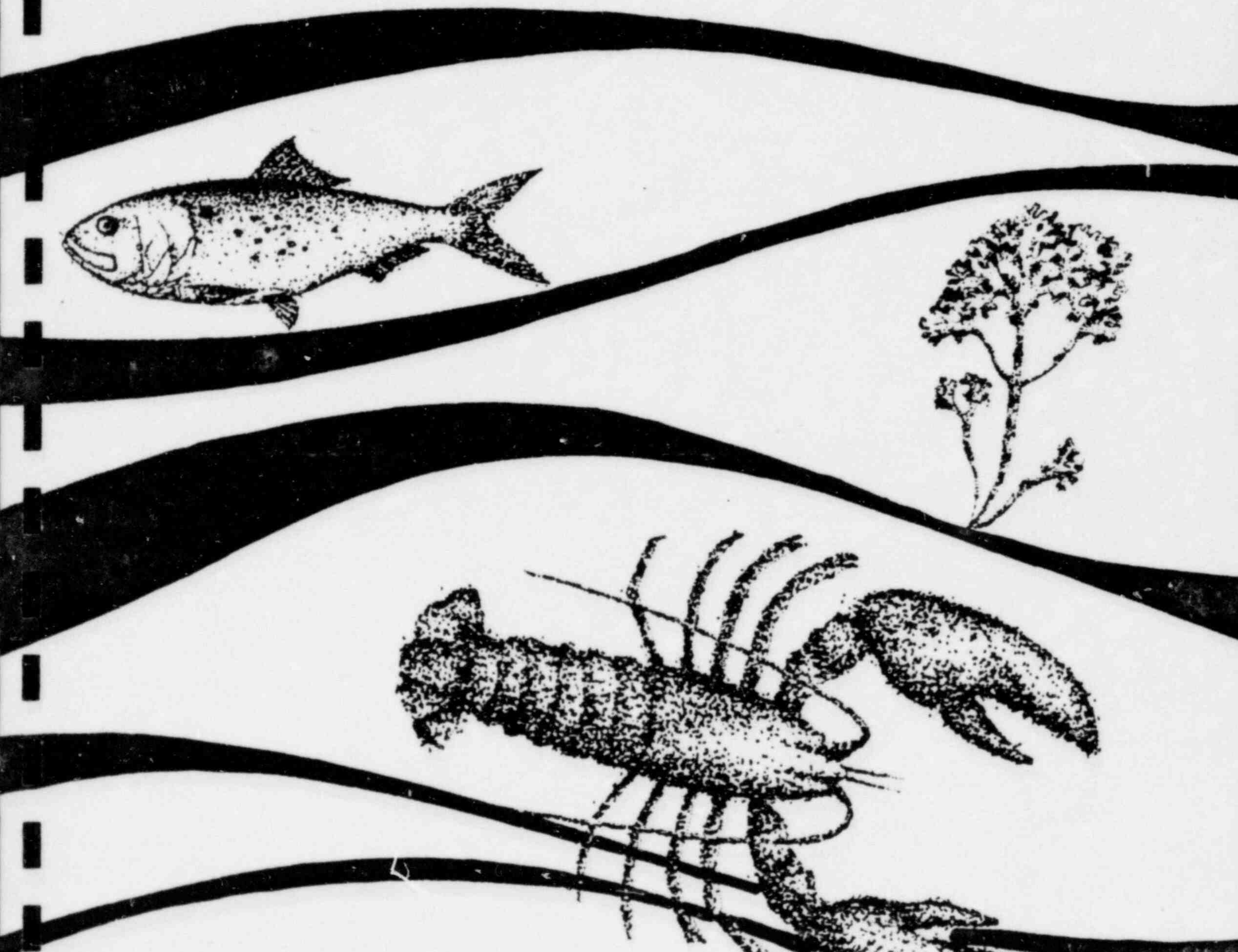
marine ecology studies

Related to Operation of Pilgrim Station

SEMI-ANNUAL REPORT NUMBER 20
JANUARY 1982 — JUNE 1982



BOSTON EDISON COMPANY
NUCLEAR OPERATIONS SUPPORT DEPARTMENT

BOSTON Edison COMPANY

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MARINE ECOLOGY STUDIES
RELATED TO OPERATION OF PILGRIM STATION

SEMI-ANNUAL REPORT NO. 20

REPORT PERIOD: JANUARY 1982 THROUGH JUNE 1982

DATE OF ISSUE: OCTOBER 31, 1982

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SUMMARY

Highlights of the environmental surveillance and study program results obtained over this reporting period (January - June 1982) are presented below:

Marine Fisheries Studies:

1. Irish moss landing statistics for June 1982 compared to June 1981 indicated that landings decreased 33.9% and effort 50.7%. Pooled area harvest rate increased from 189.1 (1981) to 253.6 lbs/hr (1982). Harvest rate from Area 5 (Pilgrim Station - 266.6 lbs/hr) increased 23.8% from 1981, and Area 1 (control) harvest rate (323.8 lbs/hr) increased 44.5% above the 1981 rate. This indicates Pilgrim Station operation had no adverse impact on the Irish moss species.

2. Winter flounder, skate spp., longhorn sculpin, windowpane, ocean pout and yellowtail flounder were the dominant fishes in the January - June 1982 otter trawl catch. CPUE increased from 1981 for winter flounder (28.5 to 29.0), longhorn sculpin (1.4 to 2.5) and ocean pout (0.7 to 1.3). CPUE decreased for skate spp. (9.6 to 6.8), windowpane (5.1 to 1.5) and yellowtail flounder (8.1 to 1.0). Pelagic fish mean catch at the original gill net station (151.3 fishes/set) increased from 1981 when 118.3 fishes/set were taken. Pollock (36.5%), cunner (22.1%)

and northern searobin (5.3%) accounted for 63.9% of the total catch. Pollock CPUE decreased from 92.6 to 55.3 and cunner increased 19.4 to 33.6 compared to January - June 1981. It was suggested that declines in the most abundant species' CPUEs were the result of natural variability, and that Pilgrim Station operation had no detrimental effect on benthic and pelagic fish studied in 1982.

3. Shrimp trawl catch from March-June 1982 recorded fifteen benthic fish species with winter flounder, yellowtail flounder, windowpane, little skate, ocean pout, longhorn sculpin and fourspot flounder composing 97.3% of the total. Mean CPUE for all species was 26.3 compared to 27.1 in 1981. Individual species CPUEs were also comparable to March - June 1981 with winter flounder at 11.6, little skate 5.7, yellowtail flounder 4.1, windowpane 3.0, and longhorn sculpin 1.0.

4. Adult lobster mean monthly catch rate per pot haul in May and June 1982 was 0.45 lobsters (0.41 in 1981). Berried female lobsters accounted for 2.7% of the total catch for this period compared to 5.5% in 1981.

5. In May - June 1982 fish observational dive surveys five species were observed in the thermal plume area. Cunner, pollock and tautog were the most numerous

species seen. No fish showed abnormal behavior and no gas bubble disease symptoms were observed on routine observational dives. Most species were in greatest concentrations at stations in the direct path of the thermal plume, indicating attraction to the Pilgrim Station thermal effluent.

6. Atlantic silverside accounted for 80% of the March - April 1982 haul seine (shore zone) fish catch with a total of seven species collected. Shrimp (Crangon spp.) dominated the invertebrate catch. Fish captured in the PNPS intake embayment were Atlantic silverside, sand lance spp., and winter flounder.

Impingement Studies:

1. The mean January - June 1982 impingement collection rate was 1.07 fish/hr. The rate ranged from 0.25 fish/hr (January and February) to 2.41 fish/hr (March) with Atlantic silverside comprising 34.2% of the catch, followed by threespine stickleback 14.4%, bay anchovy 9.3%, cunner 9.3%, alewife 4.7%, and winter flounder 4.7%.

2. In March 1982, when the high fish impingement rate of 2.41 was recorded, Atlantic silverside accounted for 92.5% of the fishes collected. This is historically the maximum impingement period for Atlantic silverside.

3. The mean January - June 1981 invertebrate collection rate was 1.55/hr with the horseshoe crab accounting for 61.5%, sand shrimp 15.2%, rock crab 5.9%, green crab 5.1%, and American lobster 4.3% of the catch.

4. Sixteen American lobsters were sampled for a six-month rate of 290 lobsters impinged, assuming 100% operation of Pilgrim Station.

5. Impinged fish survival (pooled for static and continuous washes) at the end of the new Pilgrim Station sluiceway was 13.3% (short-term) and 6.7% (long-term). Fish introduced in front of operating traveling screens showed initial survival of 100% for cunner, 99.1% for winter flounder and 14.6% for Atlantic silverside. Long-term survival percentages were 100, 85.5 and 4.1, respectively.

Benthic Studies:

1. Per recommendation by the benthic subcommittee of the PATC, the Manomet Point samples were again collected and sorted.

2. Two new faunal species were added to the list; these were both gastropods.

3. Manomet Point had the greatest densities of faunal organisms and also the greatest species richness.

4. The Effluent station had higher diversity and evenness than the two control sites in August.

5. Normal classification analysis performed suggests slight but evident changes in community structure of the Effluent due to PNPS operation.

6. The total algal biomass at all stations declined between the August 1981 and March 1982 collections.

7. The Phyllophora epiphytic fraction showed higher biomass than the Chondrus epiphytic fraction.

Plankton Studies:

1. Entrainment

   a. A total of 36 species of fish eggs and/or larvae were found in the January - June 1982 entrainment collections.

   b. Egg collections for January - June 1982 were dominated by Atlantic cod (January - February), winter flounder (March - April), labridae - Limanda group (May - June), Atlantic mackerel and windowpane (May - June).

c. Larval collections for January - June 1982 were dominated by sand lance (January - March), rock gunnel (February - April), winter flounder (April - June), grubby (February - April), cunner (June), rockling (May), and Atlantic mackerel (June).

d. One lobster larvae was collected in the entrainment samples for 1982.

e. Several rainbow smelt larvae were collected in June 1982.

2. Winter Flounder Egg Viability Studies

a. Winter flounder (*Pseudopleuronectes americanus*) eggs were collected to determine if these eggs survive entrainment at PNPS.

b. Samples were taken from both the intake bay and the discharge canal, in order to look at egg viability both before and after entrainment.

c. Winter flounder eggs do survive entrainment, and some winter flounder eggs collected prior to entrainment are dead.

INTRODUCTION

A. Scope and Objective

This is the twentieth semi-annual report on the status and results of the environmental surveillance and study programs related to the operation of Pilgrim Nuclear Power Station (PNPS). The study programs discussed in this report relate specifically to the Cape Cod Bay ecosystem with particular emphasis on the Rocky Point area. This is the eighth semi-annual report in accordance with the environmental monitoring and reporting requirements of the PNPS Unit 1 (#MA0003557) NPDES permit from the U.S. Environmental Protection Agency. A multi-year (1969-1977) report incorporating marine fisheries, benthic, plankton-entrainment and impingement studies was submitted to the NRC in July 1978 as required by the PNPS Appendix B, Tech. Specs. Programs in these areas have been continued under the PNPS NPDES permit.

The objectives of the Environmental Surveillance and Study Program are to determine whether the operation of PNPS results in measurable effects on the marine ecology and to evaluate the significance of any observed effects. If an effect of significance is detected, Boston Edison Company has committed to take steps to correct or mitigate any adverse situation. These studies are guided by an Administrative-

Technical Committee which is chaired by a member of the U.S. Environmental Protection Agency and whose membership includes representatives from the University of Massachusetts, the Mass. Division of Water Pollution Control, the Mass. Division of Marine Fisheries, the National Marine Fisheries Service (NOAA), the U.S. Bureau of Sport Fisheries and Wildlife, the U.S. Environmental Protection Agency and Boston Edison Company. Copies of the Minutes of the Pilgrim Station Administrative-Technical Committee meetings held during this reporting period are included in Section IV.

B. Marine Biota Studies

1. Marine Fisheries Studies

A marine fisheries study initiated in 1969 is being conducted by the Commonwealth of Massachusetts, Division of Marine Fisheries (DMF).

The occurrence and distribution of fish around Rocky Point and at sites outside the area of temperature increase are being studied. Groundfish and pelagic species are sampled using otter trawl (5 stations) and gill net (2 stations) collections (Figure 1) made at one-month intervals.

In 1981, two additional fish sampling techniques were added and the frequency of otter trawl and gill net sampling reduced to accommodate these. The new techniques are shrimp trawling and haul seining which provide more PNPS impact-related sampling of benthic fish and shore zone fish, respectively. Shrimp trawling is done twice/month at 4 stations and haul seining once/week during March/April, August/September and November/December at 4 stations (Figure 2).

Studies have been conducted since early 1970 of local lobster stock catch statistics for areas off Rocky and Manomet Points (Figure 3). Catch statistics continue to be collected approximately weekly throughout the fishing season (May-November).

The recording of total landings of Irish moss harvested in the study area began in 1971. To facilitate comparisons of the amount of moss harvested in the immediate discharge area with control areas, the coastline was divided into eight monitoring zones (Figure 4). The total weight of moss harvested and the effort expended within each monitoring zone by each raker are recorded daily.

A finfish observational dive program was initiated in June 1978. SCUBA gear is utilized on biweekly dives from May-October (weekly mid-August to mid-September) at 6 stations (Figure 2) in the PNPS thermal plume area.

Results of the marine fisheries studies during the reporting period are presented in Section IIIA.

2. Benthic Studies

The studies described in this report were conducted by Taxon, Inc., Salem, Massachusetts.

The benthic flora and fauna were sampled at three locations at depths of 10 feet (MLW) (Figure 1). Quantitative (rock substratum) samples were collected, and the dominant flora and fauna in each plot were recorded. Sampling was conducted two times per year to determine biotic changes, if any. Transet sampling off the discharge canal to determine the extent of the denuded and stunted zones is conducted four times a year. Results of the benthic surveys reported during this period are discussed in Section IIIB.

3. Plankton Studies

Since August 1973, Marine Research, Inc. (MRI) of Falmouth, Massachusetts has been studying entrainment in Pilgrim Station cooling water of fish eggs and larvae, and lobster larvae (from 1973-1975 phytoplankton and zooplankton were also studied). Figure 5 shows the entrainment contingency sampling station locations. Information generated through these studies has been utilized to make periodic modifications in the sampling program to more

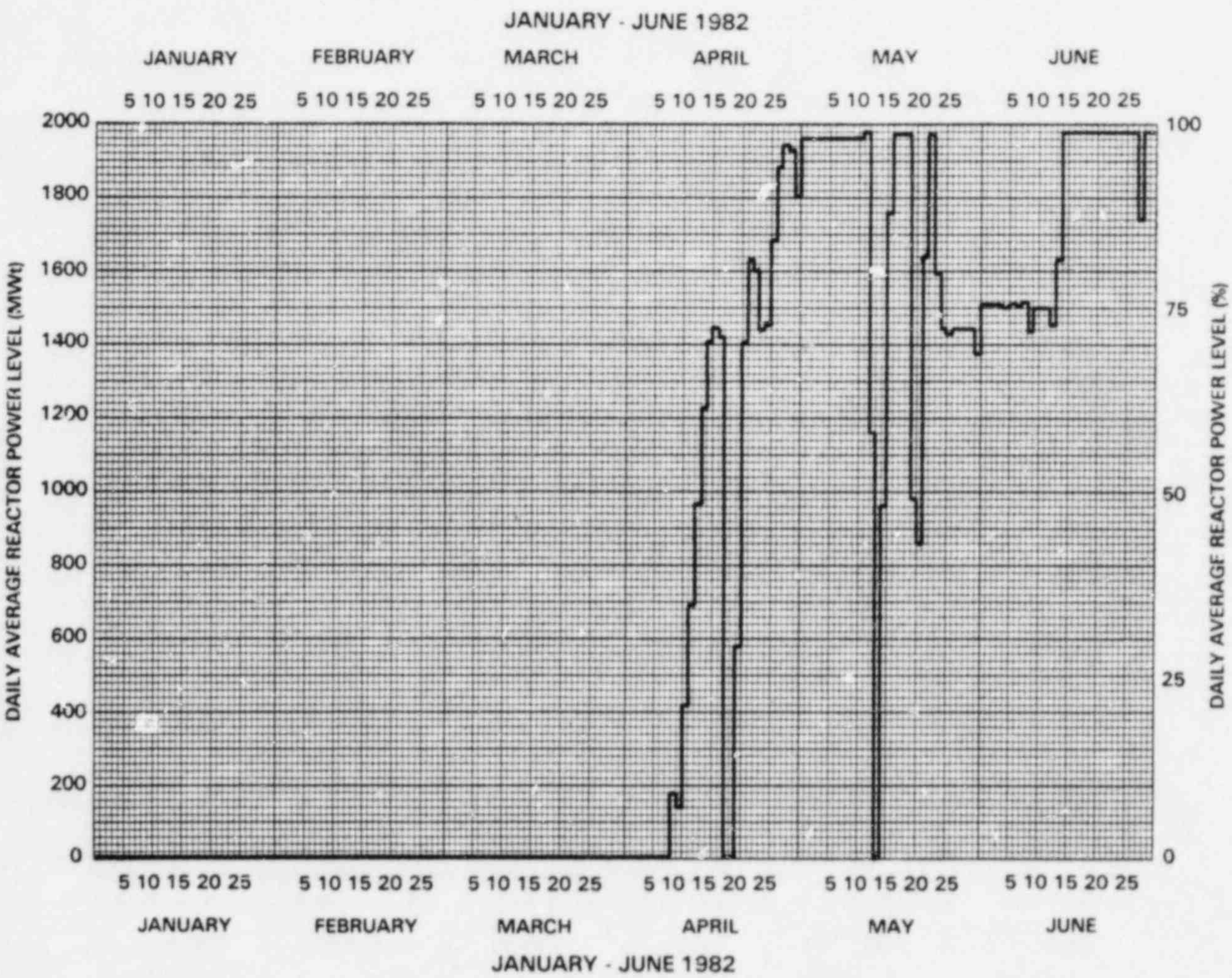

Figure 6. Daily Average Reactor Thermal Power Level (MW_t and %) from January-June 1982 for Pilgrim Nuclear Power Station.

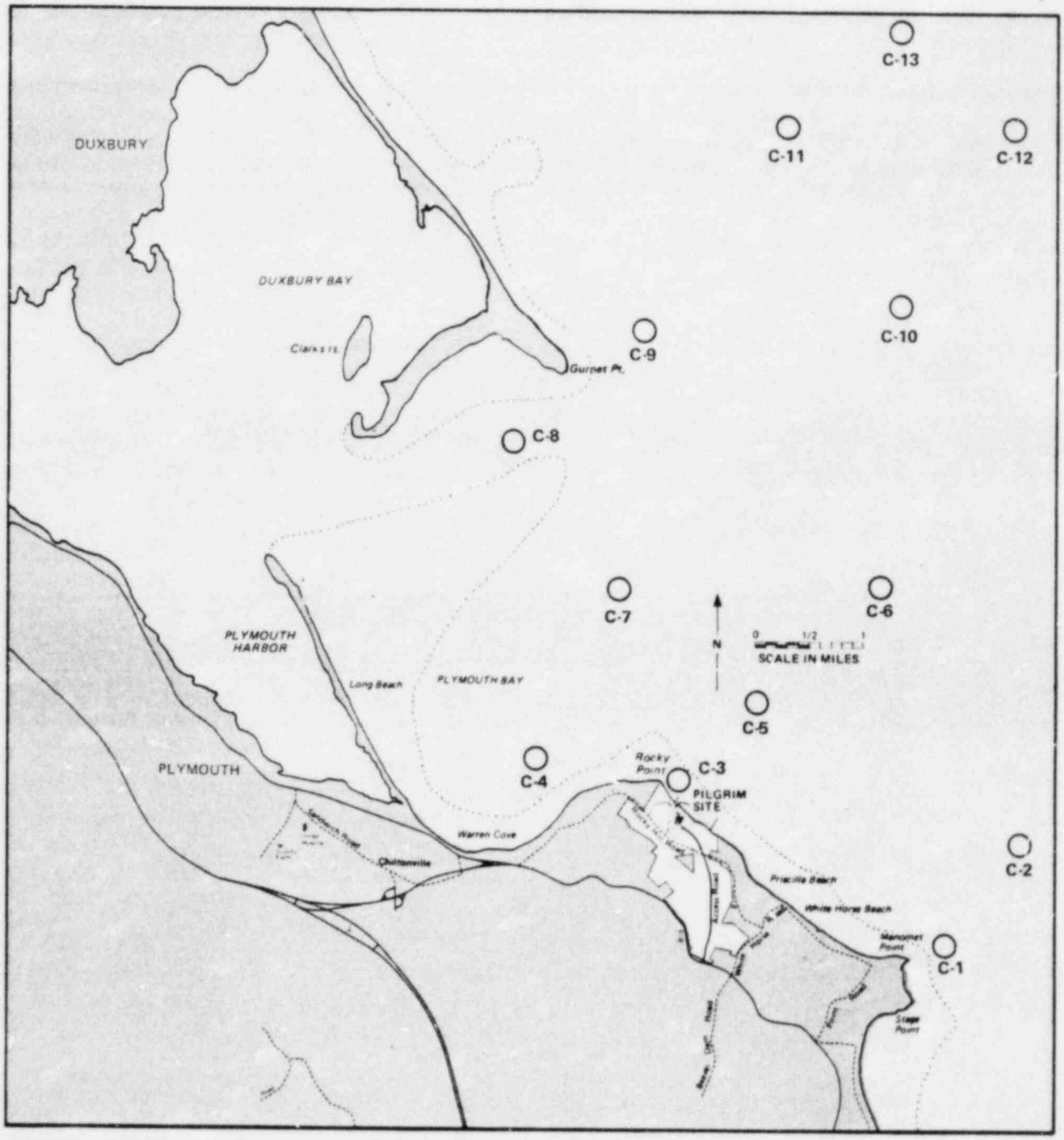

Figure 5. Location of Entrainment Contingency Plan Sampling Stations, C.

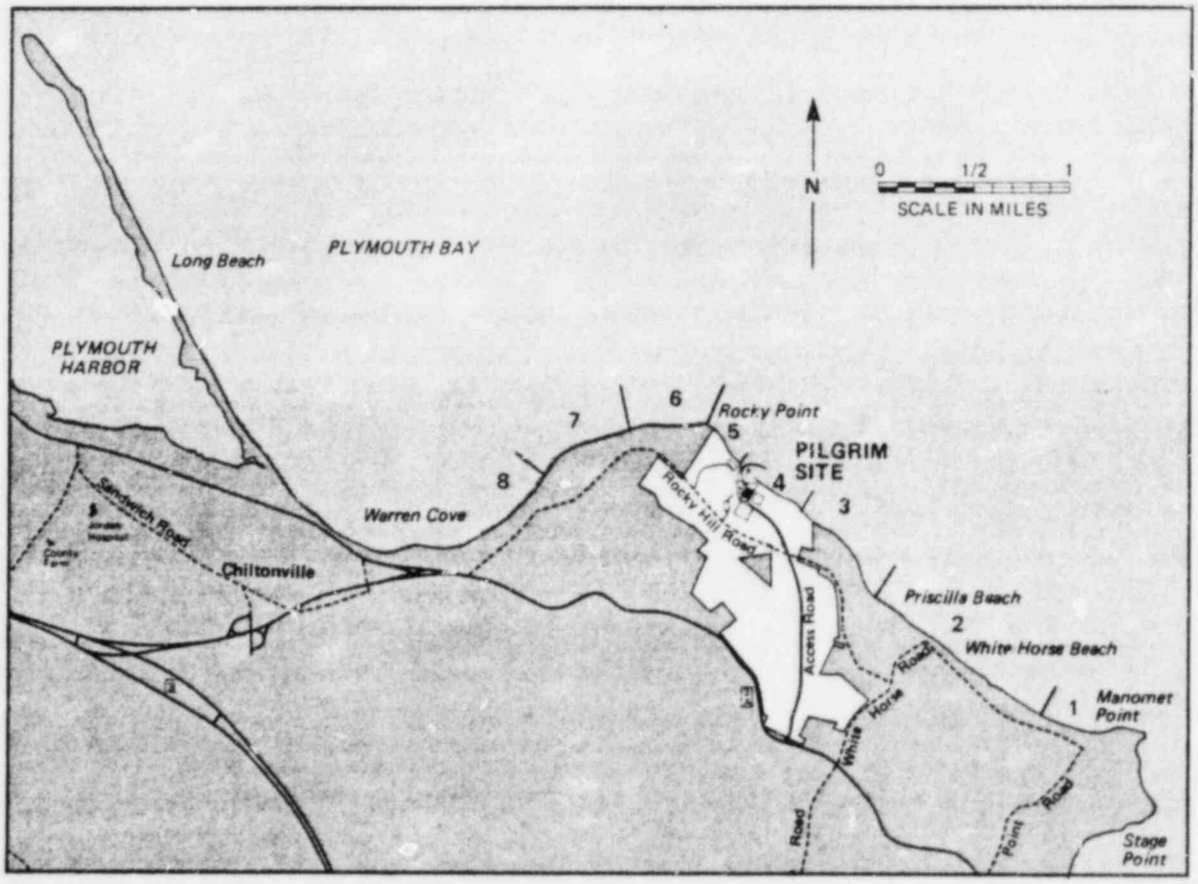

Figure 4. Irish Moss Commercial Harvesting Areas for Marine Fisheries Studies.

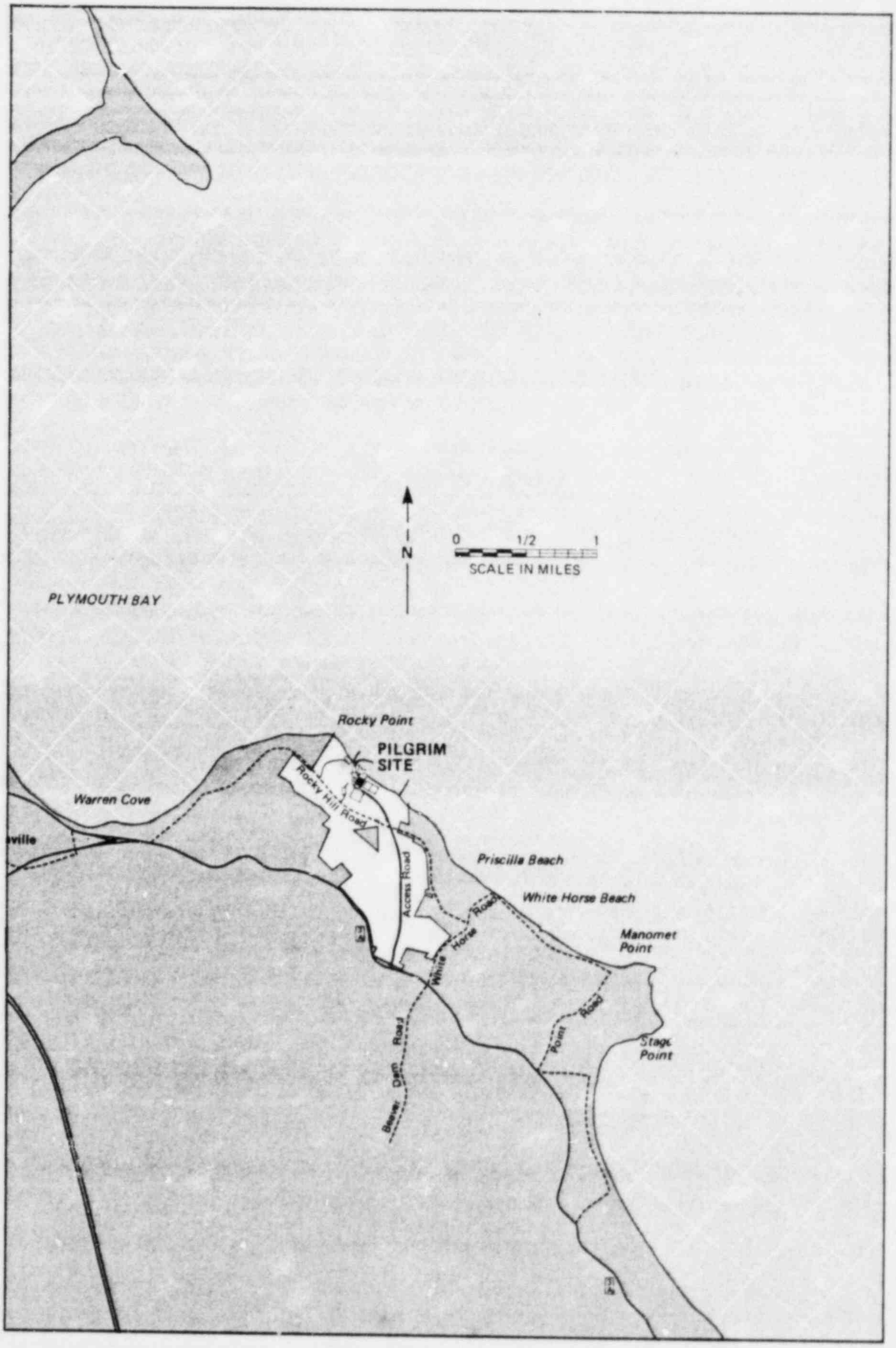

Figure 3. Lobster Pot Sampling Grid for Marine Fisheries Studies.

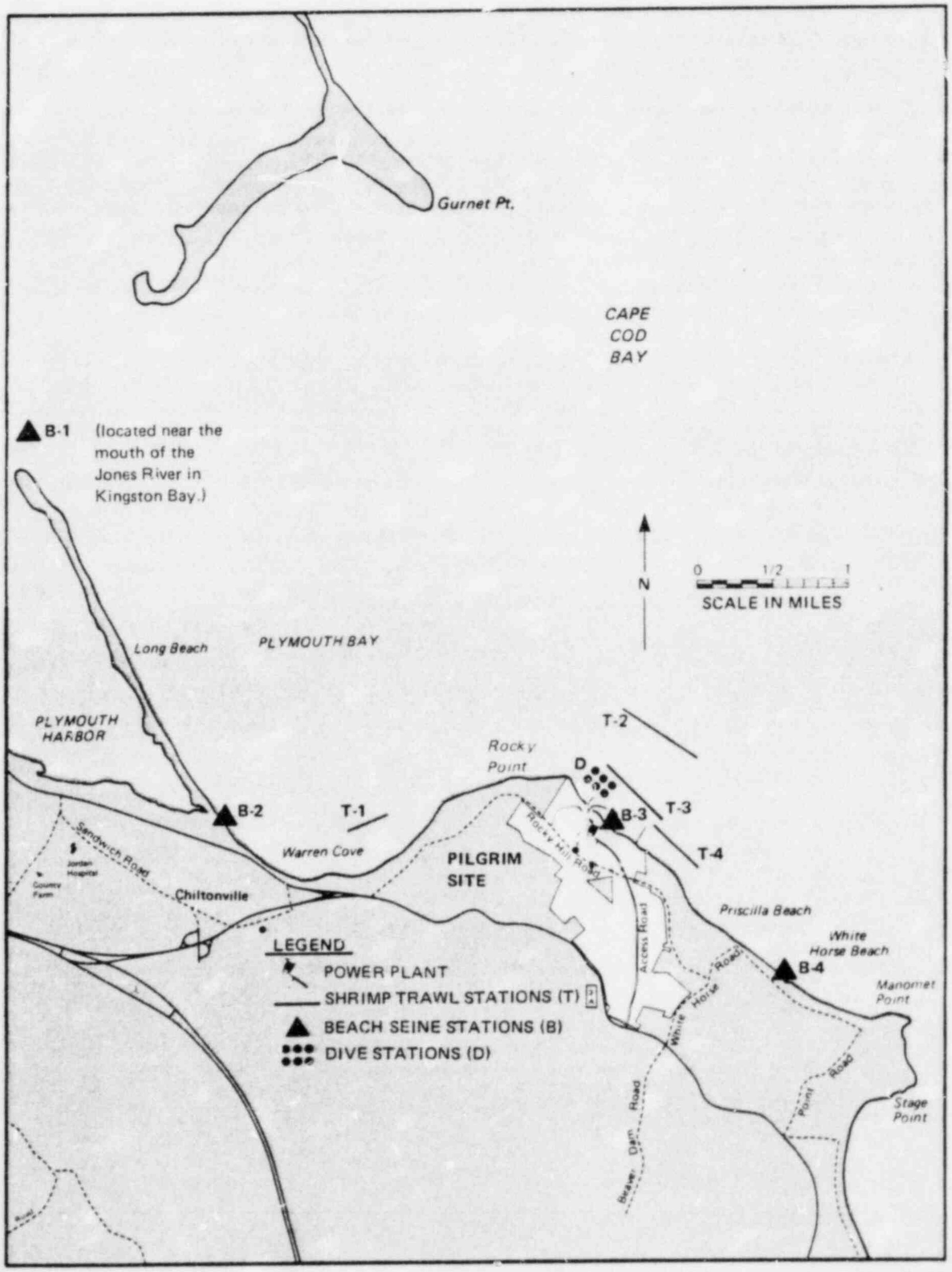

Figure 2. Location of Shrimp Trawl, Beach Seine and Dive Sampling Stations for Marine Fisheries Studies.

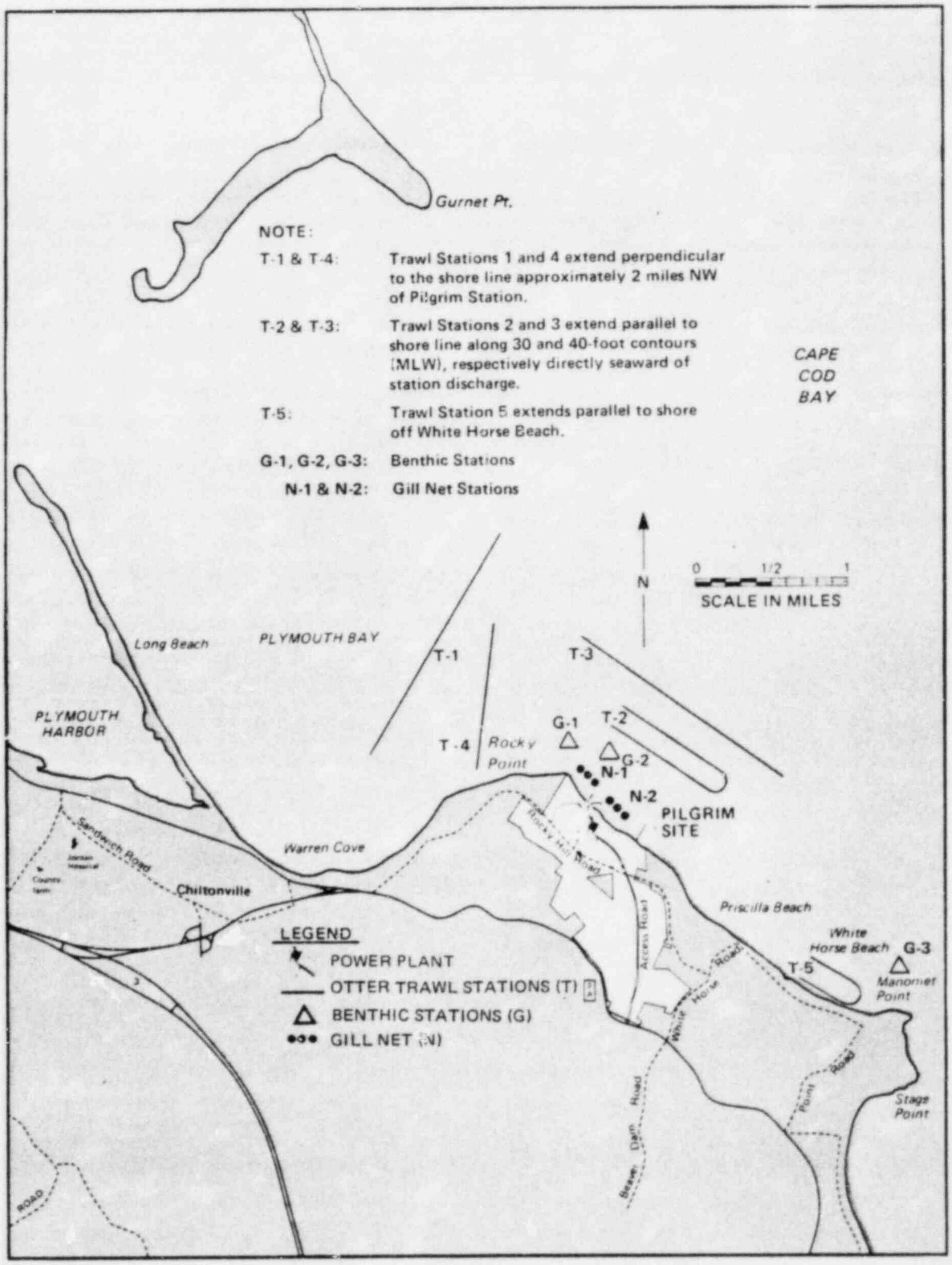

Figure . Location of Otter Trawl and Gill Net Sampling Stations for Marine Fisheries Studies, and Benthic Studies Sampling Stations

#MA0003557. Fish survival studies were conducted in 1982 to determine its effectiveness in protecting marine life.

Results of the impingement monitoring and survival programs for this reporting period are discussed in Sections IIID.1 and IIID.2, respectively.

C. Fish Surveillance Studies

In Spring 1976, regular fish spotting overflights were commenced as part of a continuing effort to monitor the times when large concentrations of fish might be expected in the Pilgrim vicinity. Since September 1976, and regularly from May-October since 1978, dive inspections have been conducted of the Pilgrim discharge canal in order to evaluate fish barrier net durability, and effectiveness in excluding fishes from the discharge canal.

Annual summary reports for these efforts for 1982 will be presented in Semi-Annual Report No. 21.

D. Station Operation History

The daily average, reactor thermal power levels from January through June 1982 are shown in Figure 6.

efficiently address the question of the effect of entrainment. These modifications have been developed by the contractor, and reviewed and approved by the Pilgrim A-T Committee on the bases of the program results. Plankton studies in 1982 emphasized consideration of ichthyoplankton entrainment. The 1982 entrainment report was prepared by Boston Edison Company. Data were collected by Marine Research, Inc. Results of the ichthyoplankton entrainment studies for this reporting period are discussed in Section IIIC.

4. Impingement Studies

The Pilgrim 1 impingement program commenced in November 1972 to speciate and quantify the organisms carried onto the four intake traveling screens. Through June 1976, the Mass. Division of Marine Fisheries reported on collection by private contractors. In January 1976, Marine Research Institute began both collecting and reporting on results of this program. Since January 1979, Marine Research, Inc. has been conducting impingement sampling with results being reported on by Boston Edison Company.

A new screen wash sluiceway system was installed at Pilgrim 1 in 1979 at a total cost of approximately $150,000. This new sluiceway system was required by the U.S. Environmental Protection Agency and the Mass. Division of Water Pollution Control as a part of NPDES Permit

PROGRESS REPORT
ON
STUDIES TO EVALUATE POSSIBLE EFFECTS
OF THE
PILGRIM NUCLEAR POWER STATION
ON THE MARINE ENVIRONMENT

Project Report No. 33 (January-June, 1982)
Summary Report No. 14

By

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September 15, 1982

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INTRODUCTION

Since 1969, the Division of Marine Fisheries (DMF) has conducted ecological studies to detect and evaluate non-radiological impacts of Pilgrim Nuclear Power Station (PNPS) - Unit I operation on marine resources in the offsite waters of Cape Cod Bay. This report summarizes data collected by DMF from January to June, 1982 in the environs of PNPS. Numerical tabulations and computed indices of abundance are compared by area and over time to identify data trends and relationships. Unless otherwise indicated, methods and materials employed in sampling are identical to those described in past reports.

LOBSTER CATCH

A total of 681 lobster pots, containing 1,241 lobsters, was sampled during this reporting period. Data collection commenced on 18 May. Spatial distribution of sampled pots is presented in Figure 1. Catch data by quadrat are included as an appendix to this report (Appendix A).

We sampled 308 legal lobsters from May-June. Mean monthly catch rates (catch per pot haul) of legal lobsters ($\geq$ 81 mm carapace length) for all quadrats combined are found in Table 1, together with monthly rates from past years. Mean legal catch rate (0.45) for May declined from last year (0.58); however, June's catch rate of 0.46 increased from last year's value (0.26). It is noteworthy that this is the highest value recorded for this month. Catch rates for quadrats: H-11, I-11, and I-12, the area most impacted by plant discharge, averaged 0.29. The two-month average for all quadrats combined was 0.45 legal lobsters per pot haul, which is within the upper range of rates obtained in past years.

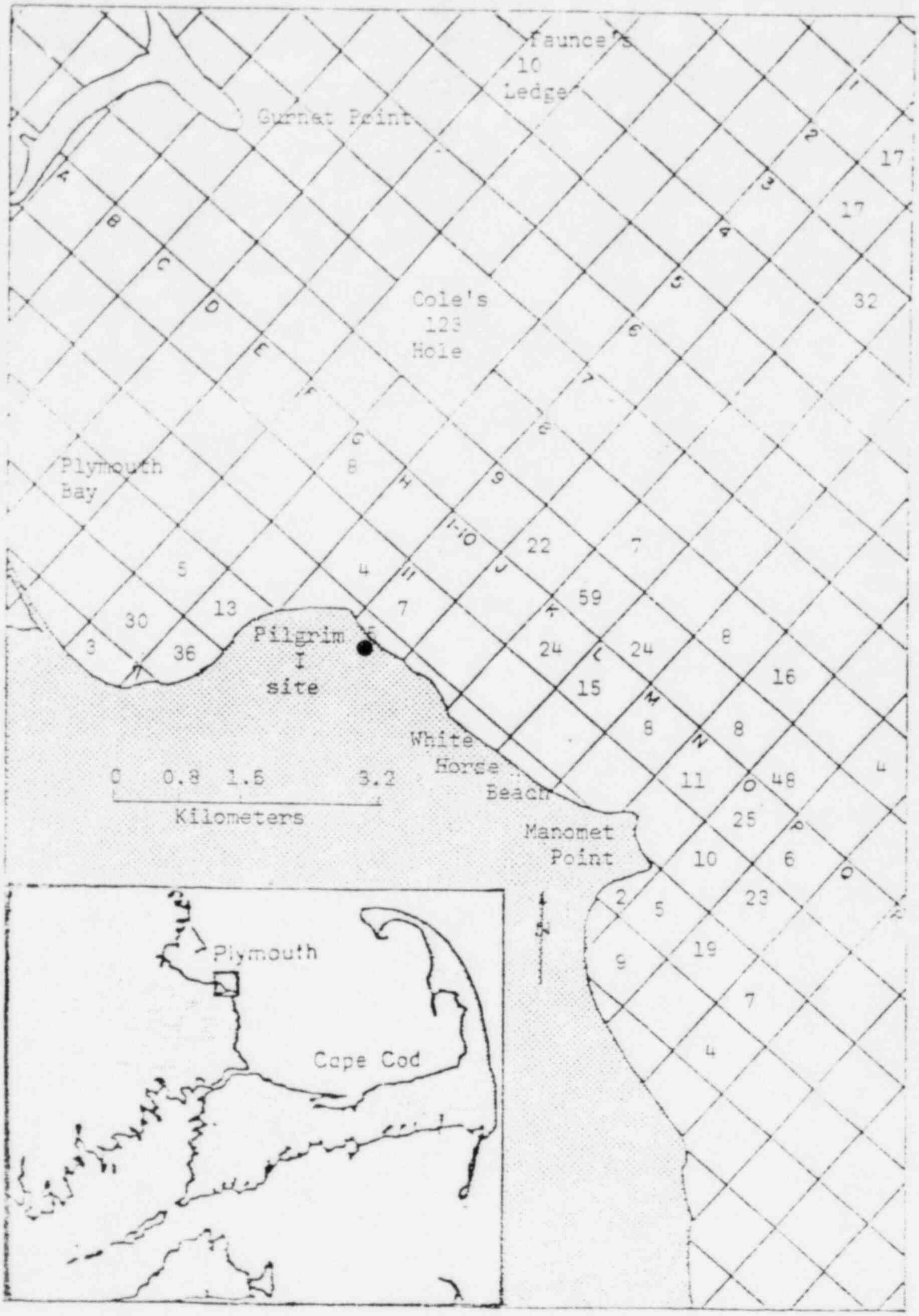

Figure 1. Distribution of lobster pots sampled, May-June, 1981.

Table 1.

Average legal lobster catch per pot haul per month for all quadrats combined.

	March	April	May	June	July	Aug	Sept	Oct	Nov
1970	-	-	0.41 (330)	0.30 (351)	0.54 (627)	0.75 (667)	0.61 (571)	0.68 (691)	0.80 (72)
1971	0.68 (95)	0.46 (331)	0.62 (681)	0.32 (591)	0.68 (723)	0.86 (730)	0.77 (668)	0.70 (668)	-
1972	-	0.59 (428)	0.55 (248)	0.31 (519)	0.66 (718)	0.80 (707)	1.30 (477)	0.88 (352)	-
1973	-	0.46 (135)	0.39 (646)	0.41 (634)	0.74 (625)	0.60 (295)	0.56 (279)	0.82 (151)	-
1974	-	-	0.38 (309)	0.33 (341)	1.00 (544)	0.51 (595)	1.09 (499)	0.64 (455)	-
1975	-	0.32 (322)	0.23 (525)	0.26 (555)	0.64 (314)	0.58 (299)	0.81 (278)	0.70 (269)	0.65 (233)
1976	-	-	0.27 (438)	0.21 (541)	0.69 (641)	0.59 (554)	0.34 (570)	1.11 (37)	0.63 (178)
1977	-	0.48 (379)	0.46 (417)	0.29 (203)	0.55 (555)	0.47 (663)	0.72 (604)	0.86 (664)	-
1978	-	-	0.41 (374)	0.30 (571)	0.63 (441)	0.62 (775)	1.09 (279)	0.71 (162)	-
1979	-	-	0.31 (130)	0.29 (659)	0.54 (797)	0.59 (491)	0.50 (200)	0.42 (272)	0.58 (271)
1980	-	-	0.21 (107)	0.25 (477)	0.63 (983)	0.64 (849)	0.58 (476)	0.84 (520)	0.63 (255)
1981	-	-	0.58 (318)	0.26 (798)	0.62 (744)	0.64 (352)	0.96 (696)	0.73 (482)	0.57 (377)
1982	-	-	0.45 (410)	0.46 (271)					

(Number of pots hauled.)

A total of 34 berried females (i.e., carrying external eggs) was sampled; of these, 20 were sublegal (< 81 mm carapace length). These ovigerous individuals comprised 2.7% of the total lobsters sampled and 4.1% of the captured females. This represents a noticeable decline from last year's values of 5.5% and 8.4%, respectively.

Traditional fishing pressure in the study area has been concentrated on three rocky ledges which extend perpendicular to shore, located off Rocky Point, White Horse Beach, and Manomet Point (Fairbanks et al. 1972). Since 1978, commercial fishermen have expanded their fishing areas by intensifying their efforts on sand substrate.

Data from project trawl studies have indicated an increase of lobsters inhabiting sand bottom. During the years of 1970 through 1978, mean catch per 20-minute tow (utilizing a half-scale Yankee trawl, equipped with a codend liner of 3.8 cm mesh) of lobsters in Warren Cove and at Rocky Point ranged between 0.47 and 3.54. From 1979-1980, a total of 3,746 lobsters was collected in 229 trawl tows for a mean catch per tow of 16.4. In 1981, 3,001 lobsters were taken in 134 tows of both a half-scale Yankee, and half-scale Wilcox trawl for a combined mean of 22.4. Mean catch rate in 1982 for January to June, a traditional period of reduced lobster activity, was 26.9 which provides further evidence of an apparent increase in the abundance of lobsters on sand bottom.

IRISH MOSS HARVEST

Harvesting of Irish moss (Chondrus crispus) commenced on 11 June, 1982. Landing statistics through 30 June are presented in Table 2. Figure 2 depicts the eight coastal zones constituting the study area. Due to adverse weather

Table 2. Irish moss landing statistics, June, 1971-1982.

Landings
(lbs-wet weight)

Area	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	30,937	27,940	20,630	30,115	15,990	36,575	18,185	29,015	20,775	28,350	22,925	12,710
2	18,734	31,829	11,730	30,760	20,650	72,185	37,520	40,390	26,422	44,865	59,082	42,525
3	3,900	930	80	400	8,285	9,260	6,435	7,842	3,315	3,545	4,738	1,795
4	6,602	9,017	3,365	3,035	6,115	4,305	5,785	5,889	1,275	2,606	1,880	3,030
5	43,234	24,314	4,440	460	22,720	33,375	25,635	8,417	14,750	25,996	15,778	9,385
6	14,480	16,800	6,090	13,495	31,290	16,665	6,505	4,222	12,642	6,735	3,048	1,770
7	5,007	2,885	-	190	7,960	1,020	-	2,215	-	-	-	-
8	5,859	4,090	-	-	2,830	100	-	660	-	-	-	-
Totals	128,753	117,805	46,335	78,455	115,840	173,485	100,065	98,650	79,179	112,099	107,451	71,015

Table 2. Irish moss (continued)

Effort
(hours)

Area	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	129.74	148.81	116.25	98.42	50.50	147.00	72.00	108.48	97.86	123.35	102.28	39.25
2	124.35	221.13	101.25	89.92	93.17	395.25	194.75	164.32	243.20	198.36	334.03	178.99
3	22.25	7.67	.50	1.00	28.25	35.42	65.17	33.15	23.96	17.62	33.46	6.13
4	35.37	45.93	14.08	11.08	15.92	23.75	25.25	37.40	9.08	19.59	12.75	15.25
5	210.22	131.33	31.75	1.83	72.42	115.83	92.25	46.90	76.50	134.57	73.29	35.20
6	58.83	76.58	39.50	41.00	73.58	54.33	26.92	19.50	52.45	45.37	12.49	5.25
7	27.91	19.00	-	0.50	24.75	4.58	-	5.75	-	-	-	-
8	25.50	15.25	-	-	11.50	0.33	-	2.83	-	-	-	-
Totals	634.17	665.70	303.33	243.75	370.08	776.50	476.33	418.33	503.05	538.86	568.30	280.07

Table 2. Irish moss (continued)

Harvest Rate
(lbs/hr)

Area	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	238.5	187.8	177.5	306.0	316.6	248.8	252.6	267.5	212.3	229.8	224.1	323.8
2	150.7	143.9	115.8	342.1	221.6	182.6	192.7	245.8	108.6	226.2	176.9	236.5
3	175.3	121.3	160.0	400.0	293.3	261.5	98.8	236.6	138.4	201.2	141.6	292.8
4	186.6	196.3	238.9	273.8	334.2	181.3	229.1	157.5	140.4	133.0	147.4	198.7
5	205.7	185.1	139.8	250.9	313.7	288.1	277.9	179.5	192.8	193.2	215.3	266.6
6	246.1	219.4	154.2	329.1	425.2	306.7	241.7	216.5	241.0	148.5	244.0	337.1
7	179.4	151.9	-	380.0	380.6	222.6	-	385.2	-	-	-	-
8	229.8	268.2	-	-	246.1	300.0	-	233.0	-	-	-	-
*	203.0	177.0	152.8	321.9	313.0	223.4	210.1	235.8	157.4	208.0	189.1	253.6

* Seasonal harvest rate total lbs wet weight/total effort hrs.

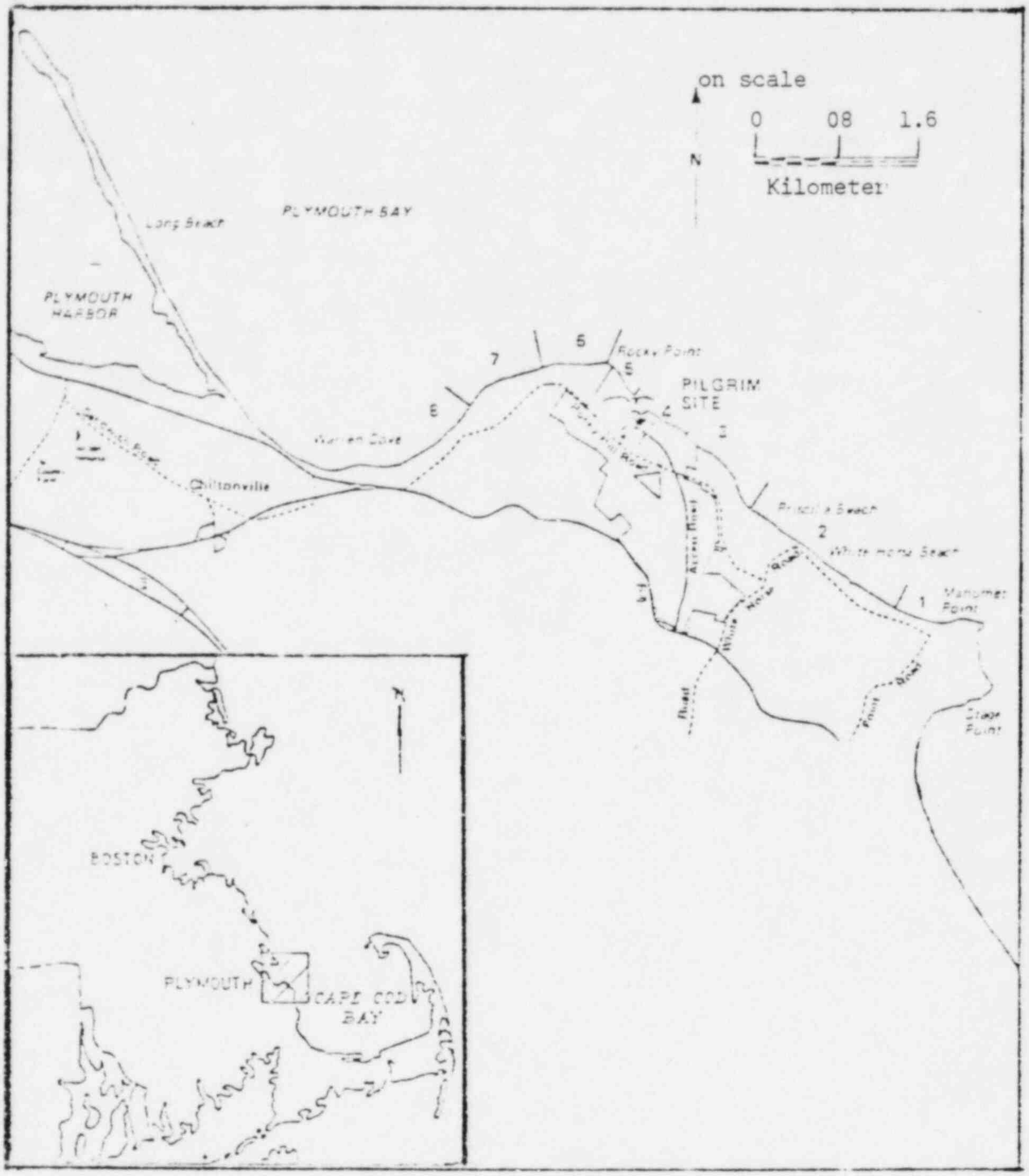

Figure 2. Irish moss harvest zones.

conditions, four days were lost to harvesting during the sampling period.

Rakers expended 280.07 hours of effort while harvesting 71,015 lbs (wet weight) of moss (Table 2). The mean harvest rate for the entire study area was 253.6 lbs/hr. These totals do not include 2,365 lbs harvested outside the study area from the Ellisville (Indian Hill) area and landed at White Horse Beach.

Both total effort and landings are the second lowest ever for this period, partly reflecting the relatively short harvesting period (20 days). However, the mean harvest rate (pooled data) is the third highest recorded during the study. Landings and effort decreased throughout all harvest areas except Zone 4, while harvest rates increased in all zones. Greatest effort (63.9% of the total) and highest landings (59.6%) were again recorded from Zone 2 (White Horse Beach). For the fourth consecutive spring no raking was conducted in Zones 7 and 8.

A comparison of Zone 1 (control) and Zone 5 (discharge) revealed that landings, effort and mean harvest rate were greater in Zone 1. Harvest rate for both areas, however, improved from last spring by 45% in Zone 1 and 24% in Zone 5.

There are fewer rakers this year, which directly contributes to both reduced effort and landings. Harvest rates indicate, however, that with less competition, rakers are obtaining more moss per unit of effort.

