EXHIBIT 8

Environmental Changes associated with a Florida Power Plant

Damage to the biota of Biscayne Bay by the heated effluent of a power plant is demonstrated quantitatively and qualitatively. Algae and grasses are found to be replaced by blue-green filamentous algal mats; seasonal recovery is slow and the affected areas contain fewer kinds and smaller numbers of animals. Increased temperature is the chief cause.

In June 1968, we began a study of the effects of the heated effluent from Florida Power and Light Company's Turkey Point power plant on the shallow water environment of Biscayne Bay and on the resident biota. The results, although preliminary, lead me to stress the importance of careful site selection in the planning of the new nuclear power plants at Puerto Rico, Colombia, Argentina, Mexico, Brazil and in other tropical regions. At least one of these, at Angra dos Reis in Baia Grande, Brazil, is likely to have similar consequences to that at Turkey Point, unless it is placed in an area of better circulation.

The Turkey Point power plant is located about 40 km south of Miami on the western shore of Biscayne Bay. This part of the bay has an area of about 26,000 ha and is separated from the central portion of the bay by Featherbed Bank, and from Card Sound by the Arsenicker Keys and Cutter Bank. The bay is about 2 m in depth. In the area between Turkey Point and Point (the site of the discharge canal) the water is mostly less than 1 m deep.

Along the mainland shore there is a shelf about a half mile wide composed of mud and peat sediments, normally covered by turtle grass (*Thalassia testudinum*) and algae. East of this, the bottom is mostly covered with a thin layer of coarse sediment composed of broken shell and calcareous algal fragments. The hard bottom is characterized by the attached algae, *Udotea* and *Penicillus,* and by the drifting algae *Laurencia.* Sponges, alcyonarians and corals are common in areas where salinities remain relatively high and stable. On the shoreline of the Florida Keys, to the east, there is again a sediment shelf which is dominated by *Thalassia,* but this region has more echinoderms and reef forms than the western shore of the bay.

Effects on Currents and Temperature

Before the construction of the power plant the water circulation adjacent at Turkey Point was to the NNE on the ebb tide and SSW on a flood tide, except when winds produced other patterns. A net northward transport is indicated by sediment ripples. Two fossil fuel units began operation on April 1967 and April 1968. These use bay water to cool their steam condensers, and discharge this water at the rate of 35 $m^3 sec^{-1}$ at Turtle Point. This discharge has changed the current pattern, and there is now a consistent NNE flow. This pattern persists, regardless of tide, except when strong NW winds cause the flow to go east-south-east (Figure 1).

Bay water temperature measured on Pelican Bank, a shallow grass flat beyond the influence of the effluent, varied from a minimum of 10°C in winter to 32°C in summer. The fossil fuel plants increased the water temperature 6-7°C, and the discharge was, on average, 5°C above normal. About 10-12 ha were subjected to a temperature elevation of 4-5°C, 60 ha to 3-4°C, 120 ha to 2-3°C, 250 ha to 1-2°C water and over 400 ha to 0.5-1°C (Fig. 2).

In addition to the heat carried by the effluent, there was increased turbidity due to an organic substance, and increased iron concentrations in the effluent. An additional pollutant was copper, probably arising from the use of shark repellents during Air Force rescue

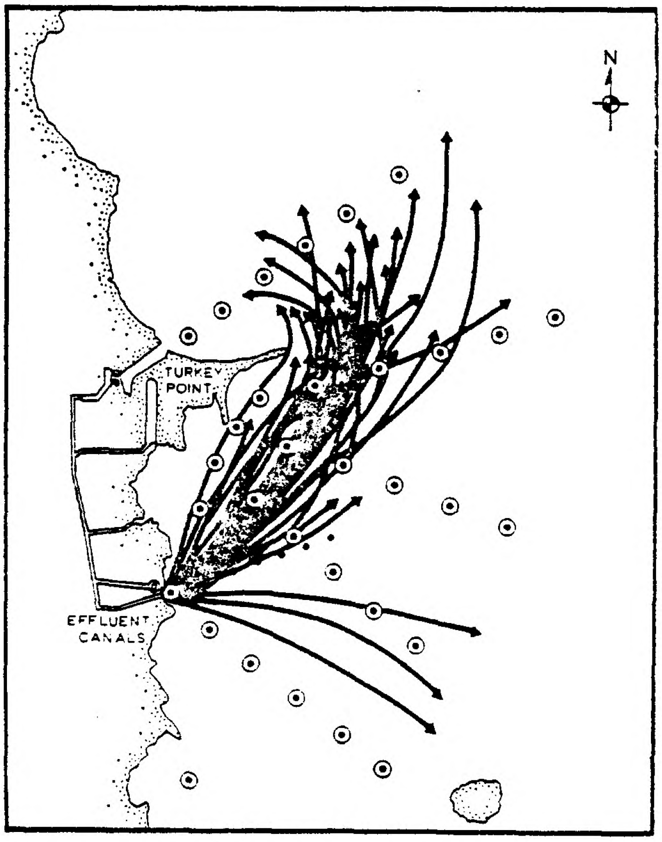

Fig. 1 Location of the axis of the thermal plume at Turkey Point.

