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A SURVEY OF THE SIPUNCULA OF THE INDIAN RIVER LAGOON

Mary E. Rice, Julianne Piraino and Hugh F. Reichardt

ABSTRACT

From 22 stations in the Indian River Lagoon, ranging from Haulover Canal in the north to St. Lucie Inlet in the south, 18 species of sipunculans are reported. Habitats include oyster beds, subtidal and intertidal sand, seagrass beds, and sea walls. The greatest number of species occurs near inlets: Sebastian, Fort Pierce, and St. Lucie. The most widely distributed sipunculan in the Indian River Lagoon is *Phascolion cryptum*, averaging 3 cm in length. Usually buried in the upper 5 cm of sandy sediments associated with seagrass beds, it inhabits discarded gastropod shells in shallow waters throughout the lagoon. Development is direct, a crawling vermiform stage hatching from egg coverings within 2 days. The second most widely distributed sipunculan is *Themiste lageniformis*, attaining a maximum extended length of 4 cm. Occurring most commonly near the inlets of Fort Pierce and Saint Lucie, it is associated either with oyster beds, where it lives in and among the shells, or with the encrusting fauna on sea walls, among the vermetid snails, sponges, and tunicates. In oyster beds near Fort Pierce it occurs in densities as great as 2,100·m^2. This species is parthenogenic; its development includes a short-lived non-feeding pelagic larval stage. Other species, found mostly in relatively small numbers near the inlets, are characterized generally by developmental patterns with long-lived feeding pelagic larvae. Whether they establish breeding populations in the Indian River Lagoon has not been determined.

The presence of sipunculans in the Indian River Lagoon (IRL) has been noted in several ecological studies of the macrobenthos (Young et al., 1975; Young and Young, 1977, 1978; Virnstein et al., 1983), as well as in studies of sipunculan reproduction (Rice, 1975a, 1975b; Rice et al., 1983; Pilger, 1987, 1989). Young and Young (1977), in a review of the community structure of the macrobenthos associated with seagrasses in the IRL, ranked the sipunculan *Phascolion cryptum* Hendrix, 1975 as third in abundance at a Haulover station and fourth at Link Port and St. Lucie stations. Virnstein et al. (1983) reported that this same species, an infaunal sand burrower, was abundant in both seagrass beds and sand bottoms. A study on the ecology and reproduction of *Phascolion cryptum* at a Link Port site (Rice et al., 1983) found that densities were consistently higher in seagrass beds than in bare sand areas surrounding seagrass and that reproduction occurred throughout the year with a trend toward increased activity from November through May. Other studies on reproduction of the sipunculan *Themiste lageniformis* Baird, 1868 reported that the specimens were collected in the IRL (Pilger, 1987, 1989). In a listing of breeding seasons of sipunculans (Rice, 1975b) three species, *Themiste lageniformis*, *T. alutacea*, and *Golfingia* (=*Nephasoma*) *pellucida*, were recorded as from Fort Pierce, Florida, but no distinction was made as to whether they were lagoonal or coastal.

The observations reviewed in this paper have been accumulated over a period of 22 years, mostly as part of a long-term research program on the systematics, reproduction and larval biology of the phylum Sipuncula in Florida and the Caribbean. As many as 14 species are added to the previously published records of species occurring in the IRL. Although collecting sites were established primarily as sources of specimens for reproductive studies, the information accumulated through these collections provides insight into the distribution of sipunculan spe-

cies along the length of the IRL and their association with inlets and specific habitats.

Materials and Methods

Twenty-two stations were sampled, ranging from Haulover in the north to Saint Lucie Inlet in the south. The Appendix lists the locality of each station, and a description of the habitat.

Measurements of density were made for two species, *Phascolion cryptum* and *Themiste lageniformis*. Densities of *Phascolion cryptum* were measured as described by Rice et al. (1983). Collections were made with a device that sampled areas of the bottom 15 × 15 cm to a depth of 5 cm. Samples were sieved through a screen with a 2.8 mm mesh and specimens removed. For *Themiste lageniformis* 0.25 m^2 quadrats were sampled along a transect on an intertidal oyster reef at Boot Toe Point near the Fort Pierce Inlet at monthly intervals for 1 year. Quadrats were measured by an open-ended stainless steel rectangular collector, measuring 25 × 25 cm, that was hammered through the shells of the oyster bar. All shells and surrounding sediment within the area demarcated by the collector were removed and examined for sipunculans.

