVER	INT FILAM EXTENT COVER	INT FILAM PERCENT COVER	INT LIVE TAG COHORT NO_	INT LIVE TAG COUNT	INT OTHER LIVE MOLL COUNT	INT OYSTER EXTENT COVER	INT OYSTER PERCENT COVER
INT BARE NET -All		0.933	0.070	-0.117			-0.560	-0.560	0.277	-0.277	-0.989
INT BURROW COUNT	0.933		-0.434	0.242			-0.246	-0.246	-0.221	-0.498	-0.382
INT DEAD TAG COHORT NO_	0.070	-0.434		.952(*)			0.413	0.413	0.406	-0.239	0.132
INT DRIFT PERCENT COVER	-0.117	0.242	.952(*)				0.234	0.234	0.084	-0.620	-0.471
INT FILAM EXTENT COVER											
INT FILAM PERCENT COVER											
INT LIVE TAG COHORT NO_	-0.560	-0.246	0.413	0.234				1.000(**)	0.687	-0.406	0.816
INT LIVE TAG COUNT	-0.560	-0.246	0.413	0.234			1.000(**)		0.687	-0.406	0.816
INT OTHER LIVE MOLL COUNT	0.277	-0.221	0.406	0.084			0.687	0.687		-.964(*)	-0.499
INT OYSTER EXTENT COVER	-0.277	-0.498	-0.239	-0.620			-0.406	-0.406	-.964(*)		.804(**)
INT OYSTER PERCENT COVER	-0.989	-0.382	0.132	-0.471			0.816	0.816	-0.499	.804(**)	
INT PERI EXTENT COVER	-0.406	-0.069	-0.126	-0.423			-0.216	-0.216	-0.291	-0.369	-0.607
INT PERI NET -All		0.262	-0.312	-1.000(**)			0.062	0.062	0.333	1.000(**)	-1.000(**)
INT PERI PERCENT COVER	-0.109	0.306	-.908(**)	-0.461			-0.614	-0.614	-.730(*)	-0.155	-0.489
INT SAV EXTENT COVER											
INT SAV PERCENT COVER											
INT SPECIES NUMBER	-0.693	-0.195	0.807	.827(*)			1.000(**)	1.000(**)	-0.284		
INT TAG EXTENT COVER	0.136	-0.192	0.131	.783(*)			-0.095	-0.095	-0.174	-0.649	-0.522
INT TAG PERCENT COVER	0.879	-0.040	0.598	0.594			-0.075	-0.075	0.552	-0.552	-0.356
LIVE OYSTERS %	-1.000(**)	-0.573	-0.107	0.061			0.552	0.552	-0.417	0.156	0.339
MAX_ OYSTER HT_	1.000(**)	-0.197	0.944	0.610			-0.281	-0.281	-0.539	0.164	0.294
NO_ OYSTER SPAT	-0.987	-0.374	0.352	-0.236			0.884	0.884	0.096	0.282	0.545
SUB BARE NET -All	-0.743	.765(*)	-0.425	-0.391			-0.062	-0.062	-0.358	0.563	.834(*)
SUB BURROW COUNT	0.870	-0.292	0.249	-0.073			-0.129	-0.129	0.248	-0.125	-0.144
SUB DEAD TAG COHORT NO_	0.170	-0.546	.837(**)	0.371			0.262	0.262	0.303	-0.435	-0.513
SUB DRIFT EXTENT COVER	0.866	0.279	0.458	0.235			-0.982	-0.982	-0.189	-0.151	-0.515
SUB DRIFT NET -All	-0.923	-0.174	0.458	-0.060			0.478	0.478	-0.843	0.396	-0.029
SUB DRIFT PERCENT COVER	.983(*)	0.026	0.151	-0.235			-0.510	-0.510	0.353	0.256	-0.020

1B	INT BARE NET -All	INT BURROW COUNT	INT DEAD TAG COHORT NO_	INT DRIFT PERCENT COVER	INT FILAM EXTENT COVER	INT FILAM PERCENT COVER	INT LIVE TAG COHORT NO_	INT LIVE TAG COUNT	INT OTHER LIVE MOLL COUNT	INT OYSTER EXTENT COVER	INT OYSTER PERCENT COVER
SUB FILAM EXTENT COVER											
SUB FILAM NET -All											
SUB FILAM PERCENT COVER											
SUB FUNGUS EXTENT COVER											
SUB FUNGUS PERCENT COVER											
SUB LIVE COHORT NO_	-0.389	-0.285	0.511	0.156			0.000	0.000	-0.345	0.385	0.134
SUB LIVE TAG COUNT	-0.389	-0.285	0.511	0.156			0.000	0.000	-0.345	0.385	0.134
SUB OTHER LIVE MOLL COUNT	0.023	-0.268	-0.002	-0.254			-0.256	-0.256	-0.180	0.126	-0.328
SUB OYSTER EXTENT COVER	0.241	-0.088	-0.419	-0.310			-0.866	-0.866	-0.322	0.393	0.501
SUB OYSTER PERCENT COVER	0.189	0.081	-0.466	-0.352			-0.839	-0.839	-0.344	0.374	0.570
SUB PERI EXTENT COVER	-0.440	-0.060	-0.177	-0.245			-0.255	-0.255	-0.309	-0.098	-0.241
SUB PERI NET -All		1.000(**)	-1.000(**)								
SUB PERI PERCENT COVER	-0.440	0.239	-0.713	-0.257			-0.448	-0.448	-0.612	0.013	-0.185
SUB SAV EPI COVER	-1.000(**)	-0.777	-1.000(**)	-0.694					-0.560	0.799	0.464
SUB SAV EPI LUX	-1.000(**)	-0.665	-1.000(**)	-0.630					-0.419	0.801	0.629
SUB SAV EXTENT COVER	0.674	0.361	-0.504	-0.103			-0.810	-0.810	-0.133	-0.225	-0.485
SUB SAV NET -All	-1.000(**)	-0.266	-1.000(**)	-0.902					-1.000(**)	0.569	0.161
SUB SAV NET SHRIMP	-1.000(**)	-0.420	-1.000(**)	-0.891					-1.000(**)	0.550	-0.031
SUB SAV PERCENT COVER	-0.007	-0.221	-0.708	-0.214			-0.524	-0.524	-0.343	0.087	-0.350
SUB SAV SPECIES NUMBER	0.961	0.607	-0.404	-0.208			-0.866	-0.866	0.445	-0.789	-0.480
SUB TAG EXTENT COVER	0.478	0.127	-0.428	.743(*)			-0.317	-0.317	-0.274	-.982(**)	-.815(*)
SUB TAG PERCENT COVER	0.863	.902(**)	0.226	0.593			-0.220	-0.220	0.563	-.888(**)	-0.685
SUB TUNICATE EXTENT COVER											
SUB TUNICATE PERCENT COVER											
INT DEAD TAG COUNT	-0.335	-0.365	.921(**)	.955(*)			0.538	0.538	0.273	-0.330	0.556
INT DRIFT EXTENT COVER	0.322	0.464	0.878	.736(*)			0.336	0.336	0.495	-0.645	-.684(*)
INT DRIFT NET -All	-0.334	-0.411	0.957	0.996			-0.364	-0.364	-.998(*)		-1.000(**)

2A	INT PERI EXTENT COVER	INT PERI NET -All	INT PERI PERCENT COVER	INT SAV EXTENT COVER	INT SAV PERCENT COVER	INT SPECIES NUMBER	INT TAG EXTENT COVER	INT TAG PERCENT COVER	LIVE OYSTERS %	MAX_ OYSTER HT_	NO_ OYSTER SPAT
INT BARE NET -All	-0.406		-0.109			-0.693	0.136	0.879	-1.000(**)	1.000(**)	-0.987
INT BURROW COUNT	-0.069	0.262	0.306			-0.195	-0.192	-0.040	-0.573	-0.197	-0.374
INT DEAD TAG COHORT NO_	-0.126	-0.312	-.908(**)			0.807	0.131	0.598	-0.107	0.944	0.352
INT DRIFT PERCENT COVER	-0.423	-1.000(**)	-0.461			.827(*)	.783(*)	0.594	0.061	0.610	-0.236
INT FILAM EXTENT COVER											
INT FILAM PERCENT COVER											
INT LIVE TAG COHORT NO_	-0.216	0.062	-0.614			1.000(**)	-0.095	-0.075	0.552	-0.281	0.884
INT LIVE TAG COUNT	-0.216	0.062	-0.614			1.000(**)	-0.095	-0.075	0.552	-0.281	0.884
INT OTHER LIVE MOLL COUNT	-0.291	0.333	-.730(*)			-0.284	-0.174	0.552	-0.417	-0.539	0.096
INT OYSTER EXTENT COVER	-0.369	1.000(**)	-0.155				-0.649	-0.552	0.156	0.164	0.282
INT OYSTER PERCENT COVER	-0.607	-1.000(**)	-0.489				-0.522	-0.356	0.339	0.294	0.545
INT PERI EXTENT COVER		-0.559	0.327			-0.316	.947(**)	-0.180	0.173	-0.254	-0.357
INT PERI NET -All	-0.559		0.056				-0.930	-0.436	1.000(**)	-1.000(**)	1.000(**)
INT PERI PERCENT COVER	0.327	0.056				-0.312	0.116	-0.448	0.292	-0.064	-0.265
INT SAV EXTENT COVER											
INT SAV PERCENT COVER											
INT SPECIES NUMBER	-0.316		-0.312				0.504	0.088	0.252	0.729	0.043
INT TAG EXTENT COVER	.947(**)	-0.930	0.116			0.504		0.066	0.087	-0.167	-0.429
INT TAG PERCENT COVER	-0.180	-0.436	-0.448			0.088	0.066		-0.523	0.555	-0.348
LIVE OYSTERS %	0.173	1.000(**)	0.292			0.252	0.087	-0.523		0.592	.634(*)
MAX_ OYSTER HT_	-0.254	-1.000(**)	-0.064			0.729	-0.167	0.555	0.592		0.377
NO_ OYSTER SPAT	-0.357	1.000(**)	-0.265			0.043	-0.429	-0.348	.634(*)	0.377	
SUB BARE NET -All	-0.187	1.000(**)	-0.118			-0.168	-0.578	-0.355	0.411	0.051	.720(*)
SUB BURROW COUNT	-0.445	-0.509	-0.408			-0.341	-0.233	0.480	-.639(*)	-0.075	-0.166
SUB DEAD TAG COHORT NO_	0.276	-0.206	-0.470			0.415	0.497	0.390	-0.132	0.017	0.039
SUB DRIFT EXTENT COVER	-0.195		0.024			-0.069	0.342	0.454	-.697(*)	-0.267	-.867(**)
SUB DRIFT NET -All	0.163		0.025			0.038	0.266	-0.382	0.389	0.268	0.725
SUB DRIFT PERCENT COVER	-0.397		-0.288			-0.272	-0.139	0.025	-.764(*)	-0.634	-0.520

2B	INT PERI EXTENT COVER	INT PERI NET -All	INT PERI PERCENT COVER	INT SAV EXTENT COVER	INT SAV PERCENT COVER	INT SPECIES NUMBER	INT TAG EXTENT COVER	INT TAG PERCENT COVER	LIVE OYSTERS %	MAX_ OYSTER HT_	NO_ OYSTER SPAT
SUB FILAM EXTENT COVER									0.354	-0.006	0.501
SUB FILAM NET -All											
SUB FILAM PERCENT COVER									0.354	-0.006	0.501
SUB FUNGUS EXTENT COVER											
SUB FUNGUS PERCENT COVER											
SUB LIVE COHORT NO_	-0.265	0.556	-0.062			0.560	-0.307	-0.201	0.442	.867(**)	0.530
SUB LIVE TAG COUNT	-0.265	0.556	-0.062			0.560	-0.307	-0.201	0.464	0.483	.679(*)
SUB OTHER LIVE MOLL COUNT	-0.161	0.778	0.269			-0.326	-0.286	-0.151	0.145	0.186	-0.077
SUB OYSTER EXTENT COVER	0.080		0.426				-0.482	-0.139	0.037	0.022	-0.156
SUB OYSTER PERCENT COVER	0.206		0.530				-0.428	-0.174	0.121	0.084	-0.035
SUB PERI EXTENT COVER	.996(**)	-0.566	0.362			-0.200	.962(**)	-0.175	0.172	-0.221	-0.299
SUB PERI NET -All	-1.000(**)		1.000(**)								
SUB PERI PERCENT COVER	0.556	-0.668	.761(*)			-0.200	0.581	-0.314	0.292	-0.015	-0.174
SUB SAV EPI COVER	0.180		0.303				-.994(**)	-0.687	0.764		0.991
SUB SAV EPI LUX	-0.071		0.051				-.983(*)	-0.579	0.628		0.948
SUB SAV EXTENT COVER	0.333		0.600			-0.452	-0.170	0.390	-0.221	0.171	-0.223
SUB SAV NET -All	0.207		0.207				-0.875	-0.949	-0.751	-1.000(**)	-0.799
SUB SAV NET SHRIMP	0.684		0.684				-.999(*)	-0.975	-0.674	-1.000(**)	-0.729
SUB SAV PERCENT COVER	0.520		0.748			-0.209	-0.495	-0.169	-0.032	0.012	-0.346
SUB SAV SPECIES NUMBER	0.433		0.370			-0.540	0.276	0.397	0.027	0.109	0.012
SUB TAG EXTENT COVER	.980(**)	-1.000(**)	0.455			0.346	.995(**)	0.011	0.034	-0.188	-0.366
SUB TAG PERCENT COVER	0.224	-1.000(**)	-0.057			0.054	0.429	.856(**)	-0.361	0.026	-0.416
SUB TUNICATE EXTENT COVER											
SUB TUNICATE PERCENT COVER											
INT DEAD TAG COUNT	-0.284	-0.074	-.835(**)			0.984	-0.059	0.328	0.340	0.876	0.697
INT DRIFT EXTENT COVER	-0.042	-1.000(**)	-0.201			0.478	.803(**)	0.585	-0.055	0.412	-0.244
INT DRIFT NET -All	-0.649		-0.649			1.000(**)	0.649	-0.164	0.341	1.000(**)	0.180

3A	SUB BARE NET -All	SUB BURROW COUNT	SUB DEAD TAG COHORT NO_	SUB DEAD TAG COUNT	SUB DRIFT EXTENT COVER	SUB DRIFT NET -All	SUB DRIFT PERCENT COVER	SUB FILAM EXTENT COVER	SUB FILAM NET -All	SUB FILAM PERCENT COVER	SUB FUNGUS EXTENT COVER
INT BARE NET -All	-0.743	0.870	0.170	-0.267	0.866	-0.923	.983(*)				
INT BURROW COUNT	.765(*)	-0.292	-0.546	-0.474	0.279	-0.174	0.026				
INT DEAD TAG COHORT NO_	-0.425	0.249	.837(**)	.865(**)	0.458	0.458	0.151				
INT DRIFT PERCENT COVER	-0.391	-0.073	0.371	0.503	0.235	-0.060	-0.235				
INT FILAM EXTENT COVER											
INT FILAM PERCENT COVER											
INT LIVE TAG COHORT NO_	-0.062	-0.129	0.262	0.246	-0.982	0.478	-0.510				
INT LIVE TAG COUNT	-0.062	-0.129	0.262	0.246	-0.982	0.478	-0.510				
INT OTHER LIVE MOLL COUNT	-0.358	0.248	0.303	-0.016	-0.189	-0.843	0.353				
INT OYSTER EXTENT COVER	0.563	-0.125	-0.435	-0.007	-0.151	0.396	0.256				
INT OYSTER PERCENT COVER	.834(*)	-0.144	-0.513	-0.325	-0.515	-0.029	-0.020				
INT PERI EXTENT COVER	-0.187	-0.445	0.276	0.197	-0.195	0.163	-0.397				
INT PERI NET -All	1.000(**)	-0.509	-0.206	-0.356							
INT PERI PERCENT COVER	-0.118	-0.408	-0.470	-0.460	0.024	0.025	-0.288				
INT SAV EXTENT COVER											
INT SAV PERCENT COVER											
INT SPECIES NUMBER	-0.168	-0.341	0.415	0.734	-0.069	0.038	-0.272				
INT TAG EXTENT COVER	-0.578	-0.233	0.497	0.383	0.342	0.266	-0.139				
INT TAG PERCENT COVER	-0.355	0.480	0.390	0.123	0.454	-0.382	0.025				
LIVE OYSTERS %	0.411	-.639(*)	-0.132	-0.248	-.697(*)	0.389	-.764(*)	0.354		0.354	
MAX_ OYSTER HT_	0.051	-0.075	0.017	0.130	-0.267	0.268	-0.634	-0.006		-0.006	
NO_ OYSTER SPAT	.720(*)	-0.166	0.039	-0.182	-.867(**)	0.725	-0.520	0.501		0.501	
SUB BARE NET -All		-0.259	0.289	0.018	-.683(*)	-0.322	-0.186	.948(**)		.948(**)	
SUB BURROW COUNT	-0.259		-0.011	0.053	0.505	0.036	0.566	-0.362		-0.362	
SUB DEAD TAG COHORT NO_	0.289	-0.011		.831(**)	0.299	0.175	0.147	0.368		0.368	
SUB DRIFT EXTENT COVER	-.683(*)	0.505	0.299	0.388		-0.432	.711(*)				
SUB DRIFT NET -All	-0.322	0.036	0.175	0.259	-0.432		-0.651				
SUB DRIFT PERCENT COVER	-0.186	0.566	0.147	0.349	.711(*)	-0.651					

