The Effects of Thermal Additions on the Biota of Southern Biscayne Bay, Florida[1]

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INTRODUCTION

A FLORIDA POWER AND LIGHT COMPANY plant at Turkey Point, Biscayne Bay, provides electric power for Dade County, Florida. A gas-oil generator became operational in April 1967, and a second in April 1968. Two nuclear units currently under construction are scheduled for operation in 1971 and 1972. The two conventional plants each produce 432,000 kw and each has a cooling water flow requirement of 635 cubic feet per second (cfs) (=4,762 gallons per second). The nuclear plants will each produce 760,000 kw and require 1,490 cfs of cooling water. Thus the total output will eventually be 2,384,000 kw and the cooling water requirements will be 4,250 cfs.

At the present time the temperature is raised approximately 5°C while passing through the plant. With the nuclear plants in operation the temperature increase will be 7-8°C. The temperature at the outfall into Biscayne Bay is now about 5°C above the normal inshore bay temperatures.

The Rosenstiel School of Marine and Atmospheric Sciences has grants sponsored by the Atomic Energy Commission and the Federal Water Pollution Control Administration to study the effects of heated effluents on the biota of Biscayne Bay. These projects are coordinated by Dr. Richard Bader and the research is conducted by personnel from all divisions of the School. This paper presents some preliminary results.

BIOLOGICAL METHODS

The effect of the heated effluent on the turtle grass, *Thalassia testudinum*, and the macro-algal communities is being studied by marking areas with metal squares and counting the individual plants within the squares at periodic intervals throughout the year, according to the methods developed by Zieman (1968).

Quantitative samples of fishes and macro-invertebrates have been obtained with a 10-foot otter trawl (shrimp try net) with ½-inch stretched mesh liner. Fig. 1 shows the 28 trawling stations occupied during the first year of the study. In the first 6 months, stations radiating from the plant in northerly, northeasterly and southeasterly directions were visited monthly, and seven trawl hauls were made at each station. After 6 months it became obvious that the outer stations in these transects were not affected by the heated effluent and were generally different in bottom type and biota than the stations closer to shore. Starting in January 1969 these 8 stations were deleted. Eight additional stations, A-H, were added in zones of transition. These were in

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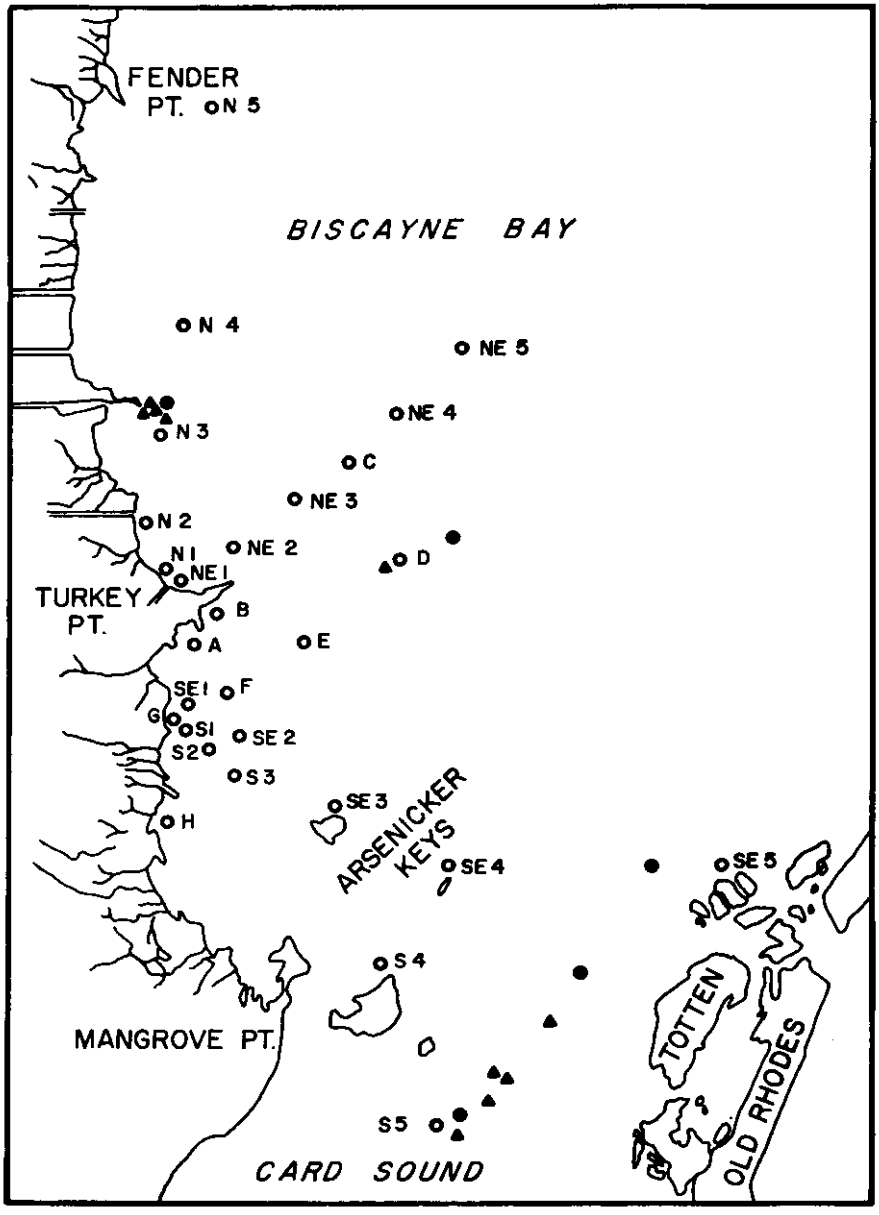

