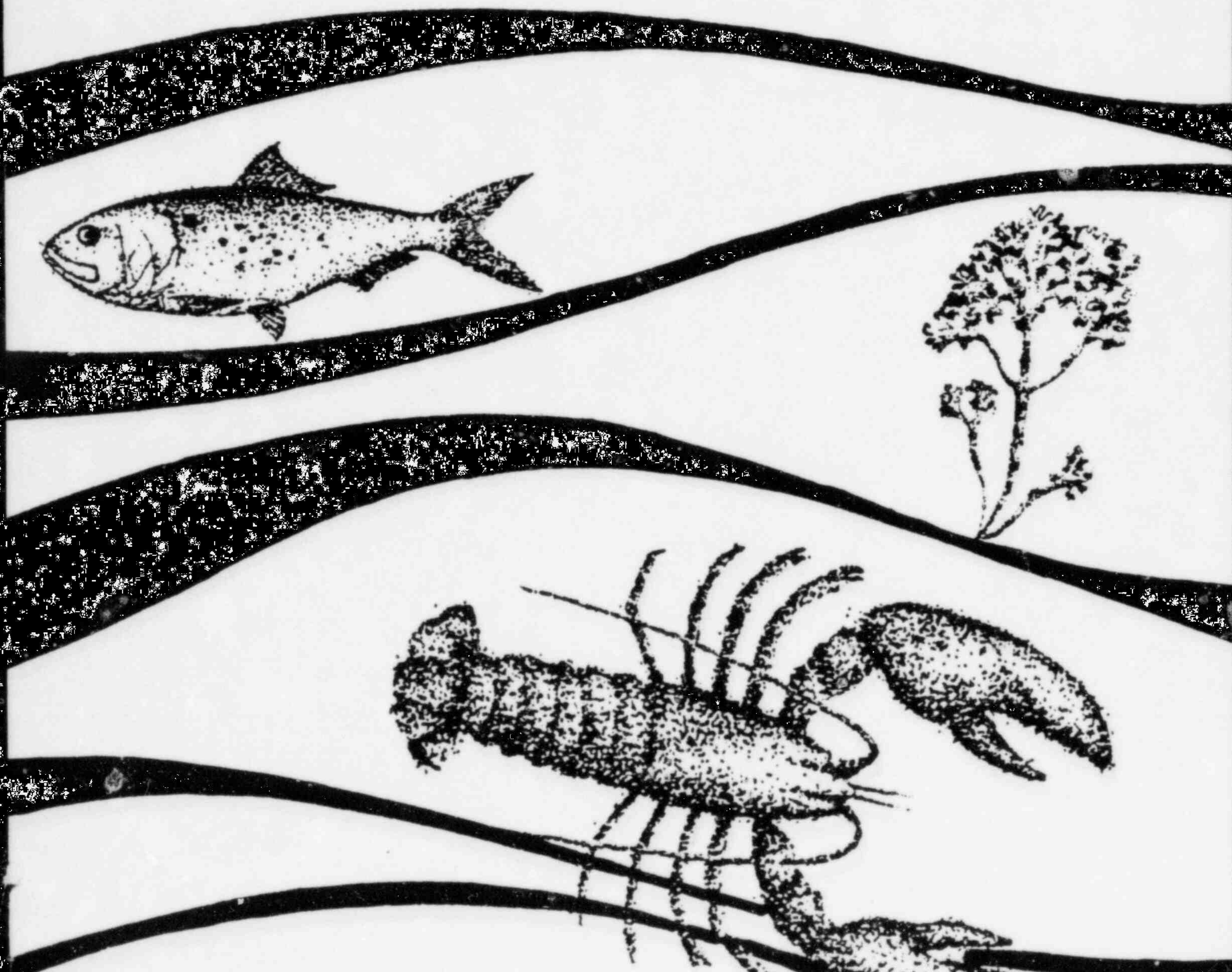
marine ecology studies

Related to Operation of Pilgrim Station

SEMI-ANNUAL REPORT NUMBER 21
JANUARY 1982 — DECEMBER 1982



BOSTON EDISON COMPANY
NUCLEAR OPERATIONS SUPPORT DEPARTMENT

BOSTON Edison COMPANY

NUC3-E1

MARINE ECOLOGY STUDIES
RELATED TO OPERATION OF PILGRIM STATION

SEMI-ANNUAL REPORT NO. 21

REPORT PERIOD: JANUARY 1982 THROUGH DECEMBER 1982

DATE OF ISSUE: APRIL 30, 1983

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SUMMARY

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

Marine Fisheries Studies:

1. Irish moss landing statistics for June - August 1982 compared to 1981 indicated that landings increased 5.8% and effort decreased 0.9%. Pooled area harvest rate was the fourth highest recorded in 12 years and increased from 181.7 in 1981 to 194.0 lbs/hr in 1982. Harvest rate from Area 5 (Pilgrim Station - 190.9 lbs/hr) decreased 2.6% from 1981, and Area 1 (control) harvest rate (197.0 lbs/hr) decreased 4.2% below the 1981 rate. This indicates Pilgrim Station operation had no adverse impact on the Irish moss species.

2. Winter flounder, skate spp., yellowtail flounder, windowpane, longhorn sculpin and ocean pout were the dominant fishes, respectively, in the January - December 1982 otter trawl catch. CPUE decreased from 1981 for winter flounder (38.5 to 30.2), skate spp. (8.6 to 7.8), windowpane (4.4 to 3.4) and yellowtail flounder (10.0 to 3.5). CPUE increased for longhorn sculpin (2.2 to 3.2) and ocean pout (0.6 to 0.7). American lobster CPUE for

1982 (26.0) was similar to 1981 (27.0). Pelagic fish mean catch at the original gill net station (150.5 fishes/set) decreased 33.0% from 1981 when 224.7 fishes/set were taken. Pollock (36.4%), cunner (25.8%) and Atlantic herring (8.8%) accounted for 71.0% of the total catch. Pollock CPUE decreased from 110.7 to 54.8, cunner 40.7 to 38.8 and Atlantic herring 44.4 to 13.3 compared to January - December 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 - December 1982 recorded twenty-six benthic fish species with winter flounder, little skate, windowpane, yellowtail flounder, longhorn sculpin and fourspot flounder composing 96.1% of the total. Mean CPUE for all species was 30.7 compared to 28.3 in 1981. Individual species CPUEs declined from 1981 for winter flounder (13.6 to 11.4) and yellowtail flounder (5.2 to 3.8), while they increased for skate spp. (3.7 to 6.5), windowpane (3.1 to 6.3) and longhorn sculpin (0.3 to 2.0).

4. Adult lobster mean monthly catch rate per pot haul in May - November 1982 was 0.65 lobsters (0.62 in 1981).

In the Pilgrim Station discharge area the legal lobster catch per pot was 0.43. Berried female lobsters accounted for 1.8% of the total catch for this period compared to 2.3% in 1981.

5. In May - November 1982 fish observational dive surveys approximately 2,100 fishes of eight species were observed in the thermal plume area. Cunner, pollock, tautog and Atlantic silverside were the most numerous species seen. No fish showed abnormal behavior and no gas bubble disease symptoms were observed on routine observational dives. Most fishes (43%) were in greatest concentrations at stations in the direct path of the thermal plume, indicating attraction to the Pilgrim Station thermal effluent. In June and July a possible fungal or bacterial growth was observed on the bottom and dead mussels were noted beneath this growth.

6. Atlantic silverside accounted for 65.3%, bay anchovy 18.7% and sand lance 10.2% of the 1982 haul seine (shore zone) fish catch with a total of twenty-two species collected. Shrimp (Crangon spp.) dominated the invertebrate catch. Fish captured in the PNPS intake embayment included Atlantic silverside, sand lance spp., winter flounder, northern puffer and northern pipefish.

7. Fishing power trials comparing the otter and near-shore (shrimp) trawls in September/October showed the former gear caught more species and 3 times greater number of fishes than the latter gear.

Impingement Studies:

1. The mean January - December 1982 impingement collection rate was 0.93 fish/hr. The rate ranged from 0.13 fish/hr (August) to 2.41 fish/hr (March) with Atlantic silverside comprising 20.7% of the catch, followed by bay anchovy 11.5%, cunner 9.8%, rainbow smelt 9.4%, and threespine stickleback 6.7%.

2. In March and April 1982, Atlantic silverside impingement accounted for 83.2% of the fishes collected. This is historically the maximum impingement period for Atlantic silverside.

3. The mean January - December 1982 invertebrate collection rate was 1.33/hr with the long-finned squid and horseshoe crab accounting for 40.8 and 33.6% of the catch, respectively.

4. Thirty-two American lobsters were sampled for a yearly rate of 408 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 13.2% (short-term) and 5.9% (long-term) from 1980-1982. Fish introduced in front of operating traveling screens in 1982 showed initial survival of 100% for cunner, 99.5% for winter flounder and 19.9% for Atlantic silverside. Long-term survival percentages were 100, 68.7 and 4.9, respectively.

Fish Surveillance Studies:

1. Fish overflights in 1982 spotted five major species categories: herring, Atlantic menhaden, pollock, Atlantic mackerel and baitfish. Both Atlantic herring and pollock were noted schooling inside the PNPS intake breakwaters at times during 1982, and 50,000 pounds of Atlantic menhaden were observed within the discharge vicinity in August. Regulatory authorities were not notified as no incidents occurred involving these fish.

2. Dive inspections of the fish barrier net at the end of the Pilgrim discharge canal revealed it was operating successfully in excluding fishes during 1982. Several species of biota that were resident in the discharge canal, or could pass the barrier net's 2" mesh were noted upstream of it. Live fish were observed in the canal only in May, and they included a small school of Atlantic silversides, and a

Coho salmon beneath the cod end of the barrier net. No live individuals observed appeared stressed or showed gas bubble disease symptoms. Many sportfish were in evidence downstream (seaward) of the barrier net as indicated by sportfishermen's catches.

Benthic Studies:

1. Some minor changes in faunal taxonomy were observed; however it is not yet clear if these are actually new species to the area.

2. Dominant species patterns were similar at all three sites with several notable differences. A chief difference was the depressed dominance of mussels at Effluent where Mytilus was only the fourth most abundant species.

3. Sediment at the Effluent Station is a combination of Mytilus edulis shell fragments and entrapped sand particles. Sediment of this nature is not found at the Rocky Point and Manomet Point Stations.

4. Based on transect study observations, it is possible that an enhancement effect operates during winter months, with the overall impacted zone being reduced due to rapid cooling of the discharge water through mixing with cold seawater. In September, the total area encompassed by the denuded and stunted zones covered approximately 2328 m^2, whereas in December the area covered was 2082 m^2.

5. The <u>Chondrus/Phyllophora</u> condition index study indicated that <u>Phyllophora</u> was more heavily colonized, presumably due to its ability to tolerate epiphyte-induced stress.

<u>Plankton Studies</u>:

1. Entrainment

   a. A total of 37 species of fish eggs and/or larvae were found in the January - December 1982 entrainment collections.

   b. Egg collections for 1982 were dominated by Atlantic cod (January - February), winter flounder (March - April), labridae - <u>Limanda</u> group (May - August), Atlantic mackerel and windowpane (May - October). Menhaden were most abundant in September. Hake and rockling were abundant in June - September. Cod eggs were most abundant in November and December, and labrids were present in December.

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

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

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

3. Larval Winter Flounder Studies

a. The main part of the 1982 larval winter flounder program was designed to test the assumption that all winter flounder entrained at PNPS originate from Plymouth Harbor, Kingston and Duxbury Bay (PHKDB).

b. The data support the assumption that PHKDB is the sole source of larval flounder entrained at PNPS.

c. Some larvae from Green Harbor River are probably entrained; however this number is quite small compared with numbers of larval flounder form PHKDB.

d. The second part of the 1982 program involved supplementary winter flounder egg studies, designed to estimate the age of winter flounder eggs collected at PNPS.

e. Results indicated that 40.9% of the live eggs (n=44) collected at PNPS appeared to be considerably younger than 7 days. Thirty-six percent were less than 3 days old and 15.0% were 1 day old.

f. The data strongly suggest that some flounder spawning occurs nearer PNPS than inside PHKDB.

INTRODUCTION

A. Scope and Objective

This is the twenty-first 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 ninth 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 VI.

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 1983 otter trawl sampling and 1 gill net station (south of the PNPS discharge canal) will be terminated.

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. In 1983 the Irish moss harvest study will be terminated.

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 Battelle New England Marine Research Lab, Duxbury, 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 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.1. The 1982 winter flounder larvae report was prepared by Marine Research, Inc., and is included in Section III C.2.

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 #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 are presented in Sections IVA and IVB, respectively.

D. Studies' Integration

This is a new section of the Marine Ecology Semi-Annual Reports which attempts to integrate results from different study areas, where possible, for a more comprehensive understanding of the Western Cape Cod Bay ecosystem and Pilgrim Station's influence on it. Analyses appear in Section V.

E. Station Operation History

The daily average, reactor thermal power levels from January through December 1981 and 1982 are shown in Figure 6, and for July 1972 through December 1980 in Figure 7.