3B	SUB BARE NET -All	SUB BURROW COUNT	SUB DEAD TAG COHORT NO_	SUB DEAD TAG COUNT	SUB DRIFT EXTENT COVER	SUB DRIFT NET -All	SUB DRIFT PERCENT COVER	SUB FILAM EXTENT COVER	SUB FILAM NET -All	SUB FILAM PERCENT COVER	SUB FUNGUS EXTENT COVER
SUB FILAM EXTENT COVER	.948(**)	-0.362	0.368	0.018						1.000(**)	
SUB FILAM NET -All											
SUB FILAM PERCENT COVER	.948(**)	-0.362	0.368	0.018				1.000(**)			
SUB FUNGUS EXTENT COVER											
SUB FUNGUS PERCENT COVER											
SUB LIVE COHORT NO_	0.109	-0.199	0.428	0.436	-0.349	0.533	-0.451				
SUB LIVE TAG COUNT	.758(**)	-0.300	0.508	0.354	-0.349	0.533	-0.451	.794(*)		.794(*)	
SUB OTHER LIVE MOLL COUNT	-0.215	-0.128	0.154	-0.012	0.293	0.213	-0.141	-0.177		-0.177	
SUB OYSTER EXTENT COVER	0.055	-0.465	0.163	-0.052	-0.040	-0.283	-0.093				
SUB OYSTER PERCENT COVER	0.142	-0.434	0.138	-0.098	-0.175	-0.192	-0.171				
SUB PERI EXTENT COVER	0.030	-0.355	0.286	0.231	-0.011	0.840	-0.171				
SUB PERI NET -All		1.000(**)	-1.000(**)	-1.000(**)							
SUB PERI PERCENT COVER	-0.018	-0.036	-0.174	-0.183	0.051	0.840	-0.133				
SUB SAV EPI COVER	0.482	-0.889	-0.494	-0.395	-0.990	0.170	-0.813				
SUB SAV EPI LUX	0.656	-0.755	-0.608	-0.583	-0.945	0.008	-0.754				
SUB SAV EXTENT COVER	-0.173	0.022	0.294	-0.180	0.387	-0.299	-0.139				
SUB SAV NET -All	-0.422	0.016	0.552	0.907	0.964	0.903	0.542				
SUB SAV NET SHRIMP	-0.427	-0.362	0.472	0.675	0.930	0.977	0.192				
SUB SAV PERCENT COVER	-0.189	-0.481	0.223	-0.018	0.462	0.057	-0.175				
SUB SAV SPECIES NUMBER	-0.080	0.358	-0.044	-0.611	-0.063	0.131	-0.383				
SUB TAG EXTENT COVER	-0.302	-0.271	0.385	0.342	0.318	-0.227	-0.142	-0.204		-0.204	
SUB TAG PERCENT COVER	-0.324	0.291	0.482	0.254	0.393	-0.493	-0.062	-0.240		-0.240	
SUB TUNICATE EXTENT COVER											
SUB TUNICATE PERCENT COVER											
INT DEAD TAG COUNT	-0.253	0.092	0.624	.820(*)	-0.169	0.531	-0.350				
INT DRIFT EXTENT COVER	-0.661	-0.089	0.624	0.355	0.174	0.344	-0.384				
INT DRIFT NET -All	0.335	-0.244	0.649	0.989	0.181	1.000(**)	-0.343				

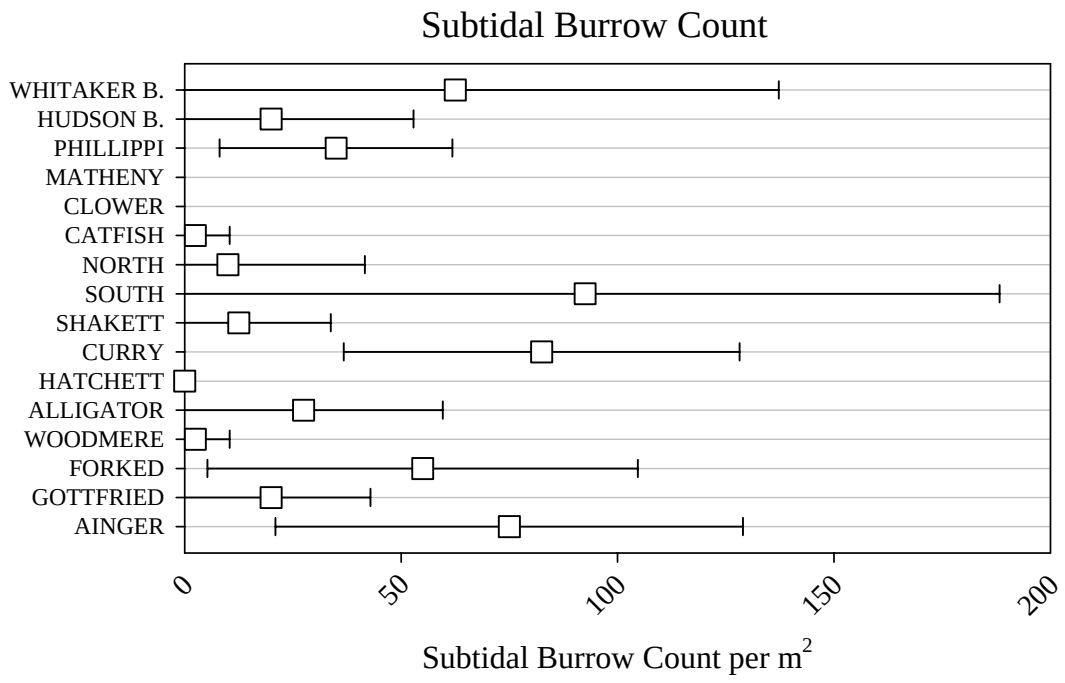
4A	SUB FUNGUS PERCENT COVER	SUB LIVE COHORT NO_	SUB LIVE TAG COUNT	SUB OTHER LIVE MOLL COUNT	SUB OYSTER EXTENT COVER	SUB OYSTER PERCENT COVER	SUB PERI EXTENT COVER	SUB PERI NET -All	SUB PERI PERCENT COVER	SUB SAV EPI COVER	SUB SAV EPI LUX	SUB SAV EXTENT COVER
INT BARE NET -All		-0.389	-0.389	0.023	0.241	0.189	-0.440		-0.440	-1.000(**)	-1.000(**)	0.674
INT BURROW COUNT		-0.285	-0.285	-0.268	-0.088	0.081	-0.060	1.000(**)	0.239	-0.777	-0.665	0.361
INT DEAD TAG COHORT NO_		0.511	0.511	-0.002	-0.419	-0.466	-0.177	-1.000(**)	-0.713	-1.000(**)	-1.000(**)	-0.504
INT DRIFT PERCENT COVER		0.156	0.156	-0.254	-0.310	-0.352	-0.245		-0.257	-0.694	-0.630	-0.103
INT FILAM EXTENT COVER												
INT FILAM PERCENT COVER												
INT LIVE TAG COHORT NO_		0.000	0.000	-0.256	-0.866	-0.839	-0.255		-0.448			-0.810
INT LIVE TAG COUNT		0.000	0.000	-0.256	-0.866	-0.839	-0.255		-0.448			-0.810
INT OTHER LIVE MOLL COUNT		-0.345	-0.345	-0.180	-0.322	-0.344	-0.309		-0.612	-0.560	-0.419	-0.133
INT OYSTER EXTENT COVER		0.385	0.385	0.126	0.393	0.374	-0.098		0.013	0.799	0.801	-0.225
INT OYSTER PERCENT COVER		0.134	0.134	-0.328	0.501	0.570	-0.241		-0.185	0.464	0.629	-0.485
INT PERI EXTENT COVER		-0.265	-0.265	-0.161	0.080	0.206	.996(**)	-1.000(**)	0.556	0.180	-0.071	0.333
INT PERI NET -All		0.556	0.556	0.778			-0.566		-0.668			
INT PERI PERCENT COVER		-0.062	-0.062	0.269	0.426	0.530	0.362	1.000(**)	.761(*)	0.303	0.051	0.600
INT SAV EXTENT COVER												
INT SAV PERCENT COVER												
INT SPECIES NUMBER		0.560	0.560	-0.326			-0.200		-0.200			-0.452
INT TAG EXTENT COVER		-0.307	-0.307	-0.286	-0.482	-0.428	.962(**)		0.581	-.994(**)	-.983(*)	-0.170
INT TAG PERCENT COVER		-0.201	-0.201	-0.151	-0.139	-0.174	-0.175		-0.314	-0.687	-0.579	0.390
LIVE OYSTERS %		0.442	0.464	0.145	0.037	0.121	0.172		0.292	0.764	0.628	-0.221
MAX_ OYSTER HT_		.867(**)	0.483	0.186	0.022	0.084	-0.221		-0.015			0.171
NO_ OYSTER SPAT		0.530	.679(*)	-0.077	-0.156	-0.035	-0.299		-0.174	0.991	0.948	-0.223
SUB BARE NET -All		0.109	.758(**)	-0.215	0.055	0.142	0.030		-0.018	0.482	0.656	-0.173
SUB BURROW COUNT		-0.199	-0.300	-0.128	-0.465	-0.434	-0.355	1.000(**)	-0.036	-0.889	-0.755	0.022
SUB DEAD TAG COHORT NO_		0.428	0.508	0.154	0.163	0.138	0.286	-1.000(**)	-0.174	-0.494	-0.608	0.294
SUB DRIFT EXTENT COVER		-0.349	-0.349	0.293	-0.040	-0.175	-0.011		0.051	-0.990	-0.945	0.387
SUB DRIFT NET -All		0.533	0.533	0.213	-0.283	-0.192	0.840		0.840	0.170	0.008	-0.299
SUB DRIFT PERCENT COVER		-0.451	-0.451	-0.141	-0.093	-0.171	-0.171		-0.133	-0.813	-0.754	-0.139

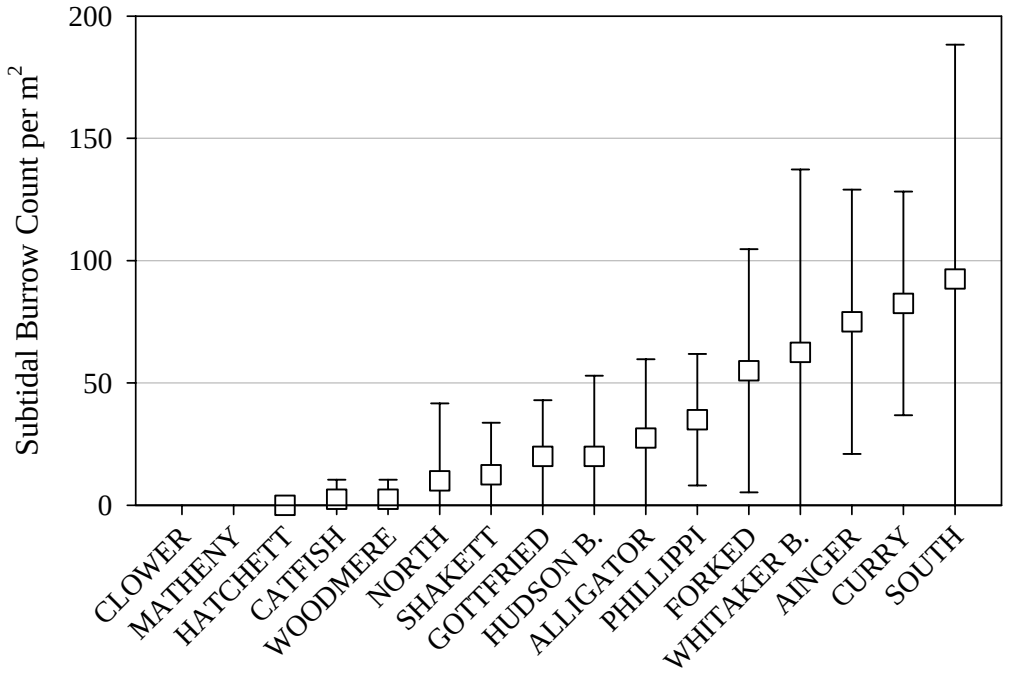
4B	SUB FUNGUS PERCENT COVER	SUB LIVE COHORT NO_	SUB LIVE TAG COUNT	SUB OTHER LIVE MOLL COUNT	SUB OYSTER EXTENT COVER	SUB OYSTER PERCENT COVER	SUB PERI EXTENT COVER	SUB PERI NET -All	SUB PERI PERCENT COVER	SUB SAV EPI COVER	SUB SAV EPI LUX	SUB SAV EXTENT COVER
SUB FILAM EXTENT COVER			.794(*)	-0.177								
SUB FILAM NET -All												
SUB FILAM PERCENT COVER			.794(*)	-0.177								
SUB FUNGUS EXTENT COVER												
SUB FUNGUS PERCENT COVER												
SUB LIVE COHORT NO_		1	1.000(**)	.564(*)	0.288	0.264	-0.256		-0.260	0.823	0.653	0.229
SUB LIVE TAG COUNT		1.000(**)	1	0.251	0.288	0.264	-0.256		-0.260	0.823	0.653	0.229
SUB OTHER LIVE MOLL COUNT		.564(*)	0.251	1	0.089	-0.056	-0.201		-0.195	0.586	0.385	.786(*)
SUB OYSTER EXTENT COVER		0.288	0.288	0.089	1	.978(**)	-0.490		-0.406	0.332	0.214	0.731
SUB OYSTER PERCENT COVER		0.264	0.264	-0.056	.978(**)		-0.436		-0.361	0.367	0.243	.774(*)
SUB PERI EXTENT COVER		-0.256	-0.256	-0.201	-0.490	-0.436		-1.000(**)	0.601	-0.452	-0.574	-0.017
SUB PERI NET -All							-1.000(**)		1.000(**)			
SUB PERI PERCENT COVER		-0.260	-0.260	-0.195	-0.406	-0.361	0.601	1.000(**)		-0.452	-0.574	0.038
SUB SAV EPI COVER		0.823	0.823	0.586	0.332	0.367	-0.452		-0.452		.967(*)	0.024
SUB SAV EPI LUX		0.653	0.653	0.385	0.214	0.243	-0.574		-0.574	.967(*)		-0.086
SUB SAV EXTENT COVER		0.229	0.229	.786(*)	0.731	.774(*)	-0.017		0.038	0.024	-0.086	
SUB SAV NET -All		0.378	0.378	0.143	0.378	0.464				1.000(**)	1.000(**)	-0.328
SUB SAV NET SHRIMP		0.707	0.707	0.524	0.707	0.705				1.000(**)	1.000(**)	-0.021
SUB SAV PERCENT COVER		0.529	0.529	.949(**)	.802(*)	.894(**)	-0.181		-0.150	0.617	0.454	.743(*)
SUB SAV SPECIES NUMBER		-0.227	-0.227	0.177	-0.294	-0.077	0.548		0.548	-.983(*)	-.995(**)	0.603
SUB TAG EXTENT COVER		-0.303	-0.287	-0.205	-0.425	-0.425	.980(**)		.669(*)	-0.847	-0.849	0.282
SUB TAG PERCENT COVER		-0.265	-0.334	-0.075	-0.292	-0.316	0.262		0.147	-0.757	-0.703	0.481
SUB TUNICATE EXTENT COVER												
SUB TUNICATE PERCENT COVER												
INT DEAD TAG COUNT		0.600	0.600	-0.093	-.998(*)	-1.000(*)	-0.323	-1.000(**)	-0.672	-1.000(**)	-1.000(**)	-0.777
INT DRIFT EXTENT COVER		0.212	0.212	0.131	-0.358	-0.384	0.043		-0.011	-0.494	-0.608	0.304
INT DRIFT NET -All		0.983	0.983	-0.008	1.000(**)	1.000(**)	-0.649		-0.649			-0.335

