ISSN 0095-0157

FLORIDA MARINE RESEARCH PUBLICATIONS

Nearshore Marine Ecology at Hutchinson Island, Florida: 1971-1974

IV. Lancelets and Fishes

CHARLES R. FUTCH AND STEVEN E. DWINELL

Florida Department of Natural Resources
Marine Research Laboratory

Number 24

May 1977

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ABSTRACT

Futch, C. R., and S. E. Dwinell. 1977. Nearshore Marine Ecology at Hutchinson Island, Florida: 1971-1974. IV. Lancelets and Fishes. Fla. Mar. Res. Publ. No. 24. 23 pp. Five stations adjacent to Hutchinson Island, Florida, in depths between 5.0 and 12.0 m were sampled by trawl and benthic grab bimonthly during 1971-1973. Three of these stations were sampled by trawl monthly (day and night) during 1973-1974. Three surf zone stations were sampled by beach seine bimonthly between 1971-1973.

Grab samples produced 645 lancelets, *Branchiostoma virginiae*. Maximum recorded abundance was 1,750 per m^2. Spawning occurred between February and March and again from June through August. Lancelets spawned in February or March either did not survive, or migrated to unsampled areas. During the first year of life, growth was about 2.5-3.0 mm per month, and slower thereafter. Maximum life span of lancelets in this area is about two years. Distribution and abundance of lancelets among the five stations was more related to sediment composition and texture than to any other ecological factor considered. Most lancelets settled and grew to maturity in sediments of primarily coarse sand with little or no silt.

Trawl and beach seine samples produced 75 species of fishes. This sampling covered only two macrohabitats, the surf zone and sand-shell bottom zone. A preliminary list of reef fishes captured in previous unrelated work is provided. Additional studies will be necessary to fully document the ichthyofauna of the area.

Contribution No. 284, Florida Department of Natural Resources Marine Research Laboratory

This public document was promulgated at annual cost of $1088 or $0.55 per copy and paid for by the Florida Power and Light Company to make research results and marine resources information available to scientists and the public.

INTRODUCTION

In July 1970, the Atomic Energy Commission issued a construction permit to Florida Power and Light Company to build an 850 megawatt nuclear power plant (St. Lucie Unit No. 1) on Hutchinson Island, Florida (Figure 1). The plant is constructed to use Atlantic Ocean water for cooling, then discharge the heated effluent back into the Atlantic. In April 1971, Florida Power and Light Company provided funding for a long-term environmental study of marine life and seawater conditions adjacent to the power plant. This study, directed by the Florida Department of Natural Resources Marine Research Laboratory (FDNRMRL), was designed to gather baseline environmental data in the area to be influenced by the thermal plume, as projected by power company engineers. This report describes the life history of lancelets of the area and provides an annotated checklist of fishes collected during the study.

STATION DESCRIPTION AND SAMPLING RATIONALE

Detailed descriptions of stations and sampling rationale and procedures, provided by Gallagher (1977a; 1977b) are summarized. Five offshore stations and three beach stations (Figure 1, Table 1) were selected. Station I, located on the beach terrace about 0.5 km offshore, was characterized by well-sorted, compacted very fine sand (Figure 2). Water depth averaged 7.5 m (range: 6-9 m). Station II was about 1.5 km ENE of Station I in the trough between beach terrace and offshore shoal. Sediments were predominantly in the coarse sand fraction (Figure 3). Water depth averaged about 11 m (range: 9-12 m). Station III, about 3.5 km offshore on a line from Stations I and II, was located atop Pierce Shoal. This shoal rises to an average of about 7 m (range: 5-8 m). Bottom sediments were well sorted and predominantly (ca 75%) medium sand (Figure 4). Station IV, also in the offshore trough, was about 1.6 km SE of Station II. Sediments were almost identical in composition to those of Station II (Figure 5). Water depth averaged 10 m (range: 9-12 m). Station V, about 2.2 km NNW of Station II, was also in the offshore trough and in similar depths as Station IV. Sediments were poorly sorted; large shell fragments were the largest size class encountered. More silt (sediments in the 4 phi fraction) was found at this station than at any other (Figure 6). Beach Stations VI, VII, and VIII were located along the beach near the proposed intake and discharge structures. Locations of these stations varied from month to month as much as 100 m. The ever-changing beach profile, sometimes covering, sometimes exposing coquina rock reefs, dictated such changes.

TABLE 1. COORDINATES OF HUTCHINSON ISLAND SAMPLING STATIONS

STATION	° N Lat.	° W Long.
I	27° 21.3′	80° 14.1′
II	27° 21.6′	80° 13.2′
III	27° 22.0′	80° 12.4′
IV	27° 20.7′	80° 12.8′
V	27° 22.9′	80° 13.9′
VI	27° 21.4′	80° 14.5′
VII	27° 21.2′	80° 14.4′
VIII	27° 20.9′	80° 14.4′

Between September 1971 and July 1973, all stations were sampled every other month (daytime only). Offshore stations were sampled by Shipek grab and trynet to collect invertebrates and fishes; a beach seine was employed to capture surf zone fishes. Between September 1973 and August 1974, trynet tows were made monthly at Stations I, II, and III. Each station was sampled during night and day. In June 1975, an effort was made to sample fishes associated with the numerous coquina rock and associated sabellariid worm (*Phragmatopoma lapidosa* Kinberg) reefs along the shoreline near the study area.

SECTION I—LANCELETS

Lancelets are conspicuous components of nearshore sandy-bottomed marine habitats throughout tropical, warm temperate, and boreal (sensu Briggs, 1974) regions of the world. Lancelets typically lie buried in the sand with only their buccal regions exposed. Their adaptation to a filter-feeding mode of life is well documented (e.g., Orton, 1913; Barrington, 1937; Young, 1955). The literature provides a strong body of evidence that lancelet distribution is limited largely by sediment character, water salinity, and temperature.

Lancelets comprise a single subphylum, Acrania, a single class, Amphioxi, and a single order, Amphioxiformes. There are three nominal families, Branchiostomidae, Epigonichthyidae, and Amphioxididae. The last appears to consist of larval forms of other lancelet families (Hubbs, 1922; Bigelow and Farfante, 1948; Young, 1955; Berrill, 1955) and is, therefore, of questionable status. Five branchiostomids and one epigonichthyid are known from the western North Atlantic. These include *Branchiostoma caribaeum* Sundevall, *B. floridae* Hubbs, *B.*

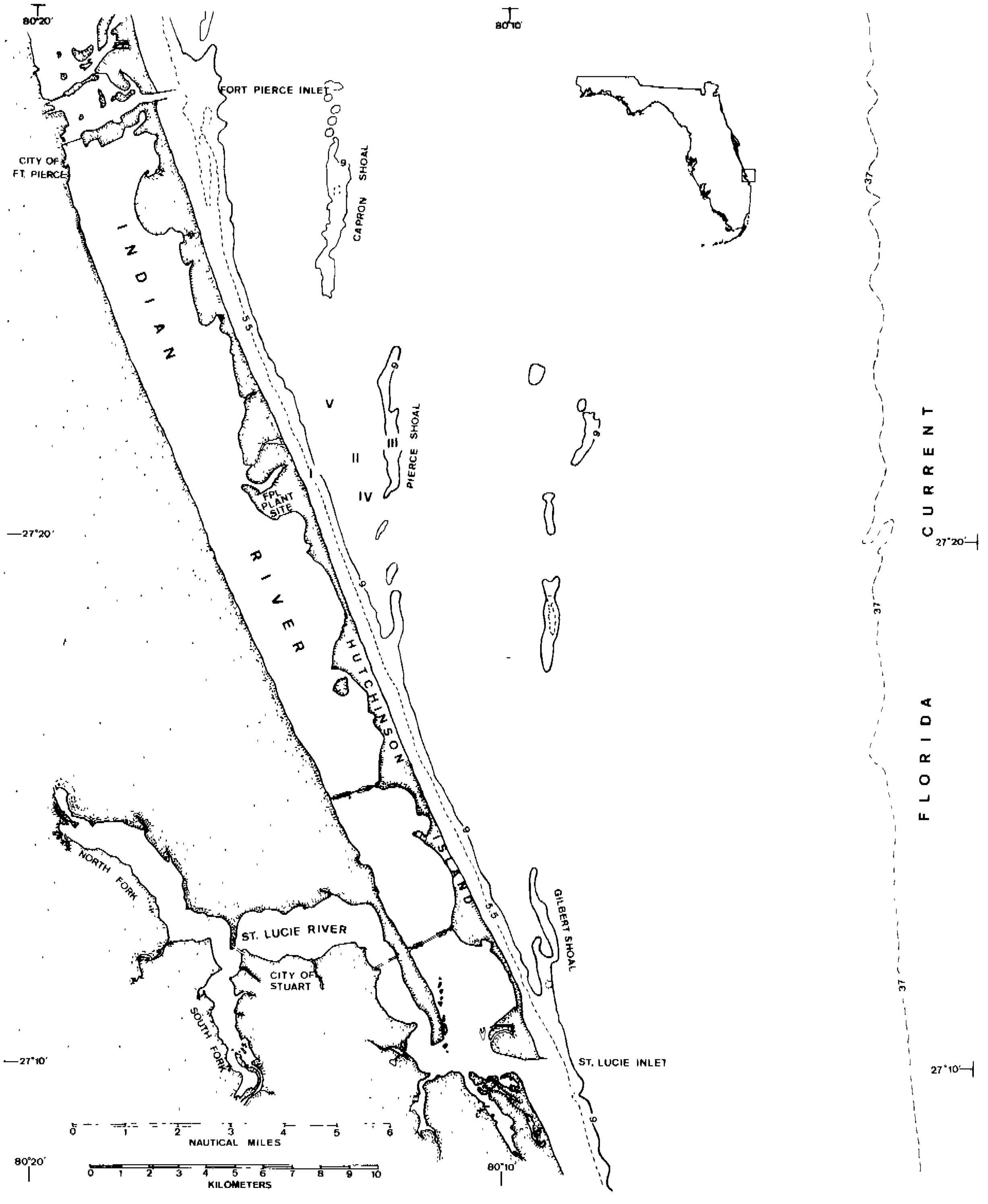

Figure 1. Station locations at Hutchinson Island, Florida.

