Tampa Bay Estuary Program
Technical Publication # 05-06

Gammaridean Amphipoda of Tampa Bay, Florida (Gulf of Mexico): Taxonomic Composition, Distribution, and Association with Abiotic Variables

FINAL REPORT

August 2006

GAMMARIDEAN AMPHIPODA OF TAMPA BAY, FLORIDA (GULF OF MEXICO): TAXONOMIC COMPOSITION, DISTRIBUTION, AND ASSOCIATION WITH ABIOTIC VARIABLES

PREPARED FOR:
THE TAMPA BAY ESTUARY PROGRAM
ST. PETERSBURG, FL
JUNE 2006

Stephen A. Grabe[1], David J. Karlen, Christina M. Holden, Barbara K. Goetting, Sara E. Markham and Thomas L. Dix
Environmental Protection Commission of Hillsborough County
The Roger P. Stewart Center
3629 Queen Palm Drive
Tampa, Florida 33619

Present Address:
Janicki Environmental, Inc.
1155 Eden Isle Drive NE
St. Petersburg, FL 33704 USA
Sgrabe@Janickienvironmental.com

Acknowledgements

This program has benefited from support by the Tampa Bay Estuary Program, Environmental Protection Commission of Hillsborough County, Hillsborough County Board of County Commissioners, Manatee County Environmental Management Department, Pinellas County Department of Environmental Management, the U.S.E.P.A., and the Southwest Florida Water Management District. Appreciation is extended to S. LeCroy and D. Camp for identifying/verifying the identifications of many of these amphipods. Additionally, there are numerous current and former employees of the EPCHC who contributed to this project.

Table of Contents

List of Tables

List of Figures

List of Figures-continued

Introduction

Gammaridea (Crustacea Amphipoda) are widely recognized as sensitive indicators of ecological degradation, including contaminanted sediments (Bellan-Santini 1980; Swartz *et al*. 1982; Thomas 1993; Poggiale and Dauvin 2001). They are also of ecological importance because of their role in energy transformation—as detritivores, primary consumers, and carnivores (Zimmerman *et al.* 1979; Oliver *et al.* 1982; Oakden 1984; Mukai and Iijima 1995; Duffy and Hay 2000), as well as prey for finfish (Carr and Adams 1973; Franz and Tanacredi 1992; Llanso *et al*. 1998) and avifauna (Goss-Custard 1977).

Although a faunal list for nearshore waters of the Gulf of Mexico has not been formally assembled, Camp (1998) reports 236 species of Gammaridea from Florida waters and recent work by LeCroy (2000; 2002) has added at least 34 taxa.

This report examines the distribution and taxonomic composition of gammaridean amphipods from soft substrata in Tampa Bay and explores the association between the presence of the more frequently occurring species and several abiotic variables, including ecological stressors. Representative specimens from these collections are deposited in the U.S. National Museum.

Materials and Methods

Study Design

A benthic monitoring program for Tampa Bay commenced in 1993 under the auspices of the Tampa Bay National Estuary Program (1996). This monitoring program employs a stratified (by seven bay segments), probabilistic design (Larsen *et al*. 1994; Coastal Environmental, Inc. 1994).

Bay segments included Old Tampa Bay, Hillsborough Bay, Middle Tampa Bay, Lower Tampa Bay, Terra Ceia Bay, the Manatee River and Boca Ciega Bay (Figure 1). Hexagonal grids were superimposed over the seven bay segments of the Tampa Bay estuarine system. Within each hexagon, the sampling location is randomly determined, with a known probability of inclusion. All sampling took place during a summer-fall “Index Period”: late July-early October.

In 2002, Special Study areas were added to address areas with poor sample coverage yet considered likely to exhibit “degraded” sediments. These areas were Bayboro Harbor (St. Petersburg), the west-central area of Old Tampa Bay, and the Ybor, Sparkman, and Seddon Channel areas of upper Hillsborough Bay.

A second monitoring program, the Hillsborough Independent Monitoring Program [HIMP] commenced in 1999 and was superimposed on the above design. This second program is focused on the putative effects of reduced freshwater inflow (for drinking water) on the Lower Hillsborough River, the Palm River and McKay Bay, and the Alafia River; the Little Manatee River is a “reference” estuary for this study (Figure 1).

This publication incorporates bay-wide data from 1993-2001, the 2002 “Special Study” areas, and the HIMP data from 1999-2002.

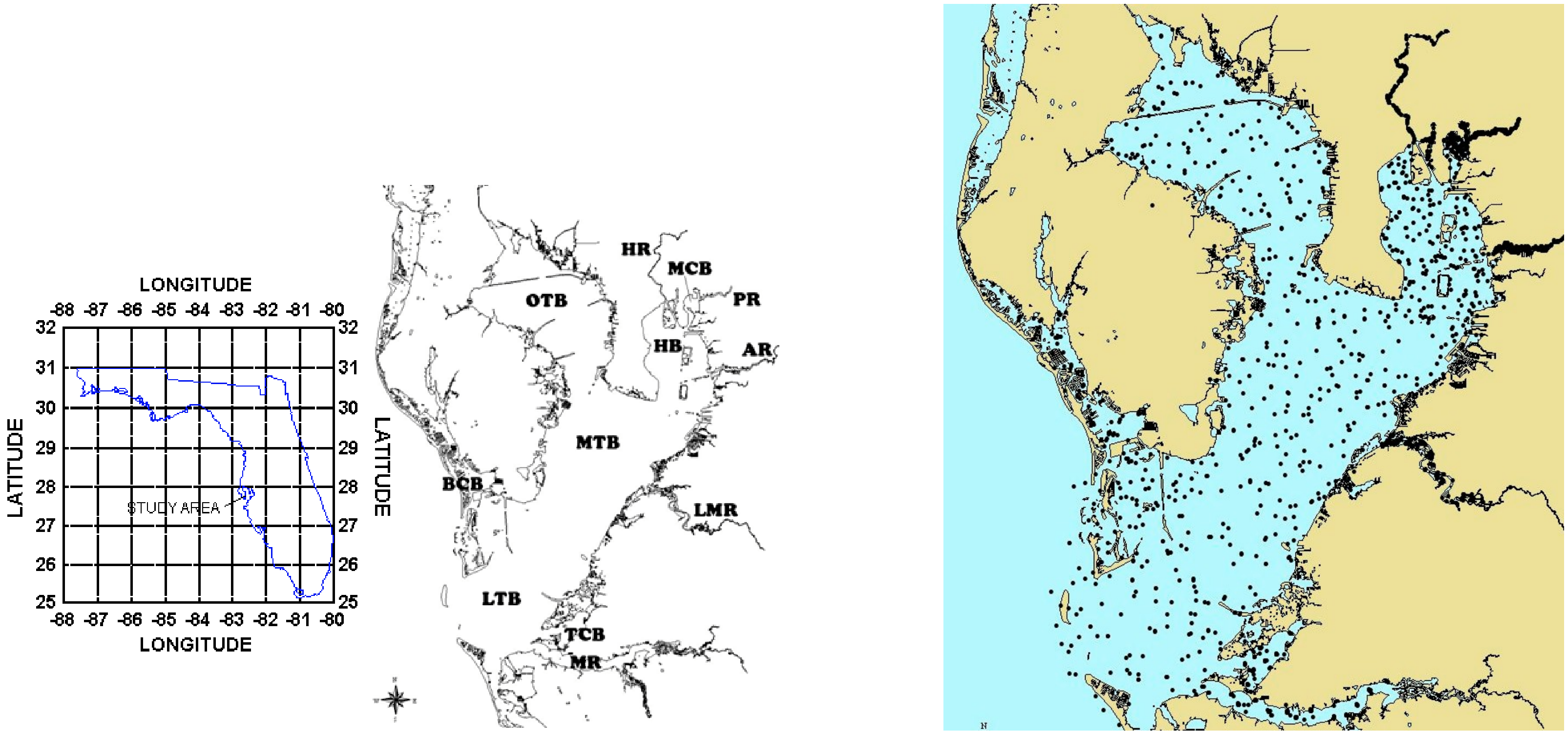


Figure 1. Location of sampling stations in Tampa Bay, Florida, 1993-2002. Bay segments are OTB (Old Tampa Bay), HB (Hillsborough Bay), MTB (Middle Tampa Bay), LTB (Lower Tampa Bay), TCB (Terra Ceia Bay), MR (Manatee River), BCB (Boca Ciega Bay). Subareas are HR (Hillsborough River), PR (Palm River), MCB (McKay Bay), AR (Alafia River), and LMR (Little Manatee River).

Field Methods

Benthic infauna, hydrographic profiles, and sediments were collected using the standard EMAP techniques adopted by USEPA for the Louisianan Province (Holland 1990). At each station the water column profile 3 (temperature, dissolved oxygen [DO], and salinity) was measured with a Hydrolab Surveyor.

Sediment samples were collected with a stainless steel 0.04 m^2 Young sampler (Figure 2). A core was removed from each sample and stored, on ice, for subsequent analysis of the % silt+clay content [%SC].

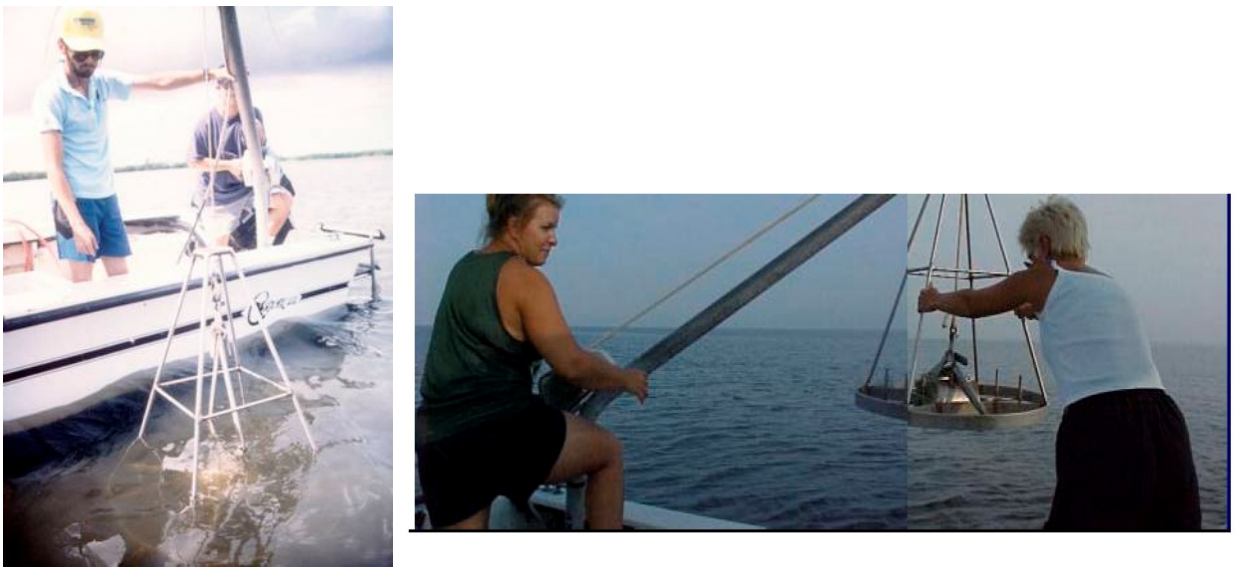


Figure 2. Young-modified Van Veen sampler
(Photographs: S. A. Grabe)

This core was also examined for the presence of an apparent redox potential discontinuity layer [RPD]. The apparent RPD width demarcates reduced and oxidized sediments (Rosenberg *et al*. 2001). The depth of the upper, oxidized layer is influenced by bioturbation (Rosenberg *et al*. 2001). In order for bioturbation to occur, the near-bottom DO regime must be adequate to sustain a diverse benthic assemblage (Nilsson and Rosenberg 2000). If an RPD was discernible its width was measured with a metric ruler.

Benthic samples were stored on ice after adding a solution of magnesium sulfate to relax the organisms. Samples were later sieved (0.5 mm mesh) and then fixed in a 10% solution of borax-buffered formalin and Rose Bengal.

Additional samples were collected from the seven primary bay segments and from a random subsample of HIMP sites for analysis of sediment contaminants (trace metal, organochlorine pesticides, PCBs, and PAHs).

Laboratory Methods

Analysis of the %SC content followed a modification (Versar, Inc. 1993) of Plumb (1981). Sediment contaminant analyses followed methods outlined in USEPA (1993) and Grabe and Barron (2004). Benthic samples were sorted and all organisms were identified to the lowest practicable identification level.

Data Analyses

Logistic regression techniques (*cf*. Huisman *et al.* 1993; Peeters and Gardiniers 1998; Ysebaert *et al*. 2002) were used to aid in characterizing habitat "preferences" and associations with two ecological stressors: near-bottom DO and an index of sediment contamination incorporating trace metals, PAHs, and PCBs (MacDonald *et al*. 2004). Species occurring in at least 2.5% of the 1,628 samples were incorporated in these analyses.

Forward stepwise multiple logistic regression [LR] (SPSS, Inc. 2000) was used to identify abiotic variables best able to predict the occurrence of the selected species. Transformed abiotic variables used in this analysis include depth, salinity, temperature, DO ($\log_{10}$ n+1), %SC (arc sine [ASN]). RPD and the sediment contaminant index (Predicted Effects Level [PEL] Quotient) were analyzed separately since the number of samples for these variables was considerably smaller than for the hydrographic and sediment variables. TableCurve 2D (SYSTAT 2002) was used to develop univariate Gaussian logistic regression equations from which the "optimum" value and the "tolerance" (preferred range) could be calculated (Peeters and Gardiniers 1998).

Sediment type (*e.g*., medium sand sized sediments, muds) was categorized by regressing %SC *vs*. mean grain (ϕ) size for Tampa Bay data collected by Long *et al*. (1994) using TableCurve 2D (SYSTAT 2002): $\%SC= 1/(0.0097+1.575*e^{\phi}$ (adjusted $r^2=0.947$). Wentworth size classes for sediments (*cf*. Percival and Lindsay 1997) were then estimated from the %SC data. Based upon this relationship,

- coarse sands (and shell hash) were defined as having <1.7%SC;
- medium sands >1.7<4.51 %SC;
- fine sands >4.51<11.35%SC and
- very-fine sands >11.35<25.95%SC.
- Muds were defined as being $\geq$25.95%SC.

The RPD data were evaluated using criteria proposed by Summers *et al*. (1993) for Louisianian Province estuaries. An RPD <10-mm may be indicative of anaerobic sediments and an RPD >50-mm may represent aerobic sediments.

Community structure was examined using the SIMPER, CLUSTER, and ANOSIM procedures in PRIMER (Clarke and Warwick 2001; PRIMER-E Ltd. 2001). In the SIMPER analyses, data (square-root transformed densities) were post-stratified by habitat and the rank order of species explaining up to 20% of the dissimilarity within each habitat were calculated. The ANOSIM procedure was used to determine which habitats differed in community structure. In its application, we compared community structure across salinity zones holding sediment type constant and across sediment types holding salinity zone constant. Only results from "adjacent" habitats are presented. That is, in low mesohaline salinities, medium sand habitats are compared with coarse and fine sand habitats and coarse and fine sand habitats are not addressed. The CLUSTER procedure was used to examine the relationships between a suite of tube-building polychaetes with an amphipod (*Listriella barnardi*) considered to inhabit polychaete tubes (Feeley and Wass 1971; Bousfield 1973). These analyses were run, by bay segment, using presence-absence data.

Results

Study area

Sample depths during the study ranged from 0.1 to 14.7-m (Figure 3). Bay salinities are typically in the polyhaline (18-30 PSU) range and tributary salinities are typically mesohaline (5 to 18 PSU) (Figure 4). Tampa Bay substrata are predominantly medium to fine sand-sized sediment, although mud-sized sediments are located in tributaries and portions of Hillsborough Bay (Figures 5 and 6).

The predominant habitats (defined by Venice salinity zone and sediment type) in the sample population are polyhaline medium and fine sands in the bay proper and polyhaline muds and fine sands in the tributaries (Table 1; Figure 6). Approximately 20% of the tributary samples were from low salinity (tidal freshwater and oligohaline) habitats (Table 1). The RPD data showed that bay sediments were more aerobic (>30%) than tributary sediments (<10%) (Figure 7). More than 80% of the tributary samples had an RPD <10-mm, indicative of anaerobic sediments.

Ninety-one samples were reported to have submerged aquatic vegetation [SAV] at the locations. Although four species of halophytes are present in Tampa Bay (*Thalassia testudinum*, *Halodule wrightii*, *Syringodium filiforme*, and *Halophila engelmanni*) species identifications were not always made in the field notes.

The DO concentrations in the bay are generally above 4 ppm, whereas the tributaries experience more stress from hypoxia (Figure 8). The PEL Quotient was generally <0.05 in the bay proper, indicative of "clean" sediments (Figure 9). The median PEL Quotient in the tributaries was >0.05 and approximately 20% of the samples had PEL Quotients >0.34, indicative of contaminated sediments. The highest PEL quotients (>1) were typically found in two urban tributaries: the Hillsborough and Palm Rivers.

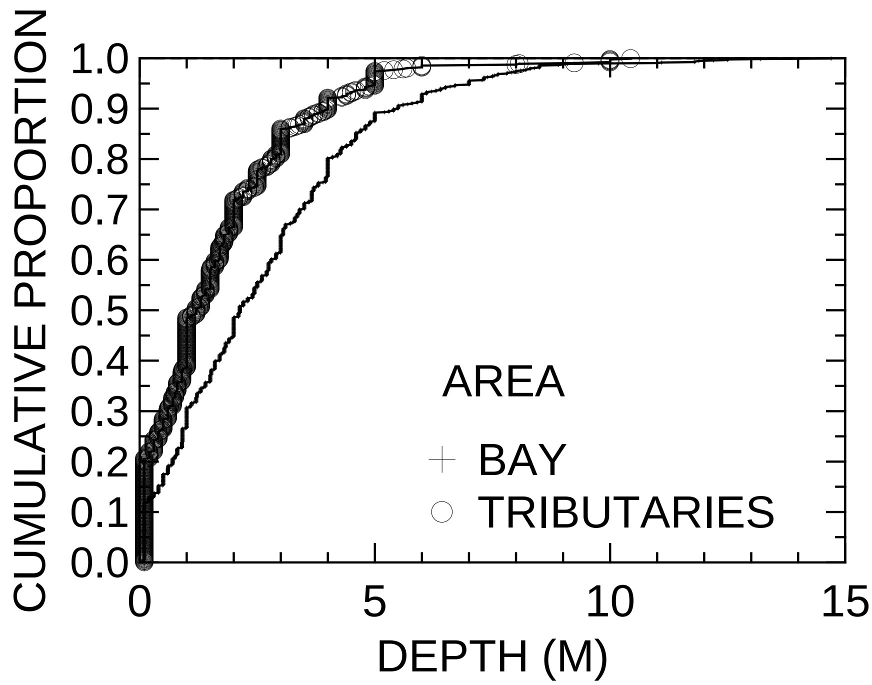


Figure 3. Cumulative distribution plot of sample depths in Tampa Bay (1993-2002), by study area: bay vs. tributaries.

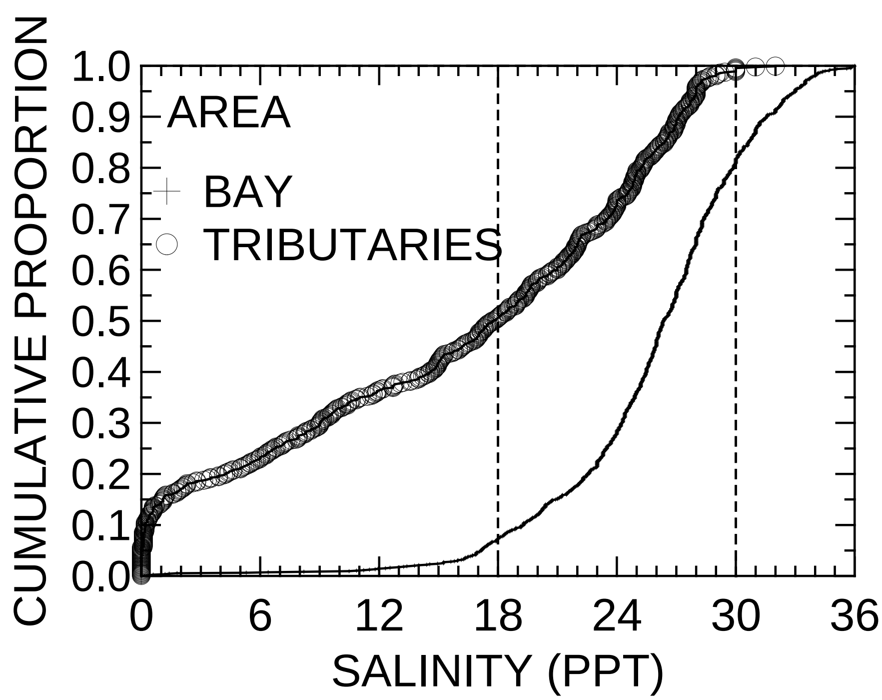


Figure 4. Cumulative distribution plot of near-bottom salinities in Tampa Bay (1993-2002), by study area: bay vs. tributaries.

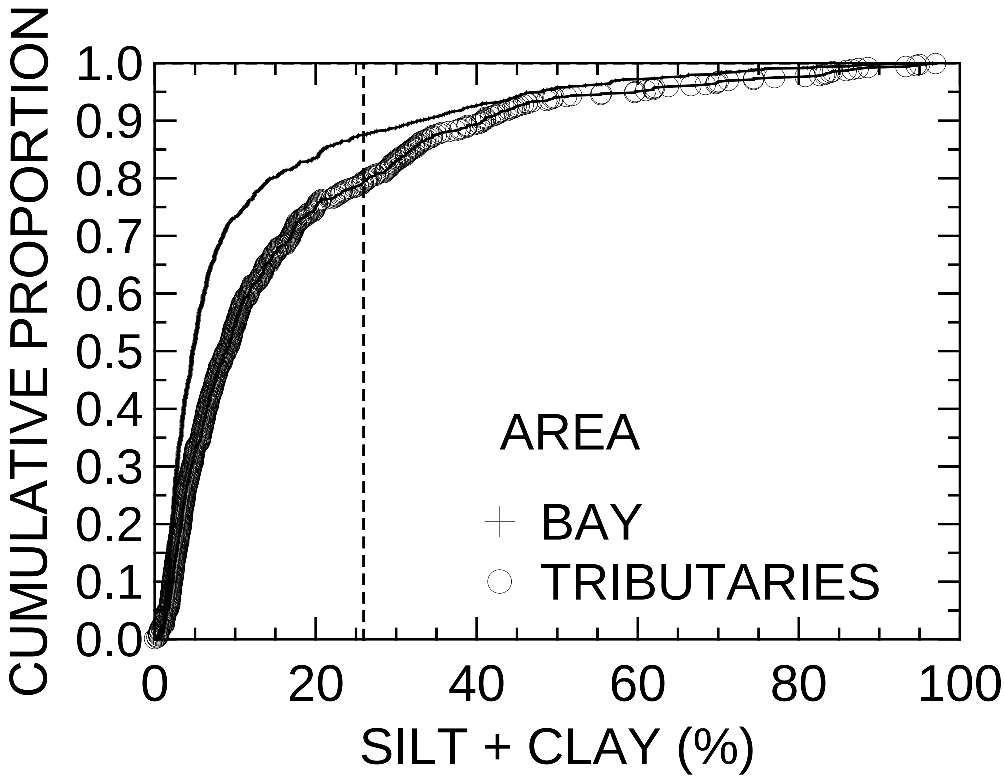


Figure 5. Cumulative distribution plot of the % silt+clay content of sediments in Tampa Bay (1993-2002), by study area: bay vs. tributaries. Vertical lines demarcate sand and mud-sized sediments.

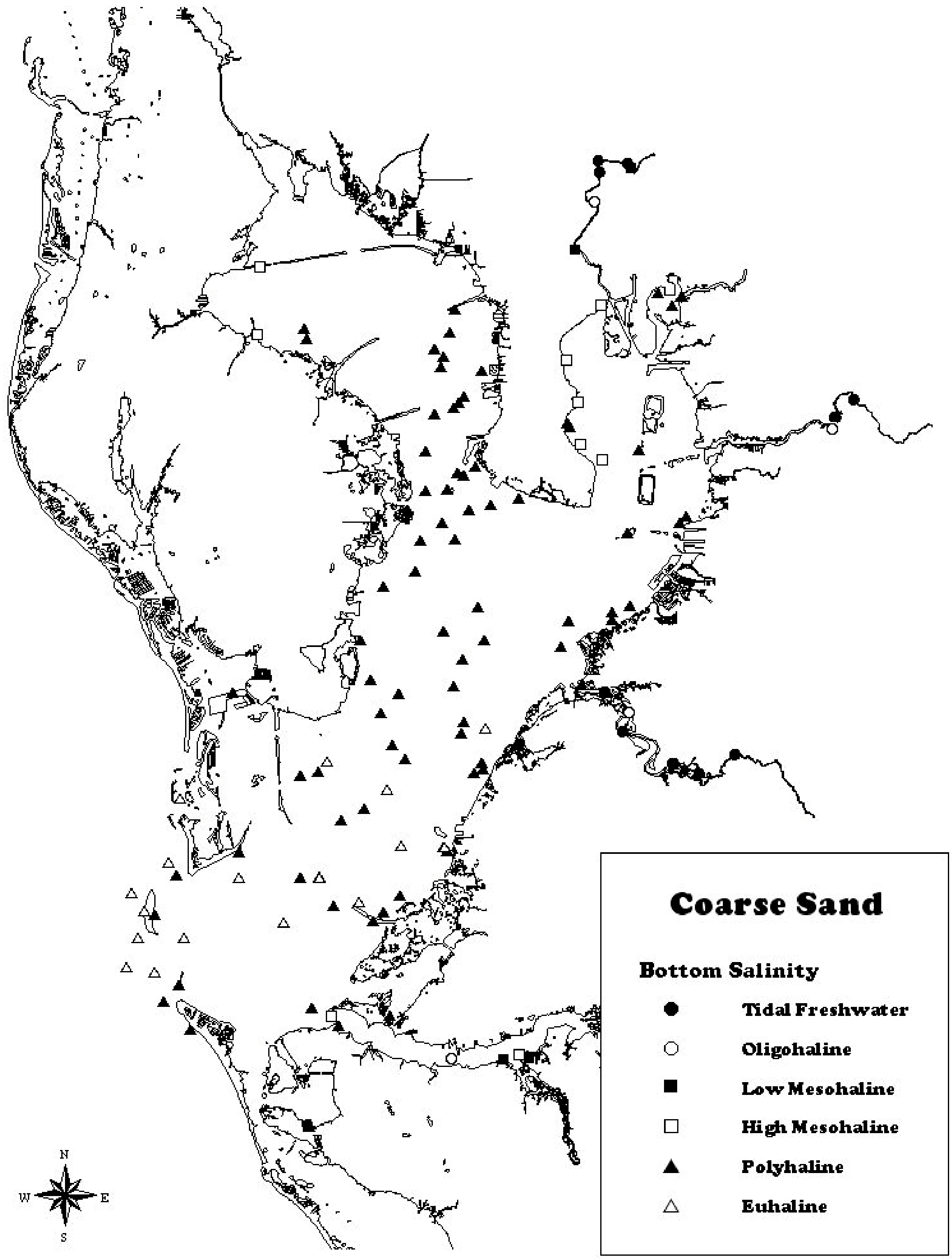


Figure 6. Maps depicting the distribution of habitats in Tampa Bay, Florida: Coarse Sands.