training operations. Copper was distributed unevenly in the bay near Turkey Point. The concentrations of nutrient chemicals seemed to be greater than usual for subtropical estuaries. Dissolved oxygen concentrations were usually saturated and the lowest values observed in early morning hours were between 3 and 4 ppm.

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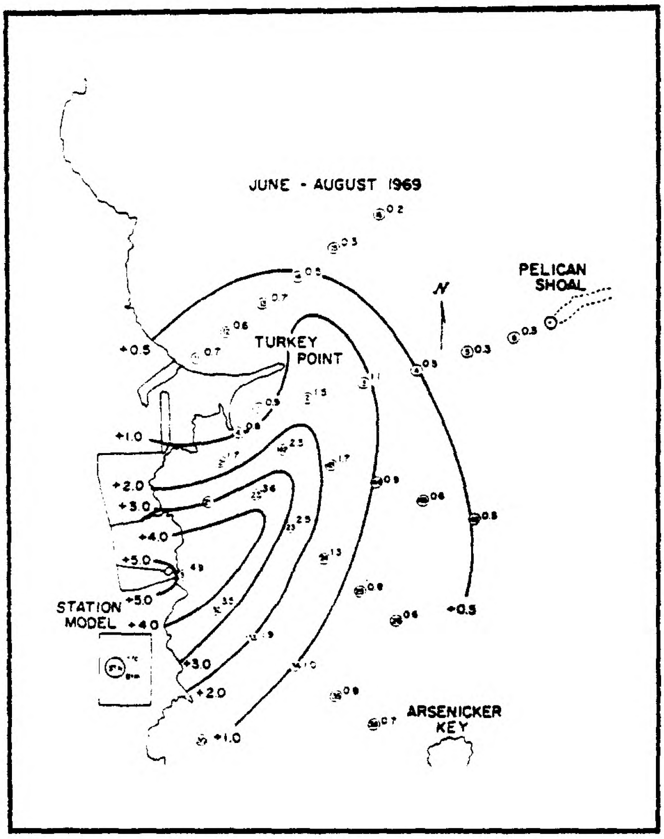

Fig. 2 Average summer increase in temperature (Sfc. surface; btm. bottom).

Effects on Plants

Plant abundance was studied by diving and counting the numbers of algae and *Thalassia* blades inside permanently marked grids at fourteen stations. After the power plant began operating, all the normal green, red and brown algae disappeared in an area of 12-20 ha and were replaced by a blue-green algal mat. In an area of 8-10 ha outside this, most of the macro-algae disappeared; *Thalassia* survived in sparse stands. In winter this area was colonized by *Diplanthera* which died in June when the temperature rose and salinity fell. A reduced number of species and abundance of algae, and a lowered production of *Thalassia* were noted in an area of about 120 ha, which corresponds closely with the location of the +3°C isotherm (Roessler and Zieman, 1970; Zieman 1970).

Effects on Animals

Animals were sampled monthly by otter trawls lined with 13 mm mesh. Seven replicate hauls were made at each station. A total of twenty-eight stations have been studied (Fig. 3). During the first 18 months of the study, station G located within the +4°C isotherm produced almost no animals (2.5/drag). Two stations (SEI and SI) located within the +3°C isotherm produced fewer species and fewer individuals (41 and 13/drag) than similar areas in the bay which were outside the heated area. Two stations (S2 and F) located within the +2°C isotherm had greater numbers of animals (116 and 234/drag) comprising mostly molluscs (75 and 147/drag) and crustaceans (37 and 79/drag). These are apparently using the dying vegetation as a food source (Table 1). Stations located outside the +2°C isotherm were not noticeably affected, but detailed analysis may indicate some seasonal changes in numbers of species, abundance and species dominance, particularly in the summer.