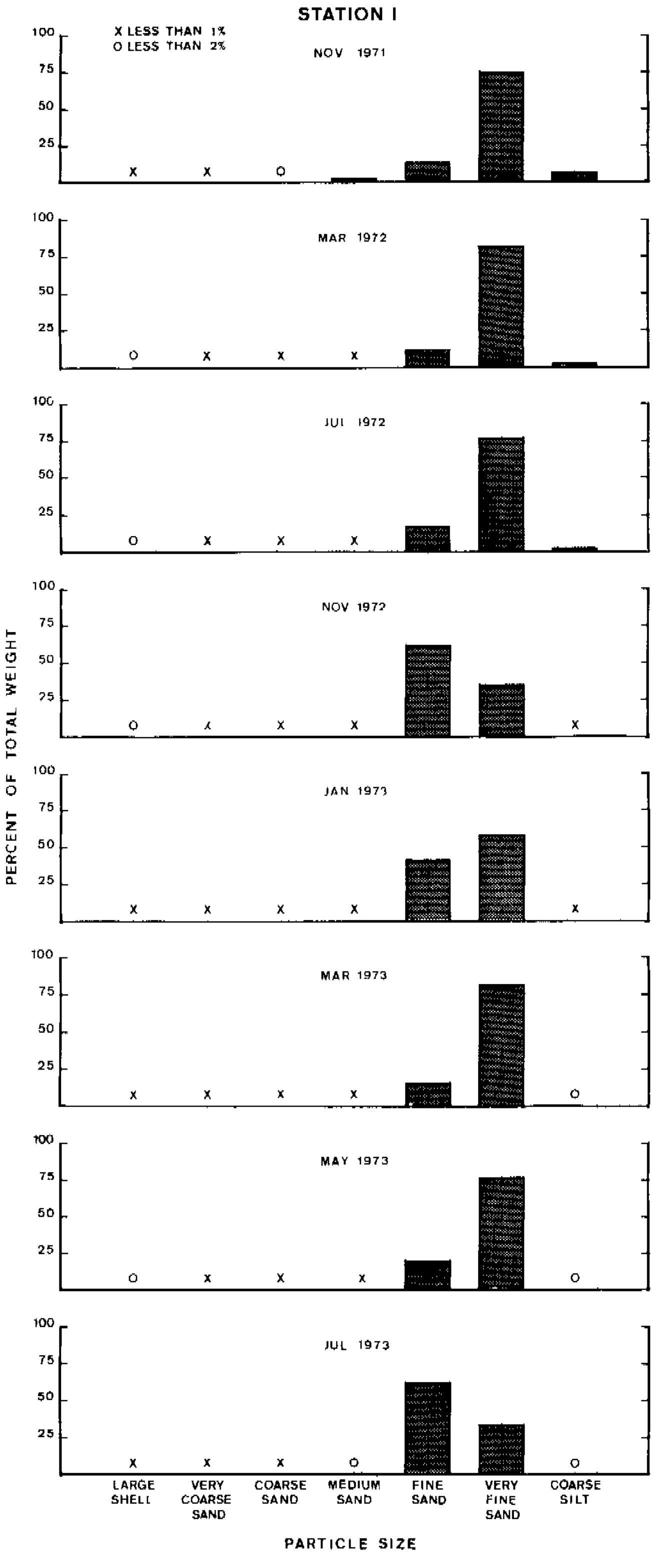

Figure 2. Sediment particle sizes at Station I.

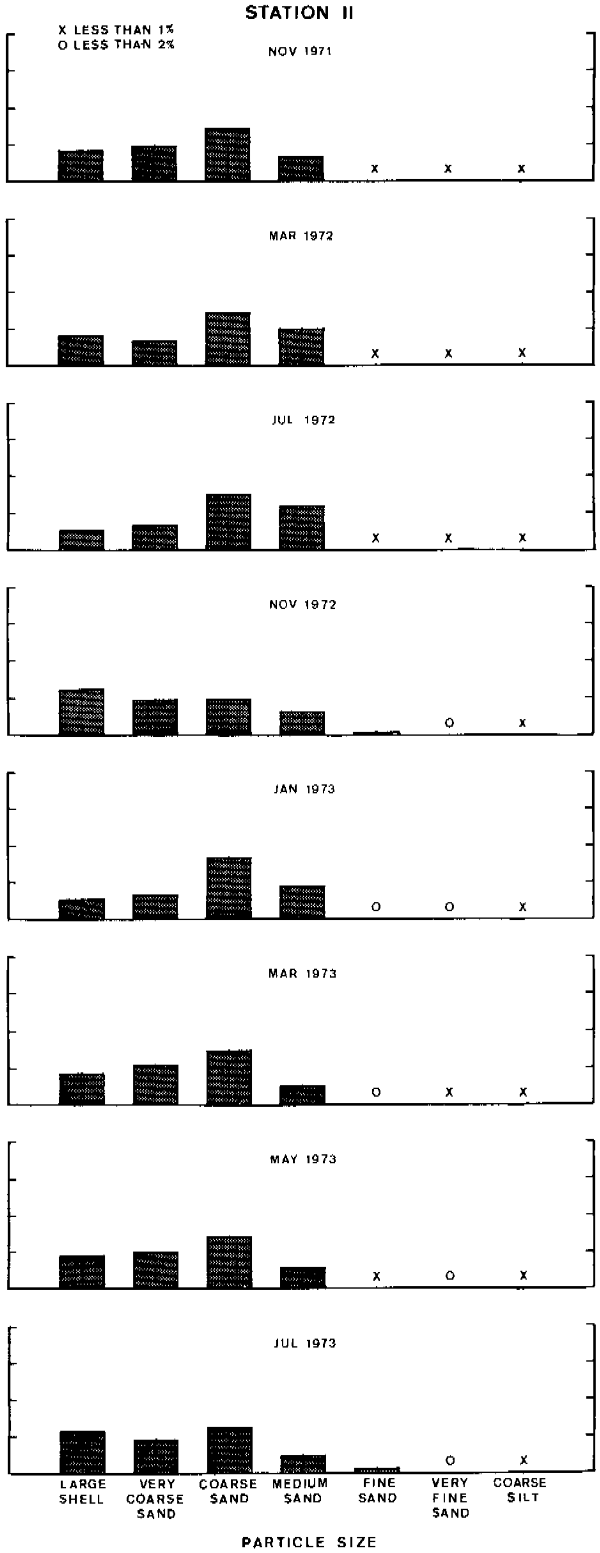

Figure 3. Sediment particle sizes at Station II.

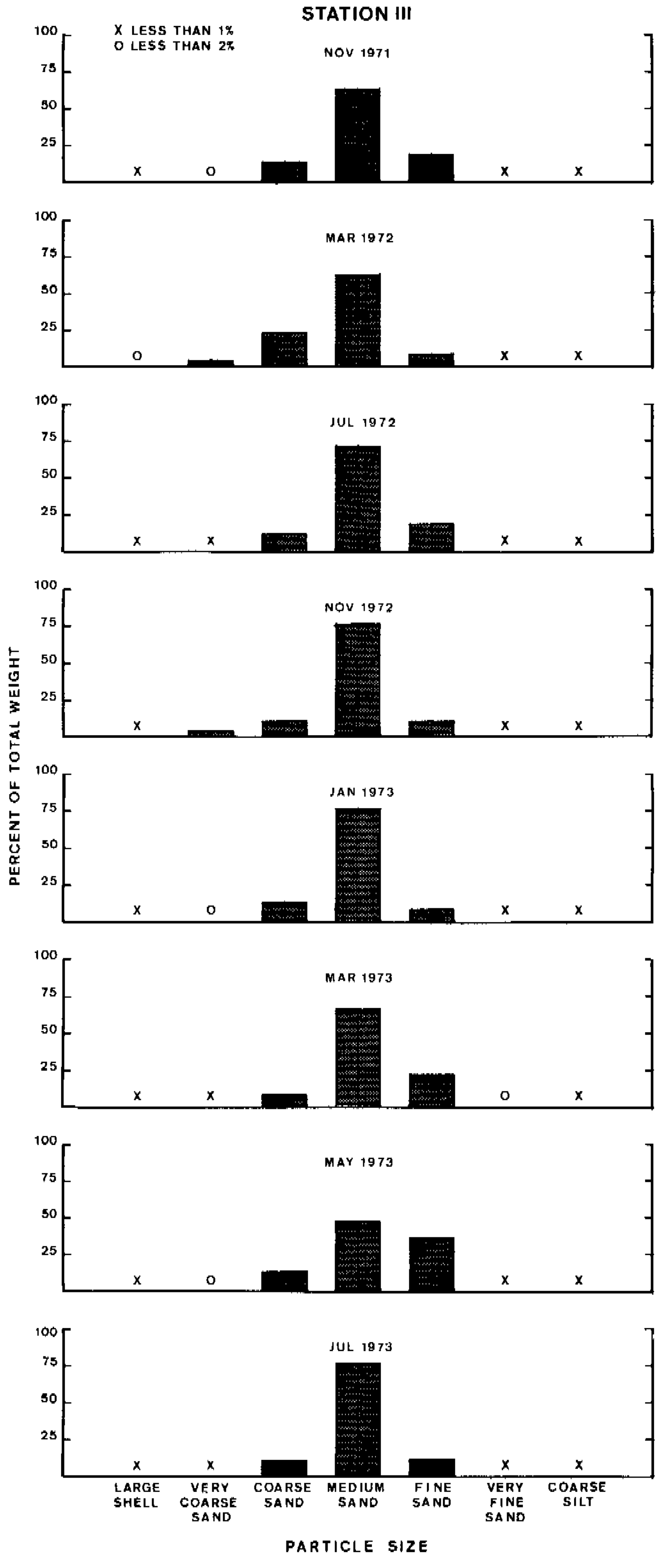

Figure 4. Sediment particle sizes at Station III.

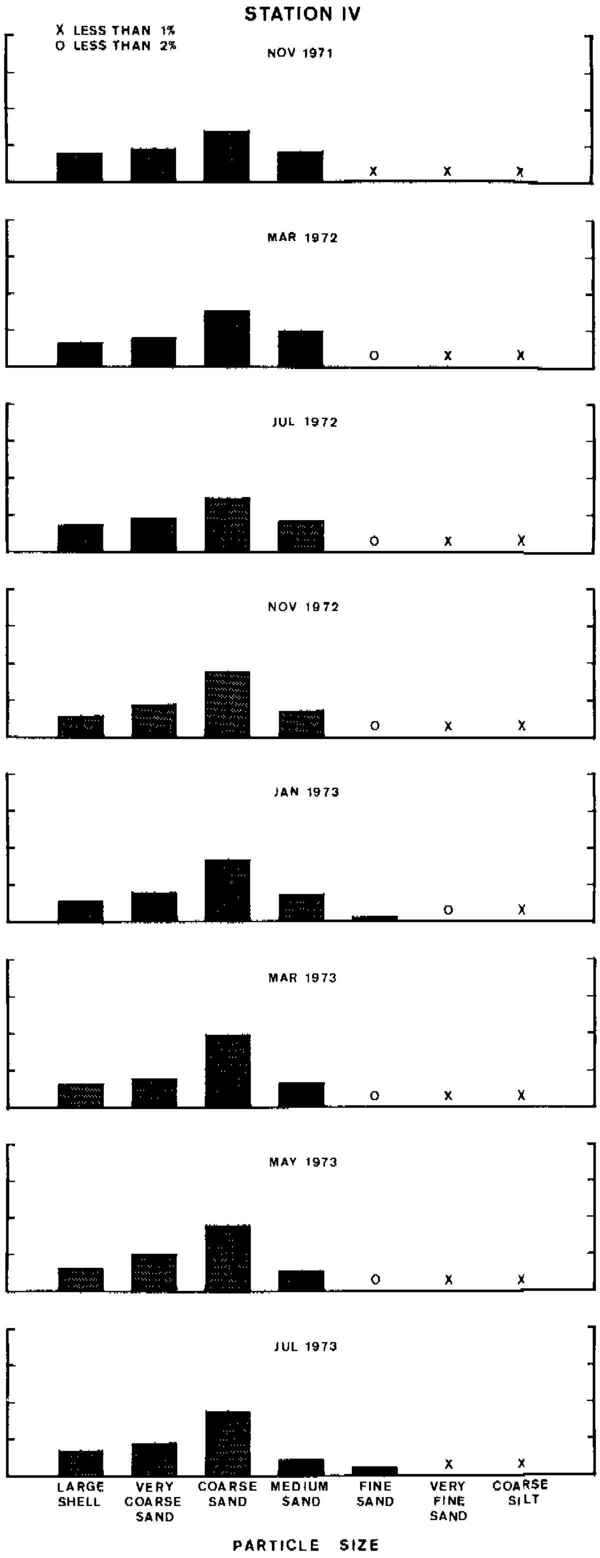

Figure 5. Sediment particle sizes at Station IV.

