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Studies of Effects of Thermal Pollution in Biscayne Bay, Florida

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STUDIES OF EFFECTS OF THERMAL POLLUTION IN BISCAYNE BAY, FLORIDA

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ABSTRACT

Field studies on the effects of thermal additions from the Florida Power & Light Company's discharge at Turkey Point have been conducted to determine the effects of this effluent on the macroinvertebrates and fishes of the area.

Replicate samples with a 3 m (10 foot) otter trawl lined with .63 mm (1/4 in.) bar mesh were made monthly at 20 stations. Data on temperature, salinity and oxygen were collected during each sampling period. Additional chemical data were collected when opportunity existed.

The experimental results suggest that maximum summer temperatures above 32°C cause detrimental changes in the environment which are reversible in the winter while temperatures above 33°C cause damage which does not recover during the cooler months. Intermitant flow of discharge water is not as damaging as constant flow. Card Sound appears to be as productive as Biscayne Bay and temperatures exceeding 33°C will also cause damage in Card Sound.

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SECTION I

CONCLUSIONS

(1) Average temperature elevations above 4°C caused almost barren conditions where few animals and almost no macroalgae or seagrasses occurred. The area at Turkey Point which was elevated above 4°C with two fossil fuel units and 1230 cfs flow was approximately 75 acres.

(2) Average temperature elevations between 3 and 4°C above ambient summer water temperatures caused serious depletion in the biota; and this damage was not compensated for by increased production due to warming in winter. At Turkey Point the area between 3 and 4°C was approximately, 100 acres.

(3) Average temperature elevations between 2 and 3°C caused damage to the biota in summer; but this was reversed by increased productivity in winter. At Turkey Point the area between +2 and 3°C was approximately 125 acres.

(4) A total area of about 300 acres showed a decline in abundance of animals which was statistically measureable for at least part of the year. In approximately 125 acres the increased winter catches compensated for the low summer catches and in approximately 250 acres winter recovery indicated that there would be relatively rapid recolonization if the discharge were stopped. The inner barren zone of about 50 acres would recover slowly if at all due to the death of the rhizomes of the Thalassia and changes in the sediment.

(5) The optimal temperature for diversity of species and maximum numbers of individuals was between 26 and 28°C.

(6) The fifty percent upper exclusion temperature for fishes, mollusks, crustaceans, porifera, coelenterates, echinoderms and for all species combined was between 30 and 34°C, the 75 percent upper exclusion temperature was between 35 and 39°C.

(7) Areas with fluctuating temperature were not as severly damaged as those areas constantly exposed to elevated temperatures.

(8) Most animals were caught in areas where red algae Laurencia or Digenia were abundant; less were taken in Thalassia and least where little or no algae or seagrasses occurred.

(9) With the increased temperature and increased flow expected with the nuclear generators, the area of damage will increase; unless alternate methods of cooling are implemented.

(10) On an annual basis Card Sound was as productive or slightly more productive than southern Biscayne Bay. Catches were greatest in winter and least in late spring and summer.

SECTION II

RECOMMENDATIONS

From the field observations in the Turkey Point - Card Sound area several recommendations can be made.

(1) Maximum summer discharge temperature should not exceed 33°C at the site of the discharge. Alternately a temperature anomaly of +3°C should be the maximum permitted.

(2) An alternating discharge - non discharge cycle would decrease the amount of damage.

(3) A discharge into Card Sound has greater possibilities for lessening the damage to the benthic organisms than the Turkey Point discharge. This is because of mixing possibilities with a "jet discharge" in the deeper Card Sound Basin.

(4) A closed cooling pond system with make-up water borrowed from the bay and/or Florida City Canal seems to be the most practical solution to the dilema - environmental protection vs. need for electric power.

SECTION III

INTRODUCTION

Concern over the effects of thermal additions from steam electric stations has been expressed by numerous scientists and conservation organizations. Adams (1968) reviewed most of the pertinent literature at that time in an 87 page manuscript. Since 1968 research and the literature on the effects of power plant operations has expanded exponentially (see Coutant 1969, 1969b, 1970 and Ulrikson and Stockdale 1970). Until recently, little work has been done on the problem in tropical or subtropical estuaries. However, extensive research is now being conducted in Puerto Rico by M. J. Cerame-Vivas, and by P. L. Jokiel in Hawaii, and in South Florida by the Rosenstiel School of Marine and Atmospheric Science which has an ongoing multi-disciplinary study of the problem in Biscayne Bay.

This paper presents data on the diversity and abundance of invertebrates and fishes collected in this Biscayne Bay study and attempts to relate these findings to variables measured by other parts of the program including temperature, chemical factors and algal abundance. It also offers a mathematical model which predicts the effects of temperature on the diversity of the fauna.

SECTION IV

BACKGROUND

Biscayne Bay is approximately 35 miles long and its maximum width is 8 miles. The "A:-shaped bay is enclosed to the east by a series of barrier islands which extend north and south, leaving a shoal area "the safety valve" in the center. The greatest depths of 4 m occur in the southern and central area. Shoaling occurs toward the mainland and barrier islands. The mainland side of the southern bay is fringed by mangrove swamps and soft organic sediments. The southern portion of the bay is separated from the central bay by Featherbed Bank. Turkey Point is a narrow spit of land which projects from the mainland into the bay 2/3 of the way between Featherbed Bank and Cutter Bank which separates Biscayne Bay from Card Sound. Biscayne Bay is connected to Card Sound by several small channels and the dredged Intracoastal Waterway channel. Card Sound is bordered to the south by Card Bank.

Sibenaler (1953) reviewed the status of the Biscayne Bay commercial fisheries. U.S. Fish and Wildlife statistics indicate that Biscayne Bay currently supports fisheries which land over 600,000 pounds of seafood, 95% of the value of which (ca $250,000) consists of bottom-living invertebrates: sponges, spiny lobsters and stone crabs (Idyll, 1967). In addition there is a valuable (ca $400,000) bait shrimp fishery (Tabb and Kenney, 1967). There is considerable sport-fishing, and the Bay serves as a nursery for many finfish and shellfish. Many species of wading birds feed in the shallows and nest in the uninhabited Arsenicker Keys which have long been known as a frigate bird roost. Pumpkin Key in Card Sound is often visited by white crown pigeons.

The hydrography of the northern portion of the bay was briefly discussed by Milliken (1949) and reviewed by Hela et al (1957). The southern portion of the bay and Card Sound have been investigated by Richardson (1966) Pritchard and Carpenter (1968) Dean (1970) Michel (1970a, 1970b, 1971) Taylor (1971), Lee and Rooth (1971) and Schneider (1969). Most of these studies were done in connection with the Power plant siting. In general the western portion of the bay and sound have tidal currents which are generally along shore flowing southerly on a flood tide and northerly on an ebb tide. The discharge from Florida Power & Light Company causes a constant N.E. flow around Turkey Point. The eastern portion of the bay is generally quite well mixed with ocean water due to tidal exchange through the inlets among the upper Keys (Taylor, 1971; Michel, 1971).

Chemistry studies of Biscayne Bay were almost non existant prior to the building of the power plant at Turkey Point. McNulty (1970)

provided data on nutrients in north bay. After the power plant construtcion chemical studies were conducted by Bader (1969), Bader & Tabb (1970), Nugent (1970), Gerchakov, Segar and Stearns (1971) and Segar, Gerchakov and Johnson (1971). In general these authors concluded that the operation of the power plant has influenced the chemical balance of the area immediately adjacent to the effluent, but that the changes were minor and probably did not significantly alter the ecosystem.

The sediments of Card Sound were studied by Early and Goodell (1968), Wanless (1969) and additional sediment work has been reported by Iversen and Roessler (1970) and by Segar, Gerchakov and Johnson (1971).

The small phytoplankton and epiphyton of the bay are poorly known. Bsharah (1957) and Miller and Moore (1953) reported on nannoplankton from stations east of Biscayne Bay. Reyes-Vasquez (1965) and Sprogis (1971) reported on benthic diatom populations of the bay with the latter study being conducted in the Turkey Point area.

The sea grasses and macro algae have been investigated by Voss and Voss (1955), Voss (1959) Moore (1963) McNulty (1961) Zieman (1968 and 1970) Jones (1968) and Thorhaug (1965 and 1971). Additional work on the thermal tolerance of selected algae has been reported by Thorhaug et al (1971).

The benthic communities and fish fauna of Biscayne Bay have received more study. Fouling organisms and benthic organisms associated with sewage pollution in north bay have been studied by Joseph and Nichy (1955) McNulty (1961 and 1970) and Moore and Frue (1959). H. B. Moore and his associates have presented data on benthic communities and the ecology of numerous species of urchins, pelecypods, gastropods and brittle stars from the central bay. A summary of 20 years-work is presented in Moore (1971). Roessler (1965) collected fishes in the central bay by trawling. Kohout and Kolopinski (1964) studied the effects of fresh water springs on the biota. Since 1968 when the thermal addition studies began, reports by Roessler and Zieman (1970), Hagan and Purkerson (1970), Bader, Roessler and Thorhaug (1970), Iversen and Roessler (1971) and Roessler et al (1971) have summarized findings on the benthic communities in the vicinity of Turkey Point and in Card Sound. Nugent (1970) reported on fishes and invertebrates within the canal system at Turkey Point. In addition Bunt (1971) and Fell, et al (1971) have discussed some aspects of the benthic microorganisms.

Zooplankton was studied in the northern and central bay by Smith et al (1950) Woodmansee (1958) and Reeve (1964a and 1964b and 1966). Additional plankton studies in southern Biscayne Bay have been

conducted by de Sylva (1970), Reeve (1970), and Reeve and Cosper (1971a & b). The latter four of these reports are concerned with the effect of the Turkey Point Plant.

The above is not an exhaustive literature review of Biscayne Bay but merely is an indication of the scant knowledge which was available prior to the interest sparked by Environmental Protection Agency's interest in the Turkey Point problem and the broad environmental program which has developed with the aid of support from the Environmental Protection Agency, Atomic Energy Commission, Florida Power & Light, National Science Foundation, (Sea Grant), National Institute of Health and National Oceanographic & Atmospheric Administration (Sea Grant).

SECTION V

OBJECTIVES

The objectives of this study were (1) to predict the effects of the heated discharge from the Turkey Point nuclear power units on the benthic fauna, (2) to measure the effects of the fossil fuel units and (3) to study the benthic fauna and fishes of southern Biscayne Bay and Card Sound.

SECTION VI

METHODS

Hydrographic Studies

Temperature was recorded during each trawling trip at each sampling station with a mercury thermometer or thermister probe. In addition continuous recording Ryan Model F thermographs were maintained at stations SE I, I, A, B, D, E and F (Figure 1).

Chemistry

Surface and bottom measurements of salinity and oxygen were made at each trawling station during each trawling trip. Oxygen was measured with a YSI model 54 in situ recorder. Salinity was determined with a American Optical refractometer, with a Beckman RS5-3 portable salinometer or by determination on the Wheatstone conductivity bridge.

Biology

Seven trawl samples were taken at each of the trawl stations at monthly intervals. A 3 meter foot rope length otter trawl lined with .63 mm bar mesh was used for all samples. The tows were made with the wind and the net covered approximately 30-35 meters during each tow. The net was emptied into wash tubs at the completion of each tow. After seven tows were completed the contents of each tub were rough sorted. The kind and weight of vegetation were recorded and the animals preserved in a 10 percent formalin solution. Later the reduced samples were sorted and counts of each species made. Polychaetes were not identified or counted. Amphipods, isopods, the gastropod *Batillaria minima* and the pelecypod *Brachiodontes exustes* were not counted because of their high abundance and small size which allowed escapement and inadequate sampling.

Day catches were compared to night catches with a non parametric paired T test using each species taken by trawling at 20 stations. Night samples were collected within 24 hours of the day samples. Five stations were sampled each month for 4 months. Two tows were made at each night station and those were compared with 2 daylight tows which had vegetation catches similar to the night tows.

Analysis

Statistical treatment was confined to major taxa and species that comprised more than 1 percent of the total animal catch. For major taxa a Friedman's non parametric analysis of variance was used to

detect differences among stations with the effects of month removed by coding. A simple arithmetic mean and 95 per cent confidence limit was used to judge which stations produced high and low catches.

For the more abundant species the logarithm of the catch plus one was determined and the total catch calculated by summing these log values for the seven tows. Parametric analysis of variance was performed for the 20 stations and 24 months using the average catch per tow at each station month combination. The interaction was tested against the error term and the principal components against the pooled error and interaction (Brownlee, 1965). Confidence limits were calculated for row means and column means. Observations outside the confidence interval were considered significant.

A stepwise multiple regression with logarithm (catch + 1)/tow as the dependent variable and vegetation weight, temperature and salinity as independent variables was conducted for each of the major species to evaluate which environmental variable was most important and to attempt to evaluate the role of temperature.

Selection of Sampling Stations

Initially 20 stations were chosen on a pattern radiating from the Turkey Point Power Plant. The transects were chosen to run northward along the shoreline, northeast parallel to the "Barge Canal", eastward on a line from the effluent canal to the Florida Keys and southeastward from the effluent canal to marker 14 of the Intracoastal Waterway system on the border of Card Sound. Five stations were located on each transect, approximately 1/4, 1/2, 1, 3, and 5 miles from the plant but spacing was varied to place stations near landmarks which would facilitate finding the stations.

By the end of six months of study it was obvious that the effect of the thermal pollution would not reach the 3 and 5 mile stations on any of the transects while the oil burning units were in operation. However, it was still possible that the additional volume of cooling water needed for the proposed nuclear generators might increase the effected area to such an extent that the 1 mile stations would no longer serve as controls. Therefore quarterly samples were taken at the 3 and 5 mile stations from January 1969 through June 1970. An additional 8 stations (A-G) were added in Turkey Point area in order to better deliniate the area of damage and to obtain controls with similar sediment type and vegetation, (Figure 1). One of these stations, A, was added in September and routinely investigated from that period onward. This station, located off the mouth of the Little River, a minor discharge canal, showed little damage despite being close to a discharge point. This was of sufficient interest to include the area as a regular station.

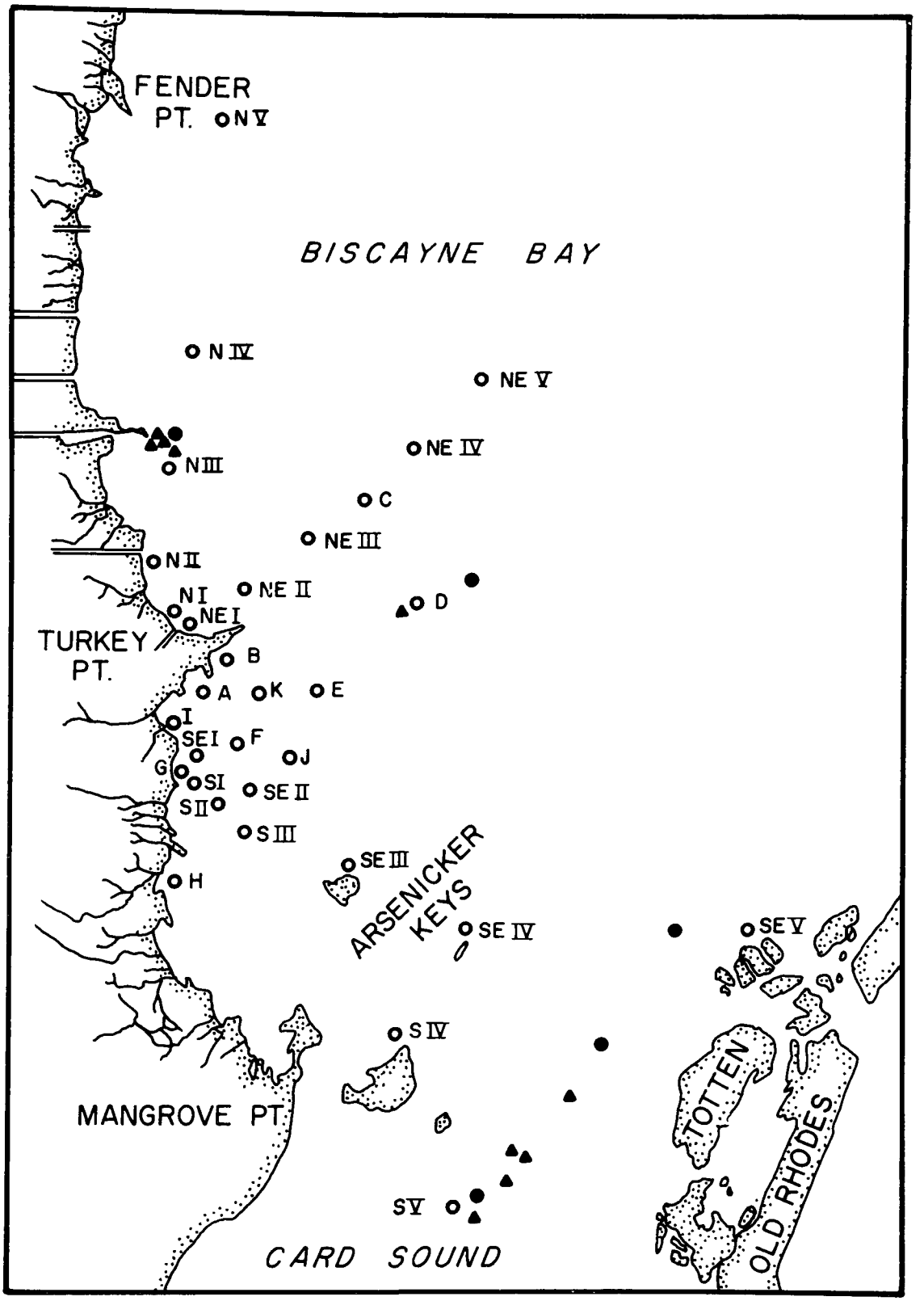

FIGURE 1. LOCATION OF STATIONS IN BISCAYNE BAY, FLORIDA

In the early summer of 1969 Florida Power & Light announced a plan to change the discharge site to Card Sound. By the spring of 1970 work had begun on the extension canal to Card Sound. As a consequence stations were located in Card Sound and stations north of the plant were reduced to three control stations; B, SE IV, SE V were also discontinued. An additional 3 stations I, J, K were added in Biscayne Bay to fill in regions elevated more than 2°C and in the mouth of the Little River where algae, Thalassia and Diplanthera were present despite high temperatures. Stations S IV and S V were reinstated as monthly stations in anticipation of potential changes when the nuclear units went on line and the discharge into Card Sound was at a peak. The pattern in Biscayne Bay was adequate to monitor damage while the effluent was still discharged into Biscayne Bay and to measure if recovery occurred after the discharge was stopped. Ten stations were added in Card Sound to obtain base line data in this basin and to measure changes which probably would occur when the discharge through Model Land Company Canal begins, (Figure 2).

Table 1 is a summary of physico-chemical variables, depth, sediment type and depth for each station. It can be seen that four basic bottom cover types were sampled (Table 2). Stations N I, N II, N III, N IV, N V, NE I, NE II, NE III, SE II, SE III, S I, S III, A, F, H, J and K were characterized by the red algae Digenia or Laurencia and the sea grass Thalassia testudinum. Stations B, D, E, I, NE V, SE IV, and SE V were in relatively pure turtle grass Thalassia communities although the grass was very sparce at NE V. Stations NE IV and C were located where there was sand and scattered Udotea, Penicillus and Acetabularia. Stations S IV and S V had sponges, alcyonarians and corals as the dominant bottom cover but some Thalassia was also present. Stations G, S I and SE I which were bare or with scattered algae and sea grasses probably belong in the first category except for the power plant effect (Zieman, 1970).

Two divisions of the stations can be made on the basis of sediment depth. One group has relatively deep sediments and the other has only a few centimeters of coarse sediment. In general the deeper sediments occur along the mainland shore, near the Arsenicker Keys and near the Florida Keys. Wanless (1969) has adequately discussed the origin and composition of the sediments in this region. In general where there is more than 50 cm of sediment Thalassia predominated (Zieman, 1970) and this relation can be seen in Tables 1 & 2.

There is a relationship between the kinds and numbers of benthic animals and fishes caught and the types of bottom cover present. Areas where Laurencia or Digenia occur produced the most animals. Pure Thalassia was less productive but had greater numbers of animals of sport or commercial value. Bare sand with scattered algae or sponge-alcyoncian areas were least productive.

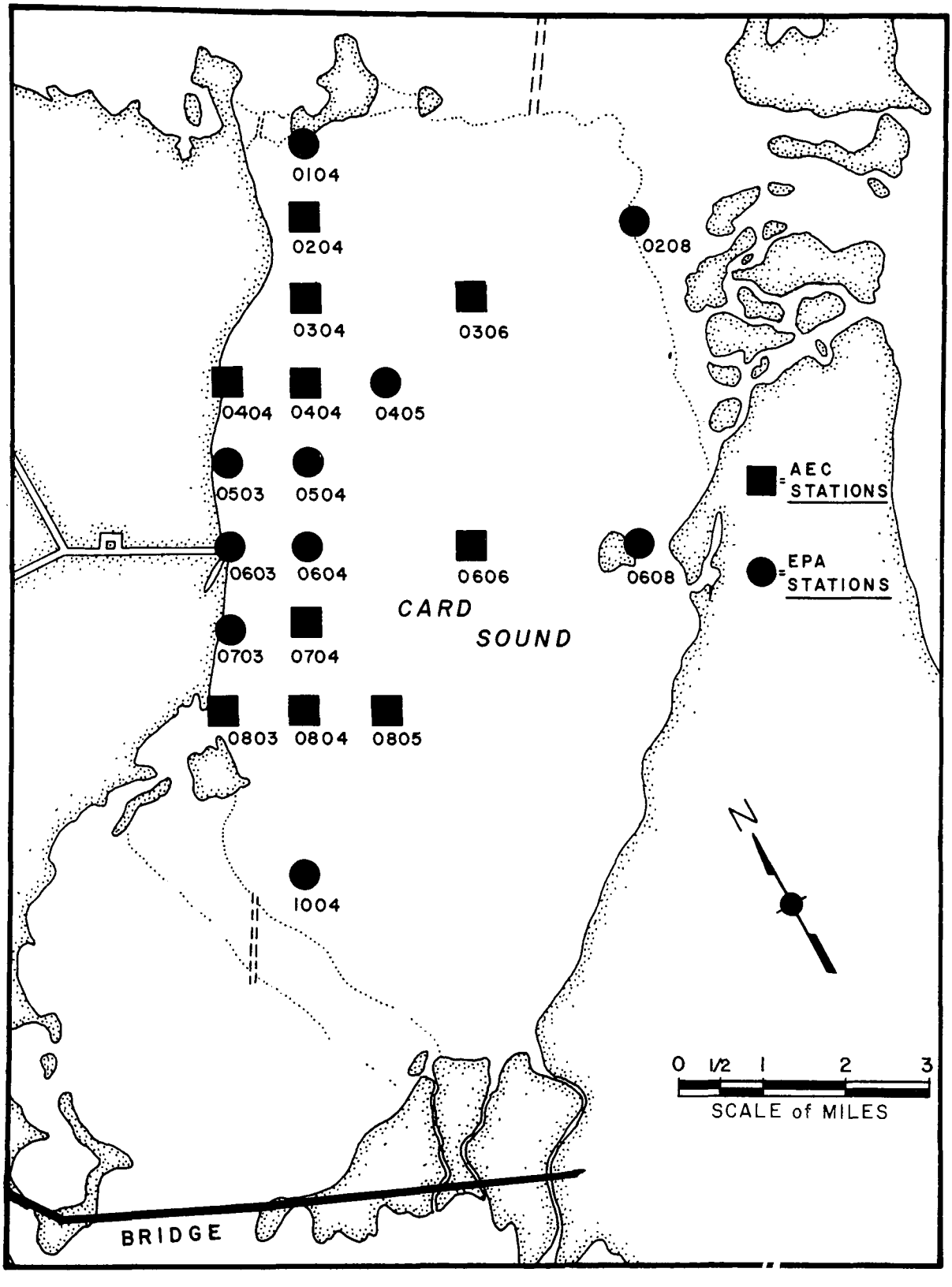

FIGURE 2. LOCATION OF STATIONS IN CARD SOUND, FLORIDA

TABLE 1

PHYSICAL AND CHEMICAL DATA FOR BISCAYNE BAY

& CARD SOUND TRAWL STATIONS

Station	Distance from Effluent (m)	Distance from Shore (m)	Sediment Type	Sed. Depth (cm)	Water Depth (m)	Bottom Salinity (ppt) Max.	Bottom Salinity (ppt) Min.	Bottom Dissolved Oxygen Max.	Bottom Dissolved Oxygen Min.
N I	2075	165	coarse sand & shell fragments	31	1.2	37.7	14.5	8.1	5.0
N II	2890	150	soft mud	14	1.3	37.3	15.7	8.9	2.8
N III	4220	480	coarse sand, shell fragments & mud pockets	58	1.3	37.7	15.7	7.8	4.0
N IV	5965	1465	coarse sand	5	1.6	28.9	13.3	8.0	4.0
N V	12760	665	coarse sand with some mud	15	1.0	20.1	5.0	9.0	5.0
NE I	1945	150	coarse sand & shell fragments	32	1.4	38.1	16.9	8.8	4.9
NE II	2815	630	mud & sand	19	1.4	38.5	18.9	8.3	4.7
NE III	3740	1555	coarse sand & shell fragments	26	1.6	38.5	20.1	8.1	4.8
NE IV	5590	3425	coarse sand & shell fragments	1	1.9	32.9	24.1	8.0	4.0
NE V	6850	4685	sand & broken shell	14	2.5	32.9	24.5	7.0	4.0
SE I	185	165	mud & fibrous peat	20	1.6	38.5	19.3	8.1	4.4
SE II	1370	1075	sand & some mud	20	1.7	37.3	20.1	8.5	4.5
SE III	2945	75	mud-sand	108	1.4	38.1	20.1	8.4	4.7
SE IV	4705	520	sand & mud	91	1.3	34.5	23.3	8.0	4.0
SE V	8295	405	sand & mud	116	1.6	35.3	27.3	7.0	3.5

TABLE 1 cont.

Station	Distance from Effluent (m)	Distance from Shore (m)	Sediment Type	Sed. Depth (cm)	Water Depth (m)	Bottom Salinity (ppt) Max.	Bottom Salinity (ppt) Min.	Bottom Dissolved Oxygen Max.	Bottom Dissolved Oxygen Min.
S I	185	150	soft mud	84	1.4	38.5	17.3	7.9	4.0
S II	815	610	coarse sand & shell	8	1.6	38.5	19.3	8.1	3.0
S III	1390	1075	coarse sand & shell fragments	5	1.4	38.9	19.3	8.5	4.5
S IV	4870	315	sand & mud with with some bare rock	18	1.2	32.9	24.5	6.0	3.0
S V	7465	1035	sand	24	2.2	33.7	24.5	7.0	4.0
A	980	220	muddy sand	5	1.5	38.5	18.5	8.2	3.8
B	1705	165	sandy mud	28	1.4	38.5	18.9	9.5	4.3
C	4705	2535	coarse sand & mud pockets	10	1.7	38.5	22.9	7.9	4.9
D	4165	2520	sandy mud	79	1.0	38.5	23.3	8.1	5.3
E	2335	1295	sand	23	2.0	38.5	20.9	9.1	5.1
F	760	520	sand & mud	28	1.7	38.5	20.1	10.0	4.9
G	90	90	muddy sand & peat	39	1.3	38.5	18.1	7.7	3.0
H	1833	222	coarse sand & mud pockets	16	1.4	38.5	18.5	7.8	4.9
I	537	75	soft mud	54	2.0	43.8	28.1	9.7	3.7
J	870	833	mud & sand	11	1.6	43.7	30.6	7.3	4.7
K	1445	500	sand & mud	25	2.0	43.8	29.8	7.8	3.6

TABLE 1 cont.

CARD SOUND

Station	Distance from Shore (m)	Sediment Type	Sed. Depth (cm)	Water Depth (m)	Bottom Salinity (ppt)		Bottom Dissolved Oxygen (ppm)	
0104	30	muddy sand	44	1.5	40.9	30.4	8.4	4.7
0204	407	mud & sand	50	2.0	41.1	33.3	8.1	5.2
0208	741	calcareous sand	140	1.0	37.7	30.4	8.0	4.4
0304	537	sand	1	2.5	40.6	32.1	8.5	5.4
0306	2259	sand	30	2.5	39.4	35.3	8.0	5.6
0403	40	sand	30	1.0	40.8	33.7	7.9	5.6
0404	870	sand	1	2.5	40.2	34.5	8.0	5.6
0405	1815	sand	24	3.0	40.2	30.4	8.2	5.7
0503	40	sand & fibrous peat	25	1.0	41.3	30.8	7.8	5.6
0504	1019	sand	18	3.0	40.3	30.5	7.8	5.6
0603	40	mud	107	2.0	41.5	30.9	7.6	4.6
0604	889	sand	1	3.0	40.9	30.4	7.8	5.3
0606	1445	sand & mud	3	3.5	40.6	35.3	8.0	5.8
0608	50	muddy sand	15	2.0	41.7	30.7	8.0	5.6
0703	40	muddy sand	137	1.0	41.2	31.3	7.9	5.6
0704	1000	sand	1	3.0	41.2	34.5	7.7	5.9
0803	40	mud & sand	105	1.0	41.8	32.9	7.8	5.7
0804	1037	sand	1	3.0	41.3	34.9	7.7	6.0
0805	1963	sand	11	3.0	41.2	35.3	7.8	6.0
1004	1241	mud & sand	9	2.5	41.9	30.3	8.0	5.7

TABLE 2

TEMPERATURE AND VEGETATION DATA FOR BISCAYNE BAY
TRAWLING STATIONS JULY-DECEMBER 1968

Station	Bottom Temp. Maximum	Bottom Temp. Minimum	$\bar{\Delta}t$	Dominant Vegetation	Average pounds/tow
N I	37.6	13.5	-0.17	Laurencia Thalassia	7.32
N II	36.6	15.7	-0.68	Laurencia & Diplanthera	6.68
N III	30.4	15.4	25.08*	Laurencia Thalassia	5.70
N IV	30.7	13.8	-0.85	Laurencia Thalassia	3.77
N V	37.3	14.2	-0.02	Digenia & Laurencia Thalassia	17.29
NE I	30.4	14.2	-0.76	Laurencia, Diplanthera & Thalassia	7.69
NE II	38.1	14.8	-0.35	Laurencia Thalassia	9.46
NE III	32.2	15.3	-0.11	Laurencia & Thalassia	5.23
NE IV	30.4	15.4	-0.41	Udotea Penicillus & sponges	1.33
NE V	30.5	15.6	-0.63	Thalassia	0.01
SE I	37.5	22.4	+5.25	Digenia & peat	1.78
SE II	36.3	20.4	+2.20	Laurencia, Batophora & Thalassia	4.13
SE III	37.8	16.5	+1.17	Laurencia & Thalassia	6.31
SE IV	31.4	17.6	+1.31	Thalassia & Laurencia	1.29
SE V	38.7	17.7	+0.37	Thalassia	0.23
S I	38.0	22.7	+5.26	Diplanthera	1.23
S II	32.9	18.0	+2.25	Laurencia & Thalassia	3.75
S III	31.8	18.1	+0.93	Laurencia & Thalassia	1.43
S IV	30.1	20.0	+1.05	Some Thalassia & sponges	0.73
S V	30.8	18.2	+0.41	Alcyonarians & sponges	0.03

* = Average Ambient Temperature

TEMPERATURE AND VEGETATION DATA FOR BISCAYNE BAY
TRAWLING STATIONS JANUARY 1969-JUNE 1970

Station	Bottom Temp. Maximum	Bottom Temp. Minimum	$\bar{\Delta}t$	Dominant Vegetation	Average pounds/tow
N I	30.2	15.0	+0.35	Laurencia & Thalassia	11.46
N II	32.0	15.0	+0.29	Laurencia & Diplanthera	9.36
N III	31.5	15.0	+0.24	Laurencia & Thalassia	20.67
NE I	30.9	15.5	+0.57	Laurencia, Thalassia & Diplanthera	10.70
NE II	31.0	15.8	+0.60	Laurencia & Thalassia	13.25
NE III	30.7	15.1	+0.27	Laurencia & Thalassia	9.87
SE I	34.1	19.8	+3.59	Diplanthera, Laurencia & peat	3.12
SE II	34.0	16.1	+0.74	Laurencia, Thalassia & Batophora	7.91

TABLE 2 cont.

Station	Bottom Temp. Maximum	Bottom Temp. Minimum	$\bar{\Delta t}$	Dominant Vegetation	Average pounds/tow
SE III	32.1	14.8	+0.26	Thalassia & Laurencia	4.97
S I	35.3	21.0	+3.65	Diplanthera	1.30
S II	34.2	19.4	+2.39	Laurencia & Thalassia	11.16
S III	34.1	16.1	+0.75	Laurencia & Thalassia	6.09
A	31.5	15.8	+1.48	Laurencia & Thalassia	6.06
B	31.1	15.9	+0.89	Thalassia & Laurencia & sand	4.53
C	31.9	15.4	+0.18	Udotea Penicillus	3.69
D	31.0	15.2	mean ambient 24.13	Thalassia	2.00
E	32.0	15.1	+0.31	Laurencia & Thalassia	3.66
F	35.0	15.8	+1.82	Thalassia, Digenia & Laurencia	15.79
G	34.5	22.5	+4.56	Acetabularia (winter) & blue-green-diatom mat	0.09
H	35.0	18.2	+1.46	Laurencia & Thalassia	9.91

TEMPERATURE AND VEGETATION DATA FOR CARD SOUND
TRAWL STATIONS 1 JULY 1970 MAY 1971

Station	Bottom Temp. Maximum	Bottom Temp. Minimum	$\bar{\Delta t}$	Dominant Vegetation	Average pounds/tow
0104	30.4	13.5	24.13	Thalassia	4.57
0208	30.4	14.2	24.35	Thalassia	0.42
0405	30.9	16.2	24.63	Laurencia	4.56
0503	30.8	16.5	24.89	Laurencia	10.23
0504	31.0	16.3	24.75	Laurencia	7.15
0603	30.9	16.5	24.95	Diplanthera	3.52
0604	30.4	16.5	24.67	Laurencia	11.44
0608	30.7	15.1	24.82	Thalassia	0.72
0703	31.3	16.8	25.15	Laurencia	2.87
1004	30.3	16.8	24.78	Laurencia & Thalassia	3.52
SEPTEMBER 1970-MAY 1971					
0204	27.9	16.4	23.42	Thalassia & Laurencia	5.86
0304	28.0	16.5	23.38	Laurencia & Thalassia	21.15
0306	27.9	14.8	23.03	Thalassia	4.67
0403	27.9	16.2	23.53	Laurencia & Thalassia	11.47
0404	27.9	16.6	23.34	Laurencia	11.56
0606	28.1	16.2	23.38	Thalassia & Laurencia	10.30
0704	28.0	16.5	23.45	Laurencia & Thalassia	11.83
0803	27.9	16.6	23.66	Laurencia & Thalassia	5.59
0804	28.0	16.8	23.46	Laurencia & Thalassia	18.22
0805	28.0	16.8	23.45	Laurencia	10.75

Salinity at the inshore stations was variable and followed the seasonal pattern of rainfall and runoff of the area. The stations closer to the Florida Keys were more stable and remained close to 35 ppt due to the influence of tidal influxes of oceanic waters from the passes through the Keys (Figure 3). The salinity influenced the distribution of animals. The sponges, alcyonarians, corals and echinoderms were prevalent on the eastern side of the bay where salinities remained relatively stable but were almost absent near the mainland shore where salinities fluctuated widely and dropped to low levels following the spring and fall rainy seasons. Other crustacea such as Portunus spinimanus, Portunus gibbesi, and fishes Monacanthus cilatus, M. hispidus and Alutera schoepfi, were also apparently restricted to the areas of high, relatively constant salinity. In this region reef and reef flat forms occasionally occurred. A number of organisms including the pelecypods, Crassostrea virginia, Brachiodontes exustus, the fish Sphoeriodes testudinus, and crustacea Callinectes similus, Callinectes ornatus, Alpheus normani etc. are common only along the mainland shoreline.

Station G was characterized by temperatures 4.5°C (9°F) above the ambient bay water, stations S I and S II were characterized by temperatures 3.5°C (7.2°F) above ambient stations S II was characterized by temperatures 2.5°C above ambient. A, F and H were characterized by temperatures between 1 and 2°C above ambient, stations SE II, S III and B average between .7 and 1°C above ambient, stations N I, N II, N III, N IV, N V, NE I, NE II, NE III, NE IV, NE V, SE III, SE IV, SE V, S IV, S V, C, D and E were considered controls in terms of temperature.

All of the stations in the heated area were in the zone in which sediment was relatively deep and were probably characterized by red algae and Thalassia or pure Thalassia bottom cover. Additional data on monthly observations of temperature salinity and oxygen are presented in Appendix Tables 1-3.

Station N V located off Moody Canal had variable types of bottom cover. During the initial months of the study, the red alga Digenia simplex was dominant. During the early autumn the flood gates on Moody Canal were opened and the Digenia disappeared. Later when the salinity rose again the area was colonized by Laurencia spp.

Stations N I and NE I were located at the landward end of the Barge Canal and were separated by the width of the 100 m wide channel. The bottom type, depth and vegetation were similar. However, differences in catches could result from greater currents at N I or some recirculated discharge water passing over NE I.

Station B was located in the bight immediately south of Turkey Point. This area received less tidal mixing than other stations, and essentially was excluded from influence of the thermal plume by the geography of the area.

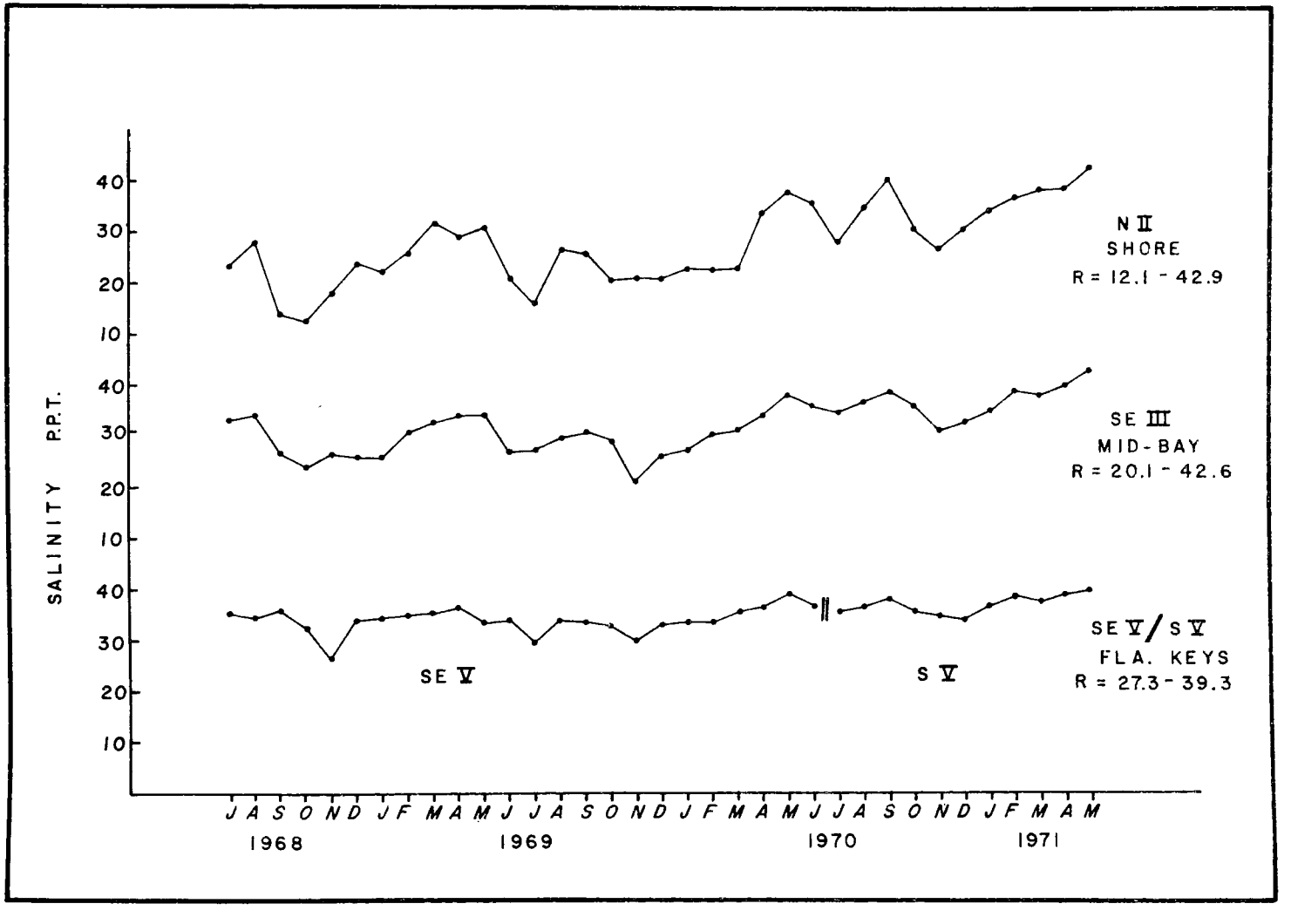

FIGURE 3. MONTHLY SALINITY OBSERVATIONS AT AN INSHORE STATION N II, A MID-BAY STATION SE III AND OFFSHORE STATIONS SE V/ S V

Station D located on the Thalassia flat called Pelican Bank was used as a temperature control station because it was a shallow station removed from the influence of the thermal discharge and land runoff. Prior to the establishment of station D in January 1969, NE III was used as a measure of ambient temperatures.

Although physical and chemical data are reported for stations I, J and K they were only sampled for benthic fauna after July 1970. Insufficient data was collected to warrant analysis. However, station I which was located in the mouth of the Little River provided data which indicated a pulsed flow of hot water may be less harmful than a continuous discharge. Animal catches at this station were not as low as at those stations receiving continuous flow and the sea grasses and macro algae were present in all seasons.

The temperature varied greatly with the tide stage. On an ebb tide heated discharge water covers the station but on the flood tide the station is covered with cooler bay water. Thus the benthic community is subjected to alternating periods of warm and cool water. Figure 4 is a copy of a thermograph strip chart for the period 3 - 30 July 1970 with the tidal and solar cycle. The temperature was affected by the solar radiation (indicated by maximum temperatures occurring when the flood-ebb transition occurs near noon) and the tidal cycle as indicated by the approximately 6 hr. periods between temperature maxima. The temperature averaged 2.64°C above that of the control station D. However, the stage of the tide influenced this average and since the monthly observation was made during the new moon period during the morning hours when the tide was high the average difference is probably low.

The vegetation at station SE I varied seasonally and reflected the temperature on the effluent. In summer the station was almost devoid of plants except for diatoms, blue green algae, scattered Acetabularia and some Digenia. In winter and spring the area was colonized by Diplanthera wrightii which was often coated with the diatoms Campylostylus and Synedra. Vegetation at station G was virtually absent. A few specimens of Acetabularia crenulata were observed in winter and a blue green algal diatom mat was present. Occasionally the red alga Dasya was present in the winter months.

For several stations the abundance, growth and productivity of algae and sea grasses measured by Zieman (1970) and Thorhaug (1971) or the epiphytic diatoms recorded by Sprogis (1971) were compared to our animal data because the same stations were occupied by the trawling survey. Trawl station A was located near algae station 23, trawl station F was equivalent to algae station 24. Trawl station SE II was near algae station 45. Trawl station S II was near algae station 26 and trawl station H was near algae station 16. The seasonal pattern of algae and grass production can therefore be compared with animal catches at these stations in Biscayne Bay.