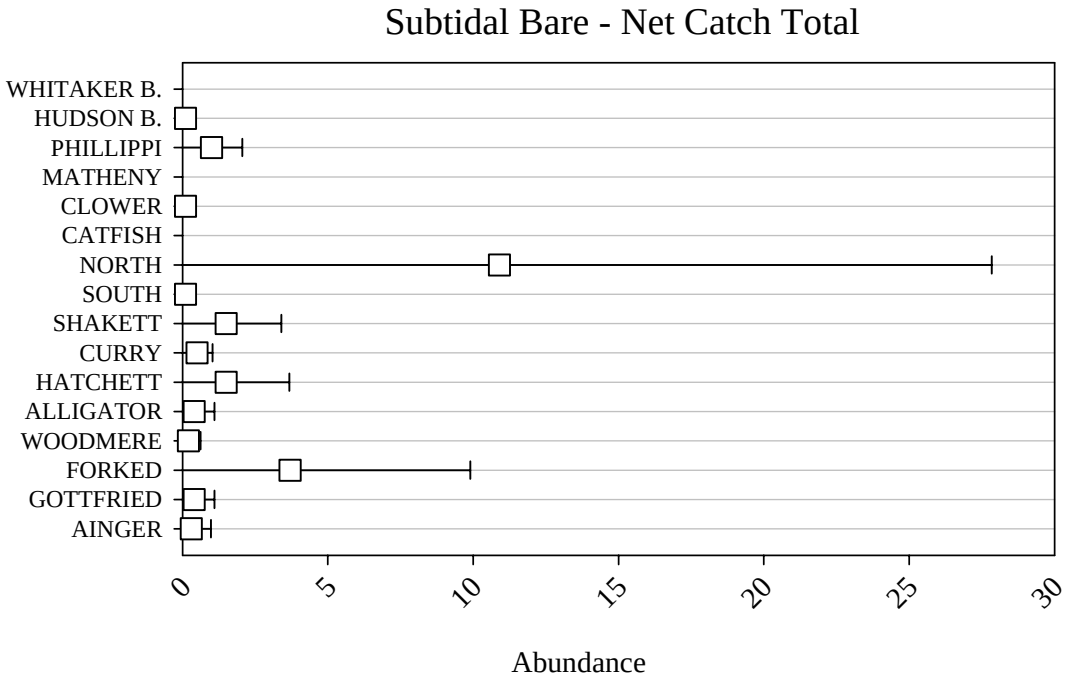
5A	SUB SAV NET -All	SUB SAV NET SHRIMP	SUB SAV PERCENT COVER	SUB SAV SPECIES NUMBER	SUB TAG EXTENT COVER	SUB TAG PERCENT COVER	SUB TUNICATE EXTENT COVER	SUB TUNICATE PERCENT COVER	INT DEAD TAG COUNT	INT DRIFT EXTENT COVER	INT DRIFT NET -All
INT BARE NET -All	-1.000(**)	-1.000(**)	-0.007	0.961	0.478	0.863			-0.335	0.322	-0.334
INT BURROW COUNT	-0.266	-0.420	-0.221	0.607	0.127	.902(**)			-0.365	0.464	-0.411
INT DEAD TAG COHORT NO_	-1.000(**)	-1.000(**)	-0.708	-0.404	-0.428	0.226			.921(**)	0.878	0.957
INT DRIFT PERCENT COVER	-0.902	-0.891	-0.214	-0.208	.743(*)	0.593			.955(*)	.736(*)	0.996
INT FILAM EXTENT COVER											
INT FILAM PERCENT COVER											
INT LIVE TAG COHORT NO_			-0.524	-0.866	-0.317	-0.220			0.538	0.336	-0.364
INT LIVE TAG COUNT			-0.524	-0.866	-0.317	-0.220			0.538	0.336	-0.364
INT OTHER LIVE MOLL COUNT	-1.000(**)	-1.000(**)	-0.343	0.445	-0.274	0.563			0.273	0.495	-.998(*)
INT OYSTER EXTENT COVER	0.569	0.550	0.087	-0.789	-.982(**)	-.888(**)			-0.330	-0.645	
INT OYSTER PERCENT COVER	0.161	-0.031	-0.350	-0.480	-.815(*)	-0.685			0.556	-.684(*)	-1.000(**)
INT PERI EXTENT COVER	0.207	0.684	0.520	0.433	.980(**)	0.224			-0.284	-0.042	-0.649
INT PERI NET -All					-1.000(**)	-1.000(**)			-0.074	-1.000(**)	
INT PERI PERCENT COVER	0.207	0.684	0.748	0.370	0.455	-0.057			-.835(**)	-0.201	-0.649
INT SAV EXTENT COVER											
INT SAV PERCENT COVER											
INT SPECIES NUMBER			-0.209	-0.540	0.346	0.054			0.984	0.478	1.000(**)
INT TAG EXTENT COVER	-0.875	-.999(*)	-0.495	0.276	.995(**)	0.429			-0.059	.803(**)	0.649
INT TAG PERCENT COVER	-0.949	-0.975	-0.169	0.397	0.011	.856(**)			0.328	0.585	-0.164
LIVE OYSTERS %	-0.751	-0.674	-0.032	0.027	0.034	-0.361			0.340	-0.055	0.341
MAX_ OYSTER HT_	-1.000(**)	-1.000(**)	0.012	0.109	-0.188	0.026			0.876	0.412	1.000(**)
NO_ OYSTER SPAT	-0.799	-0.729	-0.346	0.012	-0.366	-0.416			0.697	-0.244	0.180
SUB BARE NET -All	-0.422	-0.427	-0.189	-0.080	-0.302	-0.324			-0.253	-0.661	0.335
SUB BURROW COUNT	0.016	-0.362	-0.481	0.358	-0.271	0.291			0.092	-0.089	-0.244
SUB DEAD TAG COHORT NO_	0.552	0.472	0.223	-0.044	0.385	0.482			0.624	0.624	0.649
SUB DRIFT EXTENT COVER	0.964	0.930	0.462	-0.063	0.318	0.393			-0.169	0.174	0.181
SUB DRIFT NET -All	0.903	0.977	0.057	0.131	-0.227	-0.493			0.531	0.344	1.000(**)
SUB DRIFT PERCENT COVER	0.542	0.192	-0.175	-0.383	-0.142	-0.062			-0.350	-0.384	-0.343

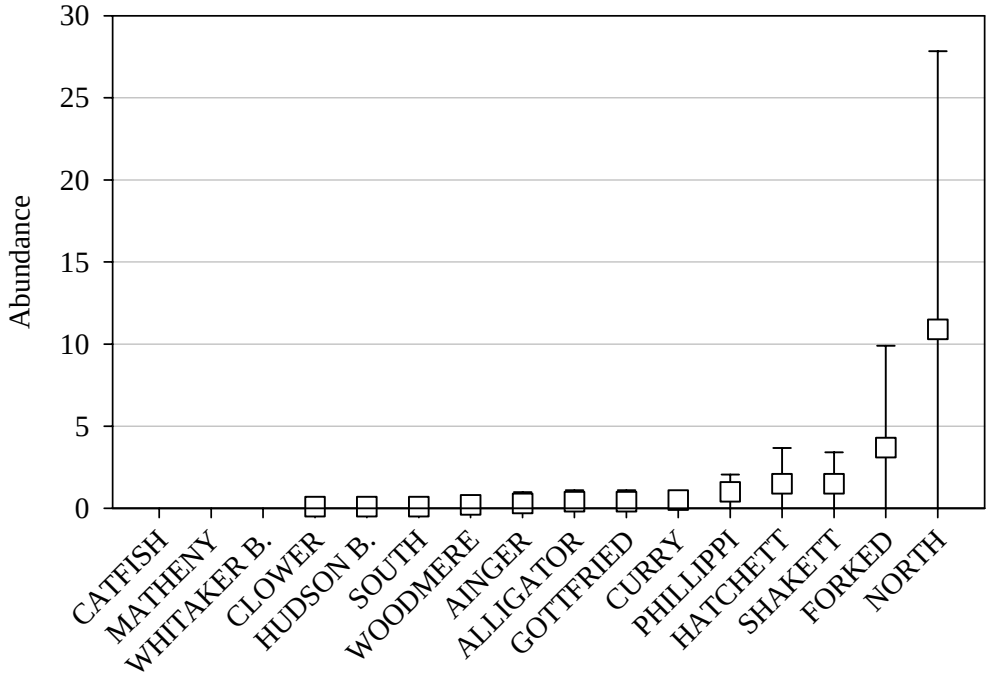
5B	SUB SAV NET -All	SUB SAV NET SHRIMP	SUB SAV PERCENT COVER	SUB SAV SPECIES NUMBER	SUB TAG EXTENT COVER	SUB TAG PERCENT COVER	SUB TUNICATE EXTENT COVER	SUB TUNICATE PERCENT COVER	INT DEAD TAG COUNT	INT DRIFT EXTENT COVER	INT DRIFT NET -All
SUB FILAM EXTENT COVER					-0.204	-0.240					
SUB FILAM NET -All											
SUB FILAM PERCENT COVER					-0.204	-0.240					
SUB FUNGUS EXTENT COVER											
SUB FUNGUS PERCENT COVER											
SUB LIVE COHORT NO_	0.378	0.707	0.529	-0.227	-0.303	-0.265			0.600	0.212	0.983
SUB LIVE TAG COUNT	0.378	0.707	0.529	-0.227	-0.287	-0.334			0.600	0.212	0.983
SUB OTHER LIVE MOLL COUNT	0.143	0.524	.949(**)	0.177	-0.205	-0.075			-0.093	0.131	-0.008
SUB OYSTER EXTENT COVER	0.378	0.707	.802(*)	-0.294	-0.425	-0.292			-.998(*)	-0.358	1.000(**)
SUB OYSTER PERCENT COVER	0.464	0.705	.894(**)	-0.077	-0.425	-0.316			-1.000(*)	-0.384	1.000(**)
SUB PERI EXTENT COVER			-0.181	0.548	.980(**)	0.262			-0.323	0.043	-0.649
SUB PERI NET -All									-1.000(**)		
SUB PERI PERCENT COVER			-0.150	0.548	.669(*)	0.147			-0.672	-0.011	-0.649
SUB SAV EPI COVER	1.000(**)	1.000(**)	0.617	-.983(*)	-0.847	-0.757			-1.000(**)	-0.494	
SUB SAV EPI LUX	1.000(**)	1.000(**)	0.454	-.995(**)	-0.849	-0.703			-1.000(**)	-0.608	
SUB SAV EXTENT COVER	-0.328	-0.021	.743(*)	0.603	0.282	0.481			-0.777	0.304	-0.335
SUB SAV NET -All		0.918	0.274	-0.658	-0.995	-0.989			-1.000(**)	-0.302	
SUB SAV NET SHRIMP	0.918		0.626	-0.554	-0.903	-0.923			-1.000(**)	-0.121	
SUB SAV PERCENT COVER	0.274	0.626		0.051	-0.082	-0.032			-0.622	0.220	-0.335
SUB SAV SPECIES NUMBER	-0.658	-0.554	0.051		0.414	0.536			-0.765	0.282	-1.000(**)
SUB TAG EXTENT COVER	-0.995	-0.903	-0.082	0.414		0.468			-0.481	.909(**)	-0.625
SUB TAG PERCENT COVER	-0.989	-0.923	-0.032	0.536	0.468				-0.174	.771(*)	-0.461
SUB TUNICATE EXTENT COVER											
SUB TUNICATE PERCENT COVER											
INT DEAD TAG COUNT	-1.000(**)	-1.000(**)	-0.622	-0.765	-0.481	-0.174				0.690	0.939
INT DRIFT EXTENT COVER	-0.302	-0.121	0.220	0.282	.909(**)	.771(*)			0.690		0.649
INT DRIFT NET -All			-0.335	-1.000(**)	-0.625	-0.461			0.939	0.649	

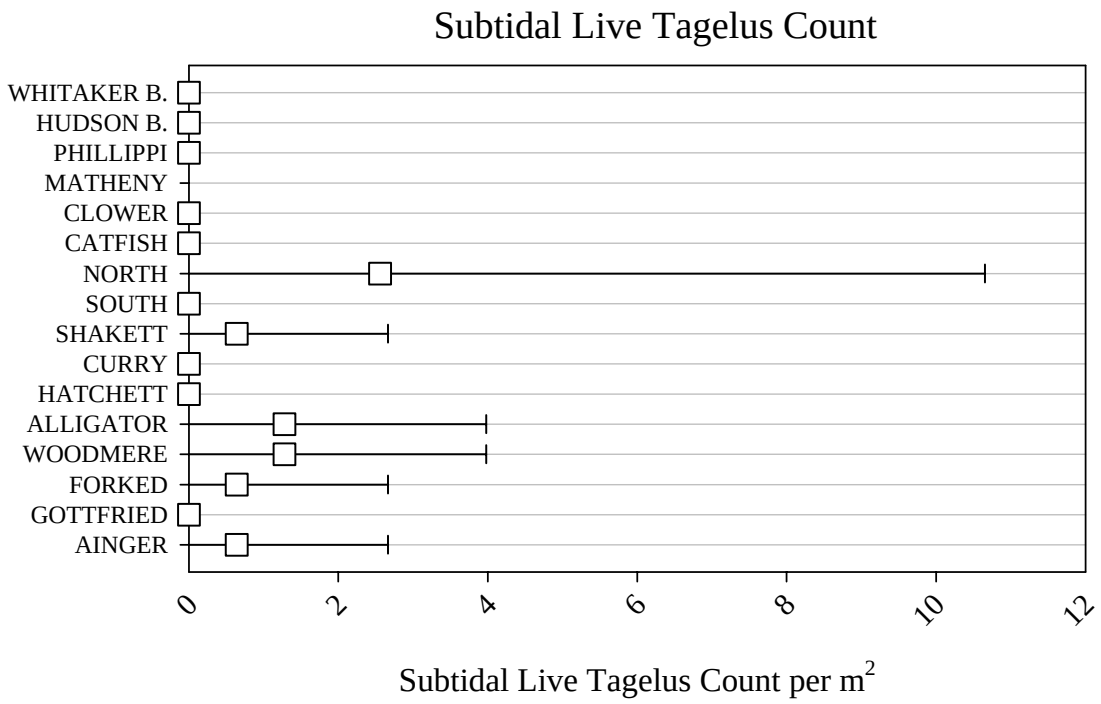
APPENDIX 4. 2007 data depicted by creek from north to south (upper panel) and from low to high values (lower panel) for the nine variables comprising the tidal creek condition index.

