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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

WATER RESOURCES DIVISION

HYDROBIOLOGICAL CHARACTERISTICS OF SHARK RIVER ESTUARY, EVERGLADES NATIONAL PARK, FLORIDA

By

Benjamin F. McPherson

OPEN-FILE REPORT

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ABSTRACT

Water quality in the Shark River estuary was strongly influenced by seasonal patterns of rainfall, water level, and temperature. During the rainy season (summer and early fall) the salinity in the 20-mile long estuary ranged from that of fresh water to half that of sea water while concentrations of dissolved oxygen were low, 2-5 milligrams per liter (mg/l) presumably because, among other factors, microbial activity and respiration were accelerated by high temperatures (30-33°C). During the dry season (late fall through spring) the salinity ranged from 18 grams per liter (g/l) in the headwaters to 36 g/l at the Gulf during a dry year such as 1967 and from 1 to 25 g/l during a wet year such as 1969. Concentrations of dissolved oxygen increased from 2-3 mg/l in the summer of 1967 to 4-7 mg/l in the winter of 1968, and temperature decreased from an average of about 30°C in summer to 20°C in winter. Water level declined 5 to 10 decimeters in the headwaters during the dry season, and salinity and tidal action increased. Large amounts of submerged vegetation died in some headwater creeks at the end of the dry season, presumably killed by salinities above 3 g/l. The decaying organic matter and the decrease in photosynthesis resulted in low dissolved oxygen (1-2 mg/l). Fish died at this time probably as a result of the low dissolved oxygen.

Trace elements, heavy metals, and insecticides occurred in the waters of the estuary in concentrations below those indicated as harmful for aquatic life by current standards established by the Federal Water Pollution Control Administration (1968). The insecticides detected were concentrated in the sediment and in various organisms.

The patterns of distribution of planktonic and small nektonic animals in the estuary were related to salinity. Copepods (*Arcatia tonsa*, *Labidocera aestiva*, *Pseudodiaptomus coronatus*), cumaceans (*Cyclaspis* sp.), chaetognaths (*Sagitta hispida*), bay anchovies (*Anchoa mitchilli*), and scaled sardines (*Harengula pensacolae*) were the dominant animals collected in the higher salinities (10-25 g/l) near the mouth of the estuary. Amphipods (*Corophium* sp. and *Grandidierella* sp.), mysids (*Mysidopsis almyra* and *Gastrosaccus dissimilis*), crab larvae, and the young anchovies, sardines, and related fish were the dominant forms in the brackish water (1-10 g/l) of the mid-estuary. The presence of large numbers of juvenile and young animals indicated the importance of these brackish waters as nursery grounds. Aquatic insects, cyclopoid copepods (*Macrocyclops* sp.), cladocerans, mysids (*Taphromysis bowmani*), ostracods (*Cypridopsis* sp.), fresh-water prawns (*Palaemonetes paludosus*), and various marshfish were dominant in the "fresh" headwaters.

The amount of plant detritus collected in the estuary averaged about ten times that of the zooplankton. The estimated mean wet-weight of the zooplankton was 65 milligrams per cubic meter (mg/m^3) and ranged from 1 to 173 mg/m^3, with smallest amounts occurring in the "fresh" headwaters.

Nekton, consisting of small fish and prawns, ranged from 3 to 214 mg/m^3 in weight and had a mean of 30 mg/m^3. Largest catches were made in the headwaters at the end of the dry season, where the weight of the standing crop increased more than 15 times during the sampling period. The small fish and prawns, which were concentrated in the headwaters as the water level dropped, served as a rich source of food for predatory marine fish and birds.

INTRODUCTION

The estuaries of Everglades National Park provide food for birds and fish and are nursery grounds for various marine organisms (Tabb, 1963). Both functions depend on a seasonal flow of unpolluted fresh water, which mixes with sea water to form a brackish-water environment. The quality and quantity of fresh water necessary to maintain optimum estuarine conditions, however, is not known.

Purpose and scope

The purpose of this investigation is to describe biological populations in Shark River estuary in Everglades National Park and to relate these to the aquatic environment. Information of this type is essential to a better understanding of the importance of the fluctuation of salinities in the estuaries in maintaining the natural dynamic ecological system.

Shark River estuary is one of the largest and more important estuaries in the Park. Much of the water flowing south out of Conservation Area 3A moves through the Shark River Slough toward the estuary. The upper end of the estuary supports a large number of fresh-water animals and is an important feeding and nesting area for wading birds.

This investigation extended from October 1968 to June 1969, a period that includes both wet and dry seasons. Some water-quality and biological data collected prior to this by the U. S. Geological Survey are also included in this paper.

Location and description of Shark River estuary

Shark River estuary is a relatively narrow and shallow body of water near the center of the western boundary of Everglades National Park (fig. 1). It extends from the numerous creeks of its headwaters in the Shark River Slough about 20 miles to its mouth, at Ponce de Leon Bay on the Gulf of Mexico (fig. 2). Water depth in the estuary ranges from 1.5 to 4.6 meters and varies in response to seasonal changes in the flow of fresh water and to tides. The bottom of the estuary is generally bare limestone, but shell and organic debris accumulate in some places. The banks of the estuary are composed of varying amounts of peat and marl, which form levees usually less than a meter higher than the surrounding land. Trees and other plants form a thick river-bank forest on these levees. In the upper part of the estuary this forest includes the red mangrove (*Rhizophora mangle*), buttonwood (*Conocarpus erectus*), cabbage palm (*Sabal palmetto*), dahoon holly (*Ilex cassine*), cocoplum (*Chrysobalanus icaco*), pond apple (*Annona glabra*), willow, (*Salix amphibia*) and leather fern (*Acrostichum* sp.). The forest, generally less than 10 meters wide, merges with the saw grass (*Mariscus jamaicensis*) marsh. The number of tree species decreases toward the mouth of the estuary, where the red mangrove is dominant (fig. 3).

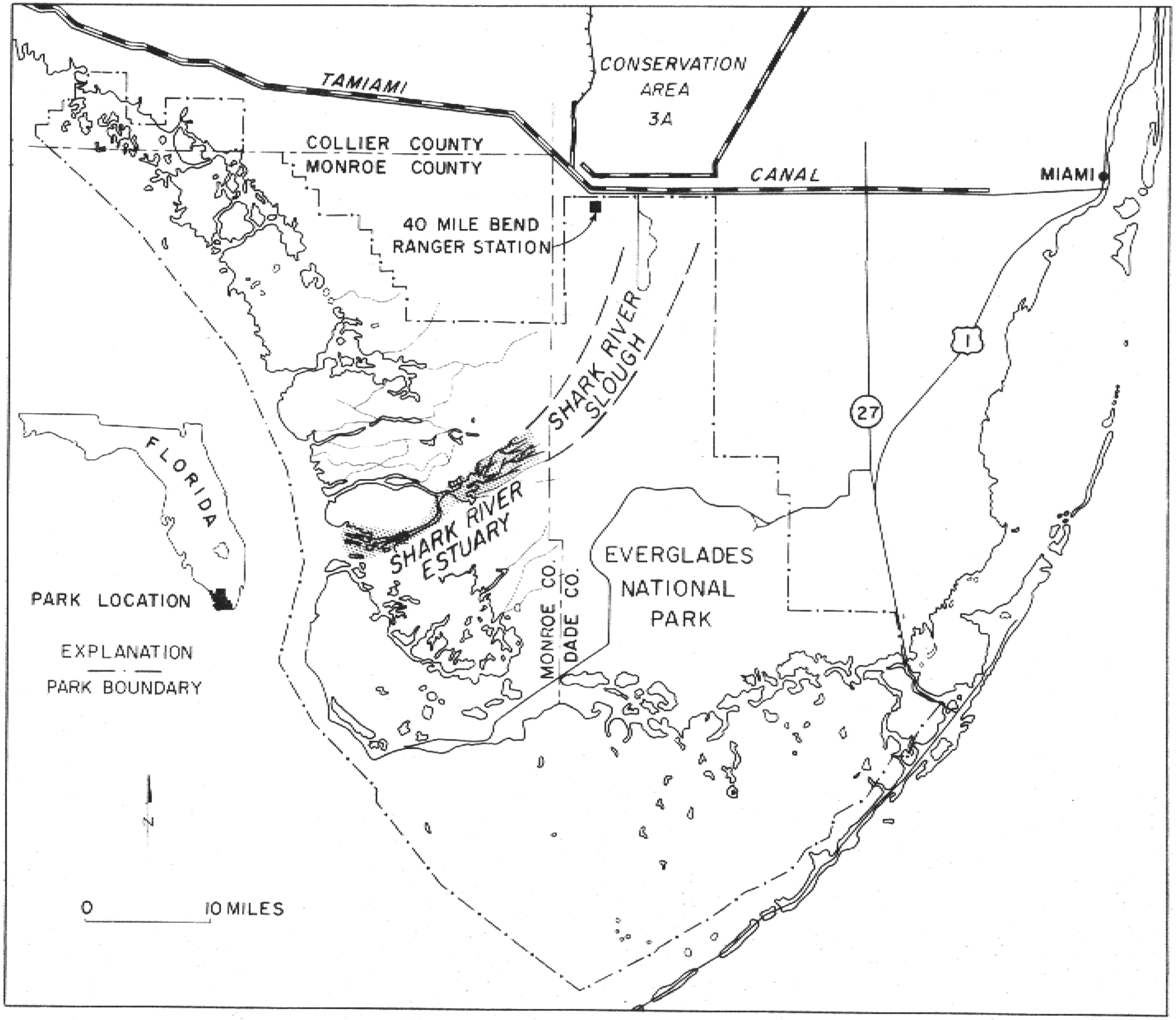


Figure 1. Map of Everglades National Park in southern Florida.

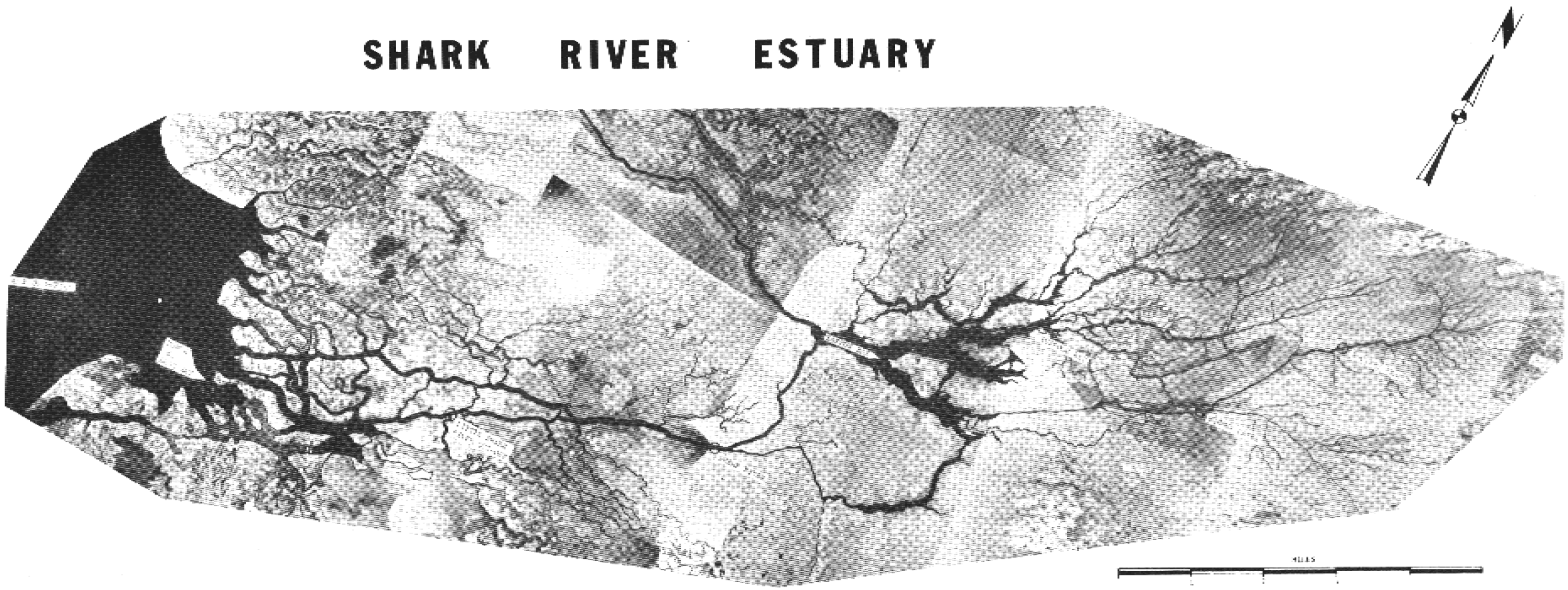


Figure 2. Uncontrolled photomosaic, Shark River estuary, showing sampling sites

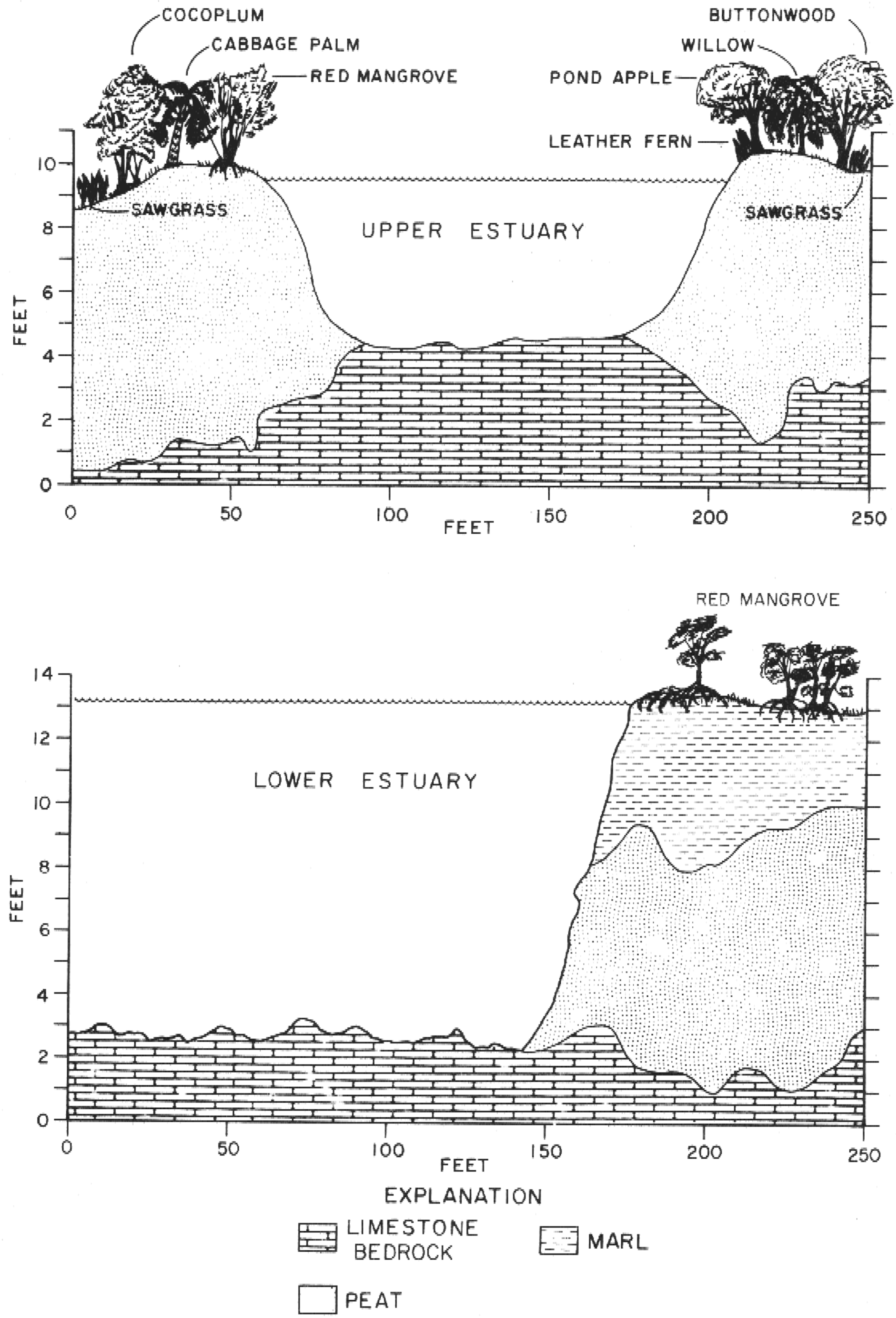


Figure 3.--Typical subsurface sections of the upper and lower part of Shark River estuary (adapted from Spackman, Scholl, and Taft, 1964).

The waters of Shark River estuary are a mixture of Gulf of Mexico water, fresh-water runoff from Shark River Slough, and rainfall on and in the vicinity of the estuary. Although there is a salinity gradient from mouth to headwaters, the water is vertically homogeneous because of the shallowness of the estuary and the mixing effects of wind and tide. In the lower or seaward part of the estuary, water levels usually change several decimeters during each tidal cycle, and tidal currents approach speeds of 4 miles per hour. In the headwaters, fresh-water inflow is the major influence on the character of the estuary. Water levels there change seasonally by 5 to 10 decimeters in response to seasonal changes in fresh water inflow and local rainfall. Near the peak of the rainy season, the flow of fresh water is maximal and salinities are low throughout the estuary. During the dry season the fresh-water inflow is reduced, water levels decline, and sea water extends up the estuary.

Sampling stations

Eight stations, listed in Table 1, were sites of regular hydrobiological sampling. In addition, other locations in the estuary were sampled occasionally to gather more data on feeding and distribution of animals.

Table 1.--Hydrologic stations and data collected in Shark River estuary.

Reference No.	U.S.G.S. No.	Name	Lat.	Long.	Date that continuous recording was begun				
					Water level	Discharge	Sp. conductance	Temp.	Periodic water quality
1	2-2908.58	Shark River at Ponce de Leon Bay	25°20'06"	81°06'48"	-	-	-	-	1963
2	2-2908.54	Little Shark River Cut-Off	25°26'30"	80°59'10"	-	-	-	-	1966
3	2-2908.5	Shark River	25°23'10"	81°01'00"	1960	1960	1962	1962	1964
4	2-2908.44	Tarpon Bay at Point 7	25°25'04"	80°59'22"	-	-	-	-	1962
5	2-2908.42	Tarpon Bay at Tussock Key	25°25'56"	80°57'30"	-	-	1962	1962	1962
6	2-2908.41	Rookery Branch	25°26'50"	80°53'37"	-	-	1962	1962	1962
7	2-2908.3	Everglades P-35	25°27'20"	80°52'30"	1953	-	-	-	1960
8	2-2908.35	Squawk Creek	25°25'34"	80°55'22"	-	-	-	-	1968

Data collection and sampling methods

Analyses for common chemical constituents in Shark River estuary were begun by the U.S. Geological Survey in 1960. Concentrations of trace elements, heavy metals, and insecticides were determined in late 1966. Samples were analyzed for total nitrogen and phosphorus during 1968-69 study period. Samples were taken several decimeters below the surface, unless otherwise indicated. All samples, except those for nitrogen, trace elements, and heavy metals were untreated in the field. Nitrogen samples were preserved with $Hg\ Cl_2$. Trace element and heavy metal samples were filtered (0.45μ) and treated with HNO_3. All water samples, except those for insecticide determinations, were analyzed at the Geological Survey Laboratory in Ocala, Florida. Table 2 lists the measured constituents and the methods used in the determinations. Dissolved oxygen, specific conductance, temperature, and pH were measured in the field. Table 3 lists the techniques and equipment used for field analyses.