Systematic Survey

Eighteen species have been recorded in the IRL. They include representatives of all 6 families and 9 of the 17 genera recognized in a recent classification of the Sipuncula (Gibbs and Cutler, 1987). Species are listed below under the appropriate family designation, along with the station numbers at which they have been collected (See Appendix).

Family Sipunculidae.—Sipunculus nudus Linnaeus, 1766, Stations 88, 154, 290, 294, 304, 333; *Sipunculus polymyotus* Fisher, 1947, Stations 154, 316, 332; *Xenosiphon* sp., Station 332; *Siphonosoma cumanense* (Keferstein, 1867), Station 316; *Siphonosoma ingens* (Fisher, 1947), Station 316; *Siphonosoma* sp., Station 316.

Family Golfingiidae.—Nephasoma pellucidum (Keferstein, 1865), Stations 83, 156.

Family Phascolidae.—Phascolion cryptum Hendrix, 1975, Stations 83, 87, 89, 146, 153, 154, 318, 336, 337, 338.

Family Themistidae.—Themiste alutacea (Grube and Oersted, 1858), Stations 83, 86, 87, 156, 304; *Themiste lageniformis* Baird, 1868, Stations 83, 86, 156, 196, 322, 326.

Family Phascolosomatidae.—Antillesoma antillarum (Grube and Oersted, 1858), Stations 83, 87, 156; *Phascolosoma perlucens* Baird, 1868, Stations 83, 87, 156, 304; *Phascolosoma varians* Keferstein, 1865, Stations 83, 156, 304.

Family Aspidosiphonidae.—Aspidosiphon fischeri ten Broeke, 1925, Station 156; *Aspidosiphon parvulus* Gerould, 1913, Station 156; *Aspidosiphon spinososcutatus* Fischer, 1922, Station 156; *Aspidosiphon steenstrupii* Diesing, 1859, Station 156; *Aspidosiphon* sp., Stations 83, 156.

Representatives of each family are illustrated in Figure 1.

Distribution in the Indian River Lagoon

The 22 stations at which sipunculans were collected span a distance of 102 nautical miles along the length of the IRL from Haulover in the north to St. Lucie Inlet in the south (Appendix, Fig. 2). Fifteen of the 22 stations are within 1 nautical mile of an inlet: 3 near Sebastian Inlet; 9 near Fort Pierce Inlet; 3 near St. Lucie Inlet. The remaining 7 stations are within the main body of the lagoon, 5 being within 1.5 nautical miles of the Link Port Channel. The number of species and the families represented at these stations are illustrated in Figure 2. For simplification, stations within a radius of 1.5 nautical miles are grouped together, thus 7 sites are shown in the figure.

The number of species is higher at the stations surrounding the inlets than in other parts of the lagoon. Of the three inlets, the most southerly, St. Lucie Inlet, has the greatest number of species (Fig. 2). A grouping of species into families