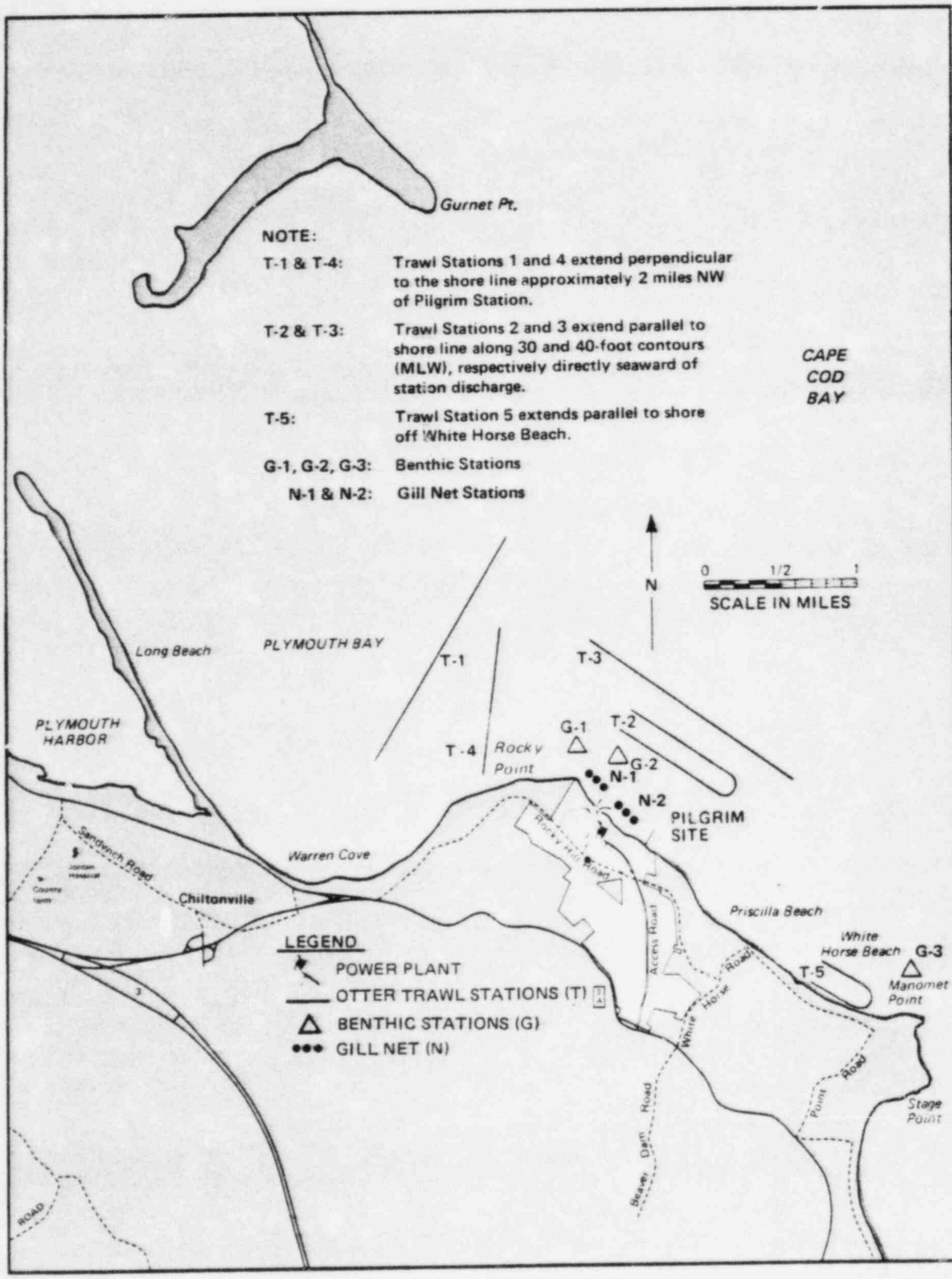


Figure 1. Location of Otter Trawl and Gill Net Sampling Stations for Marine Fisheries Studies, and Benthic Studies Sampling Stations

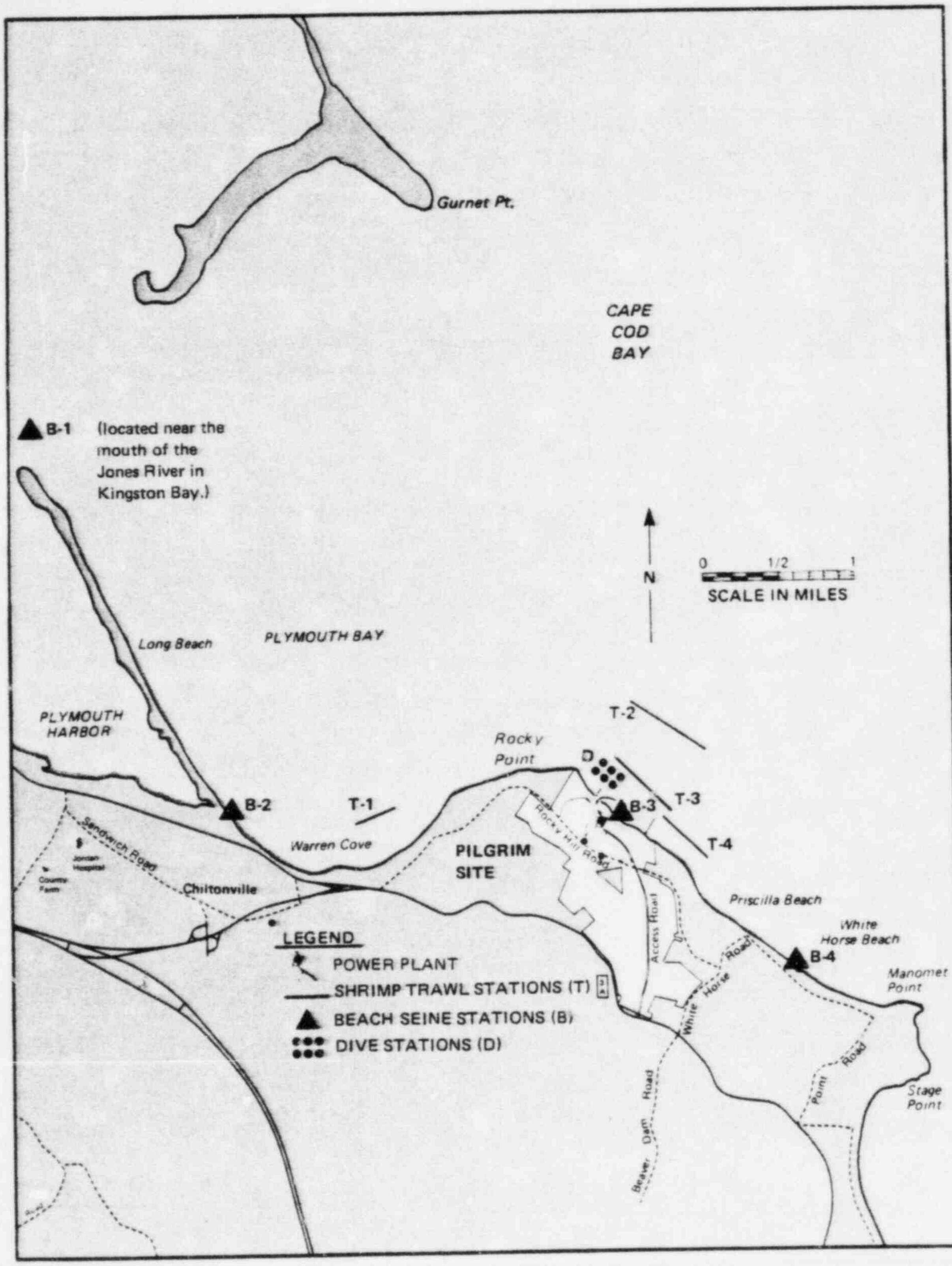


Figure 2. Location of Shrimp Trawl, Beach Seine and Dive Sampling Stations for Marine Fisheries Studies.

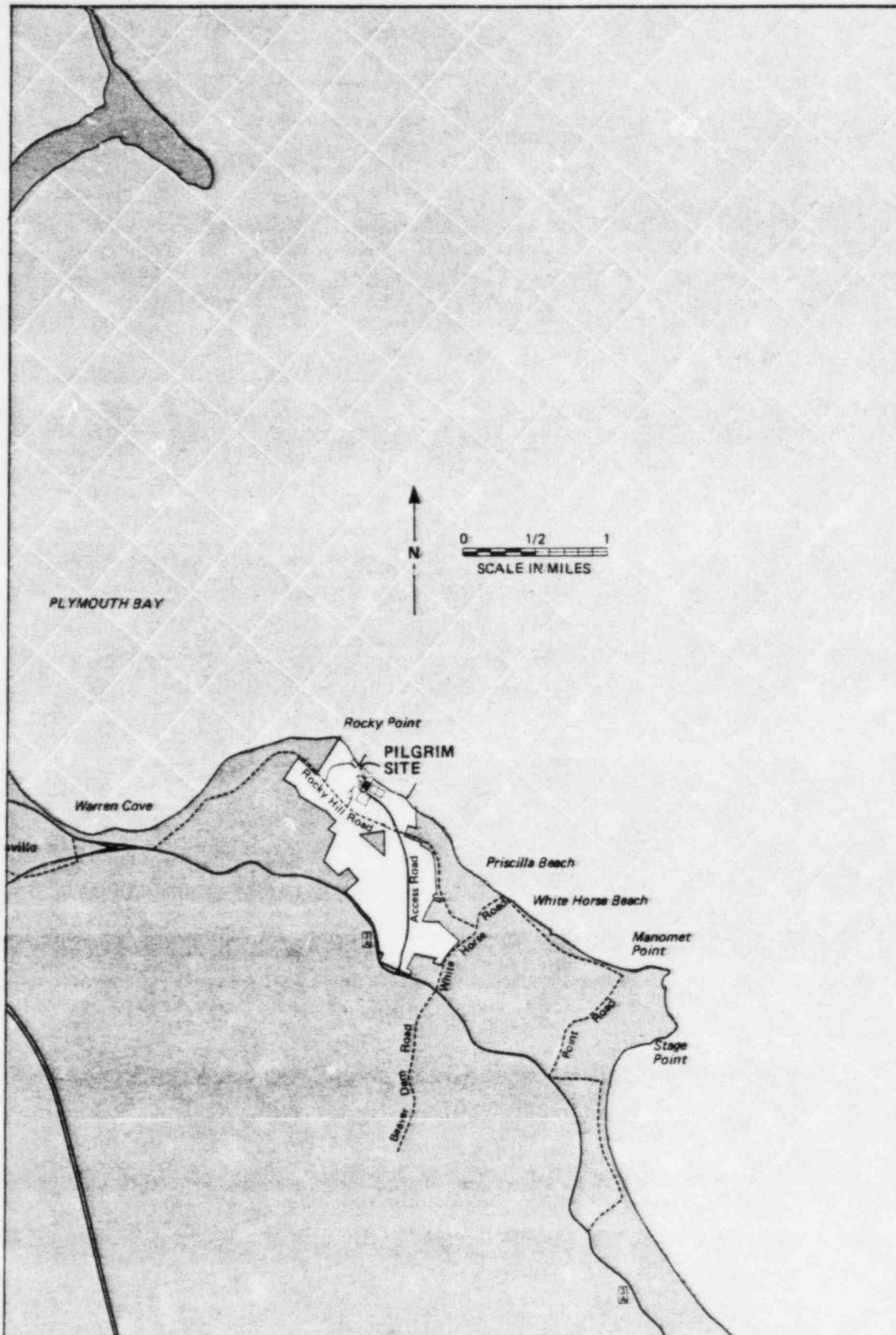


Figure 3. Lobster Pot Sampling Grid for Marine Fisheries Studies.

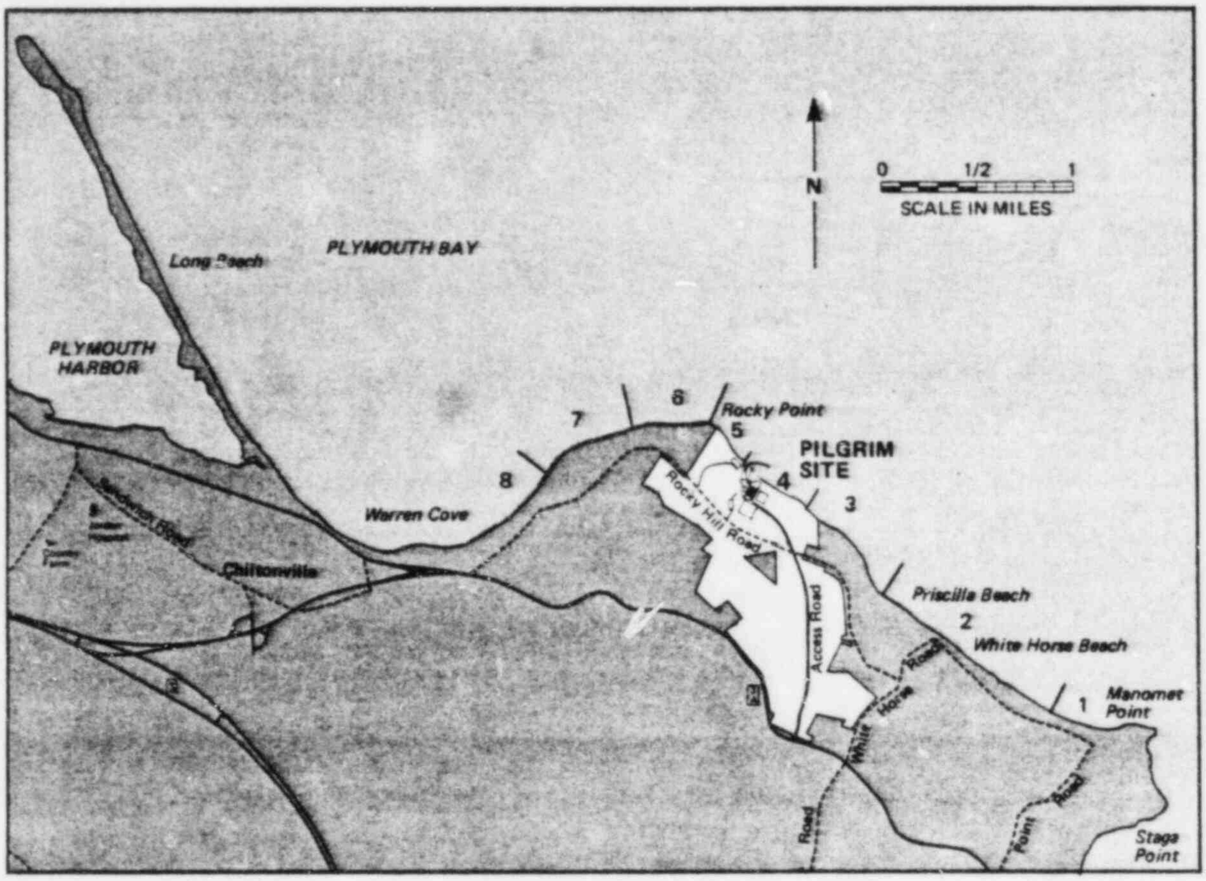


Figure 4. Irish Moss Commercial Harvesting Areas for Marine Fisheries Studies.