Samples for analyses of chlorinated hydrocarbon insecticides in water, sediments, and organisms were sent to the Geological Survey Water Quality Laboratory in Washington, D.C. Quantitative determinations on water were made by the methods described by Lamar, Goerlitz and Law (1964). By these methods concentrations of chlorinated hydrocarbons can be measured in the 0.01 micrograms per liter (μg/1) range.

Table 2.--Determinations and methods used by the U. S. Geological Laboratory in Ocala, Florida for water samples from Shark River estuary in 1968-69 (M.E. Beard, written communication, 1969).

Determination	Method	Reference
Aluminum	Ferron-orthophenanthroline	1/
Arsenic	Silver diethyldithiocarbamate	2/
Boron	Carmine	1/
Bromide	Oxidation	1/
Calcium	Atomic absorption spectroscopy	3/
Chloride	Mercuric nitrate	2/
Chromium	Atomic absorption spectroscopy	3/
Copper	Atomic absorption spectroscopy	3/
Fluoride	Zirconium-eriochrome cyanine-R	1/
Iodide	Oxidation	1/
Iron	Bipyridine	1/
Lead	Atomic absorption spectroscopy	3/
Lithium	Atomic absorption spectroscopy	3/
Magnesium	Atomic absorption spectroscopy	3/
Manganese	Atomic absorption spectroscopy	3/
Nickel	Atomic absorption spectroscopy	3/
Nitrogen, ammonia (as NH_4)	Nesslerization	1/
Nitrogen, nitrate (as NO_3)	Cadmium reduction	4/
Nitrogen, nitrite (as NO_2)	Diazotation	4/
Nitrogen, organic (as N)	Kjeldahl	1/
Phosphorus, ortho-(PO_4)	Modified phosphomolybdate	5/
Phosphorus, total (as PO_4)	Modified persulfate oxidation	1/, 5/, 6/
Potassium	Atomic absorption spectroscopy	3/
Silica	Molybdate blue	1/
Sodium	Atomic absorption spectroscopy	3/
Strontium	Atomic absorption spectroscopy	3/
Sulfate	Modified spectrophotometric thorin	1/
Tannin and Lignin	Tungsto-molybdophosphoric acid	2/
Zinc	Atomic absorption spectroscopy	3/

1/ Rainwater and Thatcher (1960)
2/ Standard methods for examination of water and waste water (1965)
3/ Perkin-Elmer Corp. (1964)
4/ Morris and Riley (1963)
5/ Fishman and Skougstad (1965)
6/ Gales et. al. (1966)

Table 3.--Methods and equipment used for the collection of field water-quality data in 1968-69.

Measured constituents or properties	Field technique and equipment
Dissolved oxygen	Alsterberg modification of Micro-Winkler technique described by Slack (1968)
Specific conductance	
Instantaneous	Lab-Line Lectro Mhometer (Model Mc-1) Industrial
Continuous	Instruments Conductivity Recorder (Model RQ)
pH	Port-o-matic meter
Temperature	
Instantenous	Thermometers
Continuous	Ryan thermograph (Model D-30)

Determinations of insecticides in sediment and plant material were made by the procedures suggested by Marvin Yates of the Geological Survey in Washington D.C. (written communications, 1970). The procedure of Onley and Bertuzzi (1966) was employed for extraction of insecticides from animals.

Quantitative biological samples were taken at stations 1 through 6 using a No. 2 plankton net (0.37 millimeter, mesh aperture) and a one-meter ring net (9.5 mm mesh aperture in front half and 3.0 mm mesh in rear half or cod end). The plankton net and the ring net were towed behind a boat at the surface of the water for 5 and 10 minutes, respectively. The velocity of the water passing through these nets was measured with a Price current meter. Because the time of each tow was measured, the volume of water passing through the net could be computed. Initial collecting with the ring net and plankton net indicated that more animals were collected during the night than during the day, so standard sampling with this gear was made at night. Most tows were made on a flooding tide, against the current, however, for comparative purposes, some sampling was also made on the ebbing tide on January 21, 1969.

A 4.9-meter otter trawl was towed for 10-minutes in Ponce de Leon Bay. The trawl could not be used effectively at the upper stations because it snagged on the bottom. Qualitative biological samples also were collected by hand, with dip nets, seines, and with several types of traps and dredges. Temperature and specific conductance were measured at the time of each biological sampling.

Biological samples were preserved in 5 to 10 percent formalin for later examination in the laboratory. Fish and larger invertebrates were counted, measured and weighed (wet weight). The gut contents of selected specimens were examined. The settled volume (seston) and the total volume of each plankton sample were measured. The sample was then thoroughly stirred. A subsample of known volume was removed and placed in a petri dish for examination under a stereoscopic microscope. The animals in the subsample generally were identified to the species level and counted.

Where specimens were numerous, however, this was impractical, so an arbitrarily selected number was examined for species identification. Subsamples were examined until the total count for one or more of the dominant species exceeded 50. The number of individuals per cubic meter was calculated for each species. To permit comparisons of the available zooplankton biomass, several specimens of each of the common species were weighed on a Cahn Electrobalance. The mean weight was then used to convert the number of specimens per cubic meter to milligrams per cubic meter.

Dissolved solids are usually reported as concentrations of chloride or, more commonly, as salinity in estuarine investigations. To make the results of this study directly comparable, specific conductance was converted to chloride concentration using the observed relation between specific conductance and chloride concentration at Rookery Branch (fig. 4). Chloride concentration was converted to salinity using the following formula (Reid, 1961): Salinity ppt = 0.03 + 1.81 + chloride concentration ppt (parts per thousand). Parts per thousand is equivalent to grams per liter.

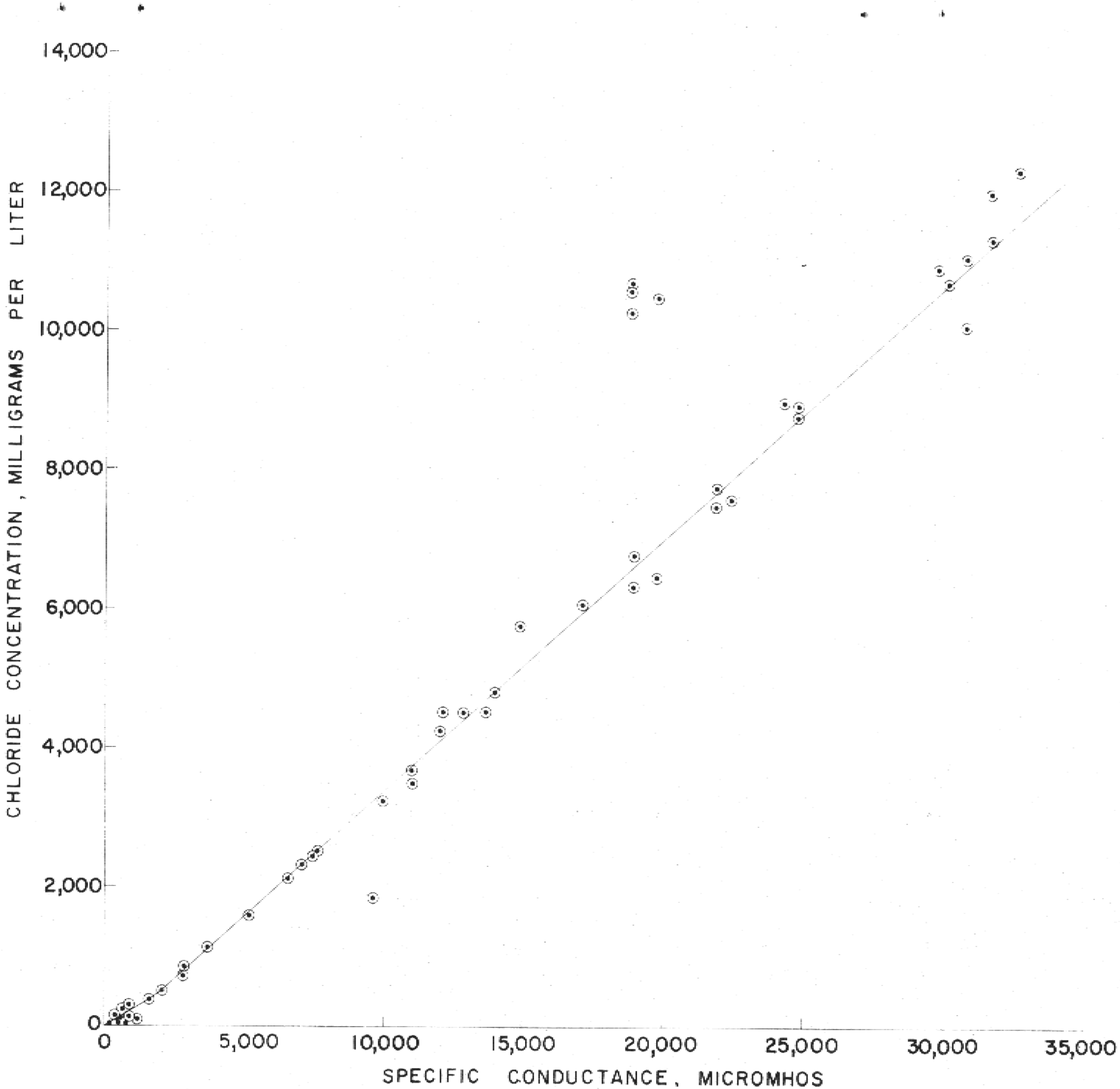


Figure 4.--Relation of specific conductance to chloride concentration at Rookery Branch in Shark River estuary.

Acknowledgments

Research was done while I was working as a National Research Council - U.S. Geological Survey Postdoctoral Associate. Various members of the staff of the Miami office of the Survey helped with this study. I discussed the original ideas and plans for the project with Milton Kolipinski. Both he and Aaron Higer helped in planning for the project and in an analysis of the data. Fred Hoover helped me collect data in the field.

Several people helped me with the identification of animals. From the University of Miami these included Dr. Martin Roessler (fish), Mr. Robert Gore (crabs), Mr. Wesly Rouse (shrimp), Mrs. Maria Foyo (copepods), Dr. Lowell Thomas (Brittlestars), and Mr. Robert Work (sponges and polycheates). Dr. E. L. Bousfield, National Museum of Canada, identified selected samples of amphipods. Dr. Torleiv Brattegard, Biological Station, Norway, helped with the identification of the mysids and cumaceans. I. G. Sohn, U. S. Geological Survey, identified the ostracod *Cypridopsis* sp. Selected specimens of plankton were weighed by Dr. Michael Reeve of the University of Miami.

HYDROLOGIC CONDITIONS

Rainfall, water-level, and salinity

The average annual percipitation in the Everglades National Park area of south Florida is about 55 inches, most of which falls during June through October. Large amounts of rainfall are often associated with tropical storms. Rainfall, however, varies greatly from year to year, from severe drought to very high amounts. As an example of extremes, the annual rainfall in Conservation Area 3A, just north of Everglades National Park was 39 inches in 1951 but 77 inches in 1947 (Hartwell, written communication, 1969). Monthly rainfall from June 1962 to June 1969, and the average for the period are shown on figure 5. The average annual rainfall for the period 1962 through 1969 ranged from 49.49 to 75.11 inches.

Seasonal changes in salinity in Shark River estuary were related to seasonal patterns of rainfall (fig. 5). During the rainy season much of the estuary contained fresh water, and salinity at the mouth was only about half that of sea water (fig. 6). During the dry season salinity increased to maximal values for the year, but these values varied from year to year, depending on the amount of rainfall. During drought, such as January to May, 1967 (6 inches of rainfall at 40-mile bend Ranger Station), the salinity in the estuary ranged from 18 g/l at Station P-35 to 36 g/l at Ponce de Leon Bay. During the same months of a wet year, such as 1969 (11 inches of rainfall at 40-mile bend), the salinity ranged from 1 to 25 g/l at the same stations. Salinities were low at Rookery Branch during the winters of 1966 (4 g/l) and 1969 (2 g/l) when compared with six other years in which values reached about 18 g/l (fig. 5). The low salinities in 1966 and 1969 occurred after periods of relatively heavy rainfall (table 4).

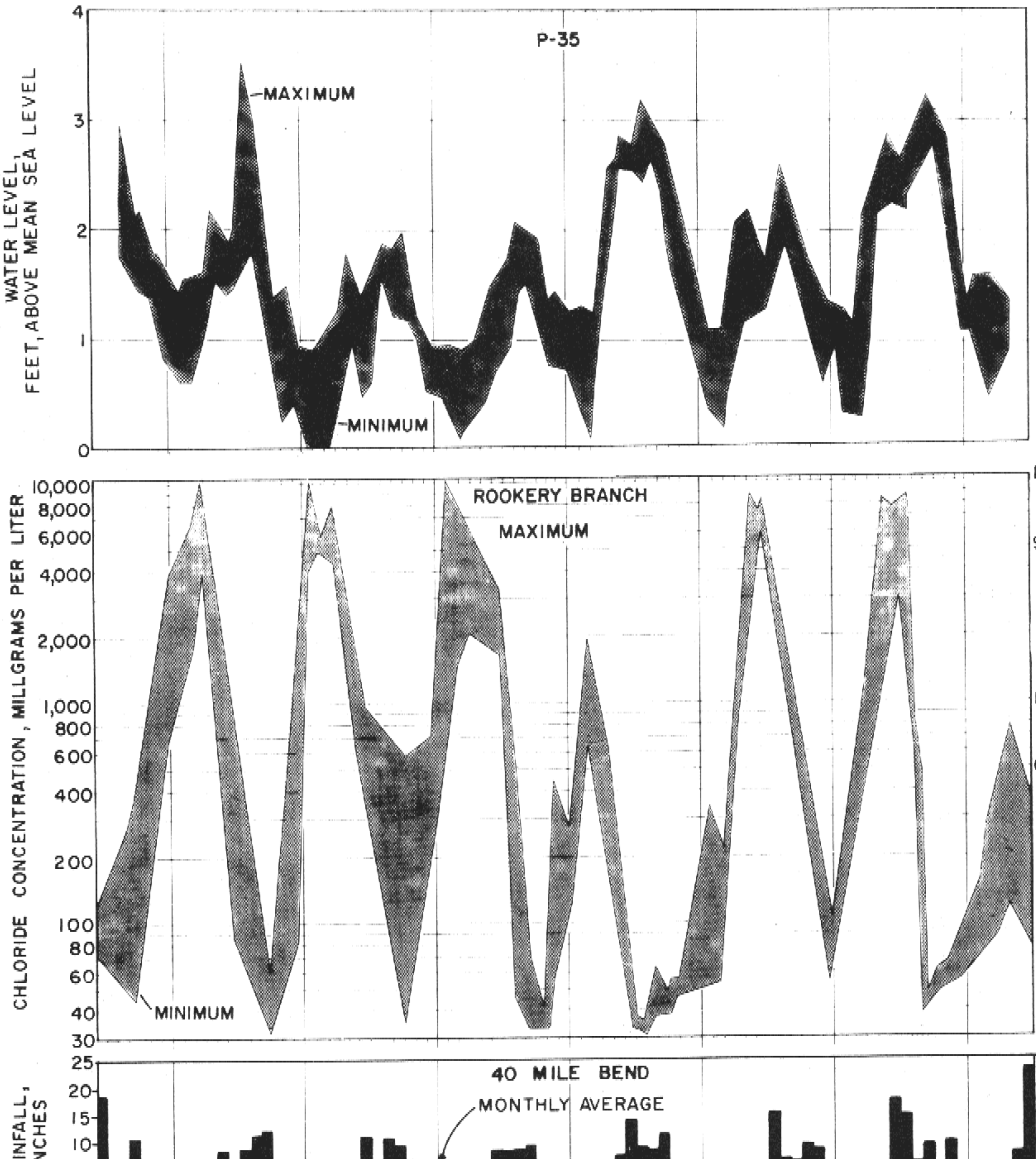


Figure 5.--Relation between rainfall at 40-mile bend Ranger Station, salinity at Rookery Branch, and water level at station P-35 between 1962 and 1969. Maximum and minimum salinities and water levels (mean daily) are shown for each month.

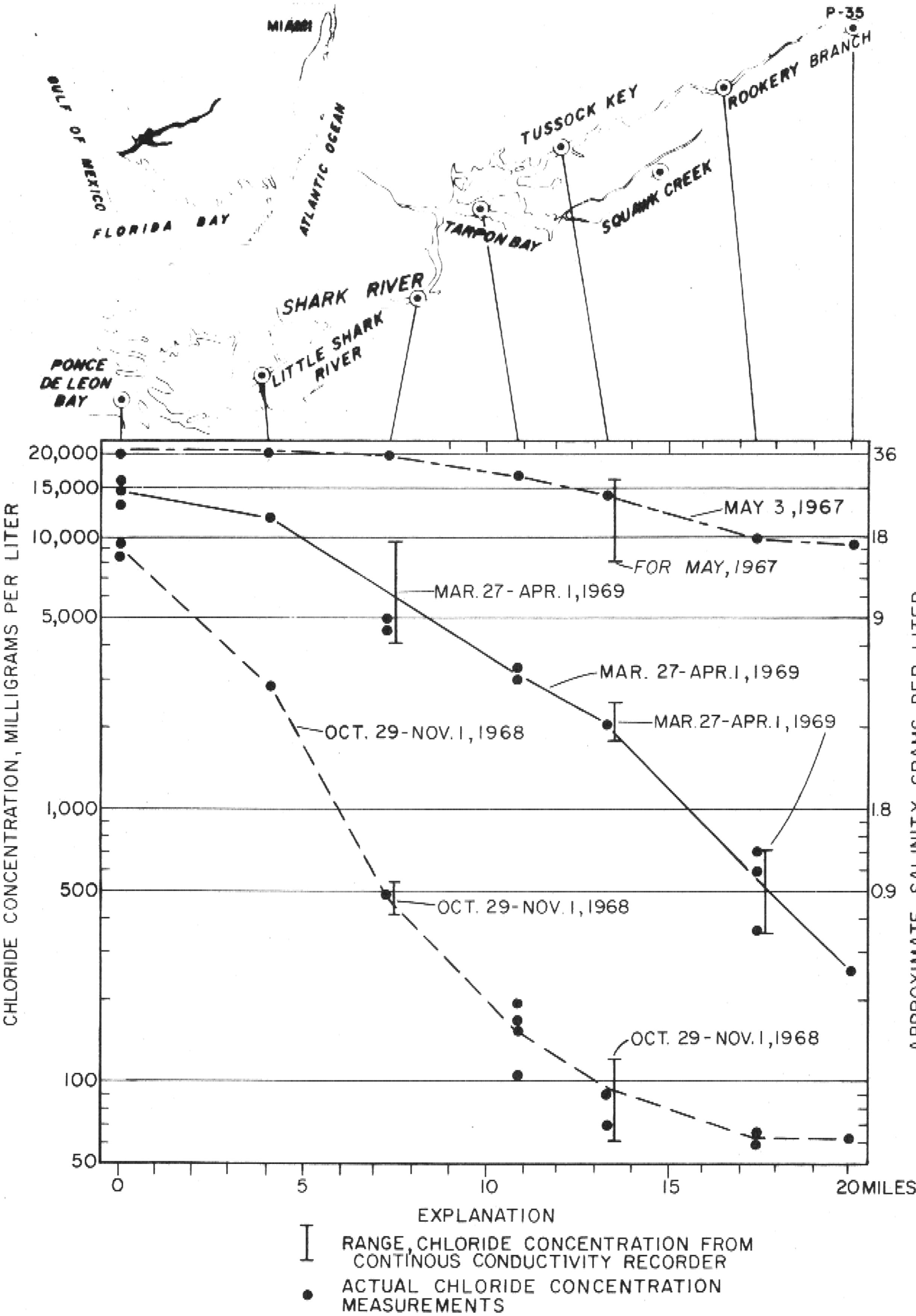


Figure 6.--Chlorinity-salinity gradient in Shark River estuary during wet (October 29-November 1, 1968) and dry (March 27-April 2, 1969 and May 3, 1967) seasons.