OTTER TRAWL

Otter trawling continued in the vicinity of Pilgrim Station with five stations (Figure 3) being sampled monthly. Single 20-minute tows were made with a replicate set most often made at Station 2 (surveillance site) to

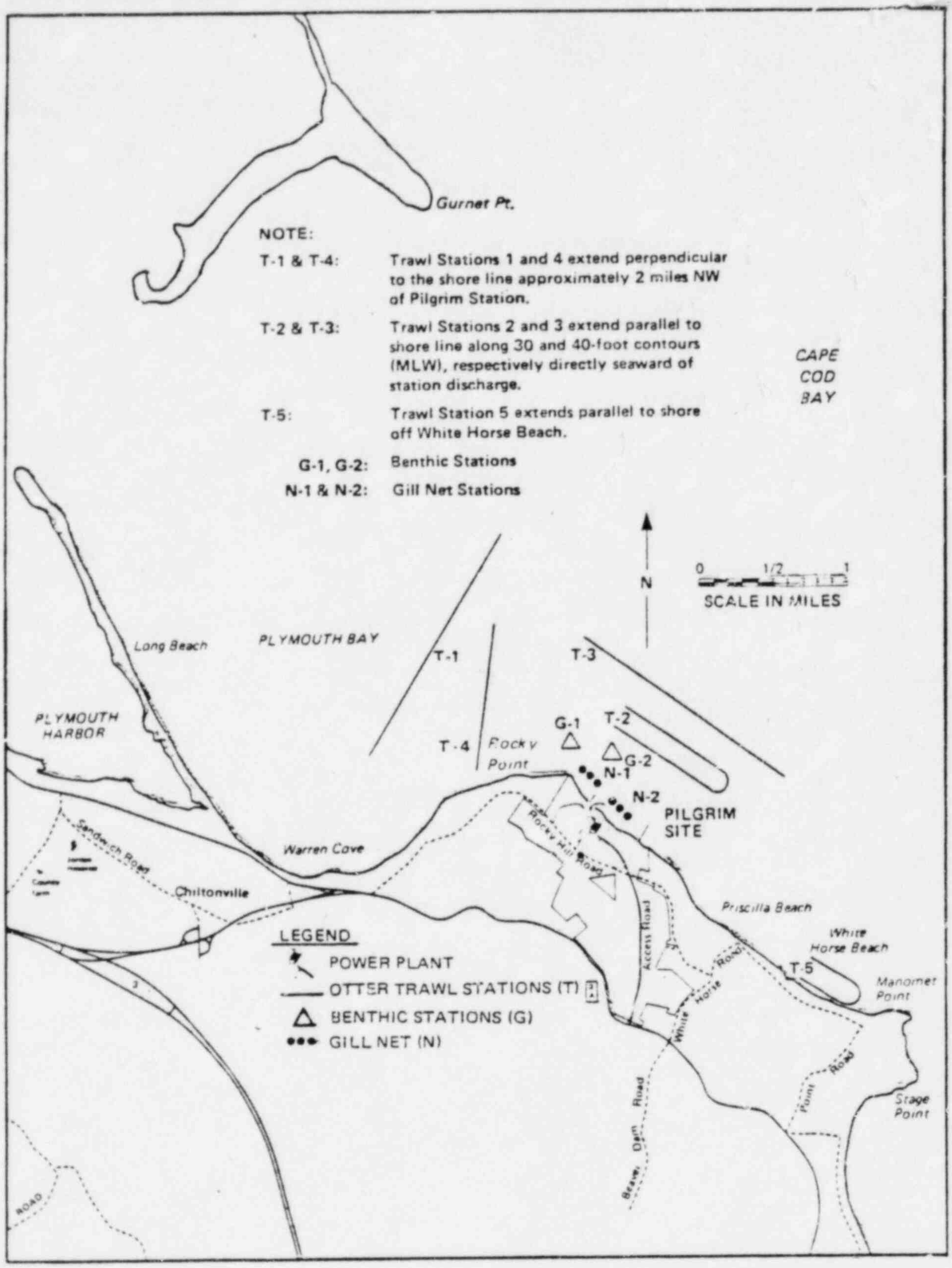

Figure 3. Location of Otter Trawl and Gill Net Sampling Stations for Marine Fisheries Studies, and Benthic Studies Sampling Stations.

improve accuracy of relative abundance estimates. These estimates of stock abundance were derived from catch per unit effort (CPUE) data, i.e., mean catch/tow. No sampling was possible in January because of ice conditions in the study area.

Water temperatures were below 1 C until the April sampling. From January-March (winter), bottom temperatures exceeded those recorded at the surface, but from April-June (spring) the reverse was true. During spring sampling, bottom water temperatures averaged from 3.4-13.4 C. Catches of all dominant groundfish were relatively low in the winter as compared to spring. Water temperature was clearly a determinant of fish distribution in this inshore area.

Winter flounder was the numerically dominant species of the groundfish assemblage (Table 3). This was the only species captured by trawling in the study area in February and also predominated in March collections. As in 1980 and 1981, abundance was greatest at Stations 1 and 4 (Table 4). Overall mean CPUE for the study area was about the same as last year (Table 3), suggesting a stable population pattern.

Skates were second in abundance in trawl samples. Catch data suggested that their abundance spatially was inversely related to depth. Largest numbers were encountered at Station 1 in Warren Cove (Table 5) which is consistent with study findings from 1970-1976, where collectively 46% of the total skate catch was made. The pooled abundance estimate for the sampled population was down from last year (Table 3), suggesting a possible decline in the biological population inhabiting the geographical region under consideration.

Small numbers of longhorn sculpin and ocean pout were captured only in April and May (Tables 6 and 7). Overall abundance indices for sculpin during the winter and spring seasons declined through 1977 but have shown a slight

Table 3. Otter trawl catch per unit effort for dominant community species (pooled stations' data) from January-June, 1970-1982.

Year	winter flounder	skate spp.	longhorn sculpin	windowpane	ocean pout	yellowtail flounder
1970	19.9	1.4	9.9	1.3	29.0	3.3
1971	22.5	1.7	5.8	2.1	20.7	5.1
1972	12.4	1.3	6.6	2.6	11.4	3.6
1973	10.3	1.8	4.6	2.0	10.7	1.7
1974	9.2	1.1	3.7	1.4	4.7	1.9
1975	9.3	1.0	1.7	2.0	4.7	3.0
1976	8.5	1.0	0.9	1.7	2.6	5.5
1977	9.2	4.2	0.4	2.5	2.1	1.8
1978	10.8	3.4	1.1	1.6	1.5	2.2
1979	19.5	14.0	3.0	3.8	4.8	7.2
1980	20.1	10.2	1.2	3.9	0.5	7.7
1981	28.5	9.6	1.4	5.1	0.7	8.1
1982	29.0	6.8	2.5	1.5	1.3	1.0

Table 4. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-June, 1982.

Winter flounder (<u>Pseudopleuronectes americanus</u>)

Date	Jan.	Feb.	Mar.	Apr.	May	June	Mean No./tow
<u>Station 1</u>	(No tows made this month because of ice conditions.)						
No. of fish		0	0	50	42	93	37.0
Size range (mm)		-	-	69-370	88-401	120-368	
Mean size (mm)		-	-	195.8	233.8	253.9	
<u>Station 2</u>							
No. of fish		2	8	36	39	43	25.6
Size range (mm)		112-363	90-400	89-421	118-455	155-395	
Mean size (mm)		227.5	252.6	243.1	299.0	292.9	
<u>Station 3</u>							
No. of fish		3	15	25	17	37	19.4
Size range (mm)		368-370	148-375	101-360	110-371	132-371	
Mean size (mm)		369.0	298.3	227.5	227.1	265.8	
<u>Station 4</u>							
No. of fish		4	7	52	50	56	33.8
Size range (mm)		111-328	312-485	88-375	78-376	146-373	
Mean size (mm)		263.5	365.9	207.8	287.1	278.5	
<u>Station 5</u>							
No. of fish		-	-	-	-	23	-
Size range (mm)		-	-	-	-	102-381	
Mean size (mm)		-	-	-	-	281.8	

Table 5. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-June, 1982.

Skates (Raja spp.)

Date	Jan.	Feb.	Mar.	Apr.	May	June	Mean No./tow
Station 1	(No tows made this month because of ice conditions.)						
No. of fish		0	0	1	9	49	11.8
Size range (mm)		-	-	300	350-482	145-535	
Mean size (mm)		-	-	300.0	424.7	363.8	
Station 2							
No. of fish		0	2	1	2	26	6.2
Size range (mm)		-	-	313	311-500	213-505	
Mean size (mm)		-	-	313.0	429.8	347.2	
Station 3							
No. of fish		0	1	0	1	12	2.8
Size range (mm)		-	-	-	328	171-490	
Mean size (mm)		-	-	-	328.0	343.8	
Station 4							
No. of fish		0	5	0	5	21	6.2
Size range (mm)		-	-	-	407-495	108-505	
Mean size (mm)		-	-	-	436.4	320.7	
Station 5							
No. of fish		-	-	-	-	3	-
Size range (mm)		-	-	-	-	285-485	
Mean size (mm)		-	-	-	-	385.0	

Table 6. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-June, 1982.

Longhorn sculpin (*Myoxocephalus octodecemspinosus*)

Date	Jan.	Feb.	Mar.	Apr.	May	June	Mean No./tow
Station 1							
No. of fish	(No tows made this month because of ice conditions.)	0	0	0	1	0	0.2
Size range (mm)		-	-	-	275	-	
Mean size (mm)		-	-	-	275.0	-	
Station 2							
No. of fish		0	0	20	3	0	4.6
Size range (mm)		-	-	228-325	268-320	-	
Mean size (mm)		-	-	290.7	284.7	-	
Station 3							
No. of fish		0	4	6	4	0	2.8
Size range (mm)		-	-	258-310	287-402	-	
Mean size (mm)		-	-	284.8	320.5		
Station 4							
No. of fish		0	0	4	8	0	2.4
Size range (mm)		-	-	268-300	275-330	-	
Mean size (mm)		-	-	288.2	294.5	-	
Station 5							
No. of fish		-	-	-	-	0	-
Size range (mm)		-	-	-	-	-	
Mean size (mm)		-	-	-	-	-	

Table 7. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-June, 1982.

Ocean pout (Macrozoarces americanus)

Date	Jan.	Feb.	Mar.	Apr.	May	June	Mean No./tow
Station 1	(No tows made this month because of ice conditions.)						
No. of fish		0	0	1	4	0	1.0
Size range (mm)		-	-	602	524-671	-	
Mean size (mm)		-	-	602.0	607.0	-	
Station 2							
No. of fish		0	0	5	9	0	2.8
Size range (mm)		-	-	350-610	510-670	-	
Mean size (mm)		-	-	550.6	591.5	-	
Station 3							
No. of fish		0	0	3	2	0	1.0
Size range (mm)		-	-	546-620	471-580	-	
Mean size (mm)		-	-	585.2	525.5	-	
Station 4							
No. of fish		0	0	0	2	0	0.4
Size range (mm)		-	-	-	615-650	-	
Mean size (mm)		-	-	-	632.5	-	
Station 5							
No. of fish		-	-	-	-	0	-
Size range (mm)		-	-	-	-	-	
Mean size (mm)		-	-	-	-	-	

Table 8. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-June, 1982.

Windowpane (*Scophthalmus aquosus*)

Date	Jan.	Feb.	Mar.	Apr.	May	June	Mean No./tow
Station 1	(No tows made this month because of ice conditions.)						
No. of fish		0	0	0	2	2	0.8
Size range (mm)		-	-	-	270-271	164-172	
Mean size (mm)		-	-	-	270.5	168.0	
Station 2							
No. of fish		0	1	0	1	7	1.8
Size range (mm)		-	-	-	220	172-275	
Mean size (mm)		-	-	-	220.0	227.4	
Station 3							
No. of fish		0	0	3	1	5	1.8
Size range (mm)		-	-	186-337	315	150-305	
Mean size (mm)		-	-	275.7	315.0	230.7	
Station 4							
No. of fish		0	0	0	1	7	1.6
Size range (mm)		-	-	-	290	160-357	
Mean size (mm)		-	-	-	290.0	238.0	
Station 5							
No. of fish		-	-	-	-	2	-
Size range (mm)		-	-	-	-	285-485	
Mean size (mm)		-	-	-	-	385.0	

Table 9. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-June, 1982.

Yellowtail flounder (Limanda ferruginea)

Date	Jan.	Feb.	Mar.	Apr.	May	June	Mean No./tow
Station 1	(No tows made this month because of ice conditions.)						
No. of fish		0	0	0	4	1	1.0
Size range (mm)		-	-	-	92-338	265	
Mean size (mm)		-	-	-	220.8	265.0	
Station 2							
No. of fish		0	0	2	6	2	2.0
Size range (mm)		-	-	205-377	190-371	225-250	
Mean size (mm)		-	-	291.0	257.8	237.5	
Station 3							
No. of fish		0	2	0	1	3	1.2
Size range (mm)		-	171-246	-	347	227-282	
Mean size (mm)		-	208.5	-	347.0	245.8	
Station 4							
No. of fish		0	0	0	0	0	0.0
Size range (mm)		-	-	-	-	-	
Mean size (mm)		-	-	-	-	-	
Station 5							
No. of fish		-	-	-	-	0	-
Size range (mm)		-	-	-	-	-	
Mean size (mm)		-	-	-	-	-	

Table 10. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-June, 1982.

American lobster (*Homarus americanus*)

Date	Jan.	Feb.	Mar.	Apr.	May	June	Mean No./tow
Station 1							
No. of legals		0	0	0	1	1	0.4
No. of sublegals		0	0	0	33	79	22.4
Total No.		0	0	0	34	80	22.8
Station 2							
No. of legals		0	0	0	1	8	1.8
No. of sublegals		0	0	2	48	107	31.4
Total No.		0	0	2	49	115	33.2
Station 3							
No. of legals		0	0	0	0	2	0.4
No. of sublegals		0	0	0	18	166	36.8
Total No.		0	0	0	18	168	37.2
Station 4							
No. of legals		0	0	0	2	0	0.4
No. of sublegals		0	0	0	43	84	25.4
Total No.		0	0	0	45	84	25.8
Station 5							
No. of legals		-	-	-	-	0	-
No. of sublegals		-	-	-	-	18	-
Total No.		-	-	-	-	18	-

upswing since 1978 (Table 3). Ocean pout have been characterized by a general long-term decline in level of abundance in the study area since the inception of sampling.

Windowpane and yellowtail flounder were infrequently taken in winter (Tables 8 and 9). Mean CPUE for both species declined from last year; with the value obtained for the former being the lowest since 1974 and that for the latter, the lowest of the entire study (Table 3).

American lobsters were not trawled until April and then only at Station 2 (surveillance site). Catches increased in May and into June (Table 10). Legal lobsters (≥ 81 mm carapace length) comprised only 2.5% of the total catch. For the last five years, lobster fishing has intensified on sand bottom in the study area as evidenced by the increased deployment of lobster gear there. Furthermore, from 1978-1981, our average trawl catch per tow (pooled annual data) was 15.4 lobsters, which far exceeded catch rates from all preceding years. From January-June, 1982, the mean CPUE of lobsters was 26.9, indicating an upward trend in level of relative abundance on trawlable bottom.

NEARSHORE TRAWLING

Nearshore trawling commenced on 10 March and continued biweekly through June. Sampling was omitted during January and February due to inclement weather. At each station, tows were extended to 15 minutes. We believe the additional five minutes per tow will improve the accuracy of the data collected. Catch per unit effort (CPUE) was used as the measure of relative abundance. Catch data for replicate tows were averaged by species to generate mean catch estimates.

A total of 842 fish representing 15 species was collected in 32 tows (Table 11). Seven species: winter flounder, yellowtail flounder, windowpane, little skate, ocean pout, longhorn sculpin, and fourspot flounder comprised 97.3% of the total catch. Warren Cove (Station 1) yielded the greatest pooled catch per tow (31.0), while station-wide CPUE for all species combined averaged 26.3.

Winter flounder was the dominant species, comprising 42.0% of the total catch. Remarkably similar, this species comprised 42.4% of the total catch in 1981. Winter flounder were most abundant at Station 1 where we obtained a mean CPUE for all dates of 17.2 (Table 12). The average catch at other stations ranged from 8.5-11.5; while CPUE for pooled stations was 11.6.

Little skate ranked second in abundance, comprising 20.8% of the total catch. In 1981, skate spp. ranked fourth at 14.2% of the total catch. Mean CPUE ranged from 3.6 to 7.1 with the largest concentrations occurring at Station 1. Pooled CPUE was 5.7 (Table 13).

The largest catches of yellowtail flounder occurred at Stations 2 and 3, where we obtained mean CPUE's of 5.6 and 5.1, respectively (Table 12). Yellowtail flounder comprised 16.2% of the total catch this year, as compared to 22.8% in 1981. Overall mean catch per tow was 4.1.

Windowpane ranked fourth in abundance, constituting 11.4% of all fish captured. This species ranked third in 1981 when it comprised 15.8% of the catch. Catch data were similar at each station with CPUE ranking from 2.7-3.3. Catch per tow for pooled station averaged 3.0.

Longhorn sculpin represented only 4.0% of the total catch, ranking fifth in abundance. The largest catches were obtained at Stations 2 and 3. CPUE averaged 1.4 at both locations. The mean catch per unit effort for

Table 11. Total catch by finfish species captured at each near-shore trawl station, January-June, 1982.

# of Tows	Station 1 7	Station 2 7	Station 3 10	Station 4 8	Total 32	% of total catch
winter flounder	125	65	101	63	354	42.0
little skate	50	46	36	43	175	20.8
yellowtail flounder	9	38	57	32	136	16.2
windowpane	21	23	27	25	96	11.4
longhorn sculpin	2	10	14	8	34	4.0
ocean pout	3	3	3	3	12	1.4
fourspot flounder	3	4	1	5	13	1.5
northern searobin	0	2	3	0	5	0.6
hake spp.	1	1	2	0	4	0.5
rainbow smelt	0	3	1	0	4	0.5
Atlantic cod	2	1	0	0	3	0.4
Atlantic silverside	0	1	0	2	3	0.4
sea raven	1	0	0	0	1	0.1
lumpfish	0	0	0	1	1	0.1
cunner	0	0	1	0	1	0.1
# species	10	12	11	9	15	
Total # of fish	217	197	246	182	842	
$\bar{x}$ Catch per 15 min. tow (pooled species)	31.0	28.1	24.6	22.7	26.3	

Table 12. Near-shore trawl catch data for commercial species at Station 1-4 from March-June, 1982.

Winter flounder (Pseudopleuronectes americanus)

	3/10	3/24	4/20	5/3	5/27	6/3	6/22	Mean catch/ unit effort
Station 1								
# Fish	1.0	8.0	28.0	26.0	-	21.5	19.0	17.2
Size range (mm)	339	95-390	88-387	102-370	-	198-398	251-330	
Mean size (mm)	-	303.0	218	279.0	-	288.0	289.0	
Station 2								
# Fish	0	3.0	6.0	21.0*	10.0	7.0	19.0	9.4
Size range (mm)	-	245-320	78-364	120-331	270-350	151-342	133-362	
Mean size (mm)	-	281.0	229.0	255.0	312	281.0	293.0	
Station 3								
# Fish	0	6.2*	18.0	12.5	12.3*	19.5*	12.0	11.5
Size range (mm)	-	88-328	93-367	110-370	95-365	98-321	170-396	
Mean size (mm)	-	212.0	260.0	254.0	285.0	267.0	313.0	
Station 4								
# Fish	1.0	6.9*	15.0	17.0	5.0	8.0	6.6*	8.5
Size range (mm)	350	302-352	104-382	105-356	279-331	145-375	265-358	
Mean size (mm)	-	323.0	279.0	253.0	306.0	280.0	317.0	
Pooled Stations								11.6

* Value adjusted to 15 minute tow.

Table 12. Yellowtail flounder (*Limanda ferruginea*) (cont.)

	3/10	3/24	4/20	5/3	5/27	6/3	6/22	Mean catch/ unit effort
Station 1								
# Fish	0	0	1.0	2.0	-	3.0	0	1.0
Size range (mm)	-	-	352	252-370	-	245-303	-	
Mean size (mm)	-	-	-	311.0	-	266.0	-	
Station 2								
# Fish	0	0	0.5	6.0*	23.0	5.0	5.0	5.6
Size range (mm)	-	-	357	230-330	99-330	101-335	233-320	
Mean size (mm)	-	-	-	265.0	259.0	217.0	276.0	
Station 3								
# Fish	1.1*	0.6*	5.0	4.0	22.0*	3.0*	0	5.1
Size range (mm)	215	175	155-376	150-251	118-362	111-290	-	
Mean size (mm)	-	-	281.0	232.0	265.0	201.0	-	
Station 4								
# Fish	0	1.2*	1.0	6.0	12.0	10.0	2.3*	4.6
Size range (mm)	-	125	177	215-375	222-312	151-300	141-275	
Mean size (mm)	-	-	-	275.0	269.0	240.0	208.0	
Pooled Stations								4.1

* Value adjusted to 15 minute tow.

Table 13. Near-shore trawl catch data (catch/unit effort) for dominant community species, January-June, 1982.

Station	little skate (*Raja erinacea*)	windowpane (*Scophthalmus aquosus*)	longhorn (*Myoxocephalus octodecemspinosus*)	ocean pout (*Macrozoarces americanus*)	fourspot flounder (*Paralichthys oblongus*)
	Species				
1	7.1	3.0	0.3	0.4	0.4
2	6.6	3.3	1.4	0.4	0.6
3	3.6	2.7	1.4	0.3	0.1
4	5.4	3.1	1.0	0.4	0.6
Pooled Stations	5.7	3.0	1.0	0.4	0.4

pooled stations was 1.0.

All species of finfish captured in nearshore trawling were also caught in the otter trawl investigations; however, the latter effort obtained an additional nine species. Winter flounder and little skate ranked first and second, respectively, with both gear types, but percent catch composition of these species differed (Table 14). A total of 1,127 fish (26 tows) was captured in the otter trawl program as compared to 842 (32 tows) in the nearshore trawl program.

GILL NET

Monthly gill net sets were made at two sampling stations (Figure 3), as sea conditions allowed. Sampling on consecutive nights was impossible because of the weather.

A new gill net, identical to the old one (Lawton et al. 1981) was brought into service during the month of June. This was necessitated by our capture in May of a new species - a male basking shark, which was approximately 5.5 m (18 ft) in length. This resulted in the destruction of the 15.2 cm (6 in) mesh panel of the gill net and up to 50% of the panels on either side. The shark was estimated to weigh between 680-907 kg (1500-2000 lb) and was approximately three years old (Bigelow and Schroeder 1953).

This year, to provide more synoptic information, length measurements of skates, searobins, sculpins, and sea ravens have been recorded. This will enable us to examine size structure of these populations.

Four sets at Station 1 yielded 605 fish, comprising 28 species (Tables 15 and 16). Five sets at Station 2 yielded 683 fish, representing 24 species. Cancer crabs (Cancer irroratus and C. borealis) were again caught in large

Table 14. Percent catch composition for near-shore trawl and otter trawl programs, January-June, 1982.

Species	Near-shore trawl % of total catch	Otter trawl % of total catch
winter flounder	42.0	63.0
little skate	20.8	13.4
yellowtail flounder	16.2	2.5
windowpane	11.4	3.5
longhorn sculpin	4.0	5.1
ocean pout	1.4	3.2

Table 15. Gill net collections (five panels of 3.8-8.9 cm mesh) at two sites in the vicinity of PNPS from January-June, 1982.

Species	Number	Percent of total catch*	Size range (mm)	Mean catch/set (C.P.U.E.)**
pollock	216 (139)	39.7 (22.2)	197-360 (171-425)	54.0 (1.5)
cunner	133 (4)	24.4 (0.6)	109-260 (149-225)	33.3 (0)
northern searobin	31 (32)	5.7 (5.1)	245-361 (220-325)	7.8 (8.0)
alewife	27 (19)	5.0 (3.0)	150-278 (175-285)	6.8 (2.8)
Atlantic cod	21 (7)	3.9 (1.1)	235-452 (385-502)	5.3 (0.5)
Atlantic menhaden	19 (13)	3.5 (2.1)	250-297 (271-325)	4.8 (3.3)
tautog	18 (7)	3.3 (1.1)	311-329 (210-508)	4.5 (0)
winter flounder	14 (16)	2.6 (2.6)	220-399 (96-433)	3.5 (2.3)
Atlantic herring	11 (296)	2.0 (47.3)	191-275 (180-326)	2.8 (73.5)
longhorn sculpin	9 (26)	1.7 (4.2)	292-331 (214-339)	2.3 (2.8)
Atlantic mackerel	8 (11)	1.5 (1.8)	373-412 (371-408)	2.0 (1.3)
striped bass	8 (6)	1.5 (1.0)	376-425 (335-435)	2.0 (0)
Atlantic tomcod	7 (0)	1.3 (0)	215-253	1.8 (0)
sea raven	6 (0)	1.1 (0)	260-432	1.5 (0)
rainbow smelt	6 (13)	1.1 (2.1)	190-215 (172-285)	1.5 (3.3)
red hake	5 (5)	0.9 (0.8)	381-491 (341-431)	1.3 (1.3)
blueback herring	1 (2)	0.2 (0.3)	196 (274-275)	0.3 (0)
grubby	1 (0)	0.2 (0)	115	0.3 (0)
hickory shad	1 (0)	0.2 (0)	363	0.3 (0)
silver hake	1 (2)	0.2 (0.3)	338	0.3 (0.5)
smooth dogfish	1 (2)	0.2 (0.3)	962	0.3 (0.5)
little skate	0 (13)	0 (2.1)	(302-542)	0 (3.0)
windowpane	0 (4)	0 (0.6)	(185-303)	0 (1.0)

Table 15. Gill net collections (five panels of 3.8-8.9 cm mesh) at two sites in the vicinity of PNPS from January-June, 1982. (continued).

Species	Number	Percent of total catch*	Size range (mm)	Mean catch/set (C.P.U.E.)**
black sea bass	0 (3)	0 (0.5)	(240-275)	0 (0.8)
fourspot flounder	0 (3)	0 (0.5)	(293)	0 (0.8)
coho salmon	0 (1)	0 (0.2)	(386)	0 (0.3)
spiny dogfish	0 (1)	0 (0.2)	(940)	0 (0.3)
yellowtail flounder	0 (1)	0 (0.2)	(326)	0 (0.3)
Total	544 (626)			136.0 (156.5)

( ) Numbers in parenthesis represent fish captured at Station 2.
* From five panels of 3.8-8.9 cm mesh.
** Calculations do not include data from a two-day set.

Table 16. Gill net collections (two panels of 11.4-15.2 cm mesh) at two sites in the vicinity of PNPS from January-June, 1982.

Species	Number	Percent of total catch*	Size range (mm)	Mean catch/set (C.P.U.E.)**
tautog	17 (17)	27.9 (29.8)	320-441 (308-460)	4.3 (0.3)
winter flounder	16 (10)	26.2 (17.5)	222-345 (223-325)	4.0 (1.5)
Atlantic cod	7 (3)	11.5 (5.3)	403-853 (495-529)	1.8 (0)
smooth dogfish	6 (1)	9.8 (1.8)	927-1172 (1000)	1.5 (0.3)
pollock	5 (2)	8.2 (3.5	345 (171-370)	1.3 (0)
sea raven	5 (2)	8.2 (3.5)	300-355 (276-348)	1.3 (0.3)
basking shark	1 (0)	1.6 (0)	5500	0.3 (0)
cunner	1 (0)	1.6 (0)	270	0.3 (0)
Atlantic mackerel	1 (0)	1.6 (0)	385	0.3 (0)
northern searobin	1 (0)	1.6 (0)	285	0.3 (0)
scup	1 (0)	1.6 (0)	300	0.3 (0)
little skate	0 (6)	0 (10.5)	(336-568)	0 (1.5)
windowpane	0 (6)	0 (10.5)	(271-303)	0 (1.5)
Atlantic herring	0 (3)	0 (5.3)	(283-290)	0 (0.8)
Atlantic menhaden	0 (3)	0 (5.3)	(290-292)	0 (0.5)
black sea bass	0 (1)	0 (1.8)	(245)	0 (0.3)
fourspot flounder	0 (1)	0 (1.8)	(335)	0 (0.3)
striped bass	0 (1)	0 (1.8)	(465)	0 (0.0)
yellowtail flounder	0 (1)	0 (1.8)	(359)	0 (0.3)
Total	61 (57)			15.3 (14.3)

( ) Numbers in parenthesis represent fish captured at Station 2.
* From two panels of 11.4-15.2 cm mesh.
** Calculations do not include data from a two-day set.

numbers at Station 2, particularly during an unplanned two-day set in May. Also taken at the latter site were large numbers of sub-legal lobsters.

Mean catch per unit effort (CPUE), i.e., catch per overnight set, for the seven panels at Station 1 was 151.3 (pooled species), a 22% increase over last year's value of 118.3. At Station 2, mean CPUE (pooled species) was 115.0 (excluding data from the two-day set in May) as compared to 168.4 for last year.

Catch per set for individual species and for the fish assemblage were calculated for the five original (3.8-8.9 cm mesh) panels (pooled) and two larger panels (11.4-15.2 cm mesh) combined at both sites (Tables 15 and 16). Because sample size (number of sets) was low, the exclusion of data from the two-day set at Station 2 influenced estimates of relative abundance. For example, a mean CPUE (five panels) of 1.5 was obtained for pollock, even though a total of 159 fish were taken (total includes fish taken in May). If catch data from the May set were included, the mean CPUE was 31.8. Catch estimates for other species, e.g., tautog, were similarly affected and any comparisons made with other years should be interpreted with caution.

Pollock was again the most abundant species captured at Station 1, comprising 39.7% of the total catch (five panels). The mean CPUE (54.0) decreased somewhat from last year (69.3). Whereas at Station 2, the dominant species was Atlantic herring (47.3% of total catch). Mean CPUE was 73.5, which is markedly higher than that (2.8) obtained for this period in 1981.

The second most abundant fish captured at Station 1 was the cunner (24.4% of total catch); CPUE averaged 33.3, which is 52% higher than last year's value of 16.0. Pollock was second in total catch (22%) at Station 2. The mean CPUE of 1.5 is a drastic reduction from last year's abundance estimate of 56.6; but, as mentioned, this year's quantification may be biased by the necessitated two-day set.

Northern searobin ranked third in abundance (5.1% of total catch) at Station 1; mean CPUE was 7.8. In 1981, striped bass was third in the dominance hierarchy, with a mean catch per set of 4.0 as compared to this year's catch estimate of 2.5. The northern searobin was also third in numerical catch at Station 2, constituting 5.1% of the total catch. The mean CPUE (8.0) decreased slightly from last year (10.2).

Atlantic mackerel ranked third in 1981's dominance hierarchy, but was tenth this year. CPUE was 13.2 in 1981, but only 1.3 in 1982.

Catch in the two larger panels (11.4-15.2 cm mesh) was predominated by tautog at both stations, partially reflecting a size-selective factor. Last year, Atlantic cod was the dominant species netted at Station 1, while northern searobin prevailed at Station 2. Winter flounder was second in abundance at both stations. CPUE averaged 4.0 at Station 1 which represents a 75% increase from last year's level (1.0). By contrast, relative abundance at Station 2 decreased from 4.4 to 1.5, or 66%. Atlantic cod ranked third at Station 1; CPUE was 1.8. Whereas, in 1981, Atlantic mackerel was third in abundance when CPUE was 5.6 as compared with the capture of a single individual this year. Third in abundance at Station 2 was the little skate, with a mean CPUE of 1.5. Winter flounder ranked third last year.

As demonstrated by previous data, variations occur in the local abundance of finfish species over time. Therefore, variability in abundance estimates, as compared with past findings, possibly reflects natural population fluctuations and/or distribution shifts.

HAUL SEINE

Haul seining begun last year was re-initiated in March, 1982 to sample the nearshore fish community in the environs of Pilgrim Station. This year's investigation was intensified in an effort to include weekly haul seine sets which were made from March-April and are planned for August-September and November-December. Operations were conducted at different tidal stages. Field sampling paralleled periods of historically highest plant impingement of dominant shore-zone species. The identical four stations: Gray's Beach (Station 1), Warren Cove (Station 2), Pilgrim Station's intake embayment (Station 3), and White Horse Beach (Station 4) were again sampled (Figure 4). A systematic, standardized seining technique was employed utilizing a 45.7 x 1.8 m (150 x 6 ft) haul seine with a 1.8 x 1.8 x 1.8 m (6 x 6 x 6 ft) pocket of 0.48 cm (3/16 inch) square mesh (twine #63). Replicate hauls were made, whenever possible, at each station to improve data precision.

Hydrographic measurements collected in March and April revealed that salinities in the study area ranged from 26 to 34 ‰ (Table 17). Salinities, which averaged 29.8 ‰ at Station 1, 31.3 ‰ at Stations 2 and 3, and 29.2 ‰ at Station 4, were higher overall than those recorded in 1981. Water temperatures were colder this year, ranging from 1.0 to 9.0 C, as compared to last year, when the range was from 4.5 to 13.5 C. Furthermore, elevating seasonal temperatures declined markedly in early April, 1982, following an aberrant snow storm, which lashed the area. Relatively low water temperatures in March and April apparently affected the catches, which were substantially reduced from last year's two-month totals.

On 9 sampling dates, we completed 53 haul seine sets and caught 74 fish comprising at least 7 species. Of the few invertebrates seined, shrimp (Crangon spp.) were most abundant, being captured at each station. Generally,

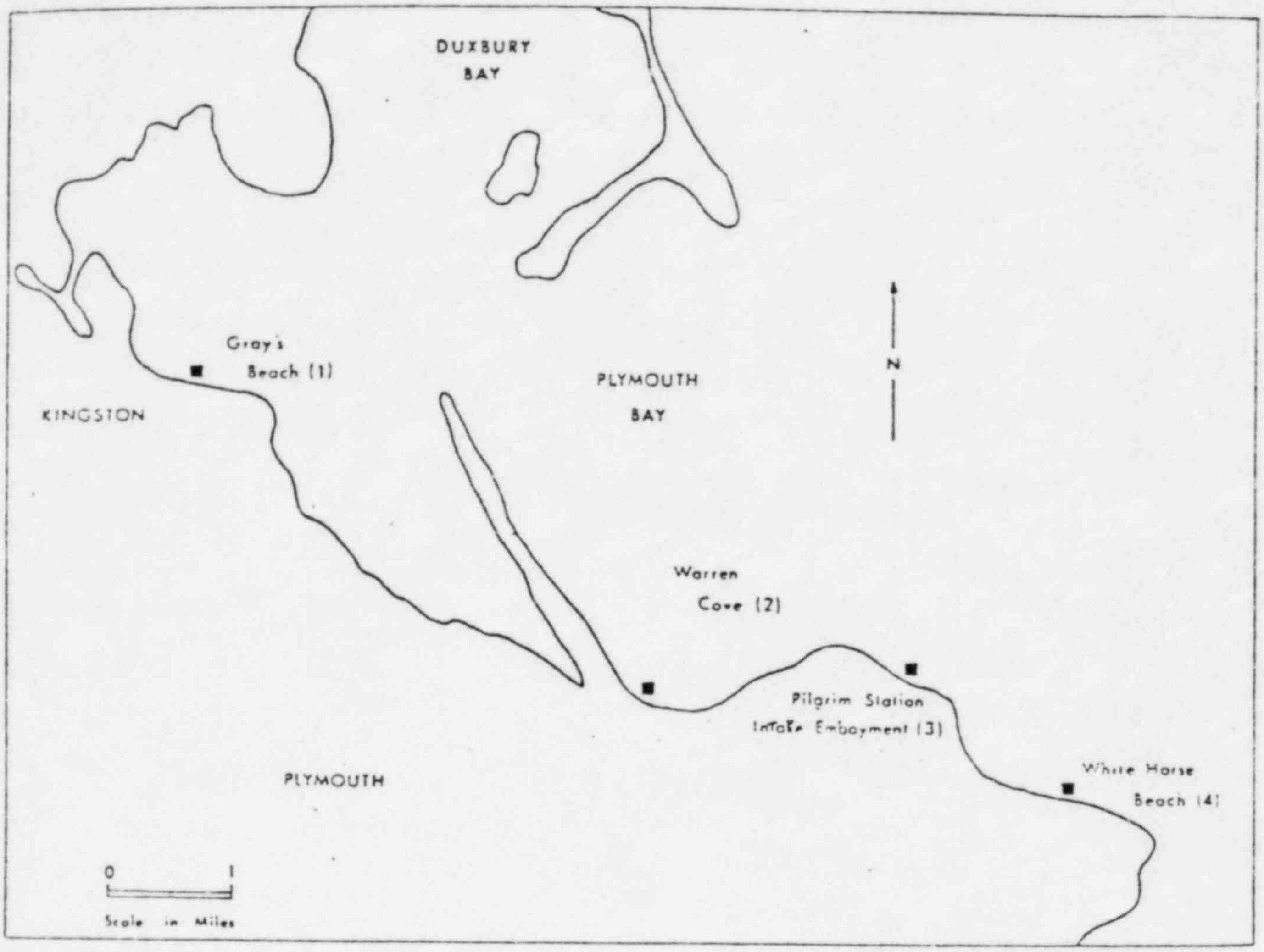

Figure 4. Haul seine station locations in the vicinity of PNPS, 1982.

Table 17. Hydrographic measurements recorded while haul seining in the environs of Pilgrim Nuclear Power Station, March-April, 1982.

Salinity ($^{o}/_{oo}$)

Date	Station 1 Gray's Beach	Station 2 Warren Cove	Station 3 Intake	Station 4 White Horse Beach
3/4	28	34	34	-
3/12	30	29	33	28
3/18	31	31	33	28
3/26	30	33	32	32
4/1	-	32	32	-
4/9	-	-	-	-
4/16	-	-	-	-
4/23	30	30	26	29
4/30	30	30	29	29

Water temperature (C)

Date	Station 1 Gray's Beach	Station 2 Warren Cove	Station 3 Intake	Station 4 White Horse Beach
3/4	2.2	1.0	2.0	2.0
3/12	3.0	5.0	4.0	6.0
3/18	8.5	7.5	7.0	6.0
3/26	7.0	8.0	7.0	6.0
4/1	4.2	5.0	4.2	-
4/9	1.5	2.0	2.5	2.5
4/16	9.0	7.0	6.5	7.0
4/23	8.0	8.0	7.0	8.0
4/30	8.0	9.0	7.0	7.0

Atlantic silverside was the dominant finfish at each location and comprised 80% of the total seine catch.

Three taxa (Atlantic silverside, sand lance spp., and winter flounder) were collected in the intake embayment. Silversides and sand lance were the only fish collected at this site last year during the same time period. Fish were captured in the intake on only two dates - both in April, at water temperatures of 4.2 and 7.0 C, respectively.

Species diversity of finfish was greatest at Gray's Beach, where Atlantic silverside, American eel, white hake, and mummichog were taken. Fish were captured on four sampling dates, with the second highest total number (28) of fish recorded at this station.

Only two species of fish were caught at both White Horse Beach and Warren's Cove. The Atlantic silverside was taken at each location while northern pipefish appeared in the catch at White Horse and winter flounder in Warren Cove. The largest single catch of a species was 28 silversides taken at White Horse Beach in early April.

UNDERWATER FINFISH OBSERVATIONS

The 1982 underwater finfish observational study began on 6 May with results being reported through 30 June. Survey stations were identical to those in 1981 (Figure 5). Stations S_1 and S_2 were located in areas of stunted algal growth, D_1 and D_2 in the direct path of the thermal discharge, and C_1 and C_2 were controls. Linear distances between stations are indicated on Figure 5).

Five finfish species (pollock, cunner, tautog, Atlantic cod and striped bass) were recorded during diving observations (Table 18). No fish were noted

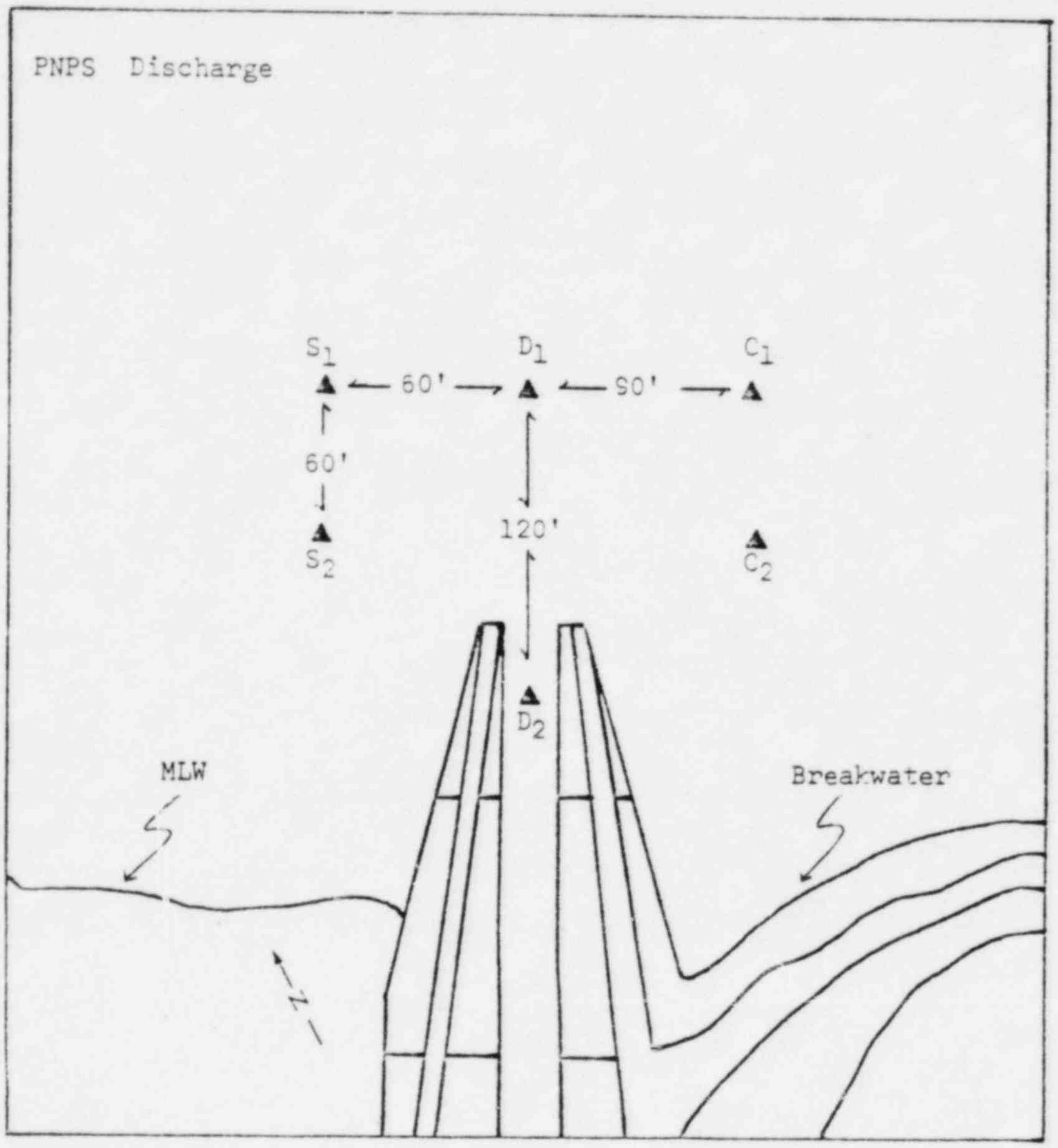

Figure 5. Finfish observational diving stations at PNPS, 1982.

Table 18. Occurrence of finfish species at each observational station from 6 May through 30 June, 1982.

Species	Stations					
	S_1	S_2	D_1	D_2	C_1	C_2
Pollachius virens (pollock)	+				+	+
Tautogolabrus adspersus (cunner)	+	+	+	+	+	+
Tautoga onitis (tautog)			+	+	+	+
Gadus morhua (cod)			+		+	
Morone saxatilus (striped bass)				+		

Table 19. Surface and bottom water temperatures (C) at each observational station from 6 May through 30 June, 1982.

	6 May		21 June		30 June	
Station	Surface	Bottom	Surface	Bottom	Surface	Bottom
S_1	18.0	11.0	-	14.4	21.0	14.0
S_2	17.5	11.0	-	14.4	16.0	12.0
D_1	18.0	10.0	22.0	14.4	22.0	16.0
D_2	21.0	11.0	22.0	16.7	22.0	16.0
C_1	18.0	11.0	-	14.4	22.0	16.0
C_2	16.0	12.0	-	14.4	22.0	16.0

Table 20. Approximate numbers of finfish species that occurred at each observational station from 6 May through 30 June, 1982.

Station	6 May	21 June	30 June	Approximate total for all dates combined
		Pollock		
S_1	*			
S_2			3	3
D_1	*			
D_2				
C_1	*	4	14	18
C_2		8	5	13
				34
		Cunner		
S_1	*	8	27	35
S_2		3	14	17
D_1	*	25	25	50
D_2		35	125	160
C_1	*	6	22	28
C_2		5	10	15
				305
		Tautog		
S_1	*			
S_2				
D_1	*	1	4	5
D_2		12	10	22
C_1	*	2	1	3
				30
		Cod		
S_1	*			
S_2				
D_1	*		10	10
D_2				
C_1	*			
C_2			1	1
				11
		Striped bass		
S_1	*			
S_2				
D_1	*			
D_2			6	6
C_1	*			
C_2				
				6

* No observations at this station this date.

at the three stations surveyed during our first dive of 6 May. Surface and bottom water temperatures from May-June ranged from 16.0-22.0 C and 10.0 - 16.7 C, respectively (Table 19).

Cunner was the only species observed at all stations at least once. The majority (69%) were sighted at Stations D_1 and D_2. Lengths ranged from approximately 5-20 cm (TL).

Pollock were observed in the control and stunted zones. Most (91%) were seen in the control zone. Sizes were estimated to range from 10-38 cm (TL).

Tautog were most often sighted at Station D_2 but were also observed, although in fewer numbers, at Stations D_1 and C_1 (Table 20). Sizes ranged from about 20-50 cm (TL). The largest individual, approximately 50 cm, occurred at Station D_2.

Six striped bass were observed on one occasion at Station D_2. They ranged in size from approximately 35-40 cm (TL). Several young-of-the-year Atlantic cod, approximately 5 cm in length, were sighted at Stations D_1 and C_1, on 30 June (Table 20).

Most finfish species displayed an apparent attraction to the thermal effluent, but none exhibited an abnormal appearance or behavior pattern. No signs of gas bubble disease were evident.

SUMMARY

Over 1200 lobsters were sampled during this reporting period. The mean legal catch for May declined from last year, but the catch rate for June was the highest ever recorded. Ovigerous females comprised 2.7% of the total catch; this represents a notable decline from last year. Approximately 59% of

the ovigerous females were of sublegal size. Mean catch rates for lobsters captured during otter and nearshore trawling have continued to increase, indicating an increase in abundance of lobster on sand substrate.

Fewer rakers this year contributed to r duced effort and landings; however, rakers obtained more moss per unit effort due to less competition. The mean harvest rate was the third highest recorded since study inception. Greatest effort and highest landings were recorded from Zone 2 (White Horse Beach). A comparison of Zone 1 (control) and Zone 5 (discharge) revealed that landings, effort, and mean harvest rate were greater in Zone 1.

Catches of all dominant groundfish in the otter trawl were low in winter; water temperature was a determinant of fish distribution in the area sampled. Winter flounder and skates ranked first and second in abundance. The largest numbers of both species were captured at Station 1 (Warren Cove). Longhorn sculpin and ocean pout were captured in small quantities. Sculpin abundance indices have been on the upswing since 1978 while those for ocean pout have generally been decreasing since study inception. Mean CPUE values for windowpane and yellowtail flounder declined from last year. The value for windowpane was the lowest since 1974, and for yellowtail flounder, the lowest of the entire study.

Nearshore trawl tows were extended to 15 minutes to improve accuracy of data. Winter flounder and skates ranked first and second in abundance with the largest concentrations occurring at Station 1. All species of finfish captured by nearshore trawl were also caught in the otter trawl; however, the latter effort obtained nine additional species. Winter flounder and little skate ranked first and second with both gear types, but percent catch composition of these species differed.

A new species - a male basking shark, was captured in the gill net at Station 2. Mean CPUE increased 22% over last year's value at Station 1 but decreased 32% at Station 2. In the five smaller panels, pollock was the most abundant species captured at Station 1, but Atlantic herring was most abundant at Station 2. In the two largest panels, tautog was captured in the greatest numbers at both stations. Variations in finfish abundance patterns possibly reflect natural population fluctuations.

Atlantic silverside was the dominant species collected in the haul seine. Shrimp (Crangon spp.) were the most abundant invertebrates seined. Water temperatures were lower in March and April than last year and apparently affected total catch, resulting in reduced numbers of fish taken. Fish were captured only during April in the intake embayment. The largest single catch of a species was taken at White Horse Beach in early April.

Five species of finfish were observed during underwater finfish observations; however only one species - cunner, was observed at all stations. Most species displayed an attraction to the thermal effluent, but none exhibited an abnormal appearance or behavior pattern, and no signs of gas bubble disease were evident.

ACKNOWLEDGEMENTS

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Appendix A.

Summary of Lobster Pot Catch Data

January - June, 1982.

	# Sampling Days	# of Pots	Total Catch	Male	Female	Sub Legals	legals	Eggers	Legals /Pot	Catch /Pot	Ratio Legals	Ratio Sub-legals	Ratio Eggers
F-13	1	5	6	1	5	1	5	0	0.2	1.2	1.0	5.0	0.0
F-14	2	30	68	26	42	15	52	1	0.5	2.3	1.0	3.5	0.1
F-15	1	3	9	5	4	1	8	0	0.3	3.0	1.0	8.0	0.0
G-10	1	8	15	2	13	4	11	0	0.5	1.9	1.0	2.8	0.0
G-13	3	13	39	22	17	9	30	0	0.7	3.0	1.0	3.3	0.0
G-14	3	36	123	55	68	19	102	2	0.5	3.4	1.0	5.4	0.1
G-15	1	7	21	9	12	2	19	0	0.3	3.0	1.0	9.5	0.0
H-11	1	4	10	5	5	1	9	0	0.2	2.5	1.0	9.0	0.0
I-11	1	7	8	5	3	3	5	0	0.4	1.1	1.0	1.7	0.0
I-12	1	5	1	1	0	1	0	0	0.2	0.2	1.0	0.0	0.0

# Sampling Days	# of Pots	Total Catch	Male	Female	Sub Legals		legals	Eggers	Legals /Pot	Catch /Pot	Ratio Legals:	Sub-legals:	Eggers
1	17	34	13	21	7	J-1	25	2	0.4	2.0	1.0	3.6	0.3
1	17	19	6	13	4	J-2	15	0	0.2	1.1	1.0	3.8	0.0
2	22	61	14	47	13	J-9	44	4	0.6	2.8	1.0	3.4	0.3
1	32	26	5	21	5	K-3	19	2	0.2	0.8	1.0	3.8	0.4
1	7	22	8	14	8	K-8	14	0	1.[illegible]	3.1	1.0	1.8	0.0
2	59	139	45	94	24	K-9	108	7	0.4	2.4	1.0	4.5	0.3
2	24	43	15	28	7	K-10	36	0	0.3	1.8	1.0	5.1	0.0
1	24	55	17	38	17	L-9	36	2	0.7	2.3	1.0	2.1	0.1
1	15	20	7	13	7	L-10	12	1	0.5	1.3	1.0	1.7	0.1
1	8	17	5	12	3	M-8	14	0	0.4	2.1	1.0	4.6	0.0

# Sampling Days	# of Pots	Total Catch	Male	Female	Sub Legals	legals	Eggers	Legals /Pot	Catch /Pot	Ratio Legals:	Sub-legals:	Eggers
						M-10						
1	8	15	3	12	5	8	2	0.6	1.9	1.0	1.6	0.4
						N-8						
1	16	31	12	19	11	20	0	0.7	1.9	1.0	1.8	0.0
						N-9						
1	8	12	4	8	5	7	0	0.6	1.5	1.0	1.4	0.0
						N-10						
1	11	24	6	18	8	16	0	0.7	2.2	1.0	2.0	0.0
						N-12						
1	2	2	0	2	1	1	0	0.5	1.0	1.0	1.0	0.0
						0-9						
1	48	62	16	46	22	36	4	0.5	1.3	1.0	1.6	0.2
						0-10						
2	25	35	12	23	13	21	1	0.5	1.4	1.0	1.6	0.1
						0-11						
1	10	8	4	4	3	5	0	0.3	0.8	1.0	1.7	0.0
						0-12						
1	5	4	1	3	1	3	0	0.2	0.8	1.0	3.0	0.0

# Sampling Days	# of Pots	Total Catch	Male	Female	Sub Legals	legals	Eggers	Legals /Pot	Catch /Pot	Ratio Legals:	Sub-legals:	Eggers
O-13												
1	9	12	4	8	7	5	0	0.8	1.3	1.0	0.7	0.0
P-8												
1	4	4	0	4	1	3	0	0.2	1.0	1.0	3.0	0.0
P-10												
1	6	12	3	9	1	11	0	0.2	2.0	1.0	11.0	0.0
P-11												
1	23	24	5	19	10	14	0	0.4	1.0	1.0	1.4	0.0
P-12												
1	19	28	4	24	14	13	1	0.7	1.5	1.0	0.9	0.1
Q-12												
1	7	9	4	5	2	7	0	0.3	1.3	1.0	3.5	0.0
Q-13												
1	4	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Cole's Hole												
3	123	207	67	140	50	153	4	0.4	1.7	1.0	3.1	0.1
Faunce's Ledge												
1	10	16	4	12	3	12	1	0.3	1.6	1.0	4.0	0.3

BENTHIC STUDIES
IN THE VICINITY OF
PILGRIM STATION

Report No. 20
Setember 1981 - August 1982

Prepared by:
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1. EXECUTIVE SUMMARY

This report presents the results of benthic monitoring studies designed to assess the effects of Pilgrim Nuclear Power Station (PNPS) Unit One thermal discharge on marine faunal and floral communities. The data contained herein were based upon field observations and quantitative benthic samplings performed between September 1981 and August 1982. All data were analyzed and interpreted with respect to possible PNPS impact. Current data were also compared with those reported for prior years' monitoring efforts.

A community approach has been utilized, whenever possible, in order to permit quantitative measurements of such diverse community parameters as species richness, faunal densities, diversity, and algal community structure. Statistical analyses of quantitative data allowed evaluation of community overlap and other parameters which delineated the degree of similarity between the control (Rocky Point and Manomet Point) and experimental (Effluent) stations. In addition to a community approach, specific representative species were also monitored. However, since the value of individual species as indicators of stress is often limited, this approach comprised only a minor aspect of the entire study.

The fauna and flora which have been found in the PNPS area represent a diverse arctic-boreal assemblage. Many of the species are near the southern limit of their geographical distribution, and are found infrequently, if at all, south of Cape Cod Bay. These species are presumed to be less resistant to thermal stress, and are therefore observed as potential indicators of environmental impact.

The marine environment surrounding PNPS primarily consists of two major substratum types, rock and sand. The intertidal zone, together with the shallow subtidal (less than 20 feet), is primarily rock. Sand predominates in the deeper areas, as well as in areas to the north and south of the study area. The Effluent experimental site was located within the path of the discharge plume while the Rocky Point and Manomet Point control sites were located 0.3 nm (nautical miles) north and 2.0 nm south respectively from the Effluent site. The control sites were chosen to resemble the experimental station, especially with respect to exposure and substratum type. However, as there will always be some differences in substrate type and exposure, the three sites were not identical.

Faunal analyses included determination of species richness, faunal density, species dominance, community overlap, diversity, and multivariate classification techniques. Algal analyses consisted of community overlap, species biomass, and plant and animal colonization of Chondrus and Phyllophora.

For each parameter, the experimental station was compared with the control stations. Current data were also compared with previous years' data in order to detect intermediate to long-term changes in the faunal and algal communities at all stations. The results of the analyses can be separated into three groups:

A. Studies indicating no PNPS impact
B. Studies suggesting possible PNPS impact
C. Studies indicating PNPS impact

1.1 Studies Indicating No PNPS Impact

Directly beyond the mouth of the discharge there is a denuded zone where strong current in combination with elevated temperatures inhibits normal benthic community development. We are interested mainly in the area immediately beyond this zone, where the biota are influenced solely by the thermal component of the plume. PNPS discharges cooling water with a nominal maximum temperature of 37°C and a maximum ΔT of 16.2°C (Marcello, 1975); however, the temperatures reaching the benthos at the Effluent study site are considerably lower due to plume detachment from the bottom and rapid mixing with ambient water. A maximum ΔT of 7.0°C was determined for the Effluent ten foot rock station (BECo Benthic Map Study, 1980).

Although obvious degradation in various population parameters has been noted at the Effluent station in comparison to the Rocky Point and Manomet Point controls, these appear to be restricted to relatively discrete faunal components or to times when the Effluent station is included within the near-field stunted zone described in previous reports. The results of the classification analyses, which consider the entire population simultaneously, have tended to confirm very minor impacts at this location due to PNPS operation except when the station site is within the spatially-limited acute impact zone, when impacts are more obvious.

Algal community overlap analyses indicated that the species composition of the Effluent, Manomet Point, and Rocky Point populations was highly similar. The high degree of overlap between the three stations indicated a lack of discharge impact. Algal biomass differences between the Effluent and control stations for the category "remaining benthic species" were not statistically significant for either the August 1981, March 1982, or composite October 1979 through March 1982 data. In addition, no significant differences between Effluent and control stations were found for either Chondrus or Phyllophora epiphytic biomass. Results of the Condiition Index study also showed no appreciable differences in epiphytic and faunal infestation levels between experimental and control stations for either Chondrus or Phyllophora.

1.2 Studies Suggesting Possible PNPS Impact

Throughout this program, the pattern of change in faunal population parameters at the Effluent 10' station has presented an inconclusive picture of potential PNPS impact at this site. A recent intensive study of acute near-field impacts of the PNPS discharge (McGrath, 1980) found that the location of the Effluent 10' station is near the seaward limit of the area where impacts of the PNPS discharge may be readily observed. Given the expected variation in extent of the acute impact area and the inherent variability in relocation of the Effluent station over the course of several years, it is probable that this station has at times been within the impact area while at other times it has been beyond it. This may well be responsible for much of the variability in population parameters seen in this area.

Species richness and population density data, as well as density data for Mytilus edulis, have all appeared to indicate impacts of PNPS at the Effluent station in some previous samplings. Species richness is a very stable and conservative parameter throughout the area except at the Effluent, and it appears that the marked variation at Effluent is an effect of PNPS, though the usual high variability has not been so evident in recent data. For the March 1982 data, however, species richness at Effluent was identical with that recorded at Rocky Point.

We have noted previously, but not for the most recent data, that perhaps due to the decreased algal cover in the area, the Effluent station supports greater settlement of juvenile mussels than either Rocky Point or Manomet Point. This has had an effect on the remaining population parameters producing increased overall population densities and, due to decreased evenness, depressed diversity index values. When the Mytilus data are removed from the data set, these discrepancies are often no longer apparent, and for some collections, including both samplings in the current year, no differences in Mytilus populations were evident.

1.3 Studies Indicating PNPS Impact

The most obvious impacts of PNPS on the benthic marine environment are the denuded and stunted areas immediately seaward of the discharge canal jetties. The nature and extent of these areas have been fully discussed in previous reports, and the current samplings provide little additional information on their present condition.

