MOTE MARINE LABORATORY

Charlotte Harbor •
Key West Conch Baby Farm •
Mote Aquaculture Park •
Tropical Research Laboratory •

April 18, 2006

Mr. Michael G. Heyl
Southwest Florida Water Management District
7601 U.S. Highway 301
Tampa, Fl. 33637-6759

Re: District Purchase Order 05PC0001646-1: Anclote River Mollusk and Vegetation Survey

Dear Mr. Heyl:

This two-part report describes studies conducted by Drs. Ernest Estevez and Brad Robbins on mollusks and shoreline type within the Anclote River. This study is part of the Southwest Florida Water Management District's program to describe west-central Florida tidal rivers for the purpose of establishing regulatory minimum flows in each.

The project called for live and dead mollusks to be assessed using rapid survey techniques comparable to those previously used by Mote Marine Laboratory in studies of the Peace, Myakka, Weeki Wachee and Alafia Rivers, Shell Creek, and McKay, Dona, and Roberts Bays. A "windshield" survey of the Anclote River' shorelines coupled with an assessment of aerial photographs and landuse maps was used to delineate the River's shoreline by type.

Please accept the enclosed materials as a final letter report of findings for the cited effort.

We appreciate the opportunity to have conducted this interesting study, and hope the District finds it useful in its work.

Sincerely,

Ernest D. Estevez, Ph.D.
Director
Center for Coastal Ecology

Bradley D. Robbins
Manager
Landscape Ecology Program

Part One: Mollusk Survey

Rapid-survey methods were employed from December 12, 2005 to February 10, 2006, to census the macro-mollusk communities of the Anclote River, Florida. The Anclote River was sampled from its mouth to river kilometer (RK) 3.0 on one kilometer intervals; then on half kilometer intervals to RK 12.0, and then at RK 13, 14, and 15. A District RK map was used to locate stations and all sampled sites corresponded to sites defined by the Scope of Work, except that RK 11.5 was moved to RK 11.3 to avoid local human disturbances. Because RK 16 was not sampled as per the Purchase Order, a replacement effort was made at RK -1.0.

Because the primary objective of the study was to identify down-stream patterns in species dispersion, samples were collected across each transect at representative sites, and data were pooled for the entire transect. In single-channel reaches, subtidal samples were collected close by opposite banks and at evenly spaced intervals across the channel. In reaches with marsh islands and multiple channels, subtidal effort was distributed so as to sample in each channel or basin.

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

Subtidal samples (< MLW) were collected by a petite ponar grab rather than pipe cores because larger mollusks are often missed or lost by the cores. Ponar grabs offer a larger sampling surface area (0.0232 square meters) than pipe cores (0.00456 square meters). A sample was comprised of one ponar grab at a given location. Five such subtidal samples were taken in different environments along each half-kilometer transect, giving a per-transect sampling surface area of 0.116 square meters. Contents of each sample were concentrated over a 3.0 millimeter sieve and processed in the field. Unknowns were bagged and returned to the Laboratory for identification.

Intertidal samples (> MLW) usually were collected by spade although ponar grabs were used in areas where the substratum was unfit for wading. Intertidal effort was the same as subtidal effort except that hand collections of particular species were added to intertidal samples so as to record the presence of rare or cryptic species. The gastropods, *Neritina* and *Littoraria*, for example, are often found in low numbers, near the tops of black needlerush shoots. Oysters and mussels likewise grow cryptically behind mangrove roots or within crevices of fallen wood.

Where safe to do so, subtidal areas were also visually reconnoitered by wading or snorkeling and intertidal areas were walked in search of rare occurrences.

Specimens were sorted as live or dead and identified in the field or Laboratory. For each species in each sample, both live and dead median size was determined by arranging specimens from smallest to largest and measuring the median specimen to the nearest millimeter. Gastropods were measured from the apex to opposite end; bivalves were measured from front end to hind end. For data analysis, a mean value of median sizes was computed for each species. The percentage of juveniles (<10 mm) if any was recorded by species where identification was possible, for live and dead lots at each transect. Condition was scored for each whole live animal or single dead valve as percent covered by mechanical erosion, shell dissolution, or other loss or damage.

Findings

An Excel spreadsheet of all species at all stations is provided in Attachment 1. This Report contains graphs depicting data for individual species that were numerous enough to warrant description, an Exhibit section for other species, and graphs depicting summary community data and the spatial arrangement of species as a function of river kilometer for both rivers.

A total of 38 taxa were collected. Species richness was high, even in comparison to other tidal streams in southwest Florida that have been studied by the same method. Species richness values for other systems are 11 in Shell Creek, 15 in the Weeki Wachee River, 20 in the Alafia River, 24 in the Myakka, and 34 in both the Peace and Dona/Roberts Bay systems.

The mollusk fauna of the Anclote River is similar to that of other studied streams, in terms of their species composition in low-salinity reaches. The lower Anclote, on the other hand, supports a number of species not found in other recently-studied rivers. The additional species reflect the proximity of the river to Anclote Anchorage, where conditions are favorable for a productive and diverse molluscan fauna. The lower Anclote River is most similar to the Dona/Roberts Bays area in this regard, where the Gulf of Mexico is also immediately adjacent.

In terms of species abundance, the jackknife clam, *Tagelus plebeius*, was most common. *Tagelus* is an excellent indicator of the tidal river community. Only one mussel species, *Geukensia demissa*, was common but two other intertidal species, *Polymesoda caroliniana* and *Littoraria irrorata*, also were abundant. As shown in the following list, oysters were common in comparison to other species but this rank is an artifact of their high numbers in reefs.

Rank Order Abundance of Mollusk Species in the Anclote River.

Species	Total	Percent	Cumulative Percent
Crassostrea virginica	276	28.78	28.78
Molgulidae	142	14.81	43.59
Tagelus plebeius	112	11.68	55.27
Geukensia demissa	71	7.40	62.67
Polymesoda caroliniana	62	6.47	69.13
Mulinia lateralis	36	3.75	72.89
Chione cancellata	31	3.23	76.12
Littoraria irrorata	31	3.23	79.35
Laevicardium mortoni	28	2.92	82.27
Tellina tampaensis	28	2.92	85.19
Ischadium recurvum	27	2.82	88.01
Carditamera floridana	19	1.98	89.99
Nassarius vibex	15	1.56	91.55
Anomalocardia auberiana	10	1.04	92.60
Anomia simplex	8	0.83	93.43
Crepidula plana	8	0.83	94.26
Anodontia alba	7	0.73	94.99
Argopecten gibbus	5	0.52	95.52
Bulla striata	5	0.52	96.04
Lucinisca nassula	4	0.42	96.45
Melongena corona	4	0.42	96.87
Prunum apicinum	4	0.42	97.29
Cerithium muscarum	3	0.31	97.60
Conus jaspidus stearnsi	3	0.31	97.91
Polinices duplicatus	3	0.31	98.23
Brachiodontes exustus	2	0.21	98.44
Ensis minor	2	0.21	98.64
Rangia cuneata	2	0.21	98.85
Amygdalum papyrium	1	0.10	98.96
Arene tricarinata	1	0.10	99.06
Atrina rigida	1	0.10	99.17
Corbicula maniliensis	1	0.10	99.27
Laevicardium laevigatum	1	0.10	99.37
Lima pellucida	1	0.10	99.48
Mactra fragilis	1	0.10	99.58
Melampus coffeus	1	0.10	99.69
Mytilopsis leucophaeata	1	0.10	99.79
Trachycardium egmontianum	1	0.10	99.90
Turbo castanea	1	0.10	100.00

The Anclote River fauna is comprised of many species that were represented by dead-only material, even when Anclote Anchorage fauna are discounted. Despite extra effort to identify and censor relict or fossil material, a few of the dead-only reports may represent contamination of the modern fauna. The Anclote River west of U.S. Highway Alternate 19 has been dredged extensively, exposing and spoiling much old material as subtidal and intertidal fill, and as eroding spoil islands.

Compared to other southwest Florida rivers studied by similar methods, Anclote River mollusk collections tended to produce small specimens that occurred in low densities and over shorter reaches of the river. Considering these tendencies along with high species richness, Anclote River fauna may be shaped by constant but low levels of successful recruitment, followed by slow growth or high mortality prior maturation. Reasons for small mollusk sizes, densities, and ranges are not evident from the collected data.

Low densities make interpretation of individual species data difficult when so few stations were occupied. The introduced, naturalized and invasive species *Corbicula maniliensis* was found as dead material at RK 11.3, but may not occur in the river's upstream reaches owing to steep channel banks and unsuitable sediment conditions at depth.

The subtidal clam *Rangia cuneata* was also found at only one station (RK 15.0) but is probably a stable element of the fauna because it was collected as both live and dead material and as very large specimens. One live *Rangia* measured 76 mm and is the largest live *Rangia* specimen collected to date in mollusk surveys in southwest Florida. Mussel species that tend to occupy broad river reaches elsewhere occur at one or two stations in the Anclote River, and except for one species discussed below, mussels are not a dominant element of the Anclote's molluscan fauna.

Tagelus was present as live and dead material. Their shells are fragile so it is reasonable to assume that the material was recent. Highest densities were from RK 4.0-6.5 and largest live and dead shells were upstream of RK 5.0 (Figure 1). *Geukensia demissa* was the only mussel to occur in high density or occupy a substantial reach of the river. This mostly intertidal species was most abundant downstream but largest, upstream within its 11 kilometer reach (Figure 2). Another intertidal species, *Polymesoda caroliniana*, was common in the upper half of the tidal river and, like Tagelus, was most abundant downstream but largest, upstream within its reach (Figure 3).

Oyster was encountered at 13 stations between the river mouth and RK 9.0, but their range and abundance is imperfectly described by sampling on half or whole kilometer intervals. In general, small and mostly dead oyster reefs occur at and near the river mouth and lower few kilometers, but large live reefs are most conspicuous from RK 4.0 to RK 7.0. Reefs then become smaller and more widely spaced upstream to near RK 9.0. Intertidal oysters were more common than subtidal ones and, like the other intertidal species, were most abundant downstream but largest, upstream within its reach (Figure 4).

One species collected in very high number was not a mollusk but is reported here because its presence corresponded with a paucity of mollusks, and like many clams, it is also a filter-feeder. A soft tunicate in the Family Molgulidae represented about 15 percent of the total specimen count. It was primarily subtidal, only found alive, and very abundant in off-channel areas between RK 3.0 and 5.0 (Figure 5).

Distribution patterns for the combined fauna are interesting. Attached graphs depict the dispersion of species in relation to river position, using various attributes. Sorts of species occurrence by upstream or downstream appearances (Figures 6, 7) show strong changes, characteristic of rapid rates of community structure evolution. The marine community of Anclote Anchorage is distinctive. Once within the river the lower river fauna shifts near RK 4.0 and then diminishes with upstream distance. Above RK 8.0 a riverine, low salinity community prevails.

A downstream "sag" appears in species richness near RK 2.0 (Figures 8,9), and is evident in faunal densities in the RK 1.0-3.0 reach (Figures 10,11). This depression in diversity and density is not regarded to be a property of the natural mollusk community but rather the effect of severe habitat limitations imposed by extensive dredging and spoiling, and the effects of a high energy environment created by boat wakes. On balance, sharp declines in abundance from RK 4.0 to 5.0, and sharp declines in diversity from RK 5.0 to 6.0, are considered to be the result of naturally occurring changes in community structure.

Remarks

The Anclote River presents a diverse fauna relative to other tidal systems studied by similar methods. The present survey depicts a fauna comprised of many small and often dead specimens of many species, most of which occur in relatively short river reaches. Species replacement rates are high as a function of river location (Figure 12). An authentic tidal river fauna occurs in the Anclote River, primarily from RK 7.5 to RK 11.3. It is bracketed by a downstream estuarine and an upstream oligohaline fauna. An apparent "sag" in downstream richenss and density is considered to be the consequence of habitat constraints. The constraining effects of tunicate competition, heavy algal accumulations at some stations, and poor sediments probably account for some of the patterns observed in Anclote mollusk fauna, especially in off-channel and back-bay areas. Dynamic means, ranges, and extremes of salinity along the tidal river may also contribute to the observed results though no salinity data were collected in the present effort.

Notes

Two stations with positions not specified by the Anclote River kilometer map are:

RK	Location	Latitude	Longitude
-1.0	Anclote Anchorage	28.17786	82.81018
11.3	Anclote River	28.17216	82.72421

Exhibits

Graphs of mollusk species data for species with low occurrences.

Attachment

1. Excel file, "Ancloteclamdata"- species occurrences, density, size, juveniles, and condition.

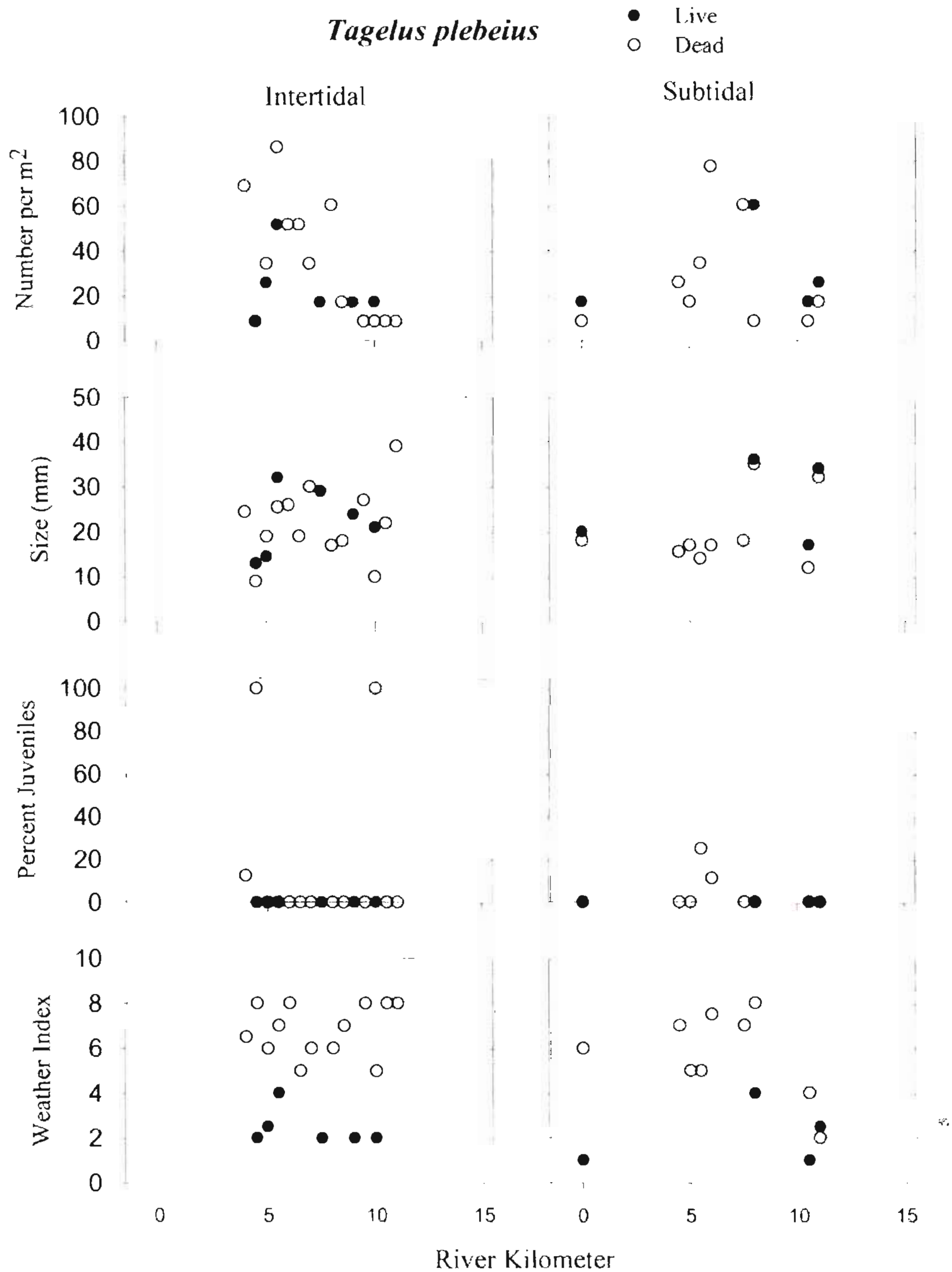


Figure 1: Habitat, density and condition data for *Tagelus plebius*.