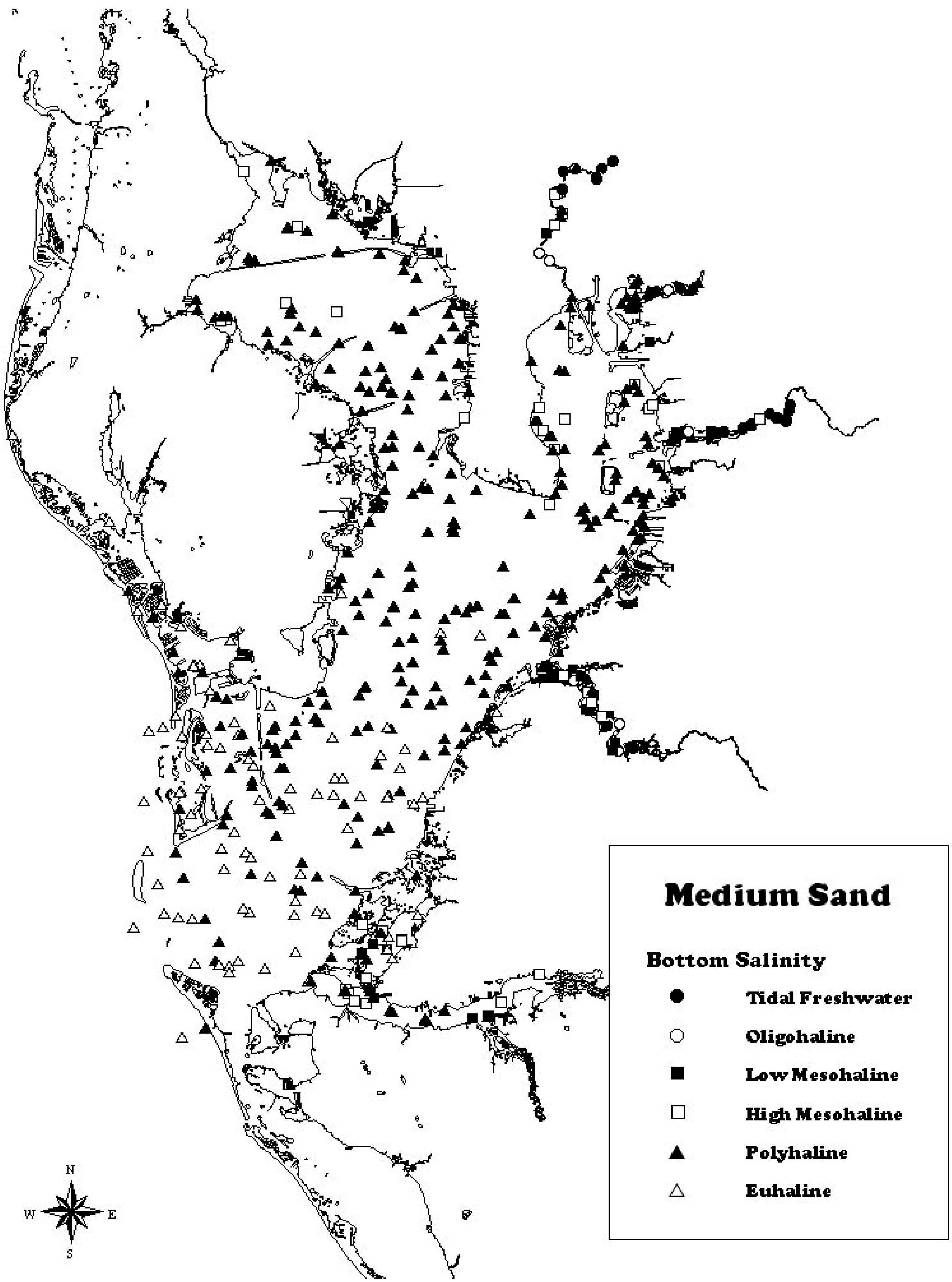


Figure 6-continued. Maps depicting the distribution of habitats in Tampa Bay, Florida: Medium Sands.

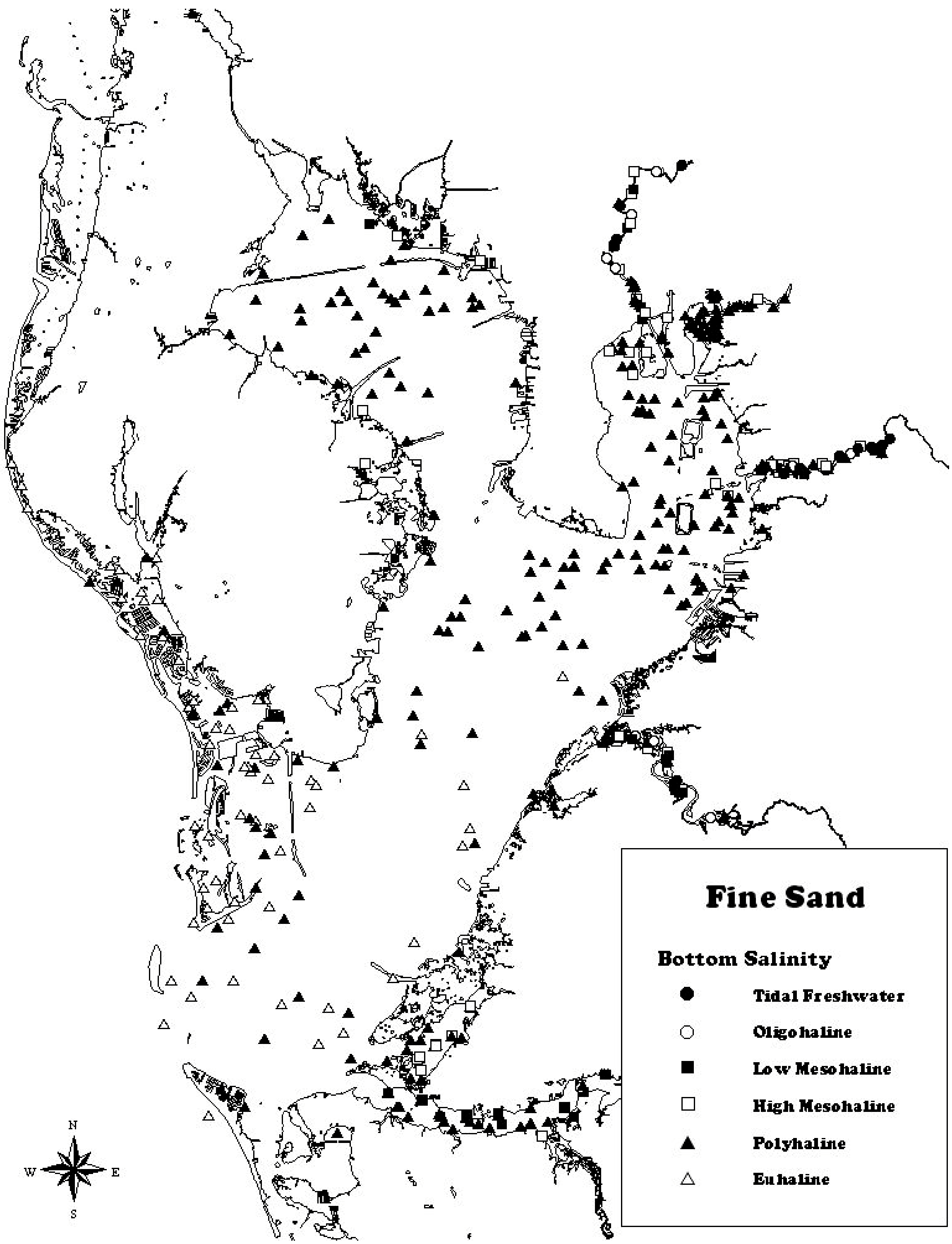


Figure 6-continued. Maps depicting the distribution of habitats in Tampa Bay, Florida: Fine Sands.

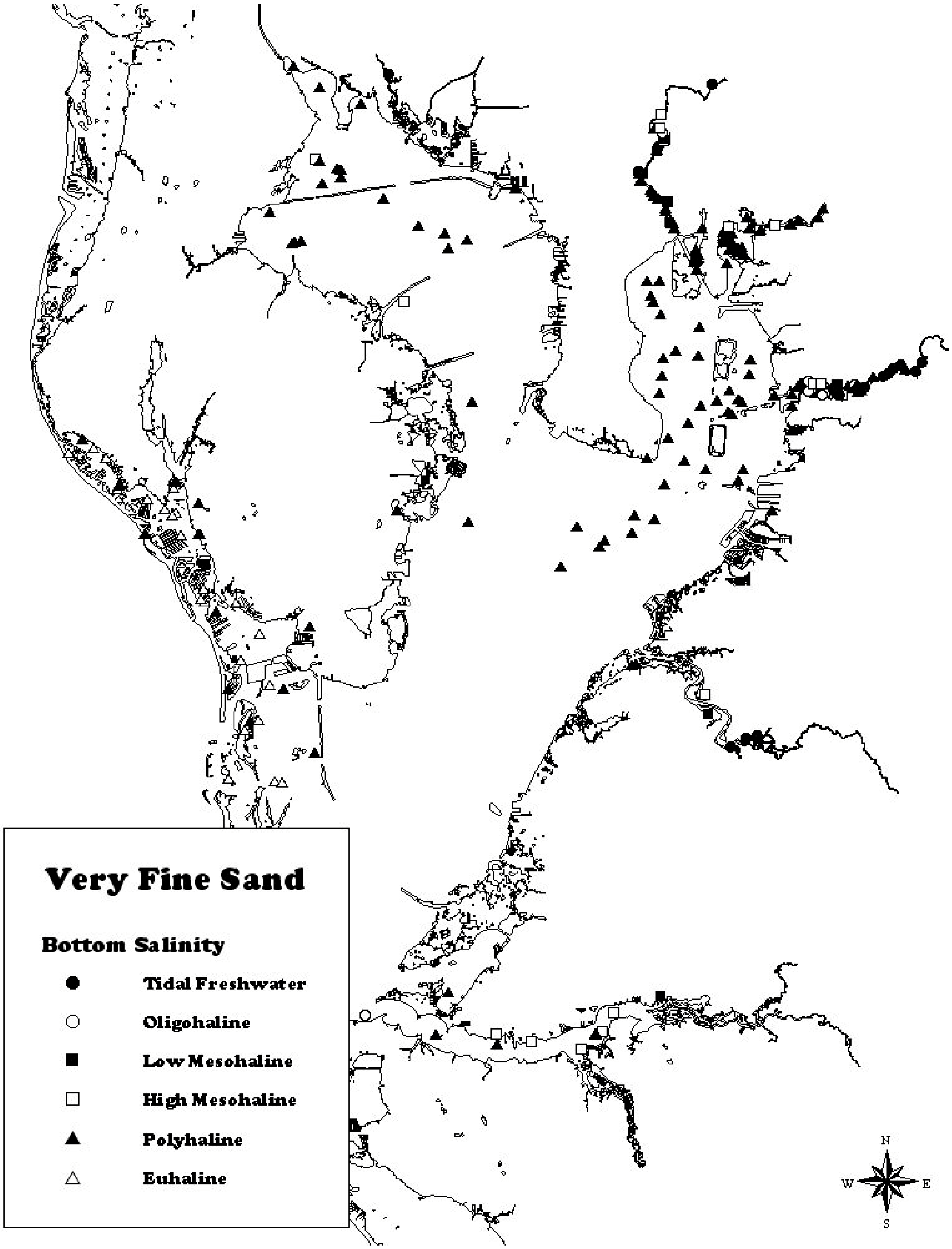


Figure 6-continued. Maps depicting the distribution of habitats in Tampa Bay, Florida: Very-fine Sands.

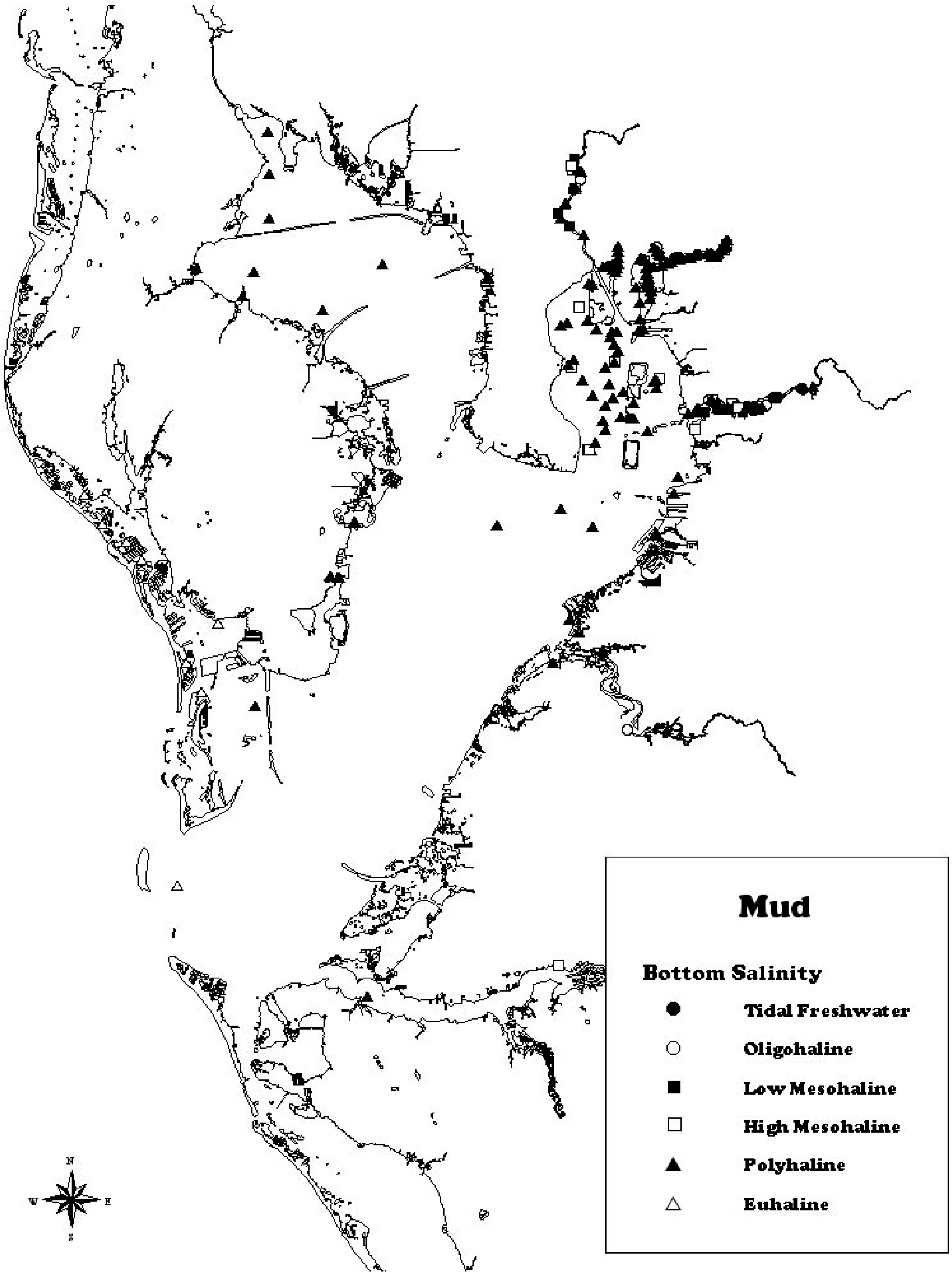


Figure 6-continued. Maps depicting the distribution of habitats in Tampa Bay, Florida: Muds.

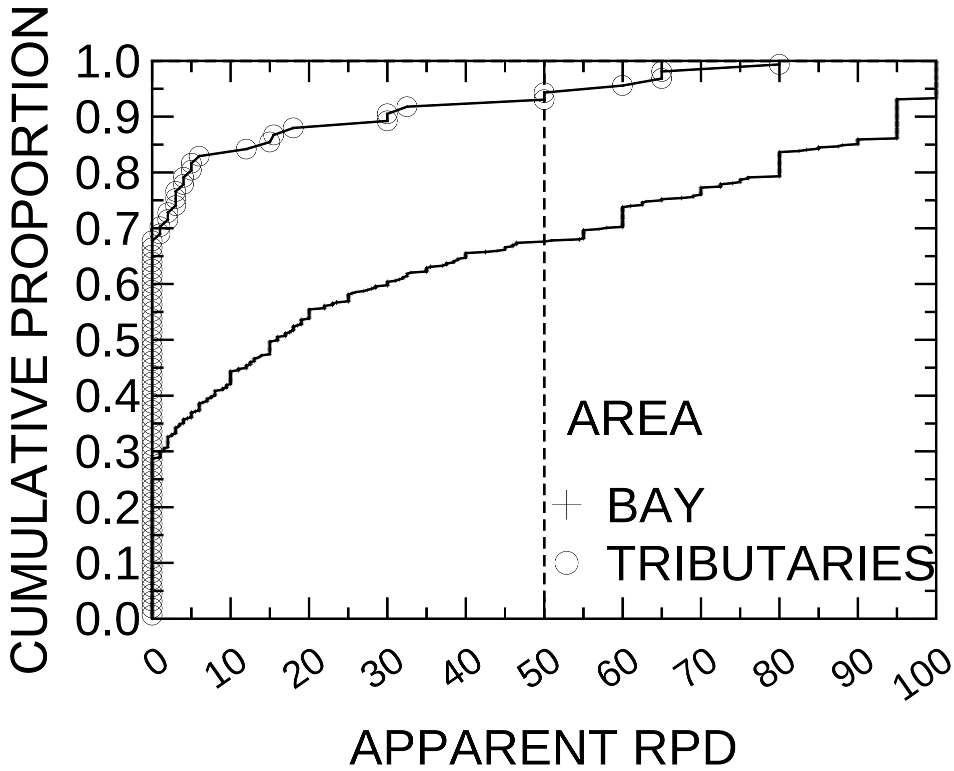


Figure 7. Cumulative distribution plot of the apparent RPD in Tampa Bay (1993-2002), by study area: bay vs. tributaries. Vertical lines demarcate aerobic and anaerobic sediments.

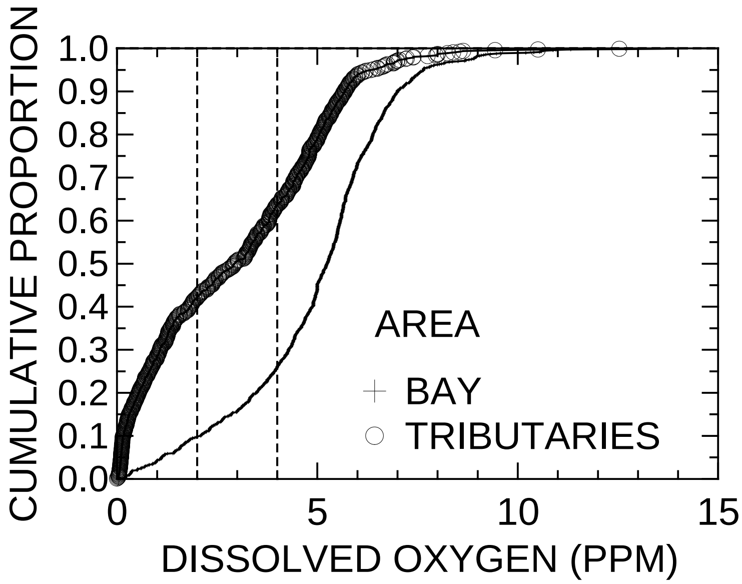


Figure 8. Cumulative distribution plot of near-bottom Dissolved oxygen in Tampa Bay (1993-2002), by study area: bay vs. tributaries.

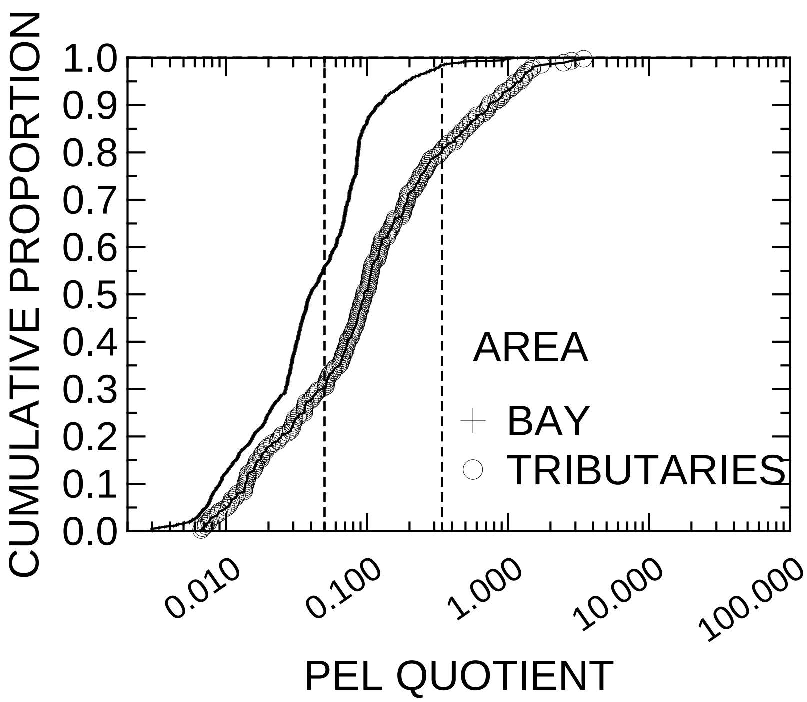


Figure 9. Cumulative distribution plot of the composite PEL Quotient in sediments in Tampa Bay (1993-2002), by study area: bay vs. tributaries. Vertical lines demarcate "degraded" and "clean" sediments.

Table 1. Habitats (as % occurrence) sampled in Tampa Bay, Florida (1993-2002). N=number of observations.

HABITAT	ALL DATA (n=1,562)	TAMPA BAY PROPER (n=968)	TRIBUTARIES (n=594)
TIDAL FRESHWATER			
COARSE SAND	0.7	0.0	1.8
MEDIUM SAND	1.2	0.1	3.0
FINE SAND	0.8	0.0	2.0
VERY FINE SAND	1.3	0.1	3.2
MUD	0.8	0.0	2.0
OLIGOHALINE			
COARSE SAND	0.4	0.0	1.0
MEDIUM SAND	1.1	0.0	2.9
FINE SAND	1.0	0.0	2.7
VERY FINE SAND	0.6	0.0	1.5
MUD	0.5	0.0	1.5
LOW MESOHALINE			
COARSE SAND	0.3	0.1	0.7
MEDIUM SAND	1.8	0.3	4.0
FINE SAND	2.7	0.1	6.9
VERY FINE SAND	1.0	0.0	2.7
MUD	0.5	0.1	1.2

Table 1. continued

HABITAT	ALL DATA	TAMPA BAY PROPER	TRIBUTARIES
HIGH MESOHALINE			
COARSE SAND	0.6	0.6	0.5
MEDIUM SAND	2.9	2.6	3.4
FINE SAND	2.9	1.4	5.2
VERY FINE SAND	1.4	0.3	3.2
MUD	1.2	0.7	2.0
POLYHALINE			
COARSE SAND	4.9	7.5	0.7
MEDIUM SAND	20.4	26.0	11.3
FINE SAND	17.1	19.5	13.1
VERY FINE SAND	9.3	9.4	9.1
MUD	12.2	11.2	14.0
EUHALINE			
COARSE SAND	1.1	1.8	0.0
MEDIUM SAND	5.6	8.8	0.3
FINE SAND	3.9	6.3	0.0
VERY FINE SAND	1.6	2.5	0.0
MUD	0.3	0.5	0.0

Taxonomic Composition

At least 73 species of gammaridean amphipods have been identified to date from Tampa Bay (Table 2). The most speciose families included Aoridae (9 species), Melitidae (8), and Ampeliscidae (7). More than 19% of the species are undescribed.

Three *Ampelisca* species (*A. holmesi, A. abdita*, and *Ampelisca* sp. C) and *Listriella barnardi* were the most frequently occurring amphipods (Table 3). Within the bay proper, *Metharpinia floridana*, *Eudevenopus honduranus*, and *Rudilemboides naglei* also occurred in >20% of the samples. *Grandidierella bonnieroides* was the most frequently occurring species in the tributaries followed by *A. abdita* and *A. holmesi* (Table 3).

The most abundant species (mean >200 m^{-2}) in the bay proper were *A. holmesi* and *R. naglei.* In the tributaries the numerical dominants were *A. abdita, Apocorophium louisianum* (>140,000 m^{-2} in one sample from the Little Manatee River), *G. bonnieroides,* and *A. holmesi* (Table 4).

Amphipod community structure within salinity zones

Benthic structure across sediment gradients within salinity zones generally were not significantly different (ANOSIM test; p>0.05). Exceptions were medium *vs*. fine-sands in low mesohaline salinities (p=0.03), and, in polyhaline salinities, medium *vs*. fine sands (p=0.01) and very fine sands *vs*. muds (p=0.01).

Grandidierella bonnieroides is the species most characteristic of tidal freshwaters and oligohaline habitats, regardless of sediment type, and is also typical of low mesohaline medium and fine sand-sized sediments (Table 5). *Ampelisca abdita* and *A. holmesi* are characteristic of medium to very fine sand-sized sediments in low and high mesohaline salinities. In polyhaline and euhaline salinities, *M. floridana* is typical of coarse and medium sands; *A. holmesi* is also characteristic of all but coarse sands in polyhaline salinities and of medium and fine sands in euhaline salinities.

Amphipod community structure within sediment types

Benthic structure within sediment types across adjacent salinity zones were also generally not different (ANOSIM test; p>0.05). Exceptions were medium sand habitats in tidal freshwater *vs*. oligohaline waters (p=0.03) and low *vs*. high mesohaline salinities (p=0.05). The polyhaline and euhaline assemblages differed in very-fine sand-sized sediments (p=0.01).

Grandidierella bonnieroides is characteristic of all sediment types in the lowest salinity zones (Table 6). *Metharpinia floridana* is most characteristic of coarse sands in the higher salinity waters of Tampa Bay. In medium, fine, and very-fine sands ampeliscid amphipods become more important to community structure in salinities >0.5 PSU. Mud-sized sediments generally have the fewest species and lowest densities.

Table 2. Taxonomic inventory of gammaridean Amphipoda collected from Tampa Bay, Florida, 1993-2002.

Ampeliscidae
Ampelisca abdita Mills 1964
Ampelisca agassizi (Judd 1896)
Ampelisca bicarinata Goeke & Heard 1983
Ampelisca holmesi Pearse 1908
Ampelisca vadorum Mills 1963
Ampelisca sp. A of LeCroy 2002
Ampelisca sp. C of LeCroy 2002

Amphilocidae
Apolochus cf. casahoya McKinney 1978
Apolochus sp. A of LeCroy 2002
Apolochus sp. B of LeCroy 2002
Hourstonius laguna

Ampithoidae
Cymadusa compta (Smith 1873)

Aoridae
Bemlos mackinneyi (Myers 1978)
Bemlos setosus (Myers 1978)
Bemlos spinicarpus
Globoslembos smithi (Holmes 1905)
Grandidierella bonnieroides Stephensen 1947
Lembos unifasciatus
Paramicrodeutopus cf. myersi (Bynum & Fox 1977)
Plesiolembos rectangulatus (Myers 1977)
Rudilemboides naglei Bousfield 1973

Table 2. continued.