Because of the restructuring of the monitoring program in 1981, it is possible to use the statistical resolution provided by five replicates at three stations to extract more quantitative conclusions from the data set. In August, the Effluent site supported significantly fewer species than the controls; this was assumed to be directly related to the PNPS discharge. A similar pattern was found for faunal density and it was again evident that the decrease in number of organisms at the Effluent was due to PNPS operation. This was true for the general population both with and without the faunal dominant, Mytilus edulis, and for the Mytilus densities alone.

For the August data, four of the ten individual species whose abundances have been monitored were found to be significantly less abundant at the Effluent station. In previous reports we have only considered those species for which there were significant differences between Effluent and both control sites to be indicative of a reduction in density due to PNPS operation. Because of differences between the two controls, this pattern was not shown by any of the four species although the data were generally suggestive of PNPS impact. Two of the species (Margarites umbilicalis and Pleusymtes glaber) have been definitely impacted for the last several collections and these again are believed to be responding to the PNPS discharge.

In March, however, the patterns described for August were no longer evident and there were no demonstrable differences in population parameters or in densities of individual species between the Effluent and the controls. The only significant differences seen were between Manomet Point, which had unusually high populations in March, and the remaining two stations.

Algal biomass studies showed that Chondrus biomass was significantly lower at Effluent than at Manomet Point and Rocky Point for both the August 1981 and March 1982 collections, as well as for the composite data of October 1975 through March 1982. Effluent also showed significantly higher Phyllophora biomass than control stations for the August 1981 and composite data of October 1975 through March 1982. This pattern has also consistently emerged from previous years' data. It is hypothesized that increased scouring associated with the higher current velocity and sedimentation of the discharge plume is at least partly responsible for the lowered Chondrus density at Effluent. The reduced Chondrus density, in turn, permits increased colonization by Phyllophora, a species considered to be more resistant to scouring effects. Effluent also showed significantly lower total algal biomass than control stations for both the current and composite data. The lower Effluent biomass is primarily a reflection of reduced Chondrus biomass.

Representatives of the warm-water algal species Gracilaria foliifera and Bryopsis plumosa were encountered only at the Effluent station. Both species have frequently been collected at Effluent in previous years, but have never been recorded from control stations. The continued occurrence of these species at Effluent is judged to be a direct effect of PNPS thermal discharge.

2. INTRODUCTION

This report presents the results of the most recent series of benthic monitoring surveys performed to assess the impact of Pilgrim Nuclear Power Station (PNPS) Unit I thermal effluent on the inshore benthic community. PNPS is a 655MW^e nuclear steam-electric generating station located on the northwest shore of Cape Cod Bay, five miles southeast of Plymouth Harbor, Massachusetts. The algal and faunal data presented and analyzed in this report were derived from field collections conducted in August 1981 and March 1982.

A re-evaluation of the benthic monitoring program was undertaken in the summer of 1981. Several revisions in both the overall scope and the immediate objectives of the existing program were proposed by the Benthic Subcommittee of the Pilgrim Administrative Technical Committee (PACT). All PACT recommendations were subsequently adopted by the Boston Edison Company, and have been incorporated into the current benthic program. The adopted modifications include:

(1) Adoption of a semiannual (August 1981 and March 1982) benthic sampling schedule (benthic sampling had been conducted four times per year from September 1974 through June 1981).

(2) Re-establishment of Manomet Point as an active benthic survey control station (Manomet Point had served as a control station from September 1974 through June 1980; from September 1980 through June 1981, Manomet Point samples were collected to be archived only).

(3) Decreasing the number of replicate samples - from six to five - to be collected in each sampling period at each benthic survey station (three replicates per station were collected from September 1974 through June 1980, and six replicates were taken from September 1980 through June 1981).

(4) Initiation of diver transect surveys to be performed in August and December, 1981 and March and June, 1982 to assess the effects of PNPS cooling water discharge on near-field benthic communities.

All of the above modifications were put into effect with the August 1981 collections.

The primary analytical technique used throughout this program has been a community structure approach; however, specific data on algal biomass, dominant faunal and algal species, and densities of selected faunal species were also investigated. All data were analyzed and compared with data from previous samplings and with control station results.

Final identification and analysis of all faunal material was supervised by Dr. Allan D. Michael and Richard McGrath. Initial sorting of samples was accomplished under the direction of Jan White. Algal taxonomy and analysis was supervised by Walter Grocki. All personnel involved with the compilation of this report were active participants in all aspects of the program.

3. METHODS

3.1 Benthic Sampling Methods

The benthic sampling methods currently in use for the 1981 through 1982 survey period have evolved from a sampling strategy originally devised and implemented by TAXON, Inc. in September 1974. In 1981, a re-evaluation of the benthic program led to the adoption of several changes in sampling stations and sampling methods (see Section 2). All modifications were put into effect with the August 1981 collections.

3.1.1 Benthic Sampling Stations

Sampling and observation of benthic faunal and algal communities was conducted in August 1981 and March 1982 at three rock-substratum stations: Effluent, Manomet Point and Rocky Point (Figure 1). All stations were located at a depth of 10' (MLW). The Effluent station has been designated the near-field experimental site, and is located directly seaward of the center line of the dischagre canal. The Rocky Point station is located approximately 0.25 nautical miles (nm) northeast of the Effluent site. Originally, Rocky Point served as a far-field experimental site; however, the absence of any evidence suggesting discharge related effects at this station strongly indicated that it would function well as a control site. The Manomet Point station, which has traditionally served as a control site, is located approximately 2.0 nm south of the Effluent site.

Precise station locations were originally established using line-of sight positioning techniques, with highly visible structures located on the shore serving as the reference points. The Rocky Point station was established by lining up the microwave relay tower with the off-gas stack. The Effluent site was identified as the center line between the two discharge jetties, and the Manomet Point site was originally fixed by lining up the two southernmost telephone poles on top of Manomet Point. Station relocation techniques are sufficiently reliable to insure that all sampling occurs within a radius of 25-50 meters of the originally established station locations.

3.1.2 Sampling Methods

All sampling was performed by a team of SCUBA diver-biologists operating from a 23-foot outboard. Sampling equipment consisted of an

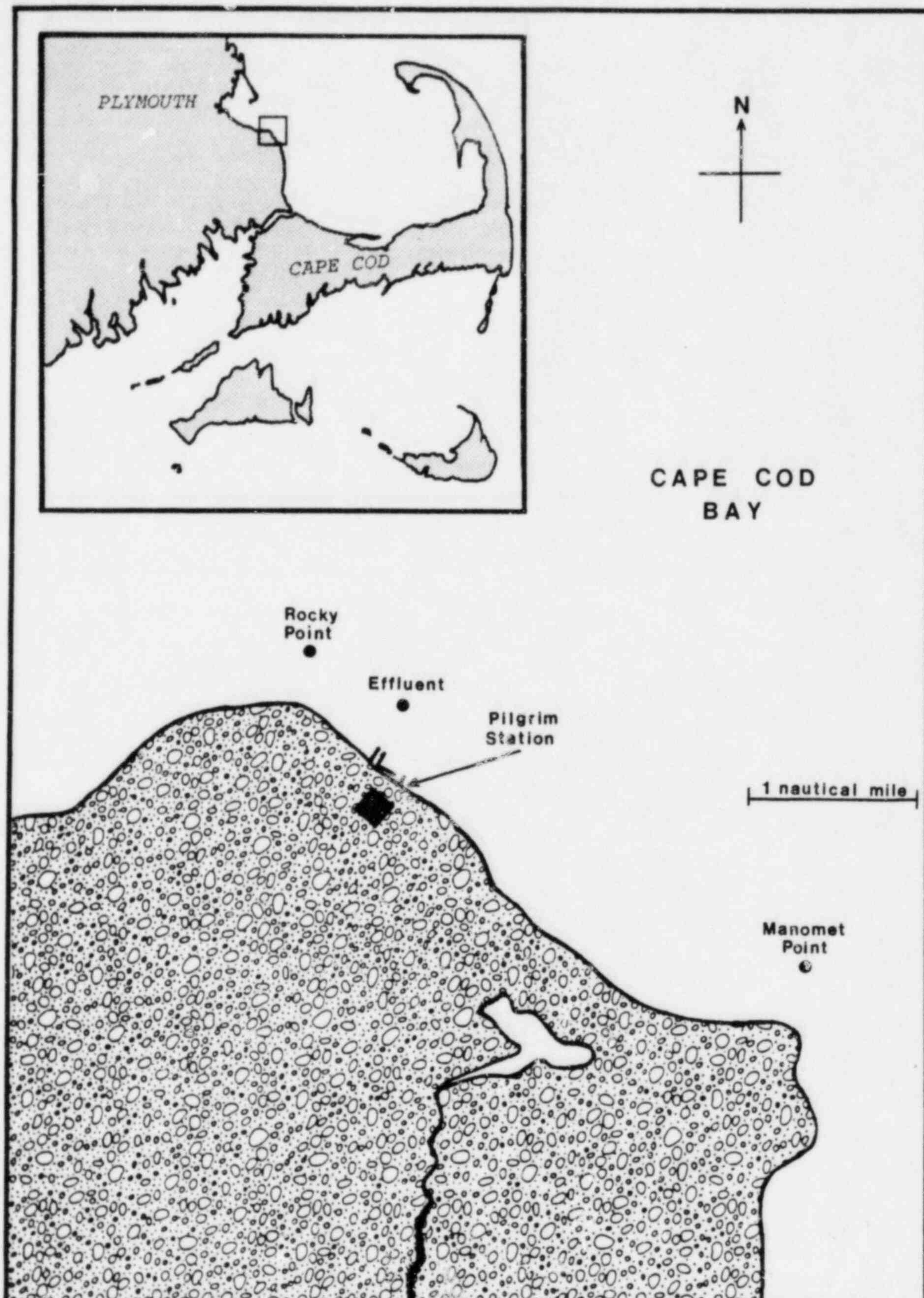

Figure 1. Location of the Rocky Point, Effluent, and Manomet Point subtidal (10' MLW) rock-substratum stations.

airlift sampling device and a ($33cm^2$) metal pipe-frame quadrat (Figure 2). The use of the pipe-frame quadrat insured that a uniform surface area of 1089 cm was consistently sampled from each rock. A standard SCUBA tank supplied the suction necessary for the operation of the airlift device.

Upon determination that the precise location of a station had been reached, divers descended to the bottom with the sampling equipment and randomly chose large, flat-surfaced rocks or boulders for sampling. Smaller rocks with less than twice the surface area of the quadrat were eliminated from sampling considerations because of their increased susceptibliity to movement and dislodgement during harsh storms and the resultant destabilization of the resident communities. The quadrat was placed on the surface of a selected rock, and the airlift device was positioned a few inches directly above the quadrat. The SCUBA tank valve was opened, releasing pressurized air through a connector hose and into the airlift device. All attached plant and animal material within the quadrat was then cut free of the rock substrate with a scraper. The material was uplifted into the airlift device by the force of the rising air, and was deposited in a 0.05mm mesh bag affixed to the top of the device. When all biota had been removed from the substrate and lifted into the mesh bag, the bag was tied and stored, and a replacement bag was attached to the airlift device. The divers then located the next suitable rock and the sampling process was repeated. Five replicate samples were taken at each station.

3.1.3 Laboratory Procedures

3.1.3.1 Faunal Material

Samples were transported to the laboratory in their original mesh bags. In the laboratory, samples were transferred into Nalgene jars and fixed in a 10% formalin solution for at least 48 hours. The algal and faunal fractions of each sample were then separated by washing the animals off the algae and into a 0.5mm retaining screen. The faunal fraction was preserved in a solution of 70% ethanol, and the algal fraction was returned to a 5% formalin solution.

The faunal fraction of each sample was stained with a solution of rose bengal and alcohol prior to processing. Processing of the samples was accomplished in two steps. Presorting enta' ed the removal of all

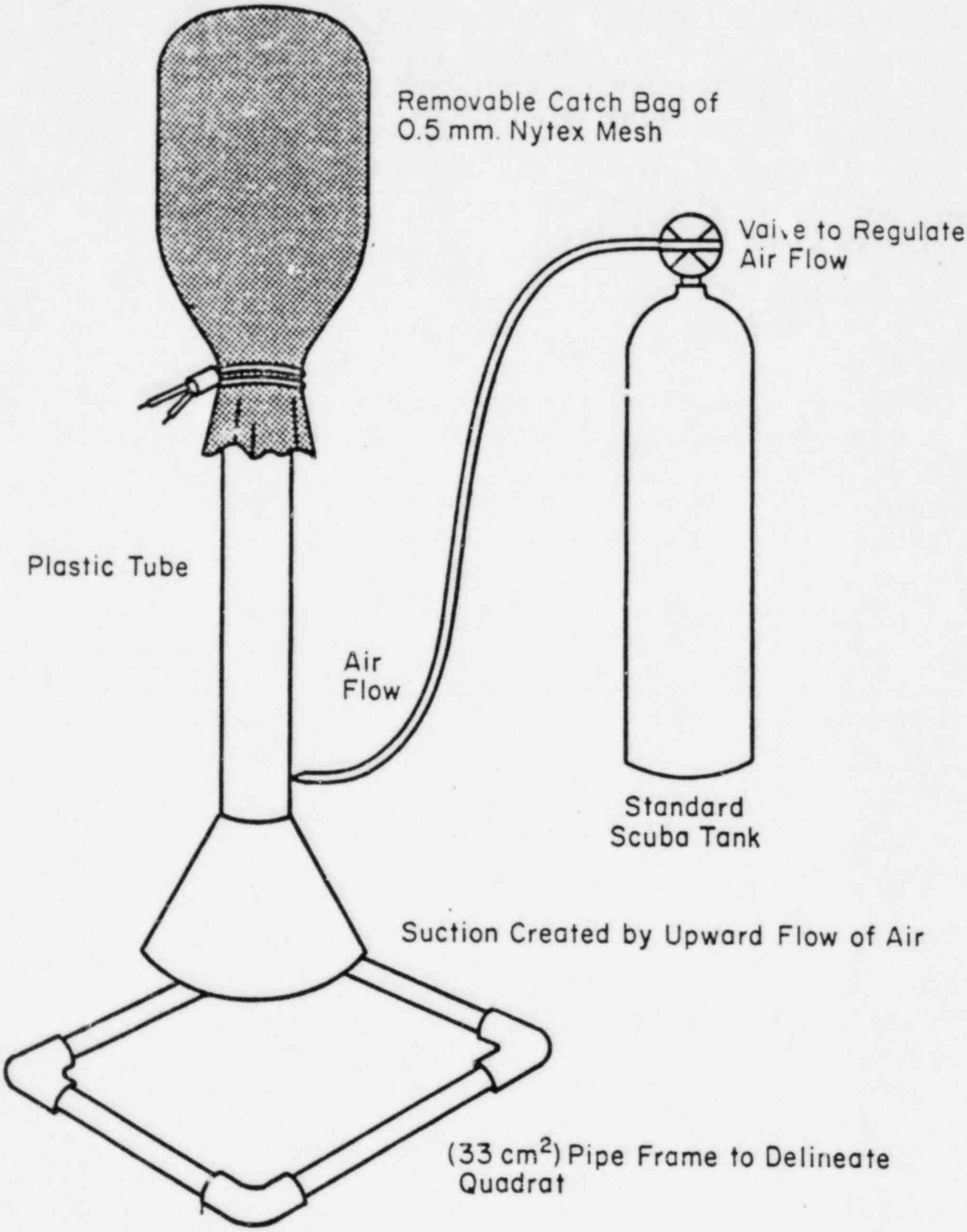

Figure 2. Rock substratum airlift sampling device.

faunal material from the residue and the identification of specimens to major taxonomic groups. All identifications were performed using a binocular dissection scope with a magnification range of 7 to 40 power. Due to the non-quantitative sampling of spirorbid worms and colonial ectoprocts, only qualitative representatives of these species were retained for identification. Species commonly exhibiting very high densities, such a Mytilus edulis and Hiatella arctica, were left in the residue to be counted.

Final sorting was performed by experienced taxonomists using both binocular dissection and compound microscopes. Individual animals were identified to the species level whenever possible. A reference collection consisting of representatives of all species encountered to date is maintained, and is continually updated as additional species are found.

3.1.3.2 Algal Material

The algal component of each replicate sample was examined, using both a dissection and compound microscope, to determine the presence or absence of 38 indicator species. The relative abundance of each indicator taxon encountered was also noted for each sample. The indicator species currently under observation were originally chosen in September 1978, and were carefully selected from a listing of the several hundred algal species recorded from the Pilgrim I study sites in the 1974 - 1978 period. As a group, the indicator species include members of each of the major algal families, and also include representatives of a variety of habitat types; the group includes all of the dominant species within the study area, the majority of the macrophytic species, and the most common epiphytic species. Although the indicator species constitute only a small fraction of the total number of species inhabiting the study area, they comprise by far the most substantial part of the algal community as measured by both percent cover and biomass.

The Chondrus crispus and Phyllophora spp. fractions of each replicate sample were examined to assess the degree of algal and faunal colonization of the host species. The algal colonizers were epiphytic species such as Spermothamnion repens, Ceramium rubrum, Cystoclonium purpureum, and Polysiphonia spp.; the faunal colonizers were primarily the encrusing hydrozoan and bryozoan species. Each Chondrus and Phyllophora replicate fraction was compared with a set of five reference samples which were ranked in order of increasing levels of algal and faunal infestation. Each fraction was then assigned the numerical value of the reference sample with which it most closely compared. Separate algal and faunal colonization indices were then determined for the Chondrus and Phyllophora populations of each station by summing the values assigned to the five replicate samples. The separate Chondrus and Phyllophora condition index values, which provide a measure of the total infestation (epiphytism and encrustation combined) of each species at each station, were obtained by adding together the separate colonization values for animal and plant colonization.

Dry weight biomass of each sample was determined for five separate algal fractions; Chondrus crispus, Phyllophora spp., epiphytes of Chondrus, epiphytes of Phyllophora, and the remaining benthic species. Total algal biomass was also determined. Each fraction was weighed on a Mettler balance after drying for 72 hours in a standard drying oven set at 80°C.

3.1.4 Statistical Analyses

The number of faunal individuals for each species was tallied on species lists, the sums for the five replicates added, and this numerical data was then punched onto data cards. Data analysis was performed on the Woods Hole Oceanographic Institution (WHOI) VAX 11 computer. Diversity coefficients, including the Brillouin and Shannon-Wiener formulas, were calculated on replicate data and on the combined data, and are presented graphically in the form of hierarchical dendrograms. The diversities were calculated using the Program PRARE1 and classification used the Virginia Institute program SPSTCL. Community overlap of faunal species and of algal species was determined using Jaccard's coefficient of similarity (Grieg-Smith, 1964). The method used the formula

$$CC = \frac{C_{ij}}{A_i + A_j - C_{ij}}$$

where C_{ij} = the number of species shared by the two stations,

A_i = the number of species at station i, and

A_j = the number of species at station j.

This method of calculating overlap considers only the number of species in each sample and those shared. It does not take into account actual abundances of these species. Quantitative data was considered in the coefficient used to calculate similarity values as part of classification analysis.

3.2 Transect Study Methods

A line was deployed perpendicularly across the mouth of the discharge jetty. The weighted transect line was attached to the center of this line and deployed along the main central axis of the discharge canal for 200 meters offshore. A third line, marked at one meter intervals, was deployed perpendicularly to the transect line by divers on the bottom, and oriented at 90° via compass. An experienced algologist transversed this third line underwater and recorded the distance from the center line at which the denuded area in the central path of the discharge changed to stunted algal growth, and also the precise point at which the algal cover became "normal". This was done every 10 meters, and on each side of the center line, until the offshore limit of the stunted zone was encountered.

Although we have used the term denuded to describe the central part of the impact area, this zone is not actually devoid of all algal cover. Individual algal specimens are present, but these do not occur as clumps and are often confined to the sides of rocks. Characteristically warm-water species are also found in this central area. In appearance, this zone is similar to an early successional stage of new substratum where the most dominant feature is large patches of bare rock or rock covered with only a bacterial slime. Although the lack of algal cover precludes the presence of most benthic invertebrates, some species are able to thrive in this type of situation. Chief among these are the mussels, which were present in clusters between rocks and also in dense mats on some rock surfaces. Other species which are attracted to the bare areas are Littorina (periwinkles) and Asterias (starfish).

Our operational distinction between "denuded" and "stunted" was based on Chondrus. The denuded zone was defined as that area where Chondrus occurs only as stunted plants restricted to the sides and crevices of rocks. No Chondrus is found on the upper surfaces of rocks in this area, except where the microtopography of the rock surfaces creates small protected areas. In the stunted zone Chondrus is found on the upper surfaces of the rocks but is noticeably inferior in height, density, and frond development. The normal zone was considered to begin at that point where these factors were typical for the depth and substratum in question, based upon our algologist's several years of experience in the Pilgrim Station area.

4. FAUNA

4.1. Systematics

Analysis of the 15 replicate samples collected in August, 1981 added two species to the taxonomic list of Plymouth area benthic fauna developed by this program. Both new species are members of the Mollusca, Class Gastropoda, and were discussed in Semi-Annual Report No. 19.

The two new species, Skeneopsis planorbis and Sayella unifasciata, were not recorded from the March, 1982 quantitative sampling, nor were any other additional species new to the program.

4.2. Community Structure

4.2.1. Species Richness

Species richness for the August 1981 and March 1982 samplings is presented in Table 1. As mentioned in the Methods section, the table includes data for Manomet Point, sampling at which was re-instated with the first collection in this contract year. Values for species per square meter represent cumulative numbers of species over all replicates (total area sampled = $0.55m^2$) rather than mean values per replicate.

Also, since rate of addition of species is not linear with respect to increasing sample size, the values underrepresent the actual species richness per square meter. Because the present program is based upon five replicate samples at each station, the m^2 data are not directly comparable with earlier data developed from three and six replicate collections.

Manomet Point had the greatest overall species richness in August, containing a cumulative total of 95 species in the five replicates. Rocky Point was next highest with a total of 89 species, while Effluent supported only 81 species among the five replicates.

A similar pattern is seen when the mean species per replicate is calculated for the three locations (Table 1). Rocky Point had the greatest per replicate richness with a mean of 60.0 species followed closely by Manomet Point at 58.8 species. Effluent again had markedly lower mean richness with 48.6 species per replicate.

The observed differences in mean number of species per replicate

Table 1: Faunal species richness (S), faunal density with (N) and without (N') Mytilis edulis; August, 1981 and March, 1982.

	August, 1981			March, 1982		
Station/Replicate	S	N	N'	S	N	N'
Rocky Point						
1	56	7,806	5,410	34	5,914	3,670
2	59	10,732	8,584	51	3,134	2,178
3	60	13,058	10,086	31	10,768	6,080
4	51	9,488	7,020	42	10,824	5,544
5	74	19,040	10,608	37	5,097	2,049
m^2	-	110,422	76,602	-	65,630	35,850
Manomet Point						
1	54	13,462	7,962	49	14,808	4.340
2	59	8,430	6,144	33	19,500	5,112
3	60	15,476	7,364	44	20,458	5,342
4	65	11,356	9,156	42	19,902	5,350
5	56	16,120	9,648	45	16,956	4,976
m^2	-	119,091	73,967	-	168,265	46,132
Effluent						
1	48	3,812	2,752	38	5,599	2,786
2	46	4,264	3,232	29	8,746	3,238
3	42	4,272	3,000	45	8,131	5,935
4	64	6,220	5,080	31	10,312	8,608
5	43	3,970	2,920	22	2,944	1,830
m^2	-	34,784	31,194	-	65,621	37,770

were tested via single-classification analysis of variance (ANOVA) (Sokal and Rohlf, 1969 p. 204) and found to be marginally significant at $.05 < p < .01$. Two a priori comparisons were planned prior to performing the ANOVA: Effluent vs. Rocky Point and Manomet Point and Rocky Point vs. Manomet Point. The appropriate respective hypotheses were 1) Is the experimental station significantly different form the two controls? and 2) Are the two controls significantly different from each other?

Using this procedure, it was determined that the Effluent supported significantly fewer species in August per replicate than the controls ($p < .05$) and there was no significant difference between the controls themselves.

For the March, 1982 collection, a similar pattern of total species at each site was evident: Manomet Point supported the most species (69) followed closely by Rocky Point at 64. The Effluent was considerably lower at only 54 species.

Mean species richness at all stations was markedly lower in March in comparison with August, following the previously described trend of decreasing numbers of species during the winter. Mean species per replicate was tested via a single-classification ANOVA in a manner similar to that performed for the August data and no significant difference was found among the three stations.

The pattern of variation in species richness since September, 1979 is shown in Figure 3. The values for October, 1980 to June, 1981 have been corrected from six to three replicates using the procedure of Gaufin, et al (1956) and the results from the August, 1981 and March, 1982 samplings were similarly reduced from five to three replicates. It is apparent that both Effluent and Rocky Point experienced a moderate increase in species richness in the fall of 1981 with a marked drop in richness occurring between then and March, 1982: this is the typical seasonal pattern that we have identified in previous reports.

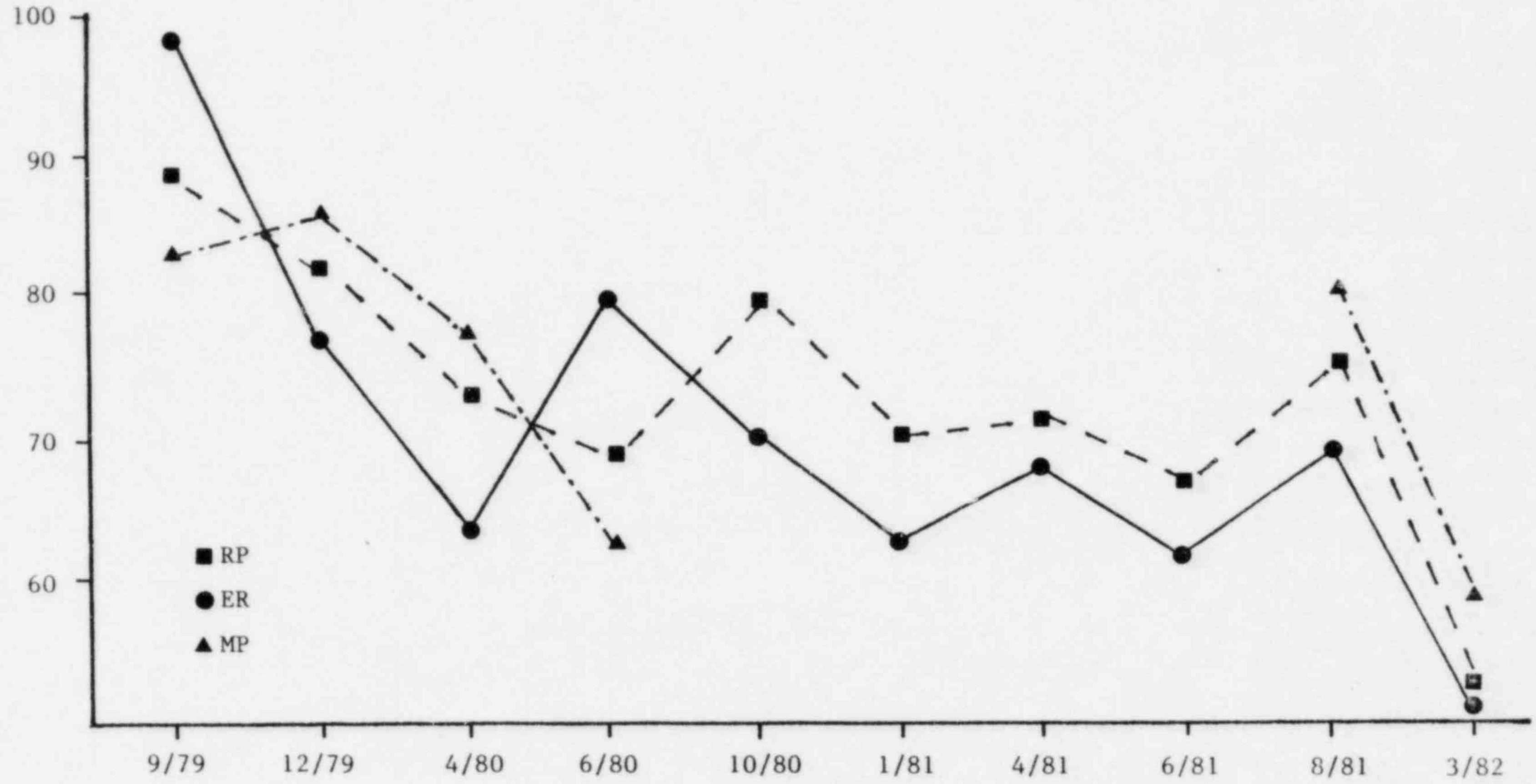

Figure 3. Species richness at rock stations for the period September, 1979 through March, 1982.

4.2.2. Faunal Density

Values for densities of benthic macrofauna per replicate and per square meter for the October, 1980 through March, 1982 samplings are presented in Table 1 and Figure 4. Unlike the species richness data, these values are not sample size dependent and may be compared directly with previous years.

For the August, 1981 sampling, greatest faunal densities were found at Manomet Point, with nearly 120,000 organisms per m^2. Rocky Point also had similarly elevated densities of approximately 110,000/m^2. Densities at Effluent were much reduced at only 35,000/m^2. This is a reversal of the normal pattern of greater densities at the Effluent site as described in Report No. 18 (BECO, 1981). For the March, 1982 sampling Manomet Point again had the highest faunal densities, with over 165,000 organisms per square meter. Rocky Point and Effluent had nearly identical densities of 65,000/m^2. This continues the somewhat anomalous pattern of depressed densities at Effluent in comparison with prior years and would probably be indicative of the most recent samplings being taken within the stunted zone described in previous reports except for the observation that the majority of these differences are due solely to mussels (N', Table 1).

Figure 5 shows the faunal density data with the large numbers of juvenile mussels (Mytilis edulis) excluded, and Figure 6 shows the number of Mytilis only. It is clear from these plots that the late summer sampling represents a seasonal low for mussel populations at the Effluent site and this is especially apparent in the present collection. When the mussel data are excluded from the density plots, the pattern of lower densities at Rocky Point and Manomet Point and greater densities at Effluent remains consistent, and the March 1982 data continue to support those conclusions.

The observed differences in faunal density data were examined via single-classification ANOVAs for overall density, density without mussels, and density of mussels, respectively. As described above for the species richness data, two a priori comparisons (corresponding to ER vs. RP + MP, and RP vs. MP) were conducted for each ANOVA, with the null hypothesis being that of equality of means.

In all three cases for the August 1981 data, the ANOVA was significant at $p < .01$, indicating significant differences in mean faunal densities

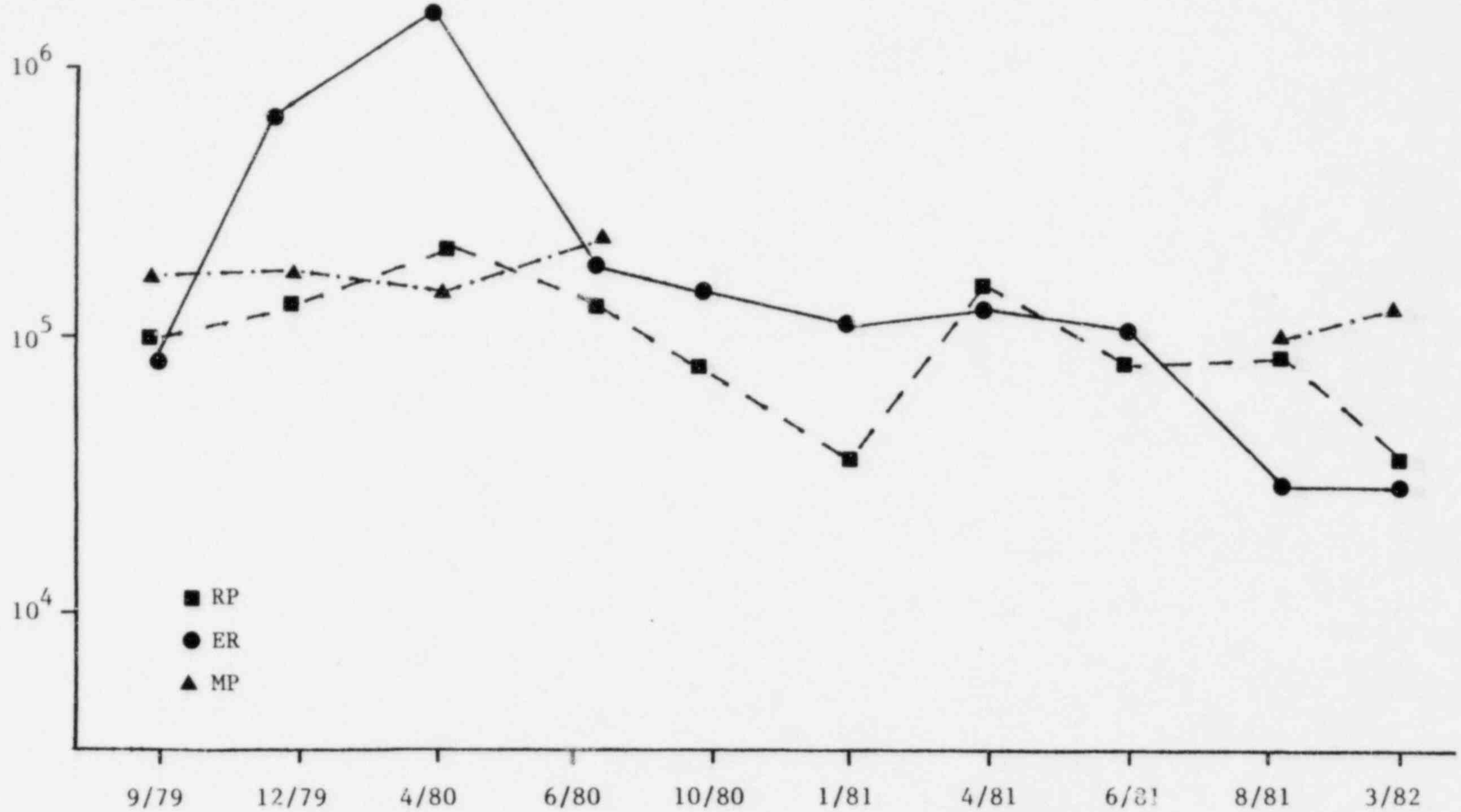

Figure 4. Faunal densities (per m^2) for the period September, 1979 through March, 1982.

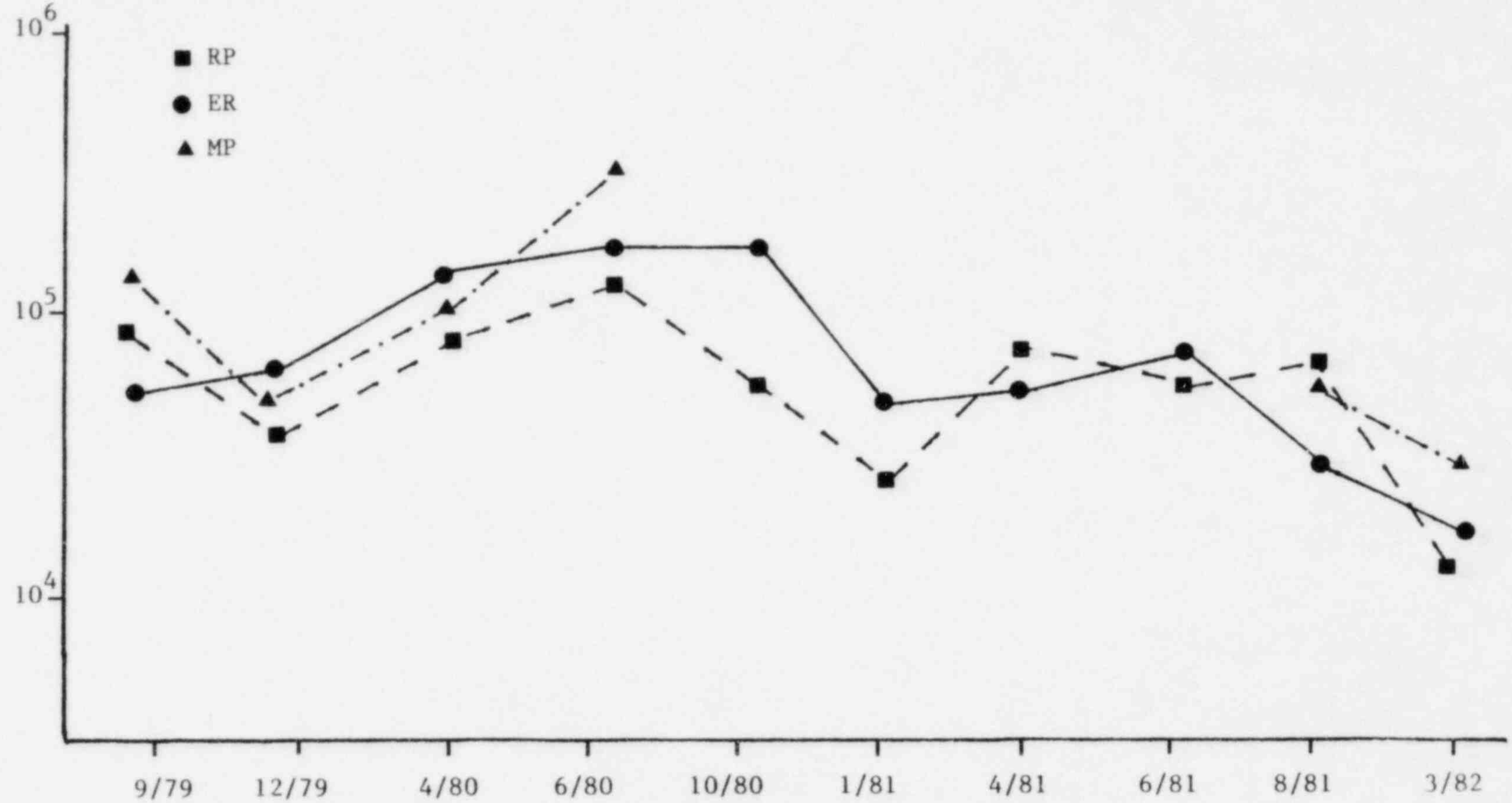

Figure 5. Faunal densities (per m^2) excluding Mytilis edulis for the period September, 1979 through March, 1982.

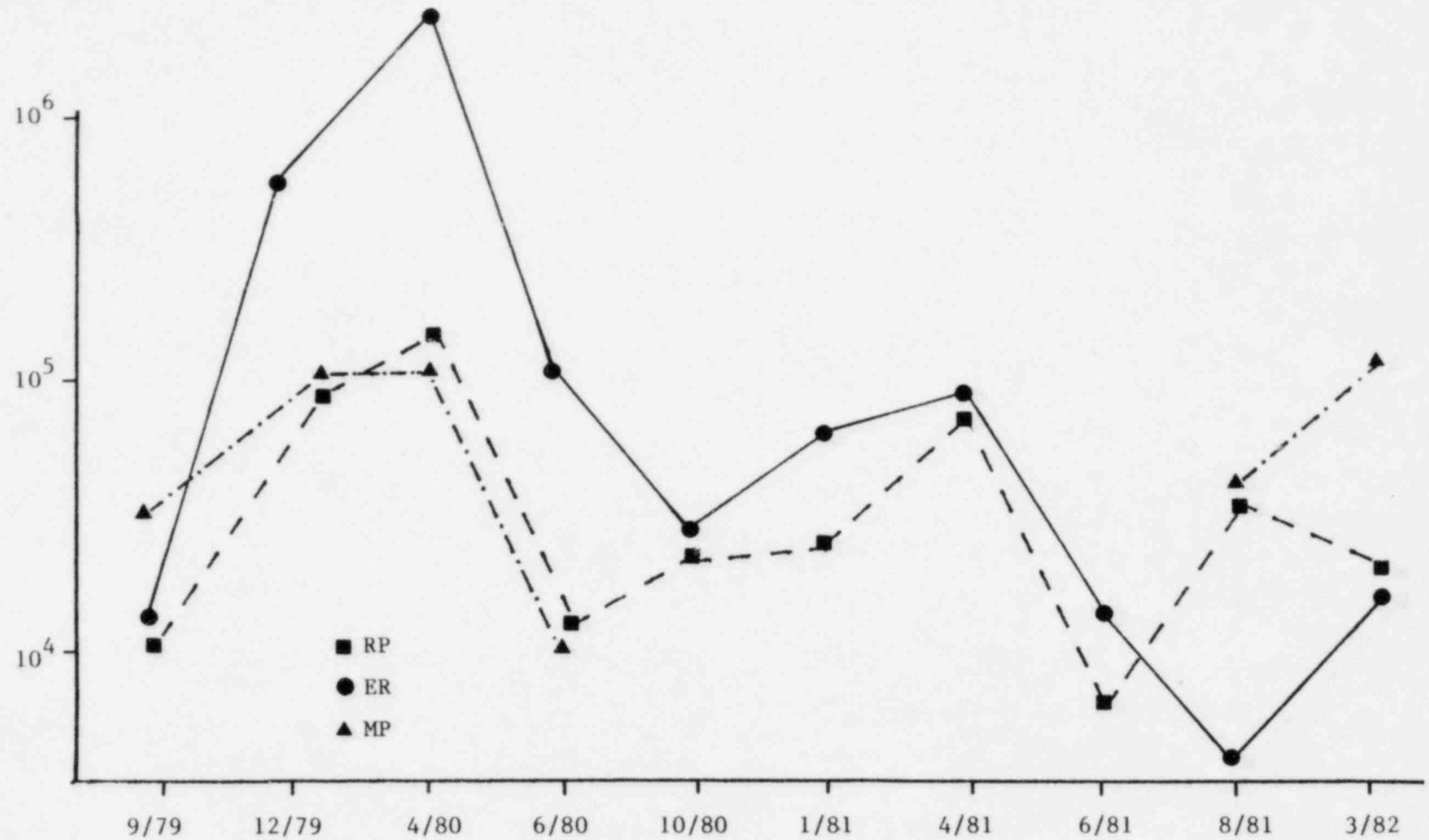

Figure 6. Mytilis edulis densities (per m^2) at rock stations for the period September, 1979 through March, 1982.

among the three sites. Also in all cases in August, the comparisons between the Effluent and the combined controls was significant at $p < .001$ while the comparison between the controls was not significant. These results indicate that during August the Effluent station supported fewer benthic macrofaunal organisms than both Rocky Point and Manomet Point and suggests that the proximity of PNPS is in some way responsible for this effect, most likely through reduction in algal biomass, especially biomass of Chondrus crispus, as was noted in Semi-Annual Report No. 19.

For the March 1982 data an entirely different pattern was evident. For the total numbers of individuals and numbers of mussels, the overall ANOVA was significant at $p < .001$; however, the comparison between the Effluent and the combined controls was not significant. In addition, the overall ANOVA for densities excluding mussels was not significant. Inspection of the data revealed that the differences observed were due to a large settlement of mussels at Manomet Point which apparently did not occur at Rocky Point and Effluent. Because the faunal pattern at the two latter stations was identical, it is clear that this lack of settlement at Effluent is unrelated to operation of PNPS.

4.2.3. Individual Species

Abundances of ten selected benthic species were examined for spatial patterns which might be related to operation of PNPS. The species selected for this analysis were chosen because of their overall abundance and/or importance in indigenous benthic communities in the Plymouth area or because of their potential effectiveness as "indicators" of adverse impact.

For each species, abundances were tested by means of a single-classification ANOVA followed by two a priori comparisons (ER vs. MP + RP, MP vs. RP). The purpose of the analysis was to detect species which had significantly lower densities at Effluent when compared with the combined control stations data and which occur in similar densities at the controls. The assumption is that such a pattern of abundance would be related to PNPS operation. The summarized results of these analyses are presented in Table 2.

The results of this analysis for the August, 1982 data were discussed fully in the Semi-Annual Report No. 19 and indicated that none of the

Table 2: Results of ANOVA on replicate densities of ten individual species; August, 1981 and March, 1982. Calculated statistical probability shown for tests indicating significant differences. ns = not significant.

August, 1981

Species	ANOVA	ER vs. MP + RP	MP vs. RP
Jassa falcata	$p < .01$	ns	$p < .01$[3]
Ischyrocerus anguipes	ns	$.05 < p < .10$[1]	ns
Pleusymtes glaber	$p < .001$	$p < .001$[1]	$p < .001$[3]
Caprella penantis	$p < .01$	$p < .001$[1]	$.05 < p < .10$[4]
Aeginina longicornis	$p < .001$	$p < .001$[1]	$p < .01$[3]
Lacuna vincta	ns	ns	ns
Margarites umbilicalis	$p < .001$	$p < ,001$	$p < .05$[3]
Nereis pelagica	ns	ns	$p = .01$[3]
Capitella capitata	ns	ns	ns
Asterias forbesi	$p < .001$	$p < .001$[2]	$p < .05$[3]

March, 1982

Species	ANOVA	ER vs. MP + RP	MP vs. RP
Jassa falcata	ns	ns	ns
Ischyrocerus anguipes	$p < .001$	$p < .001$[1]	$p < .001$[3]
Pleusymtes glaber	$p < .001$	$p < .001$[1]	$p < .001$[3]
Caprella penantis	$p < .01$	ns	$p < .001$[3]
Aeginina longicornis	ns	ns	$p < .001$[3]
Lacuna vincta	ns	ns	$p < .001$[3]
Margarites umbilicalis	$p < .01$	$p < .001$[1]	$p < .01$[3]
Nereis pelagica	ns	ns	$p < .01$[3]
Capitella capitata	ns	ns	$p < .001$[3]
Asterias forbesi	$p < .05$	$p < .01$[2]	$p < .001$[3]

Notes:

1. Mean density for MP + RP greater than Effluent.
2. Mean density for Effluent greater than MP + RP.
3. Mean density for MP greater than RP.
4. Mean density for RP greater than MP.

selected species exhibited a pattern of abundance which would clearly indicate an effect of PNPS. Four species, however, had patterns which were suggestive of such a conclusion: Pleusymtes glaber, Caprella penantis, Aeginina longicornis and Margarites umbilicalis.

For the March, 1982 data there was again no single species whose pattern of abundance clearly indicated impacts due to PNPS operation. This was apparently related to abnormally high densities of nearly all species at the Manomet Point station. Of the four species which had reduced densities at Effluent in March when compared with the control sites (Ischyrocerus anguipes, Pleusymtes glaber, Margarites umbilicalis and Asterias forbesi) all four also had significant differences in densities between the controls.

Two of the species with this abundance pattern, Margarites and Pleusymtes, have previously been identified as being reduced in abundance at the Effluent. Although the high densities at Manomet Point appear to be responsible for reducing the magnitude of this observation for March, it remains clear that abundances for these species in the Effluent area have been decreased, apparently as a result of PNPS operation.

4.3. Species Dominance

The ten numerically dominant species at each station for the August 1981 sampling are shown in Table 3a. In spite of some differences in the order of dominance among the stations, the overall similarity in dominance structure is evident. Mytilis edulis and Caprella penantis were the most common species at all three sites, followed by a suite of amphipod species. At both the Manomet Point and Rocky Point control sites, the gastropod Margarites umbilicalis and the bivalve Hiatella arctica were highly placed in the species list; these species were not among the dominants at Effluent, and this observation confirms the apparent impact of PNPS on Margarites which has been discussed in previous reports.

The pattern of species dominance was tested for correlation between pairs of stations using Spearman's rho, a rank-correlation coefficient (Sokal and Rohlf, 1969). Despite the superficial similarity among the three rankings, none of the three possible station pairings was found to be significantly correlated. It was noted in Semi-Annual Report No. 19 that this was an unusual result and was probably due only to random

Table 3a. Numerical dominance of faunal species, August 1981.

Station Species	Number	Percent
Manomet Point		
Mytilus edulis	24,570	37.89
Caprella penantis	9,436	14.55
Hiatella arctica	4,184	6.45
Margarites umbilicalis	3,008	4.64
Pleusymtes glaber	2,972	4.58
Jassa falcata	2,916	4.50
Idotea phosphorea	2,010	3.10
Corophium acutum	1,992	3.07
Calliopius laevisculus	1,524	2.35
Dexamine thea	1,364	2.10
Effluent		
Mytilus edulis	5,554	24.64
Caprella penantis	2,596	11.52
Idotea phosphorea	1,716	7.61
Dexamine thea	1,636	7.24
Corophium bonelli	1,176	5.22
Corophium acutum	1,140	5.06
Jassa falcata	1,088	4.8[illegible]
Amphithoe rubricata	976	4.33
Calliopius laevisculus	928	4.12
Hiatella arctica	779	3.46
Rocky Point		
Mytilus edulis	18,416	30.63
Caprella penantis	14,268	23.73
Dexamine thea	6,208	10.33
Margarites umbilicalis	5,140	8.55
Hiatella arctica	2,012	3.35
Corophium bonelli	1,844	3.07
Idotea phosphorea	1,168	1.94
Corophium acutum	1,012	1.68
Amphithoe rubricata	984	1.64
Amphipoda juvenile	932	1.55

variation.

For the March, 1982 data (Table 3b), the pattern of dominance at all three stations was consistent, but notably different in some aspects than the August pattern. Mytilis edulis was again dominant at all three sites but Caprella penantis was markedly less common than in August, generally placing near the middle of the 10 most common species. Jassa falcata was more common in March and Margarites and Hiatella did not appear in any of the rankings.

The March rankings data were tested for correlation in a manner identical to that described for August and all three possible pairings were found to be significantly correlated. This marks a return to the pattern normally seen and indicates that the anomalous pattern in August did not persist between samplings.

4.4. Community Overlap

Within-habitat community overlap was computed from replicate data of each station using Jaccard's Coefficient of Community (Grieg-Smith, 1964). This index is calculated as:

$$CC = \frac{C_{ij}}{A_i + A_j - C_{ij}}$$

where:

C_{ij} = the number of species shared by the two stations,

A_i = the number of species at station i, and

A_j = the number of species at station j.

This index evaluates the similarity of two replicates using the species content only, without regard to the numeric distribution among the species. Species abundances are considered in the classification analysis.

Within-habitat overlap values are shown by replicate for each station in Table 4. For both the August, 1981 and March, 1982 samplings, all three stations had mean replicate overlap of approximately 60%, indicating generally similar environmental homogeneity among the three sites. This value was somewhat low for the area, particularly for a late summer sampling (BECO, 1981), but was not sufficiently low to be considered anomalous.

Table 3b: Numerical dominance of faunal species, March 1982.

Station Species	Number	Percent
Manomet Point		
Mytilis edulis	122,138	73.32
Jassa falcata	11,107	6.67
Corophium acutum	8,742	5.25
Lacuna vincta	6,413	3.85
Caprella penantis	5,987	3.59
Ischyrocerus anguipes	2,593	1.56
Calliopius laevisculus	1,719	1.03
Dexamine thea	1,550	.93
Amphipoda juvenile	1,455	.87
Pontogeneia inermis	786	.47
Effluent		
Mytilis edulis	24,490	37.70
Jassa falcata	15,581	23.85
Lacuna vincta	6,136	9.39
Corophium acutum	5,781	8.85
Calliopius laevisculus	3,556	5.44
Caprella penantis	3,287	5.03
Corophium bonnelli	1,264	1.94
Amphipoda juvenile	1,242	1.90
Dexamine thea	1,212	1.86
Littorina littorea	590	.90
Rocky Point		
Mytilis edulis	27,673	42.17
Calliopius laevisculus	15,184	23.14
Lacuna vincta	4,286	6.53
Corophium acutum	3,387	5.16
Dexamine thea	3,276	4.99
Caprella penantis	2,876	4.38
Jassa falcata	1,792	2.73
Pontogeneia inermis	1,543	2.35
Corophium bonnelli	801	1.22
Onoba aculeus	702	1.07

Table 4: Community overlap (Jaccard's Coefficient of Community) by replicate; August, 1981 and March, 1982.

August, 1981

Replicates	Manomet Point	Rocky Point	Effluent
1-2	68.66%	57.53%	56.67%
1-3	57.14	61.11	57.89
1-4	59.46	55.07	58.57
1-5	57.14	58.54	54.10
2-3	58.67	67.61	67.31
2-4	58.97	59.42	57.97
2-5	59.72	68.35	64.81
3-4	60.26	60.87	55.88
3-5	56.76	63.41	63.46
4-5	55.13	60.26	57.35

March, 1982

Replicates	Manomet Point	Rocky Point	Effluent
1-2	60.78%	49.12%	52.27%
1-3	60.34	62.50	62.75
1-4	59.65	52.00	56.82
1-5	59.32	61.36	46.34
2-3	63.83	54.72	57.45
2-4	63.04	66.07	62.16
2-5	52.94	66.04	70.00
3-4	72.00	52.08	65.22
3-5	61.82	74.36	48.89
4-5	74.00	68.09	65.63

4.5. Species Diversity

Shannon-Wiener diversity (H') and evenness (J') were calculated by replicate for both collections; these values are presented in Table 5.

The Effluent station had significantly higher diversity and evenness values than both Manomet Point and Rocky Point during August. Diversity and evenness were both at their annual maxima with many values near 4.0 and 0.7, respectively, being recorded.

This pattern of diversity values is the reverse of what has usually been seen in the PNPS benthic data; the Effluent station usually has depressed diversity due to differentially greater recruitment of juvenile mussels. Although the poor settlement of mussels at the Effluent in August contributed in part to the observed diversity pattern, it was not sufficient to explain the results, which were essentially the same even when mussels were excluded.

As may be seen from Table 3, the pattern of dominance at Effluent in August is different from either of the control sites in the degree of dominance of the numerically most dense species. At the Effluent, dominance is more evenly distributed; this increase in evenness produces higher diversity values, and thus the observed pattern of greater diversity at the Effluent.

For the March, 1982 data diversities were generally lower throughout the study area. This was due to generally greater dominance by Mytilis with consequently depressed evenness. This was particularly evident at Manomet Point where the dominance by mussels was greatest. Evenness at Manomet Point averaged only .32 and the resulting diversity values were significantly lower than those seen at both Rocky Point and Effluent.

4.6. Classification Analysis

The Woods Hole Oceanographic Institution recently converted its general-purpose scientific computing facility hardware from Xerox Sigma 7 to DEC VAX/11. Virtually all of the programs which we have been using to analyze PNPS data since the initiation of this study are being converted to the new system by WHOI programming personnel. The program we have used in the past to conduct classification analysis (SPSTCL) has not been completely converted to the new system and therefore it was not possible to analyze the August, 1981 and March, 1982 data in R-mode.

Table 5: Information theory diversity values by replicate; August, 1981 and March, 1982.

August, 1981

Replicate	Manomet Point H'	Manomet Point J'	Rocky Point H'	Rocky Point J'	Effluent H'	Effluent J'
1	3.35	0.58	3.42	0.56	3.88	0.70
2	3.84	0.66	3.90	0.66	3.96	0.72
3	2.95	0.50	3.25	0.55	3.87	0.72
4	4.05	0.68	3.32	0.58	4.07	0.68
5	3.36	0.58	3.01	0.48	4.04	0.75

March, 1982

Replicate	Manomet Point H'	Manomet Point J'	Rocky Point H'	Rocky Point J'	Effluent H'	Effluent J'
1	1.93	0.34	3.04	0.60	2.55	0.49
2	1.63	0.32	3.73	0.66	2.09	0.43
3	1.72	0.31	2.32	0.47	2.89	0.53
4	1.80	0.33	2.62	0.49	2.77	0.56
5	1.83	0.33	2.47	0.47	2.88	0.65

The dendrogram shown in Figure 7 was derived from replicate data using the CLUST1 subroutine of SPSTCL. The similarity coefficient used was Bray-Curtis similarity and the clustering algorithm was UPGMA.

Three major divisions are evident in the dendrogram. The first of these includes three replicates from the Effluent site in March. The largest cluster incorporates all samples from August and the final group includes the remainder of the March samples.

Although the pattern evident in the dendrogram is complex, it is obvious that the Effluent site has a tendency to group separately from Manoment Point and Rocky Point. It is also true that the two control sites are separated but apparently to a lesser extent than the Effluent.

In summary, the results of the classification analysis appear to indicate some uniqueness at the Effluent site. This is the typical pattern seen in the historical data, and continues to indicate a small but discernible impact due to PNPS operation.