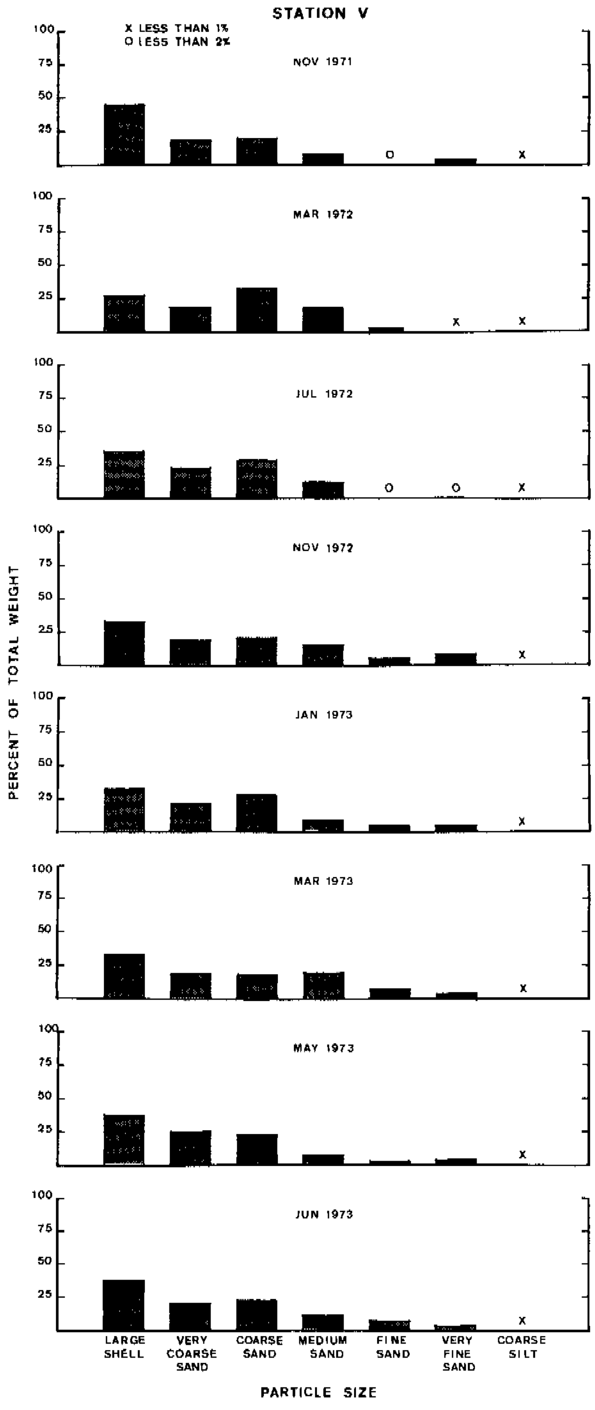

Figure 6. Sediment particle sizes at Station V.

bermudae Hubbs, *B. virginiae* Hubbs, *B. bennetti* Boschung and Gunter, and *Asymmetron lucayanum* Andrews (Hubbs, 1922; Bigelow and Farfante, 1948; Boschung and Gunter, 1966).

Hubbs (1922:8) stated: "All of the lancelets from the East Coast of the United States, variously referred to as *lanceolatum* or *caribaeum*, are perhaps conspecific with the Chesapeake form [*B. virginiae*]. It seems not improbable that *virginiae* and *floridae* will be found to intergrade." Although Bigelow and Farfante (1948) considered *virginiae* a junior synonym of *caribaeum*, their evidence is not convincing. Boschung and Gunter (1962) followed the classification by Bigelow and Farfante but later (1966:485) returned to Hubbs' (1922) classification, recognizing *virginiae* as a distinct species. Because of frequent overlaps in "diagnostic" characters, taxonomy of lancelets is somewhat uncertain. Berrill (1955:186-7) boldly asserted that: "we are dealing with a single type that varies only within certain very restricted limits." He further called the presently used taxonomic criteria "trivial differences." He believed that their early (Silurian) evolution into a form largely unmodified throughout the years, and their restriction to a nearshore "ecological asylum" suggested evolution of but a single species. However, Webb (1955), and later Boschung and Gunter (1962), demonstrated that the degree of variability of a single character differed among some nominal species, and showed that a statistical analysis of character variability is crucial in making taxonomic decisions. Our reference to Hutchinson Island specimens as *Branchiostoma virginiae* is based partly upon meristic observations, but largely upon recognition of the species by Webb (1955) and Boschung and Gunter (1966). Almost 60% of the specimens were too small to have developed dorsal and anal fin ray chambers, structures of primary importance in identification. We are not certain how intergradations might be manifested morphologically, nor are we satisfied that clinal variation in meristic characters has been appropriately addressed. Although this line of reasoning might be classified as "taxonomic four-flushing" (Dr. G.M. Sutton, in Peterson, 1962:257), a detailed statistical treatment of meristic characters is beyond the scope of this study. Thus, we rely upon the latest systematic treatment (Boschung and Gunter, 1966) for our decision.

METHODS AND MATERIALS

Lancelets were captured with a Shipek bottom grab. The grab took an individual sample of 0.04 m^2; five replicates were taken at each station. Each sample was fixed in 10% Formalin. Lancelets were later removed; small specimens were stored in 3% buffered Formalin, larger ones were transferred to 40% isopropanol. Lancelets were measured to the nearest 0.1 mm total length with an ocular micrometer or vernier calipers. The following list of materials examined includes station number, date, number of specimens, and size range.

Station I: July 1973, 2(3.4, 3.5).

Station II: September 1971, 21(5.9-59.8); November 1971, 16(13.6-52.8); January 1972, 12(18.6-55.0); March 1972, 7(23.5-51.5); May 1972, 13(21.8-56.3); July 1972, 7(28.3-52.4); September 1972, 18(4.6-19.6); November 1972, 2(13.7); January 1973, 5(14.2-20.5); March 1973, 6(17.7-53.6); May 1973, 2(30.0, 39.3); July 1973, 3(3.5-45.1).

Station III: September 1971, 17(6.7-13.4); November 1971, 1(18.2); January 1972, 2(20.6, 28.4); January 1973, 1(12.3); March 1973, 2(4.3, 4.4); July 1973, 350(3.1-4.1).

Station IV: September 1971, 1(5.8); November 1971, 8(11.1-39.1); January 1972, 72(15.1-59.8); March 1972, 5(4.9-50.8); May 1972, 3(7.3-25.7); July 1972, 2(47.0, 50.1); September 1972, 9(4.5-50.8); November 1972, 19(10.3-53.7); January 1973, 1(56.6); March 1973, 3(50.2-52.9); May 1973, 6(27.9-54.2).

Station V: September 1971, 8(9.2-57.4); November 1971, 1(37.7); January 1972, 4(15.5-22.2); March 1972, 1(22.3); September 1972, 3(41.5-45.9); January 1973, 8(17.3-27.1); March 1973, 2(19.3, 22.1); May 1973, 2(28.8, 51.4).

RESULTS AND DISCUSSION

A total of 645 lancelets were taken in Shipek grab samples at Stations I—V between September 1971 and July 1973 (Table 2). Mean number of individuals per square meter varied from 0 to 1,750. At Stations II and IV, where lancelets were most consistently encountered, abundance averaged 46.5 and 53.8 individuals per m^2. These means are not necessarily valid; early analyses of variance showed large variations among replicate samples. Lancelets probably conformed to a negative binomial (clumped) distribution, and five replicates were insufficient. However, time and resource allocations precluded ameliorative sampling modifications. Despite sampling inadequacies, sufficient lancelets were captured such that inferences can be made regarding life history and factors influencing their distribution and abundance in the study area.

TABLE 2. ABUNDANCE OF *BRANCHIOSTOMA VIRGINIAE* BY STATION BY MONTH

DATE	I	II	III	IV	V
SEP 71	0	21	17	1	8
NOV 71	0	16	1	8	1
JAN 72	0	12	2	72	4
MAR 72	0	7	0	5	1
MAY 72	0	13	0	3	0
JUL 72	0	7	0	2	0
SEP 72	0	18	0	9	3
NOV 72	0	2	0	19	0
JAN 73	0	5	1	1	8
MAR 73	0	6	2	3	2
MAY 73	0	2	0	6	2
JUL 73	2	3	350	0	0

These are actual numbers captured. To obtain number per m^2, multiply the individual value by 5. ($0.04\ m^2 \times 5$ replicates $\times\ 5 = 1\ m^2$).

LIFE HISTORY

SPAWNING

Breder and Rosen (1966) reviewed the literature on spawning of lancelets. There is no specialized spawning behavior, but a general release of gametes with chance fertilization. Webb (1958) found that *B. nigeriense* Webb, a tropical species found off West Africa, spawned from August through October and March through May. Chin (1941) stated that *B. belcheri* (Gray), a tropical Indo-West Pacific species, spawns twice yearly from May through July and again in December. *B. lanceolatum* (Pallas) in Indian waters spawns in July and August and December through February (Azariah, 1965a). Spawning of *B. virginiae* in the study area occurs in February or March, and again in June through August, judging from time of appearance of small individuals in bottom grab samples (Figure 7). Occurrence of planktonic lancelet larvae in September and October 1972 and February 1973 (B. Glass and L. Walker, FDNRMRL, personal communication) provides corroborative evidence. The length frequency histogram (Figure 7) indicates that individuals settling in March may not survive. Alternatively, there is the possibility that lancelets migrated from the sampling area at this time.