FIG. 1. Map of Biscayne Bay adjacent to Turkey Point showing the location of trawl sample stations.

areas which had similar bottom types and algal communities to those observed near the effluent.

RESULTS

Temperature data collected by ourselves, the Federal Water Pollution Control Administration and Florida Power and Light (in addition to several infrared aerial scans) showed that water from the effluent canal is about 5°C higher than the bay temperatures. The isotherms (Δ°C above ambient) for

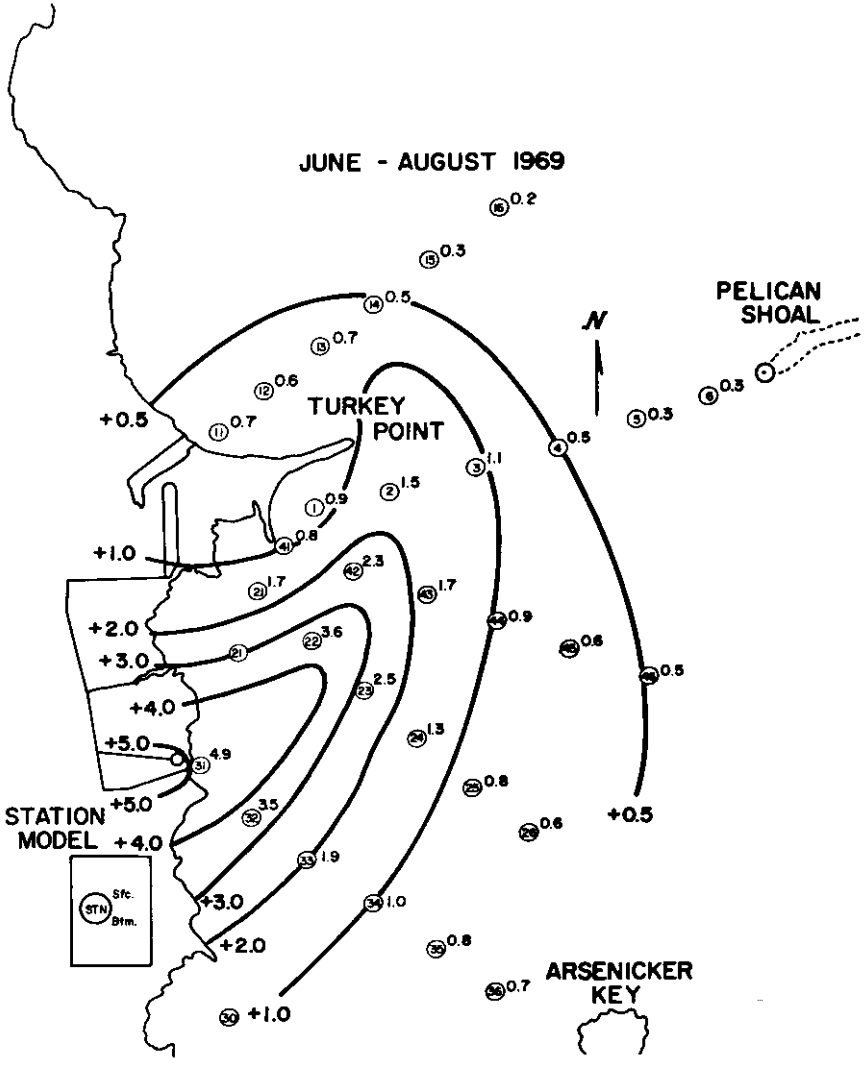

FIG. 2. Map of Biscayne Bay adjacent to Turkey Point showing the average summer increase in temperature due to heated effluents.

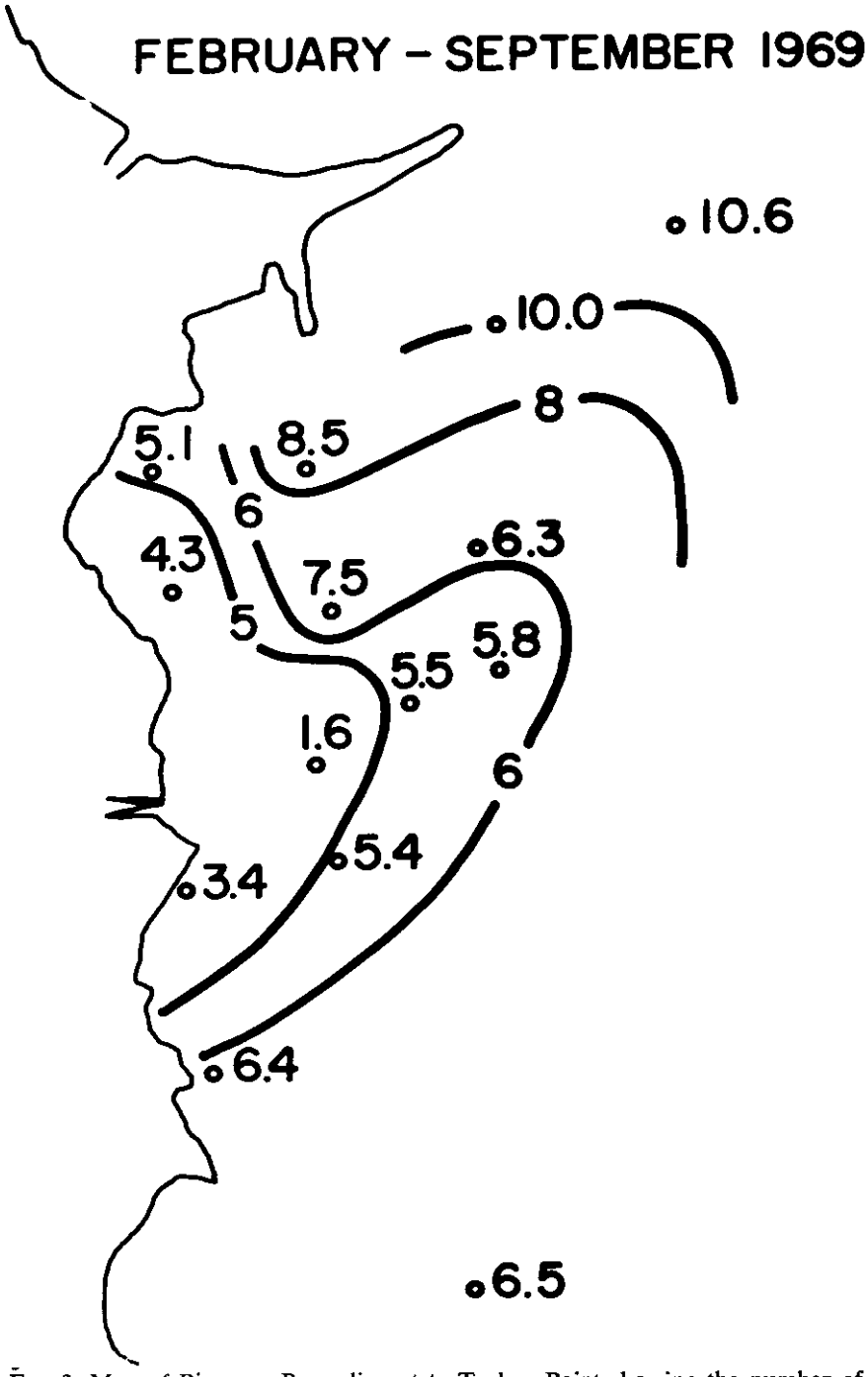

FIG. 3. Map of Biscayne Bay adjacent to Turkey Point showing the number of species of macro-algae.