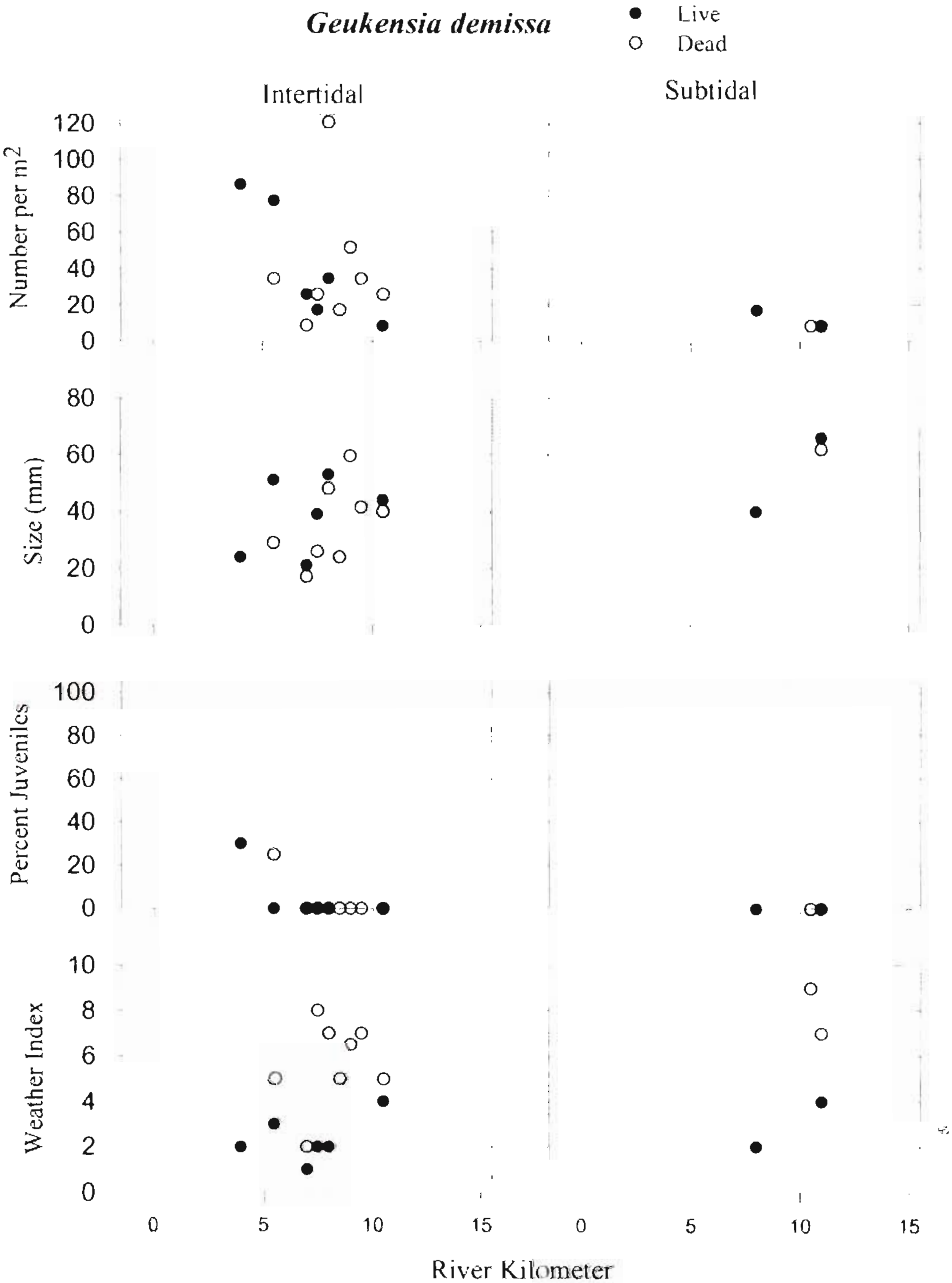


Figure 2: Habitat, density and condition data for *Geukensia demissa*.

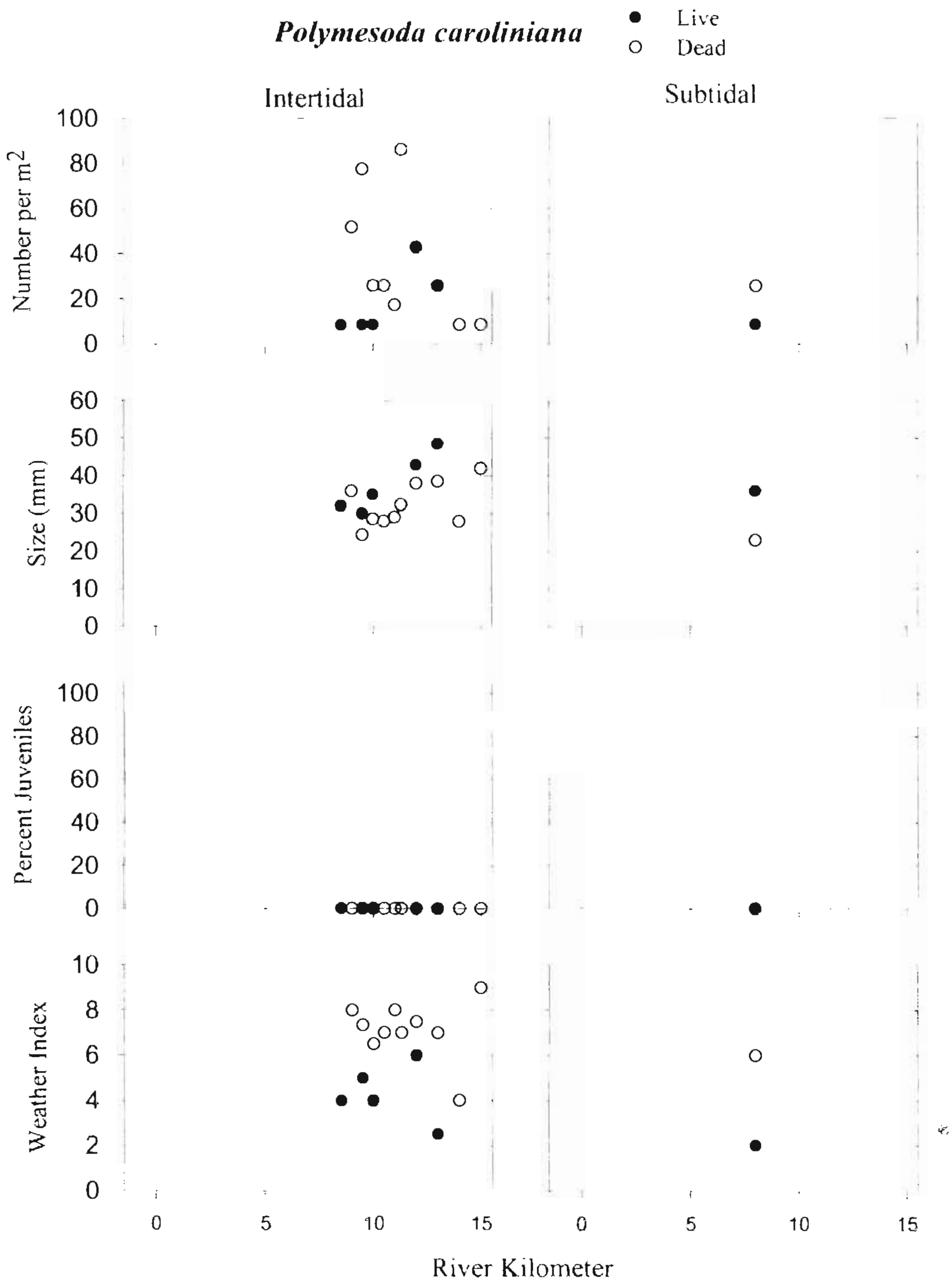


Figure 3: Habitat, density and condition data for *Polymesoda caroliniana*.

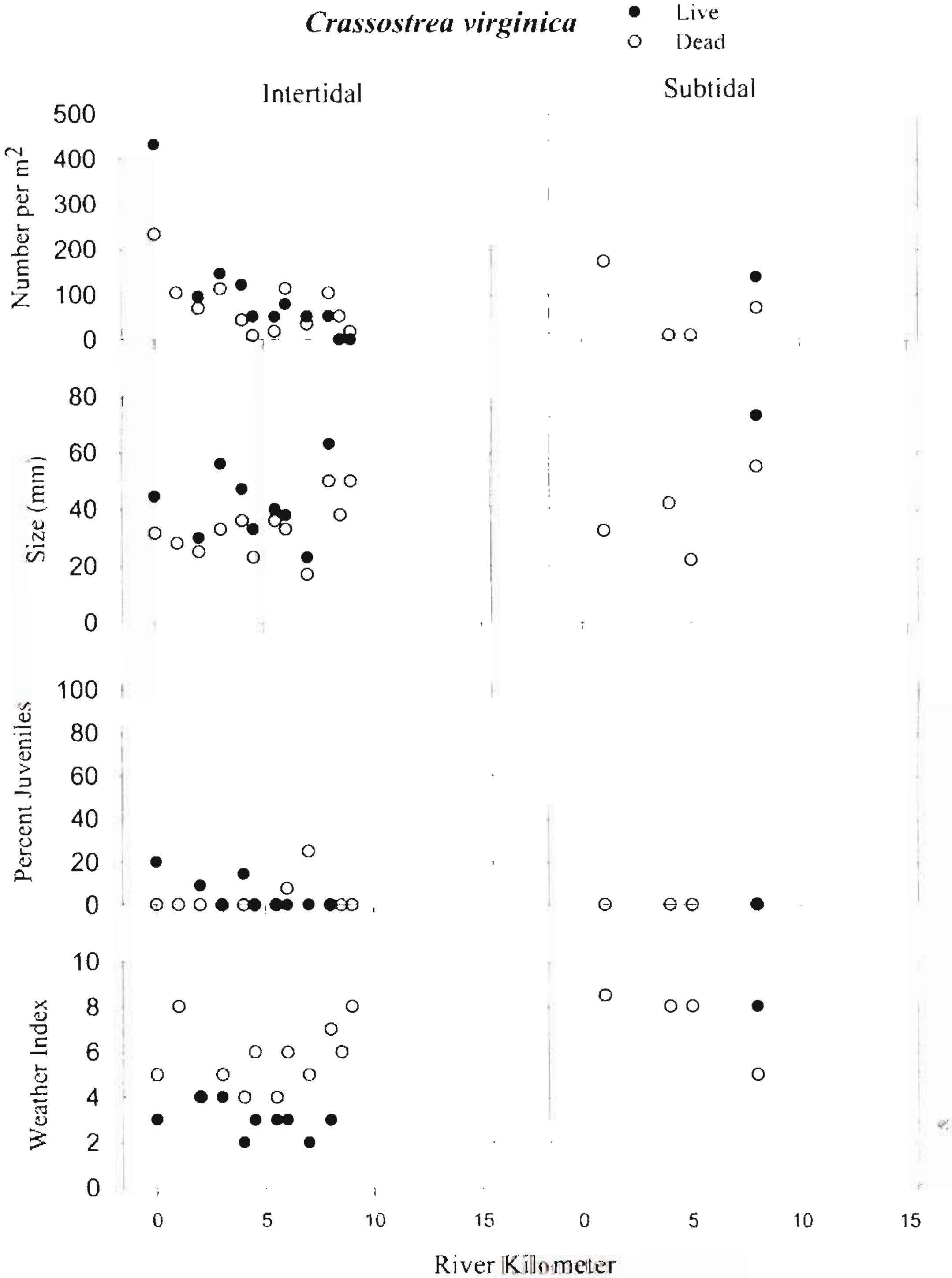


Figure 4: Habitat, density and condition data for *Crassostrea virginica*.

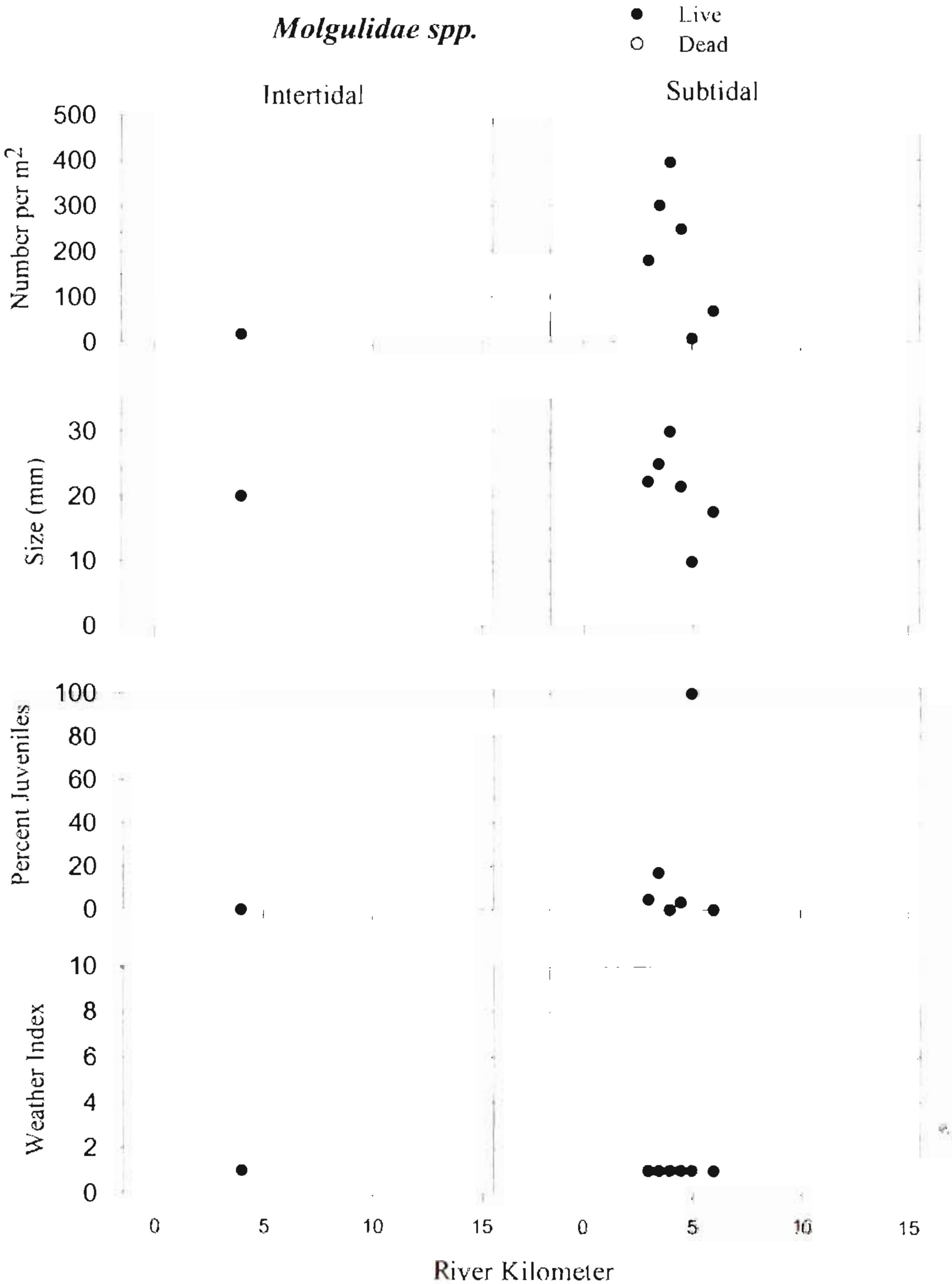


Figure 5: Habitat, density and condition data for Molgulidae sp.

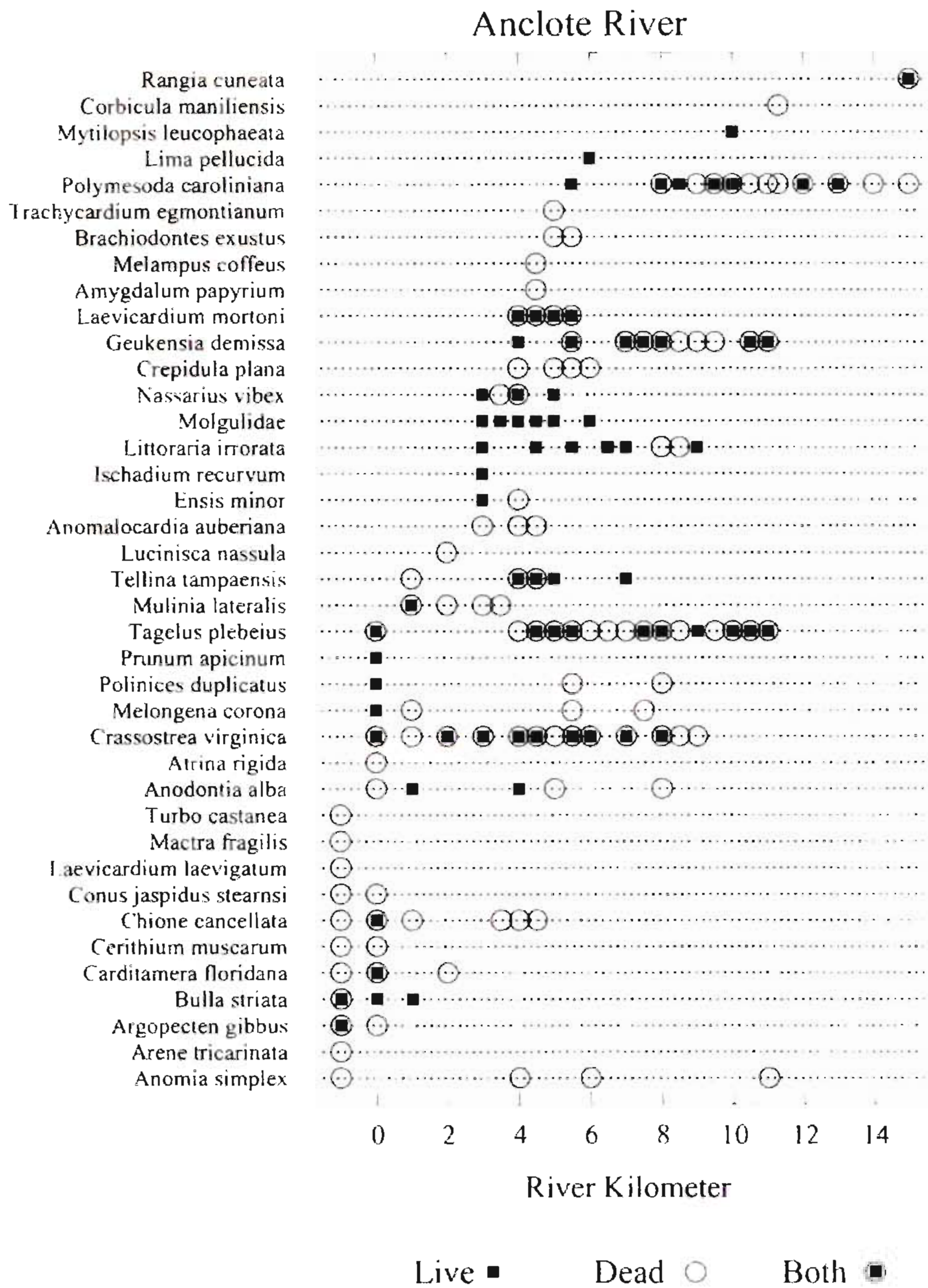


Figure 6: Upstream sort of species occurrences for live and dead material by river kilometer.