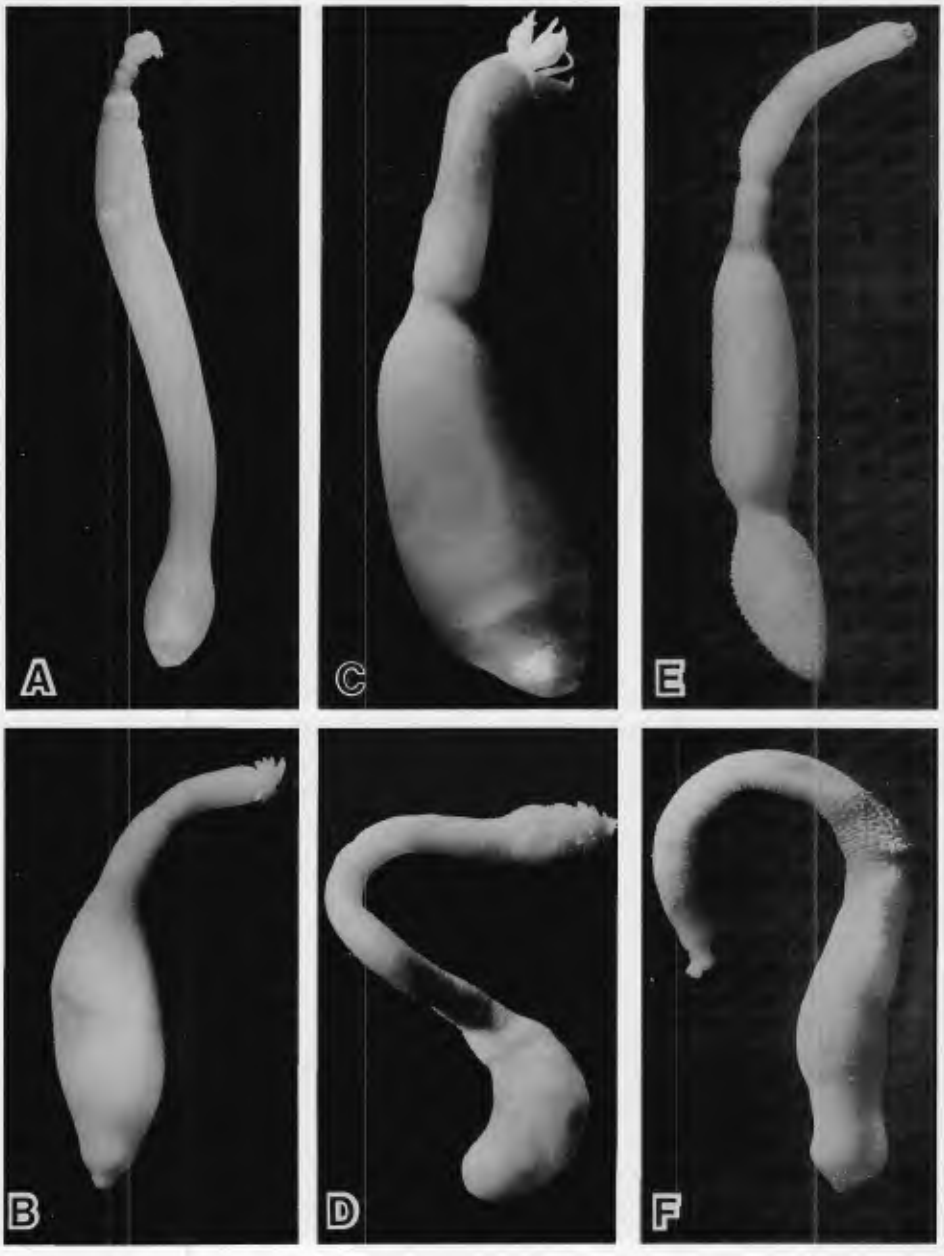

Figure 1. Representatives of the families of Sipuncula from the Indian River Lagoon. A. *Sipunculus nudus*, 2×. Young specimen. Adults reaching 30 cm in length. B. *Nephasoma pellucidum*, 7×. C. *Themiste lageniformis*, 5×. D. *Phascolion cryptum*, 4×. E. *Phascolosoma perlucens*, 5×. F. *Aspidosiphon spinososcutatus*, 6×.