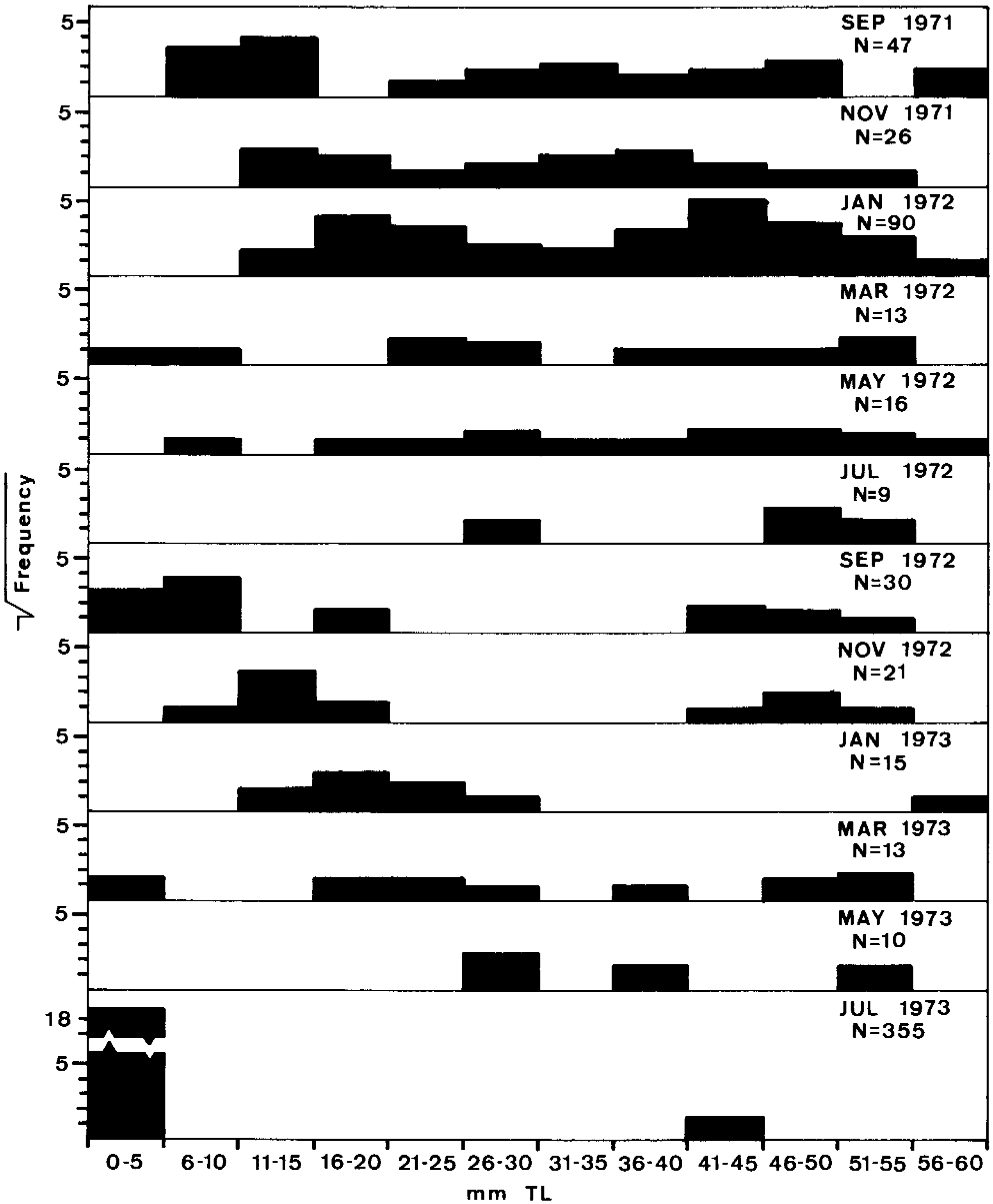

Figure 7. Length-frequency of lancelets, *Branchiostoma virginiae* Hubbs, at Stations I-V, September 1971 through July 1973.

AGE AND GROWTH

Shipek grab samples contained 364 *Branchiostoma virginiae* individuals smaller than 5.0 mm. Of these, 97% (353) were taken at Station III in July 1973; all were between 3.1 and 4.1 mm. The literature indicates that lancelets are planktonic larvae within this size range. *B. caribaeum* (= *virginiae*) settles to the bottom at about 7.5 to 8.0 mm (Bigelow and Farfante, 1948:14). *B. nigeriense* may remain planktonic for 74 to 140 days, attaining a length of 5.9 mm; attenuation of larval life without change in length was documented by Webb (1958). Larvae of *B. senegalense* Webb may settle between 6.0 and 9.5 mm, with a planktonic life of three to six months (Gosselck and Kuehner, 1973). *B. lanceolatum* has a larval life of two and one-half to three months (Webb, 1969a; Courtney, 1975). Duration of planktonic life of *B. belcheri* is not known, but pelagic larvae as large as 5.2 mm have been captured (Wickstead and Bone, 1959). Gosselck and Kuehner (1973:68) indicated that larval life of *B. senegalense* may be prolonged by absence of suitable substrate, presumably in much the same manner as retardation of metamorphosis in some flatfishes (Kyle, 1913:5) or polychaetous annelids (e.g., Day and Wilson, 1934; Wilson, 1948). Nevertheless, four lines of evidence indicate the small *B. virginiae* taken at Station III in July 1973 had assumed benthic existence: First, Webb (1969a) demonstrated that planktonic lancelet larvae are distributed throughout the water column during the day, not clustered near the bottom as Wickstead and Bone (1959) postulated. Second, *B. virginiae* were not captured in plankton tows at any station in July 1973. Third, the Shipek grab is an intrinsically poor plankton sampler. Fourth, the nature of sediments at Station III might have been particularly amenable for small lancelets. This will be discussed in detail in a subsequent section.

The age of *B. virginiae* at settling in the study area is not known; they were not well represented in plankton collections. Webb (1958:345) showed that *B. nigeriense* between 3.1 and 5.0 mm are from about 30-68 days old. Growth rate of *B. virginiae* is probably comparable. Webb (1958:340) correlated number of gill pouches with total length and age in *B. nigeriense*. Examination of ten *B. virginiae* individuals showed a similar correlation between number of gill pouches and total length; we assume these variables correlate with age. Minimum age at settling in the study area is probably 30 days.

Nelson (1969) noted three distinct year classes of *B. caribaeum* (= *floridae*) in Tampa Bay, Florida, indicating that individuals of the species do not exceed four years of age there. Chin (1941) found that *B. belcheri* lives for two or three years, but Webb (1958:336) suggested that the species occasionally lives three to four years. However, Webb (1958:350) showed that *B. nigeriense* had an annual life cycle. He suspected that other species "of relatively small size" (ca 30 mm maximum) were also annuals. We can discern only two distinct age classes of *B. virginiae* from Hutchinson Island. The trimodal length frequency population structure evident in March and May 1972 and March 1973 included young lancelets that did not survive to constitute a year class, or migrated from the study area.

Modal progressions of length frequencies suggest that *B. virginiae* in the study area grow an average of 2.5-3.0 mm per month, at least for the first 8-10 months after settling. Similar growth rates have been reported for *B. belcheri* and *B. nigeriense* (Chin, 1941; Webb, 1958). Assuming a growth rate of 2.5-3.0 mm per month is constant over 24 months, the maximum size of *B. virginiae* would be 54-75 mm (including size at settling of 3 mm). The largest specimen captured was 59.8 mm, well within the expected range. However, Chin (1941), Webb (1958), and Nelson (1969) found that sexual maturity occurred at about 30 mm in *B. belcheri*, *B. nigeriense*, and *B. caribaeum* (= *floridae*), respectively. Our data show that modal progressions become obscure between 30 and 40 mm size classes. If somatic growth is sacrificed for gonadal development at about 30 mm, the validity of length frequency analysis as a test for age classes might be compromised. Thus, there are two, and possibly three year classes evident in the Hutchinson Island population.

ECOLOGY

Berrill's (1955) view that lancelets are restricted to a tropical or warm temperate nearshore sand bottom "ecological asylum" is largely true, but nevertheless, an oversimplification. Limiting factors in lancelet distribution and abundance include sediment character, water temperature, salinity and depth, abundance of phytoplankton, and access to tidal currents.

SEDIMENT CHARACTER

Most evidence indicates that sediment character is the most important factor in lancelet distribution. Chin (1941) discovered that *B. belcheri* was most numerous where the bottom was mostly coarse sand. Webb and Hill (1958) found that *B. nigeriense* preferred coarse sand with less than 25% fine grains, with little or no silt. Boschung and Gunter (1962) reported that *B. caribaeum* (= *floridae*) in Mississippi Sound were found mostly on coarse or medium sand, rarely on silt, and not at all on clay. *B. arabiae* Webb and *Asymmetron lucayanum* in the western Persian Gulf were found where "more than half of the sedimentary elements were larger than 0.5 mm" (Dawson, 1964). Azariah (1965b) reported *Branchiostoma lanceolatum, B. indicum* (Willey), and *B. tattersalli* (Hubbs) in Indian waters from sediments comprised predominantly (69%) of particles between 0.991 and 0.495 mm diam. Lancelets (*B. virginiae*) off the coast of Savannah, Georgia, were found in clean sand sediments comprised of over 30% coarse sand grains (Cory and Pierce, 1967). On the other hand, *B. bennetti* is known only from "mud or muddy sand" off Louisiana (Boschung and Gunter, 1966:485). Also, Webb (1969b) demonstrated that *B. lanceolatum* at Helgoland was not necessarily dependent upon sediment texture, but other factors, such as permeability, amount of organic film attached to the grains, smoothness of the grains, and the degree of sorting. Distribution of lancelets at Hutchinson Island stations appeared largely determined by sediment texture. The following discussion describes the relationship.

Station I. Sediments at this station were well-sorted, very fine sands (Figure 2). Only two lancelets (3.4 and 3.5 mm) occurred there in July 1973. This single occurrence was accompanied by a change in texture from very fine sand to fine sand. Sediments here do not permit establishment of permanent populations of lancelets; the substrate appears too compacted to allow lancelets to burrow into it (see Webb and Hill, 1958:382).

Stations II and IV. Sediments at these stations were almost identical (Figures 3 and 5). The predominant fraction was coarse sand. Lancelet abundance at these two stations was similar. The sediment composition appeared equivalent to that graphed and described by Cory and Pierce (1967) as "offshore sediments." They found such sediments to support densest *B. caribaeum* (= *virginiae*) populations along the east coast of the United States. Webb and Hill (1958) found that *B. nigeriense* preferred a substrate primarily of coarse sand mixed with a wide range of other sand grain sizes. Sediments at Stations II and IV fit that description.

Station III. Sediments here were predominantly (ca 75%) polished, well-sorted medium sand (Figure 4). Although many lancelets settled here, no adults were found. The largest lancelet captured was 28.4 mm. This shoal may serve as a "nursery ground" for the lancelet population in the area. Webb and Hill (1958:383) speculate that juveniles should be able to live in sediments with higher fractions of finer sands than can adults. Our evidence suggests this is true. There were very few fishes captured at this station (see next section), indicating minimal predation. Also, Webb and Hill thoroughly documented lancelets' abilities to seek amenable habitats. It is likely that young lancelets settle at Station III, then migrate down to favorable sediments in the trough.

Station V. Sediments here were poorly sorted, most (ca 30%) were large shell fragments (Figure 6); more silt was found here than at any other station. The relatively larger silt fraction at this station is not evident in Figure 6, but the difference was quantifiable. This sediment type probably accounted for the relative paucity of lancelets at Station V. Large, angular, poorly polished grains and silt fractions are known to be unsuitable for lancelet habitation (Webb and Hill, 1958).