Table 4.--Monthly, seasonal, and annual rainfall (inches) at 40-mile bend Ranger Station, Tamiami Trail

	1962	1963	1964	1965	1966	1967	1968	1969	29-year Average 1940-69
Annual	E 54.37	E 59.61	55.28	49.49	E 58.50	53.52	66.84	75.11	54.06
January	1.45	.59	1.00	1.42	4.40	1.88	1.22	3.15	1.51
February	.47	3.71	1.54	2.71	1.23	1.17	1.76	1.88	1.59
March	3.73	1.19	2.03	1.33	.76	2.81	1.59	2.05	1.91
April	.75	.50	4.36	1.98	2.74	.10	.55	3.49	2.64
May	E 6.23	7.97	4.37	2.36	6.84	2.76	16.69	4.01	5.94
June	E 18.20	5.54	10.36	7.24	12.02	14.06	14.11	23.48	9.76
July	E 4.51	8.09	3.79	7.55	E 7.90	5.86	5.22	6.34	6.03
August	3.77	10.57	10.50	7.78	E 7.16	5.22	8.11	5.58	7.02
September	E 10.54	E 11.72	9.13	8.60	9.76	8.34	6.81	11.51	9.26
October	2.99	E 4.01	6.48	5.52	4.61	7.69	8.97	11.75	5.90
November	1.41	2.79	.79	2.38	.42	2.16	1.78	.54	1.47
December	.32	2.93	.93	.62	.66	1.47	.03	1.33	1.03
Jan. through April	6.34	5.99	8.93	7.44	9.48	5.96	5.12	10.57	7.65

E - Estimated

Changes in water level of 5 to 10 decimeters occurred seasonally in the upper part of the estuary. Highest water levels at station P-35 during 1962-69 were recorded during 1963, 1966, 1968, and 1969. More rain fell during those years than during the 4 other years of record (table 4).

Temperature

The average temperature of the water in Shark River estuary ranges from about 20°C during winter to 30°C during summer. Maximum and minimum temperatures, however, drop below 15° and rise above 32°C (fig. 7). Water temperature, at times, also changes several degrees in a few hours. During the winter of 1968-69 water temperature at Rookery Branch decreased from 18°C to 13°C in 2 hours. These rapid changes were not recorded on the Ryan thermograph. The monthly range recorded by this instrument, then, does not give the actual maximum and minimum, but a "smoothed or average" temperature curve. This explains why some of the actual measurements are outside the range recorded by the thermographs (fig. 7). The rapid changes in temperature observed in the estuary occurred soon after sunset, when there was a noticeable cooling of the air.

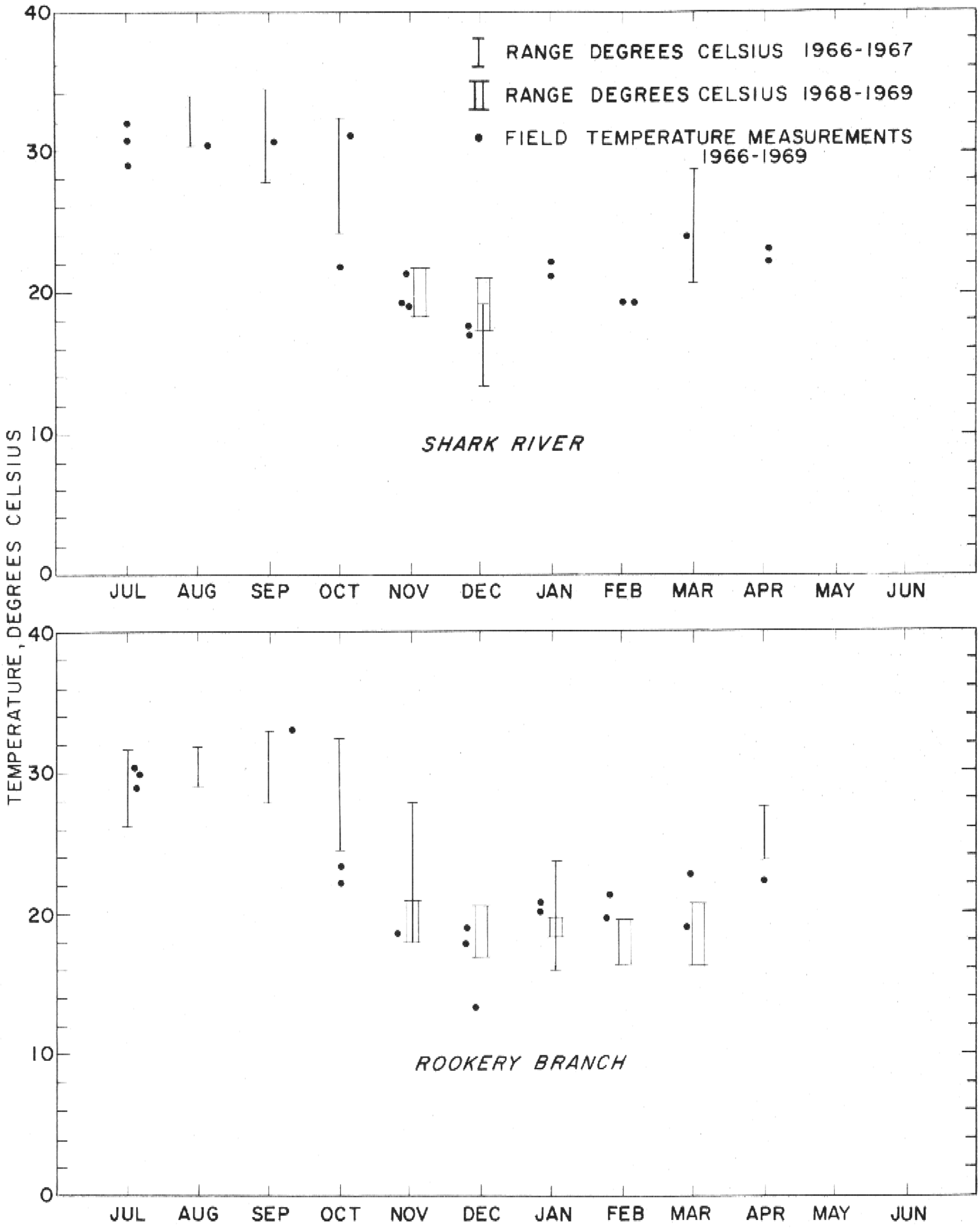


Figure 7.--Monthly ranges of temperature at two stations in Shark River estuary in 1966-69.

pH

Measurements of pH were made in the surface waters of Shark River estuary between March 27 and April 2, 1969. Daytime values at eight stations ranged from 6.6 to 7.3 (table 5). The same range was observed at Tarpon Bay over 24 hours. The slight acidity of the water probably results from the flushing of organic acids from the mangrove marshes and bottom sediments and from the production of carbon dioxide by decomposition of organic material.

Table 5.--pH determinations made in Shark River estuary, Mar. 26-31, 1969. Time of day is shown in parenthesis.

Station Name and Number	Ponce de Leon Bay 1	Little Shark 2	Shark River 3	Tarpon Bay 4	Tussock Key 5	Squawk Creek 8	Rookery Branch 6	P-35 7
	6.9 (1445)	6.6 (1400)	6.7 (1027)	7.3 (0955)	6.7 (1330)	7.1 (0700)	6.9 (0845)	6.9 (1100)
				6.6 (1200)		6.7 (1430)	6.9 (1000)	
				7.0 (1215)		6.8 (1500)		
				6.9 (2000)				

Dissolved oxygen

Dissolved oxygen was measured monthly at seven stations in Shark River estuary between July 1966 and May 1967. Concentrations were higher near the mouth of the estuary and in the headwaters than in the mid-estuary (table 6). The higher concentration at the mouth probably resulted from tidal mixing of oxygenated water from the Gulf. Highest concentrations in the headwaters occurred during the day as a result of photosynthetic activity by the submerged vegetation, such as the pondweed, *Najas*. Inflow of oxygenated water from Shark River Slough and the everglades, with their dense growths of algae and other plants, also may have contributed to the high concentration of oxygen in the headwaters.

Table 6.--Monthly and mean concentrations of dissolved oxygen (mg/l) in Shark River estuary between July 1966 and May 1967 and December 1968 and June 1969. Time given in parenthesis.

Stations	Time of transect	Ponce de Leon Bay	Little Shark	Shark River	Tarpon Bay	Tussock Key	Rookery Branch	P-35
Station No.		1	2	3	4	5	6	7
Miles from mouth		0	4.2	7.3	10.8	13.4	17.3	20.0
July, 1966	(1000-1500)	-	2.2	1.8	2.8	2.0	1.9	2.7
Aug.	(1000-1400)	-	3.8	2.4	2.4	2.4	2.0	3.1
Sept.	(0900-1400)	4.7	2.8	2.1	3.0	3.0	1.6	3.8
Oct.	(1100-1600)	5.1	4.0	3.6	3.4	2.1	2.3	5.1
Nov.	(1100-1500)	4.7	4.7	4.5	4.0	2.6	2.8	3.4
Dec.	(1200-1600)	3.2	6.0	5.1	4.2	5.5	6.0	5.7
Jan., 1967	(1200-1600)	5.7	5.1	6.0	3.6	5.1	3.2	4.9
Feb.	(1100-1500)	6.2	5.1	4.0	5.3	4.2	5.1	6.4
Mar.	(1200-1700)	6.6	5.3	4.2	4.6	4.7	4.5	4.0
Apr.	(1200-1600)	7.4	7.4	5.1	6.2	4.7	11.8	-
May	(1200-1500)	4.4	4.4	2.0	3.5	2.3	5.0	11.3
Mean 1966-67		5.3	4.6	3.7	3.9	3.5	4.2	5.0
Dec., 1968	(1000-1400)	6.4	5.7	5.8	5.3	5.6	5.2	-
Jan., 1969	(1430-1730)	6.0	5.2	4.9	6.5	4.2	4.4	-
Feb.								
Mar.	(0930-1500)	5.4	5.0	-	-	5.0	6.9	6.9
Apr.								
May								
June	(1030-1530)	4.5	2.1	2.1	3.1	-	3.6	3.6
Mean 1968-69		5.6	4.5	4.3	5.0	4.9	5.0	5.3

Note: Determinations in 1966-67 were made by Kolipinski and Higer, U. S. Geological Survey.

Diurnal fluctuations of dissolved oxygen in the upper estuary and adjacent glades were greater than those in the lower estuary. Concentrations in the upper estuary and glades usually varied by 5-10 mg/l during 24-hour cycles, with highest values occurring in late afternoon and lowest values in early morning (Kolipinski and Higer, written commun. 1967). Concentrations in the lower estuary generally varied by only 1-2 mg/l during a 24-hour cycle, and there was no decernable diurnal pattern in these small fluctuations. The larger diurnal fluctuations of dissolved oxygen in the upper estuary resulted from the greater amounts of submerged vegetation and the smaller volume of water in the upper areas. During the wet season of 1968, this vegetation extended downstream almost to Tarpon Bay; farther seaward, the estuary was relatively barren of aquatic plants. During the dry season, vegetation in some of the lower streams of the headwaters, such as Squawk Creek, died as salinity increased. Dissolved oxygen decreased and remained below 2 mg/l in these areas.

The concentration of dissolved oxygen was usually low during summer (table 6). In July 1966 values of 2-3 mg/l were observed throughout the estuary. These concentrations increased during the fall and winter to levels of about 4-7 mg/l, and then decreased to about 2-5 mg/l by late spring. A similar pattern was observed in 1968-69 (fig. 8). The lower dissolved oxygen concentrations during summer resulted from an increased temperature, which lowered solubility of oxygen, increased respiration rates of organisms, and increased oxidation rates of organic detritus.

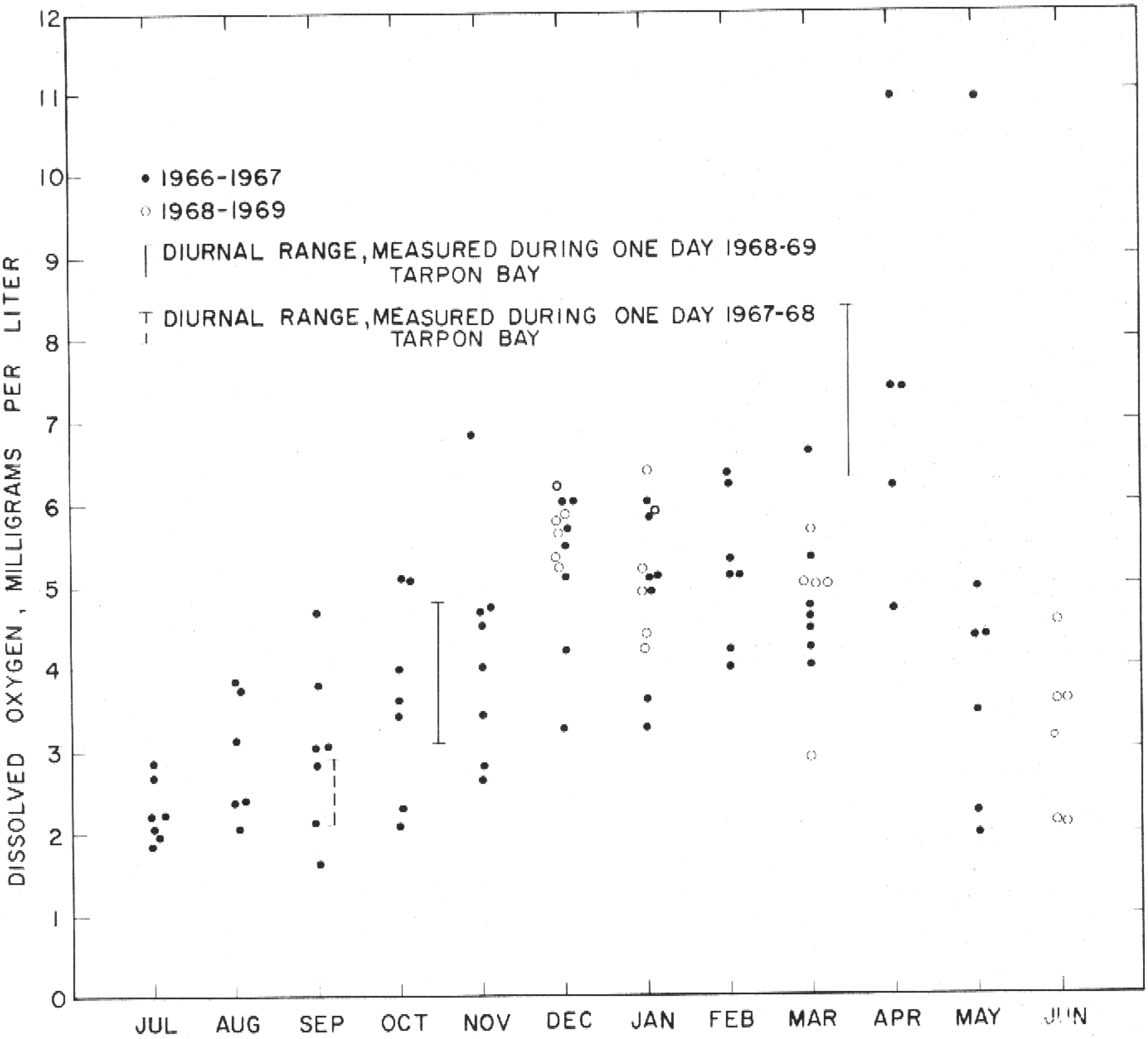


Figure 8.--Dissolved oxygen at stations 1-7 in the waters of Shark River estuary in 1966-69.

Other Chemical constituents

The chemical constituents, other than dissolved oxygen, that occur in the waters of Shark River estuary may be divided into three groups. In one group, containing such ions as calcium, chloride, magnesium, sodium, potassium, sulfate, bromide, boron, strontium, and fluoride, concentrations were correlated with specific conductance (table 7). Ions in this group occurred in high concentrations in the seaward part of the estuary. A second group consisting of silica (SiO_2) and tannins and lignins was in higher concentrations in the fresh-water part of the estuary than in the more saline part (table 8). A third group of constituents including nitrogen, phosphorus (table 9), various trace elements, heavy metals (table 10), and pesticides appeared to have a variable distribution in the estuary, and seasonal trends and spatial patterns were not apparent.

Table 7.--Concentrations of common chemical constituents in mg/l in Shark River estuary as related to specific conductance (1968-69).

Station Name and number		Date	Specific Conductance[1/]	Calcium	Magnesum	Sodium	Potassium	Sulfate	Chloride	Bromide	Boron	Strontium	Fluoride
Ponce de Leon Bay	1	Mar 26, 1969	42,600	372	1,040	8,800	310	2,080	15,800	67	3.5	5.4	1.2
Little Shark Cut-off	2	Dec 20, 1968	29,800	272	725	6,250	231	-	10,800	34	.21	4.0	.9
Ponce de Leon Bay	1	Oct 1, 1968	22,100	190	500	4,180	160	980	7,450	24	1.8	2.8	.8
Shark River	3	Mar 26, 1969	20,600	234	440	3,810	132	880	6,850	22	1.6	3.1	.7
Tarpon Bay	4	Mar 26, 1969	13,200	182	270	2,280	70	561	4,200	23	.72	2.2	.5
Little Shark Cut-off	2	Nov 1, 1968	9,600	103	200	1,650	66	390	2,900	2.4	.79	1.5	.5
Shark River	3	Feb 22, 1969	9,400	146	194	1,550	52	376	2,900	17	.71	1.7	.4
Tussock Key	5	Mar 26, 1969	5,700	122	108	895	26	200	1,640	12	.38	1.4	.3
Shark River	3	Dec 20, 1968	5,400	102	103	885	32	202	1,570	9.6	.15	1.0	.4
Tarpon Bay	4	Dec 18, 1968	3,200	80	62	500	18	114	890	4.0	.17	1.0	.4
Tussock Key	5	Dec 18, 1968	1,900	75	35	274	9.7	58	495	2.4	.10	.8	.4
Shark River	3	Nov 1, 1968	1,210	46	21	160	6.1	34	288	-	.16	.4	.3
Tarpon Bay	4	Oct 31, 1968	720	42	12	82	3.2	14	143	.8	.12	.32	.3
Rookery Branch	6	Dec 18, 1968	620	59	10	59	2.0	3.2	102	.8	.04	.40	.3
Tussock Key	5	Oct 31, 1968	580	40	9.8	63	2.6	8.0	106	.8	.08	.36	.3
P-35	7	Dec 19, 1968	500	55	8.8	41	1.5	0	66	.8	.06	.50	.3
Rookery Branch	6	Oct 31, 1968	410	38	7.0	36	1.5	.4	56	0	.07	.42	.3
P-35	7	Oct 1, 1968	358	32	6.1	33	1.5	.8	50	.8	.08	.32	.3

1/ Values as micromhos at 25°C

Table 8.--Concentrations of silica (SiO_2) and tannin and lignin in Shark River estuary, 1962-68

Station Name and number		SiO_2 mg/l		No. of Samples	Tannin and Lignin mg/l		No. of Samples
		Range	Median		Range	Median	
Ponce de Leon Bay	1	1.0-6.8	2.5	8	0.2-0.6	0.3	7
Little Shark Cut-off	2	1.9-5.2	2.8	3	0.4-0.8	0.7	11
Shark River	3	0-5.7	3.6	10	0.5-1.4	1.0	10
Tarpon Bay	4	2.0-5.0	3.4	5	0.5-1.4	1.0	10
Tussock Key	5	1.6-7.0	4.1	8	0.5-1.5	1.0	10
Rookery Branch	6	1.4-5.8	4.0	8	0.5-1.2	1.1	10
P-35	7	1.4-16.0	4.1	18	0.5-1.1	1.0	7

Table 9.--Concentrations of nitrogen and phosphorus in Shark River estuary at Stations 1-7

Constituent	Dates	Number of Samples	Range mg/l	Median mg/l
Nitrate (NO_3)[1/]	1960-69	175	0.00- 39	1.3
Nitrate (NO_3)	1968-69	21	0.00- 2.5	.1
Nitrite (NO_2)	1968-69	21	0.00- 0.14	.01
Ammonia nitrogen (NH_4)	1968-69	21	0.00 - 0.60	.05
Organic nitrogen	1968-69	21	0.06 - 9.7	1.0
Orthophosphate (PO_4)	1960-69	140	0.00 - 16	.08
Orthophosphate (PO_4)	1968-69	11	0.00 - 0.01	.00
Total phosphorus (as PO_4)	1968-69	21	0.00 - 0.05	.02

1/ Determinations of nitrate prior to 1968 were made following the method outlined by Rainwater and Thatcher (1960). In 1968-69 determinations were made following Morris and Riley (1963).