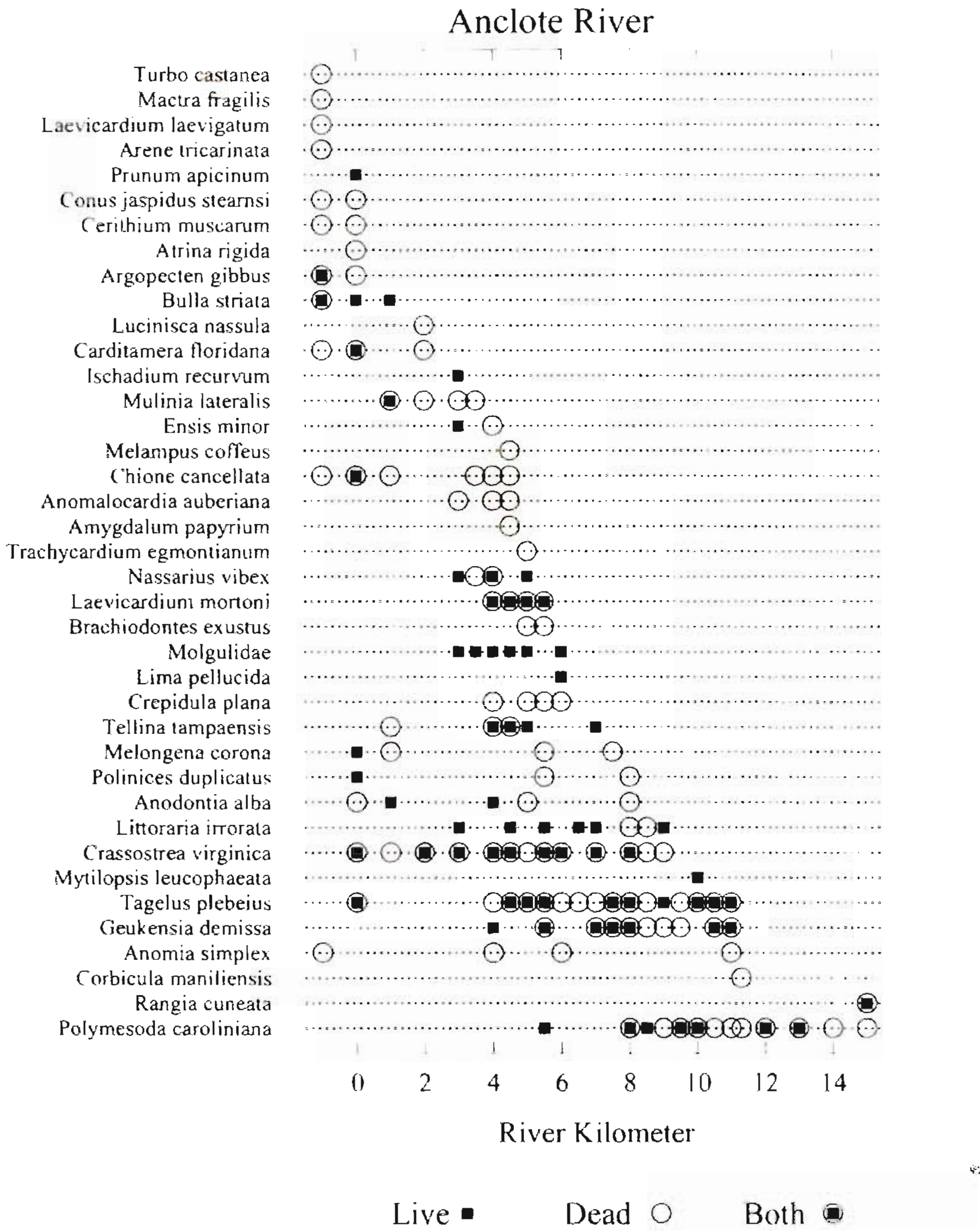


Figure 7: Downstream sort of species occurrences for live and dead material by river kilometer.

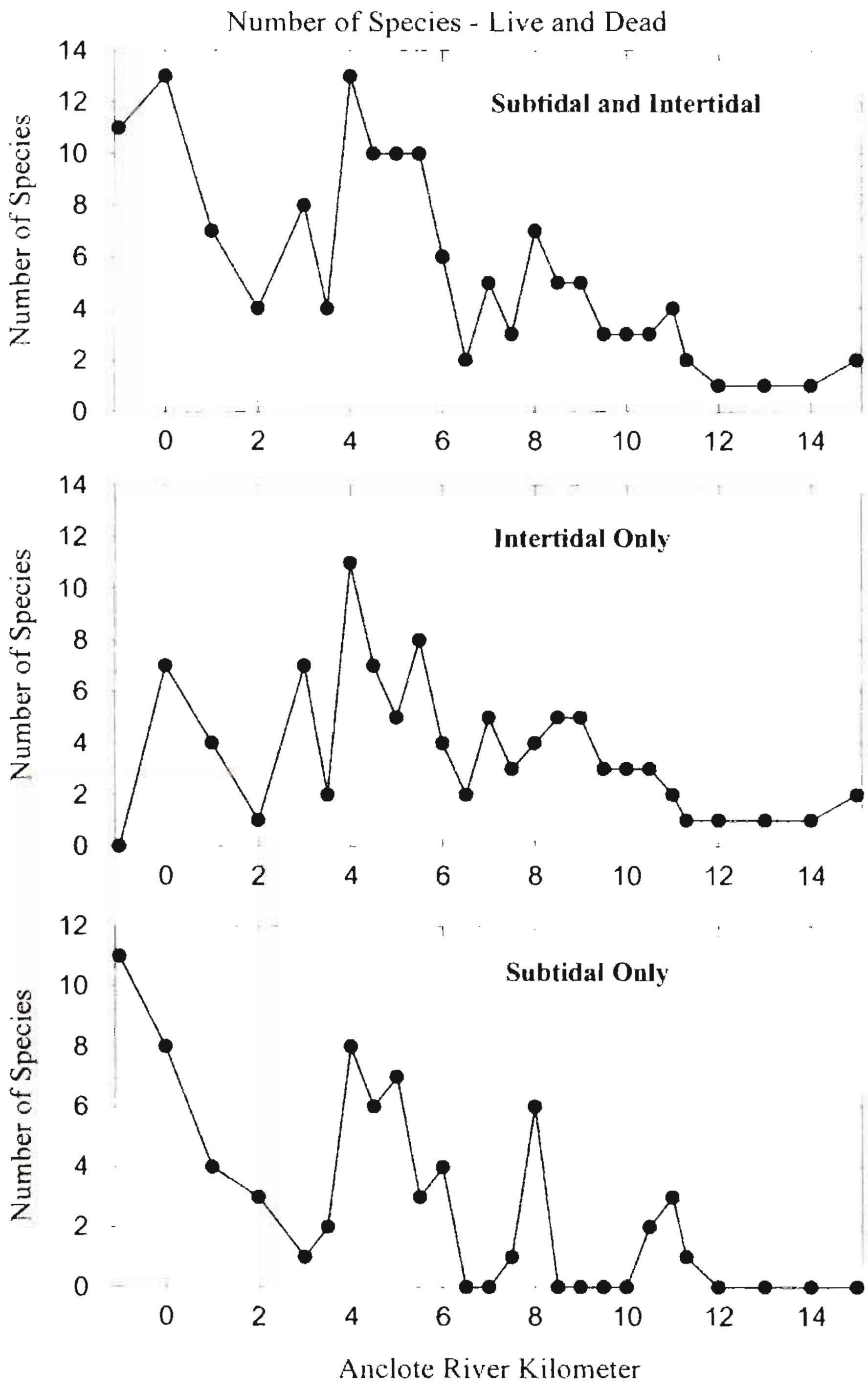


Figure 8: Species richness by river kilometer for live and dead material combined.

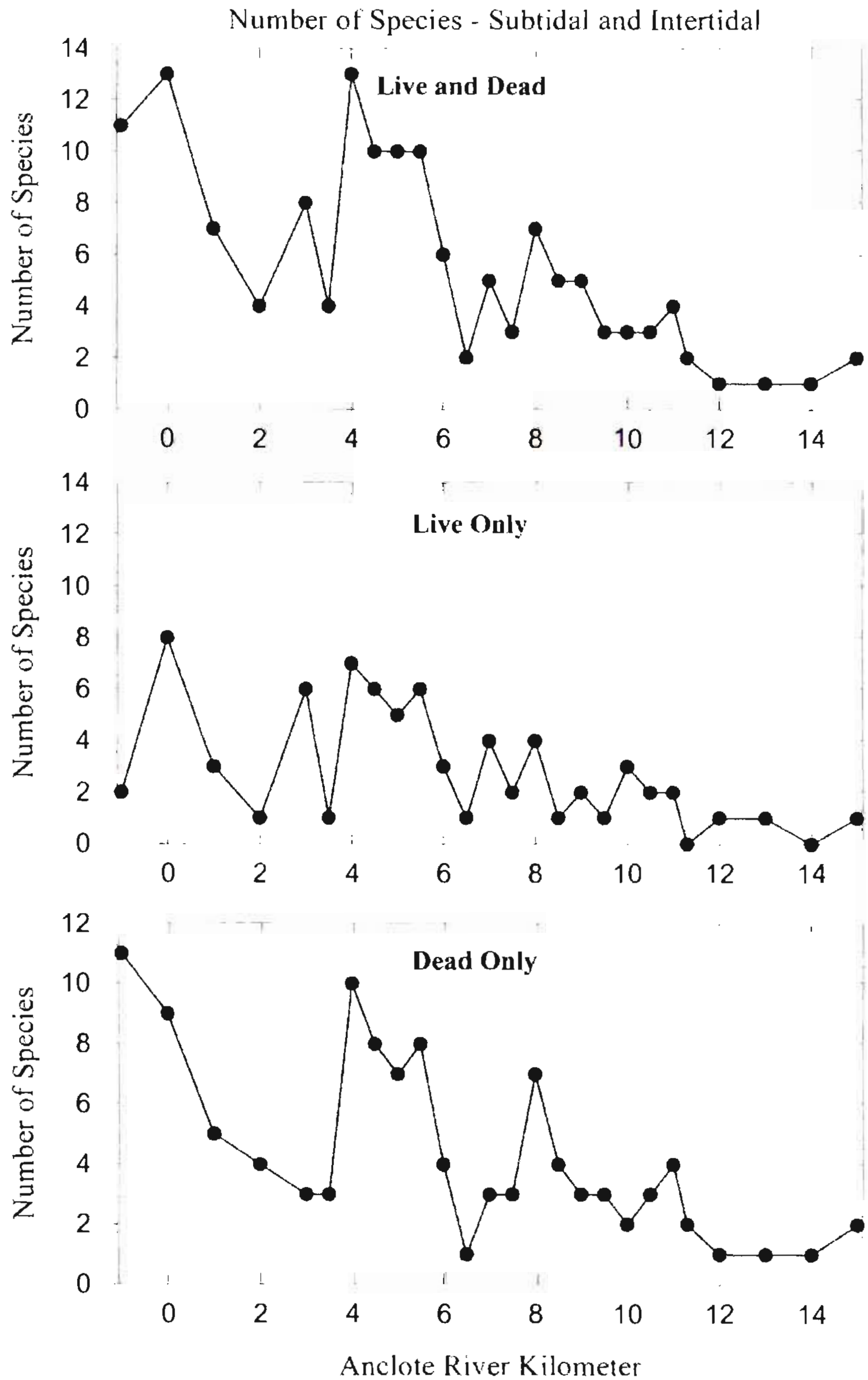


Figure 9: Species richness by river kilometer for intertidal and subtidal material combined.

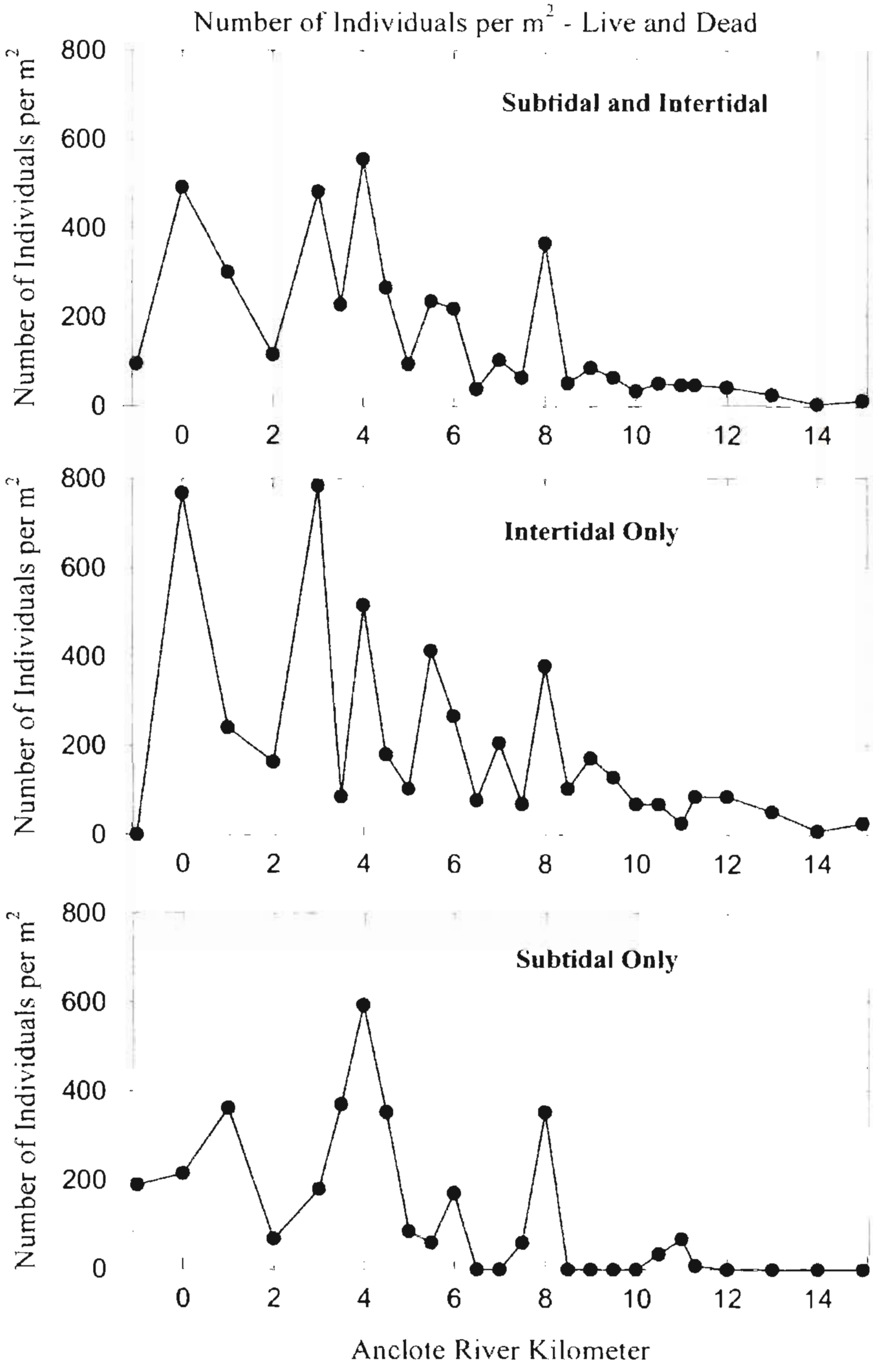


Figure 10: Faunal density by river kilometer for live and dead material combined.