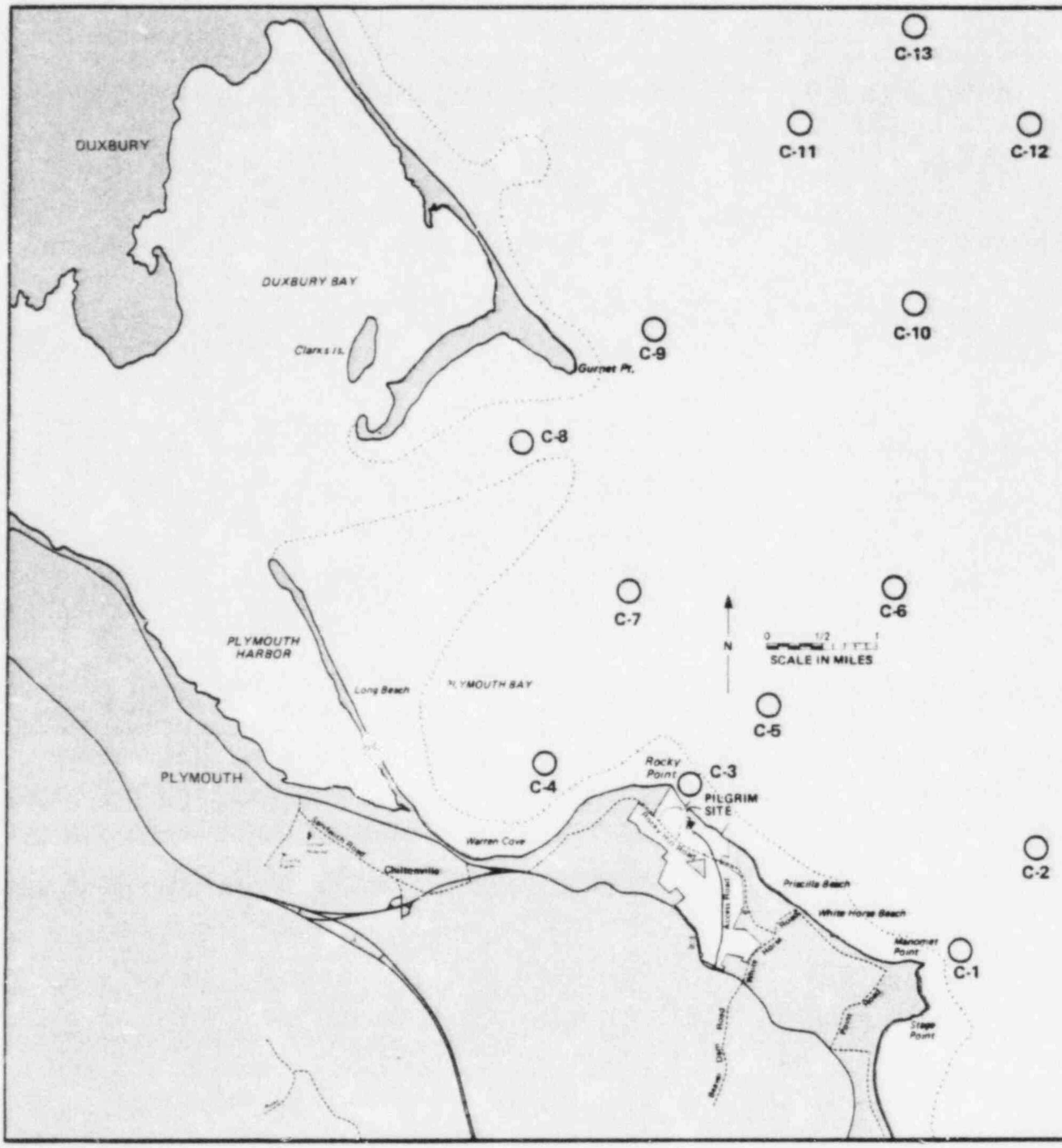
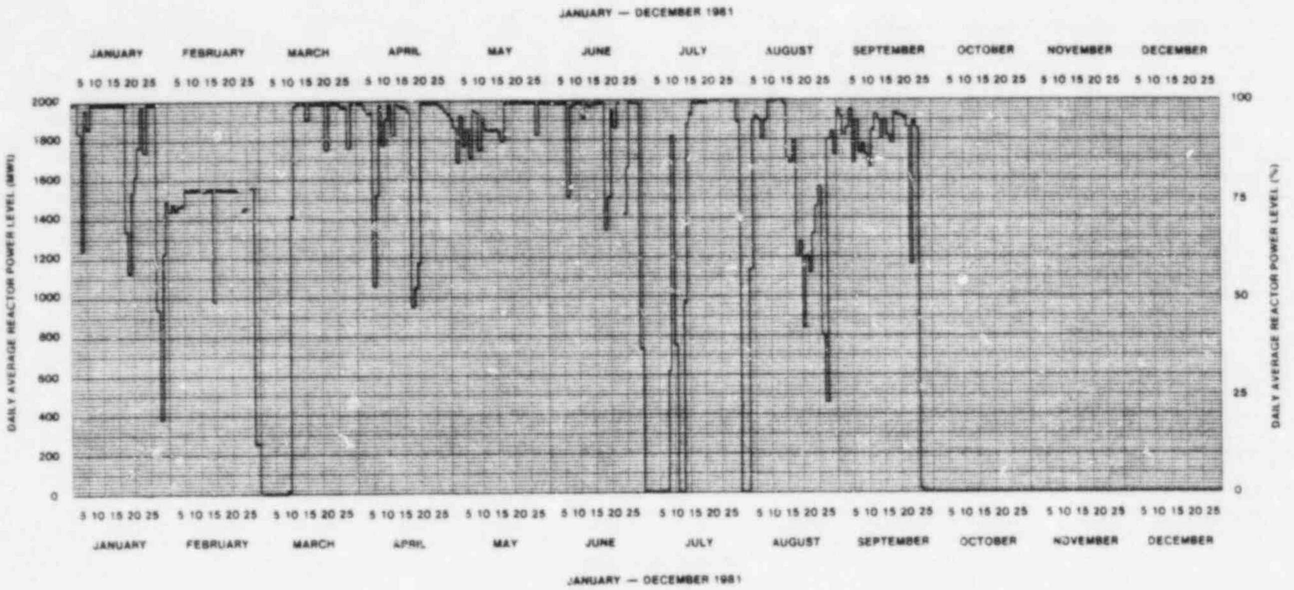


Figure 5. Location of Entrainment Contingency Plan Sampling Stations, C.



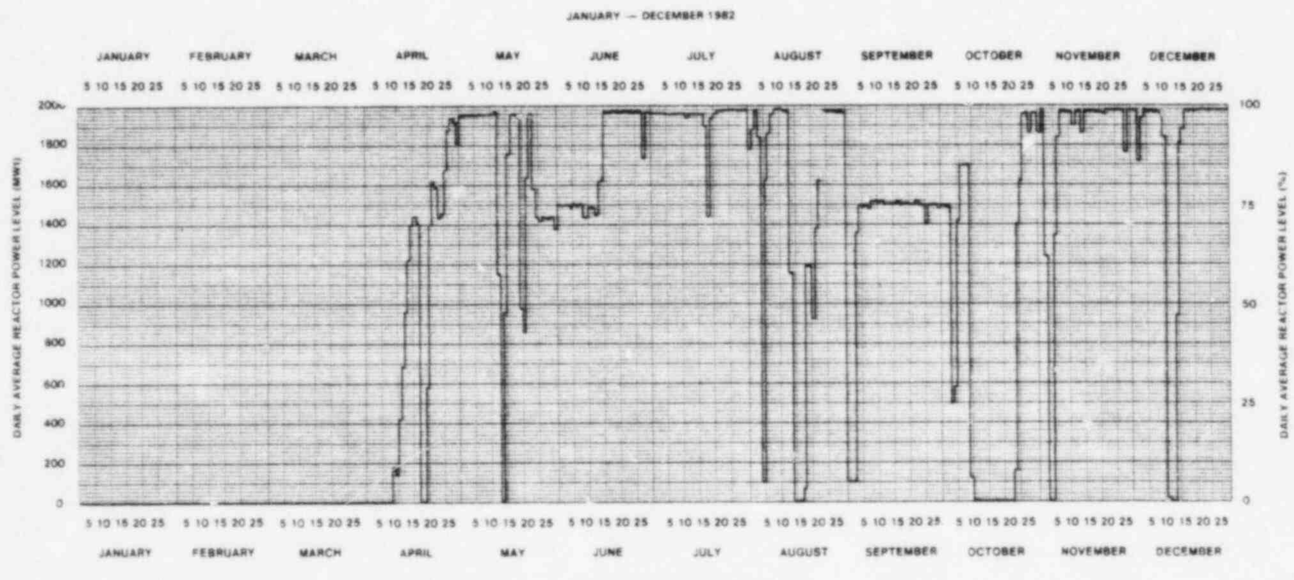


FIGURE 6. Daily Average Reactor Thermal Power Level (MW_t and %) from January 1981- December 1982 for Pilgrim Nuclear Power Station.

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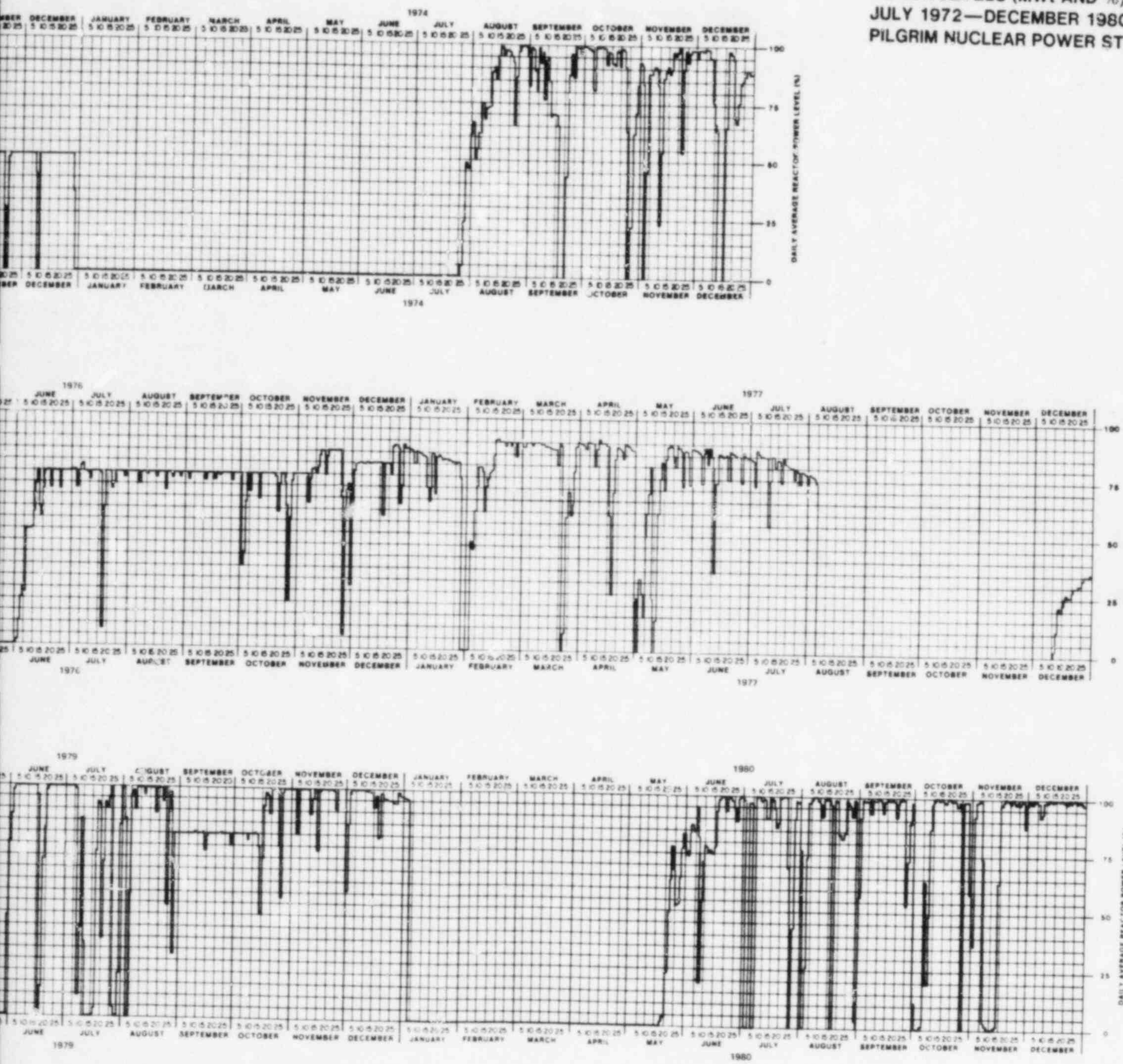
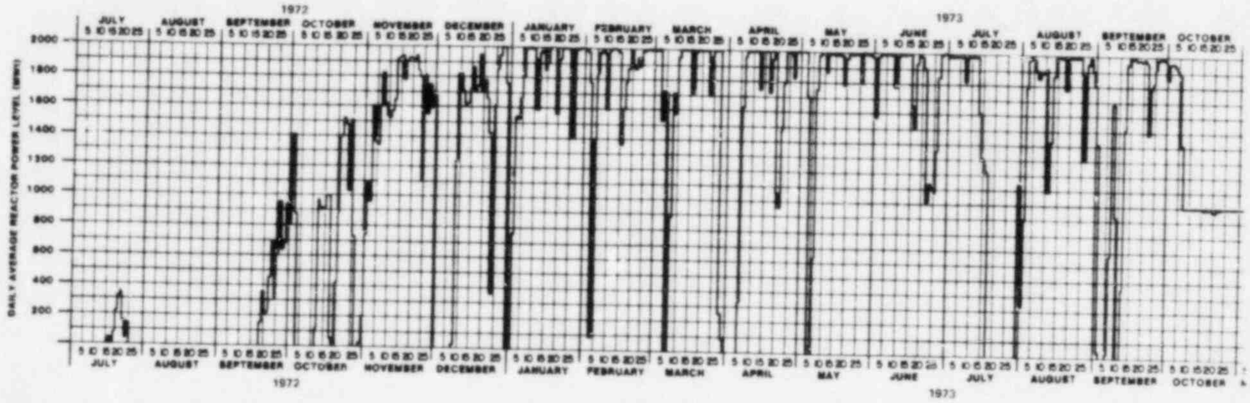


FIGURE 7. DAILY AVERAGE REACTOR THERMAL POWER LEVELS (MWt AND %) FROM JULY 1972—DECEMBER 1980 FOR PILGRIM NUCLEAR POWER STATION.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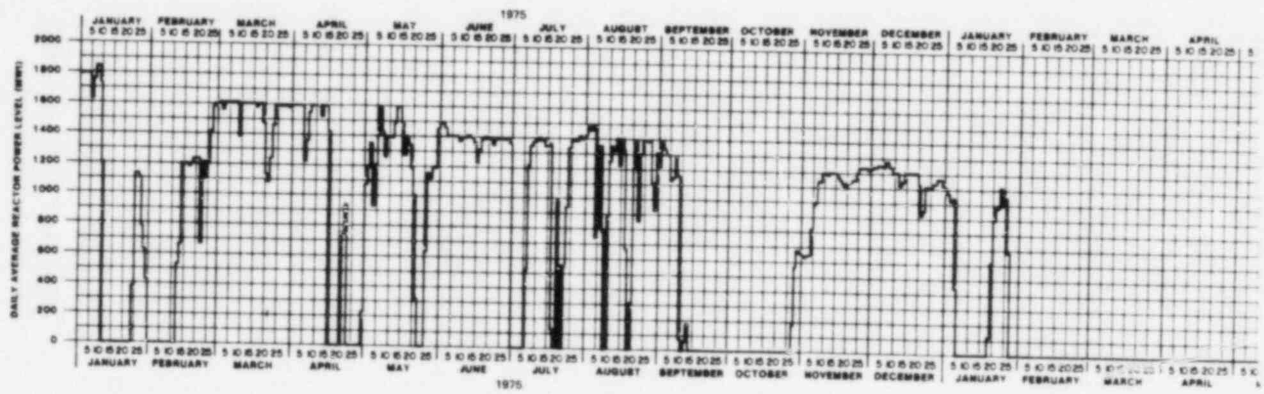
DAILY AVERAGE REACTOR POWER LEVEL (MWt)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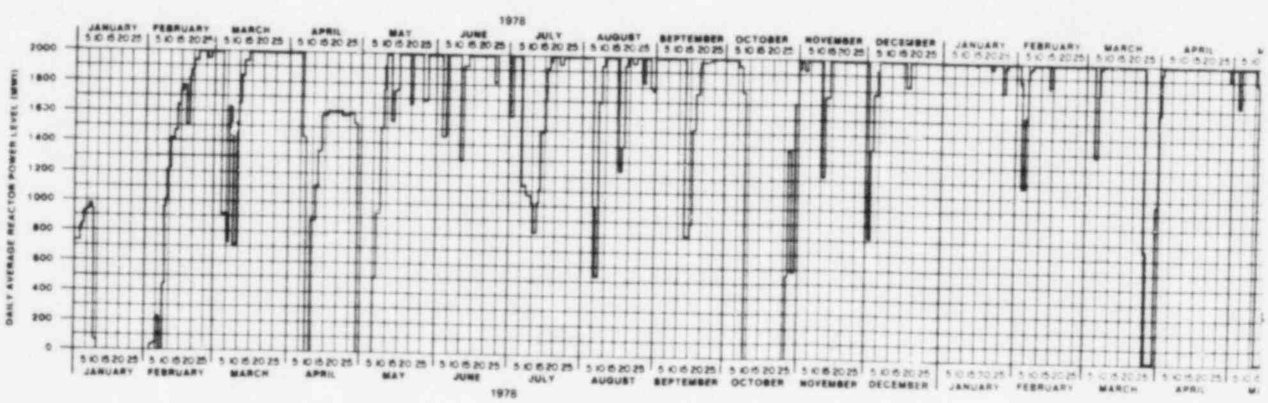
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DAILY AVERAGE REACTOR POWER LEVEL (MWt)

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

Project Report No. 34 (January-December, 1982)
Summary Report No. 15

By

Robert P. Lawton, Phillips Brady, Christine Sheehan,
Mando Borgatti and Vincent Malkoski

February 25, 1983

Massachusetts Department of Fisheries,
Wildlife and Recreational Vehicles
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Boston, Massachusetts 02202

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1. Divers making observations at a 'control' station, located outside the influence of the thermal discharge.