Argissidae
Argissa hamatipes (Norman 1869)

Bateidae
Batea catharinensis Muller 1865

Corophiidae
Americorophium ellisi (Shoemaker 1943)
Apocorophium louisianum (Shoemaker 1934)
Laticorophium cf. baconi (Shoemaker 1934)
Monocorophium acherusicum (Costa 1851)
Monocorophium tuberculatum (Shoemaker 1934)

Eusiridae
Pontogeneia bartschi Shoemaker 1948

Gammaridae
Gammarus mucronatus Say 1818
Gammarus cf. tigrinus Sexton 1939

Haustoriidae
Acanthohaustorius uncinus Foster 1989
Pseudohaustorius sp.

Hyalidae
Genus undetermined

Isaeidae
Microprotopus raneyi Wigley 1966
Microprotopus shoemakeri Lowry 1972
Photis melanica McKinney 1980
Photis sp. C of LeCroy 2002
Photis sp. E of LeCroy 2002
Photis sp. F of LeCroy 2002

Table 2. continued

Ischyroceridae
Cerapus sp. A of LeCroy
Cerapus sp. C of LeCroy
Cerapus sp. D of LeCroy
Erichthonius brasiliensis (Dana 1853)

Leucothoidae
Leucothoe spinicarpa (Abildgard 1789) complex

Liljeborgiidae
Listriella barnardi Wigley 1966

Lysianassidae
Hippomedon sp. A of LeCroy
Shoemakerella cubensis (Stebbing 1897)

Megaluropidae
Gibberosus myersi (McKinney 1980)

Melitidae
Ceradocus sp.
Duliciella appendiculata (Say 1818)
Dulichiella sp. A of LeCroy 2002
Elasmopus levis (Smith 1873)
E. pocillimanus (Bate 1862)
Maera caroliniana Bynum & Fox 1977
Maera sp. n
Melita elongata Sheridan 1980

Oedicerotidae
Ameroculodes miltoni
Hartmanodes nyei (Shoemaker 1933)
Americhelidium americanum (Bousfield 1973)

Table 2. continued

Phoxocephalidae
Eolbrolgus spinosus (Holmes 1905)
Metharpinia floridana (Shoemaker 1933)
Rhepoxynius epistomus (Shoemaker 1938)
Rhepoxynius sp. A of LeCroy

Platyischnopidae
Eudevenopus honduranus Thomas & Barnard 1983

Podoceridae
Podocerus brasiliensis (Dana 1853)

Psammogammaridae
Psammogammarus sp.

Stenothoidae
Parametopella texensis McKinney, Kalke & Holland 1978
Stenothoe gallensis Walker 1904
Stenothoe georgiana Bynum & Fox 1977
Stenothoe minuta Holmes 1905
Stenothoe sp. A of LeCroy

Synopiidae
Metatiron triocellatus (Goeke 1982)
Metatiron tropakis (Barnard 1972)

Table 3. Ranked percent occurrence of gammaridean amphipods (in >2.5% of samples) in the Tampa Bay estuarine system, Tampa Bay proper, and tributaries to Tampa Bay, 1993-2002.

TAMPA BAY ESTUARY	% OCC	TAMPA BAY PROPER	% OCC	TRIBUTARIES	% OCC
Ampelisca holmesi	46.6	*A. holmesi*	47.6	*G. bonnieroides*	50.5
Listriella barnardi	34.5	*L. barnardi*	44.9	*A. abdita*	47.4
A. abdita	26.7	*Ampelisca sp. C*	32.6	*A. holmesi*	44.1
Ampelisca sp. C	25.7	*M. floridana*	26.2	*A. vadorum*	14.1
Grandidierella bonnieroides	20.4	*E. honduranus*	24.8	*A. louisianum*	12.3
Eudevenopus honduranus	19.9	*R. naglei*	23.8	*Cerapus spp.*	9.4
Rudilemboides naglei	20.2	*A. abdita*	19.2	*L. barnardi*	7.5
Metharpinia floridana	19.5	*A. vadorum*	15.6	*E. honduranus*	5.1
A. vadorum	14.1	*A. uncinus*	13.6	*Ampelisca sp. C*	4.8
Cerapus spp.	12.1	*Cerapus spp.*	13.6	*R. naglei*	4.5
Acanthohaustorius uncinus	9.8	*E. brasiliensis*	12.9	*Hourstonius laguna*	3.9
Erichthonius brasiliensis	9.5	*S. cubensis*	10.9	*M. elongata*	3.9
Shoemakerella cubensis	7.6	*G. bonnieroides*	10.5	*M. floridana*	3.0
Cymadusa compta	7.5	*C. compta*	10.4	*Gammarus mucronatus*	2.7
Paramicrodeutopus cf. myersi	6.9	*P. cf. myersi*	7.8		
Eobrolgus spinosus	4.7	*Ampelisca sp. A*	6.2		
Ampelisca sp. A	4.5	*E. levis*	6.0		
Elasmopus levis	4.4	*B. catharinensis*	5.6		
Batea catharinensis	4.2	*E. spinosus*	5.5		
Hartmanodes nyei	4.1	*H. nyei*	4.5		
Apocorophium louisianum	3.8	*A. agassizi*	3.5		
Melita elongata	3.1	*M. elongata*	2.7		
A. agassizi	2.5	*Lembos unifasciatus*	2.7		
		A. bicarinata	2.6		

Table 4. Ranked mean abundance (maximum) of amphipods occurring in ≥2.5% of samples. Tampa Bay estuarine system, Tampa Bay proper, and tributaries to Tampa Bay, 1993-2002.

TAMPA BAY ESTUARY	MEAN (MAXIMUM) NUMBER m^{-2})	TAMPA BAY PROPER	MEAN (MAXIMUM) NUMBER m^{-2})	TRIBUTARIES	MEAN (MAXIMUM) NUMBER m^{-2})
Ampelisca holmesi	247 (63,060)	*A. holmesi*	266 (22,050)	*A. abdita*	377 (63,600)
A. abdita	149 (63,060)	*R. naglei*	203 (17,900)	*A. louisianum*	377 (146,725)
Apocorophium louisianum	136 (146,725)	*M. floridana*	83 (2,075)	*G. bonnieroides*	268 (41,600)
Rudilemboides naglei	131 (17,900)	*A. uncinus*	72 (5,500)	*A. holmesi*	214 (8,400)
Grandidierella bonnieroides	105 (41,600)	*Ampelisca sp. C*	63 (6,950)	*Cerapus spp.*	120 (12,475)
Cerapus spp.	78 (13,750)	*Cerapus spp.*	54 (13,750)	*A. vadorum*	26 (7,600)
Metharpinia floridana	55 (2,075)	*E. honduranus*	59 (2,375)	*M. elongata*	9 (3,550)
Acanthohaustorius uncinus	46 (5,500)	*L. barnardi*	32 (800)	*M. floridana*	5 (950)
Ampelisca sp. C	41 (6,950)	*C. compta*	42 (9,575)	*E. honduranus*	4 (375)
Eudevenopus honduranus	39 (2,375)	*Ampelisca sp. A*	41 (12,500)	*H. laguna*	3 (350)
Cymadusa compta	27 (9,575)	*S. cubensis*	24 (3,400)	*R. naglei*	3 (512)
Ampelisca sp. A	26 (12,500)	*E. brasiliensis*	22 (3,700)	*Ampelisca sp. C*	2 (300)
Listriella barnardi	21 (800)	*A. abdita*	20 (2,900)	*L. barnardi*	2 (175)
A. vadorum	21 (7,600)	*A. vadorum*	17 (2,400)	*Gammarus mucronatus*	1 (200)
Shoemakerella cubensis	16 (3,400)	*E. spinosus*	14 (1,925)		
Erichthonius brasiliensis	15 (3,700)	*G. bonnieroides*	12 (2,525)		
Eobrolgus spinosus	9 (1,925)	*M. elongata*	8 (2,625)		
Melita elongata	9 (3,550)	*E. levis*	7 (1,075)		
Elasmopus levis	5 (1,075)	*B. catharinensis*	6 (1,575)		
Batea catharinensis	4 (1,575)	*P. cf. myersi*	5 (525)		
Paramicrodeutopus cf. myersi	4 (525)	*Lembos unifasciatus*	2 (450)		
Hartmanodes nyei	1 (200)	*A. agassizi*	2 (350)		
A. agassizi	1 (350)	*A. bicarinata*	2 (500)		
		H. nyei	1 (200)		

Table 5. Summary of SIMPER analyses by sediment type within salinity zones: species (ranked) contributing up to 20% of the dissimilarity within habitats (mean numbers m^{-2}).

Tidal Freshwater Habitats (<0.5 PSU)

Coarse sands	Medium sands	Fine sands	Very fine sands	Muds
Grandidierella bonnieroides (327)	*G. bonnieroides* (197)	*G. bonnieroides* (125)	*G. bonnieroides* (25)	*G. bonnieroides* (13)

Oligohaline Habitats (0.5 to 5.0 PSU)

Coarse sands	Medium sands	Fine sands	Very fine sands	Muds
G. bonnieroides (375) *Ampelisca holmesi* (29)	*G. bonnieroides* (1,474) *Ampelisca abdita* (37) *Apocorophium louisianum* (57)	*G. bonnieroides* (286) *A. abdita* (1,292) *A. holmesi* (10) *A. louisianum* (13)	*G. bonnieroides* (8)	EMPTY

Low Mesohaline Habitats (5.0 to 12.0 PSU)

Coarse sands	Medium sands	Fine sands	Very fine sands	Muds
G. bonnieroides (45)	*G. bonnieroides* (2,063) *A. holmesi* (300) *A. abdita* (229) *A. louisianum* (738) *Cerapus spp*. (71)	*A. abdita* (541) *G. bonnieroides* (402) *A. holmesi* (103) *A. louisianum* (52) *Ampelisca vadorum* (15) *Cerapus* spp. (98) *Eudedvenopus honduranus* (2) *Listriella barnardi* (1) *Hourstonius laguna* (2)	*A. abdita* (52) *A. vadorum* (50 *A. holmesi* (13) *G. bonnieroides* (5)	*A. abdita* (13)

Table 5. continued

High Mesohaline Habitats (12.0 to 18.0 PSU)

Coarse sands	Medium sands	Fine sands	Very fine sands	Muds
A. holmesi (340)	*A. holmesi* (648)	*A. abdita* (525)	*A. abdita* (938)	*A. abdita* (80)
Metharpinia floridana (65)	*A. abdita* (950)	*A. holmesi* (231)	*G. bonnieroides* (9)	
L. barnardi (9)	*L. barnardi* (140)	*G. bonnieroides* (179)	*A. holmes* (173)	
	G. bonnieroides (128)	*Cymadusa compta* (35)	*Cerapus* spp. (2)	
	Rudilemboides naglei (26)	*A. vadorum* (16)		
		L. barnardi (12)		
		Cerapus spp. (106)		

Polyhaline Habitats (18.0 to 30.0 PSU)

Coarse sands	Medium sands	Fine sands	Very fine sands	Muds
M. floridana (305)	*A. holmesi* (562)	*A. holmesi* (373)	*A. abdita* (51)	*A. abdita* (51)
Eudevenopus honduranus (213)	*M. floridana (*137)	*A. abdita* (166)	*A. holmesi* (50)	*A. holmesi* (111)
Acanthohaustorius uncinus (350)	*Ampelisca* sp. C (106)	*L. barnardi* (17)	*L. barnardi* (70	*L. barnardi* (3)
	L. barnardi (39)	*Ampelisca* sp. C (33)	*G. bonnieroides* (18)	*A. vadorum* (5)
	R. naglei (469)	*A. vadorum* (24)	*A. vadorum* (17)	*M. elongata* (24)
	E. honduranus (118)	*G. bonnieroides* (50)	*Melita elongata* (35)	*G. bonnieroides* (2)
		Cerapus spp. (100)	*Ampelisca* sp. C (14)	M*onocorophium acherusicum* (1)
		R. naglei (105)	*Cerapus* spp. (8)	*R. naglei* (8)
			R. naglei (5)	*C. compta* (21)
			Elasmopus levis (4)	*Gammarus mucronatus* (1)
			Erichthonius brasiliensis (15)	
			Ampelisca sp. A (2)	
			C. compta (5)	
			Paramicrodeutopus myersi (1)	

Table 5. continued.

Euhaline Habitats (>30.0 PSU)

Coarse sands	Medium sands	Fine sands	Very fine sands	Muds
M. floridana (299)	*L. barnardi* (54)	*L. barnardi* (46)	*C. compta* (107)	*A. vadorum* (25)
A. uncinus (865)	*M. floridana* (620	*A. holmesi* (1240)	*L. barnardi* (13)	
	Ampelisca sp. C (410)	*Ampelisca* sp. C (32)	*E. brasiliensis* (42)	
	A. holmesi (69)	*C. compta* (84)	*A. abdita* (19)	
	E. honduranus (32)	*A. vadorum* (10)	*A. vadorum* (24)	
	E. brasiliensis (64)	*Cerapus* spp. (20)	*E. levis* (270)	
		G. bonnieroides (173)	*A. holmesi* (16)	
			Lembos unifasciatus (7)	
			P. myersi (2)	
			G. bonnieroides (11)	
			Bemlos spinicarpus (8)	
			Microprotopus raneyi (2)	

Table 6. Summary of SIMPER analyses by salinity zone within sediment types: species (ranked) contributing up to 20% of the dissimilarity within habitats (mean numbers m^{-2}).

Coarse Sands (<1.7%SC)

Tidal Freshwater	Oligohaline	Low Mesohaline	High Mesohaline	Polyhaline	Euhaline
G. bonnieroides (327)	*G. bonnieroides* (375)	*G. bonnieroides* (45)	*A. holmesi* (340)	*M. floridana* (305)	*M. floridana* (299)
	A. holmesi (29)		*M. floridana* (65)	*E. honduranus* (213)	*A. uncinus* (865)
			L. barnardi (9)	*A. uncinus* (350)	

Medium Sands (≥1.7<4.51 %SC)

Tidal Freshwater	Oligohaline	Low Mesohaline	High Mesohaline	Polyhaline	Euhaline
G. bonnieroides (197)	*G. bonnieroides* (1,474)	*G. bonnieroides* (2,063)	*A. holmesi* (648)	*A. holmesi* (562)	*L. barnardi* (54)
	A. abdita (37)	*A. holmesi* (300)	*A. abdita* (950)	*M. floridana* (137)	*M. floridana* (620
	A. louisianum (57)	*A. abdita* (229)	*L. barnardi* (140)	*Ampelisca* sp. C (106)	*Ampelisca* sp. C (410)
		A. louisianum (738)	*G. bonnieroides* (128)	*L. barnardi* (39)	*A. holmesi* (69)
		Cerapus spp. (71)	*R. naglei* (26)	*R. naglei* (469)	*E. honduranus* (32)
				E. honduranus (118)	*E. brasiliensis* (64)

Fine Sands (≥4.51<11.35 %SC)

Tidal Freshwater	Oligohaline	Low Mesohaline	High Mesohaline	Polyhaline	Euhaline
G. bonnieroides (125)	*G. bonnieroides* (286)	*A. abdita* (541)	*A. abdita* (525)	*A. holmesi* (373)	*L. barnardi* (46)
	A. abdita (1292)	*G. bonnieroides* (402)	*A. holmesi* (231)	*A. abdita* (166)	*A. holmesi* (1,240)
	A. holmesi (10)	*A. holmesi* (103)	*G. bonnieroides* (179)	*L. barnardi* (17)	*Ampelisca* sp. C (32)
	A. louisianum (13)	*A. louisianum* (52)	*C. compta* (35)	*Ampelisca* sp. C (33)	*C. compta* (84)
		A. vadorum (15)	*A. vadorum* (16)	*A. vadorum* (24)	*A. vadorum* (10)
		Cerapus spp. (98)	*L. barnardi* (12)	*G. bonnieroides* (50)	*Cerapus* spp. (20)
		E. honduranus (2)	*Cerapus* spp. (106)	*Cerapus* spp. (100)	*G. bonnieroides* (173)
		L. barnardi (1)		*R. naglei* (105)	
		H. laguna (2)			

Table 6. continued.

Very Fine Sands (≥11.35<25.95 %SC)

Tidal Freshwater	Oligohaline	Low Mesohaline	High Mesohaline	Polyhaline	Euhaline
G. bonnieroides (25)	*G. bonnieroides* (8)	*A. abdita* (52)	*A. abdita* (938)	*A. abdita* (51)	*C. compta* (107)
A. louisianum (9)		*A. vadorum* (50)	*G. bonnieroides* (9)	*A. holmesi* (50)	*L. barnardi* (13)
Cerapus spp. (3)		*A. holmesi* (13)	*A. holmesi* (173)	*L. barnardi* (70	*E. brasiliensis* (42)
		G. bonnieroides (5)	*Cerapus* spp. (2)	*G. bonnieroides* (18)	*A. abdita* (19)
				A. vadorum (17)	*A. vadorum* (24)
				M. elongata (35)	*E. levis* (270)
				Ampelisca sp. C (14)	*A. holmesi* (16)
				Cerapus spp. (8)	*L. unifasciatus* (7)
				R. naglei (5)	*P. myersi* (2)
				E. levis (4)	*G. bonnieroides* (11)
				E. brasiliensis (15)	*B. spinicarpus* (8)
				Ampelisca sp. A (2)	*M. raneyi* (2)
				C. compta (5)	
				P. myersi (1)	

Muds (≥25.95 %SC)

Tidal Freshwater	Oligohaline	Low Mesohaline	High Mesohaline	Polyhaline	Euhaline
G. bonnieroides (13)	EMPTY	*A. abdita* (13)	*A. abdita* (80)	*A. abdita* (51)	*A. vadorum* (25)
				A. holmesi (111)	
				L. barnardi (3)	
				A. vadorum (5)	
				M. elongata (24)	
				G. bonnieroides (2)	
				M. acherusicum (1)	
				R. naglei (8)	
				C. compta (21)	
				Gammarus mucronatus (11)	

Amphipod community structure at stations with SAV

Cymadusa compta, *Erichthonius brasiliensis*, and *A. holmesi*, were the three most abundant species (Table 7) associated with SAV. Eleven species explained >40% of the dissimilarity within this assemblage.

Table 7. Summary of SIMPER analysis explaining up to 40% of the (ranked) similarity within the SAV-associated amphipod assemblages, Tampa Bay, 1993-2002.

Species	Mean number m^{-2}
C. compta	431
A. holmesi	87
Cerapus spp.	57
E. levis	36
E. brasiliensis	133
A. vadorum	19
A. abdita	20
G. bonnieroides	52
S. cubensis	23
R. naglei	8
L. barnardi	9

Taxonomic inventory and habitat characteristics

Ampeliscidae

Ampelisca abdita
(Photograph: http://www.calacademy.org/RESEARCH/izg/SFBay2K/Ampelisca%20abdita.htm)

Ampelisca abdita is most frequently encountered in the bay's tributaries although it has been found throughout the bay (Figure 10). Its "optimal" habitat in Tampa Bay is high mesohaline very fine sands in shallow (<2-m) waters. However, its "tolerance" covers almost a 20 PSU range in salinity and >40% SC range. It is typically found in sediments with a relatively narrow RPD (Table 8). *Ampelisca abdita* is "tolerant" of low DO. The association with the PEL Quotient was significant at *p*=0.12 and *A. abdita* in Tampa Bay may tolerate relatively high levels of sediment contaminants (Table 9) and has been found at PEL Quotients >2.8**.** A second stepwise logistic regression of standardized log transformed concentrations of eight metals and total PAHs showed that cadmium, silver and total PAHs were significantly associated with the presence of *A. abdita* (χ^2=0.001; McFadden's ρ^2=0.02), although tolerance ranges could not be calculated.

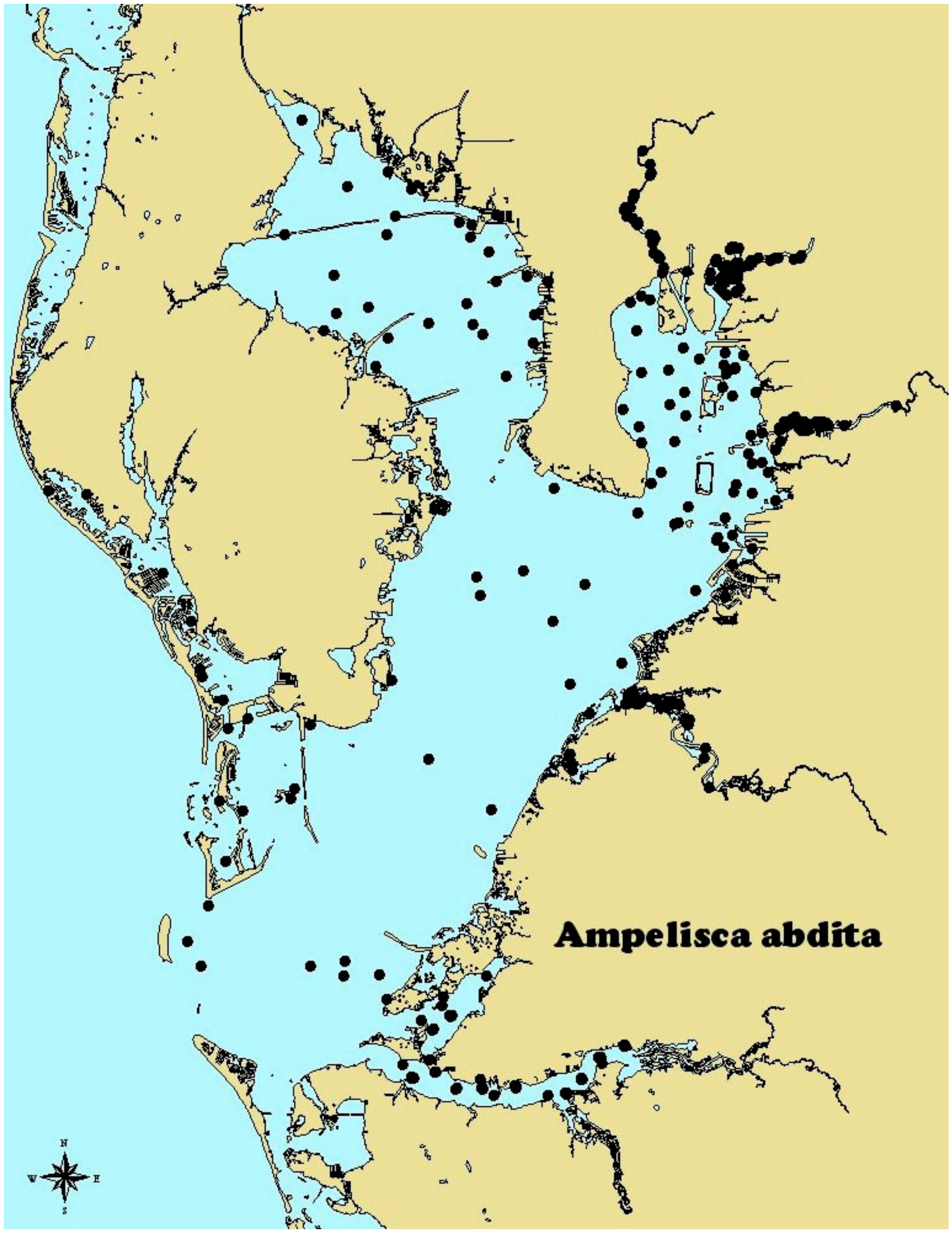


Figure 10. Map depicting the distribution of Ampelisca abdita in Tampa Bay.

Table 8. Summary of Optimum (Tolerance range) habitat characteristics for amphipod species occurring in ≥2.5% of 1628 samples collected from Tampa Bay, Florida, 1993-2002. (= selected as a significant [χ^2 <0.01] variable in forward stepwise logistic regression analysis; * selected as a significant [χ^2 <0.05] variable in univariate logistic regression analysis; NR= Gaussian logistic regression equation could not resolve either an "optimum" or a "tolerance" range).**

	SALINITY (PSU)	%SC	DEPTH (m)	RPD (mm)
AMPELISCIDAE				
Ampelisca abdita	14.4 (4.5-24.2)	15.6* (0.0-43.6)	1.5* (0.0-3.9)	22** (0-64)
A. agassizi	29.2* (26.6-31.8)	2.7* (0.0-6.9)	7.3* (4.4-10.2)	NR
A. bicarinata	30.4* (28.6-32.2)	2.8* (1.1-4.5)	8.1* (8.0-8.2)	25 (21-29)
A. holmesi	21.4* (11.0-31.8)	5.5* (0.1-10.9)	0.5* (0.0-4.4)	43** (14-72)
A. vadorum	24.2* (≥10.0)	7.9 (3.2-12.6)	NR*	40 (24-56)
Ampelisca sp. A	28.9* (24.9-32.9)	4.7* (2.5-6.9)	6.9* (4.3-9.5)	NR
Ampelisca sp. C	29.4* (24.0-34.8)	2.7* (0.0-6.9)	5.1* (2.8-7.4)	>100**
AMPHILOCHIDAE				
Hourstonius laguna	12.8 (4.5-21.1)	4.6 (1.8-7.4)	NR*	18 (18-18)
AMPITHOIDAE				
Cymadusa compta	NR*	9.0 (3.4-14.6)	0.6* (0.3-0.9)	NR
AORIDAE				
Grandidierella bonnieroides	0.0*	10.6* (0.2-20.6)	0.0* (0.0-3.1)	21 (0-65)
Lembos unifasciatus	30.6 (28.2-32.8)	11.4 (7.0-17.8)	NR	7** (1-13)
Paramicrodeutopus cf. myersi	>36.0* (≥27.5)	4.6* (1.6-7.6)	4.0* (1.6-6.4)	NR**
Rudilemboides naglei	24.4 (18.8-30.0)	2.1 (0.0-4.8)	3.1 (1.0-5.2)	71** (≥33)
BATEIDAE				
Batea catharinensis	>36.0*	NR*	13.3 (≥5.9)	87** (≥54)
COROPHIIDAE				
Apocorophium louisianum	6.6* (2.0-11.2)	10.2 (0.0-24.6)	0.6* (0.6-1.2)	29 (0-58)
GAMMARIDAE				
Gammarus mucronatus	19.9* (13.3-26.5)	3.4 (1.8-5.0)	0.6* (0.2-1.0)	29 (9-49)
HAUSTORIIDAE				
Acanthohaustorius uncinus	>36.0* (≥25.6)	1.3* (0.6-1.9)	2.2* (1.0-3.4)	81** (≥39)
ISCHYROCERIDAE				
Cerapus spp.	35.1* (≥28.4)	4.9 (0.0-10.9)	2.2* (0.0-6.8)	69** (≥20)
Erichthonius brasiliensis	>36.0*	2.4* (0.0-11.2)	4.9 (0.0-10.9)	NR**
LILJEBORGIIDAE				
Listriella barnardi	>36.0* (≥24.7)	NR*	4.8* (1.7-7.9)	95** (≥77)

Table 8. continued.