TEMPERATURE

Cory and Pierce (1967) suspected that temperatures less than 9°C limited distribution of *B. caribaeum* (= *virginiae*) along the east coast of the United States. Parker (1908) demonstrated that *B. caribbaeum* (*sic*; = *bermudae*) could withstand temperatures between 10 and 37°C. Webb and Hill (1958) determined the tolerable temperature range of *B. nigeriense* larvae and adults (also a tropical species) was 12 to 32°C. Larvae and adults showed slightly different responses, but both became inactive and died during exposure to temperature extremes. During our study, recorded temperatures ranged from 16 to 35°C; highest temperatures (those over 30°C) occurred at Stations III, IV, and V in September 1972 and at Station IV in July 1972 (Worth and Hollinger, 1977). Lowest temperatures were recorded in January and February 1973, and late July 1973. The cool July temperatures were undoubtedly a result of summer upwelling, as documented for Florida's east coast by Taylor and Stewart (1959). Although such summer upwellings can be considered commonplace occurrences, temperatures are probably high enough and the phenomenon of insufficient duration to cause widespread mortality among young lancelets spawned during winter. Ambient high temperature extremes are within limits known for this species and *B. nigeriense*. The young lancelets settling in March possibly do not survive (Figure 7). Although a temperature of 16°C is probably not of itself lethal, cessation of activity associated with cooler temperatures, as documented by Webb and Hill (1958), might render lancelets more susceptible to predation, or serve to slow or stop feeding.

SALINITY

Webb and Hill (1958) summarized previous works on salinity tolerances of various species of lancelets, and concluded that osmoregulatory powers differed among species. They demonstrated that the lower lethal threshold salinity of *B. nigeriense* was 13 ‰; the species also survived salinities up to 58.9 ‰. They noted a 14-20 h critical period in which lancelets exposed to low salinities could not recover if returned to high salinity. They also showed that distribution of the species in Lagos Lagoon, Nigeria, was controlled by low salinity resulting from spring rains. Dawson (1965) documented mass mortality of *B. caribaeum* (= *floridae*) along the Mississippi coast as a result of reduced salinity. Salinities at Hutchinson Island ranged from 33-38 ‰ (Worth and Hollinger, 1977). Although quanitites of fresh water may at times enter the Atlantic Ocean through Fort Pierce and St. Lucie Inlets, the study area is probably far enough from either to prevent large depressions in salinity. Highest salinities occurred in summer, possibly from upwelling or inshore displacement of the Gulf Stream. Salinity differences of about 5 ‰ in the study area is probably not a significant limiting factor.

WATER DEPTH

Lancelets are found most frequently no deeper than 57 m (Franz, 1927, as cited by Eisma and Wolff, 1970:104). Cory and Pierce (1967) recorded a single specimen of *B. caribaeum* (= *virginiae*) from a depth of 117 m, east of Charleston, South Carolina. Water depth was not a critical factor in distribution of the Hutchinson Island population since depths of the stations were about 7.5-12.0 m.

PHYTOPLANKTON ABUNDANCE

Pierce (1965) examined gut contents of *B. caribaeum* (= *floridae*) from Tampa Bay, Florida, and found a preponderance of phytoplankton. He accordingly postulated that lancelet abundance was dependent upon phytoplankton abundance. Phytoplankton is an important diet constituent of lancelet larvae. Wickstead and Bone (1959) listed the diatoms *Coscinodiscus*, *Pleurosigma*, *Nitzschia*, *Achnanthus*, *Navicula*, *Rhizosolenia*, and *?Cocconeis* as gut contents of *B. belcheri* near Singapore. Gosselck and Kuehner (1973) found that larvae of *B. senegalense* off Cap Blanc, Mauritania, fed predominantly upon diatoms and dinoflagellates of the genera *Thalassiosira*, *Nitzschia*, *Coscinodiscus*, *Dinophysis*, *Peridinium*, and *Ceratium*. On the other hand, Webb (1969a) examined guts of 67 *B. lanceolatum* larvae from Helgoland and found that 51% were empty, 21% contained a few small particles and diatoms, and 28% contained calanoid copepods, large chain diatoms and "large unidentified masses of organic origin."

Unfortunately, time did not permit gut content analysis of Hutchinson Island lancelets. If, however, phytoplankton and lancelet abundances are directly related, certain inferences are possible. Tester and Steidinger's (in press) report on phytoplankton in nearshore Hutchinson Island coastal waters indicates a year-round abundance of net phytoplankton. Dominant forms are the diatom genera *Skeletonema*, *Rhizosolenia*, *Chaetoceros*, *Thalassionema*, and *Nitzschia*. Moreover, bottom chlorophyll *a* values usually exceeded surface values, indicating that lancelets had an ample food supply within the benthos.

OCEAN CURRENTS

Pierce (1965:492) and Cory and Pierce (1967:656) suggested that areas subject to "noticeable tidal currents" produced greatest numbers of lancelets. Eisma and Wolff (1970) stated that *B. lanceolatum* in the English Channel occurred in areas with tidal currents from 75-125 cm per sec. Worth and Hollinger (1977) reported bottom currents of 6-27 cm per sec near Hutchinson Island during this study. We believe it likely that in the study area, currents do not directly affect distribution of lancelets. Rather, currents affect sediment characteristics which, in turn, determine lancelet distribution. Relationship between currents and sediment distribution is discussed by Gallagher (1977b).

CONCLUSIONS

Branchiostoma virginiae in the study area spawn in winter and summer; larvae spawned in winter either do not live to maturity, or migrate to unsampled areas. Young lancelets settled at 3.1-4.1 mm, presumably at an age of 30 to 68 days. For the first eight months after settling they grew 2.5-3.0 mm per month. Although modal progressions were obscured past 30 mm, there appeared to be two, possibly three year classes.

Of all physical parameters investigated, sediment texture had the most influence on distribution of lancelets at Hutchinson Island. Coarse sand sediments at Stations II and IV supported highest lancelet abundances. Large angular shell fragments and the trace of silt at Station V was less amenable habitat. Young lancelets settled at all five stations (Figure 8). Only two were taken at Station I, probably as a result of atypical sediment texture during July 1973 (Figure 2). Although lancelets settled at Station III, none matured there; they probably migrated into the trough area, locations of favorable substrate.

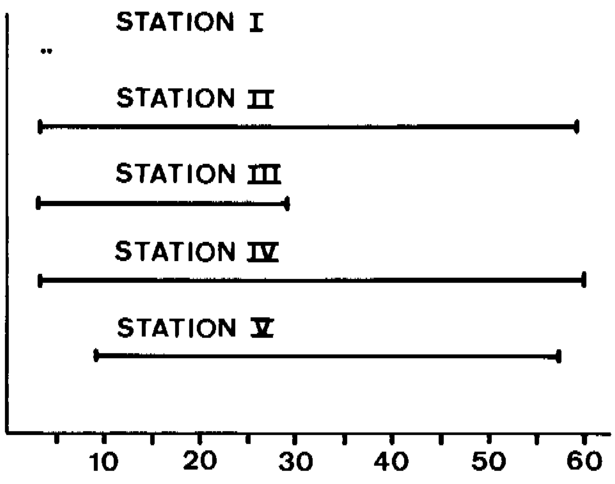

Figure 8. Size ranges of lancelets, *Branchiostoma virginiae* Hubbs, at Stations I-V, September 1971 through July 1973.

SECTION II—FISHES

Marine ichthyofauna of Florida's southeast coast (Cape Canaveral to Dry Tortugas) is well known. Fishes of the Indian River Lagoon have been reported on by Evermann and Bean (1898), Springer (1960), and Gunter and Hall (1963). Bullis and Thompson (1965), Anderson and Gehringer (1965), and Struhsaker (1969) listed collections from the adjacent continental shelf. Comprehensive treatment of fishes of this region has been recently accomplished (Gilmore, in press). Ichthyofaunal characterizations of the remainder of the southeast coast have been provided by Longley and Hildebrand (1941), Christensen (1965), Starck (1968), and Herrema (1974).

METHODS AND MATERIALS

Fishes were collected from offshore stations by a 3.7 m (door to door) balloon trynet with 1.9 cm stretched mesh on the wings and 1.3 cm stretched mesh on the cod end. It was towed 15 min in a circle near each station. At beach stations, a 15 m seine with 1.3 cm stretched mesh was used to take three replicate samples; replicates and stations were combined for analysis.

Fishes were fixed in 10% Formalin, then transferred to 40% isopropanol for storage. Voucher specimens will be cataloged into the FDNRMRL Ichthyological Collection (FSBC). Standard length or total length (TL) measurements were made to the nearest millimeter with calipers; unless otherwise noted, all measurements refer to standard length.

Fish stomach contents were removed and identified to the lowest possible category. Percentage of stomachs containing a particular food item was calculated, and approximate percent volume contribution was estimated (Randall, 1967).

RESULTS AND DISCUSSION

A total of 75 fish species were captured between September 1971 and August 1974. This represents a total of 42 h sampling, 33 h trawling and 9 h beach seining. The following annotated checklist provides species name, identification reference, capture location, capture date, number of specimens, size range, time (day or night) of capture during third year sampling, and temperature and salinity ranges where the species was taken. Starck (1968) defined primary reef fishes as those diagnostic of the reef biotope, and secondary reef fishes as those that occur on reefs but are equally characteristic of other biotopes. Primary reef fishes are marked by asterisk (*), secondary reef fishes by plus (+).

Rajiformes

Torpedinidae

+ *Narcine brasiliensis* (Olfers); Wahlquist (1966).
Beach: May 1972; 2(345, 400 mm TL). 24.9°C, 34 ‰.

Rajiidae

Raja eglanteria Bosc; Wahlquist (1966).
Station I: November 1973, Day, 1(435 TL). 24.5°C, 34 ‰.

Dasyatidae

Dasyatis sayi (Lesueur); Wahlquist (1966).
Beach: July 1973, 1(554 TL). 30.6°C, no salinity data.

Clupeiformes

Clupeidae

Brevoortia tyrannus (Latrobe); Hildebrand (1964).
Beach: March 1972, 1(248). 22.5°C, 36 ‰.

+ *Harengula jaguana* Poey; Whitehead (1973).
Beach: October 1971, 19(52-63); November 1971, 7(59-70); March 1972, 3(30-31); July 1972, 133(38-86); September 1972, 51(57-74); July 1973, 276(26-85). 23.0-30.6°C, 32-37 ‰.

Opisthonema oglinum (Lesueur); Whitehead (1973).
Beach: November 1971, 6(42-60); July 1972, 2(42, 55); September 1972, 1(63); March 1973, 1(149). 21.8-29.9°C, 32-37 ‰.

+ *Sardinella anchovia* Valenciennes; Whitehead (1973).

Beach: November 1971, 23(25-71); July 1973, 57(27-80). Station II: November 1973, Day, 2(41, 44). 22.6-30.6°C, 32-34 ‰.

Engraulidae

Anchoa cubana (Poey); Daly (1970).
Beach: November 1971, ca. 5220 ($\bar{x}$ = 42, 101 measured); July 1973, 2(49, 56). 22.6-30.6°C, 32 ‰.

Anchoa hepsetus (Linné); Daly (1970).
Station I: March 1973, 12(50-105); November 1973, Night, 1(68); November 1973, Day, 5(52-73). 22.6-30.6°C, 32-34 ‰.

Anchoa mitchilli (Valenciennes); Daly (1970).
Beach: November 1971, 5(55-81); March 1972, 1(39); July 1972, 6(35-53). Station I: February 1974, Night, 1(48). 18.8-29.4°C, 32-36 ‰.