2. A 'carpet' of Irish moss, with accompanying epiphytes, extends over the rocky bottom at a 'control' site.

3. A longhorn sculpin (Myoxocephalus octodecemspinosus) watches while divers complete observations at a station in the 'stunted' zone.

4. Starfish (Asterias spp.) observed during many dives, graze on new mussel sets in the 'stunted' zone.

5. A horseshoe crab (Limulus polyphemus) and several cunner (Tautogolabrus adspersus) are sighted at Station D_2 (discharge).

6. Cunner often occur in large numbers in the 'denuded' zone, and are pictured actively feeding on suspended particles emanating from the discharge canal.

INTRODUCTION

Ecological studies have been conducted by the Massachusetts Division of Marine Fisheries since 1969 to assess non-radiological impact of Pilgrim Nuclear Power Station - Unit I on fisheries resources in the off-site waters of western Cape Cod Bay. Data from 1982 are summarized in this report, and unless otherwise indicated, methods and materials employed in sampling programs are identical to those described in past reports. Numerical tabulations of measurements, counts, percentages, and computed indices of abundance are compared spatiotemporally to identify data trends and relationships and to examine causal agents for observed ecological phenomena.

COMMERCIAL LOBSTER CATCH STATISTICS

Lobster catch data by quadrat from the Plymouth Bay to the Manomet-Indian Hill region of Cape Cod Bay are presented in Appendix A of this report. A total of 3,374 lobster pots, containing 7,794 lobsters, was sampled during the 1982 harvest study, which ran from 18 May through 17 November.

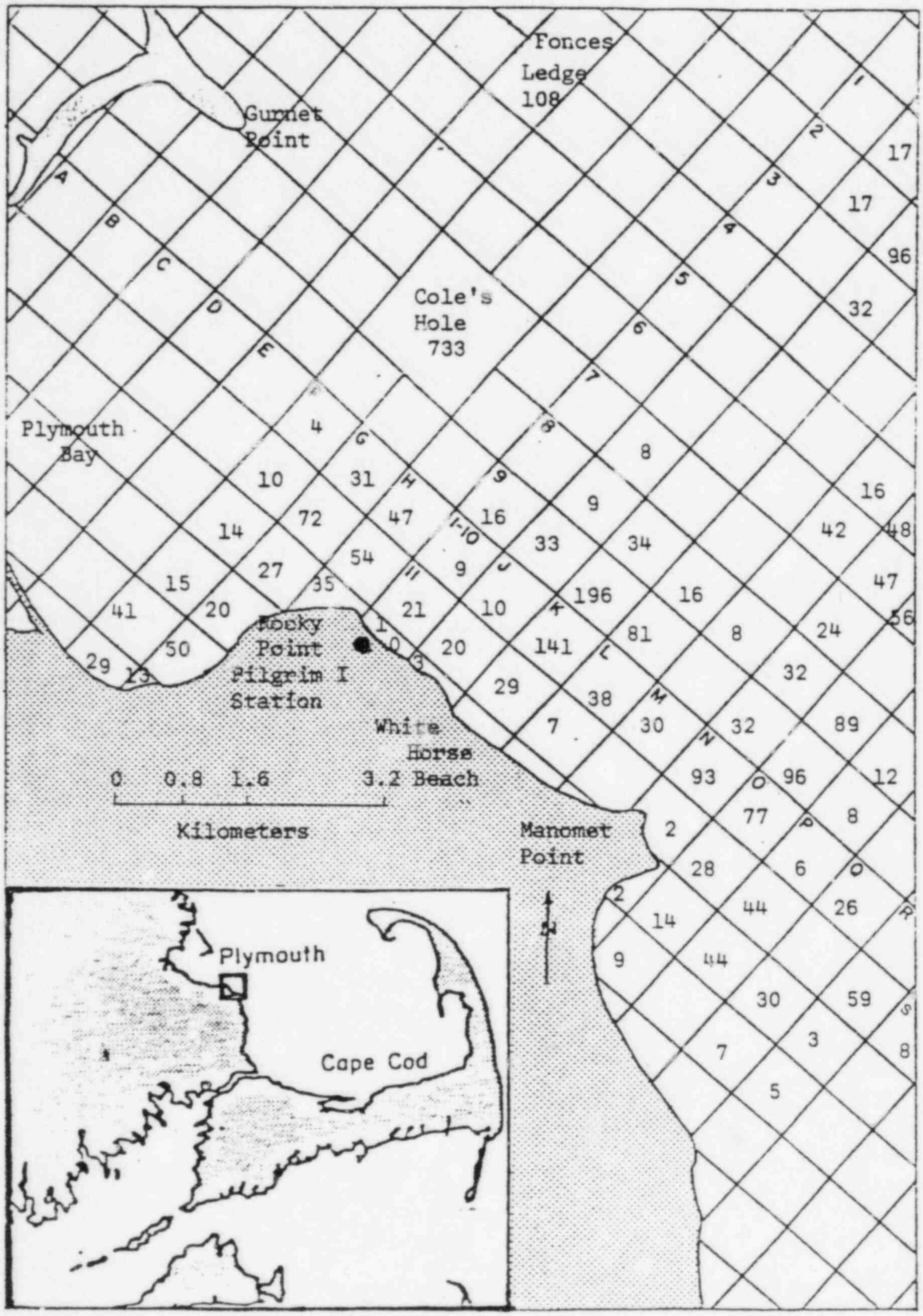
As noted last season, fishing effort determined by the number of pots fished, was higher in quadrats further offshore. Distribution of pots sampled by quadrat is presented in Figure 1.

Mean monthly catch rates (i.e., $\bar{x}$ 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. Legal catch rates of 0.46 for June and July were the highest and lowest, respectively, of the study. This is in contrast to previous years when traditionally the June catch is low (due to ecdysis) and higher in July as lobster activity increases following the molt. Cause of this phenomenon is unknown but may be related to anomalous spring conditions influencing lobster molt cycles. Commonwealth landings for 1982 are presently unavailable to ascertain if this condition was localized or regional.

The September catch rate of 1.11 legal lobsters per pot haul is the second highest value obtained during the study, 0.19 below the 1.30 high recorded in September, 1972. A catch rate of 1.11 was also obtained in October, 1976, however sample size was small (37 pots hauled).

Average seasonal (May-November) catch rate (legal and sublegals) for all quadrats combined was 2.3 lobsters per pot (Table 2). Seasonal legal catch rate averaged 0.65 in the study area, which is similar to the mean for the three pre-operational years (0.66). The mean rate (pooled data) for quadrats

Figure 1. Distribution of lobster pots sampled in 1982.



[A total of 231 pots in quadrats O-5 (16), R-9 (142), S-9 (24) and S-10 (49) was sampled, but do not appear on the grid map.]

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)	0.67 (377)
1982	-	-	0.45 (410)	0.46 (271)	0.46 (780)	0.73 (877)	1.11 (475)	0.66 (454)	0.58 (107)

(Number of pots hauled.)

Table 2. Total yearly lobster pot catch, 1970-1982.

Year	No. of pots	Total catch	Male	Female	Legals	Sub-legals	Eggers	Overall catch per pot	Overall legals per pot
1970	3200	11399	4950 (43)	6449 (57)	1889 (17)	9334 (82)	195 (2)	3.6	0.59
1971	4376	15158	6543 (43)	8615 (57)	2855 (19)	12043 (79)	260 (2)	3.5	0.65
1972	3449	12527	5484 (44)	7051 (56)	2522 (20)	9848 (79)	166 (1)	3.6	0.73
1973	2762	7821	3456 (44)	4363 (56)	1490 (19)	6267 (80)	68 (1)	2.8	0.54
1974	2762	8386	3838 (46)	4558 (54)	1922 (23)	6426 (77)	41 (0.5)	3.0	0.70
1975	2762	8210	3757 (46)	4443 (54)	1306 (16)	6884 (84)	20 (0.2)	3.0	0.47
1976	2959	9179	4308 (47)	4871 (53)	1352 (15)	7819 (85)	8 (0.1)	3.1	0.46
1977	3485	7694	3646 (47)	4078 (53)	2050 (27)	5596 (73)	27 (0.4)	2.2	0.59
1978	2432	7717	3432 (44)	4285 (56)	1535 (20)	6147 (80)	35 (0.5)	3.2	0.63
1979	2820	5596	2339 (42)	3257 (58)	1325 (24)	4214 (75)	57 (1)	2.0	0.47
1980	3667	7534	2892 (38)	4642 (62)	2181 (29)	5244 (70)	109 (1)	2.1	0.59
1981	3767	8294	3260 (39)	5034 (61)	2347 (28)	5756 (69)	191 (2.3)	2.2	0.62
1982	3374	7794	2899 (37)	4895 (63)	2195 (28)	5457 (70)	142 (1.8)	2.3	0.65

(Percent of total catch.)

H-11, H-12, I-11, and I-12, those most strongly influenced by Pilgrim Station's thermal discharge (E G and G 1976) was 1.9 lobsters per pot (0.43 legals). By comparison catch rate for reference quadrats, N-10, N-11, and M-10 (Stone and Webster 1977) was 1.9 lobsters per pot (0.70 legals). To date, there is no evidence in the catch data to indicate that the operation of Pilgrim Station has altered the availability of legal lobsters for harvesting.

Females substantially outnumber males in total catch every year (Table 2). However, in 1982 the percent catch composition of females was the highest obtained to date (8% above the 1970-1979 ten-year mean). Females comprised 63% of the total catch and males 37%, or 1.7 females for each male sampled. During the last three years, the percent composition (61-63%) of females has been higher than in the previous 10 years when values ranged from 53-58%.

There were 142 ovigerous females sampled (81 legals, 61 sublegals) representing 1.8% of the total catch and 2.9% of all captured females. This represents a marked increase from the mid-seventies and a return to levels reported during preoperational years of the study (Table 2). The monthly frequency of captured berried females varied from 0.6-6.3%. Highest frequencies occurred during June (4.3%) and October (6.3%), with levels declining during the summer months, July-September. Russell et al. (1978) also reported peak percentages of egg-bearing females in June and October in a study of the inshore Rhode Island lobster fishery.

Since 1978, commercial fishermen have expanded their fishing efforts on sand substrate. Past data from project trawl studies have indicated an increase of lobsters inhabiting sand bottom. From 1970-1978, mean catch per standardized 20-minute tow (utilizing a half-scale Yankee trawl, equipped with a cod-end 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, 3,746 lobsters were collected in 229 trawl tows made in the study area, for a mean catch per tow of 16.4. In 1981, 3,001 lobsters were collected in 134 tows of both a half-scale Yankee, and half-scale Wilcox trawl for a combined mean catch of 22.4 lobsters per tow. Mean catch rate for the combined trawls in 1982 was 20.2 lobsters per tow further substantiating the apparent sustained abundance of lobsters on sand bottom.

IRISH MOSS HARVEST

Landing statistics for the commercially harvested alga, Irish moss (Chrondrus crispus), were recorded in the Plymouth area for the twelfth consecutive year. In 1982, harvesting commenced on 11 June and terminated 1 September, when work skiffs were hauled from the water. Harvesting zones are depicted in Figure 2. Landing data through 1982 are found in Table 3.

During 390 raker days[1], harvesters numbering from 1-13 on any given day, expended a total of 1,037.0 hrs of effort and harvested 201,131 lbs (wet weight) of moss for a seasonal mean rate of 194.0 lbs/hr. Totals do not include 9,420 lbs of moss gathered outside the study area from Ellisville (Indian Hill region) and landed at White Horse Beach. A total of 367 boat trips, involving 1-12 craft per day, was made during 54 days of harvesting. Due to adverse weather and/or low raker interest, no raking occurred on 28 days of the harvesting season.

Total effort and landings are the second and third lowest values, respectively, recorded during the 12 years. However, seasonal harvest rate (pooled data) for the study area was the fourth highest recorded, only 8.6 lbs/hr below the two-year preoperational mean and 8.2 lbs/hr above the nine-year average for operational years. Percent distribution of landings (pooled data) by month was: June - 35.3%; July - 49.7%, and August - 14.9%.

Landings, effort and mean harvest rate were greater in Zone 1 (reference) than in Zone 5 (surveillance). Traditionally higher landings, effort and harvest rates occur in Zone 1, with exceptions noted in harvest rate for 1973, 1975, and 1976, and in effort for 1977 (Table 3). Landings and effort

[1]A unit of measure representing one person raking moss for one harvest day.