	SALINITY (PSU)	%SC	DEPTH (m)	RPD (mm)
LYSIANASSIDAE				
Shoemakerella cubensis	22.4* (17.1-27.7)	3.2* (0.1-6.3)	3.5 (1.1-5.9)	59** (15-95)
MELITIDAE				
Elasmopus levis	>36.0* (≥31.2)	6.6 (0.0-17.3)	NR*	NR
Melita elongata	27.1 (≥8.9)	28.3 (15.4-41.2)	NR	NR**
OEDICEROTIDAE				
Hartmanodes nyei	25.0* (≥11.7)	2.8 (0.0-6.5)	2.6 (1.3-3.9)	46 (15-77)
PHOXOCEPHALIDAE				
Eobrolgus spinosus	22.6 (19.5-25.7)	3.4* (1.8-5.0)	3.2* (1.4-5.0)	51** (16-86)
Metharpinia floridana	33.5* (≥25.0)	0.0*	6.8* (3.7-9.9)	>100** (≥91)
PLATYISCHNOPIDAE				
Eudevenopus honduranus	>36.0* (≥27.7)	0.0*	3.8* (1.9-5.7)	98** (≥53)

Table 9. Summary of ecological stressor variables for amphipod species occurring in $\geq$2.5% of 1,628 samples collected from Tampa Bay, Florida, 1993-2002: Optimum (Tolerance). (= selected as a significant ($\chi^2 \leq 0.01$) variable in logistic regression analyses; * =selected as a significant [$\chi^2 < 0.05$] variable in univariate logistic regression analysis; NR= Gaussian logistic regression equation could not resolve either an "optimum" or a "tolerance" range; NA= not applicable, epifaunal on SAV, hydroids, etc.).**

	DISSOLVED OXYGEN	PEL QUOTIENT
AMPELISCIDAE		
Ampelisca abdita	2.9* (0.1-5.7)	2.6 (0.4-2.8)
A. agassizi	6.0* (4.7-7.3)	0.00
A. bicarinata	5.2* (4.9-5.5)	0.05 (0.00-0.12)
A. holmesi	8.8* (3.8-13.8)	NR*
A. vadorum	4.0* (1.9-6.1)	0.06* (0.03-.09)
Ampelisca sp. A	5.4* (3.6-6.4)	0.06 (0.00-0.13)
Ampelisca sp. C	6.0* (4.7-7.3)	0.04 (0.00-0.09)
AMPHILOCHIDAE		
Hourstonius laguna	3.3 (2.8-3.8)	0.86 (0.47-1.26)
AMPITHOIDAE		
Cymadusa compta	NR*	NA
AORIDAE		
Grandidierella bonnieroides	NR	>3.0*
Lembos unifasciatus	7.4 (6.8-8.0)	NR
Paramicrodeutopus cf. myersi	7.0* (5.2-8.8)	0.04 (0.01-0.07)
Rudilemboides naglei	8.3* (5.1-11.5)	0.02* (0.00-0.09)
BATEIDAE		
Batea catharinensis	6.6 (5.2-8.0)	0.02 (0.00-0.08)
COROPHIIDAE		
Apocorophium louisianum	3.1* (1.9-4.3)	0.13 (0.00-0.26)
GAMMARIDAE		
Gammarus mucronatus	3.2 (2.7-3.7)	0.11 (0.05-0.16)
HAUSTORIIDAE		
Acanthohaustorius uncinus	7.2* (5.5-8.9)	0.00
	DISSOLVED OXYGEN	**PEL QUOTIENT**
ISCHYROCERIDAE		
Cerapus spp.	11.0* (5.9-14.0)	0.05* (0.00-0.09)
Erichthonius brasiliensis	8.1* (5.5-10.7)	NA
LILJEBORGIIDAE		
Listriella barnardi	7.2 (4.4-10.0)	0.03* (0.00-0.07)

Table 9. continued.

	DISSOLVED OXYGEN	PEL QUOTIENT
LYSIANASSIDAE		
Shoemakerella cubensis	10.5 (7.1-13.9)	0.04* (0.00-0.11)
MELITIDAE		
Elasmopus levis	8.6* (6.6-10.6)	0.00 (NR)
Melita elongata	NR	1.12 (0.54-1.69)
OEDICEROTIDAE		
Hartmanodes nyei	5.8* (4.0-7.6)	NR
PHOXOCEPHALIDAE		
Eobrolgus spinosus	8.2* (5.5-10.9)	0.06* (0.00-0.11)
Metharpinia floridana	6.1* (5.0-7.1)	0.00*
PLATYISCHNOPIDAE		
Eudevenopus honduranus	6.7* (5.1-8.3)	0.05* (0.00-0.14)

Ampelisca agassizi was most often found in the deeper, central portions of Tampa Bay (Figure 11). The optimal habitat is polyhaline medium sands in relatively deep water (Table 8). *Ampelisca agassizi* appears sensitive to low DO and sediment contaminants (Table 9).

Ampelisca bicarinata is found in the lower and middle portions of Tampa Bay (Figure 12). The optimal habitat is euhaline medium sands in relatively deep water (Table 8) and the preferred habitat variables occupy the narrowest ranges of the Ampeliscidae. *Ampelisca bicarinata* appears sensitive to low DO and sediment contaminants (Table 9).

Ampelisca holmesi (Photograph: C. Holden)

Ampelisca holmesi is the most widespread amphipod in Tampa Bay (Figure 13). The optimal habitat is very shallow polyhaline fine sands, although its tolerance range for salinity is >20 PSU (Table 8). With respect to ecological stressors, *A. holmesi* appears to somewhat tolerant (Table 9). Approximately 10% of its occurrences were from hypoxic sites and approximately 40% of its occurrences were at PEL Quotients >0.05.

Ampelisca vadorum is a common inhabitant of the mouths of the tributaries to the bay although it is widely distributed (Figure 14). The optimal habitat is polyhaline very fine sands and it tolerates salinities as low as 10 PSU (Table 8). *Ampelisca vadorum* appears to be relatively tolerant of subnominal DO but is sensitive to sediment contaminants (Table 9).

Ampelisca sp. A was most often collected from lower Hillsborough Bay and Middle Tampa Bay (Figure 15). The optimal habitat is relatively deep polyhaline fine sands (Table 8). The preferred habitat variables encompass a very small range for %SC. *Ampelisca* sp. A appears to be sensitive to low DO but may tolerate moderately degraded (PEL Quotient >0.05) sediments (Table 9).

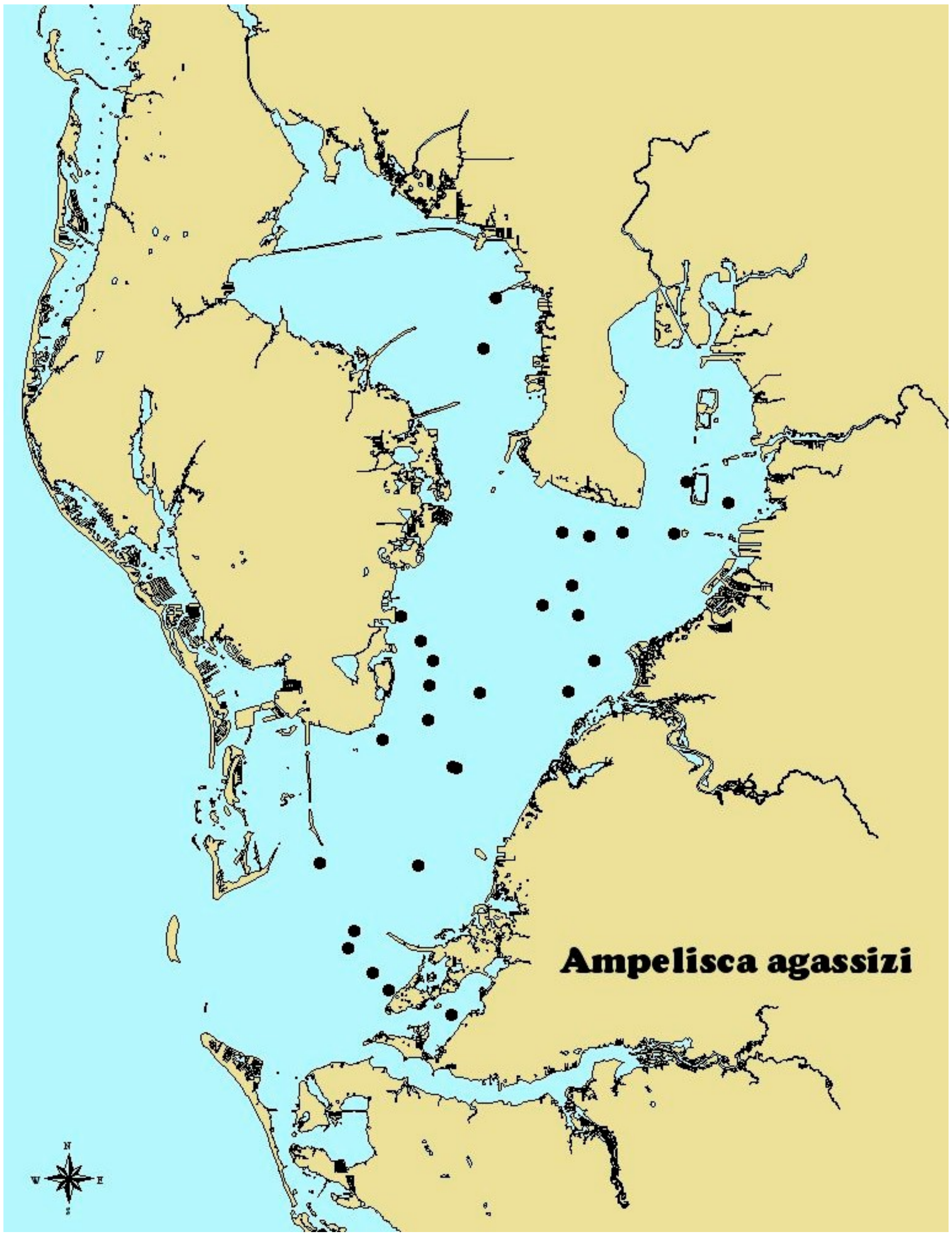


Figure 11. Map depicting the distribution of Ampelisca agassizi in Tampa Bay, Florida.

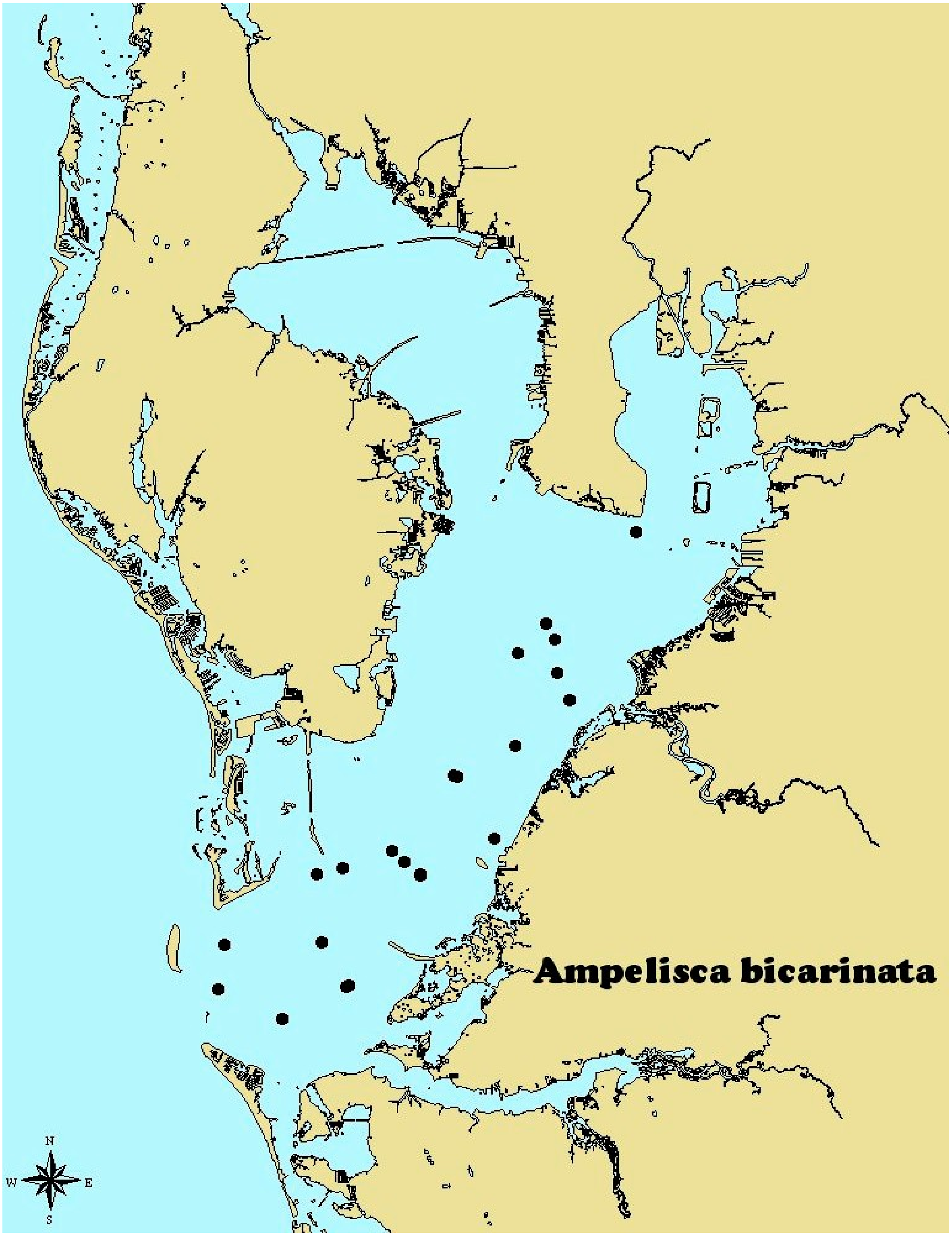


Figure 12. Map depicting the distribution of Ampelisca bicarinata in Tampa Bay, Florida.

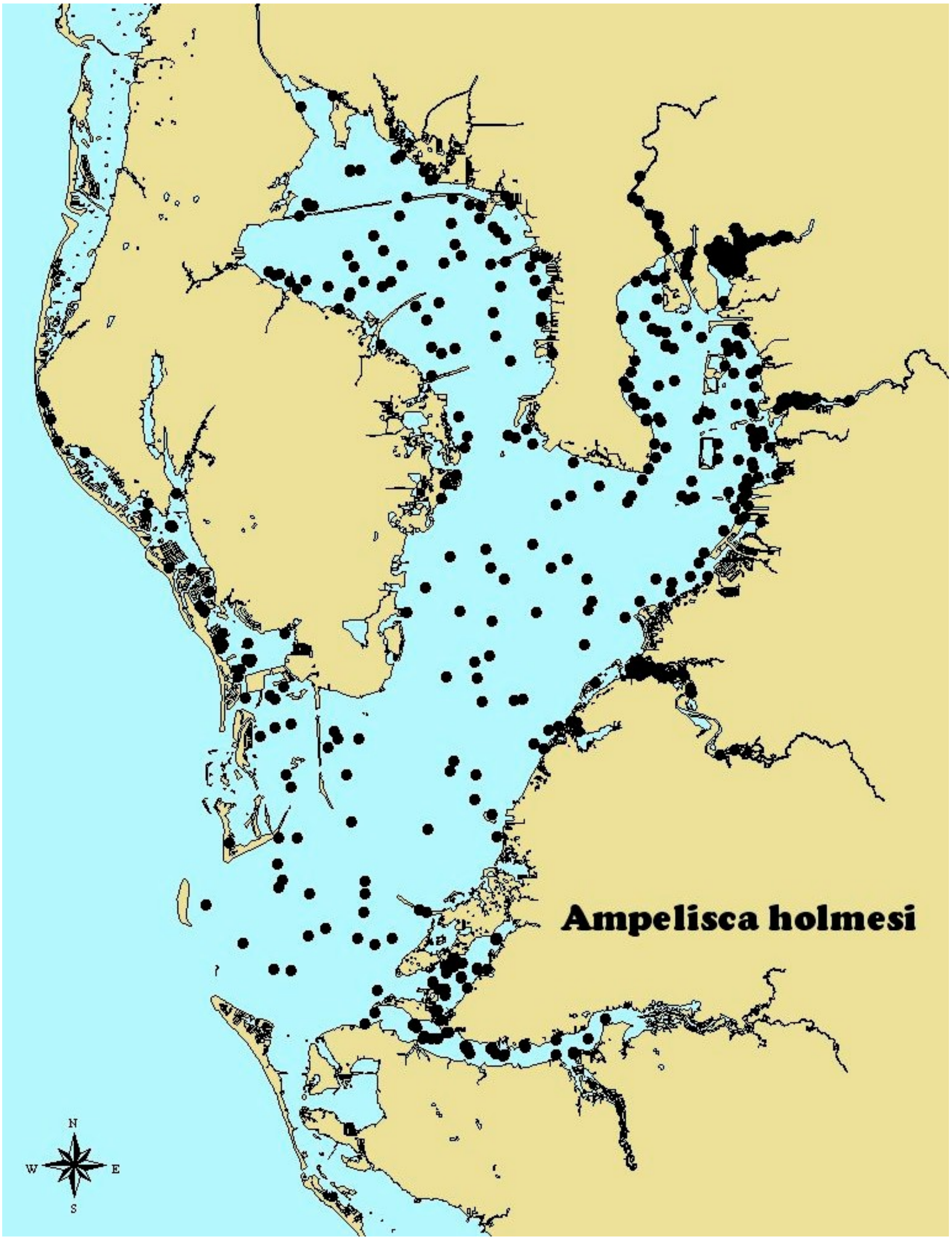


Figure 13. Map depicting the distribution of Ampelisca holmesi in Tampa Bay, Florida.

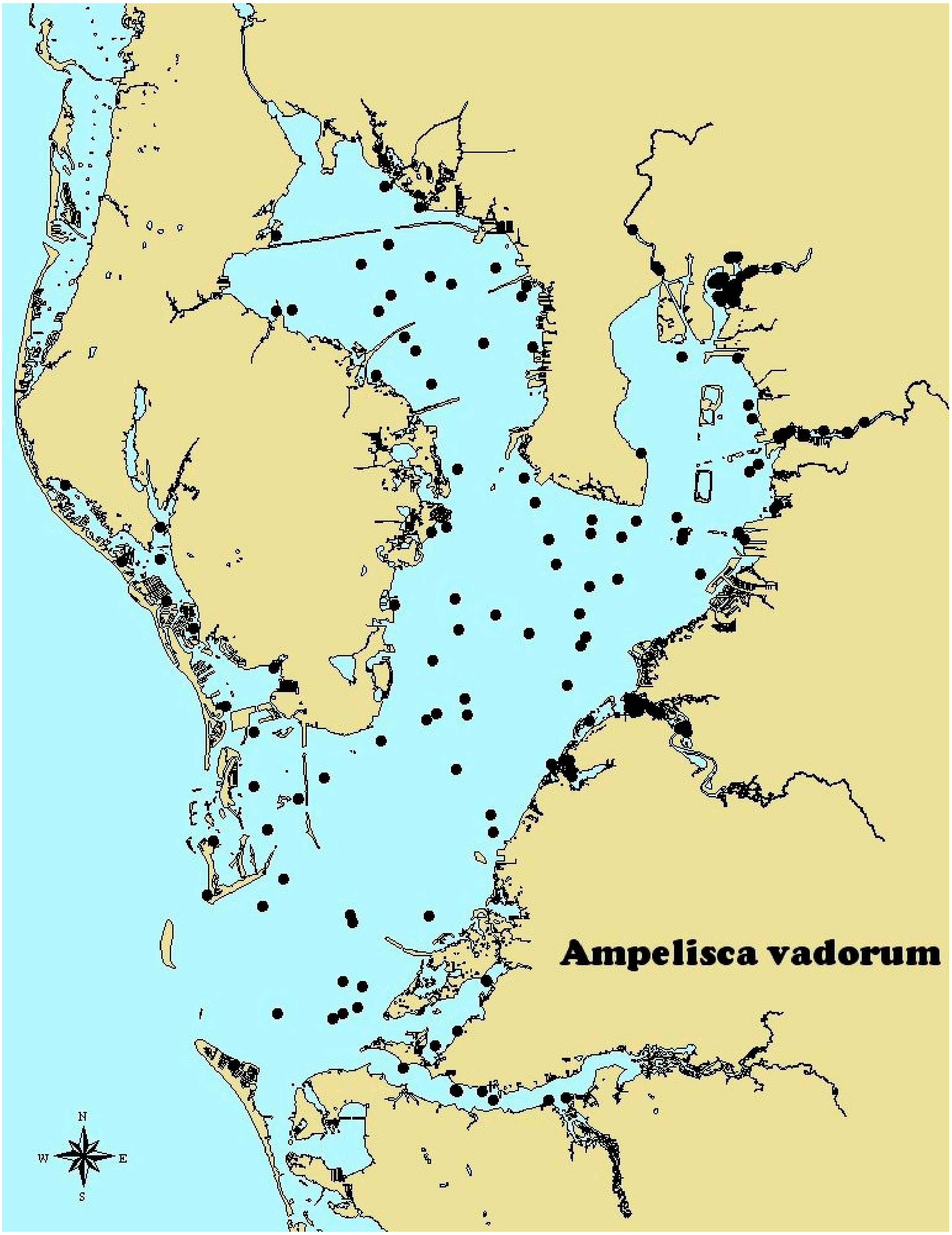


Figure 14. Map depicting the distribution of Ampelisca vadorum in Tampa Bay, Florida.

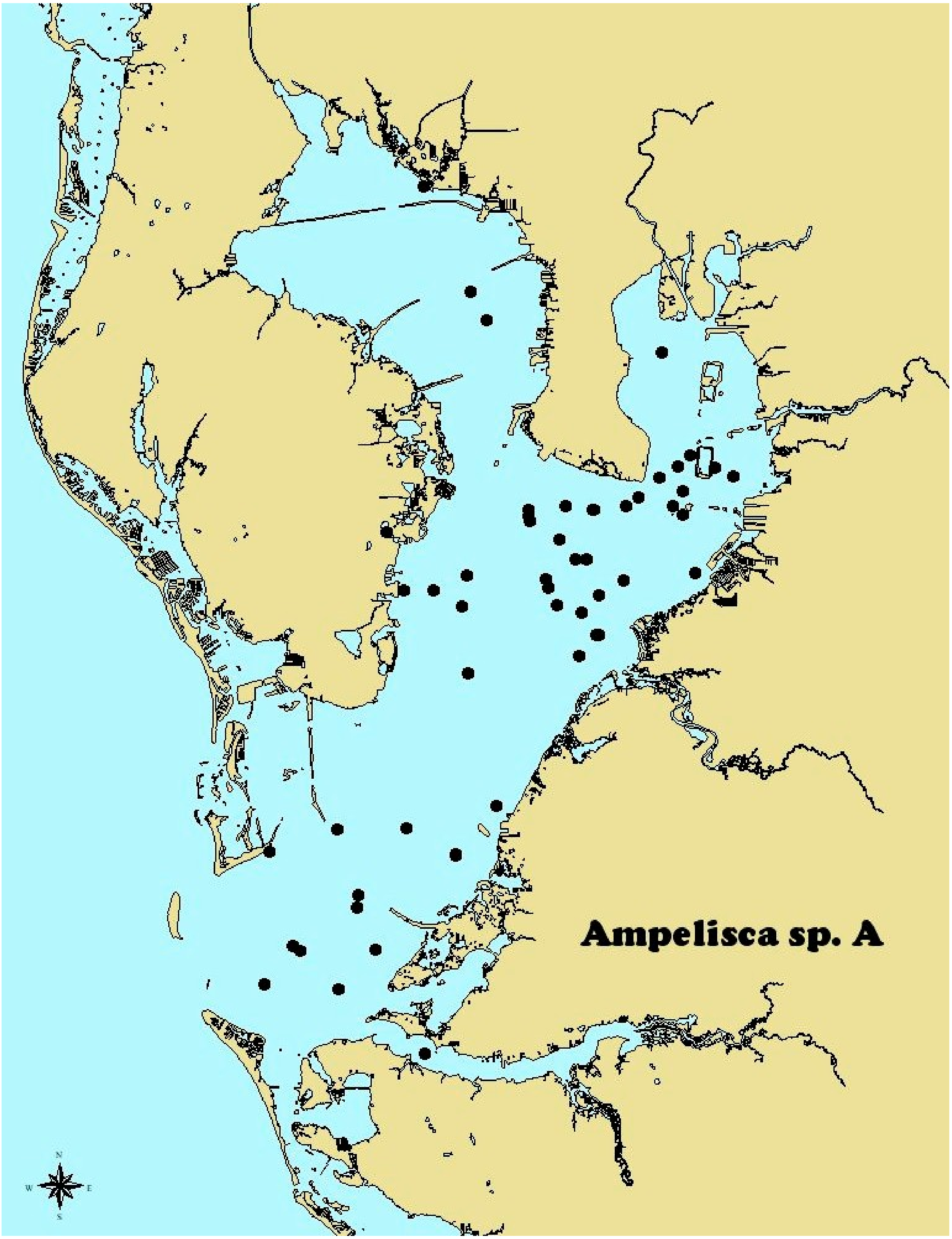


Figure 15. Map depicting the distribution of Ampelisca sp. A in Tampa Bay, Florida.

Ampelisca sp. C was widespread throughout most of Tampa Bay proper, excluding much of Hillsborough Bay and upper Old Tampa Bay; it was notably rare in the tributaries (Figure 16). The optimal habitats were polyhaline to euhaline salinities and medium sands (Table 8); it preferred depths above average for the bay and well oxygenated sediments, based upon the association with the apparent RPD. *Ampelisca* sp. C appeared to be the most sensitive of the ampeliscids to the two ecological stressors (Table 9).

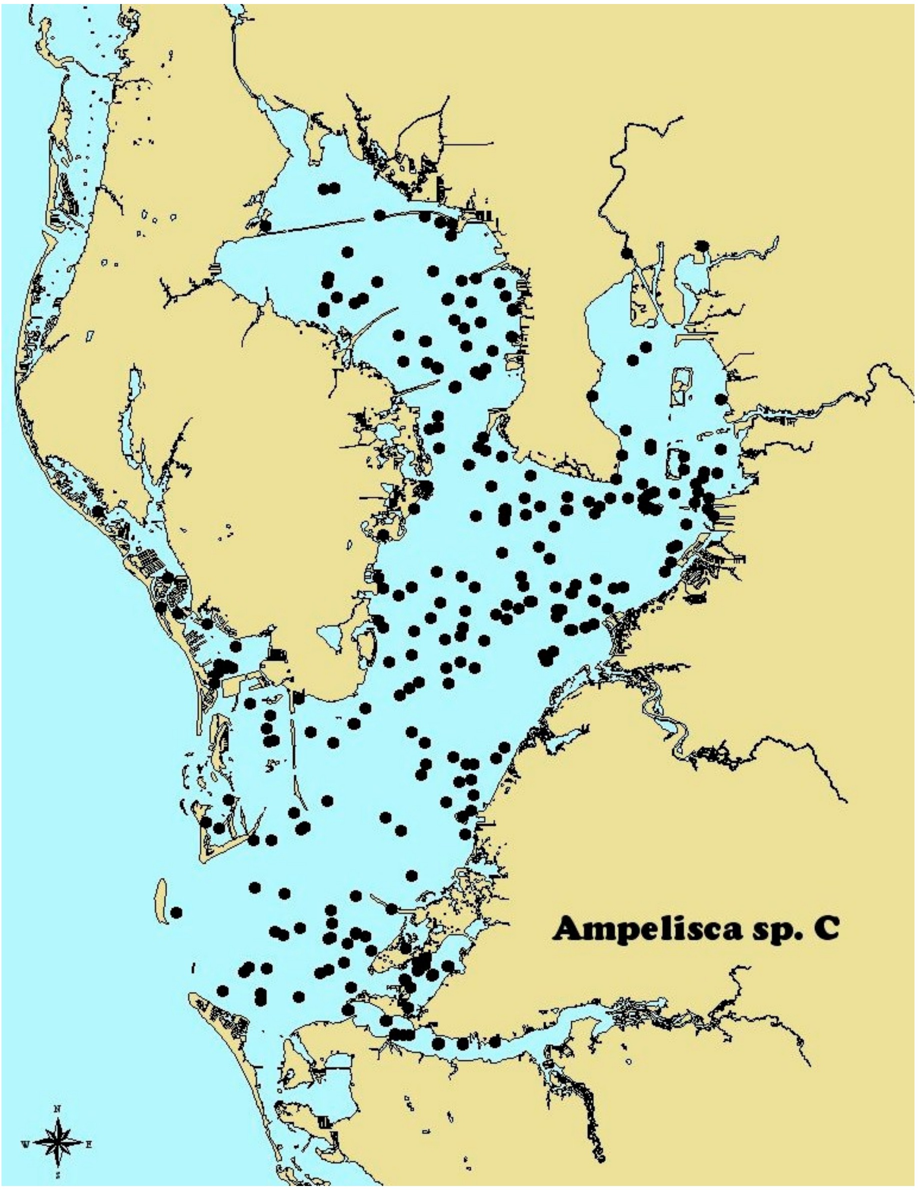


Figure 16. Map depicting the distribution of Ampelisca sp. C in Tampa Bay, Florida.