Table 10.--Concentrations of trace elements and heavy metals in the waters of Shark River estuary at Stations 1-7 - 1968-69.

Constituent	No. of samples	Range mg/l	Median mg/l	Average concentration in sea water mg/l 1/	Recommended upper limits for fish & wildlife, mg/l 2/
Aluminum	18	0.05-1.1	0.12	0.01	-
Arsenic	20	0.00-0.11	.01	.003	1.0
Chromium	20	0.00-0.07	.00	.00005	0.05
Copper	20	0.00-0.09	.00	.003	0.02 Fresh water 0.05 Sea water
Iodide	19	0.00-0.42	.00	.06	-
Iron	14	0.01-0.21	.05	.01	-
Lead	20	0.00-0.01	.00	.00003	0.1
Lithium	20	0.00-0.02	.00	.17	-
Manganese (total)	12	0.00-0.04	.01	.002	-
Zinc	20	0.00-0.07	.01	.01	-

1/ Riley and Skirrow (1965)
2/ McKee and Wolf (1963)

Four components of the nitrogen family were measured in the estuary in 1968-69. Of these, organic nitrogen was the most abundant, usually accounting for more than half of the total nitrogen. Nitrate was the second most abundant form, followed by ammonia and then by nitrite.

Nitrate was measured in the Shark River estuary between 1960 and 1969, and in some cases concentrations greater than 10 mg/l were recorded (table 9). Determinations of nitrate prior to 1968 were made following the method outlined by Rainwater and Thatcher (1960). This method is not recommended where the water has a high chloride content, because the chloride ion interferes by forming oxides of nitrogen in strong acid solutions. Because many of the determinations for nitrate were made in water of high chloride content, some of these early results may be in error. Determinations of nitrate concentration during 1968-69 were made using a method in which there is no chloride interference (Morris and Riley, 1963). Nitrate values during these latter years ranged from 0.0 to 2.5 mg/l, with a mean of 0.4 mg/l.

Total phosphorus, as PO_4, was measured at Stations 1-7 in Shark River estuary in 1968-69. Concentrations ranged from 0.00 to 0.05 mg/1, with a median value of 0.02 mg/1 (table 9). Orthophosphate, measured at the same stations from 1960 to 1969, ranged from 0.00 to 16 mg/1; the median value was 0.08 mg/1. In 94 percent of all observations, orthophosphate values ranged from 0.00 to 1.0 mg/1. All but one of the nine samples with concentrations above 1.0 mg/1 were collected during May through July. However, other samples collected during these months had low concentrations. The concentration of orthophosphate observed in 1968-69 ranged from 0.00 to 0.01 mg/1, and similar low values were recorded during previous years.

It is difficult to account for the occasional high values of orthophosphate observed in the Shark River estuary. Even in polluted estuaries values for PO_4 are generally below 1.0 mg/l (Jefferies, 1962; Saville, 1966). Most of the high values occurred in Shark River estuary during periods of low water and high salinity. Although high orthophosphate values might have resulted from the release of phosphorus into the water during the decomposition of large amounts of fresh-water vegetation, evidence for this hypothesis is lacking. However submerged vegetation does die in large quantities at times during low water as mentioned on pages 39 and 76.

Concentrations of most trace elements and heavy metals in the estuary were greater than those in the sea, but were usually below levels that are considered dangerous for aquatic life (table 10). Two samples, however, had concentrations above the recommended upper limits for fish and wildlife (McKee and Wolf, 1963). One of these samples contained 0.09 mg/l of copper and the other contained 0.07 mg/l of chrominum.

The Federal Water Pollution Control Administration (1966) recommended that the chlorinated hydrocarbon insecticide levels should not rise above 0.05 mg/l in water used to maintain aquatic life. The concentrations of these chemicals in Shark River estuary were below this currently recommended value (table 11).

Table 11.--Chlorinated hydrocarbon insecticides in surface waters, bottom sediments, plants and animals from Shark River estuary.

Ponce de Leon Bay (Station 1)	Dates	DDT	DDD	DDE	others*
Surface water µg/l	03-04-68	.01	.00	.00	.00
	10-03-68	.01	.00	.00	.00
Bottom sediment µg/kg	03-03-68	.00	2.8	0.6	.00
	10-01-68	.00	2.8	.00	.00
Oyster (*Crassostrea virginica*) µg/kg	03-04-68	.00	.00	.00	.00

P-35 (Station 7)	Dates	DDT	DDD	DDE	others*
Surface water µg/l	12-01-66	.00	.01	.00	.00
	03-04-68	.00	.00	.00	.00
	10-01-68	.02	.00	.01	.00
Bottom sediment µg/kg	03-04-68	.00	2.3	1.8	.00
	10-01-68	3.0	.00	.00	.00
SAwgrass (*Mariscus jamacensis*) µg/kg	02-27-68	2.0	.00	.05	.00
Needlegrass (*Eleocharis*) µg/kg	02-27-68	6.8	1.0	.77	.00
Fresh-water prawn (*Palaemonetes paludosus*) µg/kg	03-04-68	.00	41.10	91.60	.00
Mosquitofish (*Gambusia affinis*) µg/kg	03-04-68	460.00	78.00	270.00	.00

*Others includes aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide and lindane.

Bottom sediments and biota from Shark River estuary had concentrated chlorinated hydrocarbon insecticides above levels found in the water. Sediments had concentrations of the DDT family (DDT, DDD, DDE) that ranged from 2.8 to 4.1 micrograms per kilograms (µg/kg). A sample of sawgrass contained 2.5 µg/kg of the DDT family, and one of needlegrass contained 8.75 µg/kg. A sample of fresh-water prawns contained 132.7 µg/kg and one of mosquitofish contained 808.0 µg/kg.

AQUATIC ORGANISMS

Phytoplankton and filamentous algae

Concentrations of diatoms and other algae in Shark River estuary ranged in numbers from 0 to slightly over 10,000 cells per liter (Kolipinski and Higer, written communication, 1966-67). Highest concentrations were observed near the mouth and in the headwaters of the estuary (table 12). In the headwaters, both diatoms and other algae increased in numbers from a few cells per liter during summer to more than 5,000 cells per liter during winter and spring (Kolipinski and Higer, written communication, 1966-67). Filamentous green algae were abundant at times in the headwaters at Rookery Branch, where they were collected in volumes up to about 7 cubic centimeters per cubic meter (cc/m^3) in the winter of 1969.

Table 12.--Average number of cells per liter of phytoplankton from Shark River estuary, collected with a number 20 plankton net, July 1966-May 1967.

	Ponce de Leon Bay	Little Shark River	Shark River	Tarpon Bay	Tussock Key	Rookery Branch	P-35
Miles from Ponce de Leon Bay	0	4	7	11	13	17	20
Number of Samples	8	8	7	3	8	10	7
Diatoms/l	146	134	11	0	2	606	1,477
Other algae/l	2,355	298	19	3	282	1,647	2,160

Note.--Summarized from data of Kolipinski and Higer, written communication, (1966-67). Complete counts in Table 16 in Appendix.

Invertebrates

The invertebrates collected in Shark River estuary are listed in the Appendix (table 17). The more abundant forms are discussed below. The term abundant is used for organisms that occurred in several samples in numbers of five or more per cubic meter.

Ostracods

Ostracods in the genus *Cypridopsis* sp. were abundant in fresher parts of the estuary during winter and spring. A maximum number of 859 per cubic meter was collected at Rookery Branch on March 31, 1969. This genus was observed within a salinity range of 0.4 to 3.0 g/l (fig. 9).

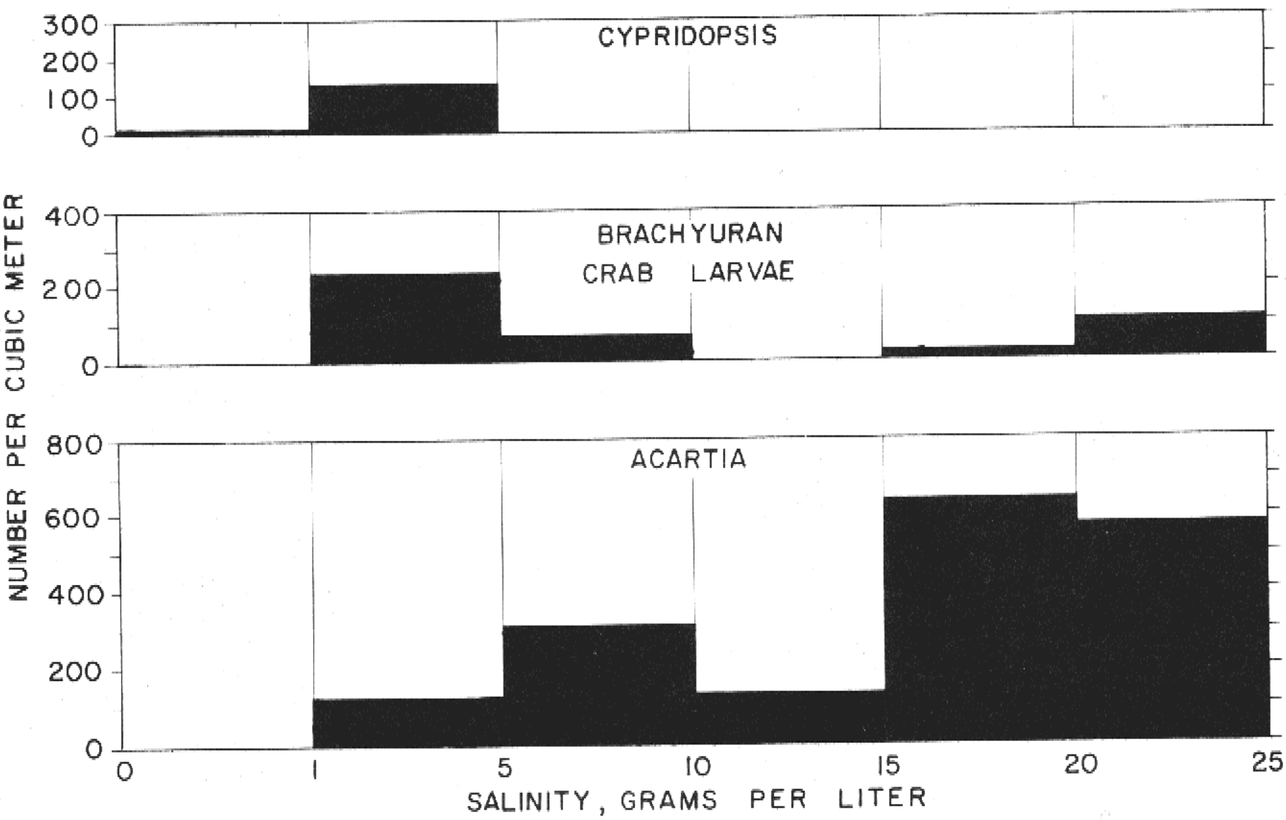
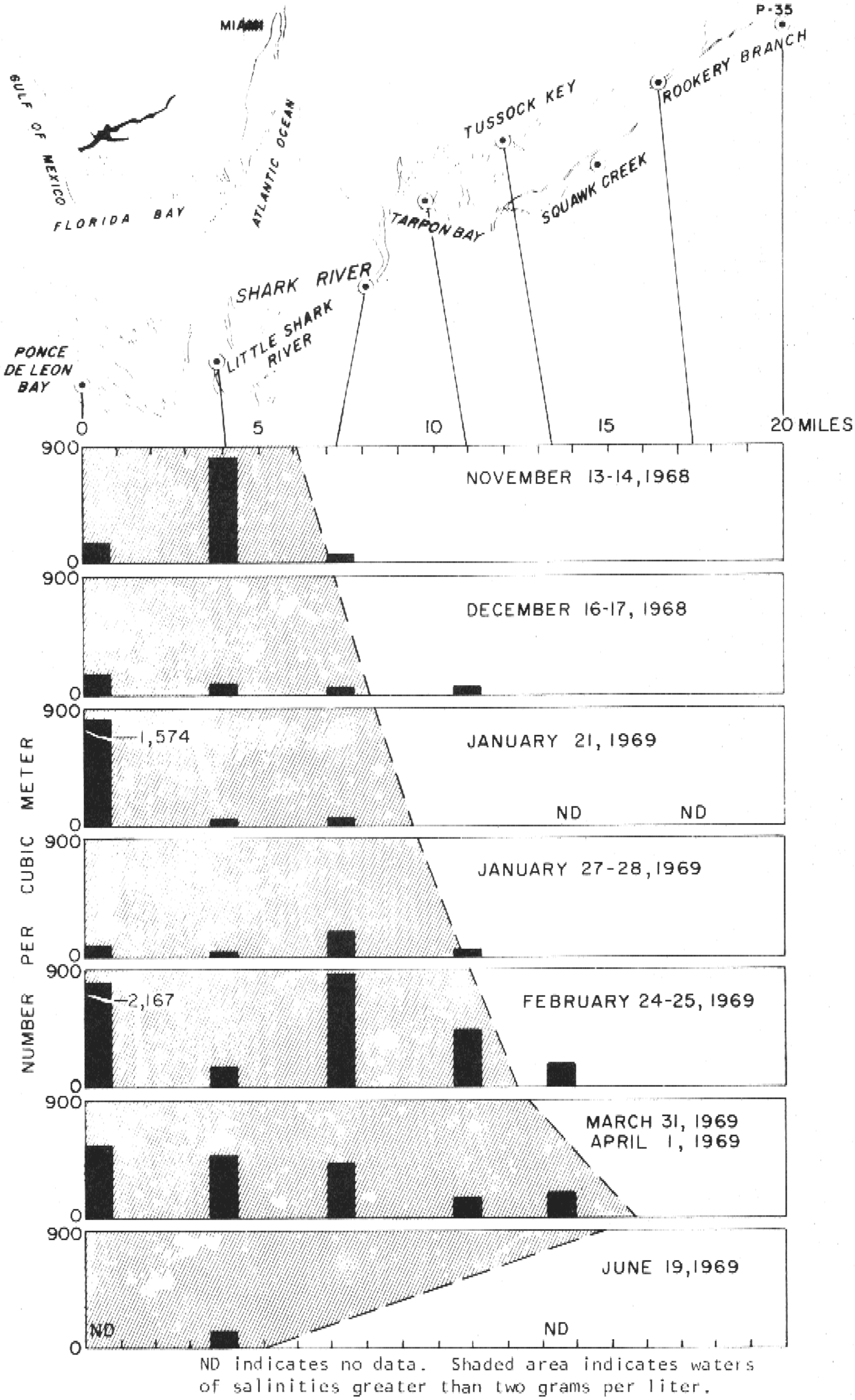


Figure 9.--The mean number of specimens per cubic meter of *Acartia*, *Cypridopsis* and crab larvae collected at different salinities in Shark River estuary.

Copepods

Arcatia sp. was the most abundant of the zooplankters observed in the estuary; it occurred in concentrations up to 2,000 per cubic meter (fig. 10). More than 100 specimens from different locations were identified as *A. tonsa* Dana, the only species observed. *A. tonsa* was collected over a salinity range of 0.4 to 22.0 g/1. Most of these copepods were collected in water with salinities greater than 2 g/1, and the greatest numbers were taken in water of salinity of about 20 g/1 (fig. 9). In November 1968 it was found only in the lower part of the estuary, over a distance of about seven miles, from Ponce de Leon Bay to the Shark River station. In the dry season it was collected from the Bay to Tussock Key station, a distance of 13 miles (fig. 9). The presence of *A. tonsa* in the upper estuary coincided with increasing salinity during the dry season.

Pseudodiaptomus coronatus Williams was present in the lower part of the estuary from Ponce de Leon Bay to the Shark River station. It was most abundant in water with salinities of about 10 to 20 g/1, but was collected in water with salinities as low as 2 g/1 (fig. 11).



ND indicates no data. Shaded area indicates waters of salinities greater than two grams per liter.

Figure 10.--Number of specimens of the copepod, Acartia, per cubic meter collected at six stations in Shark River estuary.