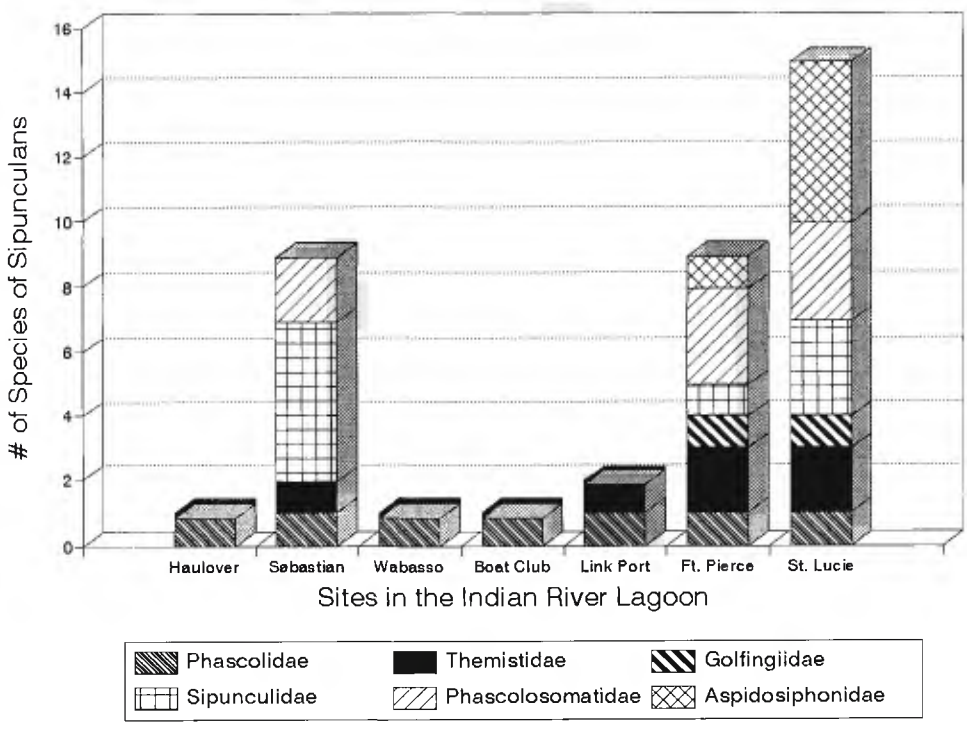

Figure 2. Distribution of sipunculans in the Indian River Lagoon.

shows that only one family, Phascolidae, represented by the single species *Phascolion cryptum,* occurs at all of the sites along the length of the lagoon. One other family with a species found at some distance from the inlets is Themistidae, represented by *Themiste lageniformis* at the group of stations designated as Link Port (Fig. 2). This species is also common near the Fort Pierce and St. Lucie Inlets where it co-occurs with a less common congener *T. alutacea.* The family Sipunculidae shows the greatest number of species at the Sebastian Inlet, whereas Aspidosiphonidae has representatives only at the more southerly inlets: 1 species at Fort Pierce Inlet and 5 species at St. Lucie Inlet.

Habitats

Table 1 distinguishes three generalized types of habitats for 13 species at various collecting localities. They are categorized as: sand and seagrass; sand flat; hard substrate.

Seagrass meadows interspersed with areas of bare sand are common throughout the IRL, particularly in shallow, subtidal regions protected from strong surf and winds. *Phascolion cryptum* is a common component of the infaunal macrobenthos in this habitat where it burrows through the upper 5 cm of sediment. Inhabiting a discarded gastropod shell, *P. cryptum* extends its introvert through the aperture, dragging the shell through the sand and, presumably, ingesting sediment as it burrows. Under laboratory conditions, this species is also observed to remain quiescent for extended periods during which it stretches its tentacles above the surface of the sand, most probably respiring and, at the same time, ingesting

Table 1. Habitats and developmental patterns of common sipunculans in the Indian River Lagoon

Species	Locality	Habitat	Developmental pattern
Phascolion cryptum[3]	Haulover, Sebastian, Wabasso, Boat Club, Link Port, Ft. Pierce, St. Lucie	sand & seagrass	direct
Siphonosoma cumanense[5]	Sebastian	sand flat	planktotrophic
Sipunculus nudus[1,5]	Sebastian, Ft. Pierce, St. Lucie	sand flat	planktotrophic
Antillesoma antillarum[3]	Ft. Pierce, St. Lucie	hard substrate	planktotrophic
Aspidosiphon fischeri[3]	St. Lucie	hard substrate	planktotrophic
Aspidosiphon parvulus[6]	St. Lucie	hard substrate	planktotrophic
Aspidosiphon spinososcutatus[7]	St. Lucie	hard substrate	planktotrophic
Aspidosiphon steenstrupii[7]	St. Lucie	hard substrate	planktotrophic
Nephasoma pellucidum[4]	Ft. Pierce, St. Lucie	hard substrate	planktotrophic
Phascolosoma perlucens[3]	Sebastian, Ft. Pierce, St. Lucie	hard substrate	planktotrophic
Phascolosoma varians[3]	Sebastian, Ft. Pierce, St. Lucie	hard substrate	planktotrophic
Themiste alutacea[3]	Sebastian, Ft. Pierce, St. Lucie	hard substrate	lecithotrophic
Themiste lageniformis[2]	Link Port, Ft. Pierce, St. Lucie	hard substrate	lecithotrophic

[1] Hatschek, 1993; [2] Pilger, 1987; [3] Rice, 1975a; [4] Rice, 1975b; [5] Rice, 1988; [6] Rice, 1989; [7] Rice, unpubl.

suspended particulate material from the sea water through the tentacular ciliary activity.