Amphilochidae

Apolochus cf. casahoya occurred in two samples from Lower Tampa Bay and the Manatee River. The abiotic data at the sites were: salinity= 10.4 to 31.0 PSU; %SC= 3.0; depth= 1.0-m; DO=5.3 to 5.6 ppm.

Apolochus sp. B occurred in 16 samples and was generally confined to the lower portions of the bay (Lower Tampa Bay and Boca Ciega Bay). This species was collected at 16.3 to 33.5 PSU salinity, 1.1 to 13.9 %SC, depths of 0.1 to 12.2 m, and DO of 2.6 to 8.9 ppm.

Hourstonius laguna was most frequently (10 of 19 occurrences) collected near the mouth of the Little Manatee River (Figure 17). The "optimal" habitat was mesohaline fine sands, although the regression equations were not significant (Table 8).

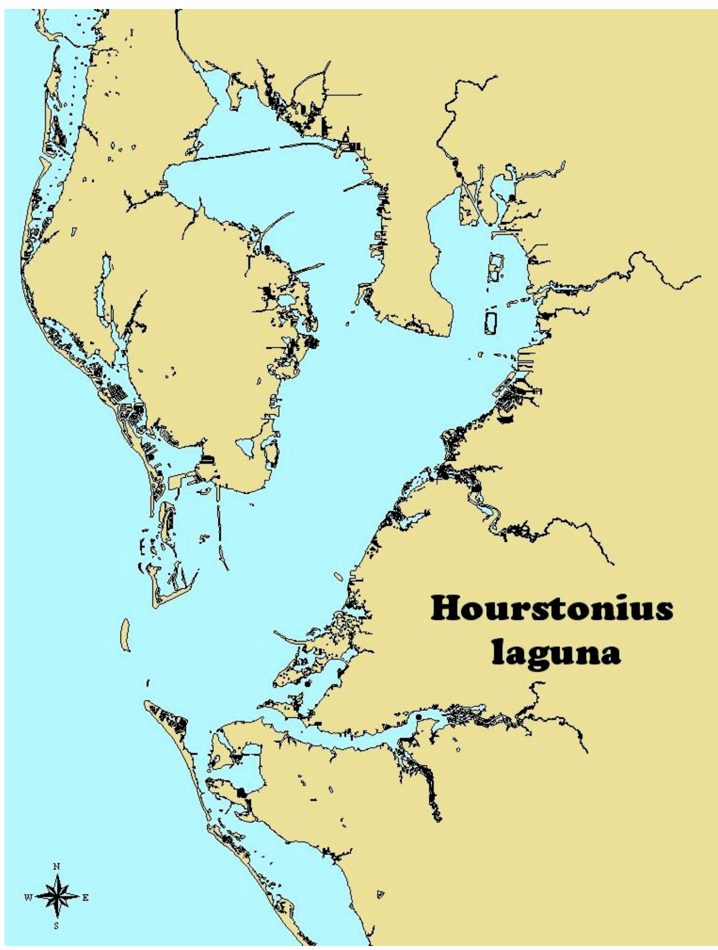


Figure 17. Map depicting the distribution of Hourstonius laguna in Tampa Bay, Florida.

Ampithoidae

Cymadusa compta
(Photograph: C. Holden)

Cymadusa compta, a tube builder (Feeley and Wass 1971), was primarily collected in peripheral areas of the middle and lower bay (Figure 18). Although *C. compta* occurred over a range of 10.4 to 34.1 PSU (mean=26.9), an optimal salinity could not be estimated. The preferred depths were <1-m. (Table 8). SAV was present at 62 of the 94 sites that *C. compta* was collected. All four species found in Tampa Bay were represented. *Cymadusa compta* appears to be sensitive to low DO (Table 9). Although an optimum DO could not be calculated, the median DO for occurrences was 6.4 ppm and the minimum DO was 2.6 ppm.

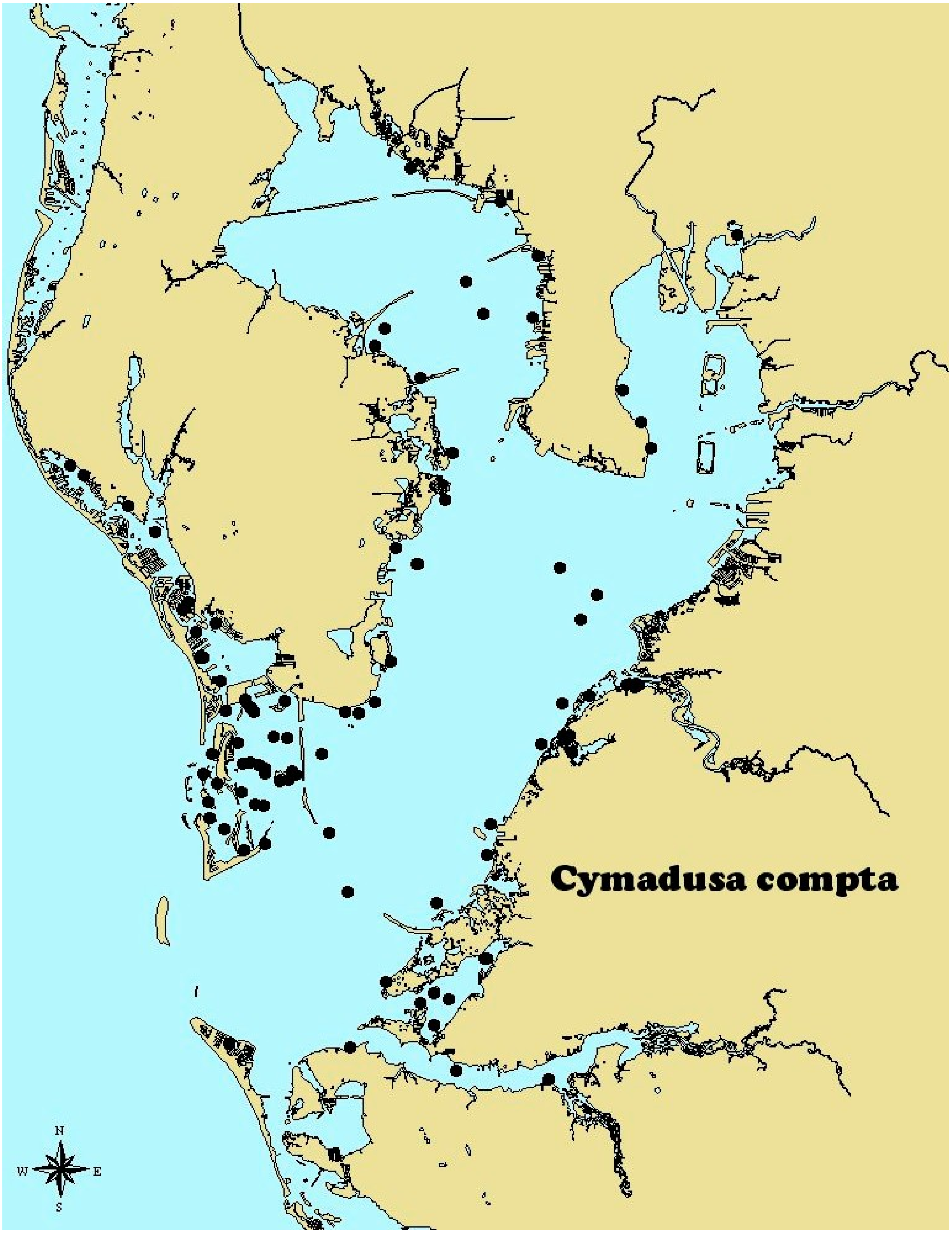


Figure 18. Map depicting the distribution of Cymadusa compta in Tampa Bay, Florida.

Aoridae

Bemlos mackinneyi was identified in five samples from Lower and Middle Tampa Bay and the Manatee River. It was found at salinities ranging from 18.9-32.8 PSU, sediments of 1.7 to 5.3 %SC, at depths of 0.9 to 5.3-m, and DO of 4.8 to 7.4 ppm.

Bemlos setosus was identified in five samples, three from Boca Ciega Bay. It was found at salinities ranging from 24.1 to 31.2 PSU, sediments of 2.2 to 4.6 %SC, at depths of 0.1 to 0.9-m, and at DO from 4.2 to 12.7 ppm.

Bemlos spinicarpus was identified in 17 samples, six from Boca Ciega Bay and three each in Lower Tampa Bay and Old Tampa Bay. It was collected at salinities ranging from 16.1-33.0 PSU, sediments of 1.8-17.1 %SC, and at depths of 0.2 to 4.6-m. It was only found in well oxygenated (4.4 to 7.5 ppm) waters.

Globosolembos smithi was identified in 11 samples, primarily from the lower bay (Lower Tampa Bay, Boca Ciega Bay, Terra Ceia Bay, and Manatee River). It was collected at salinities ranging from 17.3 to 32.8 PSU, sediments of 1.1 to 13.5 %SC, at depths of 0.4 to 5.0-m, and at DO of 3.8 to 8.1 ppm.

Grandidierella bonnieroides (Photograph: C. Holden)

Grandidierella bonnieroides was characteristic of the tributaries to Tampa Bay, and especially of the lower salinity zones (Figure 19). The "optimal" habitat was tidal freshwater fine sands (Table 8). Its preferred depths ranged to >3-m. It was among the more tolerant species to the two ecological stressors. Although a preferred range for DO could not be calculated, *G. bonnieroides* was collected at DO ranging from <0.1 to 12.5 ppm, with a median DO of 4.6 ppm. Logistic regression suggested that the "optimal" PEL Quotient was >3 (Table 9). A second stepwise logistic regression of standardized log transformed concentrations of eight metals and total PAHs showed that chromium, copper, and total PAHs were significantly associated with the presence of *G. bonnieroides* (χ^2<0.001; McFadden's ρ^2=0.05).

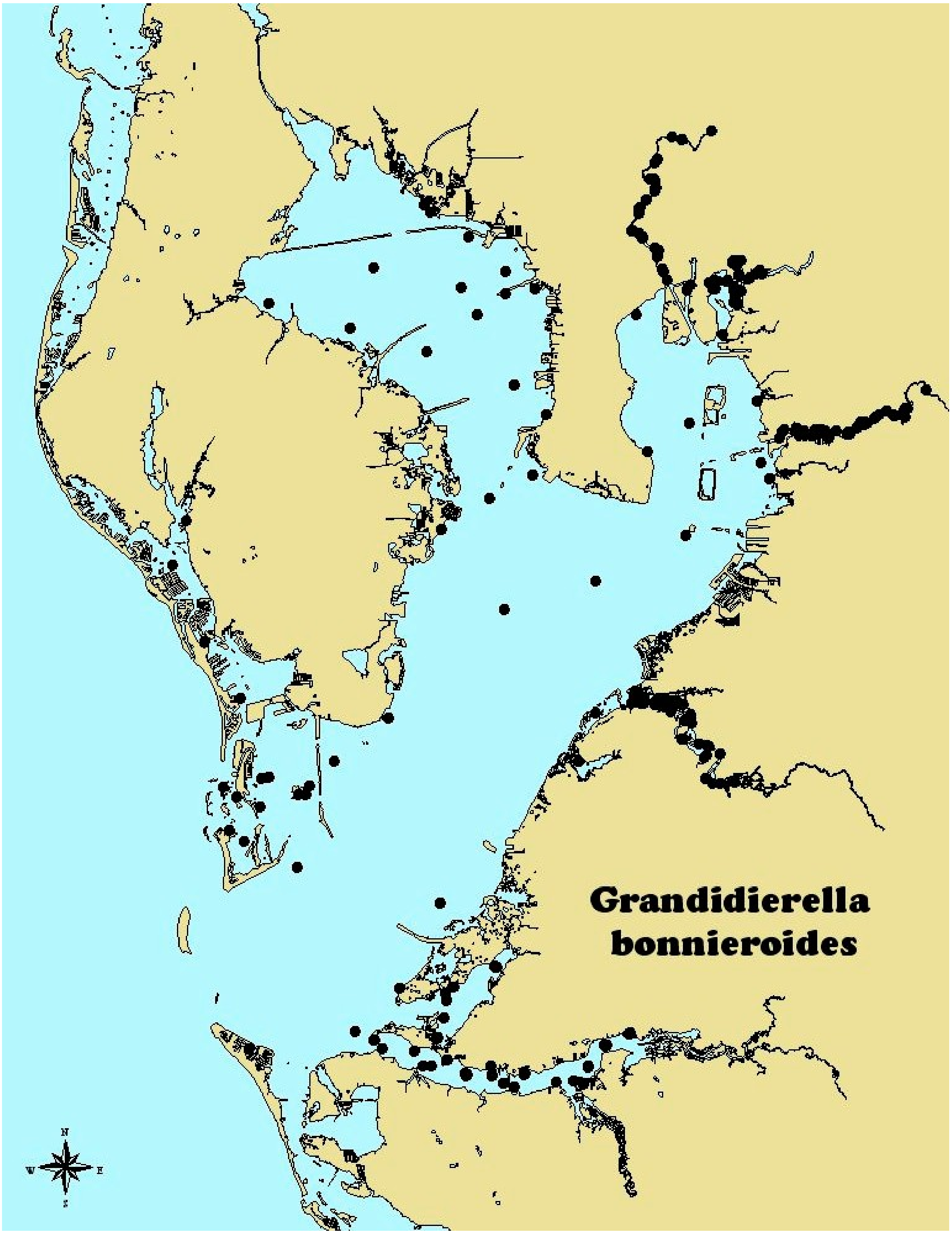


Figure 19. Map depicting the distribution of Grandidierella bonnieroides in Tampa Bay, Florida.

Lembos unifasciatus was generally collected in Boca Ciega Bay (Figure 20), although its greatest density (450 m^{-2}) was found in its only occurrence in Hillsborough Bay. Its preferred habitat was euhaline fine sands (Table 8). *Lembos unifasciatus* was collected at depths to 12-m and its median depth of occurrence was 1.2-m; an "optimal" depth could not, however, be calculated. This species was only found in well oxygenated waters (Table 9). It occurred at PEL Quotients up to 0.19, and the median PEL quotient of its occurrence was 0.03.

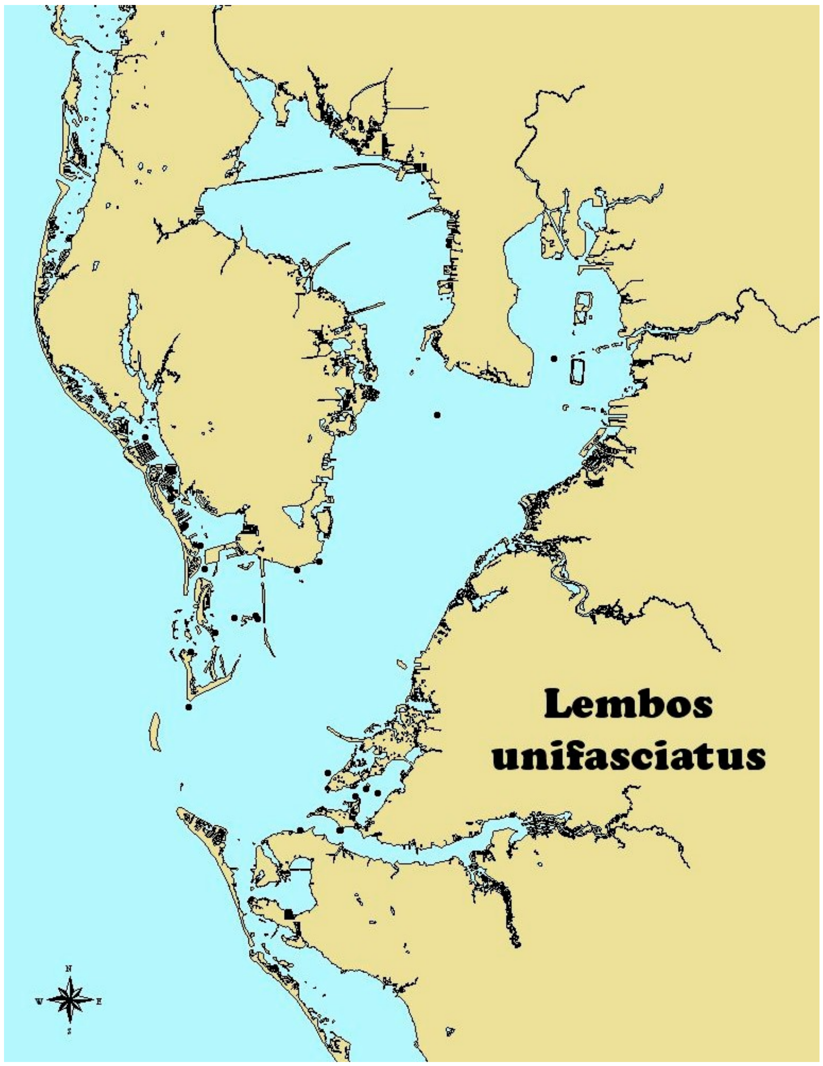


Figure 20. Map depicting the distribution of Lembos unifasciatus in Tampa Bay, Florida.

Paramicrodeutopus cf. Myersi is widely distributed in Tampa Bay (Figure 21). The preferred habitats are polyhaline-euhaline salinities and coarse to fine sands (Table 8). This species is sensitive to DO and sediment contaminants (Table 9).

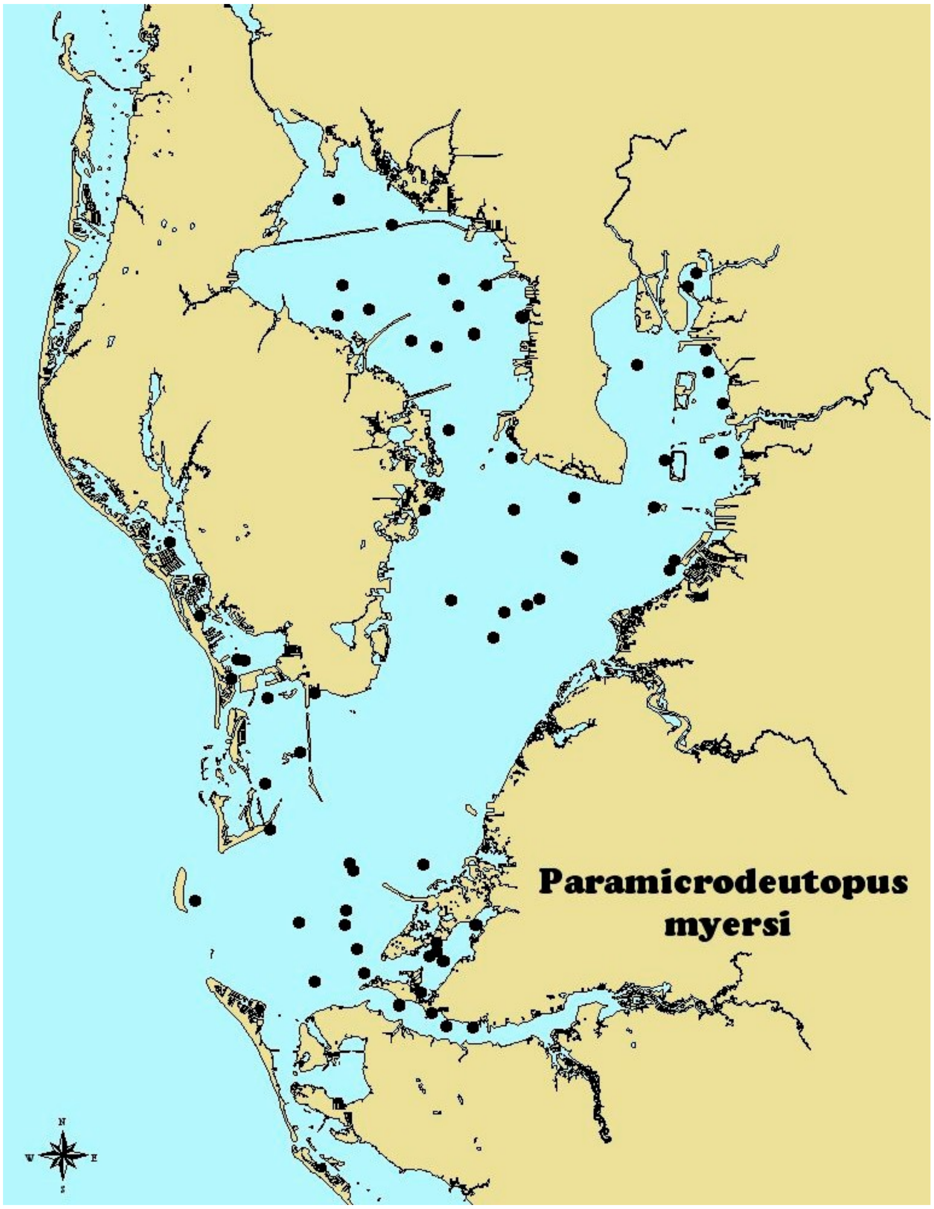


Figure 21. Map depicting the distribution of Paramicrodeutopus cf. myersi in Tampa Bay, Florida.

Plesiolembos rectangulatus was collected at five locations, four in the lower bay. Salinities ranged from 10.8 to 31.9 PSU, sediments ranged from 2.4 to 12.1 %SC, sample depths ranged from 0.6 to 6-m, and DO ranged from 5.1 to 8.1 ppm.

Rudilemboides naglei
(Photograph: C. Holden)

Rudilemboides naglei was widespread in the upper and middle portions of Tampa Bay (Figure 22). The optimal habitats included polyhaline coarse to fine sands (Table 8). *Rudilemboides naglei* preferred oxygenated sediments (optimal RPD>50 mm; Table 8) and this species appeared to be sensitive to both low DO and sediment contaminants (Table 9).

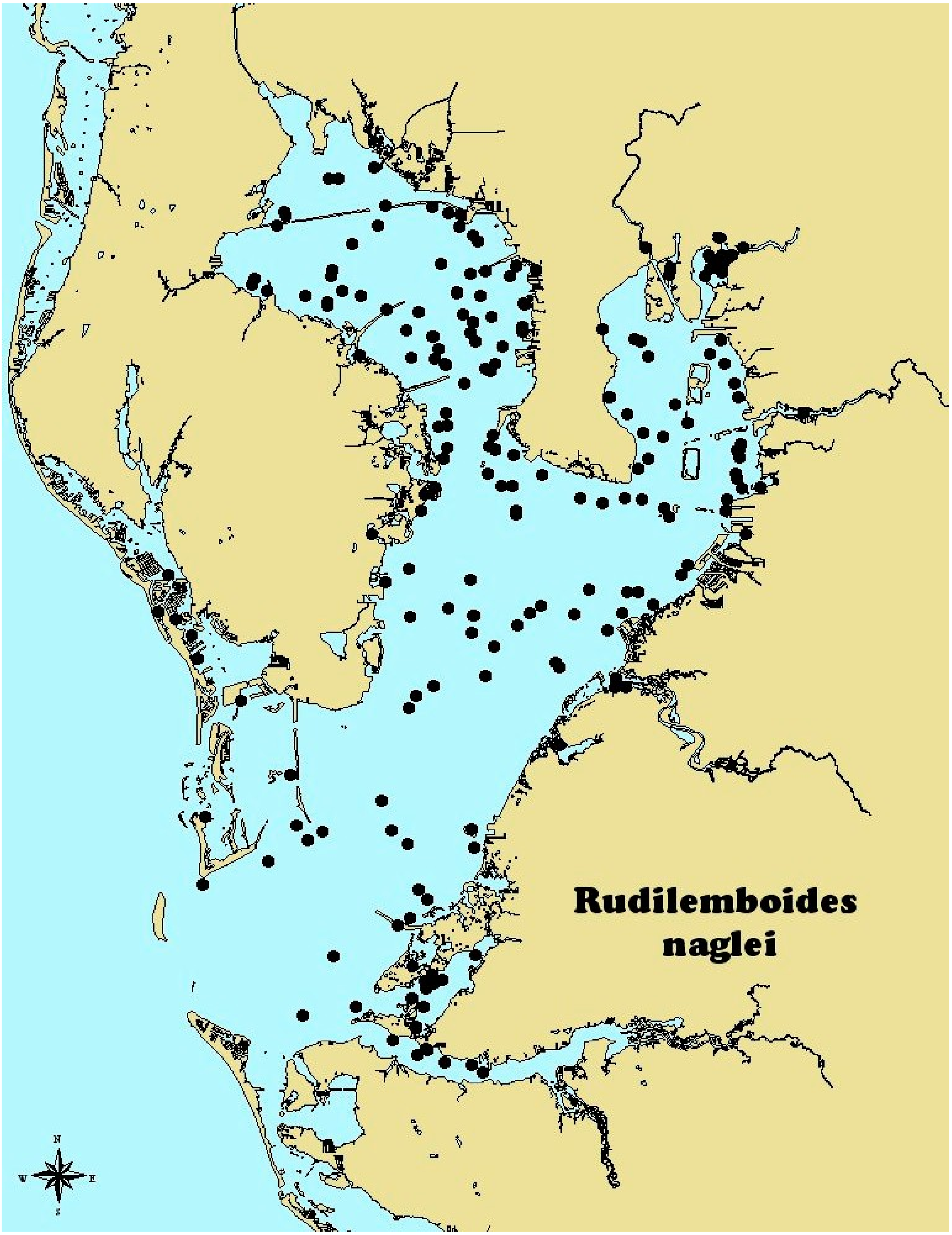


Figure 22. Map depicting the distribution of Rudilemboides naglei in Tampa Bay, Florida.

Argissidae

Argissa hamatipes was found in low ($\leq$50 m^{-2}) numbers in 14 samples, primarily in Middle (7 samples) and Old (5) Tampa bays. It was found at salinities ranging from 16.9-29.7, in sediments of 0.9-8.5 %SC, and at depths of 1.6 to 8.5-m. *Argissa hamatipes* appeared sensitive to DO (range 4.5-6.9 ppm) although somewhat tolerant of at least moderate levels of sediment contamination (PEL Quotients 0.04-0.10).

Bateidae

Batea catharinensis was collected throughout Tampa Bay, although it did not penetrate any of the tributaries (Figure 23). The preferred habitat characteristics could not be resolved with logistic regression. This species was collected over a salinity range of 10.8 to 34.5 PSU, sediments of 0.8 to 13.1 %SC, and over a wide range of depths (Table 8). *Batea catharinensis* appeared to be sensitive to low DO but may tolerate a moderate degree of sediment contamination (Table 9). The tolerance range for the PEL quotient ranged to 0.08 although >30% of the samples *B. catharinensis* was present in had PEL Quotients >0.05.