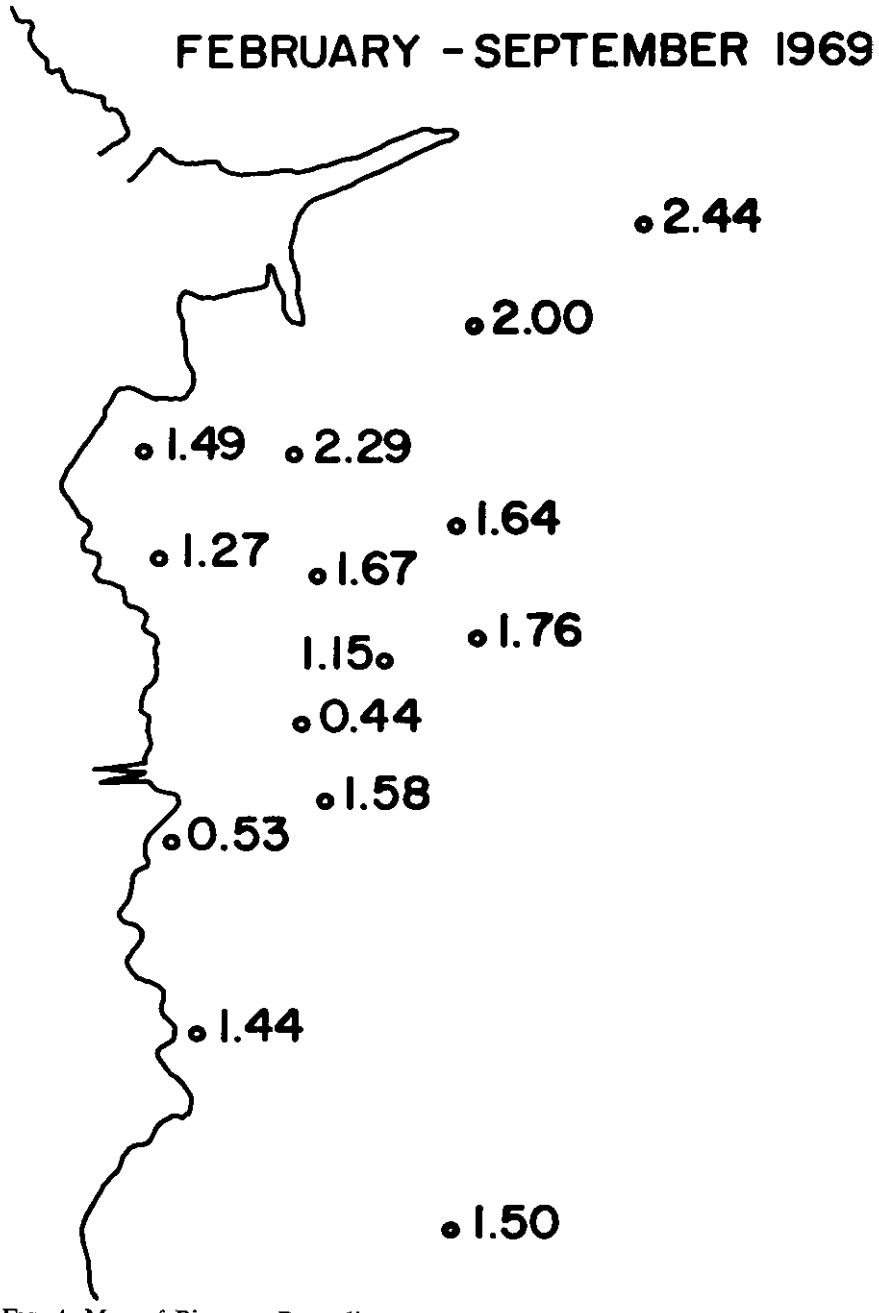

FIG. 4. Map of Biscayne Bay adjacent to Turkey Point showing the Margalef's H-bar diversity index.