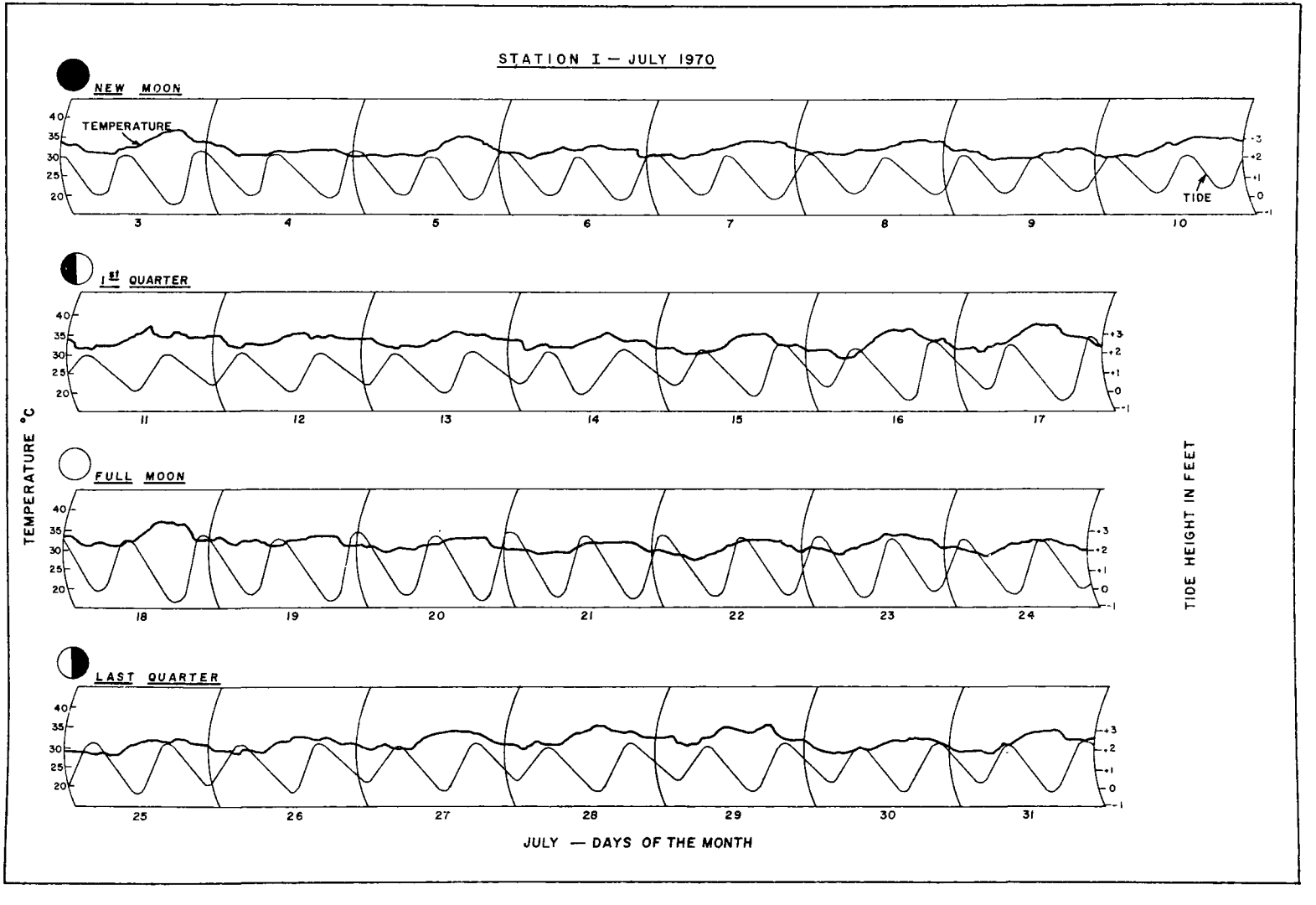

FIGURE 4. TEMPERATURE AND TIDAL CYCLE FOR THE MONTH OF JULY 1970 AT STATION I

SECTION VII

TEMPERATURES AT TURKEY POINT

During the period of the study Florida Power and Light Company has operated two fossil fuel plants each of which produces 432,000 KWe and utilizes 630 cu. ft./sec. of cooling water borrowed from the bay north of Turkey Point. Water temperature is raised 6 - 7°C when passing through the plant. There is a drop of 1 - 2°C as the water passes from the plant to the mouth of Grand Canal (See Nugent, 1970). Water entering the bay is usually elevated 5°C above ambient.

Temperature measurements for each trawling station are shown in Appendix Table 1. Supplementary temperature data taken at 32 hydrographic stations and at times other than during trawling were presented by Segar, Gerchakov and Johnson (1971). Station N III near Homestead Bayfront Park was used as a measure of ambient temperature during the first six months of the study and station D located on Pelican Bank, a shallow grass flat out of the influence of land runoff was used as a measure of ambient starting in January 1969. A few stations outside the normal thermal plume showed excessively high temperatures which were possibly the result of hot pockets or may have resulted from reader error. Because the duration of exposure to such hot pockets if they exist is very short and because the temperature was 10° cooler at the surrounding stations than at the anomalous stations. These temperatures have been reduced by 10°C in calculating average temperatures and deviations from ambient and in the regression analyses. The subtraction of 10°C from these anamalous readings decreased the average temperature and deviations by 0.4°C at the stations which were anamalous in September 1968. In the regression analyses, 484 cases were examined and the inclusion of 7 anamolous stations reduced to the mean temperature (ie the loss of 7 degrees of freedom) would not change the results. The optimum and exclusion temperature calculations used the observed temperatures. Additional temperature information is available in Tebo, Estes and Lassiter (1968) and Hagan and Purkerson (1970).

The average winter ambient temperature is about 17°C. The lowest temperature observed was 9°C. In summer the ambient temperature averages near 31°C with maximum occurring near 33°C. The effleunt averages 5°C above ambient at the outfall. The highest temperature recorded was 40°C. Lee and Rooth (1971) have predicted temperature fields and have compared their predictions with infrared aerial measurements of the temperature plume at Turkey Point

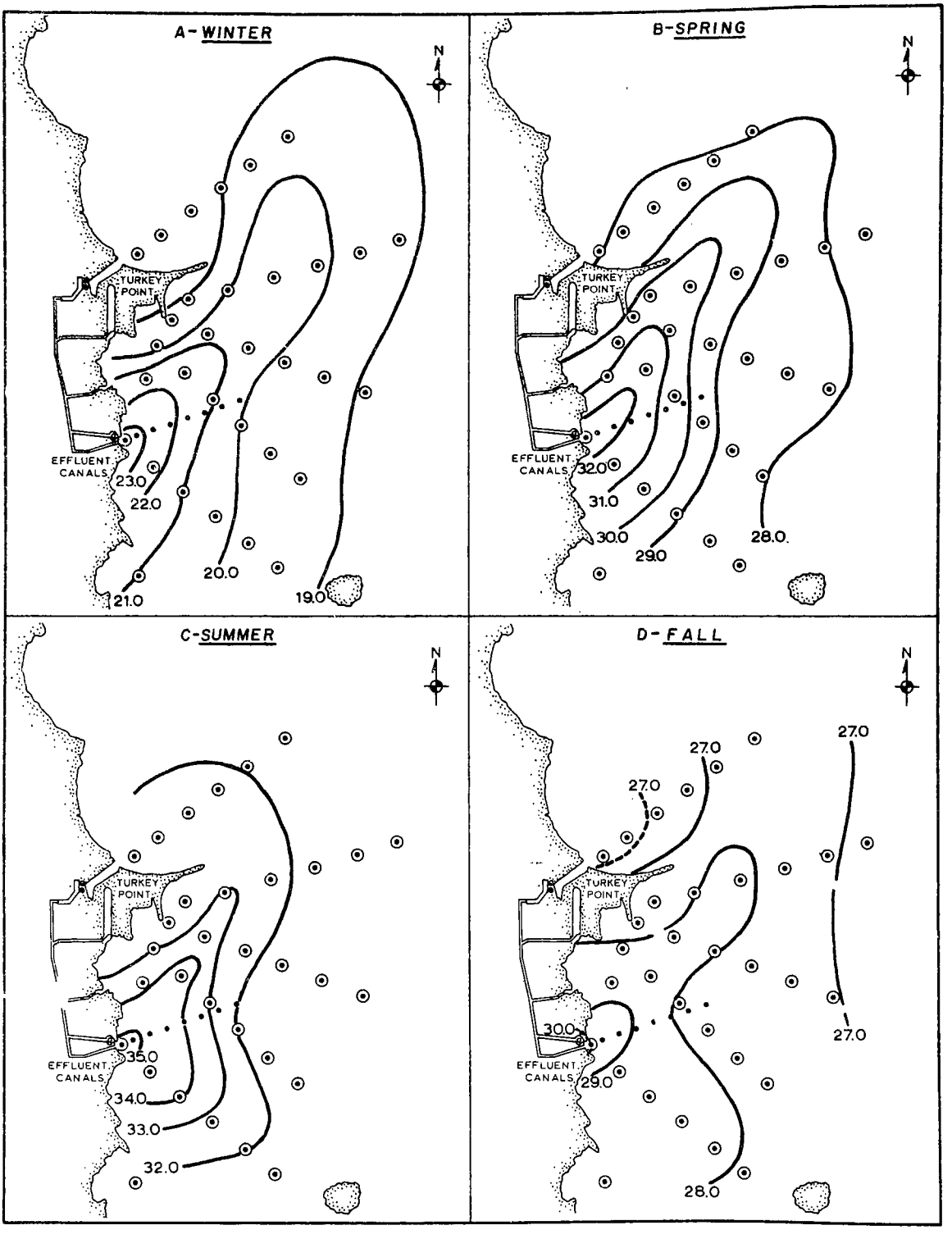

FIGURE 5. TEMPERATURE PROFILE IN °C IN A-WINTER, B-SPRING, C-SUMMER AND D-FALL

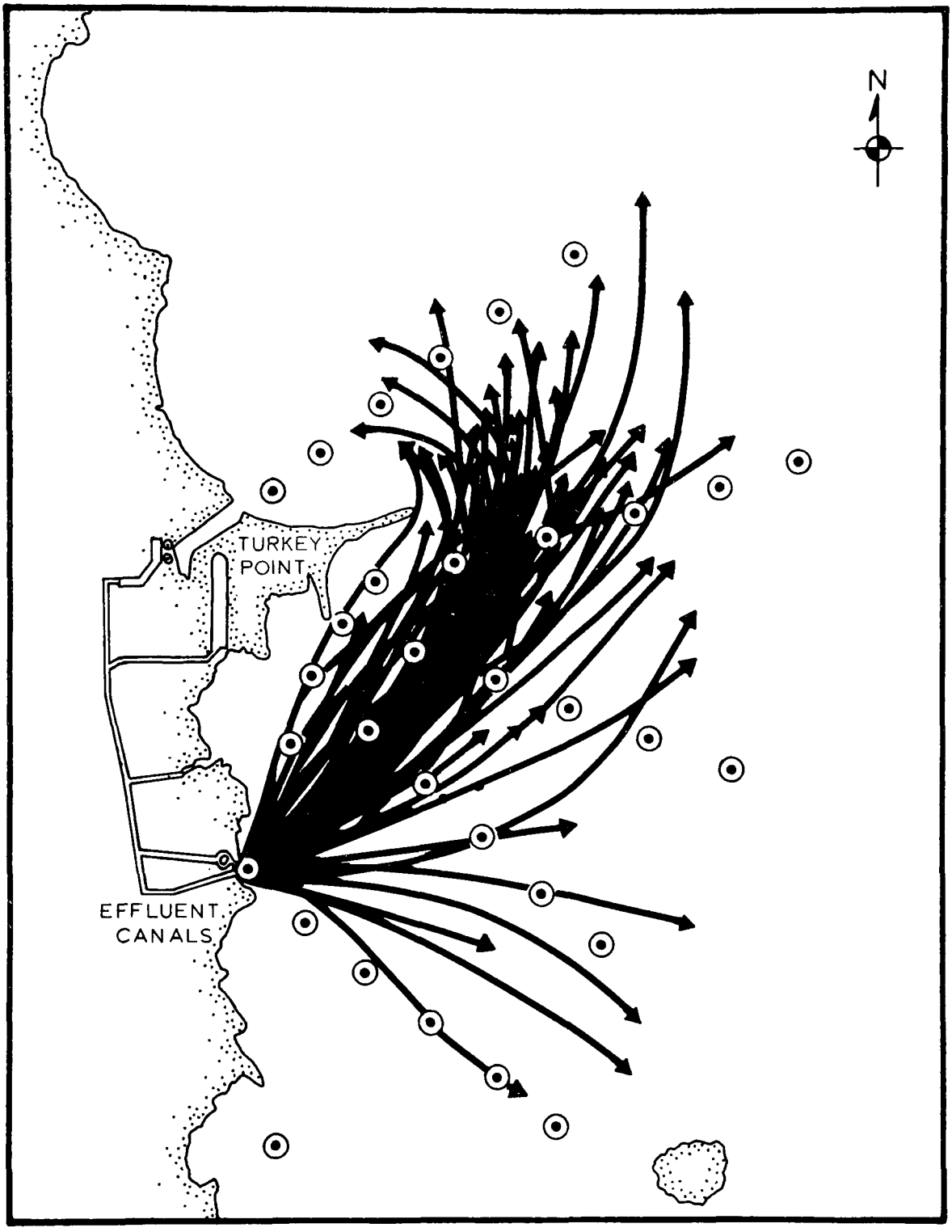

FIGURE 6. THERMAL PLUME AXIS IN 1969 and 1970

An area of approximately 30 - 50 acres was elevated +5°C, and area of 75 acres +4°C, and area of 170 acres +3°C, and area of 300 acres +2°C. Gerchakov, Segar and Stearns (1971a). Figure 5 shows a typical winter, spring, summer and fall isotherm pattern adjacent to Turkey Point.

In general the thermal plume was orientated in a northeasterly direction. Out of eighty-six observations the thermal plume was directed in a northeasterly direction in eighty cases and was deflected to the east of southeast only during periods of strong northwesterly winds which usually accompany cold fronts during the winter months (Figure 6). This northeasterly transport is relatively constant and occurred on both ebb and flood tides.

Figure 7 shows the temperature plume at three hour intervals during a full tidal cycle in September, 1969. The isotherms during (A) late flood, (B) early ebb, (C) late ebb and (D) early flood, all indicate a northeast movement of the effluent. The plume reached around Turkey Point and recirculation results.

Stratification occurred only during ebb tides and only during periods of calm (0 - 5 mph) winds which lasted for 12 hours or more. Such low wind speeds are unusual in the Miami area and climatological data from Homestead Air Force Base (approximately 3.5 miles west of Turkey Point) indicated that wind speeds less than 5 mph occurred only 13 percent of the year. This varies seasonally; the largest percent of calm wind (17 percent) occurred in August and the smallest (9 per cent) occurred in March.

It was believed that the long-term average properties of the thermal plume could be ascertained by measurements of the temperature distribution in the sediments. This assumption was based on the theory that the sediment temperature is determined by the diffusion of heat from the water-sediment interface and would provide a history of the thermal conditions of the waters above.

Figure 8 indicates the temperature of (A) the bottom water, (B) the sediment surface, (C) the sediment at 10 cm, and (D) the sediment at 20 cm on 12 August 1969. In view of the persistence of the thermal plume axis, it was not surprising that the thermal pattern in the sediments was similar to the water above. Gerchakov, Segar and Stearns (1971b) have discussed the sediment temperature profiles in detail.

Diurnal variations of 2 - 3°C or more were common. Figure 9 shows thermograph traces at two stations SE I and A during a 5-day period during July, 1969 when temperatures were extremely high. The effects of tide indicated by the lower curve: ESSA Coast and Geodetic Tide Tables (1969) corrected by data from Schneider (1969), plant load, solar radiation, and time of high tide combine to produce maximum temperature around noon during

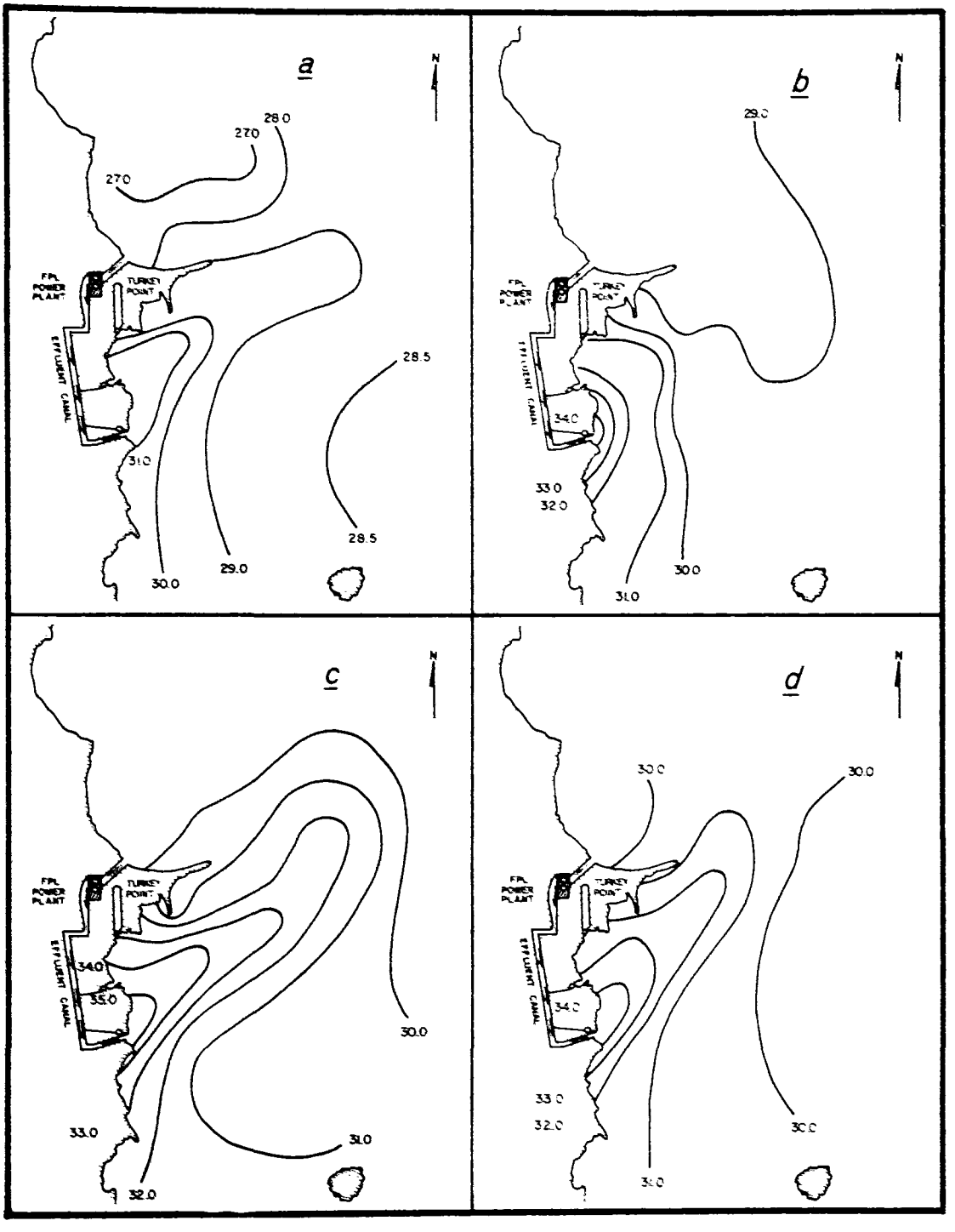

FIGURE 7. TIDAL CHANGES IN SURFACE TEMPERATURE PROFILE AT A) LATE FLOOD, B) EARLY EBB, C) LATE EBB AND D) EARLY FLOOD

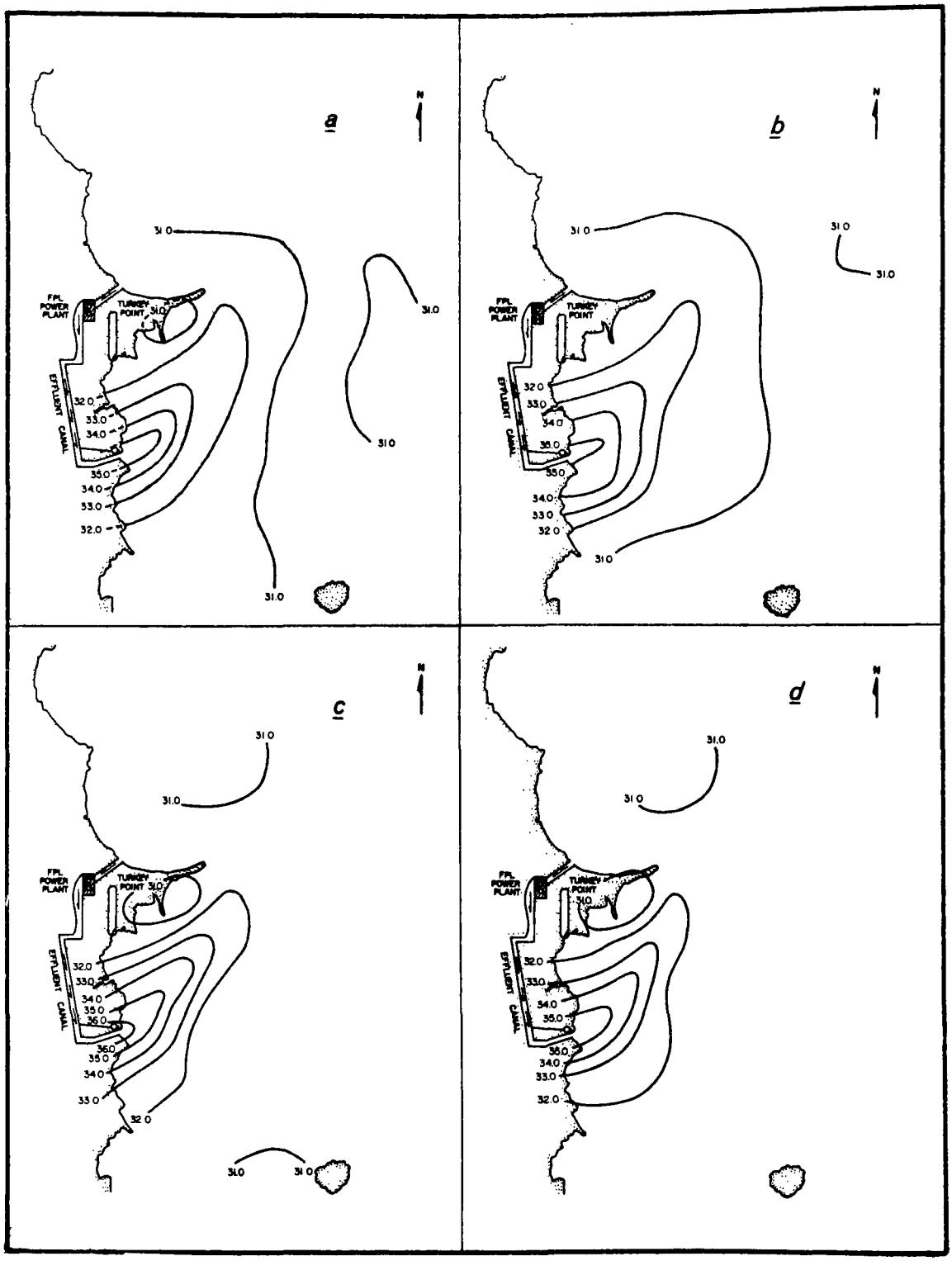

FIGURE 8. BOTTOM WATER AND SEDIMENT TEMPERATURES A) BOTTOM WATER, B) 1CMS DEPTH, C) 10 CMS DEPTH AND D) 20 CMS DEPTH

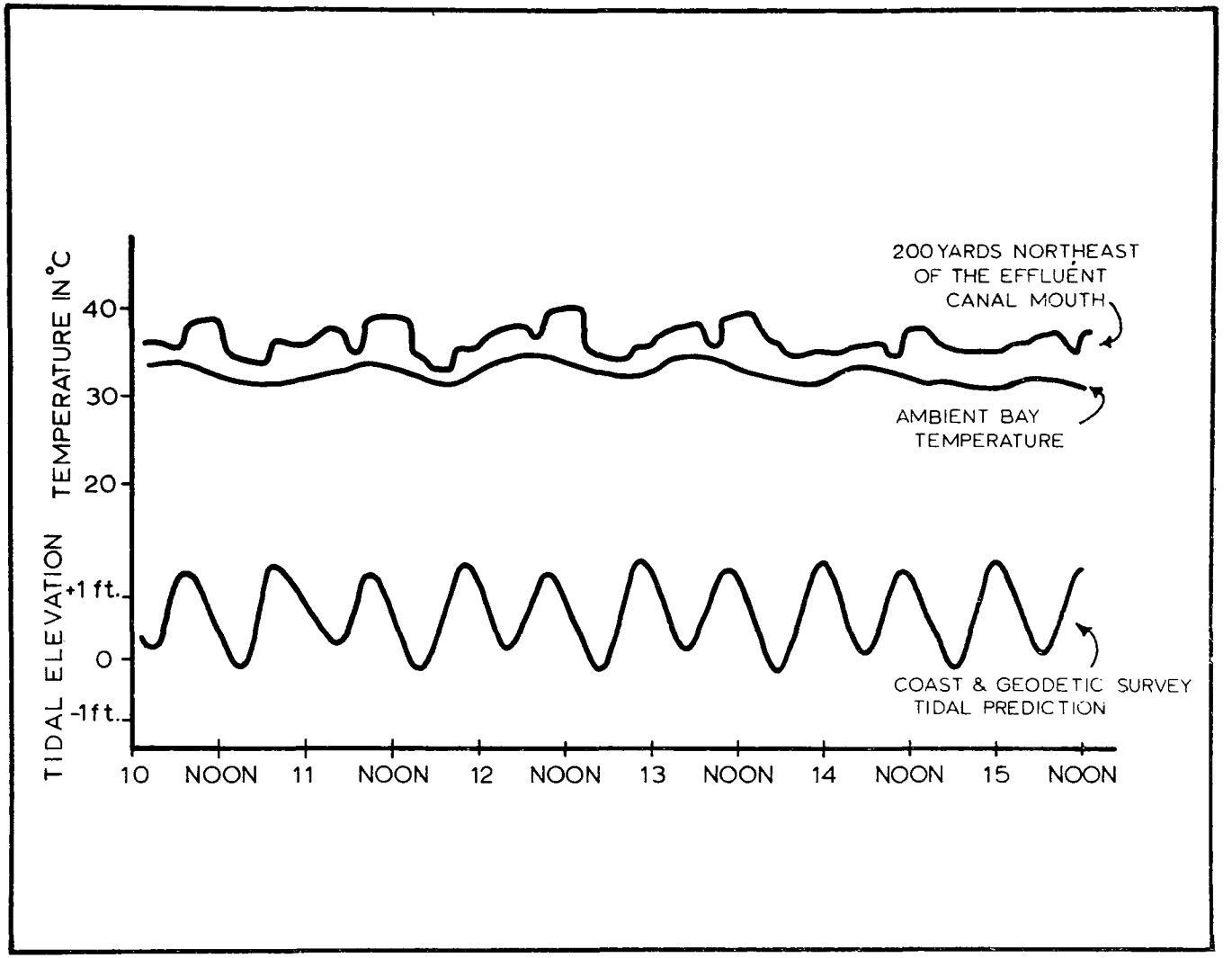

FIGURE 9. TEMPERATURE AND TIDAL CYCLE FOR THE PERIOD 10-15 JULY, 1969; THE HOTTEST DISCHARGE TEMPERATURES RECORDED

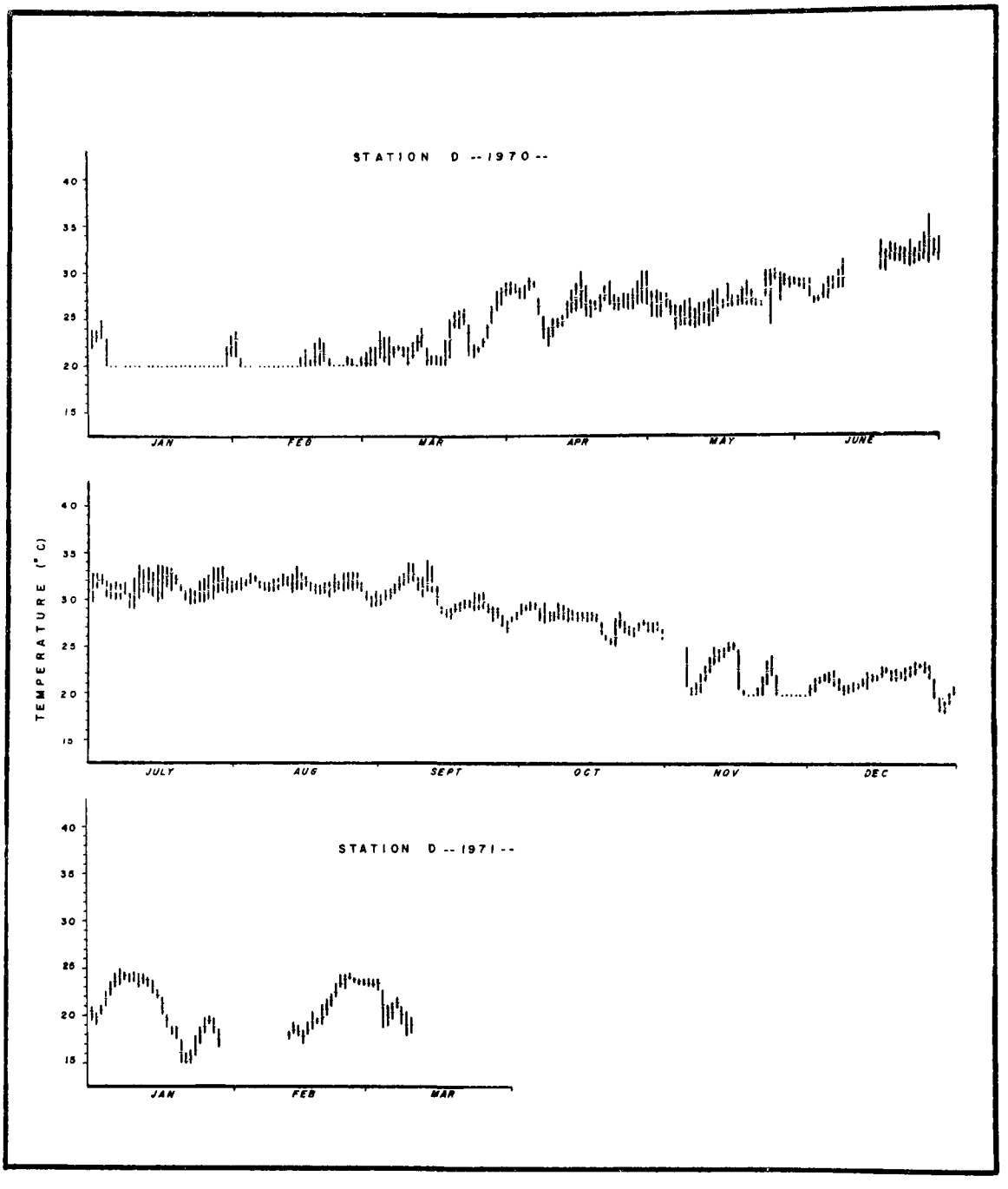

FIGURE 10. DAILY MAXIMUM, MINIMUM AND AVERAGE TEMPERATURE AT CONTROL STATION D IN 1970-71

spring tides. The temperature was not elevated as much during neap tides when high water occurred in morning and evening hours.

The seasonal pattern of daily maximum, minimum and average temperature (based on 8 three-hourly intervals starting at 0000 hours) for station D is shown in Figure 10. The Ryan thermographs have a 30°C range and the lower limit was 15 or 20°C. Therefore temperatures below these values were not recorded.

The thermograph was in continuous operation from January 1970 until March 1971. Minor gaps in June and November were due to instrument repair. Temperature drops were obvious in the general warming trend during March and April. The cold front activity is again observed in November and throughout the winter months. During the summer temperatures remain relatively constant except for diurnal variations. Heavy thunder showers, when they occur near low tides, can cause large diurnal variation. At station D the average daily temperature reached 33°C during a single day in June 1970. The maximum daily temperature exceeded 33°C on 17 days and exceeded 35°C only on one day.

A thermograph was in operation at station A from February 1969 through December 1970. Figure 11 indicates the daily maximum, minimum and average temperature is about 1.5°C higher than at station D. The large daily variation is the result of tidal influence which allows the thermal plume to pass over this station during the ebb tide and retards it on the flood tide.

Average daily temperature exceeded 35°C on one day in July 1969. The maximum daily temperature exceeded 35°C on 5 days in July and 4 days in August 1969 and 2 days in June, 1 day in July and 3 days in August 1970. The average daily temperature exceeded 33°C on 11 days in July and 6 days in August 1969 and on 2 days in June, 2 days in July and at least 5 days in August 1970. The daily maximum was above 33°C on 4 days in June, 18 in July at least 16 days in August and 2 days in September 1969 and 7 days in June, 15 days in July and almost all of August and early September of 1970.

The thermograph data for station F which averages about 2°C above that at station D is shown in Figure 12. This station was generally in the path of the thermal plume and also exhibits greater daily temperature fluctuations than D.

At station F average daily temperature exceeded 33°C for 5 days in August, 1969 and the daily maximum exceeded 35°C on 2 days. In 1970 average daily temperatures exceeded 35°C on 6 days in June, 10 in July and from mid August through early September. Average daily temperatures exceeded 33°C from mid June through September or for a period of about 4 months.

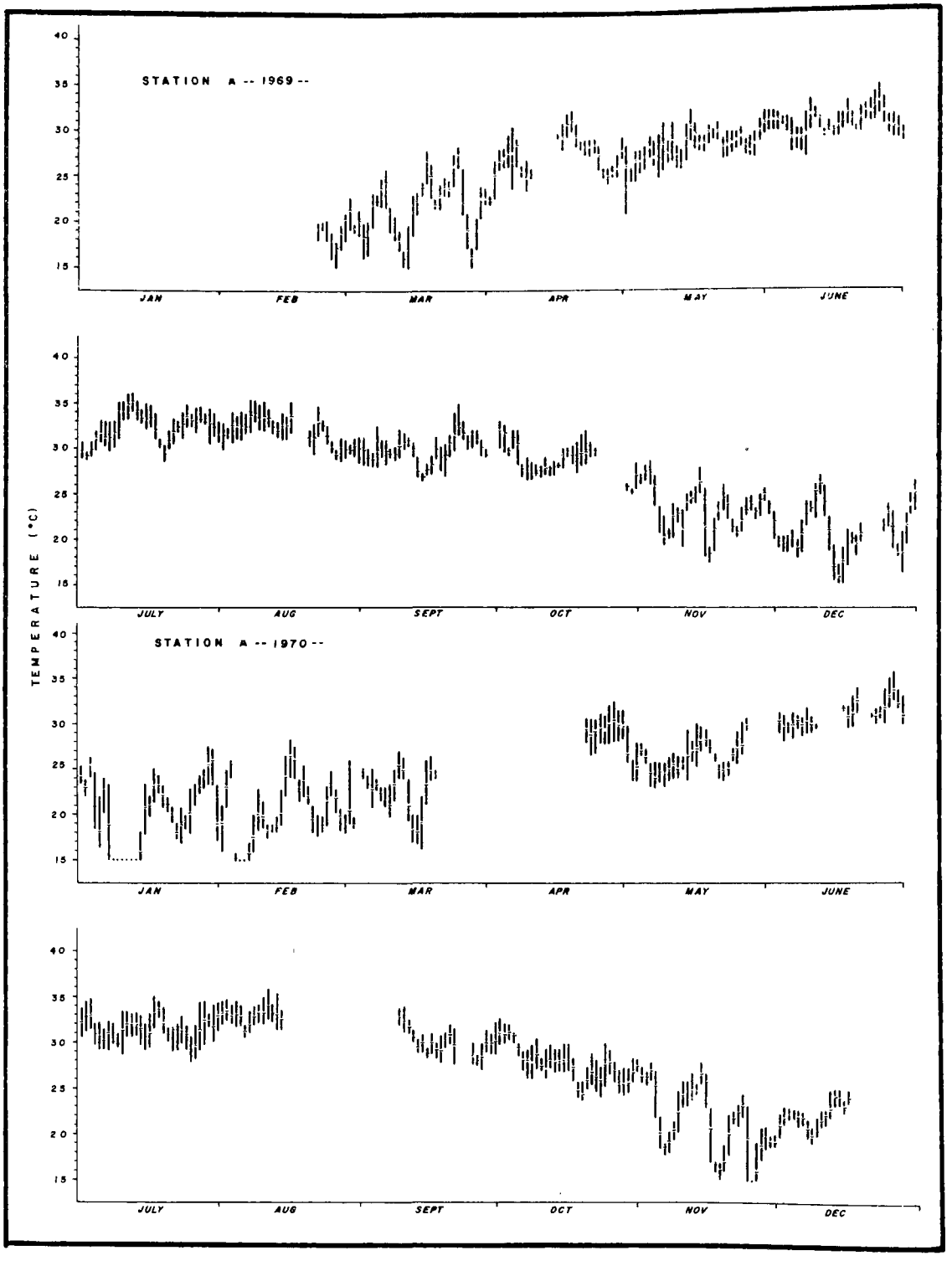

FIGURE 11. DAILY MAXIMUM, MINIMUM AND AVERAGE TEMPERATURE AT STATION A IN 1969-70

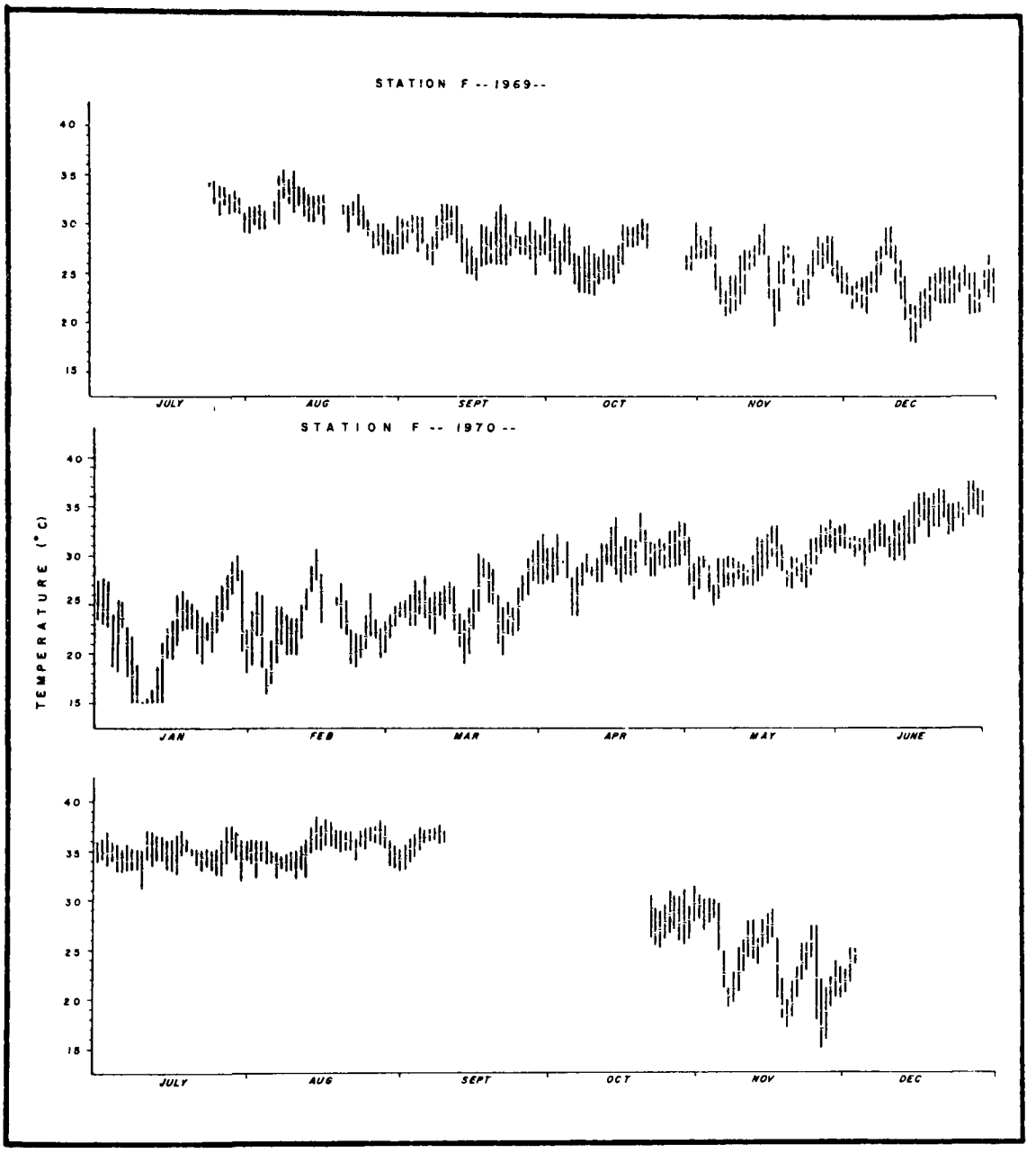

FIGURE 12. DAILY MAXIMUM, MINIMUM AND AVERAGE TEMPERATURE AT STATION F IN 1969-70

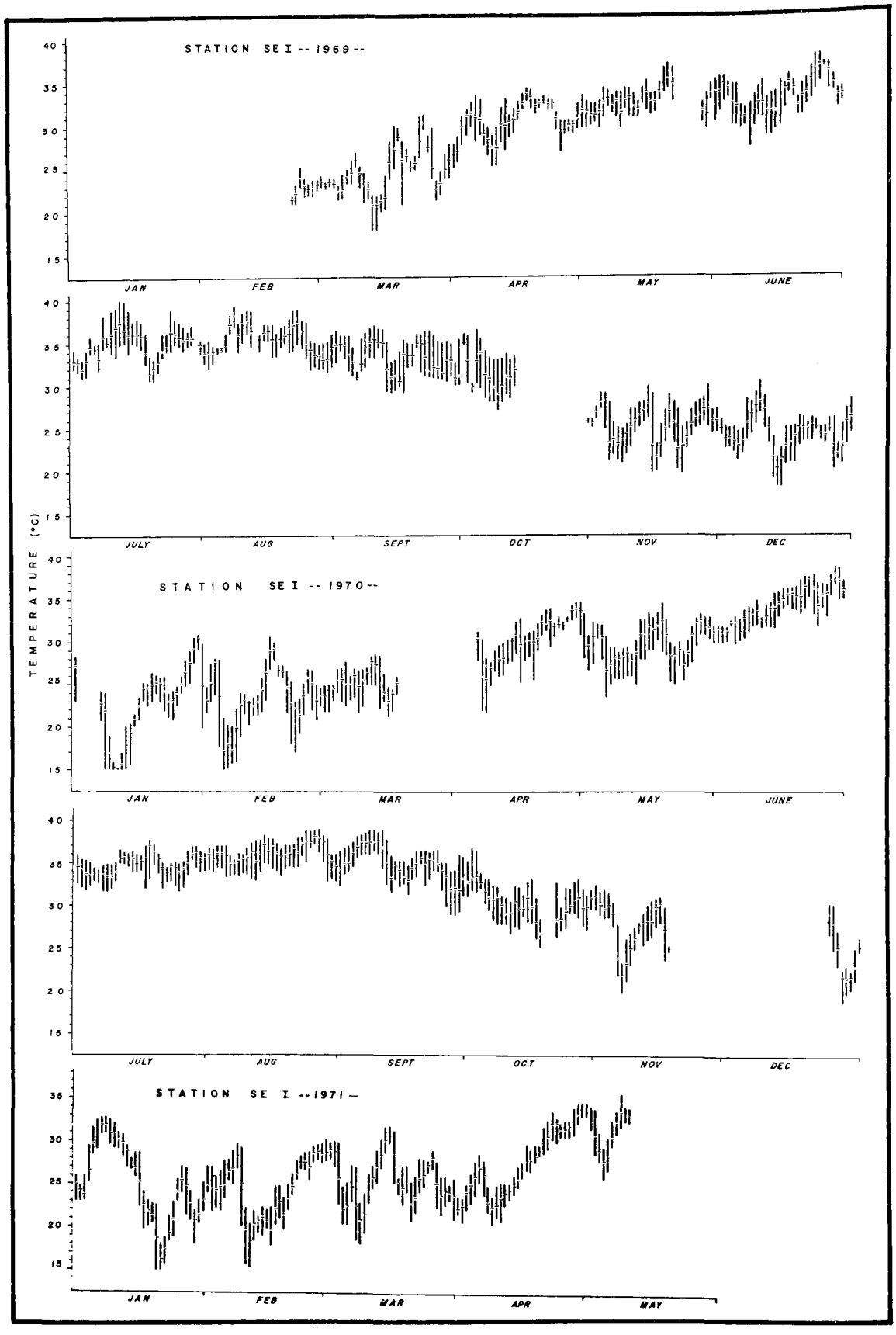

FIGURE 13. DAILY MAXIMUM, MINIMUM AND AVERAGE TEMPERATURE AT STATION SE I IN 1969, 1970 AND 1971

Thermograph data for station SE I is presented in Figure 13. This station located 185 m NE of the mouth of the effluent canal is continuously in the thermal plume. Temperatures at this station averaged 3.5°C or more above those at station D. Maximum temperatures in excess of 35°C were recorded from May through October 1969, June through September 1970 and in May, 1971. Daily averages exceeded 35°C in May through August, 1969, and June through September 1970. The maximum and average daily temperatures exceeded 33°C in April through October of 1969 and April through September of 1970. Thus the temperature exceeded 33°C for a period of six months.