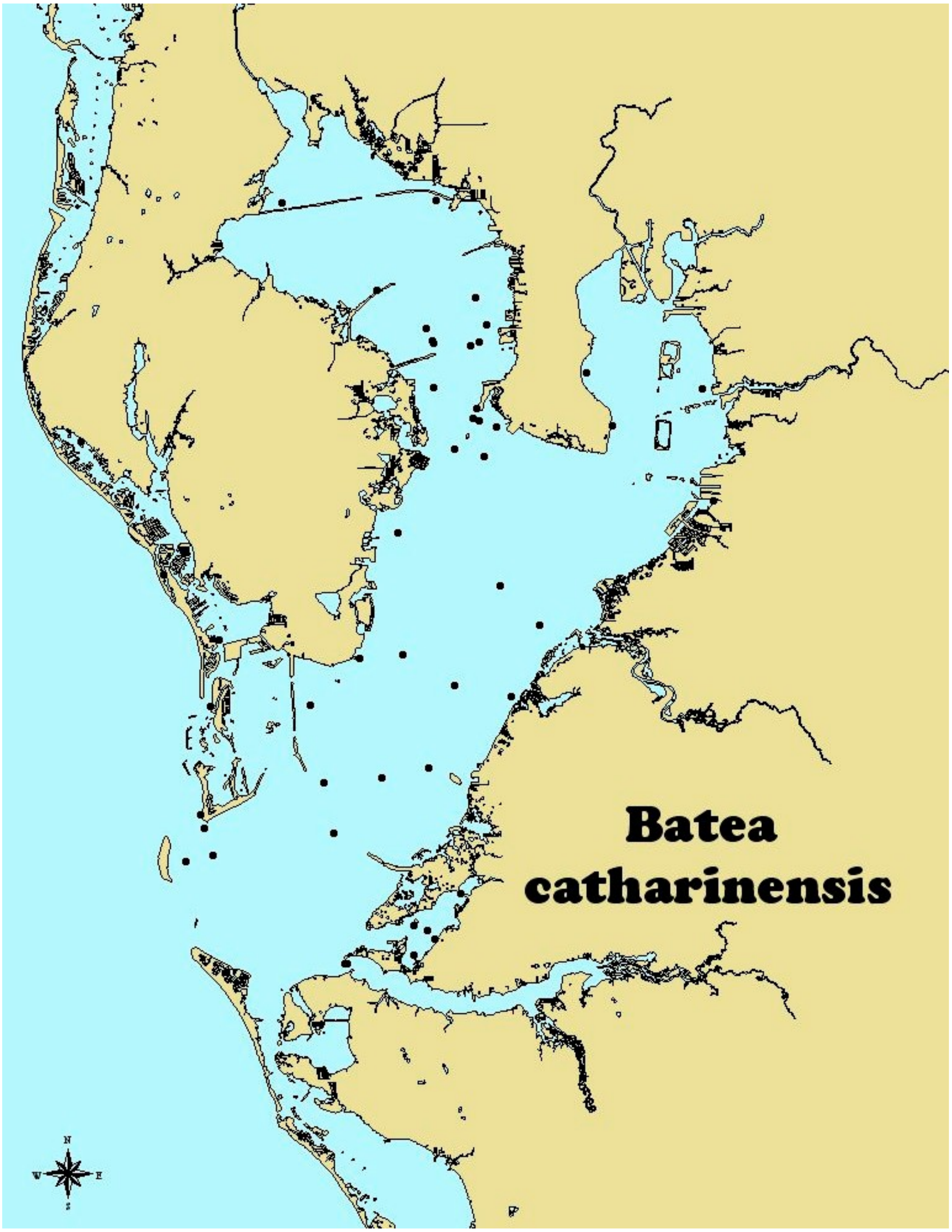


Figure 23. Map depicting the distribution of Batea catharinensis in Tampa Bay, Florida.

Corophiidae

Americorophium ellisi was collected in five samples from Boca Ciega and Old Tampa bays. It was found at salinities ranging from 11.8 to 32.6 PSU and sediments of 2.0 to 11.5 %SC. *Americorophium ellisi* was only collected from shallow sites ($\leq$0.7-m) and appeared to tolerate subnominal DO (range 3.7 to 4.9 ppm).

Apocorophium louisianum was primarily collected in the tributaries, especially the Little Manatee River (Figure 24) where it attained the highest density (>140,000 m^{-2}) of any amphipod in these collections. The preferred habitat was low mesohaline fine sands in shallow waters (Table 8). *Apocorophium louisianum* appeared to be tolerant of subnominal DO and low to moderate levels of sediment contaminants (Table 9).

Laticorophium cf. baconi was collected in 11 samples, seven from Boca Ciega Bay. It occurred at salinities ranging from 18.0 to 32.8 PSU, in sediments of 1.0 to 12.6 %SC, and at depths of 0.1 to 2.3-m. This species appeared to be sensitive to DO (range 4.4 to 11.3 ppm). It may, however, be tolerant of moderately contaminated sediments as four of the eight samples that sediment contaminants were analyzed from had a PEL Quotient>0.05.

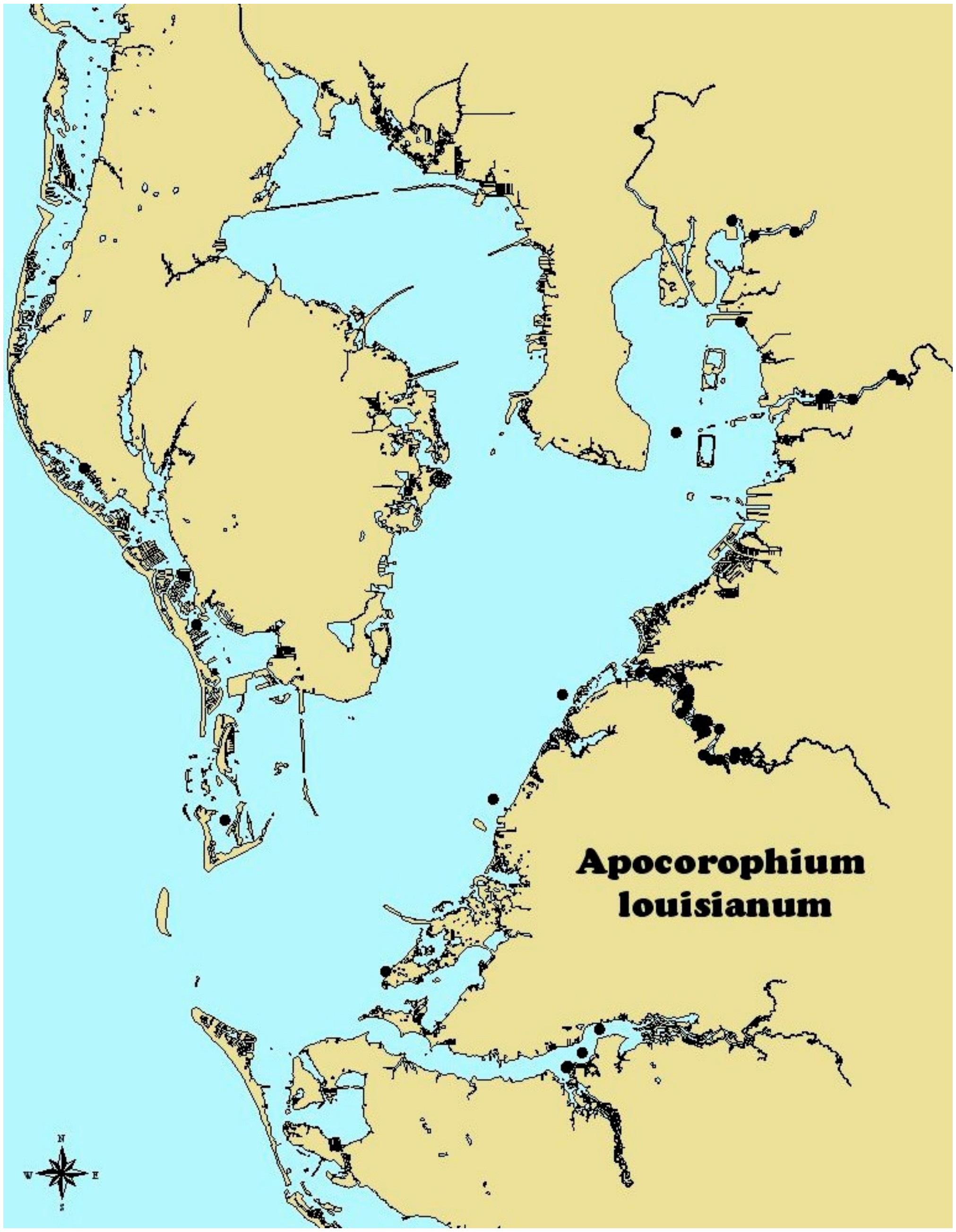


Figure 24. Map depicting the distribution of Apocorophium louisianum in Tampa Bay, Florida.

Monocorophium acherusicum
(Photograph: Victoria Museum http://www.mov.vic.gov.au/crust/mov1301i.html

Monocorophium acherusicum was collected in 19 samples, five from McKay Bay and three in both Old Tampa Bay and Boca Ciega Bay. *Monocorophium acherusicum* was found over a wide range of habitat variables (salinity 11.2 to 35.8 PSU; 1.8 to 91.8 %SC) and at depths to 5-m. This species appears to be tolerant of low DO, occurring at a range of 0.7 to 7.4 ppm with 6 locations having DO<4 ppm.

Monocorophium tuberculatum was found in three samples from Boca Ciega Bay. It occurred at salinities ranging from 30.6 to 32.6 PSU, in sediments of 7.5 to 12.4 %SC, at depths of 0.7 to 3.0-m, and at DO of 4.3 to 6.4 ppm.

Eusiridae

Pontogeneia bartschi was found in nine samples, six from Boca Ciega Bay. It occurred at salinities ranging from 18.0 to 33.4 pp, in sediments of 1.2 to 13.9 %SC, and at depths of 0.2 to 2.0-m. This species appears to be sensitive to low DO, occurring at 5.3 to 11.3 ppm.

Gammaridae

Gammarus mucronatus
(Photograph: S. Grabe)

Gammarus mucronatus was collected in 27 samples, nine each from McKay Bay and the Little Manatee River (Figure 25). Preferred habitats for *Gammarus mucronatus* included mesohaline medium to fine sands at shallow depths (Table 8). *Gammarus mucronatus* appears to be tolerant of subnominal DO and moderate levels of sediment contaminants (Table 9).

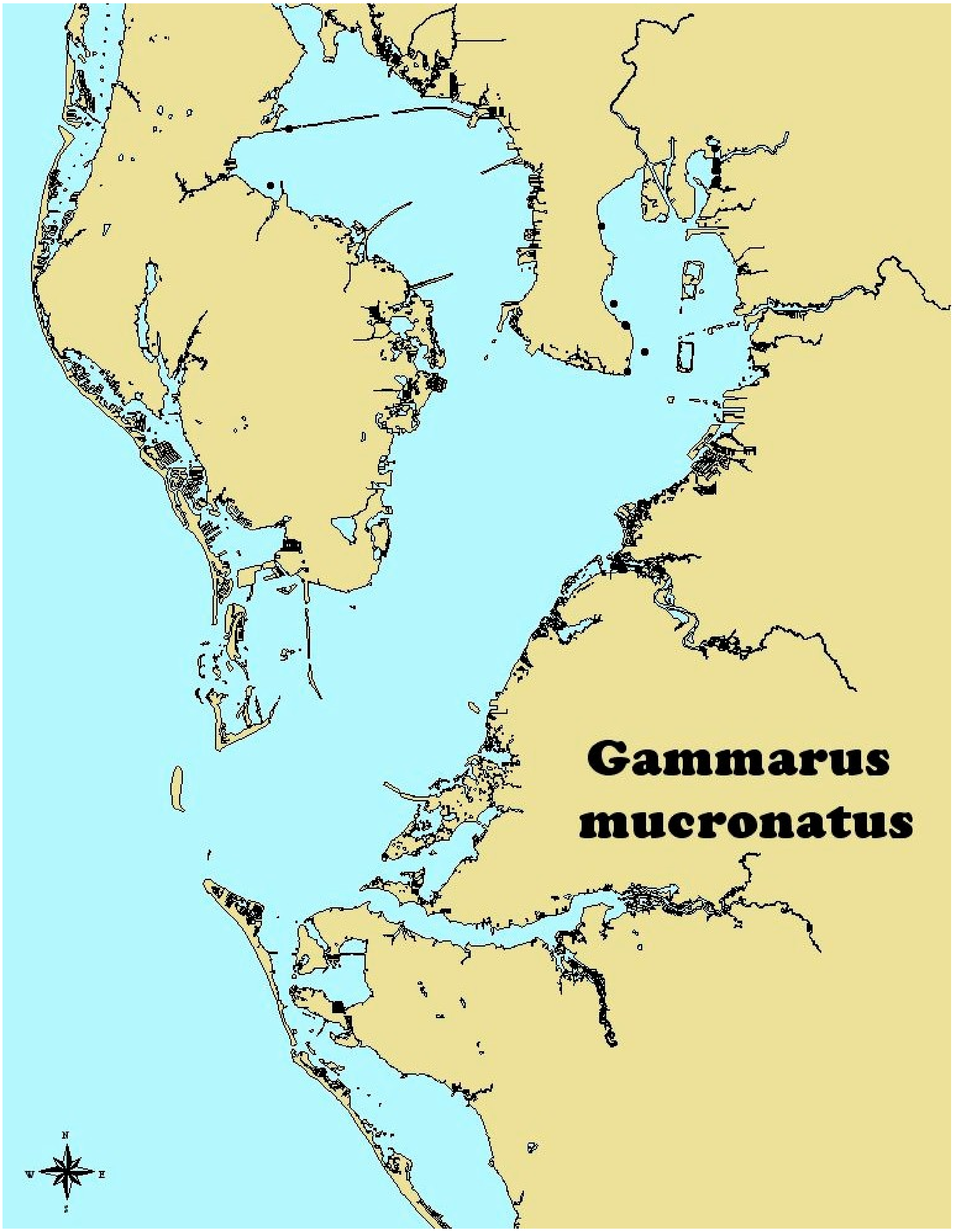


Figure 25. Map depicting the distribution of Gammarus mucronatus in Tampa Bay, Florida.

Gammarus tigrinus
(Photograph: http://www.hlug.de/medien/wasser/gewaesserguete/bericht/versalz.htm)

Gammarus cf. tigrinus was found in three samples from the Little Manatee River, all in tidal freshwater. Sediments ranged from 0.6 to 22.5 %SC, depths were ≤1-m and DO was 3.4 to 5.8 ppm.

Haustoriidae

Acanthohaustorius uncinus
(Photograph: S. Grabe)

Acanthohaustorius uncinus was generally collected along the periphery of the middle and lower reaches of Tampa Bay (Figure 26). The preferred habitats were polyhaline and euhaline salinities and coarse to medium sand-sized sediments (Table 8). *Acanthohaustorius uncinus* generally preferred oxygenated sediments (based on the RPD) (Table 8) and was sensitive to both low DO and sediment contaminants (Table 9).

Pseudohaustorius sp. was identified from a single sample in Lower Tampa Bay. The abiotic data at the site were: salinity= 34.2 PSU; %SC= 1.9; depth= 2.7-m; DO=5.6 ppm.

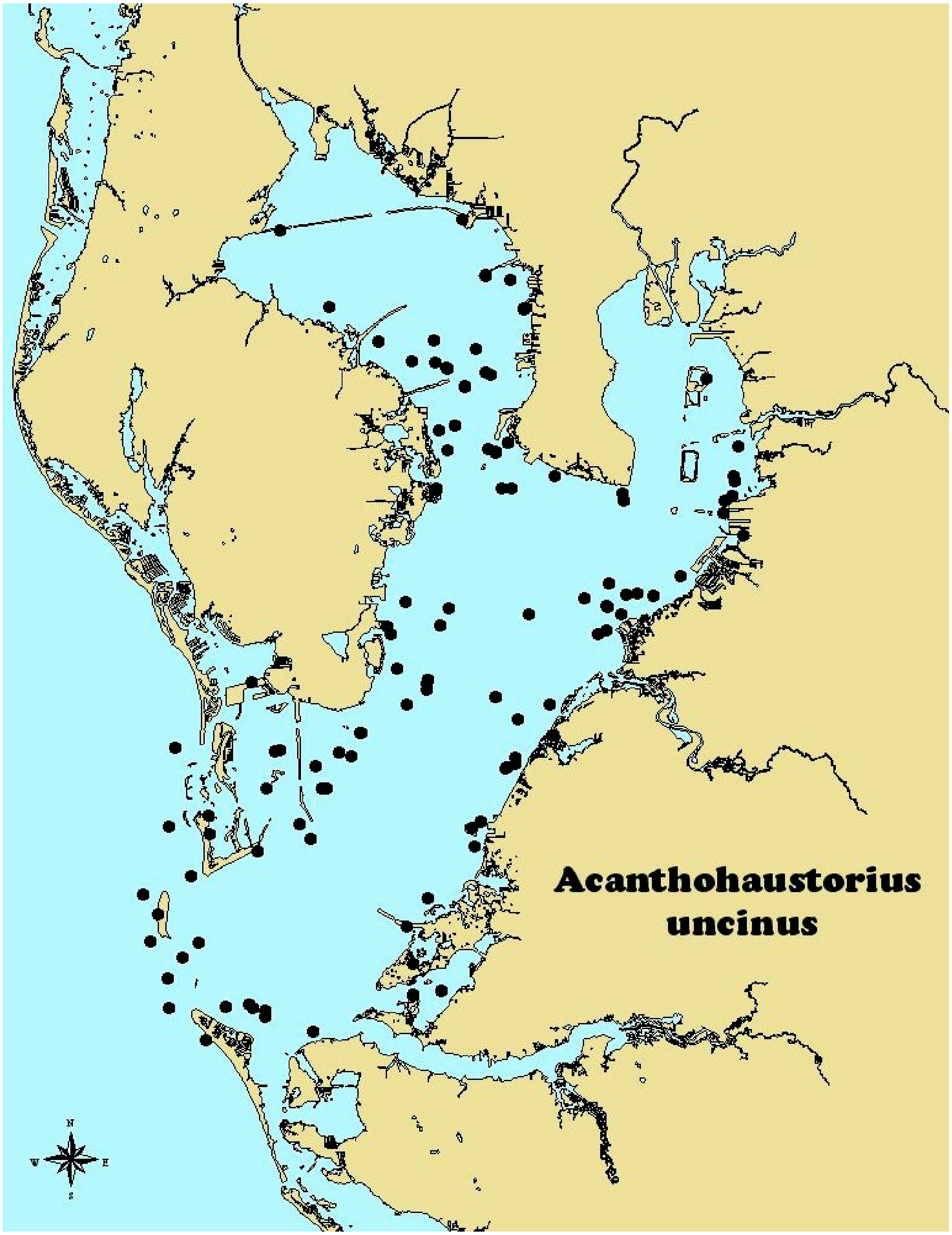


Figure 26. Map depicting the distribution of Acanthohaustorius uncinus in Tampa Bay, Florida.

Hyalidae

An unidentifiable hyalid was collected in two samples from Old Tampa Bay. Salinities were 20.9 and 21.6 PSU, sediments were 2.1 and 3.8 %SC, sample depths were 0.7 and 2.6-m, and DO was 4.1 to 6.6 ppm

Isaeidae

Microprotopus raneyi was found in 15 samples, six from Boca Ciega Bay. This species occurred at salinities ranging from 22.3 to 36.0 PSU, in sediments of 1.1 to 15.4 %SC, and at depths of 0.6 to 2.3-m. *Microprotopus raneyi* appears to be sensitive to both low DO (range: 4.5 to 7.2 ppm) and sediment contaminants (PEL Quotient range: 0.01 to 0.07).

Microprotopus shoemakeri was found in seven samples, five from Boca Ciega Bay. This species occurred at salinities ranging from 25.0 to 34.0 PSU, in sediments of 1.5 to 6.2 %SC, and at depths of 0.1 to 3.3-m. *Microprotopus shoemakeri* appears to be sensitive to both low DO (range: 4.0 to 7.1 ppm) and sediment contaminants (PEL Quotient range: 0.01 to 0.08).

Photis melanica was found in a single sample from Lower Tampa Bay. The abiotic data at the site were: salinity= 31.0 PSU; %SC= 5.6; depth= 4-m; DO=5.6 ppm.

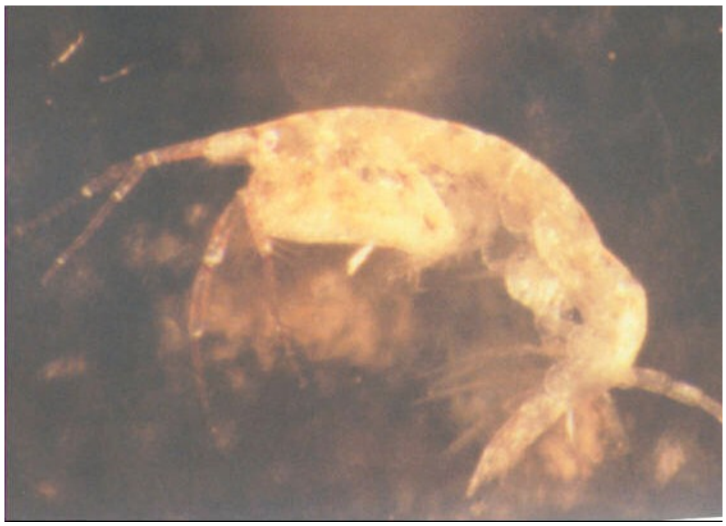
Photis sp. C occurred in 15 samples, 12 from Lower Tampa Bay, at salinities of 27.5 to 34.5 PSU, in sediments of 1.8 to 11.2 %SC, and at depths of 2.4 to 12.2-m. *Photis* sp. C appeared sensitive to low DO (range: 4.4 to 6.6) but may tolerate moderately contaminated sediments (PEL Quotient range: 0.02 to 0.13; >50% of the occurrences at a PEL Quotient >0.05).

Photis sp. E was found in two samples from Middle and Lower Tampa Bay at 28.7 and 31.0 PSU salinity, 3.9 and 5.6 %SC, at a depth of 0.1 and 4-m and at DO of 5.4 and 5.6.

Photis sp. F was found in a single sample from Middle Tampa Bay. The abiotic data at the site were: salinity= 26.9 PSU; %SC= 4.4; depth= 5.9-m; DO=5.5 ppm.

Ischyroceridae

At least three species of **Cerapus** (**C. tubularis, C. benthophilus** and **Cerapus sp. B**) were identified from Tampa Bay. Because females could not be readily distinguished, the species are treated together. Cerapus spp. are found in all segments of the bay, including the tributaries (Figure 27). The optimal habitats appear to be euhaline fine sands (Table 8). *Cerapus* spp. appear to be intolerant of subnominal DO and may be somewhat sensitive to sediment contaminants (Table 9).



Erichthonius brasiliensis
(Photograph: S. Grabe)

Erichthonius brasiliensis, an epifaunal tube builder on hydroids and ectoprocts (Feeley and Wass 1971), was widespread in Tampa Bay proper, as well as near the mouth of the Manatee River (Figure 28). This species preferred higher salinity waters and was associated with fauna that live in medium sand-sized sediments in relatively deep water (Table 8). *Erichthonius brasiliensis* appears to be sensitive to both low DO and sediment contaminants (Table 9).

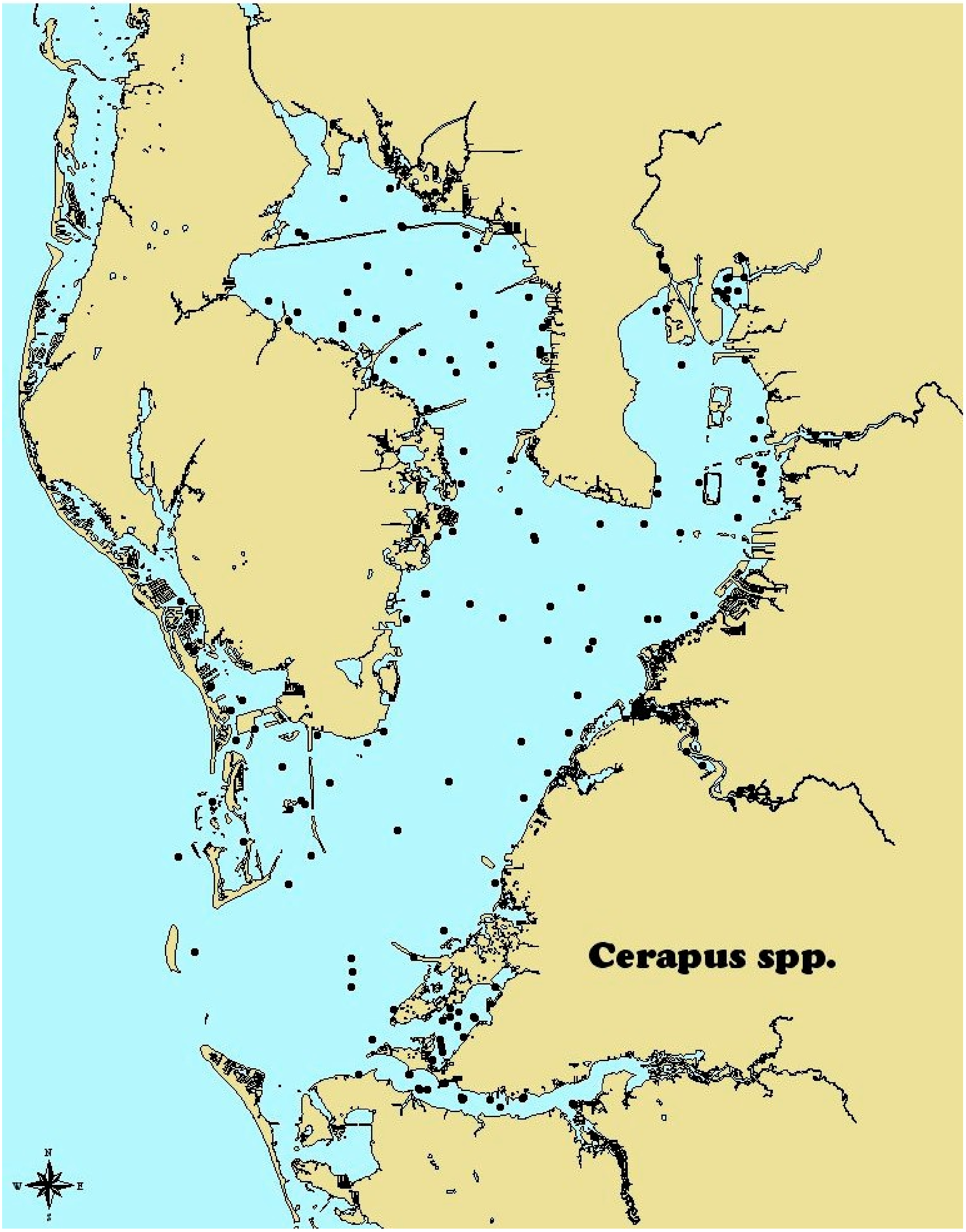


Figure 27. Map depicting the distribution of Cerapus spp. in Tampa Bay, Florida.