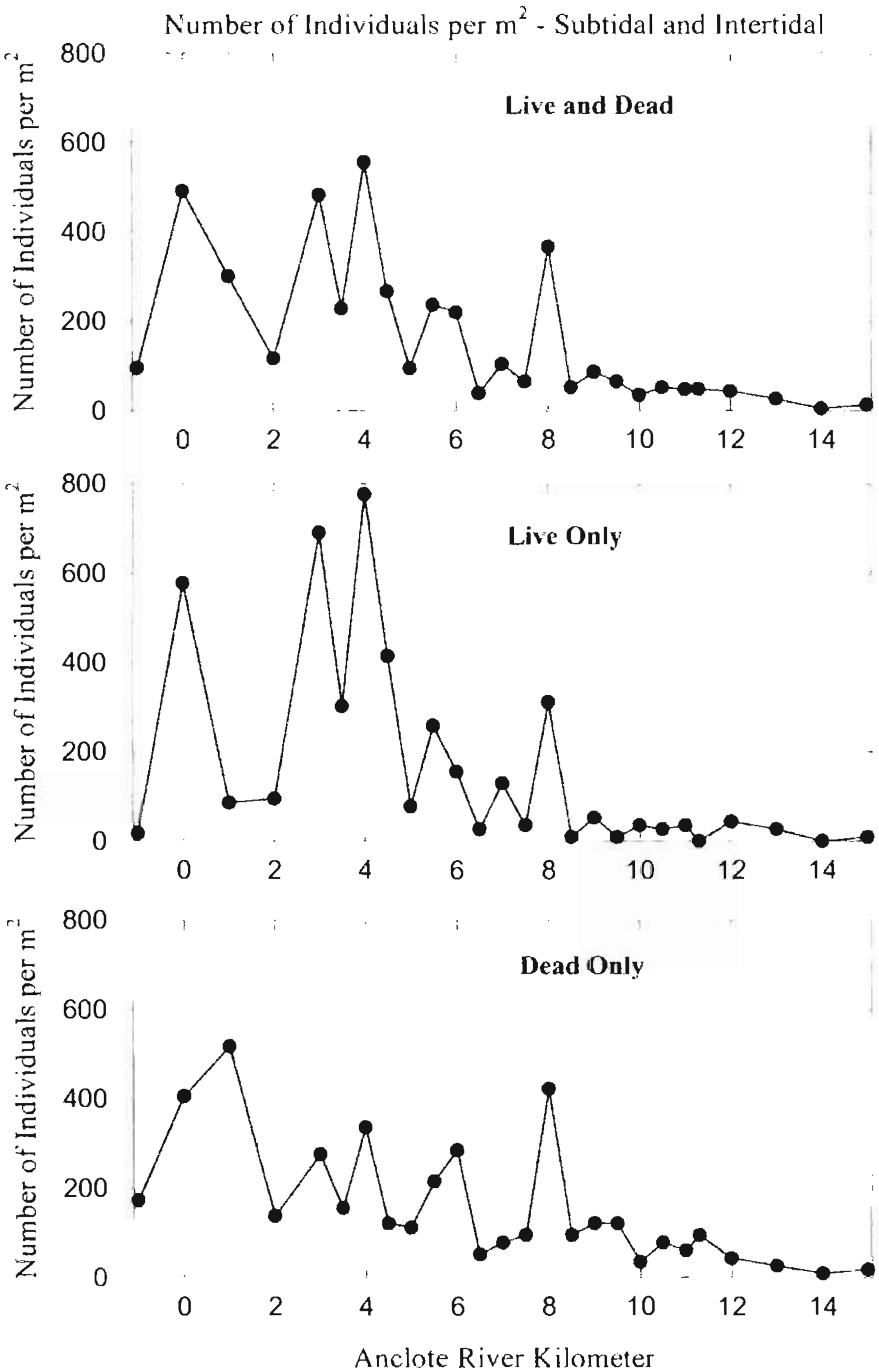


Figure 11: Faunal density by river kilometer for intertidal and subtidal material combined.

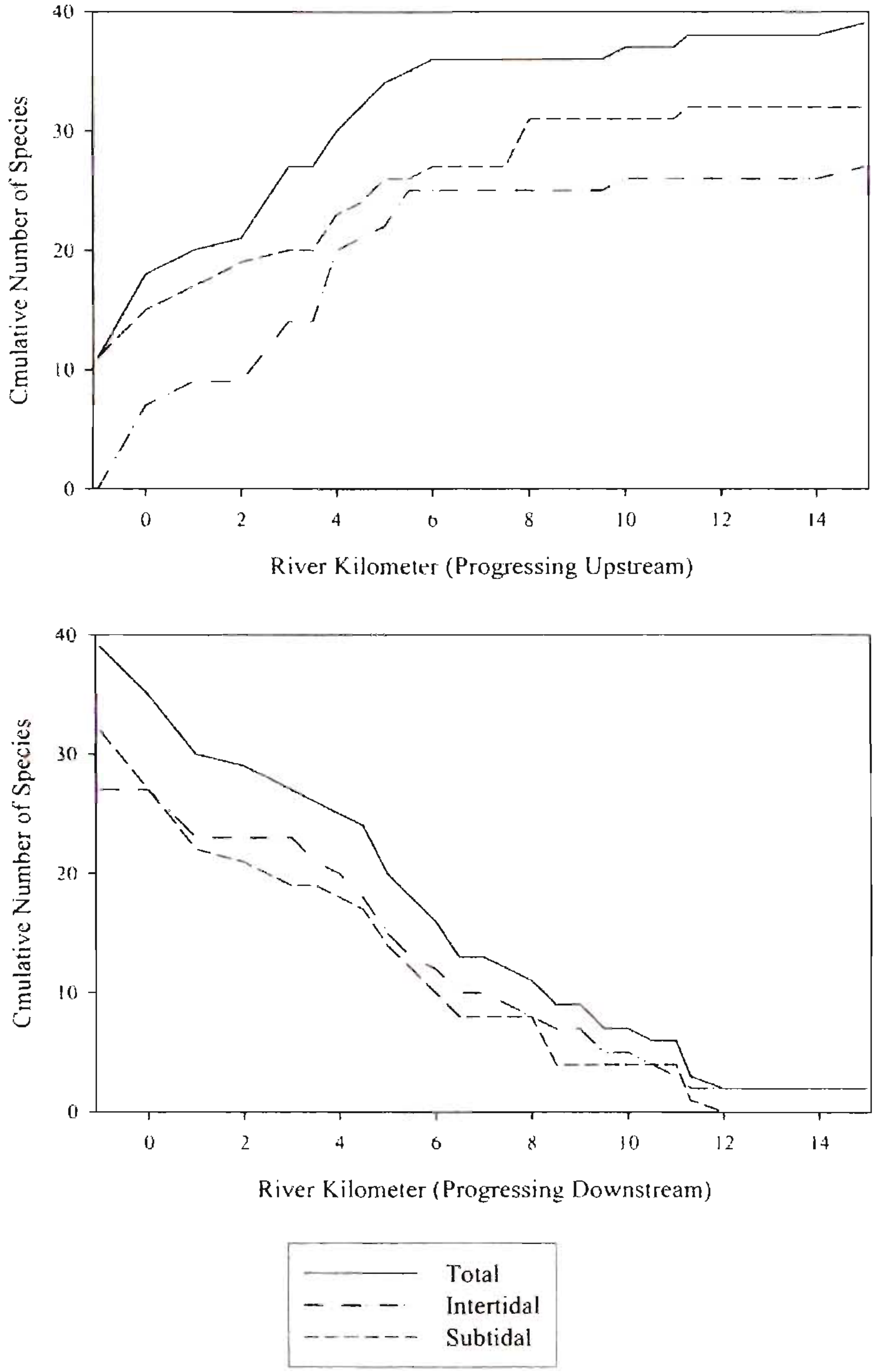
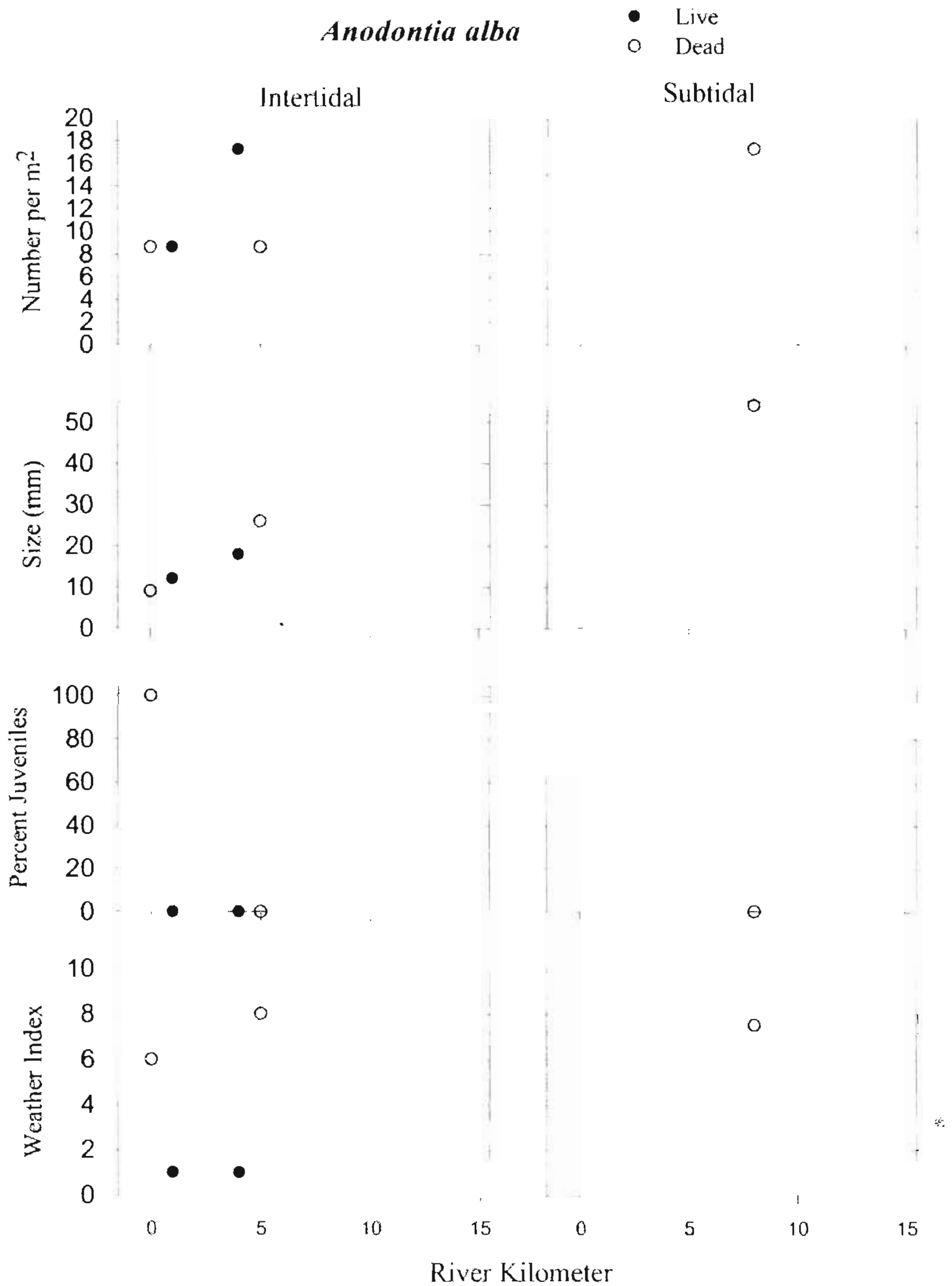
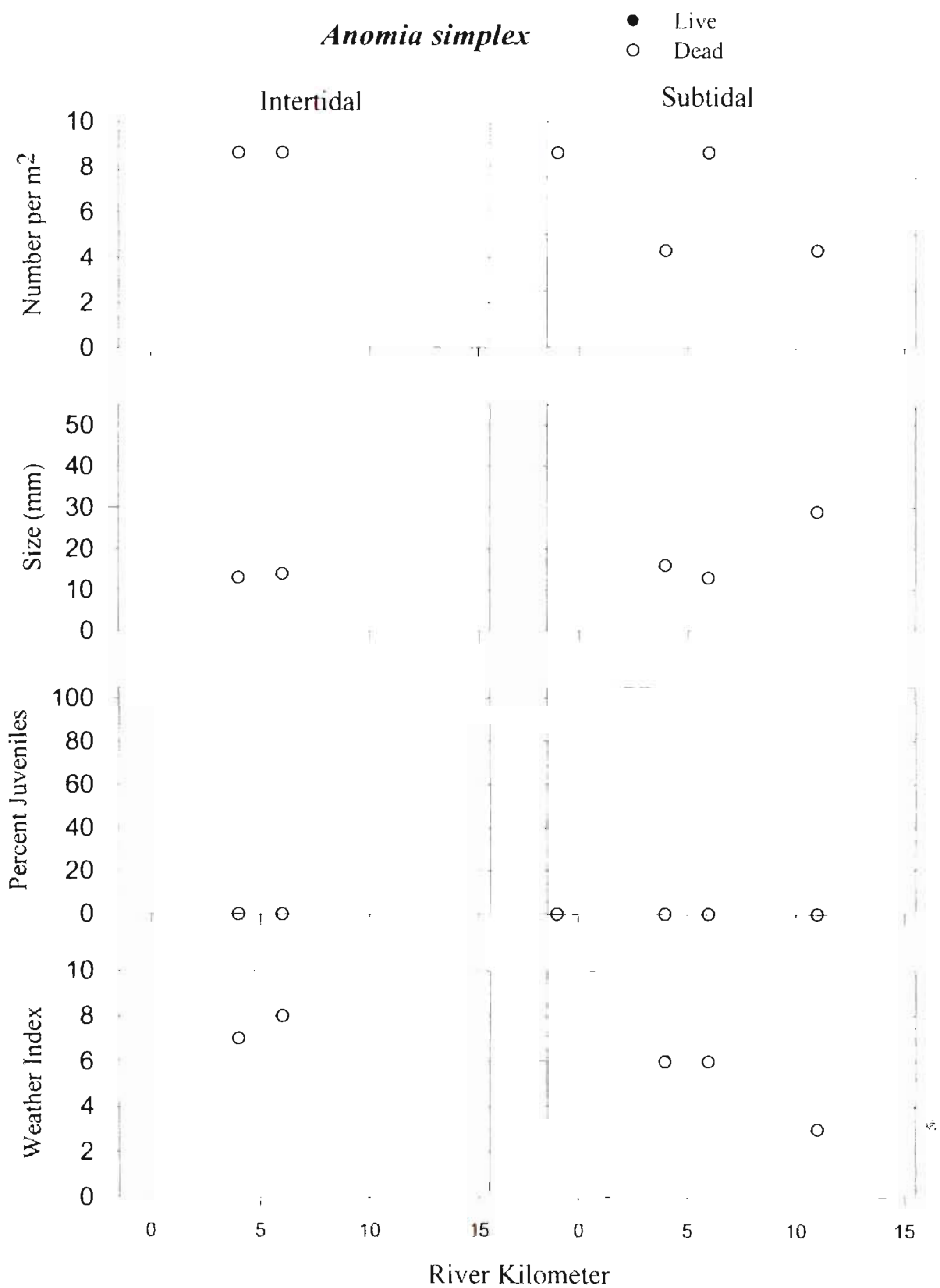
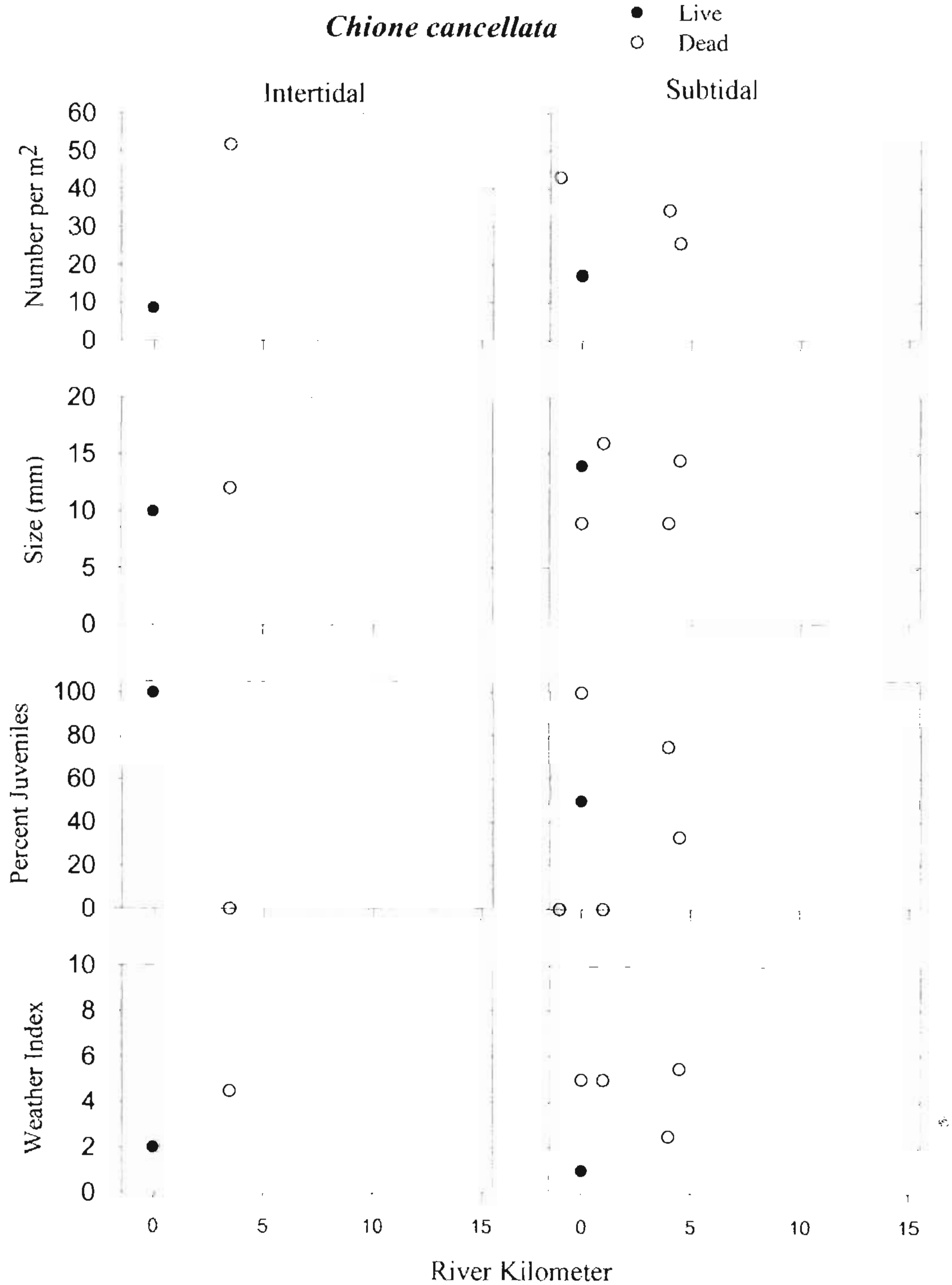


Figure 12: Cumulative species richness by river kilometer.