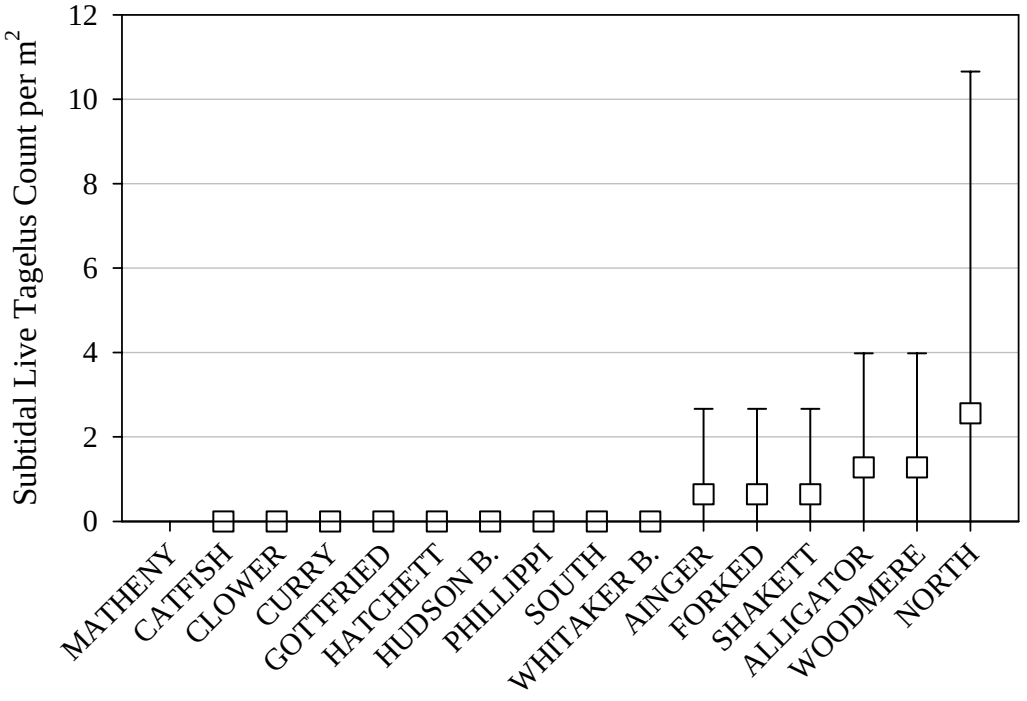


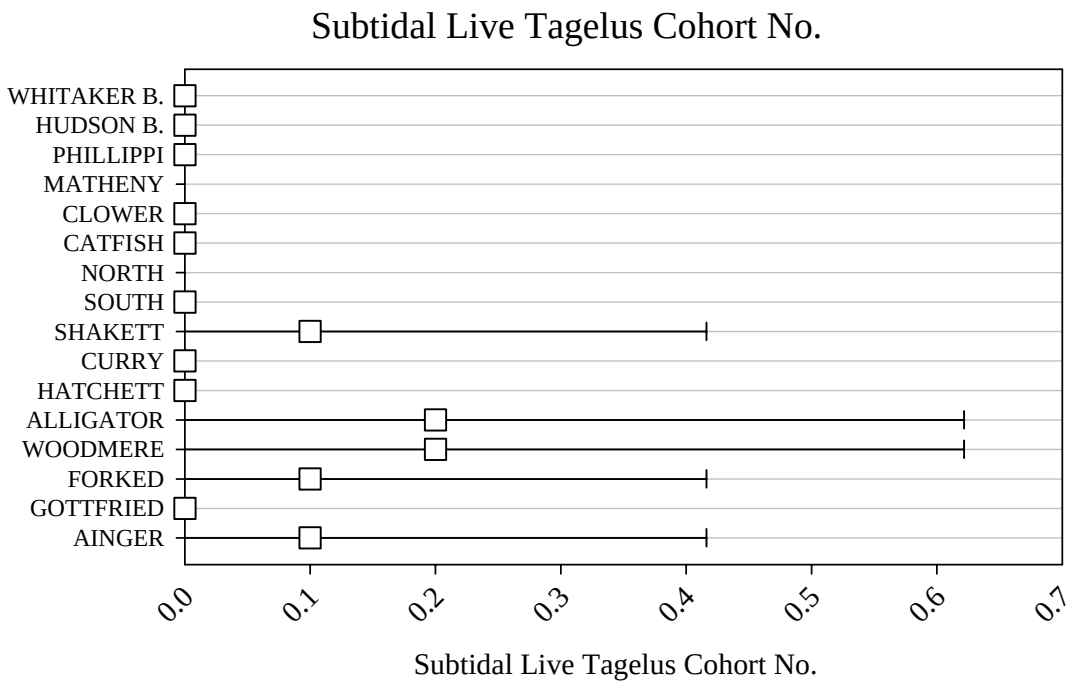


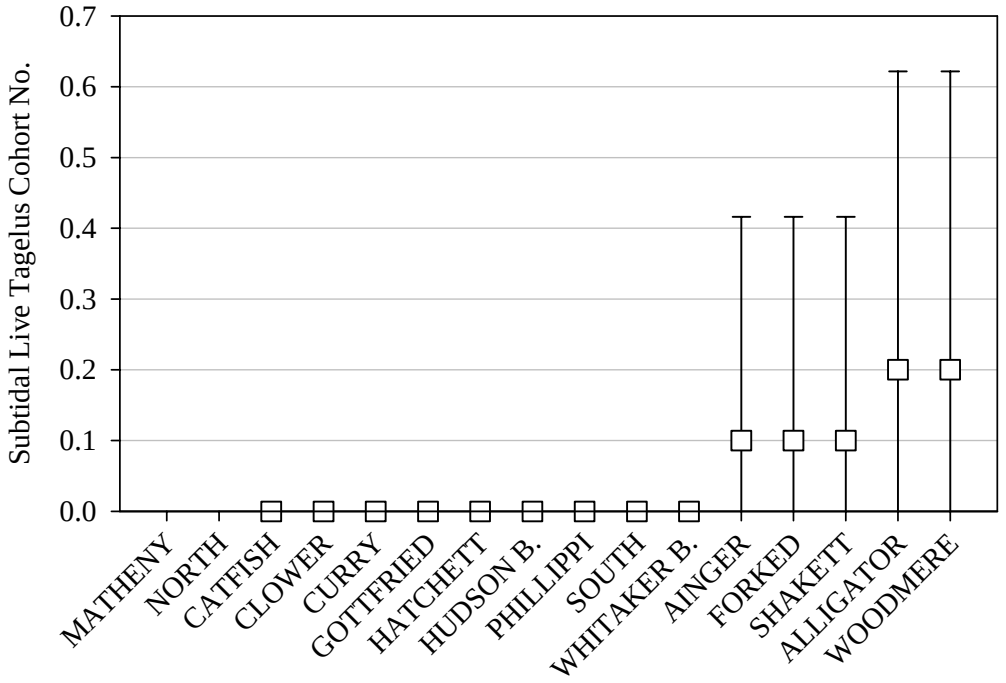

Subtidal Bare - Net Catch Total
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
5
10
15
20
25
30
Abundance

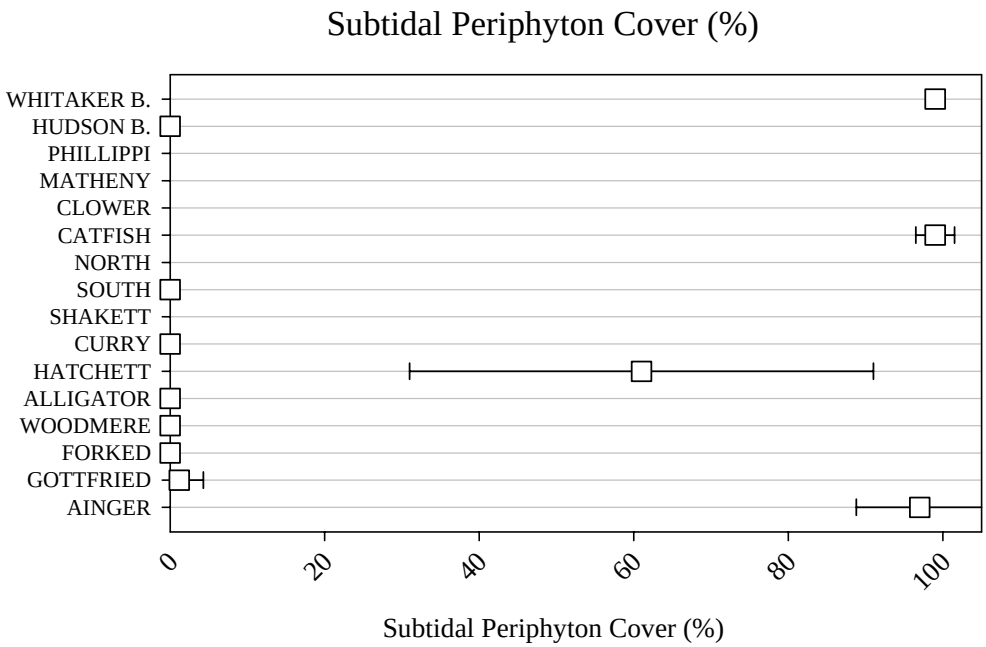

Abundance
30
25
20
15
10
5
0
CATFISH
MATHENY
WHITAKER B.
CLOWER
HUDSON B.
SOUTH
WOODMERE
AINGER
ALLIGATOR
GOTTFRIED
CURRY
PHILLIPPI
HATCHETT
SHAKETT
FORKED
NORTH

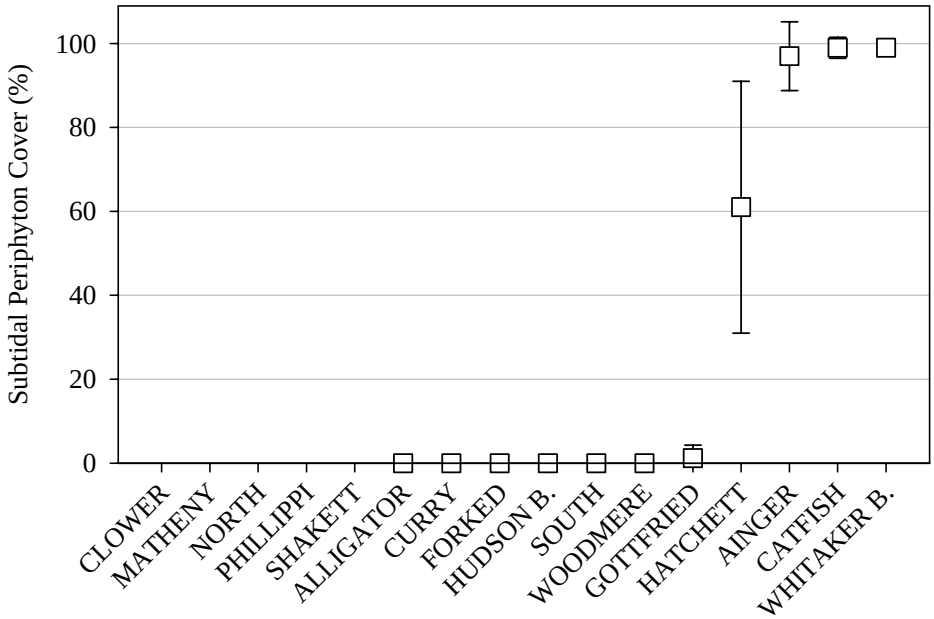

Subtidal Live Tagelus Count
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
2
4
6
8
10
12
Subtidal Live Tagelus Count per m2

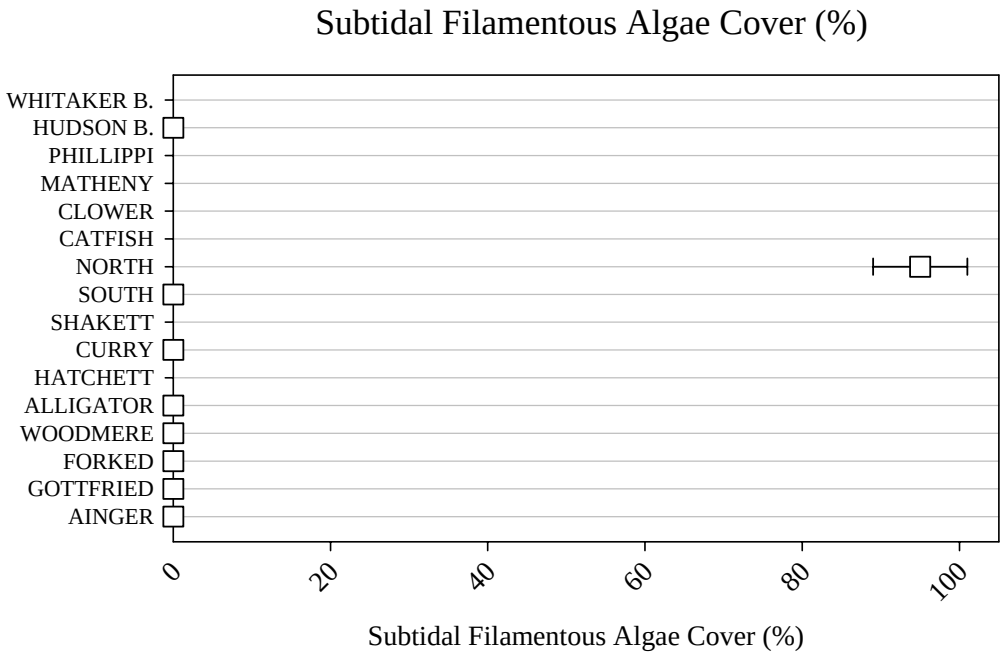

Subtidal Live Tagelus Count per m2
12
10
8
6
4
2
0
MATHENY
CATFISH
CLOWER
CURRY
GOTTFRIED
HATCHETT
HUDSON B.
PHILLIPPI
SOUTH
WHITAKER B.
AINGER
FORKED
SHAKETT
ALLIGATOR
WOODMERE
NORTH

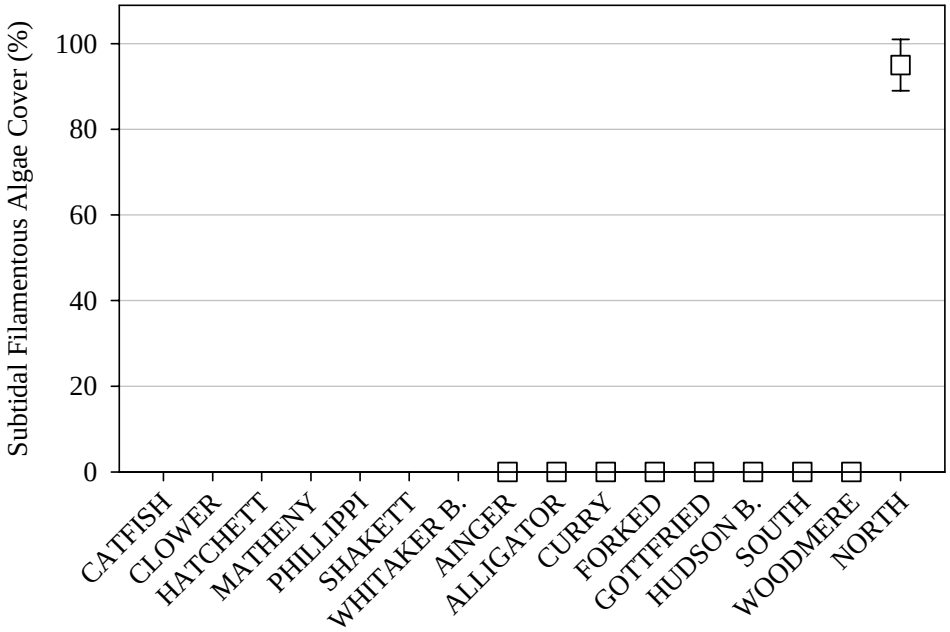

Subtidal Live Tagelus Cohort No.
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Subtidal Live Tagelus Cohort No.

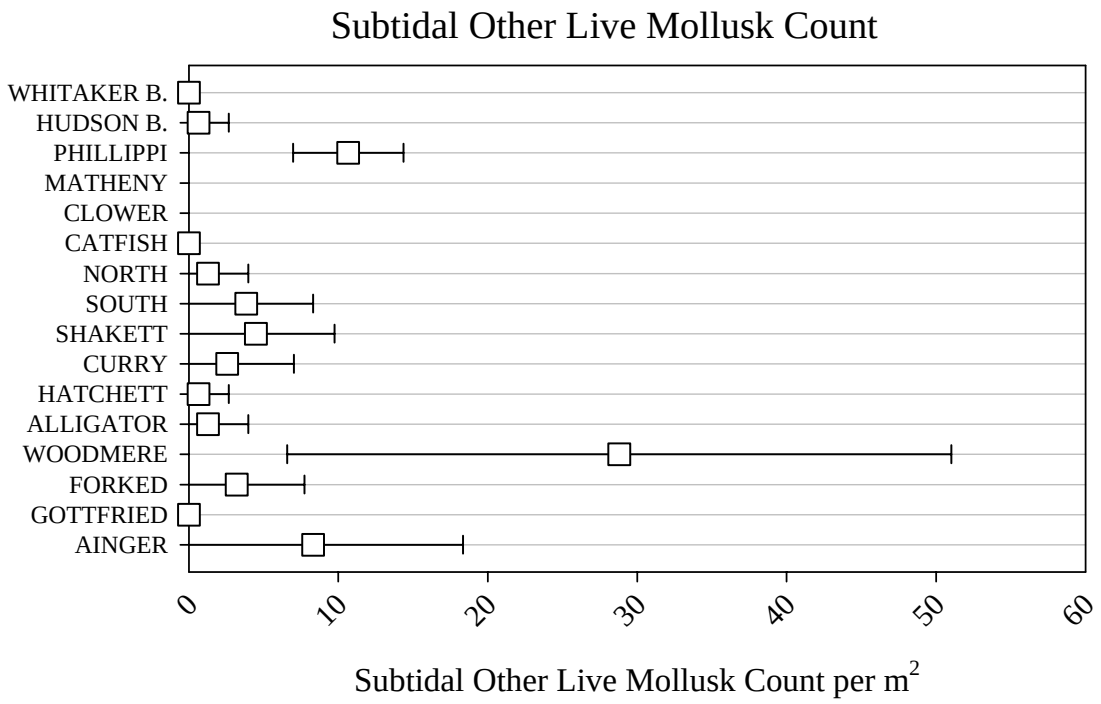

Subtidal Live Tagelus Cohort No.
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
MATHENY
NORTH
CATFISH
CLOWER
CURRY
GOTTFRIED
HATCHETT
HUDSON B.
PHILLIPPI
SOUTH
WHITAKER B.
AINGER
FORKED
SHAKETT
ALLIGATOR
WOODMERE

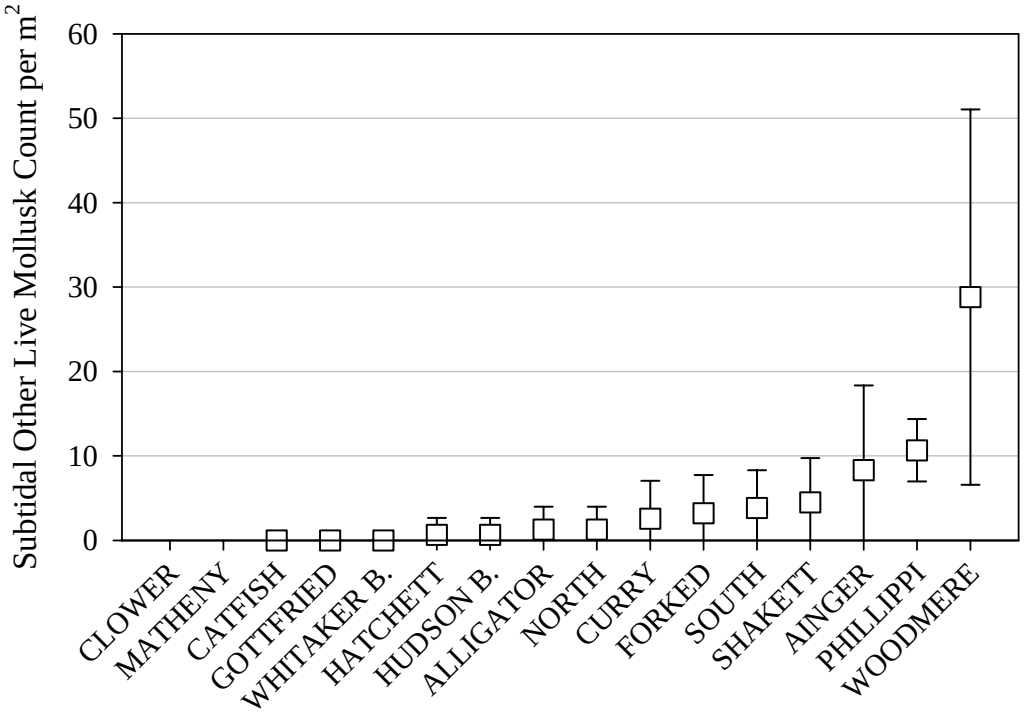

Subtidal Periphyton Cover (%)
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
20
40
60
80
100
Subtidal Periphyton Cover (%)