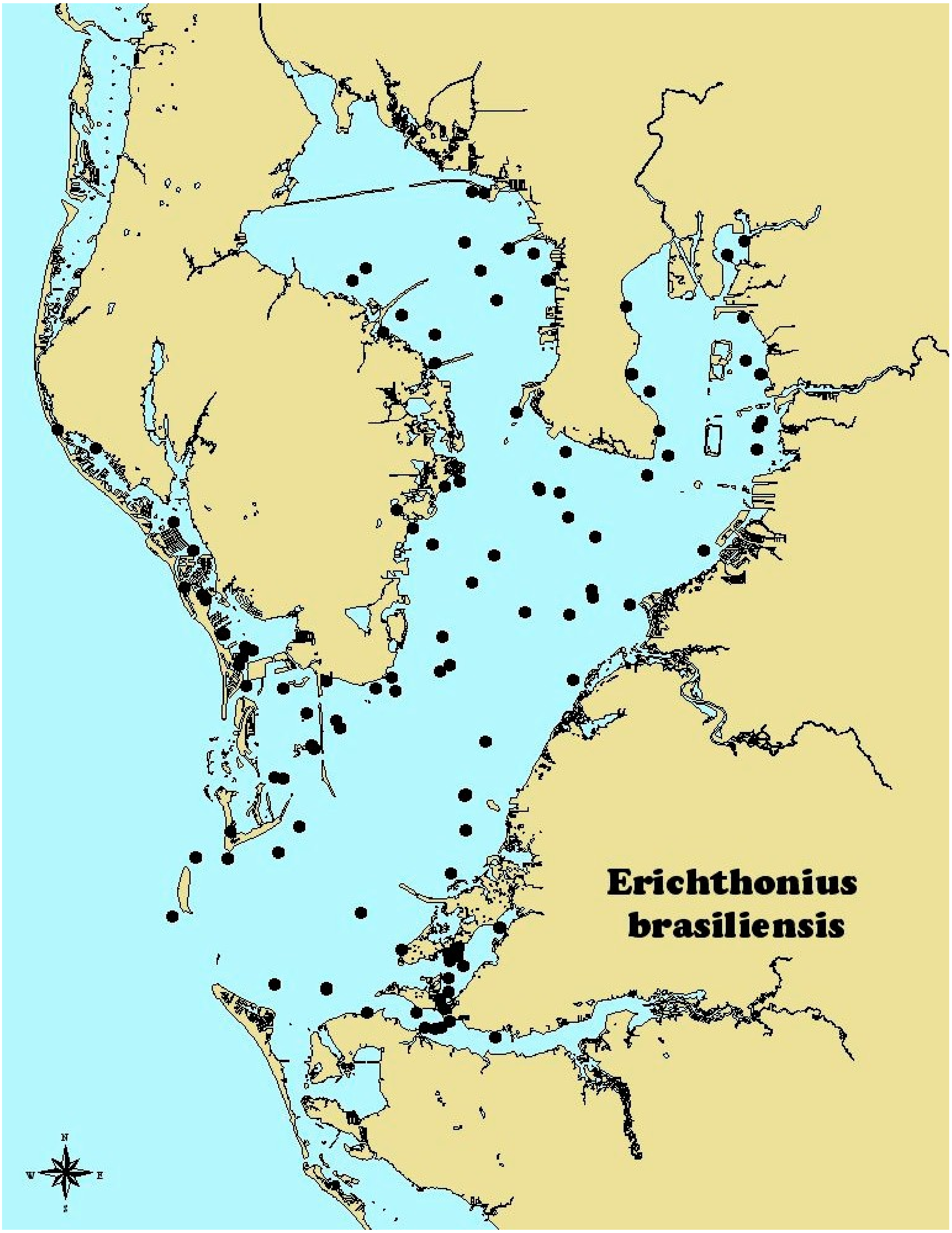


Figure 28. Map depicting the distribution of Erichthonius brasiliensis in Tampa Bay, Florida.

Leucothoidae

Leucothoe spinicarpa
(Photograph: C. Holden)

Leucothoe spinicarpa complex were found in five samples, four from Boca Ciega Bay. Salinities ranged from 24.3 to 32.2 PSU, the depths were <1.0-m and DO was 6.2 to 11.3 ppm. Although *Leucothoe* spp. are typically associated with sponges (Serejo 1998), no sponges were found in any of these samples.

Liljeborgiidae

Listriella barnardi is one of the most widespread amphipods in Tampa Bay although it rarely penetrated any of the tributaries other than the Manatee River (Figure 29). Its optimal habitat is euhaline waters deeper than 4-m (Table 8). *Listriella barnardi* was collected over a wide range of sediment types (0.1 to 69.8 %SC). The median value for %SC was 3.5% (medium sand) and oxygenated sediments were preferred (Table 8). *Listriella barnardi* appears to be sensitive to both low DO and sediment contaminants (Table 9).

Listriella spp. are believed to be inhabitants of polychaete tubes (Feeley and Wass 1971; Bousfield 1973). Cluster analyses (presence-absence; not shown) were run, for six bay segments (Old Tampa Bay, Hillsborough Bay, Middle Tampa Bay, Lower Tampa Bay, Boca Ciega Bay, and Manatee River/Terra Ceia Bay) , to examine the similarity *of L. barnardi*'s distribution with that of the more frequently occurring polychaetes (dendrograms not shown). The tubiculous polychaetes most similar in distribution included *Prionospio perkinsi* (in four segments), *Paraprionospio pinnata* and *Apoprionospio pygmaea* (each in three segments).

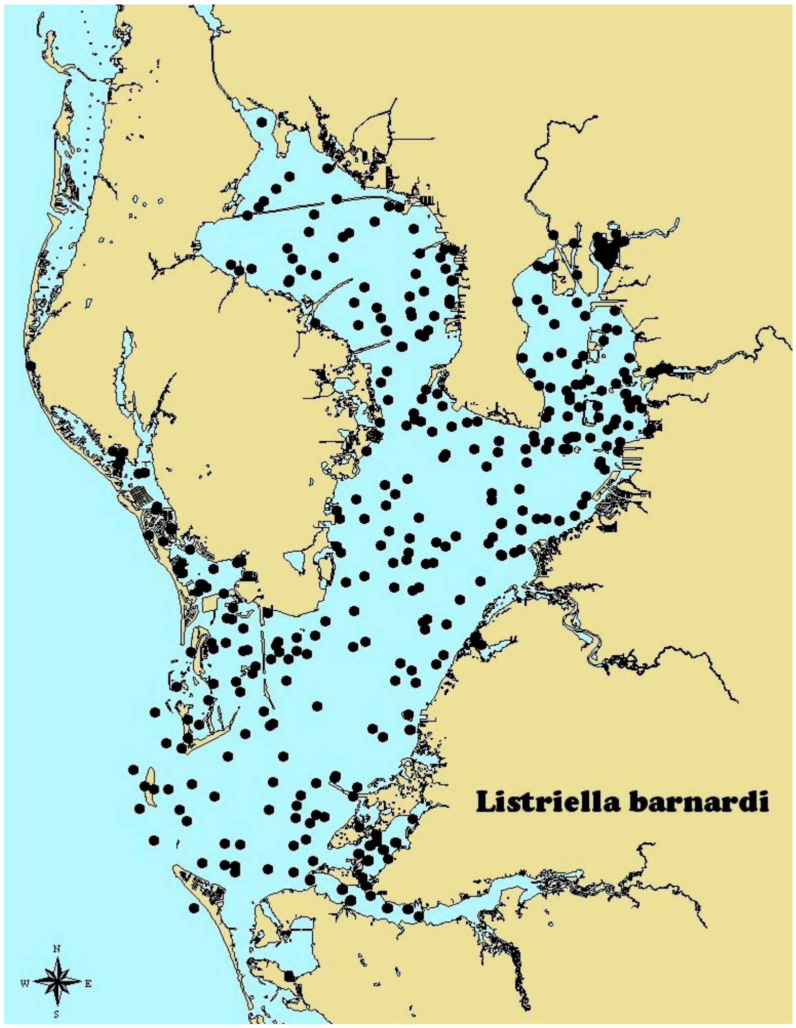


Figure 29. Map depicting the distribution of Listriella barnardi in Tampa Bay, Florida.

Lysianassidae

Hippomedon sp. A was collected in three Middle Tampa Bay samples at salinities ranging from 27.9 to 28.8 PSU, sediments of 1.6 to 3.6%SC, depths of 0.1 to 7.0-m, and DO of 5.2 to 7.3 ppm.

Shoemakerella cubensis was primarily collected from Old Tampa Bay and to a lesser extent in lower portions of the bay (Figure 30). Its preferred habitats are high mesohaline to polyhaline salinities and coarse to fine sands (Table 8). This species appears to be sensitive to low DO, although it may tolerate moderately contaminated sediments (Table 9) as approximately 40% of its occurrences were associated with PEL Quotients >0.05.

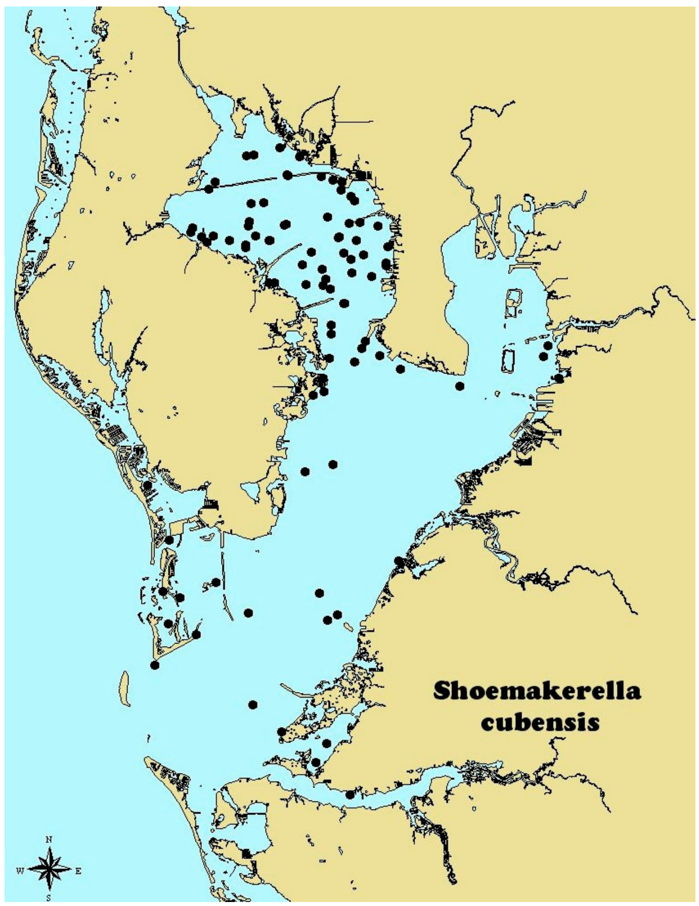


Figure 30. Map depicting the distribution of Shoemakerella cubensis in Tampa Bay, Florida.

Megaluropidae

Gibberosus myersi was present in eight samples collected during 1993 in Old, Middle, and Lower Tampa Bay. This species occurred in salinities ranging from 25.1 to 33.5 PSU, in sediments of 0.8 to 12.9 %SC and at depths of 1.1 to 7.3-m. *Gibbersous myersi* appears to be sensitive to both DO (range: 5.4 to 8.9) and sediment contaminants (PEL Quotient range: <0.01 to 0.02).

Melitidae

Ceradocus sp. was collected from a single station in Terra Ceia Bay. The abiotic data at the site were: salinity= 17.4 PSU; %SC= 4.2; depth= 2.4-m; DO=4.4 ppm.

Dulichiella appendiculata
(Photograph: SERTC: http://www.dnr.sc.gov/marine/sertc/images/photo%20gallery/ Dulichiella%20appendiculata%20100.jpg)

Dulichiella appendiculata was found in four samples, two from Boca Ciega Bay. The abiotic data at these sites were: salinity= 10.8 to 31.2 PSU; %SC= 2.4 to 4.6; depth= 0.5 to 2.4-m; DO=3.9 to 7.7 ppm.

Dulichiella sp. A was collected from a single station in the Little Manatee River. The abiotic data at the site were: salinity= 21.9 PSU; %SC= 9.7; depth= 0.9-m; DO=7.2 ppm

Elasmopus levis
(Photograph: S. Grabe)

Elasmopus levis is primarily found in the lower portions of Tampa Bay (Figure 31). Salinity, depth, and DO were all significant factors in the LR analysis. The preferred habitat is euhaline fine sands (Table 8). *Elasmopus levis* appears to be sensitive to both low DO and sediment contamination (Table 9).

Elasmopus pocillimanus was found at a single station in Middle Tampa Bay. The abiotic data at the site were: salinity= 28.8 PSU; %SC= 1.2; depth= 0.6-m; DO=4.5 ppm

Maera caroliniana was collected at a single station in Boca Ciega Bay; abiotic data are not available for this station.

Maera sp. n
(Photograph: C. Holden)

Maera sp. n was collected at a single station in Lower Tampa Bay. The abiotic data at the site were: salinity= 33.9 PSU; %SC= 6.4; depth= 4.0-m; DO=6.4 ppm

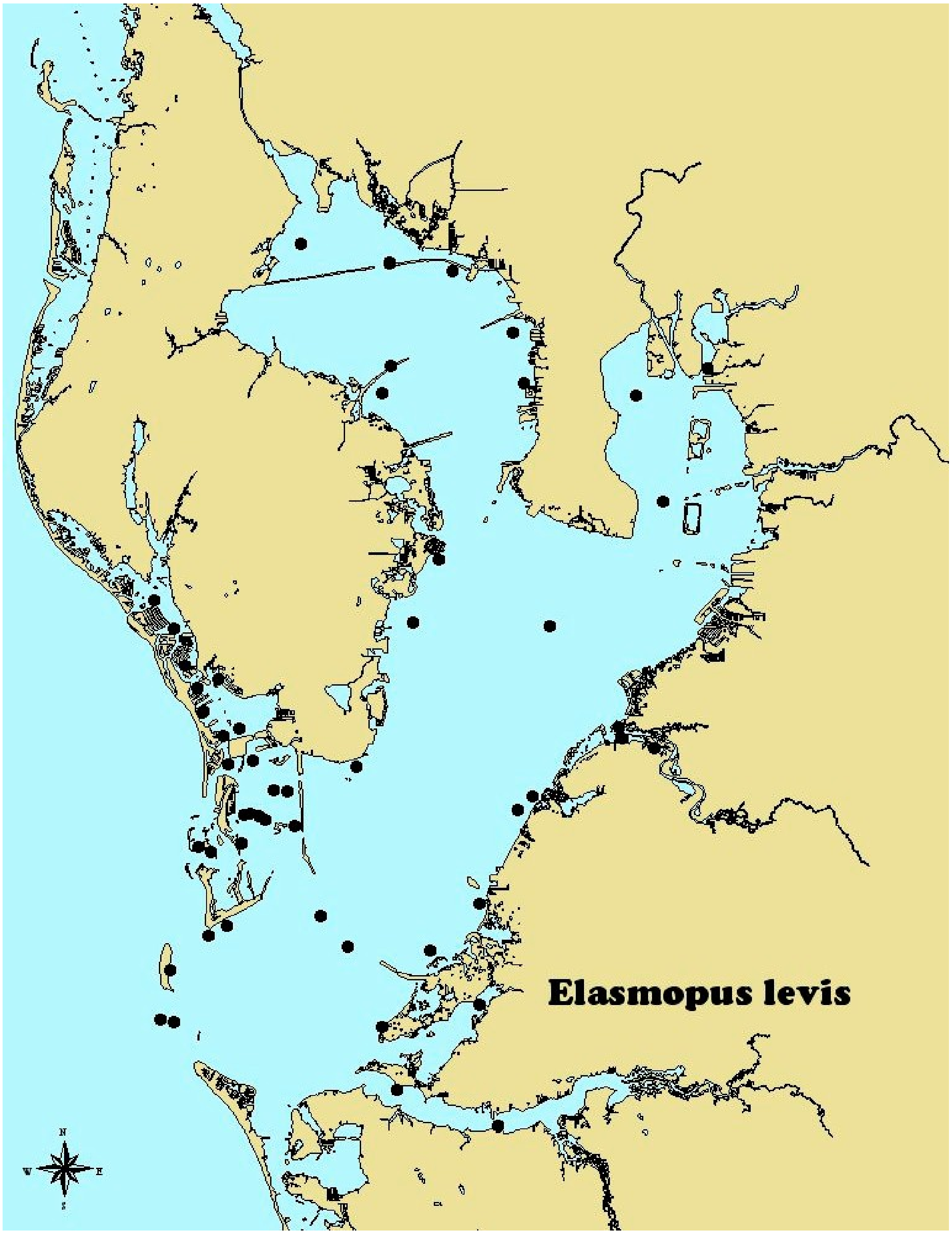


Figure 31. Map depicting the distribution of Elasmopus levis in Tampa Bay, Florida.

Melita elongata was primarily found in the tributaries and smaller bays (McKay Bay and Boca Ciega Bay) (Figure 32). The preferred habitats appeared to be low mesohaline through euhaline salinities and very fine sands and mud (Table 8). Although the LR analysis could not resolve a DO preference, this species tolerates subnominal DO. It was present at concentrations as low as 0.6 ppm and approximately 40% of its occurrences were at DO $\leq$2 ppm. *Melita elongata* may also be tolerant of contaminated sediments, although the relationship was not statistically significant (Table 9). Two of the 15 samples in which *M. elongata* occurred and sediment contaminants were analyzed had PEL Quotients >0.8 and the mean PEL Quotient for the 15 occurrences was >0.15.

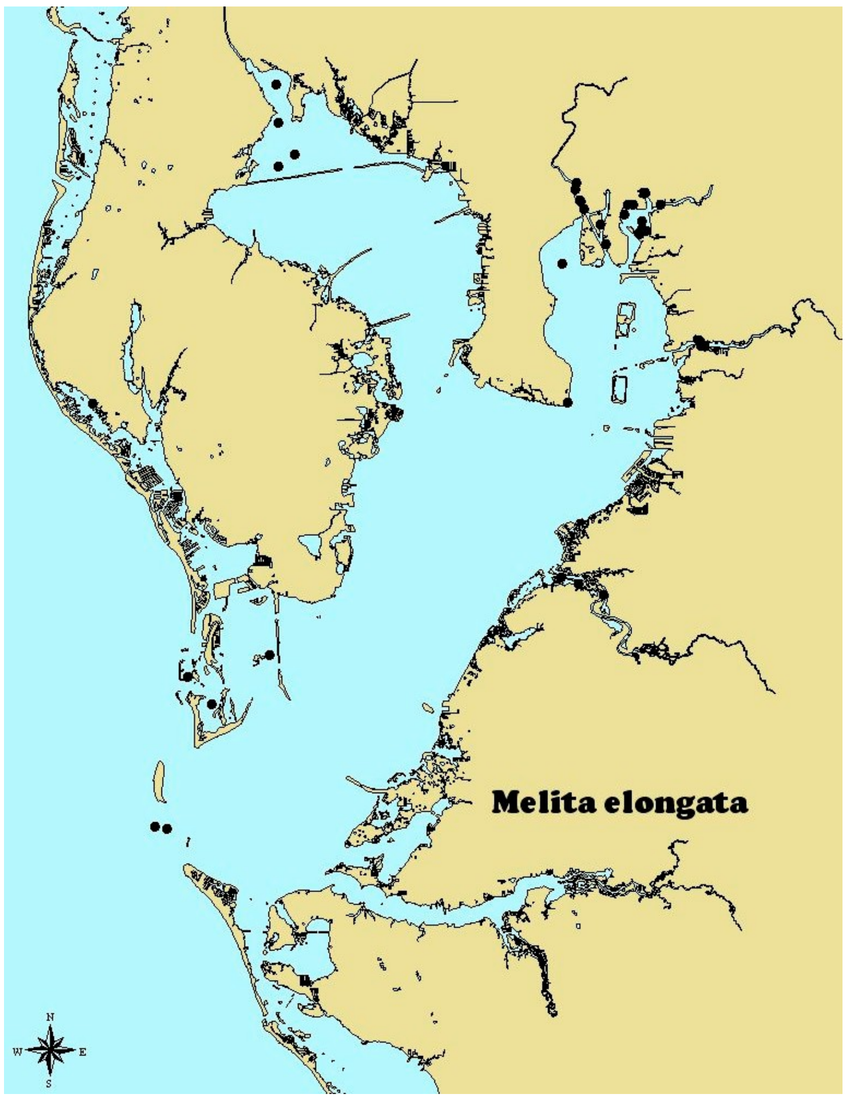


Figure 32. Map depicting the distribution of Melita elongata in Tampa Bay, Florida.

Oedicerotidae

Americhelidium americanum was collected at three locations in Lower and Middle Tampa Bay. The abiotic data at the sites were: salinity= 29.9 to 32.4 PSU; %SC= 1.6 to 6.0; depth= 0.1 to 4.0-m; DO=6.4 to 6.9 ppm.

Ameroculodes miltoni was collected at a single location in Middle Tampa Bay. The abiotic data at the site were: salinity= 26.2 PSU; %SC= 4.1; depth= 8.1-m; DO=5.6 ppm.

Hartmanodes nyei was distributed in peripheral areas of the bay, in southern Hillsborough Bay, and in Old Tampa Bay (Figure 33). Its preferred habitats span low mesohaline through euhaline salinities and coarse to fine sands in shallow to moderate water depths (Table 8). This species appears somewhat sensitive to subnominal DO (Table 9) as only approximately 10% of its occurrences were at DO <4 ppm. *Hartmanodes nyei* may be tolerant of moderate levels of sediment contaminants since it was present at a station with a PEL Quotient >1 and approximately 75% of its occurrences were in samples with a PEL Quotient >0.05.

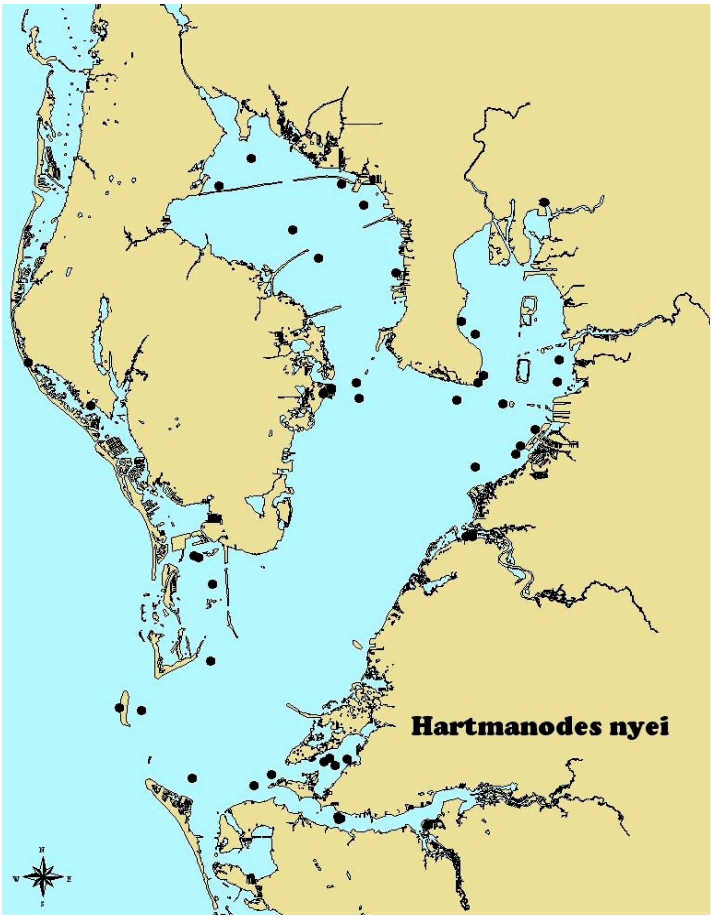


Figure 33. Map depicting the distribution of Hartmanodes nyei in Tampa Bay, Florida.

Phoxocephalidae

Eobrolgus spinosus was widespread in Old Tampa Bay (Figure 34). The preferred habitats were polyhaline medium to fine sands at moderate depths (Table 8). *Eobrolgus spinosus* was sensitive to low DO but may tolerate moderately contaminated sediments (Table 9) as >30% of its occurrences were at PEL Quotients >0.05.

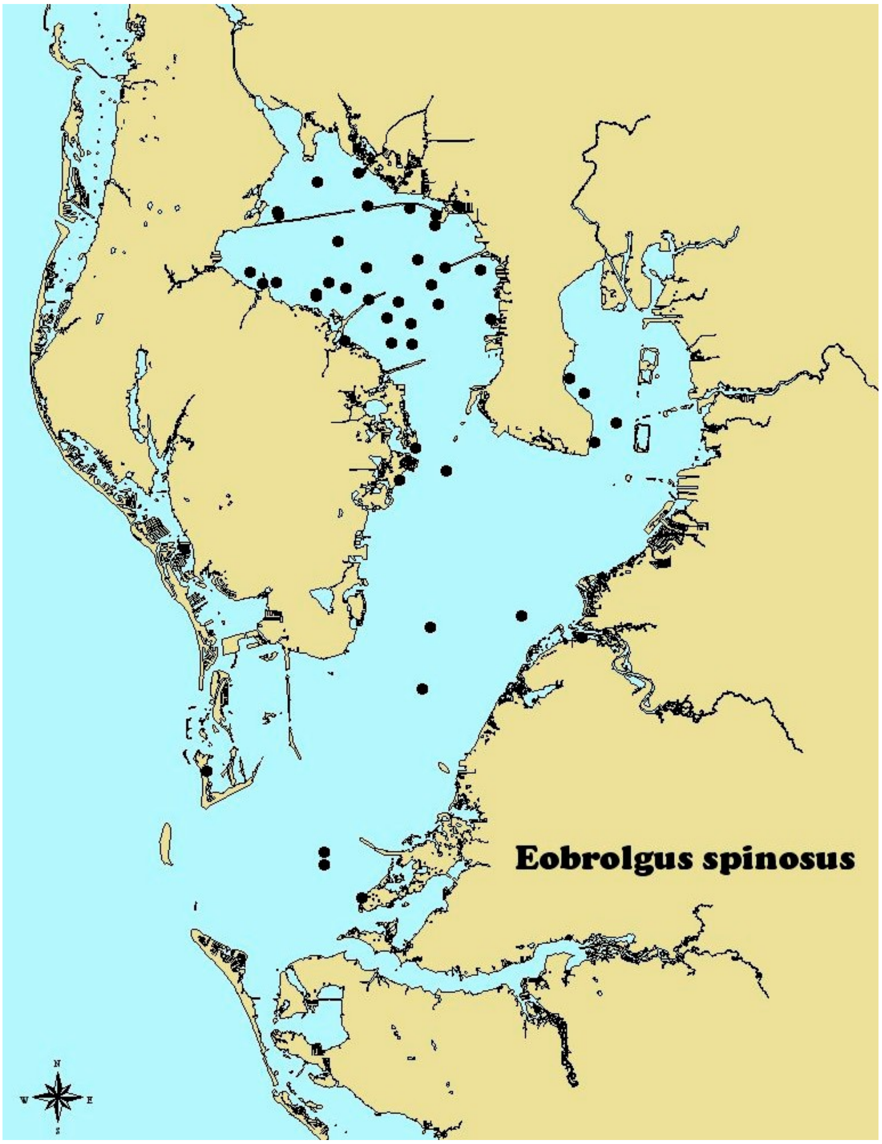


Figure 34. Map depicting the distribution of Eobrolgus spinosus in Tampa Bay, Florida.