Extensive intertidal sand flats are especially prevalent in the vicinity of the inlets of the lagoon. It is this habitat in which the large sand-burrowing species of the family Sipunculidae are found. Although numerous attempts have been made to excavate these specimens by digging on the sand flats or using a suction device, these efforts have met with limited success. Most specimens listed in this survey have been found at exceptionally low tides lying in a moribund state on the surface of the sand, apparently having emerged from the sediment spontaneously. Usually occurring in small numbers at such times, one species, *Sipunculus nudus*, has been found in large numbers on three occasions, ranging from 30 to 239 specimens on a sand flat covering roughly 100 m^2 in area in the Fort Pierce Inlet.

Hard substrates around the Fort Pierce Inlet and within the lagoon proper consist of oyster beds usually associated with mangroves or the shorelines of spoil islands. Clumps of oysters along with their empty shells provide a complex array of crevices and interstices which can be occupied by several species of sipunculans, the most common of which is *Themiste lageniformis*. Often found within discarded, sediment-filled shells, this species may erode the inner surface of the shell to form a depression in which it nestles. From such protective habitats, it extends on elaborately developed tentacular crown to feed by means of ciliary collection of particulate matter suspended in the surrounding water. This species is found in great abundance in the oyster beds in the vicinity of the Fort Pierce Inlet (see below), as well as at a spoil island approximately 5 miles north of the inlet near the Link Port channel. Six other species found in the oyster beds near the Fort Pierce Inlet, but with less frequency, are: *Antillesoma antillarum, Aspidosiphon* sp., *Nephasoma pellucidum, Phascolosoma perlucens, P. varians,* and *T. alutacea.*

At the Sebastian Inlet the only hard substrate at which collections were made was among the boulders along the inlet. Both under the boulders and among the interstices formed by them were the rock-dwelling species *Themiste alutacea* and two species of *Phascolosoma, P. perlucens* and *P. varians.*

A hard substrate near the St. Lucie Inlet at Bessie Cove consists of a sea wall which harbors a diverse community of fouling organisms, including oysters, sponges, ascidians, and vermetid gastropods. The sipunculans are found among and under the clumps of oysters and vermetids. In addition to the 7 species listed above in association with hard substrates, there are 4 species of *Aspidosiphon*: *A. fischeri, A. parvulus, A. spinososcutatus, A. steenstrupii.*

Density Measurements

Measurements of density were ascertained for the two most widely distributed sipunculans in the IRL, *Themiste lageniformis* and *Phascolion cryptum.* Densities of *T. lageniformis,* measured at monthly intervals for 1 year (1974) along a transect on an intertidal oyster bed near the Fort Pierce Inlet (Station 86), averaged 1,249 (±480) individuals per square meter, ranging from 512 to 2,112. Density measurements of *P. cryptum* were made at Link Port (Station 153) in January, 1994 for comparison with densities reported at that locality by Rice et al. (1983). From a single quantitative sampling with 10 replicates the density in January 1994 was 27 specimens per square meter.

Discussion

There is a marked concentration of sipunculan species around the inlets. Sixteen of the 18 species recorded were found only around inlets, the remaining two, *Phascolion cryptum* and *Themiste lageniformis,* occurring within the lagoon proper. These two latter species are absent in the extensive collections that we have made in the nearby coastal waters, whereas the remainder (with the exception of the unidentified species and the rare *Siphonosoma ingens*) have been found either in intertidal coastal habitats or in offshore sediments on the continental shelf. However, *P. cryptum* and *T. lageniformis* are not endemic to the lagoon, having been recorded in our collections in the Florida Keys and, in the case of *T. lageniformis,* also at Rookery Bay on the Gulf of Mexico.

Both *Themiste lageniformis* and *Phascolion cryptum* have been found in large densities in the IRL. As mentioned above, the density of *T. lageniformis* was calculated to average 1,249·m^2 (±480, SD) during 1974 in an oyster bed near the Fort Pierce Inlet. In a study by Rice et al., 1983, densities of *P. cryptum,* retained by a 2.8 mm mesh sieve, were found to range from 340 to 1,500 individuals·m^2 in a population at Link Port over the period of 1 year (1976–1977). A more recent measurement of the population of *P. cryptum* at the same Link Port site, reported in the section on Density Measurements of this paper, showed a density of only 27·m^2 for a comparable size class. Other authors reported large densities of *P. cryptum* at Link Port in the 1970's (e.g., 2,400·m^2, Young and Young, 1977, 1978). Whether the strikingly lower density reported here is indicative of a trend toward a meaningful decrease in the species density throughout the lagoon since the late 1970's cannot be determined from the available data.