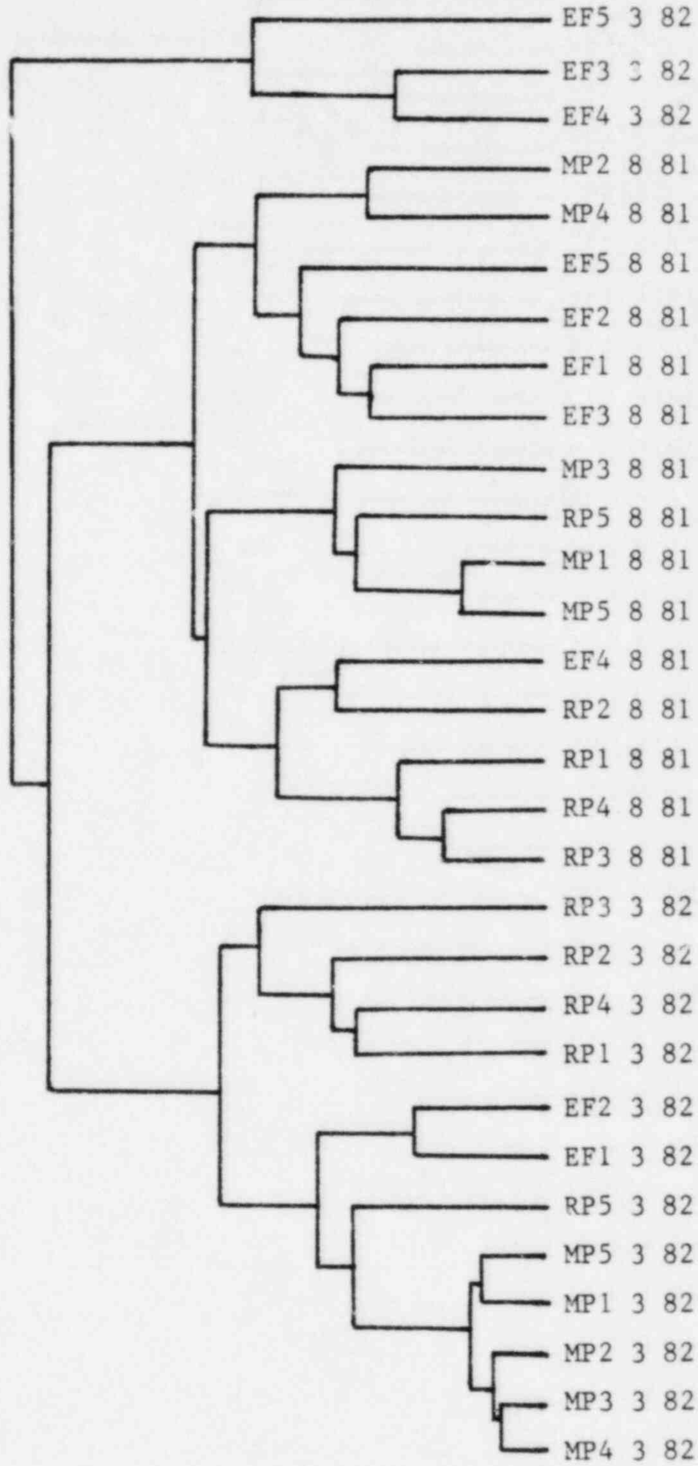

Figure 7: Normal (Q-mode) similarity dendrogram, replicate data for August 1981 and March 1982. Analysis by program BMDP2M, Bray-Curtis similarity coefficient, UPGMA clustering.

5. ALGAE

5.1 Algal Systematics

The cumulative quantitative algal species list presented in BECo Report No. 16 has been retained in the current report. No additions to the cumulative list have been made as a consequence of analysis of the August 1981 and March 1982 quantitative collections. As for all previous collections, species identifications and taxonomic determinations were based primarily upon the combined works of Parke and Dixon (1976), South (1976), and Taylor (1962).

5.2 Algal Community Description

Throughout the Manomet Point, Effluent, and Rocky Point survey areas, the rock and cobble substratum was carpeted with a thick and virtually continuous covering of the macroscopic carrageenoids Chondrus crispus and Phyllophora ssp. Chondrus has historically been found to be dominant in the Rocky Point and Manomet Point survey areas, while the two species have tended to occur in relatively equal population densities within the Effluent survey area. A considerable number of additional benthic macrophytic species were also well represented within the three survey areas. The most notable of this assemblage were Polyides rotundus, Ahnfeltia plicata, Corallina officinalis, Desmarestia aculeata, Chaetomorpha melagonium and Ulva lactuca. While each of these taxa were occasionally observed to form sizeable and well-defined populations, their most common form of occurrence was as either isolated individuals or as weakly-developed populations occurring within the pervasive Chondrus and Phyllophora covering. The epiphytic algal population was composed of a very large number of species, and constituted an important component of the algal community. Chondrus and Phyllophora served as the primary host species for all epiphytic populations. Epiphytic species were prevalent throughout the year, but attained their maximal development during the summer and early autumn months. The dominant summer and autumn epiphytes include Spermothamnion repens, Polysiphonia spp., Cystoclonium purpureum, and Ceramium rubrum; the primary winter and spring epiphytes include Rhodomela confervoides, Callophyllis cristata, Membranoptera alata, and Phycodrys rubens. Representatives of the brown algal kelp species Laminaria saccharina and Laminaria digitata were found to occur throughout the study area. The kelps were the most conspicuous components of the algal community, and occurred as solitary individuals or in large clusters of up to one dozen plants. The crustose algal community was composed of an extremely large and diverse assemblage of fleshy and calcareous species, and was dominated by Hildenbrandia rubra, Ralfsia spp., and Phymatolithon spp.

5.3 Algal Community Overlap

Community overlap analyses were performed, using Jaccard's Coefficient of Community (Greig-Smith, 1964) to quantitatively measure the extent of similarity in algal species composition between the Rocky Point, Effluent, and Manomet Point stations. The Greig-Smith model provides a mathematical evaluation of the similarity of two stations or replicates using only the species content, and without reference to any differences in the abundance of the species involved. The species occurrence records of 38 carefully selected indicator species served as the elemental data for all community overlap operations. The specific criteria employed in the selection of the indicator species have been described in the Methods section of this report.

Three separate classes of community overlap comparisons have been performed. First, community overlap between the five replicate samples of each station was determined in order to provide a relative measure of the spatial distribution of the algal species occurring at each site. Second, community overlap between the Manomet Point, Effluent, and Rocky Point replicate samples was determined in order to provide a direct measure of the degree of similarity in algal species composition between the three stations. Third, community overlap between the current and previous years' species occurrence records was determined in order to provide a measure of the temporal stability of the algal population at each station.

The results of community overlap comparisons between replicate samples of the same station for the August 1981 and March 1982 collecting periods are presented in Table 6a. An examination of the table shows that the range of replicate overlap values for the three stations was similar in both scope and magnitude; overlap generally ranged from 65 - 85% at all stations for both collecting periods. Further examination of Table 6a reveals that the calculated $\overline{X}$ replicate overlap value for the three stations showed a close degree of correspondence; the respective $\overline{X}$ values for Manomet Point, Rocky Point, and Effluent were 74.8, 78.6, and

Table 6. Algal community overlap a) between replicates, and b) between stations for August 1981 and March 1982 at the Manomet Point, Rocky Point, and Effluent subtidal (10' MLW) stations.

a) overlap between replicates

	Manomet Point		Rocky Point		Effluent	
Replicate pair	August	March	August	March	August	March
1-2	84.0%	69.2%	71.4%	63.3%	71.4%	57.1%
1-3	74.1%	75.0%	76.9%	78.6%	73.1%	61.5%
1-4	76.9%	70.4%	72.0%	70.4%	74.1%	55.6%
1-5	69.2%	66.7%	74.1%	84.6%	73.1%	62.5%
2-3	81.5%	67.9%	92.6%	63.3%	75.0%	54.8%
2-4	71.4%	63.0%	75.0%	73.1%	75.9%	50.0%
2-5	64.3%	79.2%	89.3%	67.9%	69.0%	60.7%
3-4	75.0%	75.0%	74.1%	64.3%	71.4%	64.3%
3-5	67.9%	65.5%	88.9%	77.8%	76.9%	59.3%
4-5	84.0%	66.7%	71.4%	69.2%	71.4%	59.3%
$\overline{X}$	74.8%	69.9%	78.6%	71.2%	73.1%	58.5%

b) overlap between stations

	Number of shared species		Community overlap	
Station pair	August	March	August	March
Manomet Point-Rocky Point	29	30	96.7%	88.2%
Manomet Point-Effluent	29	31	93.6%	88.6%
Rocky Point-Effluent	29	31	96.7%	88.6%

73.1% in August, and 69.9, 71.2, and 58.5% in March. The uniformly lower March values suggest that the algal population comprising each station was more sparsely distributed in that month. The above data indicate that the species comprising each station were not uniformly distributed throughout the five replicates, but exhibited a moderate degree of variation. However, the similar ranges and means of replicate overlap values shown by the three stations indicates that the algal species composition of each was similarly spatially distributed.

Direct community overlap comparisons between the three stations were based upon the combined species occurrence records of the five replicate samples taken at each station; a species was designated as occurring at a station if it was recorded from at least one of the station's replicates. Table 6b presents the results of overlap comparisons between the three stations for August 1981 and March 1982. The table shows that, for all station pairs, community overlap was higher in August (93.1 - 96.7%) than in March (88.2 - 88.6%). This indicates that the resident algal population was more uniformly distributed throughout the survey area in August. The table also shows that overlap values generated by control station pairings were not substantively different from those generated by the pairing of the experimental (Effluent) station with either control. The results indicate that species composition at the three stations was highly similar.

Short-term fluctuations in the species composition of each station were assessed by computing community overlap between the August 1981 and March 1982 species occurrence data. The results are presented in Table 7, and show that overlap values of 93.8, 84.4, and 88.7% were recorded for Manomet Point, Rocky Point, and Effluent respectively. All values are high, indicating that the species composition of each station has remained relatively stable for the August 1981 through March 1982 period.

Intermediate to long-term fluctuations in the species composition of each station were assessed by determining community overlap between current (August 1981 and March 1982) species occurrence data and those for the corresponding periods of the two preceding years. As was the case in comparisons measuring short-term fluctuations, each station served as its own control. Results are presented in Table 8, and show that overlap throughout the 1978 - 1982 period ranged from approximately 75 to 90% for all three stations. The results also show that Effluent overlap values were

Table 7 . Algal community overlap between the August 1981 and March 1982 collecting periods for the Manomet Point, Rocky Point, and Effluent subtidal (10' MLW) stations.

Station	Number of shared species	Community overlap
Manomet Point	30	93.8%
Rocky Point	28	84.8%
Effluent	30	88.7%

Table 8 . Algal community overlap between current (August 1981 and March 1982) and previous collecting periods for the Manomet Point, Rocky Point, and Effluent subtidal (10' MLW) stations.

Station Period of comparison	Number of shared species	Community overlap
Manomet Point		
August 1981-August 1979	24	80.0%
August 1981-August 1978	23	76.7%
August 1979-August 1978	21	80.8%
March 1982-March 1980	24	75.0%
March 1982-March 1979	24	75.0%
March 1980-March 1979	23	92.0%
Rocky Point		
August 1981-August 1980	27	90.0%
August 1981-August 1979	24	82.8%
August 1980-August 1979	24	85.7%
March 1982-March 1981	25	75.8%
March 1982-March 1980	24	75.0%
March 1981-March 1980	22	78.6%
Effluent		
August 1981-August 1980	27	81.8%
August 1981-August 1979	29	93.5%
August 1980-August 1979	30	93.5%
March 1982-March 1981	28	82.4%
March 1982-March 1980	27	79.4%
March 1981-March 1980	24	77.4%

not substantively different from control station values. The data indicate that all stations evidenced a similar degree of stability and temporal continuity in species composition throughout the three-year period.

An examination of the species occurrence records for August 1981 and March 1982 (Appendices 3 and 4) discloses that the green alga Bryopsis plumosa and the red alga Gracilaria foliifera were recorded only from the Effluent station. Bryopsis was encountered in two Effluent replicates in March; its level of occurrence was rare in each case. Gracilaria was recorded from all five Effluent replicates in August, and from three replicates in March; its level of occurrence ranged from rare to occasional. Both species typically occur in abundance south of Cape Cod; north of the Cape, their occurrence is limited to shallow bays and estuaries, and then only during the warmer summer and autumn months (Taylor, 1962). Both taxa have, in the past, been collected regularly and in abundance within the heated confines of the discharge jetties. Beyond the mouth of the jetties, they have also been intermittantly recorded at the Effluent intertidal, five foot, and ten foot collection sites. No occurrence has ever been recorded at either the Rocky Point or Manomet Point control stations. The continued presence of both taxa at the Effluent ten foot station in interpreted as a direct consequence of Pilgrim I thermal discharge.

5.4 Algal Biomass

Algal biomass data were obtained for the Manomet Point, Rocky Point, and Effluent stations for August 1981 and March 1982. Separate biomass determinations have been made for the benthic (Chondrus crispus, Phyllophora spp., and the remaining benthic species) and epiphytic (epiphytes of Chondrus and epiphytes of Phyllophora) algal fractions. Total algal biomass was also determined for each station.

5.4.1 Chondrus crispus biomass

Chondrus crispus biomass data for the Manomet Point, Rocky Point, and Effluent stations are presented in Tables 9 and 10 for the respective August 1981 and March 1982 collecting periods. The tables show the mean ($\bar{x}$) biomass value for each station as well as the individual values for the five replicates taken at each station.

The tables show that all three stations evidenced highest Chondrus biomass levels in August, with appreciably lower levels recorded in March.

Table 9 . Dry weight biomass values (g/m^2) for Chondrus crispus, Phyllophora spp., the remaining benthic species, total epiphytic biomass, and total algal biomass for the Manomet Point, Rocky Point, and Effluent subtidal (10' MLW) stations for August 1981.

Station/ replicate	Chondrus crispus	Phyllophora spp.	Remaining benthic species	Epiphytic species	Total algal biomass
Manomet Point					
1	786.1 (85%)	114.5 (12%)	24.7 (3%)	44.2	969.4
2	618.4 (79%)	147.7 (19%)	19.8 (2%)	53.7	839.6
3	505.7 (66%)	164.2 (21%)	102.3 (13%)	72.0	844.2
4	421.3 (70%)	141.7 (23%)	43.1 (7%)	93.9	700.0
5	399.8 (66%)	170.9 (28%)	33.3 (6%)	83.3	687.3
$\overline{X}$	546.3 (74%)	147.8 (20%)	44.6 (6%)	69.5	808.2
Rocky Point					
1	73.9 (48%)	28.1 (18%)	53.5 (34%)	149.6	305.1
2	404.4 (70%)	58.7 (10%)	117.9 (20%)	77.6	658.5
3	510.7 (84%)	60.2 (10%)	35.5 (6%)	88.5	694.9
4	342.4 (74%)	61.6 (13%)	61.6 (13%)	67.7	533.3
5	418.7 (67%)	142.1 (23%)	61.6 (10%)	102.2	724.1
$\overline{X}$	350.0 (70%)	70.1 (14%)	65.9 (14%)	97.1	583.1
Effluent					
1	394.6 (68%)	183.6 (31%)	4.8 (1%)	27.6	610.6
2	119.4 (36%)	188.9 (56%)	26.5 (8%)	77.9	412.7
3	217.7 (45%)	222.6 (46%)	42.8 (9%)	41.8	524.9
4	155.4 (42%)	148.7 (41%)	63.3 (17%)	100.4	467.8
5	82.6 (26%)	178.1 (56%)	58.0 (18%)	82.8	401.5
$\overline{X}$	193.9 (47%)	184.4 (44%)	39.1 (9%)	66.1	483.5

Table 10. Dry weight biomass values (g/m^2) for Chondrus crispus, Phyllophora ssp., the remaining benthic species, total epiphytic biomass, and total algal biomass for the Manomet Point, Rocky Point, and Effluent subtidal (10' MLW) stations for March 1982.

Station replicate	Chondrus crispus	Phyllophora spp.	Remaining benthic species	Epiphytic species	Total algal biomass
Manomet Point					
1	345.4 (65%)	163.3 (31%)	21.7 (4%)	56.9	587.3
2	182.7 (46%)	151.4 (39%)	60.5 (15%)	88.8	483.4
3	123.4 (38%)	162.7 (49%)	43.6 (13%)	70.0	399.7
4	414.7 (66%)	210.8 (33%)	6.6 (1%)	66.7	698.8
5	292.7 (64%)	141.1 (31%)	24.7 (5%)	59.4	517.9
$\bar{X}$	271.8 (58%)	165.9 (35%)	31.3 (7%)	68.4	537.4
Rocky Point					
1	156.5 (36%)	200.2 (46%)	78.5 (18%)	34.7	469.9
2	247.5 (48%)	149.3 (29%)	120.8 (23%)	9.9	527.5
3	10.1 (4%)	88.4 (31%)	181.3 (65%)	37.8	317.6
4	14.0 (5%)	101.8 (39%)	147.4 (56%)	76.3	339.5
5	23.9 (7%)	166.5 (52%)	130.7 (41%)	4.7	325.8
$\bar{X}$	90.4 (25%)	141.2 (39%)	131.7 (36%)	32.7	396.1
Effluent					
1	100.3 (24%)	137.9 (32%)	187.2 (44%)	2.0	427.4
2	200.9 (56%)	71.8 (20%)	87.5 (24%)	0.8	361.0
3	24.1 (11%)	143.5 (68%)	45.1 (21%)	9.7	222.4
4	1.2 (1%)	154.3 (83%)	31.1 (16%)	19.2	205.8
5	32.9 (13%)	136.3 (51%)	96.3 (36%)	6.9	272.4
$\bar{X}$	71.9 (25%)	128.8 (44%)	89.4 (31%)	7.7	297.8

The decline in biomass between the two periods was 74.2% for Rocky Point, 52.7% for Effluent, and 50.2% for Manomet Point. This biomass pattern has also been seen in the data of previous years' collections, and reflects the normal seasonal growth cycle of Chondrus. Chondrus germination and growth rates are highest from late spring to early autumn (Taylor), and typically result in an increase in the population during the summer months; conversely, markedly reduced winter germination and growth rates, coupled with a high incidence of adult and juvenile plant mortality as a consequence of harsh winter storms, typically results in a reduction in the Chondrus population from the late autumn to early spring months.

Further examination of Tables 9 and 10 reveals that, for both the August and March collecting periods, the Effluent station produced the lowest Chondrus biomass, while Manomet Point produced the highest, and Rocky Point produced intermediate-level values. The $\bar{x}$ Effluent biomass value for August (193.9 g/m^2) was 35.9% lower than the corresponding Rocky Point value (350.0 g/m^2), and 64.5% lower than the Manomet Point value (546.3 g/m^2); similarly, the March Effluent $\bar{x}$ value (71.9 g/m^2) was 20.5% lower than the Rocky Point value (90.4 g/m^2), and 73.5% lower than the Manomet Point value (271.8 g/m^2). An examination of the individual replicates for the two periods also clearly illustrates the biomass differences between the three stations. For August, the range of replicate biomass values shown by Effluent (82.6 - 394.6 g/m^2) was appreciably lower than the ranges shown by both the Rocky Point (73.9 - 510.7 g/m^2) and Manomet Point (399.8 - 786.1 g/m^2) control stations; the range of Effluent replicate biomass in March (1.2 - 200.9 g/m^2) was again lower than the ranges shown by Rocky Point (10.1 - 247.5 g/m^2) and Manomet Point (123.4 - 414.7 g/m^2). Tables 9 and 10 also show that Chondrus constituted a lower percentage of total station biomass at Effluent than at the two control stations. For August, Manomet Point and Rocky Point Chondrus comprised 74% and 70% of total biomass respectively, while the corresponding Effluent value was only 46%; the March Manomet Point value of 58% was appreciably higher than the 25% value shown by both Rocky Point and Effluent. A comparison of the ratio of Chondrus to Phyllophora (Phyllophora is Chondrus' principle competitor for available substrate at all stations) biomass at the three sites provides further indication of reduced Effluent Chondrus biomass. For August, Manomet Point and Rocky

Point displayed Chondrus/Phyllophora ratios of 5.0/1 and 3.7/1 respectively, while Effluent showed a considerably divergent ratio of 1.1/1; for March, the Effluent ratio of 0.5/1 was likewise lower than the 0.6/1 and 1.6/1 ratios shown by Rocky Point and Manomet Point respectively.

One-way analysis of variance (ANOVA) statistical treatment was applied to the replicate sample data of the August 1981 and March 1982 collections to test for significant differences in Chondrus biomass between the three stations. Separate ANOVA operations were performed on the August, March, and combined August/March data. Results are included in Table 11a-c, and show that biomass differences between stations were significantly different for each of the August (d.f. = 2/12, f = 6.883, $p < .05$), March (d.f. = 2/12, f = 5.720, $p < .05$), and combined August/March (d.f. = 2/27, f = 6.773, $p < .01$) comparison periods. A priori comparison of means (Sokal and Rohlf, 1969) showed that Effluent biomass was significantly lower than control station biomass only for the August (d.f. = 1/12, f = 9.51, $p < .05$) and combined August/March (d.f. = 1/27, f = 7.480, $p < .05$) periods. Although March Effluent biomass was also lower than that of either control station, an inspection of Table 10 suggests that the particularly high biomass recorded for Manomet Point was responsible for conferring ANOVA significance for that period. One-way ANOVA treatment was also applied to the composite replicate data of October 1975 through March 1982. Results are included in Table 12, and show that biomass differences between the three stations were statistically significant (d.f. = 2/282, f = 21.203, $p < .01$). A priori comparison of means showed Effluent biomass to be statistically lower than that of either control station (d.f. = 1/282, f = 41.541, $p < .01$). Current findings are in agreement with those reported for previous years' samplings. Effluent Chondrus biomass was previously found to be significantly lower than control station biomass for the October 1979 through June 1980 (BECo Report No. 16), September 1978 through June 1979 (BECo Report No. 14), and June 1977 through April 1978 (BECo Report No. 12) collecting and reporting periods.

Current (August 1981 and March 1982) biomass data were statistically compared with those of one year earlier in order to examine the short-term temporal stability of the Chondrus population at each station (for Manomet Point, current data were compared with those of two years earlier). ANOVA results are included in Table 13, and show that Chondrus biomass differ-

Table 11. Results of one-way analysis of variance (ANOVA) statistical treatment for location effects on <u>Chondrus crispus</u>, <u>Phyllophora</u> spp., the remaining benthic species, epiphytes of <u>Chondrus</u>, epiphytes of <u>Phyllophora</u>, and total algal biomass for the a) August 1981, b) March 1982, and c) combined August 1981 and March 1982 collections.

a) August 1981

biomass category	d.f.	f-value	level of significance
Chondrus crispus	2/12	6.883	$p<.05$
Phyllophora spp.	2/12	17.025	$p<.01$
Remaining benthic species	2/12	1.151	not significant
Epiphytes of Chondrus	2/12	2.284	not significant
Epiphytes of Phyllophora	2/12	1.102	not significant
Total algal biomass	2/12	8.176	$p<.01$

b) March 1982

biomass category			
Chondrus crispus	2/12	5.720	$p<.05$
Phyllophora spp.	2/12	1.363	not significant
Remaining benthic species	2/12	6.772	$p<.05$
Epiphytes of Chondrus	2/12	1.768	not significant
Epiphytes of Phyllophora	2/12	3.467	not significant
Total algal biomass	2/12	7.077	$p<.01$

c) August 1981 and March 1982 combined

biomass category			
Chondrus crispus	2/27	6.773	$p<.01$
Phyllophora spp.	2/27	4.827	$p<.05$
Remaining benthic species	2/27	4.947	$p<.05$
Epiphytes of Chondrus	2/27	4.245	$p<.05$
Epiphytes of Phyllophora	2/27	1.295	not significant
Total algal biomass	2/27	8.094	$p<.01$

Table 12. Results of one-way analysis of variance (ANOVA) statistical treatment for location effects on Chondrus crispus, Phyllophora spp., the remaining benthic species, epiphytes of Chondrus, epiphytes of Phyllophora, and total algal biomass for the composite collections of October 1975 through March 1982.

Biomass category	d.f.	f-value	level of significance
Chondrus crispus	2/282	21.203	p<.01
Phyllophora spp.	2/282	14.431	p<.01
Remaining benthic species*	2/111	3.316	p<.05
Epiphytes of Chondrus*	2/111	5.281	p<.01
Epiphytes of Phyllophora*	2/111	1.049	not significant
Total algal biomass	2/282	4.917	p<.01

* Data available only from September 1979 to the present.

Table 13. Results of one-way analysis of variance (ANOVA) statistical treatment for short-term period effects (August 1981 and March 1982 vs. August 1980 and March 1981) on Chondrus crispus, Phyllophora spp., the remaining benthic species, epiphytes of Chondrus, epiphytes of Phyllophora, and total algal biomass for the Manomet Point, Rocky Point, and Effluent stations.

	d.f.	f-value	level of significance
Chondrus crispus			
Manomet Point*	1/14	0.045	not significant
Rocky Point	1/20	1.712	not significant
Effluent	1/20	2.647	not significant
Phyllophora spp.			
Manomet Point*	1/14	1.779	not significant
Rocky Point	1/20	0.072	not significant
Effluent	1/20	0.978	not significant
Remaining Benthic Species			
Manomet Point*	1/14	0.012	not significant
Rocky Point	1/20	0.173	not significant
Effluent	1/20	2.539	not significant
Epiphytes of Chondrus			
Manomet Point*	1/14	0.347	not significant
Rocky Point	1/20	0.002	not significant
Effluent	1/20	9.566	$p<.01$
Epiphytes of Phyllophora			
Manomet Point*	1/14	8.415	$p<.05$
Rocky Point	1/20	0.003	not significant
Effluent	1/20	28.423	$p<.01$
Total Algal Biomass			
Manomet Point*	1/14	0.215	not significant
Rocky Point	1/20	3.049	not significant
Effluent	1/20	6.800	$p<.05$

* Current (August 1981 and March 1982) Manomet Point data are compared with the data of August 1979 and March 1980.

ences between the two yearly periods were not significant for any station. Despite the absence of statistically significant differences, all stations showed decreases in biomass over the two yearly periods (Table 14). The $\bar{x}$ Effluent value for the current year's collections (132.9 g/m^2) represents a modest 39.8% decline from the previous year's level (220.9 g/m^2); the current year's Rocky Point value (220.2 g/m^2) represents a decline of 35.3% from the previous year's level (340.2 g/m^2); the current year's Manomet Point value (409.0 g/m^2) represents a slight 4.3% decline from the previous year's level (427.3 g/m^2). Biomass differences between the two yearly periods are not considered to be extreme for any station, and are typical of the magnitude of change which has traditionally been seen whenever the collections of successive years have been compared.

It is hypothesized that a heightened degree of sand and sediment scouring at the Effluent station is primarily responsible for the significantly lower Chondrus biomass values which have been reported for both current (August 1981 and March 1982) and composite (October 1975 through March 1982) data. The Effluent station substratum is composed of a considerably greater percentage of sand and sediments than are the Manomet Point and Rocky Point control stations. Although the greater part of the sand is considered to be naturally occurring, it is likely that some sediment deposition occurs as a result of the PNPS Unit I discharge current. The force of the discharge current is also presumed to intensify scouring at the Effluent station. The principle effects of scouring are an inhibition of algal germination and abrasion-induced dislodgement of juvenile and mature plants (Newroth, 1970). Chondrus is a relatively delicate plant, and is considered to be particularly susceptible to the effects of scouring (Prince, 1971). PNPS thermal perturbation is not judged to be a contributing factor to the lower Effluent biomass.

5.4.2 Phyllophora spp. biomass

Phyllophora spp. biomass values for the Manomet Point, Rocky Point, and Effluent stations are presented in Tables 9 and 10 for the August 1981 and March 1982 collecting periods respectively.

The tables show that the three stations displayed markedly dissimilar Phyllophora biomass patterns over the August to March collecting periods. Effluent and Manomet Point showed relatively high biomass in August;

Table 14. Dry weight biomass values (g/m^2) for Chondrus crispus, Phyllophora spp., the remaining benthic species, epiphytes of Chondrus, epiphytes of Phyllophora, and total algal biomass for the current (August 1981 and March 1982) and previous year's (August 1980 and March 1981) collections.

	previous year's collections	current year's collections	% change
Chondrus crispus			
Manomet Point*	427.3	409.0	- 4.3%
Rocky Point	340.2	220.2	- 35.3%
Effluent	220.9	132.9	- 39.8%
Phyllophora spp.			
Manomet Point*	129.8	156.8	+ 20.8%
Rocky Point	112.0	105.7	- 5.6%
Effluent	141.4	156.7	+ 10.8%
Remaining Benthic Species			
Manomet Point*	36.3	38.0	+ 4.7%
Rocky Point	84.9	98.8	+ 16.4%
Effluent	34.9	64.3	+ 84.2%
Epiphytes of Chondrus#			
Manomet Point*	0.077	0.067	- 13.0%
Rocky Point	0.244	0.239	- 2.0%
Effluent	0.154	0.043	- 72.1%
Epiphytes of Phyllophora#			
Manomet Point*	0.558	0.273	- 51.1%
Rocky Point	0.562	0.547	- 2.7%
Effluent	0.188	0.831	+342.0%
Total Algal Biomass			
Manomet Point*	708.2	672.7	- 5.0%
Rocky Point	628.0	489.6	- 22.0%
Effluent	547.0	390.8	- 28.6%

* Current (August 1981 and March 1982) Manoment Point data are compared with the data of August 1979 and March 1980.

\# Values indicate grams of epiphyte per gram of host species.

Manomet Point then displayed a moderate 12.2% biomass increase in March, while Effluent showed a moderate 30.2% decline over the same period. Rocky Point, in contrast, displayed low biomass in August, but showed a dramatic 101.4% increase in March. The absence of a singular uniform seasonal biomass pattern among the three stations is not unusual. In previous years, Phyllophora biomass has demonstrated a tendancy to increase during the winter months. However, the pattern has only irregularly been recorded, and has rarely been observed to occur simultaneously at all stations.

Tables 9 and 10 also show that no single station consistently produced either the highest or lowest Phyllophora biomass for the two collecting periods. For the August collecting period, Effluent produced the highest biomass values, while Rocky Point produced the lowest, and Manomet Point produced intermediate-level values; for March, Manomet Point produced the highest biomass, Effluent the lowest, and Rocky Point an intermediate-level value. The August $\bar{x}$ biomass value for Effluent (184.4 g/m^2) was 24.8% greater than the corresponding Manomet Point value (147.8 g/m^2), and 163.1% greater than the Rocky Point value (70.1 g/m^2); the March Manomet Point $\bar{x}$ value (165.9 g/m^2) was 17.3% higher than the Rocky Point value (141.2 g/m^2), and 28.8% higher than the Effluent value (128.8 g/m^2). An examination of replicate biomass values for the two collecting periods further underscores the differences between the three stations. The range of Effluent replicate biomass for August (148.7 - 222.6 g/m^2) was moderately higher than the range shown by Manomet Point (114.5 - 170.9 g/m^2), and appreciably higher than the range shown by Rocky Point (28.1 - 142.1 g/m^2); for March, the range of Phyllophora replicate biomass values shown by Manomet Point (141.1 - 210.8 g/m^2) was moderately higher than the range shown by Rocky Point (88.4 - 200.2 g/m^2), and substantially higher than the range shown by Effluent (71.8 - 154.3 g/m^2). Inspection of Tables 9 and 10 also shows that, for both the August and March collecting periods, Phyllophora biomass comprised a higher percentage of total station biomass at Effluent than at the two control stations. For August, Effluent Phyllophora comprised 44% of total station biomass, while Manomet Point and Rocky Point showed lower values of 20% and 14% respectively; similarly, for March, the 44% Effluent value was higher than the 39% and 35% values shown by Rocky Point and Manomet Point respectively. The relatively high Effluent value for March is attributed primarily to the particularly low Chondrus biomass recorded in that same period.

One-way ANOVA statistical treatment was applied separately to the August, March, and combined August/March replicate biomass data to test for significant Phyllophora biomass differences between stations. The results are included in Table 11a-c, and show that biomass differences between stations were statistically significant only for the August (d.f. = 2/12, f = 17.025, $p < .01$) and combined August/March (d.f. = 2/27, f = 4.827, $p < .05$) comparison periods. A priori comparison of means showed that Effluent biomass was statistically higher than control station biomass only in the August (d.f. = 1/12, f = 19.031, $p < .01$) period. For the combined August/March periods, an examination of Tables 9 and 10 indicates that relatively low Rocky Point biomass, particularly in August, was responsible for conferring ANOVA significance. One-way ANOVA treatment was also applied to the composite replicate data of October 1975 through March 1982. Results are included in Table 12, and show that Phyllophora biomass differences between the three stations were significantly different (d.f. = 2/282, f = 14.431, $p < .01$). A priori comparison of means showed Effluent biomass to be statistically higher (d.f. = 1/282, f = 12.764, $p < .01$) than that of either control station. Current results are only in partial agreement with those which have been reported for previous years' samplings. In the past, Effluent has consistently displayed higher Phyllophora biomass that the two control stations. Effluent biomass was previously found to be significantly higher than that of control stations for the August 1980 through June 1981 (BECo Report No. 18) and the June 1977 through April 1978 (BECo Report No. 12) collecting and reporting periods. Effluent Phyllophora biomass was also higher than control station biomass for the June 1978 through June 1979 (BECo Report No. 14) and the September 1979 through June 1980 (BECo Report No. 16) periods, although the differences were not significant.

Current (August 1981 and March 1982) Phyllophora biomass data were statistically compared with those of one year earlier in order to examine the temporal stability of the population at each station. ANOVA treatment results are included in Table 13, and show that differences between the current and previous year's biomass levels were not significant for any station. The results indicate that the Phyllophora population at each station has remained relatively stable over the two year period. Despite the overall continuity, moderate fluctuations in biomass were observed for all stations . The $\bar{x}$ Manomet Point value for the current year's collections (156.8 g/m^2) represents a 20.8% increase from the previous year's level (129.8 g/m^2); the current year's Effluent value (156.7 g/m^2) is 10.8% greater than the value recorded for the previous year (141.1 g/m^2); and, the current year's Rocky Point value (105.7 g/m^2) represents a slight 5.6% decline from the previous year's level (112.0 g/m^2).

Physical attributes of the PNPS discharge plume, together with the unique substratum characteristics of the Effluent station, are believed to be responsible for the higher Effluent Phyllophora biomass levels. The Effluent station substratum is composed of a greater amount of coarse sand, sediments and silt than the Rocky Point and Manomet Point control stations, with some sediment deposition probably occurring as a consequence of the discharge plume. The presence of sand and sediments is known to fascilitate abrasion of algal holdfasts (Newroth, 1970). Phyllophora, due to its coarse morphological structure, is believed to be minimally affected by abrasion, and is thought to outcompete other benthic species (particularly Chondrus) in substrate areas containing large amounts of sand. Prince (1971) has also observed that Phyllophora will dominate the subtidal algal community in sand-substrate environments.

5.4.3 Biomass of the remaining benthic species

Biomass values for the category "remaining benthic species" are presented in Tables 9 and 10 for the respective August 1981 and March 1982 collecting periods. The category is comprised of all benthic taxa exclusive of Chondrus crispus, Phyllophora spp., and Laminaria spp. For all stations and collecting periods, the category was dominanted by Corallina officinalis, Polyides rotundus, Desmarestia aculeata, Ahnfeltia plicata, Chaetomorpha linum, Chaetormorpha melagonium, and Ulva lactuca.

Tables 9 and 10 show that the three stations did not evidence a common seasonal biomass pattern for the August and March periods. Manomet Point and Rocky Point showed relatively high biomass in August; Manomet Point then showed a moderate 30.3% decline in March, while Rocky Point showed an abrupt 99.8% increase. Effluent displayed low biomass in August, but showed a precipitous 128.6% increase in March. The absence of a shared seasonal biomass pattern at the three stations is not considered to be unusual. In previous years, remaining benthic species biomass values have been characterized by erratic fluctuations throughout the year, with very little indication of any underlying seasonal pattern, and with very little conformity among stations.

The tables also show that, with few exceptions, remaining benthic species biomass was lower than both Chondrus and Phyllophora biomass for all stations and collecting periods. The data further show that, for both collecting periods, remaining benthic species biomass differences between the three stations were less excessive than those which have been observed for Chondrus and Phyllophora. Highest remaining benthic species biomass in both the August and March collections was shown by Rocky Point; Effluent showed the lowest biomass in August, while Manomet Point showed the lowest in March. The August $\bar{x}$ biomass value for Rocky Point (65.9 g/m^2) was 55.8% greater than the Manomet Point value (44.6 g/m^2), and 68.5% greater than the Effluent value (39.1 g/m^2). The March Rocky Point value (131.7 g/m^2) was 47.3% higher than the Effluent value (89.4 g/m^2), and 32.5% higher than the Manomet Point value (31.1 g/m^2). The range of Rocky Point replicate biomass values were likewise greater than those of both Manomet Point and Effluent for both collecting periods. The range of Rocky Point replicate biomass for August (35.5 - 117.9 g/m^2) was substantially higher than those shown by Effluent (4.8 - 63.3 g/m^2) and Manomet Point (19.8 - 102.3 g/m^2); for March, the Rocky Point range (78.5 - 181.3 g/m^2) was moderately higher than the Effluent range (31.1 - 187.2 g/m^2), and conspicuously higher than the Manomet Point range (6.6 - 60.5 g/m^2). Tables 9 and 10 also show that remaining benthic species biomass generally constituted a lower percentage of total station biomass than did Chondrus and Phyllophora. Values ranged from 6% (Manomet Point) to 14% (Rocky Point) in August, and from 7% (Manomet Point) to 36% (Rocky Point) in March.

One-way ANOVA treatment was separately applied to the August, March, and combined August/March replicate biomass data to test for statistical differences between stations. The results, which are included in Table 11a-c, show that biomass differences between stations were significant only for the March (d.f. = 2/12, f = 6.772, $p < .05$) and combined August/March (d.f. = 2/27, f = 4.947, $p < .05$) comparisons. A priori comparison of means showed that Effluent was not statistically different from the two control stations for either comparison. An examination of Tables 9 and 10 suggests that the particularly low Manomet Point value in March was responsible for ANOVA significance for both the March and combined August/March periods. One-way ANOVA treatment was also applied to the composite replicate data of September 1979 through March 1982. Results are included in Table 12, and show that biomass differences between the three stations were statistically different (d.f. = 2/111, f = 3.316, $p < .05$). A priori comparison of means showed that Effluent was not statistically different from the control stations. A review of previous years' data suggests that lower Manomet Point biomass was responsible for the significant differences. Current results are in overall agreement with those which have been reported for previous years' samplings. In the past, Effluent biomass has not been found to be different from that of control stations. In addition, Manomet Point has previously been observed to exhibit lower biomass than Effluent and Rocky Point, although differences between stations were rarely statistically significant.

Current remaining benthic species data were statistically compared with those of one year earlier in order to examine temporal stability at each station. ANOVA treatment results are included in Table 13, and show that differences between the two yearly periods were not significant for any station. Despite the absence of statistically significant differences, an examination of Table 14 shows that all stations exhibited biomass increases over the two yearly periods. The $\bar{x}$ Manomet Point value for the current year's collections (38.0 g/m^2) represents a slight 4.7% increase over the previous year's level (36.3 g/m^2); the current year's Rocky Point value (98.8 g/m^2) represents a modest 16.4% increase above the previous year's level (84.9 g/m^2); and, the current year's Effluent value (64.3 g/m^2) represents a substantial 84.2% increase over the level of the previous year (34.9 g/m^2).

5.4.4 Biomass of the epiphytic species

Total epiphytic biomass for August 1981 and March 1982 is presented in Tables 9 and 10 respectively. Biomass for the separate Chondrus crispus and Phyllophora spp. epiphytic fractions is presented in Table 15. Epiphytic biomass levels showed a strong positive correlation with the biomass levels of the associated host species. The correlation is normal

Table 15. Dry weight biomass for a) epiphytes of Chondrus crispus, and b) epiphytes of Phyllophora spp. for the Manomet Point, Effluent, and Rocky Point subtidal (10' MLW) stations for August 1981 and March 1982.

a) epiphytes of Chondrus crispus

Replicate	Manomet Point August	Manomet Point March	Effluent August	Effluent March	Rocky Point August	Rocky Point March
1	35.4 (0.045)	14.0 (0.041)	7.0 (0.018)	0.1 (0.001)	66.3 (0.897)	7.5 (0.048)
2	18.6 (0.030)	16.2 (0.089)	10.5 (0.088)	0.1 (0.001)	46.3 (0.114)	0.7 (0.003)
3	36.2 (0.072)	5.4 (0.044)	7.8 (0.036)	0.2 (0.008)	71.5 (0.140)	3.1 (0.307)
4	40.4 (0.096)	17.2 (0.041)	16.9 (0.109)	0.1 (0.083)	57.3 (0.167)	8.3 (0.593)
5	49.7 (0.124)	24.6 (0.084)	4.4 (0.053)	1.2 (0.036)	69.0 (0.165)	0.3 (0.013)
$\overline{X}$	36.1 (0.073)	15.5 (0.060)	9.3 (0.061)	0.3 (0.026)	62.1 (0.297)	4.0 (0.193)

b) epiphytes of Phyllophora spp.

Replicate	Manomet Point August	Manomet Point March	Effluent August	Effluent March	Rocky Point August	Rocky Point March
1	8.8 (0.077)	42.8 (0.262)	20.6 (0.112)	2.0 (0.014)	83.3 (2.964)	27.3 (0.136)
2	35.1 (0.238)	72.6 (0.480)	67.4 (0.357)	0.7 (0.010)	31.3 (0.533)	9.2 (0.062)
3	35.8 (0.218)	64.6 (0.397)	34.0 (0.153)	9.4 (0.066)	17.0 (0.282)	34.7 (0.393)
4	53.5 (0.378)	49.5 (0.235)	83.5 (0.562)	19.1 (0.124)	10.4 (0.169)	68.1 (0.669)
5	33.6 (0.197)	34.8 (0.247)	78.4 (0.440)	5.7 (0.042)	33.2 (0.243)	4.4 (0.026)
$\overline{X}$	33.4 (0.222)	52.9 (0.324)	56.8 (0.325)	7.4 (0.051)	35.0 (0.836)	28.7 (0.257)

Legend: 00.0 (0.000)
- (0.000) → adjusted value (grams of epiphyte per gram of host species)
- 00.0 → actual recorded biomass (g/m^2)

and anticipated, and simply demonstrates that the extent of development of an epiphytic algal population is, in large part, determined by the extent of development of the affected host species population. All epiphytic biomass values were mathematically adjusted in Table 15 in order to eliminate the variability induced by the relationship between the epiphytic and host species' populations. The adjusted values, which denote the weight (in g/m^2) of epiphytes per gram of host species, serve as more meaningful units of comparison, and are readily amemable to statistical analyses.

An examination of Table 15 reveals that Phyllophora epiphytic biomass exceeded Chondrus epiphytic biomass at all three stations for both collecting periods, indicating that Phyllophora was the more heavily epiphytized species throughout the survey area. The higher Phyllophora epiphytism values are believed to reflect, at least in part, the greater capability of Phyllophora to tolerate the increased stresses associated with increased infestation. Morphologically, the wiry Phyllophora is considerably tougher and sturdier than Chondrus. Consequently, Phyllophora may be able to withstand levels of epiphytism which, for Chondrus, would be sufficient to bring about dislodgement from the substratum. Results of the Chondrus/Phyllophora Condition Index study (Section 5.4.6) also showed that Phyllophora was more heavily epiphytized than Chondrus. Higher Phyllophora epiphytic biomass values have previously been reported for the September 1980 through June 1981 (BECo Report No. 18) and the September 1979 through June 1980 (BECo Report No. 16) collecting periods.

Examination of Table 15a reveals that, for all stations, the Chondrus epiphytic fraction showed highest biomass levels in August, with appreciably lower levels recorded in March. The decline in biomass between the two periods was 17.8% for Manomet Point, 35.0% for Rocky Point, and 57.4% for Effluent. The lower March biomass values are primarily a reflection of the loss of numerous summer annual epiphytic species over the winter months.

Further examination of Table 15a shows that, for both the August and March collecting periods, Rocky Point produced the highest Chondrus epiphytic biomass, Effluent produced the lowest, and Manomet Point produced intermediate level biomass. The $\bar{x}$ Rocky Point biomass value for August (0.297 g/epiphytic species per g/Chondrus) was 306.8% higher than the

Manomet Point value (0.073), and 386.9% higher than the Effluent value (0.061); similarly, the March Rocky Point $\bar{x}$ value (0.193) was 221.7% higher than the Manomet Point value (0.060), and 642.3% higher than the Effluent value (0.026).

One-way ANOVA statistical treatment was performed on replicate sample data to test for significant differences between stations. The results are included in Table 11a-c, and show that Chondrus epiphytic biomass differences were significant only for the combined August/March (d.f. = 2/27, f = 4.245, $p < .05$) comparison period. A priori comparison of means showed that Effluent biomass was not significantly different from that of the control stations. Examination of Table 15 suggests that the high Rocky Point biomass recorded for both the August and March collecting periods was responsible for the significant difference finding. One-way ANOVA statistical treatment was also applied to the composite replicate data of September 1979 through March 1982. Results, which are included in Table 12, show that biomass differences between stations were significant (d.f. = 2/111, f = 5.281, $p < .01$). A priori comparison of means showed that Effluent biomass was not statistically different from control station biomass. A review of previous years' data indicates that the significant differences were due to high Rocky Point biomass.

Current Chondrus epiphytic biomass data were compared to the corresponding data of one year earlier to test for temporal short-term stability at each station. Results of ANOVA statistical treatment are given in Table 13, and show that biomass differences between the two yearly periods were significant only for Effluent (d.f. = 1/20, f = 9.566, $p < .01$). Examination of Table 14 shows that the $\bar{x}$ Effluent biomass value for the current year (0.043) represents a 72.1% decline from the previous year's level (0.154). Manomet Point and Rocky Point showed less precipitous biomass reductions over the two year period; the current year's Manomet Point value (0.067) represents a modest 13.0% decline from the previous year's level (0.077), while the current year's Rocky Point value (0.239) represents a slight 2.1% decline from the level of one year earlier (0.244).

Table 15b shows that Phyllophora epiphytic biomass values for the three stations did not evidence a common seasonal pattern over the August 1981 to March 1982 collecting periods. Effluent and Rocky Point showed appreciable biomass declines of 84.3% and 69.3% respectively between the two periods, while Manomet Point displayed a 45.9% increase.

Table 15b also shows that no single station consistently produced either the highest or lowest Phyllophora epiphytic biomass for the two collecting periods. Rocky Point and Manomet Point produced the highest and lowest biomass respectively in August, while Manomet Point and Effluent produced the highest and lowest respectively in March. The August Rocky Point value (0.836 g/epiphytic species per g/Phyllophora) was 157.2% greater than the Effluent value (0.325), and 276.6% greater than the Manomet Point value (0.222); the March Manomet Point value (0.324) was 26.1% greater than the Rocky Point value (0.257), and 535.3% greater than the Effluent value (0.051).

One-way ANOVA statistical treatment was applied to the replicate biomass data of August and March to test for statistical differences between stations. Results, which are included in Table 11a-c, show that Phyllophora epiphytic biomass differences were not significant for either the August, March, or combined August/March comparison periods. One-way ANOVA treatment was also performed on the composite replicate data of September 1979 through March 1982. Results are given in Table 12, and show that biomass differences between the three stations were again not significant.

Current data were compared with those of one year earlier in order to assess the temporal stability of the Phyllophora epiphytic biomass population at each station. Results of ANOVA treatment are included in Table 13, and show that biomass differences between the two yearly periods were significant for both Manomet Point (d.f. = 1/14, f = 8.415, $p < .05$) and Effluent (d.f. = 1/20, f = 28.423, $p < .01$). Examination of Table 14 shows that the current year's Manomet Point value (0.273) represents a 51.1% decline from the previous year's level (0.558), while the Effluent value for the current year (0.831) represents an increase of 342.0% over the level of one year ago (0.188). The table also shows that the current year's Rocky Point value (0.547) represents a slight 2.7% decline from that of one year earlier (0.562).

5.4.5 Total algal biomass

Total algal biomass data for each station is given in Tables 9 and 10 for the August 1981 and March 1982 collections respectively. The data shows that the three stations registered biomass declines of nearly identical proportion between August and March. Rocky Point and Manomet Point showed respective declines of 32.1% and 33.5% between the two periods, while Effluent displayed a slight greater decline of 38.4%. Lowered March biomass levels have also been recorded from previous years' data, and reflect the seasonal elimination of numerous summer annual and pseudoperennial species over the winter months. More specifically, the reduced March levels are a reflection of a seasonal reduction in the biomass of Chondrus crispus, which is the dominant species and single most important contributor to total algal biomass at each station.

Further examination of Tables 9 and 10 reveals that, for both the August and March collecting periods, the Effluent station produced the lowest total algal biomass, while Manomet Point produced the highest, and Rocky Point produced intermediate-level values. The $\bar{x}$ Effluent value for August (483.5 g/m^2) was 17.1% lower than the corresponding Rocky Point value (583.1 g/m^2), and 40.2% lower than the Manomet Point value (808.2 g/m^2); similarly, the March Effluent value (297.8 g/m^2) was 24.8% lower than the Rocky Point value (396.1 g/m^2), and 44.6% lower than the Manomet Point value (537.4 g/m^2). An examination of the individual replicates for the two periods further underscores the biomass differences between the stations. For August, the range of replicate biomass values shown by Effluent (401.5 - 610.6 g/m^2) was appreciably lower than the ranges shown by both Rocky Point (305.1 - 724.1 g/m^2) and Manomet Point (687.3 - 969.4 g/m^2); the range of Effluent replicate biomass in March (205.8 - 427.4 g/m^2) was also lower than the ranges shown by Rocky Point (317.6 - 527.5 g/m^2) and Manomet Point (399.7 - 698.8 g/m^2).

One-way ANOVA statistical treatment was applied to the August, March, and combined August/March replicate biomass data to test for significant differences between stations. Results are included in Table 11a-c, and show that total algal biomass differences between stations were statistically significant for each of the August (d.f. = 2/12, f = 8.176, $p < .01$), March (d.f. = 2/12, f = 7.077, $p < .01$), and combined August/March (d.f. = 2/27, f = 8.094, $p < .01$) comparison periods. A priori comparison of means showed that Effluent biomass was significantly lower than control station biomass for each of the August (d.f. = 1/12, f = 9.513, $p < .01$), March (d.f. = 1/12, f = 9.285, $p < .05$), and August/March (d.f. = 1/27, f = 9.561, $p < .01$) comparisons. One-way ANOVA was also performed on the composite replicate data of October 1975 through March 1982. Results, which are given in Table 12, show that biomass differences between the three stations were statistically significant (d.f. = 2/282, f = 21.203, $p < .01$). A priori comparison of means showed Effluent biomass to be statistically lower (d.f. = 1/282, f = 5.132, $p < .05$) than that of either control station.

Current data were compared with those of one year earlier in order to examine short-term temporal stability at each station. ANOVA treatment results are included in Table 13, and show that total algal biomass differences between the current and previous year's data were significant only for Effluent (d.f. = 1/20, f = 6.800, $p < .05$). Examination of Table 14 shows that the $\bar{x}$ Effluent biomass value for the current year's collections (390.8 g/m^2) represents a 28.6% decline from the previous year's level (547.0 g/m^2). Rocky Point and Manomet Point showed less extreme biomass declines over the two yearly periods. The current year's Rocky Point value (489.6 g/m^2) represents a 22.0% decline from the previous year's level (628.0 g/m^2), while the current year's Manomet Point value (672.7 g/m^2) represents a slight 5.0% decline from the level of one year earlier (708.2 g/m^2).

The significantly lower total algal biomass recorded for the Effluent station is primarily a reflection of reduced Chondrus biomass. Although Effluent has also typically shown greater Phyllophora biomass than the two control stations, this increase has not been sufficient to counterbalance the reduction in Chondrus. Reduced Effluent total algal biomass has also been reported for the September 1979 through June 1980 (BECo Report No. 16) and the September 1980 through June 1981 (BECo Report No. 18) collecting and reporting periods.

5.4.6 The Chondrus/Phyllophora condition index study

Plant and animal colonization values for Chondrus crispus and Phyllophora spp. for August 1981 and March 1982 are presented in Table 16a; condition index values for the two species are given in Table 17. An inspection of the tables shows that, for all three stations and in both collecting periods, Phyllophora was more heavily colonized with both epiphytes and encrusting fauna than was Chondrus. It is judged that the higher Phyllophora infestation values reflect, at least in part, the greater capability of Phyllophora to tolerate the increases stresses associated with heavy epiphytic and faunal colonization. Morphologically, the wiry Phyllophora is considerably tougher and sturdier than Chondrus. As a result of its structural superiority, Phyllophora may be able to withstand levels of infestation which, for Chondrus, would be sufficient to bring about dislodgement from the substratum. Higher Phyllophora colonization and condition index values have also been recorded for the September 1980 through June 1981 (BECo Report No. 18) and the September 1979 through June 1980 (BECo Report No. 16) collecting periods.

The tables also show that, for all stations, algal and faunal colonization of both Chondrus and Phyllophora declined markedly between the August and March collecting periods. The decline, which reflects the loss of numerous summer annual species over the winter months, has frequently been reported for previous years' collections.

Chondrus colonization values, as seen in Table 16a, showed a moderate degree of variation among stations. Effluent epiphytization values were lower than those of the two control stations in August; in March, the three stations displayed nearly identical values. Manomet Point and Effluent faunal colonizations values for August were appreciably higher than those for Rocky Point; very similar values, however, were shown by the three stations in March. Chondrus condition index values, as shown in Table 17, were nearly identical for e station in each of the two collecting periods. The values shown by all stations were very similar to those which have been reported for previous years' collections.

Phyllophora colonization values, as seen in Table 16b, also showed variations between stations for the two collecting periods. Although the three stations showed markedly similar epiphytization levels in August,

Table 16. Colonization values for <u>Chondrus crispus</u> and <u>Phyllophora</u> spp. for the Manomet Point, Effluent, and Rocky Point subtidal (10' MLW) stations for August 1981 and March 1982.

a) <u>Chondrus crispus</u>

	Algal Colonization						Faunal Colonization					
	Manomet Pt		Effluent		Rocky Pt		Manomet Pt		Effluent		Rocky Pt	
Replicate	Aug	Mar	Aug	Mar	Aug	Mar	Aug	Mar	Aug	Mar	Aug	Mar
1	2	1	1	1	4	1	2	1	4	1	1	1
2	1	2	1	1	2	1	2	2	3	1	1	1
3	2	1	1	1	3	2	2	2	2	1	1	1
4	2	1	3	1	3	2	3	1	3	1	1	1
5	3	1	1	1	2	1	3	2	2	1	1	1
Total	10	6	7	5	14	7	12	8	14	5	5	5

b) <u>Phyllophora</u> spp.

	Algal Colonization						Faunal Colonization					
	Manomet Pt		Effluent		Rocky Pt		Manomet Pt		Effluent		Rocky Pt	
Replicate	Aug	Mar	Aug	Mar	Aug	Mar	Aug	Mar	Aug	Mar	Aug	Mar
1	1	2	1	1	3	2	3	2	3	1	1	1
2	3	3	3	1	3	1	4	2	3	2	2	1
3	2	3	2	1	2	3	3	1	4	1	3	1
4	4	2	4	1	2	3	4	3	3	1	2	1
5	2	4	[illegible]	1	2	1	4	2	3	1	3	1
Total	12	14	13	5	12	10	18	10	16	6	11	5

Table 17. Condition Index values for *Chondrus crispus* and *Phyllophora* spp. for the Manomet Point, Rocky Point, and Effluent subtidal (10' MLW) stations for August 1981 and March 1982.

Chondrus crispus
Condition Index

Station	Collecting period August 1981	 March 1982
Manomet Point	22	14
Effluent	21	10
Rocky Point	19	12

Phyllophora spp.
Condition Index

Station	Collecting period August 1981	 March 1982
Manomet Point	30	24
Effluent	29	11
Rocky Point	23	15

Effluent showed appreciably lower values than both Manomet Point and Rocky Point in March. Rocky Point faunal colonization values were slightly lower than those of Manomet Point and Effluent in each of the two collecting periods. Similarly to Chondrus condition index values, Phyllophora condition index values for the three stations were in relatively close agreement for both collecting periods. The Phyllophora colonization and condition index values shown by all stations closely corresponded to those which have been reported for previous years' collections.

6. NATURE AND EXTENT OF DENUDED AND STUNTED AREAS IN THE IMMEDIATE VICINITY OF THE DISCHARGE

6.1. Introduction

In January of 1980 we initiated an intensive investigation of the near-field effects of the PNPS discharge on marine benthic communities (McGrath, 1980). One phase of that study comprised a small-scale mapping of the denuded and stunted areas immediately in front of the discharge.

This mapping has now been completed six times: January and August, 1980; August, 1981; and March, May and June, 1982. The results of the latter four mappings are included herein. A full discussion of methods and additional background information on the purpose of this phase of the benthic program are included in BECO Semi-Annual Report No. 16.

6.2. August, 1981 Configuration

The extent of the near-field benthic stunted and denuded zones immediately offshore from the PNPS discharge is shown in Figure 8 . The denuded area, defined as the area essentially devoid of Chondrus crispus and most other indigenous algal species, extended approximately 85m offshore measured from the mean high water (MHW) mark on the discharge canal jetties. The denuded zone extended considerably futher to the left (west) of the plume centerline, reaching a maximum lateral spread of 16m in that direction. To the right of the centerline the lateral extent of the denuded zone reached a maximum lateral extent of only 9m. The total area contained within this zone, exclusive of the denuded bottom within the discharge canal itself, was calculated to be approximately $1400m^2$.

Beyond the denuded zone, the stunted zone, defined as the area where rocks were populated with Chondrus of reduced density and height, extended offshore 95m from the MHW mark and was somewhat narrower than recorded in January, 1980 (BECO, 1980). As was the case for the denuded zone, the stunted zone extended further to the west of the plume centerline than it did to the right, reaching maximum lateral spread of 27m and 13m, respectively. The outer boundary of the stunted zone was calculated to encompass an area of approximately $2250m^2$.