Laboratory studies on algae, shrimp larvae and crab larvae indicate that prolonged exposure to temperatures between 33 and 34°C are lethal to *Penicillus*, *Valonia*, pink shrimp, stone crabs and carideans. This is in agreement with the field observations that suggest that an increase of +3°C over the summer ambient of 31°C causes death to algae, reduced production in *Thalassia* and changes in the animal communities.

Nugent (1970) reported the results of studies on the effects of the heated effluent on some of the larger fishes and other animals in the effluent canal and a control canal. He made collections by means of gill nets, traps, hoop nets and slate panels. Gill net catches of white mullet, striped mullet, fantail mullet, snook and blue crabs were similar in the heated and control canals during winter months, but were significantly smaller in the heated canal in summer. Catches of grey snappers and tarpon at the heated and control stations were similar. The lemon shark was the only fish species taken in greater numbers in the heated canal compared to the control station. Catches of pinfish in traps at different stations seemed to vary according to temperature. They were driven from the heated canal in summer when the temperature reached 40°C and did not return until autumn when the temperature reached 21°C. Juvenile blue crabs were caught in greater numbers in the heated canal except in July and August.

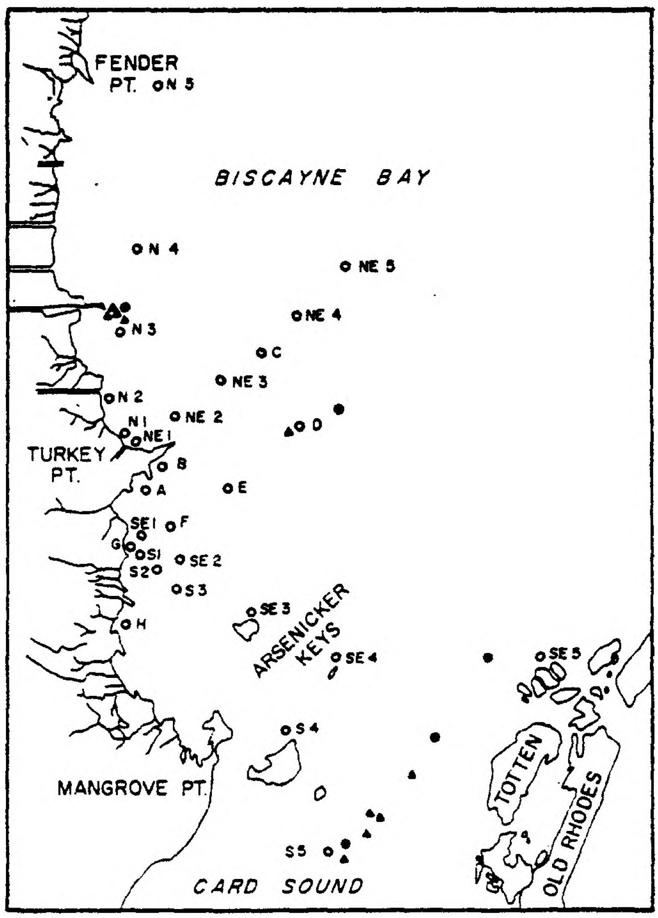

Fig. 3 Location of trawl sampling stations.

Table 1 Catch per drag of Algae and Animals and Average Annual Deviation from Ambient Temperature at Trawl Stations