Station I located in the mouth of Little River a minor discharge canal which receives about 8 percent of the discharge is subjected to tidal variations in temperature (Nugent, 1970). The flood tide backs up the canal and cooler bay water covers the station. On ebb tides the effluent covers the station and high temperatures are experienced.

A copy of the thermograph trace and adjusted tidal cycle is shown in Figure 4. This results in about a 5°C difference between daily maximum and minimum temperatures (Figure 14). Thus although the daily maximum temperatures exceeded 33°C from June through mid-September 1970 and part of April and May 1971 the average daily temperature only exceeds 33°C on 7 days in July and 4 days in August 1970. The daily average temperature never exceeds 35°C but the maximum daily temperature was in excess of 35°C on 23 days during the summer of 1970 and on 3 days in May, 1971. More detailed analysis of the temperature structure within the canal system was given by Nugent (1970).

Baseline temperature data in Card Sound were gathered for approximately one year. These data are presented in Appendix Table 1, and in Segar, Gerchakov and Johnson (1971). An analysis of these data and additional temperature measurements were presented by Lee and Rooth (1970) in their consideration of circulation and flushing in Card Sound.

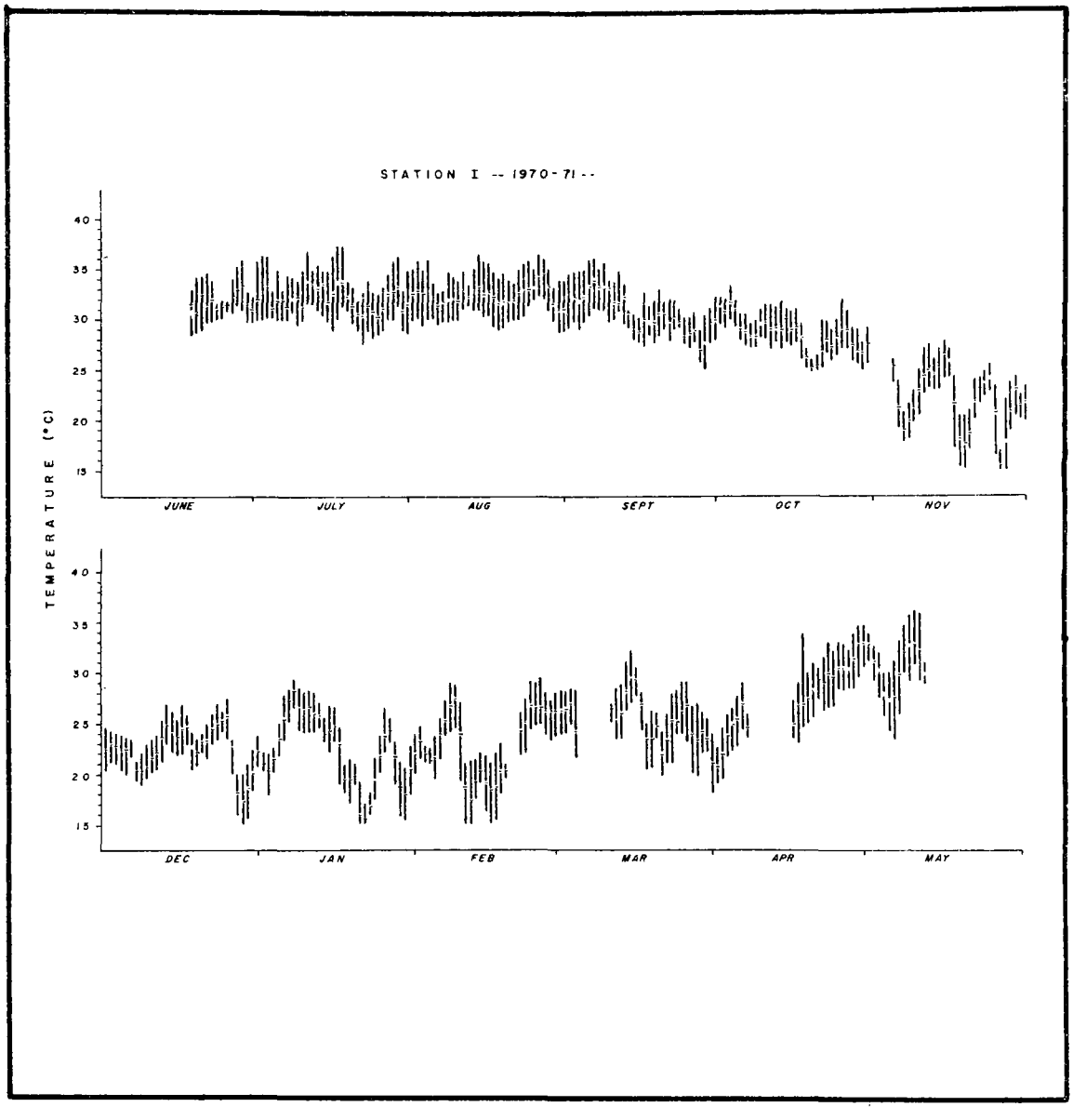

FIGURE 14. DAILY MAXIMUM, MINIMUM AND AVERAGE TEMPERATURE AT STATION I IN 1970-71

SECTION VIII

CHEMISTRY AT TURKEY POINT

During each trawling trip measurements of salinity and dissolved oxygen were made. The results are summarized in Appendix Tables 2 and 3 and additional measurements were presented by Segar, Gerchakov and Johnson (1971) and Lee and Rooth (1971).

Salinity in Biscayne Bay was correlated with rainfall values but this relation was somewhat modified by the influence of runoff when flood control dams on Florida City Canal, Mowry Canal, Moody Canal, etc., were opened to permit drainage. Normally there was a salinity gradient with low salinity near the western shore and an upward gradient as one proceeded eastward. This phenomenon is also discussed by Kohout and Kolopinski (1964). During the 1970-71 drought period the salinity gradient was reversed. Figure 15 illustrates a typical wet season and dry season isohaline distribution.

The mainland shore stations were subjected to large salinity fluctuations, those in mid bay experienced a smaller range of salinity and those stations near the passes which connect directly to the ocean received the least salinity variation (Figure 3).

Lee and Rooth (1971) have examined the salinity in Card Sound and have indicated that the normal salinity gradient implied little miximg of the western portion of the Sound with the Atlantic except during periods of strong northwesterly winds such as accompany cold fronts.

Data on salinity at 32 additional hydrographic stations in Biscayne Bay and at times other than when trawling was done are summarized by Segar, Gerchakov and Johnson (1971).

Additional salinity data for Biscayne Bay and Card Sound are available, Tebo, Estes and Lassiter (1968), Lee and Rooth (1971) and Rooth and Lee (1971).

Meausrements of dissolved oxygen indicated that the water was generally well oxygenated. Subsequent to passage through the plant a slight reduction in oxygen occurred probably due to simple equilibration with the atmosphere at the elevated temperature. An additional decrease occurred when large amounts of organic materials were being contributed by runoff from the mangrove region adjacent to the plant (Nugent, 1970).

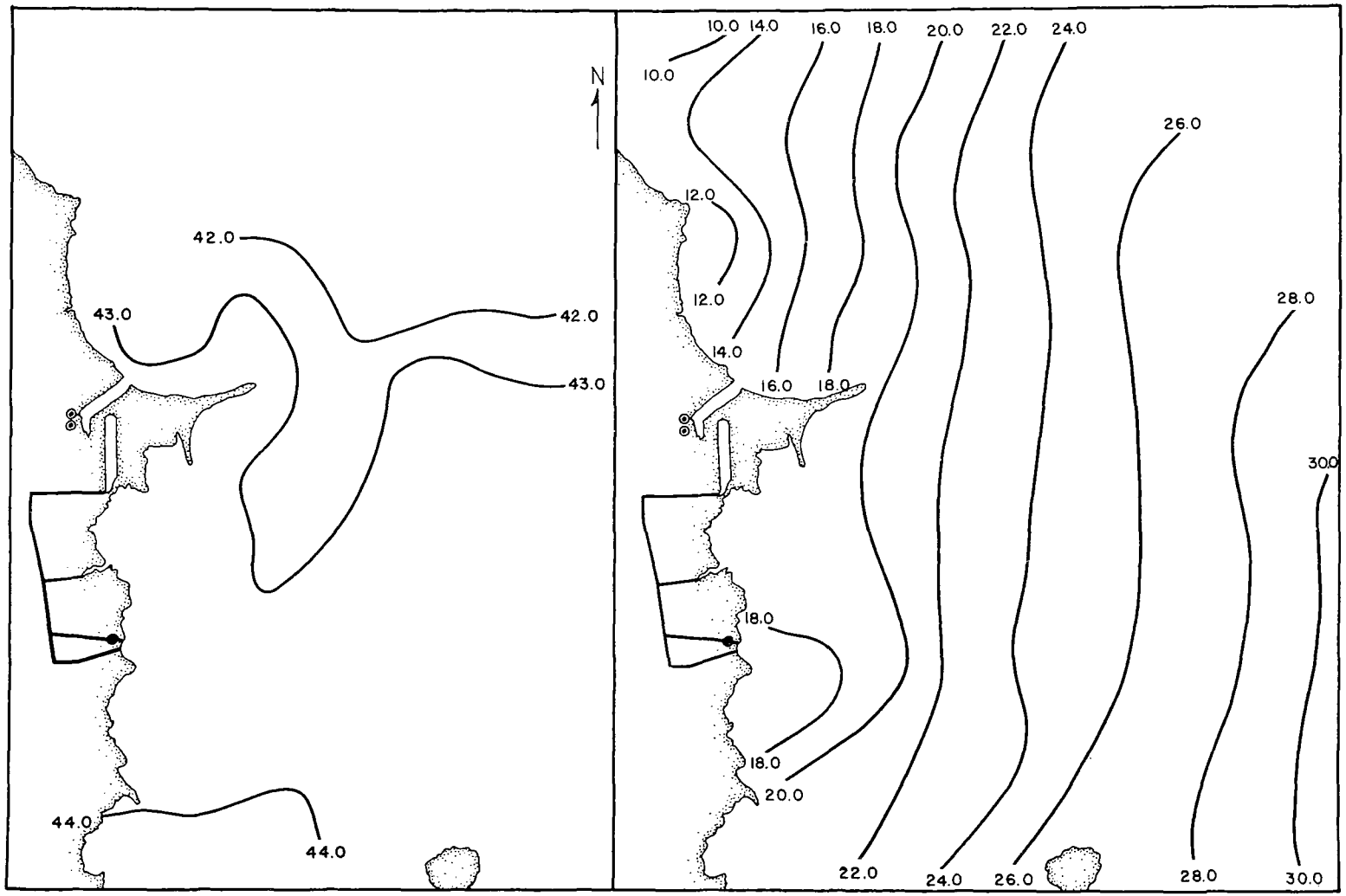

FIGURE 15. ISOHALINES IN BISCAYNE BAY DURING A) DRY SEASON AND B) WET SEASON

Diurnal oxygen cycles were particularly evident on calm days. Oxygen values were low in early morning hours and increased to supersaturated conditions by afternoon. This was the result of photosynthesis by sea grasses and macroalgae. A typical diurnal pattern is shown in Figure 16. Extreme oxygen values ranged from 83 per cent saturated (3.4 mls. O_2/l) to 230 percent saturation (11.1 mls. O_2/l).

In the area immediately around the canal mouth supersaturation was rarely observed. This was probably due to the lack of macroalgae and sea grass combined with the swift currents and high turbulence.

Generally oxygen values followed a natural seasonal curve with higher values occurring in the colder winter months and lower values in the warm summer months. The supersaturated conditions which occurred in summer over dense grass or algae beds was an exception to this pattern but can easily be attributed to photosynthesis and little wind-induced mixing of the water. Monthly oxygen measurements for each trawling station are presented in Appendix Table 3. Additional data for 32 hydrographic stations and for times other than during trawling operations were summarized by Segar, Gerchakov and Johnson (1971).

Other chemical parameters could not be related to animal distribution due to the sporadic nature of collection and analysis of water samples and the lack of funds to continue the chemistry program. Data collected under the support of the AEC were summarized by Segar, Gerchokov and Johnson (1971) and interpreted by Gerchakov, Segar and Stearns (1971).

Measurements of the nutrients nitrite, nitrate, phosphate, total phosphorous, silicate, total dissolved inorganic carbon, and total dissolved organic carbon were made as well as measurements of dissolved iron, copper, zinc, pH, alkalinity and Eh of the sediments. In addition, in Card Sound, measurements of gross alpha and gross beta radiation were made together with gamma spectra analysis for selected ions.

Segar, Gerchakov and Johnson (1971: IV-60-62) summarized their findings and stated that micronutrients (NO_3, NO_2, Si O_3 and PO_4) were slightly enriched in the discharge water. The carbon dioxide/carbonate system of the heated water may have been altered by plant operation. Trace transitional metals (Fe, Cu, Zn) are enriched in the area of heated water.

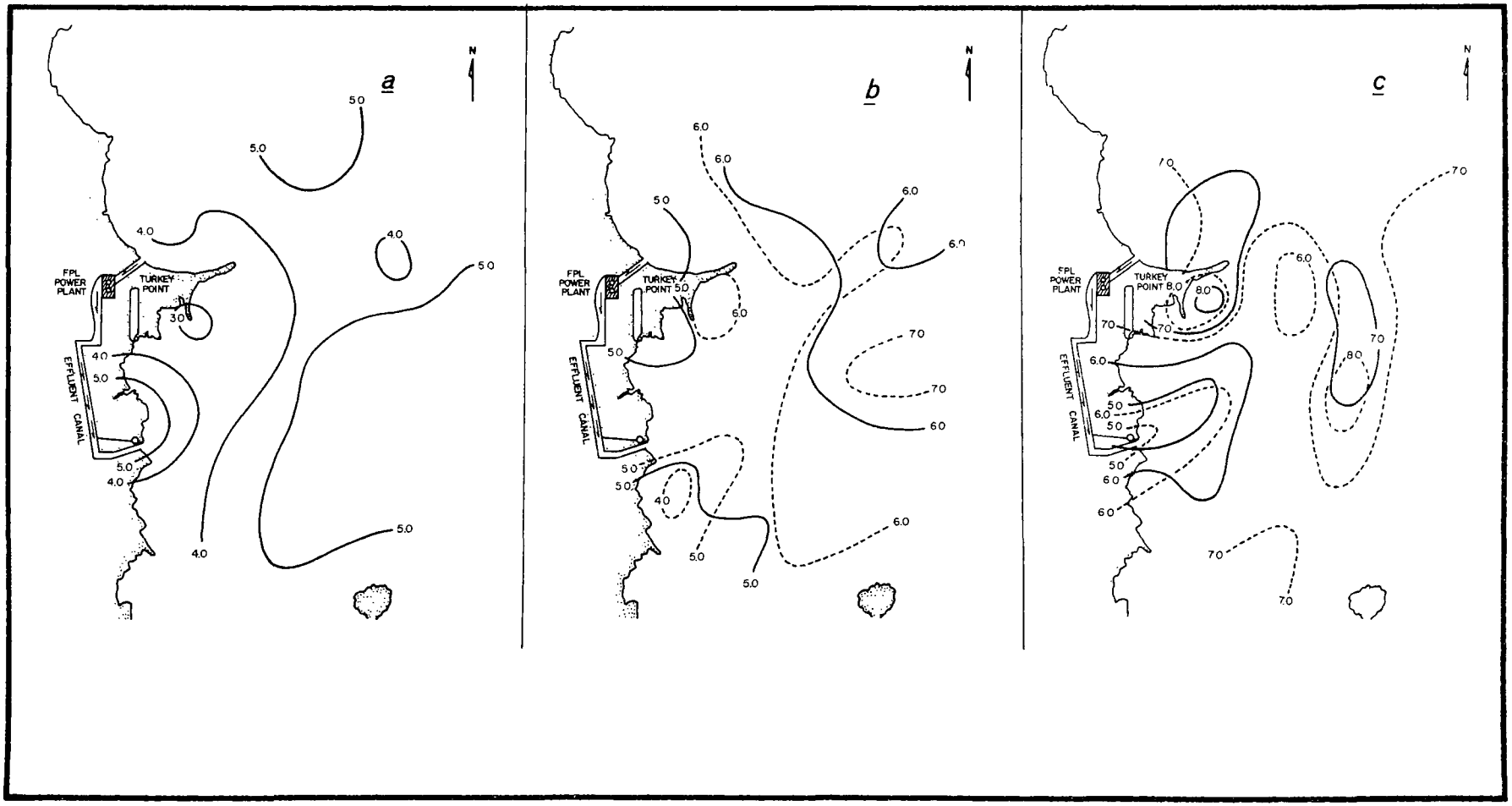

FIGURE 16. DIURNAL VARIATION OF DISSOLVED OXYGEN (MLS, O_2/L): A. 0810-0945, B. 1154-1306, C. 1455-1625 HOURS DST IN AUGUST 1969. SOLID LINES ARE SURFACE VALUES - DASHED LINES ARE BOTTOM VALUES

SECTION IX

EXCLUSION AND OPTIMAL TEMPERATURES

For each of the 354 species collected in the trawl samples a 10 by 45 matrix of catch per tow at each 5 ppt salinity increment and 1°C increment was constructed. The matrix was made by summing the catch for each species collected at each station each month and dividing this by the effort. This value was then placed in the proper temperature row and salinity column. A count was kept of the number of c/e enteries and the average catch per tow was calculated.

The use of the average catch per tow calculated by $(\frac{\Sigma c/e}{N})$ when $c \geq 1$ for the 7 tows at the particular station - month combination caused no difficulty in selecting upper and lower temperatures at which the species was found but the catch per tow at extreme temperatures was unjustly weighted. That is if 10 animals were caught per drag once at 40°C and 0 per drag on 9 occasions the result would be 10 per drag with the first method but only 1 per drag with the latter more preferred formula. The preferred $\Sigma c/\Sigma e$ was not used because of computer limitations. The mathematical weighting plus high catches of animals at stations with anomalously high temperatures in September 1968 (see Appendix Table 1) resulted in large catches of some species at high temperatures.

For each species it was possible to select the highest temperature at which the species was caught, the lowest temperature at which the species was caught and, the temperature at which the highest catch per tow occurred.

From the maximum temperature data it is possible to construct an upper exclusion temperature curve. If the cumulative percent of the number of species is plotted against the maximum temperature at which they were observed an ogive results. A probit transformation provides a straight line relating temperature to the exclusion of species due to heat. From this relation the exact temperature that would have protected a given percentage of the species is determined.

From the minimum temperature data similar relations can be obtained and the lower exclusion temperature can be calculated to protect any percentage of the species.

The intersection of these two curves is of considerable interest because it represents an optimal temperature. That is, the temperature at which the greatest diversity of species can exist. Some species are excluded at this temperature and these represent summer (high temperature) or winter (low temperature) immigrants. These animals depend

on the seasonal cycling of temperature.

A third curve, the maximum catch curve, is derived from the maximum catch per tow data. A plot of the cummulative percentage of the number of species which exhibit maximum catch per tow at or below each temperature against temperature can be used to calculate the temperature which will produce the maximum numbers of individuals.

These three curves were plotted and the regressions calculated for fish, mollusks, crustaceans, porifera, coelenterates, echinoderms and all species combined (Figures 17 - 19).

For each of these taxonomic groupings six values were calculated, the lower exclusion temperature at which 75 percent of the species were excluded due to cold, (LET_{75}) the lower exclusion temperature at which 50 percent of the species was excluded due to cold (LET_{50}), the optimal temperature for numbers of individuals (max. c/e) the optimal temperature for diversity of species, (max. div.) the upper exclusion temperature at which 50 percent of the species were excluded due to heat (UET_{50}) and the upper exclusion temperature at which 75 percent of the species were excluded due to heat (UET_{75}). The results are summarized in Table 3.

TABLE 3

EXCLUSION AND OPTIMUM TEMPERATURES FOR ANIMALS IN BISCAYNE BAY, FLORIDA

Taxa	LET_{75}	LET_{50}	Max c/e	Max Div.	UET_{50}	UET_{75}
Fish	15.6	21.1	25.9	26.6	31.8	37.8
Mollusks	15.3	19.7	25.5	26.0	32.7	37.4
Crustaceans	14.8	19.6	25.8	26.0	33.3	38.7
Porifera	0.2[1]	9.1[1]	24.9	24.3	31.4	35.5
Coelenterates	13.0	18.2	17.2[2]	26.0	29.9	32.5
Echinoderms	15.4	20.5	26.2	27.3	31.8	35.2
Combined	14.3	19.3	25.7	26.3	33.4[3]	38.6

[1]Have critical lower threshold near 15-16°C which produces non-normal curve.
[2]Believed to be low because salinity excludes corals and alcyonarians from inshore stations subjected to heated effluent.
[3]Curve tends to exhibit positive kurtosis actual UET_{50} probably lower.

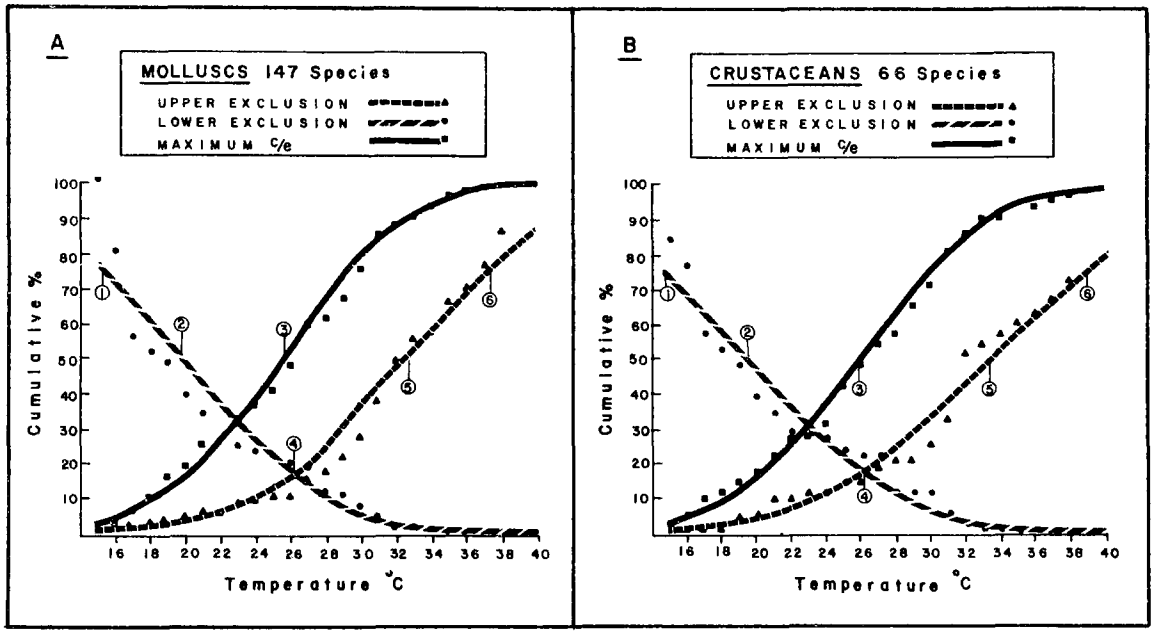

FIGURE 17. EXCLUSION AND OPTIMUM TEMPERATURES FOR A) MOLLUSKS AND B) CRUSTACEANS

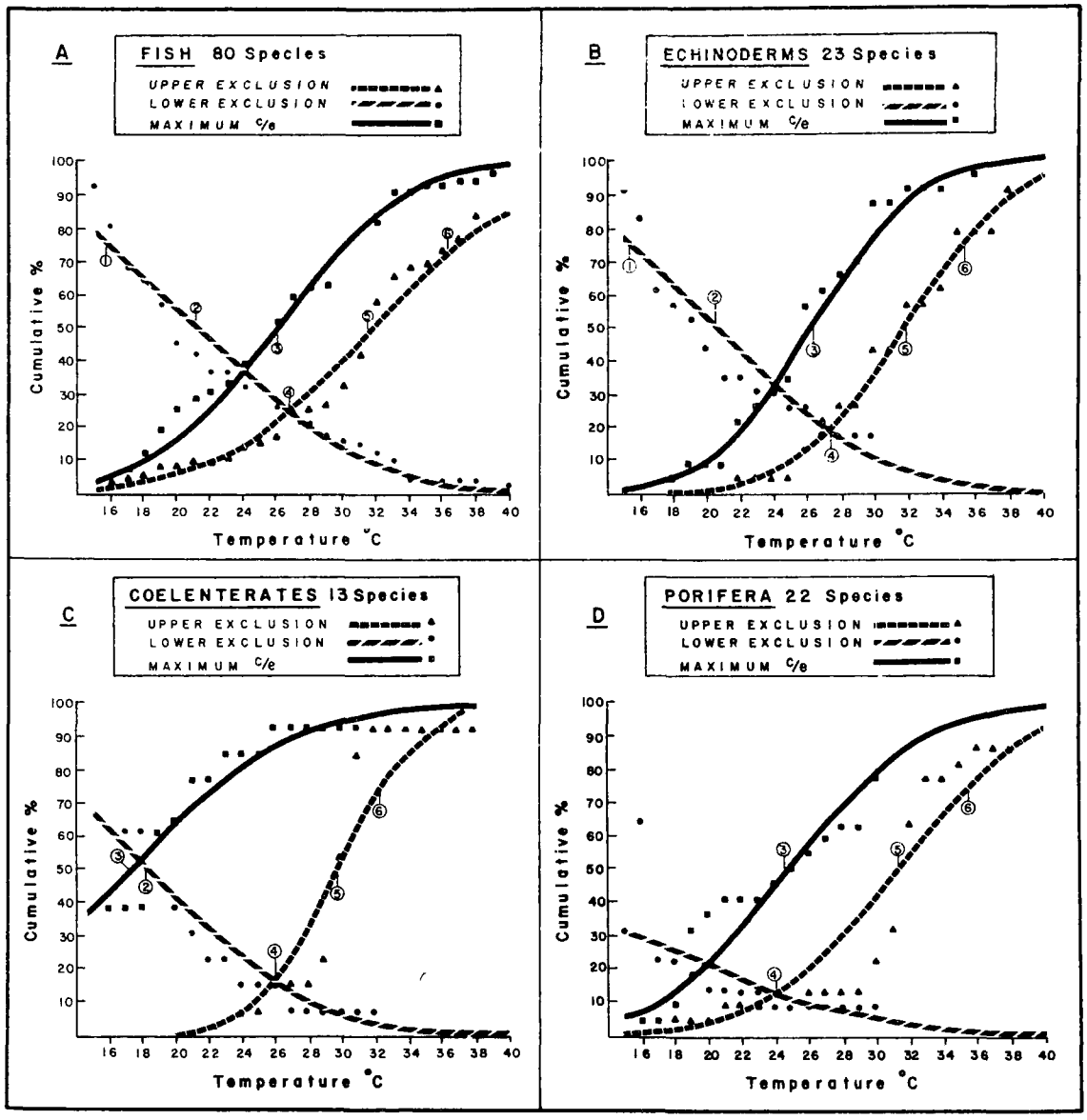

FIGURE 18. EXCLUSION AND OPTIMUM TEMPERATURES FOR A) FISH, B) ECHINODERMS, C) COELENTERATES AND D) PORIFERA

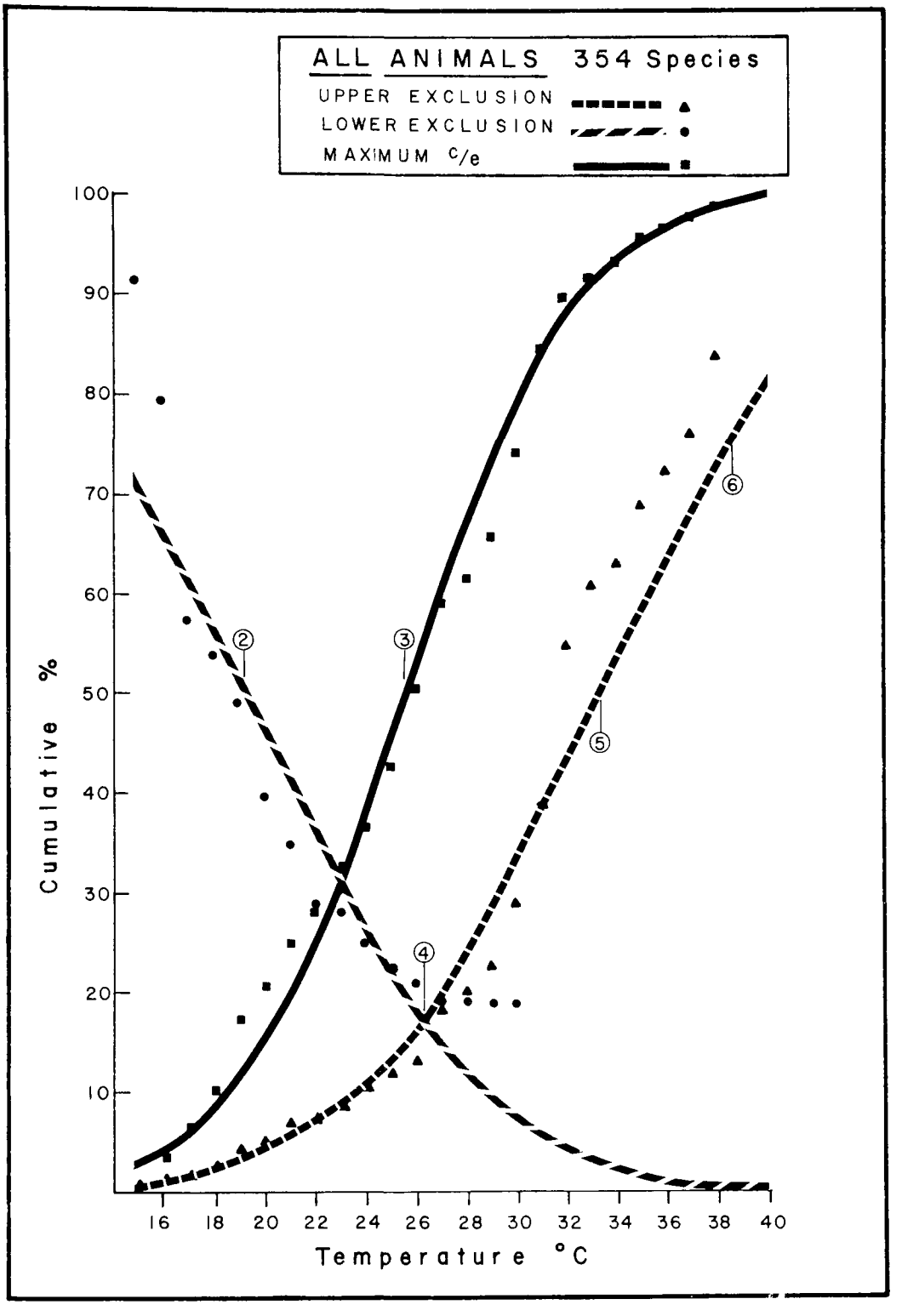

FIGURE 19. EXCLUSION AND OPTIMUM TEMPERATURES FOR 354 SPECIES OF ANIMALS COLLECTED AT TURKEY POINT

In general there was good agreement among the groups and between the optimum temperatures based on the maximum catch per tow and the intersection of the two exclusion curves. This consistancy indicated the use of catch per tow only in successful tows had little effect on the calculation of critical temperatures.

An examination of Figure 18D indicates that there is a threshold temperature for porifera near 15 - 16°C below which these animals virtually disappear. This threshold is not adequately represented by the model. Sponges are restricted to mid-and eastern bay stations and excluded from the western bay by salinity fluctuations. Special studies are in progress to further clarify the tolerance limits of sponges which were poorly represented in trawl catches.

The calculated temperature for numbers of coelenterates was too low. The corals and alcyonarians were poorly represented in trawl studies and were excluded from the area of thermal stress due to the salinity changes near the western shore of the bay. The tolerance limits of these animals are being investigated by Mr. Lee Purkerson of Environmental Protection Agency and by Clark, Joy and Rosenthal (1970).

In the combined species the calculated UET_{50} and UET_{75} appeared too high because the number of species which were excluded between 30 and 32.5°C were greater than expected. Linear interpolation between actual data points indicated a UET_{50} of 32°C and a UET_{75} of 37°C.

The optimal temperatures were close to the annual average bay temperature and the 50 percent exclusion temperatures are near the winter and summer averages. Thus the observed fauna appears to have evolved to withstand the normal temperature variations and have little ability to withstand increases above the normal summer average temperature or decreased below normal winter average.

The most sensitive inshore group of animals were the fishes. The UET_{50} for these was 31.8°C. However, fishes generally will move from an area before being killed and thus we believe the regulations should be based on UET_{50} of mollusks or crustaceans which is approximately 33°C.

Due to the controversial nature of selecting the percent of species to be protected a table of constants based on two years of field observations on 354 species is presented which will allow the calculation of temperature needed to protect any percentage of species desired by the regulatory personnel (Table 4). The percentage of species permitted to be excluded must exceed the percentage of species present at the optimal temperature for diversity of species.

TABLE 4

EQUATION AND CONSTANTS TO CALCULATE EXCLUSION TEMPERATURES

$$X = \frac{Y - \bar{y} + b\bar{x}}{b}$$

X = temperature in °C
$\bar{x}$ = mean temperature
Y = probit value for percent of species excluded (cannot be less than percent of species at optimal temperature)
$\bar{y}$ = mean of probit values
b = slope of regression between temperature and probit of Y

Taxa	curve	$\bar{y}$	b	$\bar{x}$
Fish				
(80 sp)	LET	4.3	- .1225	27.0
	Max c/e	5.1	- .1636	26.5
	UET	4.4	- .1302	27.0
Mollusks	LET	4.0	- .1540	26.0
(147 sp)	Max c/e	5.2	- .1842	26.5
	UET	4.2	- .1445	27.0
Crustaceans	LET	4.2	- .1415	25.0
(66 sp)	Max c/e	5.1	- .1649	26.5
	UET	4.2	- .1250	27.0
Porifera	LET(1	3.9	- .0758	23.0
(22 sp)	Max c/e	4.7	- .1628	23.0
	UET	4.5	- .1615	28.0
Coelenterates	LET	4.2	- .1293	24.5
(13 sp)	Max c/e(2	5.8	- .1287	23.5
	UET	5.3	- .2571	31.0
Echinoderms	LET	4.7	- .1323	22.5
(23 sp)	Max c/e	5.2	- .2028	23.5
	UET	4.6	- .1964	31.0
All species	LET	4.0	- .1349	27.0
(354 sp)	Max c/e	5.1	- .1814	26.5
	UET	4.2	- .1297	27.0

SECTION X

ANIMAL DISTRIBUTION AND ABUNDANCE

In July 1968 - June 1970, 3360 samples produced about 288,000 animals from Biscayne Bay in the vicinity of the Turkey Point power plant. The catch of each species at each station was reported by Bader and Roessler (1971 Tables V-1 and V-2). Analysis of the data must be separated into two time periods because of differences in station locations and sorting techniques.

Analysis of the 20 stations sampled from July 1968 - December 1968 indicated that a total of 48,128 animals were collected. Non - parametric analysis of variance indicated that the abundance of organisms at the 20 stations was not homogeneous, catches were significantly higher than the average (57 animals per drag) at stations N V, SE II and SE III. Table 2 summarizes the vegetation type and abundance for each of the stations and examination of these tables indicates that the three stations with greatest abundance of animals share large catches of vegetation, principally Laurencia or Digenia.

Catches were below average at stations N II, NE IV, NE V, SE I, SE IV, SE V, S I and S V. These stations all produced low catches of vegetation as well as low animal catches. There appears to be three major causes for low catches of vegetation at certain stations. First, Zieman (1970) Roessler and Zieman (1970) and Thorhaug (1971), have shown that in an area of about 300 acres from the mouth of the Turkey Point effluent canal the amount of algae and sea grass is seasonally reduced by temperature effects. At stations N II and N V located near the mouth of the Florida City Canal and Moody Canal the vegetation is killed during periods of freshwater discharge. This was particularly evident at station N II located 150 m from the mouth of Florida City Canal and less so at N V located 300 m from the mouth of Moody Canal. However, at N V the dense Digenia growth observed in July and August 1968 was totally killed in September but quickly replaced by Laurencia. The freshwater influence at station N V was also indicated by the presence of the pelecypods Crassostrea virginica, Amygdalum papyria, Congeria leucophaeta and, Anomalocardia cuneimeris. The third reason for low catches of vegetation is due to stations located on Thalassia flats. The otter trawl does not uproot the Thalassia but only catches the dead fragments of the blades. The Thalassia beds are dominant on the shallows near the Arsenicker Keys on Pelican Bank and near the Florida Keys on the eastern side of the bay.

Thus we believe the low abundance of animals at stations S I and SE I which were in the thermal plume and were elevated 5.26 and 5.25°C above ambient was the direct result of temperature increases or indirect result of temperature which adversly effected the algae and sea grass,

used as food and shelter by the animals. Further study is needed to separate these alternatives. The low catches at station N II are probably caused by fresh water discharge from a point source at the mouth of the Florida City Canal. And low catches at Stations NE IV, NE V, SE IV, SE V and S V result because these offshore stations have sparse vegetation or nearly pure Thalassia communities with little unattached vegetation.

After January 1969 a washing technique was used in field sorting which made the collection of small mollusks and other animals more efficient. In this period 2,520 samples produced about 240,000 animals. Despite the lack of offshore stations which were found to be significantly below average producers in the first six months the differences in catches among stations were found to be significant ($Pr \leq .01$). Catches were above the average of 96 animals per tow at stations N III, S II and F and below average at stations SE I, S I, B, C, D, and G ($Pr \leq .01$). The above average catches were from stations with high catches of Laurencia. Of these stations N III was considered unaffected by temperature. Station S II was elevated about 2.4°C and Station F was elevated 1.9°C. Low catches were associated with higher temperatures. Thus station SE I was elevated 3.6°C, station S I was elevated 3.7°C and G was elevated 4.6°C. Low catches at stations B, C, and D appear to be related to the vegetation which was predominately Thalassia and therefore produced only between 2 and 4.5 lbs. of Laurencia and other algae per tow.

Although the total numbers of organisms showed no change or perhaps a slight increase up to a Δt of +2.4°C and a marked drop in numbers at stations elevated 3.5°C, it is of considerable interest to examine the individual natural groupings of animals involved. In cases where abundance permits or where the species is of economic importance, statistical evaluation of the dominant species follows.

Fishes were poorly represented in the trawl samples. The total fish catch, 7,478 individuals, comprised 2.23 percent of the total organisms collected. Although the trawl will not adequately collect the larger fast swimming species nor the snapper and grunt populations which prefer to congregate around rock ledges, coral heads, or submerged trees, gear selectivity is not the only reason for low abundance of fishes. Roessler (1965) Tabb and Manning (1961) and Tabb (unpubl.) have used the same gear and trawling techniques and have collected significant quantities of fishes. Observations made by diving to obtain an estimate of the efficiency of the gear in the Turkey Point area indicated few fishes were present.

Roessler (1965) indicated that night samples produced significantly greater numbers of fishes. Difficulties of navigation and sample handling preclude routine night sampling. However, series of day-night comparisons were made in the Turkey Point area during the summer of 1969. The results (Table 5) indicated no significant differences between day and night catches of fishes. However,

significantly more mollusks and crustaceans were collected at night. Other animals such as sponges and echinoderms were caught in equal abundance in daylight and night samples. Despite the greater abundance of mollusks and crustacea at night no species were caught which were not taken in daylight samples.

TABLE 5

NIGHT-DAY COMPARISON OF CATCHES AT 20 STATIONS AT TURKEY POINT

Taxa	No. species	Z	Pr.
Fishes	19	.28	.400 ns
Mollusks	57	2.63	.004 **
Crustaceans	19	2.61	.005 **
Porifera	8	.11	.460 ns
Echinoderms	8	.42	.340 ns

** Significantly different Pr. $\leq$ .01

Examination of fish catches in the period July - December 1968 indicated significantly higher than average catches (3.27 fish/tow) at station N V and lower than average catches at stations SE I and S I. The low catches at stations S I and SE I are probably the result of elevated temperatures and the resulting lack of algae and sea grasses (Table 2).

During the period January 1969 - June 1970 catches were above average (1.65 fish/tow) at stations N II, N III and F and below average at stations S I, S III, B, D, and G. Of these stations S I and G were in the thermal plume and elevated 3.7 and 4.6°C respectively. Stations B and D are located in Thalassia and produced little red algae (4.5 and 2.0 lbs/tow). The reason for low catches at S III is not known.

No fish comprised as much as 1% of the total catch of animals. The dominant species of fishes collected were Lucania parva, Micrognathus crinigerus, Opsanus beta and Gobiosoma robustum. These comprise 23, 16, 14, and 24 percent of the fishes caught respectively.

Lucania parva, the rainwater killifish occurred along the mainland shore particularly off the mouth of drainage canals. Eighty-nine percent occurred at stations along the north (N) transect or at stations NE I and NE II. These fish are known to prefer low salinity (Tabb and Manning 1961) and can occur over a wide salinity range (Roessler, 1970).

Micrognathus crinigerus, the fringed pipefish occurred at all stations but was most abundant at the mid-bay stations with large amounts of Laurencia. Catches at stations SE II, SE III, NE II and NE III comprised 50 percent of the total catch. Catches were low at stations N II and N V probably due to freshwater and at stations SE I, S I and G due to temperature elevations associated with the thermal discharge. Catches were also low at stations NE V, SE V, S IV and S V because of the low abundance of red algae at these outer stations.

Opsanus beta, the Gulf toadfish is known to hybridize with O. tau in Biscayne Bay (Schultz and Reid, 1937) and some of the 1083 specimens may have been O. tau or hybrids but the majority were O. beta. They were most abundant at stations with large catches of red algae Laurencia or Digenia.

Stations N III, N V, and F produced 47 percent of the specimens. No Opsanus were taken at station G elevated 4.6°C above ambient and catches were low at stations S I and SE I, elevated 3.7 and 3.6°C respectively. Catches were also low at stations NE IV, NE V, SE IV, SE V, S V and B. The first five of these are offshore stations which had little red algae. The reason for low catches at B is not known but may be related to poor water circulation.

The most abundantly collected fish was Gobiosoma robustum the code goby. Catches at stations N III, N V and F produced 57 percent of the 1783 specimens collected. No Gobiosoma were taken at NE V, SE V, or S V. Catches were low at NE IV, S III, S IV, C, D, and E which had little red algae and at stations SE I, S I, and G which were elevated over 3.5°C. Catches at station S II elevated 2.4°C were normal. Catches at stations A, F, and H, elevated 1.5, 1.8 and 1.5°C, were also close to average. Thus it appears that the critical temperature for Gobiosoma robustum is between 2.5 and 3.5°C above ambient.

Other fishes collected included silver perch Bairdiella chrysura, sheepshead Archosargus probatocephalus, barracuda Sphyraena barracuda, sea trout Cynoscion nebulosus, snappers Lutjanus analis, L. apodus, L. griseus, L. jocu, L. synagris, pinfish Lagodon rhomboides, gag Mycteroperca microlepis, grunts Orthopristis chrysopterus and Haemulon spp. and flounder Paralichthys albigutta which have some value as pan or sport fishes.

Of these only Lutjanus griseus and Lagodon rhomboides were common. Lutjanus griseus prefers rocks or stumps and was not adequately sampled. Nugent (1970) has conducted studies on this species within the effluent canal system and found gray snapper to be relatively temperature tolerant. They migrate from the effluent canals only during the hottest period of summer.

Lagodon rhomboides does not appear to be adversly effected on an annual basis by the temperatures observed. Too few specimens were available to examine seasonal patterns. Nugent (1970) trapped these fish in the effluent canals. He found that pinfish were more abundant in the heated canal in winter and less abundant in summer than in his control station. The dependence of this species on the sea grasses or attached algae is well documented and (Caldwell 1957; Darnell, 1958 and Springer and Woodburn, 1960) indicated that these fishes feed on vegetation.