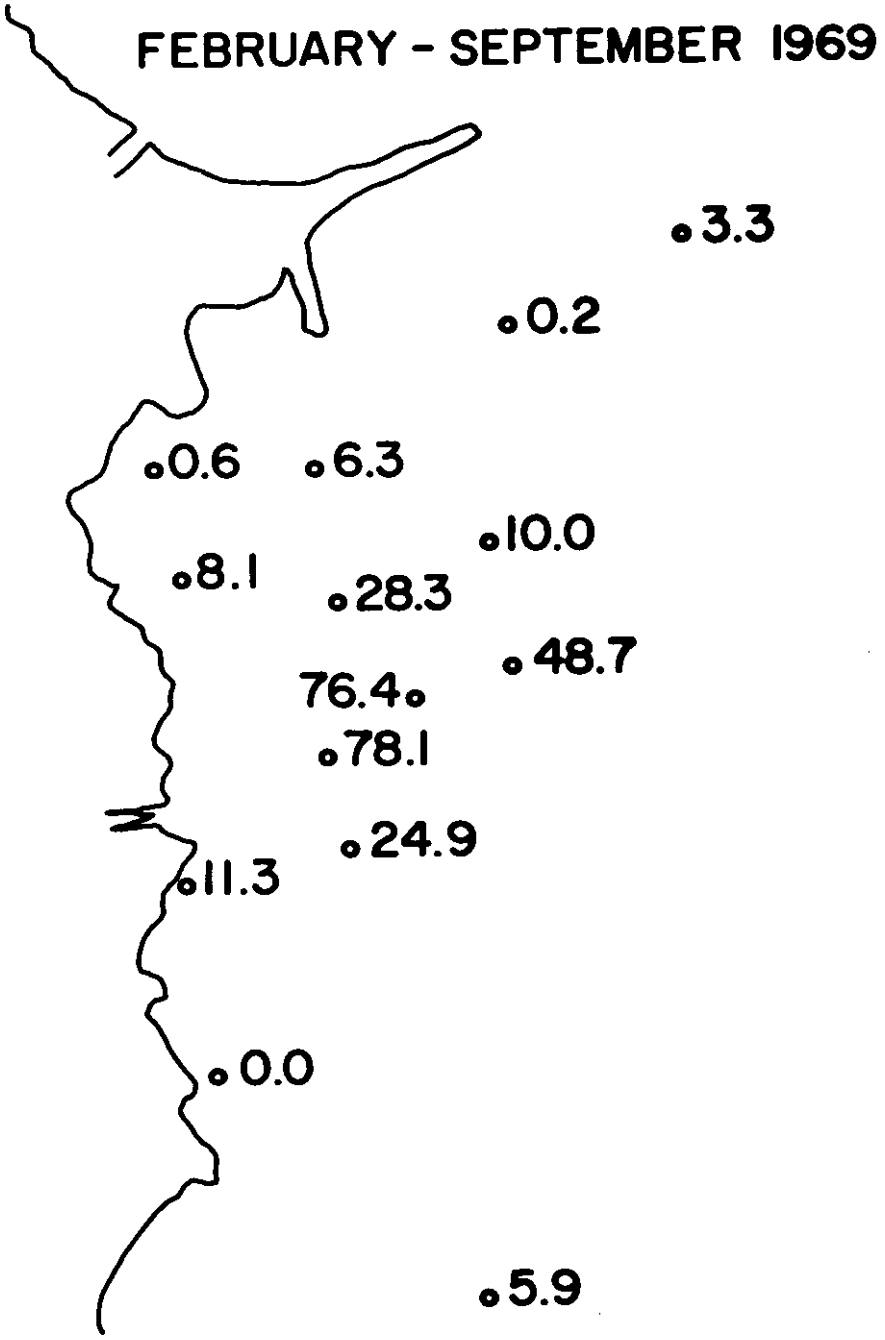

FIG. 5. Map of Biscayne Bay adjacent to Turkey Point showing the relative abundance of blue-green and filamentous-green algal mats.

the period June-August 1969 show the general northeast flow of the heated effluent around Turkey Point (Fig. 2). At this stage of analyses these are expressed as degrees above ambient, though it is the actual temperature and its duration that causes damage. The summer temperatures at the mouth of the effluent canal are between 36-37°C. During the hottest part of the summer, high temperatures of 38-39°C have occurred with a maximum of 40.3°C recorded. At the same time the temperature at a shallow station in mid-bay ranged from 31-32°C.