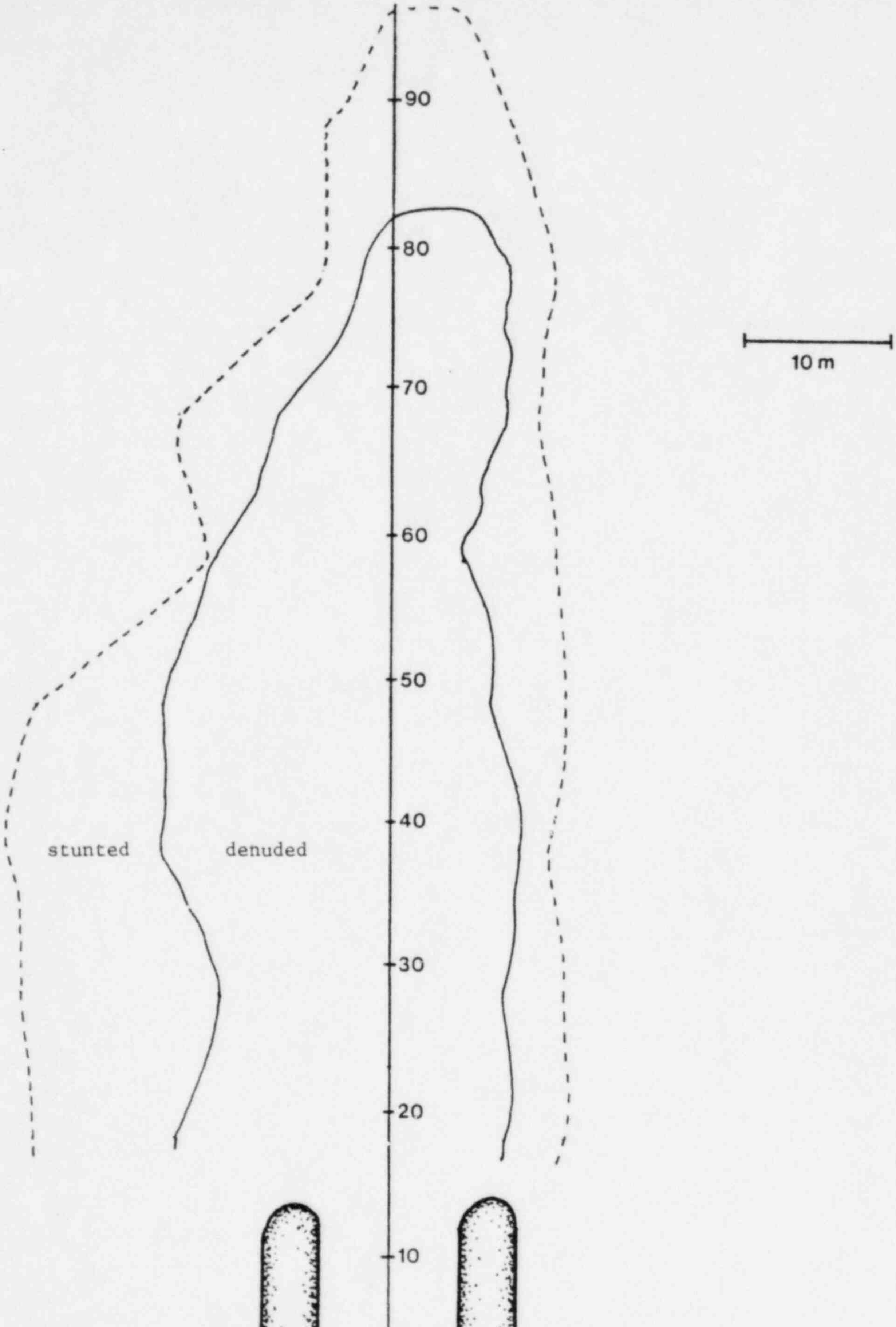

Figure 8. Configuration of the denuded and stunted zones, August 1981.

6.3. March, 1982 Configuration

The acute near-field impact zones in March, 1982 (Figure 9) were reduced in extent in comparison with those reported previously. The denuded zone extended approximately 70m from the MHW mark and was nearly symmetrical about the discharge plume centerline, extending laterally 8 - 10m to the right (east) and 10 - 12m to the left (west). The total amount of bottom contained within this zone was approximately $1100m^2$, exclusive of the area with the canal itself.

The stunted zone in March had a configuration very similar to that described above for August, except that it extended only 85m offshore. As has been noted in previous reports (BECO, 1980), the stunted zone extended further to the left (west) of the discharge plume centerline, reaching a maximum extent of 25m. To the east, the stunted zone was narrower, extending only 15m from the centerline. The stunted zone encompassed an area calculated to be $1900m^2$ (including the denuded zone).

6.4. May, 1982 Configuration

The results of the May, 1982 survey (Figure 10) indicated a considerable increase in the extent of both the denuded and stunted zones in comparison with the March survey. The denuded zone extended offshore an additional 15 meters in May, reaching approximately the 85m mark; the stunted zone was similarly increased.

The lateral extent of both areas was also markedly increased, particularly to the left (west) of the plume centerline. The maximum extent of impacts to the west was 36m at the 60m offshore mark giving the shape of this zone a rather unusual appearance. It may be possible that the stunting in this area was not a direct effect of PNPS operation and represented random variation in Chondrus condition that will be rapidly reversed. To the right (east) of the discharge jet, the lateral extent of the stunted area remained essentially unchanged from previous surveys.

The denuded area was also laterally expanded in comparison with the previous survey though not as markedly so as the stunted zone. The unusual shape of the stunted area described above was also seen in the denuded area configuration, and produced a greater lateral extent of

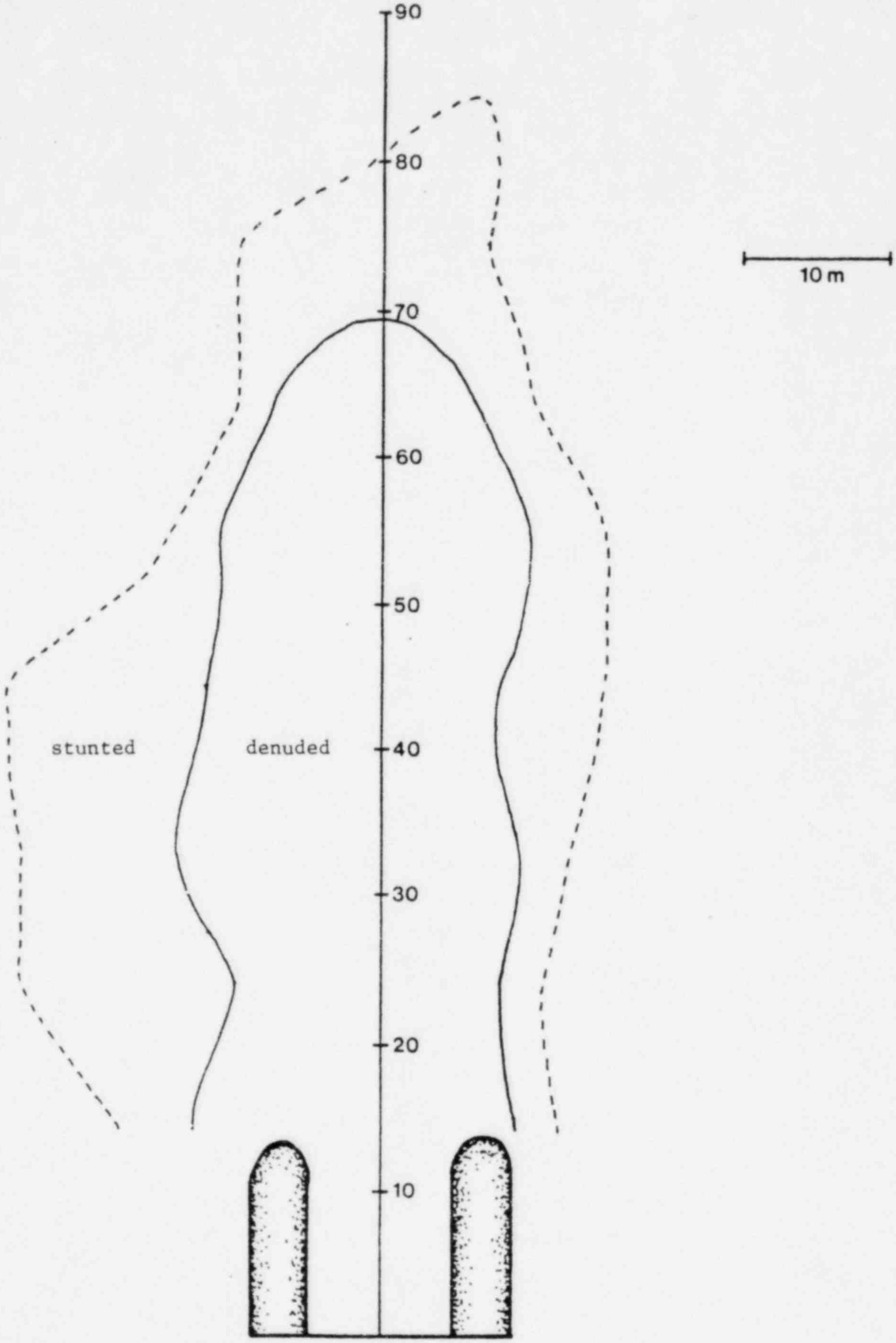

Figure 9. Configuration of the denuded and stunted zones, March 1982.

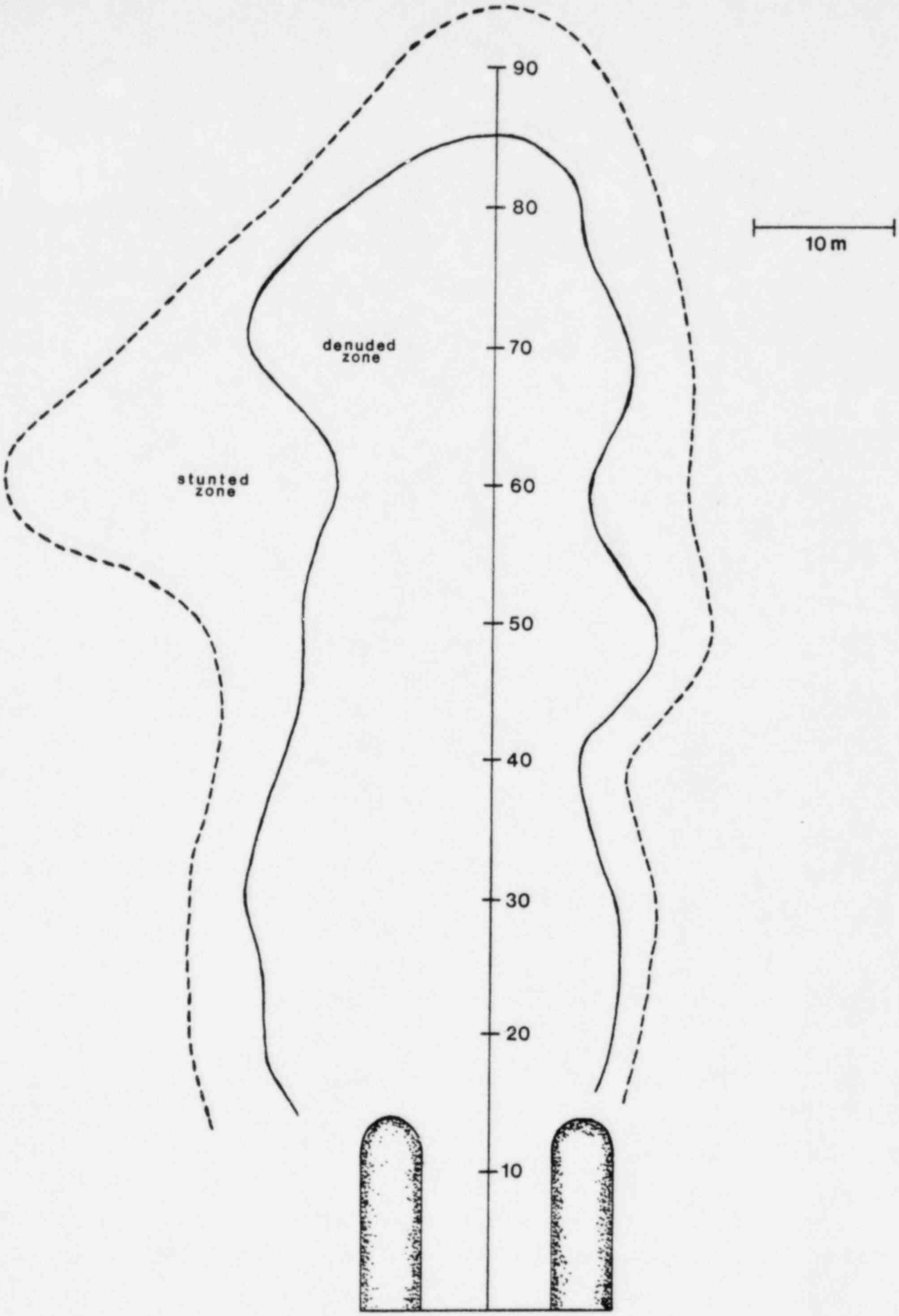

Figure 10. Configuration of the denuded and stunted zones, May 1982.

this zone at larger distances offshore than had been seen previously. To the east, the extent of the denuded zone remained essentially unchanged.

The area encompassed within the denuded zone was calculated to be $1536m^2$, which is the greatest extent of this zone seen to date. The total impacted area (denuded and stunted) in May was $2400m^2$.

6.5. June, 1982 Configuration

The results of the June, 1982 survey indicated few changes from the May description. The denuded zone extended slightly further offshore, passing the 90m mark, but was somewhat reduced in width. The stunted zone had expanded to the west, particularly in the area from 20m to 50m offshore, and was also somewhat more expanded to the east (Figure 11).

The spatial extent of the denuded zone decreased slightly from May to June, and was calculated to be $1346m^2$. The total area contained within both zones increased slightly, however, to $2595m^2$.

6.6. Variation in Impact Zone Configuration

With data available from six small-scale mappings of the near-field impact zones, we believe that the area has reached a dynamic equilibrium and does not appear to be increasing with continued PNPS operation.

The denuded zone encompassed $1140m^2$ in January of 1980 and actually appeared to decrease to $947m^2$ in August, 1980, a period which was believed to be a seasonal maximum of stress for benthos in the discharge area. The next survey, in August of 1981, recorded the maximum extent seen at that time for the denuded zone ($1400m^2$). Shortly after that survey, PNPS went off-line for refueling and remained off-line until after the March, 1982 mapping. Although the area decreased to $1100m^2$ during this time, additional re-establishment of Chondrus during the shutdown was prevented by winter conditions being not conducive to Chondrus germination and growth.

The May, 1982 showed a sharp increase in the denuded zone (to over $1500m^2$) which was probably related to the shock of the station coming back on-line. This situation apparently stabilized rapidly, however, and the size of the zone decreased slightly between May and June, 1982.

The total impact area (including both the denuded and stunted zones)

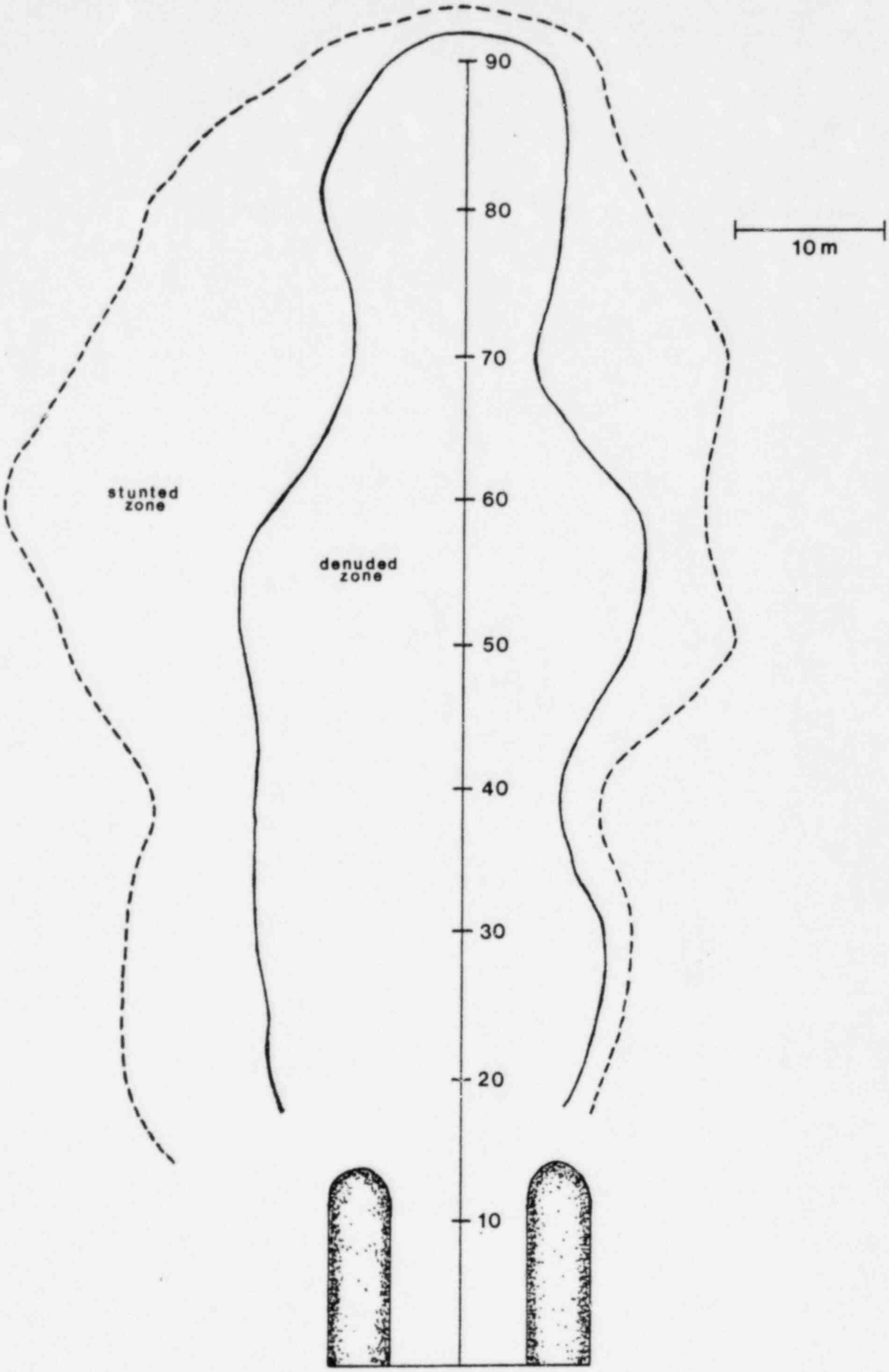

Figure 11. Configuration of the denuded and stunted zones, June 1982.

has undergone a different pattern of changes, and actually reached its maximum extent ($2926m^2$) when the denuded zone was at its least (August, 1980). It is evident that, although it appears that the areas have reached some sort of equilibrium, they are not following a simple seasonal cycle and we are unable to discern a pattern from six surveys spaced over 30 months.

7. SUMMARY

7.1 Faunal Summary

7.1.1 Systematics

Two new species were added to the list of Plymouth fauna developed by this program. These were Skeneopsis planorbis and Sayella unifasciata, two small gastropods which were present in the August 1981 samples. No new species were found in the March 1982 samples.

7.1.2 Community Structure

7.1.2.1 Species Richness

Manomet Point had greatest species richness for both samplings followed, in August, by Rocky Point and Effluent. In March, there was no detectable difference in richness between Rocky Point and Effluent. The depressed species richness at Effluent in August was statistically significant.

7.1.2.2 Faunal Density

Manomet Point had greatest densities of faunal organisms for both samplings. In August, this was followed closely by Rocky Point but Effluent densities were much reduced due to the lack of juvenile mussels. The depressed faunal density at Effluent was highly statistically significant. In March, there was no discernible difference between Rocky Point and Effluent for this parameter and both locations had moderate densities of mussels.

7.1.2.3 Individual Species

For the August sampling, four of the ten selected species had abundance patterns which were strongly suggestive of an impact due to PNPS at Effluent. These included Margarites umbilicalis and Pleusymtes glaber, two species which have been identified in the past as apparently being excluded from the Effluent.

In March, however, there was no evidence of the pattern seen in August although this was probably due to the high abundances of all species at Manomet Point.

7.1.3 Species Dominance

Overall similarity of dominance structure was generally similar for all sites and both samplings. In August, however, this relationship was not statistically significant although it has been in the past. This was noted as probably being due only to random variation and, by March, the three dominance structures were again seen to be highly correlated.

7.1.4 Community Overlap

Community overlap values remained constant for both samplings at approximately 60-65%. There were no evident differences in within-habitat overlap among the three sites. The amount of overlap seen during the year is slightly lower than in previous years but is not believed to be indicative of a trend at this point.

7.1.5 Species Diversity

The Effluent station had higher diversity (H') and evenness (J') than the two control sites in August. As discussed in previous reports, these parameters are largely controlled by mussel densities, and the lack of a dense mussel population at Effluent in August was responsible for these results. The influx of juvenile mussels in March produced lower diversities throughout the area, particularly at Manomet Point, where diversities and evenness were lower than at Rocky Point or Effluent.

7.1.6 Classification Analysis

Due to hardware changes at Woods Hole's computing facility, it was not possible to perform the full suite of classification analyses that had been conducted for previous reports. However, similar routines were used to provide nearly equivelant information.

In August, the replicates from the Effluent site were clearly unlike Rocky Point and Manomet Point, presumably due to PNPS impact. This has been the typical pattern seen in previous years. The same pattern also prevailed in March although the dendrogram did not distinguish the Effluent site as clearly as in August. The overall conclusions from this analysis are of slight but clearly evident changes in community structure at the Effluent station due to PNPS operation.

7.2 Algal Summary

7.2.1 Algal Systematics

No previously unrecorded algal taxa have been added to the PNPS species list as a consequence of analysis of the August 1981 and March 1982 collections. No taxonomic or nomenclatural changes in the cumulative species list have been made since the most recent report. Taxonomic determinations were based upon the works of Parke and Dixon (1976), South (1976), and Taylor (1957).

7.2.2 Algal Community Description

The Manomet Point, Effluent, and Rocky Point subtidal (10' MLW) rock substratum stations were dominated by Chondrus crispus and Phyllophora spp., with Polyides rotundus, Corallina officinalis, and Ahnfeltia plicata occurring in lesser densities. Laminaria saccharina and L. digitata occurred singly or in dense clusters throughout the survey region. The most conspicuous epiphytes were Spermothamnion repens, Polysiphonia spp., and Ceramium rubrum. Hildenbrandia rubra, Phymatolithon spp., and Ralfsia spp. dominated the crustose community.

7.2.3 Community Overlap

Community overlap analyses were performed between stations, as well as between replicates of the same station, using Jaccard's Coefficient of Community. Replicate overlap values for August 1981 and March 1982 were found to be similar for the Effluent, Manomet Point, and Rocky Point stations. The results indicate that the spatial distribution of the algal community was similar at the three stations. Direct comparisons between stations yielded high values, indicating that species composition at the three stations was very similar. Results are in agreement with those obtained from previous years' data.

Examination of species occurrence records for August 1981 and March 1982 revealed that the typically warm-water species Gracilaria foliifera and Bryopsis plumosa were found only at the Effluent station. Both taxa have, in previous years, commonly been encountered at all stations along the Effluent transect, but not at stations along control station transects. The continued presence of the two species at Effluent is judged to be a thermal consequence of PNPS discharge.

7.2.4 Algal Biomass

7.2.4.1 Chondrus crispus Biomass

Chondrus crispus biomass declined at all stations between the August 1981 and March 1982 collecting periods. The magnitude of the decline was 74% for Rocky Point, 53% for Effluent, and 50% for Manomet Point. Lowered March Chondrus biomass has also been observed for previous years' collections, and is attributed to reduced winter germination and growth rates coupled with population losses suffered as a consequence of harsh winter storms.

Effluent Chondrus biomass was significantly lower than that of Rocky Point and Manomet Point for August 1981 and for the combined collections of August 1981/March 1982. Lower Effluent biomass was also recorded for March 1982, although differences between stations were not statistically significant. Effluent biomass was also found to be significantly lower than control station biomass when the composite data of October 1975 through March 1982 were tested. Significantly lower Effluent Chondrus biomass has also been demonstrated for previous years' collections, and is attributed to the abundance of sand and gravel substratum at the Effluent station in conjunction with the high current velocity and sedimentation associated with the Pilgrim Nuclear Power Station (PNPS) discharge plume. Chondrus is known to be particularly adversely affected by the scouring and abrasion associated with such conditions.

Chondrus biomass for the current year's collections (August 1981 and March 1982) was lower than that recorded for the preceding year's collections at all stations. The decline in biomass between the two yearly periods was 40% for Effluent, 35% for Rocky Point, and 4% for Manomet Point. Differences between the two yearly periods were not statistically significant for any station.

7.2.4.2 Phyllophora spp. Biomass

Phyllophora spp. did not evidence a uniform seasonal biomass pattern for the three stations. Manomet Point and Rocky Point biomass increased by 12% and 101% respectively between the August and March collections, while Effluent showed a 30% biomass decline over the same period. The data are consistent with previous years' findings, as Phyllophora spp. has historically failed to display consistent seasonal biomass patterns.

Effluent Phyllophora biomass was significantly higher than that of both control stations for August 1981, but not for March 1982 or for the combined August 1981/March 1982 periods. Effluent biomass was, however, found to be significantly higher than control station biomass for the composite data of October 1975 through March 1982. The findings are only in partial agreement with those which have been reported for previous years' data. In the past, Effluent has consistently shown significantly higher Phyllophora biomass than Manomet Point and Rocky Point. The traditionally higher Effluent biomass is considered to be a result of the greater capability of Phyllophora to tolerate the large amounts of sand and sediments which characterize the Effluent station substratum. The PNPS discharge plume is judged to contribute to the high concentration of sand and sediments at the Effluent station. Effluent Phyllophora may also benefit from reduced competition from Chondrus.

A comparison of current year's biomass data with those of the preceding year indicates that the Phyllophora population at each station has remained relatively stable during the two-year period. Manomet Point and Effluent showed biomass increases of 21% and 11% respectively over the two yearly periods, while Rocky Point displayed a 6% decline. Differences between the two periods were not statistically significant for any station.

7.2.4.3 Biomass of the Remaining Benthic Species

The three stations did not display a common seasonal pattern for remaining benthic species biomass for the August and March collecting periods. Rocky Point and Effluent showed biomass increases of 100% and 129% respectively between the two periods, while Manomet Point showed a 30% decline. Data are in overall agreement with those which have been reported for previous years' collections, as remaining benthic species biomass has traditionally failed to display consistent seasonal patterns.

Effluent remaining benthic species biomass was not significantly different from that of control stations for either the August 1981, March 1982, combined August/March, or composite September 1979 through March 1982 periods. The data also showed Manomet Point to have exhibited generally lower biomass than that of both Rocky Point and Effluent for all periods. The data are consistent with those of previous years.

Remaining benthic species biomass for the current year's collections was higher than that recorded for the preceding year's collections for all stations. The increase in biomass between the two yearly periods was 84% for Effluent, 16% for Rocky Point, and 5% for Manomet Point. Differences between the two yearly periods were not statistically significant for any station.

7.2.4.4 Biomass of the Epiphytic Species

The Phyllophora epiphytic fraction showed higher biomass than the Chondrus epiphytic fraction at all three stations for both the August and March collecting periods. It is theorized that the higher Phyllophora epiphytism values reflect, at least in part, the greater capability of Phyllophora to withstand the increased stresses associated with heavy infestation.

The three stations displayed similar seasonal patterns of high August biomass and low March biomass for both the Chondrus and Phyllophora epiphytic fractions. Lowered March biomass has also been reported from previous years' data, and largely reflects the elimination of the summer annual epiphytic species over the winter months.

Effluent epiphytic biomass was not significantly different from that of the control stations for either the August 1981, March 1982, combined March/August, or composite September 1979 through March 1982 periods. The data showed that Chondrus epiphytic biomass was higher at Rocky Point than at Manomet Point and Effluent throughout the period, while Phyllophora epiphytic biomass levels were generally similar for all three stations.

Chondrus epiphytic biomass for the current year's collections was lower than that recorded for the prior year's collections at all stations. The decline in biomass between the two yearly periods was 72% for Effluent, 13% for Manomet Point, and 2% for Rocky Point. The decline was statistically significant only for Effluent. Changes in Phyllophora epiphytic biomass levels since the preceding year's collections did not follow a uniform pattern for the three stations. Rocky Point and Manomet Point showed biomass declines of 3% and 51% respectively over the two yearly periods, while Effluent displayed a 342% increase. Differences between the two periods were statistically significant for Manomet Point and Effluent.

7.2.4.5 Total Algal Bicmass

Total algal biomass declined at all stations between the August and March collections. The extent of the decline was 32% for Rocky Point, 33% for Manomet Point, and 38% for Effluent. Lowered March biomass levels have also been recorded from previous years' data, and are attributed to the seasonal elimination of numerous summer annual and pseudoperrenial species (particularly Chondrus) over the winter months.

Effluent total algal biomass was significantly lower than that of both control stations for the August 1981, March 1982, combined March/August, and composite October 1975 through March 1982 periods. The findings are consistent with those which have been reported for previous years' data. The lower Effluent biomass is primarily a reflection of the smaller Effluent Chondrus population.

Total algal biomass for the current year's collections was lower than that recorded for the preceding year's collections at all stations. The decline in biomass over the two yearly periods was 29% for Effluent, 22% for Rocky Point, and 5% for Manomet Point. Differences between the two yearly periods were statistically significant only for the Effluent station. For all three stations, the declines were primarily reflections of lowered Chondrus biomass in the current year's collections.

7.2.4.6 Chondrus/Phyllophora condition index study

Phyllophora showed higher levels of infestation by encrusting faunal and epiphytic algal species than Chondrus at all stations in both August 1981 and March 1982. The morphologically sturdier Phyllophora is considered to be more resistant to the increased stresses associated with heavy plant and animal colonization.

Colonization and condition index values for both Chondrus and Phyllophora were generally similar at all stations, although a moderate degree of variation was exhibited by the three stations for both the August and March collections. The findings are in general agreement with those which have been reported for previous years' data, and indicate an overall equality of epiphytization and encrustation levels throughout the survey region.

7.3. Nature and Extent of Denuded and Stunted Areas

7.3.1. August, 1981 Configuration

The denuded zone in August of 1981 extended 85m offshore from the mean high water mark on the discharge canal jetties and was more laterally expanded to the left (west) of the discharge. The total area within the denuded zone was $1400m^2$, nearly 50% larger than the area of the August 1980 denuded zone.

The stunted zone extended 95m offshore, also being more extensive laterally to the left side of the discharge centerline. The total area within both impacted zones was $2250m^2$, considerably smaller than the $2926m^2$ recorded in August 1980.

7.3.2. March, 1982 Configuration

A survey of near-field impact zone configuration in March, 1982, following several months of refueling outage, indicated some reductions in the size of the denuded and stunted areas. The denuded zone extended approximately 70m offshore and was nearly symmetrical about the plume centerline. The denuded zone included $1100m^2$, a considerable reduction from the August value of $1400m^2$ and an area equivalent to that seen in January of 1980 ($1140m^2$).

7.3.3. May, 1982 Configuration

The results of the May 1982 survey indicated a significant increase in area of both zones compared with March. The impacted area extended 85m offshore, 15m further than March and was considerably wider, especially to the west.

The denuded zone in May encompassed an area of $1536m^2$, the largest area included in this zone since the initiation of the survey in January 1980. The total impacted area, however, included only $2400m^2$, which represents an increase over March but is still well below the maximum area recorded thus far.

7.3.4. June, 1982 Configuration

There was relatively little change in the extent of the impact areas between the May and June surveys. The denuded zone extended slightly further offshore, but was also narrower and represented a slight reduction in denuded bottom area, to 1346m^2. The total impacted area in June was a slight increase over May and encompassed 2595m^2, still less than the maximum area recorded.

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Appendix 1a. Replicate (total numbers of species) and station (numbers of species per m^2) faunal data for Rocky Point, August 1981.

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m^2)
COELENTERATA						
Haliclystus salpinx	100	228	212	240	140	1,690
Metridium senile	-	16	12	8	32	125
PLATYHELMINTHES						
Notoplana atomata	-	24	8	-	4	66
NEMERTEA						
Nemertea	-	-	-	-	-	-
Oerstedia dorsalis	-	20	16	12	12	110
MOLLUSCA						
Acmaea testudinalis	12	16	8	-	-	66
Aeolidia papillosa	-	-	-	-	-	-
Alvania areolata	16	-	12	4	4	66
Anomia simplex	-	-	4	-	-	7
Anomia aculeata	-	-	-	-	-	-
Bivalvia	4	-	-	-	-	7
Cerastoderma pinnulatum	36	8	8	20	20	169
Crepidula plana	8	4	-	4	24	73
Crepidula sp.	-	-	-	-	-	-
Diaphana minuta	4	-	4	-	-	15
Ensis directus	-	-	-	-	-	-
Gastropoda (juvenile)	-	-	-	-	-	-
Hiatella arctica	204	324	432	244	808	3,695
Hydrobia minuta	12	-	-	-	-	22
Lacuna vincta	140	64	80	188	168	1,175
Lepidochiton ruber	-	-	-	-	-	-
Littorina littorea	4	-	4	-	-	15
Margarites umbilicalis	560	664	1,604	812	1,500	9,440
Mitrella lunata	-	4	4	-	4	22
Modiolus modiolus	-	-	-	-	-	-
Mya arenaria	4	-	-	-	8	22
Mytilus edulis	2,396	2,148	2,972	2,468	8,432	33,822
Nudibrachia (juvenile)	-	-	-	-	-	-
Odostomia bartschi	-	-	-	-	8	15
Omalogyra atomus	4	-	4	-	-	15
Onchidoris aspera	16	52	76	36	52	426
Onoba aculea	128	52	88	84	164	948
Petricola pholadiformis	20	8	20	16	48	206
Sayella unifasciata	-	-	-	-	-	-
Siliqua costata	-	-	-	4	4	15
Skeneopsis planorbis	-	-	-	-	4	7
Tellina agilis	8	24	4	-	44	147
Turbonilla interrupta	-	-	-	-	-	-
ANNELIDA						
Ampharetidae	-	-	-	-	4	7
Amphitrite sp.	-	-	-	4	-	7
Aricidea jeffreysii	-	4	-	4	-	15

Appendix la.(continued)

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m²)
Asabellides oculata	-	-	4	4	-	15
Autolytus prismaticus	-	-	-	-	-	-
Capitella capitata	-	-	4	-	8	22
Capitellidae	-	4	-	4	4	22
Chaetozone sp.	-	-	-	-	-	-
Cirratulus cirratus	-	-	-	-	-	-
Cirratulus grandis	-	-	-	-	-	-
Clymenella torquata	-	-	-	-	4	7
Dodecaceria coralii	-	-	-	-	7	7
Dorvilleidae	-	-	-	-	-	-
Eteone longa	-	-	-	-	-	-
Eulalia viridis	4	4	-	-	4	22
Eumida sanguinea	-	-	-	-	-	-
Exogone hebes	-	-	-	-	-	-
Fabricia sabella	-	-	-	-	12	22
Harmothoe imbricata	32	108	80	48	84	646
Hirudinea	-	-	-	-	-	-
Lepidonotus squamatus	-	-	4	4	4	22
Maldanidae	-	-	-	-	-	-
Naineris quadricuspida	-	16	4	-	8	51
Nereis arenaceodonta	-	-	-	-	4	7
Nereis pelagica	-	8	-	-	-	15
Nereis zonata	4	-	20	4	8	66
Nereidae	-	32	-	-	12	81
Nicolea venustula	-	52	40	48	28	309
Oligochaeta	-	12	4	8	4	51
Orbiniidae	-	-	4	-	-	7
Paraonis fulgens	-	-	-	-	-	-
Pectinaria gouldii	-	4	-	-	4	15
Pholoe minuta	8	12	20	8	24	132
Phyllodoce maculata	28	4	40	12	20	191
Phyllodocidae	-	-	-	-	-	-
Polychaeta	-	-	-	-	-	-
Polycirrus sp.	16	12	4	12	4	88
Polydora sp.	-	-	-	-	-	-
Potamilla reniformis	-	-	-	-	-	-
Sabellaria vulgaris	-	-	-	-	-	-
Sabellidae	-	-	-	-	-	-
Spionidae	-	4	-	-	-	7
Stauronereis caecus	-	-	-	-	-	-
Streblospio benedicti	-	-	-	-	-	-
Syllidae	-	-	-	-	7	7
Tharyx acutus	-	4	4	-	-	15
ARTHROPODA						
Aeginina longicornis	40	92	84	80	88	705
Amphithoe rubricata	96	440	120	112	216	1,807
Amphipoda	196	296	160	172	108	1,712
Anoplodactylus lentus	-	-	-	-	-	-
Calliopius laeviscululus	24	80	32	68	72	544

Appendix 1a. (continued)

PHYLUM Species	1	2	Replicate 3	4	5	Station (No./m²)
Cancer irroratus	20	12	12	16	16	147
Cancer borealis	8	-	8	-	8	44
Caprella penantis	1,808	1,828	4,028	2,900	3,704	26,204
Caprellidae	20	-	-	116	24	294
Corophium acutum	128	352	232	76	224	1,858
Corophium bonelli	48	936	256	88	516	3,387
Crangon septemspinosa	-	-	-	-	-	-
Cytherois zostericola	8	4	-	-	12	37
Cytheridea americana	152	48	76	164	116	1,021
Decapoda	-	-	-	-	-	-
Dexamine thea	932	1,480	1,512	944	1,340	11,401
Diastylis sp.	-	-	-	-	-	-
Edotea triloba	4	4	4	-	4	29
Eualus pusiolus	4	16	16	-	16	96
Idotea phosphorea	44	544	268	112	200	2,145
Idotea balthica	20	172	8	20	56	507
Ischyrocerus anguipes	-	24	16	12	28	147
Jaera marina	-	-	-	-	12	22
Jassa falcata	8	48	8	52	36	279
Marinogammarus stoerensis	-	-	-	-	-	-
Ostracoda sp. 1	8	-	-	-	16	44
Ostracoda sp. 2	-	12	-	4	4	37
Ostracoda sp. 3	-	-	20	4	20	81
Ostracoda sp. 4	-	-	-	-	-	-
Oxyurostylis smithi	4	12	8	-	4	51
Pagurus longicarpus	4	-	-	-	-	7
Phoxichilidium femoratum	4	-	-	8	4	29
Phoxocephalus holbelli	88	64	80	68	160	845
Pleusymtes glaber	16	56	72	36	112	536
Polygordius sp.	4	4	-	-	8	37
Pontogeneia inermis	100	104	16	16	40	507
Proboloides holmesi	-	-	-	-	-	-
Protohaustorius deichamannae	-	-	-	-	-	-
ECHINODERMATA						
Amphipholis squamata	4	-	-	8	-	22
Asterias forbesi	8	16	24	12	16	140
Henricia sanguinolenta	-	-	-	-	-	-
Ophiopholis aculeata	12	52	24	-	16	191
Strongylocentrotus droehbachiensis	208	88	156	72	84	1,117
CHORDATA						
Colonial ascidacea	-	4	4	-	8	37
Solitary ascidacea	24	8	4	28	52	213

Appendix 1b. Replicate (total numbers of species) and station (numbers of species per m^2) faunal data for Effluent, August 1981.

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m^2)
COELENTERATA						
Haliclystus salpinx	-	8	4	20	12	81
Metridium senile	128	100	100	160	200	1,264
PLATYHELMINTHES						
Notoplana atomata	-	-	4	4	-	15
NEMERTEA						
Nemertea	8	8	8	28	4	103
Oerstedia dorsalis	-	-	-	-	-	-
MOLLUSCA						
Acmaea testudinalis	20	-	-	4	-	44
Aeolidia papillosa	12	4	8	16	-	73
Alvania areolata	-	-	4	-	-	7
Anomia simplex	-	-	-	-	-	-
Anomia aculeata	-	-	-	-	-	-
Bivalvia	-	-	-	-	-	-
Cerastoderma pinnulatum	-	8	-	-	-	15
Crepidula plana	16	-	8	16	8	88
Crepidula sp.	-	12	-	-	-	22
Diaphana minuta	-	-	4	-	4	15
Ensis directus	-	-	-	-	-	-
Gastropoda (juvenile)	-	-	-	-	8	15
Hiatella arctica	92	92	128	68	44	779
Hydrobia minuta	-	-	-	-	-	-
Lacuna vincta	16	80	56	140	92	705
Lepidochiton ruber	-	-	-	-	-	-
Littorina littorea	-	-	-	-	-	-
Margarites umbilicalis	16	12	20	20	4	132
Mitrella lunata	-	-	-	-	-	-
Modiolus modiolus	-	-	-	-	-	-
Mya arenaria	-	-	-	-	-	-
Mytilus edulis	1,060	1,032	1,272	1,140	1,050	10,200
Nudibrachia (juvenile)	-	-	-	-	-	-
Odostomia bartschi	-	-	-	-	-	-
Omalogyra atomus	-	-	-	-	-	-
Onchidoris aspera	44	20	152	48	72	617
Onoba aculea	-	8	-	-	-	15
Petricola pholadiformis	-	-	-	16	4	37
Sayella unifasciata	-	-	-	-	-	-
Siliqua costata	-	-	-	-	-	-
Skeneopsis planorbis	-	-	-	-	-	-
Tellina agilis	8	4	-	16	-	51
Turbonilla interrupta	-	-	-	-	-	-
ANNELIDA						
Ampharetidae	-	-	-	-	-	-
Amphitrite sp.	-	-	-	-	-	-
Aricidea jeffreysii	-	-	-	-	-	-

Appendix 1b.(continued)

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m²)
Asabellides oculata	-	-	-	-	-	-
Autolytus prismaticus	-	-	-	-	-	-
Capitella capitata	-	-	-	8	-	15
Capitellidae	4	-	-	-	-	7
Chaetozone sp.	-	-	-	-	-	-
Cirratulus cirratus	-	-	-	-	-	-
Cirratulus grandis	-	-	-	8	12	37
Clymenella torquata	-	-	-	-	-	-
Dodecaceria coralii	-	4	-	-	-	7
Dorvilleidae	-	-	-	-	-	-
Eteone longa	8	-	-	4	-	22
Eulalia viridis	-	4	12	4	8	51
Eumida sanguinea	-	4	-	-	-	7
Exogone hebes	-	-	-	-	-	-
Fabricia sabella	-	-	-	-	-	-
Harmothoe imbricata	4	12	20	24	12	114
Hirudinea	-	-	-	-	-	-
Lepidonotus squamatus	-	-	-	-	-	-
Maldanidae	-	-	-	-	-	-
Naineris quadricuspida	-	-	-	-	-	-
Nereis arenaceodonta	-	-	-	-	-	-
Nereis pelagica	-	-	-	-	-	-
Nereis zonata	-	16	20	40	16	151
Nereidae	-	-	12	-	-	22
Nicolea venustula	-	4	-	16	8	51
Oligochaeta	4	-	-	56	-	110
Orbiniidae	-	-	-	-	-	-
Paraonis fulgens	-	-	-	-	4	7
Pectinaria gouldii	-	-	-	8	-	15
Pholoe minuta	4	-	-	8	-	22
Phyllodoce maculata	20	8	4	32	20	154
Phyllodocidae	4	-	-	-	-	7
Polychaeta	-	-	-	4	-	7
Polycirrus sp.	-	-	-	-	-	-
Polydora sp.	-	-	-	-	-	-
Potamilla reniformis	-	-	-	-	-	-
Sabellaria vulgaris	4	-	-	-	-	7
Sabellidae	-	-	-	-	-	-
Spionidae	-	-	-	4	-	7
Stauronereis caecus	-	-	-	4	-	7
Streblospio benedicti	-	-	-	-	-	-
Syllidae	-	-	-	-	-	-
Tharyx acutus	-	-	-	12	-	22
ARTHROPODA						
Aeginina longicornis	40	12	52	32	16	279
Amphithoe rubricata	168	244	156	228	180	1,792
Amphipoda	120	208	20	116	-	852
Anoplodactylus lentus	-	-	-	4	-	7
Calliopius laeviscululus	60	228	120	244	276	1,704

Appendix 1b.(continued)

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m²)
Cancer irroratus	12	4	28	56	56	287
Cancer borealis	20	8	4	12	12	103
Caprella penantis	272	372	264	1,388	300	4,768
Caprellidae	-	-	28	64	-	169
Corophium acutum	236	268	248	292	96	2,094
Corophium bonelli	156	144	188	396	292	2,160
Crangon septemspinosa	-	-	-	-	-	-
Cytherois zostericola	-	-	-	4	-	7
Cytheridea americana	-	8	-	36	12	103
Decapoda	8	4	8	4	4	51
Dexamine thea	388	420	144	492	192	3,055
Diastylis sp.	-	-	-	-	4	7
Edotea triloba	12	16	-	4	24	103
Eualus pusiolus	4	4	4	8	-	37
Idotea phosphorea	220	436	620	232	208	3,152
Idotea balthica	8	64	72	12	88	448
Ischyrocerus anguipes	4	-	-	4	-	15
Jaera marina	-	-	-	-	-	-
Jassa falcata	416	76	364	164	68	1,998
Marinogammarus stoerensis	4	-	-	-	-	7
Ostracoda sp. 1	-	4	4	12	-	37
Ostracoda sp. 2	-	-	-	4	-	7
Ostracoda sp. 3	4	-	-	4	-	15
Ostracoda sp. 4	4	-	-	16	-	37
Oxyurostylis smithi	-	-	-	-	-	-
Pagurus longicarpus	8	8	4	4	12	66
Phoxichilidium femoratum	-	-	-	-	-	-
Phoxocephalus holbelli	-	12	-	8	4	44
Pleusymtes glaber	20	20	60	12	180	536
Polygordius sp.	12	20	-	240	68	624
Pontogeneia inermis	44	144	40	56	208	1,087
Proboloides holmesi	-	-	-	4	-	7
Protohaustorius deichamannae	-	-	-	-	-	-
ECHINODERMATA						
Amphipholis squamata	4	-	-	-	-	7
Asterias forbesi	56	56	44	60	56	500
Henricia sanguinolenta	-	-	-	-	-	-
Ophiopholis aculeata	12	16	8	-	-	66
Strongylocentrotus droehbachiensis	28	32	44	16	16	250
CHORDATA						
Colonial ascidacea	-	-	-	-	-	-
Solitary ascidacea	4	-	12	8	4	51

Appendix 1c. Replicate (total numbers of species) and station (numbers of species per m^2) faunal data for Manomet Point, August 1981.

PHYLUM Species	Replicate 1	 2	 3	 4	 5	Station (No./m^2)
COELENTERATA						
Haliclystus salpinx	-	-	8	-	-	15
Metridium senile	-	-	-	-	-	-
PLATYHELMINTHES						
Notoplana atomata	42	10	12	2	8	136
NEMERTEA						
Nemertea	4	4	12	-	4	44
Oerstedia dorsalis	-	-	8	-	-	15
MOLLUSCA						
Acmaea testudinalis	8	4	4	6	-	40
Aeolidia papillosa	-	-	-	-	-	-
Alvania areolata	-	-	-	-	-	-
Anomia simplex	4	-	4	4	-	22
Anomia aculeata	2	2	-	-	-	7
Bivalvia	-	-	-	-	8	15
Cerastoderma pinnulatum	42	8	128	22	184	705
Crepidula plana	12	2	20	8	16	107
Crepidula sp.	-	-	-	-	-	-
Diaphana minuta	4	2	4	6	-	29
Ensis directus	-	-	-	-	-	-
Gastropoda (juvenile)	-	-	-	-	-	-
Hiatella arctica	422	412	1828	682	840	7,684
Hydrobia minuta	-	-	-	-	-	-
Lacuna vincta	112	114	104	188	104	1,142
Lepidochiton ruber	-	-	8	4	-	22
Littorina littorea	-	-	-	-	-	-
Margarites umbilicalis	562	472	632	494	848	5,524
Mitrella lunata	-	-	-	-	-	-
Modiolus modiolus	-	2	-	-	-	4
Mya ar[illegible]	2	-	-	-	-	4
Mytilus edulis	5,500	2,286	8,114	2,200	6,472	45,128
Nudibrachia (juvenile)	-	20	4	12	-	66
Odostomia bartschi	8	2	12	2	-	44
Omalogyra atomus	-	-	-	-	-	-
Onchidoris aspera	310	178	260	192	328	2,329
Onoba aculea	94	44	112	74	128	830
Petricola pholadiformis	-	-	-	8	-	15
Sayella unifasciata	-	-	4	-	-	7
Siliqua costata	-	-	-	-	-	-
Skeneopsis planorbis	-	-	-	-	-	-
Tellina agilis	-	-	8	-	16	44
Turbonilla interrupta	-	-	4	6	16	48
ANNELIDA						
Ampharetidae	-	-	-	-	-	-
Amphitrite sp.	-	-	-	-	-	-
Aricidea jeffreysii	-	-	4	-	-	7

Appendix 1c .(continued)

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m²)
Asabellides oculata	2	4	8	-	8	40
Autolytus prismaticus	2	-	-	-	-	4
Capitella capitata	-	2	12	-	-	26
Capitellidae	-	-	-	4	8	22
Chaetozone sp.	-	-	-	-	4	7
Cirratulus cirratus	-	-	4	-	-	7
Cirratulus grandis	-	-	-	-	-	-
Clymenella torquata	-	-	-	-	-	-
Dodecaceria coralii	-	10	-	2	8	37
Dorvilleidae	-	-	8	-	4	22
Eteone longa	-	-	-	-	-	-
Eulalia viridis	16	4	4	12	16	114
Eumida sanguinea	-	-	4	-	-	7
Exogone hebes	-	-	-	2	-	7
Fabricia sabella	-	-	-	-	-	-
Harmothoe imbricata	60	34	32	58	64	455
Hirudinea	4	-	-	-	-	7
Lepidonotus squamatus	-	2	-	-	-	4
Maldanidae	-	-	-	2	8	19
Naineris quadricuspida	4	2	8	2	-	29
Nereis arenaceodonta	-	-	-	-	32	59
Nereis pelagica	12	18	28	18	16	169
Nereis zonata	-	-	-	-	-	-
Nereidae	-	-	-	-	-	-
Nicolea venustula	154	96	332	66	136	1,440
Oligochaeta	-	-	12	4	24	73
Orbiniidae	-	-	-	-	-	-
Paraonis fulgens	-	-	-	-	-	-
Pectinaria gouldii	-	-	-	-	-	-
Pholoe minuta	2	2	8	8	8	51
Phyllodoce maculata	10	6	48	6	48	217
Phyllodocidae	-	-	-	-	-	-
Polychaeta	-	-	-	-	-	-
Polycirrus sp.	-	4	4	-	8	29
Polydora sp.	-	-	-	-	20	37
Potamilla reniformis	-	2	-	-	-	4
Sabellaria vulgaris	-	-	-	-	-	-
Sabellidae	2	-	-	-	-	4
Spionidae	-	-	-	2	-	4
Stauronereis caecus	-	-	-	-	-	-
Streblospio benedicti	-	-	-	4	-	7
Syllidae	-	-	4	-	8	22
Tharyx acutus	-	-	-	-	-	-
ARTHROPODA						
Aeginina longicornis	178	108	36	116	120	1,025
Amphithoe rubricata	120	188	160	408	136	1,859
Amphipoda	340	136	88	320	224	2,035
Anoplodactylus lentus	-	-	-	-	-	-
Calliopius laevisculus	200	156	240	768	160	2,799

Appendix 1c. (continued)

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m^2)
Cancer irroratus	56	16	48	24	80	411
Cancer borealis	8	12	-	4	16	73
Caprella penantis	2,328	988	1,332	1,828	2,960	17,330
Caprellidae	2	-	-	-	56	107
Corophium acutum	404	524	200	568	296	3,658
Corophium bonelli	140	296	240	248	208	2,079
Crangon septemspinosa	4	-	-	-	-	7
Cytherois zostericola	-	-	-	4	-	7
Cytheridea americana	-	-	8	12	-	37
Decapoda	8	8	-	12	-	51
Dexamine thea	264	180	312	368	240	2,505
Diastylis sp.	-	-	-	-	-	-
Edotea triloba	-	-	-	-	-	-
Eualus pusiolus	26	6	8	20	24	154
Idotea phosphorea	422	346	224	394	625	3,691
Idotea balthica	28	52	-	60	16	287
Ischyrocerus anguipes	-	48	32	80	-	294
Jaera marina	-	-	-	-	-	-
Jassa falcata	432	1012	144	872	456	5,355
Marinogammarus stoerensis	-	-	-	-	-	-
Ostracoda sp. 1	-	-	8	10	8	48
Ostracoda sp. 2	-	-	-	6	-	11
Ostracoda sp. 3	-	-	-	-	-	-
Ostracoda sp. 4	2	-	4	2	-	15
Oxyurostylis smithi	-	-	-	-	-	-
Pagurus longicarpus	-	-	-	2	-	4
Phoxichilidium femoratum	-	4	-	-	-	7
Phoxocephalus holbelli	-	4	-	-	8	26
Pleusymtes glaber	692	384	472	784	640	5,458
Polygordius sp.	-	-	-	4	-	7
Pontogeneia inermis	140	132	64	120	120	1,058
Proboloides holmesi	-	8	-	16	8	59
Protohaustorius deichamannae	-	4	-	-	-	7
ECHINODERMATA						
Amphipholis squamata	34	12	16	14	32	198
Asterias forbesi	52	12	24	34	56	327
Henricia sanguinolenta	8	2	-	-	-	18
Ophiopholis aculeata	34	8	12	40	48	261
Strongylocentrotus droehbachiensis	116	20	148	66	80	790
CHORDATA						
Colonial ascidacea	8	4	-	2	8	40
Solitary ascidacea	40	12	36	50	104	444

Appendix 2a. Replicate (total numbers of species) and station (numbers of species per m^2) faunal data for Rocky Point, March 1982.

PHYLUM Species	Replicate 1	 2	 3	 4	 5	Station (No./m^2)
NEMERTEA						
Nemertea		16		4	10	55
Oerstedia dorsalis		2				4
MOLLUSCA						
Aeolidia papillosa	4					7
Anomia simplex		2		2		7
Bivalvia unid.	2					4
Cerastoderma pinnulatum		2		2		7
Crepidula plana		6	4	2	4	29
Diaphana minuta		8		2	4	26
Gastropoda unid.				4		7
Gastropoda juvenile		4				7
Hiatella arctica		10		16	10	66
Lacuna vincta	347	380	298	680	602	4286
Littorina littorea	16	14	10	6	17	116
Lunatia heros		4		10		26
Margarites umbilicalis	24	50	8	90	46	400
Mitrella lunata	44	80	24	38	18	375
Mya arenaria		2			2	7
Mytilis edulis	2244	956	3540	5280	3048	27673
Omalogyra atomus				10		18
Onchidoris aspera	6	14				37
Onoba aculea	24	94	26	116	122	702
Petricola pholadiformis	2	10	4	6	30	95
Spisula solidissima				6		11
Tellina agilis		8				15
ANNELIDA						
Cirratulis grandis	2					4
Dodecaceria coralii		2				4
Harmothoe imbricata	4	58	12	56	44	320
Minuspio sp.		4				7
Naineris quadricuspida		2				4
Nephtydae		2				4
Nephtys caeca			2		2	7
Nereis pelagica		4		4		15
Nicolea venustula	2	2	2	6	4	29
Pholoe minuta	10	20	6		14	92
Phyllodoce maculata	6	12	8	4	4	62
Polygordius sp.		2				4
ARTHROPODA						
Aeginina longicornis	6					11
Amphithoe rubricata	4	24	16	48	8	180
Amphipoda juvenile	116	32	72	56	16	536
Anoplodactylus lentus	2					4

Appendix 2a (continued).

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m²)
Calliopius laevisculus	860	468	4688	2160	92	15184
Cancer irroratus	4	20		8	8	73
Caprella penantis	562	112	318	352	222	2876
Corophium acutum	588	176	464	472	144	3387
Corophium bonelli	88	40	104	152	52	801
Cytheridea americana		2	2		14	33
Dexamine thea	328	164	376	664	252	3276
Edotea triloba				2	2	7
Eualus pusiolus		2	2			7
Idotea balthica	20	4	4	28	32	162
Idotea phosphorea	30	44	14	54	88	422
Ischyrocerus anguipes	68	28	16	48	16	323
Jassa falcata	288	84	352	176	76	1792
Leptochelia savignyi				2		4
Pagurus longicarpus		2		4		11
Phoxocephalus holbolli	8	44	8	16	48	228
Pleusymtes glaber	4	40		8	4	103
Pontogeneia inermis	168	56	368	216	32	1543
Proboloides holmesi			16			29
ECHINODERMATA						
Amphipholis squamata		2		4	2	15
Asterias forbesi		6	2		2	18
Ophiopholis aculeata	4					7
Strongylocentrotus droehbachiensis	2	8	2	8	6	48
CHORDATA						
Solitary ascidacea		6		2		15

Appendix 2b. Replicate (total numbers of species) and station (numbers of species per m^2) faunal data for Effluent, March 1982.

PHYLUM Species	Replicate 1	 2	 3	 4	 5	Station (No./m^2)
NEMERTEA						
Nemertea	5		6	4		28
Oerstedia dorsalis			2			4
MOLLUSCA						
Aeolidia papillosa	9	6	39	30	20	191
Anomia simplex		2				4
Bivalvia juvenile			2			4
Crepidula plana	2					4
Gastropoda unid.	1					2
Hiatella arctica	4		2			11
Lacuna vincta	447	564	832	1082	416	6136
Littorina littorea	73	56	28	60	104	590
Margarites umbilicalis	3	2	16	4	4	55
Mitrella lunata	12	8	2			40
Mya arenaria			2			4
Mytilis edulis	2813	5508	2196	1704	1114	24490
Omalogyra atomus	1					2
Onchidoris aspera			2			4
Onoba aculea	5	2	16			42
Petricola pholadiformis	2		4	4		18
Tellina agilis	2					4
Turbonilla sp.			2			4
ANNELIDA						
Cirratulis grandis	1		2			6
Eulalia viridis		2	2			7
Fabricia sabella	1		4			9
Harmothoe imbricata	27	6	12	22	12	145
Nereis pelagica		2	4	2	2	18
Nicolea venustula	1	2	2			9
Paraonis fulgens	1					2
Pholoe minuta		2	16	10		79
Phyllodoce maculata	1		6	2		17
Polydora socialis			36			66
Sabellaria vulgaris		2				4
ARTHROPODA						
Aeginina longicornis						
Amphithoe rubricata		8	40	32	4	154
Amphipoda juvenile	48	48	152	408	20	1242
Balanus balanoides			2		2	7
Calliopius laevisculus	756	744	56	184	196	3556
Cancer irroratus	1		2	4		13
Caprella penantis	194	416	508	486	186	3287
Carcinus maenus	5		2			13
Corophium acutum	328	440	672	1456	252	5781
Corophium bonelli	92	120	192	248	36	1264

Appendix 2b (continued).