Mollusks were the most abundant group of animals in our collections. We obtained 178,315 individuals comprised of 147 species. This represented 53 percent of the total animal catch. Brachiodontes exustus and Bittium varium were excluded from the counts.

Analysis of the mollusk data indicated a significant difference in catches among stations during the period July - December 1968. Catches were above the average of 21.7 mollusks per tow at N V and SE III. Catches were low at stations NE V, SE I, SE V, S I and S V (Pr $\leq$ .05). The high catches at stations N V and SE III correspond with high catches of red algae Digenia simplex and Laurencia poitei. The mollusk catch at station N V was comprised mostly of Crassostrea virginica, Amydalum papyria and an unidentified hydrobiid gastropod which were abundant in July when the salinity was 12 ppt and 36 lbs/tow of algae, mostly Digenia, was taken. The high abundance of individuals and lack of variety of species indicated the unstable conditions which were due to the Moody Canal discharge. In the following months the Digenia was killed by fresh water and later replaced by Laurencia.

Low catches of mollusks were related to low catches of algae (Table 2). The low abundance of algae at stations S I and SE I can be attributed to the effluent which elevated temperatures +5.26 and 5.25°C during this period.

In the period January 1969 - June 1970 catches were above the average of 51 mollusks per tow at stations N III and F and below average at SE III, S I, B, C, D, and G. Again the high catches of mollusks were associated with high catches of algae and low mollusk abundance with low catches of algae. Station S I was elevated 3.7°C and station G was elevated 4.6°C. Stations SE III, B, D, and C were in areas where Thalassia was dominant and little Laurencia was taken.

Only three species of mollusks were taken which could be considered to be of commercial or sport fishery value. These were the oyster, Crassostrea virginica and the scallops Aequipecten irradians and A. gibbus nuculus. Several other species can be eaten but are either seldom used or rare in the area of study.

Aequipecten gibbus nuculus was represented by 26 specimens. Half of these occurred at station SE V near the Caesar's Creek Inlet and 92 percent were taken in mid-bay and eastern bay stations. This species appeared to prefer the more oceanic water found on the eastern side of the bay (See Lee and Rooth 1971).

TABLE 6

CATCH AND CATCH PER TOW OF AEQUIPECTEN IRRADIANS

Station	Number	C/E
N I	25	.15
N II	2	.01
N III	219	1.29
N IV	318	5.30
N V	4	.07
NE I	34	.20
NE II	49	.29
NE III	55	.32
NE IV	4	.07
NE V	0	.00
SE I	0	.00
SE II	175	1.03
SE III	179	1.05
SE IV	82	1.37
SE V	17	.28
S I	0	.00
S II	14	.08
S III	80	.47
S IV	119	1.98
S V	4	.07
A	6	.04
B	24	.19
C	10	.08
D	25	.20
E	43	.33
F	42	.33
G	0	.00
H	5	.04

$\bar{x} = .53$

$S_{\bar{x}} = .20$

95% C.I.=

$.13 \leq .53 \leq .93$

TABLE 7

CATCH AND CATCH PER TOW OF *LIMA PELLUCIDA*

Station	Number	C/E
N I	1	.01
N II	10	.06
N III	66	.39
N IV	24	.40
N V	1	.02
NE I	3	.02
NE II	28	.16
NE III	274	1.61
NE IV	14	.23
NE V	16	.27
SE I	12	.07
SE II	415	2.44
SE III	58	.34
SE IV	5	.08
SE V	1	.02
S I	6	.04
S II	79	.46
S III	190	1.12
S IV	9	.15
S V	41	.68
A	3	.02
B	4	.03
C	51	.40
D	29	.23
E	175	1.37
F	129	1.01
G	0	.00
H	14	.11

$\bar{x} = .42$

$S_{\bar{x}} = .11$

95% C.I. $= .20 \leq .42 \leq .64$

A. irradians was widely distributed throughout the study area. It was collected at all stations except NE V, SE I, S I and G.

These stations produced low catches of algae. Stations SE I, S I, and G were elevated more than 3.5°C and this increased temperature caused the algae to disappear from the area. Table 6 shows the catch per tow at each station. The average catch was .53 Aequipecten per tow. Stations N II, N V, NE IV, S II, S V, A, C, and H were below average while N III, N IV, SE II, SE III, SE IV, and S IV were high producers. In the first summer these animals were relatively abundant and appeared to migrate from the southern stations northward. Young specimens were taken in winter and appeared to migrate northward as they grew. After the first summer few adults were seen but this is not unexpected because the bay scallops are known to have extensive migrations and disappear from a region for extended periods of time.

The concentrations of oysters at station N V during the summer of 1968 was discussed earlier.

A list of all mollusks taken and the catches at each station was reported by Bader and Roessler (1971). The columbellids, Columbella mercatoria, Columbella rusticoides and juvenile Columbella spp (probably mostly C. rusticoides) were an important group which together comprise 1.26 percent of the animal catch. Catches were generally low at the inshore stations and high at mid-bay and eastern bay stations provided the red alga Laurencia was common. Thus the off shore stations NE V, SE IV, SE V, and S IV and S V produced low catches ($Pr \leq .05$) because of low algal abundance (Table 2). Stations heated more than 3.5°C ambient produced low catches of columbellids.

Tabb and Manning (1961) found these gastropods to be abundant in the Thalassia communities in the Everglades estuary. In the present study C. mercatoria was collected over a temperature range from 15 to 35°C with the highest catch per tow at 25°C. Columbella juveniles were taken in the range 16 to 39°C with the highest catch per tow at 35°C C. rusticoides was collected from 15 to 39°C with highest catches per tow at 26°C.

C. mercatoria was taken from 0 - 5 to 35 - 40 ppt with highest catch per tow occurring between 30 and 35 ppt. Columbella juveniles were observed from 5 - 10 to 35 - 40 ppt with maximum catch per tow at 35 - 40 ppt. C. rusticoides was observed from 10 - 15 to 35 - 40 ppt and had its highest catch per tow at 35 - 40 ppt. Data from Everglades estuary collected by Tabb showed C. mercatoria at a salinity of 34.2 ppt and a range of 8.9 to 60.4 ppt for C. rusticoides.

Lima pellucida, the Antillean lima was represented by 1658 specimens which comprised 0.49 percent of the animal catch. The catch per tow is shown in Table 7. The average catch per tow was 0.42. Lima were collected at all stations except G, which was elevated 4.5°C

above ambient and had virtually no macroalgae present. Catches were below average at stations N I, N II, N V, NE I, NE II, SE I, SE IV, SE V, S I, S IV, A, B, G, and H. Catches were above average at NE III, SE II, S III, SV, E and F. The distribution was spotty throughout the bay. Catches were low at stations G, S I, SE I elevated more than 3.5°C; catches at station S II (+2.5°C) were average and SE II (+0.75°C) were above average. Again this indicated a 3°C increase above ambient appeared to be the maximum allowable increase.

Lima pellucida was observed over a range of temperatures from 15 to 35°C with the highest catch per tow occurrring at 19°C. The salinity range was from 10-15 ppt to 35-40 ppt with the highest catch per tow at 20-30 ppt. Tabb (unpublished) found a salinity range of 24.6 to 54.8 ppt. in the Everglades estuary.

Triphora nigrocincta, the black-lined triphora, was represented by 1749 specimens which comprised 0.52 percent of the animals and 0.98 percent of the mollusks collected. This small gastropod was never collected at stations NE V, SE V, S I, S IV, and S V. These are mid-bay and eastern bay stations except for station S I which was elevated more than 3.5°C above ambient. The catch per tow for each station is shown in Table 8. Catches at stations N I, N II, N V, NE IV, SE III, SE IV, C, D, and G were below the mean of 0.47 Triphora nigrocincta per tow and catches were above average at stations N III, F and H. These stations elevated 0.2, 1.5 and 1.8°C respectively produced 80 percent of the specimens. Sixty-one percent came from F and H. Temperatures between 1 and 2°C above ambient therefore did not lower the crop of Triphora. Station S II elevated 2.4°C had near average catches and therefore 2.5°C did not appear critical. Station S I elevated 3.7°C produced catches significantly below average as did station G elevated 4.6°C. Therefore the critical temperature appeared to fall between +2.5 and +3.5°C. The catch rate of 0.18 T. nigrocincta at SE I elevated 3.5°C but still with some Laurencia indicated the importance of benthic macroalgae.

T. nigrocincta was collected over a temperature range from 16 to 35°C with the highest catch per tow at 18°C. The salinity range was 10-15 to 35-40 ppt with the highest catches occurring at 20-25 ppt. Tabb (unpublished) found that in the Everglades estuary these animals occurred over a range of 31.8 to 50.0 ppt.

Turbo castaneus, the chestnut turbin, was represented by 1884 specimens which comprised 0.56 percent of the animals caught; 1.1 percent of the mollusks. Two stations SE III and D which were shallow water, mid-bay stations characterized by deep sediments and dense Thalassia communities produced 87 percent of the specimens.

Tabb and Manning (1961) recorded this species only from Sandy Key Basin in the Everglades estuary. This was a relatively clear water, stable salinity station with Thalassia as the dominant vegetation. Thus the habitat preference in Biscayne Bay and the Everglades appears similar.

TABLE 8

CATCH AND CATCH PER TOW OF *TRIPHORA NIGROCINCTA*

Station	Number	C/E
N I	6	.03
N II	8	.05
N III	169	.99
N IV	46	.77
N V	1	.02
NE I	29	.17
NE II	88	.52
NE III	52	.31
NE IV	1	.02
NE V	0	.00
SE I	31	.18
SE II	24	.14
SE III	3	.02
SE IV	3	.05
SE V	0	.00
S I	0	.00
S II	66	.39
S III	42	.25
S IV	0	.00
S V	0	.00
A	63	.40
B	22	.17
C	7	.05
D	3	.02
E	20	.16
F	564	4.41
G	3	.02
H	498	3.89

$\bar{x} = .47$

$S_{\bar{x}} = .20$

95% C.I. = $.07 \leq .47 \leq .87$

Turbo was collected over a range of temperature from 16°C to 39°C with the highest catch per tow occurring at 17°C. The salinity range was 5 - 10 to 35 - 40 ppt with highest catches between 25 - 35 ppt.

The crustaceans were the second most abundant group of animals in our collections. We obtained 111,179 specimens comprised of 66 species. This represented 33 percent of the animal catches. No isopods or amphipods were counted or identified although they contributed significantly to the Biscayne Bay productivity.

Analysis of the crustacean catch data indicated significant differences in catch among stations during the period July - December 1968 ($Pr \leq .01$). Catches at N II, NE IV, NE V, SE I, S IV, and S V were below the mean catch of 27.5 mollusks per tow. Station N II located off the mouth of Florida City Canal, experienced periods of low salinity. Stations SE I and S I were elevated 5°C above ambient. The remaining stations were eastern bay stations which produced little red algae and low numbers of animals.

Catches were above average at stations N I, N IV, N V, NE I, NE II, SE II, and SE III. These were generally inshore stations which also had high catches of the red algae Laurencia or Digenia. The high catches at station N V (off Moody Canal) were primarily the result of Alpheus heterochaelis, Neopanope packardii, Pagurus bonairensis, Palaemonetes intermedius and Hippolyte pleuracantha which were abundant in July - September, 1968, when N V was covered with dense stands of Digenia simplex. The remaining stations with high catches generally had high catches of Laurencia poitei (Table 2). During the period January 1969 through June 1970 the mean catch per tow of crustaceans for the 20 stations was 39.8. Catches were below average ($Pr \leq .05$) at stations N II, SE I, S I, A, B, D, E, and G. Station N II was subjected to lowered salinities, stations SE I, S I and G were subjected to temperatures elevated more than 3.5°C above ambient and stations A, B, D, and E were Thalassia stations with little red algae or sponge cover. Catches were significantly above average at stations N III, NE I, NE II, NE III which produced high catches of Laurencia and at stations SE II, S II and F which were heated between 0.7 and 2.4°C above ambient and also produced sizeable catches of Laurencia poitei.

Several crustaceans of economic value were collected during the study. These included the blue crab Callinectes sapidus, stone crab Menippe mercenaria, spiny lobster, Panulirus argus, and shrimps of the genus Penaeus. Most of the penaeid shrimp collected were juveniles (less than 10 mm carapace length) which are difficult to identify to species. P. aztecus, P. braziliensis and P. duorarum were the dominant species. The portunid crabs of the genus Callinectes were also represented by several species including C. sapidus, C. ornatus, C. similus and juveniles which were not

identified to species. Other swimming crabs of this family, Portunus depressifrons, P. gibbessi, P. spinimanus and P. sebae were collected but were uncommon. Most of the Portunus were collected at mid-bay or eastern bay stations.

The average catch of C. sapidus was 0.034 blue crabs per tow. Catches were above average at stations N II, SE I, S I and G. Station N II was influenced by freshwater discharge from Florida City Canal and stations SE I, S I, and G were in the path of the effluent and averaged more than 3.5°C above ambient. Thus it appears that the heated effluent does not adversely affect catches of blue crabs. Catches were generally high along the shoreline and low in mid-bay or in the more oceanic regime near the Florida Keys.

Other members of the genus Callinectes showed a similar trend. C. similis occurred in greatest abundance at the three stations (SE I, S I, and G) elevated more than 3.5°C. Catches were above the average of 0.26 Callinectes spp. per tow at stations N V, SE I, S I, and G (Table 9). Station N V was influenced by freshwater runoff while stations SE I, S I and G were off the effluent canal and averaged more than 3.5°C above ambient.

The genus Callinectes appears to prefer shoreline habitats along the mainland shore and is replaced at the Florida Keys stations by various members of the genus Portunus. This was also apparent in more northern areas of Biscayne Bay (Park, 1969).

Only 38 Menippe mercenaria were collected and these were all juveniles. Adult stone crabs burrow in soft mud in Thalassia beds or hide in rocky areas. Therefore they were not adequately sampled by the trawl gear. During a fish kill in the effluent canal (Hagan & Purkerson, 1970) reported that numerous stone crabs were killed by temperature in excess of 37°C. Thorhaug et al. (1971) have experimentally determined lethal limits for juvenile and larval stone crabs and these were: eggs, 36.3-38.5; first zoea, 34.4-36.0; second zoea, 33.1-34.2; fifth zoea, 34.7-35.5; megalopa, 36.0-37.0; juveniles, 28.9-30.5.

The commercially valuable shrimp of the genus Penaeus were represented by 7 P. aztecus, 4 P. braziliensis, 254 P. duorarum and 594 undetermined juveniles most of which were probably P. duorarum. Costello and Allen (1966) discussed the occurrence of other Penaeids in bait catches in Biscayne Bay. The nocturnal habits of these shrimps makes our estimates minimal but since all areas were fished equally the relative numbers should reflect trends in distribution. The catch of each species and catch per tow of the total penaeid catch is shown in Table 10. Catches were above the average of 0.22 shrimp per tow at stations N V, SE I, and S I. Catches at station G fell within

TABLE 9

CATCHES OF CALLINECTES BY SPECIES AND STATION AND CATCH/TOW OF C. SAPIDUS AND C. SPP.

Station	C. ornatus	C. sapidus	C. similis	C. Juv.	Total	Effort	C/T 1/	C/T 2/ and Total
N I	38	9	0	9	56	170	.059	.33
N II	31	19	0	2	52	170	.112	.31
N III	6	5	0	5	16	170	.029	.09
N IV	2	0	0	0	2	60	.000	.02
N V	27	2	2	8	39	60	.017	.65
NE I	33	4	0	24	61	170	.024	.36
NE II	23	7	0	22	52	170	.041	.31
NE III	29	0	1	6	36	170	.000	.21
NE IV	3	0	0	0	3	60	.000	.05
NE V	2	0	0	0	2	60	.000	.02
SE I	89	41	2	35	167	170	.241	.98
SE II	11	3	0	4	18	170	.018	.11
SE III	18	0	1	6	25	170	.000	.15
SE IV	0	0	0	0	0	60	.000	.00
SE V	4	0	0	0	4	60	.000	.07
S I	131	30	6	61	228	170	.176	1.34
S II	28	6	2	11	47	170	.035	.28
S III	20	2	0	1	23	170	.012	.14
S IV	11	0	0	0	11	60	.000	.18
S V	0	0	0	0	0	60	.000	.00
A	3	4	0	0	7	156	.026	.04
B	0	1	0	0	1	128	.007	.01
C	18	0	1	4	23	128	.000	.18
D	0	0	0	2	2	128	.000	.02
E	0	0	0	0	0	128	.000	.00
F	27	5	1	13	46	128	.039	.36
G	40	12	14	11	77	128	.094	.60
H	22	3	0	22	47	128	.023	.37
Total	616	153	30	246	1045	3572		

C. sapidus
$\bar{x}$ = .034
$S\bar{x}$ = .011
95% CI =
.01 ≤ .03 ≤ .05

C. spp.
$\bar{x}$ = .26
$S\bar{x}$ = .06
95% CI =
.14 ≤ .26 ≤ .38

1/ C. sapidus 2/ C. spp.

TABLE 10

CATCHES OF *PENAEUS* BY STATION AND C/E OF PENAEIDS

Station	*P. aztecus*	*P. braziliensis*	*P. duorarum*	*P.* spp. Juveniles	Total	Effort	C/E	
N I	0	0	1	9	10	170	.059	
N II	0	0	19	37	56	170	.329	
N III	2	0	9	21	32	170	.188	$\bar{x}$ = .22
N IV	0	0	2	6	8	60	.133	$S\bar{x}$ = .07
N V	0	1	4	35	40	60	.667	95% CI =
NE I	0	0	4	22	26	170	.153	.09 $\leq$ .22 $\leq$ .35
NE II	0	1	2	5	8	170	.047	
NE III	0	0	4	8	12	170	.071	
NE IV	0	0	1	2	3	60	.050	
NE V	0	0	0	2	2	60	.033	
SE I	0	0	44	95	139	170	.818	
SE II	0	0	4	8	12	170	.071	
SE III	1	0	1	11	13	170	.076	
SE IV	0	0	0	3	3	60	.050	
SE V	1	0	1	2	4	60	.067	
S I	0	0	85	204	289	170	1.700	
S II	0	0	6	14	20	170	.118	
S III	1	0	5	27	33	170	.194	
S IV	1	0	7	9	17	60	.283	
S V	0	0	1	0	1	60	.017	
A	0	0	5	3	8	156	.051	
B	0	1	14	2	17	128	.133	
C	1	0	7	2	10	128	.078	
D	0	0	2	0	2	128	.016	
E	0	0	4	3	7	128	.055	
F	0	0	6	8	14	128	.109	
G	0	1	6	32	39	128	.304	
H	0	0	10	24	34	128	.266	
Total	7	4	254	594	859			

the 95% confidence interval. Elevated temperatures did not reduce the catches of shrimp unless the heated sediments prevented burrowing and made the shrimp more available to daylight samples. The low catches at mid-bay and eastern bay stations probably reflects the distribution of bottom sediment. The offshore stations are characterized by solid coraline rock outcroppings which are not suitable for burrowing.

Thorhaug et al. (1971) experimentally established critical upper temperatures for larval and postlarval shrimp. These were: nauplii, 30.5-31.5; first protozoea, 36.0-37.6; third protozoea, 36.8-37.8; third mysis, 36.8-37.8; first post larvae, 37.9-40.7; juvenile, 36.3-38.5. However, since shrimp do not enter the estuary before they are advanced postlarvae temperature does not appear to be critical.

A total of 6291 sponges were collected. These were comprised mainly of Chondrilla nucula, the chicken liver sponge, which will be analyzed below and an unidentified brownish sponge which can survive in salinity below those usually tolerated by marine sponges. The greatest diversity of sponges occurred at the offshore stations.

A non parametric analysis of variance indicated a significant difference in the catch of sponges among the 20 stations sampled from July-December, 1969. Sponges were absent from inshore stations N II, N III, SE I, S I, S II and S III. Except for the last two stations, these were all located along the shoreline and were subjected to salinity fluctuations beyond the range tolerated by marine sponges. The few sponges taken in the inshore area were the chicken liver sponge, Chondrilla nucula, the "brown bay sponge", the fire sponge Tedania ignis or drifting sponges of other species usually found attached in mid-bay stations. Sponge catches were above average at stations NE IV, S IV and S V. These stations were far enough from the mainland to receive little influence from runoff and were generally subjected to oceanic water exchange through the tidal passes (See Lee and Rooth, 1971).

During the period January, 1969-June, 1970 there were differences in catches among stations. Sponges were collected at each of the 20 stations except S I, and were significantly below the average catch of 1.96 sponges per tow at the inshore stations N II, SE I, B and G. Station N II was subjected to freshwater discharge from Florida City Canal and SE I, S I and G were in the power plant discharge. Station B was located in the bight south of Turkey Point and received little circulation by water currents. The remaining inshore stations including N I, N III, NE I, NE II, NE III, SE II, S II, A and H produced catches which fell within the 95 percent confidence interval and therefore it is felt that fresh water

and heated discharge reduced the catches of sponges. Catches were above average at D and F and these high catches were primarily due to the chicken liver sponge Chondrilla nucula.

During the study about 6 - 12 commercial sponge boats worked in Biscayne Bay and Card Sound. They fished the mid-bay region from the Featherbed Banks through Card Sound. The shallows near Featherbed Bank and near the Arsenicker Keys and areas close to the Florida Keys were most frequently exploited. The principle species landed were grass sponge, Spongia graminea; glove sponge, Spongia cheiris; and Hippiospongia lachne, the wool sponge. Although these sponges were occasionally taken in trawl samples, sparse collections and intolerance of the low salinity found near the effluent precludes determination temperature effects on the individual species except for Chondrilla discussed later. The work by Storr (1964) should be consulted for temperature affects on sponge growth and reproduction. Additional studies on sponges in Card Sound are in progress to determine tolerance limits.

Coelenterates, mostly corals and alcyonarians, were present and comprised about 0.10 percent of the catch. The firmly attached corals and alcyonarians are not adequately sampled by trawls. Mr. L. Purkerson is studying these animals and additional studies have been reported by Clark, Joy, and Rosenthal (1970) for specimens located near a desalinization plant in Key West which also discharges heated effluents. The work of Mayer (1914) should also be consulted.

In general the corals and alcyonarians were more abundant in the eastern half of the bay and scarce on the western side. This reflects the salinity tolerances of these animals. An attempt to predict optimal and exclusion temperatures is important because in Card Sound, the proposed discharge site, these forms occur close to the mainland shore due to the lower runoff into Card Sound and consequent stable salinity. None of the species were of commercial value and none were taken in sufficient numbers to warrant separate discussion.

Echinoderms were represented by 8079 individuals comprised of 23 species. They represented 2.4 percent of the animal catch. During the period July - December, 1968, the mean catch for the 20 stations was 3.56 echinoderms per tow. Echinoderms were absent from stations N I, N II, N V and SE I. Catches were low at N IV, NE II, NE V, SE I, SE IV and S I ($Pr \leq .05$). These are generally inshore stations which are subjected to wide ranges of salinity. The low catches at NE V may reflect the low amount of vegetation and sponges which appear to be habitats favored by echinoderms.

The reasons for low catches at SE IV are unknown. Catches were above average at stations N IV, NE IV, SE II, SE III, SE V, S II and S IV (Pr $\leq$ .05). These stations are located in the middle or eastern part of the bay except for N IV, SE II, and S II where most of the echinoderm catch consisted of the small holothurian Leptosynapta parviaptina.

Analysis of catch data for the 20 stations occuppied from January, 1969 - June, 1970 indicated differences in catches among stations (Pr $\leq$ .01). The mean catch was 1.54 echinoderms per tow. The reduction in catch per effort from that observed in the period July - December, 1968, reflected the concentration of stations in the inshore region and deletion of offshore stations. Catches were below average at stations N I, N II, N III, NE I, SE I, S I, S II, A, B, F and G which were inshore stations. Stations G, S I, SE I, S II and F were in the effluent plume but the widespread low abundance near the mainland shore indicated salinity was the controling factor, Catches were high at offshore stations NE II, SE II, SE III, S III, C and E which generally produced relatively high catches of vegetation and had stable salinity conditions.

A considerable bank of data exists on the sea urchins of the Miami area due to the long term studies of Dr. H. B. Moore and many of his students. The most common urchin in southern Biscayne Bay is Lytechinus variegatus. This urchin comprised 9 percent of the echinoderm catch. Ninety-eight percent of the Lytechinus were taken at four eastern bay stations (NE V, SE V, S IV and S V). They appeared to prefer areas of stable salinity averaging near 35 ppt and only areas where Thalassia was present.

The starfish Echinaster sentus comprised 14 percent of the echinoderms. This starfish appeared to avoid areas of extreme salinity variations and was most commonly captured in dense Laurencia stands. The brittlestar Ophiactis savignyi comprised 14 percent of the echinoderm catch. It was most commonly caught in Laurencia stands where salinity changes were not extreme.

The remaining taxa including Platyhelminthes, Tunicata and Bryozoa were taken too infrequently and were too few in number (i.e., they represent about 0.08 percent of the animal catch) to be discussed further.

The dominant species in order of decreasing abundance were hermit crab, Pagurus bonairensis; the lunate dove shell, Mitrella lunata; the caridean shrimp, Thor floridanus; the fly-speckled cerith, Cerithium muscarum; the Atlantic modulus, Modulus modulus; the striate bubble shell, Bulla umbilicata; a second cardiean shrimp, Hippolyte pleuracantha; the checkered pheasant shell, Tricolia affinis; the worm shell gastropod, Vermicularia spirata; Atlantic marginella, Prunum apicinum; the ivory cerith, Cerithium eberneum; the sea cucumber, Leptosynapta parviaptina; the paper mussel, Amygdalum papyria and the chicken liver sponge Chondrilla nucula.

These species were represented by 74,594 (22.3 per cent of total animal catch), 47,146 (14.0 per cent), 38,312 (11.4 per cent), 23,040 (6.9 per cent), 10,815 (3.2 per cent), 9.694 (2.9 per cent), 9.446 (2.8 per cent), 8.915 (2.7 per cent), 6,838 (2.0 per cent), 5,919 (1.8 per cent), 4,706 (1.4 per cent), 4,215 (1.3 per cent), 3,863 (1.2 per cent), 3,785 (1.1 per cent) and 3,686 (1.1 per cent) individuals respectively. Thus these 15 species comprised 76 per cent of the total catch and the remaining 339 species comprised only 24 per cent of the catch. Other dominant organisms, the mussel Brachiodontes exustus and the variable bittium Bittium varium, were not counted because of the difficulty of separating Brachiodontes spat from the red algae Digenia simples or because of the minute size and extreme abundance of Bittium varium.

The above nine species of mollusks, four species of crustaceans, one sponge and one echinoderm occurred in sufficient abundance to permit further analysis. Tables 11 and 12 show the sum of the transformed, data for each station for the periods July 1968 - December 1968 and January 1969 - June 1970 respectively with the 95 per cent confidence interval indicated in the last columns. Stations in which no individuals were taken were not included in the analysis of variance nor considered in calculating the 95 per cent confidence limits. The transformed catches for each month and each station were presented by Bader and Roessler (1971: Table V-3). A trend is obvious. Those stations which produced little algae had low catches of animals while those stations which had large populations of algae, mostly the red algae Laurencia spp. and Digenia simplex, produced high catches of animals.

In the first 6 months of the study station S I located in the thermal plume and 5.25 degrees above the ambient temperature recorded at station N III produced low catches of Cerithium muscarum (fly-speckled cerithium), Vermicularia spirata (worm shell gastropod), Hippolyte pleuracantha (caridean shrimp), Thor floridanus (caridean shrimp), and Pagurus bonairensis (hermit crab). Station SE I also elevated 5.25 by the thermal plume produced low catches of Bulla striata (striate bubble shell), Modulus modulus (Atlantic modulus), Vermicularia spirata, Hippolyte pleuracantha, Thor floridanus, Pagurus bonairensis and Leptosynapta parvipatina (small sea cucumber).

Stations N II and N V were located off the mouths of Florida City Canal and Moody Canal respectively. During the rainy season (August and September) salinity at these stations was lowered and at station N V the red algae Digenia simplex was killed leaving bare sand for several months. The area was later recolonized by Laurencia. At station N II the dominant vegetation was Diplanthera wrightii (Cuban shoal weed) which is a faster colonizer and more tolerant species of sea grass than the usual grass Thalassia testudinum (turtle grass).

The relatively stenohaline forms such as the sea cucumber Leptosynapta, chicken liver sponge, Chondrilla, checkered pheasant, Tricolia affinis and the gastropod Vermicularia spirata which is generally found partially inbedded in sponges were scarce or absent at these stations.

TABLE 11

SUMMARY OF CATCHES, Σ LOG (CATCH + 1), FOR THE PERIOD JULY - DECEMBER 1968

Species	N I	N II	N III	N IV	N V	NE I	NE II	NE III	NE IV	NE V	95% Confidence Limits lower	upper
Amydalum papyria	0.60	1.20	0.60	0.90	43.20	0.00	0.30	0.00	0.00	0.00	0.42	8.82
Bulla umbilicata	2.90	11.53	7.82	11.24	4.38	9.74	8.95	3.42	0.90	1.50	1.68	10.08
Cerithium muscarum	8.84	9.31	12.27	8.68	12.44	10.84	8.53	8.25	1.50	1.00	3.36	13.44
Mitrella lunata	8.15	7.62	4.14	6.86	13.32	10.83	5.75	1.90	0.30	0.00	0.84	8.40
Modulus modulus	10.62	4.63	9.46	26.26	0.60	9.59	7.43	2.98	1.08	0.60	2.10	10.50
Prunum apicinum	5.52	6.39	3.15	2.58	3.76	2.28	1.68	1.30	0.00	0.00	0.00	7.56
Tricolia affinis	1.08	0.60	0.00	0.00	1.08	0.30	2.98	8.23	5.56	1.00	0.00	7.14
Vermicularia spirata	0.60	0.78	0.30	7.68	0.00	0.00	2.88	4.96	10.09	2.52	5.88	12.18
Hippolyte pleuracantha	15.14	12.43	7.39	5.40	6.94	13.84	11.67	3.16	1.08	0.00	0.84	9.24
Thor floridanus	26.14	7.70	16.25	24.96	1.50	26.47	34.58	27.83	12.18	4.68	10.92	26.88
Neopanope packardii	18.56	1.85	18.93	30.97	52.96	20.78	28.09	18.47	8.26	1.98	8.82	21.42
Pagurus bonairensis	49.31	17.44	44.53	55.38	13.53	44.43	48.27	30.57	17.69	1.64	17.64	34.44
Chondrilla nucula	0.00	0.00	0.00	0.30	0.30	0.60	4.90	2.04	0.00	0.00	0.00	3.36
Leptosynapta parvipatina	0.00	0.00	0.90	16.83	0.00	5.33	9.46	7.45	7.95	2.58	2.94	14.70

Species	SE I	SE II	SE III	SE IV	SE V	S I	S II	S III	S IV	S V	95% Confidence Limits lower	upper
Amydalum papyria	0.60	0.30	0.00	0.00	0.00	0.60	0.78	0.30	0.00	0.00	0.42	8.82
Bulla umbilicata	0.30	10.99	6.97	0.60	0.00	3.81	18.90	3.30	1.80	0.00	1.68	10.08
Cerithium muscarum	9.00	15.88	14.23	4.94	0.30	1.68	29.10	7.03	6.52	0.30	3.36	13.44
Mitrella lunata	5.72	0.90	0.90	0.30	0.00	4.79	2.58	0.90	0.30	0.00	0.84	8.40
Modulus modulus	1.68	6.44	15.57	3.34	0.30	2.64	14.00	2.28	5.10	0.60	2.10	10.50
Prunum apicinum	0.60	4.38	12.94	0.00	0.00	0.30	7.30	0.60	0.00	0.00	0.00	7.56
Tricolia affinis	0.78	5.74	15.69	6.32	0.90	0.78	0.30	1.80	1.68	0.90	0.00	7.14
Vermicularia spirata	0.90	29.01	8.62	2.28	1.30	2.28	31.81	13.53	21.70	2.38	5.88	12.18
Hippolyte pleuracantha	0.60	3.70	4.54	0.30	0.00	0.60	0.78	0.00	0.30	0.30	0.00	9.24
Thor floridanus	5.89	41.58	49.93	17.36	2.98	5.58	26.52	25.75	14.93	4.26	10.92	26.88
Neopanope packardii	9.98	15.57	19.85	3.78	0.78	9.19	16.18	4.68	3.60	0.00	8.82	21.42
Pagurus bonairensis	13.98	41.36	36.23	8.60	1.15	8.73	48.12	32.09	4.56	0.90	17.64	34.44
Chondrilla nucula	1.38	1.20	6.53	0.30	0.60	0.90	2.10	0.60	0.78	1.38	0.00	3.36
Leptosynapta parvipatina	0.00	29.10	13.25	6.84	0.48	0.60	16.13	21.65	1.68	3.06	2.94	14.70

TABLE 12

SUMMARY OF CATCHES, Σ LOG (CATCH + 1), FOR THE PERIOD JANUARY, 1969 - JUNE, 1970.

Species	N I	N II	N III	NE I	NE II	NE III	SE I	SE II	SE III	S I	95% Confidence Limits lower	upper
Amygdalum papyria	0.00	2.28	10.84	0.00	0.00	0.00	0.00	0.30	0.00	0.48		
Bulla umbilicata	37.98	40.51	54.00	89.73	54.19	12.96	17.98	23.31	16.82	5.65	21.42	44.10
Cerithium eberneum	3.01	8.82	4.55	0.60	2.76	13.08	12.16	25.14	5.46	1.08	5.04	20.16
Cerithium muscarum	62.98	102.36	151.97	44.02	59.71	13.94	79.53	25.08	33.64	19.61	41.58	66.78
Mitrella lunata	78.02	72.89	182.42	103.32	97.06	33.77	70.77	20.00	10.67	32.30	45.36	73.08
Modulus modulus	77.97	90.49	38.34	82.82	63.82	29.43	3.64	46.35	27.67	2.76	34.02	56.70
Prunum apicinum	29.46	76.37	84.52	30.07	24.61	14.85	11.59	15.91	7.42	0.78	17.64	35.28
Tricolia affinis	20.11	1.20	4.94	12.63	32.61	50.28	1.68	24.04	46.77	0.60	11.34	31.50
Vermicularia spirata	0.90	0.48	5.08	1.50	4.56	54.07	0.00	83.62	15.57	1.50	16.38	34.02
Hippolyte pleuracantha	87.46	61.85	99.93	92.94	94.29	35.37	11.42	22.44	16.61	2.76	30.24	52.92
Thor floridanus	30.07	4.56	70.92	59.57	112.70	110.35	13.78	121.58	85.82	4.68	51.66	81.90
Neopanope packardii	12.00	8.10	39.08	31.39	29.98	43.62	12.64	29.43	29.71	5.06	13.86	28.98
Pagurus bonairensis	152.03	95.18	195.33	167.36	176.62	150.45	65.41	134.86	103.10	46.26	98.28	128.52
Chondrilla nucula	1.38	0.60	3.33	1.68	1.90	9.45	2.88	27.95	20.87	0.00	10.08	25.20
Leptosynapta parvipatina	0.00	0.30	0.30	0.00	0.00	26.07	0.00	54.44	38.70	0.00	13.86	31.50

TABLE 12 (con't.)

Species	S II	S III	A	B	C	D	E	F	G	H	95% Confidence Limits lower	upper
Amygdalum papyria	0.90	0.00	0.00	0.30	0.00	0.00	0.00	0.30	0.00	0.60		
Bulla umbilicata	61.63	24.67	42.57	17.96	4.26	0.78	10.91	80.21	0.90	63.29	21.42	44.10
Cerithium eberneum	87.26	12.43	3.45	1.08	5.51	0.00	4.94	15.40	0.00	14.07	5.04	20.16
Cerithium muscarum	113.44	18.74	64.02	19.61	2.88	5.73	5.60	141.74	1.20	113.00	41.58	66.78
Mitrella lunata	102.82	22.62	61.31	50.23	5.86	4.44	3.88	134.17	3.24	94.86	45.36	73.08
Modulus modulus	83.79	18.18	65.36	50.53	14.16	3.66	14.78	96.79	0.00	49.52	34.02	56.70
Prunum apicinum	29.39	6.24	25.75	16.21	2.94	0.00	1.08	55.99	0.00	40.67	17.64	35.28
Tricolia affinis	12.07	32.88	15.06	12.76	30.71	46.17	33.32	27.23	0.90	10.53	11.34	31.50
Vermicularia spirata	58.05	72.25	1.20	11.99	33.02	7.09	49.80	31.49	0.00	10.45	16.38	34.02
Hippolyte pleuracantha	26.43	29.71	35.80	33.14	17.20	12.54	13.61	47.16	0.00	58.74	30.24	52.92
Thor floridanus	115.47	113.67	48.41	36.29	70.46	39.16	64.51	142.40	0.30	79.58	51.66	81.90
Neopanope packardii	42.69	12.97	7.24	6.69	21.94	8.24	5.76	62.58	0.78	18.13	13.86	28.98
Pagurus bonairensis	172.60	107.12	83.50	89.08	67.07	33.95	63.29	207.77	14.10	141.37	98.28	128.52
Chondrilla nucula	9.86	14.10	20.91	3.34	3.98	110.52	3.00	77.09	0.00	1.68	10.08	25.20
Leptosynapta parvipatina	10.10	56.25	0.00	2.94	44.13	10.79	42.16	0.60	0.00	3.76	13.86	31.50

Other animals which were closely associated with Laurencia were also significantly lower in the catches. This was especially noted for the caridean shrimp, Thor floridanus. Catches of the paper mussel shell, Amygdalum papyrium, the lunate dove shell, Mitrella lunata and the xanthid crab, Neopanope packardii were above average at N V, but the bulk of the catch was made during the summer when salinities were relatively normal and the station was covered with the red algae Digenia simplex.

Stations NE IV, NE V, SE IV, SE V, S IV and S V were midbay or offshore stations which had relatively stable salinity, only natural temperature fluctuations and little red algae. Their location off the nearshore sediment wedge which produces the greatest amount of benthic macroalgae probably led to the low catches of most animals.

Due to the differences in the offshore station populations and the desire to obtain better resolution of the effect of the thermal additions stations N IV, N V, NE IV, NE V, SE IV, SE V, S IV and S V were discontinued after December 1968 and stations A - H were added. At the same time an improved field sorting technique which retained more of the smaller organisms was initiated. Thus catches for the two periods are not equivalent and should be treated separately.

Stations SE II and S II elevated 2.25°C above the ambient control station temperature produced above average catches of Cerithium muscarum (fly-speckled cerith), Modulus modulus (Atlantic modulus), Vermicularia spirata (worm shell gastropod) and Thor floridanus (caridean shrimp).

In the analysis of data collected between January 1969 and June 1970, it was even more obvious that Tricolia, Vermicularia, Chondrilla and Leptosynapta were midbay or offshore forms, as was the ivory cerith Cerithium eberneum.

Amongst the typical inshore species there is a significant decrease in abundance of all species analyzed at station G which has an average temperature deviation of 4.5°C above the ambient measured at station D on Pelican Bank. Station S I elevated 3.5 degrees above the ambient also showed lowered catches of all species. Station SE I elevated 3.5° had reduced catches of all species except the ceriths, Cerithium eberneum, C. muscarum and the chicken liver sponge, Chondrilla nucula. All of the C. eberneum were taken in October, 1969 when the temperature was 28.5°C. All of the Chondrilla were taken during the winter and spring of 1969 when the temperature was low. C. muscarum occurred throughout the year and was apparently not killed or forced to emigrate. The presence of this cerith probably reflects the 3 lbs. per tow of vegetation taken at SE I. The algae seem to be essential to the cerith for food or shelter.

Catches of the mollusks of the sediment shelf; Bulla umbillicata, Cerithium muscarum, Mitrella lunata, Modulus modulus and Prunum apacinum were low at the stations located more than 1250 meters from

shore (NE III, C, D, E). The crustaceans Hippolyte, Thor, Neopanope and Pagurus although abundant at station NE II, were scarce at stations C, D and E. Station NE III produced more than 9 lbs. of algae per tow, while C, D and E in Thalassia beds produced considerably less. Thus these crustacea appear to depend on red algae for feed and shelter.

At stations S II, F and H which averaged 2.39°, 1.82° and 1.46°C respectively above the ambient temperature measured at station D the catches were significantly high. Station SE II, elevated + 0.74°C had above average catches of Cerithium eberneum, Neopanope packardii, Thor floridanum, Pagurus bonairensis, Chondrilla nucula and Leptosynapta parvipatina. Catches of Cerithium muscarum, Mitrella lunata, Prunum apacinum, Vermicularia spirata and Hippolyte pleuracantha were significantly low.

In all of the analysis of variance tests the interaction between months and stations was significant. For all species tested the catches were significantly different among stations. For all species except Tricolia affinis and Chondrilla nucula in the July 1968 - December 1968 period catches were different among months. Usually the differences in catch among stations was greater than that among months, (Tables 13 and 14).

In order to try to understand the interaction terms, graphs of the catches indicated by triangles and temperature represented by solid circles at selected stations were made for each species. For the striate bubble shell, Bulla umbilicata, catches were generally low in winter and high in summer, however the stations heated by 3.5°C or more produced low catches in summer (Figure 20). The catches of the ivory cerith, Cerithium eberneum were sporadic and no seasonal trends were evident. The fly-speckled cerith, Cerithium muscarum produced highest catches in spring, (Figure 21). At a number of control stations the abundance dropped in the 1969-70 winter and did not recover in the spring. Other stations did recover and this produces the significant interaction. The biological reasons are not apparent from the data. Catches of the lunate dove shell, Mitrella lunata, were generally highest during the months of January through May and lowest from August through November, catches increased at heated stations in winter and decreased in summer (Figure 22) but this trend was also evident at control stations. At station S I production fell below the control station NE I in March, 1969 when the heated station temperature was 31.3°C. At stations S II and H production fell below the control in July when the water temperature was 34.2 at S II and 35.0 at station H. After the low production period during the summer there was a lag after bay temperatures began to drop in which the catches at stations S II and H were below NE I until November. This lag probably reflects the period of time needed for the algae population to recolonize the area and for immigration and larval settlement of Mitrella.

Catches of the Atlantic modulus Modulus modulus (Figure 23) indicate that stations elevated 1.5 to 2.5°C above ambient produced high catches in summer while control station N III and station SE I elevated 3.5 did not.