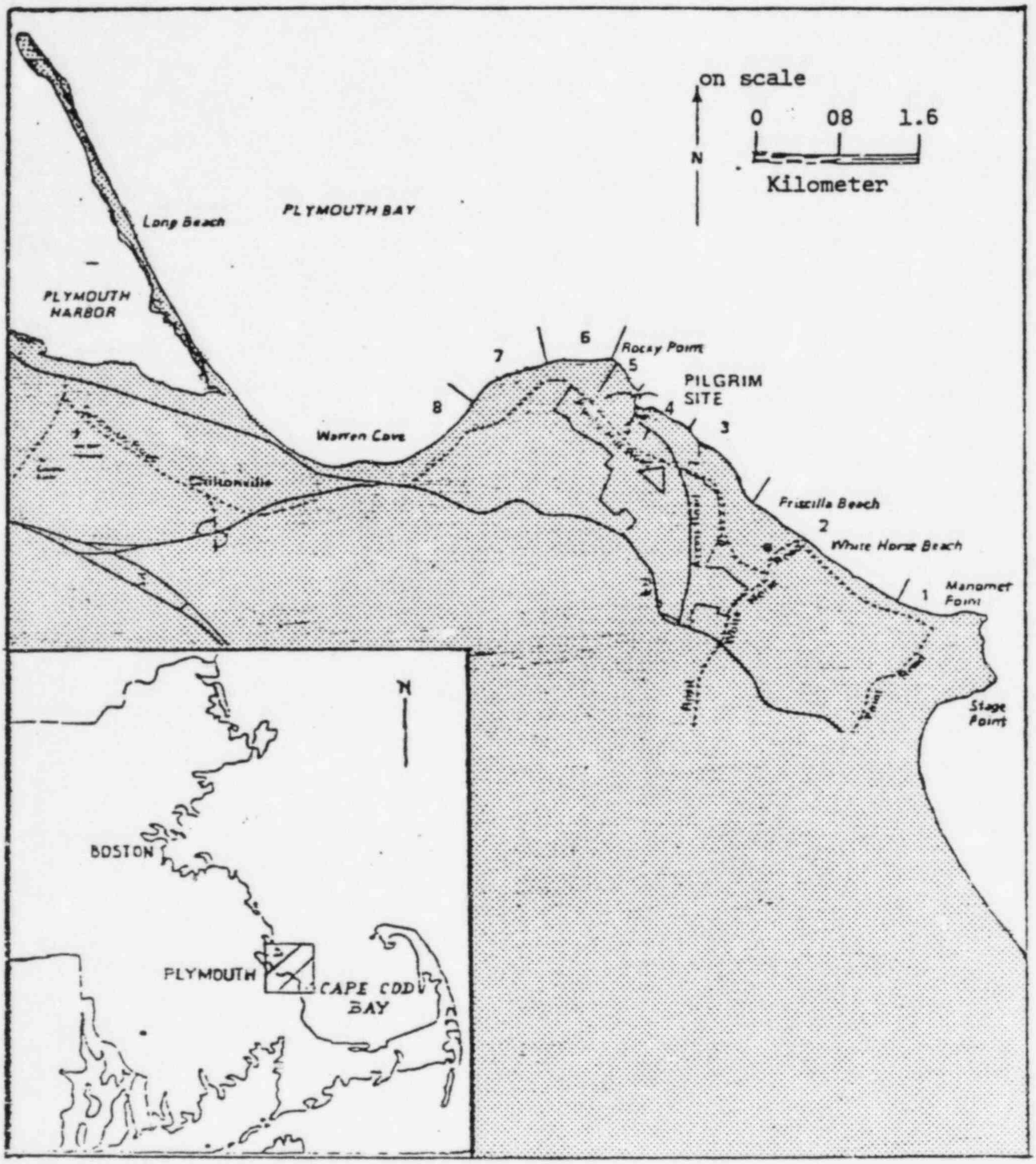


Figure 2. Irish moss harvest zones.

increased from 1981 levels by 57.5% and 64.5%, respectively in Zone 1 and by 23.6% and 26.9% in Zone 5.

By contrast, in Zone 2 (White Horse Beach), landings and effort decreased from last year by 12.6% and 18.9%, respectively. However, this zone again accounted for the major portion of harvesting activity, providing 46.2% of the seasons' landings and 47.3% of the effort. This reflects the extensive harvesting pressure at this location. Work conducted in Zones 1 and 2 combined produced 75.2% of the effort and 74.5% of the landed moss. From Zone 5 (surveillance), 17.4% of the harvest and 17.7% of the effort were recorded. Zones 3 and 4 each accounted for 3.1% or less of the total harvest and effort. As in 1981, highest harvest rate (305.3 lbs/hr) was obtained in Zone 6; however, landings and effort there represented only 3.1% and 2.0%, respectively, of the seasons' totals.

Limited harvesting occurred in Zone 8 (southern edge of Warren Cove), which has been the trend throughout operational years. Zone 8 accounted for only 0.3% of the seasons' moss poundage and 0.6% of the effort. Zone 7 was not harvested.

By employing harvest rate to compare zones, the bias inherent in comparing areas of unequal size is reduced, and a measure of success for this fishery is provided. During preoperational years (1971-1972), harvest rates in Zone 5 (surveillance) averaged almost 90% of that from Zone 1 (reference). In the operational years (1973-1982) harvest rates from Zone 5 exceeded that of Zone 1 on three occasions, fluctuating from 64.8% to 110.7% of that in the reference Zone with an average of 91.6% for the 10-year period. Throughout the operational period, the relationship in harvest rate between reference and surveillance zones has remained fairly constant in this local fishery.

Table 3. Irish moss landing statistics from the vicinity of PNPS, 1971-1982.

Landings
(lbs-wet weight)

Area	1971	1972	1973	1974	1975	1976	1977	1978	1979*	1980	1981	1982
1	92,637	133,402	57,045	105,110	79,652	72,950	68,045	54,685	56,240	63,475	36,157	56,965
2	78,060	110,246	45,310	91,290	89,614	125,140	129,235	110,668	76,297	120,899	106,208	92,878
3	10,719	17,295	4,140	11,730	16,487	25,250	16,680	12,824	12,830	14,985	13,024	6,260
4	23,252	31,402	7,695	10,795	14,317	7,010	16,275	9,864	13,037	8,151	2,992	3,030
5	82,724	78,567	18,815	28,515	72,557	56,330	65,595	34,870	37,582	52,428	28,376	35,085
6	39,925	56,881	24,995	17,230	74,417	24,280	29,145	10,580	31,237	21,045	3,380	6,198
7	14,727	17,004	30	215	10,517	2,230	-	2,215	70	-	-	-
8	33,429	28,368	605	25	3,252	235	1,025	660	-	1,350	-	715
	375,473	473,165	158,635	264,910	380,813	313,515	326,000	236,366	227,293	282,333	190,137	201,131

* Does not include 3,085 lbs from study area for which effort was not recorded.

Effort
(hours)

Area	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	411.4	573.1	343.4	446.4	339.2	373.3	291.8	239.8	249.6	282.2	175.8	289.2
2	443.7	776.3	345.8	391.9	562.8	840.8	959.2	721.5	551.7	673.0	603.6	490.2
3	55.7	90.6	22.8	77.8	83.0	149.6	145.3	56.0	102.2	82.1	84.0	32.1
4	113.6	155.9	41.3	39.7	47.9	47.8	100.0	59.1	99.0	50.3	23.4	15.2
5	406.8	374.9	102.3	139.7	290.7	284.2	322.5	236.0	201.1	278.3	144.8	183.8
6	170.7	233.9	128.8	79.0	219.5	88.7	137.5	42.5	133.5	98.8	14.8	20.3
7	87.6	80.3	0.1	1.3	27.8	11.2	-	5.8	0.5	-	-	-
8	119.7	108.1	1.4	0.3	13.9	1.2	3.3	2.8	-	1.8	-	6.2
	1809.2	2393.1	985.9	1176.1	1584.8	1796.8	1959.6	1363.5	1337.7	1466.5	1046.4	1037.0

Harvest Rate
(lbs/hr)

Area	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	225.2	232.8	166.1	235.5	234.4	195.4	234.4	228.0	225.3	224.9	205.7	197.0
2	175.9	142.0	131.0	232.9	159.2	148.8	134.7	153.4	138.3	179.6	176.0	189.5
3	192.4	190.9	181.6	150.8	198.6	158.8	114.8	229.0	125.5	182.6	155.0	195.0
4	204.7	201.4	186.3	271.9	298.9	146.8	162.8	166.9	131.7	162.0	127.9	199.3
5	203.4	209.6	183.9	204.1	249.6	198.2	203.4	147.8	186.9	188.4	196.0	190.9
6	233.9	243.2	193.7	218.1	339.0	273.8	212.0	248.9	233.8	213.0	228.4	305.3
7	168.1	211.8	300.0	165.4	378.3	207.8	-	381.9	140.0	-	-	-
8	279.3	262.4	432.1	83.3	234.0	201.5	307.5	235.7	-	750.0	-	115.3
*	207.5	197.7	160.9	225.2	227.7	174.5	166.4	173.4	169.9	192.5	181.7	194.0

* Seasonal harvest rate.

(Total lbs wet weight/total effort hrs.)

Each year, as the harvesting season progresses, cropping of moss decreases stock availability, while epiphytization reduces product quality. This progressive trend was evident in both the reference and surveillance zones, in 1982, in that monthly harvest rates declined from June-August. This diminishing return for effort expended probably contributed to the waning enthusiasm of rakers and the large number of days (18) when harvesting was not conducted in August. Only 3 of the last 16 days in the season were utilized for gathering moss.

In assessing power plant effects, three findings are pertinent: there is consistent propinquity in harvest rate between Zone 5 (surveillance) and Zone 1 (reference) during the preoperational and operational years; the 12-year mean harvest rate in the surveillance zone exceeded the mean seasonal rate for all zones by 7.6 lbs/hr; and there was an increase of 23.6% in surveillance zone landings over last season (Table 3).

OFFSHORE BENTHIC FINFISH COLLECTIONS

Bottom trawling with a half-Yankee 10.7 m otter-door trawl from the Division's R/V F.C. WILBOUR continued on a monthly schedule in the environs of Pilgrim Station. Five stations, at depths of 6-12 m (MLW), were sampled (Fig. 3). Single 20-minute tows were conducted with a duplicate haul generally made at one randomly selected station each cruise. We examined the data base for seasonal trends in abundance of dominant demersal fish stocks and compared annual measures of relative abundance (i.e., mean catch per 20-minute tow-CPUE) by station. Adverse weather and deployment of lobster gear in the study area resulted in abbreviated tows or tow omissions on several occasions.

Fifty-seven tows were completed and 2,785 fish caught comprising 26 species. In 1981, we also trawled 26 species of finfish. The number of species caught ranged from 12 at Station 5 (off White Horse Beach) to 18 at Station 3 (12 m depth contour), the deepest sampling location; 17 species were captured at Station 2 (surveillance site). Catch abundance (pooled species) was highest at Station 1 in Warren Cove where 32% of all the fish were trawled.

Winter flounder (Pseudopleuronectes americanus) once again were numerically dominant, comprising 47.8% of total catch. From 1970-1981, this species has constituted from 33.4 - 56.0% of the annual trawl catch. Catches were highest in Warren Cove and off Rocky Point (Station 4) and lowest at Station 5 off White Horse Beach (Table 4). June was the month of greatest abundance. Winter flounder ranged in size from 69-505 mm ((TL), with the average size of the fish caught each month generally increasing throughout the year.

The pooled mean CPUE for this species (30.2) decreased from last year (Table 5) by 22% but, nevertheless, was substantially higher than the grand

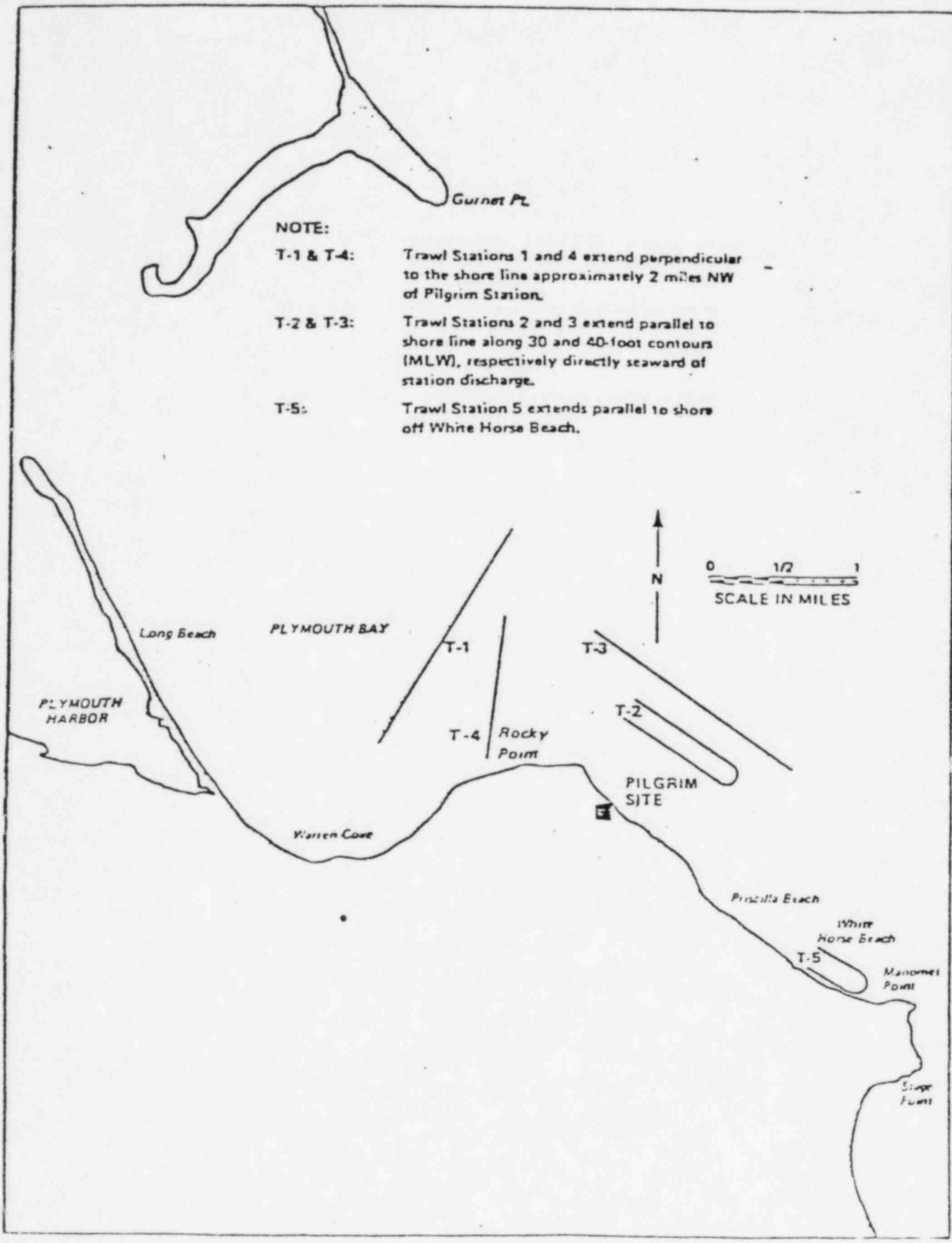


Figure 3. Otter trawl station locations in the vicinity of PNPS.