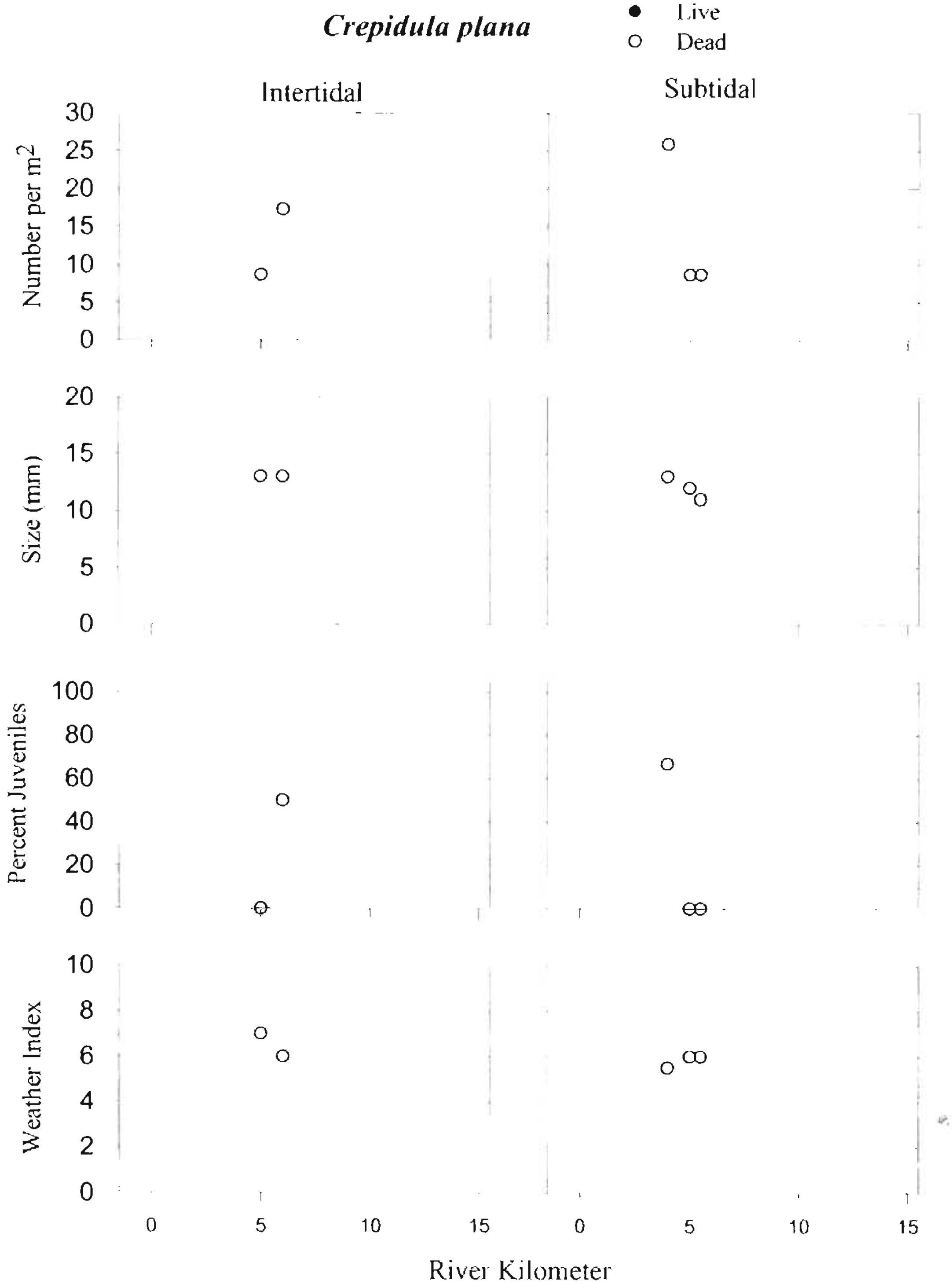
Exhibits

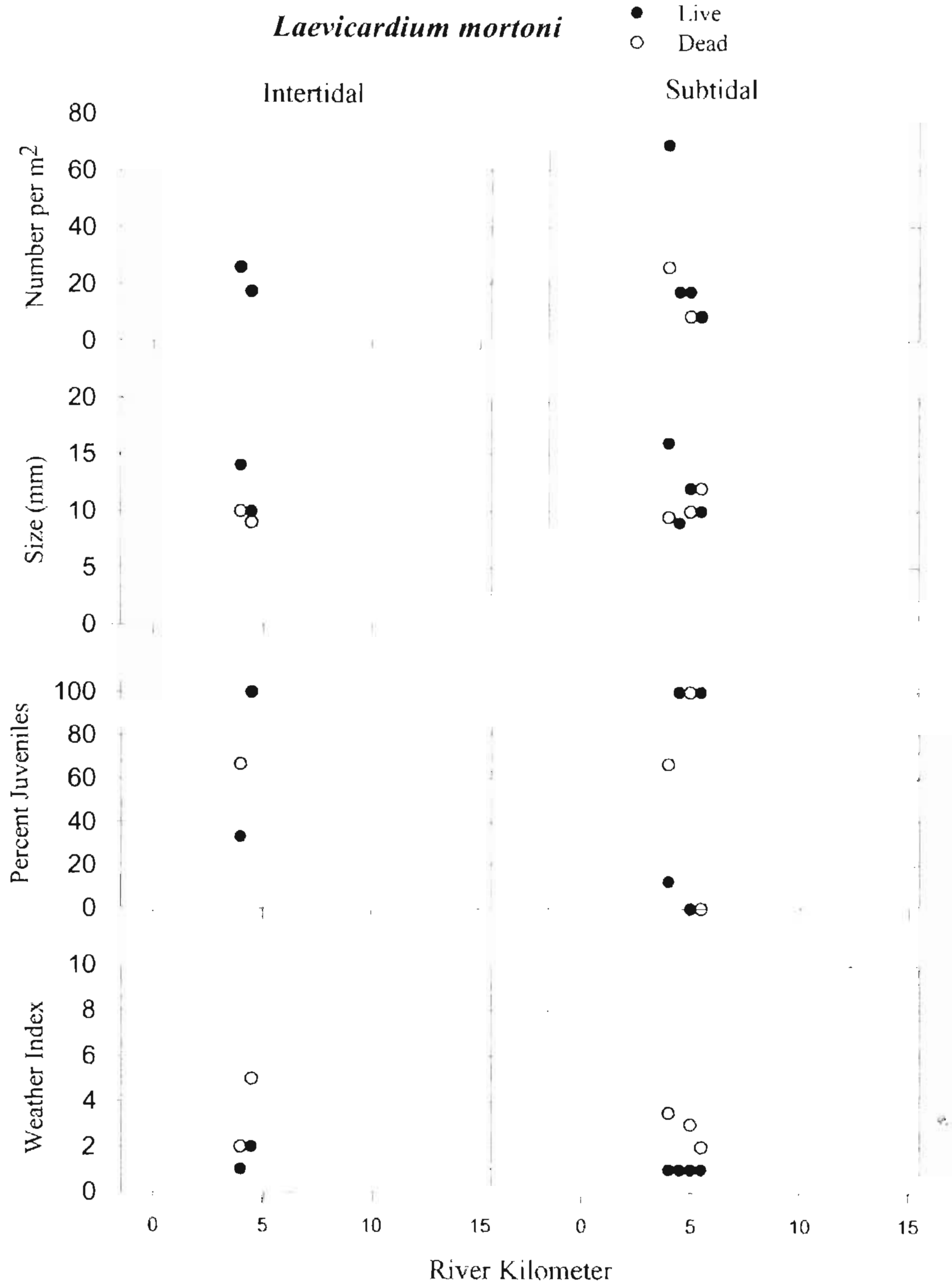

Anodontia alba
Live
Dead
Intertidal
Subtidal
Number per m2
20
18
16
14
12
10
8
6
4
2
0
Size (mm)
50
40
30
20
10
0
Percent Juveniles
100
80
60
40
20
0
Weather Index
10
8
6
4
2
0
0
5
10
15
0
5
10
15
River Kilometer

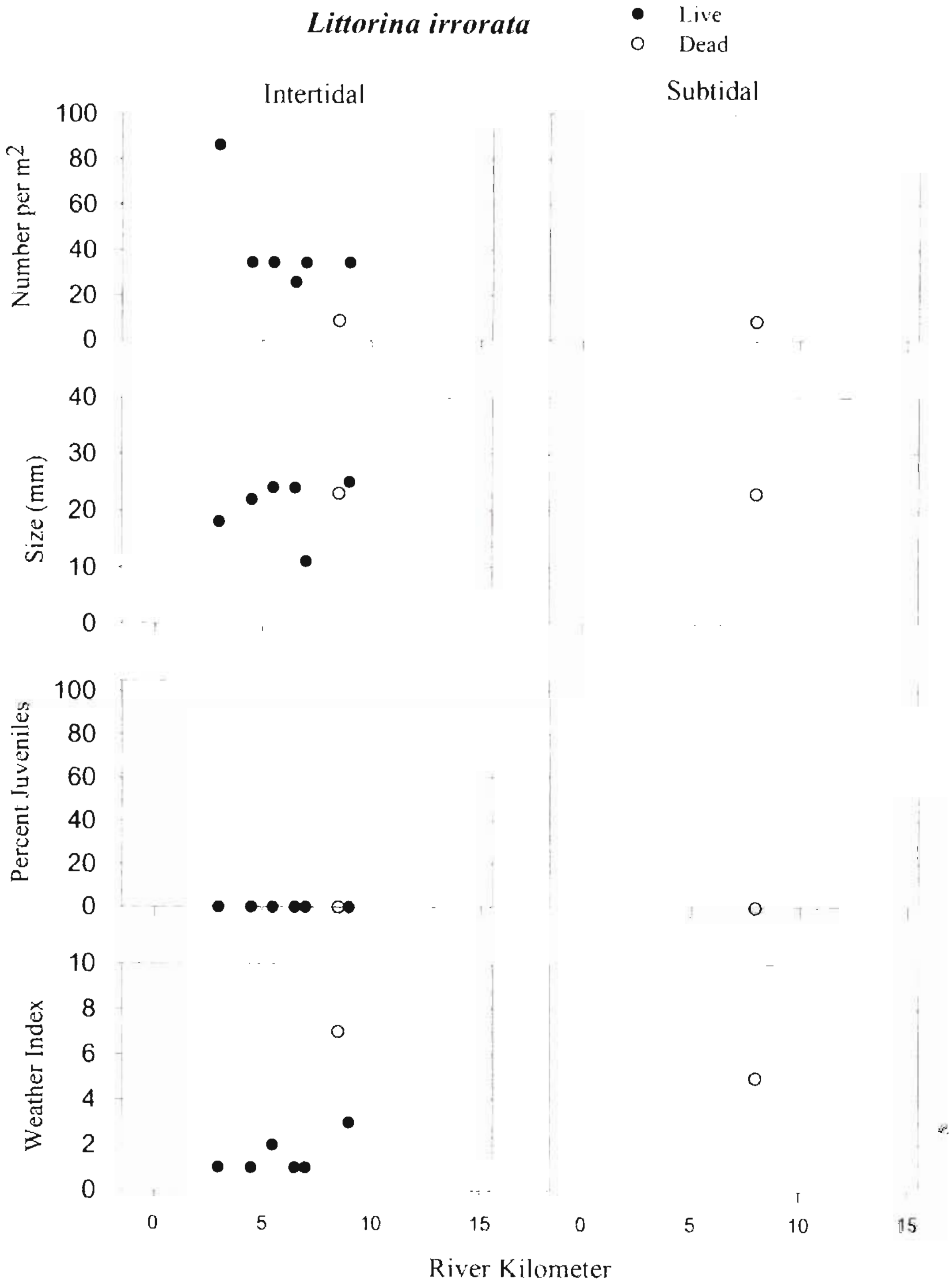

Anomia simplex
Live
Dead
Intertidal
Subtidal
Number per m²
Size (mm)
Percent Juveniles
Weather Index
River Kilometer
0
5
10
15

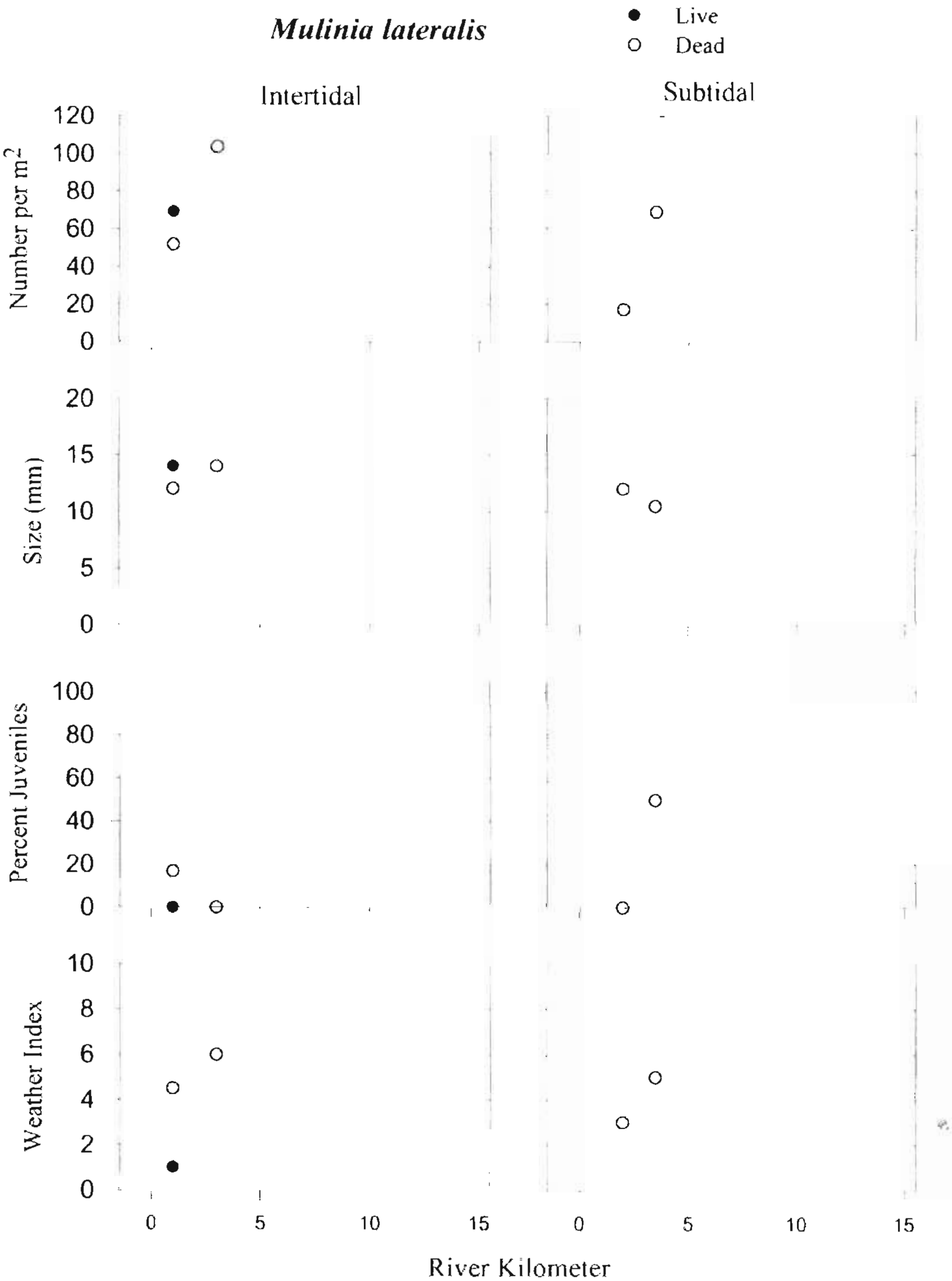


Chione cancellata
Live
Dead
Intertidal
Subtidal
Number per m2
60
50
40
30
20
10
0
Size (mm)
20
15
10
5
0
Percent Juveniles
100
80
60
40
20
0
Weather Index
10
8
6
4
2
0
0
5
10
15
0
5
10
15
River Kilometer