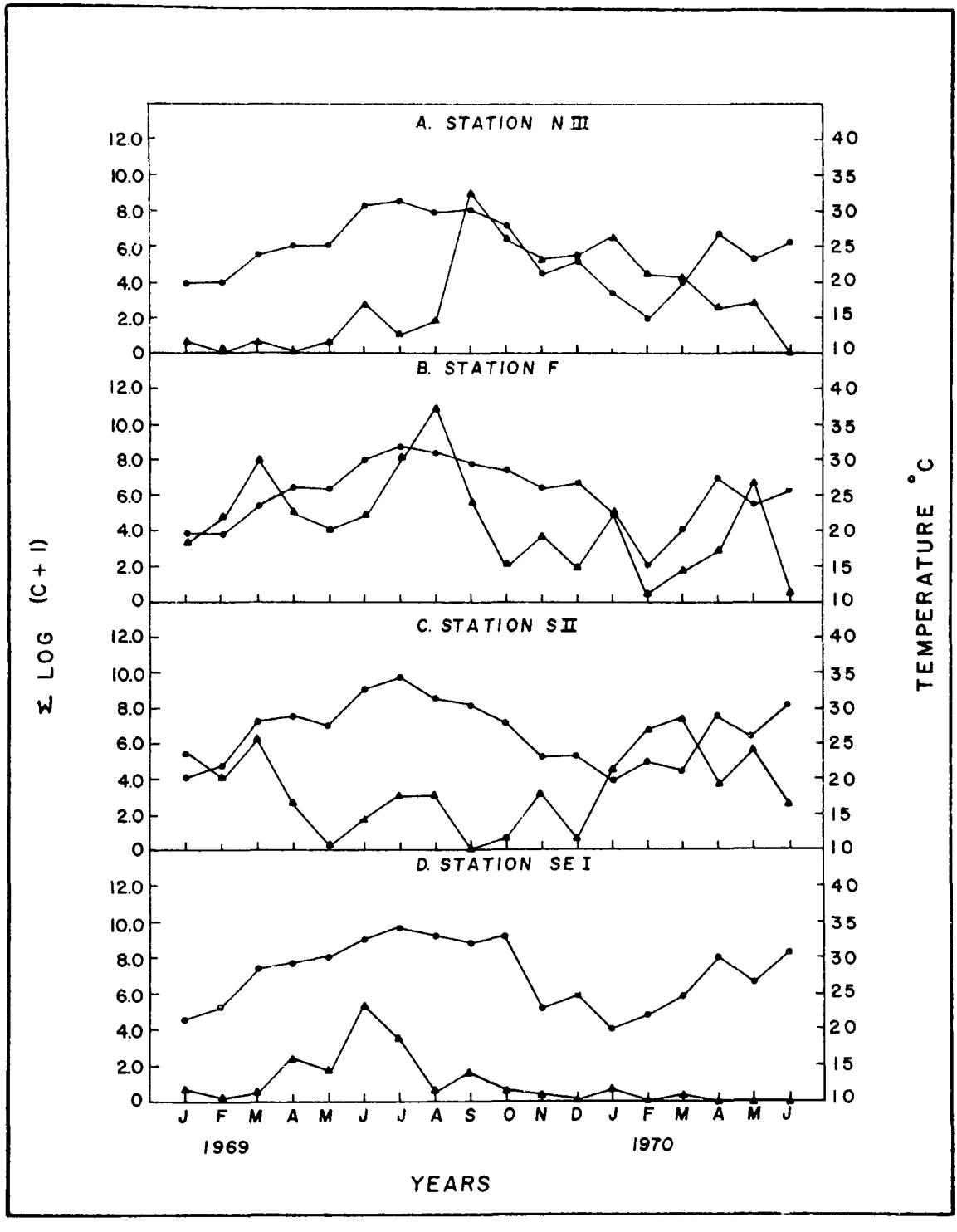

FIGURE 20. SEASONAL DISTRIBUTION OF BULLA UMBILICATA AT STATIONS A) N III B) F C) S II AND D) SE I

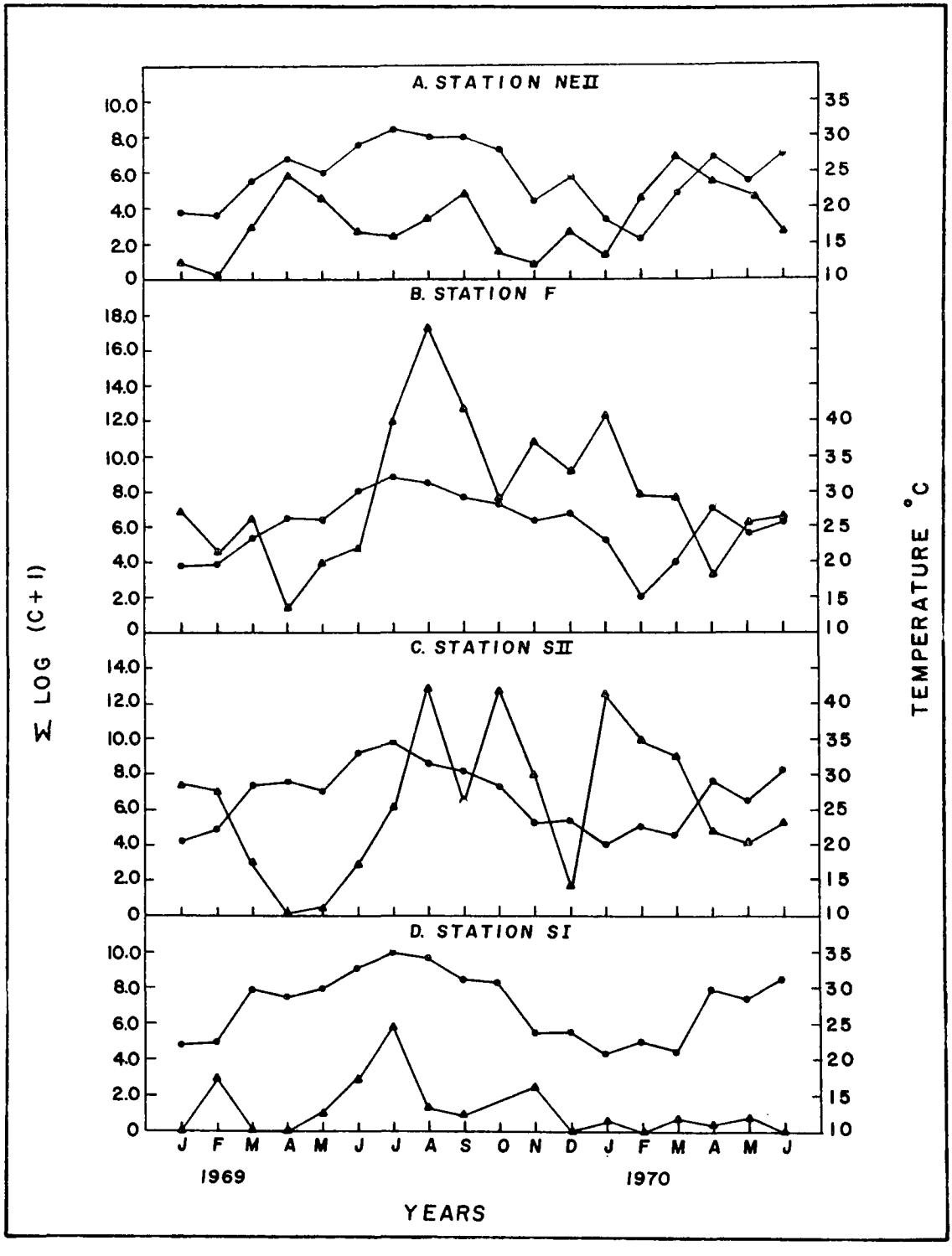

FIGURE 21. SEASONAL DISTRIBUTION OF CERITHIUM MUSCARUM AT STATIONS A) NE II B) F C) S II AND D) S I

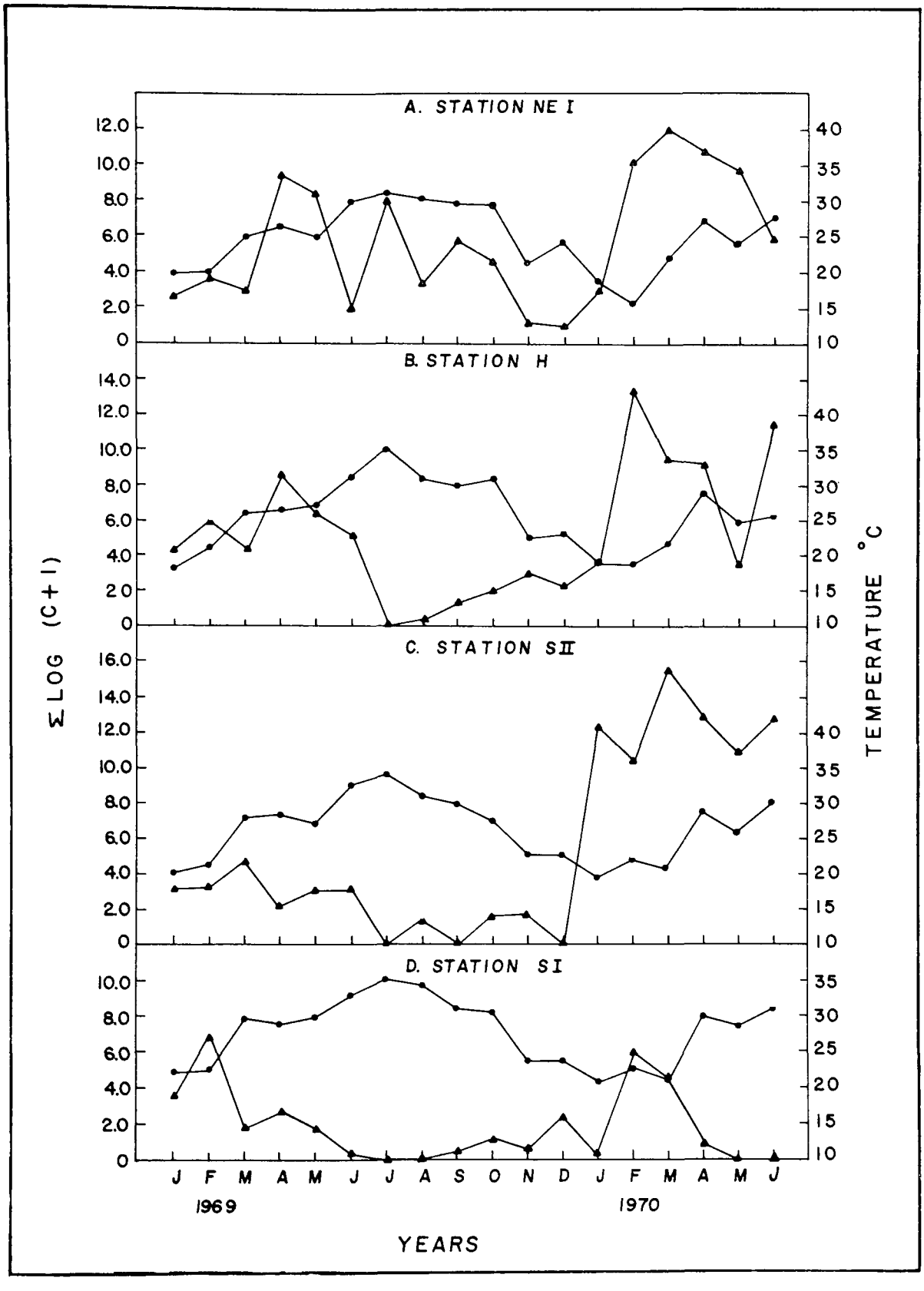

FIGURE 22. SEASONAL DISTRIBUTION OF MITRELLA LUNATA AT STATIONS A) NE I B) H C) S II AND D) S I

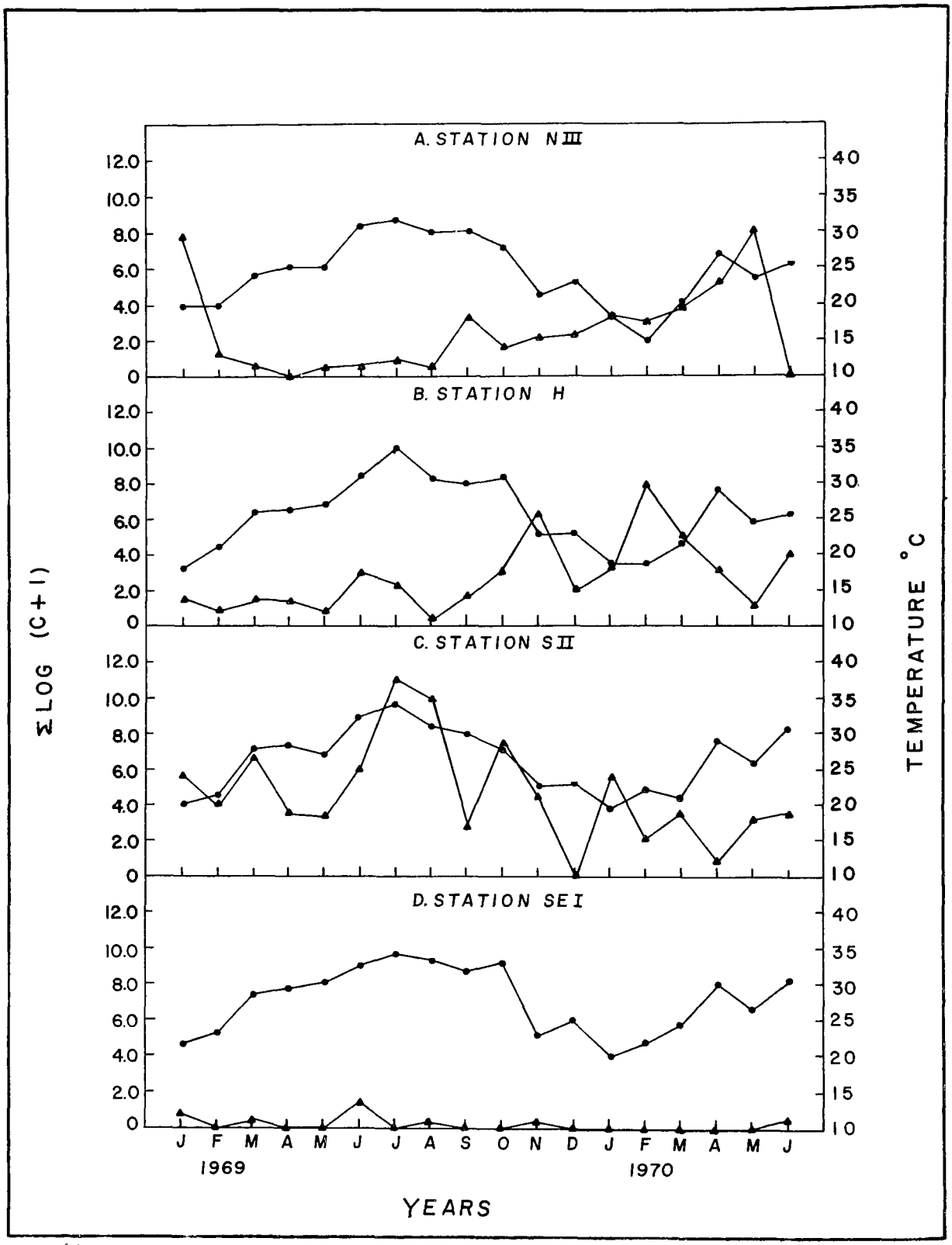

FIGURE 23. SEASONAL DISTRIBUTION OF MODULUS MODULUS AT STATIONS A) N III B) H C) S II AND D) SE I

TABLE 13

ANALYSIS OF VARIANCE AMONG MONTHS AND AMONG STATIONS.
JULY - DECEMBER, 1968.

Species	source	df	ms	F	F'
Amygdalum papyria	month	5	.33		5.50**
	station	10	3.93		65.50**
	month x station	50	.33	16.50**	
	error	396	0.02		
	error + inter.	446	0.06		
	Total	461	0.14		
Bulla umbilicata	month	5	.40		6.67**
	station	17	.61		10.17**
	month x station	85	.20	4.00**	
	error	648	.05		
	error + inter.	733	.06		
	Total	755	.08		
Cerithium muscarum	month	5	0.40		5.00**
	station	19	1.07		13.38**
	month x station	95	0.20	3.33**	
	error	720	0.06		
	error + inter.	815	0.08		
	Total	839	0.10		
Mitrella lunata	month	5	.25		6.25**
	station	16	.38		9.50**
	month x station	80	.13	4.33**	
	error	612	.03		
	error + inter.	692	.04		
	Total	713	.05		
Modulus modulus	month	5	.39		7.80**
	station	19	1.03		20.60**
	month x station	95	.10	2.50**	
	error	720	.04		
	error + inter.	815	.05		
	Total	839	.07		
Prunum apicinum	month	5	.34		8.50**
	station	13	.28		7.00**
	month x station	65	.12	4.00**	
	error	504	.03		
	error + inter.	569	.04		
	Total	587	.05		

TABLE 13 (con't)

Species	source	df	ms	F	F'
Tricolia affinis	month	5	.06		1.00ns
	station	17	.30		5.00**
	month x station	85	.28	9.33**	
	error	648	.03		
	error + inter.	733	.06		
	Total	755	.07		
Vermicularia spirata	month	5	.43		7.17**
	station	17	2.32		38.67**
	month x station	85	.15	3.00**	
	error	648	.05		
	error + inter.	733	.06		
	Total	755	.11		
Hippolyte pleuracantha	month	5	.56		11.20**
	station	16	.64		12.80**
	month x station	80	.19	6.33**	
	error	612	.03		
	error + inter.	692	.05		
	Total	713	.07		
Thor floridanus	month	5	4.55		22.75**
	station	19	4.47		22.35**
	month x station	95	.78	6.00**	
	error	720	.13		
	error + inter.	815	.20		
	Total	839	.34		
Neopanope packardii	month	5	.28		2.33**
	station	18	3.94		32.83**
	month x station	90	.35	3.89**	
	error	684	.09		
	error + inter	774	.12		
	Total	797	.21		
Pagurus bonairensis	month	5	1.19		5.67**
	station	19	8.54		40.67**
	month x station	95	.77	5.92**	
	error	720	.13		
	error + inter.	815	.21		
	Total	839	.44		

TABLE 13 (con't)

Species	source	df	ms	F	F'
Chondrilla nucula	month	5	.01		1.00ns
	station	14	.08		8.00**
	month x station	70	.02	2.00**	
	error	540	.01		
	error + inter.	610	.01		
	Total	629	.02		
Leptosynapta parvipatina	month	5	2.07		20.70**
	station	15	1.67		16.70**
	month x station	75	.34	4.86**	
	error	576	.07		
	error + inter.	651	.10		
	Total	671	.15		

F' tested against pooled error and interaction

** significant at 99% level

TABLE 14

ANALYSIS OF VARIANCE AMONG MONTHS AND AMONG STATIONS. JANUARY, 1969 - JUNE 1970

Species	source	df	ms	F	F'
Bulla umbilicata	month	17	1.64		12.62**
	station	19	5.70		43.85**
	month x station	323	.57	9.50**	
	error	2160	.06		
	error + inter	2483	.13		
	Total	2519	.18		
Cerithium eberneum [1]	month	11	1.91		21.22**
	station	17	2.48		27.56**
	month x station	187	.45	11.25**	
	error	1296	.04		
	error + inter.	1483	.09		
	Total	1511	.13		
Cerithium muscarum	month	17	2.00		11.76**
	station	19	18.44		108.47**
	month x station	323	.78	9.75**	
	error	2160	.08		
	error + inter	2483	.17		
	Total	2519	.32		
Mitrella lunata	month	17	4.70		23.50**
	station	19	19.53		97.65**
	month x station	323	.85	8.50**	
	error	2160	.10		
	error + inter.	2483	.20		
	Total	2519	.38		
Modulus modulus	month	17	1.96		16.33**
	station	18	9.78		81.50**
	month x station	306	.42	6.00**	
	error	2052	.07		
	error + inter.	2358	.12		
	Total	2393	.20		
Prunum apicinum	month	17	.56		6.22**
	station	17	4.75		52.78**
	month x station	289	.32	6.40**	
	error	1944	.05		
	error + inter	2233	.09		
	Total	2267	.13		

TABLE 14 (con't)

Species	source	df	ms	F	F'
Tricolia affinis	month	17	1.29		11.73**
	station	19	2.06		18.73**
	month x station	323	.39	5.57**	
	error	2160	.07		
	error + inter.	2483	.11		
	Total	2519	.14		
Vermicularia spirata	month	17	1.26		14.00**
	station	17	5.95		66.11**
	month x station	289	.27	3.86**	
	error	1944	.07		
	error + inter.	2233	.09		
	Total	2267	.15		
Hippolyte pleuracantha	month	17	2.11		17.58**
	station	18	7.85		65.42**
	month x station	306	.44	6.29**	
	error	2052	.07		
	error + inter.	2358	.12		
	Total	2393	.19		
Thor floridanus	month	17	4.16		16.64**
	station	19	15.14		60.56**
	month x station	323	.97	6.92**	
	error	2160	.14		
	error + inter.	2483	.25		
	Total	2519	.39		
Neopanope packardii	month	17	.64		10.67**
	station	19	2.18		36.33**
	month x station	323	.13	2.60**	
	error	2160	.05		
	error + inter.	2483	.06		
	Total	2519	.08		
Pagurus bonairensis	month	17	4.28		17.12**
	station	19	24.96		99.84**
	month x station	323	.96	6.40**	
	error	2160	.15		
	error + inter.	2483	.25		
	Total	2519	.46		

TABLE 14 (con't)

Species	source	df	ms	F	F'
Chondrilla nucula	month	17	.27		4.50**
	station	17	7.16		119.33**
	month x station	289	.13	2.60**	
	error	1944	.05		
	error + inter.	2233	.06		
	Total	2267	.11		
Leptosynapta parvipatina	month	18	.75		9.38**
	station	12	3.82		47.75**
	month x station	216	.28	5.60**	
	error	1391	.05		
	error + inter.	1607	.08		
	Total	1637	.11		

F' tested against pooled error and interaction

** significant at 99% level

[1] July 1969 - June 1970

Catches of the common Atlantic marginella, Prunum apicinum, (Figure 24) were high in spring at the control N II but these peaks were not as pronounced at heated stations. At station H elevated 1.5°C the catches dropped when temperature exceeded 32.5 and recovered in the fall when temperatures fell below 30°C. However, at station F elevated 1.8° the catches were highest in July when temperature was close to 35°C, at this time large quantities of detritus formed by dying Laurencia were present at station F. Thorhaug, Moore and Albertson (1971) have shown this gastropod to have a short term temperature tolerance up to 43°C in laboratory experiments. It is likely that exclusion occurs when the food and shelter gained from algae are destroyed. At station SE I elevated 3.5°C the catches dropped when temperatures rose above 32.5°C. The temperature remained above 32.5 from June through October, and although catches began to recover in December and January 1970, they did not recover to the extent noted in the previous year or at cooler stations.

Catches of the checkered phesant shell, Tricolia affinis, (Figure 25) were high in the winter and spring of 1969. At the control station NE II catches fell in July when temperature exceeded 30°C and salinity fell below 20 ppt. In September, when temperature fell below 30°C and salinity rose above 25 ppt the catches recovered. Catches decreased again in the winter of 1970 and remained low until the end of the study. Station F, averaging 1.8°C above the ambient measured at D, exhibited high catches in the winter and spring of 1969. In June when the temperature exceeded 30°C, the catches fell to zero. Recovery in the fall of 1969 was slight and only a slight increase was noted in the spring of 1970. Station S II averaging 2.4°C above ambient produced Tricolia during the winter and spring of 1969. In July the temperature reached 34.2°C above ambient and catches fell to zero, some recovery was observed in March - June, 1970. Stations averaging 3.5°C above ambient or more, produced only a few scattered individuals.

Like the above species the worm shell gastropod, Vermicularia spirata appeared to prefer offshore stations with stable salinity. Catches at the control station NE III were highest in winter and lowest in spring and early summer. At station SE II averaging 0.74°C above ambient catches were high in March 1969 fell in late spring, recovered in July and then declined steadily until the end of the project (Figure 26).

The caridean shrimp Hippolyte pleuracantha was most abundant in winter and less common in summer. At the control station, N I, catches were relatively high throughout the year (Figure 27). Low catches were recorded in May, October, and November, 1969 and in June, 1970. These low catches correspond to periods of low salinity. At station F averaging 1.8°C above ambient catches were higher in winter than in summer. In April when the temperature exceeded 25°C, the catches fell but specimens were collected in June when the temperature was 32°C.

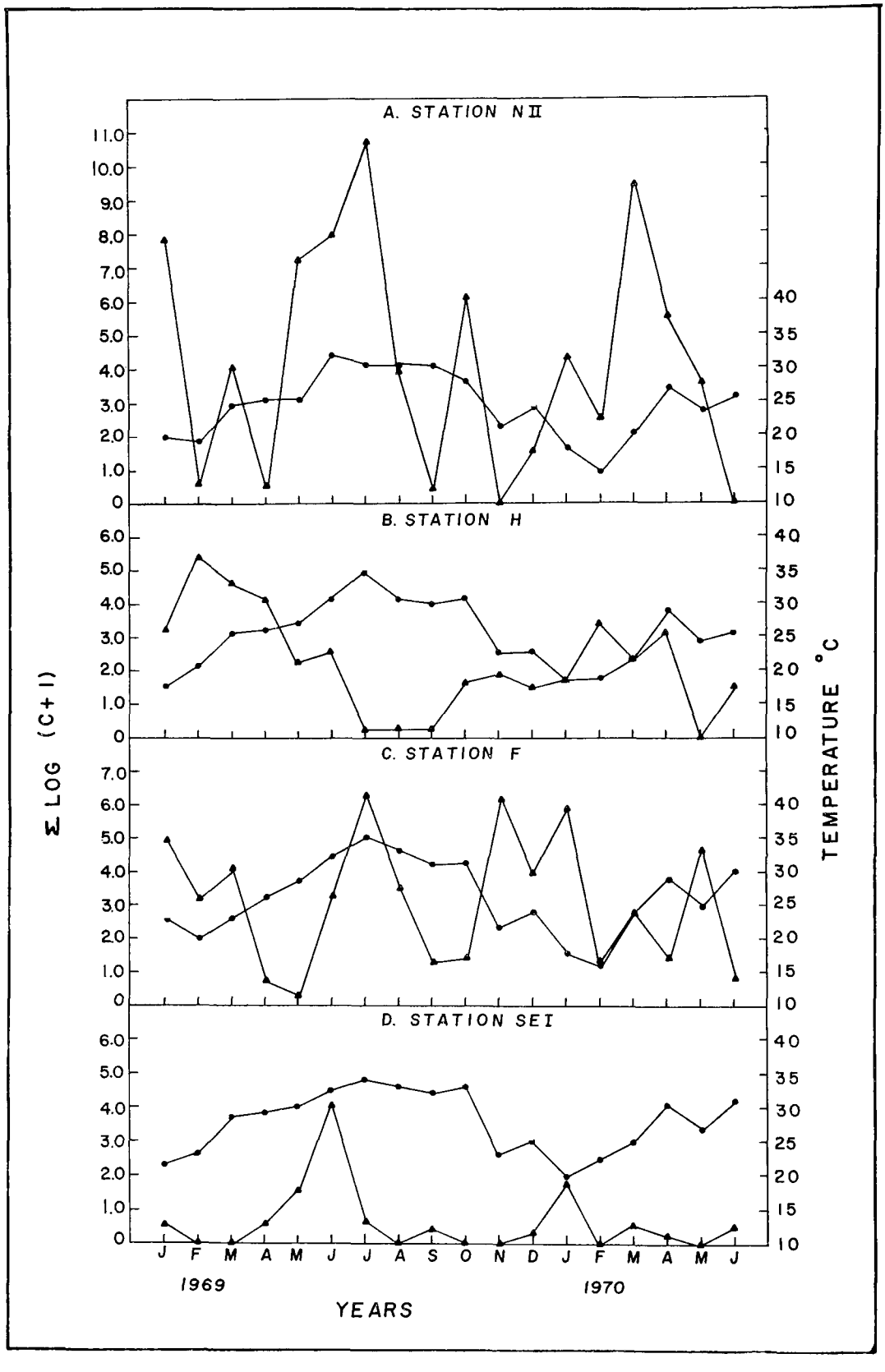

FIGURE 24. SEASONAL DISTRIBUTION OF PRUNUM APICINUM AT STATIONS A) N II B) H C) F AND D) SE I

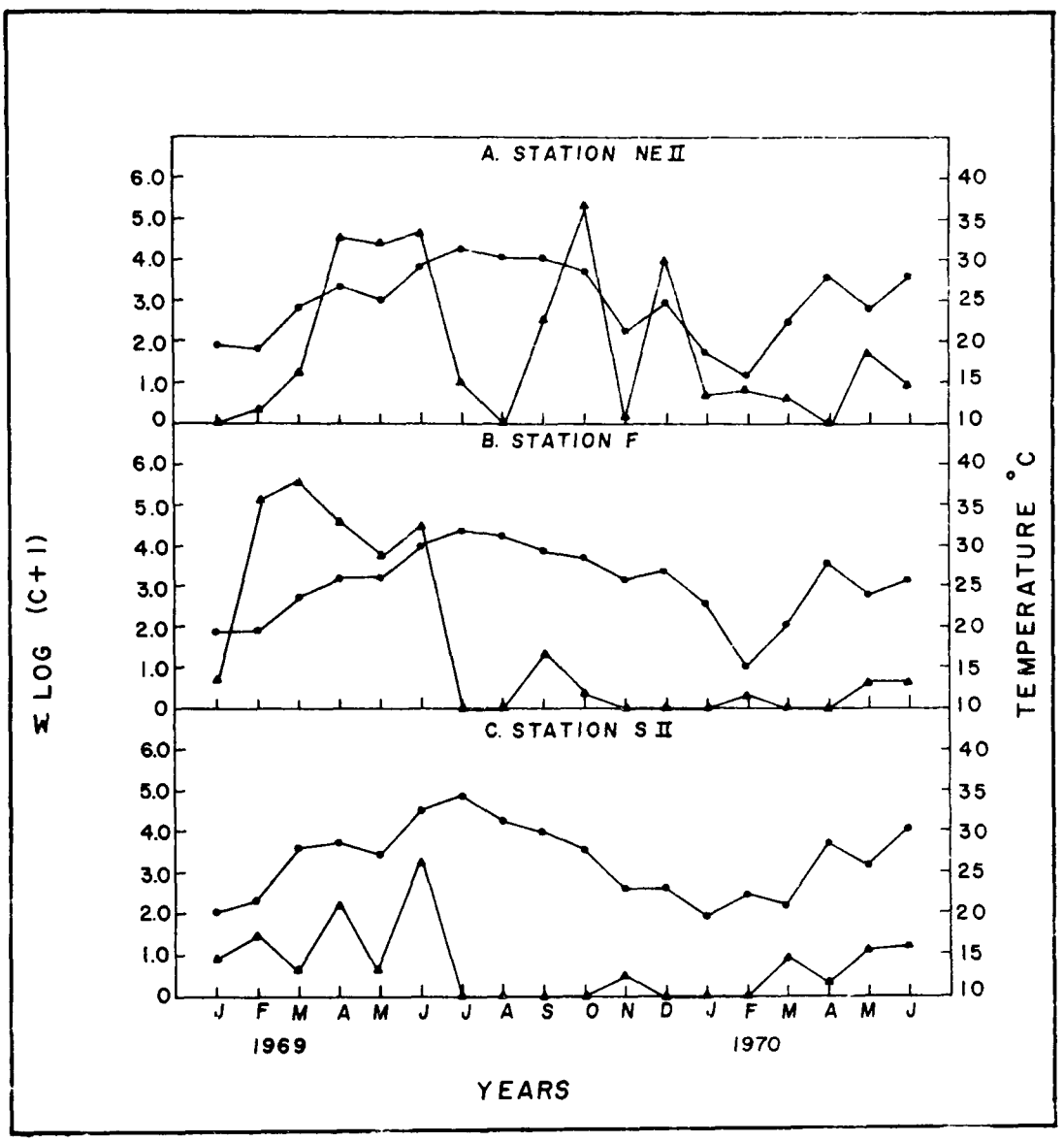

FIGURE 25. SEASONAL DISTRIBUTION OF TRICOLIA AFFINIS AT STATIONS A) NE III B) F AND C) S II

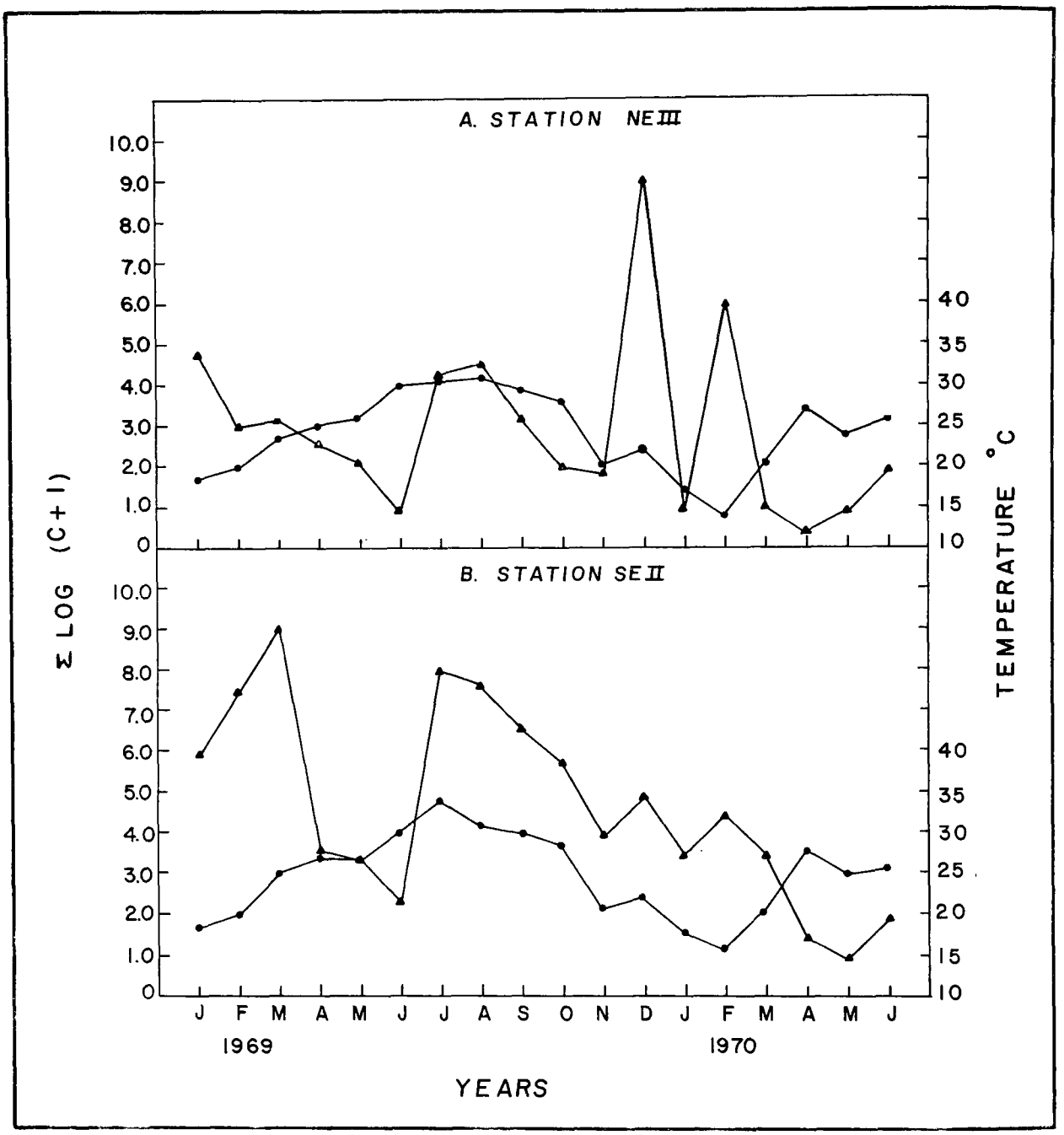

FIGURE 26. SEASONAL DISTRIBUTION OF VERMICULARIA SPIRATA AT STATIONS A) NE III AND B) SE II

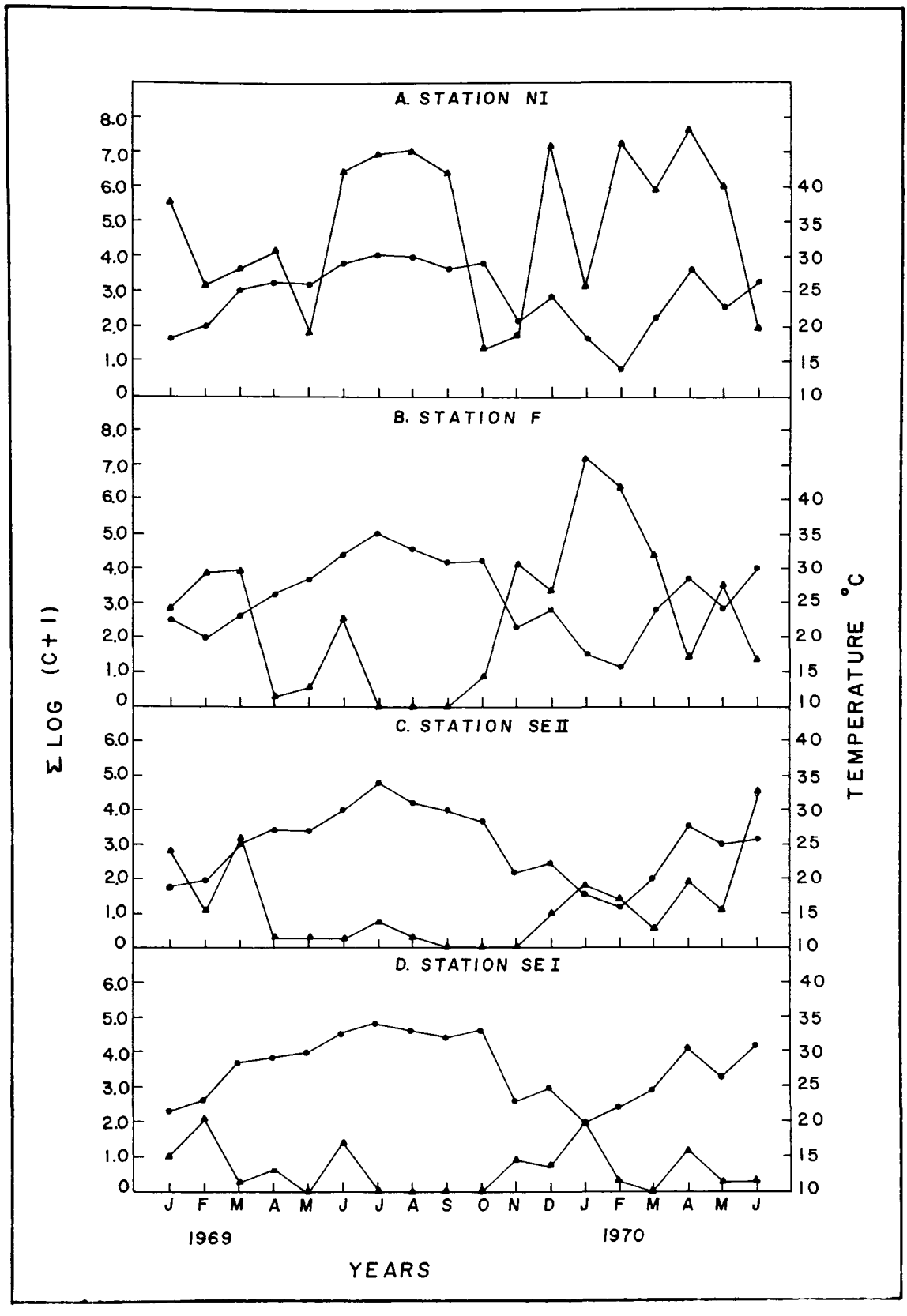

FIGURE 27. SEASONAL DISTRIBUTION OF HIPPOLYTE PLEURACANTHA AT STATIONS A) N I B) F C) SE II AND D) SE I

When temperature exceeded 32°C, catches fell to zero and did not recover until October when the temperature fell below 32°C. Catches were highest in January 1970, and remained relatively high until the end of the project in June when the temperature was 30°C. At station SE II averaging 2.5°C above ambient the averall catch was depressed. When temperature exceeded 27°C in April, 1969, catches fell and remained low until the following December. Winter and spring catches at this station showed recovery. At station SE I averaging 3.5°C above ambient the catch rate was low. During the winter of 1969 a few specimens were caught but when the temperature exceeded 27.5°C catches decreased. In June, 1969 the species was present at 32.5°C but in July when the temperature was 34°C the catches fell to zero. Recovery did not occur until November when temperatures of 24°C were recorded. In the following spring catches fell to zero in March when the temperature rose to 25°C but subsequent recovery till the end of the project was noted.

The caridean shrimp, Thor floridanus, exhibited relatively low catches in winter and high catches in summer at control stations such as NE II (Figure 28). At station S II averaging 0.75°C above ambient the annual catch was greater than at the control station, but summer catches were depressed and spring and fall catches were higher. In July the temperature exceeded 33°C and no Thor were taken. At station F averaging 1.8°C above ambient catches were relatively high in winter but depressed in July and August. In these summer months temperature exceeded 33°C. This reversal in pattern compared to NE II, the control, could account for the interaction significance. The annual production was not reduced at station F because of higher abundance during the winter and the geometric mean for the 18 month period was higher at station F than at control stations. Station S I averaging 3.7°C above ambient had depressed catches in all seasons compared to the control. The seasonal distribution of Thor at stressed stations closely followed the pattern of algal abundance described by Zieman (1970). It's possible that this shrimp is dependent on algae and its distribution is controlled by the abundance and type of vegetation. When summer temperatures exceed 33°C the algal abundance and catches of Thor dropped. If the duration of exposure to high temperature was less than two months recolonization in the fall and winter permitted the annual crop to match that of control stations. If the duration of exposure exceeded two months, there was only partial recovery and the annual crop was depressed below that taken at control stations.

The mud crab Neopanope packardii provided low catches in summer and fall at the control station N III, relatively high catches in summer at stations S II and F which averaged 2.4 and 1.8°C above ambient and low catches at all seasons at station SE I which averaged 3.6°C above ambient (Figure 29). Catches of Neopanope averaged over all stations were low in November and December 1969 but above average in January and February 1969 and March 1970. Thus there does not appear to be a temperature related seasonality and only stations with temperatures exceeding 3.5°C on the average and low catches of algae produced depressed catches.