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

Winter flounder (Pseudopleuronectes americanus)

Month	Jan.	Feb.	Mar.	Apr.	May	June
Station 1						
No. of fish	(No tows made this month because of ice conditions.)	0	0	50	42	93
Size range (mm)		-	-	69-370	88-401	120-368
Mean size (mm)		-	-	195.8	233.8	253.9
Station 2						
No. of fish		2	8	36	39	43
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
Station 3						
No. of fish		3	15	25	17	37
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
Station 4						
No. of fish		4	7	52	50	56
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
Station 5						
No. of fish		-	-	-	-	23
Size range (mm)		-	-	-	-	102-381
Mean size (mm)		-	-	-	-	281.8

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

Winter flounder (*Pseudopleuronectes americanus*)

Month	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean No./tow	Total Catch
Station 1								
No. of fish	37	52	53	41	53	10	39.2	431
Size range (mm)	158-321	170-360	168-348	255-360	97-347	112-406		
Mean size (mm)	265.1	287.2	291.0	302.2	280.0	265.0		
Station 2								
No. of fish	*	*	*	31	50	10	27.4	219
Size range (mm)	-	-	-	225-385	93-398	188-413		
Mean size (mm)	-	-	-	317.2	311.0	299.4		
Station 3								
No. of fish	24	*	*	*	34	22	22.1	177
Size range (mm)	146-340	-	-	-	222-348	212-505		
Mean size (mm)	286.5	-	-	-	331.0	321.0		
Station 4								
No. of fish	8	39	75	54	59	5	37.2	409
Size range (mm)	250-350	165-366	168-388	262-370	222-382	178-352		
Mean size (mm)	316.0	295.0	294.0	310.4	297.0	295.4		
Station 5								
No. of fish	14	15	24	8	12	*	16.0	96
Size range (mm)	127-340	145-420	181-451	285-370	300-440	-		
Mean size (mm)	289.0	254.0	282.3	325.1	345.0	-		
							30.2	1,332

* No tows because of interference by commercial lobster gear.

Table 5 . Otter trawl catch per unit effort for dominant community species (pooled stations' data) from January-December, 1970-1982.

Year	winter flounder	skate spp.	longhorn sculpin	windowpane	ocean pout	yellowtail flounder
1970	48.7	3.7	10.2	3.3	16.0	7.5
1971	41.6	3.7	6.1	3.2	11.1	12.0
1972	29.0	3.1	7.0	3.1	6.2	5.3
1973	23.8	2.0	5.3	2.7	5.6	5.3
1974	9.8	2.7	2.5	2.0	2.9	3.1
1975	9.3	2.4	1.1	3.5	2.6	4.8
1976	13.8	3.6	0.8	4.3	1.6	8.3
1977	16.0	7.9	0.6	3.7	0.5	5.3
1978	10.6	5.4	1.1	2.5	0.9	4.1
1979	32.0	14.4	3.2	7.7	2.2	11.5
1980	32.9	11.1	1.9	4.1	0.3	11.2
1981	38.5	8.6	2.2	4.4	0.6	10.0
1982	30.2	7.8	3.2	3.4	0.7	3.5

mean catch estimate (20.7) for all other operational years (1973-1981) combined. Catch estimates declined at all stations from last year. Winter flounder has been subject to long-term fluctuations in abundance that have been region-wide (Lawton et al. 1981). A downward trend, noted in the Plymouth area from 1970-1975, was subsequently followed by a resurgence in relative abundance (Table 5).

For the second consecutive year, skate spp. (primarily little skate, Raja erinacea) ranked second in total catch (12.2%). Catches were highest during warmer months and at Station 1 in Warren Cove (Table 6). The pooled mean CPUE for this species decreased slightly from the 1981 index (Table 5) but was greater than the preoperational and operational averages. CPUE declined at Stations 1-3 but increased slightly at Stations 4 and 5; this is just the opposite of what happened in 1981.

Catches of yellowtail flounder (Limanda ferruginea) were highest in August and November (Table 7); none were caught in February when water temperatures have been traditionally lowest in the study area. Mean annual catch per tow was highest at Station 2 (surveillance site). Relative abundance markedly declined, by 65.0%, overall from last year's index level. Pooled CPUE for this species was the second lowest value obtained for the entire groundfish study (Table 5). Over the years, catch data have fluctuated with highs occurring in 1971 (preoperational) and 1979-1980 (operational). Clark et al. (1981) reported that bottom trawl index values for 1980 were among the highest observed for Cape Cod yellowtail flounder in a survey conducted since the early 1960's.

Windowpane (Scopthalmus aquosus) were rarely taken in the study area in winter; their abundance increased in summer and into the fall (Table 8). Catches of this flatfish, commonly called sand flounder, were highest on sand substrate which prevails off White Horse Beach (Station 5) and in Warren Cove

(Station 1). The annual pooled abundance estimate declined by 1.0 fish per tow from 1981 to 1982, but nevertheless, the 1982 index value was slightly greater than the preoperational (1970-1972) mean (Table 5).

Longhorn sculpin (Myoxocephalus octodecemspinosus) occurred in the study area primarily in spring and fall, with highest catches obtained in November (Table 9). Spatially, sculpin were most abundant at the deeper depth strata found at Stations 2 and 3. Catch-per-tow indicate a trend of declining abundance, more or less continual from a high of 10.2 in 1970 to a low of 0.6 in 1977; subsequent index values have fluctuated somewhat but at a slightly increased level from the nadir (Table 5). Mean annual CPUE (pooled station data) increased from 1981 by 1.0 fish per standard tow.

Small numbers of ocean pout (Macrozoarces americanus) were captured primarily in April and May. Catches were highest at Stations 2 and 3 (Table 10). Ocean pout like longhorn sculpin reflect an identical trend of declining relative abundance through the preoperational years and half-way into the operational period; this was followed by a slight upswing in 1979 (Table 5).

American lobsters (Homarus americanus) were not captured in number until May, when bottom temperatures warmed to 8 C and above. Overall, catches peaked in June and remained relatively high until November (Table 11). A total of 1,145 lobsters was trawled; 93.6% were sublegal (< 81 mm CL). Our lobster pot catch study revealed that 70% of the lobsters captured by traps in 1982 were sublegal. Throughout the study area, catch rates (catch/tow) in 1982 ranged from 4.0-45.4 (legals & sublegals), with a mean of 26.0. By way of comparison, from 1970-1978, we trawled from 0.5-3.5 lobsters per tow in the Plymouth area. Lobsters catches greatly increased in 1979; annual CPUE for 1979-1980 averaged 16.4 and increased further in 1981 to 27.0.

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

Skates (*Raja* spp.)

Month	Jan.	Feb.	Mar.	Apr.	May	June
Station 1	(No tows made this month because of ice conditions.)					
No. of fish		0	0	1	9	49
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
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
Size range (mm)		-	-	-	328	171-490
Mean size (mm)		-	-	-	328.0	343.8
Station 4						
No. of fish		0	5	0	5	21
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-December, 1982 (continued).

Skates (*Raja* spp.)

Month	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean No./tow	Total Catch
Station 1								
No. of fish	9	17	19	24	6	0	12.2	134
Size range (mm)	230-460	285-520	292-532	301-510	302-425	-		
Mean size (mm)	328.0	387.0	349.0	380.4	364.0	-		
Station 2								
No. of fish	*	*	*	4	11	0	5.8	46
Size range (mm)	-	-	-	282-362	320-530	-		
Mean size (mm)	-	-	-	314.0	454.0	-		
Station 3								
No. of fish	2	*	*	*	21	0	4.6	37
Size range (mm)	128-140	-	-	-	210-462	-		
Mean size (mm)	234.0	-	-	-	341.0	-		
Station 4								
No. of fish	2	9	18	8	9	1	7.1	78
Size range (mm)	308-341	300-510	256-511	305-460	319-520	558		
Mean size (mm)	324.5	391.0	344.4	384.0	412.4	558.0		
Station 5								
No. of fish	0	32	2	6	3	*	7.7	46
Size range (mm)	-	260-540	476-503	110-480	153-393	-		
Mean size (mm)	-	359.4	490.0	325.0	277.0	-		
							7.8	341

* No tows because of interference by commercial lobster gear.

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

Yellowtail flounder (*Limanda ferruginea*)

Month	Jan.	Feb.	Mar.	Apr.	May	June
Station 1	(No tows made this month because of ice conditions.)					
No. of fish		0	0	0	4	1
Size range (mm)		-	-	-	92-338	265
Mean size (mm)		-	-	-	220.8	265.0
Station 2						
No. of fish		0	0	2	6	2
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
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
Size range (mm)		-	-	-	-	-
Mean size (mm)		-	-	-	-	-
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-December, 1982 (continued).

Yellowtail flounder (<u>Limanda ferruginea</u>)

Month	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean No./tow	Total Catch
Station 1								
No. of fish	2	22	2	1	6	0	3.5	38
Size range (mm)	255-280	185-400	305-318	310	310-348	-		
Mean size (mm)	268.0	304.0	313.3	310.0	330.0	-		
Station 2								
No. of fish	*	*	*	2	24	2	4.8	38
Size range (mm)	-	-	-	295-355	216-360	318-341		
Mean size (mm)	-	-	-	317.3	305.0	330.0		
Station 3								
No. of fish	7	*	*	*	10	5	3.5	28
Size range (mm)	123-305	-	-	-	188-328	211-366		
Mean size (mm)	214.0	-	-	-	238.0	312.0		
Station 4								
No. of fish	2	6	8	1	12	0	2.6	29
Size range (mm)	288-298	285-400	275-335	305-340	305-344	-		
Mean size (mm)	293.0	318.0	311.0	323.0	325.0	-		
Station 5								
No. of fish	0	1	1	1	17	*	3.3	20
Size range (mm)	-	285	250	305	266-364	-		
Mean size (mm)	-	285.0	250.0	305.0	309.1	-		
							3.5	153

* No tows because of interference by commercial lobster traps.

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

Windowpane (*Scophthalmus aquosus*)

Month	Jan.	Feb.	Mar.	Apr.	May	June
Station 1	(No tows made this month because of ice conditions.)					
No. of fish		0	0	0	2	2
Size range (mm)		-	-	-	270-271	164-172
Mean size (mm)		-	-	-	270.5	168.0
Station 2						
No. of fish		0	1	0	1	7
Size range (mm)		-	-	-	220	172-275
Mean size (mm)		-	-	-	220.0	227.4
Station 3						
No. of fish		0	0	3	1	5
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
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 8. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-December, 1982 (continued).

Windowpane (Scophthalmus aquosus)

Month	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean No./tow	Total Catch
Station 1								
No. of fish	3	6	10	10	8	0	3.7	41
Size range (mm)	251-280	195-360	228-312	100-362	248-301	-		
Mean size (mm)	266.0	272.0	247.0	265.2	273.3	-		
Station 2								
No. of fish	*	*	*	3	14	0	3.3	26
Size range (mm)	-	-	-	165-331	216-295	-		
Mean size (mm)	-	-	-	292.3	267.3	-		
Station 3								
No. of fish	1	*	*	*	7	0	2.1	17
Size range (mm)	176	-	-	-	111-327	-		
Mean size (mm)	176.0	-	-	-	241.0	-		
Station 4								
No. of fish	0	2	8	1	6	0	2.2	25
Size range (mm)	-	245-335	257-305	86	95-300	-		
Mean size (mm)	-	289.0	282.3	86.0	223.0	-		
Station 5								
No. of fish	1	19.5	2	1	15	*	6.8	41
Size range (mm)	331	160-340	265-280	275	249-316	-		
Mean size (mm)	331.0	249.0	273.0	275.0	284.1	-		
							3.4	150

* No tows because of interference by commercial lobster gear.

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

Longhorn sculpin (*Myoxocephalus octodecemspinosus*)

Month	Jan.	Feb.	Mar.	Apr.	May	June
Station 1	(No tows made this month because of ice conditions.)					
No. of fish		0	0	0	1	0
Size range (mm)		-	-	-	275	-
Mean size (mm)		-	-	-	275.0	-
Station 2						
No. of fish		0	0	20	3	0
Size range (mm)		-	-	228-325	268-320	-
Mean size (mm)		-	-	290.7	284.7	-
Station 3						
No. of fish		0	4	6	4	0
Size range (mm)		-	-	258-310	287-402	-
Mean size (mm)		-	-	284.8	320.5	
Station 4						
No. of fish		0	0	4	8	0
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 9. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-December, 1982 (continued).

Longhorn sculpin (*Myoxocephalus octodecemspinosus*)

Month	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean No./tow	Total Catch
Station 1								
No. of fish	0	0	0	0	6	0	0.6	7
Size range (mm)	-	-	-	-	271-308	-		
Mean size (mm)	-	-	-	-	290.0	-		
Station 2								
No. of fish	*	*	*	0	23	3	6.1	49
Size range (mm)	-	-	-	-	244-325	271-319		
Mean size (mm)	-	-	-	-	282.0	294.0		
Station 3								
No. of fish	0	*	*	*	22	8	5.5	44
Size range (mm)	-	-	-	-	208-335	253-322		
Mean size (mm)	-	-	-	-	266.3	283.3		
Station 4								
No. of fish	0	2	0	0	12	2	2.6	28
Size range (mm)	-	245-267	-	-	243-315	242-288		
Mean size (mm)	-	256.0	-	-	286.2	265.0		
Station 5								
No. of fish	0	0	0	0	11	*	1.8	11
Size range (mm)	-	-	-	-	266-338	-		
Mean size (mm)	-	-	-	-	305.1	-		
							3.2	139

* No tows because of interference by lobster gear.

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

Ocean pout (<u>Macrozoarces americanus</u>)

Month	Jan.	Feb.	Mar.	Apr.	May	June
Station 1	(No tows made this month because of ice conditions.)					
No. of fish		0	0	1	4	0
Size range (mm)		-	-	602	524-671	-
Mean size (mm)		-	-	602.0	607.0	-
Station 2						
No. of fish		0	0	5	9	0
Size range (mm)		-	-	350-610	510-670	-
Mean size (mm)		-	-	550.6	591.5	-
Station 3						
No. of fish		0	0	3	2	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
Size range (mm)		-	-	-	615-650	-
Mean size (mm)		-	-	-	632.5	-
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-December, 1982 (continued).

Ocean pout (Macrozoarces americanus)

Month	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean No./tow	Total Catch
Station 1								
No. of fish	0	0	0	0	0	0	0.5	5
Size range (mm)	-	-	-	-	-	-		
Mean size (mm)	-	-	-	-	-	-		
Station 2								
No. of fish	-	-	-	0	0	0	1.8	14
Size range (mm)	-	-	-	-	-	-		
Mean size (mm)	-	-	-	-	-	-		
Station 3								
No. of fish	0	-	-	-	0	4	1.1	9
Size range (mm)	-	-	-	-	-	540-612		
Mean size (mm)	-	-	-	-	-	581.0		
Station 4								
No. of fish	0	-	0	0	0	0	0.2	2
Size range (mm)	-	-	-	-	-	-		
Mean size (mm)	-	-	-	-	-	-		
Station 5								
No. of fish	0	0	0	0	0	-	0.0	0
Size range (mm)	-	-	-	-	-	-		
Mean size (mm)	-	-	-	-	-	-		
							0.7	30

* No tows because of interference by lobster gear.

Table 11. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-December, 1982.