Fig. 3 shows the average distribution of numbers of species of algae throughout the year. The correlation of numbers of species with the distance from the canal mouth along the main axis of the thermal plume is pronounced, as is the relationship with the temperature profile. The same general pattern (Fig. 4) also correlates with Margalef's H-bar (Margalef, 1958) diversity index. Both the index and the number of species increase in all directions from the outfall. The lower diversity index is a reliable indicator of stress conditions. Fig. 5 shows the average density (percent cover) of a blue-green and filamentous-green algal mat on the sediment. Here the distribution is an inverse of the previous ones. The replacement of the typical estuarine algal flora with the mat or felt forming micro-algae is also a sign of stress in the environment.

Fig. 6 shows the production of blade material produced by *Thalassia* at two different times. The left side of the figure shows the production in grams

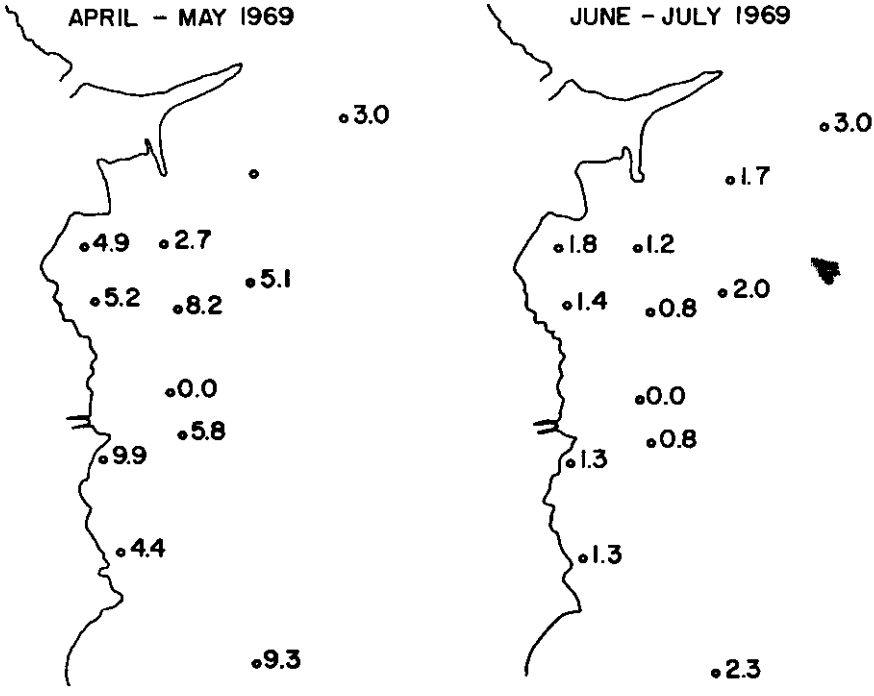

FIG. 6. Map of Biscayne Bay adjacent to Turkey Point showing the production of turtle grass in spring and summer of 1969.

dry weight/meter^2/day for the period of April and May 1969. In an inner area of the canal mouth there is no production shown since there is no *Thalassia*. Out from this, the production is higher but there is little pattern to the production rates. The figures for June and July 1969, on the right, show that areas which had been high producers during the preceding months are now much poorer, and there is a general increase in production outward from the canal mouth. The pattern closely resembles that of algal diversity.

Fig. 7 shows a comparison of the sizes of the areas from which *Thalassia* and the macro-algae have disappeared. In September 1968 the totally barren area was about 30-35 acres, and in September 1969 about 50 acres. The zone from which there was some *Thalassia* but no macro-algae in September 1968 was about 50-60 acres; one year later it was about 70-75 acres. Beyond the areas shown in the figure, an additional zone of about 50 acres showed marked reduction in the numbers of plants. In another contiguous zone of about 170 acres, some damage to the plants was also noted. Thus a total of about 300 acres showed some damage and this area corresponds closely to the +3°C