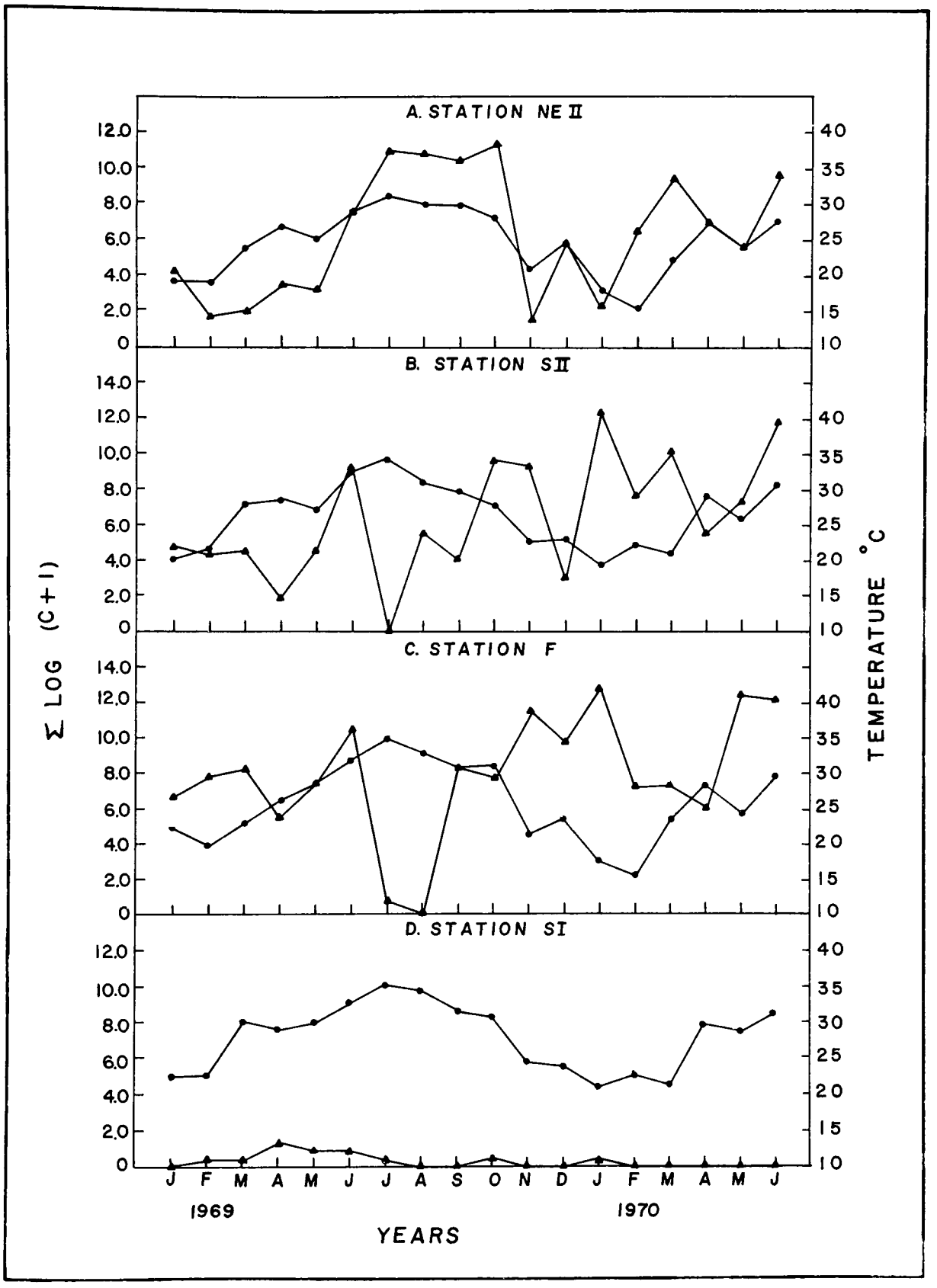

FIGURE 28. SEASONAL DISTRIBUTION OF THOR FLORIDANUS AT STATIONS A) NE II B) S II C) F AND D) S I

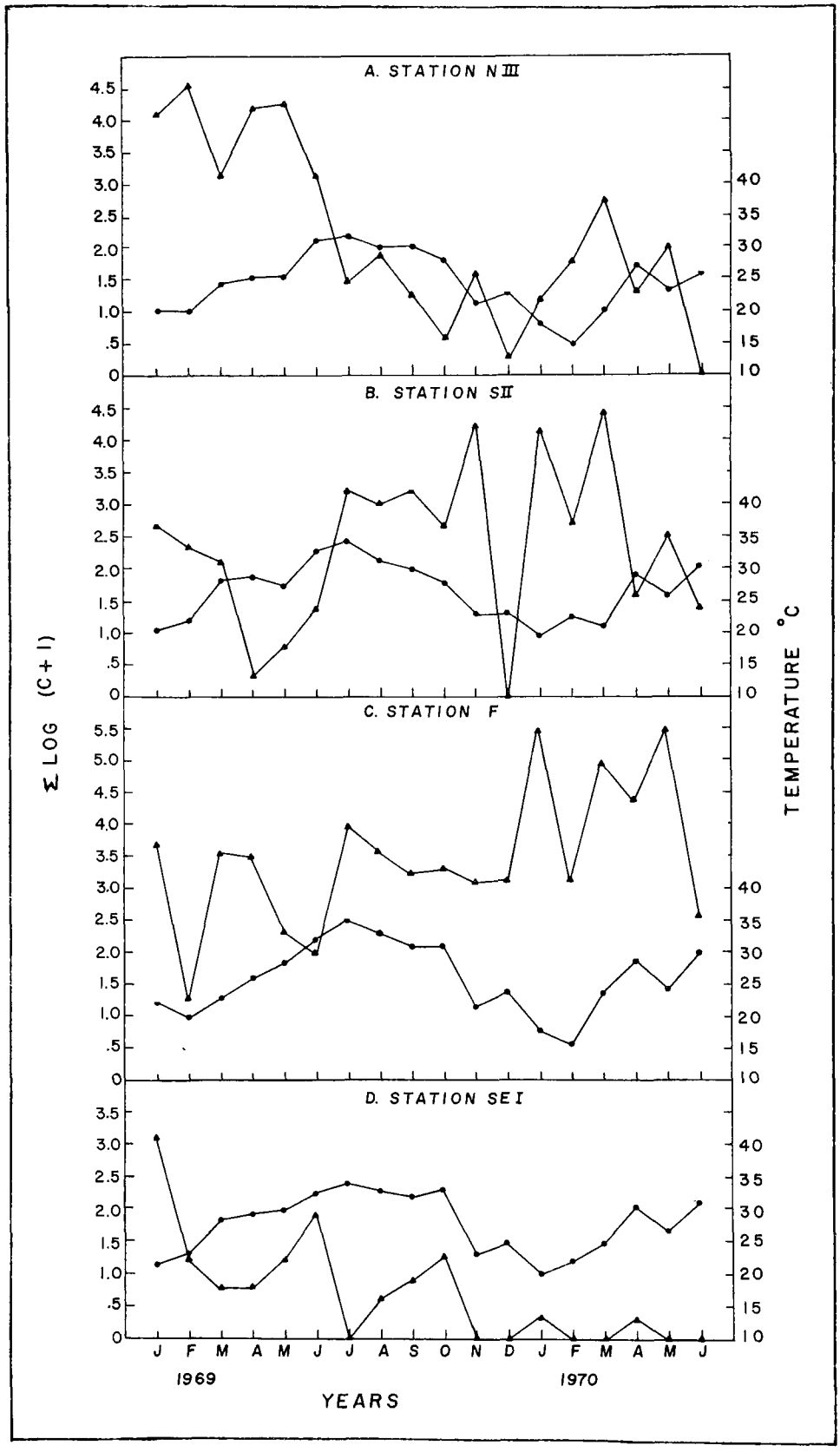

FIGURE 29. SEASONAL DISTRIBUTION OF NEOPANOPE PACKARDII AT STATIONS A) N III B) S II C) F AND D) SE I

The hermit crab Pagurus bonairensis produced highest catches in spring and summer at control stations N I and N II (Figure 30). At station S II which averaged 2.4°C above the control station D, the annual catch was about equal to that of the controls, but catches were highest in winter. At station S I which averaged 3.6°C above ambient, catches were moderate in winter and low in summer. A sharp decline in catch rate was apparent in spring when the temperature rose above 30°C. No hermit crabs were caught in July, August or September when temperatures exceeded 31.5°C. The low catches in summer depressed the annual catch below that taken at control stations. At station G averaging 4.6°C above ambient the annual production was low compared to control stations. A few hermit crabs were taken in the winter and spring of 1969 but catches dropped to zero from July through October. Recovery in the winter and spring of 1970 was spotty and did not match the production in the previous year.

The chicken liver sponge, Chondrilla nucula, was scarce at all inshore stations probably due to salinity. Considering all station, catches were highest in January, 1969 and lowest in April, 1970. At station D, a control station, catches were highest in fall and winter and lowest in spring and summer. At stations S II averaging 2.4°C above ambient and station SE I averaging 3.6°C above ambient the annual catch rate was depressed but the seasonal pattern was the same as found at D (Figure 31).

Catches of the small sea cucumber, Leptosynapta parvipatina, were generally high in winter and low in summer. Station E, considered a control, showed a peak in catch in March 1969, reduced catches during the summer, a second peak in December, 1969 and a third peak in March, 1970. At station SE II averaging 0.75°C above the control station catches were high in January, 1969, decreased throughout the spring and summer and then recovered in the following winter (Figure 32). Catches fell again in the spring of 1970 and reached zero in May. Station S II, averaging 2.4°C above control station D, produced less Leptosynapta annually than control stations. The catches were relatively high in March, 1969 fell to zero in July when the temperature exceeded 33.5 and did not recover until the following April. Catches fell to zero again in June, 1970 when the temperature exceeded 30°C.

In general those species which exhibited maximum catches in summer at control stations were depressed in summer at heated stations. Thus producing a significant interaction term in the analysis of variance. Those species with maximum catches in winter appeared to coinside with salinity controlled species which were generally scarce at inshore stations during the summer rainy season.

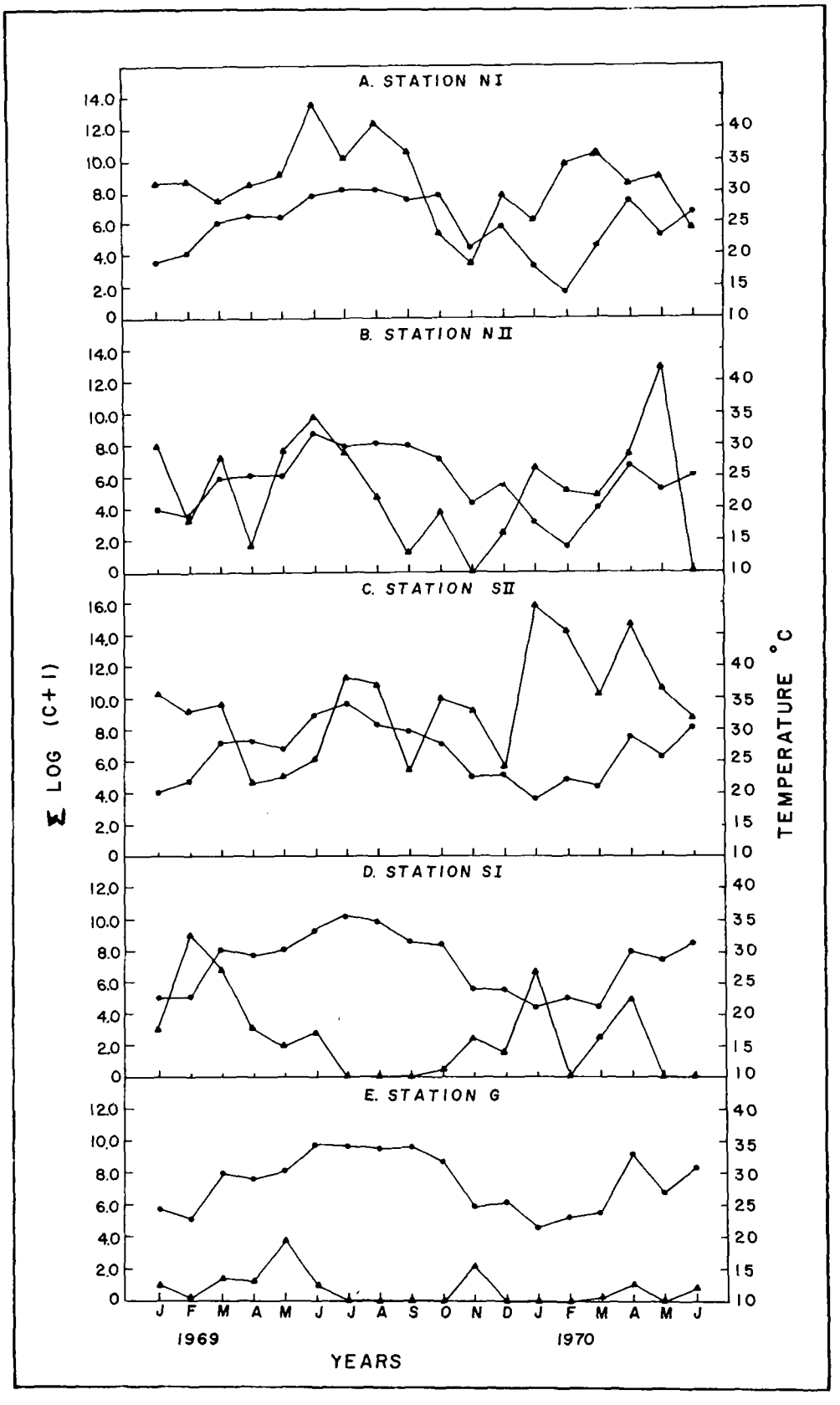

FIGURE 30. SEASONAL DISTRIBUTION OF PAGURUS BONAIRENSIS AT STATIONS A) N I B) N II C) S II D) S I AND E) G

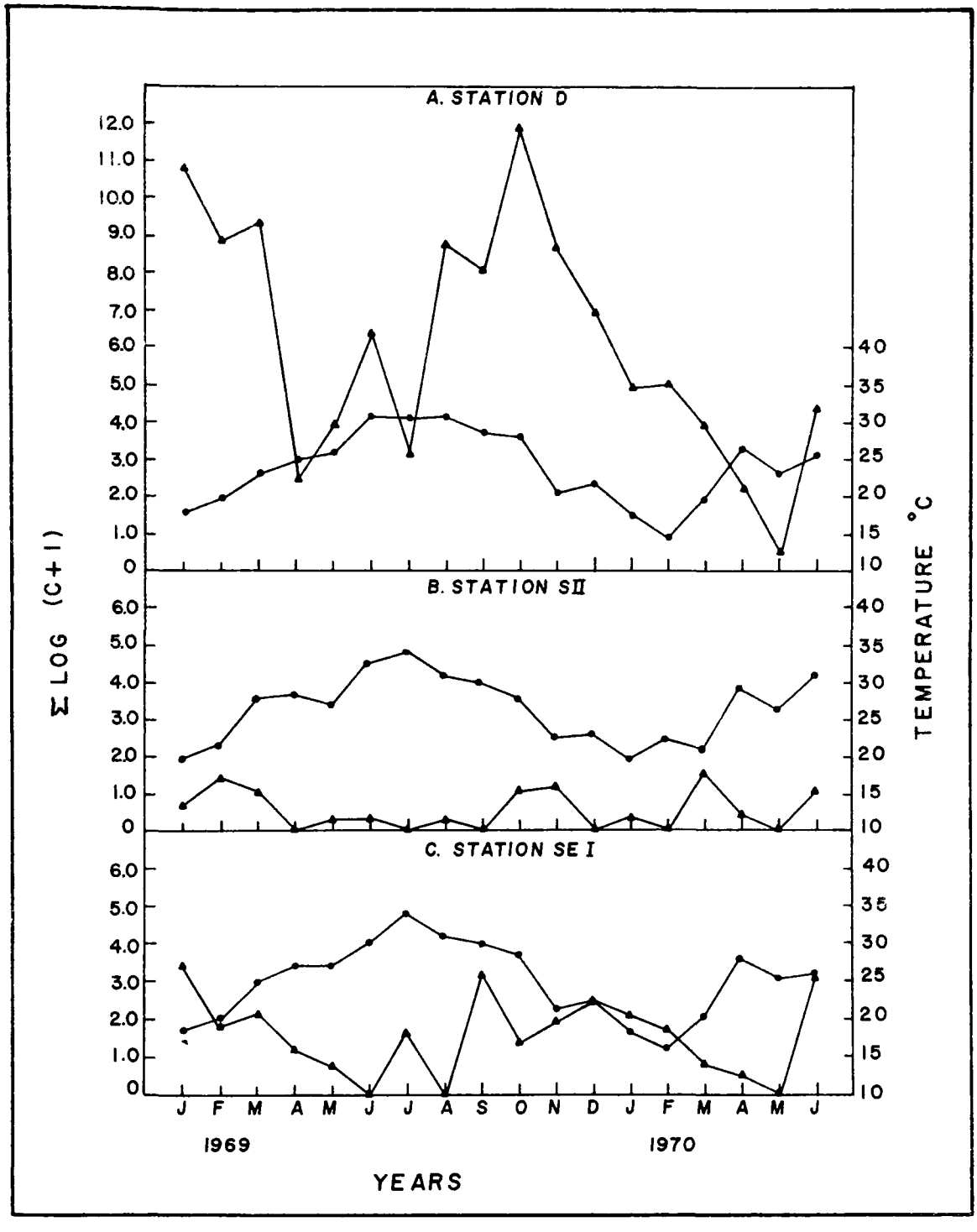

FIGURE 31. SEASONAL DISTRIBUTION OF CHONDRILLA NUCULA AT STATIONS A) D B) S II AND C) SE II

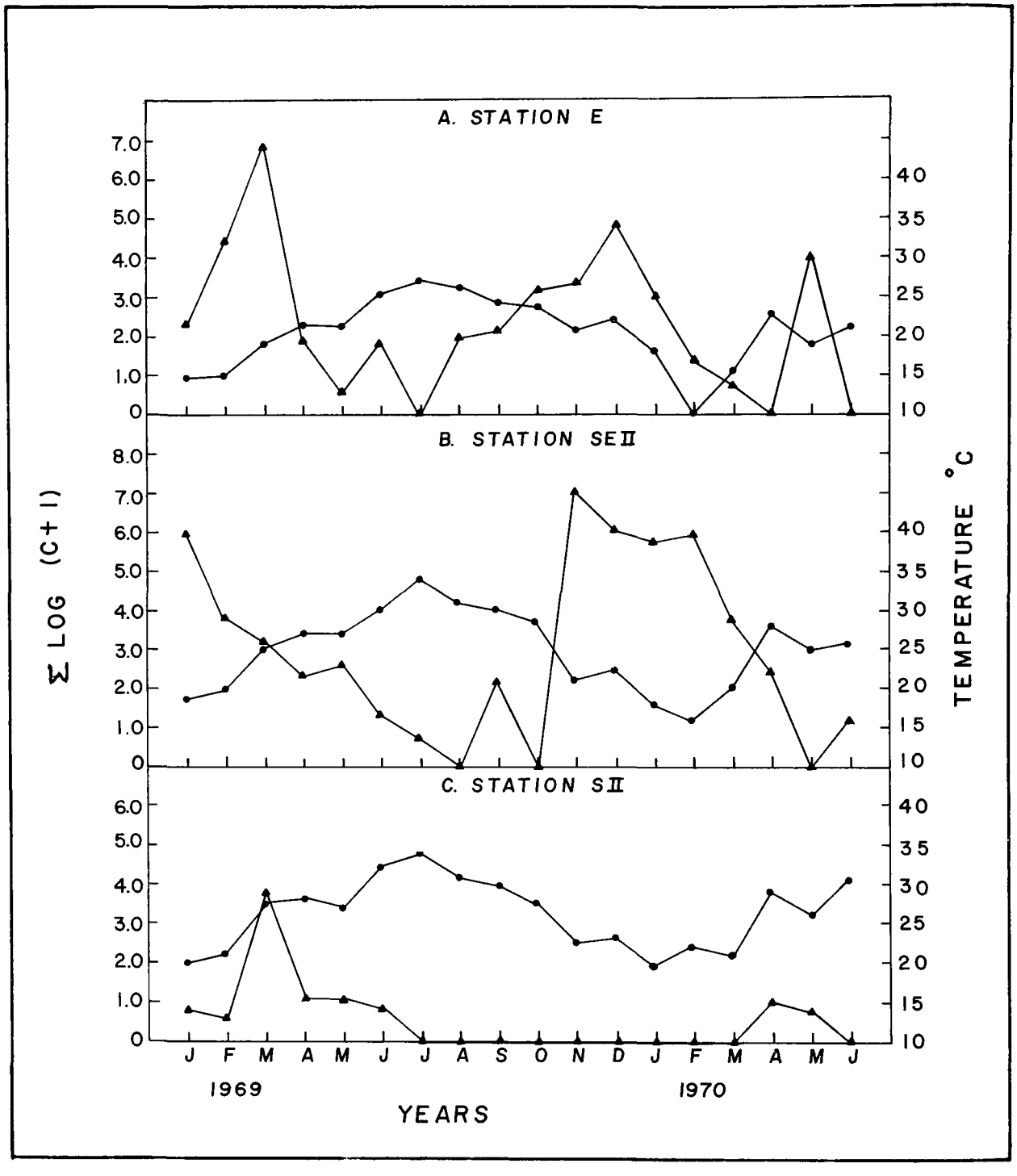

FIGURE 32. SEASONAL DISTRIBUTION OF LEPTOSYNAPTA PARVIPATINA AT STATIONS A) E B) SE II AND C) S II

A linear stepwise multiple regression was attempted to indicate the relative importance of temperature, salinity, and vegetation on the catches of the dominant organisms. The high degree of relatedness (Table 15) of the independent variables (temperature, salinity and vegetation weight) implies extreme caution should be used in interpreting the results of the stepwise regression.

The variable most important in predicting the catch of the gastropods Bulla, Cerithium eberneum, C. muscarum, Mitrella, Modulus and Prunum was vegetation weight. The catches of the crustaceans Hippolyte, Thor, Neopanope and Pagurus were also best correlated with vegetation. The gastropods Tricolia and Vermicularia, the chicken liver sponge Chondrilla and the sea cucumber Leptosynapta were best correlated with salinity.

The significance of adding temperature and salinity to the predictive equation after adjusting the catch for the effect of vegetation can be seen in Table 16.

For Bulla, Cerithium eberneum, C. muscarum and Neopanope temperature appeared as the secondary variable. In the case of C. eberneum the effect of temperature was not significant. For Mitrella, Modulus, Prunum, Hippolyte, Thor and Pagurus the secondary variable was salinity. In the case of Prunum salinity was not significant. Temperature was significant as the tertiary variable for Mitrella, Hippolyte and Thor.

The effect of vegetation and temperature on catches of Tricolia, Vermicularia, Chondrilla and Leptosynapta after adjusting for salinity is shown in Table 16. The secondary varible for these four species was vegetation. Leptosynapta was not significantly related with vegetation. The tertiary variable temperature was significant only for Chondrilla.

To visually examine the effect of temperature on catches of the dominant species scatter diagrams of the average of the transformed catch data were compared with the average temperature anomaly for each of the 20 stations. The mean catch value for all stations occurring at each 1°C anomaly interval was calculated and a trend line drawn through these points.

The striate bubble Bulla umbilicata was collected over a temperature range of 14 - 39°C. Highest catches occurred at 31°C and the catch rate fell sharply at temperatures in excess of 36°C. Figure 33a indicates that catches of Bulla are not related with temperature anomalies between 0 and +1°C. In this range vegetation and bottom type appear to be the controlling factors. Temperature increases averaging between 1 and 3°C above ambient produce average or above average catches on an annual basis. Catches are reduced at stations which average more than 3°C above ambient and fall to near zero at the single station (G) averaging 4.5°C above ambient.

TABLE 15

SIMPLE CORRELATION MATRICES BETWEEN CATCHES OF ABUNDANT ANIMALS, LOG (CATCH + 1)/TOW, VEGETATION WEIGHT. TEMPERATURE AND SALINITY.

Species	Catch	Veg.	Temp.	Sal.
Bulla umbilicata				
Catch	1.000	.666	.573	.530
Veg.		1.000*	.685*	.665*
Temp.			1.000*	.961*
Sal.				1.000*
Cerithium eberneum				
Catch	1.000	.419	.346	.331
C. muscarum				
Catch	1.000	.795	.623	.590
Mitrella lunata				
Catch	1.000	.742	.557	.586
Modulus modulus				
Catch	1.000	.748	.610	.591
Prunum apicinum				
Catch	1.000	.771	.505	.487
Tricolia affinis				
Catch	1.000	.377	.455	.472
Vermicularia spirata				
Catch	1.000	.418	.515	.520
Hippolyte pleuracantha				
Catch	1.000	.781	.562	.590
Thor floridanus				
Catch	1.000	.709	.706	.699
Neopanope packardii				
Catch	1.000	.650	.580	.554
Pagurus bonairensis				
Catch	1.000	.843	.791	.800
Chondrilla nucula				
Catch	1.000	.352	.381	.408
Leptosynapta parvipatina				
Catch	1.000	.247	.417	.446

* same for all species

____ most significant variable

TABLE 16

SUMMARY OF STEPWISE REGRESSION BETWEEN LOG (CATCH + 1)/TOW, VEGETATION WEIGHT, TEMPERATURE AND SALINITY.

Species	b	R^2	$F = \left(\frac{b}{s_b}\right)^2$
Bulla umbilicata			
Vegetation	.021	.443	130.69**
Temperature	.008	.469	18.37**
Salinity	-.005	.477	7.09**
Cerithium eberneum			
Vegetation	.009	.176	36.81**
Temperature	.002	.182	1.01ns
Salinity	<-.001	.182	.09ns
Cerithium muscarum			
Vegetation	.041	.633	349.82**
Temperature	.007	.644	9.77**
Salinity	-.004	.647	3.17**
Mitrella lunata			
Vegetation	.042	.550	275.79**
Salinity	.014	.566	33.36**
Temperature	-.012	.583	20.44**
Modulus modulus			
Vegetation	.030	.560	233.13**
Salinity	.003	.578	2.53**
Temperature	< .001	.578	.01ns
Prunum apicinum			
Vegetation	.024	.771	425.82**
Salinity	.001	.772	1.35ns
Temperature	< .001	.772	< .01ns
Hippolyte pleuracantha			
Vegetation	.031	.610	756.05**
Salinity	.009	.619	11.37**
Temperature	-.008	.638	25.01**
Thor floridanus			
Vegetation	.030	.502	112.47**
Salinity	.006	.595	5.31**
Temperature	.005	.598	3.06**
Neopanope packardii			
Vegetation	.017	.423	107.56**
Temperature	.005	.457	7.04**
Salinity	-.001	.457	.45ns
Pagurus bonairensis			
Vegetation	.056	.710	429.40**
Salinity	.017	.813	43.85**
Temperature	-.002	.813	.40ns
Tricolia affinis			
Salinity	.005	.223	9.91**
Vegetation	.003	.230	4.58**
Temperature	-.001	.231	.17ns

TABLE 16 (con't)

Species	b	R^2	$F = \left(\frac{b}{s_b}\right)^2$
Vermicularia spirata			
Salinity	.004	.270	179.04**
Vegetation	.004	.279	6.30**
Temperature	.002	.281	.80ns
Chondrilla nucula			
Salinity	.005	.166	12.71**
Vegetation	.004	.178	8.47**
Temperature	-.002	.182	2.49*
Leptosynapta parvipatina			
Salinity	.006	.199	16.75**
Vegetation	-.002	.203	2.10ns
Temperature	-.001	.204	.47ns

* significant 95% level

** significant 99% level

ns not significant

The ivory cerith, Cerithium eberneum, catches were fairly uniform from 0 to +1°C above ambient. Catches at station S II averaging 2.4°C above ambient were high and this point may bias (Figure 33b). Catches at station G averaging 4.5°C above ambient were zero. Thus it appears that there is little effect of temperature on this species until temperature anomalies reach +4°C. Above this additional temperature will cause a decline. This corroborates the findings in the multiple regression analysis.

The fly-speckled cerith, Cerithium muscarum, occurred in samples taken over a temperature range of 14 - 39°C. The species also was tolerant to salinity, occurring from 5 - 40 ppt. A preference was indicated by highest catches per tow between 15 - 30 ppt. Stations averaging 0 - 3°C above ambient temperature had variable catches but they were generally high at inshore stations with red algal populations. Stations elevated between 3 and 4°C were high if algae were present and low if algae were scarce, (Figure 33c). Station G, averaging more than 4°C above ambient, produced only 4 specimens.

The lunate dove shell, Mitrella lunata was taken over a temperature range of 14 - 39°C; the highest catch per tow as at 33°C. The high catch per tow resulted from a single observation at this temperature and the optimum is probably lower. Mitrella was observed over the entire range of salinity encountered in the study but was seldom taken below 10 ppt. The trend line (Figure 33d) indicates an increase in catches with increasing average temperature anomaly between 0 and +3°C. Between +3 and +4° there is a decrease in catches and station G elevated 4.5°C produced significantly fewer lunate dove shells.

The Atlantic modulus, Modulus modulus, was caught over a temperature range of 14 - 39°C. Highest catch per tow occurred at 36°C but dropped rapidly when this temperature was exceeded. Zero catches at this temperature also occurred and the largest total number of Modulus occurred at temperatures lower than 36°C and the optimum is probably near 30°C. The species was collected over the range of salinity observed in the study. Catches at stations averaging between 0 and 3°C above ambient were relatively high while those averaging more than 3.5°C over ambient produced low catches (Figure 34a).

The common Atlantic marginella, Prunum apicinum, was collected over a temperature range from 16 to 39°C. The catches at the highest temperature occurred in September, 1969 when several "control" stations exhibited temperatures 10°C above the expected temperature. If these were not recorder errors, the duration of exposure to a pocket of heated water was short and did not cause mortalities. The maximum catch per tow occurred at 21°C and this temperature is probably close to optimal for the species. The salinity range observed for this gastropod was 10 - 40 ppt. The highest catch per tow occurred between 15 and 25 ppt. This salinity range is similar to that reported by

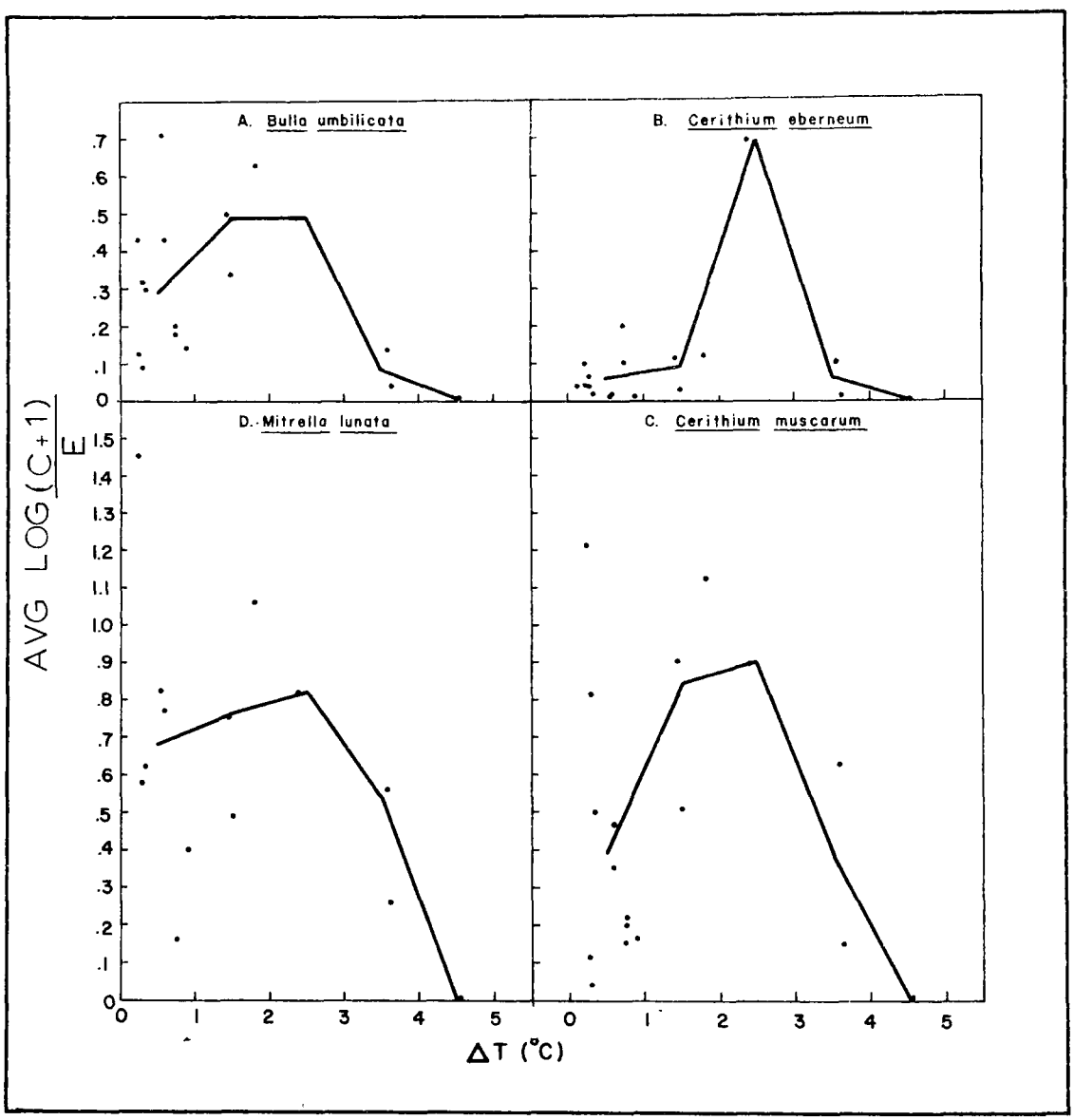

FIGURE 33. CATCHES OF A) BULLA UMBILICATA B) CERITHIUM EBERNEUM C) CERITHIUM MUSCARUM AND D) MITRELLA LUNATA COMPARED TO THE TEMPERATURE ANOMALY AT TURKEY POINT

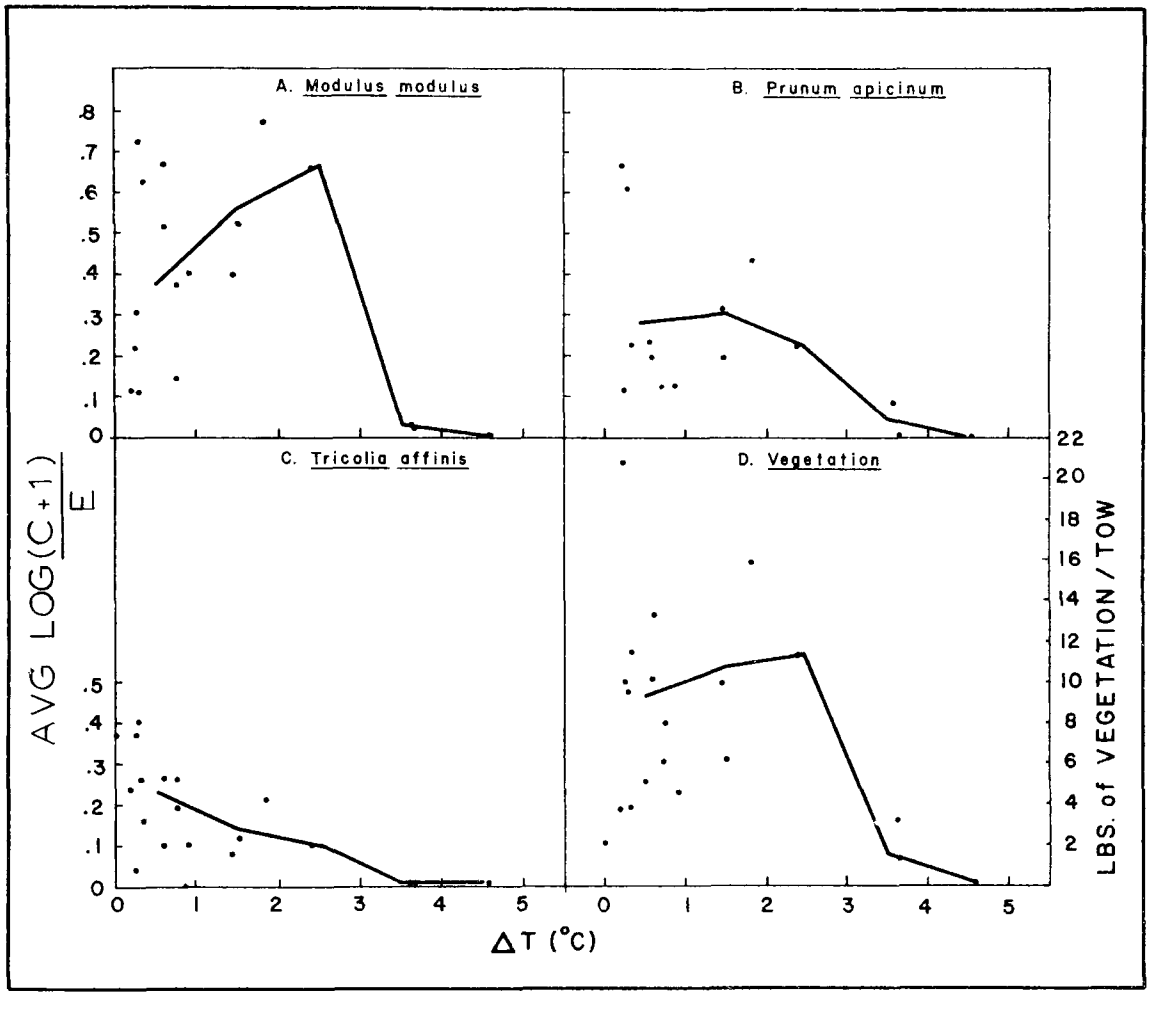

FIGURE 34. CATCHES OF A) MODULUS MODULUS, B) PRUNUM APICINUM C) TRICOLIA AFFINIS AND D) VEGETATION COMPARED TO THE TEMPERATURE ANOMALY AT TURKEY POINT

Tabb and Manning (1961) in Everglades Park but subsequent work indicated a salinity range from 8.9 - 66.0 ppt in the Everglades estuary. Stations averaging between 0 and 3°C above ambient produced relatively high catches of Prunum while those elevated more than 3°C had reduced catches, (Figure 34b). Station G elevated 4.5°C above ambient produced no common Atlantic marginella.

The checkered pheasant shell, Tricolia affinis, was collected at temperatures ranging from 15 to 39°C. The highest catch per tow occurred at 23°C. The observed salinity range was from 5 - 40 ppt. Highest catches occurred between 20 and 30 ppt and this variable is important in limiting abundance. Temperature anomalies of +2.5°C or less did not appear to significantly affect catch rate of Tricolia, but there was a severe reduction in catches at +3.5°C and no Tricolia were taken in the zone elevated 4.5°C, (Figure 34c).

The worm shell gastropod, Vermicularia spirata, occurred over a temperature range of 15 to 30°C. Although this gastropod occurred over a salinity range from 0 - 40 ppt the optimal salinity indicated by maximum catch per tow was between 20 and 25 ppt. Salinity seems to be the dominant variable controlling abundance, probably through limiting the distribution of the sponges commonly associated with Vermicularia. Thus although temperature anomalies of 3.5°C and higher produce low catches of Vermicularia, the absence of observations of high temperature in areas where salinity was close to 35 ppt consistantly precludes conclusions about the effect of temperature on this species.

The caridean shrimp, Hippolyte pleuracantha, was collected over a temperature range from 14 - 39°C. The salinity range was from 0 - 40 ppt with the highest catches occurring between 20 - 25 ppt. In Everglades Park Tabb (unpublished) found this species to occur from 8.9 - 60.6 ppt but Tabb and Manning (1961) reported Hippolyte was most frequently taken in Thalassia in Florida Bay and uncommon in the less saline Coot and Whitewater Bays.

Hippolyte pleuracantha appears to be more susceptable to elevated temperatures than most of the dominant species. Figure 35a indicates that average temperature increases less than 2°C above ambient have little effect on the catches of Hippolyte but increases 2.5°C and more result in decreased catches.

Thor floridanus, a caridean shrimp, with wide tolerance and wide distribution, was caught over a temperature range from 14 to 39°C. The salinity range was from 0 to 40 ppt. Tabb and Manning (1961) reported this species was abundant in the Everglades estuary but it preferred salinities near 35 ppt. Tabb's unpublished data indicated a range of 15.0 to 60.6 ppt could be tolerated.

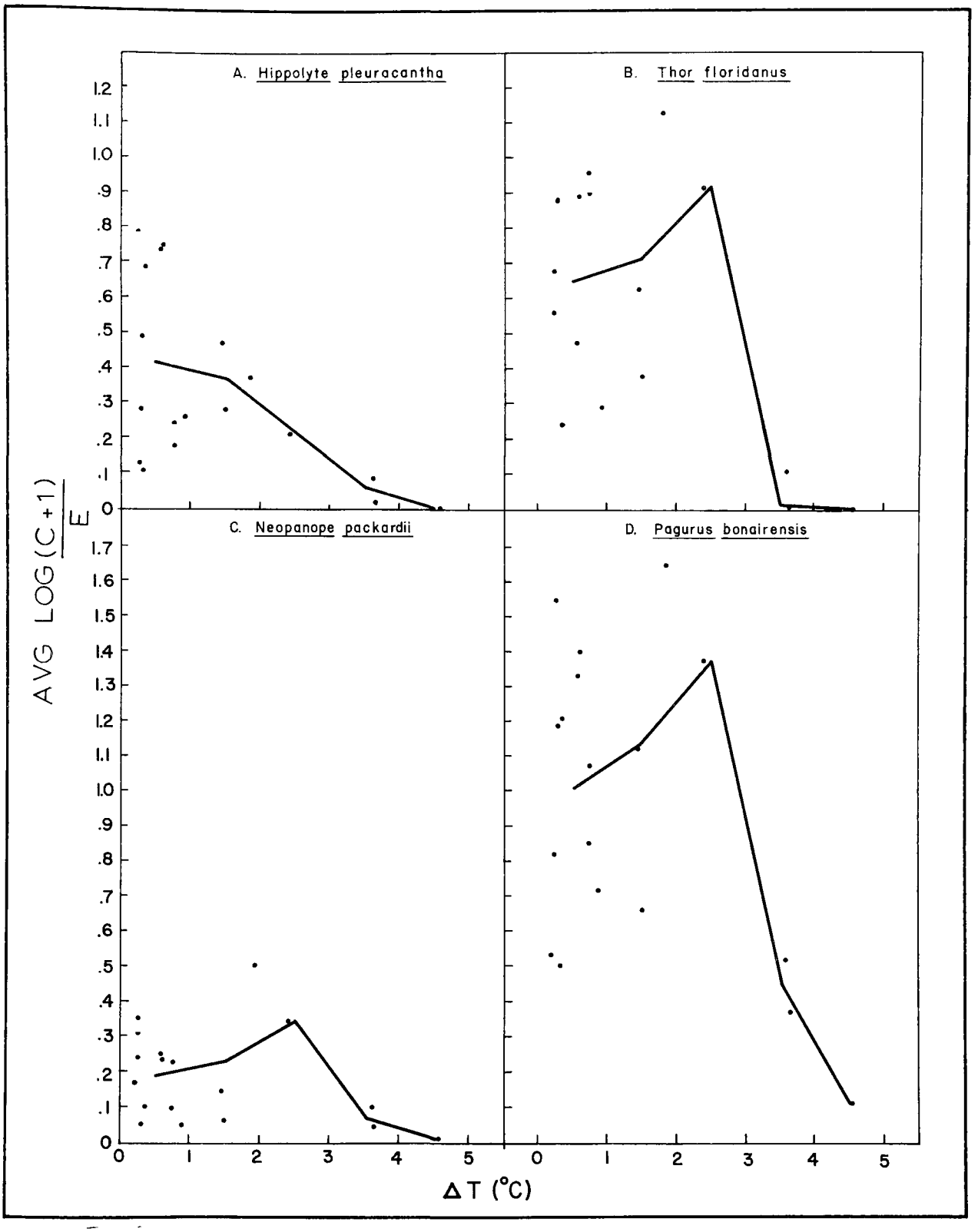

FIGURE 35. CATCHES OF A) HIPPOLYTE PLEURACANTHA B) THOR FLORIDANUS C) NEOPANOPE PACKARDII AND D) PAGURUS BONAIRENSIS COMPARED TO THE TEMPERATURE ANOMALY AT TURKEY POINT

The catches of Thor appeared to have little relation to elevated temperatures at stations averaging 0 - 2°C above ambient. The influence of bottom type, sediment depth and vegetation were dominant. Stations averaging between 2 and 3°C above ambient produced catches of Thor equal to or greater than the ambient stations. Stations elevated more than 3°C produced almost no Thor (Figure 35b).

The mud crab, Neopanope packardii, was collected over a temperature range of 14 to 39°C. The observed salinity range was from 0 - 40 ppt. The highest catches occurred between 5 and 15 ppt. Tabb (unpublished) recorded this xanthid over a salinity range of 8.9 to 58.0 ppt. The highest catches in the Everglades estuary were at high salinities. Two reasons for the discrepancy in salinity preference may be postulated. First Neopanope is closely related to red algae distribution, and the red algae are found in near shore areas of Biscayne Bay where salinity is seasonally lowered while in the Everglades the algae are located offshore in more stable salinity areas. Second in the Everglades Neopanope is replaced in the brackish waters by another euryhaline xanthid Rithropanopeus harrisii.

Odum (1970) found Rithropanopeus in his North River study and stated it was primarily a detritus feeder with a few copepods, amphipods, and isopods included in the diet. We believe Neopanope fills a similar niche in the red algae (Laurencia - Digenia) community in Biscayne Bay.

Catches of Neopanope at stations averaging from 0 to 2.5°C above ambient did not appear to be correlated with the temperature anomaly. Catches at stations elevated 3°C or more were low (Figure 35c).

The hermit crab, Pagurus bonairensis, was collected over a range of temperature from 14 to 39°C. The observed salinity range was from 0 to 40 ppt. Tabb and Manning (1961) reported (P. annulipes =) P. bonairensis from a wide range of areas in the Everglades estuary. The apparent replacement of P. bonairensis by Paguristes tortugae in Card Sound probably reflects a preference for the thick near shore sediment wedge and associated red algae (Laurencia - Digenia) community by Pagurus in Biscayne Bay and a preference for the hard bottom green algae (Halimeda, Udotea, Penicillus) community by Paguristes in Card Sound.

Catches of Pagurus appeared independent of temperature or perhaps increased slightly between the range of + 0 to 3°C above ambient but there was a sudden decrease in catches at stations where the average temperature increase exceeded +3.0°C (Figure 35d).

The chicken liver sponge, Chondrilla nucula, was collected over a range of temperatures from 16 to 39°C with the highest catch per tow recorded at 24°C. The observed salinity range was from 10 to 40 ppt with maximum catches occurring at the upper end of the salinity range.

The small sea cucumber, Leptosynapta parvipatina, was caught over a range of temperatures from 14 to 39°C and over a salinity range of 0 - 40 ppt.

SECTION XI

CARD SOUND STUDIES

Sampling at 10 stations in Card Sound was begun in July 1970. These stations were concentrated near the Model Land Company canal which was the proposed discharge point into Card Sound. A list of the physical parameters is given in Table 1 and algae catches are summarized in Table 2. Additional physical and chemical data are presented in Appendix Tables 1 - 3.

A list of animals collected and their catch and catch per tow was presented by Bader and Roessler (1971). In general the catches were greater than those in Biscayne Bay. Figure 36 shows the catches taken in Biscayne Bay and in Card Sound during the month of October, 1970. In both areas 20 stations were sampled and 140 tows made. The amount of vegetation and number of animals was nearly double in Card Sound. The catches were greatest where Laurencia was dominant and Figure 37 indicated that for most of the taxa the catch per pound of weed was comparable in Biscayne Bay and Card Sound. Sponges, echinoderms and some mollusks appeared more abundant in Card Sound. This was probably the result of more stable salinity and clear water at the mainland shore stations in Card Sound.