Anchoa nasuta Hildebrand and Carvalho; Daly (1970).
Beach: November 1971, ca. 6000 ($\bar{x}$ = 41, 98 measured); July 1972, 3(40-41); July 1973, 304(30-61). 22.6-30.6°C, 32-36 ‰.

Anchoa sp.
Station II: November 1973, Day, 6(41-43). Station III: November 1973, Day, 3(39-44). 24.5-24.6°C, 34 ‰.
Remarks: Specimens were poorly preserved, and could not be identified confidently.

Engraulis eurystole (Swain and Meek); Daly (1970).
Beach: November 1971, 7(35-63). 22.6-23.0°C, 32 ‰.

Myctophiformes

Synodontidae

Synodus foetens (Linné); Anderson et al. (1966).
Station I: May 1972, 1(168); April, 1974, Night, 1(393). Station II: March 1972, 1(135); January 1974, Night, 1(264); March 1974, Night, 1(259); May 1974, Night, 1(240). Station IV: November 1971, 1(220); January 1972, 1(254); July 1972, 1(178). 21.0-25.4°C, 33-38 ‰.

+ *Trachinocephalus myops* (Forster); Anderson et al. (1966).
Station II: August 1974, Night, 1(107). Station III: February 1974, Day, 1(138); April 1974, Night, 3(77-129); July 1974, Day, 1(90). 19.5-27.0°C, 36-39 ‰.

Siluriformes

Ariidae

Arius felis (Linné); Jordan and Evermann (1896).
Beach: September 1972, 4(159-179). Station I: November 1973, Night, 1(199). Station II: November 1973, Night, 1(168); December 1973, Night, 1(187); February 1974, Night, 2(192, 201). Station III: October 1973, Night, 1(204); November 1973, Night, 4(139-171). 19.2-29.3°C, 34-36 ‰.

Batrachoidiformes

Batrachoididae

Porichthys plectrodon Jordan and Gilbert; Gilbert and Kelso (1971).
Station II: December 1973, Night, 1(66). 19.2°C, 36 ‰.

Gadiformes

Ophidiidae

Ophidion grayi (Fowler); Robins (1957).
Station I: November 1973, Night, 2(147, 236). Station II: November 1973, Night, 1(187); August 1974, Night, 3(174-200). Station III: November 1973, Night, 1(192). 24.3-26.0°C, 34-39 ‰.

+ *Ophidion holbrooki* (Putnam); Jordan and Evermann (1898).
Station I: November 1973, Night, 4(202-230). Station II: August 1974, Night, 1(129). 24.5-26.0°C, 34-39 ‰.

Gasterosteiformes

Fistulariidae

* *Fistularia tabacaria* (Linné); Böhlke and Chaplin (1968).
Station II: August 1974, Night, 1(406). 26.0°C, 39 ‰.
Remarks: This species was captured during a time when high salinity Gulf Stream waters invaded the study area, as confirmed by the U.S. Naval Oceanographic Office (1974a; 1974b).

Syngnathidae

Hippocampus sp.
Station I: February 1974, Day, 1(24). 18.7°C, 36 ‰.

Perciformes

Serranidae

+ *Centropristis philadelphica* (Linné); Miller (1959).
Station V: November 1971, 1(123); January 1972, 1(114); May 1972, 1(120). 24.1-24.2°C, 34-36 ‰.

+ *Centropristis striata* (Linné); Miller (1959).
Station II: November 1973, Night, 1(106). 24.3°C, 34 ‰.

+ *Diplectrum formosum* (Linné); Randall (1968).
Station II: June 1974, Night, 3(47-116); August 1974, Night, 1(102). 25.7-26.0°C, 36-39‰.

Pomatomidae
Pomatomus saltatrix (Linné); Jordan and Evermann (1896).
Beach: November 1971, 2(62, 330); January 1972, 2(292, 329); May 1972, 4(245-285); July 1972, 3(37-45). Station II: November 1973, Day, 1(243). Station III: November 1973, Day, 1(253). 22.6-29.8°C, 32-37 ‰.

Carangidae
+ *Caranx crysos* (Mitchill); Dahlberg (1975).
Beach: November 1971, 1(185); July 1973, 2(71, 81). 22.6-30.6°C, 32 ‰.
+ *Caranx hippos* (Linné); Dahlberg (1975).
Beach: November 1971, 1(135). 22.6°C, 32 ‰.
Caranx sp.
Beach: September 1972, 1(37). 29.5°C, 36 ‰.
Chloroscombrus chrysurus (Linné); Dahlberg (1975).
Beach: November 1971, 43(37-66). Station I: March 1973, 3(81-98); November 1973, Night, 3(46-51); November 1973, Day, 6(33-156). Station II: November 1973, Day, 6(60-146). Station III: November 1973, Day, 5(64-161); August 1974, Day, 2(35, 39). 22.6-27.0°C, 32-39 ‰.
+ *Decapterus punctatus* (Agassiz); Dahlberg (1975).
Beach: July 1972, 7(67-83); July 1973, 2(82, 89). 29.9-30.6°C, 37 ‰.
Selene vomer (Linné); Dahlberg (1975).
Beach: March 1972, 7(145-160). Station I: November 1973, Night, 2(67, 78); November 1973, Day, 7(67-84). Station III: November 1973, Day, 4(74-94). 22.5-24.6°C, 34-36 ‰.
Trachinotus carolinus (Linné); Dahlberg (1975).
Beach: October 1971, 19(75-114); November 1971, 2(132, 150); March 1972, 2(62, 63); May 1972, 1(385); July 1972, 6(29-133); September 1972, 14(45-169); November 1972, 1(109); March 1973, 2(86, 123); May 1973, 3(25-40); July 1973, 9(21-101). 21.9-30.6°C, 32-37 ‰.
+ *Trachinotus falcatus* (Linné); Dahlberg (1975).
Beach: October 1971, 13(80-145); September 1972, 50(25-68); November 1972, 1(30); January 1973, no data. 22.3-29.5°C, 35-37 ‰.
Trachinotus goodei Jordan and Evermann; Dahlberg (1975).
Beach: November 1972, 3(131-158); January 1973, 4(82-98); March 1973, 4(87-128). 20.8-22.3°C, 35-37 ‰.

Lutjanidae
+ *Lutjanus synagris* (Linné); Bölke and Chaplin (1968).
Station I: January 1974, Night, 1(167); February 1974, Night, 1(151). 18.8-23.1°C, 35-36 ‰.

Gerreidae
Diapterus olisthostomus (Goode and Bean); Dahlberg (1975).
Beach: May 1972, 2(160, 178). 24.9°C, 36 ‰.
+ *Eucinostomus argenteus* Baird and Girard; Böhlke and Chaplin (1968).
Beach: July 1973, 2(55, 62). Station I: July 1974, Night, 2(68, 72). Station III: November 1973, Night, 2(92). 24.4-30.6°C, 34-35 ‰.
+ *Eucinostomus gula* (Quoy and Gaimard); Böhlke and Chaplin (1968).
Beach: November 1971, 1(90); July 1973, 1(81). Station IV: November 1971, 2(83, 84). 23.8-30.6°C, 32-36 ‰.

Pomadasyidae
* *Anisotremus virginicus* (Linné); Böhlke and Chaplin (1968).
Station I: January 1974, Night, 2(80, 149). 23.1°C, 35 ‰.
* *Haemulon aurolineatum* Cuvier; Courtenay (1961).
Station IV: July 1972, 5(103-151). 22.5°C, 38 ‰.
Orthopristis chrysoptera (Linné); Dahlberg (1975).
Station I: October 1973, Night, 1(188). Station II: November 1973, Night, 2(140, 157); August 1974, Night, 1(192). 24.3-28.2°C, 34-39 ‰.

Sparidae
+ *Archosargus probatocephalus* (Walbaum); Jordan and Evermann (1898).
Station I: November 1971, 8(190-283); January 1972, 3(194-209); October 1973, Day, 1(192); November 1973, Day, 1(210). Station II: November 1973, Day, 1(227). 24.1-28.4°C, 34 ‰.
* *Diplodus argenteus* (Valenciennes); Jordan and Evermann (1898).
Beach: July 1973, 1(41). 30.6°C, no salinity data.
Lagodon rhomboides (Linné); Jordan and Evermann (1898).
Beach: November 1971, 1(113). 22.6°C, 32 ‰.

Sciaenidae
+ *Bairdiella sanctaeluciae* (Jordan); Jordan and Evermann (1898).
Station I: November 1973, Night, 3(119-190); November 1973, Day, 1(102). Station II: November 1973,

Night, 1(134). 24.1-24.5°C, 34 ‰.

Remarks: These specimens were identified by Mr. R. Grant Gilmore, Harbor Branch Foundation. This species "is one of the few southern continental fishes known north of the Yucatan Straits" (Gilbert and Kelso, 1971:35).

Cynoscion nothus (Holbrook); Guest and Gunter (1958).
Station I: November 1973, Night, 1(62); November 1973, Day, 1(75). 24.1-24.5°C, 34 ‰.

* *Equetus acuminatus* (Bloch and Schneider); Böhlke and Chaplin (1968).
Station IV: July 1972, 1(78). 22.5°C, 38 ‰.

Larimus fasciatus Holbrook; Dahlberg (1975).
Station I: November 1973, Night, 6(21-33); November 1973, Day, 2(136, 145). Station III: November 1973, Night, 1(181). 24.1-24.5°C, 34 ‰.

Leiostomus xanthurus Lacépède; Dahlberg (1975).
Beach: November 1971, 59(150-185, 30 measured). Station I: November 1973, Day, 1(171); February 1974, Night, 1(170). Station II: November 1973, Day, 2(167, 180). 18.8-24.5°C, 32-36 ‰.

Menticirrhus americanus (Linné); Dahlberg (1975).
Station I: November 1973, Night, 1(167); December 1973, Night, 1(178). Station III: November 1973, Night, 2(187, 203). 18.7-24.5°C, 34-36 ‰.

Menticirrhus littoralis (Holbrook); Dahlberg (1975).
Beach: October 1971, 52(29-112); November 1971, 7(52-95); May 1972, 1(88); July 1972, 11(43-113); September 1972, 27(43-100); November 1972, 7(35-162); March 1973, 1(85); May 1973, 5(20-165); July 1973, 8(54-184). 21.8-30.6°C, 32-37 ‰.

Menticirrhus saxatilis (Bloch and Schneider); Dahlberg (1975).
Beach: July 1973, 2(81, 91). 30.6°C, no salinity data.

Pogonias cromis (Linné); Dahlberg (1975).
Beach: March 1972, 1(215); September 1972, 1(245). 22.5-29.3°C, 36 ‰.

Stellifer lanceolatus (Holbrook); Dahlberg (1975).
Station I: November 1973, Night, 8(35-55). 24.5°C, 34 ‰.

Umbrina coroides Cuvier; Gilbert (1966).
Beach: October 1971, 66(36-113); November 1971, 14(45-190); January 1972, 1(124); July 1972, 25(53-113); September 1972, 1(58); January 1973, 2(no measurement); July 1973, 251(18-127). Station I: November 1973, Night, 1(156). Station III: November 1973, Day, 3(171-191). 20.8-30.6°C, 32-37 ‰.