American lobster (<u>Homarus americanus</u>)

Month	Jan.	Feb.	Mar.	Apr.	May	June
Station 1	(No tows made this month because of ice conditions.)					
No. of legals		0	0	0	1	1
No. of sublegals		0	0	0	33	79
Total No.		0	0	0	34	80
Station 2						
No. of legals		0	0	0	1	8
No. of sublegals		0	0	2	97	107
Total No.		0	0	2	98	115
Station 3						
No. of legals		0	0	0	0	4
No. of sublegals		0	0	0	18	331
Total No.		0	0	0	18	335
Station 4						
No. of legals		0	0	0	2	0
No. of sublegals		0	0	0	43	84
Total No.		0	0	0	45	84
Station 5						
No. of legals		-	-	-	-	0
No. of sublegals		-	-	-	-	18
Total No.		-	-	-	-	18

Table 11. Otter trawl catch data at stations 1-5 in the environs of Pilgrim Nuclear Power Station from January-December, 1982 (continued).

American lobster (<u>Homarus americanus</u>)

Month	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean No./tow	Total Catch
Station 1								
No. of legals	9	1	12	0	0	9	2.2	24
No. of sublegals	45	20	75	1	1	0	23.1	254
Total No.	54	21	87	1	1	0	25.3	278
Station 2								
No. of legals	*	*	*	4	7	0	2.5	20
No. of sublegals	-	-	-	33	0	0	29.9	239
Total No.	-	-	-	37	7	0	32.4	259
Station 3								
No. of legals	0	*	*	*	2	0	0.8	6
No. of sublegals	5	-	-	-	3	0	44.6	357
Total No.	5	-	-	-	5	0	45.4	363
Station 4								
No. of legals	3	6	6	3	2	0	2.0	22
No. of sublegals	0	7	47	15	3	0	18.1	199
Total No.	3	13	53	18	5	0	20.1	221
Station 5								
No. of legals	0	0	0	1	0	*	0.2	1
No. of sublegals	0	4	1	0	0	-	3.8	23
Total No.	0	4	1	1	0	-	4.0	24

* No tows because of interference by lobster gear.

26.0	legals	73
	sub-legals	1,072
	total	1,145

In summary, abundance estimates for skates, longhorn sculpin, windowpane, and ocean pout changed very little from 1981-1982. However, stock estimates for winter flounder and yellowtail flounder showed pronounced declines, which were evident at all stations sampled. The relative abundance of lobsters declined from the high of last year but was still at a level that greatly exceeded the first nine years of studies.

NEARSHORE BENTHIC FINFISH COLLECTIONS

In our long-term endeavor to gauge power plant impact on the nearshore benthic finfish community, we continued small vessel trawling to effectively sample coastal areas 3-10 m in depth (Lawton et al. 1981). Tows in the impact area were made approximately 30-200 m seaward of the intake breakwaters and discharge outlet, respectively (Fig. 4). Sampling, which was increased in frequency from last year (monthly to biweekly), began 10 March and concluded 30 December. Towing time was also increased from 10 to 15 minutes to more representatively sample community structure (Pennington and Grosslein 1978). No hauls were executed in January, February, or September due to inclement weather.

Catch per 15 minute tow (CPUE) was employed as a measure of relative abundance. Data for replicate tows were averaged for each station (by species) to generate mean catch estimates. When uncontrollable factors prevented the completion of a 15 minute haul, catch rates were adjusted accordingly.

The expanded catch for fish taken in 79 hauls at all stations, all dates, was 2,421.1 (Table 12). Nine additional species - Atlantic cod, lumpfish, northern puffer, Atlantic tomcod, northern kingfish, northern pipefish, Atlantic seasnail, summer flounder, and grubby - were acquired this year. No more than five individuals of any of these species were captured on any one occasion. Winter skate (Raja ocellata) were identified to species level for the first time this year, but comprised a very small percentage of the total catch (Table 12).

Winter flounder ranked first in numerical abundance, comprising 34.9% of the total catch. Little skate ranked second at 21.0%, while windowpane (20.4%) was third. Yellowtail flounder was also abundant, totaling 12.3%

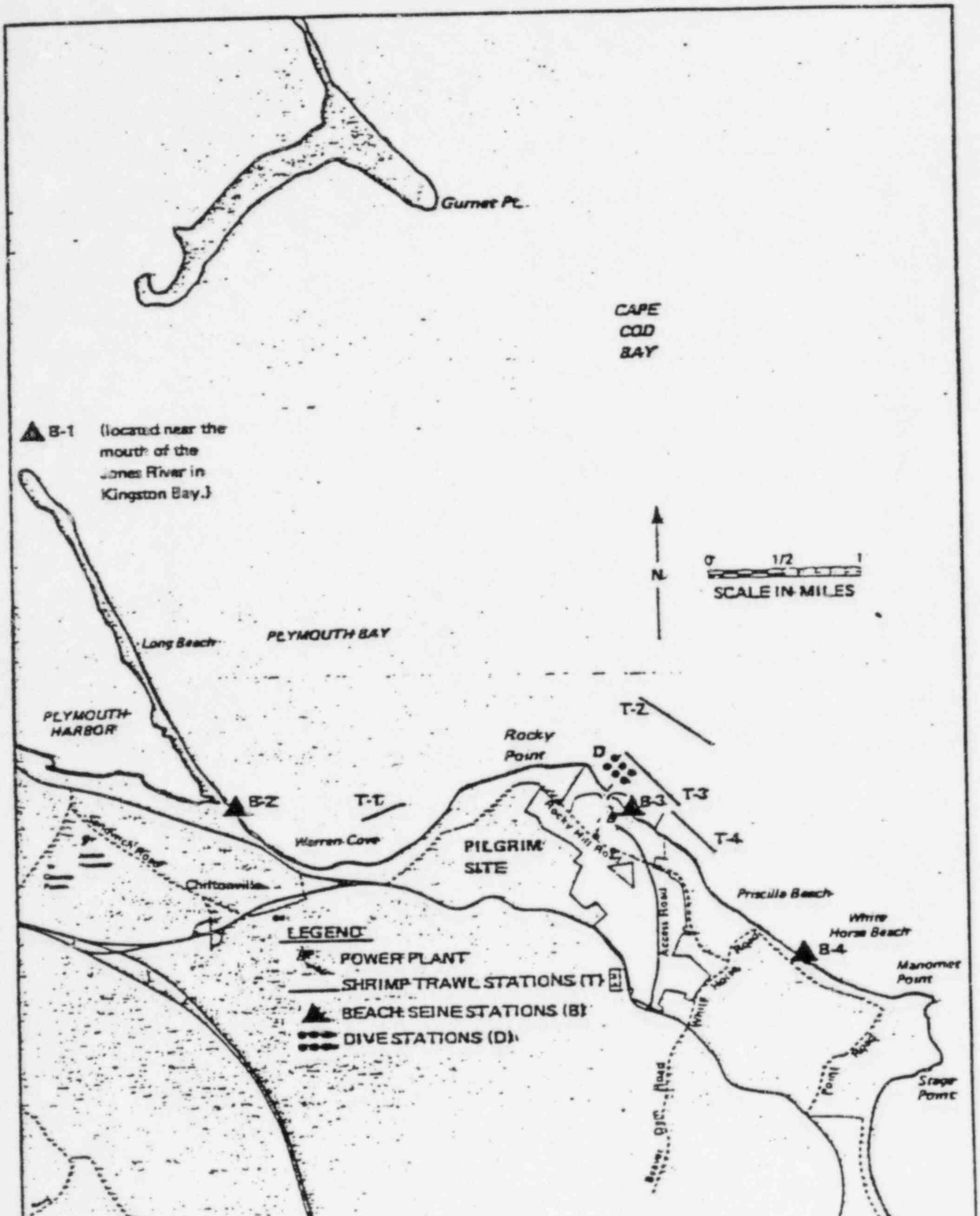


Figure 4. Location of Shrimp Trawl, Beach Seine and Dive Sampling Stations for Marine Fisheries Studies.

Table 12. Total numbers and percent composition of each finfish species captured by near-shore trawling at Stations 1-4, January-December, 1982

	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Total	Percent of total catch
Number of tows	19	17	25	18	79	
winter flounder	296.6*	160.0*	210.4*	177.5*	844.5*	34.9
little skate	82.8*	108.0*	196.3*	122.3*	509.4*	21.0
windowpane	82.3*	113.5*	166.2*	133.0*	495.0*	20.4
yellowtail	27.0*	66.5*	105.0*	100.3*	298.8*	12.3
longhorn sculpin	4	124.0*	15.4*	13.5*	156.9*	6.5
fourspot flounder	2	8.5*	8.3*	6.2*	25.0*	1.0
ocean pout	3	3.5*	3.2*	3	12.7*	0.5
Atlantic silverside	1	1	2	7	11.0	0.5
rock gunnel	9				9.0	0.4
hake spp.	1	4	3.0*		8.0*	0.3
winter skate			3	3.1*	6.1*	0.3
rainbow smelt	1	3	1	1	6.0	0.2
cunner	3		1.5*	1	5.5*	0.2
northern searobin		2	3.2*		5.2*	0.2
Atlantic cod	2	2		1	5.0	0.2
lumpfish	1		3	1	5.0	0.2
northern pipefish	1			2	3.0	0.1
sea raven	3				3.0	0.1
silver hake	1		1		2.0	< 0.1
Atlantic seasnail	1			1	2.0	< 0.1
northern puffer		1			1.0	< 0.1
Atlantic tomcod		1			1.0	< 0.1
northern kingfish			1		1.0	< 0.1
butterfish				1	1.0	< 0.1
summer flounder				1	1.0	< 0.1
grubby			1		1.0	< 0.1
Total species	18	14	17	17	26	
Total numbers of fish	521.7	598.0	726.5	574.9	2421.1	
Pooled catch/tow	29.0	35.2	29.1	31.9	30.7	

* Represents expanded value based on 15 minute tows.

of the catch (Table 12).

This year's winter flounder and yellowtail flounder catch data (Tables 13 & 14) reflected overall declines in relative abundance from last year. Even thoug towing times were longer this year, CPUE (pooled stations) declined for winter flounder from 13.6 in 1981 to 11.4 (1982) and for yellowtail flounder from 5.2 (1981) to 3.8 (1982).

The opposite was true for the other three dominant genera - skate spp., windowpane, and longhorn sculpin (Table 15). An increase in relative abundance over last year was noted, even allowing for the expanded towing time. For the remaining species, occurrence was incidental, with each comprising 1% or less of the catch.

Total catch and CPUE of winter flounder were highest at Station 1 (Warren Cove) in both 1981 and 1982. This result corresponds with data collected over 12 years of otter trawling; winter flounder abundance indices were always greatest in Warren Cove. Yellowtail flounder were captured in greatest numbers at Station 3 (discharge area) both years, while CPUE was highest at this site in 1982 but at Station 4 (White Horse Beach) in 1981. Catch and relative abundance for skate spp. (primarily little skate) were highest in the discharge area in both 1981 and 1982. Catch per unit effort for windowpane was highest in the discharge area last year as opposed to White Horse Beach this year. The absolute abundance of longhorn sculpin in the study area apparently increased in 1982, in that total catch and CPUE rose from 24.5* and 0.3 in 1981 to 156.9* and 7.3 in 1982, respectively. The greatest numbers of sculpin were taken both years at Station 2.

* represents expanded value.

Table 13. Near-shore trawl catch data for winter flounder (*Pseudopleuronectes americanus*) at Stations 1-4, 1982.

Dates	3/10		3/24		4/20		5/3	
	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2
Station 1								
# Fish	1		8		28		26	
Size range (mm)	339		95-390		88-387		102-320	
Mean size (mm)	-		304		218		279	
Station 2								
# Fish	0		3		0	12	21.0*	
Size range (mm)	-		245-320		-	78-364	120-331	
Mean size (mm)	-		281		-	229	255	
Station 3								
# Fish	0		6.4*	6.0*	18		10	15
Size range (mm)	-		110-328	88-311	93-367		130-355	110-320
Mean size (mm)	-		199	230	260		292	206
Station 4								
# Fish	1		6.9*		15		17	
Size range (mm)	350		302-352		104-382		105-356	
Mean size (mm)	-		323		279		253	

Dates	5/27		6/3		6/22		7/12	
	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2
Station 1								
# Fish	-		22	21	19		0	
Size range (mm)	-		198-362	245-398	251-330		-	
Mean size (mm)	-		282	295	289		-	
Station 2								
# Fish	10		7		19		6	
Size range (mm)	270-350		151-342		133-362		262-360	
Mean size (mm)	312		281		293		306	
Station 3								
# Fish	19	4.6*	19.5*		12		8.8*	
Size range (mm)	95-365	322-338	98-321		170-396		262-340	
Mean Size (mm)	276	328	267		313		309	
Station 4								
# Fish	5		8		3.5*	10.0*	10	5
Size range (mm)	279-331		145-375		281-358	265-351	152-350	130-328
Mean size (mm)	306		280		327	313	307	274

Dates	7/26		8/10		8/26		10/6	
	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2
Station 1								
# Fish	36		4	18	9.6*	9	33	
Size range (mm)	170-374		265-300	185-390	261-321	275-335	176-376	
Mean size (mm)	292		282	302	292	300	300	
Station 2								
# Fish	9		4.5*		-		13	18
Size range (mm)	233-354		260-330		-		301-381	268-350
Mean size (mm)	293		289		-		325	303
Station 3								
# Fish	6	5.8*	22.8*		7	4	17	
Size range (mm)	181-337	277-381	223-355		272-317	275-305	176-348	
Mean size (mm)	272	306	292		294	293	287	
Station 4								
# Fish	18		24		0		17.1	
Size range (mm)	275-372		156-350		-		225-345	
Mean size (mm)	319		287		-		298	

Table 13. (continued)

Dates	10/18		11/2		11/17		12/1	
	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2
Station 1								
# Fish	39		1		13		6	3
Size range (mm)	198-372		312		303-398		300-387	177-338
Mean size (mm)	314		-		336		328	271
Station 2								
# Fish	12		14		4		7.5*	
Size range (mm)	291-350		206-515		295-378		286-375	
Mean size (mm)	315		322		327		335	
Station 3								
# Fish	0	4	0	1.5*	8	14	-	
Size range (mm)	-	280-365	-	365	268-354	290-382	-	
Mean size (mm)	-	306	-		324	338	-	
Station 4								
# Fish	17		9		6		5	
Size range (mm)	118-410		255-365		294-348		127-341	
Mean size (mm)	305		329		274		263	

Dates	12/30		Total # of tows	Total # of fish	Mean catch/tow
	Tow 1	Tow 2			
Station 1					
# Fish	-		19	296.6	16.7
Size range (mm)	-				
Mean size (mm)	-				
Station 2					
# Fish	-		17	160.0	9.2
Size range (mm)	-				
Mean size (mm)	-				
Station 3					
# Fish	0	1	25	210.4	9.6
Size range (mm)	-	356			
Mean size (mm)	-	-			
Station 4					
# Fish	-		18	177.5	10.2
Size range (mm)	-				
Mean size (mm)	-				

* Represents expanded values.