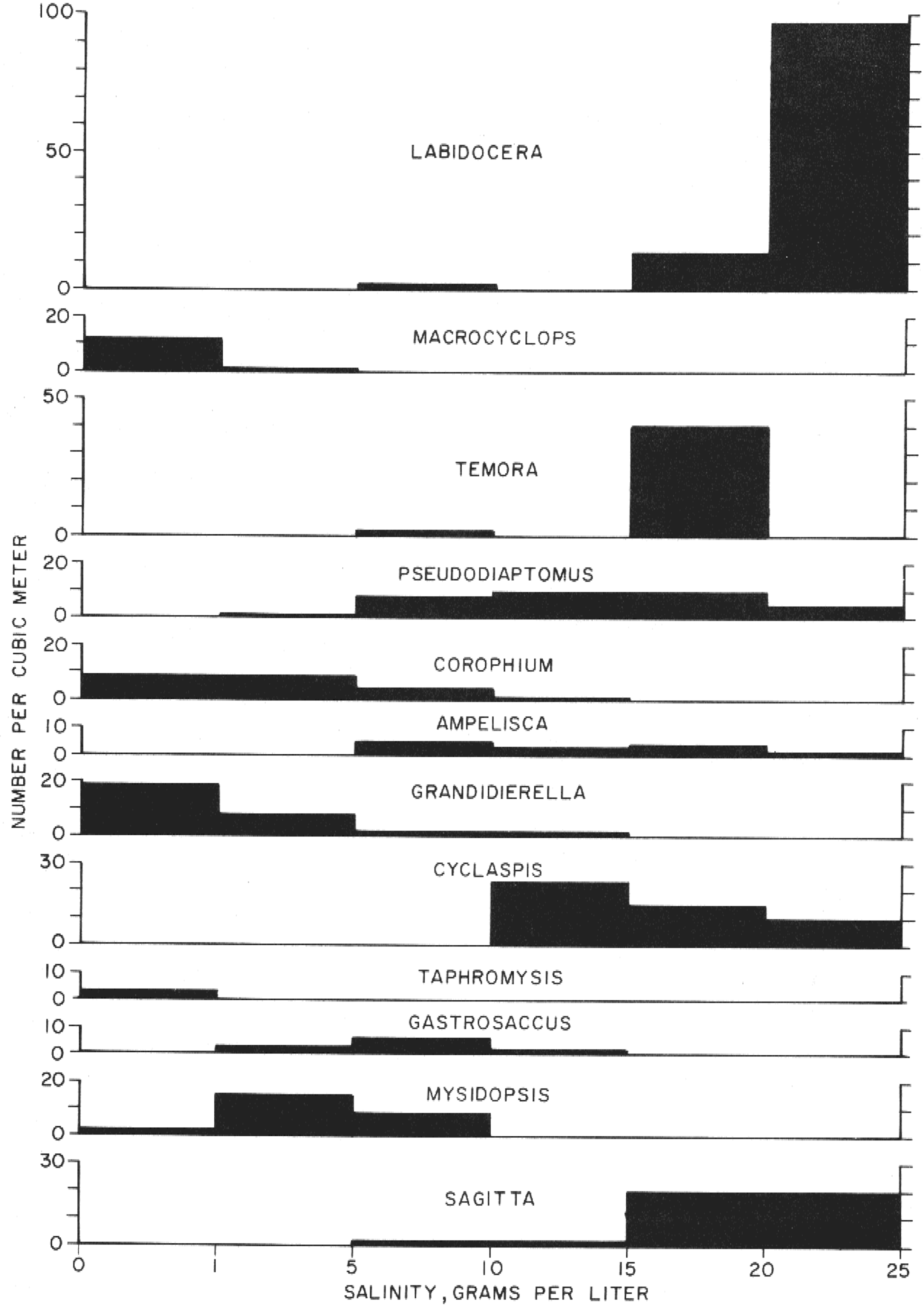


Figure 11.--The mean number of specimens of different zooplankters per cubic meter collected at different salinities in Shark River estuary.

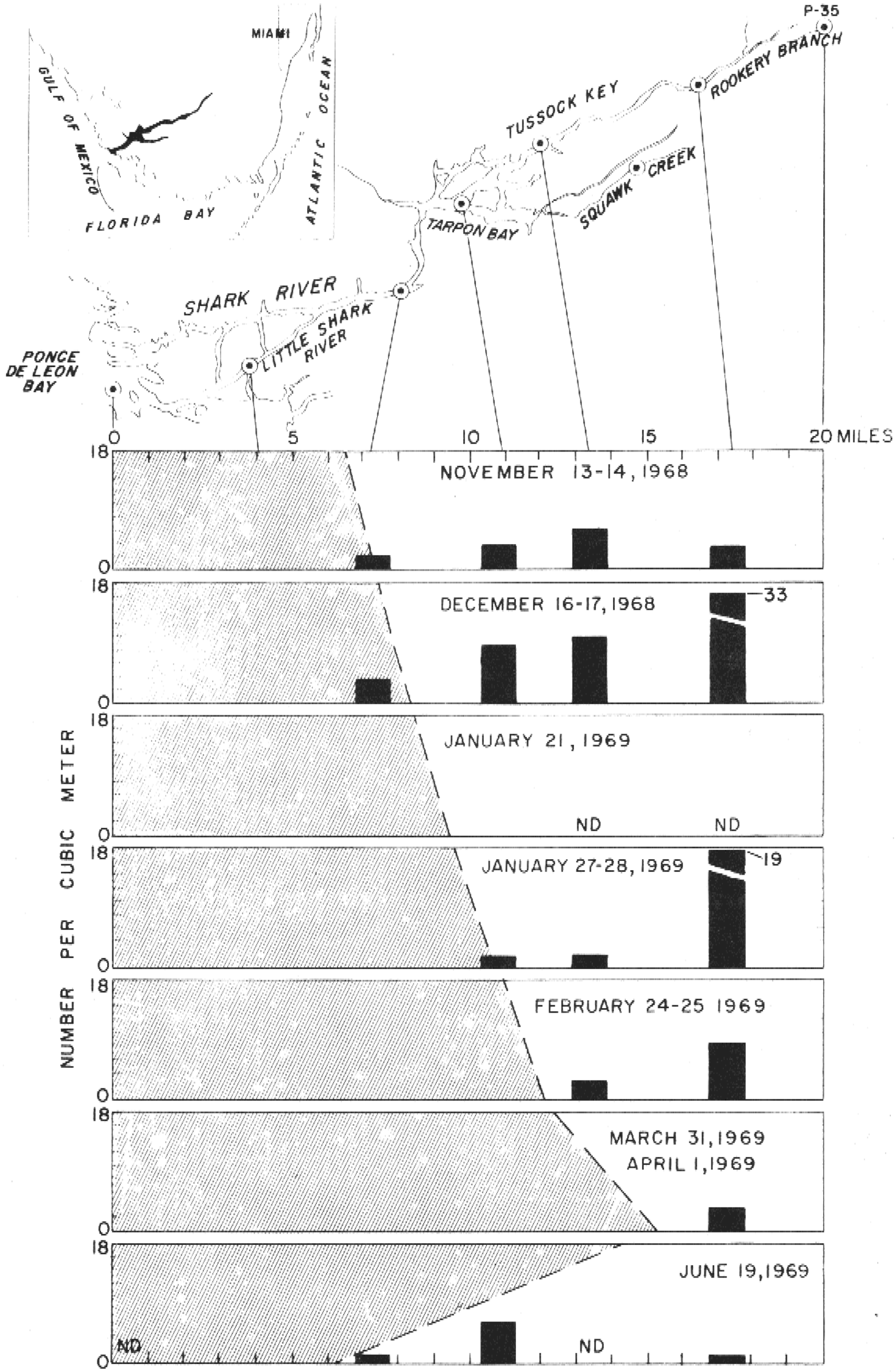
Labidocera aestiva Wheeler was absent from plankton samples in November and December 1968, but occurred during the winter months in Ponce de Leon Bay, when salinities approached 20 to 25 g/l, and in the Little Shark and Shark Rivers at salinities as low as 8 g/l.

Temora turbinata (Dana) was observed in plankton samples only in December 1968 and January 1969 in water that ranged in salinity from 10 to 20 g/l.

Cyclopoid copepods were found in the "fresher" parts of the estuary, mostly in water of less than 2 g/l salinity (fig. 12). Most of these specimens belonged to the genus Macrocyclops.

Mysid shrimp

Three species of mysids were collected in the estuary. Although their distributions overlapped, each species occurred over a different environmental range. Taphromysis bowmani Bacescu was found only in the upper estuary in salinities that ranged from 0.1 to 1.2 g/l. Mysidopsis almyra Bowman was found in the upper and mid-estuary in salinities that ranged from 0.1 to 12.2 g/l. It was most abundant in salinities of about 2 to 7 g/l. Gastrosaccus dissimilis Coifman occurred primarily in the lower part of the estuary in salinities that ranged from 2.8 to 19.7 g/l (fig. 11).



ND indicates no data. Shaded area indicates waters of salinities greater than two grams per liter.

Figure 12.--Number of cyclopoid copepods per cubic meter collected in Shark River estuary.

M. almyra and G. dissimilis were most abundant in the February and the March-April 1969 samples, occurring in numbers between 10 and 20 per cubic meter at some stations (fig. 13). Most of these were juveniles.

T. bowmani was most abundant in November 1968. Females with eggs were noted at that time.

Cumaceans

Cumaceans in the genus Cyclaspis occurred in relatively large numbers in the plankton of the Little Shark and the Shark Rivers. Only a few individuals were observed in November and December 1968, but numbers increased in later sampling. Between January and March 1969 the mean number of cumaceans observed at these stations was 23 per cubic meter and the maximum number observed was 64 per cubic meter (Shark River station on February 25, 1969).

Isopods

Several species of isopods occurred sporadically and in small numbers in the plankton. These are listed in the Appendix (table 17). The most commonly collected species was Edotea montosa (Stimpson) which Rouse (1970) noted from bottom detrital tows in Shark River. Probopyrus floridensis, a parasite on the fresh-water prawn, was not observed in the plankton (see page 71).

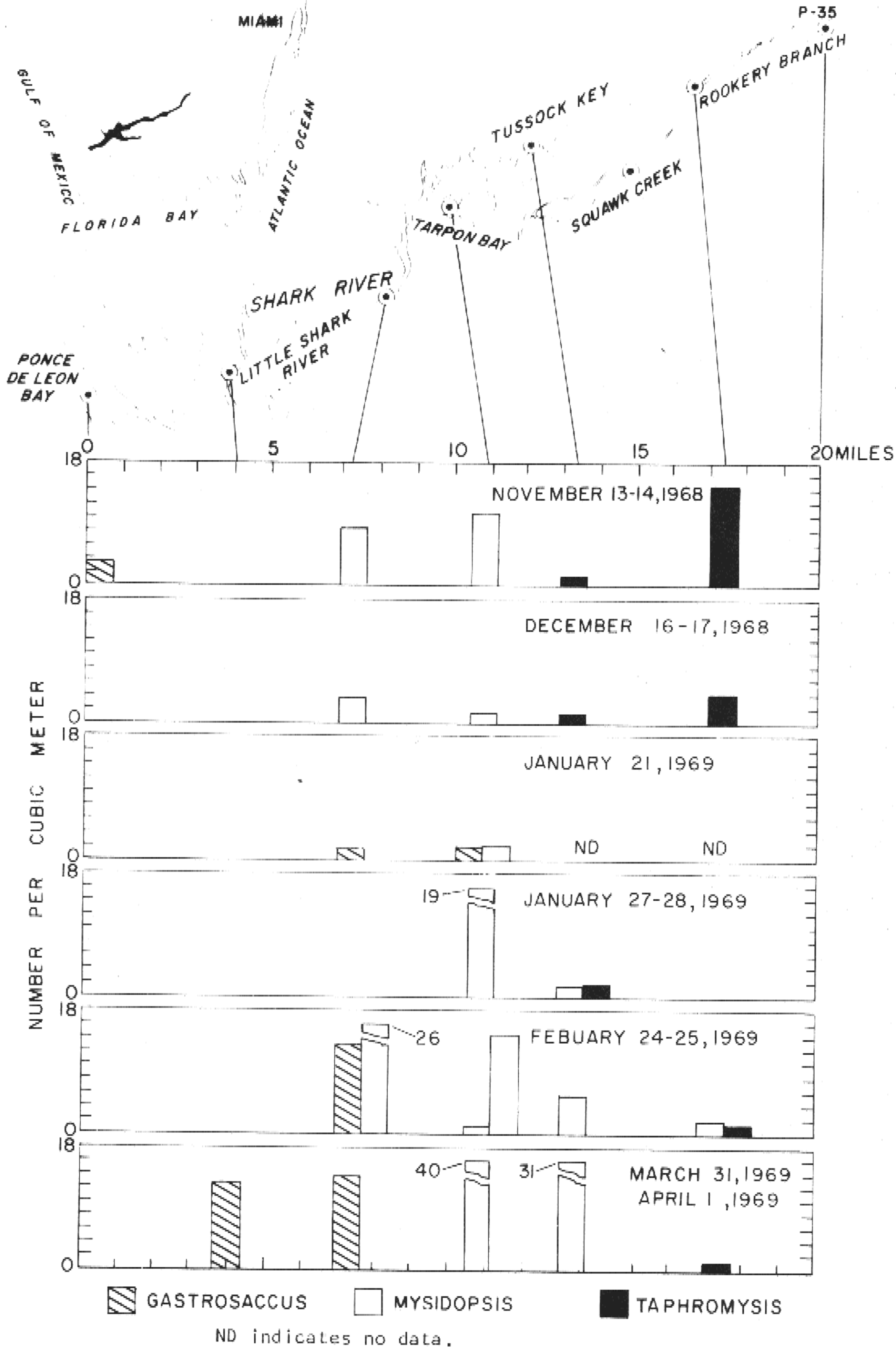


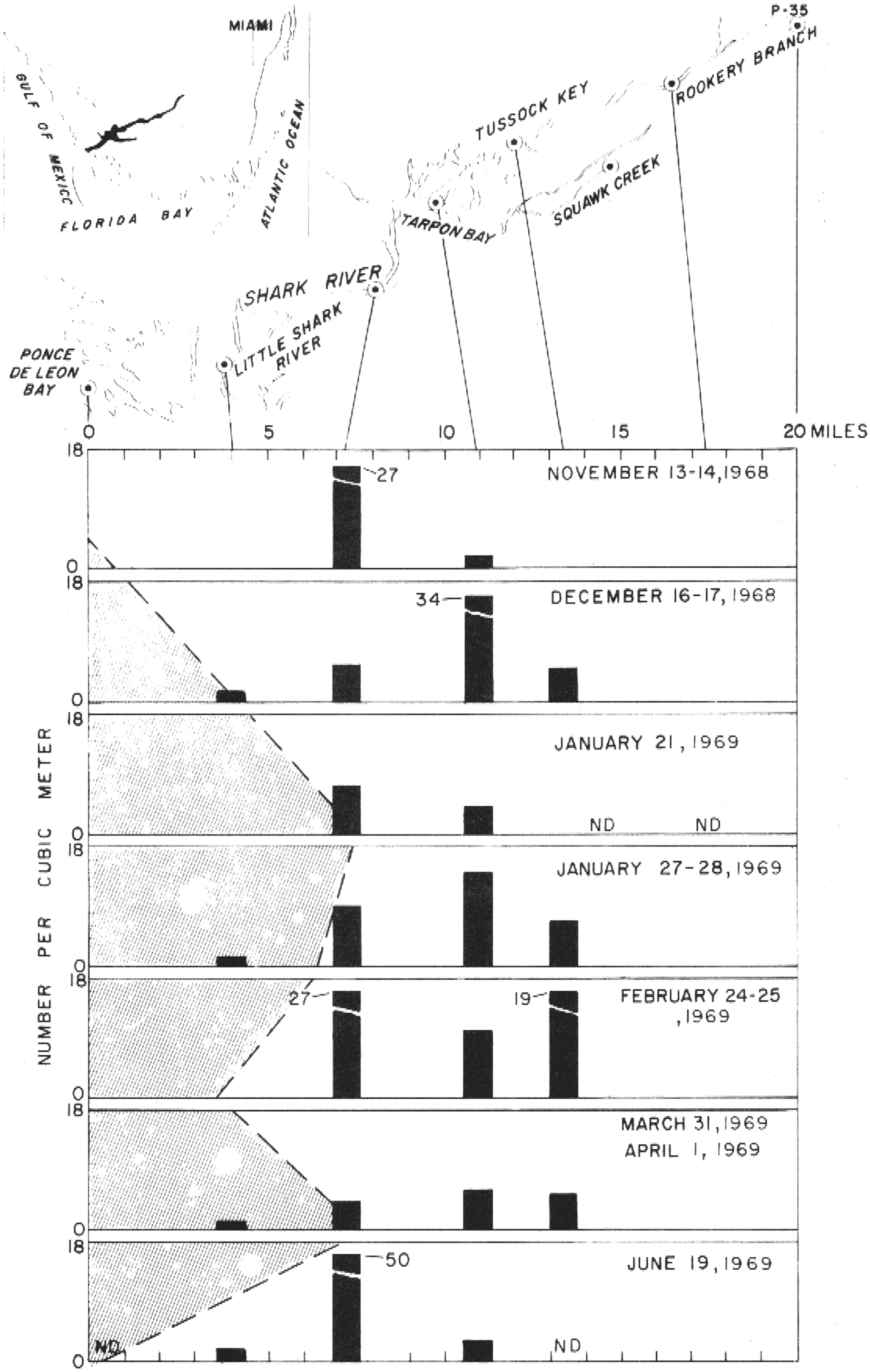
Figure 13.--Number of specimens of three mysids (Gastrosaccus dissimilis, Mysidopsis almyra and Taphromysis bowmani) per cubic meter collected in Shark River estuary.

Amphipods

Amphipods are common in the plankton of Shark River estuary and because of their relatively large size and their abundance, they are a prime source of food for fish.

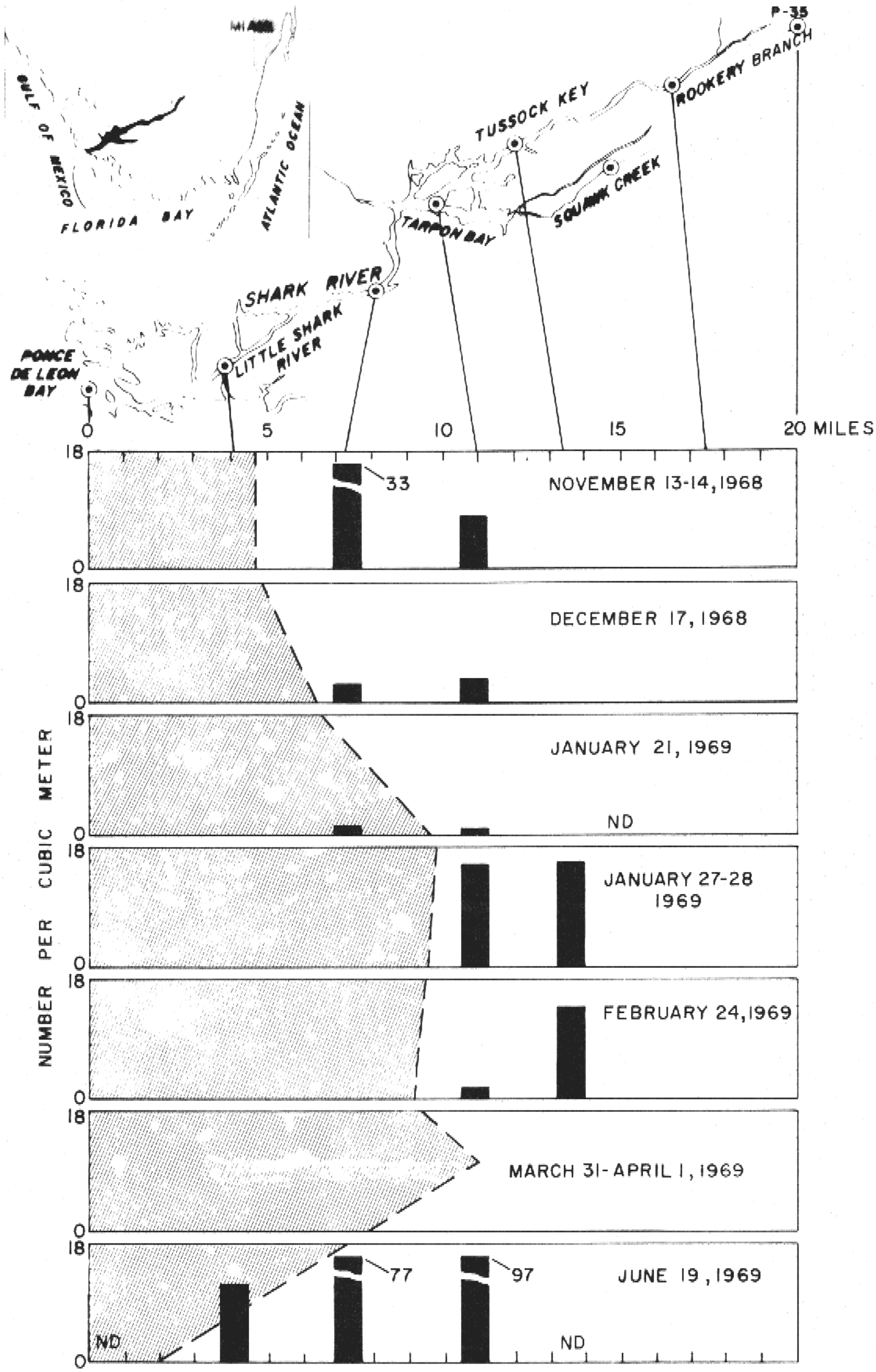
Corophium sp. and Grandidierella sp. were the most abundant amphipods collected in the estuary. The former was found in numbers of up to 50 per cubic meter, and the latter in numbers of up to 97 per cubic meter. Specimens of these genera from each station were identified as C. louisianum Shoemaker and G. bonnieri Stebbing. Both were found most abundant in salinities from less than 1 g/l to 5 g/l, however Corophium extended into slightly higher salinities than Grandidierella (fig. 11). Both species were found only in the mid-estuary, from Little Shark River to Tussock Key, in 1968-69 (figs. 14 and 15). Grandidierella sp., however, was found as far inland as station P-35 in June 1965 (5.4 g/l of salinity).