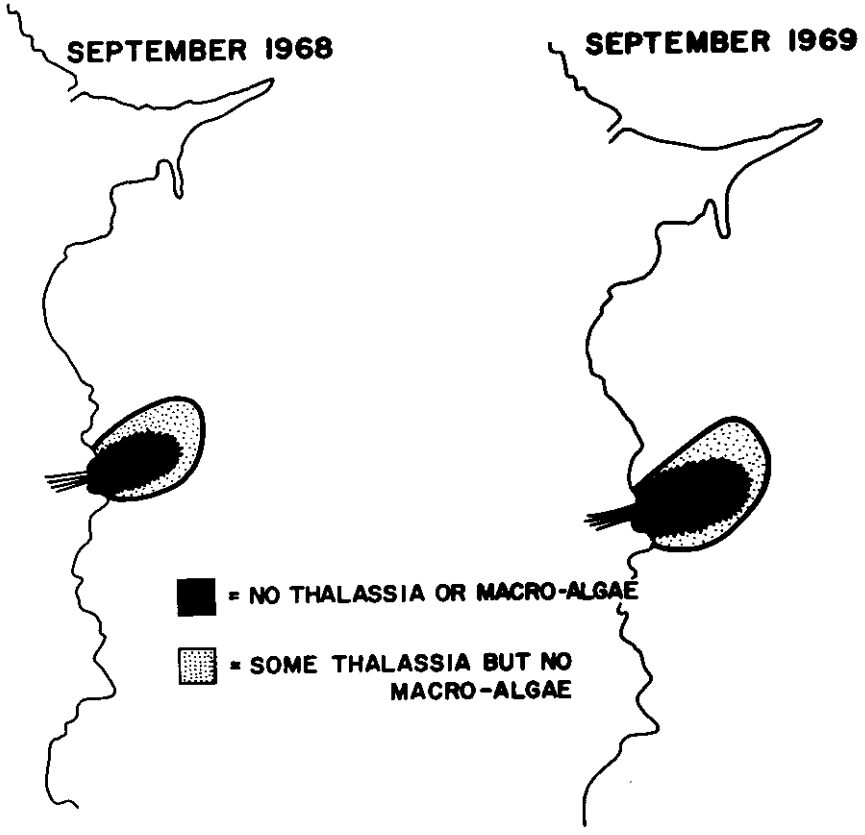

FIG. 7. Diagrams of Biscayne Bay adjacent to Turkey Point showing the relative area of severe and partial damage in September 1968 and September 1969.