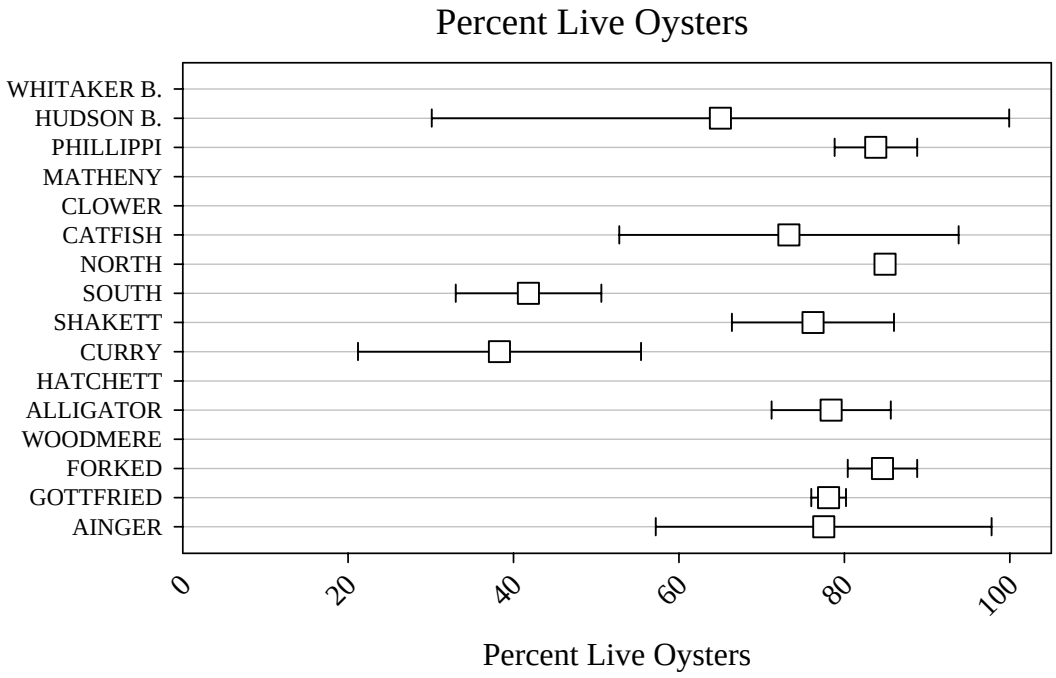

Subtidal Periphyton Cover (%)
100
80
60
40
20
0
CLOWER
MATHENY
NORTH
PHILLIPPI
SHAKETT
ALLIGATOR
CURRY
FORKED
HUDSON B.
SOUTH
WOODMERE
GOTTFRIED
HATCHETT
AINGER
CATFISH
WHITAKER B.

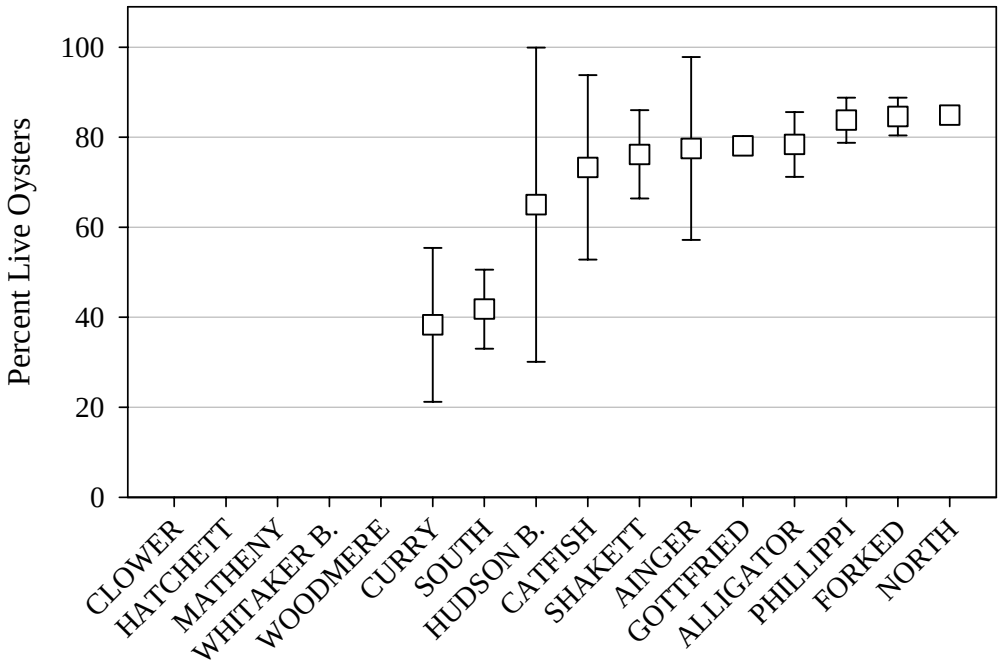

Subtidal Filamentous Algae Cover (%)
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
20
40
60
80
100
Subtidal Filamentous Algae Cover (%)

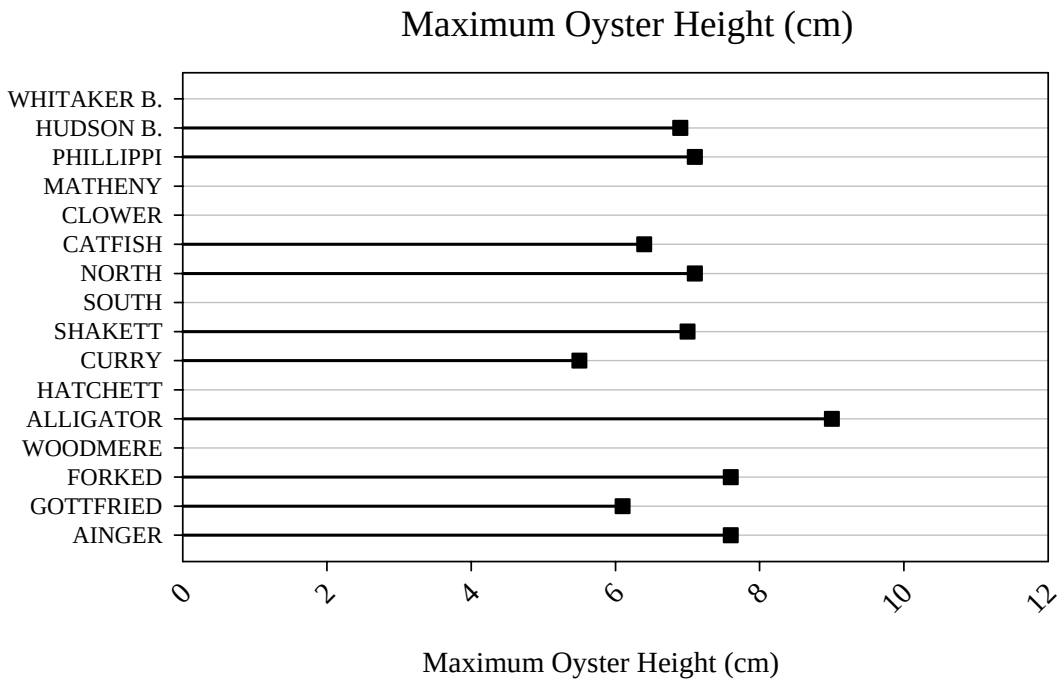

Subtidal Filamentous Algae Cover (%)
100
80
60
40
20
0
CATFISH
CLOWER
HATCHETT
MATHENY
PHILLIPPI
SHAKETT
WHITAKER B.
AINGER
ALLIGATOR
CURRY
FORKED
GOTTFRIED
HUDSON B.
SOUTH
WOODMERE
NORTH

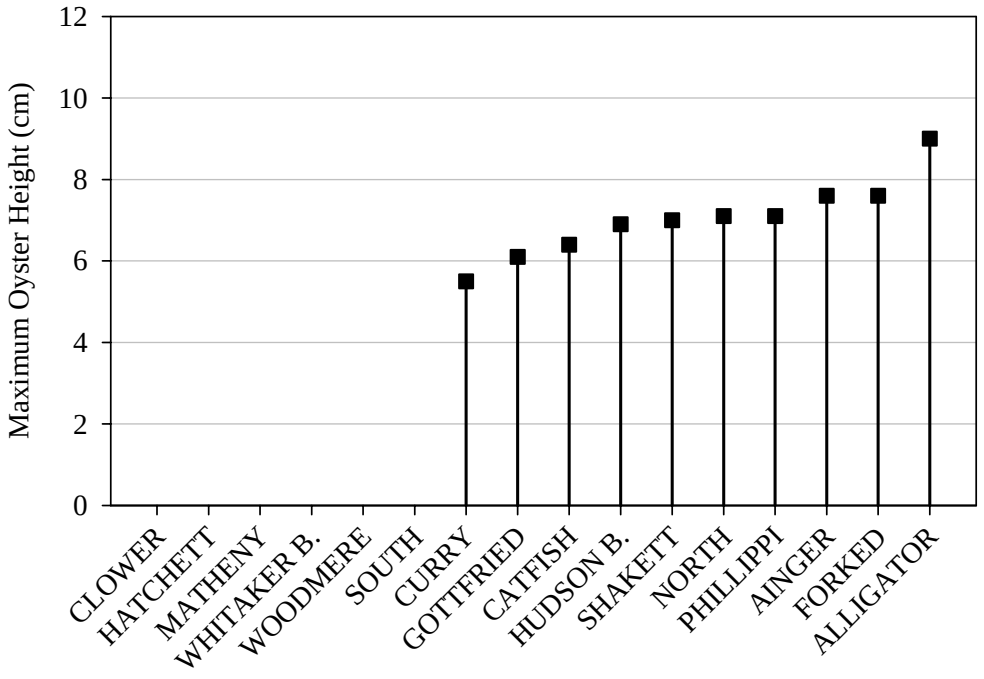

Subtidal Other Live Mollusk Count
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
10
20
30
40
50
60
Subtidal Other Live Mollusk Count per m2


Subtidal Other Live Mollusk Count per m2
60
50
40
30
20
10
0
CLOWER
MATHENY
CATFISH
GOTTFRIED
WHITAKER B.
HATCHETT
HUDSON B.
ALLIGATOR
NORTH
CURRY
FORKED
SOUTH
SHAKETT
AINGER
PHILLIPPI
WOODMERE


Percent Live Oysters
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
20
40
60
80
100
Percent Live Oysters


Percent Live Oysters
100
80
60
40
20
0
CLOWER
HATCHETT
MATHENY
WHITAKER B.
WOODMERE
CURRY
SOUTH
HUDSON B.
CATFISH
SHAKETT
AINGER
GOTTFRIED
ALLIGATOR
PHILLIPPI
FORKED
NORTH


Maximum Oyster Height (cm)
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
2
4
6
8
10
12
Maximum Oyster Height (cm)


Maximum Oyster Height (cm)
0
2
4
6
8
10
12
CLOWER
HATCHETT
MATHENY
WHITAKER B.
WOODMERE
SOUTH
CURRY
GOTTFRIED
CATFISH
HUDSON B.
SHAKETT
NORTH
PHILLIPPI
AINGER
FORKED
ALLIGATOR

APPENDIX 5. Master table of Pearson correlation coefficients for all pairs of creek and watershed attributes. Significant (p< 0.05) positive and negative correlations are red and signified by (*); highly significant (p< 0.01) positive and negative correlations are red and signified by (**).

	Crk Indx	meansal	sal_cv	mnDO	do_cv	WS Age	LDI	PERSOLID	PERMOIS
Crk Indx		0.150	-0.165	-0.105	0.086	-0.488	-0.444	0.322	-0.322
meansal	0.150		-.957(**)	0.309	-0.256	0.060	-0.098	0.330	-0.330
sal_cv	-0.165	-.957(**)		-0.215	0.175	-0.050	0.065	-0.357	0.357
mnDO	-0.105	0.309	-0.215		-.937(**)	-0.298	-0.069	0.533	-0.533
do_cv	0.086	-0.256	0.175	-.937(**)		0.392	0.152	-.650(*)	.650(*)
WS Age	-0.488	0.060	-0.050	-0.298	0.392		.842(**)	-.756(**)	.756(**)
LDI	-0.444	-0.098	0.065	-0.069	0.152	.842(**)		-.525(*)	.525(*)
PERSOLID	0.322	0.330	-0.357	0.533	-.650(*)	-.756(**)	-.525(*)		-1.000(**)
PERMOIS	-0.322	-0.330	0.357	-0.533	.650(*)	.756(**)	.525(*)	-1.000(**)	
PERORG550	-0.319	-0.237	0.244	-0.481	0.566	.794(**)	.504(*)	-.952(**)	.952(**)
PERSAND	0.352	0.292	-0.271	0.473	-0.559	-.718(**)	-.515(*)	.866(**)	-.866(**)
PERSILT	-0.360	-0.294	0.275	-0.472	0.559	.727(**)	.528(*)	-.873(**)	.873(**)
PERCLAY	-0.094	-0.152	0.135	-0.432	0.483	0.352	0.119	-.510(*)	.510(*)
MEAN	0.233	0.223	-0.235	0.430	-0.500	-0.375	-0.175	.667(**)	-.667(**)
MEDIAN	0.111	0.215	-0.252	0.448	-0.510	-0.303	-0.057	.679(**)	-.679(**)
MODE	0.030	0.085	-0.207	0.249	-0.321	-0.098	0.135	0.460	-0.460
STDDEV	-0.410	-0.324	0.306	-0.407	0.441	.563(*)	0.366	-.671(**)	.671(**)
SKEWNESS	-0.275	-0.435	0.412	-0.521	.591(*)	0.400	0.192	-.740(**)	.740(**)
KURTOSIS	0.338	0.349	-0.316	0.352	-0.450	-0.321	-0.171	.567(*)	-.567(*)
Taxa	.669(**)	0.050	0.038	-0.045	-0.070	-.574(*)	-.731(**)	0.360	-0.360
Inds_m2	.527(*)	-0.005	0.051	-0.137	0.119	-.625(**)	-.662(**)	0.399	-0.399
Shan(2)	0.476	-0.010	0.104	-0.021	-0.182	-0.179	-0.304	0.061	-0.061
Pielou	0.095	-0.111	0.179	-0.089	-0.131	0.210	0.130	-0.229	0.229
Margalef	.629(*)	0.051	0.041	-0.043	-0.092	-0.465	-.661(**)	0.270	-0.270
Gini	0.373	-0.124	0.218	-0.139	-0.057	-0.039	-0.143	-0.103	0.103
BOD	0.150	-0.268	0.273	0.220	-0.095	0.237	.544(*)	-0.122	0.122
COD	0.014	-0.014	0.000	0.044	0.158	.591(*)	.729(**)	-0.366	0.366
TSS	0.091	0.281	-0.302	-0.077	0.314	.552(*)	0.411	-0.382	0.382
TDS	0.116	-0.255	0.198	-0.071	0.302	0.412	0.456	-.538(*)	.538(*)
TP	-0.002	-0.458	0.469	0.382	-0.331	-0.119	0.226	0.103	-0.103
TN	0.289	-0.200	0.226	0.278	-0.230	0.038	0.380	0.079	-0.079
PbCuZnCd	-0.159	-0.085	0.037	-0.167	0.405	.730(**)	.680(**)	-.683(**)	.683(**)
Oil & Grease	0.347	-0.083	0.058	-0.107	0.271	0.323	.529(*)	-0.223	0.223