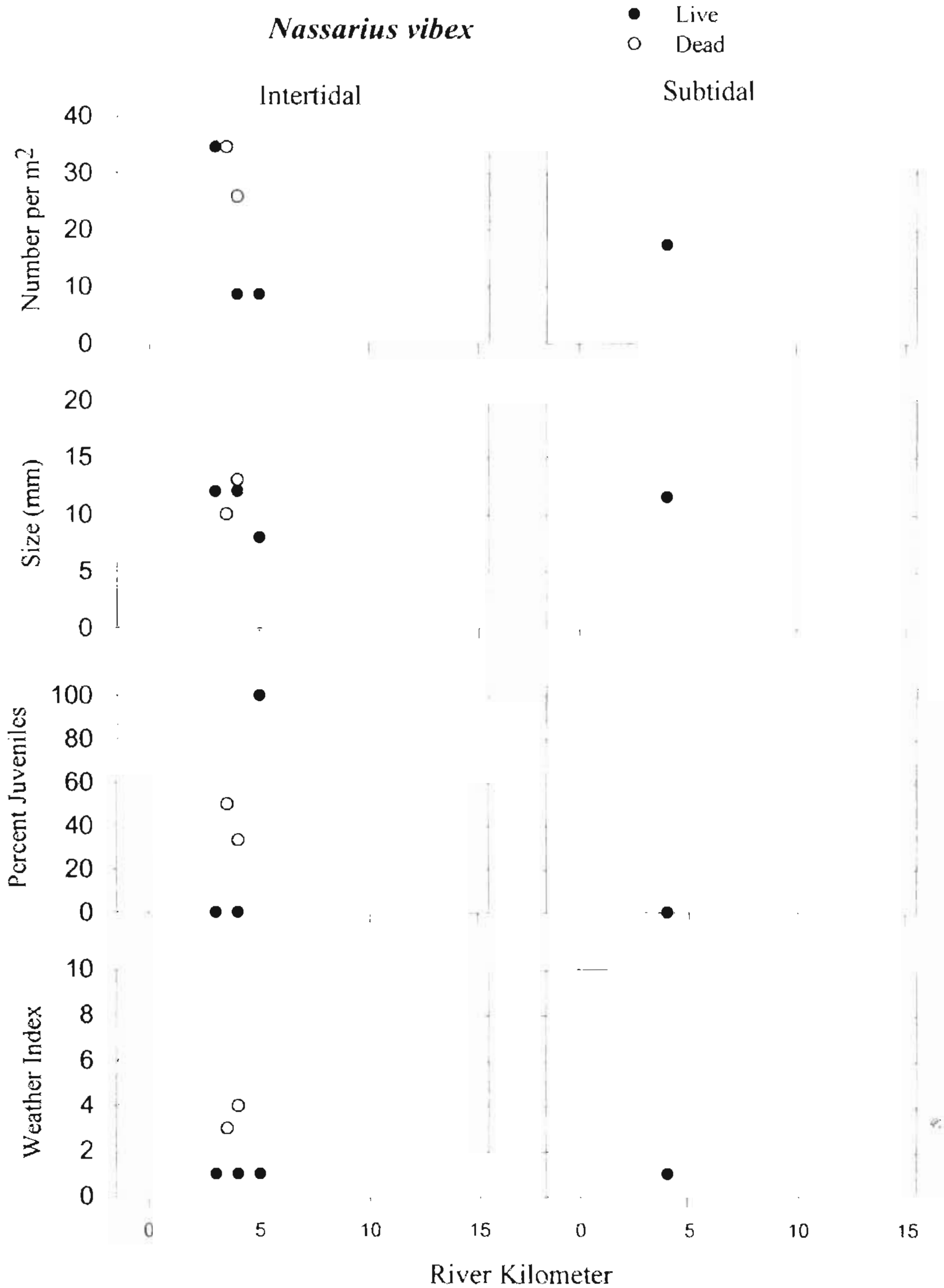

Crepidula plana
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
River Kilometer
0
5
10
15
20
25
30
40
60
80
100


Laevicardium mortoni
Live
Dead
Intertidal
Subtidal
Number per m2
80
60
40
20
0
Size (mm)
20
15
10
5
0
Percent Juveniles
100
80
60
40
20
0
Weather Index
10
8
6
4
2
0
0
5
10
15
0
5
10
15
River Kilometer

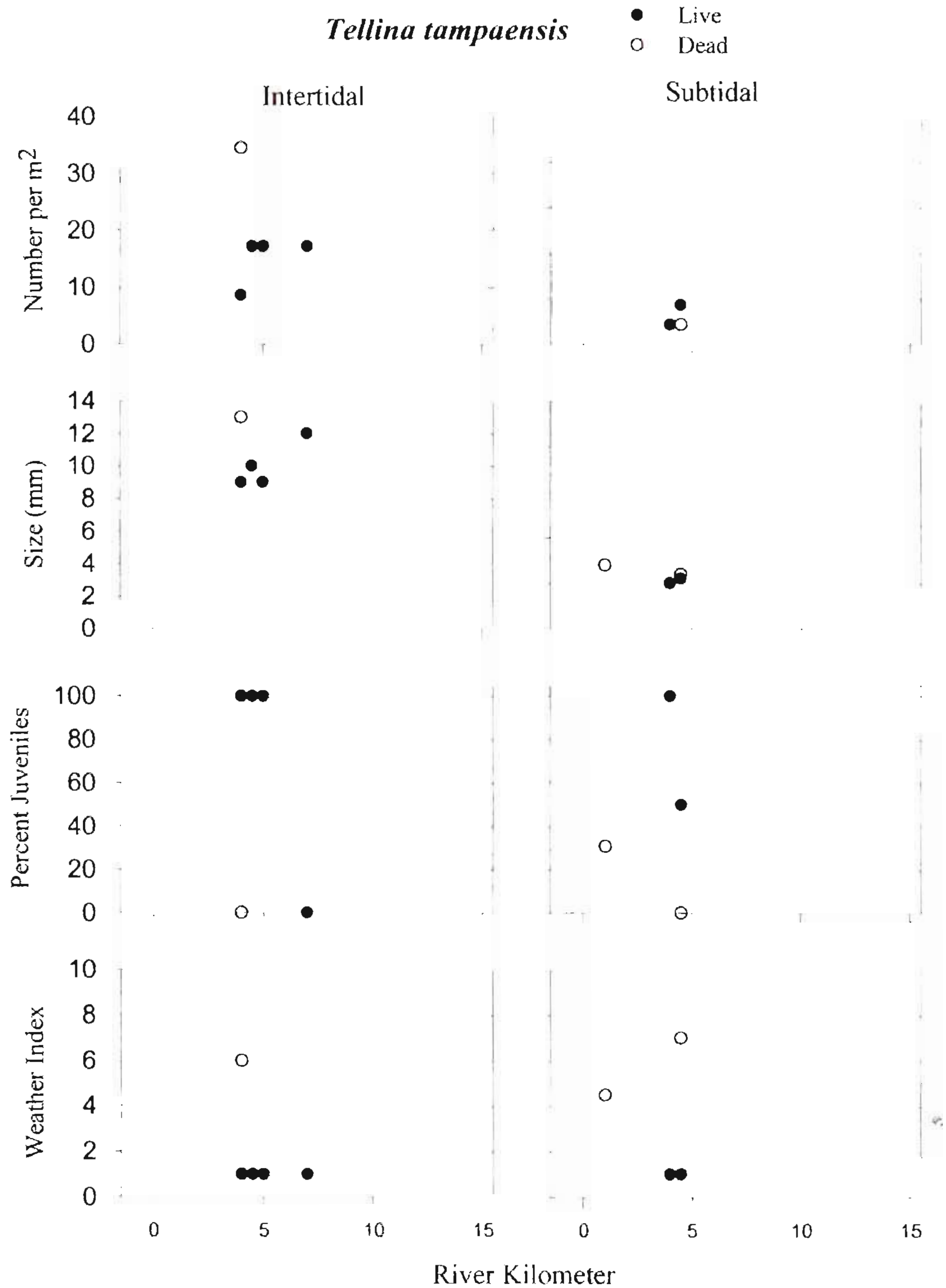

Littorina irrorata
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
River Kilometer
0
5
10
15



Mulinia lateralis
Live
Dead
Intertidal
Subtidal
Number per m2
120
100
80
60
40
20
0
Size (mm)
20
15
10
5
0
Percent Juveniles
100
80
60
40
20
0
Weather Index
10
8
6
4
2
0
0
5
10
15
0
5
10
15
River Kilometer



Nassarius vibex
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
0
5
10
15
0
5
10
15
River Kilometer



Tellina tampaensis
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
River Kilometer

Part Two: Shoreline Mapping

A "windshield" survey of the Anclote River to identify changes/breaks in shoreline type was conducted during January 2006. The survey was conducted from a small boat. All shorelines associated with the main channel (Figure 1) of the river including island and bayou shorelines were included in the survey. Changes/breaks in shoreline type were spatially registered using a WAAS-enabled GPS and photographed digitally. Logistic constraints (e.g. sawyers and logjams) associated with the river's narrow physiognomy upstream of RK18 restricted the survey to areas below RK20.

Field data were used to create a GIS shapefile depicting the river's shoreline with segments defined by type (e.g. mangrove) using the appropriate FLUCCS code (Tables 1 – 4). Segment definitions were developed to represent a minimum of 90% of the visible shoreline as seen from the survey boat - for example, medium density residential areas with single story units (1211) with a narrow fringe of mangrove trees are defined as 1211 not as mangrove swamp (612).

Each shoreline segment was classified at FLUCCS Levels 1 through 4 as depicted in Figures 2 through 5 with classifications based on a compilation of the survey data and data (e.g. shoreline position) extracted from the District's 2004 (1:24000) natural color aerial photographs. After completing this exercise, the river was split into additional segments defined by river kilometer and shoreline position (North or South) (Figure 6) using data provided by the District (Figure 7). This shapefile was used to categorize each shoreline segment by river kilometer and shoreline position (Figure 8). Note that river kilometer polygons are not of equal size because of the sinuosity of the river. This caveat is also true for the amount of shoreline contained in the smaller shoreline position polygons created (Figure 9). Differences in the proportion of shoreline by river kilometer and shoreline position are illustrated in Figure 10.

FLUCCS Level 1 (Wetlands) is the dominant shoreline classification category with the Urban and Built-Up (FLUCCS 1; Table 1) being secondary. A comparison of these categories across river kilometers is illustrated in Figure 11. More specific wetland categories (FLUCCS Level 2; Table 2) show large-scale breaks in shoreline by category (Figure 12). This pattern does not change when examining the shoreline segments at the more specific FLUCCS Level 3 or 4 classifications (e.g. Figure 13). Less generalized Urban and Built-Up categories (FLUCCS Level 2) shows that the largest concentration of high density urbanization can be found at RK5 and 6 (Figure 14), indicative of Tarpon Springs and its wharves with high-density housing extending from RK1 to RK15 (Figure 14).

The most specific category used to classify the river's shoreline segments was FLUCCS Level 4 (Table 4). From a remote sensing perspective this is considered a fairly high level of resolution (1:6000); however, mapping at this level of resolution resulted in some areas of interest not being identified in the shoreline shapefile because of their small size. For example, just above RK16 is a freshwater marsh fringe (Figure 15) that is < 1 m wide and no more than 15 m in length. Although this is identifiable from a boat, it does meet the criteria of representing a minimum of 90% of the visible shoreline as seen from the survey boat thus it is not represented in the shoreline shapefile. Other freshwater wetlands are illustrated in Figures 16 through 18. Saltwater wetlands including both forested and non-forested are illustrated in Figures 19 through 23. Examples of armored shores at varying urban classifications are illustrated in Figures 24 through 28. Finally, Figure 29 is an example of FLUCCS code 8147 defined by this study as a bridge.

In addition to this letter report, the project's deliverables include 1) an Excel file containing shoreline segment length, segment endpoint coordinates, FLUCCS code, river kilometer, and other ancillary information; 2) an Arc shapefile depicting shoreline classifications at each FLUCCS level; 3) the 1999 FLUCCS classification shapefile; 4) the 2004 (1:24000) natural color aerial photographs; and 5) digital images of shoreline designations.

Table 1: Level 1 FLUCCS descriptions.

Level 1	Attribute
1	Urban and Built-Up
2	Agriculture
3	Rangeland
6	Wetlands
7	Barren Land
8	Transportation, Communications and Utilities

Table 2: Level 2 FLUCCS descriptions.

Level 2	Attribute
11	Residential, Low Density
12	Residential, Medium Density
13	Residential, High Density
14	Commercial and Services
15	Industrial
18	Recreational
19	Open Land
21	Cropland and Pastureland
32	Shrub and Brushland
61	Wetland Hardwood Forests
63	Wetland Forested Mixed
64	Vegetated Non-Forested Wetlands
71	Beaches Other Than Swimming
74	Disturbed Land
81	Transportation
83	Utilities

Table 3: Level 3 FLUCCS descriptions.

Level 3	Attribute
111	Fixed Single Family Units
113	Mixed Units
121	Fixed Single Family Units
131	Fixed Single Family Units
133	Multiple Dwelling Units
145	Tourist Services
150	Industrial
155	Other Light Industrial
159	Industrial Under Construction
181	Swimming Beach
182	Golf Course
186	Community Recreational Facilities
191	Undeveloped Land within Urban Areas
193	Urban Land in transition without positive indicators of intended activity
194	Other Open Land
211	Improved Pasture
322	Coastal Scrub
612	Mangrove Swamps
630	Wetland Forested Mixed
642	Saltwater Marshes
710	Beaches Other Than Swimming Beaches
743	Spoil Areas
744	Fill Areas
814	Roads and Highways
815	Port Facilities
831	Electric Power Facilities

Table 4: Level 4 FLUCCS descriptions.

Level 3	Attribute
1111	Single Story Units
1112	Two of More Story Units
1130	Mixed Units
1211	Single Story Units
1311	Single Story Units
1330	Multiple Dwelling Units
1335	Townhouse Units
1450	Tourist Services
1500	Industrial
1550	Other Light Industrial
1590	Industrial Under Construction
1810	Swimming Beach
1820	Golf Course
1860	Community Recreational Facilities
1910	Undeveloped Land within Urban Areas
1930	Urban Land in transition without positive indicators of intended activity
1940	Other Open Land
2110	Improved Pasture
3220	Coastal Scrub
6120	Mangrove Swamps
6300	Wetland Forested Mixed
6422	Needlerush
7100	Beaches Other Than Swimming Beaches
7430	Spoil Areas
7440	Fill Areas
8147	Bridges
8150	Port Facilities
8152	Piers
8310	Electric Power Facilities

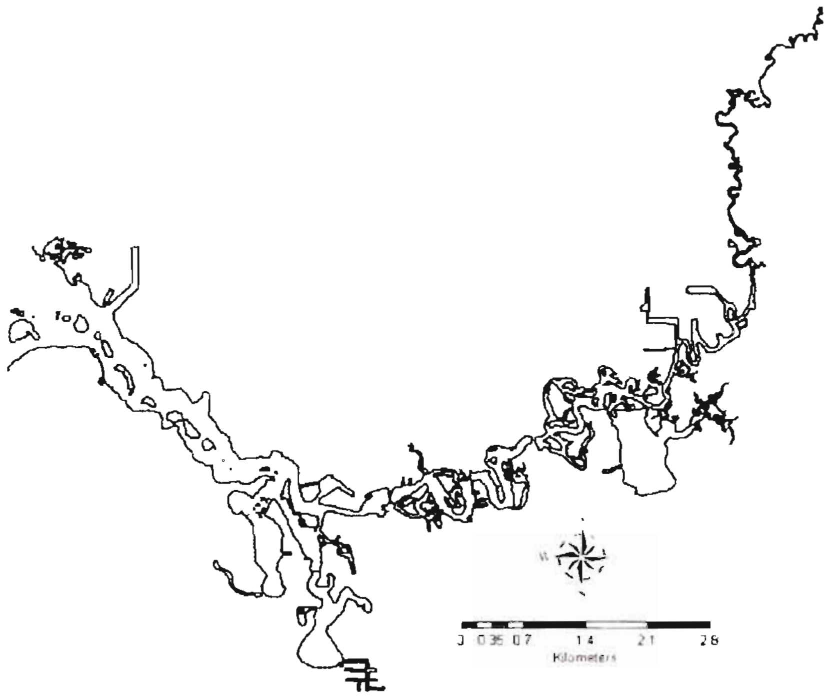


Figure 1: Shoreline depiction delineated from the District's 2004 natural color aerial photographs (1:24000).

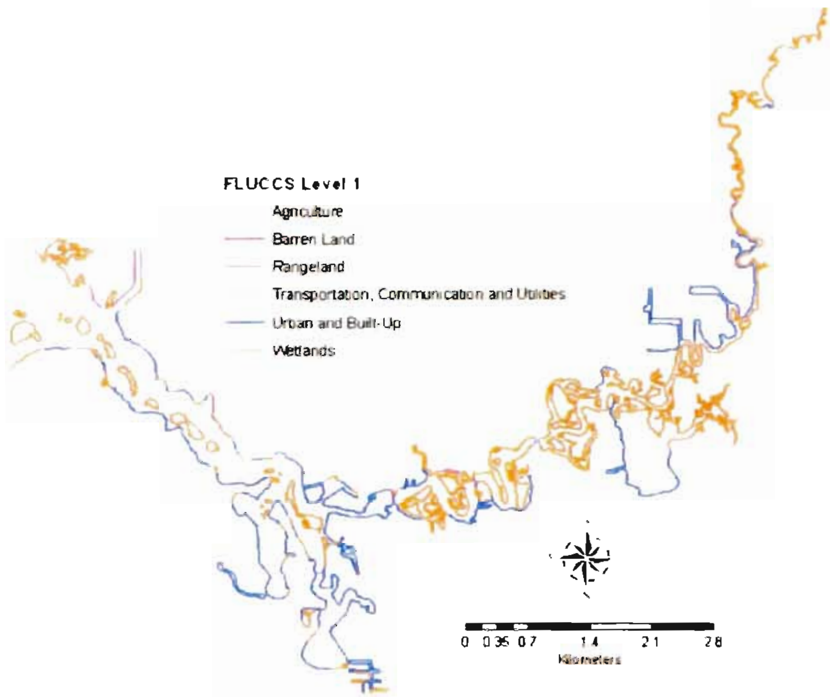


Figure 2: A depiction of the Anclote River's shoreline with shoreline segments defined at FLUCCS Level 1.