Ephippidae

+ *Chaetodipterus faber* (Broussonet); Böhlke and Chaplin (1968).
Station I: January 1974, Night, 1(139). 23.1°C, 35 ‰.

Mugilidae

Mugil cephalus Linné; Jordan and Evermann (1896).
Beach: October 1971, 5(102-108). 28.2°C, 35 ‰.

Mugil curema Valenciennes; Jordan and Evermann (1896).
Beach: November 1972, 1(132). 22.2°C, 36 ‰.

Polynemidae

Polydactylus octonemus (Girard); Jordan and Evermann (1896).
Beach: November 1972, 2(77, 85). 22.3°C, 36 ‰.

Trichiuridae

Trichiurus lepturus Linné; Dahlberg (1975).
Station I: November 1973, Day, 2(138, 187 TL). Station II: November 1973, Day, 2(144, 349 TL). 24.1-24.5°C, 34 ‰.

Scombridae

+ *Scomberomorus maculatus* (Mitchill); Rivas (1951).
Beach: July 1972, 1(80). 29.8°C, 36 ‰.

Nomeidae

Psenes cyanophrys Valenciennes; Haedrich (1967).
Station III: August 1974, Day, 1(14). 27.0°C, 39 ‰.

Remarks: This fish, characteristic of oceanic waters, was undoubtedly transported into the study area by the Gulf Stream (see account of *Fistularia tabacaria*).

Ariommidae

Ariomma regulus (Poey); Haedrich (1967).
Station III: August 1974, Day, 1(39). 27.0°C, 39 ‰.

Remarks: See account of *Psenes cyanophrys*.

Scorpaeniformes

Scorpaenidae

+ *Scorpaena brasiliensis* Cuvier; Eschmeyer (1965).
Station II: September 1973, Night, 1(46). Station V: November 1971, 2(48, 70). 24.1-27.2°C, 36 ‰.

Triglidae

Prionotus salmonicolor Fowler; Ginsburg (1950).

Station I: November 1971, 1(119); January 1972, 2(107, 124). Station V: January 1972, 1(130); May 1972, 1(150). 24.2-24.8°C, 34-36 ‰.

Prionotus scitulus Jordan and Gilbert; Ginsburg (1950).

Station II: September 1971, 1(158); March 1972, 1(144); November 1973, Night, 11(101-181); December 1973, Night, 1(125); March 1974, Night, 2(128, 144); June 1974, Night, 3(50-142). Station III: November 1973, Night, 4(100-137); June 1974, Night, 1(99). Station IV: September 1972, 1(163). Station V: November 1971, 1(88). 19.2-32.0°C, 34–37‰.

Pleuronectiformes

Bothidae

* *Bothus ocellatus* (Agassiz); Topp and Hoff (1972).

Station II: March 1974, Night, 1(121). Station V: September 1971, 1(68). 21.4-24.1°C, 36–37 ‰.

Bothus robinsi Topp and Hoff; Topp and Hoff (1972).

Station II: November 1973, Night, 1(84); April 1974, Night, 1(47); August 1974, Day, 1(90). Station III: September 1973, Night, 5(73-107); October 1973, Day, 2(90, 100); November 1973, Night, 1(85); June 1974, Night, 1(34); July 1974, Day, 1(49). Station IV: November 1971, 1(124); September 1972, 4(57-131). 23.8-32.0°C, 34–36‰.

Remarks: This species was described and named by Jutare (1962) in an unpublished Masters Thesis, but it appears as though Topp and Hoff's (1972) treatment of the species constitutes the first *bona fide* published description.

\+ *Citharichthys macrops* Dresel; Topp and Hoff (1972).

Station I: September 1971, 1(51); July 1972, 1(42). Station II: July 1972, 1(42); September 1973, Night, 1(85). Station V: November 1971, 2(70, 92); January 1972, 1(90). 24.0-27.1°C, 34-38 ‰.

Etropus crossotus Jordan and Gilbert; Topp and Hoff (1972).

Station I: November 1971, 1(110). no data.

Paralichthys albigutta Jordan and Gilbert; Topp and Hoff (1972).

Station I: November 1971, 2(185, 245). no data.

\+ *Syacium papillosum* (Linné); Topp and Hoff (1972).

Station II: November 1973, Night, 1(128). Station IV: November 1971, 1(220). Station V: January 1972, 1(215); May 1972, 1(190). 23.8-24.3°C, 34-36 ‰.

Cynoglossidae

Symphurus plagiusa (Linné); Topp and Hoff (1972).

Station I: March 1973, Night, 1(126). 21.5°C, 36 ‰.

Tetraodontiformes

Balistidae

* *Aluterus schoepfi* (Walbaum); Berry and Vogele (1961).

Station II: August 1974, Night, 2(322, 480). 26.0°C, 39 ‰.

Remarks: This single occurrence is probably attributable to the presence of the Gulf Stream in the study area (see *Fistularia tabacaria*).

\+ *Monacanthus hispidus* (Linné); Berry and Vogele (1961).

Station II: September 1973, Night, 1(127); November 1973, Day, 1(140); April 1974, Night, 1(52); June 1974, Night, 2(57, 138); August 1974, Night, 2(96, 97). Station IV: September 1972, 1(31). 24.3-32.0°C, 34–39 ‰.

COMMUNITY RELATIONSHIPS

Time and funding restraints did not permit a thorough study of ichthyofauna in the area. Only two macrohabitats, the surf zone and the sand-shell bottom as deep as 12 m, up to 3.5 km offshore were studied. Also, some preliminary observations on reef-fish fauna were made.

SURF ZONE FISHES

Thirty-five species of fishes were captured in the surf zone by beach seine; 71% of these were taken only at beach stations (VI-VIII). Percent frequency of occurrence of fishes in 12 (combined stations and replicates) samples was calculated. Most frequently occurring fishes included *Trachinotus carolinus* (83%), *Menticirrhus littoralis* (75%), *Umbrina coroides* (58%), *Trachinotus falcatus* (33%) and *T. goodei* (25%). Several clupeoid fishes, including *Harengula jaguana* (50%), *Opisthonema oglinum* (33%), *Anchoa mitchilli* (25%) and *A. nasuta* (25%), were captured, sometimes in very large numbers. Eight species (24%) of surf zone fishes were primary or secondary reef fishes, a result of station proximity to worm rock reefs. Most species and most individuals were captured in September through November. However, no species was taken often enough or in sufficient quantities for length frequency analysis.

Detailed stomach content analyses were compromised by insufficient or infrequent catches of most species. Stomach contents of the most frequently encountered fishes are given in Table 3. *Menticirrhus littoralis, Trachinotus carolinus* and *T. goodei* appear to have fed largely or exclusively on the decapod crustacean *Emerita talpoida* (Say). These crustaceans are burrowers in the surf zone. *Trachinotus falcatus* stomachs contained mostly weathered shell typical of beach sediments; some unidentifiable soft organic matter was present as well. One fish examined had ingested several *Emerita talpoida* individuals. *Umbrina coroides* appeared to have fed largely in the water column. The inferior mouth position of this species suggests bottom feeding, but stomach contents indicated otherwise. Gilbert (1966:252) collected *U. coroides* over sand and mud bottoms. This is additional evidence that the species does not rely on a group or groups of benthic prey related to a specific substrate. Stomach contents of the clupeiform fishes were unidentifiable, probably as a result of improper preservation.

TABLE 3. STOMACH CONTENTS OF FREQUENTLY CAPTURED SURF ZONE FISHES

Species	Contents	% Frequency	% Volume
Trachinotus carolinus			
6 examined, 1 empty	Decapods	100	100
	Emerita talpoida		
Trachinotus falcatus			
7 examined, 1 empty	Beach shell, unidentifiable soft organic matter	83	80
	Decapods	17	20
	Emerita talpoida		
Trachinotus goodei			
7 examined, none empty	Decapods	86	95
	Emerita talpoida		
	Fish	14	5
Umbrina coroides			
10 examined, 3 empty	Fishes	29	40
	Anchoa mitchilli		
	Unidentified remains	29	40
	Shrimps	29	5
	Acetes americanus Ortmann		
	Amphipods	43	5
	Mysids	14	5
	Polychaetes	14	5
Menticirrhus littoralis			
3 examined, none empty	Decapods	100	100
	Emerita talpoida		

OFFSHORE STATION FISHES

Offshore stations (I-V) were divided into three subgroups for this analysis, based on sediment type and hydrographic characteristics. The first (Station I) was located about 0.5 km offshore at the seaward margin of the beach terrace at a mean depth of 7.5 m. Bottom sediments consisted of hard-packed sand. Twenty-nine fish species were taken here; 38% (11) of these were taken only at Station I. Of these 11 species, ten were taken in only one month, the other was taken in two successive months. Thus, Station I appears to be a transitional zone between surf zone, trough station, the shoal stations, and nearshore reefs. Lack of bottom relief and paucity of food organisms such as decapod crustaceans and polychaete worms at this station (D. Camp, N. Whiting, T. Perkins, FDNRMRL, personal communication) probably accounts for the transitional nature.

Downslope from the beach terrace at mean water depth of about 11 m (about 3 km offshore) were the trough stations (II, IV, and V). All were similar in hydrography and sediment character

(Gallagher, 1977a; 1977b; Worth and Hollinger, 1977). Thirty fish species were captured at trough stations; 42% (13) were taken only at these stations. Seventeen species (57%) taken here were primary or secondary reef fishes. This was undoubtedly influenced by proximity to reef facies. From 59 trawls taken at these three stations over three years (36 at Station II, 12 at Station IV, and 11 at Station V; the net was lost in September 1972), frequencies of occurrence of fish species were calculated. Benthic fishes apparently typical of this biotope included *Synodus foetens* (12%), *Prionotus scitulus* (12%), *Bothus robinsi* (8%), *Citharichthys macrops* (7%), *Syacium papillosum* (7%), *Arius felis* (5%), and *Centropristis philadelphica* (5%). Fishes, lancelets, and crustaceans constituted major food items of these fishes (Table 4).

The shoal station (III), located atop Pierce Shoal about 3.5 km offshore, differed considerably from other stations in hydrography and sediment character. Of 13 species collected here, the stromateoids *Ariomma regulus* and *Psenes cyanophrys* occurred there exclusively. As noted, they were taken in August 1974 when Gulf Stream waters invaded the study area. Only two fish species were primary or secondary reef fishes. From 36 trawls taken at Station III, fishes occurring most frequently were *Bothus robinsi* (14%), *Trachinocephalus myops* (8%), *Arius felis* (6%) and *Prionotus scitulus* (6%). Paucity of fish species at this station may be related to the occurrence of fewer food organisms than at trough stations. Stomach contents of listed species are included in Table 4.