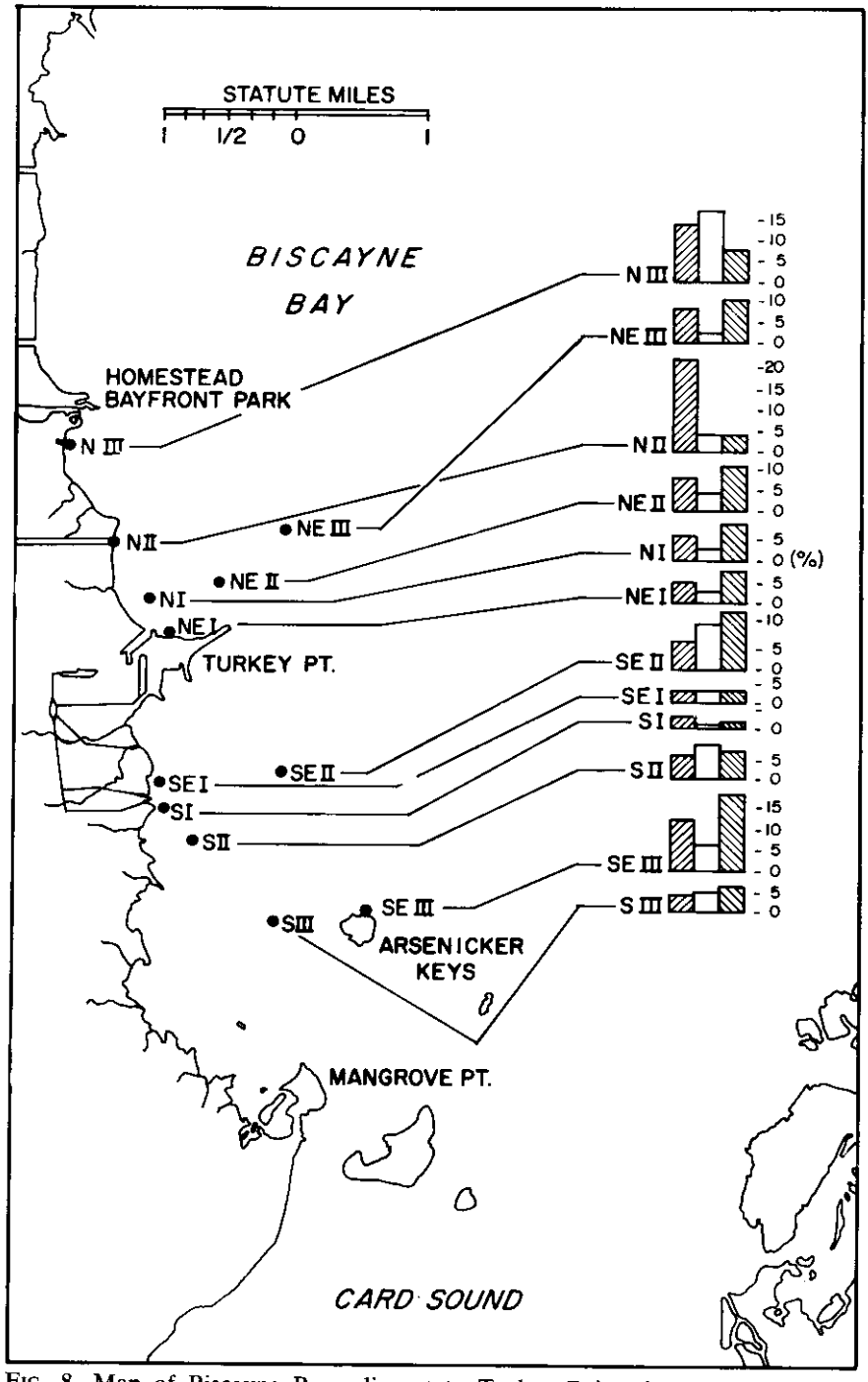

FIG. 8. Map of Biscayne Bay adjacent to Turkey Point showing the percent of fish (diagonal /), molluscs (solid) and crustaceans (diagonal \) taken at 12 trawling stations from July 1968-June 1969.

isotherm. These figures are for early September of these years, at which time the standing crops are usually lowest due to high temperatures in August. Aerial photos of the inner area show dark patches. In the summer and winter these are usually areas of exposed peat, or holes into which peat has washed, while in the fall and spring they are usually colonized heavily by shoal grass *(Diplanthera)*. This diagram and other studies give indications that the sea grasses tend to be more resistant to the thermal stress than the algae. This may be attributable to the conservative properties of the underground rhizome system which comprises about 80% of the weight of the seagrass and can store food reserves upon which the plant can rely in times of stress. This is not generally available to algae.

MACROFAUNA

The total numbers of fishes, molluscs and crustaceans were determined for each station and for the combined stations for the period July 1968-June 1969. The average catch was calculated for the 12 stations. If the catch at an individual station differed by more than one half or by double the average catch, it was considered a significant difference.

The percent of the numbers of fishes, molluscs and crustaceans taken at each station (Fig. 8) indicates that stations S-I and SE-I have fewer fishes and crustaceans than the other stations, and S-I has fewer molluscs. The stations in the transition zone (S-II and SE-II) have more molluscs than the other stations. This is probably due to the large amount of dead vegetation which serves as a source of food for the molluscs.

The high percent of fishes at Station N-II, located off the mouth of the Florida City Canal, is due to large catches of the rainwater killifish *(Lucania parva)*. The high percent of crustaceans occurring at SE-III is a result of high catches taken when large amounts of *Laurencia* were present. The high percent of molluscs at N-III resulted from large catches of *Mitrella lunata* taken in the spring when *Laurencia* was abundant.

In general, stations with large amounts of *Laurencia* produce the greatest variety and numbers of animals. *Thalassia* produces fewer animals, and areas of sand produced the least.

CONCLUSIONS

Heated water dumped into Biscayne Bay has reduced the diversity and abundance of algae and animals in a small area adjacent to the mouth of the effluent canals at Turkey Point. The region where virtually all plants and animals have been killed or greatly reduced in numbers corresponds closely to the +4°C isotherm and includes an area of about 125 acres. A second zone in which algae have been damaged and species numbers and diversity reduced corresponds generally to the +3°C isotherm and covers an area of about 170 additional acres. In this latter area there is some increase in molluscs and crustaceans but a decrease in numbers of fishes. The increased flow rates and higher temperatures expected when the nuclear generators become operational will increase the damaged areas unless additional cooling measures are taken.

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