	PERORG550	PERSAND	PERSILT	PERCLAY	MEAN	MEDIAN	MODE	STDDEV	SKEWNESS
Crk Indx	-0.319	0.352	-0.360	-0.094	0.233	0.111	0.030	-0.410	-0.275
meansal	-0.237	0.292	-0.294	-0.152	0.223	0.215	0.085	-0.324	-0.435
sal_cv	0.244	-0.271	0.275	0.135	-0.235	-0.252	-0.207	0.306	0.412
mnDO	-0.481	0.473	-0.472	-0.432	0.430	0.448	0.249	-0.407	-0.521
do_cv	0.566	-0.559	0.559	0.483	-0.500	-0.510	-0.321	0.441	.591(*)
WS Age	.794(**)	-.718(**)	.727(**)	0.352	-0.375	-0.303	-0.098	.563(*)	0.400
LDI	.504(*)	-.515(*)	.528(*)	0.119	-0.175	-0.057	0.135	0.366	0.192
PERSOLID	-.952(**)	.866(**)	-.873(**)	-.510(*)	.667(**)	.679(**)	0.460	-.671(**)	-.740(**)
PERMOIS	.952(**)	-.866(**)	.873(**)	.510(*)	-.667(**)	-.679(**)	-0.460	.671(**)	.740(**)
PERORG550		-.893(**)	.898(**)	.575(*)	-.622(*)	-.616(*)	-0.355	.734(**)	.714(**)
PERSAND	-.893(**)		-.999(**)	-.734(**)	.798(**)	.675(**)	0.354	-.922(**)	-.836(**)
PERSILT	.898(**)	-.999(**)		.711(**)	-.784(**)	-.662(**)	-0.340	.919(**)	.839(**)
PERCLAY	.575(*)	-.734(**)	.711(**)		-.868(**)	-.790(**)	-.598(*)	.715(**)	.549(*)
MEAN	-.622(*)	.798(**)	-.784(**)	-.868(**)		.945(**)	.766(**)	-.732(**)	-.743(**)
MEDIAN	-.616(*)	.675(**)	-.662(**)	-.790(**)	.945(**)		.902(**)	-.562(*)	-.688(**)
MODE	-0.355	0.354	-0.340	-.598(*)	.766(**)	.902(**)		-0.267	-0.446
STDDEV	.734(**)	-.922(**)	.919(**)	.715(**)	-.732(**)	-.562(*)	-0.267		.849(**)
SKEWNESS	.714(**)	-.836(**)	.839(**)	.549(*)	-.743(**)	-.688(**)	-0.446	.849(**)	
KURTOSIS	-.561(*)	.799(**)	-.801(**)	-.536(*)	.695(**)	.542(*)	0.287	-.884(**)	-.935(**)
Taxa	-0.354	0.478	-0.493	-0.017	0.139	-0.080	-0.338	-0.430	-0.290
Inds_m2	-0.443	.500(*)	-.516(*)	-0.010	0.149	0.005	-0.256	-0.433	-0.357
Shan(2)	-0.008	0.122	-0.133	0.131	-0.048	-0.227	-0.333	-0.106	-0.051
Pielou	0.296	-0.228	0.225	0.207	-0.196	-0.277	-0.218	0.227	0.202
Margalef	-0.243	0.381	-0.395	0.018	0.089	-0.135	-0.355	-0.339	-0.195
Gini	0.122	0.007	-0.017	0.204	-0.136	-0.313	-0.387	-0.047	-0.001
BOD	0.063	0.041	-0.025	-0.321	0.342	0.309	0.280	-0.160	-0.128
COD	0.342	-0.228	0.242	-0.074	0.107	0.103	0.155	0.016	0.002
TSS	0.403	-0.236	0.242	0.098	-0.023	-0.078	-0.047	-0.007	0.044
TDS	.531(*)	-0.417	0.423	0.189	-0.144	-0.156	0.028	0.146	0.189
TP	-0.155	0.241	-0.225	-.502(*)	.526(*)	.511(*)	0.459	-0.226	-0.190
TN	-0.158	0.192	-0.179	-0.363	0.326	0.273	0.155	-0.226	-0.160
PbCuZnCd	.692(**)	-.572(*)	.581(*)	0.253	-0.235	-0.209	0.004	0.291	0.271
Oil & Grease	0.164	-0.135	0.144	-0.024	0.003	-0.038	-0.042	-0.028	0.035

	Taxa	Inds_m2	Shan(2)	Pielou	Margalef	Gini	BOD	COD	TSS
Crk Indx	.669(**)	.527(*)	0.476	0.095	.629(*)	0.373	0.150	0.014	0.091
meansal	0.050	-0.005	-0.010	-0.111	0.051	-0.124	-0.268	-0.014	0.281
sal_cv	0.038	0.051	0.104	0.179	0.041	0.218	0.273	0.000	-0.302
mnDO	-0.045	-0.137	-0.021	-0.089	-0.043	-0.139	0.220	0.044	-0.077
do_cv	-0.070	0.119	-0.182	-0.131	-0.092	-0.057	-0.095	0.158	0.314
WS Age	-.574(*)	-.625(**)	-0.179	0.210	-0.465	-0.039	0.237	.591(*)	.552(*)
LDI	-.731(**)	-.662(**)	-0.304	0.130	-.661(**)	-0.143	.544(*)	.729(**)	0.411
PERSOLID	0.360	0.399	0.061	-0.229	0.270	-0.103	-0.122	-0.366	-0.382
PERMOIS	-0.360	-0.399	-0.061	0.229	-0.270	0.103	0.122	0.366	0.382
PERORG550	-0.354	-0.443	-0.008	0.296	-0.243	0.122	0.063	0.342	0.403
PERSAND	0.478	.500(*)	0.122	-0.228	0.381	0.007	0.041	-0.228	-0.236
PERSILT	-0.493	-.516(*)	-0.133	0.225	-0.395	-0.017	-0.025	0.242	0.242
PERCLAY	-0.017	-0.010	0.131	0.207	0.018	0.204	-0.321	-0.074	0.098
MEAN	0.139	0.149	-0.048	-0.196	0.089	-0.136	0.342	0.107	-0.023
MEDIAN	-0.080	0.005	-0.227	-0.277	-0.135	-0.313	0.309	0.103	-0.078
MODE	-0.338	-0.256	-0.333	-0.218	-0.355	-0.387	0.280	0.155	-0.047
STDDEV	-0.430	-0.433	-0.106	0.227	-0.339	-0.047	-0.160	0.016	-0.007
SKEWNESS	-0.290	-0.357	-0.051	0.202	-0.195	-0.001	-0.128	0.002	0.044
KURTOSIS	0.423	0.404	0.233	-0.037	0.355	0.219	0.180	0.055	0.029
Taxa		.743(**)	.714(**)	0.229	.971(**)	.608(*)	-0.230	-0.381	-0.156
Inds_m2	.743(**)		0.156	-0.341	.571(*)	0.092	-0.162	-0.346	-0.204
Shan(2)	.714(**)	0.156		.838(**)	.838(**)	.963(**)	-0.081	-0.194	-0.153
Pielou	0.229	-0.341	.838(**)		0.423	.876(**)	0.014	-0.026	-0.141
Margalef	.971(**)	.571(*)	.838(**)	0.423		.733(**)	-0.238	-0.360	-0.133
Gini	.608(*)	0.092	.963(**)	.876(**)	.733(**)		0.007	-0.077	-0.091
BOD	-0.230	-0.162	-0.081	0.014	-0.238	0.007		.860(**)	0.461
COD	-0.381	-0.346	-0.194	-0.026	-0.360	-0.077	.860(**)		.802(**)
TSS	-0.156	-0.204	-0.153	-0.141	-0.133	-0.091	0.461	.802(**)	
TDS	-0.320	-0.223	-0.256	-0.163	-0.319	-0.151	.575(*)	.700(**)	.647(**)
TP	-0.202	-0.090	-0.132	-0.062	-0.223	-0.084	.792(**)	0.446	0.006
TN	-0.022	0.007	0.099	0.110	-0.041	0.131	.888(**)	.669(**)	0.245
PbCuZnCd	-.517(*)	-0.445	-0.351	-0.122	-0.480	-0.213	0.490	.784(**)	.788(**)
Oil & Grease	-0.083	-0.066	0.046	0.081	-0.091	0.113	.812(**)	.833(**)	.578(*)

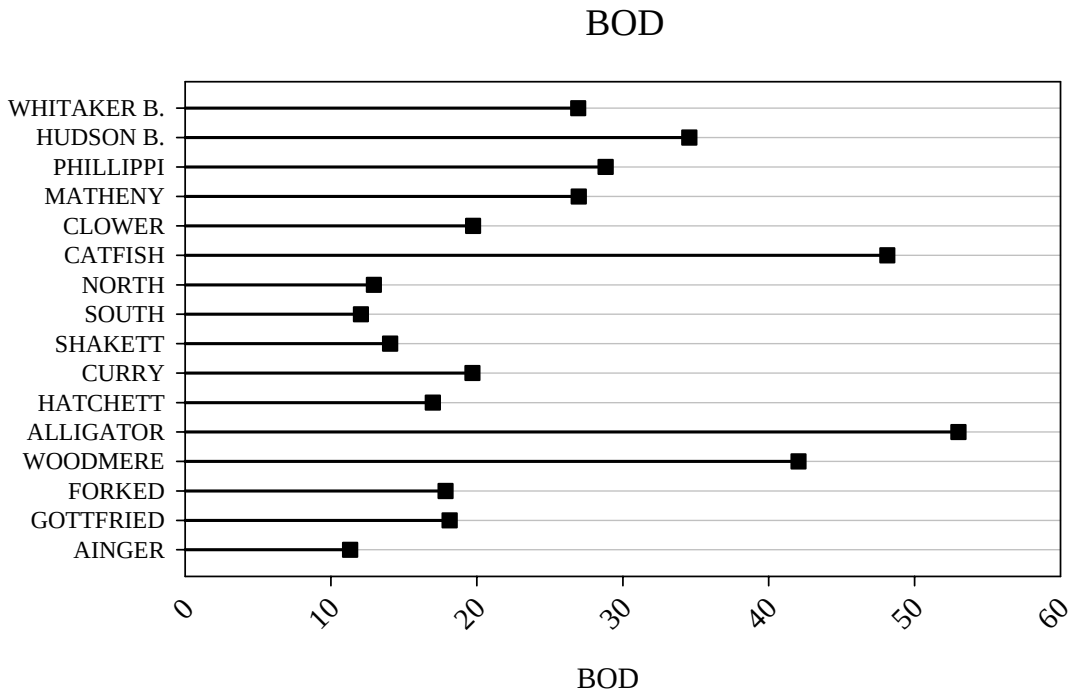
	TP	TN	PbCuZnCd	Oil & Grease
Crk Indx	-0.002	0.289	-0.159	0.347
meansal	-0.458	-0.200	-0.085	-0.083
sal_cv	0.469	0.226	0.037	0.058
mnDO	0.382	0.278	-0.167	-0.107
do_cv	-0.331	-0.230	0.405	0.271
WS Age	-0.119	0.038	.730(**)	0.323
LDI	0.226	0.380	.680(**)	.529(*)
PERSOLID	0.103	0.079	-.683(**)	-0.223
PERMOIS	-0.103	-0.079	.683(**)	0.223
PERORG550	-0.155	-0.158	.692(**)	0.164
PERSAND	0.241	0.192	-.572(*)	-0.135
PERSILT	-0.225	-0.179	.581(*)	0.144
PERCLAY	-.502(*)	-0.363	0.253	-0.024
MEAN	.526(*)	0.326	-0.235	0.003
MEDIAN	.511(*)	0.273	-0.209	-0.038
MODE	0.459	0.155	0.004	-0.042
STDDEV	-0.226	-0.226	0.291	-0.028
SKEWNESS	-0.190	-0.160	0.271	0.035
KURTOSIS	0.182	0.204	-0.200	0.047
Taxa	-0.202	-0.022	-.517(*)	-0.083
Inds_m2	-0.090	0.007	-0.445	-0.066
Shan(2)	-0.132	0.099	-0.351	0.046
Pielou	-0.062	0.110	-0.122	0.081
Margalef	-0.223	-0.041	-0.480	-0.091
Gini	-0.084	0.131	-0.213	0.113
BOD	.792(**)	.888(**)	0.490	.812(**)
COD	0.446	.669(**)	.784(**)	.833(**)
TSS	0.006	0.245	.788(**)	.578(*)
TDS	0.369	0.237	.901(**)	.504(*)
TP		.642(**)	0.169	0.323
TN	.642(**)		0.137	.854(**)
PbCuZnCd	0.169	0.137		0.480
Oil & Grease	0.323	.854(**)	0.480	

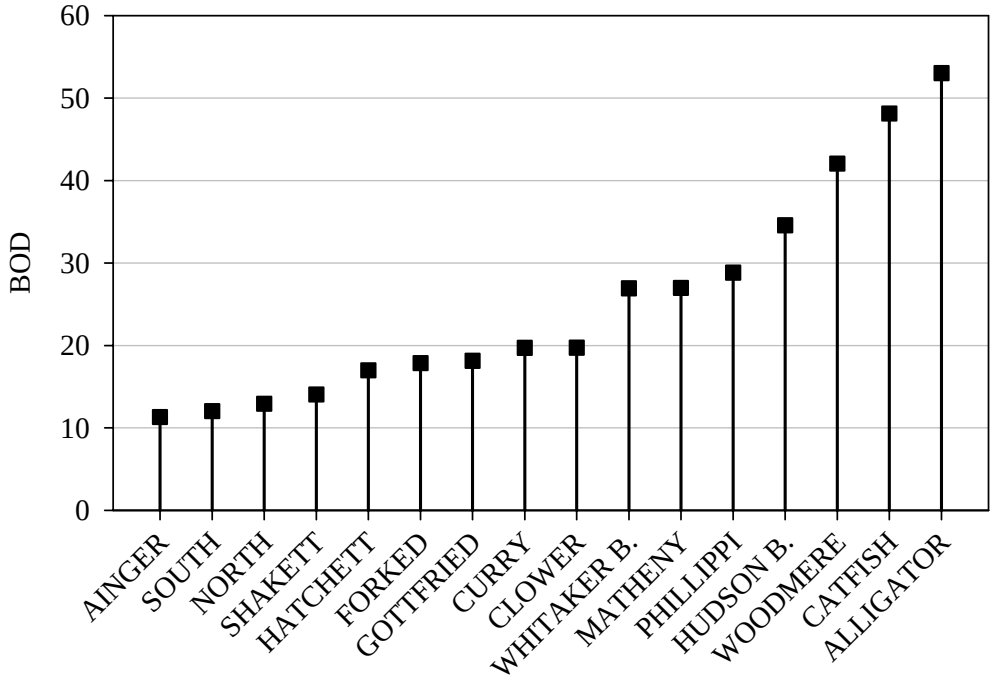
APPENDIX 6. Master table of Pearson correlation coefficients for the tidal creek condition index and May 2007 water quality data. Significant (p< 0.05) positive and negative correlations are red and signified by (*); highly significant (p< 0.01) positive and negative correlations are red and signified by (**).

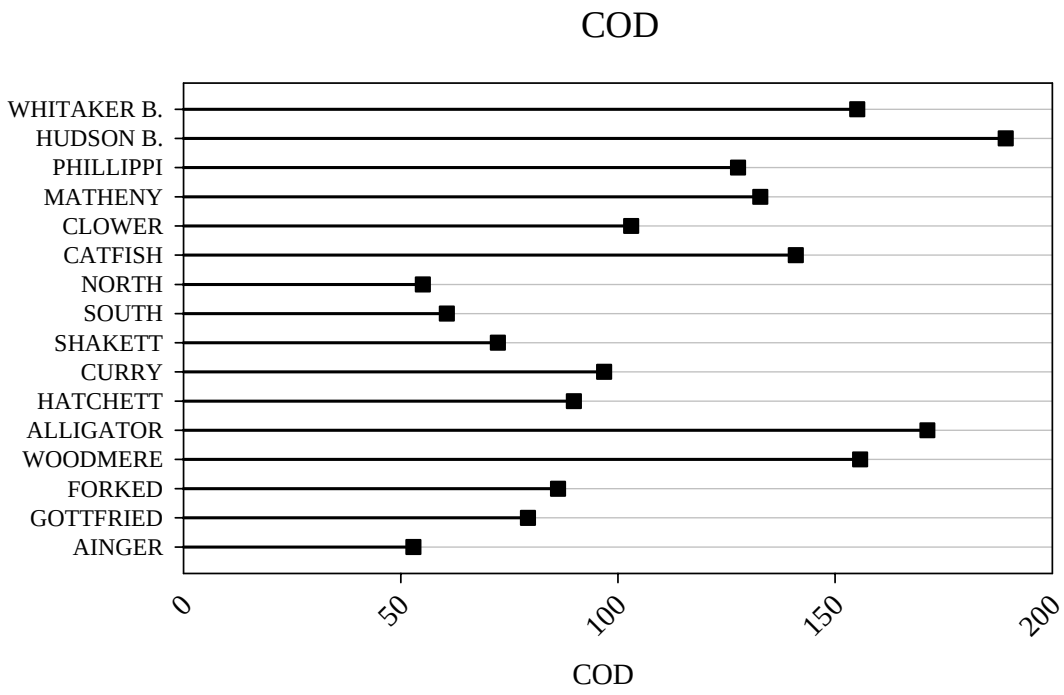
	TEMPW_C	index	DO_MGL	CHLA_MG/M3	COND_UMHOCM	TSS_MGL	TURB_NTU	TKN_MGL	TN_MGL
TEMPW_C		-0.409	-0.004	0.553	0.213	0.027	-0.032	0.473	0.460
DO_MGL	-0.004	0.097	1.000(**)	-0.444	-0.154	-0.198	-0.491	-0.053	-0.069
index	-0.409		0.097	-0.210	-0.023	0.171	-0.094	-0.460	-0.487
DO_MGL	-0.004	0.097		-0.444	-0.154	-0.198	-0.491	-0.053	-0.069
CHLA_MG/M3	0.553	-0.210	-0.444		-0.006	0.124	0.314	0.392	0.381
COND_UMHOCM	0.213	-0.023	-0.154	-0.006		.588(*)	0.007	-0.507	-0.485
TSS_MGL	0.027	0.171	-0.198	0.124	.588(*)		0.412	-0.204	-0.191
TURB_NTU	-0.032	-0.094	-0.491	0.314	0.007	0.412		0.280	0.288
TKN_MGL	0.473	-0.460	-0.053	0.392	-0.507	-0.204	0.280		.997(**)
TN_MGL	0.460	-0.487	-0.069	0.381	-0.485	-0.191	0.288	.997(**)	
NOX_MGL	0.076	-0.539	-0.188	0.028	0.001	0.048	0.218	0.463	0.528
OP_MGL	0.158	-0.189	-.579(*)	.677(*)	-0.291	-0.044	0.460	.595(*)	.613(*)
TP_MGL	0.322	-0.264	-0.460	.840(**)	-0.119	-0.011	0.417	.576(*)	.586(*)
NH3_MGL	-0.225	-0.508	-0.246	-0.009	-0.503	-0.076	0.476	0.557	.591(*)