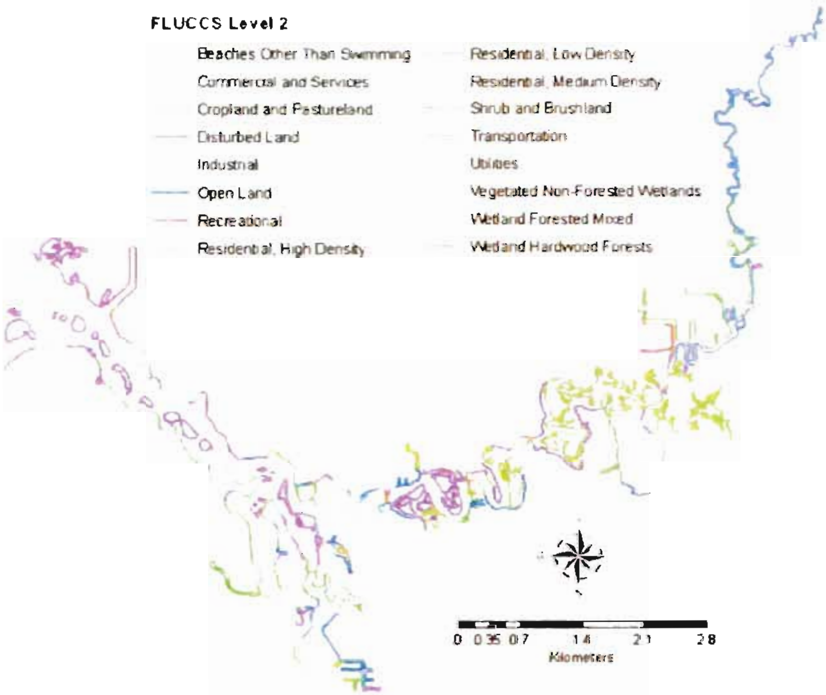


Figure 3: A depiction of the Anclote River's shoreline with shoreline segments defined at FLUCCS Level 2.

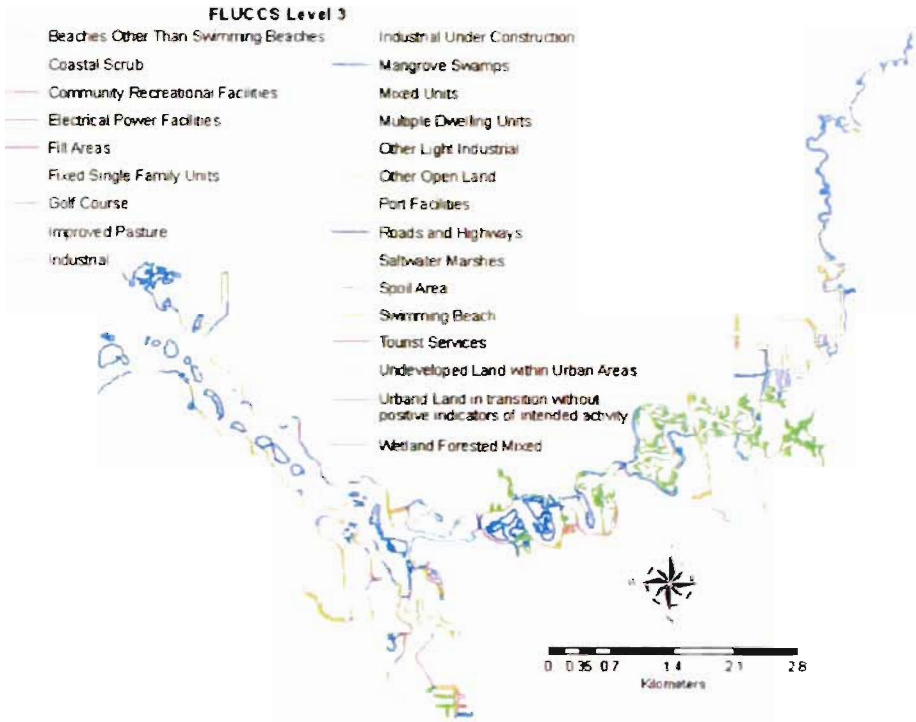


Figure 4: A depiction of the Anclote River's shoreline with shoreline segments defined at FLUCCS Level 3.

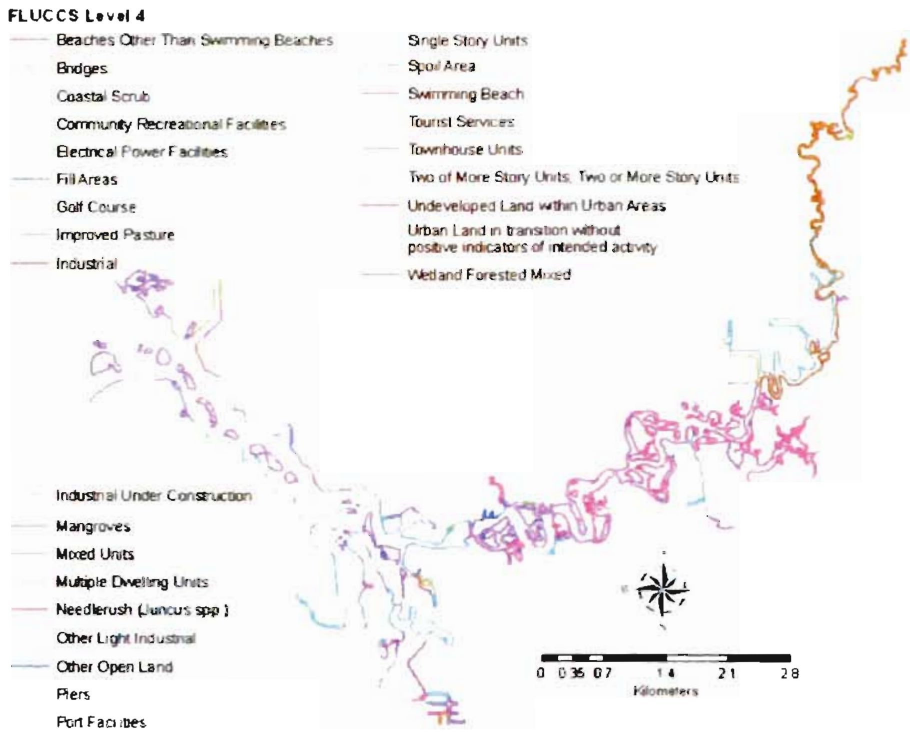


Figure 5: A depiction of the Anclote River's shoreline with shoreline segments defined at FLUCCS Level 4.

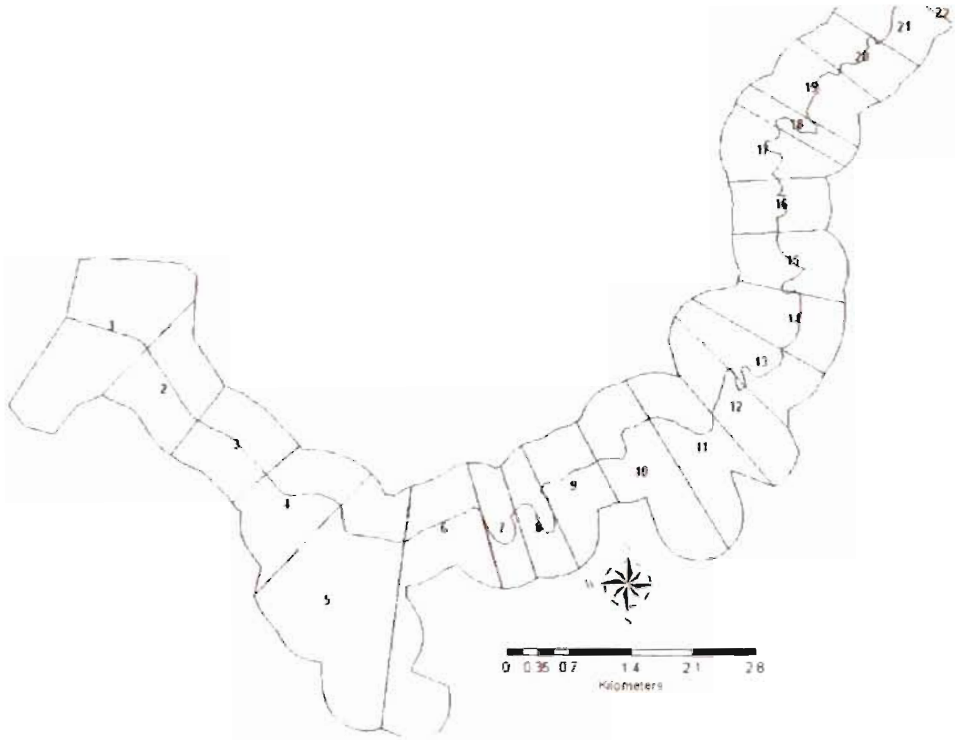


Figure 6: Anclote River divisions based on river kilometer and shoreline.

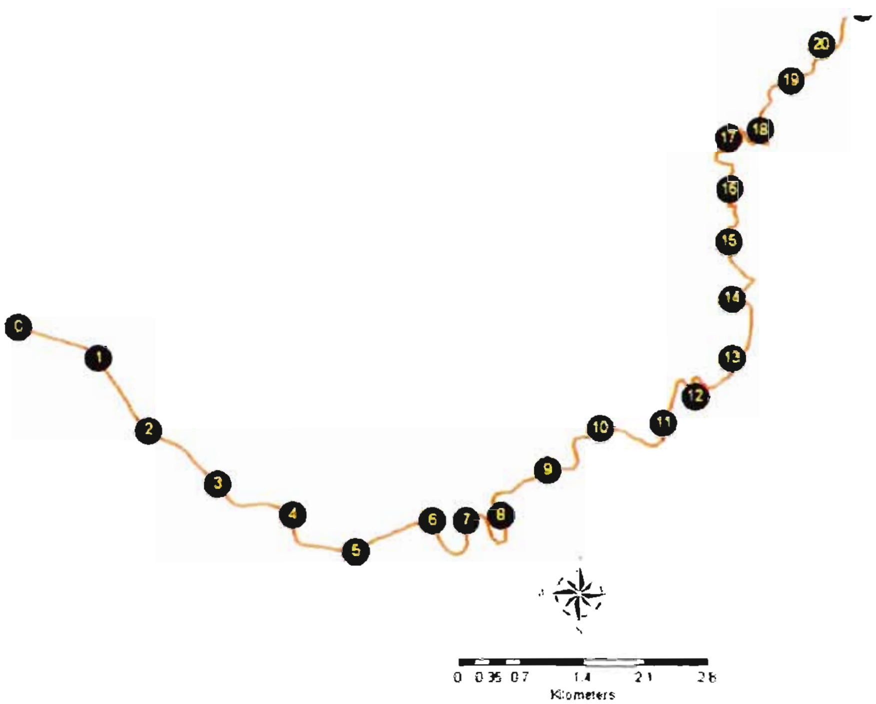


Figure 7: A representation of two shapefiles (centerline and river km) and their associated data provided by the District.

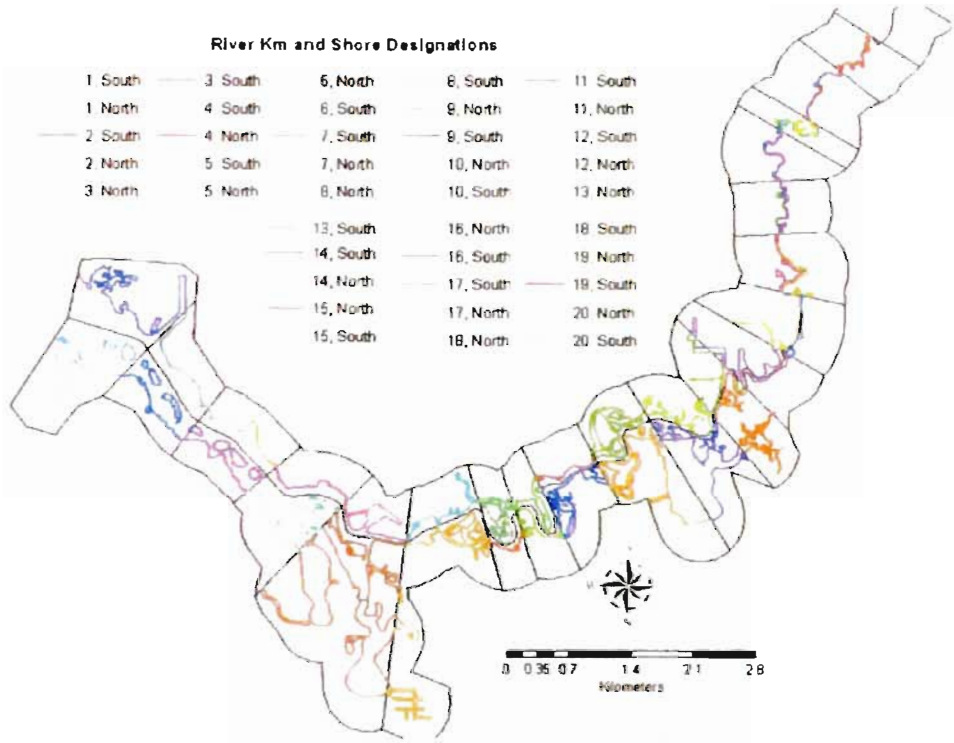


Figure 8: Anclote River shoreline segments clipped with the shapefile depicted in Figure 6.

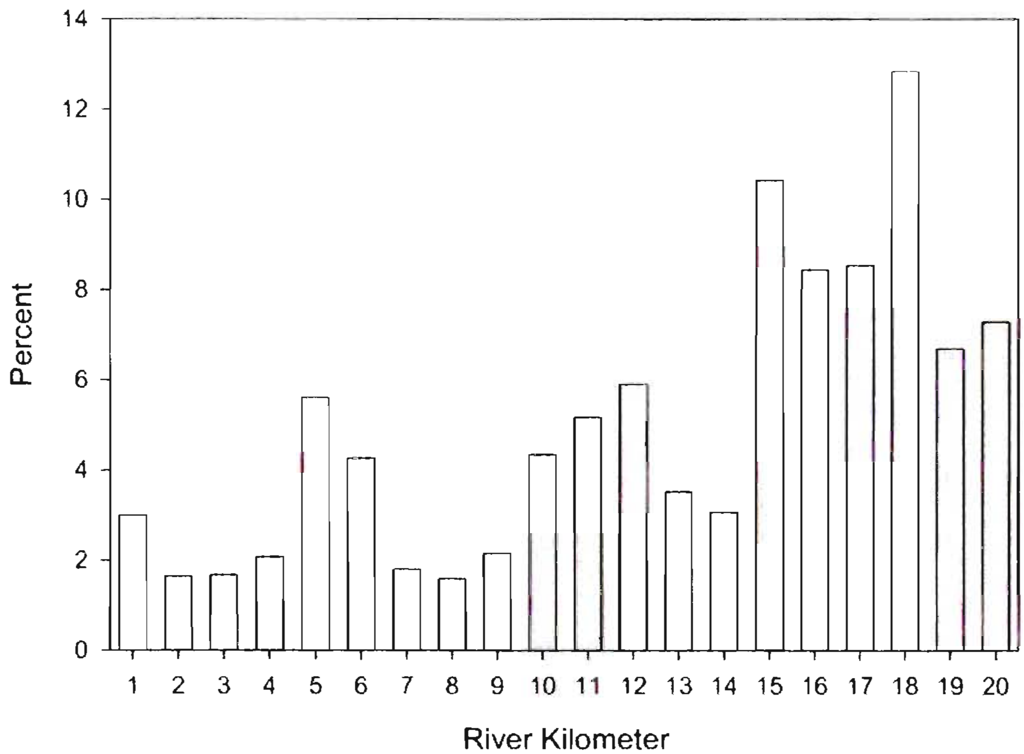


Figure 9: Distribution of shoreline length by river kilometer.

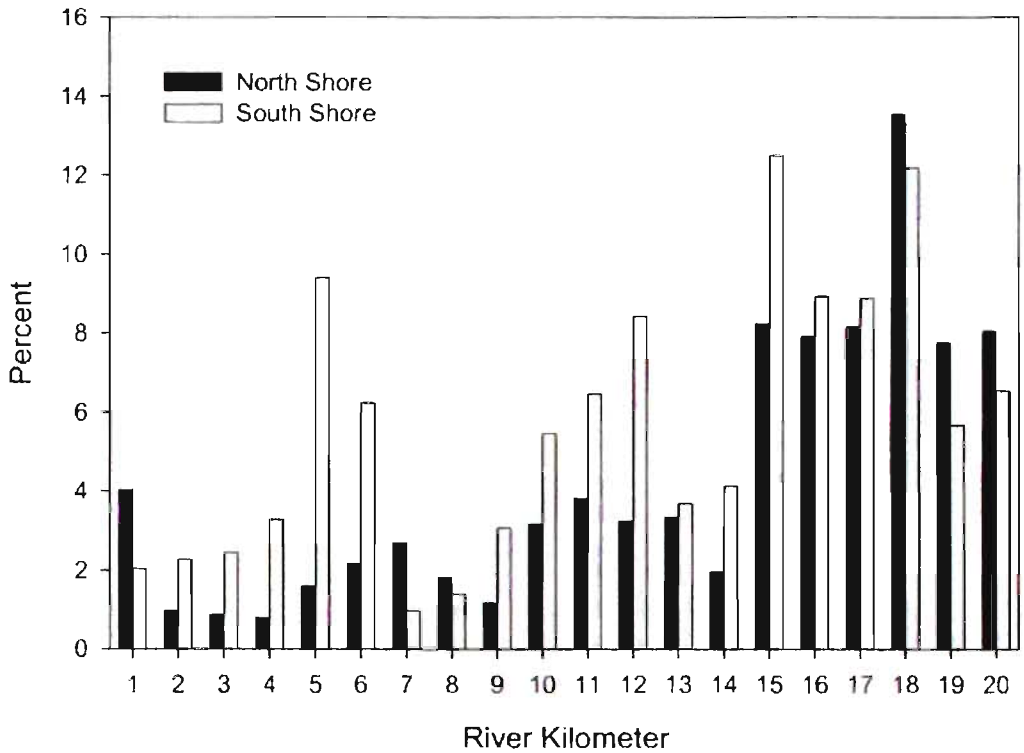


Figure 10: Distribution of shoreline length by river kilometer and shore designation.