The amphipod, Ampelisca sp., occurred in more saline water than did either of the former species (fig. 11). It was most abundant in Little Shark River, where it was taken in numbers of up to 15 per cubic meter. A number of specimens were identified as A. abdita Mills.



ND indicates no data. Shaded area indicates waters of salinities greater than ten grams per liter.

Figure 14.--Number of specimens of the amphipod, Corophium, per cubic meter collected in Shark River estuary.



ND indicates no data. Shaded area indicates waters of salinities greater than 5 grams per liter.

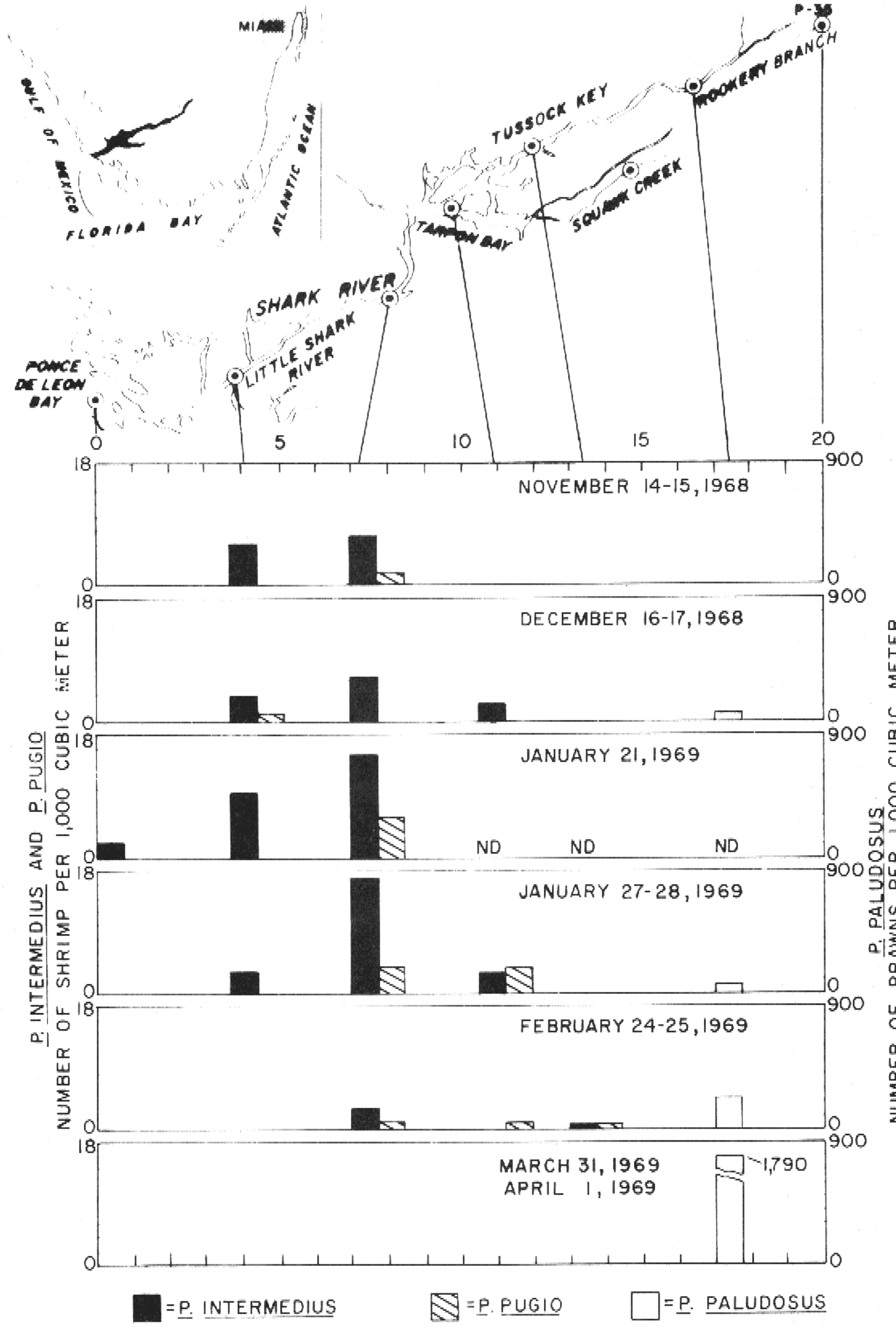
Figure 15.--Number of specimens of the amphipod, Grandidierella, per cubic meter collected in Shark River estuary.

Several other amphipods were collected, but in fewer numbers. Cerapus tubularis Say, a tube-dwelling amphipod, was collected on several occasions in Little Shark River. Although amphipods were uncommon in samples from Ponce de Leon Bay, Paraphoxus spinosus Holmas occurred occasionally in the plankton hauls.

Decapods

Larval crabs and shrimp are an important part of the zooplankton in the estuary. Although a variety of forms were observed, brachyuran crabs, probably in the family Dorippidae, were most abundant. They were found in concentrations of over 1,000 per cubic meter, with the greatest concentrations occurring during winter and early spring. The brachyuran larvae (Dorippidae?) were most abundant in the salinity range 1 to 5 g/l, and were not observed in water with salinities over 10 g/l (fig. 9). Other types of crab larvae were collected at higher salinities. Shrimp larvae were present in many plankton samples, but they were never as abundant as crab larvae.

Three species of the shrimp, *Palaemonetes*, occurred in Shark River estuary, each with a slightly different range. The fresh water prawn, *P. paludosus* (Gibbes), was found only in Rookery Branch and at station P-35 where salinity ranged from 0.1 to 1.2 g/1. *P. intermedius* Holthius and *P. pugio* Holthius were found only in the more brackish-water regions of the estuary below Rookery Branch. Although both occurred at some stations, *P. intermedius* extended farther seaward than *P. pugio*. *P. pugio* was found in a salinity range of 0.4 to 12.2 g/1 and was most abundant between 4.0 and 11.0 g/1, while *P. intermedius* was collected was collected in salinities ranging from 1.0 to 20.4 g/1, and was most abundant between 10.0 and 18.0 g/1 (fig. 16).



ND indicates no data.

Figure 16.--Number of specimens of three species of the shrimp Palaemonetes (P. paludosus, P. pugio and P. intermedius) per 1,000 cubic meters in Shark River estuary.

The number of specimens of *P. paludosus* at Rookery Branch and P-35 increased markedly during winter and spring. Figure 16 shows the seasonal increase at Rookery Branch. At P-35 only a few prawns were collected in October and November 1968 with a dip net. On February 24, 1969, 86 were collected in one dip, and on March 31, 1969, 172 per dip were taken. This increase in numbers probably resulted from a seasonal lowering of the water level. As the water level dropped large areas of land were exposed and aquatic animals were concentrated into streams and ponds.

Most of the specimens of *P. paludosus* collected in October and November 1968 were parasitized by the isopod *Probopyrus floridensis* Richardson. However, only a few individuals were parasitized in winter. Out of the 897 specimens collected in Rookery Branch on March 31, 1969, only 38 had this parasitic isopod.

Richardson (1905) reported that *Palaemonetes exilipes* (= *P. paludosus*) from the St. Johns River and the Little River in Florida were parasitized by *Probopyrus floridensis*.

Cladocerans, mites, and insects

Small numbers of unidentified cladocerans, water mites, and aquatic insects occurred in the plankton samples. The most common insects observed were pupae from the family Chironomidae and nymphs from the order Odonata. Insects were most abundant at Rookery Branch, where up to nine per cubic meter were observed on February 24, 1969. The cladocerans and water mites covered a greater range of salinities, being distributed from Rookery Branch to Shark River during the fall. During the winter and spring, as salinities increased, they were found only at Tussock Key and Rookery Branch. Cladocerans and water mites were found in numbers up to eight and four per cubic meter, respectively.

Chaetognaths

Sagitta hispida Conant was collected primarily in Ponce de Leon Bay, but some specimens were taken at the Little Shark River station. Although *S. hispida* was observed over a salinity range of 7.5 to 22.0 g/l, it was common only at salinities above 15 g/l (fig. 11). Its occurrence in Ponce de Leon Bay appeared to be sporadic; a maximum number of 83 per cubic meter was counted on January 21, 1969, but seven days later only one per cubic meter was found.

Fish

The bay anchovy, *Anchoa mitchilli* (Valenciennes), was the most abundant fish observed in the estuary. It was collected from Ponce de Leon Bay to Tussock Key, over a salinity range of 0.3 to 22.0 g/1. Adults were commonly found only in the seaward parts of the estuary, while the young were found primarily in the mid-and upper estuary. Adults were caught most abundantly during November and December 1968. Ten minute tows with the one-meter ring net in November 1968 and 4.9 meter otter trawl in December 1968 yielded 110 and 131 specimens, respectively. The catch decreased in subsequent months and only a few adults were found after December 1968.

Other fish commonly found in the marine parts of the estuary were the scaled sardine, *Harengula pensacolae* Goode and Bean, the pinfish, *Lagodon rhomboides* (Linnaeus), and the silver jenny, *Eucinostomus gula* (Quoy and Gaimard). Table 18 (appendix) lists all species collected.

Juvenile fish were abundant in the brackish waters (1-10 g/1) of the estuary. Anchovies and sardines occurred in greatest numbers, but lizard fish and other unidentified fish also were collected. Anchovies less than 25 mm in length (probably A. mitchilli) were found during each sampling period. They occurred in numbers of up to 2 per m^3. Juvenile sardines (probably H. pensacolae) were collected only on March 31 to April 1, 1969, when they occurred in numbers of over 0.5 per m^3.

The dominant fish collected at the fresh-water Rookery Branch and P-35 stations were the least killifish, Heterandria formosa Agassiz, the mosquitofish Gambusia affinis (Baird and Girand), bluefin killifish, Lucania goodei Jordan, and the spotted sunfish, Lepomis punctatus (Valenciennes). The catch of these fish and of fresh-water prawns increased during winter and reached a maximum in late spring, at the time of low water level. The declining water level forced these animals from shallow glades and ponds into the remaining creeks. Increasing salinities also may have concentrated animals in the remaining fresh-water.

EFFECTS OF NATURAL WATER QUALITY CHANGES
ON THE BIOTA OF SHARK RIVER ESTUARY

Dead fish were observed in the headwaters of the estuary in May 1967 at Rookery Branch and in March 1969 at Squawk and Avocado Creeks. In 1967 no information was collected to indicate the cause or causes of death; however, in 1969 observations were more complete and water-quality data were collected.

On the morning of March 27, 1969, dying sunfish (*Lepomis* sp.) were seen at the surface of Squawk Creek. During the next few days hundreds of dead fish were observed along several miles of Squawk Creek and the adjacent Avocado Creek. Sunfish (*Lepomis* sp.), catfish (*Ictalurus* sp.), and mullet (*Mugil* sp.) were the most common. Several dead bass (*Micropterus salmoides*), one lake chubsucker (*Catostomidae erimyzon*), one American eel (*Anguilla rostrata*), one snook (*Centropomus* sp.), and one sheepshead (*Archosargus probatocephalus*) were also seen.

The area of the fishkill was characterized by turbid, brown-colored water that was easily distinguished from the water in the unaffected areas. Dissolved oxygen in the turbid water was 1-2 mg/l during the March 27-29 observation period and remained low in the creeks during April, although the turbidity and color diminished by the end of April. Salinities in the creeks increased from less than 1 g/l in February to just over 3 g/l in March. At the time the fish died, water temperature and pH were normal, ranging from 20 to 23°C and from 6.7 to 6.9, respectively. The available data suggest that low dissolved oxygen concentration was the immediate cause of the fish mortality.

Avocado and Squawk Creeks had dense stands of aquatic "grass" (predominantly *Najas* sp). Sometime in March prior to the fish mortality most of this vegetation died in the areas where the fishkills occurred, and this plant mortality was coincidental with increasing salinities. *Najas guadalupensis* tolerates salinities up to 3.6 g/l (Chamberlain, 1960). Farther up the estuary where salinities were lower, this aquatic vegetation still flourished and the dissolved oxygen was normal. These data suggest that increased salinities resulted in plant mortality. The dead plant material in the water undoubtedly decreased concentrations of dissolved oxygen.

STANDING CROP

The amount of seston, or suspended matter, collected in the estuary with the No. 2 plankton net ranged from less than 1 to over 7 cc/m^3, with a mean volume of 1.2 cc/m^3. Most of the seston consisted of organic detritus of plant origin, whereas a smaller part of the seston consisted of zooplankton. Although organic detritus was usually the most abundant constituent of the seston, in a few samples it was scarce and the volume of the zooplankton could be measured. Zooplankton volumes are of interest for comparative purposes. They ranged from a few hundredths of a cc/m^3 to one cc/m^3. Other investigators have reported similar results in estuaries on the east coast of the United States (Cronin et. al. 1962) and on the Gulf Coast of Florida (Kelly and Dragovich, 1967).

The estimated wet-weight of zooplankton collected in the estuary ranged from less than 1 to 173 mg/m^3. The average weight per cubic meter at different salinities ranged from 15 mg/m^3 at 0-1 g/l to 80 mg/m^3 at 5-10 g/l. (fig. 17). The average weight for all samples was 65 mg/m^3.

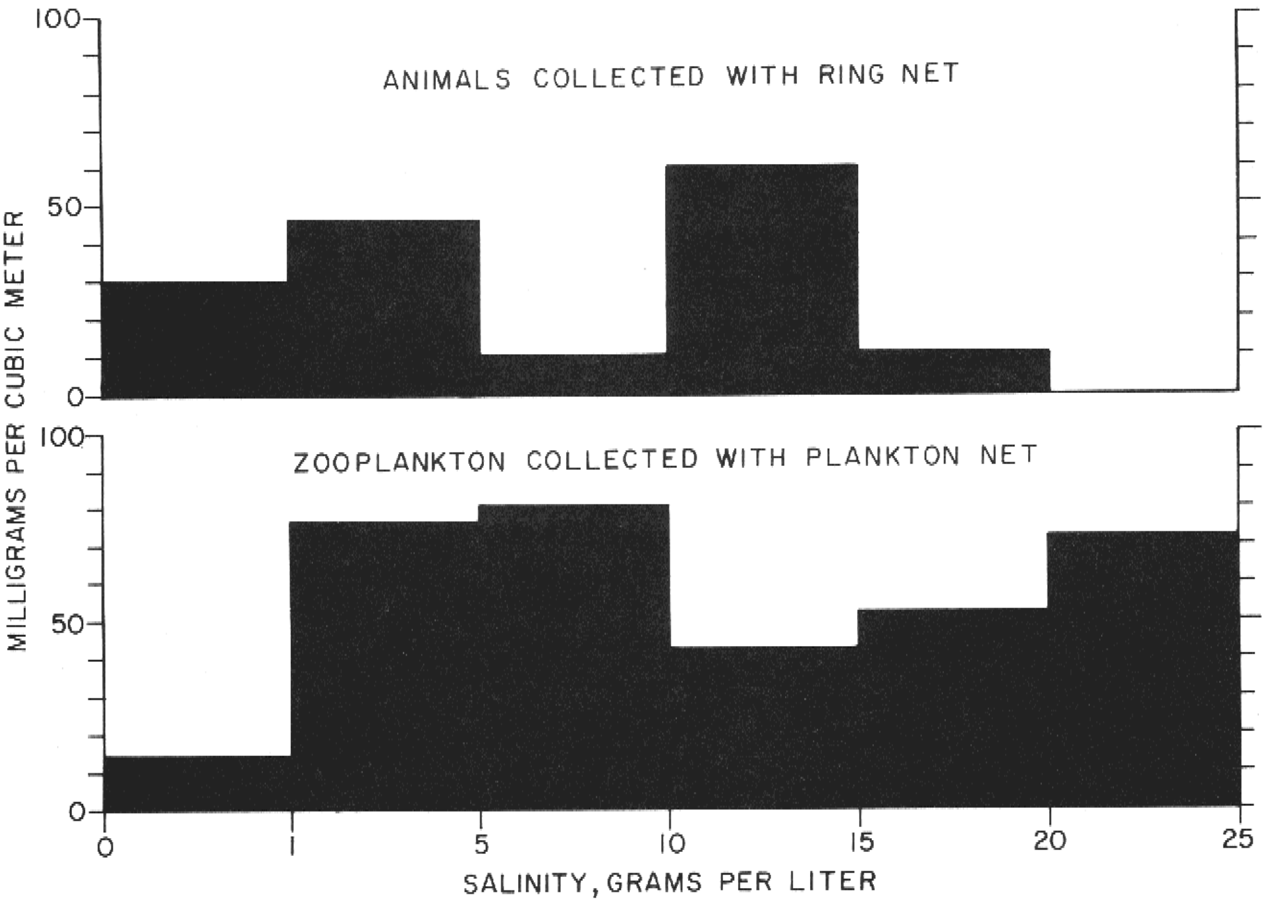
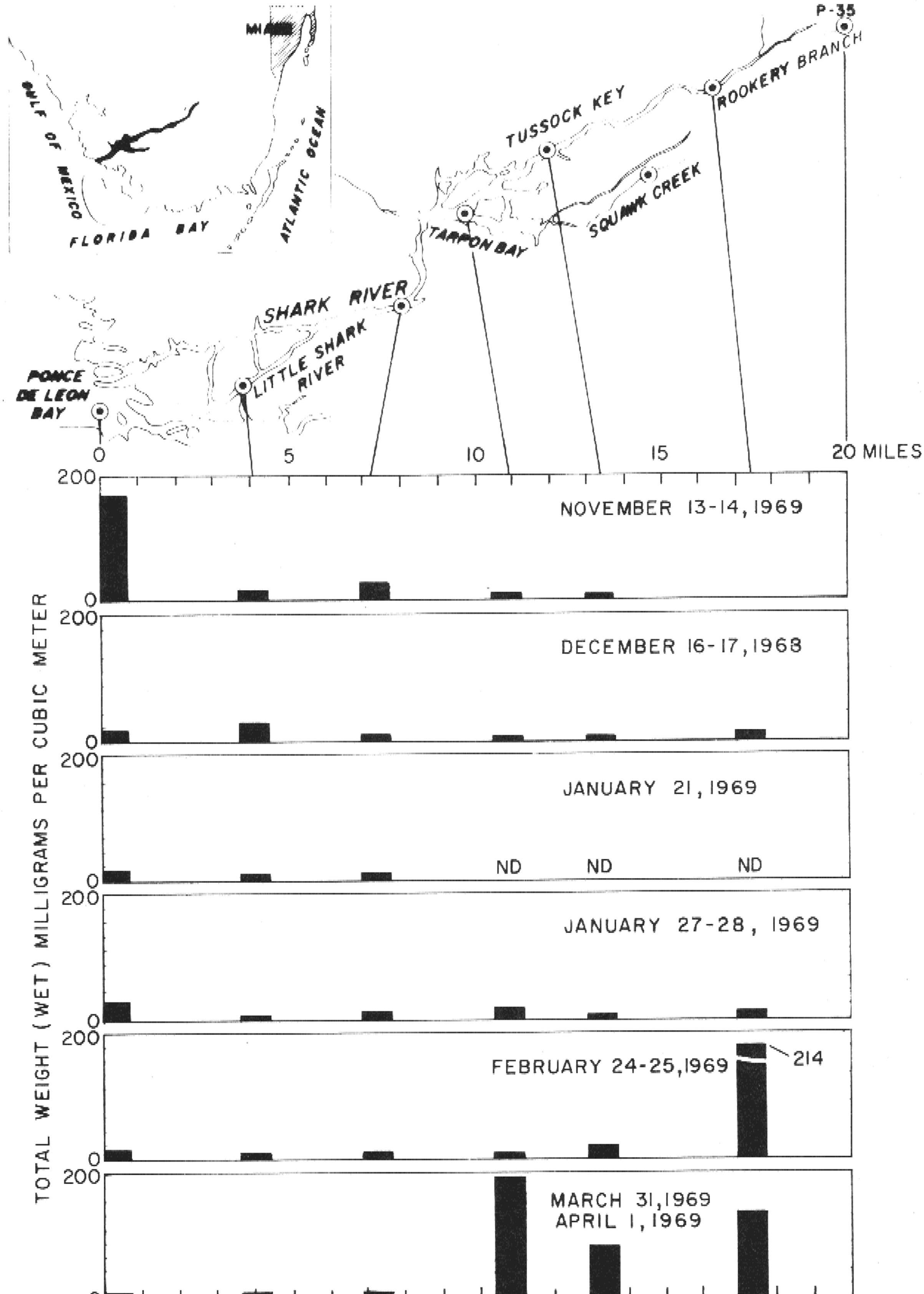


Figure 17.-- Mean wet-weight of the common zooplankton species collected with the number two plankton net, and animals collected with the one-meter ring net at different salinities in Shark River estuary, November 1968 to April 1969.