The high standing crop found in Card Sound is contradictory to the low catches found by Iversen and Roessler (1970). However, in the late spring and during the summer of 1971 catches of Laurencia diminished and the animal catches also decreased. Thus there may be a seasonal pattern with low abundance in spring when the study of Iversen and Roessler was conducted. Low catches in the spring of 1971 may also be the result of the drought induced high salinity of 47 ppt.

Card Sound in which about 1500 samples were taken, produced 24 species not collected in Biscayne Bay. Most of these were brittle stars, mollusks and crustaceans associated with the sponge community found in Card Sound. Biscayne Bay has produced 153 species not yet encountered in Card Sound. Because of the much greater effort (approximately 5000 samples) in Biscayne Bay this is not unexpected. Most of the species unique to Biscayne Bay were mainland sediment shelf forms which are tolerant of lowered salinity.

Two rare or unique forms have been found quite common in Card Sound. One of these the nudibrauch Felimare bayeri was known only from two specimens described by Marcus and Marcus (1967) from Biscayne Bay near the Rickenbacker Causeway.

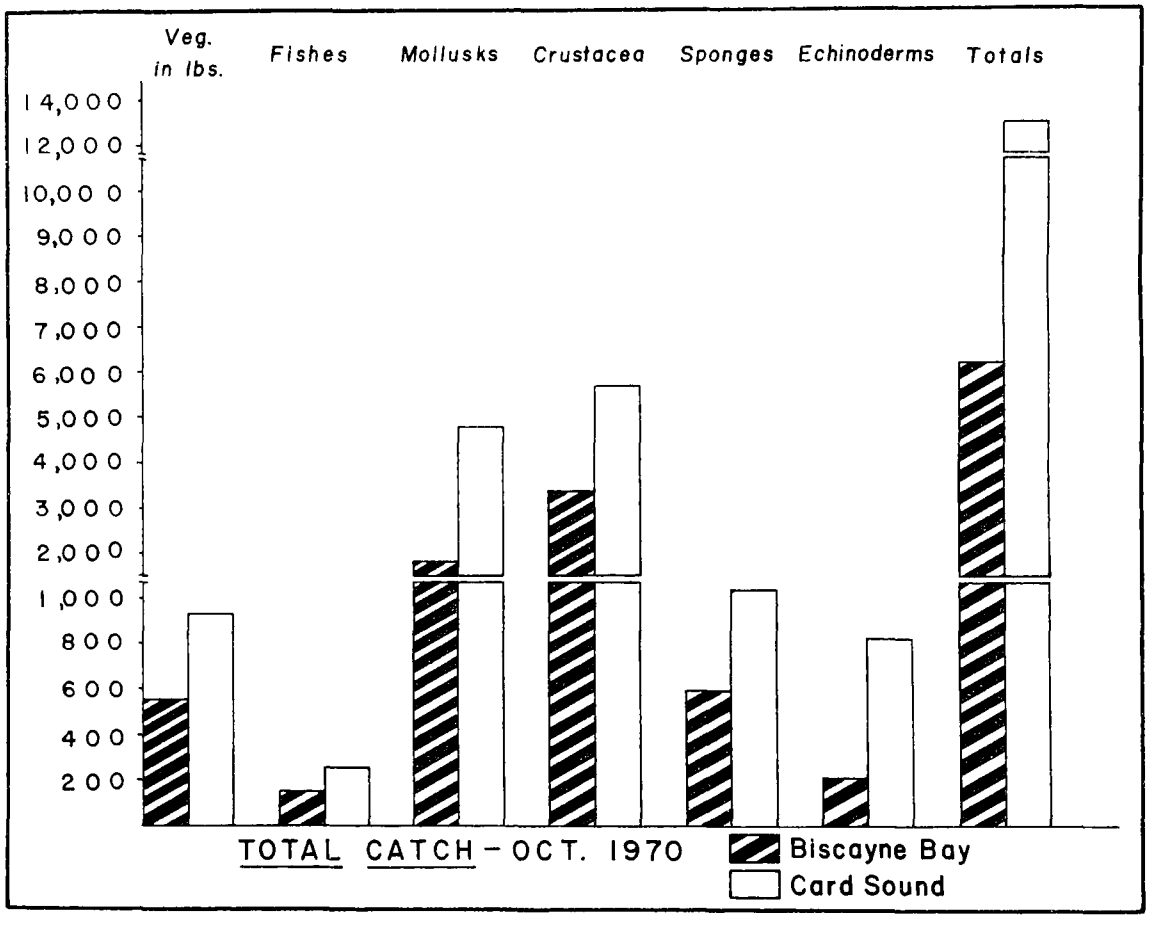

FIGURE 36. COMPARISON OF CATCHES OF ANIMALS BETWEEN CARD SOUND AND BISCAYNE BAY

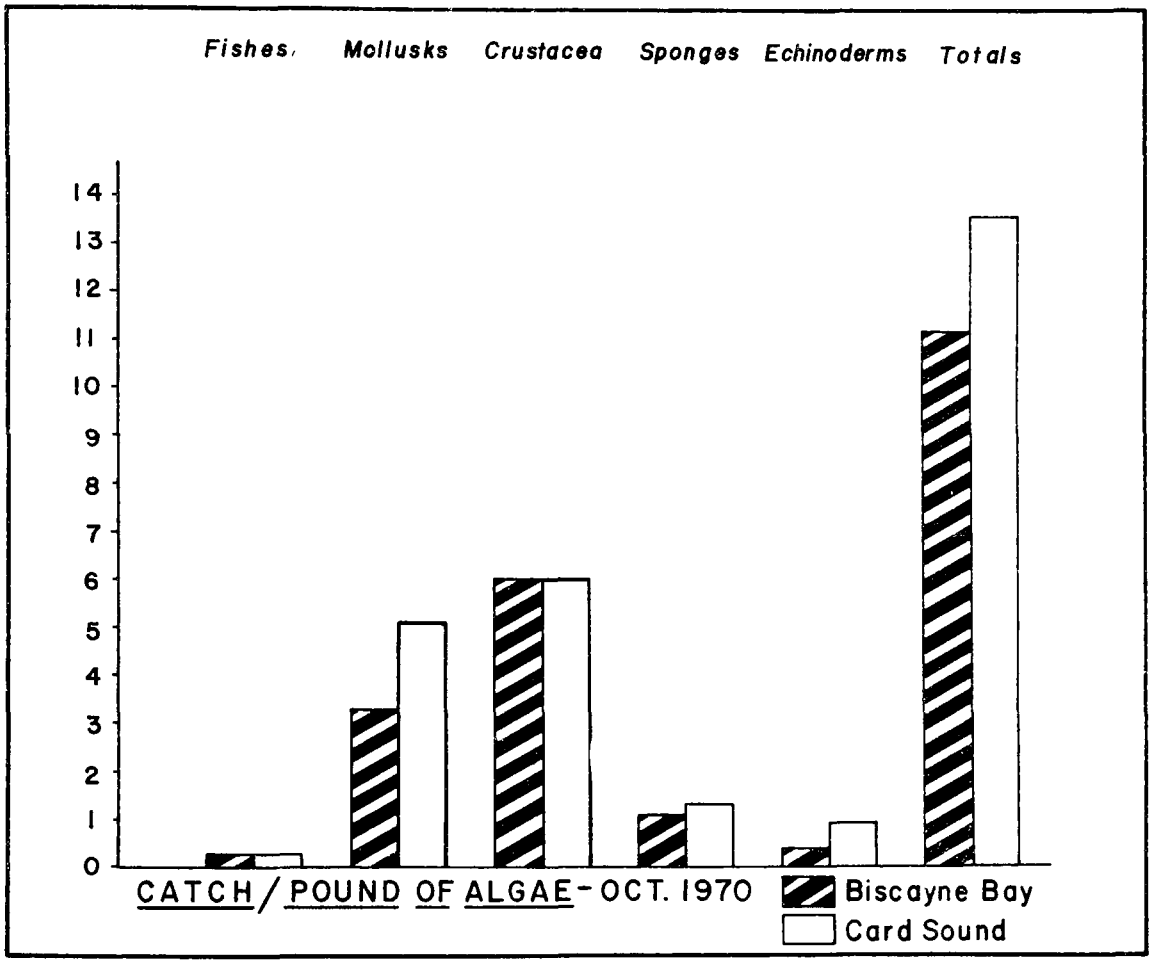

FIGURE 37. COMPARISON OF THE CATCH OF ANIMALS PER POUND OF VEGETATION BETWEEN CARD SOUND AND BISCAYNE BAY

A small rissoid gastropod which is probably an undescribed member of the genus Barleeia appeared commonly near the Arsenicker Keys. Of the 165 specimens collected 97% occurred at S V and S IV. The remainder were taken at various stations in Card Sound.

Because less than a full year of sampling was possible before the termination of this project no detailed analysis was attempted. However, the catch data is adequate to serve as a baseline to compare post operational population levels after the opening of the Card Sound discharge canal. Additional samples at a reduced number of stations are being collected with U.S. Atomic Energy Commission support this will permit further definition of the Card Sound discharge.

REQUIRED RESEARCH

With the present plans to build a cooling system of ponds or canals and interim discharges into Biscayne Bay and Card Sound at various rates a unique opportunity exists to have before and after studies in Card Sound and to measure the possible recovery and rate of recovery in Biscayne Bay. These studies are especially important because of the temporary plans of many power plants to discharge into bays and estuaries until cooling ponds or towers are constructed. They will determine if damage caused by hot water is reversible and how soon recovery will occur.

Also essential are studies of the community dynamics. Standing stock estimates are useful for proving damage but the energy flow and dynamic pathways are important to the well being of the ecosystem and its use by man.

SECTION XII

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SECTION XIV

APPENDICES

APPENDIX TABLE 1. TEMPERATURE (°C) BY MONTH AND STATION

	1968						1969					
STA.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE
NI S	30.5	32.9	37.8	27.2	17.6	13.4	18.5	19.9	25.0	26.0	25.7	29.0
(1) B	----	33.0	37.6	27.3	17.6	13.5	18.6	19.8	25.0	26.0	25.5	30.0
NII S	29.8	30.1	36.9	27.7	16.4	16.1	19.8	19.5	24.8	25.5	25.3	31.0
(2) B	----	30.7	36.6	27.2	16.4	15.7	19.8	19.0	24.8	25.3	25.2	32.0
NIII S	32.4	30.1	27.4	27.6	17.3	15.6	19.7	20.0	24.2	25.2	25.3	31.0
(3) B	----	30.4	26.9	28.2	17.2	15.4	19.9	20.0	24.2	25.1	25.3	31.0
NIV S	32.0	30.8	26.8	26.4	16.2	14.2	----	19.5	23.5	25.0	25.5	31.5
(4) B	----	30.7	26.6	26.2	16.2	13.8	----	19.0	23.7	25.0	25.2	31.9
NV S	30.5	31.5	37.6	26.8	19.2	14.3	----	18.0	24.8	25.5	25.4	32.0
(5) B	----	31.5	37.3	26.8	20.1	14.2	----	18.0	24.8	25.3	25.2	32.0
NE I S	31.5	30.1	26.7	26.0	17.2	13.8	19.0	19.9	24.8	26.0	25.8	29.5
(6) B	----	30.4	26.6	26.2	17.0	14.2	19.5	19.8	24.8	26.0	24.8	29.9
NE II S	30.6	31.7	38.8	26.4	17.2	14.2	19.4	19.0	24.0	26.5	25.9	29.0
(7) B	----	31.8	38.1	25.9	17.2	14.8	19.5	19.0	24.0	26.5	25.2	29.0
NE III S	30.7	31.9	29.2	26.1	17.4	16.2	18.2	19.0	23.5	25.3	26.5	30.0
(8) B	----	32.2	28.2	26.0	17.4	15.3	18.4	19.0	23.5	25.2	26.1	30.0
NE IV S	29.5	30.2	28.9	25.6	19.6	16.1	----	19.0	23.0	25.0	26.5	32.0
(9) B	----	30.4	27.5	25.6	19.6	15.4	----	19.0	23.0	25.0	26.0	31.0
NE V S	27.8	30.5	28.0	25.7	19.7	15.7	----	18.5	23.0	25.4	25.9	30.5
(10) B	----	30.5	27.5	25.7	19.6	15.6	----	19.0	22.5	25.3	25.5	29.5
SE I S	34.0	37.0	30.5	30.7	29.6	22.5	21.6	22.5	28.5	29.0	29.8	33.0
(11) B	----	37.5	30.1	28.4	29.6	22.4	21.6	23.0	28.5	29.1	29.9	32.5
SE II S	31.5	31.3	35.5	26.4	23.6	20.4	18.7	19.7	25.0	28.0	27.4	30.0
(12) B	----	31.1	36.3	26.4	23.5	20.4	18.7	19.8	25.0	27.1	27.0	30.0
SE III S	30.8	31.6	37.6	26.6	24.7	16.5	18.6	19.0	24.5	26.0	26.2	30.0
(13) B	----	31.7	37.8	26.6	24.3	16.5	18.6	19.0	24.7	26.0	26.1	30.0
SE IV S	32.2	31.4	29.4	26.4	20.0	17.8	----	19.0	24.0	24.0	26.0	30.0
(14) B	----	31.4	29.8	26.4	20.0	17.6	----	18.8	24.0	24.0	26.0	30.0
SE V S	29.5	31.2	38.7	26.4	19.4	17.8	----	19.0	23.5	25.0	30.0	32.0
(15) B	----	31.2	38.7	26.4	19.2	17.7	----	19.0	23.5	25.0	30.0	32.0

STA.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE
			1968						1969			
S I S	35.7	37.5	30.0	27.9	38.2	22.2	22.3	22.0	30.0	28.3	30.0	35.0
(16) B	----	38.0	29.4	27.9	38.2	22.7	22.3	22.5	30.0	28.9	29.8	33.0
S II S	33.2	32.8	26.8	27.8	26.6	18.0	20.3	21.0	28.0	28.4	28.0	34.0
(17) B	----	32.9	26.8	26.6	26.5	18.0	20.3	21.3	28.0	28.5	27.2	32.6
S III S	31.8	31.7	27.5	26.6	20.6	18.3	19.5	19.5	25.0	25.9	27.7	31.0
(18)	----	31.8	27.5	26.4	20.5	18.1	19.4	19.5	25.0	25.9	27.3	31.0
S IV S	29.0	30.1	28.0	26.2	23.8	20.0	----	19.0	23.8	26.1	27.0	29.0
(19)	----	30.1	27.9	26.2	23.6	20.0	----	19.2	23.9	26.1	26.8	29.5
S V S	29.8	31.6	28.3	26.4	19.5	18.2	----	20.5	23.5	26.0	27.0	29.0
(20) B	----	30.8	28.3	26.4	19.5	18.2	----	20.3	23.5	25.5	26.8	29.5
A S	----	----	30.1	26.3	27.7	20.1	18.9	19.9	26.5	27.9	27.3	29.0
(21) B	----	----	29.1	26.4	27.6	20.0	18.9	19.8	26.3	27.9	27.0	30.0
B S	----	----	----	----	----	----	19.8	18.5	25.4	26.2	25.5	31.0
(22) B	----	----	----	----	----	----	19.8	19.0	25.7	26.2	25.0	31.0
C S	----	----	----	----	----	----	18.6	19.0	24.0	25.0	26.3	31.0
(23) B	----	----	----	----	----	----	18.9	19.0	24.0	24.8	26.0	30.0
D S	----	----	----	----	----	----	18.1	20.0	23.5	25.0	26.1	31.0
(24) B	----	----	----	----	----	----	18.6	19.5	23.5	25.3	26.0	30.5
E S	----	----	----	----	----	----	19.4	19.8	23.5	26.0	26.3	30.0
(25) B	----	----	----	----	----	----	19.4	19.8	23.7	26.0	26.1	30.0
F S	----	----	----	----	----	----	22.4	20.1	23.0	26.0	28.5	32.0
(26) B	----	----	----	----	----	----	22.4	20.2	23.0	26.0	28.7	31.0
G S	----	----	----	----	----	----	24.2	23.0	29.9	28.5	30.0	34.0
(27) B	----	----	----	----	----	----	24.3	22.9	30.1	29.0	30.5	34.5
H S	----	----	----	----	----	----	18.2	21.5	26.0	26.2	27.5	31.0
(28) B	----	----	----	----	----	----	18.2	21.0	26.0	26.3	27.1	31.0
I S	----	----	----	----	----	----	----	----	----	----	----	----
(29) B	----	----	----	----	----	----	----	----	----	----	----	----
J S	----	----	----	----	----	----	----	----	27.2	----	----	----
(30) B	----	----	----	----	----	----	----	----	28.0	----	----	----
K S	----	----	----	----	----	----	----	----	----	----	----	----
(31) B	----	----	----	----	----	----	----	----	----	----	----	----

STA.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE
			1969						1970			
N I S	30.1	30.0	28.5	29.0	21.0	24.2	18.0	14.0	21.1	28.0	22.8	26.4
(1) B	30.2	30.1	29.5	29.0	21.1	24.5	18.5	15.0	21.1	27.9	22.9	26.1
N II S	29.8	30.1	28.9	28.1	20.8	23.6	18.1	14.1	20.8	27.2	23.1	25.6
(2) B	30.1	30.6	30.0	28.0	21.1	23.9	18.5	15.0	20.2	27.1	23.2	25.6
N III S	31.0	29.9	29.0	28.0	21.0	23.1	17.9	14.1	20.3	26.9	23.1	25.6
(3) B	31.5	29.9	30.0	28.0	21.1	23.0	18.0	15.0	20.1	26.9	23.1	25.6
N IV S	29.9	30.1	28.5	27.7	20.9	22.2	17.2	13.9	20.1	26.8	23.1	25.6
(4) B	30.2	30.2	29.2	27.9	20.9	22.1	17.9	14.8	20.0	26.8	23.1	25.6
N V S	30.0	32.2	29.5	27.4	20.5	22.4	17.0	14.0	21.0	26.7	23.0	25.4
(5) B	30.2	32.0	29.5	27.7	20.9	22.3	17.5	14.9	20.2	26.8	23.0	25.4
NE I S	31.0	30.1	28.7	28.7	20.9	24.0	18.1	14.9	22.1	27.4	24.0	27.6
(6) B	30.9	30.2	29.5	29.0	21.2	24.1	18.5	15.5	22.0	27.3	24.0	27.6
NE II S	31.0	30.0	29.0	28.4	21.0	24.5	18.0	15.0	22.8	27.6	24.0	28.0
(7) B	31.0	30.1	29.9	28.5	21.0	24.8	18.6	15.8	22.3	27.8	23.9	28.0
NE III S	30.1	30.2	29.9	28.5	20.5	22.5	18.0	14.5	22.5	27.0	24.1	26.6
(8) B	30.7	30.5	30.1	28.6	20.8	22.9	18.1	15.1	22.3	27.1	24.1	26.6
NE IV S	31.3	30.9	29.4	28.2	20.2	22.2	17.1	14.0	20.5	27.1	23.8	25.8
(9) B	31.2	30.6	29.0	28.5	20.2	22.2	17.7	15.1	20.0	27.1	23.9	25.8
NE V S	31.3	30.8	28.8	29.0	20.2	22.0	17.0	14.5	20.0	27.1	23.9	26.0
(10) B	31.2	30.9	28.4	29.0	20.3	22.0	17.5	15.5	20.0	27.1	24.0	26.0
SE I S	34.0	33.0	33.1	33.1	22.2	24.1	19.1	21.3	25.0	30.6	26.5	31.2
(11) B	34.1	33.1	31.9	33.2	23.0	24.8	19.8	22.0	24.5	30.4	26.5	31.1
SE II S	33.1	31.5	29.1	28.4	21.1	22.8	17.3	15.1	20.5	27.8	24.8	25.9
(12) B	34.0	31.2	30.0	28.5	21.2	22.6	17.9	16.1	20.2	27.8	24.9	25.8
SE III S	32.1	31.7	29.1	28.7	20.9	22.7	17.1	14.0	20.3	27.9	23.3	25.8
(13) B	32.1	31.6	29.4	28.8	21.0	22.5	17.2	14.8	20.3	27.9	23.2	25.8
SE IV S	32.2	31.1	28.9	29.1	21.0	22.3	17.0	13.8	20.2	27.9	23.3	25.8
(14) B	32.1	31.2	29.1	28.3	21.1	22.3	17.1	14.8	20.0	27.9	23.6	25.8
SE V S	32.2	31.0	28.4	28.6	21.0	22.6	17.1	14.1	20.1	27.6	24.0	25.9
(15) B	32.4	31.0	28.6	28.7	21.5	22.2	17.3	15.1	20.0	27.6	24.0	25.8

STA.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE
			1969						1970			
S I S	35.2	33.7	33.2	31.0	23.5	23.3	21.1	21.5	22.0	30.0	28.1	31.0
(16) B	35.3	34.5	31.5	31.0	23.9	23.8	21.0	22.4	21.2	29.6	28.5	31.1
S II S	34.4	31.1	29.5	28.0	22.1	23.1	19.1	21.3	21.1	29.2	25.6	30.4
(17) B	34.2	31.2	29.9	28.0	22.7	23.1	19.4	22.2	21.0	29.0	25.8	30.6
S III S	34.1	32.1	29.0	28.0	22.9	22.6	17.5	15.5	21.0	27.6	23.7	25.8
(18) B	34.1	31.9	29.2	28.1	22.1	22.5	18.0	16.1	20.4	27.9	23.8	25.9
S IV S	33.9	32.4	29.4	29.0	21.8	22.0	16.9	14.1	21.0	27.9	23.2	25.9
(19) B	33.5	32.6	29.8	29.1	21.8	22.1	17.0	14.9	20.3	27.9	23.3	25.9
S V S	32.9	31.8	29.5	29.1	22.2	22.2	16.8	14.9	20.1	27.3	24.1	26.6
(20) B	32.7	31.8	29.5	29.0	22.1	22.1	17.1	15.2	20.0	27.7	24.2	26.5
A S	30.9	31.1	31.1	29.9	21.5	26.0	18.1	15.1	24.1	29.3	24.0	28.5
(21) B	31.1	31.5	31.2	29.9	21.5	26.3	18.3	15.8	24.0	29.3	23.9	28.3
B S	30.8	30.8	31.0	28.5	21.1	25.8	16.5	15.0	22.8	28.5	24.0	26.4
(22) B	31.0	30.9	31.1	28.8	21.3	26.0	16.9	15.9	22.8	28.5	24.2	26.4
C S	32.0	31.0	30.5	28.6	20.4	22.2	17.5	14.8	20.5	26.9	23.8	25.8
(23) B	31.9	31.0	29.4	28.7	20.8	22.1	17.9	15.4	20.0	27.0	23.9	25.8
D S	30.9	31.1	28.9	28.6	20.7	22.1	17.6	14.8	20.0	26.8	23.5	25.8
(24) B	31.0	31.0	29.0	28.5	20.8	22.0	17.9	15.2	19.9	26.9	23.4	25.4
E S	32.1	31.2	29.2	28.3	20.8	22.1	17.6	14.3	20.1	27.8	23.8	25.8
(25) B	32.0	31.2	29.4	28.5	21.0	22.0	18.0	15.1	20.1	27.8	23.9	25.9
F S	35.0	33.0	31.0	31.0	21.5	24.0	17.1	15.2	23.5	28.6	24.5	29.9
(26) B	35.0	33.1	31.0	31.3	21.6	24.1	17.8	15.8	23.7	28.6	24.3	30.0
G S	34.0	34.1	34.0	30.5	24.4	25.1	22.1	22.5	23.9	32.5	27.0	31.1
(27) B	34.2	34.1	34.3	32.0	24.7	25.5	22.5	23.1	23.9	33.0	27.1	31.0
H S	35.0	30.9	29.9	31.0	22.8	22.9	18.9	18.1	21.0	29.4	24.5	25.9
(28) B	35.0	30.9	30.1	31.0	22.8	23.0	19.1	18.9	21.6	29.3	24.6	25.8
I S	----	----	----	----	----	----	----	----	----	----	----	----
(29) B	----	----	----	----	----	----	----	----	----	----	----	----
J S	----	----	----	----	21.2	24.9	17.9	14.8	22.0	27.9	24.3	26.5
(30) B	----	----	----	----	21.5	24.5	18.3	15.3	21.7	27.9	24.4	26.5
K S	----	----	----	----	22.0	23.2	17.1	14.8	24.0	27.5	24.4	28.5
(31) B	----	----	----	----	22.0	23.2	17.9	15.1	23.9	27.9	24.3	28.5

STA.	JUL.	AUG.	1970 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1971 MAR.	APR.	MAY
N I S	28.5	30.8	28.2	28.5	26.2	15.2	17.4	15.7	24.2	22.9	25.8
(1) B	28.9	30.8	28.3	28.5	25.9	15.1	17.3	15.9	24.3	22.9	25.8
N II S	28.8	30.7	29.0	27.7	26.2	15.1	17.4	16.1	24.8	22.6	26.3
(2) B	28.5	30.6	28.9	27.7	26.4	15.1	17.2	16.1	24.8	22.6	26.3
N III S	----	----	----	----	----	----	----	----	----	----	----
(3) B	----	----	----	----	----	----	----	----	----	----	----
N IV S	----	----	----	----	----	----	----	----	----	----	----
(4) B	----	----	----	----	----	----	----	----	----	----	----
N V S	----	----	----	----	----	----	----	----	----	----	----
(5) B	----	----	----	----	----	----	----	----	----	----	----
NE I S	----	----	29.9	28.9	25.9	15.1	18.0	16.5	25.0	23.8	28.5
(6) B	----	----	29.6	28.9	25.7	15.2	18.0	16.4	25.1	23.5	27.8
NE II S	28.3	31.3	29.9	28.9	25.9	15.2	18.2	16.1	24.8	23.8	27.0
(7) B	29.5	31.3	29.9	29.0	26.0	15.2	18.2	16.1	24.8	23.5	27.2
NE III S	----	----	29.0	28.8	25.8	15.2	18.8	15.9	24.1	22.9	27.9
(8) B	----	----	29.1	28.8	26.1	15.1	18.8	16.0	24.1	22.7	27.9
NE IV S	----	----	----	----	----	----	----	----	----	----	----
(9) B	----	----	----	----	----	----	----	----	----	----	----
NE V S	----	----	----	----	----	----	----	----	----	----	----
(10) B	----	----	----	----	----	----	----	----	----	----	----
SE I S	32.7	36.0	33.8	33.5	29.2	20.5	22.1	21.0	27.5	27.0	32.5
(11) B	32.1	36.0	33.8	31.1	28.0	20.6	22.1	21.0	27.5	27.0	32.0
SE II S	30.5	31.4	30.8	29.3	29.5	15.8	19.0	18.0	25.1	24.4	31.0
(12) B	30.3	30.8	30.6	28.8	27.3	15.7	19.0	18.0	25.1	23.9	30.0
SE III S	29.5	30.3	30.2	28.9	27.0	16.1	17.9	16.1	24.0	23.5	31.0
(13) B	29.6	30.4	30.2	28.6	27.1	16.1	17.9	16.1	24.0	23.5	30.0
SE IV S	----	----	----	----	----	----	----	----	----	----	----
(14) B	----	----	----	----	----	----	----	----	----	----	----
SE V S	----	----	----	----	----	----	----	----	----	----	----
(15) B	----	----	----	----	----	----	----	----	----	----	----

STA.	JUL.	AUG.	1970 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1971 MAR.	APR.	MAY
S I S	35.0	36.0	35.9	32.2	30.7	21.6	22.0	21.8	27.0	26.6	32.0
(16) B	32.7	36.0	34.0	30.9	29.7	21.9	22.0	22.0	27.0	26.7	32.0
S II S	32.9	35.2	33.1	30.6	29.5	20.0	21.7	22.0	26.5	26.6	32.0
(17) B	31.1	35.4	33.0	30.5	28.9	20.1	22.0	21.1	26.5	26.6	31.0
S III S	29.7	30.6	30.3	28.8	28.7	16.3	18.2	18.1	26.0	25.3	29.1
(18) B	29.8	30.6	30.2	28.5	28.0	16.2	18.1	18.2	26.1	25.1	29.0
S IV S	29.9	30.1	30.1	28.6	26.5	16.1	17.9	16.1	25.0	23.6	29.0
(19) B	29.9	30.1	30.0	28.6	26.5	16.1	17.9	16.2	25.0	24.1	29.0
S V S	30.0	30.3	30.5	28.6	26.5	16.1	18.0	16.0	23.8	23.1	27.0
(20) B	29.9	30.3	30.2	28.4	26.5	16.1	18.0	16.0	23.9	23.2	27.0
A S	31.5	32.2	31.8	30.6	26.4	15.1	19.9	16.9	26.1	25.0	29.0
(21) B	31.6	32.2	31.8	30.6	26.3	15.2	20.0	17.0	26.1	24.9	29.0
B S	----	----	30.6	29.2	26.2	15.1	18.4	16.8	25.1	24.8	28.0
(22) B	----	----	29.2	29.3	26.1	15.2	18.3	16.9	25.1	24.6	28.5
C S	----	----	28.9	28.0	26.0	15.7	17.9	16.0	24.9	22.3	27.1
(23) B	----	----	28.9	28.0	25.8	15.8	17.9	16.1	24.8	22.3	27.0
D S	28.8	30.1	29.1	27.8	26.1	15.8	17.6	15.9	23.7	22.7	26.8
(24) B	29.1	30.1	28.9	27.8	26.1	15.9	17.8	15.9	23.7	22.4	27.0
E S	29.7	30.3	29.5	28.2	26.0	15.7	18.1	16.3	24.1	23.2	27.0
(25) B	30.1	30.3	29.3	28.2	26.1	15.6	18.1	16.4	24.0	23.0	28.0
F S	30.9	32.8	32.8	30.1	26.3	15.9	21.2	18.0	26.5	25.4	30.0
(26) B	31.4	33.0	32.5	30.2	26.4	16.0	21.2	18.0	26.5	25.5	30.0
G S	34.2	36.0	35.9	34.2	31.5	22.2	21.5	22.1	27.1	27.0	33.0
(27) B	34.9	36.0	35.9	34.2	31.6	22.2	21.7	22.3	27.1	27.2	33.0
H S	31.2	30.8	30.8	29.7	28.3	17.3	19.5	19.0	26.1	25.9	29.0
(28) B	31.2	30.9	30.7	29.4	28.1	17.3	19.5	19.1	26.1	26.1	29.0
I S	29.3	32.8	32.6	30.7	28.3	16.9	19.5	18.1	26.0	27.4	31.0
(29) B	30.3	32.7	32.5	30.5	28.5	17.0	19.6	18.1	26.0	27.4	30.5
J S	30.6	33.7	30.5	29.0	26.4	16.0	19.8	17.8	25.1	26.4	30.0
(30) B	30.9	33.2	30.2	28.7	26.5	16.0	19.9	17.8	25.1	25.9	30.5
K S	30.6	32.1	31.5	29.4	26.1	15.1	20.0	17.0	26.0	25.3	27.0
(31) B	30.9	32.0	31.2	29.5	26.0	15.1	20.1	17.0	26.0	25.2	27.5

STA.		JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY
				1970						1971		
0104	S	29.6	30.4	28.2	28.0	24.0	20.1	24.5	14.9	21.0	19.8	27.1
(32)	B	29.7	30.4	28.2	28.0	23.6	20.1	24.5	13.5	20.8	19.5	27.1
0204	S	----	----	27.5	28.2	23.5	20.0	24.2	16.0	20.3	21.8	27.8
(33)	B	----	----	27.7	27.5	24.8	20.0	24.5	16.4	20.2	21.8	27.9
0208	S	30.1	30.4	27.2	27.9	25.0	20.1	24.1	14.0	21.3	21.8	28.0
(36)	B	30.1	30.4	27.2	27.8	24.0	20.1	24.1	14.2	21.3	20.7	28.0
0304	S	----	----	27.3	27.7	23.0	20.0	24.5	16.5	20.5	22.2	27.8
(38)	B	----	----	27.3	27.7	23.9	20.0	24.5	16.5	20.4	22.1	28.0
0306	S	----	----	27.9	28.0	23.0	20.2	24.2	13.9	19.9	21.7	27.7
(39)	B	----	----	27.9	27.9	23.0	20.2	24.2	14.8	19.7	21.7	27.9
0403	S	----	----	28.0	27.9	25.0	20.0	24.2	15.9	21.3	22.4	27.2
(41)	B	----	----	27.9	27.9	24.5	20.0	24.5	16.2	20.9	22.4	27.5
0404	S	----	----	27.2	27.7	24.1	20.1	24.1	16.0	20.4	22.0	27.2
(42)	B	----	----	27.7	27.9	24.0	20.2	24.1	16.6	20.3	22.0	27.3
0405	S	30.7	30.3	27.8	27.9	23.7	20.1	24.2	16.2	20.3	21.7	27.6
(43)	B	30.9	30.4	27.9	27.9	23.8	20.2	24.1	16.2	19.9	21.8	27.8
0503	S	30.2	30.6	27.8	27.9	24.9	20.2	24.5	16.1	21.0	21.1	27.5
(45)	B	30.7	30.8	27.9	27.8	24.8	20.1	24.5	16.5	20.8	22.2	27.9
0504	S	30.2	30.5	27.9	28.0	25.1	20.1	24.0	16.0	20.6	22.0	27.6
(46)	B	31.0	30.5	27.9	27.9	24.1	20.2	24.0	16.3	20.3	22.0	28.0
0603	S	30.4	31.1	27.8	29.9	24.5	20.0	24.9	16.2	20.9	22.3	27.2
(48)	B	30.6	30.9	27.8	28.9	24.6	20.1	24.1	16.5	20.8	22.4	27.7
0604	S	30.1	30.3	28.0	27.9	24.1	20.1	24.0	16.2	20.6	22.0	27.6
(49)	B	30.1	30.4	28.0	27.8	24.0	20.1	24.2	16.5	20.4	22.0	27.9
0606	S	----	----	28.0	28.0	24.0	20.1	24.2	15.9	20.4	22.1	28.0
(51)	B	----	----	28.0	27.9	23.8	20.1	24.1	16.2	20.1	22.1	28.1
0608	S	30.5	30.7	28.0	28.2	24.0	20.5	24.5	15.3	21.0	22.2	28.5
(52)		30.6	30.7	28.0	28.2	24.0	20.5	24.5	15.1	20.7	22.3	28.5
0703	S	30.5	30.8	28.0	29.1	25.0	20.1	24.9	16.5	20.9	22.3	27.5
(53)	B	30.8	31.3	27.9	28.9	25.0	20.1	24.9	16.8	21.0	22.1	27.9

STA.		JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY
				1970						1971		
0704	S	----	----	28.0	28.0	24.0	20.1	24.2	16.2	20.6	22.2	27.2
(54)	B	----	----	28.0	28.0	24.0	20.1	24.0	16.5	20.4	22.2	27.8
0803	S	----	----	27.9	28.2	25.0	20.2	24.7	16.2	21.1	22.3	27.8
(56)	B	----	----	27.9	27.9	25.0	20.2	24.2	16.6	20.9	22.3	27.9
0804	S	----	----	28.1	27.9	24.5	20.1	24.2	16.5	20.6	22.2	27.2
(57)	B	----	----	28.0	27.8	24.5	20.1	24.0	16.8	20.4	22.2	27.3
0805	S	----	----	28.1	27.9	24.0	20.1	24.5	16.5	20.9	22.0	27.5
(58)	B	----	----	28.0	27.8	24.0	20.1	24.1	16.8	20.2	22.1	27.9
1004	S	30.0	30.3	27.8	28.6	24.5	20.5	24.5	16.8	21.2	22.3	27.2
(63)	B	30.3	30.3	27.8	28.3	24.0	20.5	24.0	16.8	20.5	22.3	27.8

APPENDIX TABLE 2. SALINITY (ppt) BY MONTH AND STATION

	1968						1969					
STA.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE
N I S	24.9	32.1	23.3	10.5	18.5	24.9	22.1	28.9	31.3	27.3	31.7	11.7
(1) B	----	31.3	24.5	10.9	17.7	24.9	21.7	28.9	31.3	27.7	31.7	21.3
N II S	23.3	27.7	13.7	12.1	17.7	22.9	22.0	25.7	31.3	28.5	31.3	12.9
(2) B	----	25.7	20.5	13.7	17.7	23.3	22.0	25.7	31.3	28.9	30.5	20.9
N III S	22.5	28.1	20.1	11.7	16.1	22.5	20.9	21.7	30.9	27.3	29.3	13.7
(3) B	----	28.9	24.1	16.9	18.1	22.5	20.9	22.5	31.7	27.7	28.9	21.7
N IV S	23.3	28.1	15.3	13.7	17.7	22.5	----	24.9	30.1	23.3	28.1	09.3
(4) B	----	28.9	13.3	16.5	17.7	21.7	----	25.3	30.1	23.3	27.7	20.5
N V S	12.1	16.1	20.1	05.0	09.7	17.3	----	18.9	25.7	23.3	19.3	06.5
(5) B	----	18.5	20.1	05.0	13.3	17.7	----	19.3	25.7	23.7	17.7	14.5
NE I S	25.7	27.7	23.3	12.5	17.7	24.9	22.5	29.3	31.3	26.1	31.3	10.9
(6) B	----	27.7	24.1	13.5	18.1	25.7	22.9	28.9	31.3	27.3	31.3	21.7
NE II S	25.7	28.5	17.7	14.1	20.1	25.7	23.2	28.9	31.3	28.1	31.3	12.1
(7) B	----	28.5	23.7	17.3	20.1	25.7	23.7	28.9	31.3	28.1	31.7	23.2
NE III S	26.5	29.7	18.5	22.1	20.9	25.7	24.5	29.7	31.7	29.3	33.7	14.5
(8) B	----	29.7	24.1	22.5	21.7	26.5	25.7	29.7	31.5	29.3	33.3	25.3
NE IV S	28.1	32.5	26.9	23.7	27.3	27.3	----	30.9	34.9	33.7	33.7	21.3
(9) B	----	32.9	28.1	24.1	26.5	28.1	----	31.3	34.9	33.7	33.3	27.7
NE V S	29.3	32.5	27.7	24.5	28.9	30.1	----	32.9	35.7	34.1	34.1	25.7
(10) B	----	32.9	28.9	24.5	28.9	30.5	----	32.9	35.7	34.5	32.5	29.3
SE I S	26.9	31.7	18.1	19.3	20.9	25.3	22.9	28.9	30.9	27.3	31.3	16.9
(11) B	----	32.1	20.9	20.9	20.5	25.3	23.3	28.9	30.5	27.3	31.3	20.1
SE II S	26.9	32.1	26.1	22.5	26.1	25.3	23.3	29.3	30.9	31.7	32.1	20.9
(12) B	----	32.9	26.1	22.5	26.1	25.3	23.3	29.3	30.7	31.7	32.1	24.1
SE III S	32.9	33.3	26.5	23.7	25.7	25.7	25.3	29.3	32.1	33.7	34.1	25.7
(13) B	----	33.7	25.9	23.7	25.3	25.7	25.7	30.5	32.1	33.7	33.7	26.5
SE IV S	34.5	32.1	29.3	24.9	23.3	30.5	----	30.9	33.7	35.3	33.7	29.7
(14) B	----	30.5	32.1	24.9	23.3	30.5	----	31.7	33.3	34.9	33.7	29.7
SE V S	35.3	34.5	35.7	32.1	26.5	33.7	----	31.7	35.3	36.1	33.3	33.7
(15) B	----	33.8	35.3	32.1	27.3	33.7	----	34.9	35.3	36.1	33.3	33.7

STA.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE
	1968						1969					
S I S	26.5	32.1	24.1	15.3	20.9	25.7	22.5	28.9	31.3	29.3	34.1	17.7
(16) B	----	32.1	23.7	15.3	20.1	25.7	22.5	28.9	31.3	28.9	32.1	20.9
S II S	26.1	28.9	23.3	18.5	21.7	24.9	22.5	29.3	31.3	28.9	32.5	18.5
(17) B	----	28.7	24.9	22.5	21.7	24.9	22.5	29.3	32.1	28.5	32.1	22.5
S III S	27.7	32.1	26.5	19.3	21.7	24.9	23.3	29.3	31.3	32.1	33.3	22.5
(18) B	----	32.9	26.5	22.1	21.3	24.9	23.3	29.3	31.3	32.1	33.7	24.9
S IV S	32.9	30.5	29.7	23.7	25.7	28.9	----	30.5	33.3	35.3	32.9	29.7
(19) B	----	32.1	29.7	23.3	25.7	28.9	----	30.9	33.3	34.9	33.3	29.7
S V S	33.7	32.1	32.9	24.5	27.3	30.5	----	32.9	34.5	34.9	26.8	32.1
(20) B	----	32.1	32.9	24.5	26.5	30.5	----	32.9	34.1	35.3	33.7	32.1
A S	----	----	20.1	20.9	18.5	25.3	22.1	27.7	30.5	27.7	27.0	20.9
(21) B	----	----	21.3	20.9	20.1	24.9	22.1	27.7	30.5	27.7	31.7	20.9
B S	----	----	----	----	----	----	24.1	28.1	30.7	27.3	25.0	20.5
(22) B	----	----	----	----	----	----	24.1	28.5	30.9	26.9	30.9	21.3
C S	----	----	----	----	----	----	27.3	29.7	33.3	32.3	26.0	17.7
(23) B	----	----	----	----	----	----	28.9	30.5	34.1	32.3	33.3	26.1
D S	----	----	----	----	----	----	28.1	31.7	34.1	32.5	26.0	22.1
(24) B	----	----	----	----	----	----	29.3	32.1	33.7	32.1	33.7	26.5
E S	----	----	----	----	----	----	24.1	30.9	32.5	33.7	26.1	20.5
(25) B	----	----	----	----	----	----	24.1	30.9	32.5	33.4	33.7	28.5
F S	----	----	----	----	----	----	24.1	29.7	31.0	29.3	28.7	20.9
(26) B	----	----	----	----	----	----	24.1	29.3	31.3	28.9	32.1	23.7
G S	----	----	----	----	----	----	23.7	28.1	31.3	27.3	30.5	17.7
(27) B	----	----	----	----	----	----	27.7	28.1	30.5	27.3	32.1	17.7
H S	----	----	----	----	----	----	24.1	28.9	30.5	32.5	27.1	20.9
(28) B	----	----	----	----	----	----	24.5	28.9	30.5	33.3	33.7	20.9
I S	----	----	----	----	----	----	----	----	----	----	----	----
(29) B	----	----	----	----	----	----	----	----	----	----	----	----
J S	----	----	----	----	----	----	----	----	----	----	----	----
(30) B	----	----	----	----	----	----	----	----	----	----	----	----
K S	----	----	----	----	----	----	----	----	----	----	----	----
(31) B	----	----	----	----	----	----	----	----	----	----	----	----