			Catch/effort								
Station	± Ambient Temp.(°C.)	Effort	Weed (kgs)	Fish	Mollusks	Crustaceans	Sponges	Coelenterates	Echinoderms	Misc.	Total
N1	+ 0.30	128	4.6	1.8	20.5	40.6	1.7	0.16	0.00	0.00	64.7
N2	+ 0.34	128	3.2	4.8	43.9	14.1	0.1	0.04	0.01	0.01	62.9
N3	+ 0.27	128	6.4	4.4	129.5	51.3	0.7	0.02	0.07	0.00	186.0
N4	− 0.16	54	3.1	2.6	89.1	81.9	2.1	0.06	7.48	0.00	183.3
N5	+ 0.07	54	8.9	23.1	361.2	47.1	0.0	0.02	0.00	0.00	431.5
NE1	+ 0.33	128	3.4	1.9	32.1	39.2	1.4	0.02	0.52	0.00	75.1
NE2	+ 0.23	128	5.0	2.1	28.7	60.2	1.7	0.03	1.03	0.00	93.8
NE3	+ 0.01	128	4.0	2.3	38.2	65.3	0.7	0.08	4.98	0.00	111.5
NE4	− 0.13	54	1.0	1.3	8.9	12.6	2.1	0.43	6.33	0.01	31.7
NE5	− 0.32	54	0.1	0.8	1.9	3.6	0.9	0.22	1.61	0.00	9.1
SE1	+ 3.25	128	1.4	0.9	28.4	11.4	0.2	0.02	0.02	0.00	40.8
SE2	+ 0.86	128	3.2	1.6	54.9	62.1	1.5	0.02	7.03	0.02	127.1
SE3	+ 0.34	128	2.7	2.2	40.1	61.4	1.9	0.00	3.73	0.00	109.2
SE4	− 0.02	54	1.0	1.5	16.6	6.8	1.0	0.24	1.39	0.00	27.6
SE5	+ 0.25	54	0.1	2.4	1.6	1.0	0.5	0.56	6.57	0.00	12.7
S1	+ 3.42	128	0.7	0.6	5.7	7.0	0.1	0.00	0.04	0.00	13.4
S2	+ 1.99	128	3.5	1.6	75.4	36.6	0.4	0.00	2.22	0.00	116.1
S3	+ 0.86	128	1.7	0.9	23.2	29.6	0.7	0.02	5.78	0.00	60.3
S4	+ 0.75	52	0.5	1.2	10.7	4.5	7.6	0.04	8.23	0.00	32.3
S5	+ 0.52	54	0.1	1.4	2.6	1.3	4.4	1.65	6.24	0.00	17.7
A	+ 1.39	114	2.3	1.3	41.4	14.8	1.0	0.00	0.05	0.00	58.6
B	+ 0.84	86	2.4	1.1	16.6	17.8	0.3	0.01	0.21	0.02	36.1
C	+ 0.08	86	1.5	1.6	17.0	24.2	0.9	0.05	5.29	0.00	49.1
D	20.45[1]	86	0.8	0.9	15.5	8.1	20.3	0.17	0.70	0.03	45.8
E	+ 0.28	86	1.7	1.0	24.4	15.1	0.6	0.03	5.27	0.01	46.5
F	+ 1.81	86	7.0	1.9	146.6	78.9	6.6	0.05	0.03	0.00	234.1
G	+ 4.20	86	0.0	0.2	0.5	1.7	0.0	0.00	0.00	0.00	2.5
H	+ 1.39	86	3.5	1.7	45.2	24.0	0.7	0.08	0.23	0.00	71.8

[1] Station D was considered the temperature control station.

Hoop net catches indicated that most mobile animals leave the effluent canals in summer. Mangrove snapper are one of the last fishes to leave the heated canal, and tarpon remain throughout the summer. The other fishes return in autumn when the temperature is lower. Barnacle settlement on slate panels indicated that settlement was inhibited at the station closest to the plant effluent during June and July. Growth rates were similar in control and affected areas in summer, but in winter growth was greater in the heated areas.

Future Effects

It is not yet possible to predict what will happen when the nuclear reactors begin to operate and the cooling water requirements increase by a factor of 3.5. The 120 ha area of damage may increase to 400 ha, or by a square function. Furthermore, the effluent may be discharged in a different area, some 8 km south of the present location, since the Florida Power and Light Company is constructing a canal to Card Sound for this purpose; prediction is thus made even more difficult. Card Sound is a smaller body of water 5 km wide by 8 km long, with an average depth of 3 m. It has a slow flushing period (Dean 1969, 1970; Michel 1970). The rim of sediments and *Thalassia* is extremely narrow and the deep water comes close to shore (Wanless, 1969). The shoreline flora and fauna are similar to those in Biscayne Bay (Iversen & Roessler, 1969) and temperatures of 3°C above ambient will damage animals and plants. The effects on the sponge-alcyonarian community are unknown since this community was not subjected to temperature stress in Biscayne Bay.

An additional problem which will probably be encountered with the nuclear reactors is damage to planktonic organisms and larval forms of the benthic communities. Zooplankton and the larval forms of many species of fishes and invertebrates are present in Biscayne Bay and Card Sound in all seasons. With the present fossil fuel plants, 35 m^3sec^{1-} of water are being passed through the plant. When the nuclear generators are operating the total water requirements will be 120 m^3sec^{-1}. The consequent temperature rise of 8°C and mechanical damage will undoubtedly kill some of the plankton passing through the plant.

An additional 110-170 m^3sec^{-1} of bay water will be added to the effluent from the plant to provide cooling. The plankton in this water will be subjected to a rise in temperature of from 2-4°C for a period of 4.5h or more. In laboratory studies it has been shown that the copepod (*Acartia tonsa*) dies when temperature exceeds 36°C despite adaption to high temperature (Reeve and Cosper, 1970).