The animals collected in the estuary with the one-meter ring net consisted primarily of palaemonid shrimp, marshfish, anchovies, and sardines. The wet-weight of these animals ranged from 3 to 214 mg/m^3. The average weight at different salinities ranged from 3 mg/m^3 at 20-25 g/l to 60 mg/m^3 at 10-15 g/l (fig. 17).

The largest catches were made in the headwaters during the latter part of the dry season (fig. 18). The weight of the standing crop increased over 15 times in this region during the sampling period. This increase was coincidental with decreasing water level and the increasing salinity in the lower estuary.

The animals collected in Ponce de Leon Bay with the otter trawl consisted primarily of the pinfish (Lagodon rhomboides), the silver jenny (Eucinostomus gula), the bay anchovie (Anchoa mitchilli), and the scaled sardine (Harengula pensacolae). The average catch per 10 minute tow was 126 gms of pinfish, 84 gms of silver jenny, 21 gms of bay anchovie, and 17 gms of scaled sardine. The total catch with the otter trawl was variable, ranging from 0 to over 800 gms per haul.



ND indicates no data collected.

Figure 18.--Total wet-weight (mg) per cubic meter of animals collected with the one-meter ring net at six stations in Shark River estuary.

FOOD RELATIONSHIPS

Organic detritus and associated microorganisms are an important constituent in the food chains of an estuary. Odum (oral communication 1969) stated that many invertebrates and some fish in the North River of Everglades National Park feed on detritus and associated microorganisms. The detritus-feeding animals include amphipods, cumaceans, mysids, aquatic insects, crabs, shrimp, some marshfish, and mullet. Heald (1969) found that two species of amphipods and a xanthid crab were important consumers of detritus in the North River and that in the process they contributed significantly to the degradation of the detritus. Detritus and its associated microorganisms appeared to be a major food item for some invertebrates collected in Shark River estuary. It was observed commonly in the guts of amphipods (*Corophium* sp.; *Grandidierella* sp.), mysids (*Mysidopsis almyra*), and palaemonid shrimps (*Palaemontes intermedius*, *Palaemonetes paludosus*).

Small fish from the estuary and adjacent marshes feed on a variety of foods (fig. 19). The guts of some marshfish from Shark River Slough, such as the sheepshead minnow (Cyprinodon variegatus) and the sailfish molly (Mollienisia latipinna), contained filamentous algae, phytoplankton, and detritus of plant origin. Others, such as the mosquitofish (Gambusia affins) and the flagfish (Jordanella floridae), contained primarily small arthropods (Kolipinski and Higer, 1969). The guts of Anchovies (Anchoa mitchilli) and scaled sardines (Harengula pensacolae) from the estuary contained mainly small crustaceans, including copepods, amphipods, mysids, and cumaceans (table 13).

Larger fish collected in the estuary, such as the pinfish (Lagodon rhomboides), the silver jenny (Eucinostomus gula), sea catfish (Galeichthys felis), the gray snapper (Lutjanus griseus), and the red drum (Sciaenops ocellata) had a variety of invertebrates in their guts, including amphipods, crabs, shrimp, and polycheate worms (table 13). The crab, Rithropanopeus harrisii, was found in the guts of the last three species, all from the mid-estuary. Odum (1970) found that this crab was important in the diet of various fish in the North River.

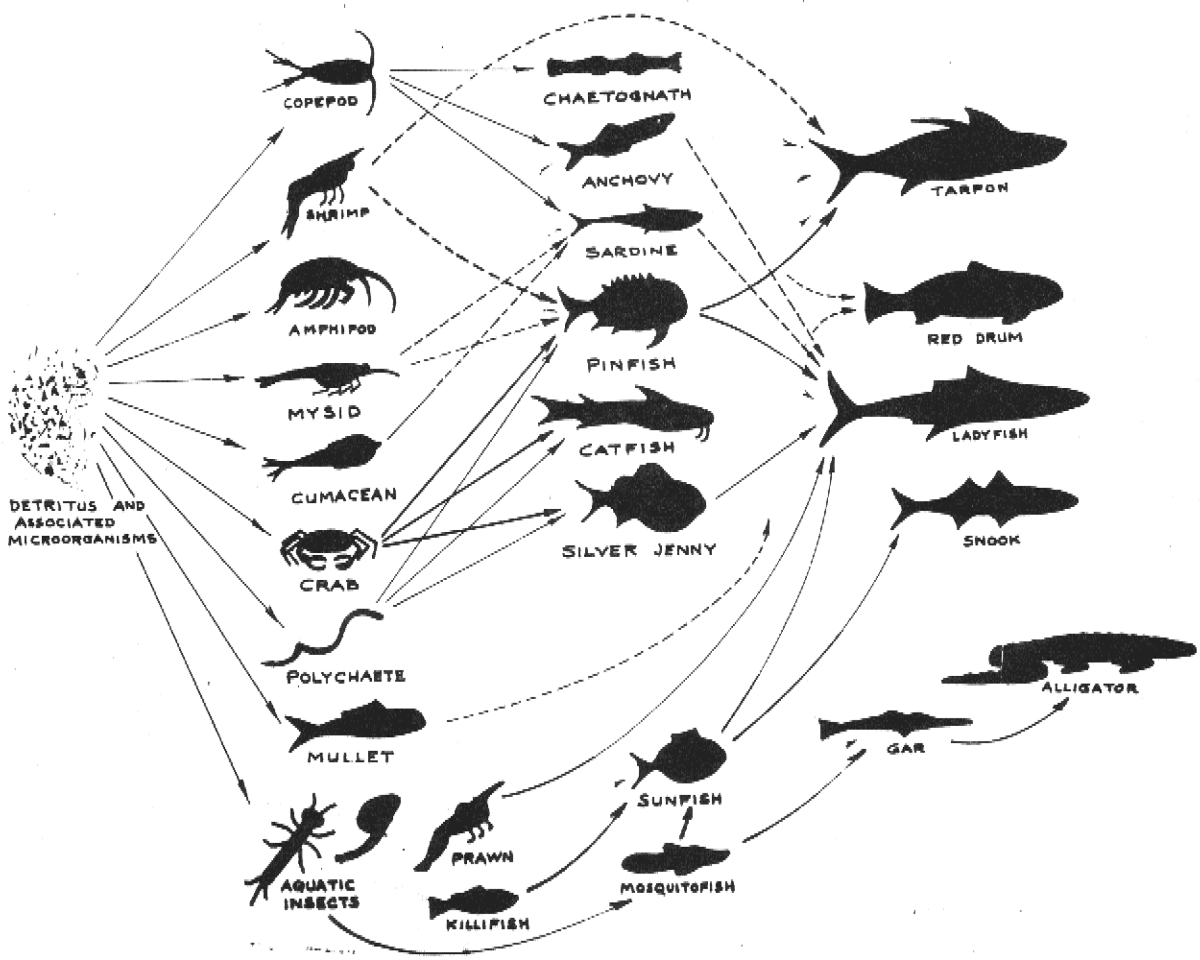


Figure 19.--Animals commonly collected or observed in Shark River estuary and some of their food relations.

NOTE: Shaded area indicates fresh water.

Table 13.--Gut content of selected fishes from Shark River estuary, November 1968 to April 1969.

Species	Station number	Size range* mm	Number examined	Food in Gut	Number of fish with food item
Anchoa mitchilli	1, 2	42-55	15	copepods (*Labidocera*, *Acartia*)	10
(bay anchovie)				amphipods (*Ampelisca*, others)	6
				mysids (*Gastrosuccus*)	2
				empty	3
Harengula	1, 2	58-71	7	Copepods	2
pensacolae				Amphipods (*Ampelisca*)	2
(scaled sardine)				Cumaceans (over 100 *Cyclaspis*)	1
				empty	2
Lagodon	1	89-111	5	unidentified shrimp	3
rhomboides				crab	1
(pinfish)				unidentified crustaceans	1
				empty	1
Eucinostomus gula	1	100 *	3	polychaete worms	3
(silver jenny)				detritus	2
Galeichthys felis	3	250 *	3	shrimp, *Penaeus*	1
(sea catfish)				crab, *Rhithropanopeus harrisii*	1
				amphipod, *Parhyalella whelpleyi*	1
Lutjanus griseus	3, 4	150 *	2	*Penaeus*	1
(gray snapper)				crab, *Rhithropanopeus harrisii*	1
Sciaenops ocellata	4	350 *	1	many crabs, *R. harrisii*	1
(red drum)	6		1	sunfish	1
Elops saurus (ladyfish)	6	350 *	3	sailfin molly	1
				bluefin Killifish	2
				mosquitofish	1
				shrimp, *Palaemonetes* (about 15)	1
				empty	1
Caranx hippos (crevalle jack)	1	200 *	1	blackcheek tonguefish *Symphurus plagiusa*	1

* Approximate values

During the dry season, large fish, such as tarpon (Megalops atlantica), snook (Centropomus sp.), lady fish (Elops saurus), and red drum (Sciaenops ocellata) were seen or caught in the headwaters of Shark River estuary. These fish, along with birds, such as the American bittern (Botaurus lentiginosus), the green heron (Butorides virescens), the great blue heron (Ardea herodias), and the wood ibis (Mycteria americana), fed on the smaller fish and prawns that were concentrated in the deeper channels in the headwaters where water levels had declined.

SUMMARY

Shark River estuary is a narrow, 20-mile long body of water in Everglades National Park that extends from its headwaters in the dendritic creeks of Shark River Slough to its mouth at the Gulf of Mexico. The bottom of the estuary is generally exposed limestone or a thin layer of sediment and shell, and the sides are marl or peat. The banks of the estuary are slightly higher than the surrounding land and support a dense growth of mangroves and other plants. The estuary is usually less than 10 feet deep, and its waters are well-mixed vertically by wind and tide. Salinity changes seasonally, with highest values usually occurring in spring and lowest in late summer or early fall. The seasonal rainfall varies considerably, and these differences have a marked effect on the salinity and biological composition of the estuary. During drought, such as January to May 1967, the salinity in the estuary ranged from about 18 g/l in the headwater to 36 g/l at the mouth. During the same months in wet years, such as 1969, the salinity ranged from about 1 to 25 g/l along the length of the estuary. During the rainy season much of the estuary contained fresh water, and the salinity at the mouth was only about half that of sea water.

Hydrologic conditions in the estuary are not always favorable for aquatic plants and animals. Observations in 1966 and 1969 indicated low concentrations of dissolved oxygen (2-5 mg/l) throughout the estuary during summer. High temperatures (30-33°C) and the presence of organic detritus with associated microorganisms probably explain these low dissolved oxygen values. Increasing salinities during the spring of 1967 and 1969 presumably killed large amounts of submerged vegetation in the headwaters of the estuary, resulting in low dissolved oxygen (1-2 mg/l) and the death of fish. Heavy metals and pesticides occur in the waters of the estuary in concentrations below those currently considered dangerous for aquatic life (FWPCA, 1968). Pesticides are concentrated in the sediments and in various organisms.

Although phytoplankton were relatively scarce in the estuary, zooplankton and small nektonic animals were abundant. The distribution of the latter forms could be related to salinity. Copepods (Acartia tonsa, Labidocera aestiva, Pseudodiaptomus coronatus), cumaceans (Cyclaspis sp.), chaetognaths (Sagitta hispida), bay anchovies (Anchoa mitchilli), and scaled sardines (Harengula pensacolae) were the dominant forms collected at the seaward end of the estuary in the highest salinities (10-25 g/l). The dominant forms in the brackish water (1-10 g/l) of the mid-estuary were amphipods (Corophium sp., Grandidierella sp.), mysids (Mysidopsis almyra, Gastrosaccus dissimilis), crab larvae, and the young of anchovies, sardines, or related fish. The presence of large numbers of juvenile and young animals indicated the importance of these brackish waters as nursery grounds. Zooplankton concentrations were reduced in the fresh headwaters of the estuary, being represented there mainly by aquatic insects, cyclopoid copepods (Macrocyclops sp.), cladocerans, mysids (Taphromysis bowmani), and ostracods (Cypridopsis sp.). Various marshfish (including the bluefin killifish, Lucania goodei; sheepshead killifish, Cyprinodon variegatus; mosquitofish, Gambusia affinis; and least killifish, Heterandria formosa) and the fresh-water prawn (Palaemonetes paludosus) were the dominant small nektonic forms in these waters.

The standing crop of phytoplankton, coarse detritus, zooplankton, and small nektonic animals in the estuary were determined. Concentrations of phytoplankton ranged from 0 to 10,800, with a mean of 761 cells per liter. Highest concentrations occurred near the mouth and in the headwaters of the estuary. The amount of plant detritus in the water was quite variable, but values averaged roughly 1-2 cc/m^3. The estimated wet-weight of the zooplankton ranged from 1 to 173 mg/m^3, with a mean of 65 mg/m^3. Lowest weights and numbers occurred in the fresh-water portions of the estuary. The weight of the nekton, consisting of small fish and prawns, ranged from 3 to 214 mg/m^3, with a mean of 30 mg/m^3. Largest catches occurred in the headwaters at the end of the dry season. The catch at Rookery Branch increased from 7 mg/m^3 in the fall of 1968 to 130 mg/m^3 in the spring of 1969.

Organic detritus from plants is an important source of food for many invertebrates and some fish in the estuary. Fish, such as anchovies and sardines, fed on zooplankton. Larger fish, such as the silver jenny, sea catfish, and pinfish fed on an assortment of invertebrates. The concentration of marshfish, sunfish, and prawns in the deeper channels within the headwaters during low water periods resulted in a rich feeding area for large marine fish and wading birds.

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APPENDIX

Table 14.--Concentrations of nitrogen and phosphorus in mg/l in Shark River estuary 1968-69. 1/

Date	Nitrate NO_3	Nitrite NO_2	Ammonia NH_4	N-Organic	Ortho-phosphorus PO_4	Total phosphorus PO_4
			2-2908.58 Shark River at Ponce de Leon Bay			
Oct. 1, '68	0.3	0.01	0.07	9.7	--	0.05
Mar. 27, '69	0.1	0.01	0.09	0.37	0.00	0.03
			2-2908.54 Shark River Cut off			
Nov. 1, '68	0.1	0.01	0.02	0.84	--	0.02
Dec. 20, '68	0.1	0.02	0.05	0.79	--	0.03
Feb. 22, '69	0.1	0.02	0.03	0.75	0.00	0.03
			2-2908.50 Shark River			
Nov. 1, '68	0.0	0.01	0.04	0.98	--	0.03
Dec. 20, '68	0.2	0.0	0.07	0.99	--	0.01
Feb. 22, '69	0.1	0.15	0.02	2.4	0.00	0.01
Mar. 26, '69	0.0	0.01	0.01	1.2	0.00	0.03
			2-2908.44 Tarpon Bay at Mid-Bay Pass			
Oct. 31, '68	2.5	0.00	0.02	0.84	--	0.02
Dec. 18, '68	0.1	0.00	0.19	0.98	0.01	0.01
Mar. 26, '69	0.3	0.02	0.05	1.4	0.00	0.02
			2-2908.42 Tarpon Bay at Tussock Key			
Oct. 31, '68	0.7	0.01	0.08	1.1	--	0.01
Dec. 18, '68	0.1	0.00	0.35	0.98	0.01	0.03
Mar. 26, '69	0.1	0.01	0.01	1.2	0.00	0.02

Table 14.--Concentrations of nitrogen and phosphorus in mg/l in Shark River estuary 1968-69. 1/ (cont'd)

Date	Nitrate NO_3	Nitrite NO_2	Ammonia NH_4	N-Organic	Ortho-phosphorus PO_4	Total phosphorus PO_4
		2-2908.41 Rookery Branch				
Oct. 31, '68	1.0	0.0	0.03	0.86	--	0.01
Dec. 18, '68	0.1	0.0	0.54	1.2	0.00	0.00
Feb. 24, '69	0.2	0.05	1.0	1.6	0.00	0.01
		2-2908.3 P-35				
Oct. 1, '68	0.9	0.02	0.06	2.7	--	0.02
Oct. 31, '68	1.0	0.01	0.04	1.1	--	0.03
Dec. 19, '68	0.1	0.00	0.58	1.3	0.01	0.03

1/ Concentrations from 1960 to 1967 given by Kolipinski and Higer (1969)

Table 15.--Trace elements and heavy metals (mg/l) in water from Shark River estuary, 1968-69.