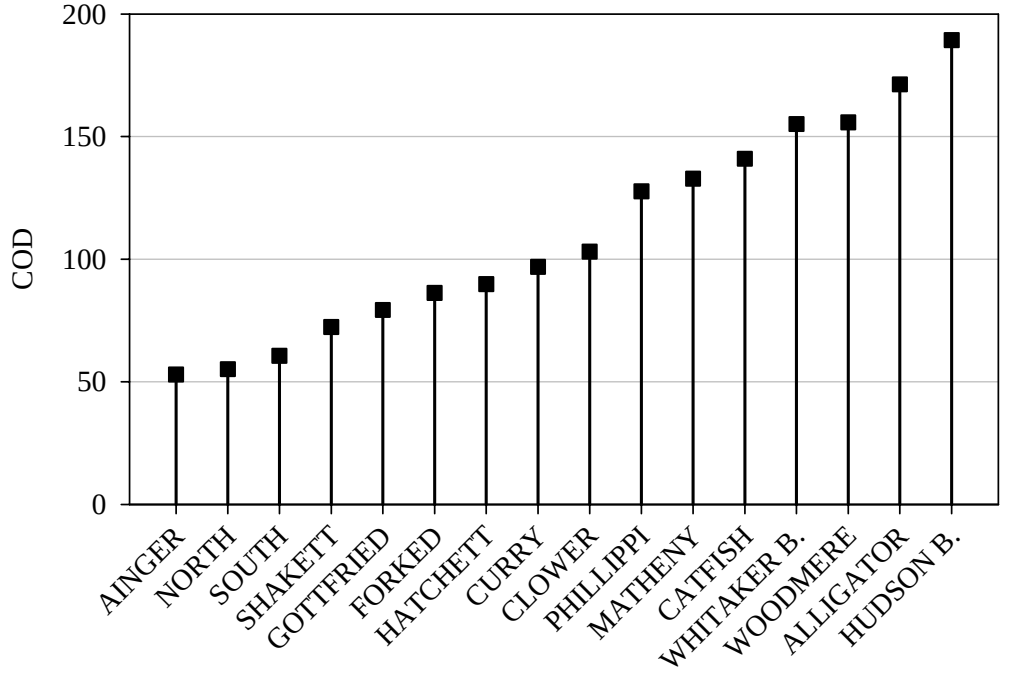
	OP_MGL	TP_MGL	NH3_MGL
TEMPW_C	0.158	0.322	-0.225
DO_MGL	-.579(*)	-0.460	-0.246
index	-0.189	-0.264	-0.508
DO_MGL	-.579(*)	-0.460	-0.246
CHLA_MG/M3	.677(*)	.840(**)	-0.009
COND_UMHOCM	-0.291	-0.119	-0.503
TSS_MGL	-0.044	-0.011	-0.076
TURB_NTU	0.460	0.417	0.476
TKN_MGL	.595(*)	.576(*)	0.557
TN_MGL	.613(*)	.586(*)	.591(*)
NOX_MGL	0.472	0.373	.673(*)
OP_MGL		.893(**)	0.465
TP_MGL	.893(**)		0.265
NH3_MGL	0.465	0.265	

APPENDIX 7. 2004 pollutant load model outputs. All values are pounds/acre/year.






COD
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
50
100
150
200
COD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150
100
50
0
COD
AINGER
NORTH
SOUTH
SHAKETT
GOTTFRIED
FORKED
HATCHETT
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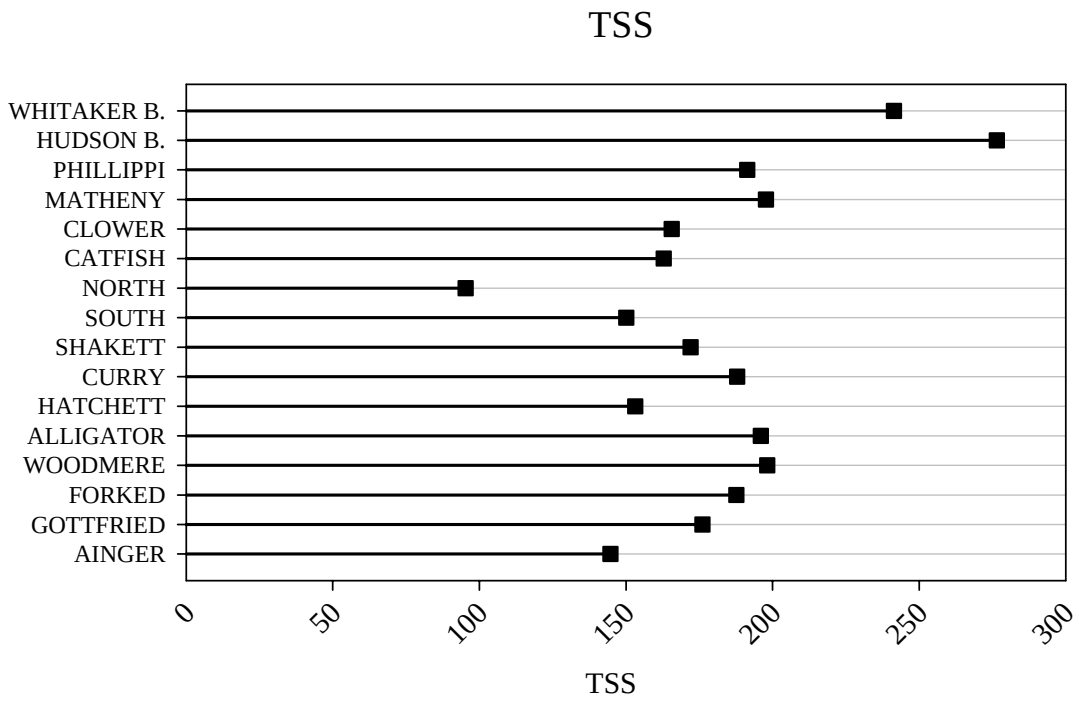
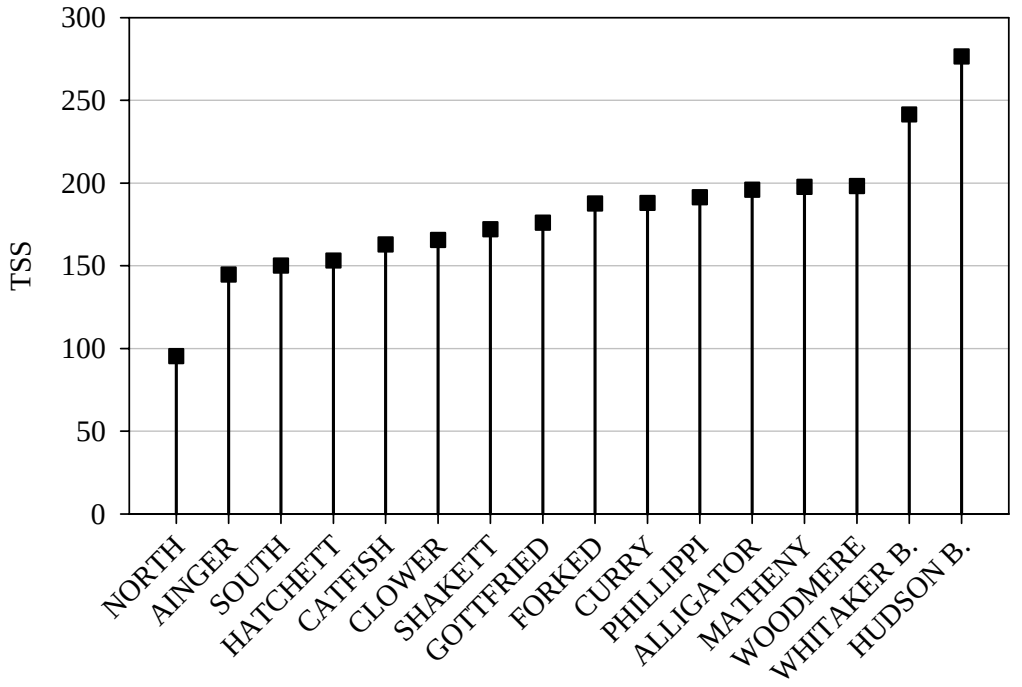
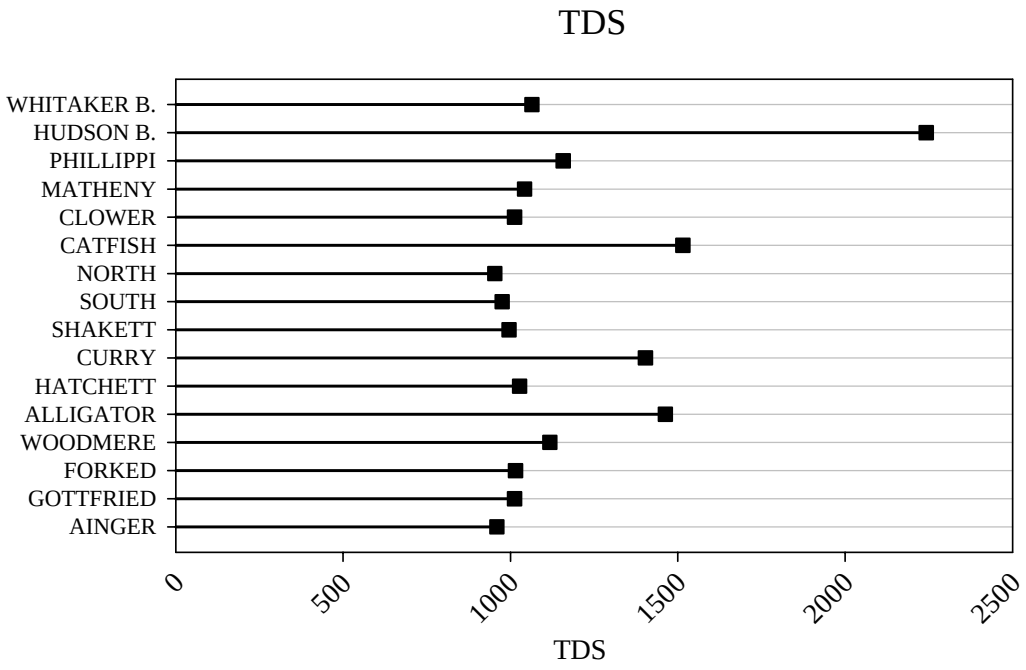
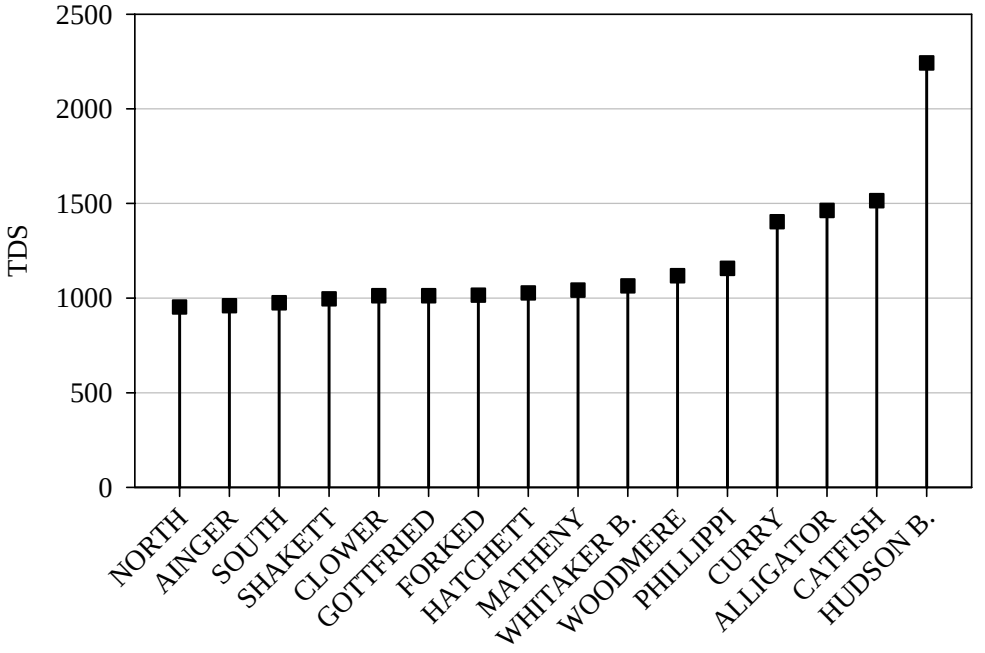
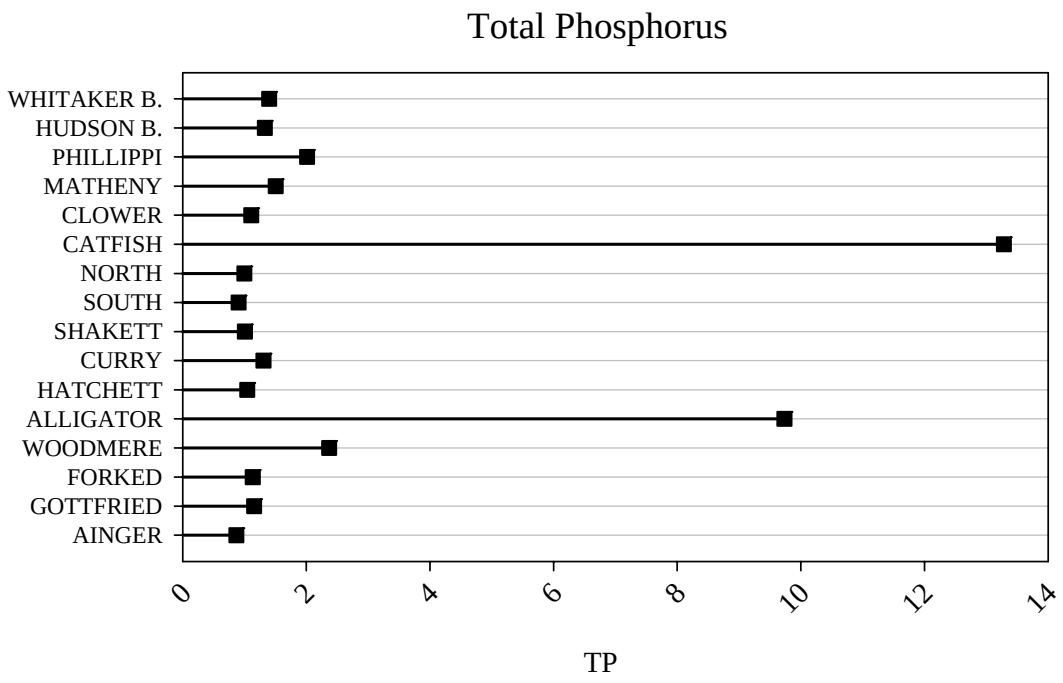
CLOWER
PHILLIPPI
MATHENY
CATFISH
WHITAKER B.
WOODMERE
ALLIGATOR
HUDSON B.