TABLE 4. STOMACH CONTENTS OF FREQUENTLY CAPTURED OFFSHORE STATION FISHES

Species	Contents	% Frequency	% Volume
Synodus foetens			
4 examined, 1 empty	Fish	100	100
	Prionotus sp.		
	Clupeidae		
	Unidentified		
Trachinocephalus myops			
6 examined, 2 empty	Fish	50	50
	Unidentified remains	25	35
	Shrimps	25	5
	Sicyonia sp.		
	Crabs	25	5
	Portunus gibbesii (Stimpson)		
	Stomatopods	25	5
	Acanthosquilla biminiensis (Bigelow)		
Arius felis			
12 examined, 1 empty	Fish	18	45
	Unidentified remains	36	40
	Holothurians	18	10
	Crabs	18	2
	Calappa sp.		
	Mysids	9	1
	Shrimps	18	1
	Polychaetes	9	1
Centropristis philadelphica			
1 examined	Crabs		50
	Portunus sp.		
	Unidentified		
	Shrimps		25
	Processa sp.		
	Stomatopods		25
Prionotus scitulus			
17 examined, 8 empty	Crabs	44	30
	Portunidae		
	Unidentified		
	Panopeus sp.		

(Continued)

TABLE 4. STOMACH CONTENTS OF FREQUENTLY CAPTURED OFFSHORE STATION FISHES (Continued)

Species	Contents	% Frequency	% Volume
Prionotus scitulus (Continued)	Shrimps	33	30
	Metapenaeopsis goodei (Smith)		
	Sicyonia sp.		
	Processidae		
	Unidentified remains	22	20
	Lancelets	22	10
	Branchiostoma virginiae		
	Unidentified crustaceans	33	5
	Amphipods	11	4
	Mysids	11	1
Bothus robinsi			
14 examined, 2 empty	Lancelets	17	30
	Branchiostoma virginiae		
	Polychaetes	42	26
	Phyllodoce arenae Webster		
	Syllis amica Quatrefages		
	Opheliidae		
	Unidentified		
	Unidentified remains	33	12
	Fish	8	10
	Synodus foetens		
	Mollusks	25	4
	Ervilia concentrica (Holmes)		
	Epitoneum sp.		
	Olivella sp.		
	Pteropods		
	Shrimps	25	4
	Lucifer sp.		
	Processa sp.		
	Amphipods	25	3
	Trichophoxus sp.		
	Crabs	25	3
	Pinnixa sp.		
	Unidentified		
	Unidentified crustaceans	8	2
	Ophiuroids	8	2
	Ostracods	8	1
	Isopods	8	1
	Copepods	8	1
	Cumaceans	8	1
Citharichthys macrops			
2 examined, none empty	Shrimps	50	50
	Stomatopods	50	50
	Acanthosquilla biminiensis		
Syacium papillosum			
1 examined	Crabs		100
	Prionoplax atlantica Kendall		
	Goneplaceidae		

REEF FISHES

Nearshore reef structures in depths less than 10 m along Hutchinson Island consisted of low-relief coquinoid ledges and worm rock (*Phragmatopoma lapidosa*). These reefs support significant algal growth but very few scleractinian corals. Although our original sampling program did not include studies on the reefs, we believed that a cursory examination of reef biota was appropriate for two reasons: First, several fishes captured in beach seine and otter trawl sampling were primary reef fishes, indicating presence of nearby reefs. Second, there is a distinct possibility that the thermal plume from the power plant may impinge on reefal areas. Thus, in June 1975, a two day sampling of nearshore reefs was undertaken. A combination of factors, including limited time, unfavorable tides, turbid water, and ineffective ichthyocides produced only three species of fishes.

The basis of the following species list was from several poison collections on nearshore reefs near St. Lucie Inlet. This work was done by M.A. Moe, Jr., E.A. Joyce, Jr., and P.R. Witham, as FDNRMRL biologists, in August 1968. All specimens were cataloged into the Ichthyological Collection, all identifications have been verified or corrected. The species list includes the species name, citation for source of identification or verification, FSBC catalog number, and remarks, if appropriate.

Anguilliformes
- Muraenidae
  - *Enchelycore nigricans* (Bonnaterre); Böhlke and Chaplin (1968); FSBC 5783, 5775.
  - *Gymnothorax moringa* (Cuvier); Böhlke and Chaplin (1968); FSBC 5555.
- Ophichthidae
  - *Ahlia egmontis* (Jordan); Böhlke and Chaplin (1968); FSBC 5782.
  - *Myrichthys acuminatus* (Gronow); Böhlke and Chaplin (1968); FSBC 5785.

Perciformes
- Serranidae
  - *Serranus subligarius* (Cope); Robins and Starck (1961); FSBC 4289.
- Grammistidae
  - *Rypticus maculatus* Holbrook; Courtenay (1967); FSBC 4281, 4288.
    Remarks: Listed by Powell et al.(1972) as *R. saponaceous.*
- Apogonidae
  - *Apogon maculatus* (Poey); Böhlke and Chaplin (1968); FSBC 4285, 4286.
  - *Apogon pseudomaculatus* Longley; Böhlke and Chaplin (1968); FSBC 4287.
  - *Astrapogon stellatus* (Cope); Böhlke and Chaplin (1968); FSBC 4279.
  - *Phaeoptyx conklini* (Silvester); Böhlke and Chaplin (1968); FSBC 4282, 4284.
- Pomadasyidae
  - *Anisotremus surinamensis* (Bloch); Chaplin and Scott (1972); FSBC 4294.
  - *Anisotremus virginicus* (Linné); Chaplin and Scott (1972); FSBC 6795.
    Remarks: Listed by Powell et al. (1972) as *Haemulon aurolineatum.*
- Sparidae
  - *Diplodus argenteus* (Valenciennes); Jordan and Evermann (1898); FSBC 4295, 4296.
    Remarks: Listed by Powell et al. (1972) as *D. holbrooki.*
- Sciaenidae
  - *Bairdiella sanctaeluciae* (Jordan); Jordan and Evermann (1898); FSBC 7879.
  - *Equetus acuminatus* (Bloch and Schneider); Böhlke and Chaplin (1968); FSBC 4277.
- Mullidae
  - *Pseudupeneus maculatus* (Bloch); Böhlke and Chaplin (1968); FSBC 4313.
- Chaetodontidae
  - *Holocanthus ciliaris* (Linné); Chaplin and Scott (1972); FSBC 5722.
- Pomacanthidae
  - *Pomacanthus paru* (Bloch); Chaplin and Scott (1972); FSBC 4292, 4293.
- Pomacentridae
  - *Abudefduf saxatilis* (Linné); Böhlke and Chaplin (1968); June 1975 collection.
  - *Pomacentrus leucostictus* Müller and Troschel; Böhlke and Chaplin (1968); FSBC 6173.
  - *Pomacentrus partitus* Poey; Böhlke and Chaplin (1968); FSBC 5742, June 1975 collection.
  - *Pomacentrus variabilis* (Castelnau); Böhlke and Chaplin (1968); FSBC 5749, 6165, 6366.
- Labridae
  - *Doratonotus megalepis* Günther; Böhlke and Chaplin (1968); FSBC 4310.
  - *Halichoeres bivittatus* (Bloch); Böhlke and Chaplin (1968); FSBC 4302, 4303.
  - *Halichoeres maculipinna* (Müller and Troschel); Böhlke and Chaplin (1968); FSBC 4300, 4301.
  - *Halichoeres poeyi* (Steindachner); Böhlke and Chaplin (1968); FSBC 4298, 4299.
- Dactyloscopidae
  - *Gillellus rubrocinctus* Longley; Böhlke and Chaplin (1968); FSBC 6330.
- Clinidae
  - *Labrisomus nuchipinnis* (Quoy and Gaimard); Böhlke and Chaplin (1968); FSBC 4308.
  - *Malacoctenus triangulatus* Springer; Springer and Gomon (1975); FSBC 4304, 4305.
    Remarks: These specimens represent a northern range extension of the species (Springer and Gomon, 1975:11).
- Blenniidae
  - *Blennius cristatus* Linné; Böhlke and Chaplin (1968); June 1975 collection.
  - *Blennius marmoreus* Poey; Böhlke and Chaplin (1968); FSBC 6360.
- Acanthuridae
  - *Acanthurus bahaianus* Castelnau; Böhlke and Chaplin (1968); FSBC 4280, 4306.
  - *Acanthurus chirurgus* (Bloch); Böhlke and Chaplin (1968); FSBC 4307.

Scorpaeniformes
- Scorpaenidae
  - *Scorpaena plumieri* Bloch; Eschmeyer (1965); FSBC 4290, 4291.

Tetraodontiformes
- Tetraodontidae
  - *Sphoeroides spengleri* (Bloch); Shipp (1974); FSBC 4297.

CONCLUSIONS

Field and laboratory efforts in this multidisciplinary study were primarily directed toward descriptions of water quality and phytoplankton and benthic invertebrate communities; sampling for fishes was ancillary. Only two macrohabitats, the surf zone and sand-shell bottom, were sampled for fishes. Use of trawl and beach seine accounted for 42 h effort, producing only 75 species of fishes within the approximately 12 km^2 study area. Gilmore's (in press) list of fishes from comparable habitats indicates that many more species occur in the study area. Our list of reef fishes is also incomplete. Herrema (1974) and Gilmore (in press) have compiled an impressive list of reef fishes known, or expected to occur on nearshore Hutchinson Island reefs.

Our study of Hutchinson Island fishes was strictly qualitative. Unequal effort between beach seining and trawling, and differences in trawling between the first two years' and the third year's sampling prevented quantitative analyses.

RECOMMENDATIONS FOR FURTHER STUDY

This study was designed to gather baseline data on seawater conditions and marine biota prior to operation of the St. Lucie No. 1 Power Plant, such that any changes wrought by thermal effluent could be assessed. The following suggestions for future research are tendered.

LANCELETS

It is clear that lancelet distribution in the study area is determined by sediment character. The present study provides a reasonable assessment of the life history of lancelets near Hutchinson Island. Data accurately reflecting abundance are lacking. Quarterly sampling, rather than bimonthly, with increased replication would better determine abundance.

FISHES

With the exception of those fishes mentioned as characteristic of trough stations, most species appear to be transient in the area. Continued trawling at Stations I, II, and III would better establish the nature of the trough fauna. We recommend increased effort in beach seining. This method produced more species per hour of effort than did trawling. This would perhaps improve our understanding of life histories of important forage fishes (e.g., *Harengula jaguana*, *Anchoa nasuta*, *A. hepsetus*, *A. mitchilli*, and *Sardinella anchovia*) and commercially important species (e.g., *Pomatomus saltatrix*, *Trachinotus carolinus*, *Scomberomorus maculatus*, and *S. cavalla*).

Greater emphasis should be placed on stomach content analyses. Sampling designed to catch greater numbers of individual species will facilitate feeding studies.

Reef fishes definitely require more study. Additional poison collections and in situ SCUBA observations are recommended.

ACKNOWLEDGEMENTS

Many individuals were involved in this multidisciplinary study. Early planning of the project and discussion of ongoing research included R.M. Ingle, E.A. Joyce, Jr., A.H. Sellen, D.S. Beaumariage, B. Eldred, K.A. Steidinger, W.G. Lyons, D.K. Camp, R.M. Gallagher, R.E. Martin, and S.P. Cobb. Our sampling trips required that a contingent of biologists from St. Petersburg travel to Jensen Beach to assist. R.M. Gallagher and his wife, Terry, were always gracious hosts; their kindness will be long remembered. D.S. Beaumariage and D.A. Hensley assisted in the laboratory. D.A. Hensley and S.A. Willis edited the manuscript; R.G. Gilmore, Harbor Branch Foundation, provided critical review.

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