Date of Collection	Aluminum (Al)	Arsenic (As)	Boron (B)	Bromide (Br)	Chromium (Cr)	Copper (Cu)	Iodine (I)	Iron (Fe)	Lead (Pb)	Lithium (Li)	Manganese (Mn)	Zinc (Zn)
2-2908.58 Shark River at Ponce de Leon Bay (Station 1)												
Oct. 1, '68	0.61	0.02	1.8	24	0.00	0.04	--	0.03	0.00	0.06	--	0.00
Mar. 26, '69	1.6	.00	3.5	67	.07	.02	.42	.01	.015	.011	.04	.00
2-2908.50 Shark River near Homestead (Station 3)												
Nov. 1, '68	.12	.00	.16	--	.00	.00	.00	.05	.01	.00	--	.00
Dec. 20, '68	.11	.06	.15	9.6	.00	.00	.00	--	.00	.02	.00	.02
Feb. 22, '69	.6	.01	.71	17	.01	.01	.42	.07	.019	.01	.01	.01
Mar. 26, '69	1.1	.02	1.6	22	.03	.02	.42	.05	.013	.05	.02	.01
2-2908.54 Shark River Cut off nr. Homestead (Station 2)												
Nov. 1, '68	.33	.00	6.79	2.4	.00	.00	.00	0.05	.00	0.02	--	0.0
Dec. 22, '68	.07	.05	.21	34	.02	.02	.00	--	.01	.10	02	.02

Table 15.--Trace elements and heavy metals (mg/l) in water from Shark River estuary, 1968-69. (cont'd).

Date of Collection	Aluminum (Al)	Arsenic (As)	Boron (B)	Bromide (Br)	Chromium (Cr)	Copper (Cu)	Iodine (I)	Iron (Fe)	Lead (Pe)	Lithium (Li)	Manganese (Mn)	Zinc (Zn)
2-2908.42 Tarpon Bay at Tussock Key nr. Homestead (Station 5)												
Oct. 31, '68	0.12	0.00	0.08	0.8	0.00	0.00	0.00	0.04	0.00	0.00	--	0.00
Dec. 18, '68	.15	.11	.10	2.4	.00	.00	.00	--	.00	.00	.00	.02
Mar. 26, '69	.5	.00	.38	12	.00	.00	.42	.1	.012	.01	.02	.02
2-2908.44 Tarpon Bay at Mid-Bay Pass (Station 4)												
Oct. 31, '68	.09	.01	.12	.8	.00	.00	.00	.04	.00	.00		.00
Dec. 18, '68	.22	.08	.17	4.0	.00	.09	.00	--	.01	.01	.02	.07
Mar. 26, '69	.8	.00	.72	23	.01	.01	.84	.09	.014	.03	.01	.01

Table 15.--Trace elements and heavy metals (mg/1) in water from Shark River estuary, 1968-69. (cont'd).

Date of Collection	Aluminum (Al)	Arsenic (As)	Boron (B)	Bromide (Br)	Chromium (Cr)	Copper (Cu)	Iodine (I)	Iron (Fe)	Lead (Pb)	Lithium (Li)	Manganese (Mn)	Zinc (Zn)
		2-2908.3 Everglades P-35 near Homestead (Station 7)										
Oct. 1, '68	--	0.01	0.00	0.8	0.00	0.00	0.00	0.5	0.00	0.00	--	0.1
Oct. 31, '68	--	.00	.08	.8	.00	.00	.00	.5	.00	.00	--	.00
Dec. 19, '68	0.08	.11	.06	.8	.00	.01	.00	--	.00	.00	.00	.2
		2-2908.41 Rookery Branch near Homestead (Station 6)										
Oct. 31, '68	.05	.01	.07	.00	.00	.00	.00	.04	.00	.00		.00
Dec. 18, '68	.02	.0	.04	.8	.00	.01	.00	--	.01	.00	.00	.02
Feb. 24, '69	.21	.01	.04	1.5	.00	.01	.42	.21	.008	.00	.01	.02

Table 16.--Number of cells per liter of phytoplankton from Shark River estuary, collected with a number 20 plankton net, July 1966 - May 1967. N = none observed; R = observed but not enumerated because of few numbers.

Station No.	1	2	3	4	5	6	7
Date							
July 13, 1966							
Diatoms	-	-	27	R	R	R	R
Other algae	-	-	18	N	R	N	N
Aug. 17, 1966							
Diatoms	-	R	R	-	N	R	R
Other algae	-	1,500	N	-	N	6,000	N
Sept. 13, 1966							
Diatoms	-	16	N	N	N	4	7
Other algae	-	852	64	8	1,581	31	33
Oct. 7, 1966							
Diatoms	28	-	56	-	6	11	-
Other algae	450	-	35	-	59	66	-
Nov. 1, 1966							
Diatoms	820	N	-	-	-	4	7
Other algae	6,600	2	-	-	-	240	56
Dec. 1, 1966							
Diatoms	60	16	-	-	-	N	300
Other algae	180	4	-	-	-	660	1,800

Table 16.--Number of cells per liter of phytoplankton from Shark River estuary, collected with a number 20 plankton net, July 1966 - May 1967. N = none observed; R = observed but not enumerated because of few numbers. (Cont'd)

Station No.	1	2	3	4	5	6	7
Date							
Jan. 5, 1967							
Diatoms	49	N	-	-	-	N	8
Other algae	4,800	3	-	-	-	340	3,700
Feb. 1, 1967							
Diatom	41	12	-	-	4	-	10,800
Other algae	13	N	-	-	10	-	7,530
Mar. 1, 1967							
Diatoms	170	1,000	3	N	3	940	-
Other algae	10,800	N	R	N	37	310	-
Apr. 5, 1967							
Diatoms	5	28	N	-	N	N	-
Other algae	N	N	N	-	N	5,100	-
May 4, 1967							
Diatoms	N	-	N	-	2	N	-
Other algae	N	-	8	-	15	5,360	-

Note: Data of Kolipinski and Higer, written communication, 1966-67.

Table 17.--Invertebrates collected in Shark River estuary between October 1968 and June 1969.

Porifera	Station No.	Gear[1]	Observed range of temperature °C	Salinity g/l
Haliclona subtriangularis (Duchassaing and Michelotti)	1	C	22	15.5
Haliclona sp.	1	C	22	15.5
Homaxinella rudis (Verrill)	1	C	15-20	13.2-15.5
Lissodendoryx isodictyalis (Carter)	1	C	15-20	13.2-15.5
Terpios fugax Duchassaing and Michelotti	1	C	15-20	13.2-15.5
Cinachyra cavernosa (Lamarck)	1	C	15-20	13.2-15.5
Higginsia sp.	1	C	15-20	13.2-15.5
Ctenophora				
Beroë sp.	1,2	B,C	15-23	10.0-19.0
Polychaeta				
Chaetoptris variopedatus	1	D	15-20	11.2-13.2
Autolytus sp.	1	A	22	19.3
Mollusca - Gastropoda				
Littorina angulifera Lamarck	2	none	--	--
Busycon contrarium Conrad	1	C	22	15.8

Table 17.--Invertebrates collected in Shark River estuary between October 1968 and June 1969 (cont'd).

	Station No.	Gear	Observed range of temperature °C	Salinity g/l
Mollusca - Pelecypoda				
Crassostrea virginica Gmelin	1	none	22	15.8
Phacoides muricatus (Spengler)	1	D	22	15.8
Tellina sp.	1	D	22	15.8
Tellidora cristata Recluz	1	D	22	15.8
Abra aequalis Say	1	D	22	15.8
Tagelus divisus Spengler	1	D	20-22	11.2-15.8
Mollusca - Cephalopoda				
Lolliguncula brevis Blainville	1	C	15-22	13.2-24.0
Crustacea				
Cladocera	3,4,5,6	B	13-23	0.2-1.9
Ostracoda				
Cypridopsis sp.	3,4,5,6	B	21-23	1.0-7.0
Copepoda				
Pseudodiaptomus coronatus Williams	1,2,3	B	16-22	1.9-22.0

Table 17.--Invertebrates collected in Shark River estuary between October 1968 and June 1969 (cont'd).

	Station No.	Gear[1]	Observed range of temperature °C	Salinity g/l
Temora turbinata (Dana)	1,2	B	16-22	16.4-20.4
Labidocera aestiva Wheeler	1,2	B	20-22	12.2-22.0
Acartia tonsa Dana	1,2,3,4,5	B	16-22	0.4-22.0
Osphranticum sp.	3,4,6	B	16-29	1.0-2.2
Macrocyclops sp.	3,5,6	B	15-30	0.1-2.2
Lernaea sp.	7	parasite on bass	18	0.2
Cirripedia (Barnacles)				
Balanus eburneus Gould	4,5,6	none	--	0.3-20.0
Mysidacea				
Gastrosaccus dissimilis Coifmann[2]	1,3,4	A,B	19-31	1.2-12.3
Mysidopsis almyra Bowman	3,4,6	A,B	18-29	0.1-12.2
Taphromysis bowmani Bacescu	5,6	A,B	13-29	0.1-0.4
Cumacea				
Cyclaspis sp.	1,2,3	B	16-22	1.9-20.4
Isopoda				
Aegathoa oculata (Say)	1,3	A,B	16-22	7.0-19.3

Table 17--Invertebrates collected in Shark River estuary between October 1968 and June 1969 (cont'd).

	Station No.	Gear[1]	Observed range of temperature °C	Salinity g/l
Cirolana parva (Hansen)?	1	A,B	18-22	19.3-20.0
Sphaeroma destructor Richardson	1,2,3	A,B	19-20	4.8-17.8
Edotea montosa (Stimpson)	3,4	A,B	16-31	1.0-12.3
Probopyrus floridensis Richardson	6,7	A	18-23	0.2-1.2
Cymodoce faxoni (Richardson)	1	B	19	20.0
Cassidinidea sp.	3	B	20	12.2
Amphipoda				
Parhyalella whelpleyi Shoemaker	3	B	20	12.2
Melita nitida Smith	2,4	B	29	2.0-8.0
Ampelisca abdita Mills	2,3	C	16-31	2.2-17.7
Paraphoxus spinosus Holmes	1,2	B	16-22	7.5-20.3
Corophium louisianum Shoemaker	2,3,4,5	B	15-31	0.1-19.7
Grandidierella bonnieri Stebbing	3,4,5	B	15-31	0.1-12.2
Cerapus tubularis Say	2	B	20-21	11.2-12.2
Gammarus mucronatus Say	4	B	--	2.0
Erichthonius brasiliensis (Dana)	2	B	--	--

Table 17.--Invertebrates collected in Shark River estuary between October 1968 and June 1969 (cont'd).

	Station No.	Gear[1]	Observed range of temperature °C	Salinity g/l
Decapoda- Natantia				
Penaeus duorarum Burkenroad	1,2	A	16-22	10.0-20.5
Trachypeneus constrictus (Stimpson)	1,2,3	A	16-20	2.2-10.0
Lucifer faxoni Borradalie	1,2,3	A,B	19-20	7.5-22.4
Leptochela serratorbita Bate	1,3	A	15-16	2.2-16.3
Periclimenes longicaudatus (Stimpson)	1,2	A	16-22	10.0-22.9
Palaemonetes intermedius Holthuis	1,2,3,4,5	A,E	15-21	0.4-20.5
P. pugio Holthuis	1,2,3,4,5	A,E	16-21	0.4-12.3
P. paludosus Gibbes	6,7	A,F	13-23	0.2-1.2
Palaemon floridanus Chase	2	A	--	17.8
Alpheus heterochaelis (Say)	1	D	20	11.2
A. normanni Kingsley	3	A	16	2.2
Ogyrides yaquiensis Armstrong	3	A	20	12.3

Table 17.--Invertebrates collected in Shark River estuary between October 1968 and June 1969 (cont'd).

	Station No.	Gear[1]	Observed range of temperature °C	Salinity g/1
Decapoda - Reptantia				
Petrolisthes armatus Gibbes	1	C	15-21	18.0-24.0
Polyonyx gibbesi Haig	1	C	15	16.1
Callinectes sapidus Rathbun	2,3,4,6	C, F	15-21	0.4-20.0
Aratus pisonii (Milne - Edwards)	2	F	--	--
Rhithropanopeus harrisii (Gould)	3,4,6	E	18-23	0.3-5.4
Hexapanopeus angustifrons Benedict and Rathbun	1	C	15	16.1-18.9
Metaporhaphis calcarata (Say)	1	C	16	16.3-18.0
Stenorynchus seticornis (Herbst)	1	C	15-21	18.0-24.0
Libinia erinacea (Milne-Edwards)?	1	C	16	16.3
Micropanope nuttingi (Rathbun)	3	C	19	5.4
Larvae of Crabs in the Family Dorippidae?	3,4,5	B	19-22	2.1-10.0
Merostomata				
Xiphosura polyphemus	3	B	19	7.0

Table 17.--Invertebrates collected in Shark River estuary between October 1968 and June 1969 (cont'd).

	Station No.	Gear[1]	Observed range of temperature °C	Salinity g/1
Arachnida				
Acarina (water mites)	3,4,5	B	16-21	0.3-2.2
Insecta[3]	4,5,6,7	B	13-21	0.1-0.4
Echinodermata				
Asteroidea				
Echinaster spinulosus	1	C	15-22	13.2-15.8
Ophiuroidea				
Ophionephthys limicola Lütken	1	D	15	13.2
Amphioplus coniortodes H.L. Clark	1	D	15	13.2
Micropholis gracillima (Stimpson)	1	D	15	13.2
Chaetognatha				
Sagitta hispida Conant	1,2	B	16-22	7.5-22.0

1. Gear: one-meter ring net (A); plankton net (B); 16-foot otter Trawl (C); dredge (D); trap (E); dip net (F)

2. Dr. M. Bacescu has transfered the mysid, Gastrosaccus dissimilis to a new genus, Coifmanniella. This new name will become valid after Dr. Bacescu's work is published.

3. Insects including mostly pupae of caddis flies, tendipid larvae and damsel fly nymphs.

Table 18.--Fish collected in Shark River estuary between October 1968 and June 1969.

Family / Species	Common name	Station No.	Observed range of temperature °C	Salinity g/l
Lepisosteidae				
Lepisosteus platyrhincus DeKay	Florida gar	6,7	23	0.1
Elopidae				
Elops saurus Linnaeus	Ladyfish	4,6,7	--	0.3
Megalops atlantica Valenciennes	Tarpon	6,7	18 -21	0.1-2.0
Clupeidae				
Harengula pensacolae Goode and Bean	Scaled sardine	1,2,3,4	15-22	3.0-20.2
Opisthonema oglinum (LeSueur)	Atlantic thread herring	1	15-21	18.9-22.9
Engraulidae				
Anchoa hepsetus (Linnaeus)	Striped anchovy	1	21	22.9
Anchoa mitchilli (Valenciennes)	Bay anchovy	1,2,3,4,5	15-22	0.4-22.9
Synodontidae				
Synodus foetens (Linnaeus)	Inshore lizardfish	1,2,3	15-20	10.0-20.5
Ariidae				
Galeichthys felis (Linnaeus)	Sea catfish	3,4	15-21	5.0-10.5
Ictaluridae				
Ictalurus nebulosus (LeSueur)	Brown bullhead	7	18	0.2

Table 18.- Fish collected in Shark River estuary between October 1968 and April 1969 (cont'd).

Family Species	Common name	Station No.	Observed range of temperature °C	Salinity g/1
Anguillidae				
Anguilla rostrata (LeSueur)	American eel	8	--	--
Ophichthidae				
Ahlia egmontis (Jordan)	Key worm eel	1	16	16.7
Belonidae				
Strongylura notata (Poey)	Redfin needlefish	1	20	22.0
Cyprinodontidae				
Cyprinodon variegatus Lacépède	Sheepshead minnow	6	13	0.2
Fundulus chrysotus (Günther)	Golden topminnow	6	15-20	0.1-0.5
Jordanella floridae Goode and Bean	Flagfish	6,7	21-23	0.1-0.3
Lucania parva (Baird and Girard)	Rainwater killifish	3,4,7	15-21	0.2-3.8
Lucania goodei Jordan	Bluefin killifish	6,7	18-23	0.1-1.2
Catostomidae				
Erimyzon sucetta (Lacépède)	Lake chubsucker	8	--	--

Table 18.--Fish Collected in Shark River estuary between October 1968 and April 1969 (cont'd).

Family / Species	Common name	Station No.	Observed range of temperature °C	Salinity g/1
Poeciliidae				
Gambusia affinis (Baird and Girard)	Mosquitofish	3,6,7	13-23	0.1-7.2
Heterandria formosa Agassiz	Least killifish	4,5,6,7	15-23	0.1-1.2
Mollienesia latipinna LeSueur	Sailfin molly	6,7	15-23	0.1-1.2
Syngnathidae				
Syngnathus floridae (Jordan and Gilbert)	Dusky pipefish	1	22	23.9
Serranidae				
Epinephelus itajara (Lichtenstein)	Jewfish	3	17-22	3.2-15.0
Lutjanidae				
Lutjanus griseus (Linnaeus)	Gray snapper	1	22	15.8
Centrarchidae				
Chaenobryttus gulosus (Cuvier)	Warmouth	6	20	0.3
Lepomis punctatus (Valenciennes)	Spotted sunfish	6,7,8	15-23	0.2-1.2
Micropterus salmoides (Lacépède)	Largemough bass	7	21	0.2
Carangidae				
Chloroscombrus chrysurus (Linnaeus)	Bumper	1	21-22	22.9-23.9
Oligoplites saurus (Bloch and Schneider)	Leatherjacket	1	20	10.9
Caranx hippos (Linnaeus)	Crevalle jack	1	22	22.9

Table 18.--Fish collected in Shark River estuary between October 1968 and April 1969 (cont'd).

Family	Species	Common name	Station No.	Observed range of temperature °C	Salinity g/1
Gerridae					
	Eucinostomus gula (Quoy and Gaimard)	Silver jenny	1,2	15-22	15.8-26.0
	Eucinostomus argenteus Baird and Girard	Spotfin mojarra	1	21	26.0
Pomadasyidae					
	Haemulon sciurus (Shaw)	Bluestriped grunt	1	22	15.8
Sciaenidae					
	Bairdiella chrysura (Lacepède)	Silver perch	1	22	15.8
	Sciaenops ocellata (Linnaeus)	Red drum	3	19	2.0
Sparidae					
	Archosargus probatocephalus (Walbaum)	Sheepshead	8	--	--
	Lagodon rhomboides (Linnaeus)	Pinfish	1	15-22	13.2-22.9
Gobiidae					
	Gobiosoma bosci (Lacepède)	Naked goby	3,5,6		0.2-0.4
	Gobisoma robustum Ginsburg	Code goby	4		5.0
Triglidae					
	Priontus scitulus Jordan and Gilbert	Leopard searobin	2	15-16	10.0-18.9
Atherinidae					
	Menidia beryllina (Cope)	Tidewater silverside	3,5	20-21	0.4-1.2

Table 18.--Fish collected in Shark River estuary between October 1968 and April 1969 (cont'd).

Family	Species	Common name	Station No.	Observed range of temperature °C	Salinity g/1
Soleidae					
	Archirus lineatus (Linnaeus)	Lined sole	1	16	16.1
	Trinectes maculatus (Bloch and Schneider)	Hogchoker	6,8	20	3.0
Cynoglossidae					
	Symphurus plagiusa (Linnaeus)	Blackcheek tonguefish	1	--	--
Gobiesocidae					
	Gobiesox strumosus Cope	Skilletfish	2,3,4	19	3.8-17.8
Tetraodontidae					
	Sphaeroides nephelus (Goode and Bean)	Southern puffer	1,2	15-20	10.0-18.9
	S. spengleri (Bloch)	Bandtail puffer	1	19	21.5
Diodontidae					
	Chilomycterus schoepfi (Walbaum)	Striped burrfish	1	15	18.9
Ogcocephalidae					
	Ogcocephalus nasutus (Valenciennes)	Shortnose batfish	1	22	15.8
	O. vespertilio (Linnaeus)	Longnose batfish	1	22	15.8