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m^2)
Cythereis emarginata			6			11
Cytherois zostericola			4	2		11
Cytheridea americana			4	2		11
Dexamine thea	64	88	272	216	20	1212
Idotea balthica	10	14	28	18	18	162
Idotea phosphorea	16	30	108	72	34	478
Ischyrocerus anguipes	16	16	8	24		118
Jassa falcata	592	592	2736	4120	444	15581
Marinogammarus stoerensis	4					7
Pleusymtes glaber						
Pontogeneia inermis	20	40	32	40	4	250
Proboloides holmesi	12					22
ECHINODERMATA						
Amphipholis squamata	1		2	2		9
Asterias forbesi	8	10	46	52	48	164
Ophiopholis aculeata	18	4	12	2	4	40
Strongylocentrotus droehbachiensis	5	12	14	18	4	97

Appendix 2c. Replicate (total numbers of species) and station (numbers of species per m^2) faunal data for Manomet Point, March 1982.

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m^2)
NEMERTEA						
Nemertea	10	12	8	18	28	140
Oerstedia dorsalis	2	2	2	2	2	18
MOLLUSCA						
Aeolidia papillosa	12	2	4	18		66
Anomia simplex			2	6		15
Cerastoderma pinnulatum				6		11
Diaphana minuta	4		4	4	2	26
Gastropoda juvenile				2		4
Gastropoda unid.	4		2			11
Hiatella arctica	28	2	16	14	6	121
Ischnochiton ruber	4	2				11
Lacuna vincta	912	370	860	506	844	6413
Littorina littorea						
Lyonsia hyalina					2	4
Margarites umbilicalis	72	32	70	68	42	522
Mitrella lunata			4		8	22
Mytilis edulis	10468	14388	15116	14552	11980	122138
Nassarius trivittatus					2	4
Onchidoris aspera	36	14	10	44	8	206
Onoba aculea	96		64	20	50	422
Petricola pholadiformis				2	6	15
Tellina agilis	8			2	4	26
Turbonilla areolata	4					7
ANNELIDA						
Asabellides oculata	4					7
Capitella capitata		2				4
Cirratulus cirratus	4					7
Dodecaceria coralii	16					29
Eulalia viridis	4	2	2			15
Eumida sanguinea	4					7
Harmothoe imbricata	56	4	40	48	10	290
Maldanidae unid.	4					7
Nephtys caeca					2	4
Nephtys incisa	8					15
Nereis pelagica	4	10	2	2	4	40
Nicolea venustula	68	8	26	44	14	294
Oligochaeta				2	2	7
Pholoe minuta	4		6		8	33
Phyllodoce maculata			6	4	20	55
Phyllodoce groenlandica			2			4
Polydora socialis		2	2			7
Polygordius sp.	4					7
Potamilla reniformis	4				2	11

Appendix 2c (continued).

PHYLUM Species	Replicate 1	 2	 3	 4	 5	Station (No./m^2)
ARTHROPODA						
Achelia spinosa			2			4
Aeginina longicornis	4		2	14	4	44
Amphithoe rubricata	20	24	32	104	192	683
Amphipoda juvenile	48	304	144	208	88	1455
Calliopius laevisculus	48	344	200	176	168	1719
Cancer irroratus	16		2	2	8	51
Caprella penantis	732	764	648	666	450	5987
Caprellidae juvenile	4					7
Corophium acutum	680	1512	928	808	832	8732
Corophium bonelli	40	56	64	16	56	426
Cythereis emarginata			2	2		7
Cytherois zostericola			2			4
Dexamine thea	156	144	120	216	208	1550
Eualus pusiolus	4					7
Idotea balthica	4	6		6	8	44
Idotea phosphorea	52	24	10	84	48	400
Ischyrocerus anguipes	164	256	344	448	200	2593
Jassa falcata	752	1072	1264	1448	1512	11107
Phoxocephalus holbolli					8	15
Pleusymtes glaber	48	40	24	32	40	338
Pontogeneia inermis	28	56	288	16	40	786
Proboloides holmesi	28	24	64	128	8	463
ECHINODERMATA						
Amphipholis squamata			6	16	4	48
Asterias forbesi	24	10	12	22	16	154
Henricia sanguinolenta				2	2	7
Ophiopholis aculeata	8	2	6	64	4	154
Strongylocentrotus droehbachiensis	24	8	14	16	8	129
CHORDATA						
Solitary ascidacea	80	2	32	50	301	

Appendix 3. Algal species collected from the replicate samples of the Effluent, Rocky Point, and Manomet Point subtidal (10' MLW) stations for the August, 1981 collecting period.

Division	Station and Replicate														
	Effluent					Rocky Point					Manomet Point				
Species	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Chlorophyta (green algae)															
Bryopsis plumosa															
Chaetomorpha linum	O	C	C	C	C	O	O	C	O	C	R	R	A	O	O
C. melagonium	R	O	O	O	R	C	R	O	O	R	R	R	C	R	O
Enteromorpha flexuosa	R	R	R	R	R		R	R	R	R				R	R
Rhizoclonium riparium	R		R	R	R		R		R		R	R	R	R	
Ulva lactuca			R		R	C	R	R	R	R				C	C
Phaeophyta (brown algae)															
Chordaria flagelliformis															
Desmarestia aculeata	R	R	R	R		R	R	R	R	R	R	R	R	R	R
D. viridis															
Laminaria digitata		R								R		R	R		
L. saccharina	R	R		R	R		R	R	R	R	R	R	R	R	R
Sphacelaria cirrosa		R	R	R		R	R	O		R	R	R		R	
Rhodophyta (red algae)															
Ahnfeltia plicata	R	R	R	R	R	R	O	R	R	O	R	R	R	R	R
Antithamnion americanum		R		R	R	R	R	R		R	R	R	R		
Bonnemaisonia hamifera				R			R			R					R
Callophyllis cristata	R	R	R		R		R	R	R	O	R	R	R	R	R
Ceramium rubrum	O	O	O	C	O	O	O	O	O	O	O	O	C	O	O
Chondrus crispus	A	O	C	C	O	O	A	A	C	A	A	A	A	C	A
Corallina officinalis	R	R	C	O	R	O	O	O	C	R	A	C	C	C	C
Cystoclonium purpureum	R	R	R	O	R	R	R	R	R	R	O	O	O	R	R
Gracilaria foliifera	O	R	R	O	O										
Gymnogongrus crenulatus												R	R		

Appendix 3. (continued)

Division / Species	Effluent 1	2	3	4	5	Rocky Point 1	2	3	4	5	Manomet Point 1	2	3	4	5
Membranoptera alata	R	R					R	R		R	R		R	R	R
Palmaria palmata															
Phycodrys rubens	R	R	R	R		R	R	R	R	O	O	O	O	O	R
Phyllophora truncata	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
P. pseudoceranoides	O	O	O	O	O	R	O	O	O	O	O	O	O	O	O
P. traillii															
Plumaria elegans															
Polyides rotundus	R	C	R	A	A	C	A	C	O	C		C	C	O	R
Polysiphonia elongata		O	R	O	R		R	O					R		
P. fibrillosa	R			O	R	O	O	O	R	R	O	R	O	O	O
P. harveyi	R	C	O	A	C	A	C	A	A	A	C	C	C	C	C
P. nigrescens		O		R		R	R	R		R			R	R	
P. urceolata	R	R	R	R	R	R	R	R	R	R	O	O	O	R	R
Rhodomela confervoides		R	R		R	R			R		R	R			
Spermothamnion repens	O	O	O	C	C	O	O	O	R	R	O	O	C	O	R
Replicate species richness	22	26	23	25	23	21	27	25	22	26	22	24	25	24	22
Station species richness			30					29					30		

Legend: A = abundant; C = common; O = occasional; r = rare.

Appendix 4. Algal species collected from the replicate samples of the Effluent, Rocky Point, and Manomet Point subtidal (10' MLW) stations for the March, 1982 collecting period.

Division	Station and Replicate														
	Effleunt					Rocky Point					Manomet Point				
Species	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Chlorophyta (green algae)															
Bryopsis plumosa		R		R											
Chaetomorpha linum	O	O	C	C	O	C	O	R	R	O	R	C	R	O	O
C. melagonium	R	R	R	R	R	O	R	R	R	R	R	R	R	R	O
Enteromorpha flexuosa	R		R	R	R			R					R		
Rhizoclonium riparium	R	R	R			R		R	R	R	R	O	R		R
Ulva lactuca	R	R	R	R	R		R			R	R	A	R	O	R
Phaeophyta (brown algae)															
Chordaria flagelliformis			R	R			R						R		
Desmarestia aculeata				R	R	R	R	R	R	R		R	R	R	R
D. viridis		R					R	R							
Laminaria digitata	R			R		R		R		R	R		R		
L. saccharina	R	R	R		R	R	R	R		R	R	R	R	R	
Sphacelaria cirrosa	R	R	R			R	R	R	R	R	R	R	R		R
Rhodophyta (red algae)															
Ahnfeltia plicata	C	A	A	C	C	A	A	O	O	A	R	O	R	R	R
Antithamnion americanum	R					R	R	R	R		R	R	R	R	R
Bonnemaisonia hamifera			R	O		R						R			
Callophyllis cristata		R		R		R	R	R		R	R		R	R	
Ceramium rubrum	R	R	R	R	R	C	R	R	O	R	O	O	O	C	O
Chondrus crispus	C	C	O	R	R	C	C	R	R	R	A	A	C	A	A
Corallina officinalis	A	O	O	O	R	O	O	R	O	C	C	O	C	O	O
Cystoclonium purpureum	R	R	R	R	R	C	R	O	R	R	O	O	C	O	O
Gracilaria foliifera			R	R	R										
Gymnogongrus crenulatus		R				R									

Appendix 4. (continued)

Division Species	Effluent 1	2	3	4	5	Rocky Point 1	2	3	4	5	Manomet Point 1	2	3	4	5
Membranoptera alata		R					R		R		R		R	R	
Palmaria palmata															
Phycodrys rubens		R	R		R	O	R	R	R	R	O	R	R	R	R
Phyllophora truncata	C	O	O	O	O	O	C	O	O	O	O	R	O	O	O
P. pseudoceranoides	C	C	O	O	O	O	C	O	O	O	R	O	O	C	O
P. traillii														R	
Plumaria elegans															
Polyides rotundus	O	C	C	C	A	A	A	A	A	A	R	C	R	R	O
Polysiphonia elongata		O			R	R	R		R	O			R	R	
P. fibrillosa			R				R		R		R				
P. harveyi			R	R								R			
P. nigrescens		R	R	R		R		R	R	R	R			R	R
P. urceolata	R	R		R	R	R	R	R	R	R	R	R	R	R	R
Rhodomela confervoides		R			R	R		R		O			R	R	R
Spermothamnion repens	R	R	R	R	R	O	R	C	C	O	O	C	C	C	C
Replicate species richness	19	25	23	23	20	25	24	25	21	23	23	21	26	23	22
Station species richness			34					32					32		

Station and Replicate

Legend: A = abundant; C = common; O = occasional; R = rare.

NUC72-A

INVESTIGATIONS OF ENTRAINMENT OF ICHTHYOPLANKTON AT PILGRIM NUCLEAR POWER STATION JANUARY - JUNE 1982

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JANUARY - JUNE
1982 ENTRAINMENT STUDY
SUMMARY

Ichthyoplankton samples were collected from the Pilgrim Nuclear Power Station discharge canal in triplicate, twice-monthly in January and February, and weekly March through June, 1982.

Eggs and/or larvae of 36 species of fish were obtained during the period January-June 1982.

Atlantic cod (Gadus morhua) were most abundant among the eggs collected in January and February. Through March and April, Winter flounder eggs (Pseudopleuronectes americanus) were dominant and cod were second in abundance. As in 1981, from early May through June the labrids (tautog, Tautoga onitis, and cunner, Tautogolabrus adspersus), and Atlantic mackerel (Scomber scombrus) were most abundant among the eggs. Windowpane (Scophthalmus aquosus) were also abundant in late May and June.

Larval collections were dominated by sand lance (Ammodytes sp.) during the months of January through March. During part of February, March and April, rock gunnel (Pholis gunnellus) and grubby (Myoxocephalus aenaeus) were also numerous. Winter flounder (Pseudopleuronectes americanus) were common during April, dominated the larval collections in May, and were third in abundance in June. Mackerel was the most common larval species during June, with cunner second in abundance.

Several larval rainbow smelt (Osmerus mordax) were collected in the June 1982 samples. One larval lobster (Homarus americanus) was collected.

SECTION I

INTRODUCTION

This report summarizes the results of ichthyoplankton sampling conducted at the Pilgrim Nuclear Power Station (PNPS) from January through June 1982 by Marine Research, Inc., (MRI) for Boston Edison Company. MRI was also responsible for sample sorting and ichthyoplankton identification. Data analyses and report preparation were carried out by the Environmental and Radiological Health and Safety Group of Boston Edison Company's Nuclear Operations Support Department.

This report is pursuant to operational environmental monitoring and reporting requirements of NPDES Permit No. 0003557 (EPA) for Pilgrim Nuclear Power Station (PNPS), Unit I. The report describes organisms entrained at PNPS as determined by samples collected from the discharge canal.

Methods are discussed in Section II and results in Section III.

SECTION II

METHODS

The entrainment sampling plan for January-June 1982 at the PNPS specified triplicate samples to be collected twice monthly in January, February, and October - December, and weekly from March through September. All samples were collected from rigging mounted approximately 30 meters from the headwall of the discharge canal (Fig. 1) at low tide during daylight. A 0.333-mm mesh, 60-cm diameter plankton net affixed to this rigging was streamed in the canal for 6 to 15 minutes depending on the abundance of plankton and detritus. In each case, a minimum of 100 m^3 of water was sampled. Exact filtration volumes were calculated with the aid of a digital flowmeter (General Oceanics Model 2030) mounted in the mouth of the net.

All samples were preserved in 10% formalin and returned to the laboratory for microscopic analysis. All fish eggs and larvae were identified to the lowest distinguishable taxonomic category and counted (these tasks were conducted by MRI). In most cases, species were identifiable. In certain cases, however, eggs--particularly in the early stages of development--could not be identified at the species level in the preserved samples. In such cases, species were grouped. A brief description of each of these egg groupings is given below.

- Gadidae-*Glyptocephalus* group (Atlantic cod, *Gadus morhua*; haddock, *Melanogrammus aeglefinus*; pollock, *Pollachius virens*; and witch flounder, *Glyptocephalus cynoglossus*); egg diameters overlap, no oil globule present.

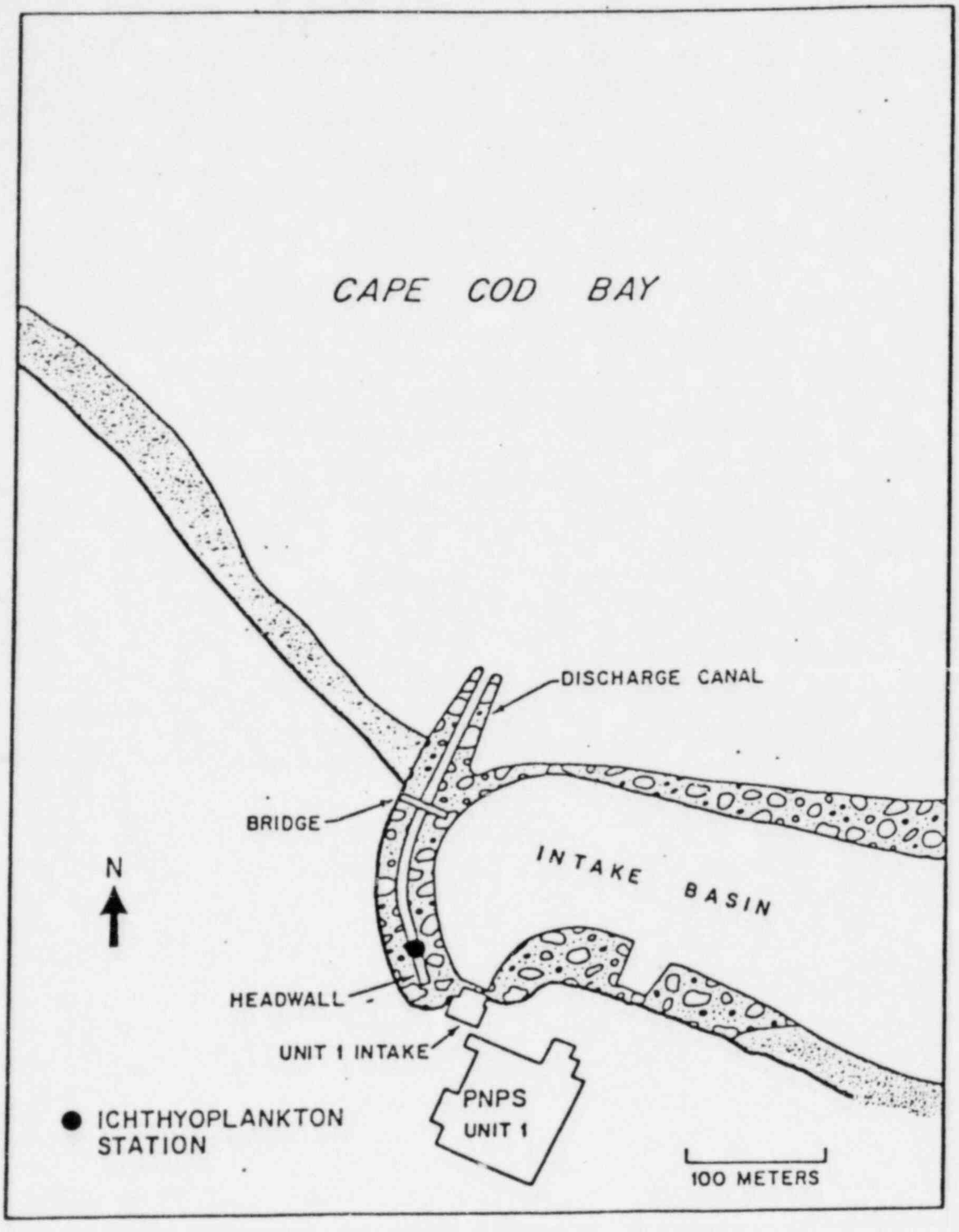

Figure 1: Entrainment sampling station in PNPS discharge canal.

Stage III eggs (those containing embryos whose tails have grown free of the yolk; Ahlstrom and Counts, 1955) are separated based on relative size and pigmentation combinations. Haddock eggs are difficult to identify until shortly before hatching (late stage III). Because of this, some early stage III haddock eggs may have been identified as cod eggs. This error should be quite small judging from the relatively low numbers of late stage III haddock eggs and haddock larvae collected during recent years. The gadidae-Glyptocephalus grouping was not necessary in January and February because it is unlikely that witch flounder spawn during these months, and haddock spawning is not likely to occur in January. We assumed haddock eggs were absent in February. All eggs of the gadidae-Glyptocephalus type were therefore classified as either cod or pollock based on differing egg diameters.

- Brosme-Scomber group (cusk, Brosme brosme, and Atlantic mackerel, Scomber scombrus): egg and oil globule diameters overlap. Differences in pigmentation permit separation of stage II (early embryo) and stage III eggs.

- Enchelyopus-Urophycis-Peprilus group (fourbeard rockling, Enchelyopus cimbrius; hake, Urophycis spp.; and butterfish, Peprilus triancathus): egg and oil globule diameters overlap. Stage III eggs are separated based on differences in embryonic pigmentation.

- Merluccius-Stenotomus-Cynoscion group (silver hake, Merluccius bilinearis; scup, Stenotomus chyrysops; and weakfish, Cynoscion regalis): egg and oil globule diameters overlap. Stage III eggs are separated into silver hake and scup-weakfish based on differences in embryonic pigmentation. Scup and weakfish eggs, which have rarely been taken, remain grouped throughout their development because differences in embryonic pigmentation are subtle and not clearly understood.

- Labridae-Limanda group (tautog, Tautoga onitis; cunner, Tautogolabrus adspersus; and yellowtail flounder, Limanda ferruginea): no oil globule present, egg diameters overlap. Stage III eggs are separated into labridae and yellowtail flounder based on differences in embryonic pigmentation. A high percentage of the two species of labrid eggs are distinguishable, but only with individual, time-consuming measurement (Marine Research, 1977a). Labrid eggs are therefore grouped in all three stages of development in the 1982 samples.

- Paralichthys-Scophthalmus group (fourspot flounder, Paralichthys oblongus, and windowpane, Scophthalmus aquosus): oil globule and egg diameters as well as pigmentation are quite similar. Separation of these two species, even at stage III, remains uncertain. They are therefore grouped in all cases.

Eggs of the bay anchovy (Anchoa mitchilli) and striped anchovy (Anchoa hepsetus) are easily distinguishable, but their larvae are not. Eggs of these fishes were therefore listed by species while the larvae are listed simply as Anchoa spp.

Seveial other groups of eggs and larvae were not identified to the species level because adequate descriptions of each species are not available at this time. These groupings are as follows:

- Urophycis spp. - consists of the red hake (U. chuss), the spotted hake (U. regius), and the white hake (U. tenuis). Most larvae (and eggs) in this genus collected at PNPS are probably the red hake (see summary in Hardy 1978).

- Menidia spp. - consists of the tidewater silverside (M. beryllina) and Atlantic silverside (M. menidia). Atlantic silverside larvae are probably more likely to occur as far north as Plymouth based on their more northern distribution.

- Ammodytes sp. - No species designation was given the sand lance because considerable taxonomic confusion exists in the literature (see for example Richards et al. 1963; Scott 1968, 1972; Winters 1970). Meyer et al. (1979) examined adults collected on Stellwagen Bank and classified them as A. americanus (= A. hexapterus). This population is probably the source of larvae entrained at PNPS.

- Prionotus spp. - consists of the northern seaobin (P. carolinus) and the striped searobin (P. evolans).

- Liparis spp. - generally we are now separting Liparis spp. Most of these are L. atlanticus or L. Coheni. They can also include striped seasnail

(L. liparis). Most of those collected at PNPS are probably L. atlanticus based on an identification by K. W. Able (personal communication, July 1978).

Because of particular interest in rainbow smelt (Osmerus mordax), cunner, and winter flounder (Pseudopleuronectes americanus), larvae of these species were classified into three or four arbitrary developmental stages. These stages and corresponding length ranges are given below.

Rainbow smelt

Stage I - From hatching until the yolk sac is fully absorbed (5-7 mm TL).
Stage II - From the end of stage I until dorsal fin rays become visible (6-12 mm TL).
Stage III - From the end of stage II onward (11.5-20 mm TL).

Cunner

Definitions of developmental stages are the same as for smelt larvae. Observed size ranges for each stage are: stage I, 1.6-2.6 mm TL; stage II, 1.8-6.0 mm TL; stage III, 6.5-14 mm TL.

Winter flounder

Stage I - From hatching until the yolk sac is fully absorbed (2.3-2.8 mm TL).
Stage II - From the end of stage I until a loop or coil forms in the gut (2.6-4 mm TL).

Stage III - From the end of stage II until the left eye migrates past the midline of the head during transformation (3.5-8 mm TL).

Stage IV - From the end of stage III onward (7.3-8.2 mm TL).

In most cases, entire samples were examined for fish larvae and the less common types of fish eggs. When a particular species was especially abundant, aliquot subsamples were taken. Such subsamples contained 100 or more specimens of a given species or grouping. Unpublished studies by Marine Research have indicated that subsampling error can be maintained at a low level if the number of specimens in an aliquot increases as the fraction represented by the aliquot grows smaller, e.g., 100 larvae are sufficient in a one-half split, but 200 should be present in a one-quarter split.

SECTION III

RESULTS

A. Ichthyoplankton Entrained

Population densities, per 100 m^3 of water, listed by date, station, and replicate for all samples collected from January-June 1981 are presented in the Appendix (available upon request). The occurrence of eggs and larvae of each species by month is summarized in Table 1. The occurrence of eggs and larvae over the period 1974-1981 and January-June 1982 are shown in Table 2. Table 3 lists the mean monthly densities of the numerically dominant fish eggs and larvae at PNPS for the period 1975-1981 and January-June 1982.

The ichthyoplankton collected may be summarized as follows:

January: Cod eggs (Gadus morhua) represented 100% of the egg catch with mean densities for the two sampling days of 0.4 and 0.6 per 100 m^3.

Five species of fishes were represented in the January larval collections. Sand lance composed 54% of the catch, with a monthly mean density of 0.6 larvae per 100 m^3. The other species, each of which represented about 12% of the total catch were rock gunnel (Pholis gunnellus), and Atlantic herring (Clupea harengus harengus).

February: Five species of fish were collected, one species as eggs and four as larvae. Cod were again abundant among the eggs with a mean density of 0.1 per 100 m^3 accounting for about 100% of the egg catch. Winter flounder eggs were not found as they usually are at this time of year. As in 1981, larval collections were dominated by sand lance and rock gunnel with mean densities over the month of 2.7 and 0.5 per 100 m^3 of water, respectively; these two species accounting for 78.5% and 15.6%, respectively, all larvae collected. The grubby (Myoxocephalus aenaeus) and tomcod (Microgadus tomcod) together represented 5.9% of larvae collected.

March: The species count rose to 11 during the month. Two species were represented by eggs - cod, and winter flounder (Pseudopleuronectes americanus). Winter flounder was 69% of the egg catch and cod eggs were identified as Gadus morhua, not merely as part of the gadid - Glytocephalus grouping, and represented about 31% of the egg catch.

Ten species of fish were represented by larvae in March. Sand lance accounted for 79% of the month's catch with a monthly mean density per 100 m^3 of water of 190.0. Grubby and rock gunnel larvae composed an additional 18.3% of the month's larval catch. Their monthly mean densities were 25.2 and 18.7 per 100 m^3, respectively. Also the longhorn sculpin and fourbeard rockling were each found in all 3 collection dates.

Three species of Myoxocephalus were identified. Other species represented included the wrymouth, Cryptacanthodes maculatus, and tomcod.

April: Twenty-two species were taken during the month, seven of these represented by eggs. Winter flounder were most abundant. Cod eggs were second most abundant. American plaice (Hippoglossoides platessoides) and yellowtail flounder (Limanda ferruginea) each composed just over 3% of the egg catch. Fourbeard rocking (Enchelyopus cimbrius) and windowpane (Scopthalmus aquosus) made up the rest of the catch.

Larvae representing 17 species, as opposed to 14 in April 1981 collections, were found. Sand lance dropped to second place instead of dominating the catch as in January, February, and March with a mean density over the month of 54.1 larvae per 100 m^3 of water accounting for 29% of the month's catch. Grubby were the most abundant, representing 48% of the catch, and rock gunnel accounted for an additional 18% of the catch. Maximum weekly mean densities for the grubby and rock gunnel were 167.2 and 74.8 per 100 m^3, respectively.

May: Of the 19 species of fish collected in the May ichthyoplankton samples, 11 were represented by eggs. Brosme-scomber eggs accounted for 58% of the egg total, becoming most abundant in the second half of May. The labrid-Limanda eggs were second in abundance. Over the month, weekly mean densities for the Brosme-scomber grouping ranged from 4.3 per 100 m^3 on May 4 to 151.4 per 100 m^3 on May 25. Mackerel eggs were third in order of abundance at 6%, even apart from the Brosme-Scomber egg grouping. The Brosme-Scomber grouping combined with mackerel eggs accounted for 64% of the egg catch with a mean density calculated over the month of 146 eggs per 100 m^3. In May 1981, the labrid-Limanda egg grouping was dominant.

Sixteen species of fish larvae were taken in the May samples. Winter flounder, sand lance, radiated shanny, and seasnail dominated the catch accounting for 92% of the total. This was similar to 1981 with the addition of sand lance. Weekly larval winter flounder densities ranged from 1.3 to 49.3 per 100 m^3. Sand lance, continued to be a dominant species as it was from January-April. Sand lance were represented by 23.6, 78.7, 3.7, 9.5 and 0.2 larvae per 100 m^3 per week in May. Fourbeard rockling, American plaice, sculpin and Atlantic mackerel accounted for an additional 5% of the larval catch. No rainbow smelt (*Osmerus mordax*) larvae were found as in May 1981. A second species of *Liparis*, *L. coheni* was found in very low densities.

June: The species count reached 21 in June. Labrid eggs clearly dominated among the 13 species of eggs collected, assuming they dominated the labrid-Limanda group.* Combined with the grouped eggs they composed 88.2% of the June egg total with weekly mean densities averaging 1763 per 100 m^3 of water. Atlantic mackerel, the Paralichthys-Scophthalmus and Enchelyopus-Urophycis-Peprilus egg groupings accounted for 9.3% of the remaining eggs. Within these two groups fourspot flounder and butterfish were probably comparatively uncommon, judging by no larvae for these species being collected in June.

Fifteen species of fishes were represented by larvae. Atlantic mackerel accounted for 41% of the larvae. Cunner and tautog accounted for 27.3% of the larval densities with monthly mean densities of 6.5 and 3.2 per 100 m^3 of water, respectively. Winter flounder were third in abundance representing 10.5% of the larvae catch. Atlantic menhaden (Brevoortia tyrannus) represented 0.1% of the catch with a mean density of 0.3 larvae per 100 m^3 of water. Osmerus mordax (Rainbow smelt) had a mean density for the month of 1.2 per 100 m^3 and represented 3.3% of the catch. Sandlance were absent from collections as eggs or larvae.

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*During the month of June, yellowtail flounder stage III eggs averaged 2.7 per 100 m^3 of water, respectively. These figures are quite low relative to the densities of stage III labrid eggs, and cunner and tautog larvae. Therefore the vast majority of labrid - Limanda eggs are assumed to be labrid eggs during June.

Table 2 summarizes by year all species by eggs and larvae collected in the PNPS discharge canal from 1974-1981 and January-June 1982. Monthly mean densities for the numerically dominant species of eggs and larvae taken in January-June 1982 are summarized in Table 3. Similar data for 1975 through 1979 were also tabulated for comparison after being standardized as follows:

1. Only 0.333-mm mesh net data were used in those cases (1975) when field sampling was carried out using both 0.333 and 0.505 mesh nets.

2. When, as in 1976 and 1977, 24-hour sampling series were conducted, the samples taken nearest the time of daylight low tide were selected for comparison, since this conforms to the routine specification for the time of entrainment sampling.

3. For the same reason only daylight low tide data were used when, in 1975, samples were also taken at high tide and/or at night.

4. Cod and pollock egg densities were summed to make up the category "gadidae" since these eggs, which are listed separately in recent reports, were not distinguished in earlier ones.

5. Sculpin larvae were identified to species beginning in 1979 following Khan (1971). They appear as Myoxocephalus spp. in Table 3 for comparison with past years.

Although samples were in fact taken once in April 1976 and once in March 1977, comparisons with other years when sampling was weekly are not valid and consequently do not appear in the Table. Data collected in 1974 were not included because samples were not collected at low tide in all cases. Mean larval densities are summarized in Table 3. As indicated in Table 3, ichthyoplankton densities recorded in 1980 do not appear unusual. In each case, densities fell within the level of variation observed over the previous four years. Several of the observed densities are of general interest.

Larval rainbow smelt have been of special interest at PNPS because, being freshwater spawners, their presence in the discharge waters of the plant may indicate that at least some of the plant's cooling water is coastal in origin. Table 4 summarizes the densities of larval smelt entrained at PNPS in April and May (the months when they are most common) 1974-1982. Smelt larvae were collected in June in 1982. Smelt were relatively abundant only in 1974 and 1977, which suggested (MRI 1978) that their presence in the discharge may result from periods of high freshwater runoff which flushes larvae from the streams in which they were spawned. Table 5 tabulates USGS discharge data for the Jones River in Kingston, Massachusetts for the months of April and May. The Jones River is a well known smelt spawning area (Lawton et al. 1979) which drains into Kingston Bay north of PNPS. Flow rates were higher in 1974 and 1977 than in 1975 and 1976. However, the data from 1978 - 1980 appear to be inconsistent, i.e., flow rates were relatively high in 1978-79 and relatively low in 1980 while larval smelt densities for all 3 years were low. Flows were relatively very low in 1981. The 1979 smelt population study in the Jones River (Lawton, 1980) reported very high egg densities, much above optimal numbers, which adversely affected egg survival to hatching.

The low smelt larvae numbers at PNPS from 1978 - 1981 may also reflect sampling error, i.e., with only three samples taken per week there is a high probability of missing a pulse of larvae flushed from the Jones River. The numbers of smelt larvae were relatively higher in 1982, but flow rates from the Jones River are not yet available.

B. Lobster Larvae Entrained

In the period January-June 1982, one lobster larva (*Homarus americanus*) was collected in June. It was a stage I larva. This compares with past years as follows:

1981: 1 larva - 1 stage IV
1980: none found.
1979: . larva - 1 stage I on July 14.
1978: none found.
1977: 3 larvae - 1 stage I on June 10; 2 stage I on June 17.
1976: 2 larvae - 1 stage I on July 22; 1 stage IV-V on August 5.
1975: 1 larva - 1 stage I, date unknown.
1974: none found.

The lobster larvae collected in 1976 were obtained during a more intensive lobster larvae program which employed a 1 meter net, collecting relatively large sample volumes, in addition to the standard 60-cm plankton net (MRI 1977b). Both larvae taken in 1976 were collected in the meter net; none were found in the routine ichthyoplankton samples.

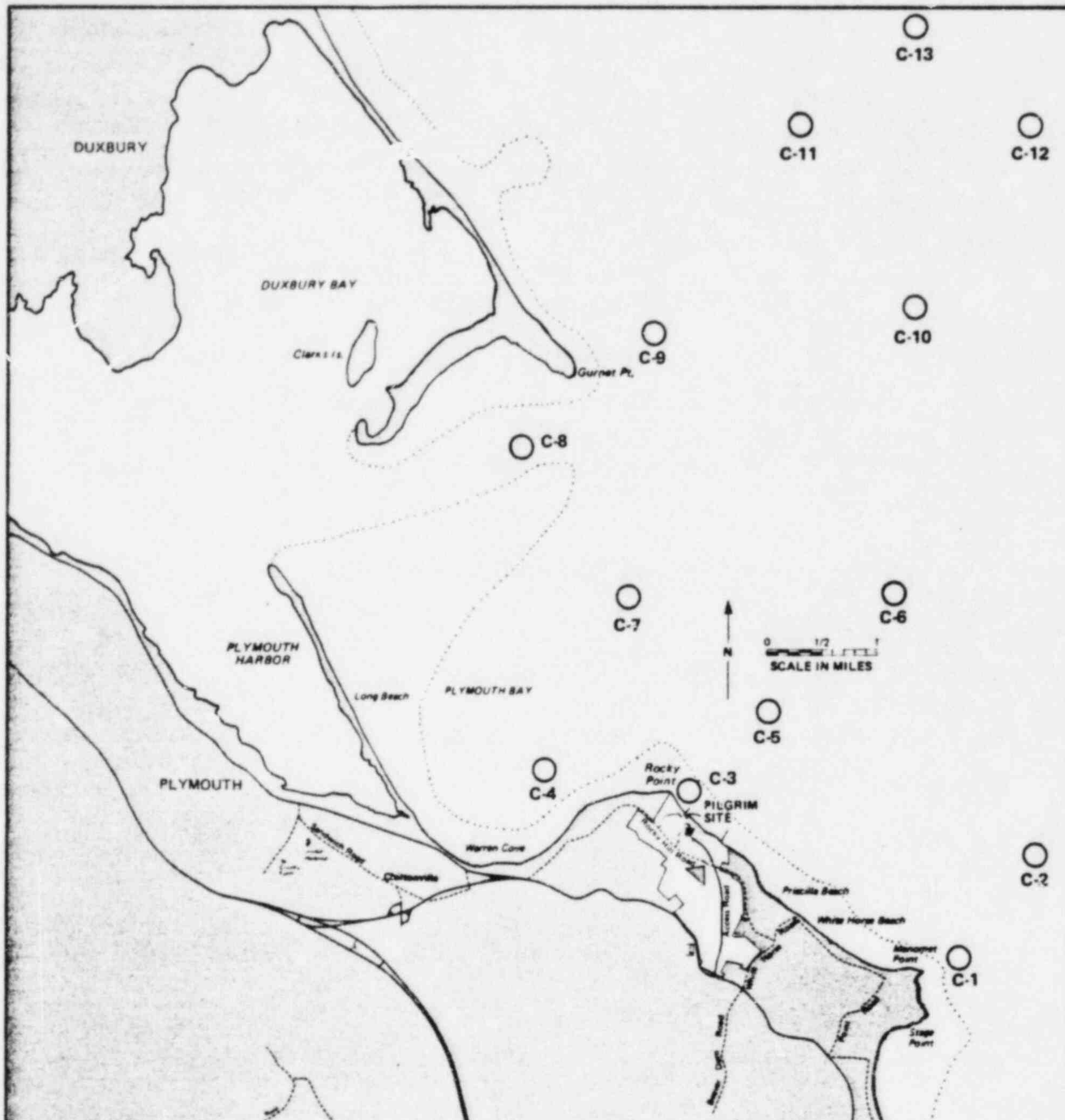


Figure 2. Location of Entrainment Contingency Plan Sampling Stations, C.

C. Contingency Sampling Plan Notification

Since the Cape Cod Bay ichthyoplankton surveys stopped in 1976, the entrainment monitoring program has always included a special contingency sampling plan (Fig. 2). This plan was designed to be implemented if the eggs or larvae of any species appear in unusually large numbers in the discharge canal when compared with previous years. For the 1982 entrainment program, as in 1981, we attempted to quantify "unusually large" by defining it as any mean density (per 100 m^3 of water) which is 50% greater than the highest mean density recorded on or near that date over the past five years (1976-1981) as recorded in previous entrainment reports. BECo. was notified by MRI three times in January-June 1982 of the occurrence of unusually large numbers. One such occurrence in April resulted in 1 extra daily set of entrainment samples being taken, until numbers returned to acceptable ranges. No bay contingency program had to be carried out.

A difficulty in attempting to use this "50% greater" approach with ichthyoplankton is related to its patchiness. A large mass of eggs, for example, may be entrained by chance, but this may not be a true indication of unusually large numbers of organisms being generally available in Cape Cod Bay and subject to entrainment.

SECTION IV

CONCLUSIONS

Fish eggs and larval densities from the PNPS entrainment collections for the period January - June 1982 fell within the level of variation observed during this period over the previous four years. The numbers entrained were not large enough to require the Cape Cod Bay contingency sampling program to be implemented.

The frequency of occurrence and levels of abundance of species represented by eggs and larvae in January - June 1982 were very similar to this period in 1981.

Table 1: Species of fish eggs (E) and larvae (L) obtained in ichthyoplankton collections from the Pilgrim Nuclear Power Station discharge canal, January-June, 1982.

Species		Jan	Feb	Mar	Apr	May	Jun
Atlantic menhaden	Brevoortia tyrannus						E/L
Atlantic herring	Clupea harengus harengus	L		L	L	L	
Anchovy	Anchoa spp.						E
Rainbow Smelt	Osmerus mordax				L		L
Goosefish	Lophius americanus						E
Cusk	Brosme brosme					E	E
Fourbeard rockling	Enchelyopus cimbrius				E	E/L	E/L
Atlantic cod	Gadus morhua	E	E	E	E/L	E/L	E/L
Atlantic Tomcod	Microgadus tomcod		L	L	L		
Silver hake	Merluccius bilinearis					E	E
Hakes	Urophycis spp.						E
Northern pipefish	Syngnathus fuscus						J*
Wrasses	Labridae					E	E
Tautog	Tautoga onitis						L
Cunner	Tautogolabrus adspersus						L

*J = Juvenile

Table 1 (Continued).

Species		Jan	Feb	Mar	Apr	May	Jun
Radiated shanny	*Ulvaria subbifurcata*				L	L	L
Rock gunnel	*Pholis gunnellus*	L	L	L	L	L	
Sand lance	*Ammodytes* sp.	L	L	L	L	L	
Wrymouth	*Cryptacanthodes maculatus*			L	L		
Atlantic mackerel	*Scomber scombrus*					E/L	E/L
Butterfish	*Peprilus triacanthus*					E	
Searobin	*Prionotus* spp.						E
Lumpfish	*Cyclopterus lumpus*						L
Grubby	*Myoxocephalus aenaeus*	L	L	L	L	L	L
Longhorn sculpin	*Myoxocephalus octodecimspinosus*			L		L	
Shorthorn sculpin	*Myoxocephalus scorpius*			L			
Alligatorfish	*Aspidophoroides monopterygius*				L		
Seasnail	*Liparis atlanticus*			L		L	L
	Liparis cohenus				L	L	
Fourspot flounder	*Paralichthys oblongus*					E	
Windowpane	*Scophthalmus aquosus*				E	L	L
Witch flounder	*Glyptocephalus cynoglossus*				E	E	E/L
American plaice	*Hippoglossoides platessoides*				E/L	E/L	
Yellowtail flounder	*Limanda ferruginea*				E	E/L	E/L
Winter flounder	*Pseudopleuronectes americanus*	L		E	E/L	E/L	L
Smooth flounder	*Liopsetta putnami*				L		

Table 2: Species of fish eggs (E) and larvae (L) collected in the PNPS discharge canal from 1974-1981, and January-June, 1982.

Species		1974	1975	1976	1977	1978	1979	1980	1981	1982
American eel	*Anguilla rostrata*	J*	J	J	J		J	J		
Alewife/blueback herring	*Alosa* spp.	L		L	L	J	L			
Atlantic menhaden	*Brevoortia tyrannus*	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L
Atlantic herring	*Clupea harengus harengus*	L	L	L	L	L	L	L	L	L
Anchovy	*Anchoa* spp.	L	L		L	L	L		E/L	E
Bay anchovy	*Anchoa mitchilli*				E	E	E			
Rainbow smelt	*Osmerus mordax*	E/L	L	L	L	L	L	-	E/L	L
Goosefish	*Lophius americanus*	E/L	E/L	E	E/L	E/L	E/L	L	E/L	E
Cusk	*Brosme brosme*	E	E/L	E/L	E/L		E/L	E/L	E	E
Fourbeard rockling	*Enchelyopus cimbrius*	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L
Atlantic cod	*Gadus morhua*	L	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L
Haddock	*Melanogrammus aeglefinus*	L	L	E/L	E/L	E/L	L			
Silver hake	*Merluccius bilinearis*	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E
Atlantic tomcod	*Microgadus tomcod*				L	L		L	L	L
Pollock	*Pollachius virens*	L	E/L	E/L	E	E/L	E/L	E/L	L	
Hakes	*Urophycis* spp.	E/L	E/L	E/L	E/L	E	E/L	E/L	E/L	E

*J = Juvenile

Table 2: (Continued).

	Species	1974	1975	1976	1977	1978	1979	1980	1981	1982
Cusk-eels/Eelpouts	Ophidiidae-Zoarcidae		L							
Atlantic needlefish	*Strongylura marina*				L				L	
Killifish	*Fundulus* spp.			E	E					
Mummichog	*Fundulus heteroclitus*						E			
Striped killifish	*F. majalis*						J			
Silversides	*Menidia* spp.			L	L	L	L	E/L	E/L	
Atlantic silverside	*Menidia menidia*	L	E/L	E/L	E					
Northern pipefish	*Syngnathus fuscus*	J*	J	J	J	J	J	J	J	J
Black sea bass	*Centropristis striata*		L					L		
Weakfish	*Cynoscion regalis*							L		
Scup	*Stenotomus chrysops*		L		L					
Northern kingfish	*Menticirrhus saxatilis*	E	L				L			
Wrasses	Labridae	E	E	E	E	E	E	E	E	E
Tautog	*Tautoga onitis*	L	L	L	L	L	L	L	L	L
Cunner	*Tautogolabrus adspersus*	L	L	L	L	L	L	L	L	L
Snakeblenny	*Lumpenus lumpretaeformis*	L	L						L	
Radiated shanny	*Ulvaria subbifurcata*	L	L	L	L	L	L	L	L	L

*J = Juvenile

Table 2: (Continued).

	Species	1974	1975	1976	1977	1978	1979	1980	1981	1982
Rock gunnel	Pholis gunnellus	L	L	L	L	L	L	L	L	L
Wrymouth	Cryptacanthodes maculatus	L				L	L		L	L
Sand lance	Ammodytes sp.	L	L	L	L	L	E/L	L	L	L
Seaboard goby	Gobiosoma ginsburgi		L		L					
Atlantic mackerel	Scomber scombrus	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L
Butterfish	Peprilus triacanthus	E/L	E/L	E/L	E	E	E/L	E/L	L	E
Searobins	Prionotus spp.	E/L	E/L	E		E	E	E/L	E/L	E
Sculpin	Myoxocephalus spp.	L	L	L	L	L	L	L	L	L
Alligatorfish	Aspidophoroides monopterygius						L		L	
Lumpfish	Cyclopterus lumpus	L		L	L				L	L
Seasnail	Liparis atlanticus	L	L	L	L	L	L	L	L	L
	Liparis cohenus									L
Smallmouth flounder	Etropus microstomus		L							
Summer flounder	Paralichthys dentatus	E/L	E/L							
Fourspot flounder	P. oblongus	E/L		E/L	E/L		L	E/L	E/L	E
Windowpane	Scophthalmus aquosus	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L
Witch flounder	Glyptocephalus cynoglossus	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L

Table 2: (Continued).

Species		1974	1975	1976	1977	1978	1979	1980	1981	1982
American plaice	Hippoglossoides platessoides	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L
Yellowtail flounder	Limanda ferruginea	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L	E/L
Winter flounder	Pseudopleuronectes americanus	E/L	E/L	L	E/L	E/L	E/L	E/L	E/L	E/L
Hogchoker	Trinectes maculatus				E	E			E	
Northern puffer	Sphoeroides maculatus				L					
Smooth Flounder	Liopsetta putnami								L	L

Table 3: Mean monthly densities of the numerically dominant fish eggs and larvae entrained at the Pilgrim Nuclear Power Station, January-December, 1975-1981 and January-June, 1982. The total column represents the total for <u>all</u> species collected by month. See text for details.

Format: Mean / Range

	JANUARY 1975	1976	1977	1978	1979
EGGS					
Gadidae-*Glyptocephalus*	-			-	-
Gadidae*	0.5 0 - 1			0.2 0 - 0.7	2.2 0 - 5
Enchelyopus-*Urophycis*-*Peprilus*	-			-	-
*Enchelyopus cimbrius***	0.1 0 - 0.6			0	0
Urophycis spp.	0			0	0
Labridae-*Limanda*	0			0	0
Labridae	0			0	0
Scomber scombrus	0			0	0
Paralichthys-*Scophthalmus*	0			0	0
Total	0.6 0 - 1			0.2 0 - 0.7	2.7 0 - 5
LARVAE					
Clupea harengus harengus	0.2 0 - 0.6			0	0
Enchelyopus cimbrius	0			0	0
Tautogolabrus adspersus	0			0	0
Ulvaria subbifurcata	0			0	0
Pholis gunnellus	0.7 0 - 3			5.1 2 - 9	1.0 0 - 5
Ammodytes sp.	6.7 0 - 18			1.4 0 - 4	4.8 0 - 11
Scomber scombrus	0			0	0
Myoxocephalus spp.	1.4 0 - 6			0.3 0 - 1	0.5 0 - 1
Liparis spp.	0			0	0
Pseudopleuronectes americanus	0			0	0
Total	9.4 0 - 25			7.4 3 - 13	8.1 0 - 12

*Represents all three egg stages from January through February.
**Represents all three egg stages from January through March.

Table 3: (Continued) Format: Mean / Range

	JANUARY 1980	JANUARY 1981	JANUARY 1982
EGGS			
Gadidae-Glyptocephalus	-	0	0
Gadidus morhua	2.8 0.3-6.2	3.4 2.2-9.1	0.5 0-1.2
Enchelyopus-Urophycis-Peprilus	-	0	0
Enchelyopus cimbrius**	0	0	0
Urophycis spp.	0	0	0
Labridae-Limanda	0	0	0
Labridae	0	0	0
Scomber scombrus	0	0	0
Paralichthys-Scophthalmus	0	0	0
Total	2.8 0.3-6.2	3.4 0.8-9.1	1.1 0-1.20
LARVAE			
Clupea harengus harengus	0	0.1 0 - 0.4	0.1 0-0.6
Enchelyopus cimbrius	0	0	0
Tautogolabrus adspersus	0	0	0
Ulvaria subbifurcata	0	0	0
Pholis gunnellus	.3 0-1.2	0.06 0-0.4	0.1 0-.6
Ammodytes sp.	16 0.-38.4	1.6 2.3-4.8	0.6 0-1.2
Scomber scombrus	0	0	0
Myoxocephalus spp.	.3 0-0.6	0	0.3 0-1.2
Liparis spp.	0	0	0
Pseudopleuronectes americanus	0	0	0
Total	17.0 0-39.0	1.8 0-4.8	1.1 0-2.43

**Represents all three egg stages from January through March.

Table 3 (Continued).

Format: Mean / Range

	FEBRUARY 1975	1976	1977	1978	1979
EGGS					
Gadidae-*Glyptocephalus*	-			-	-
Gadidae*	0.9 / 0 - 3			2.4 / 0 - 5	1.6 / 0 - 3
Enchelyopus-*Urophycis*-*Peprilus*	-			-	-
*Enchelyopus cimbrius***	0			0	0
Urophycis spp.	0			0	0
Labridae-*Limanda*	0			0	0
Labridae	0			0	0
Scomber scombrus	0			0	0
Parlichthys-*Scophthalmus*	0			0	0
Total	1.0 / 0 - 3			2.5 / 0 - 5	1.6 / 0 - 3
LARVAE					
Clupea harengus harengus	0.1 / 0 - 0.5			0.6 / 0 - 2	0
Enchelyopus cimbrius	0			0	0
Tautogolabrus adspersus	0			0	0
Ulvaria subbifurcata	0			0	0
Pholis gunnellus	3.7 / 0 - 14			1.2 / 0 - 3	2.9 / 0 - 10
Ammodytes sp.	2.1 / 0 - 8			8.8 / 0.6 - 24	11.1 / 4 - 21
Scomber scombrus	0			0	0
Myoxocephalus spp.	2.2 / 0 - 7			0.2 / 0 - 1	6.6 / 0 - 26
Liparis spp.	0			0	0
Pseudopleuronectes americanus	0			0	0
Total	10.8 / 0 - 17			11.0 / 0.8 - 29	20.9 / 4 - 58

*Represents all three egg stages from January through February.
**Represents all three egg states from January through March.

Table 3: (Continued) Format: Mean / Range

	FEBRUARY 1980	FEBRUARY 1981	FEBRUARY 1982
EGGS			
Gadidae-*Glyptocephalus*	-	0	0
Gadidae*	1.5 / 0.3-2.9	1.1 / 0-2.5	0.1 / 0-0.6
Enchelyopus-*Urophycis*-*Peprilus*	-	0	0
*Enchelyopus cimbrius***	0	0	0
Urophycis spp.	0	0	0
Labridae-*Limanda*	0	0	0
Labridae	0	0	0
Scomber scombrus	0	0	0
Paralichthys-*Scophthalmus*	0	0	0
Total	1.8 / 0.8-2.9	3.5 / 0-13.0	0.1 / 0-1.2
LARVAE			
Clupea harengus harengus	0	0	0
Enchelyopus cimbrius	0	0	0
Tautogolabrus adspersus	0	0	0
Ulvaria subbifurcata	0	0.1 / 0-.4	0
Pholis gunnellus	0.6 / 0-1.6	2.1 / 3.7-4.6	0.5 / 0-2.6
Ammodytes sp.	3.1 / 0.4-7.6	10.2 / 2.6-15.7	2.7 / 0-9.1
Scomber scombrus	0	0	0
Myoxocephalus spp.	1.9 / 0-4.7	0	0.1 / 0-0.6
Liparis spp.	0	0	0
Pseudopleuronectes americanus	0	0	0
Total	5.9 / 1.5-9.7	14.8 / 2.6-24.1	3.5 / 0-23.4

*Represents all three egg stages from January through February.
**Represents all three egg stages from January through March.

Table 3 (Continued). Format: Mean / Range

	MARCH				
	1975	1976	1977+	1978	1979
EGGS					
Gadidae-Glyptocephalus	0.6 / 0 - 2			1.5 / 0 - 3	9.2 / 0 - 32
Gadidus morhua	0.8 / 0 - 3			0.5 / 0 - 1	0.5 / 0 - 3
Enchelyopus-Urophycis-Peprilus	-			-	-
Enchelyopus cimbrius**	0			0	0
Urophycis spp.	0			0	0
Labridae-Limanda	0			0	0
Labridae	0			0	0
Scomber scombrus	0			0	0
Parlichthys-Scophthalmus	0			0	0
Total	9.7 / 0.8 - 41			2.8 / 0 - 5	12.1 / 0.4 - 35
LARVAE					
Clupea harengus harengus	0.8 / 0 - 2			0	0.4 / 0 - 1
Enchelyopus cimbrius	0			0	0
Tautogolabrus adspersus	0			0	0
Ulvaria subbifurcata	0			0	0
Pholis gunnellus	34.0 / 26 - 47			11.2 / 0.7 - 28	9.3 / 1 - 34
Ammodytes sp.	29.5 / 11 - 60			11.1 / 0.7 - 22	54.0 / 9 - 228
Scomber scombrus	0			0	0
Myoxocephalus spp.	61.4 / 17 - 137			32.8 / 11 - 65	12.3 / 1 - 35
Liparis spp.	0.5 / 0 - 1			0	0.4 / 0 - 4
Pseudopleuronectes americanus	0			0	0.03 / 0 - 0.5
Total	127.5 / 66 - 236			55.7 / 26 - 96	76.8 / 11 - 293

*Represents all three egg stages from January through February.
**Represents all three egg states from January through March.
+A single set of samples was taken in 1977. These data were not included in this comparison because weekly data sets were available in 1975, 1978, 1979, 1980 and 1981.

Table 3: (Continued)

Format: Mean / Range

	MARCH 1980	1981	1982
EGGS			
Gadidae-Glyptocephalus	.3 / 0-1.7	0	0
Gadidus morhua	.8 / 0-.5	1.5 / 0-8.5	0.4 / 0-1.8
Enchelyopus-Urophycis-Peprilus	-	0	0
Enchelyopus cimbrius**	0	0	0
Urophycis spp.	0	0	0
Labridae-Limanda	0	0	0
Labridae	0	0	0
Scomber scombrus	0	0	0
Paralichthys-Scophthalmus	0	0	0
Total	1.9 / 0-12	6.9 / 0.5-20.1	1.3 / 0-8.9
LARVAE			
Clupea harengus harengus	0.1 / 0-1.9	2.4 / 0-8.4	0.3 / 0-1.8
Enchelyopus cimbrius	0	0	0
Tautogolabrus adspersus	0	0	0
Ulvaria subbifurcata	0	0.1 / 0-.5	0
Pholis gunnellus	22.5 / 0-80.5	23.7 / 1-62.4	18.7 / 17.8-34.2
Ammodytes sp.	43 / 1-153	35.5 / 9.6-78.6	190.0 / 0-612.7
Scomber scombrus	0	0	0
Myoxocephalus spp.	63.1 / 1.1-181.9	0.04 / 0-.5	27.6 / 0-77.7
Liparis coheni	4.9 / 0-18.2	0	0.1 / 0.09
Pseudopleuronectes americanus	.15 / 0-0.7	.11 / 0-3	2.6 / 0-11.9
Total	26.8 / 3.2-382.2	99.6 / 42.6-169.1	240.6 / 31.1-714.2

*Represents all three egg stages from January through February.
**Represents all three egg stages from January through March.
+A single set of samples was taken in 1977. These data were not included in this comparison because weekly data sets were available in 1975, 1978, 1979, 1980 and 1981.

Table 3 (Continued).

Format: Mean / Range

	1975	1976+	APRIL 1977	1978	1979
EGGS					
Gadidae-*Glyptocephalus*	1.7 0 - 5		0.7 0 - 2	8.1 2 - 14	3.5 0.8 - 12
Gadidae*	2.4 0 - 6		0.3 0 - 3	8.4 0.6 - 14	1.1 0 - 3
Enchelyopus-*Urophycis*-*Peprilus*	0		0.3 0 - 1	0.1 0 - 1	0
*Enchelyopus cimbrius***	2.9 0 - 10		0.2 0 - 2	0	0.3 0 - 2
Urophycis spp.	0		0.1 0 - 0.8	0	0
Labridae-*Limanda*	4.8 0 - 18		2.5 0 - 7	11.1 0 - 26	8.1 0 - 28
Labridae	0		0.2 0 - 0.9	0.5 0 - 3	0.08 0 - 1
Scomber scombrus	0			0	0
Parlichthys-*Scophthalmus*	0.1 0 - 0.7		0	0	0
Total	33.4 1 - 84		10.2 1 - 18	63.1 8 - 114	73.9 4 - 546
LARVAE					
Clupea harengus harengus	1.3 0 - 12		0.1 0 - 1	0.3 0 - 2	0.6 0 - 3
Enchelyopus cimbrius	0		0	0	0
Tautogolabrus adspersus	0		0	0	0
Ulvaria subbifurcata	5.4 0 - 19		3.9 0 - 19	0.2 0 - 2	0.3 0 - 1
Pholis gunnellus	1.8 0 - 8		4.0 0 - 19	1.5 0 - 5	3.7 0 - 13
Ammodytes sp.	6.6 0.8 - 18		36.8 6 - 85	388.8 6 - 1252	92.1 26 - 196
Scomber scombrus	0		0	0	0
Myoxocephalus spp.	7.2 3 - 12		30.7 14 - 57	21.3 0 - 57	16.3 1 - 32
Liparis spp.	3.5 0 - 11		16.9 0 - 72	1.8 0 - 7	2.1 0 - 8
Pseudopleuronectes americanus	3.1 0.8 - 10		9.5 0 - 21	35.6 0 - 127	2.9 0 - 8
Total	29.7 14 - 43		103.1 55 - 154	458.2 21 - 1324	120.5 57 - 238

*Represents all three egg stages from January through February.
**Represents all three egg stat?s from January through March.
+A single set of samples was taken in 1976. These data were not inlcuded in this comparison because weekly data sets were available in 1975 and 1977-1981.