Metharpinia floridana
(Photograph: S. Grabe)

Metharpinia floridana was widespread throughout much of Old, Middle, and Lower Tampa Bay (Figure 35). The preferred habitats were polyhaline to euhaline salinities and coarse sands in relatively deep water (Table 8). This species had one of the widest RPD preferences (Table 8) and is very sensitive to DO. *Metharpinia floridana* may, however, tolerate moderate levels of sediment contaminants (Table 9) as almost 40% of its occurrences were at sites with PEL Quotients >0.05.

Rhepoxynius epistomus was collected once in Boca Ciega Bay. The abiotic data at the site were: salinity= 29.6 PSU; %SC= 3.0; depth= 3.3-m; DO=6.0 ppm.

Rhepoxynius sp. A was collected twice in Lower Tampa Bay. The abiotic data at the sites were: salinity= 32.6 to 34.2 PSU; %SC= 1.9 to 3.1; depth=2.2 to 2.7-m; DO=4.6 to 5.6 ppm.

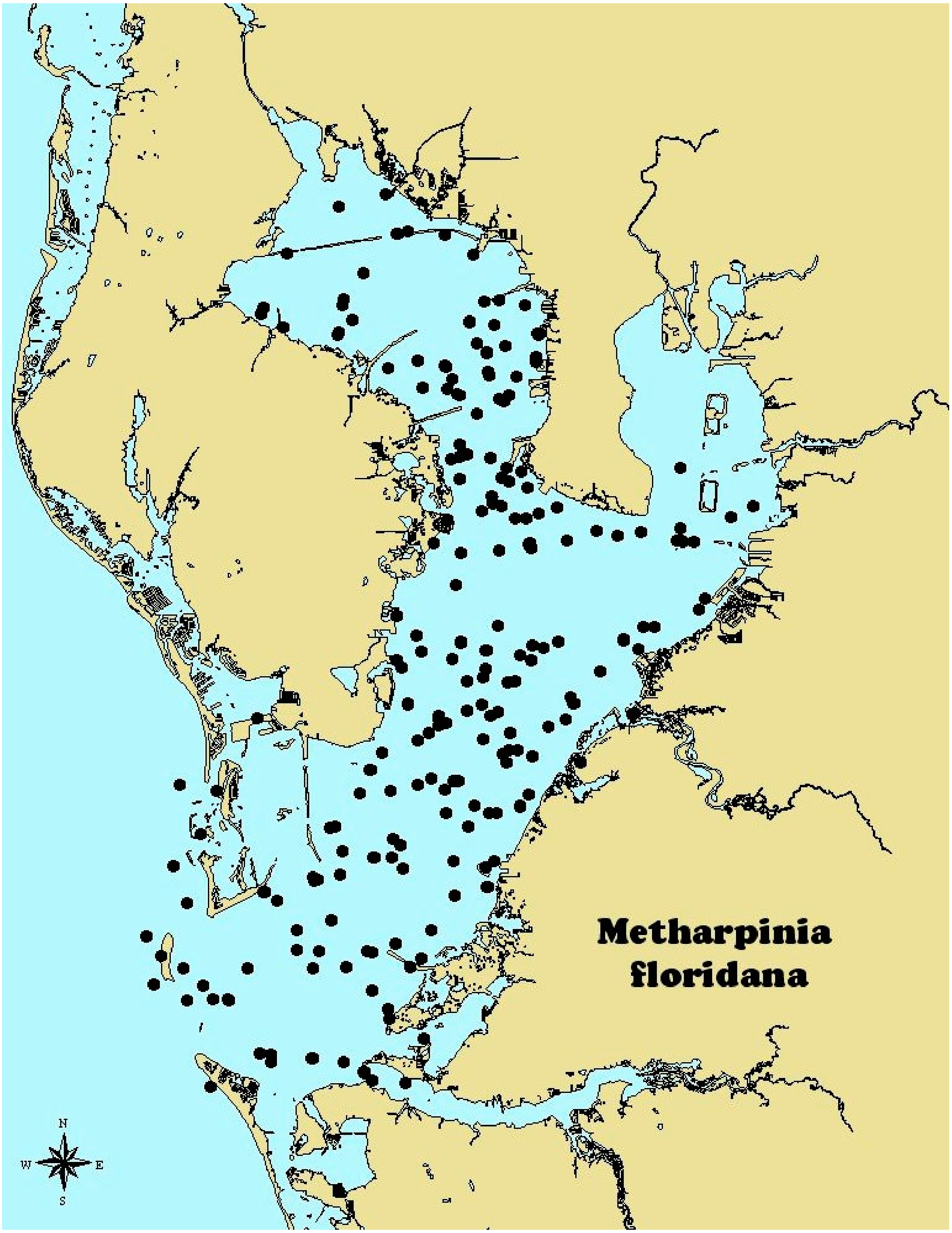


Figure 35. Map depicting the distribution of Metharpinia floridana in Tampa Bay, Florida.

Platyischnopidae

Eudevenopus honduranus was widespread throughout Old, Middle, and Lower Tampa Bay (Figure 36). The preferred habitats were polyhaline to euhaline salinities and coarse sands in relatively deep water (Table 8). This species had one of the widest RPD preferences (Table 8) and is very sensitive to DO. *Eudevenopus honduranus* may, however, tolerate moderate levels of sediment contaminants (Table 9) as almost 40% of its occurrences were at sites with PEL Quotients >0.05.

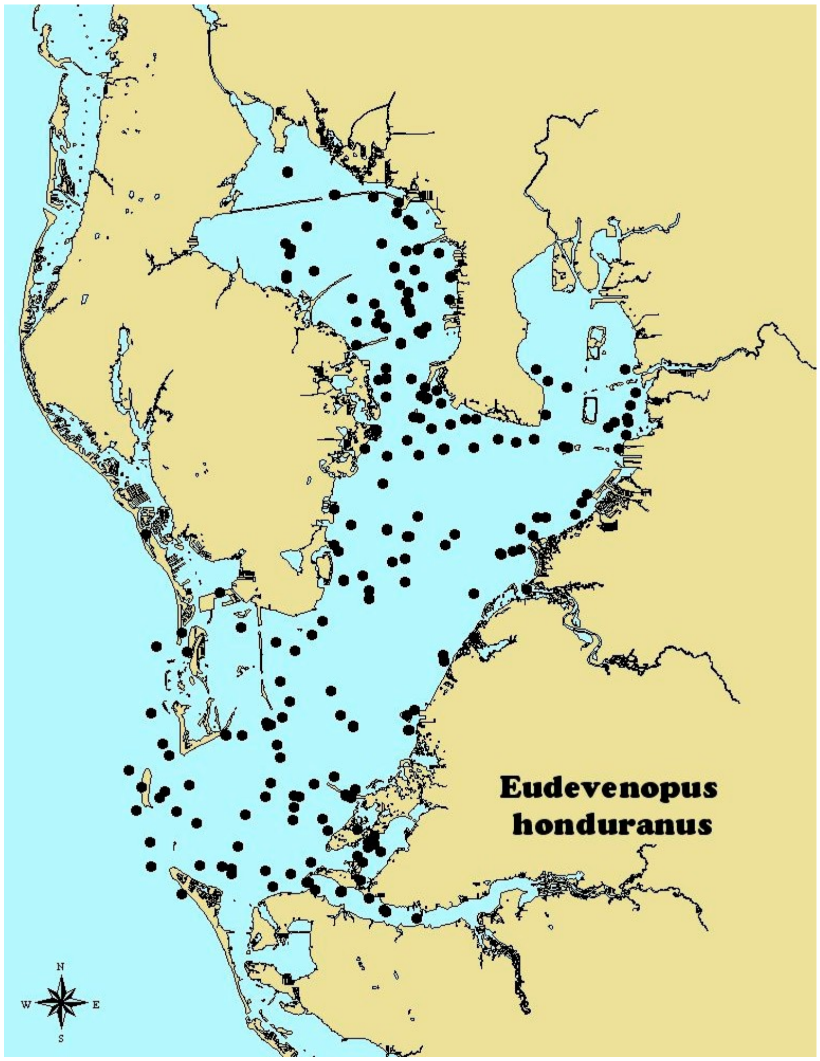


Figure 36. Map depicting the distribution of Eudevenopus honduranus in Tampa Bay, Florida.

Podoceridae

Podocerus brasiliensis was collected in a single sample from Middle Tampa Bay. The abiotic data at the site were: salinity= 30.1 PSU; %SC= 3.6; depth= 4.0-m; DO=5.9 ppm.

Psammogammaridae

Psammogammarus sp. was collected in a single sample from Lower Tampa Bay. The abiotic data at the site were: salinity= 31.0 PSU; %SC= 5.6; depth= 4.0-m; DO=5.6 ppm.

Stenothoidae

Parametopella texensis was collected in four samples from Old and Middle Tampa Bay. The abiotic data at the sites were: salinity= 22.3 to 29.0 PSU; %SC= 1.5 to 3.4; depth= 0.9 to 4.5-m; DO=4.8 to 7.0 ppm.

Stenothoe gallensis was identified from two samples in Terra Ceia Bay. The abiotic data at the sites were: salinity= 16.0 to 31.0 PSU; %SC= 3.7 to 8.7; depth= 0.9 to 1.0-m; DO=5.0 to 7.0 ppm.

Stenothoe georgiana was collected in a single sample from Boca Ciega Bay. The abiotic data at the site were: salinity= 31.6 PSU; %SC= 13.1; depth= 2.0-m; DO=6.7 ppm.

Stenothoe minuta was identified from two samples in Middle Tampa Bay and Boca Ciega Bay. The abiotic data at the sites were: salinity=26.8 to 30.4 PSU; %SC= 6.7 to 12.6; depth= 0.9 to 5.0-m; DO=5.1 to 6.5 ppm.

Stenothoe sp. A was identified from two samples in Middle Tampa Bay. The abiotic data at the sites were: salinity= 27.1 to 27.6 PSU; %SC= 1.2 to 3.7; depth= 1.8 to 3.4-m; DO=6.6 to 9.6 ppm.

Synopiidae

Metatiron tropakis
(Photograph: C. Holden)

Metatiron triocellatus was identified from eight samples in Old Tampa Bay (5), Middle Tampa Bay and Lower Tampa Bay. The abiotic data at the sites were: salinity= 17.4 to 27.4 PSU; %SC= 0.8 to 5.4; depth= 1.6 to 4.7-m; DO=5.0 to 6.3 ppm.

Metatiron tropakis was found in ten samples throughout most of the bay proper (excluding Hillsborough and Boca Ciega bays), with five occurrences in Lower Tampa Bay. The abiotic data at the sites were: salinity= 23.4 to 30.9 PSU; %SC= 0.2 to 2.7; depth= 1.1 to 9.1-m; DO=5.0 to 8.0 ppm.

Discussion

The state of knowledge of the amphipod fauna of nearshore waters of the Gulf of Mexico has expanded greatly since the late 1960s (Culpepper 1969; Farrell 1970; Thomas 1976; McKinney 1977; Thoemke 1979; LeCroy 2000, 2002). Based upon taxa found to date in Tampa Bay, 31**%** of the species have been described since 1970; however, almost 20%, including some relatively common species (*e.g*., *Ampelisca* sp. C), remain undescribed.

The amphipod assemblages were generally similar when compared across paired salinity zones (holding sediment type constant) or sediment types (holding salinity zone constant). For example, *G. bonnieroides* was the typical inhabitant of tidal freshwater and oligohaline regimes regardless of sediment type. Ampeliscid amphipods were more characteristic of medium, fine, and very-fine sands sized sediments at salinities >0.5 PSU. Medium and coarse sand-sized sediments in salinities >18 PSU were primarily populated by fossorial species such as *M. floridana, A. uncinus*, and *E. honduranus* (Bousfield 1973; Thomas and Barnard 1983; Oakden 1984; Foster 1988), although two tubiculous ampeliscids (*A. holmesi* and *A*. sp. C) were common in medium sand-sized sediments. Foster (1988) describes the habitat of *A. uncinus* as "fine to medium unvegetated sands with shell fragments and in fine to medium sands with some silt among halophytes…"; in Tampa Bay the preferred sediment type was coarse sand.

Mud habitats were generally sparsely populated by amphipods. Polyhaline mud habitats, typically located in the tributaries and western Hillsborough Bay, were the most speciose of the mud habitats. Within the mesohaline and polyhaline zones, *A. abdita* was the most representative species, although densities were generally low. Feeley and Wass (1971) and Thomas (1976) reported that *A. abdita* was associated with silt and mud substrata and Mannino and Montagna (1997) found it to be most common in sediments of 25% to 50% SC.

Within the Ampeliscidae, the four most common and abundant species differed in their preferred habitats. *Ampelisca* sp. C preferred medium sands, *A. holmesi* fine sands and both *A. abdita* and *A. vadorum* very-fine sands; the latter two species, in turn, had different salinity optima: high mesohaline for *A. abdita* and polyhaline for *A. vadorum*. Mills (1967) observed that *A. abdita* preferred finer sediments than did *A. vadorum*. Dickinson *et al.* (1980) reported *A. abdita* primarily from sand and sand-silt sediments whereas *A. vadorum* was mainly collected from sandy sediments in the Middle Atlantic Bight. In the Chesapeake Bay, Feeley and Wass (1971) report these two species from similar habitats (polyhaline muds) with depth preferences segregating the species: *A. abdita* occurring over a wider depth range and *A. vadorum* restricted to shallower areas. In Tampa Bay, it is *A. abdita* that is more typical of shallower waters.

The ampeliscids also appeared to differ in their tolerance to ecological stressors. *Ampelisca* sp. C, *A. agassizi,* and *A. bicarinata* were sensitive to both low DO and sediment contaminants. *Ampelisca* sp. A may be somewhat less sensitive. *Ampelisca vadorum* appeared to tolerate subnominal DO but was intolerant of sediment contaminants. Both *A. abdita* and *A. holmesi* appeared to be tolerant to these stressors, with *A. abdita* may be the most tolerant to stress. Although the association of *A. abdita* and the PEL Quotient is only significant at 0.13, *A. abdita* is a species commonly used as a bioassay organism (ASTM 1993; Schimmel *et al.* 1994) because it is considered to be "sensitive" to contaminants. It may be that this association is spurious since the contaminants may not be bioavailable (*cf*. DiToro *et al*. 1990). Populations from which the bioassay organisms are drawn from include San Francisco Bay and Narragansett Bay (Long *et al.* 1999). Perhaps the Tampa Bay population should be evaluated in bioassays to confirm or refute this association. Forrester *et al*. (2003) showed that, for a fish (long-jawed mudsucker, *Gillichthys mirabilis*) there was neither genetic adaptation nor a physiological acclimation to sediment contaminants, although they believed there was that potential.

Other amphipods that appear to be tolerant of both types of stressors include *G. bonnieroides* and *M. elongata. Apocorophium louisianum, A. ellisi,* and *G. mucronatus* appear to tolerate subnominal DO. A number of species appeared to tolerate intermediate levels of sediment contaminants: *Cerapus* spp., *M. floridana*, *E. spinosus*, *Photis* sp. C, *S. cubensis*, *H. nyei*, *L. unifasciatus*, *A. hamatipes*, *B. catharinensis*, and *M. acherusicum*.

Conclusions

The gammaridean amphipod fauna of Tampa Bay comprises at least 73 species, of which 14 are yet to be formally described. Amphipods characteristic of Tampa Bay include three ampeliscids (*Ampelisca abdita*, *A. holmesi*, and *Ampelisca* sp. C), *Listriella barnardi*, *Metharpinia floridana*, *Eudevenopus honduranus*, *Rudilemboides naglei*, and *Grandidierella bonnieroides*.

Amphipod assemblages differed by habitat (defined by salinity zone and sediment type). However, assemblages in adjacent salinity zones (sediment type held constant) or adjacent sediment types (salinity zone held constant) were generally similar.

Grandidierella bonnieroides was the typical inhabitant of the two lower salinity habitats. Ampeliscid amphipods were more characteristic of medium, fine, and very-fine sands sized sediments at salinities >0.5 PSU. Medium and coarse sand-sized sediments in polyhaline and euhaline salinities were primarily populated by fossorial species (*e.g. M. floridana, A. uncinus*, and *E. honduranus*).

Several species, including *A. abdita*, *Apocorophium louisianum*, *G. bonnieroides*, and *Melita elongata*, appeared to be tolerant of low DO. Species tolerant of sediment contaminants included *A. abdita*, *G. bonnieroides*, and perhaps *M. elongata*. Species which appeared to be most sensitive to ecological stressors included *Ampelisca* sp. C, *Acanthohaustorius uncinus*, *Erichthonius brasiliensis*, and *L. barnardi*.

Literature Cited

American Society for Testing and Materials (ASTM) 1993. *Standard Guide for Conducting 10-day Static Sediment Toxicity Tests with Marine and Estuarine Amphipods*. E 1367-92. American Society for Testing and Materials. Philadelphia, PA.

Bellan-Santini, D. 1980. Relationship between populations of amphipods and pollution. *Mar. Pollut. Bull.* 11:224-227.

Bousfield, E.L. 1973. *Shallow-water Gammaridean Amphipoda of New England*. 312 p. Comstock Publ. Ithaca.

Camp, D.K. 1998. Checklist of the shallow-water marine malacostracan Crustacea of Florida. *In*: *Checklists of Selected Shallow-water Marine Invertebrates of Florida* (D. K. Camp, W.G. Lyons and T.H. Perkins, eds.), p. 123-189. Florida Marine Research Center Technical Report TR-3:1-238.

Carr, W.E. S. and C.A. Adams. 1973. Food habits of juvenile marine fishes occupying seagrass beds in the estuarine zone near Crystal River, Florida. *Trans. Amer. Fish. Soc.* 102:511-540.

Clarke, K.R. and R.M. Warwick. 2001. *Change in Marine Communities: An Approach to Statistical Analysis and Interpretation.* 2nd Ed. PRIMER-E Ltd. Plymouth Marine Laboratory, UK.

Coastal Environmental Services, Inc. 1994. *Monitoring Program to Assess Environmental Changes in Tampa Bay, Florida.* TBNEP Tech. Rep. 02-93.

Culpepper, T.J. 1969. *A Taxonomic and Ecological Study of Selected Benthonic Gammarid Crustaceans from the Northeastern Gulf of Mexico*. Ph.D. Diss. 141 p. Texas A and M Univ. College Station, TX.

Dickinson, J.J., R.L. Wigley, R.D. Brodeur and S. Brown-Leger. 1980. *Distribution of Gammaridean Amphipoda (Crustacea) in the Middle Atlantic Bight Region*. NOAA Tech. Rep. NMFS SSRF-741. 46p.

DiToro, D.M., J.D. Mahony, D.J. Hansen, K.J. Scott, M.B. Hicks, S.M. Mayr, and M.S. Redmond. 1990. Toxicity of cadmium in sediments: the role of acid-volatile sulfide. *Environ. Toxicol. Chem.* 9:1487-1502.

Duffy, J.E. and M.E. Hay. 2000. Strong impacts of grazing amphipods on the organization of a benthic community. *Ecol. Monogr.* 70:237-263.

Farrell, D.H. 1970. *Ecology and Seasonal Abundance of Littoral Amphipods From Mississippi.* M.S. Thesis, 62 p. MS State Univ.

Literature Cited-continued

Feeley, J.B. and M.L. Wass. 1971. *The Distribution and Ecology of the Gammaridea (Crustacea: Amphipoda) of the Lower Chesapeake Estuaries*, 58 p. Spec. Pap. Mar. Sci. No. 2. VIMS, Gloucester Point, VA.

Forrester, G.E., B. I. Fredericks, D. Gerdeman, B. Evans, M.A. Steele, K. Zayed, L.E. Schweitzer, I.H. Suffet, R. R. Vance, and R.F. Ambrose. 2003. Growth of estuarine fish is associated with the combined concentration of sediment contaminants and shows no adaptation of acclimation to past conditions. *Mar. Environ. Res*. 56:423-442.

Foster, J.M. 1988. *Acanthohaustorius uncinus*, a new species of sand-burrowing amphipod from the northern Gulf of Mexico, with notes on its ecology (Haustoriidae: Haustoriinae). *Gulf Res. Rep*. 8:189-197.

Franz, D.R. and J.T. Tanacredi. 1992. Secondary production of the amphipod *Ampelisca abdita* Mills and its importance in the diet of juvenile winter flounder (*Pleuronectes americanus*) in Jamaica Bay, New York. *Estuaries* 15:193-203.

Goss-Custard, J.D. 1977. The energetics of prey selection by redshank in relation to prey density. *J. Anim. Ecol.* 46:1-19.

Holland, A.F. (ed.). 1990. *Near-coastal Program Plan for 1990: Estuaries.* EPA/600/4-90-033. USEPA. Washington, DC.

Huisman J, H. Oliff , and L.F.M. Fresco. 1993. A hierarchical set of models for species response analysis. *J. Vegetation Sci.* 4:37-46.

Larsen D. P., K.W. Thornton N.S. Urquart, and S.G. Paulsen. 1994. The role of sample surveys for monitoring the condition of the nation's lakes. *Environ. Monit. Assess.* 32:101-134.

LeCroy, S.E. 2000. An Illustrated Identification Guide to the Nearshore Marine and Estuarine Gammaridean Amphipoda of Florida. Volume 1. Families Gammaridae, Hadziidae, Isaeidae, Melitidae and Oedicerotidae. Prep. For FDEP. Tallahassee.

LeCroy, S.E. 2002. An Illustrated Identification Guide to the Nearshore Marine and Estuarine Gammaridean Amphipoda of Florida. Volume 2. Families Ampeliscidae, Amphilochidae, Ampithoidae, Aoridae, Argissidae, and Haustoriidae. Prep. For FDEP. Tallahassee.

Llansó, R.J., S.S. Bell, and F.E. Vose. 1998. Food habits of red drum and spotted seatrout in a restored mangrove impoundment. *Estuaries* 21:294-306.

Mannino, A. and P.A. Montagna. 1997. Small-scale spatial variation of macrobenthic community structure. *Estuaries* 20:159-173.

Literature Cited-continued

McKinney, L.D. 1977. *The Origin and Distribution of Shallow Water Gammaridean Amphipoda in the Gulf of Mexico and Caribbean Sea with Notes on their Ecology.* Ph.D. Diss. Texas A and M University, College Station. 401 p.

Mills, E.L. 1967. The biology of an ampeliscid amphipod crustacean sibling species pair. *J. Fish. Res. Bd. Canada* 24:305-355.

Mukai, H. and A. Iijima 1995. Grazing effects of a gammaridean amphipod, *Ampithoe* sp., on the seagrass, *Syringodium isoetifolium*, and epiphytes in a tropical seagrass bed of Fiji. *Ecological Research* 10:243-257.

Nilsson, H.C. and R. Rosenberg. 2000. Succession in marine benthic habitats and fauna in response to oxygen deficiency: analyzed by sediment profile imaging and by grab samples. *Marine Ecology Progress Series* 197:139-149.

Oakden, J.M. 1984. Feeding and substrate preference in five species of phoxocephalid amphipods from central California. *J. Crust. Biol.* 4:233-247.

Oliver, J.S., J.M. Oakden.,and P.N. Slattery. 1982. Phoxocephalid amphipod crustaceans as predators on larvae and juveniles in marine soft-bottom communities. *Marine Ecology Progress Series* 7:179-184.

Peeters, E.T.H. M. and J. J. P. Gardeniers. 1998. Logistic regression as a tool for defining habitat requirements of two common gammarids. *Freshwater Biology.* 39:602-615.

Percival J. B. and P.J. Lindsay. 1997. Measurement of physical properties of sediments. Pages 7-46. *In*: A. Mudroch , J.M. Azcue , and P. Mudroch, eds. *Manual of Physico-chemical Analysis of Aquatic Sediments*. Lewis Publ. Boca Raton.

Plumb, R.H. 1981. *Procedure for Handling and Chemical Analysis of Sediment and Water Samples.* Tech. Rep. EPA/CE-81-1, US Army Waterways Experiment Station, Vicksburg, MS.

Poggiale, J-C. and J-C. Dauvin. 2001. Long-term dynamics of three benthic *Ampelisca* (Crustacea-Amphipoda) populations from the Bay of Morlaix (western English Channel) related to their disappearance after the 'Amoco Cadiz' oil spill. *Marine Ecology Progress Series* 214:201-209.

PRIMER-E, Ltd. 2001. *PRIMER.* Plymouth Marine Laboratory, UK.

Rosenberg, R., H.C. Nilsson, and R.J. Diaz. 2001. Response of benthic fauna and changing sediment redox profiles over a hypoxic gradient. *Estuarine, Coastal Shelf Sci*. 53:343-350.

Schimmel, S.C., B. D. Melzian, D.E. Campbell, C.J. Strobel, S.J. Benyl, J.S. Rosen, and H.W. Buffum. 1994. *Statistical Summary EMAP-Estuaries Virginian Province 1991.* EPA/620/R/94/005. USEPA, Narragansett, RI. 77p.

Literature Cited-continued

Serejo, C. S. 1998. The genus *Leucothoe* (Crustacea, Amphipoda, Leucothoidae) on the Brazilian coast. *Beaufortia.* 48:105-135.

SPSS Inc. *SYSTAT 10*. Chicago, IL

Summers, J.K., J.M.Macauley, P.T. Heitmuller, V.D. Engle, A.M. Adams, and G.T. Brooks. 1993. *Statistical summary: EMAP-Estuaries Louisianian Province- 1991*. EPA/620/R-93/007

Swartz, R.C., W.A. Deben, K.A. Sercu and J.O. Lamberson. 1982. Sediment toxicity and the distribution of amphipods in Commencement Bay, Washington, USA. *Mar. Pollut. Bull*. 13:359-364.

SYSTAT, Inc. 2002. *Table Curve 2D.* ver. 5.01. Richmond, CA.

Thoemke, K. W. 1979. *The Life Histories and Population Dynamics of Four Subtidal amphipods from Tampa Bay, Florida.* Ph. D. Diss., 150 p. Univ. S. Florida, Tampa.

Thomas, J.D. 1976. A Survey of gammarid amphipods of the Barataria Bay, Louisiana region. *Contrib. Mar. Sci.* 20:87-100.

Thomas, J.D. 1993. Biological monitoring and tropical biodiversity in marine environments: a critique with recommendations, and comments on the use of amphipods as bioindicators. *J. Nat. Hist*. 27:795-806.

Thomas, J. D. and J. L. Barnard. 1983. *The Platyischnopidae of America (Crustacea: Amphipoda*). Smithsonian Contrib. Zool. 375. Washington, D.C. 33p.

U.S. Environmental Protection Agency. 1993. *Environmental Monitoring and Assessment Program--Laboratory methods Manual—Estuaries*. USEPA, Cincinnati, OH. [Draft]

U.S. Environmental Protection Agency. 1994. *Methods for Assessing the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods*. EPA/600/R-94/025. US Environmental Protection Agency, Narragansett, RI.

Versar, Inc. 1993. *Tampa Bay National Estuary Program Benthic Project Field and Laboratory Methods Manual.* Versar, Inc., Columbia, MD.

Watling, L. and D. Maurer. 1972. Marine shallow-water amphipods of the Delaware Bay area, U.S.A. *Crustaceana Suppl*. 3:251-266.

Ysebaert T., P. Meire, P.M.J. Herman, and H. Verbeek. 2001. Macrobenthic species response surfaces along estuarine gradients: prediction by logistic regression. *Marine Ecology Progress Series* 225:79-95.

Zimmerman, R., R. Gibson, and J. Harrington. 1979. Herbivory and detritivory among gammaridean amphipods from a Florida seagrass community. *Mar. Biol.* 54:41-47.