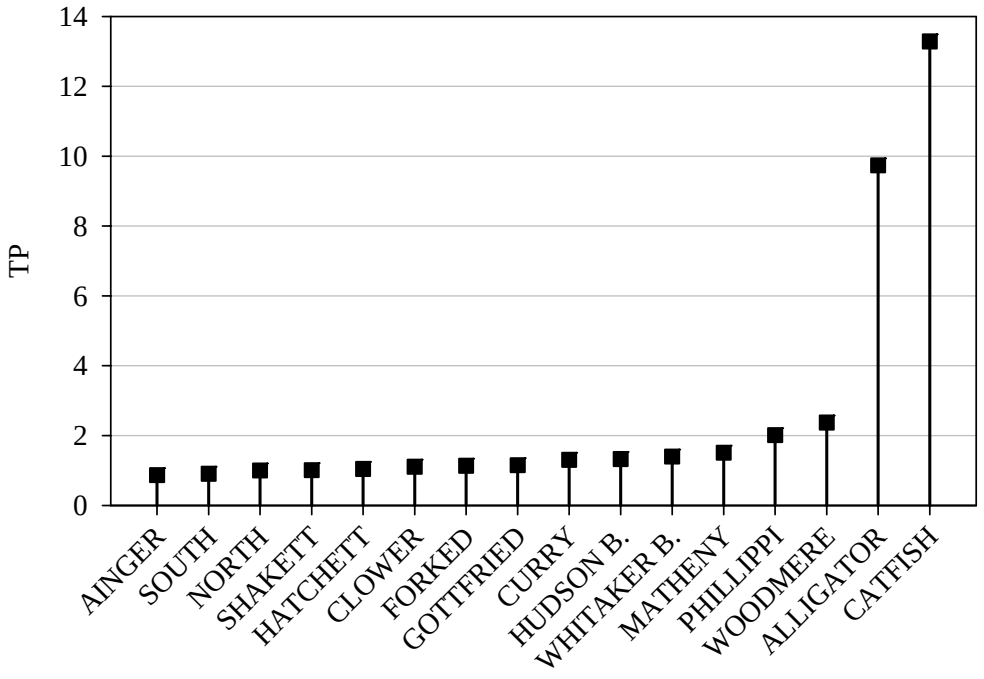

TSS
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
50
100
150
200
250
300
TSS

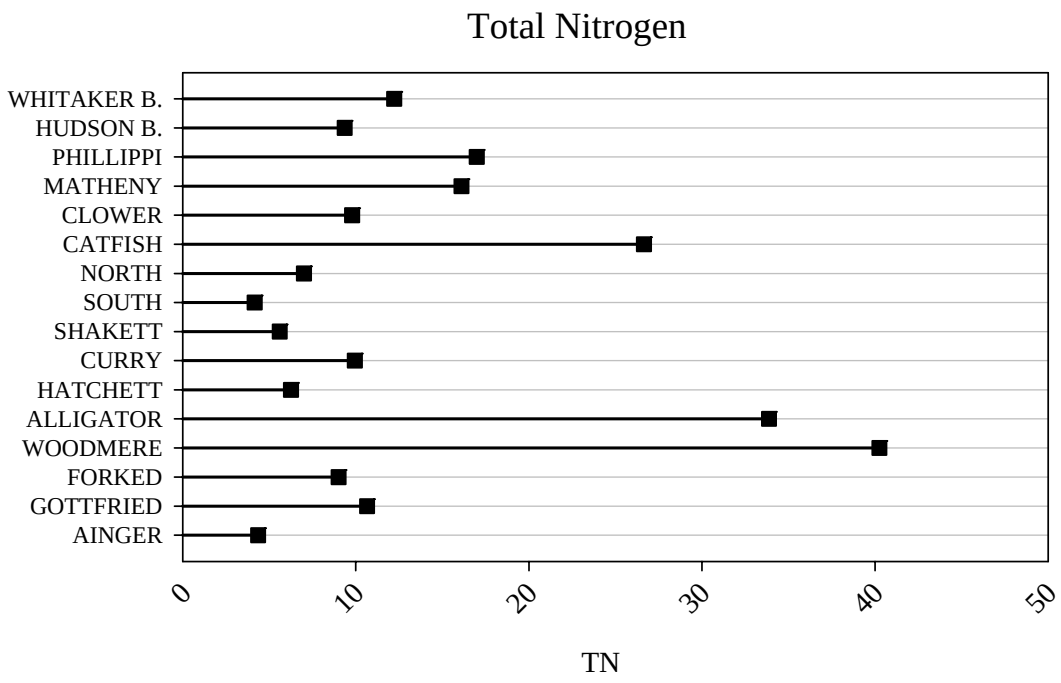

300
250
200
150
100
50
0
TSS
NORTH
AINGER
SOUTH
HATCHETT
CATFISH
CLOWER
SHAKETT
GOTTFRIED
FORKED
CURRY
PHILLIPPI
ALLIGATOR
MATHENY
WOODMERE
WHITAKER B.
HUDSON B.

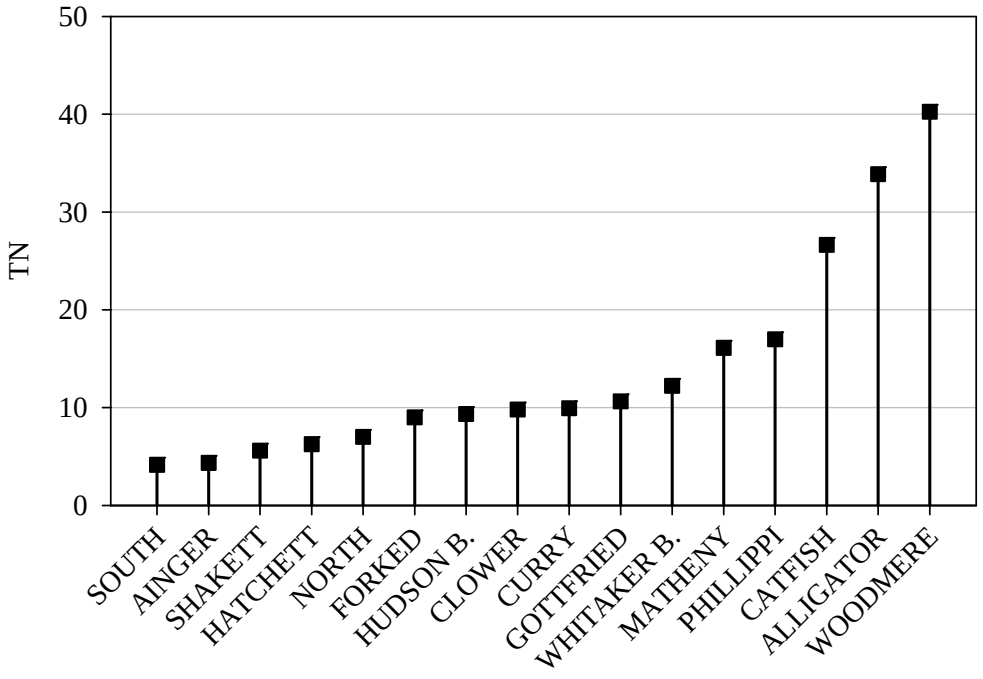

TDS
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
500
1000
1500
2000
2500
TDS

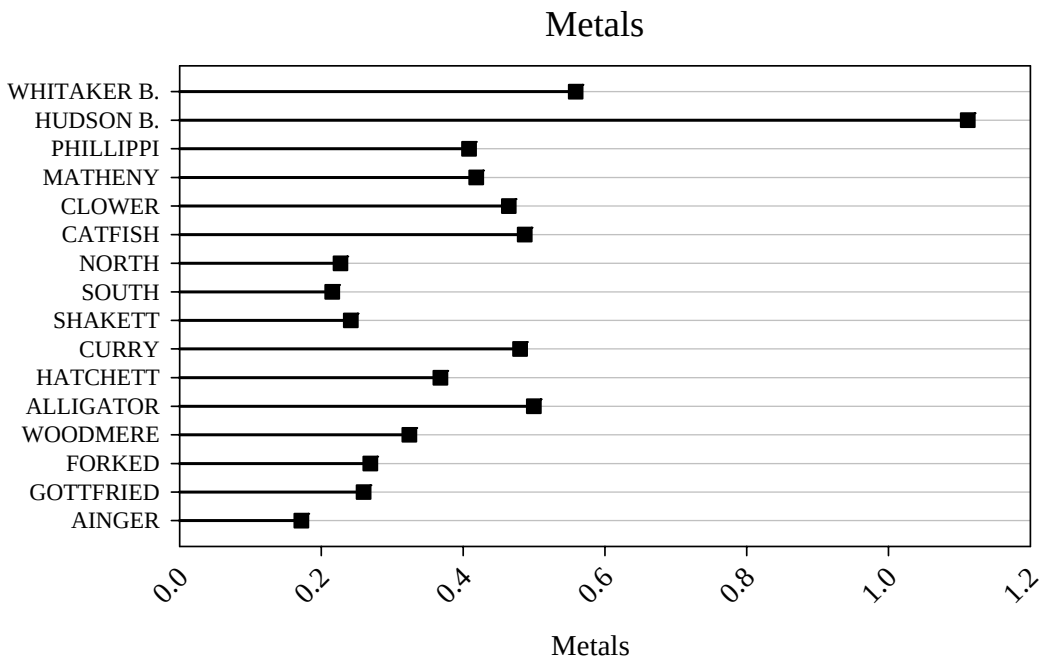

2500
2000
1500
1000
500
0
TDS
NORTH
AINGER
SOUTH
SHAKETT
CLOWER
GOTTFRIED
FORKED
HATCHETT
MATHENY
WHITAKER B.
WOODMERE
PHILLIPPI
CURRY
ALLIGATOR
CATFISH
HUDSON B.

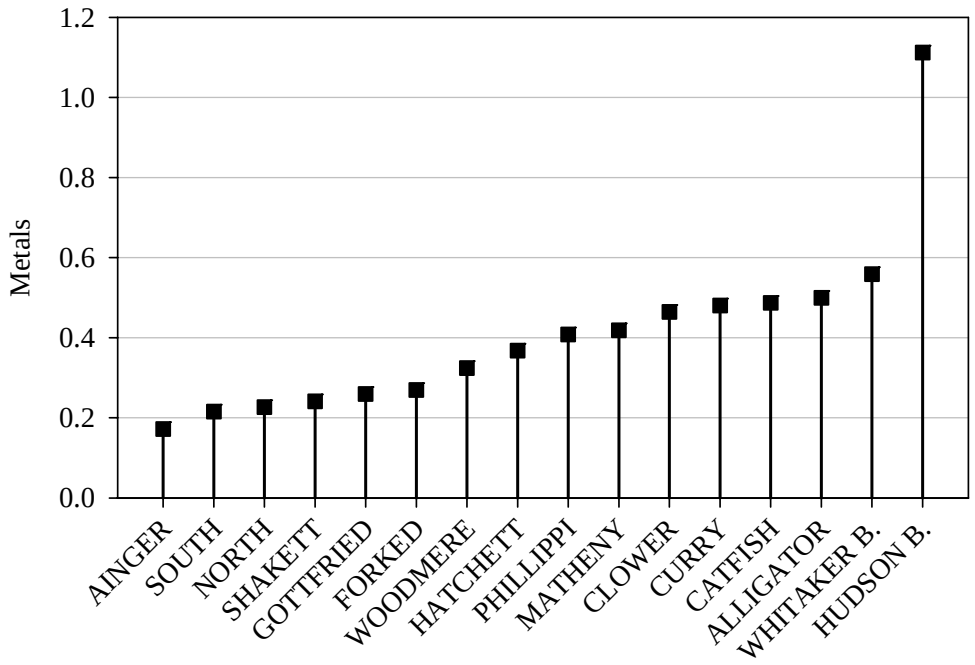

Total Phosphorus
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
2
4
6
8
10
12
14
TP

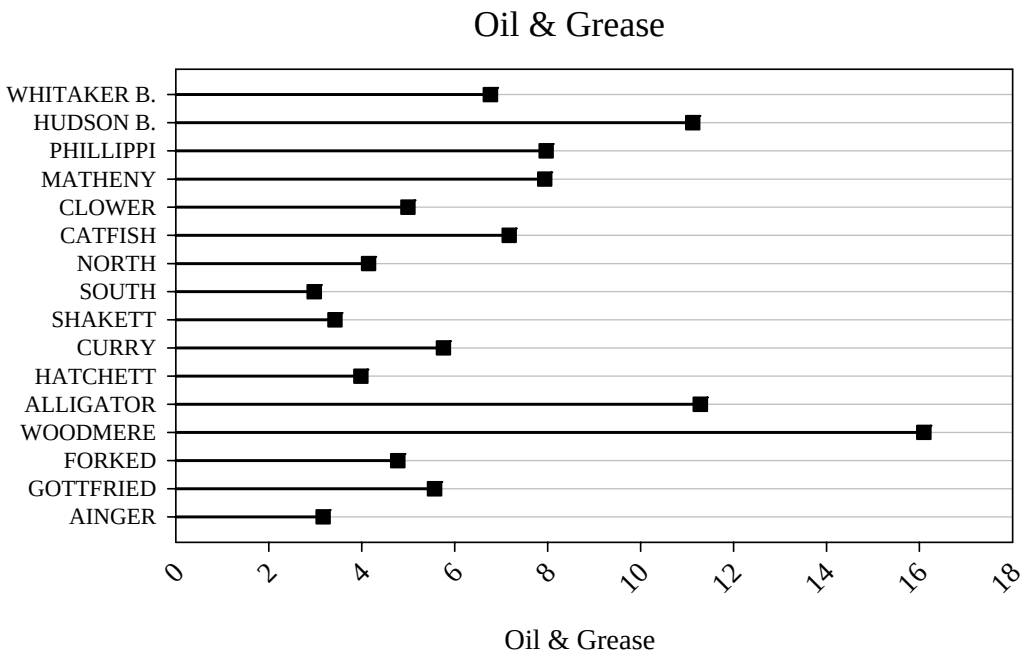

14
12
10
8
6
4
2
0
TP
AINGER
SOUTH
NORTH
SHAKETT
HATCHETT
CLOWER
FORKED
GOTTFRIED
CURRY
HUDSON B.
WHITAKER B.
MATHENY
PHILLIPPI
WOODMERE
ALLIGATOR
CATFISH

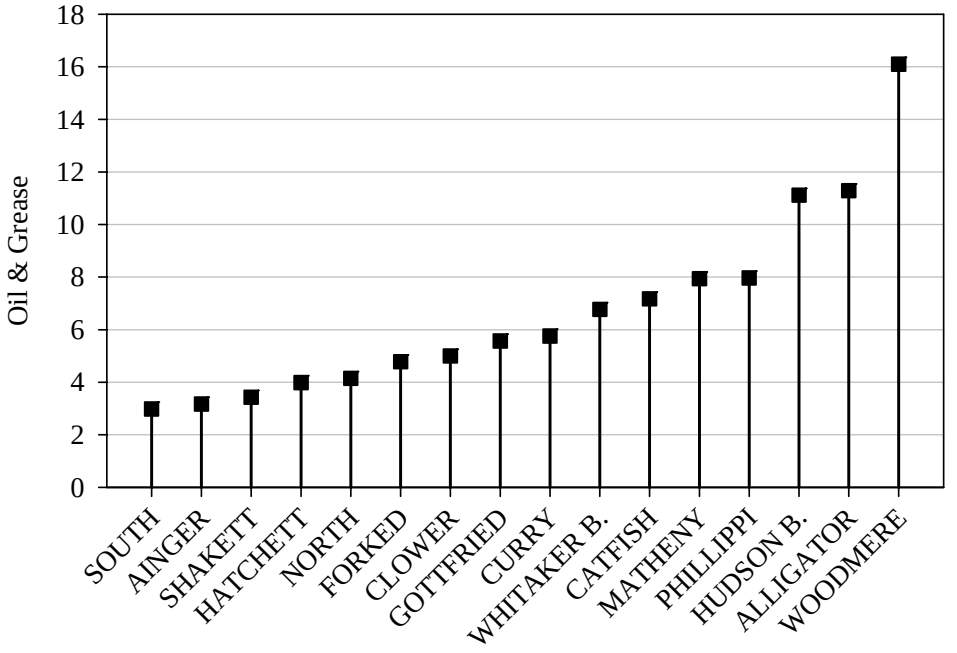

Total Nitrogen
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
10
20
30
40
50
TN


50
40
30
20
10
0
TN
SOUTH
AINGER
SHAKETT
HATCHETT
NORTH
FORKED
HUDSON B.
CLOWER
CURRY
GOTTFRIED
WHITAKER B.
MATHENY
PHILLIPPI
CATFISH
ALLIGATOR
WOODMERE


Metals
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Metals


1.2
1.0
0.8
0.6
0.4
0.2
0.0
Metals
AINGER
SOUTH
NORTH
SHAKETT
GOTTFRIED
FORKED
WOODMERE
HATCHETT
PHILLIPPI
MATHENY
CLOWER
CURRY
CATFISH
ALLIGATOR
WHITAKER B.
HUDSON B.


Oil & Grease
WHITAKER B.
HUDSON B.
PHILLIPPI
MATHENY
CLOWER
CATFISH
NORTH
SOUTH
SHAKETT
CURRY
HATCHETT
ALLIGATOR
WOODMERE
FORKED
GOTTFRIED
AINGER
0
2
4
6
8
10
12
14
16
18
Oil & Grease


Oil & Grease
0
2
4
6
8
10
12
14
16
18
SOUTH
AINGER
SHAKETT
HATCHETT
NORTH
FORKED
CLOWER
GOTTFRIED
CURRY
WHITAKER B.
CATFISH
MATHENY
PHILLIPPI
HUDSON B.
ALLIGATOR
WOODMERE