Damage to the biota of Biscayne Bay from the heated effluent of the Florida Power and Light Company's Turkey Point power plant has been demonstrated on a qualitative and quantitative basis. Algae and sea grasses have been killed and replaced by blue-green filamentous algal mats. There has been partial recovery of plants seasonally, but *Thalassia* was replaced by *Diplanthera*. Areas in which the normal algae and sea grass communities have been damaged or destroyed have fewer kinds and smaller quantities of animals. Areas in which the *Thalassia* and algae die off seasonally and recolonize in winter provide a source of detritis which causes increased abundance of a few species of molluscs and crustaceans. The area in which these changes occurred are closely associated with the temperature changes.

Since there was a partial recovery of the biota in winter when the effects of water currents and chemical

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pollutants are still present, it is believed that increased temperature is the major cause of damage. Sustained temperatures above 33°C are apparently dangerous to the biota. This temperature also appears to be critical for algae, shrimp larvae, crab larvae and fish eggs examined in the laboratory.

This work represents contribution No. 1341 from the Rosenstiel School of Marine and Atmospheric Science, Miami, and it was supported by the US Atomic Energy Commission and the Federal Water Quality Administration.

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Ecological Implications of Breakwater Construction in Monterey Harbour

An attempt is being made to assess the effects of the construction of a breakwater complex on the shallow water marine environment of Monterey Bay. Many species may be driven away by temperature and salinity fluctuations and by the accumulation of silt and pollutants.

Monterey is situated at the southern end of Monterey Bay which is broadly open to the Pacific to the west. It has been a port since 1602 when it was established as a centre for Spanish California, but it is not a natural harbour and it is particularly exposed to waves and swell from the northwest. The first wharf to be built on the Pacific coast was nevertheless constructed at Monterey in 1845. With the establishment of a permanent fishing fleet just before World War I, it became essential to provide some protection for the vessels. Thus a permeable breakwater consisting of granite rock quarried locally was constructed by the US Army Corps of Engineers between 1931 and 1934. This breakwater runs in an easterly direction from the shore north of the harbour area. It is approximately 570 m long and has proved effective in damping waves and swell coming from the north, but surge in the harbour is still a problem. In 1926 a major wharf (called Municipal Wharf No. 2) was constructed to the east of the harbour area and extended from the shore for approximately 575 m in a northerly direction. This wharf was built primarily on concrete pilings and is still in good condition. The harbour structures existing today are shown in Fig. 1.

Need for Breakwater

For many years the City of Monterey and the local fishing industry lobbied unsuccessfully to have the Corps of Engineers build a so-called companion breakwater which would be constructed to the east of Wharf No. 2 and run from the shore toward the north and northwest to near the end of the present breakwater leaving only a narrow channel for passage between the two. At first the rationale for building the new breakwater was to give additional safe moorage for the large fishing fleet, particularly by reducing surge, but with the decline of the fishing vessels due to the disappearance of the sardines along the coast the emphasis has shifted more recently to giving protection and berthing for an ever expanding fleet of pleasure craft and to afford pier space in a protected harbour for oceanographic research vessels.

Plans for Construction

In September, 1970, it was officially announced that a new breakwater complex would be built by the Army Corps of Engineers and some Federal funds were appropriated. Although there are some remaining problems regarding funding, the project is now in the advanced planning stage and there is every indication that within a year or two construction will begin (Fig. 2). Since its inception many years ago this project has become expanded many times. The new east break-

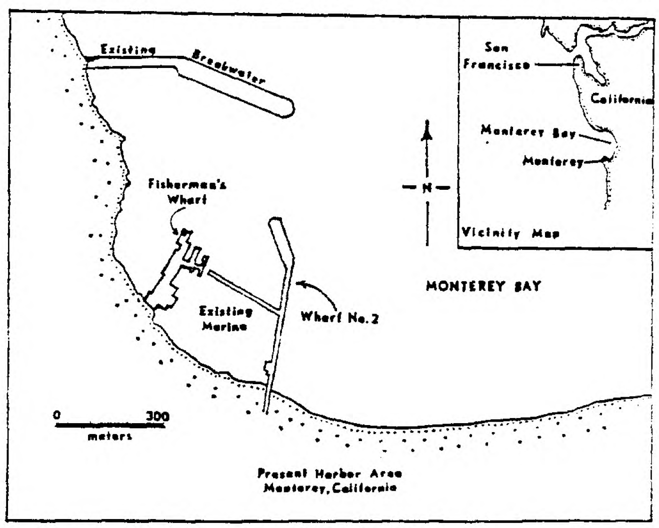

Fig. 1