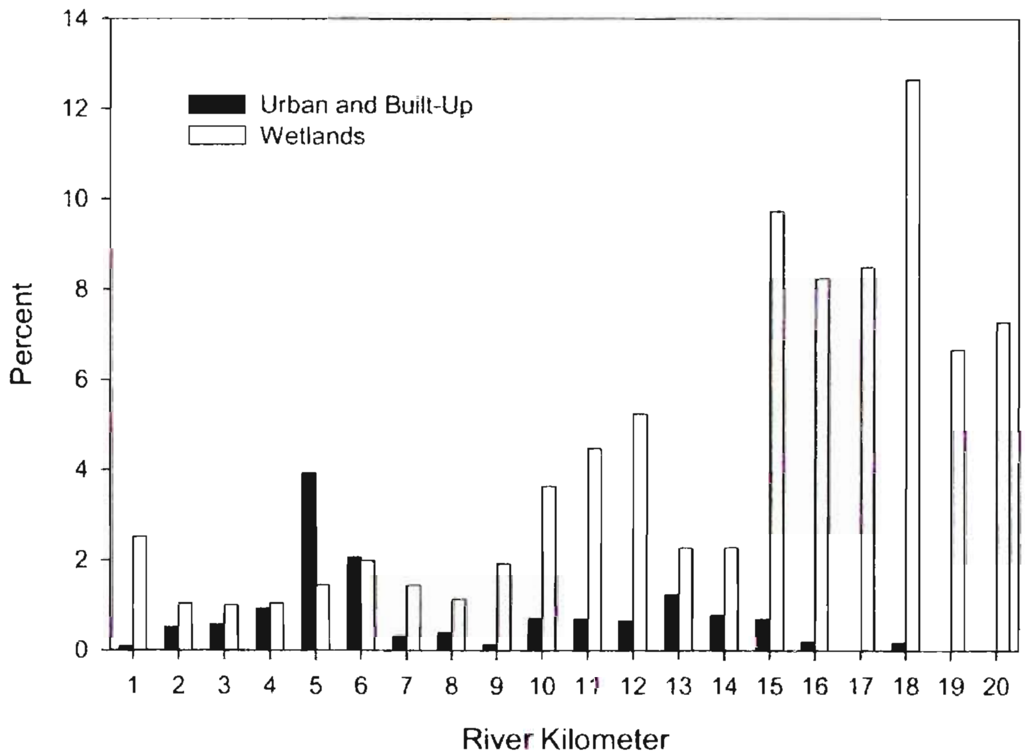


Figure 11: Distribution of major shoreline types (FLUCCS Level 1).

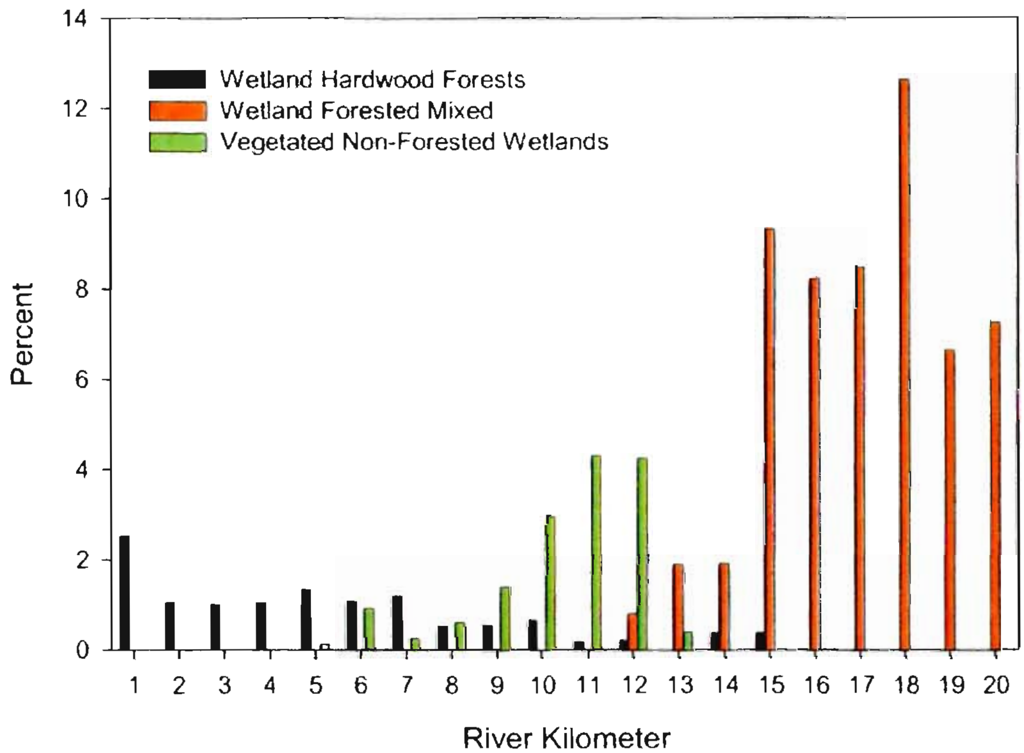


Figure 12: Distribution of wetlands by type (FLUCCS Level 2).

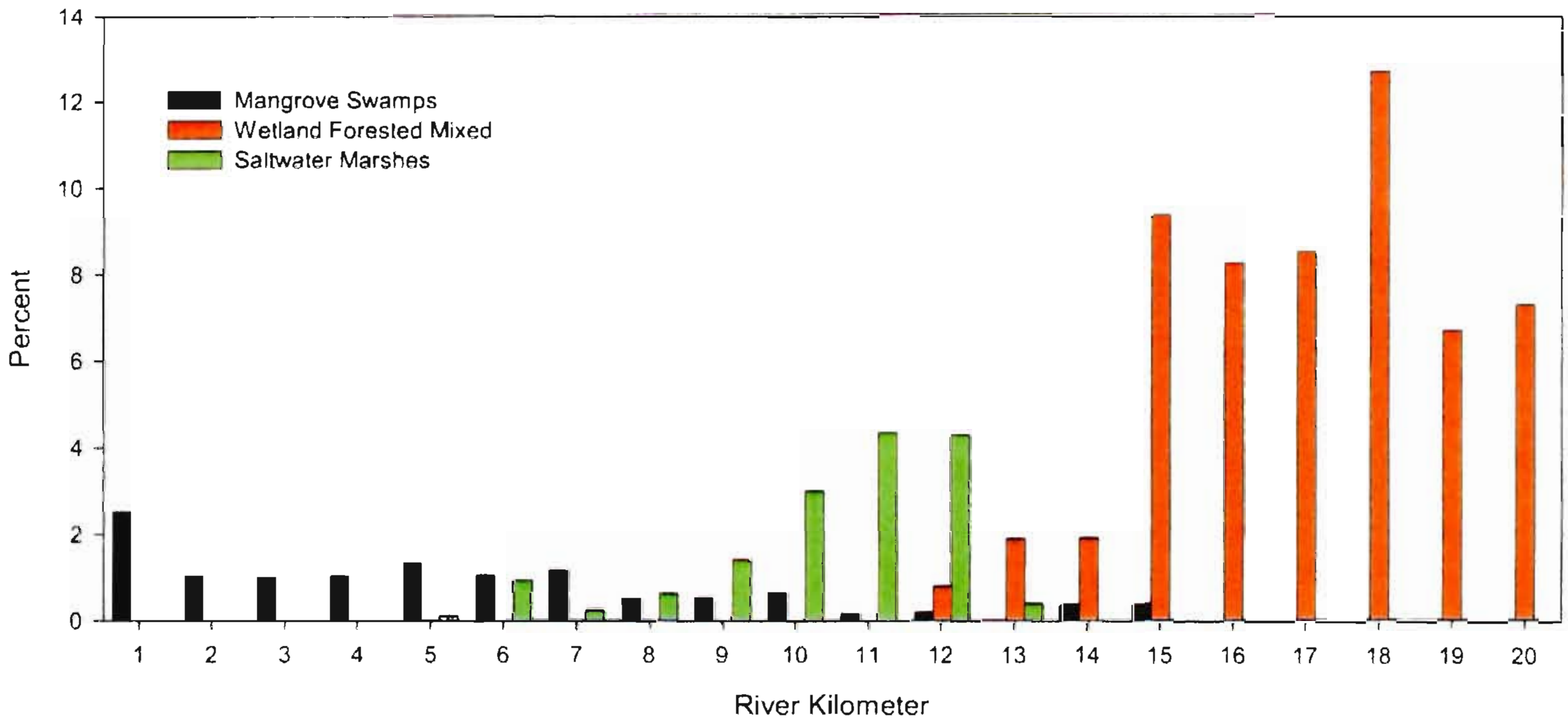


Figure 13: Distribution of wetlands (FLUCCS Level 3) by river kilometer.

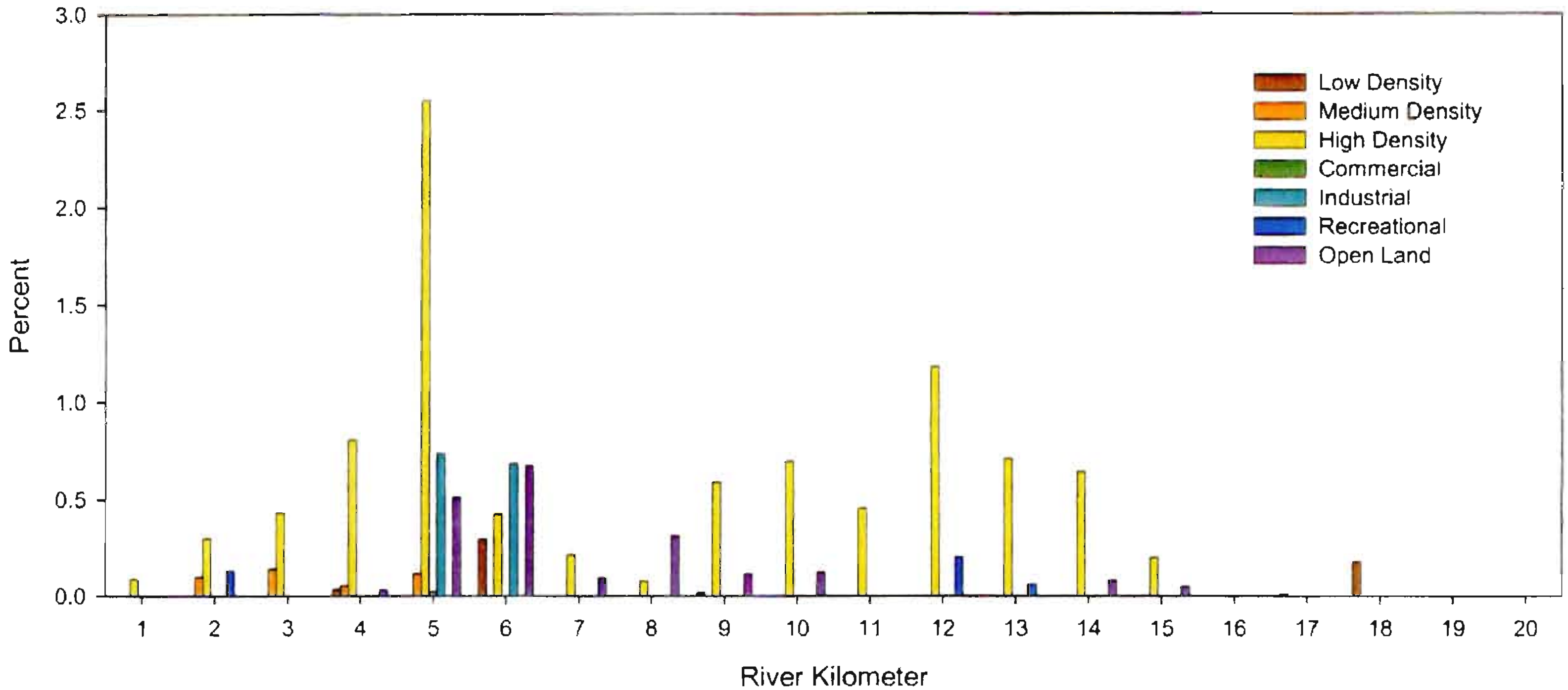


Figure 14: Distribution of urban areas (FLUCCS Level 2) by river kilometer.

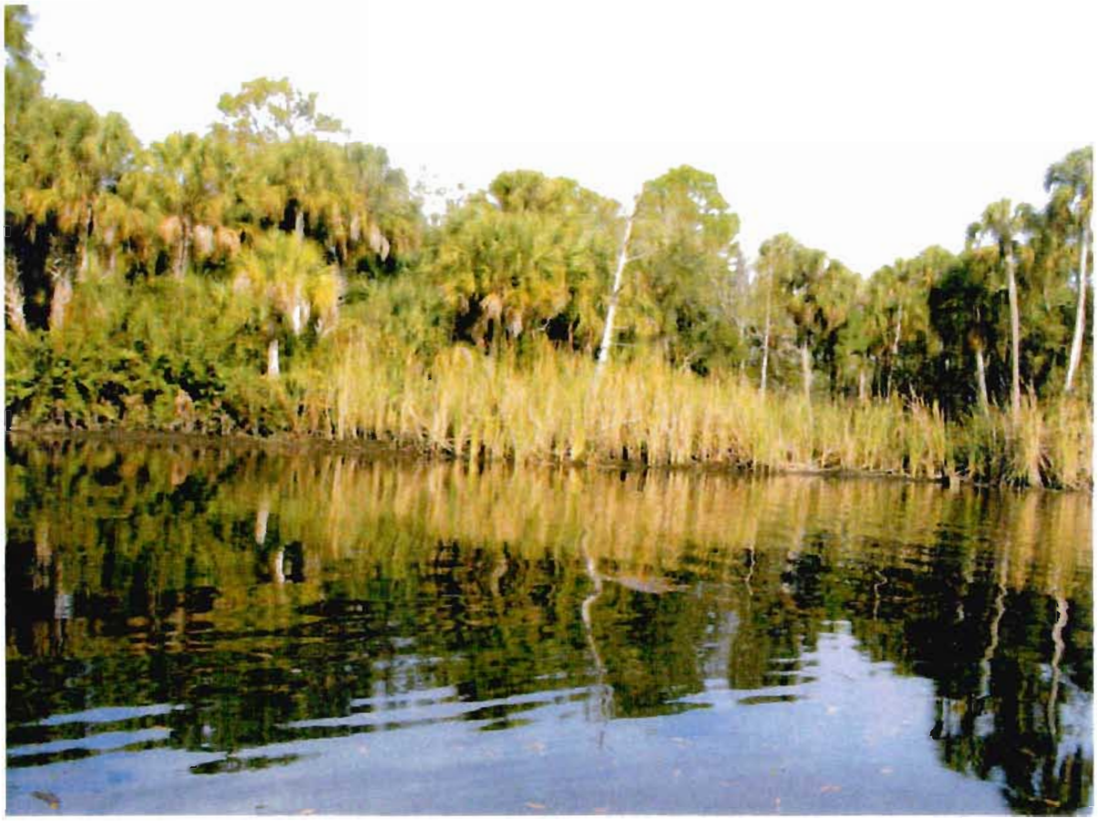


Figure 15: An example of a small freshwater marsh fringe fronting a stand of mixed hardwoods and palms at RK16.

Figure 16: An example of the natural shorelines and narrow waterway with its inherent sawyers and logjams above river km 18.

Figure 17: An example of giant leather ferns growing along a natural shoreline. This freshwater wetland, located between RK17 and RK18, is too small to be delineated in Level 4 shapefile.

Figure 18: A typical unarmored shoreline classified as FLUCCS Level 4, Wetland Forested Mixed.

Figure 19: Saltwater marsh with a single mangrove sapling at about RK12.

Figure 20: A Brazilian pepper growing along the southern bank of the river above RK13.

Figure 21: A natural shoreline bordering a single-family dwelling (FLUCCS code 1111).

Figure 22: An example of a slightly modified mangrove dominated shoreline. Note the debris or rubble used to armor the shoreline.

Figure 23: A saltwater marsh fringe (*Juncus* spp.) with mangrove seedlings at RK11.

Figure 24: Golf course located on the northern bank at RK12 with rubble used to armor the shoreline.

Figure 25: An example of new construction with rubble used to armor the shoreline at RK15.

Figure 26: An armored shoreline with docks and a small stand of *Typha* spp. at RK17.

Figure 27: Two examples of concrete walls used to armor the shoreline.

Figure 28: An example of an older shoreline armoring strategy.

Figure 29: An example of FLUCCS code 8147 at RK16 defined by this study (Table 4).