Table 3: (Continued)

Format: Mean / Range

	APRIL 1980	APRIL 1981	APRIL 1982
EGGS			
Gadidae-Glyptocephalus	2.3 3.1-7.2	0	0
Gadidus morhua	1.1 0-4.1	0.4 0-2.8	0.2 0.6-2.5
Enchelyopus-Urophycis-Peprilus	0	0	0
Enchelyopus cimbrius**	0.5 0-4.1	0.3 0-2.4	0.1 0-1.6
Urophycis spp.	0	0	0
Labridae-Limanda	0	0	0
Labridae	0.6 0-7.6	0	0
Scomber scombrus	0	0	0
Paralichthys-Scophthalmus	0	0	0
Total	26.1 0-17.6	13.5 0-77.4	5.8 0-41.6
LARVAE			
Clupea harengus harengus	0.1 0-0.5	0	1.0 0.4-5
Enchelyopus cimbrius	0	0	0
Tautogolabrus adspersus	0	0	0
Ulvaria subbifurcata	2.5 0-6.2	0.3 0-2.0	0
Pholis gunnellus	0.4 0-1.1	3.4 0-13.6	32.8 0-74.8
Ammodytes sp.	50.3 0-171.3	33.0 6.8-66.1	8.1 260.9
Scomber scombrus	0		0
Myoxocephalus spp.	16.4 0-58.8	0.4 0-1.7	88.6 0-167.2
Liparis coheni	5.3 0-20.3	0	0.9 0-4.4
Pseudopleuronectes americanus	8.9 1.5-23.8	2.1 0-3.0	5.6 0-36.2
Total	86.0 8.2-265.8	66.5 29.1-141.8	185.4 3.8-732.4

*Represents all three egg stages from January through February.
**Represents all three egg stages from January through March.
+A single set of samples was taken in 1976. These data were not included in this comparison because weekly data sets were available in 1975 and 1977-1981.

Table 3 (Continued). Format: Mean / Range

	MAY 1975	1976	1977	1978	1979
EGGS					
Gadidae-Glyptocephalus	1.0 / 0 - 3	2.3 / 0 - 6	3.4 / 0 - 11	3.4 / 0 - 14	1.4 / 0 - 5
Gadidae*	1.1 / 0 - 3	1.5 / 0 - 4	1.2 / 0 - 3	9.6 / 0 - 61	1.8 / 0 - 5
Enchelyopus-Urophycis-Peprilus	8.3 / 0 - 30	13.3 / 0 - 72	12.5 / 5 - 22	27.8 / 2 - 125	9.5 / 0.6 - 34
Enchelyopus cimbrius**	28.3 / 6 - 70	30.8 / 0 - 91	14.0 / 0 - 32	10.9 / 0 - 37	5.3 / 0 - 15
Urophycis spp.	0	0	0.4 / 0 - 3	0	0
Labridae-Limanda	145.8 / 2 - 1248	12.0 / 5 - 23	280.8 / 3 - 1240	1843.4 / 3 - 11809	1491.9 / 6 - 9475
Labridae	0.3 / 0 - 2	0	8.6 / 0 - 55	20.5 / 0 - 169	4.1 / 0 - 19
Scomber scombrus	1.8 / 0 - 6	1.2 / 0 - 5	12.7 / 0 - 67	8.5 / 0 - 62	37.5 / 0 - 155
Parlichthys-Scophthalmus	10.1 / 0 - 64	6.3 / 0 - 19	12.5 / 2 - 32	30.4 / 0 - 169	21.0 / 0 - 76
Total	196.5 / 12 - 1366	74.7 / 35 - 126	396.3 / 31 - 1324	2017.8 / 13 - 12428	1638.3 / 45 - 9925
LARVAE					
Clupea harengus harengus	2.2 / 0 - 24	0	0	0.1 / 0 - 1	0.03 / 0 - 0.5
Enchelyopus cimbrius	2.6 / 0 - 10	2.9 / 0 - 13	0.3 / 0 - 1	4.0 / 0 - 19	4.5 / 0 - 19
Tautogolabrus adspersus	0	0	0	0	0.2 / 0 - 2
Ulvaria subbifurcata	65.4 / 10 - 235	7.3 / 1 - 24	5.7 / 0 - 20	43.5 / 11 - 141	5.2 / 0 - 23
Pholis gunnellus	0.1 / 0 - 0.5	0	0	0.4 / 0 - 4	0.08 / 0 - 1
Ammodytes sp.	4.0 / 0 - 22	2.5 / 0 - 8	2.2 / 0 - 7	79.9 / 0 - 265	20.1 / 0 - 88
Scomber scombrus	0.1 / 0 - 0.4	0	0	2.6 / 0 - 27	6.1 / 0 - 29
Myoxocephalus spp.	3.2 / 0 - 11	0.5 / 0 - 2	1.2 / 0 - 9	0.3 / 0 - 37	5.9 / 0 - 17
Liparis spp.	9.2 / 0 - 30	13.0 / 6 - 31	38.9 / 0 - 112	37.0 / 1 - 92	20.3 / 6 - 40
Pseudopleuronectes americanus	13.9 / 2 - 36	7.4 / 2 - 18	16.3 / 4 - 29	38.0 / 0 - 129	18.4 / 13 - 40
Total	99.6 / 28 - 283	37.9 / 15 - 76	81.9 / 24 - 185	222.2 / 33 - 660	104.1 / 66 - 210

*Represents all three egg stages from January through February.
**Represents all three egg states from January through March.

Table 3: (continued) Format: Mean / Range

	1980	MAY 1981	1982
EGGS			
Gadidae-*Glyptocephalus*	8.5 / 1.1-5.9	0.3 / 0-2.3	0.4 / 0-1.9
Gadidus morhua	1.2 / 0-3.8	0.8 / 0-2.7	0.1 / 0-0.8
Enchelyopus-*Urophycis*-*Peprilus*	8.5 / 4.3-14.1	7.8 / 0.95-19.1	3.4 / 1.2-8.2
*Enchelyopus cimbrius***	52 / 10.2-72.6	15.1 / 0-54.8	0.9 / 0-2.3
Urophycis spp.	0	0.1 / 0-1.4	0
Labridae-*Limanda*	3024 / 4.8-9331	74.1 / 1.9-94.0	917.8 / 4.0-248.2
Labridae	119 / 0-430.5	3.6 / 0-22.8	5.3 / 0.5-14.7
Scomber scombrus	94 / 32-256.7	32.8 / 0-167.5	15.0 / 0-63.3
Paralichthys-*Scophthalmus*	34 / 6.7-66.7	22.2 / 0-63.6	11.7 / 0-43.1
Total	3489 / 1-10,314	151.6 / 29-368	251.9 / 39.5-425.4
LARVAE			
Clupea harengus harengus	0	0	0.2 / 0-1.2
Enchelyopus cimbrius	5.4 / 4.5-11	1.0 / 0-2.5	0 / 0-0.6
Tautogolabrus adspersus	1.3 / 0-8.3	0.04 / 0-.2	0
Ulvaria subbifurcata	10.2 / 4.6-21.4	10.7 / 3.5-27.0	4.0 / 0-15.9
Pholis gunnellus	0	0	0.2 / 0-2.0
Ammodytes sp.	3.8 / 1.9-9.1	1.8 / 0-3.5	23.2 / 0-29.0
Scomber scombrus	3.8 / 10.9-12.0	0.9 / 0.5-4.9	0.1 / 0-1.1
Myoxocephalus spp.	0	0	1.5 / 0-9.9
Liparis atlanticus	27.8 / 15.7-44.9	0	2.7 / 0-12.5
Liparis coheni			0.1 / 0-1.5
Pseudopleuronectes americanus	29.1 / 11.1-74.8	11.1 / 0-97.5	30.3 / 1.3-49.3
Total	104 / 0-166	69.9 / 13-234	65.4 / 8.4-181.6

*Represents all three egg stages from January through February.
**Represents all three egg stages from January through March.

Table 3 (Continued). Format: Mean / Range

	JUNE 1975	1976	1977	1978	1979
EGGS					
Gadidae-*Glyptocephalus*	1.1 / 0 - 4	2.3 / 0 - 6	2.6 / 0 - 11	2.5 / 0 - 7	1.5 / 0 - 5
Gadidae*	0.8 / 0 - 3	1.5 / 0 - 4	5.3 / 0 - 27	2.0 / 0 - 7	0.4 / 0 - 2
Enchelyopus-*Urophycis*-*Peprilus*	28.5 / 16 - 55	11.3 / 2 - 25	24.4 / 0 - 96	75.8 / 0 - 308	38.0 / 17 - 98
*Enchelyopus cimbrius***	20.0 / 1 - 76	25.6 / 9 - 90	51.5 / 5 - 114	14.7 / 0 - 33	24.3 / 2 - 65
Urophycis spp.	1.5 / 0 - 6	0.7 / 0 - 2	4.7 / 0 - 15	4.3 / 0 - 14	10.2 / 0 - 27
Labridae-*Limanda*	2432.0 / 809-5501	699.0 / 147-2258	5739.1 / 289-19078	1317.7 / 24-3876	5217.8 / 1080-10505
Labridae	137.1 / 0 - 294	75.4 / 7 - 249	185.4 / 26 - 1181	90.6 / 0 - 262	216.3 / 50 - 774
Scomber scombrus	126.3 / 4 - 746	5.0 / 0.8 - 19	55.0 / 6 - 199	151.8 / 0 - 360	18.0 / 4 - 41
Parlichthys-*Scophthalmus*	18.2 / 2 - 78	17.2 / 0 - 73	38.6 / 3 - 129	41.8 / 0 - 132	61.2 / 20 - 141
Total	2819.8 / 819-5718	856.2 / 342-2393	6301.5 / 609-19425	1934.7 / 228-5917	5620.2 / 1401-11522
LARVAE					
Clupea harengus harengus	0	0	0	0	0
Enchelyopus cimbrius	50.1 / 0 - 137	28.7 / 0 - 46	128.2 / 84 - 248	40.2 / 0 - 145	7.4 / 1 - 15
Tautogolabrus adspersus	11.3 / 0 - 39	2.6 / 0 - 13	11.5 / 0 - 750	19.5 / 0 - 107	38.8 / 4 - 78
Ulvaria subbifurcata	0.6 / 0 - 2	5.1 / 0 - 28	0	4.3 / 0 - 12	1.3 / 0 - 3
Pholis gunnellus	0	0	0	0.2 / 0 - 2	0
Ammodytes sp.	0	0.1 / 0 - 2	0	0.2 / 0 - 2	0.1 / 0 - 1
Scomber scombrus	39.9 / 0 - 149	4.2 / 0 - 15	14.0 / 0 - 55	31.5 / 0 - 126	9.9 / 0 - 37
Myoxocephalus spp.	0	0	0	0	0
Liparis spp.	2.1 / 0 - 7	0.7 / 0 - 50	6.2 / 0 - 28	16.0 / 2 - 65	1.3 / 0 - 4
Pseudopleuronectes americanus	5.5 / 0.5 - 15	6.6 / 0 - 47	4.6 / 0 - 16	15.9 / 0 - 54	9.7 / 0 - 39
Total	117.9 / 14 - 260	55.1 / 8 - 139	297.2 / 125 - 641	176.7 / 51 - 343	82.5 / 27 - 154

*Represents all three egg stages from January through February.
**Represents all three egg states from January through March.

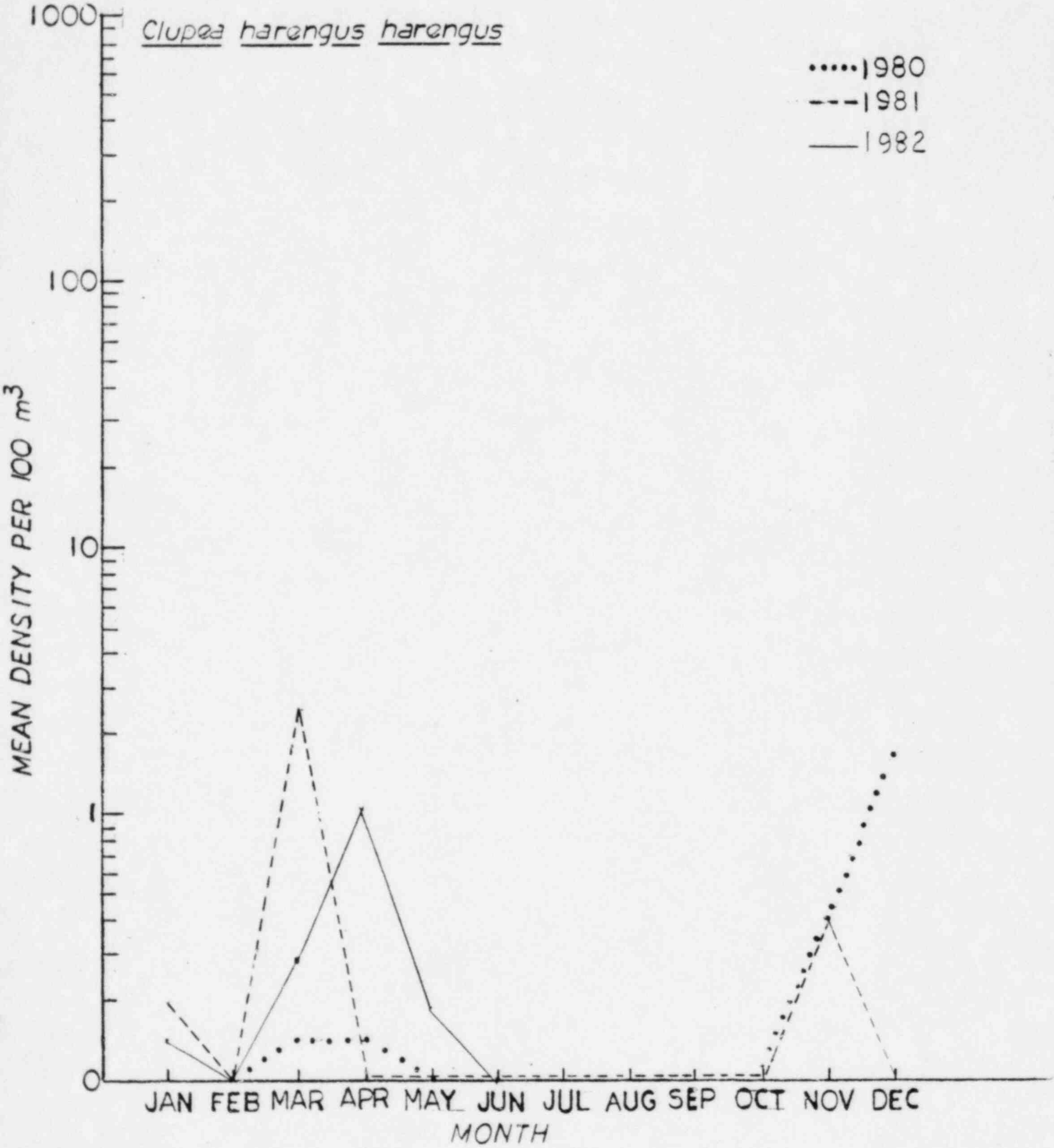
Table 3: (continued)

Format: Mean / Range

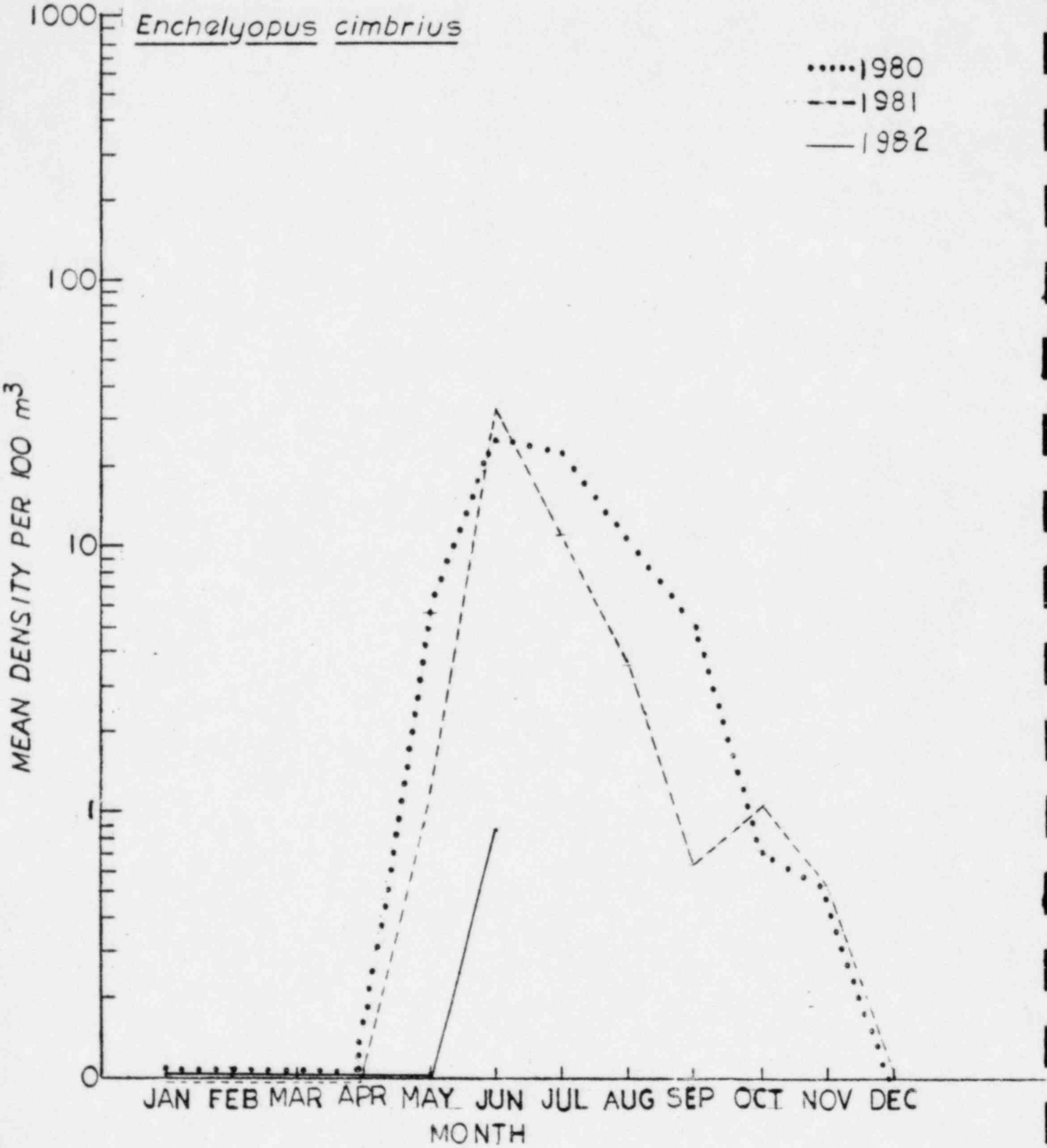
	JUNE 1980	JUNE 1981	JUNE 1982
EGGS			
Gadidae-Glyptocephalus	6.4 / 0-16	3.7 / 0-8.6	0.5 / 0-2.5
Gadidus morhua	10.6 / 0-24	5.0 / 0-21.7	0.2 / 0-0.9
Enchelyopus-Urophycis-Peprilus	14.7 / 1.9-25.6	143.8 / 3.9-634.4	8.8 / 0-18.7
Enchelyopus cimbrius	49.8 / 2.2-50.8	18.4 / 6.8-37.7	6.9 / 0-23.4
Urophycis spp.	2.2 / 3.7-4.9	9.9 / 0-56.2	1.8 / 0-5.7
Labridae-*Limanda*	631 / 248-1266	5371.8 / 184-12,537	1607.8 / 276.2-4588.4
Labridae	101.6 / 12.7-190.5	302.5 / 81.7-1492	155.2 / 75.0-237.6
Scomber scombrus	40.5 / 0-54.2	197.9 / 3.2-1083	135.2 / 0-663.1
Paralichthys-Scophthalmus	27.5 / 13.6-25.6	73.2 / 0-500.6	38.7 / 5.3-82.8
Total	760 / 499-1651	6291 / 407-22,226	1974.2 / 419.9-4912.2
LARVAE			
Clupea harengus harengus	0	0	0
Enchelyopus cimbrius	34.5 / 3.9-101.8	32.2 / 0-94.3	0.9 / 0-5.2
Tautogolabrus adspersus	45.6 / 82.7	276 / 0-693	6.5 / 0-26.4
Ulvaria subbifurcata	2 / 0-1.6	1.6 / 0-3.4	1.4 / 0-4.9
Pholis gunnellus	0	0	0
Ammodytes sp.	0	0.1 / 0-.6	0
Scomber scombrus	35.3 / 0-108.8	544.9 / 1.3-3662	14.6 / 0-80.6
Myoxocephalus spp.	0.5 / 0-7.2	0	0
Liparis atlanticus	5.8 / 0-21.2	0	0.5 / 0-3.9
Pseudopleuronectes americanus	5.8 / 2.7-19.3	2.4 / 0-6.8	3.8 / 0-16.8
Total	145.8 / 48.7-377.3	910 / 18.4-5442	35.8 / 0-136.1

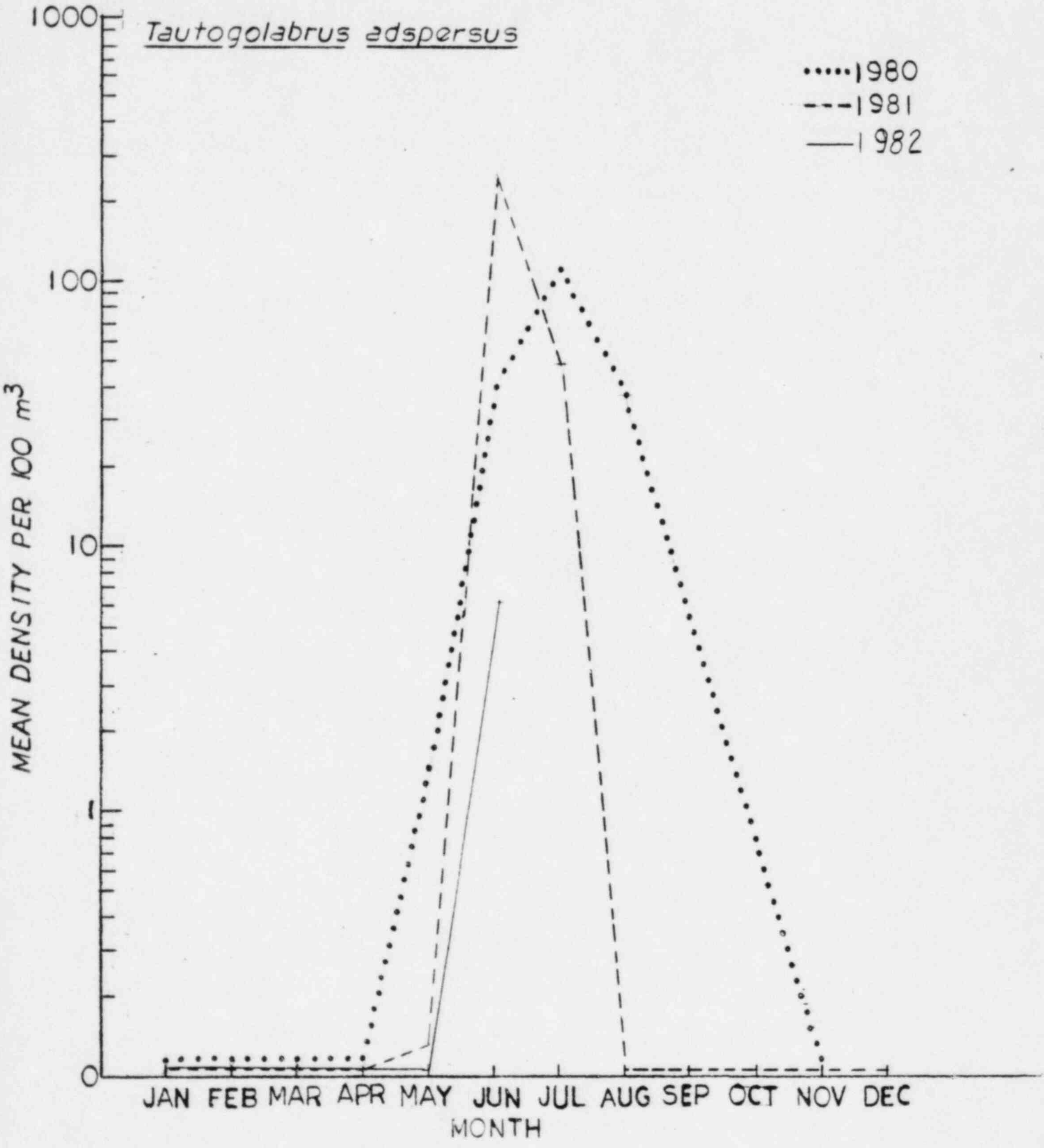
*Represents all three egg stages from January through February.
**Represents all three egg stages from January through March.

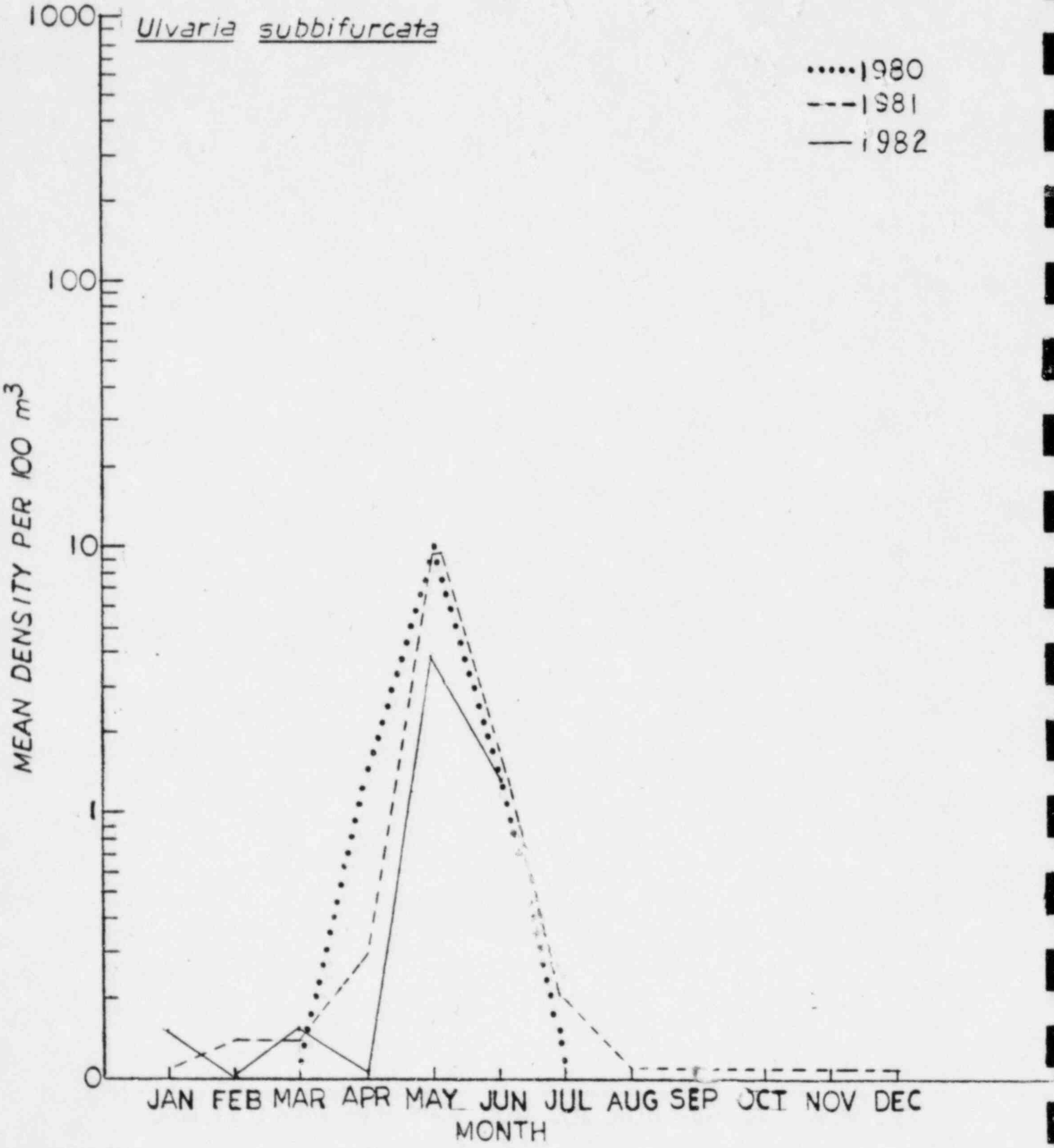
Figure 3: Mean monthly densities (per 100 m^3 of water) of the numerically dominant fish larvae entrained at the Pilgrim Nuclear Power Station, January through December, 1980-1981, and January through June, 1982.



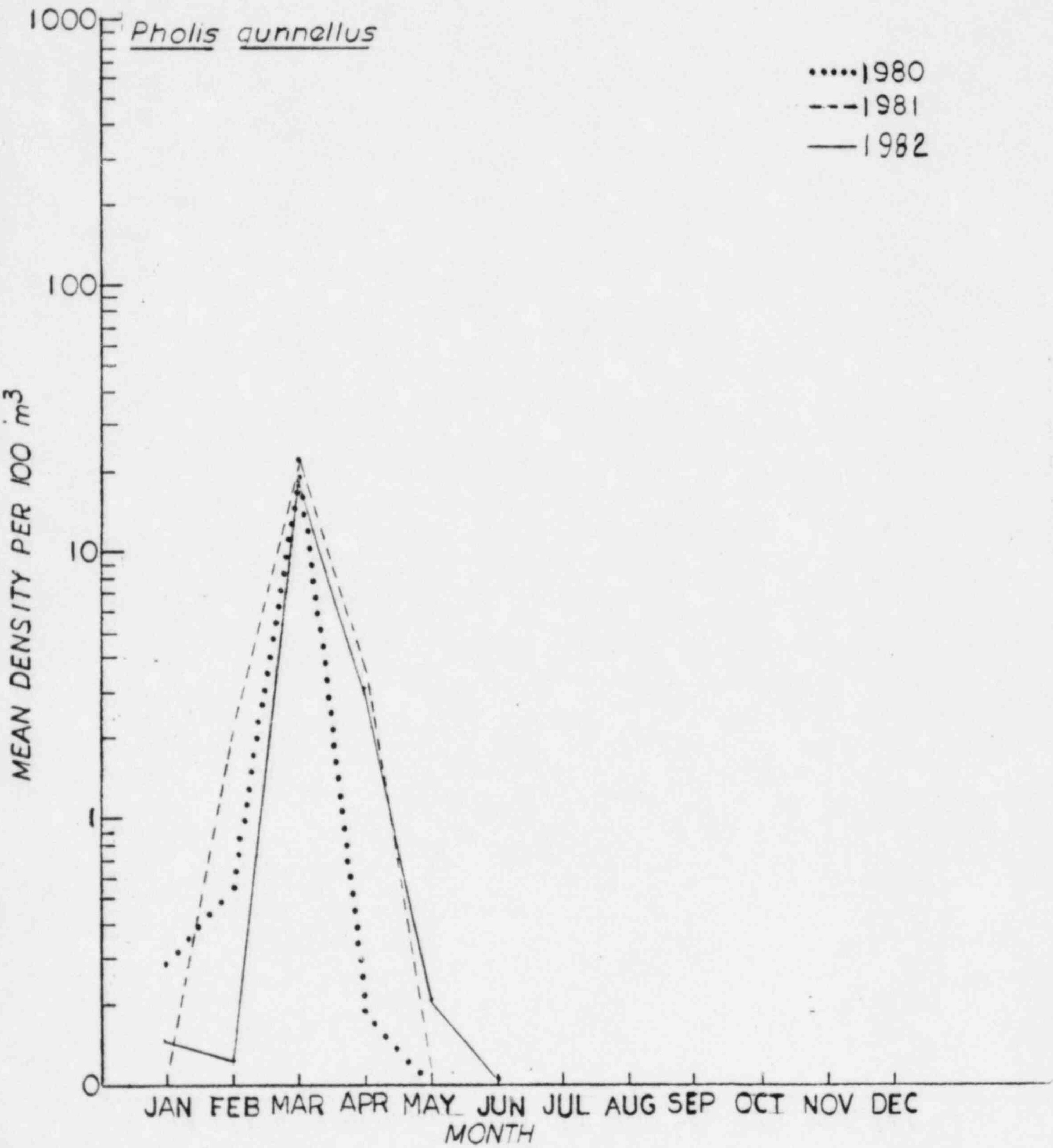
Clupea harengus harengus
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m^3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH


Enchelyopus cimbrius
1980
1981
1982
MEAN DENSITY PER 100 m^3
1000
100
10
1
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH

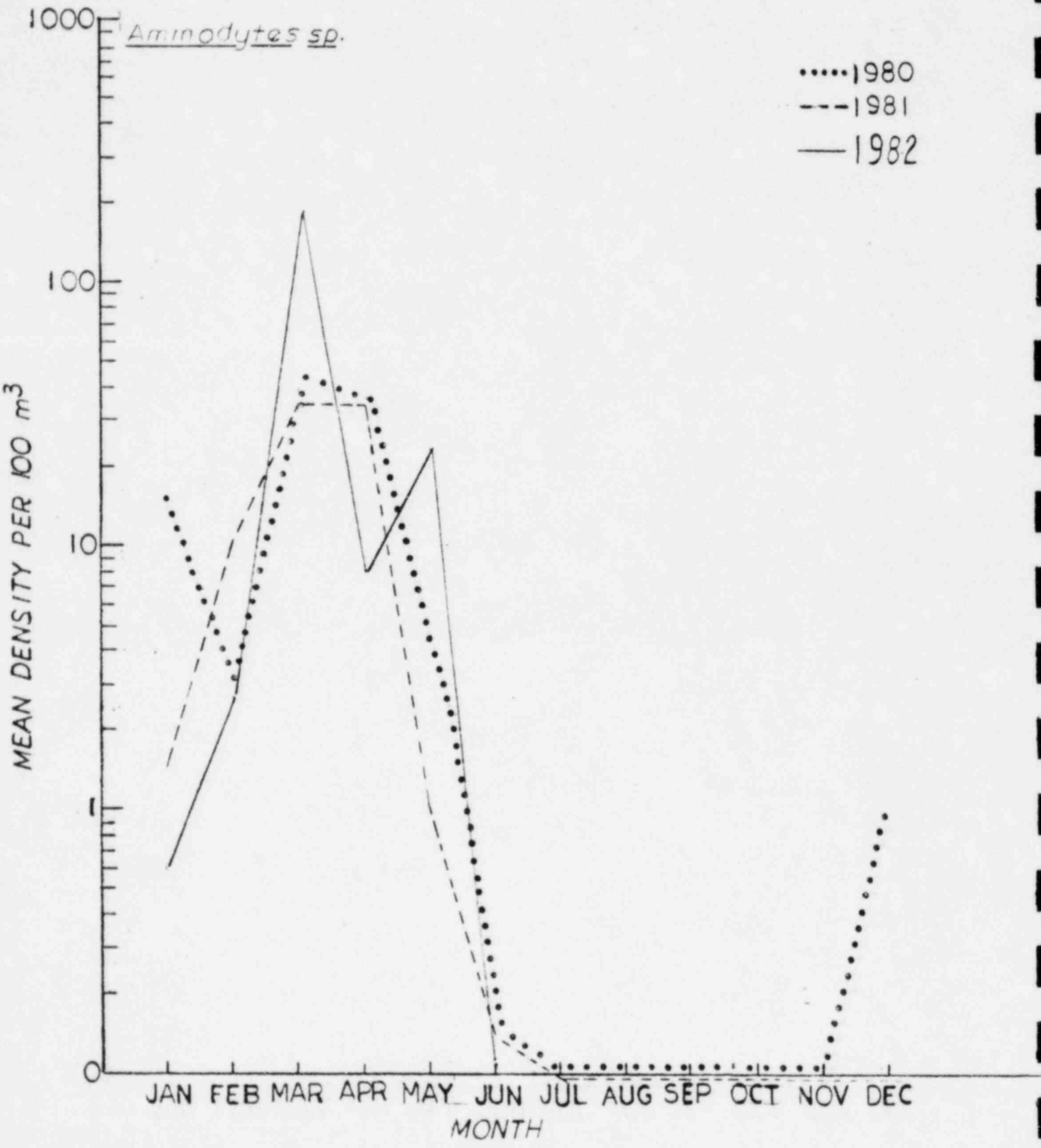

Tautogolabrus adspersus
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m^3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH



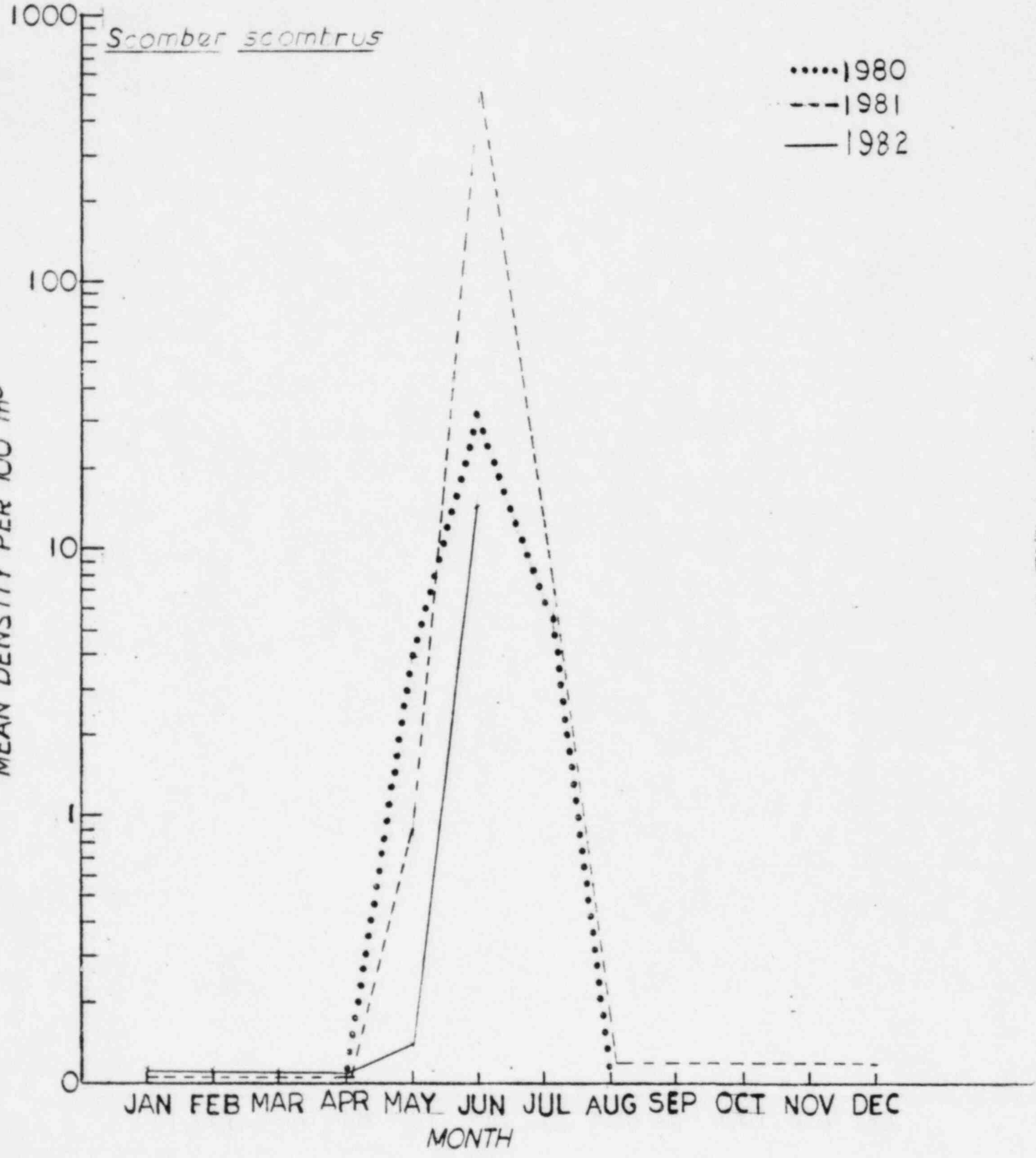
Ulvaria subbifurcata
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m^3
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH



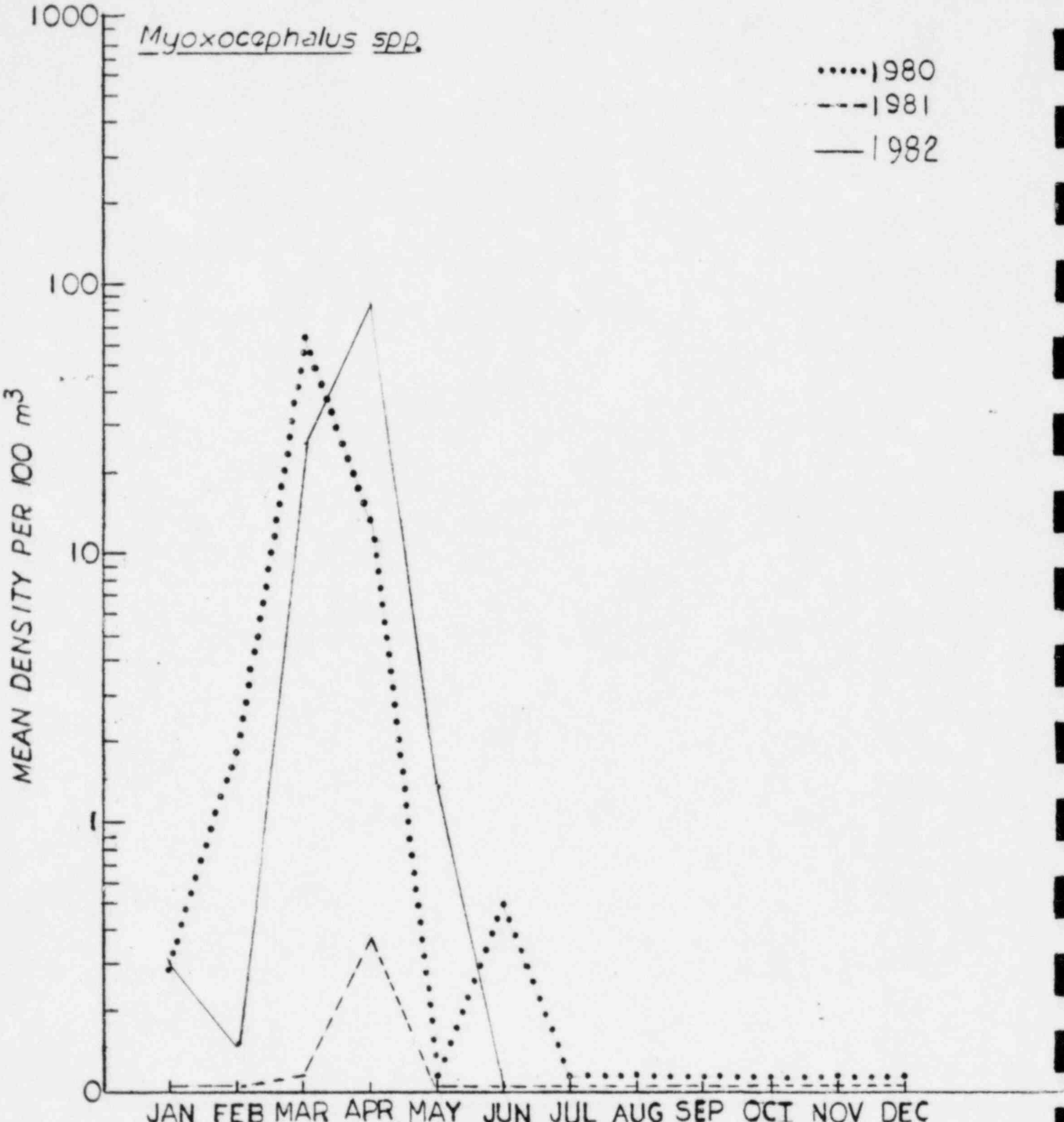
Pholis gunnellus
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m3
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH

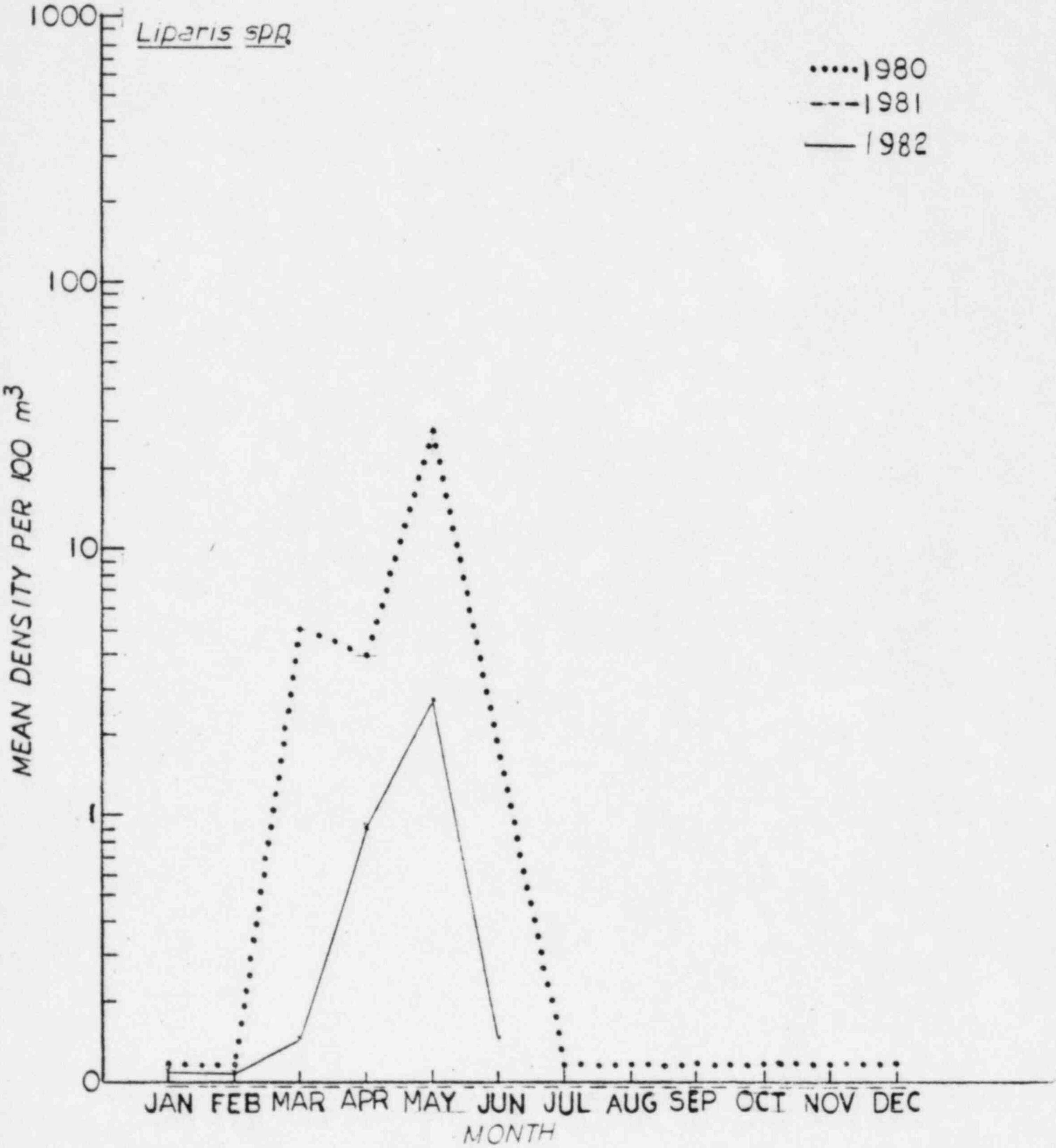


Aminodytes sp.
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m^3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

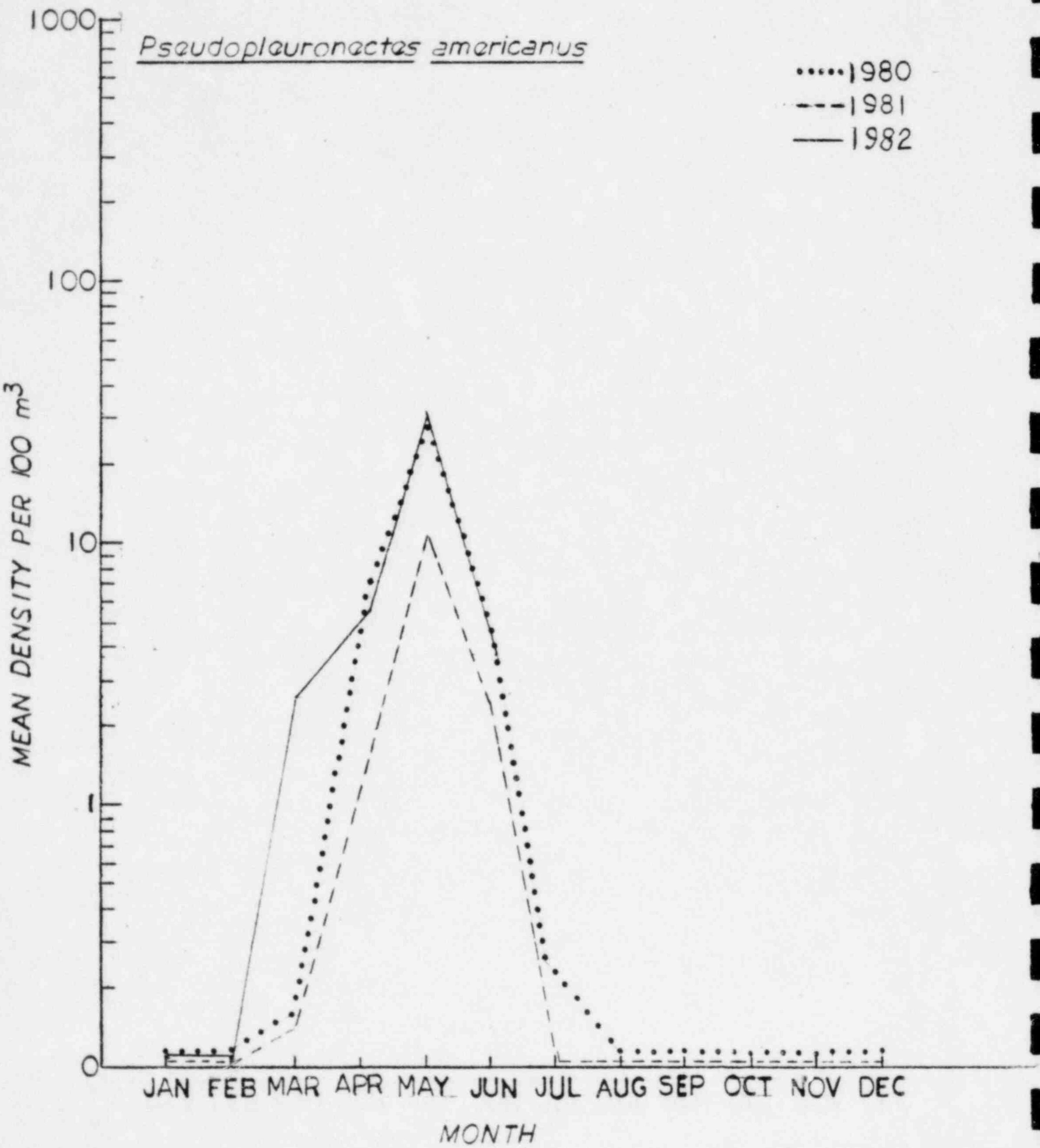


Scomber scombrus
1000
100
10
1
0
MEAN DENSITY PER 100 m^3
1980
1981
1982
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

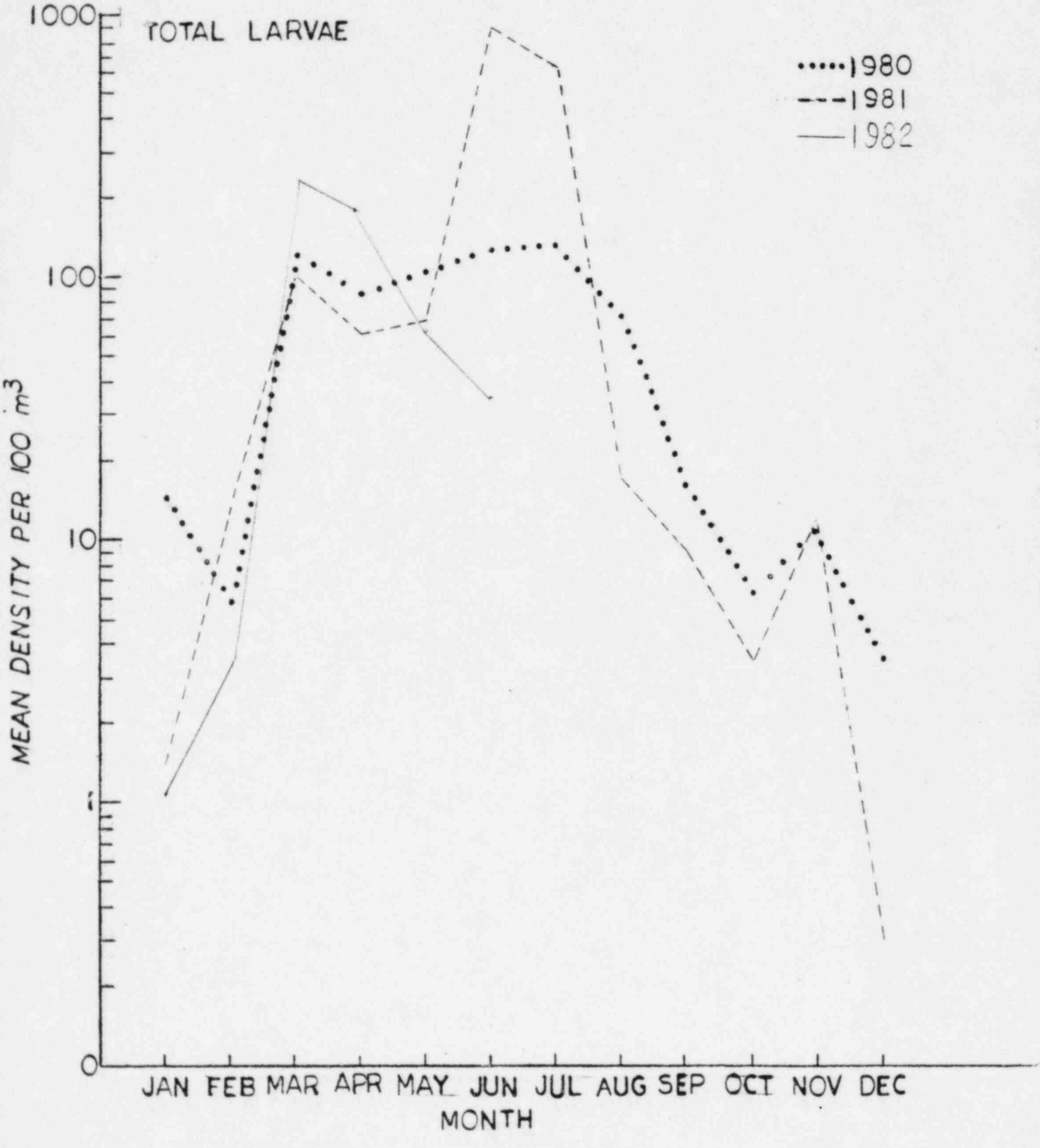

Myoxocephalus spp.
••••• 1980
- - - 1981
—— 1982
1000
100
10
1
0
MEAN DENSITY PER 100 m^3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH



Liparis spp.
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m3
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH



Pseudopleuronectes americanus
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m3
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH



TOTAL LARVAE
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

Table 4: Summary of numbers of smelt larvae entrained at PNPS during the months of April and May, 1974-1982. All densities are per 100 m^3 of water.

	1974	1975	1976	1977	1978	1979	1980	1981	1982
Summed smelt densities	395	2	3.9	1123	3.5	4.5	0	0.5	17.7
Number samples taken	30	53	57	221	27	27	18	24	15
Mean	13.2	0.05	0.07	5.1	0.1	0.17	0	0.02	1.2
Highest density	97.2	1.0	1.0	65.9	1.7	1.1	0	0.3	4.3
Sampling perod	4/24-5/25	4/1-5/27	4/29-5/7	4/1-5/27	4/3-5/3	4/5-5/29	4/8-5/28	4/6-5/26	6/2-6/29

Table 5: Mean, maximum, and minimum discharge (cfs) in the Jones River recorded at Kingston, Mass. by the U.S. Geological Survey* for the months of April and May, 1974-1981.

	1974	1975	1976	1977	1978	1979	1980	1981
April								
Mean	46.0	34.6	27.7	40.5	44.5	34.9	39.6	22.0
Maximum	84	75	44	87	82	62	73	39
Minimum	30	17	19	25	24	14	21	9
May								
Mean	33.3	18.8	21.6	33.4	48.2	50.2	22.3	12
Maximum	62	28	33	120	95	128	49	23
Minimum	18	11	16	14	19	22	12	8

*U.S.G.S. 1975, 1976, 1977, 1978, 1979, 1980, 1981. 1980-1981 data - personal communication.