From previous studies, information is available on developmental patterns of 13 of the 18 species found in the IRL (Rice, 1975a, 1975b, 1988, 1989). Table 1 indicates whether the development is direct, or whether the larval stage is lecithotrophic or planktotrophic. *Phascolion cryptum* is the only species listed with a direct development; i.e., lacking a larval stage. In this species the embryo

hatches from the egg coverings into a crawling worm. Two species, *Themiste lageniformis* and *T. alutacea*, have lecithotrophic larvae which swim for 6 to 12 days before transforming into a crawling vermiform stage. The other species have planktotrophic development with long-lived feeding larvae.

The species with planktotrophic development are all found in offshore waters and in the lagoon they are restricted to the regions around the inlets. It is not known whether these are reproducing populations in the inlets and whether they are not recruited into the lagoon proper because of restricted larval tolerances. It is of interest to note that the two species that do not occur in offshore waters, *P. cryptum* and *T. lageniformis*, either lack a larval form entirely or have a short-lived larval form. These species can establish reproducing populations within the lagoon away from inlets.

In any management plan for maintaining invertebrate biodiversity in the IRL, it will be important to consider life history patterns and the role of larvae in dispersal and establishing populations. Species with long-lived larvae, for example, are capable of dispersing over great distances and have the potential for recolonizing disturbed areas and ephemeral habitats. However, those species with short-lived larvae or no larvae can disperse only short distances and thus would be most vulnerable to disturbances. These developmental factors, along with larval tolerances and reproductive seasonality should be considered in selecting species or their habitats for protection.

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Address: *Smithsonian Marine Station at Link Port, 5612 Old Dixie Highway, Fort Pierce, Florida, 34946.*

APPENDIX

List of Stations and Habitats in the Indian River Lagoon where sipunculans were collected.

Sta. 83. Little Jim Island, SE shore, near Fort Pierce Inlet; oyster bed.
Sta. 86. Boot Toe Point, near Fort Pierce Inlet; oyster bed.
Sta. 87. Fort Pierce, SE of North Bridge; first intertidal oyster bed.
Sta. 88. Fort Pierce Inlet, N side opposite Coast Guard Station; intertidal sand bar.
Sta. 89. Near Link Port, approximately 0.5 mile N of Link Port canal, about 0.25 mi W of shore; subtidal seagrass.
Sta. 146. Haulover Canal, near Titusville, on lagoon in bay N of canal; subtidal muddy sand.
Sta. 153. Link Port, in cove just N of Link Port jetty; subtidal seagrass and sand.
Sta. 154. Bessie Cove, near St. Lucie Inlet, in lagoon NW of sea wall; intertidal sand flat.
Sta. 156. Bessie Cove, sea wall N of St. Lucie Inlet; encrusting organisms such as vermetids, sponges, oysters, tunicates on sea wall.
Sta. 196. Snapper Cut, E end, just N of Fort Pieree Inlet; oyster bed.
Sta. 290. Fort Pierce Inlet, just N of E end of South Bridge; intertidal sand bar.
Sta. 294. Little Jim Island, near Fort Pierce Inlet, S of island; intertidal sand flat.
Sta. 304. Sebastian Inlet, NW side of bridge; encrusting organisms on rock boulders of jetty.
Sta. 316. Sebastian Inlet, W of inlet in lagoon; intertidal sand flats.
Sta. 318. Big Starvation Cove, E shore of lagoon, approximately 6 mi N of Fort Pierce Inlet; subtidal muddy sand.
Sta. 322. Jack Island, SE shore; intertidal oyster bed.
Sta. 326. Spoil island, E of ICW marker 169, St. Lucie Co., FL; oyster bed.
Sta. 332. St. Lucie Inlet, sandbar N side of inlet channel; intertidal sand flat.
Sta. 333. Fort Pierce Inlet, Coon Island, S end; intertidal sand flat.
Sta. 336. Wahasso Causeway, SE side, E of boat ramp; oyster bed along mangrove and *Spartina* shoreline.
Sta. 337. Boat Club Island, SE side of island; subtidal sand and shell fragments.
Sta. 338. Coconut Point, S side, 0.75 mi S of Sebastian Inlet; muddy sand, sparse seagrass.