STA.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE
			1969						1970			
N I S	14.1	27.3	17.3	22.1	20.1	20.5	22.5	24.9	21.7	33.7	37.3	35.1
(1) B	14.5	26.9	22.5	22.1	20.1	20.5	22.7	24.9	21.7	34.1	37.7	35.0
N II S	11.7	27.3	18.5	20.1	20.1	20.9	22.1	22.5	22.9	33.7	37.3	35.7
(2) B	15.7	26.1	25.3	20.1	20.9	20.9	22.5	22.5	22.5	33.7	37.3	35.8
N III S	14.9	25.7	20.1	20.1	17.7	21.3	21.7	20.1	22.1	33.7	37.3	35.2
(3) B	15.7	26.9	26.1	21.7	22.5	21.3	22.5	20.9	22.5	33.8	37.7	36.0
N IV S	08.1	24.9	16.9	22.1	21.7	20.9	21.3	25.7	20.5	33.3	37.7	34.2
(4) B	16.9	27.3	25.7	22.1	21.7	20.9	21.3	25.7	21.3	33.7	37.7	33.9
N V S	04.5	26.9	19.5	16.1	16.9	16.9	18.5	14.5	21.3	32.5	36.5	20.5
(5) B	06.1	27.3	21.3	15.7	16.1	16.5	18.1	13.7	21.3	33.7	36.9	20.0
NE I S	15.3	26.5	16.9	22.5	20.1	20.5	22.5	24.9	23.3	34.1	38.5	36.3
(6) B	16.9	27.3	25.7	22.5	20.1	20.5	22.9	25.7	22.9	34.1	38.1	36.1
NE II S	18.1	27.3	16.5	21.7	20.1	20.5	22.9	24.9	23.3	33.7	38.5	36.2
(7) B	18.9	27.7	28.1	21.7	20.9	20.5	22.9	24.9	23.3	34.1	38.5	36.4
NE III S	19.3	27.7	25.3	22.1	20.9	21.7	24.3	26.5	23.3	34.1	38.5	35.6
(8) B	20.1	28.1	29.7	22.5	20.9	21.7	24.5	26.5	23.3	34.5	38.5	35.6
NE IV S	24.9	30.1	23.7	25.7	23.3	24.9	29.1	28.9	28.5	35.3	38.5	36.9
(9) B	24.9	30.1	31.3	25.7	23.3	24.1	28.9	28.9	28.5	35.3	38.5	37.1
NE V S	24.1	29.3	21.3	27.3	24.9	25.3	29.1	29.7	30.5	36.1	38.5	37.1
(10) B	24.6	31.7	32.9	28.1	24.9	25.7	30.1	28.9	30.5	36.1	38.9	36.6
SE I S	18.5	26.9	22.1	21.3	19.3	21.7	23.3	26.5	23.7	33.7	38.5	35.8
(11) B	19.3	26.9	22.9	21.3	19.3	21.3	23.7	25.7	23.7	33.7	38.5	35.8
SE II S	22.9	28.1	23.7	25.7	20.1	23.3	26.1	28.1	25.3	34.1	38.5	36.2
(12) B	23.3	28.9	25.3	25.7	20.1	23.7	26.1	27.3	25.7	34.1	37.3	36.2
SE III S	26.1	28.9	29.7	28.1	20.1	25.7	26.5	29.7	30.5	34.1	37.7	36.3
(13) B	26.5	29.3	30.1	28.1	20.1	25.7	26.9	29.7	30.5	33.7	38.1	36.3
SE IV S	29.3	28.9	32.5	28.1	22.5	28.1	27.3	30.5	32.1	34.5	38.1	36.0
(14) B	29.3	28.5	32.5	27.7	23.3	28.1	27.3	30.5	32.1	34.1	38.5	36.0
SE V S	31.7	33.7	30.9	32.1	27.3	32.5	32.9	33.7	34.9	36.1	38.9	36.4
(15) B	31.7	33.9	33.3	32.5	29.7	32.5	33.3	33.7	35.2	36.1	38.9	36.4
S I S	16.9	26.9	22.5	16.5	19.3	20.9	24.1	25.7	26.1	33.7	38.5	35.9
(16) B	17.3	26.9	22.9	18.5	19.3	21.3	24.1	25.7	26.1	33.7	38.5	35.9

STA.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE
			1969						1970			
S II S	16.5	26.5	25.3	21.7	19.3	20.5	24.1	25.7	26.1	33.7	38.5	36.0
(17) B	22.1	27.3	26.9	22.1	19.3	20.1	24.3	25.7	25.7	33.7	38.5	36.3
S III S	20.1	28.1	25.7	26.5	19.3	23.3	25.7	28.1	27.3	33.7	38.5	36.3
(18) B	23.7	28.5	28.5	26.5	19.3	23.3	25.7	28.1	27.7	34.9	38.9	36.3
S IV S	27.3	27.3	32.9	26.9	21.7	26.9	27.1	29.7	32.1	33.7	38.1	35.8
(19) B	27.7	27.3	32.9	26.9	21.7	26.9	27.3	29.7	32.1	34.1	38.1	35.8
S V S	28.5	28.1	32.5	29.3	24.9	28.1	28.9	32.1	32.1	35.3	38.1	35.8
(20) B	28.5	30.1	32.5	29.3	25.7	28.1	28.9	32.1	32.1	35.3	38.1	35.8
A S	18.1	27.3	22.9	19.3	20.1	21.7	24.1	24.9	23.7	33.7	38.5	35.6
(21) B	18.5	27.3	23.3	19.3	20.1	21.7	24.1	24.9	23.3	33.7	38.5	35.5
B S	19.3	27.3	23.7	19.3	20.1	22.1	24.1	27.3	23.3	33.9	38.5	35.1
(22) B	18.9	27.3	25.3	19.7	20.1	22.1	23.7	27.3	23.7	33.9	38.5	35.0
C S	22.9	28.9	29.4	24.5	22.5	23.7	28.1	28.9	26.9	35.3	38.5	36.6
(23) B	22.9	28.9	24.1	24.5	23.3	23.7	28.1	28.1	27.3	34.9	38.5	36.6
D S	27.0	30.1	20.1	28.5	23.3	25.3	28.4	29.7	28.9	35.3	38.5	36.3
(24) B	27.3	30.1	31.3	28.5	23.3	25.7	28.1	28.9	28.5	35.3	38.5	36.4
E S	22.9	28.1	22.5	27.3	20.9	24.1	26.1	30.5	28.9	34.1	38.5	36.4
(25) B	23.7	28.5	31.3	26.5	20.9	24.1	26.1	29.7	28.9	34.5	38.5	36.4
F S	19.7	27.3	23.3	21.3	20.1	20.5	24.5	28.1	23.7	33.7	38.5	36.1
(26) B	20.5	26.9	27.7	21.3	20.1	20.9	24.5	28.1	23.7	33.3	38.5	36.1
G S	18.5	26.5	22.1	20.9	19.3	21.7	24.1	25.7	23.7	33.7	38.5	35.8
(27) B	18.1	26.9	21.7	21.3	20.1	21.3	24.1	25.7	23.7	33.7	38.5	35.8
H S	14.9	27.3	27.7	16.5	19.3	20.5	24.1	25.7	28.9	33.7	38.5	36.1
(28) B	23.3	27.3	28.1	18.5	18.5	20.5	24.1	24.9	28.9	33.7	38.5	36.1
I S	----	----	----	----	----	----	----	----	----	----	----	----
(29) B	----	----	----	----	----	----	----	----	----	----	----	----
J S	----	----	----	----	20.1	23.2	25.3	27.3	24.1	33.7	38.5	35.2
(30) B	----	----	----	----	20.9	23.2	25.3	28.9	24.5	33.7	38.5	35.3
K S	----	----	----	----	20.1	20.5	24.5	27.3	24.1	33.7	38.5	36.2
(31) B	----	----	----	----	20.1	21.3	24.5	27.3	24.1	33.7	38.5	36.2

STA.	JUL.	AUG.	1970 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1971 MAR.	APR.	MAY
N I S	29.6	34.6	40.1	33.5	27.1	30.5	34.5	37.7	38.1	38.9	42.6
(1) B	31.2	34.6	39.7	33.4	27.4	29.7	34.5	37.7	38.1	39.0	42.6
N II S	27.9	34.6	40.1	30.3	26.2	30.5	34.1	37.3	37.7	38.8	42.9
(2) B	27.9	34.6	40.1	30.4	26.5	30.5	34.1	36.9	38.1	38.7	42.9
N III S	----	----	----	----	----	----	----	----	----	----	----
(3) B	----	----	----	----	----	----	----	----	----	----	----
N IV S	----	----	----	----	----	----	----	----	----	----	----
(4) B	----	----	----	----	----	----	----	----	----	----	----
N V S	----	----	----	----	----	----	----	----	----	----	----
(5) B	----	----	----	----	----	----	----	----	----	----	----
NE I S	----	----	40.9	33.6	27.3	30.5	34.5	37.7	38.5	39.2	42.9
(6) B	----	----	40.9	33.7	28.8	30.9	34.5	37.3	38.1	39.1	42.6
NE II S	28.9	34.6	40.5	34.4	27.6	30.5	34.5	37.3	38.1	39.2	42.6
(7) B	31.7	34.6	40.1	34.4	29.2	30.9	34.5	37.7	38.1	39.1	42.7
NE III S	----	----	39.3	34.5	28.5	32.1	35.3	37.7	37.7	38.9	42.7
(8) B	----	----	39.3	34.6	29.1	32.1	35.3	37.7	37.7	38.9	43.1
NE IV S	----	----	----	----	----	----	----	----	----	----	----
(9) B	----	----	----	----	----	----	----	----	----	----	----
NE V S	----	----	----	----	----	----	----	----	----	----	----
(10) B	----	----	----	----	----	----	----	----	----	----	----
SE I S	30.5	33.7	40.1	32.5	28.3	31.3	34.9	37.7	38.5	----	43.2
(11) B	30.9	33.7	40.1	34.6	29.6	32.1	35.3	37.7	38.5	----	43.0
SE II S	36.0	34.6	38.5	35.2	29.2	32.1	34.9	37.3	38.1	38.9	43.0
(12) B	36.4	35.1	38.9	35.7	30.7	32.1	34.9	37.3	38.1	39.2	43.1
SE IIIS	34.1	36.2	38.1	36.0	30.4	32.1	35.3	38.5	37.7	39.6	42.7
(13) B	34.0	36.2	38.1	36.0	30.5	32.5	35.3	38.5	37.7	39.6	42.6
SE IV S	----	----	----	----	----	----	----	----	----	----	----
(14) B	----	----	----	----	----	----	----	----	----	----	----
SE V S	----	----	----	----	----	----	----	----	----	----	----
(15) B	----	----	----	----	----	----	----	----	----	----	----
S I S	32.1	32.9	39.3	33.0	28.9	31.3	34.9	37.7	38.1	39.0	43.0
(16) B	32.1	33.7	40.1	34.6	28.9	31.3	34.5	37.7	38.1	----	43.3

STA.		JUL.	AUG.	1970 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1971 MAR.	APR.	MAY
S II	S	31.5	34.5	40.1	34.4	28.9	31.3	34.5	37.7	38.1	39.0	43.4
(17)	B	32.5	33.7	40.1	34.6	29.4	30.9	34.9	37.7	38.1	39.0	43.3
S III	S	32.6	35.4	38.5	35.6	29.7	31.3	34.9	37.7	38.1	39.3	43.9
(18)	B	34.1	35.4	38.5	35.9	30.2	31.3	34.9	37.3	38.1	39.2	43.7
S IV	S	34.3	36.9	37.7	35.9	30.3	30.9	36.1	38.1	37.7	39.5	41.2
(19)	B	34.3	36.9	37.7	35.9	30.2	30.9	36.1	38.1	37.7	39.3	41.1
S V	S	35.2	36.1	37.7	35.4	34.0	33.7	36.5	37.7	37.7	38.6	39.7
(20)	B	35.1	36.1	37.7	35.4	34.1	33.7	36.9	38.1	37.3	38.5	39.3
A	S	30.9	34.3	40.1	34.0	30.0	30.5	34.9	37.7	38.1	39.2	43.2
(21)	B	31.8	34.4	40.5	34.1	30.3	30.5	34.9	37.3	38.1	39.0	43.0
B	S	----	----	40.5	33.4	29.3	30.9	35.3	37.7	38.1	39.2	43.1
(22)	B	----	----	40.1	33.6	29.4	30.5	34.9	37.7	38.1	39.1	43.2
C	S	----	----	38.1	35.6	31.8	32.9	36.1	38.1	38.1	38.4	41.5
(23)	B	----	----	38.1	35.7	32.5	32.9	36.1	38.1	38.5	38.3	41.5
D	S	33.9	36.3	38.5	36.2	33.0	33.7	36.1	37.7	38.1	38.5	41.9
(24)	B	34.7	36.3	38.5	36.2	33.1	33.7	36.1	37.7	37.7	38.4	41.9
E	S	33.0	35.9	37.7	36.0	29.7	31.3	35.3	37.3	37.7	39.1	43.1
(25)	B	34.0	36.1	37.7	36.0	30.3	31.7	35.3	37.3	37.7	39.4	43.2
F	S	30.5	34.6	40.1	34.6	30.2	30.5	34.5	37.3	38.1	38.8	43.2
(26)	B	32.9	34.6	40.1	34.6	30.5	30.9	34.9	37.3	38.1	39.1	43.1
G	S	30.2	33.7	39.3	32.9	28.8	31.3	34.9	37.7	38.5	----	43.0
(27)	B	32.2	33.7	39.7	32.8	29.1	32.1	34.9	37.7	38.5	----	43.1
H	S	31.5	35.3	38.5	34.7	29.5	29.7	34.9	37.7	38.5	39.3	44.4
(28)	B	31.5	35.2	38.5	33.8	29.5	29.7	34.5	37.3	38.5	39.3	44.3
I	S	28.0	34.9	40.1	30.9	27.7	30.9	34.9	37.7	38.1	----	43.7
(29)	B	30.0	34.8	40.1	31.1	28.1	30.9	34.9	37.7	38.1	----	43.3
J	S	32.1	33.7	39.7	35.2	30.4	31.3	35.3	37.7	38.1	39.1	43.0
(30)	B	32.9	34.5	40.1	35.3	30.6	31.3	34.9	37.7	38.1	38.9	43.1
K	S	32.3	34.3	40.1	34.7	29.8	31.3	34.9	36.9	38.1	39.1	43.1
(31)	B	32.6	34.3	40.1	34.7	29.8	31.3	34.9	36.9	38.1	38.8	42.8

STA.		JUL.	AUG.	1970 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1971 MAR.	APR.	MAY
0104	S	33.6	30.4	37.7	33.5	33.7	30.5	37.3	37.7	37.9	39.3	40.9
(32)	B	33.5	30.4	37.7	34.2	33.7	31.3	37.3	37.7	38.0	39.3	40.9
0204	S	----	----	37.3	30.1	34.5	32.1	37.3	37.3	37.7	38.8	41.2
(33)	B	----	----	37.3	34.3	34.5	33.3	37.3	37.3	37.7	38.9	41.2
0208	S	36.0	30.4	36.5	37.5	35.3	35.3	37.3	37.3	36.5	38.0	37.9
(36)	B	36.3	30.4	36.5	37.0	35.3	35.3	37.7	37.7	36.5	38.0	37.7
0304	S	----	----	36.9	34.4	34.5	32.5	36.9	37.7	37.6	39.1	40.6
(38)	B	----	----	37.3	34.9	35.3	32.1	36.9	37.3	37.7	39.1	40.6
0306	S	----	----	37.7	36.5	35.3	34.9	37.3	38.1	37.3	38.6	39.4
(39)	B	----	----	37.7	36.4	35.3	35.3	37.7	38.1	37.4	38.5	39.4
0403	S	----	----	36.9	34.1	38.5	33.7	36.9	37.3	38.1	39.0	40.8
(41)	B	----	----	36.9	34.7	35.3	33.7	36.9	37.3	37.8	39.2	40.8
0404	S	----	----	37.7	34.3	36.1	34.5	36.9	37.3	37.7	38.9	40.3
(42)	B	----	----	37.7	35.6	36.1	34.5	37.3	37.7	37.5	38.8	40.2
0405	S	35.2	30.3	36.9	36.2	33.7	35.3	37.3	38.1	37.4	38.7	40.1
(43)	B	35.5	30.4	36.9	36.1	33.7	34.9	37.3	38.1	37.5	38.6	40.2
0503	S	33.5	30.6	36.9	34.3	33.7	32.5	36.9	37.7	38.1	39.0	41.4
(45)	B	33.7	30.8	37.3	34.2	34.5	32.5	36.9	38.5	37.9	38.8	41.3
0504	S	33.6	30.5	37.7	36.2	34.5	34.5	36.9	37.7	37.7	38.8	40.4
(46)	B	35.3	30.5	37.7	36.2	34.5	34.9	36.9	37.7	37.6	38.8	40.3
0603	S	32.3	31.1	36.9	32.6	34.5	35.3	36.9	38.5	37.8	38.9	41.3
(48)	B	33.9	30.9	36.9	33.6	34.5	35.7	36.9	37.7	37.8	39.0	41.5
0604	S	33.5	30.3	37.3	34.3	35.3	34.5	36.9	37.7	37.7	38.8	41.0
(49)	B	34.8	30.4	37.3	35.0	35.3	34.9	37.3	37.7	37.7	38.0	40.9
0606	S	----	----	36.9	36.1	35.3	35.3	37.3	38.5	37.3	38.7	40.3
(51)	B	----	----	36.9	36.1	35.3	35.3	37.3	38.5	37.3	38.6	40.6
0608	S	35.1	30.7	36.5	36.6	36.1	35.3	37.3	38.1	37.2	38.0	41.6
(52)	B	35.9	30.7	36.5	36.6	36.1	35.3	37.3	38.1	37.4	38.4	41.8
0703	S	32.5	30.8	37.3	33.9	35.3	35.7	36.5	38.1	37.7	39.2	41.3
(53)	B	33.9	31.3	36.9	33.9	35.3	35.7	36.5	37.7	37.7	39.3	41.2

STA.		JUL.	AUG.	1970 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1971 MAR.	APR.	MAY
0704	S	----	----	37.3	34.8	35.3	34.5	36.5	37.7	37.6	38.8	41.1
(54)	B	----	----	37.3	34.8	35.3	34.5	36.5	38.1	37.6	38.9	41.2
0803	S	----	----	37.3	33.8	35.3	33.3	36.1	38.1	37.8	39.2	41.9
(56)	B	----	----	37.3	34.0	35.3	32.9	36.5	37.7	37.8	39.1	41.8
0804	S	----	----	37.7	34.5	35.3	34.9	36.1	37.7	37.6	38.9	40.8
(57)	B	----	----	37.7	35.1	35.3	34.9	36.1	38.1	37.6	38.9	41.3
0805	S	----	----	36.9	35.3	35.3	35.3	36.1	37.7	37.5	38.6	41.3
(58)	B	----	----	36.9	35.8	35.3	35.3	36.1	37.7	37.4	38.6	41.2
1004	S	32.9	30.3	36.9	35.1	35.3	34.5	36.1	38.1	38.0	39.5	42.0
(63)	B	34.3	30.3	36.9	35.4	35.3	34.9	36.1	37.7	38.0	39.4	41.9

APPENDIX TABLE 3. OXYGEN (ppm) BY MONTH AND STATION

	1968						1969					
STA.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE
N I S	6.0	7.0	6.0	7.0	8.0	7.5	5.0	6.8	6.5	6.6	5.9	6.6
(1) B	---	6.0	6.0	8.0	7.0	7.0	5.0	6.7	6.6	6.5	6.0	8.1
N II S	4.0	5.0	6.0	7.0	7.0	8.0	6.0	6.7	7.2	5.8	5.9	6.4
(2) B	---	5.0	6.0	6.0	6.0	7.0	5.0	6.7	7.2	5.8	5.7	8.0
N III S	9.0	4.0	7.0	6.0	10.0	8.0	4.0	6.1	7.5	6.7	5.4	6.2
(3) B	---	5.0	8.0	9.0	10.0	7.0	4.0	6.0	7.5	6.7	5.3	6.7
N IV S	6.0	5.0	6.0	8.0	8.0	7.0	---	6.7	7.0	6.7	6.0	5.8
(4) B	---	4.0	8.0	6.0	8.0	6.0	---	6.6	7.0	6.7	6.0	7.4
N V S	5.0	6.0	6.0	7.0	8.0	7.0	---	8.2	7.6	6.4	5.2	4.2
(5) B	---	7.0	5.0	7.0	9.0	6.0	---	8.1	8.0	6.3	5.5	5.4
NE I S	6.0	5.0	5.0	7.0	8.0	7.5	7.0	7.1	6.0	5.9	5.3	6.6
(6) B	---	5.0	5.0	7.0	7.0	7.0	8.0	7.2	6.0	5.8	5.2	7.9
NE II S	7.0	7.0	7.0	7.0	8.0	9.0	5.0	7.2	7.1	5.9	5.6	6.4
(7) B	---	7.0	6.0	7.0	8.0	8.0	8.0	7.2	7.1	5.8	5.6	9.2
NE III S	8.0	7.0	7.0	7.0	7.0	6.0	6.0	7.0	6.6	6.6	6.1	6.6
(8) B	---	6.0	7.0	6.0	7.0	8.0	6.0	6.9	7.1	6.4	6.1	8.3
NE IV S	6.0	6.0	7.0	6.0	7.0	6.0	---	7.6	6.7	6.5	6.2	6.3
(9) B	---	5.0	7.0	6.0	8.0	4.0	---	7.5	6.7	6.5	6.1	6.2
NE V S	5.0	6.0	7.0	5.5	6.0	3.0	---	7.2	6.8	6.6	6.2	6.4
(10) B	---	5.0	7.0	6.0	7.0	4.0	---	7.1	6.7	6.7	6.1	6.5
SE I S	5.0	4.0	6.0	6.0	6.0	4.0	3.0	7.4	7.7	6.9	6.2	5.9
(11) B	--	5.0	8.0	6.0	6.0	4.0	6.0	7.4	7.7	6.9	6.1	8.1
SE II S	4.0	5.0	5.0	7.0	5.0	6.0	3.5	7.2	6.7	6.9	6.2	6.5
(12) B	---	5.0	5.0	6.5	6.0	6.5	4.5	7.2	6.8	6.9	6.1	8.5
SE III S	7.0	8.0	8.0	7.0	8.0	4.5	3.0	7.2	7.1	7.2	6.8	7.5
(13) B	---	7.0	7.0	7.0	7.0	6.5	3.5	7.3	7.2	7.3	6.8	8.4
SE IV S	8.0	6.0	6.0	5.0	7.0	4.0	---	7.3	6.5	7.3	6.3	6.7
(14) B	---	6.0	6.0	8.0	8.0	4.0	---	7.6	6.3	7.5	6.4	6.6
SE V S	5.0	6.0	6.0	5.5	7.0	5.5	---	7.7	6.0	6.5	6.2	6.6
(15) B	---	6.0	6.0	7.0	7.0	3.5	---	7.6	6.0	6.4	6.2	6.6

STA.	JUL.	AUG.	1968 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1969 MAR.	APR.	MAY	JUNE
S I S	5.0	5.0	4.0	7.0	7.0	4.0	3.0	7.9	6.3	6.9	6.9	5.7
(16) B	---	5.0	5.0	7.0	8.0	5.0	4.0	7.8	6.2	6.8	7.0	6.7
S II S	5.0	7.0	7.0	6.0	6.0	6.5	4.0	8.2	7.2	6.5	6.6	5.6
(17) B	---	8.0	7.0	5.0	7.0	7.0	3.0	8.1	7.2	6.4	6.9	6.5
S III S	9.0	5.0	7.0	6.0	6.0	7.0	5.0	7.8	7.0	6.4	6.3	7.0
(18) B	---	4.0	7.0	6.0	6.0	5.5	4.5	7.9	7.0	6.3	6.5	8.4
S IV S	3.0	5.0	6.0	5.0	6.0	4.0	---	7.5	6.8	6.8	6.3	6.3
(19) B	---	5.0	6.0	6.0	6.0	4.0	---	7.5	6.9	6.2	6.5	6.2
S V S	4.0	5.0	6.0	7.0	7.0	3.0	---	6.7	6.2	6.8	6.3	6.4
(20) B	---	4.0	7.0	6.0	7.0	5.0	---	6.7	6.2	6.8	6.3	6.3
A S	---	---	6.0	7.0	7.0	4.0	4.0	6.9	5.2	5.4	5.2	6.9
(21) B	---	---	8.0	7.0	8.0	5.0	4.0	6.6	5.2	5.3	4.9	8.2
B S	---	---	---	---	---	---	6.0	6.9	6.0	5.6	5.1	5.9
(22) B	---	---	---	---	---	---	6.0	6.8	6.0	5.7	5.1	9.5
C S	---	---	---	---	---	---	4.0	7.3	7.0	6.7	6.1	6.4
(23) B	---	---	---	---	---	---	5.0	7.2	7.0	6.6	6.1	6.4
D S	---	---	---	---	---	---	6.0	6.6	6.1	7.5	6.8	6.7
(24) B	---	---	---	---	---	---	7.5	6.7	6.1	7.6	7.0	6.8
E S	---	---	---	---	---	---	7.0	7.0	7.1	6.9	6.1	6.7
(25) B	---	---	---	---	---	---	6.0	6.9	7.1	6.9	6.1	9.1
F S	---	---	---	---	---	---	5.0	7.3	7.6	7.1	6.2	7.0
(26) B	---	---	---	---	---	---	8.0	7.3	7.7	7.0	6.2	10.0
G S	---	---	---	---	---	---	4.0	7.1	7.0	6.7	5.7	6.3
(27) B	---	---	---	---	---	---	3.0	7.1	7.0	6.6	5.5	6.6
H S	---	---	---	---	---	---	6.5	7.4	7.5	6.9	6.8	6.3
(28) B	---	---	---	---	---	---	7.0	7.5	7.4	7.0	6.9	6.5
I S	---	---	---	---	---	---	---	---	---	---	---	---
(29) B	---	---	---	---	---	---	---	---	---	---	---	---
J S	---	---	---	---	---	---	---	---	---	---	---	---
(30) B	---	---	---	---	---	---	---	---	---	---	---	---
K S	---	---	---	---	---	---	---	---	---	---	---	---
(31) B	---	---	---	---	---	---	---	---	---	---	---	---

STA.	JUL.	AUG.	1969 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1970 MAR.	APR.	MAY	JUNE
N I S	5.6	5.8	5.1	4.9	7.9	5.8	6.6	7.4	6.3	5.2	7.1	6.6
(1) B	5.3	6.2	5.9	5.7	8.0	5.8	6.7	7.5	6.4	5.0	7.2	5.6
N II S	5.7	3.3	3.9	3.8	8.4	6.0	6.6	7.5	6.5	5.6	5.6	6.1
(2) B	2.8	7.9	7.2	5.6	8.9	6.0	6.7	7.6	6.6	5.7	6.6	5.8
N III S	5.4	5.8	3.7	5.6	7.6	6.3	6.8	7.6	6.6	6.8	5.5	6.5
(3) B	5.0	6.3	5.4	5.0	8.0	6.3	6.8	7.8	6.6	6.1	5.7	6.0
N IV S	5.7	5.9	4.5	5.4	7.8	6.7	6.3	8.0	6.9	5.5	6.0	6.7
(4) B	4.9	5.8	5.2	5.5	7.8	6.7	6.4	8.2	7.0	5.7	6.3	6.2
N V S	3.1	5.9	4.1	5.3	8.5	6.3	7.5	7.7	6.4	5.6	5.4	6.4
(5) B	3.0	11.0	4.1	5.3	8.5	6.2	7.5	7.9	6.5	5.0	5.8	6.1
NE I S	5.8	5.6	4.9	4.9	7.6	5.7	6.9	8.0	7.8	5.1	6.1	5.9
(6) B	5.3	5.5	4.9	4.9	8.8	5.7	6.8	8.1	7.8	5.0	6.1	5.8
NE II S	5.5	4.0	4.3	5.1	8.1	6.0	6.9	7.9	8.0	5.3	6.0	5.9
(7) B	5.4	4.7	5.0	5.0	8.3	6.0	7.0	7.9	8.1	5.3	6.0	5.9
NE III S	5.6	4.9	4.3	5.1	8.0	6.7	7.9	7.9	7.5	5.8	5.9	6.5
(8) B	5.5	5.3	4.8	5.0	8.1	6.6	7.7	7.9	7.5	5.7	5.7	6.4
NE IV S	5.6	6.1	4.3	5.9	7.7	6.8	7.8	7.6	7.0	6.2	6.1	6.7
(9) B	5.4	6.1	5.8	5.9	7.7	6.8	7.9	7.8	7.0	6.2	5.8	6.1
NE V S	5.4	6.5	5.1	5.8	7.7	5.9	7.7	7.8	7.0	5.9	6.0	6.1
(10) B	5.4	6.0	5.6	5.8	7.7	5.9	7.8	8.0	7.0	5.9	5.9	6.5
SE I S	6.3	6.0	4.1	5.2	8.1	6.4	6.6	6.8	7.4	4.4	5.5	7.2
(11) B	4.6	6.1	4.4	5.1	7.9	6.3	6.6	6.8	7.4	4.3	5.7	7.7
SE II S	5.6	6.4	4.7	5.6	8.1	6.5	7.5	7.3	7.0	4.9	5.9	6.1
(12) B	6.0	6.6	5.0	5.6	8.1	6.5	7.6	7.0	7.1	5.1	5.4	5.9
SE III S	5.0	5.4	5.4	6.2	8.5	6.7	7.9	7.7	7.6	4.8	5.8	6.4
(13) B	5.8	6.2	6.3	6.3	8.4	6.7	8.0	7.7	7.8	4.7	6.0	6.3
SE IV S	5.5	6.1	5.3	5.4	7.6	6.7	7.8	7.8	6.8	4.9	5.8	5.9
(14) B	5.5	6.2	5.2	5.4	7.7	6.7	7.8	7.9	6.9	4.7	5.7	5.8
SE V S	5.7	6.3	5.3	5.5	7.1	6.5	7.5	7.9	7.0	5.2	6.0	6.3
(15) B	5.6	6.5	5.2	5.5	7.3	6.5	7.5	8.0	7.1	4.7	5.5	5.9

STA.	JUL.	AUG.	1969 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1970 MAR.	APR.	MAY	JUNE
S I S	5.7	5.3	3.6	5.1	8.3	6.3	7.1	6.2	7.1	4.7	5.5	6.3
(16) B	5.7	5.3	5.2	5.2	7.9	6.3	7.1	6.2	7.1	4.7	5.7	6.0
S II S	4.3	3.8	3.9	5.4	8.0	6.7	7.0	6.5	7.1	4.6	5.7	6.5
(17) B	7.4	4.7	5.3	5.4	7.8	6.7	7.1	6.5	7.1	4.5	5.5	5.9
S III S	5.6	7.0	4.7	6.0	8.4	6.8	7.4	7.6	7.2	4.9	5.8	6.0
(18) B	7.8	7.2	5.2	6.0	8.5	6.8	7.5	7.7	7.2	5.2	6.1	5.9
S IV S	6.5	8.0	6.7	6.9	7.5	7.0	7.8	7.7	7.5	4.9	6.2	6.5
(19) B	6.5	8.1	6.7	7.0	7.4	7.0	7.8	7.7	7.5	4.8	6.1	6.5
S V S	5.7	6.1	5.3	6.1	7.0	6.8	7.5	7.7	6.9	4.9	5.7	6.4
(20) B	5.7	6.5	5.2	6.2	6.9	6.8	7.5	7.8	6.9	4.8	5.8	6.3
A S	4.4	4.4	4.2	4.0	7.7	6.2	7.0	7.7	7.1	4.3	5.6	6.4
(21) B	4.4	5.3	5.3	3.8	8.1	6.2	7.1	7.8	7.1	4.3	5.7	6.5
B S	4.8	5.7	4.3	4.3	8.2	6.6	7.6	8.2	7.8	4.9	6.3	6.3
(22) B	4.7	7.5	6.8	4.3	8.0	6.6	7.7	8.3	7.8	4.9	6.3	6.6
C S	5.1	6.0	3.9	5.8	7.7	6.7	7.6	7.7	7.0	6.3	7.0	6.4
(23) B	5.9	5.9	4.9	5.8	7.5	6.6	7.6	7.9	7.1	6.1	5.8	6.1
D S	5.8	7.4	5.3	6.7	8.1	6.6	7.6	7.7	7.0	5.7	6.0	6.8
(24) B	6.1	8.1	6.3	6.8	8.1	6.6	7.6	7.9	7.1	5.3	6.4	6.2
E S	5.6	5.8	4.6	5.9	7.9	6.6	7.3	7.6	7.0	5.2	6.0	6.3
(25) B	6.1	8.2	5.6	6.0	7.9	6.5	7.4	7.8	7.1	5.1	5.5	6.2
F S	5.8	6.4	4.2	5.2	7.9	6.0	7.1	7.3	6.9	4.9	5.5	6.1
(26) B	5.6	6.6	5.3	5.3	7.8	6.1	7.6	7.3	6.9	4.9	5.8	5.8
G S	6.8	5.0	3.5	5.1	7.9	6.2	6.8	6.0	7.1	4.2	5.5	5.7
(27) B	6.7	5.0	3.4	5.0	7.7	6.1	6.8	6.0	6.9	4.2	5.7	5.3
H S	6.0	5.8	4.9	5.1	7.9	6.7	7.5	7.2	7.2	4.9	5.7	6.5
(28) B	6.5	5.9	4.9	5.2	7.8	6.7	7.6	7.2	7.2	5.0	5.6	6.2
I S	---	---	---	---	---	---	---	---	---	---	---	---
(29) B	---	---	---	---	---	---	---	---	---	---	---	---
J S	---	---	---	---	8.0	5.6	7.6	8.2	7.4	5.0	6.3	6.6
(30) B	---	---	---	---	8.3	5.6	7.6	8.3	7.4	5.4	6.2	6.2
K S	---	---	---	---	8.9	6.6	7.9	8.2	7.6	5.3	6.2	6.5
(31) B	---	---	---	---	8.9	6.7	8.1	8.4	7.6	5.3	6.2	6.1

STA.	JUL.	AUG.	1970 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1971 MAR.	APR.	MAY
N I S	4.8	4.8	5.2	4.4	5.7	6.5	7.6	6.5	5.7	5.1	5.1
(1) B	5.1	4.8	5.2	4.3	5.8	6.7	7.7	6.7	5.7	5.0	5.4
N II S	5.3	4.6	4.9	5.8	5.9	6.4	7.3	6.7	5.1	5.6	5.1
(2) B	4.9	4.5	4.9	5.3	5.8	6.8	7.4	6.8	5.2	5.8	4.8
N III S	---	---	---	---	---	---	---	---	---	---	---
(3) B	---	---	---	---	---	---	---	---	---	---	---
N IV S	---	---	---	---	---	---	---	---	---	---	---
(4) B	---	---	---	---	---	---	---	---	---	---	---
N V S	---	---	---	---	---	---	---	---	---	---	---
(5) B	---	---	---	---	---	---	---	---	---	---	---
NE I S	---	---	4.5	4.1	6.2	6.4	7.0	6.4	4.7	5.7	5.0
(6) B	---	---	4.4	4.2	5.7	6.4	7.0	6.5	4.7	5.4	5.2
NE II S	5.3	4.7	4.2	4.2	5.8	6.5	7.6	6.5	5.6	5.7	5.6
(7) B	4.9	4.4	4.1	4.2	5.4	6.6	7.6	6.7	5.5	5.4	5.8
NE III S	---	---	4.8	4.6	6.1	6.5	7.6	6.6	5.8	6.3	5.8
(8) B	---	---	5.6	4.9	6.2	6.8	7.6	6.7	5.9	6.2	5.8
NE IV S	---	---	---	---	---	---	---	---	---	---	---
(9) B	---	---	---	---	---	---	---	---	---	---	---
NE V S	---	---	---	---	---	---	---	---	---	---	---
(10) B	---	---	---	---	---	---	---	---	---	---	---
SE I S	4.4	5.4	5.3	6.2	5.5	6.4	8.0	6.4	5.7	6.1	6.0
(11) B	4.5	5.7	5.5	7.4	5.2	6.5	8.0	6.5	5.7	6.5	6.1
SE II S	5.2	4.7	5.7	7.2	5.6	5.8	7.3	6.2	5.6	5.2	6.1
(12) B	5.0	5.1	5.7	8.4	6.3	6.0	7.3	6.2	5.6	6.4	6.2
SE III S	5.2	5.3	7.3	9.3	8.4	7.2	7.9	6.7	6.2	7.5	8.1
(13) B	5.2	5.3	7.3	8.9	8.4	7.2	8.0	6.9	6.2	7.6	8.1
SE IV S	---	---	---	---	---	---	---	---	---	---	---
(14) B	---	---	---	---	---	---	---	---	---	---	---
SE V S	---	---	---	---	---	---	---	---	---	---	---
(15) B	---	---	---	---	---	---	---	---	---	---	---

STA.		JUL.	AUG.	1970 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1971 MAR.	APR.	MAY
S I	S	5.1	5.5	5.0	6.7	5.7	6.0	8.0	6.6	6.8	7.3	6.4
(16)	B	3.9	5.8	5.2	7.3	5.8	6.0	8.0	6.7	6.9	7.5	6.4
S II	S	4.2	5.0	5.1	6.8	5.4	6.5	7.6	7.1	6.8	7.8	6.7
(17)	B	4.4	5.2	5.0	7.1	7.2	6.6	7.6	7.1	6.9	7.9	6.7
S III	S	5.6	4.9	5.3	7.0	5.4	6.9	7.6	6.5	5.7	6.5	6.8
(18)	B	5.2	4.9	5.5	7.8	6.3	7.0	7.5	6.4	5.7	6.7	6.7
S IV	S	5.3	5.4	6.5	8.1	6.2	6.8	7.9	6.6	6.1	6.8	7.5
(19)	B	5.2	5.6	6.4	8.7	6.4	6.8	7.9	6.8	6.1	6.7	7.5
S V	S	5.6	5.2	6.1	7.0	5.9	6.5	7.6	6.7	5.7	6.6	6.8
(20)	B	5.2	5.3	6.1	6.9	5.9	6.6	7.7	6.8	5.8	6.7	6.8
A	S	4.0	4.3	5.1	6.0	4.8	6.8	6.5	6.7	5.5	5.1	5.7
(21)	B	3.8	4.3	5.2	6.5	5.7	7.0	6.6	6.6	5.6	5.2	5.6
B	S	---	---	4.9	4.2	6.1	6.4	6.1	6.3	5.3	5.6	5.9
(22)	B	---	---	4.9	4.3	5.8	6.6	6.3	6.3	5.2	5.7	6.0
C	S	---	---	5.4	5.4	6.2	6.4	7.7	6.4	5.9	6.6	6.0
(23)	B	---	---	5.4	5.3	6.0	6.6	7.8	6.4	6.0	6.5	6.0
D	S	5.3	5.2	6.2	5.9	5.7	5.7	7.5	6.8	6.3	6.6	6.9
(24)	B	4.2	4.9	6.0	6.0	5.8	5.8	7.5	6.9	6.3	6.6	6.9
E	S	4.9	5.5	5.5	7.1	5.7	5.5	7.6	6.5	6.0	6.3	6.1
(25)	B	4.0	5.9	5.4	6.8	6.0	5.7	7.6	6.6	6.0	6.4	6.0
F	S	4.2	4.3	5.0	6.4	5.3	6.5	7.3	6.6	5.6	5.2	6.0
(26)	B	3.9	4.4	5.0	6.5	5.7	6.5	7.2	6.6	5.6	5.2	6.0
G	S	5.2	5.1	4.7	6.4	5.7	6.2	7.3	5.9	4.7	5.3	5.5
(27)	B	5.1	4.8	4.7	6.5	5.8	6.4	7.4	5.9	4.7	5.3	5.6
H	S	4.6	5.1	5.6	7.1	5.4	5.6	7.1	6.3	6.2	6.3	6.9
(28)	B	4.5	4.9	5.6	7.7	5.9	5.7	7.5	6.4	6.2	6.2	6.9
I	S	4.8	3.8	5.3	6.2	4.6	6.0	5.9	5.8	5.0	6.5	6.1
(29)	B	4.6	3.7	5.4	9.7	4.6	6.0	5.9	6.0	5.0	6.6	6.2
J	S	4.7	4.1	5.3	6.9	5.3	6.3	7.3	6.5	5.8	5.6	6.1
(30)	B	4.7	4.9	5.3	6.9	6.1	6.4	7.1	6.5	5.9	6.6	6.1
K	S	3.9	4.6	4.8	5.1	5.8	5.7	7.1	6.8	5.8	5.8	5.1
(31)	B	3.6	4.7	4.6	5.1	6.0	6.0	7.1	6.8	5.7	6.0	5.2

STA.		JUL.	AUG.	1970 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1971 MAR.	APR.	MAY
0104	S	5.8	4.7	6.0	---	6.3	6.1	7.8	7.2	7.3	6.3	5.5
(32)	B	6.0	4.7	5.9	---	5.3	6.3	8.4	7.1	7.4	6.0	5.5
0204	S	---	---	5.6	---	4.2	6.0	7.1	6.6	7.6	7.0	5.8
(33)	B	---	---	5.6	---	5.2	6.2	7.3	6.4	7.4	7.0	5.7
0208	S	4.4	4.9	5.5	---	6.0	6.5	6.6	6.5	7.5	---	6.5
(36)	B	4.4	4.8	5.5	---	5.9	6.9	6.7	6.4	7.5	---	6.3
0304	S	---	---	5.6	B	5.7	6.4	6.3	6.1	7.7	6.9	5.8
(38)	B	---	---	5.6	R	5.4	6.5	6.4	5.9	7.5	6.8	5.8
					O							
0306	S	---	---	5.7	K	5.9	6.5	6.5	6.5	7.9	7.2	5.9
(39)	B	---	---	5.8	E	5.6	6.7	6.6	6.3	7.9	6.9	5.9
					N							
0403	S	---	---	5.9		5.4	7.2	7.1	5.9	7.7	---	5.8
(41)	B	---	---	6.0	O	5.6	7.2	7.7	6.0	7.8	---	5.7
					X							
0404	S	---	---	5.7	Y	5.8	7.2	6.6	5.8	7.7	B	5.9
(42)	B	---	---	5.7	G	5.6	7.3	6.7	5.9	7.8	R	5.9
					E						O	
0405	S	6.5	5.9	5.9	N	5.7	6.6	6.5	5.9	7.7	K	6.3
(43)	B	6.2	6.0	6.0		5.7	6.5	6.7	6.0	7.8	E	6.2
					M						N	
0503	S	5.8	5.4	5.6	E	5.7	6.5	6.7	5.8	7.5		5.6
(45)	B	5.8	6.1	5.7	T	5.8	6.6	6.9	6.0	7.7	O	5.6
					E						X	
0504	S	6.1	6.1	5.6	R	6.0	7.3	6.4	5.7	7.7	Y	5.9
(46)	B	5.6	6.1	5.7		5.7	7.3	6.7	5.9	7.8	G	6.0
											E	
0603	S	5.8	4.1	5.5	---	5.9	6.0	5.8	5.6	7.4	N	5.6
(48)	B	6.4	4.6	5.5	---	5.7	6.0	6.5	5.9	7.6		5.6
											P	
0604	S	6.0	4.6	5.8	---	6.0	6.5	6.6	6.0	7.9	R	5.9
(49)	B	5.3	5.6	5.9	---	6.0	6.6	6.3	6.1	7.8	O	5.8
											B	
0606	S	---	---	5.7	---	6.2	7.4	6.3	6.0	7.6	E	5.9
(51)	B	---	---	5.8	---	6.0	7.4	6.7	6.1	7.6		5.8
0608	S	5.9	5.7	5.8	---	5.7	6.8	6.7	5.9	8.0	---	6.1
(52)	B	5.7	5.6	5.8	---	5.8	6.8	7.0	6.3	7.9	---	6.1
0703	S	5.6	5.8	5.8	---	6.1	6.5	6.6	5.8	7.4	---	5.7
(53)	B	5.7	6.0	6.0	---	6.1	6.6	6.3	6.1	7.6	---	5.6
0704	S	---	---	6.0	---	6.1	6.6	6.4	6.0	7.8	---	6.0
(54)	B	---	---	6.0	---	6.2	6.7	6.4	6.0	7.7	---	5.9

STA.		JUL.	AUG.	1970 SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	1971 MAR.	APR.	MAY
0803	S	---	---	5.7	---	5.7	6.6	6.6	5.8	7.8	---	5.8
(56)	B	---	---	5.7	---	5.7	6.7	6.6	6.1	7.7	---	5.7
0804	S	---	---	5.9	---	6.1	6.7	6.4	5.9	7.6	---	6.1
(57)	B	---	---	6.0	---	6.1	6.7	6.5	6.1	7.5	---	6.2
0805	S	---	---	5.9	---	6.1	6.7	6.4	6.0	7.5	---	5.8
(58)	B	---	---	6.0	---	6.2	6.8	6.5	6.0	7.6	---	5.8
1004	S	6.0	5.9	5.6	---	6.1	6.7	6.3	6.0	7.5	---	5.8
(63)	B	5.9	6.0	5.7	---	6.2	6.8	6.3	6.0	7.9	---	5.8

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

Field studies on the effects of thermal additions from the Florida Power & Light Company's discharge at Turkey Point have been conducted to determine the effects of this effluent on the macroinvertebrates and fishes of the area.

Replicate samples with a 3 m (10 foot) otter trawl lined with .63 mm (1/4 in.) bar mesh were made monthly at 20 stations. Data on temperature, salinity and oxygen were collected during each sampling period. Additional chemical data were collected when opportunity existed.

The experimental results suggest that maximum summer temperatures above 32°C cause detrimental changes in the environment which are reversible in the winter while temperatures above 33°C cause damage which does not recover during the cooler months. Intermitant flow of discharge water is not as damaging as constant flow. Card Sound appears to be as productive as Biscayne Bay and temperatures exceeding 33°C will also cause damage in Card Sound.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
*Thermal Pollution, *Water Pollution Waste Heat *Environmental Effects *Estuaries Heated Water Biscayne Bay		

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