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Supplementary Winter Flounder Egg Studies
Conducted at Pilgrim Nuclear Power Station
March - May 1982

Marine Research, Inc.
Falmouth, Massachusetts

June 21, 1982

Introduction

Although they are demersal and adhesive when spawned, winter flounder eggs (*Pseudopleuronectes americanus*) are periodically collected in ichthyoplankton collections from the Pilgrim Nuclear Power Station (PNPS) discharge canal. The study summarized here was designed to determine if such eggs survive entrainment and continue to develop into larvae which are normal in appearance and behavior. In conjunction with this work, towed net samples were taken in the intake basin in an effort to collect winter flounder eggs prior to entrainment. If taken in sufficient numbers, survival among intake-collected eggs could be compared with survival among entrained eggs to assess the impact of egg entrainment on this species.

Methods

Ichthyoplankton entrainment at PNPS is routinely monitored once per week during the winter flounder spawning season by collecting three samples from the discharge canal. These are taken by streaming a 60 cm, 0.333-mm mesh plankton net in the canal for 10 minutes (see for example Scotton 1982 for sampling details). To study winter flounder egg survival, entrainment samples were washed into three one-gallon aerated thermos containers and returned to the laboratory for analysis rather than being preserved on site in the usual manner. So that samples would not be held at elevated discharge temperatures during the time between collection and analysis, each sample was mixed with intake water in the thermos containers. Once returned to the laboratory each sample was held in an ambient temperature water bath and examined as rapidly as possible under a microscope. All winter flounder eggs were removed and an immediate live or dead determination made. The remainder of each sample was fixed in 10% formalin and subsequently analyzed as a standard PNPS ichthyoplankton sample, the winter flounder egg counts being included in that analysis.

Among the winter flounder eggs obtained during the initial "live" sort, any live ones were transferred to one-liter aerated glass beakers held in a temperature bath set at approximately that of the bottom water of the intake basin. Water for the rearing beakers was obtained from the PNPS intake basin and filtered to 8 μ. Dead winter flounder eggs were preserved in 5% buffered formal‘- stored.

Live winter flounder eggs transferred to beakers were examined daily at which time any dead eggs were removed and preserved in formalin. Any live larvae which had hatched were examined for normal swimming behavior and development and also preserved; any dead larvae were preserved along with these.

Live winter flounder egg studies were conducted on 10 of the 13 regularly scheduled entrainment sampling dates during the March, April, May period of 1982.

Sampling in the PNPS intake basin was conducted with a ½-m, 0.333-mm mesh Tucker net towed by a small skiff. When towing, an effort was made to remain near bottom and if possible to actually strike bottom in an effort to "stir up" any winter flounder eggs. Three 10-minute tows were made on each of five dates during the March-May period. Samples were treated in an identical manner as the entrainment samples.

Results

Entrainment Samples

Table 1 summarizes the live egg sampling dates and presents the number of eggs obtained. As shown, only 11 live eggs were obtained on these dates. Among these 11 eggs, 3 (27.3%) died during development, 8 (72.7%) hatched producing normal larvae.

Considering all entrainment sampling dates on which winter flounder eggs were taken regardless of whether the samples were sorted "live", a total of

140 eggs was obtained and examined. Among these, 63 (45.0%) were classified as alive when collected. (Many of the 140 eggs, n = 70, were taken on April 29 and May 4 during periods of high wind. Large amounts of detritus in the samples would have made rapid sorting for live eggs impossible.)

Intake Samples

Intake tows were completed at PNPS on March 15, April 15, May 7, May 13, and May 24. A more temporally even distribution of effort was not possible due to heavy weather, particularly in April.

Winter flounder eggs were obtained on May 7 (n = 2) and May 13 (n = 68). The two eggs collected on May 7 were dead. Among those taken on May 13, 49 (72.1%) were alive and held at 9.5 C. A total of 15 (30.6% of 49) developed through hatching but only 10 (20.4%) were considered normal larvae.

Discussion

Meaningful survival rates cannot be determined from these studies due to the small sample sizes obtained, particularly among the entrainment collections. Two general points may be made however: 1) Winter flounder eggs do survive entrainment at PNPS, and the percentage which do so may be fairly high (73% in this one case); and 2) As noted among pelagic eggs (MRI unpublished data) a certain percentage of winter flounder eggs collected prior to entrainment are dead (30% in this study).

Literature Cited

Scotton, L.N. 1982. Investigations of entrainment of ichthyoplankton at Pilgrim Nuclear Power Station, January-December 1981. 68p. In Marine Ecology Studies Related to Operation of Pilgrim Station. Semi-Ann. Rept. 19, January 1981-December 1981. Boston Edison Co., Boston, MA.

Table 1. Dates and numbers of winter flounder eggs obtained from PNPS entrainment samples returned "live" to the laboratory.

Date*	Number of Eggs		
	Total	Dead	Alive
March 31	1	1	-
April 13	1	1	-
" 27	1	1	-
May 11	23	12	11**
" 25	9	9+	-
TOTAL	35	24	11

*Live egg sorting was conducted on March 12, April 2, 16, May 7, 17. No winter flounder eggs were found.

**Rearing temperature = 8 C.

+Four of these eggs were unfertilized.

(NUC6-C1)

IMPINGEMENT OF ORGANISMS AT PILGRIM NUCLEAR POWER STATION (January - June 1982)

Prepared by: [signature]

Robert D. Anderson
Senior Marine Fisheries
Biologist

Nuclear Operations Support Department
Boston Edison Company
800 Boylston Street
Boston, Massachusetts 02199

October 1982

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(NUC6-C5)

SECTION 1

SUMMARY

Fish impingement averaged 1.07 fish/hour during the period January-June 1982. Atlantic silverside (Menidia menidia), threespine stickleback (Gasterosteus aculeatus), bay anchovy (Anchoa mitchilli), cunner (Tautogolabrus adspersus), alewife (Alosa pseudoharengus), and winter flounder (Pseudopleuronectes americanus) accounted for 76.6% of the fishes collected.

The collection rate (no./hr.) for all invertebrates captured from January-June 1982 was 1.55. The horseshoe crab (Limulus polyphemus), sand shrimp (Crangon septemspinosa), rock crab (Cancer irroratus), green crab (Carcinus maenus), and American lobster (Homarus americanus) accounted for 91.9% of the invertebrates impinged. Mixed species of algae collected on intake screens amounted to 1,725.3 pounds.

SECTION 2
INTRODUCTION

Pilgrim Nuclear Power Station (lat. 41°56' N, long. 70°34' W) is located on the northwestern shore of Cape Cod Bay (Figure 1) with a licensed capacity of 655 MWe. The unit has two circulating water pumps with a capacity of approximately 345 cfs each and five service water pumps with a combined capacity of 23 cfs. Water is drawn under a skimmer wall, through vertical bar-racks spaced approximately 3 inches on center, and finally through vertical travelling water screens of 3/8 inch wire mesh (Figure 2). There are two travelling water screens for each circulating water pump.

This document is a report pursuant to operational environmental monitoring and reporting requirements of NPDES Permit No. 0003557 (EPA) for Pilgrim Nuclear Power Station, Unit I. The report describes impingement of organisms carried onto the vertical travelling water screens at Unit I. It presents analysis of the relationships between impingement, environmental factors, and plant operational variables.

The report is based on data collected from screen wash samples from January-June 1982. A station outage from January - mid April, 1982 limited impingement sampling when circulating pumps were not operational or travelling water screens could not be run.

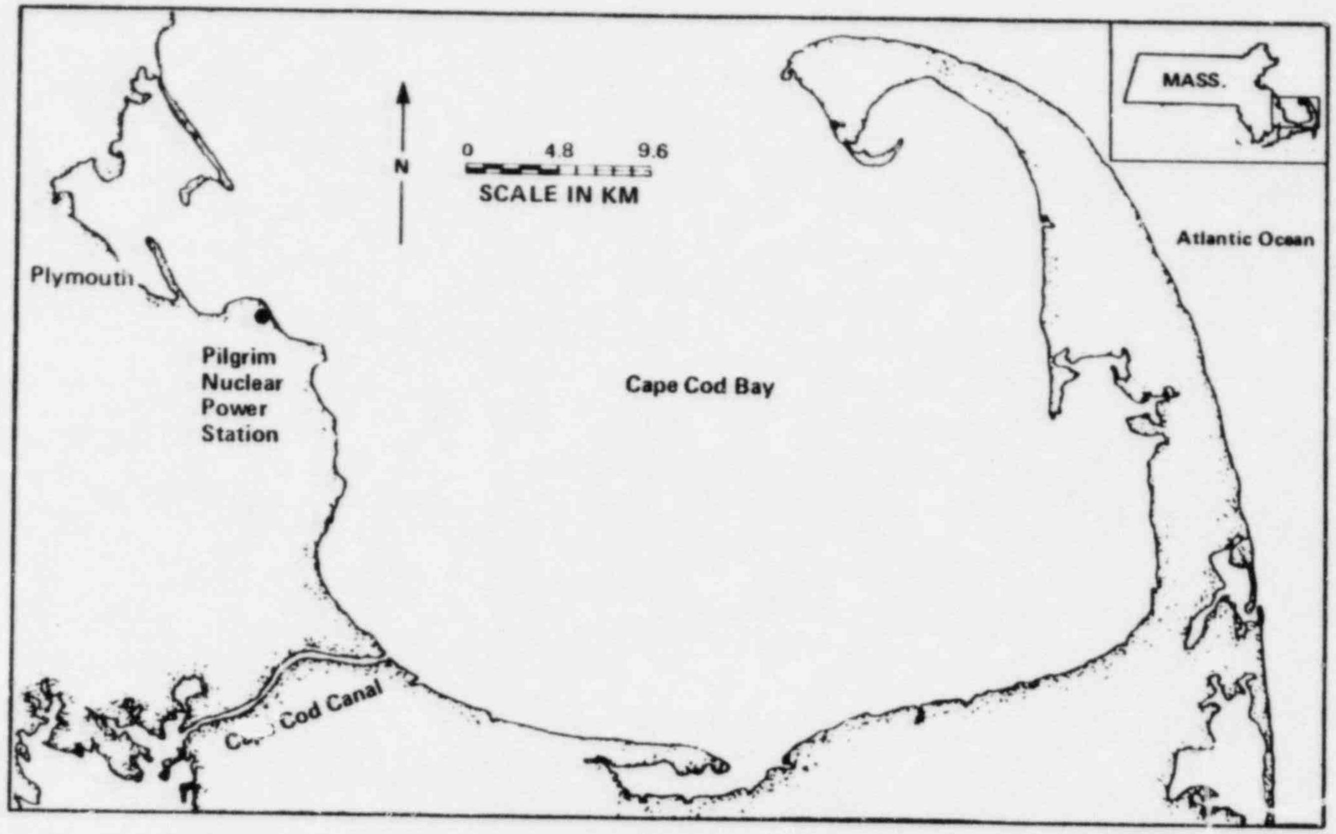

Figure 1. Location of Pilgrim Nuclear Power Station

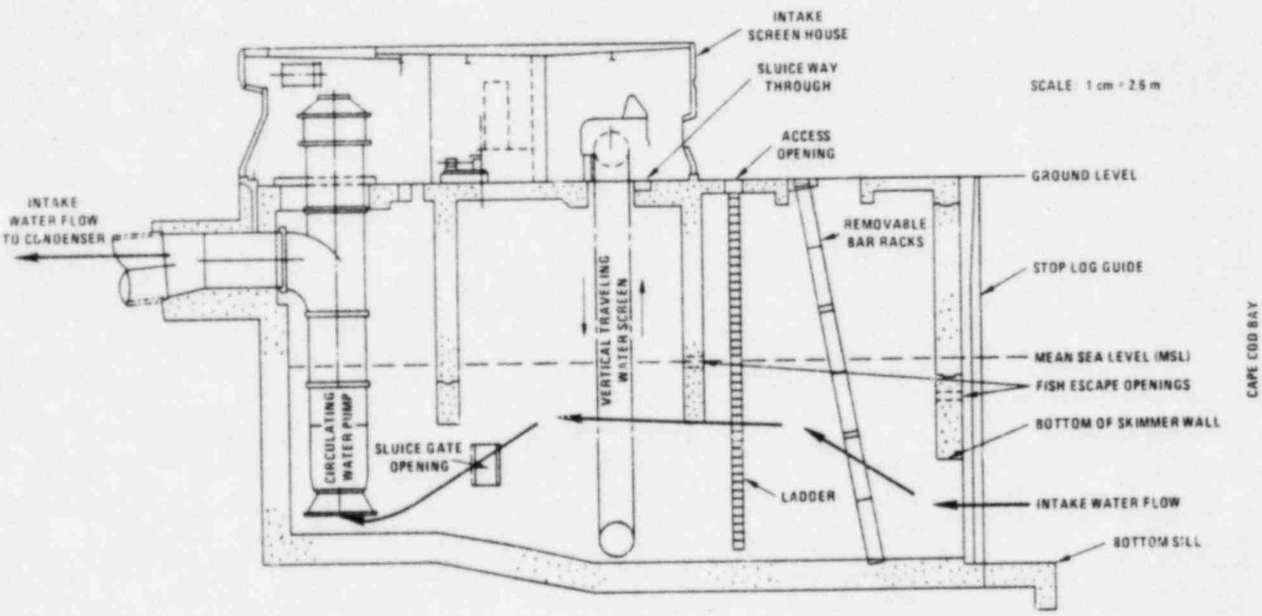

Figure 2. Intake Structure of Pilgrim Nuclear Power Station

SECTION 3
METHODS AND MATERIALS

Three screen washings each week were performed from January-June 1982 to provide data for evaluating the magnitude of marine biota impingement. The total weekly collection time was 24 hours (three separate 8-hour periods: morning, afternoon and night). Two collections represented dark period sampling and one represented light period sampling. At the beginning of each collection period, all four travelling screens were washed. Eight hours later, the screens were again washed (minimum of 20 minutes each) and all organisms collected. When screens were being washed continuously, one hour collections were made at the end of the regular sampling periods, and they represented two light periods and one dark period on a weekly basis.

Water nozzles directed at the screens washed impinged organisms and debris into a sluiceway that flowed into a trap. The original trap was made of galvanized screen (3/8-inch mesh) attached to a removable steel frame. A new trap was designed and used for sampling, in conjunction with new sluiceway survival studies, consisting of a section of corrugated pipe and fine mesh plankton netting.

Variables recorded for organisms were total numbers, and individual lengths (mm) and weight (gms) for up to 20 specimens of each species. A random sample of 20 fish or invertabrates was taken whenever the total number for a species exceeded 20; if the total collection for a species was less than 20, all were measured and weighed.

Intake seawater temperature, power level output, tidal stage, number of circulating water pumps in operation, time of day and date were recorded at time of collections. The collection rate (#/hour) was calculated as number of organisms impinged per collecting period divided by the total number of hours in that collecting period. All common and scientific names in this report follow the American Fisheries Society (1980) and Smith (1964).

SECTION 4
RESULTS AND DISCUSSION

4.1 Fishes

In 241 collection hours, 257 fishes of 30 species (Table 1) were collected from Pilgrim Nuclear Power Station intake screens during January-June 1982. The collection rate was 1.07 fish/hour. Atlantic silverside (Menidia menidia) was the most abundant species accounting for 34.2% of all fishes collected (Table 2). Threespine stickleback (Gasterosteus aculeatus), bay anchovy (Anchoa mitchilli), cunner (Tautogolabrus adspersus), alewife (Alosa pseudoharengus) and winter flounder (Pseudopleuronectes americanus) accounted for 14.4, 9.3, 9.3, 4.7 and 4.7% of the total number of fishes collected. Historically, Atlantic silversides have been impinged in high numbers during March/April which was true for this period in 1982. These were primarily adult fish that averaged 105 mm total length. The threespine stickleback were all impinged in May, and the bay anchovy in June. The other dominant species were caught over 3 month periods from March-June.

4.2 Invertebrates

In 241 collection hours, 374 invertebrates of 13 species (Table 3) were collected from Pilgrim Station intake screens between January-June 1982. The collection rate was 1.55 invertebrates/hour. Five species, horseshoe crab (Limulus polyphemus), sand shrimp (Crangon septemspinosa), rock crab (Cancer irroratus), green crab (Carcinus maenus) and American lobster (Homarus americanus) accounted for 61.5, 15.2, 5.9, 5.1 and 4.3%, respectively, of the total number of invertebrates collected.

The greatest collections of horseshoe crabs occurred in May and June, and sand shrimp in March. Sixteen specimens of the commercially important American lobster (Homarus americanus) were captured, 12 in May. This is equivalent to 290 lobsters from January-June 1982 at 100% operation of Pilgrim Station. The lobsters averaged 60.5 mm carapace length.

Approximately 1,725.3 pounds of mixed algae species were recorded during impingement sampling or 7.16 pounds/hr.

Table 1. Monthly Impingement For All Fishes Collected From Pilgrim Station Intake Screens, January - June 1982

Species	Jan.	Feb.	March	April	May	June	Totals
Atlantic silverside	1		49	35	3		88
threespine stickleback					37		37
bay anchovy						24	24
cunner				1	12	11	24
alewife				2	2	8	12
winter flounder			1	2	9		12
blueback herring						10	10
grubby	1	2		1	3	1	8
northern searobin					4	1	5
rainbow smelt				3	2		5
Atlantic menhaden						4	4
pollock				1	1	2	4
white hake					3		3
Atlantic tomcod	1		1				2
mummichog					2		2
northern pipefish				1	1		2
windowpane					1	1	2
American eel						1	1
American sand lance						1	1
Atlantic cod				1			1
Atlantic herring	1						1
fourspot flounder					1		1
little skate						1	1
northern puffer						1	1
radiated shanny			1				1
red hake			1				1
shorthorn sculpin				1			1
summer flounder						1	1
tautog					1		1
winter skate					1		1
TOTALS	4	2	53	48	83	67	257
Collection Time (hrs.)	16	8	22	65	72	58	241
Collection Rate (#/hr.)	0.25	0.25	2.41	0.74	1.15	1.16	1.07

Table 2. Species, Number, Total Length(mm), Weight(gms) and Percentage For All Fishes Collected From Pilgrim Station Impingement Sampling, January - June 1982

Species	Number	Length Range	Mean Length	Weight Range	Mean Weight	Percent of Total Fish
Atlantic silverside	88	70-240	107	2-76	7	34.2
threespine stickleback	37	50-69	58	1-3	3	14.4
bay anchovy	24	69-98	83	3-6	4	9.3
cunner	24	51-180	109	1-111	30	9.3
alewife	12	8-290	179	5-250	70	4.7
winter flounder	12	50-344	174	1-478	118	4.7
blueback herring	10	136-203	173	21-54	37	3.9
grubby	8	54-110	79	3-17	9	3.1
northern searobin	5	58-315	238	4-377	186	1.9
rainbow smelt	5	84-173	138	5-32	16	1.9
Atlantic menhaden	4	215-245	233	105-157	129	1.6
pollock	4	104-300	184	10-255	95	1.6
white hake	3	58-142	87	2-18	8	1.2
Atlantic tomcod	2	141-160	150	14-22	18	0.8
mummichog	2	80-95	88	12	12	0.8
northern pipefish	2	140-170	155	2-8	5	0.8
windowpane	2	226-310	268	160-383	271	0.8
American eel	1	320	320	-	-	0.4
American sand lance	1	175	175	18	18	0.4
Atlantic cod	1	215	215	99	99	0.4
Atlantic herring	1	240	240	76	76	0.4
fourspot flounder	1	382	382	515	515	0.4
little skate	1	450	450	700	700	0.4
northern puffer	1	119	119	41	41	0.4
radiated shanny	1	115	115	15	15	0.4
red hake	1	90	90	4	4	0.4
shorthorn sculpin	1	290	290	350	350	0.4
summer flounder	1	320	320	339	339	0.4
tautog	1	320	320	610	610	0.4
winter skate	1	490	490	770	770	0.4

(NUC6-C11)

Table 3. Monthly Impingement For All Invertebrates Collected From Pilgrim Station Intake Screens, January - June 1982

Species	Jan.	Feb.	March	April	May	June	Totals
horseshoe crab					110	120	230
sand shrimp	2	2	47	6			57
rock crab				1	10	11	22
green crab			10	2	6	1	19
American lobster					12	4	16
common starfish			5	1	8		14
long-finned squid					2	7	9
green sea urchin						2	2
lady crab						1	1
purple sea urchin					1		1
ribbon worm	1						1
unidentified crab	1						1
unidentified worm	1						1
TOTALS	5	2	62	10	149	149	374
Collection Time (hrs.)	16	8	22	65	72	58	241
Collection Rate (#/hr.)	0.31	0.25	2.82	0.15	2.07	2.52	1.55

SECTION 5
CONCLUSIONS

1. The average Pilgrim I collection rate for the period January-June 1982 was 1.07 fish/hour. Historically, the collection rate has been relatively low.

2. Thirty species of fi:h were recorded in 241 impingement collection hours.

3. The major species collected and their relative percentages of the total collections were Atlantic silverside, 34.2%; threespine stickleback, 14.4%; bay anchovy, 9.3%; cunner, 9.3%; alewife, 4.7%; and winter flounder, 4.7%.

4. The hourly collection rate for invertebrates was 1.55 with horseshoe crab, 61.5%; sand shrimp, 1'.2%; rock crab, 5.9%; green crab, 5.1%; and American lobster, 4.3% of the catch.

5. Sixteen American lobster were collected during impingement sampling which is equivalent to 290 lobsters impinged for the January-June 1982 period.

SECTION 6
LITERATURE CITED

Americal Fisheries Society. 1980. A list of Common and Scientific Names of Fishes From the United States and Canada. Spec. Pub. No. 12: 174 pp.

Smith, R. I. (Ed.). 1964. Keyes to Marine Invertebrates of the Woods Hole Region. Ma.ine Biological Laboratory. Woods Hole, Massachusetts.

Progress Report

Assessment of Finfish Survival at the Pilgrim Nuclear Power Station Screen Wash Sluiceway, March - August 1982

Marine Research, Inc.

Falmouth, Massachusetts

September 21, 1982

I. Introduction

This progress report describes studies conducted at the Pilgrim Nuclear Power Station (PNPS) screenwash sluiceway during March through August of 1982. These investigations, carried out for Boston Edison Company under Purchase Order No. 69684, represent a continuation of work performed in 1980 and 1981. Studies were designed to observe the effectiveness of a permanent sluiceway constructed in late 1979 to return fish surviving impingement to Cape Cod Bay waters and to assess impingement survival with a low pressure spray wash system installed in early 1982.

II. Methods

To determine survival rates, fish washed off the traveling screens were sampled at the end of the sluiceway (Figure 1). Special nets were constructed of 3/16-inch "delta" mesh so that all water passing down the sluiceway was filtered. Net-induced injury was minimized by using two nets interchanged frequently so that fish were confined to the net for only short periods before being transferred to pails containing ambient seawater.

Upon collection initial mortality was determined by immediately transferring fish to 8-liter pails containing ambient seawater. Dead fish (condition categories are defined below) were removed and set aside for identification and length-weight measurements. Live fish, whether healthy or injured, were transferred quickly to five-foot diameter, circular holding pools located about 20 feet from the end of the sluiceway and supplied with continuous running seawater. The pools were fitted with screen and wire mesh covers to prevent fish from jumping out and to eliminate predation by shore birds and racoons.

Fish were observed in the holding pools for one hour following introduction, and any dead fish were removed following that time. All surviving fish were held in the pools until the next scheduled sampling period approximately 55 to 56 hours later. At the end of each holding period all fish were weighed (± 0.1 gm) and measured (± 1 mm) by condition category - alive, dead, or injured. Fish were not fed during the holding period.

The survival study was combined with the finfish impingement monitoring program so that sampling was conducted three times per week (Monday 0830, Wednesday 1630, and Saturday 0030). Studies were scheduled to be conducted during the months of March, April, August, September, November, and December 1982, as in previous years; these months were selected because historically they have represented periods of greatest impingement. In 1982 we extended survival studies to the end of May due to sampling limitations in March associated with a plant outage.

Data were collected under both static and continuous wash cycles and therefore represented fish which might have spent up to eight hours on the screens (screens are routinely washed every eight hours), or only a brief time period. If the screens were static at the start of a sampling period, fish collected during the first ten minutes (the approximate time necessary for one revolution of the screens) were held in a separate pool and observed independently from any fish collected after the ten-minute period. Sampling was conducted for 0.5 hour if the screens were static prior to collection or one hour if the screens were in the continuous wash mode. Sampling would have been extended beyond these times on any given day had there been reason to believe more fish would have been collected.

Since impingement rates are generally low at PNPS, additional studies were designed for 1982 to obtain larger samples which might better define possible sources of impingement mortality. Samples of fish were collected from local waters by beach seine, otter trawl, or baited lift net and transferred to PNPS in large (32-50 gal), plastic, aerated containers. At PNPS these fish were released in front of the traveling screens (Figure 2) by lowering them in a specially designed container through the upstream access opening. The container was designed with a hinged lid so that it could be lowered below the inner skimmer wall before the fish were released. In all cases the screens and wash pumps were operating during the release period and for a minimum of one hour following the release period. Throughout these wash cycles sampling was conducted near the end of the sluiceway by a second person as described above. All fish collected this way were handled in a manner identical to that used with the naturally impinged fish. However, due to variations in collection times, holding periods for introduced fish varied from 44 to 69 hours.

These introduction studies were conducted three times per month during April, May, June, and August. The beach seine, measuring 100 by 6 feet and made of ¼-inch "delta" mesh, was used at several locations along the Plymouth Harbor side of Plymouth Beach, along the town beach in Plymouth, and along the north side of the PNPS intake. Once in April winter flounder (Pseudopleuronectes americanus) were obtained from Plymouth Harbor-Duxbury Bay using a small otter trawl. Cunner (Tautogolabrus adspersus) and pollock (Pollachius virens) were obtained in Sandwich, Massachusetts, along the southeast side of the Cape Cod Canal using a 28 in, 3/16-inch mesh lift net.

The percentage recovered among fish released in front of the screens was expected to be relatively low since we anticipated that healthy fish would avoid the 0.5 to 1.0 ft/sec current velocity at the screens and escape upstream. Because of this every effort was made to obtain large samples for the introduction studies. When collections were large, a portion of the catch was transferred directly to the holding pools to represent a control. In cases where collections were marginal, no controls were held. This was not considered a problem however since control survival was consistently high when tested in 1982 as well as in 1980 and 1981.

Condition categories during all phases of the study were defined as follows: alive - fish swimming and behaving in an apparently normal manner; dead - no body movement, no opercular movement, no response to gentle prodding; injured - tissue damage visible, fish swimming erratically, loss of equilibrium.

III. Results

A. Screen/Sluiceway Survival Studies

Sluiceway collections from March through May and August 1982 are presented in Table 1. A total of 120 fish were collected representing 24 species. Threespine stickleback (*Gasterosteus aculeatus*), Atlantic silversides (*Menidia menidia*), and cunner were most numerous, accounting for 30.8, 18.3, and 11.7% of the total, respectively.

Overall survival following the 56-hour holding periods amounted to 5.9% among static wash cycles and 8.6% among continuous wash cycles. Sample sizes within individual species were too small for analysis at this time. In general however, Atlantic silversides (n = 22) and threespine stickleback (n = 37) appeared sensitive to impingement, both species displaying 100% mortality under both static and continuous wash cycles. Cunner displayed 56-hr survival rates of 33% (n = 9) under static wash cycles and 20% (n = 5) under continuous wash cycles.

B. Screen Introductions

Table 2 summarizes the species and numbers of fish released just ahead of the traveling screens during the introduction experiments. Mummichogs (*Fundulus heteroclitus*), Atlantic silversides, cunner, and winter flounder composed the majority of fish available, accounting for 11.6, 43.6, 23.2, and 18.7% of the total, respectively. Among these species, recovery rates were highest for winter flounder (61.6%, n = 190) and lowest for mummichogs (1.7%, n = 118).

Cunner (n = 50) and mummichogs (n = 2) displayed 100% survival rates following 44 to 58 hour holding periods. Winter flounder (n = 117) showed survival of 99% after one hour and 85% after 56 to 66 hour holding periods. Finally, survival among Atlantic silversides (n = 246) was relatively low, 15% at one hour, 4% at 56 to 66 hours. High control survival rates of 100% for mummichogs, cunner, and flounder, 96% for silversides, indicated that little or no mortality could be attributed to collection methods or the holding facilities.

Sampling of naturally impinged fish will be conducted in the PNPS sluiceway during September, November, and December, and introduction studies will be completed three times per month in September and October as well. A final report summarizing all the 1982 work as well as the 1980 and 1981 data will be prepared by January 31, 1983.

IV. Summary

Fish impinged on the traveling screens at PNPS were sampled at the end of the sluiceway during the months of March through May and August 1982. A total of 120 fish were collected during this time. Pooling all species taken under both static and continuous wash periods survival rates were 13.3% upon collection and 6.7% following 56-hour holding periods.

Separate studies included releasing locally collected fishes in front of the operating traveling screens and collecting those impinged at the end of the sluiceway. Initial survival among these fish was 100% for cunner, 99.1% for winter flounder, and 14.6% for Atlantic silversides. Following approximately 2 to 3 day holding periods survival remained 100% for cunner, declined to 85.5% for winter flounder and '.1% for silversides.

These studies will continue periodically during the remainder of 1982 and will be summarized by late January 1983.

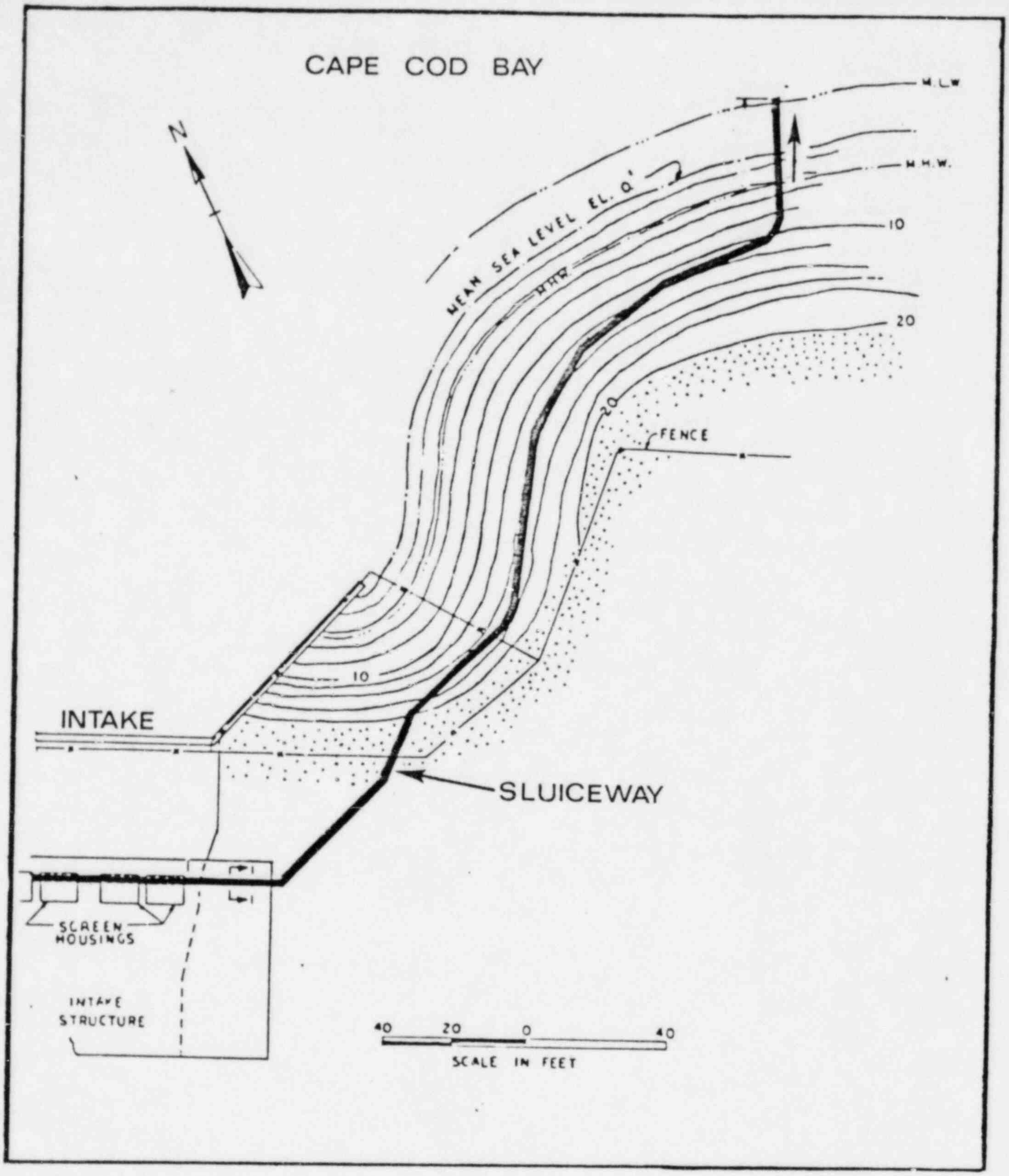

Figure 1: The PNPS sluiceway designed to return impinged fish to ambient temperature water in Cape Cod Bay. The sampling area of the sluiceway ranged between mean low water (MLW) and mean high water (MHW) depending on the tide.

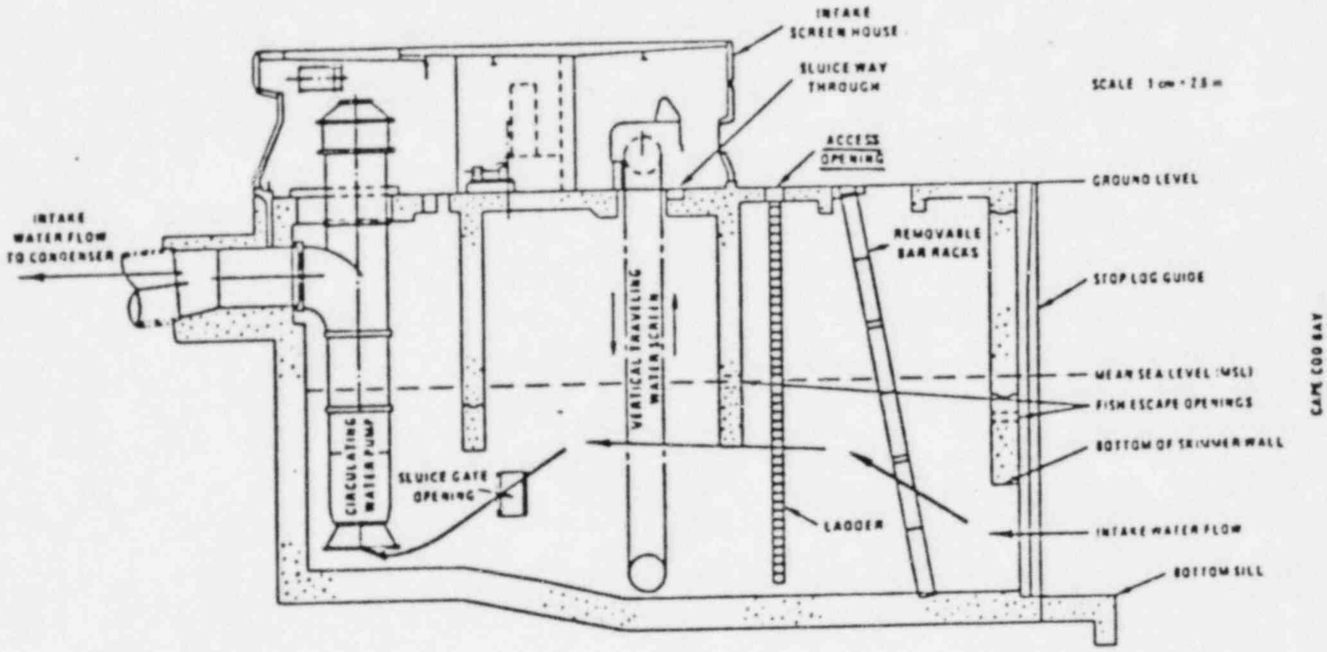

Figure 2. Diagram of the PNPS seawater intake system (illustration provided by Boston Edison Company).

Table 1. Total length mean and range (mm), total number of fish collected, number and percentage alive, and number and percentage surviving a 56-hour holding period by species in the PNPS sluiceway, March-August 1982.

Species	Total Length (mm)		Number Collected		Number (%) Collected Alive		Number (%) Surviving 56 hours	
	Mean	Range	Static Washes	Contin. Washes	Static Washes	Contin. Washes	Static Washes	Contin. Washes
Winter skate (*Raja ocellata*)	490	-	1	0	0	0	-	-
American eel (*Anguilla rostrata*)	101	-	0	1	0	1(100)	-	0
Alewife (*Alosa pseudoharengus*)	162	64 - 290	4	2	0	1(50)	-	0
Bay anchovy (*Anchoa mitchilli*)	81	-	1	0	0	0	-	-
Rainbow smelt (*Osmerus mordax*)	130	84 - 170	3	1	0	0	-	-
Atlantic cod (*Gadus morhua*)	215	-	0	1	0	0	-	-
Atlantic tomcod (*Microgadus tomcod*)	160	-	0	1	0	0	-	-
Pollock (*Pollachius virens*)	290	220 - 350	2	1	0	0	-	-
Red hake (*Urophycis chuss*)	90	-	0	1	0	0	-	-
White hake (*U. tenuis*)	100	58 - 142	2	0	0	0	-	-
Mummichog (*Fundulus heteroclitus*)	88	80 - 95	2	0	1(50)	0	0	-
Atlantic silverside (*Menidia menidia*)	107	70 - 140	8	14	0	0	-	-
Threespine stickleback (*Gasterosteus aculeatus*)	58	50 - 69	37	0	0	0	-	-
Northern pipefish (*Syngnathus fuscus*)	155	140 - 170	1	1	0	1(100)	-	1(100)
Tautog (*Tautoga onitis*)	320	-	1	0	0	0	-	-
Cunner (*Tautogolabrus adspersus*)	108	51 - 180	9	5	4(44.4)	2(40.0)	3(33.3)	1(20.0)
Radiated shanny (*Ulvaria subbifurcata*)	115	-	1	0	0	0	-	-
Northern searobin (*Prionotus carolinus*)	230	58 - 315	4	0	0	0	-	-
Grubby (*Myoxocephalus aenaeus*)	95	66 - 110	2	2	2(100)	1(50)	2(100)	1(50)
Shorthorn sculpin (*M. scorpius*)	290	-	0	1	0	0	-	-

Table 1 (continued).

Species	Total Length (mm)		Number Collected		Number (%) Collected Alive		Number (%) Surviving 56 hours	
	Mean	Range	Static Washes	Contin. Washes	Static Washes	Contin. Washes	Static Washes	Contin. Washes
Lumpfish (*Cyclopterus lumpus*)	50	-	1	0	0	0	-	-
Fourspot flounder (*Paralichthys oblongus*)	382	-	1	0	0	0	-	-
Windowpane (*Scophthalmus aquosus*)	310	-	1	0	0	0	-	-
Winter flounder (*Pseudopleuronectes americanus*)	176	50 - 344	4	4	0	3(75)	-	0
Total			85	35	7(8)	9(26)	5(6)	3(9)

Table 2. Species of fish released in front of the PNPS traveling screens, numbers recovered, survival rates, including controls, and total length data, April-August 1982.

						Total Lengths (mm)			
						Introduced		Controls	
Species	Number Introduced	Number(%) Recovered	No.(%)Alive 1 hour	No.(%)Alive 44+ hours	Control Survival(%)	Mean	Range	Mean	Range
Atlantic tomcod (*Microgadus tomcod*)	1	1(100)	1(100)	1(100)	-	172	-	-	
Red hake (*Urophycis chuss*)	3	2(67)	2(100)	2(100)	-	81	71-90	-	
Mummichog (*Fundulus heteroclitus*)	118	2(2)	2(100)	2(100)	100 (n=73)	-		97	83-107
Atlantic silverside (*Menidia menidia*)	444	246(55)	36(15)	10(4)	96 (n=245)	100	82-133	96	77-115
Threespine stickleback (*Gasterosteus aculeatus*)	11	11(100)	4(36)	3(27)	-	54	40-61	-	
Northern pipefish (*Syngnathus fuscus*)	7	3(43)	3(100)	3(100)	-	160	155-165	-	
Bluefish (*Pomatomus saltatrix*)	6	2(33)	0	-	-	69	62-76	-	
Cunner (*Tautogolabrus adspersus*)	236	50(21)	50(100)	50(100)	100 (n=14)	127	100-157	126	100-155
Windowpane (*Scophthalmus aquosus*)	2	2(100)	2(100)	2(100)	-	106	96-115	-	
Winter flounder (*Pseudopleuronectes americanus*)	190	117(62)	116(99)	100(85)	100 (n=21)	110	50-285	125	88-200

MEMORANDUM

TO: Members of the Administrative-Technical Committee, Pilgrim Power Plant Investigations

FROM: Phillips Brady, Recording Secretary, Marine Fisheries Biologist, Massachusetts Division of Marine Fisheries

SUBJECT: Minutes of the 53rd meeting of the Pilgrim Administrative-Technical Committee

DATE: April 12, 1982

The 53rd Administrative-Technical Committee meeting was called to order on 23 March 1982 at 10:10 A.M. at the Pilgrim Nuclear Station, Information Building, in Plymouth, Massachusetts by Chairman Leger. Eight agenda items were addressed.

I. Minutes of the 52nd meeting.

Corrections to the 52nd Committee minutes were proffered and are presented as a separate addendum attached to these minutes.

Also, the PATC's January 25 letter urging continued work, by the Division of Marine Fisheries, on the Jones River smelt run was discussed. In the near future an official response detailing the Division's position will be forwarded to the Committee, via Leigh Bridges.

II. Monograph update.

Work on the fisheries monograph continues. The third drafts have been presented to Bob Kendall, editor of the Transactions of the American Fisheries Society for review. Mr. Kendall felt the Committee could expect his response by mid-April regarding the material's appropriateness for a monograph publication.

III. 1982 Winter flounder larval study.

Mike Scherer of Marine Research, Inc. presented the revised proposal for "Studies of Larval Winter Flounder at the Entrance to Plymouth Harbor-Duxbury Bay and Green Harbor River Estuaries 1982". The objectives of this study are: 1) to compare the numbers of larval flounder flushed into Cape Cod Bay from the Plymouth Harbor-Duxbury Bay estuary (PHDB) with numbers from the Green Harbor estuary, and 2) to age winter flounder eggs entrained at PNPS and determine whether or not they could have come from PHDB, or if in fact these data suggest that spawning occurs nearer the plant.

Presentation of the 1981 Winter flounder larval study suggested that the area inside PHDB, as compared to that outside the harbor, represents a different nursery environment. Feeding levels inside vs. outside the harbor, also differed. Flounder larvae inside the estuary ingested a higher percent of polychaete larvae than those outside the estuary. Larval flounder densities in 1981 ranked fourth behind 1978, 1979, and 1977.

IV. Chlorine Minimization update.

Bob Anderson presented an update on the chlorine minimization program. Two areas were address:

A. Efforts are proceeding on the acquisition of all necessary permits for dredging of the plant's intake embayment. Dredging of the intake will increase the efficiency of current backwashing procedures employed at the plant.

B. A continuous chlorination program for the salt service water system is currently being evaluated. Chlorine monitors, and side stream monitors are being installed during the present outage. Studies are attempting to determine the optimal chlorine and temperature levels necessary to control biofouling throughout the salt service and circulating water systems.

V. Marine Fisheries 1981/1982 studies.

Bob Lawton, Phil Brady, Chris Sheehan, and Clare Kudera presented a summary of the 1981 marine fisheries study.

Irish moss landings. Landing statistics indicated a 4% and 28.6% decrease in pounds of moss and harvesting effort, respectively, compared to 1980 data.

Otter Trawl study. Winter flounder, skate spp., yellowtail flounder and windowpane accounted for 89.1% of the 1981 benthic fish catch. Mean catch per unit of effort (CPUE) for all species decreased in 1981 compared to 1980, from 69.8 to 66.4.

Lobster Pot study. Mean monthly catch rate per pot haul in 1981 was 0.62 lobsters slightly higher than the 0.59 reported in 1980. Overall catch rate (legals plus sublegals) was 2.9 for the discharge area and 2.2 for all areas combined. Berried female lobsters accounted for 2.3% of the total catch compared to 1.0% in 1980.

Shrimp Trawl. Sixteen benthic fish species were recorded from March-December 1981. Winter flounder, yellowtail flounder, skate spp. and windowpane composed 94.4% of the total.

Observational Dive survey. Phil Brady presented slides of the underwater observational study areas. Seven species (2,230 fishes) were noted during the May-October 1981 dive study. Cunner and pollock were the most numerous species. Large numbers of dead blue mussels were observed in connection with PNPS biofouling procedures during mid-August to mid-September.

Haul Seine. Atlantic silverside, winter flounder, mummichog, blueback herring and alewife accounted for 99.0% of the 1981 shore zone haul seine program. Twenty species were collected, however Atlantic silversides accounted for 94.4% of the total catch.

Dissolved Gas. Dissolved nitrogen gas saturation values for the discharge effluent exceeded 115% 24.1% of the time in March-November 1981. Mean nitrogen saturation values were generally near 100% at the intake and increased in the discharge with a mean high of 117.2% in April.

Smelt Reproduction. A total of 5,410 smelt was collected during 23 sampling nights. Sex ratio was 9.02 males to 1.00 female. Necropsies performed on smelt for an internal microsporidian parasite Nosema (Glugea) hertwigi revealed a 24% infestation level. The predominant age-class sampled was two-year olds.

Spawning spanned an approximate nine-week period commencing on or about 2 March 1981. Estimated weighted smelt egg production for both river vegetation and hard substrate in the Jones River was 3.29×10^9 eggs.

VI. 1982 Entrainment Studies.

Bob Anderson highlighted the 1981 entrainment studies. A total of 33 species of fish eggs and/or larvae were found during this year's collections. Egg collections were dominated by Atlantic cod (January, February, November-December); American plaice and winter flounder (March-April); Limanda group, Atlantic mackerel, and tautog (May-July); windowpane, rockling and hake (late May-September).

Larval collections for 1981 were dominated by sand lance (January-April), rock gunnel (February-April), winter flounder (April-May), grubby (January-April), Atlantic mackerel (June), cunner (June-August), rockling, hake and tautog (August), rockling (September), rockling, silver hake and hake (October-November), and Atlantic herring (December). One lobster larvae and several rainbow smelt larvae were also collected during 1981.

VII. 1982 Sluiceway studies.

Impinged fish survival at the Pilgrim sluiceway was 11.8% (short-term) and 4.4% (long-term). Fish introduced to the sluiceway after the screens evidenced 100% survival in most cases (exceptions were rainbow smelt, 0%; Atlantic silverside, 50%; and mummichogs, 86%).

A fish tagging program will be conducted during 1982 to determine survival of fish actually impinged on the plant's screens during normal operational periods.

VIII. Other Business.

A letter from Walter Grocki of TAXON to Lew Scotton discussing proposed modifications of the effluent transect survey was reviewed by the full Committee. Scheduling modifications were intended to permit:

a) assessment of the extent to which Chondrus, Phyllophora, and Laminaria have reclaimed the "stunted" and "denuded" zones since Unit 1 has been off line;

b) assess the rate at which the "stunted" and "denuded" zones return to their original (pre-shutdown) boundaries;

c) assess the length of time necessary, once Unit 1 resumes operations for the "stunted" and "denuded" zones to fully resume their original (pre-shutdown) boundaries.

Don Miller felt that determination of zonal recovery rate was of more importance than that delineating the (decimation) rate, which the proposed modifications more directly address. Don voiced concern that any alteration in benthic study work should be reviewed thoroughly by the benthic subcommittee at the very least, and then presented to the full PATC Committee.

Bob Leger suggested that the benthic subcommittee convene as soon as possible and discuss, in depth, the proposed study modifications.

Mr. Grocki was contacted during the lunch break to determine exactly what benthic work had been completed to date. It was determined that the December transect study had not been conducted due to adverse weather conditions. The pre-startup survey had been conducted, however, and an additional dive was possible during the first week of June to maintain study continuity.

The proposed study schedule was tentatively approved, with the provision that a summary report be submitted to Don Miller for evaluation at the end of April.

IX. Adjounment.

Meeting adjourned at 3:10 P.M.

Administrative-Technical Committee Meeting

March 23, 1982

Bob Leger, Chairman	U.S.E.P.A. (non-voting advisory member)
Phillips Brady, Recording Secretary	Mass. Division of Marine Fisheries
Leigh Bridges	Mass. Division of Marine Fisheries
Bob Lawton	Mass. Division of Marine Fisheries
Bob Anderson	BECo
George Kelly	NMFS - Woods Hole
Christine Sheehan	Mass. Division of Marine Fisheries
Don Miller	EPA, Narragansett (advisory member)
Gerald Szal	Mass. Division Water Pollution Control
Mike Scherer	M.R.I.
Michael Bilger	U.S.E.P.A.
Clare M. Kudera	Mass. Division of Marine Fisheries

MEMORANDUM

TO: Members of the Administrative-Technical Committee, Pilgrim Power Plant Investigations

FROM: Phillips Brady, Recording Secretary, Marine Fisheries Biologist, Massachusetts Division of Marine Fisheries

SUBJECT: Addendum to the 52nd Meeting minutes of the Administrative-Technical Committee

DATE: April 12, 1982

The minutes of the 52nd A-T Committee Meeting are corrected as follows via this addendum:

Page 1, paragraph 2, sentence 1 shall read: "Bob welcomed Mike Bilger of the U.S. EPA to the A-T Committee".

Page 5, section VII, paragraph 4, question marks ("?") are placed at the end of sentences a, b, c, and d.

PB:EB

MEMORANDUM

TO: Members of the Administrative-Technical Committee, Pilgrim Power Plant Investigations

FROM: Phillips Brady, Recording Secretary, Marine Fisheries Biologist, Massachusetts Division of Marine Fisheries

SUBJECT: Minutes of the 54th meeting of the Pilgrim Administrative-Technical Committee

DATE: June 16, 1982

The 54th Administrative-Technical Committee meeting was called to order on 15 June,1982 at 10:05 A.M. at the Pilgrim Nuclear Station, Information Building, in Plymouth, Massachusetts by Chairman Leger. Ten agenda items were addressed.

I. Minutes of the 53rd meeting.

Corrections to the 53rd Committee minutes were tendered and are attached as a separate addendum to these minutes.

II. Update - Semi-Annual Report #19.

Bob Anderson highlighted the 1981 Impingement and Fish surveillance studies. A station refueling outage from the end of September to December, 1981 limited impingement collections. A large impingement, estimated at 6,048 Atlantic silversides, occurred on 23-24 September and accounted for 85.4% of all fish sampled from January-December.

In October, an estimated 1.5 million pounds of menhaden were observed during a surveillance overflight in the vicinity of Pilgrim I discharge. No mortalities or incidents were reported.

Inspection of the (discharge canal) barrier net in 1981 revealed it was operating successfully.

Work continues on the 1982 winter flounder studies. Flounder eggs have been collected from the plant intake in an effort to determine both egg viability and age. This spring, eggs were collected on two occasions. Studies are continuing,and a completed report will be submitted in November.

III. 1983 DMF studies.

Bob Leger reviewed the response letter from the Massachusetts Division of Marine Fisheries in regards to PATC's recommendations of continued work in the Jones River. MDMF regretted present funding limitations which inhibit such work, but expressed appreciation for the Committee's interest in this matter.

Bob Lawton presented areas of fisheries' studies conducted by the DMF. DMF study areas will be discussed in greater depth at the next marine fisheries subcommittee meeting, scheduled for the third week of July. Don Miller challenged the subcommittee to look thoroughly at future study questions, regarding environmental impact and affected fish species. He further urged the development of an integrated approach delineating primary problem areas.

Phil Brady read a letter from the Marine Fisheries dive master, addressing Division policy for SCUBA diving in and around the Plant's discharge canal. The following actions were proposed for incorporation into the diving program.

1. No diving permitted in or near the discharge when levels of chlorine exceed 0.1 ppm free residual or 0.5 ppm combined residual.

2. Establishment of a communications' system to warn divers immediately if chlorine discharge levels exceed permitted levels. Prompt notification of the Division's diving board in such an event.

3. Thorough examination of all diving gear utilized in the discharge dives.

4. Advisement of the potential danger relating to hyperchlorination to every diver involved in the program.

Lew Scotton felt that the incorporation of these principles could be quickly accomplished, and the dive program made as safe and effective as possible.

IV. <u>DMF smelt study update</u>.

Committee members were referred to section V, of the Semi-Annual Report #19. Activity in the Jones River during 1981 represented the final year of a three-year study establishing baseline information on the reproduction, structure and size of the Jones River spawning population.

Phil Brady presented preliminary findings of an experiment conducted this spring measuring effects of low range pH levels (acidic waters) on smelt egg survivorship.

V. <u>Monograph status</u>.

Bob Anderson presented a memo critiquing events of the June 3rd meeting of the Monograph subcommittee in Westborough. Following the earler subcommittee meeting with the American Fisheries Society (AFS) managing editor Bob Kendall, it was evident that major modifications of the document's theme would be required.

Tom Horst offered to outline an ecological approach for the monograph as Dr. Kendall had suggested. He will meet with the various section authors to determine if such an approach can be developed. The subcommittee proposed three conditions for acceptance by the AFS editor.

1) Section I of the publication would remain basically the same as the existing document;

2) The conclusions in Section I would remain as they presently exist;

3) Power Plant impact would be a distinct monograph section.

AFS has agreed to these three points and the Committee is still pursuing the AFS avenue for publication. The subcommittee also recommended other possible avenues for journal publication be investigated, where the current document can be presented without the major alterations needed for acceptance by AFS reviewers.

George Kelly strongly urged that priorities be reevaluated and the subcommittee actively pursue alternate methods for the timely dissemination of the study findings into the open literature.

VII. Sluiceway survival status.

Throughout the whole sluiceway system, latent mortalities were assessed at approximately 20 percent. Investigating the source of mortality in 1982, fish will be introduced before the wash screens, impinged and removed via the sluiceway. Survivorship at various stages will be compared to control fish held on site. Fish survivorship appears directly related to both species type and time period on the screens. This year, fish will be evaluated for damage over the normal eigh-hour screen rotation periods.

VII. Benthic studies' status.

Don Miller presented findings of the benthic subcommittee's May meeting. The subcommittee unanimously recommended that the benthic studies be continued via the same work format and at the present effort levels. Currently, four seasonal SCUBA transect surveys and two quantitative community studies are conducted each year.

Seasonal alterations, documented for the denuded and stunted zones of the discharge, were discussed in connection with prevailing wind direction, speed, and plant operational load levels.

The subcommittee also recommended that the 1982 benthic work be sent out to bid. The Committee recommended preliminary work be conducted in August and the full contract work commence in September.

Lew will prepare a list of contractors to conduct the work, and the benthic subcommittee will review the final listings. Bob Lawton moved that, "the PATC allow Lew to screen the possible benthic contractors and select a priority list of the best three or four for inclusion in the bidding process". Following the screening, the benthic subcommittee will review the bid proposals that are submitted. Don Miller second, "with the provision that upon completion of the screening list, Lew contact the benthic subcommittee chairman".

Motion passed unanimously.

IX. Other business.

Bob Anderson informed the Committee of a proposal currently under consideration by BECo from International Sea Farms Enterprises, Inc. for the establishment of an Atlantic and Coho hatchery on the Unit II site. Following a general discussion, George Kelly moved "that the A-T Committee support the pursuit of such (new) endeavors". Bob Anderson second, and the motion passed unanimously.

X. Adjournment.

Meeting adjourned at 3:00 P.M.

Administrative-Technical Committee Meeting

June 16, 1982

Bob Leger, Chairman	U.S.E.P.A. (non-voting advisory member)
Phillips Brady, Recording Secretary	Mass. Division of Marine Fisheries
Bob Lawton	Mass. Division of Marine Fisheries
Bob Anderson	BECo
George Kelly	NMFS - Woods Hole
Christine Sheehan	Mass. Division of Marine Fisheries
Don Miller	EPA, Narragansett (advisory member)
Michael Bilger	U.S.E.P.A., Lexington
Lew Scotton	BECo
John Finn	U. Mass.

MEMORANDUM

TO: Members of the Administrative-Technical Committee, Pilgrim Power Plant Investigations

FROM: Phillips Brady, Recording Secretary, Marine Fisheries Biologist, Massachusetts Division of Marine Fisheries

SUBJECT: Addendum to the 53rd meeting minutes of the Administrative-Technical Committee

DATE: June 16, 1982

The minutes of the 53rd A-T Committee Meeting are corrected as follows:

Page 3, Section VII, paragraph 2, sentence 1 -- shall read: A fish tagging program will be conducted during 1982 to determine survival of fish actually introduced and impinged on the Plant's screens during normal operational periods.

Page 4, Section VIII, paragraph 2, sentence 1 -- shall read: Don Miller felt that determination of zonal recovery rate was of more importance than delineating the (decimation) rate, which the proposed modifications more directly address.

The Commonwealth of Massachusetts
Division of Marine Fisheries
Leverett Saltonstall State Office Building
100 Cambridge Street
Boston, Massachusetts 02202

PHILIP G. COATES
DIRECTOR

727-3193

April 1, 1982

Mr. Robert Leger
Chairman, Pilgrim Power
Plant Administrative
Technical Committee
U.S. Environmental Protection Agency
J.F. Kennedy Federal Building
Boston, MA 02203

Dear Bob,

Phil Coates has asked that I respond to your letter of January 25, 1982 relative to the recommendations by the Committee that the Division continue population dynamics work and life history parameters studies on the smelt population in the Plymouth area. The Division is aware of the importance of this recreational resource and would like very much to fund continued efforts in both management and research on smelt. However, because of funding limitations and staff reductions resulting from federal and state cutbacks, we are not in a position to continue a research program on smelt at this time. In the event that our funding situation improves in the next few years, the smelt studies will receive consideration amongst other proposals for investigation and management.

We appreciate the Committee's interest in this matter.

Sincerely,

W. Leigh Bridges (signature)
W. Leigh Bridges
Assistant Director, Research

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