Total catch 844.5   Pooled stations 11.4

Table 14. Trawl catch data for yellowtail flounder (*Limanda ferruginea*) at Stations 1-4, 1982.

Dates	3/10		3/24		4/20		5/3	
	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2
Station 1								
# Fish	0		0		1		2	
Size range (mm)	-		-		352		252-370	
Mean size (mm)	-		-				311	
Station 2								
# Fish	0		0		0	1	6.0*	
Size range (mm)	-		-		-	357	230-330	
Mean size (mm)	-		-		-	-	265	
Station 3								
# Fish	1.1*		1.1*	0	5		10	5
Size range (mm)	215		175	-	155-326		130-355	237-251
Mean size (mm)	-		-	-	281		292	245
Station 4								
# Fish	0		1.2*		1		17	
Size range (mm)	-		125		177		105-356	
Mean size (mm)	-		-		-		253	

Dates	5/27		6/3		6/22		7/12	
	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2
Station 1								
# Fish	-		2	4	0		0	
Size range (mm)	-		258-268	245-303	-		-	
Mean size (mm)	-		263	268	-		-	
Station 2								
# Fish	23		5		5		0	
Size range (mm)	99-330		101-335		233-320		-	
Mean size (mm)	259		217		276		-	
Station 3								
# Fish	25	18.5*	3.0*		0		6.2*	
Size range (mm)	118-362	150-342	111-290		-		255-303	
Mean size (mm)	263	269	201		-		274	
Station 4								
# Fish	12		10		2.3*	10.0*	13.8*	0
Size rnage (mm)	222-312		131-300		141-275	265-351	242-331	-
Mean size (mm)	269		240		208	313	293	-

Dates	7/26		8/10		8/26		10/6	
	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2
Station 1								
# Fish	3		0	1	0	0	0	
Size range (mm)	275-284		-	310	-	-	-	
Mean size (mm)	279		-	-	-	-	-	
Station 2								
# Fish	3		1.5*		-		2	1
Size range (mm)	180-330		295		-		265-312	225
Mean size (mm)	276		-		-		288	-
Station 3								
# Fish	16	0	2.1*		0	3	0	
Size range (mm)	246-315	-	285-295		-	276-285	-	
Mean size (mm)	276	-	290		-	281	-	
Station 4								
# Fish	10		8		0		1	
Size range (mm)	245-329		263-321		-		300	
Mean size (mm)	296		294		-		-	

Table 14. (continued)

Dates	10/18		11/2		11/17		12/1	
	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2	Tow 1	Tow 2
Station 1								
# Fish	0		0		10		2	2
Size range (mm)	-		-		308-368		320-398	349-356
Mean size (mm)	-		-		342		359	352
Station 2								
# Fish	2		12		0		5	
Size range (mm)	265-320		240-345		-		285-342	
Mean size (mm)	292		317		-		323	
Station 3								
# Fish	4	0	0	0	2	3	-	
Size range (mm)	312-335	-	-	-	328-464	280-360	-	
Mean size (mm)	328	-	-	-	396	320	-	
Station 4								
# Fish	2		3		3		6	
Size range (mm)	295-350		295-351		315-360		124-355	
Mean size (mm)	322		322		339		306	

Dates	12/30		Total # of tow	Total # of fish	Mean catch/tow
	Tow 1	Tow 2			
Station 1					
# Fish	-		19	27.0	1.4
Size range (mm)	-				
Mean size (mm)	-				
Station 2					
# Fish	-		17	66.5	4.3
Size range (mm)	-				
Mean size (mm)	-				
Station 3					
# Fish	0	0	25	105.0	3.4
Size range (mm)	-	-			
Mean size (mm)	-	-			
Station 4					
# Fish	-		18	100.3	5.9
Size range (mm)	-				
Mean size (mm)	-				

* Represents expanded values.

Total catch 298.8 Pooled stations 3.8

Table 15. Mean catch per unit effort data for selected community species, January-December, 1982.

Station	Skate spp. (*Raja* spp.)	Windowpane (*Scopthalmus aquosus*)	Longhorn sculpin (*Myoxocephalus octodecemspinosus*)
1	4.4	4.3	0.2
2	6.4	6.8	7.3
3	8.0	6.4	0.6
4	7.0	7.4	0.8
Pooled stations	6.5	6.3	2.0

* Represents expanded values.

After comparison of otter and near-shore trawl catch data, differences and similarities were noted. Generally, the smaller trawl captured fewer species per tow; although in 1982, 26 taxa were obtained in each trawl survey. However, there were twice as many near-shore trawl tows made, thereby increasing opportunity for sampling a greater diversity. Greater numbers of individuals were taken by the larger half-Yankee trawl than by the half-Wilcox (near-shore trawl). This was expected because of the former's larger net mouth opening and greater towing speed at which this net was fished from the R/V F.C. WILBOUR.

Despite the aforementioned differences, catch-per-tow data reflected similar trends. For example, winter flounder and yellowtail flounder catch indices from both surveys evidenced declines of relative abundance from 1981 to 1982. In addition, although the overall mean sizes for fish captured in the near-shore trawl were smaller (see FISHING POWER TRIALS, this report), because of the small cod-end liner, ranges and relative size frequencies appeared similar. The minor exception was that higher frequencies of smaller fish were caught in the half-Wilcox. This indicates that both gear types sampled comparable cross-sections of the populations.

FISHING POWER TRIALS

Following recommendations of the Administrative-Technical Committee, fishing power trials were performed this year prior to discontinuing long-term otter trawl sampling in 1983. This evaluation was undertaken to provide insight into comparative gear efficiency of the half-Yankee (otter) and half-Wilcox (near-shore) bottom trawls.

September and October were selected for the test trials because historically at that time of year, the amount of lobster gear inshore is reduced, and groundfish concentrate in the near-shore area. Tows on the first two trial dates (9 and 23 September) were conducted parallel to the coastline off Barnstable's Sandy Neck Beach - northerly from the Barnstable Harbor channel, to Scorton Creek, Sandwich. This area was chosen because trawlable bottom stretching for several miles abounded, enabling us to conduct several sets of straight, parallel tows. In October, when the majority of lobster gear in Warren Cove, Plymouth, had been moved further offshore, we executed comparative tows there.

Towing time was 20 and 15 minutes for otter trawling and near-shore trawling, respectively. As time can effect gear efficiency (Pennington and Grosslein 1978), and since the data were to be used for comparative purposes, we kept this variable consistent with past samplings. Vessel and gear specifications are listed in Table 16. Both nets were set simultaneously at the same depth (9 m). Tows were generally made within 0.4 km of each other. Thirty-seven daytime paired tows were attempted during the trials; 11 individual tows were aborted because of hangups, twisted doors or twisted net, leaving 26 suitable for comparison. Trawl catches were sorted and fish of all species were measured and enumerated. Occasionally, large catches were

Table 16. Vessel/Gear specifications for fishing power trials in September and October, 1982.

	Otter trawl	Near-shore trawl
Gear		
net	half (#35) Yankee	half-Wilcox
doors	0.8 x 1.5 m, 68 kg	0.5 x 0.9 m, 22 kg
legs	0.9 m	5.5 m
headrope	7.6 m	7.0 m
footrope	10.7 m	9.8 m
wing mesh	11.4 cm	10.2 cm
cod end mesh	3.8 cm	1.3 cm
tow speed	1.9 - 2.8 km/hr (1.0 - 1.5 kts)	1.4 - 1.9 km/hr (0.75 - 1.0 kts)
Vessel		
vessel type	side trawler	not applicable
length	15.2 m (50')	4.9 m (16')
gross tonnage	20	∿ 1/2
draft	1.7 m (5.5')	0.3 m (1')
speed	18.5 km/hr (10 kts)	37.0 km/hr (20 kts)
engine	GMV 671 Diesel inboard	Mercury outboard
drive	2.5:1 reduction	not applicable
horsepower	160 SHP	75

sub-sampled according to standard procedures. Fishing trial station data are found in Table 17.

With the half-Yankee trawl, we captured a total of 27 species, whereas with the smaller trawl we took only 20. Catch/tow for each species is listed in Table 18. Smooth dogfish and seasnail were taken only by the half-Wilcox (near-shore) trawl. Seven species (longhorn sculpin, pollock, sea raven, northern kingfish, Atlantic tomcod, lumpfish and northern searobin) were captured exclusively in the half-Yankee otter trawl tows.

Overall, the number of fish taken in the larger trawl (1,199) was nearly three times greater than that obtained in the Wilcox trawl (430). In addition, mean lengths of all species (except scup) were smaller in the latter catches (Table 19). Mean lengths of four species - winter flounder, windowpane, rainbow smelt and white hake - were significantly ($P \leq .05$) smaller (students t-test). ranges for most taxa were similar, with size frequencies exhibiting similar trends, with one exception. Fewer fish of all lengths were captured in the half-Wilcox (Figs. 5-8).

Inter-vessel/gear factors (the ratio of the otter trawl catch divided by the near-shore trawl catch) were calculated for selected species per trial and for pooled trials (Tables 18 and 20). All factors were greater than 1.0 except for rainbow smelt (0.5). Larger catches of smelt in the near-shore trawl were probably due to additional retention of smaller individuals in that net's cod-end liner (Table 19). Of note, far more butterfish and scup were captured in the larger net. These pelagic species were probably more susceptible to capture because of the F. C. WILBOUR's greater towing speed combined with the larger and perhaps higher opening of the half-Yankee trawl net.

Areal and seasonal fluctuations in abundance of most species complicate

Table 17. 1982 Fishing trial station information.

Station #	Date	Time	Depth	Surface temp. (C)	Bottom temp. (C)	Salinity (‰)
1	9/ 9/82	0958	30'	18.0	17.0	30
2	9/ 9/82	1048	30'	18.0	17.5	29
3	9/ 9/82	1125	30'	18.0	18.0	29
4	9/ 9/82	1225	30'	18.0	18.0	29
5	9/ 9/82	1333	30'	18.5	18.5	29
6	9/23/82	1030	30'	15.0	15.0	25
7	9/23/82	1105	30'	15.0	15.0	24
8	9/23/82	1140	30'	15.0	15.0	30
9	9/23/82	1345	30'	17.0	16.5	28
10	10/13/82	1006	30'	13.5	13.5	-
11	10/13/82	1053	30'	13.5	13.5	-
12	10/13/82	1142	30'	13.5	13.5	-
13	10/13/82	1258	30'	13.0	13.0	-

Table 18. Inter-vessel comparison of catch numbers for individual species.

Species	September 9, 1982 Tow # 1A†	1B*	2A	2B	3A	3B	4A	4B	5A	5B
winter flounder	13	4	2	2	1		2	2		1
windowpane	2	4	4	6	2	1	1	2	3	
yellowtail flounder										
little skate	49	17	40	10	36	21	13	19	52	11
winter skate	4			3	1					
butterfish					12					
Atlantic cod										
alewife										
rainbow smelt										
longhorn sculpin										
pollock										
rock gunnel		1								
bay anchovy										
white hake										
Atlantic silverside										
spotted hake										
smooth dogfish										
northern puffer										
northern pipefish										
sea raven										
Atlantic sea herring										
northern kingfish										
Atlantic tomcod										
lumpfish										
seasnail										
scup	1									
four-spot flounder				1		1		4		1
summer flounder	11		4	1	3	1	5		2	
northern searobin										
Totals	80	26	50	25	55	24	21	27	57	13

Species	September 23, 1982 Tow # 6A	6B	7A	7B	8A	8B	9A	9B
winter flounder	5	2	7		5	5	3	1
windowpane	3	1	1		2	1	1	2
yellowtail flounder								
little skate	9	4	50		35	10	24	15
winter skate								
butterfish			1		1		106	
Atlantic cod								
alewife								
rainbow smelt								
longhorn sculpin								
pollock								
rock gunnel								
bay anchovy								
white hake								
Atlantic silverside								
spotted hake							1	
smooth dogfish								
northern puffer		2			1		1	
northern pipefish								
sea raven								
Atlantic sea herring								
northern kingfish								
Atlantic tomcod								
lumpfish								
seasnail								
scup	36	7	10		9	2	29	1
four-spot flounder			1					
summer flounder	10		2		2		4	
northern searobin							1	
Totals	62	16	72	0	55	18	170	19

Species	October 13, 1982 Tow # 10A	10B	11A	11B	12A	12B	13A	13B
winter flounder	60	27	57	39	56	19	44	14
windowpane	11	2	7	6	8	2	27	9
yellowtail flounder	9	2	8	5	7	4	4	12
little skate	36	14	43	16	32	12	31	4
winter skate	1	1		1		3	8	2
butterfish	4		4	1	1	1	2	
Atlantic cod	4		5	2	4	2		
alewife	2					1	1	
rainbow smelt	2	3	2	1	3	4	3	14
longhorn sculpin	1		1					
pollock	1		6		1		15	
rock gunnel	1			1	1	5		
bay anchovy	1					1		
white hake	19	7	12	6	8	2	3	1
Atlantic silverside	1				1	1		
spotted hake	2	1						
smooth dogfish		1						1
northern puffer		1		1			1	1
northern pipefish	1				2	7	2	
sea raven			1				1	
Atlantic sea herring			3		1	1		
northern kingfish			1					
Atlantic tomcod					1			
lumpfish					1			
seasnail						2		
scup							1	
four-spot flounder								
summer flounder								
northern searobin								
Totals	156	59	149	78	127	67	143	58

A = otter trawl

B = near-shore trawl

computation of reliable inter-vessel/gear factors. This is evident when viewing data presented in Table 20. Inter-vessel/gear factors ranged from 0.5 to 5.5 for windowpane and 5.1 - 29.0 for scup. These wide ranges indicate that these fish were not uniformly distributed within and/or between the areas sampled according to Howe et al. (1980) or insufficient numbers of tows were made for comparison purposes. Howe et al. (ibid) state that when the distribution of fish is contagious, with the variance greater than the mean ($s^2 > \bar{x}$), a small number of tows is of limited value in deriving accurate and meaningful inter-vessel/gear comparisons. They purport that in the order of 500 tows are needed for gear comparison.

Table 19. Mean lengths, total catch in numbers, and inter-vessel factors of selected species for fishing power trials, 1982.

Species	Mean lengths A*	Mean lengths B*	Total catch A*	Total catch B*	Inter-vessel factor***
winter flounder	296.[illegible]	276.5**	255	116	2.2
rainbow smelt	138.0	95.4**	10	22	0.5
Atlantic cod	299.8	245.0	13	4	3.2
white hake	192.8	139.6**	42	16	2.6
butterfish	69.4	61.7	131	2	65.5
winter skate	462.4	452.9	14	10	1.4
windowpane	242.2	195.2**	72	37	1.9
yellowtail	186.0	190.4	28	23	1.2
scup	58.2	60.7	86	10	8.6
summer flounder	430.0	413.5	43	2	21.5
little skate	392.3	377.0	449	153	2.9

* A = otter trawl; B = near-shore trawl.

** Significantly different at P > .05.

*** $\frac{\text{Number of fish captured/otter trawl tow.}}{\text{Number of fish captured/near-shore trawl tow.}}$

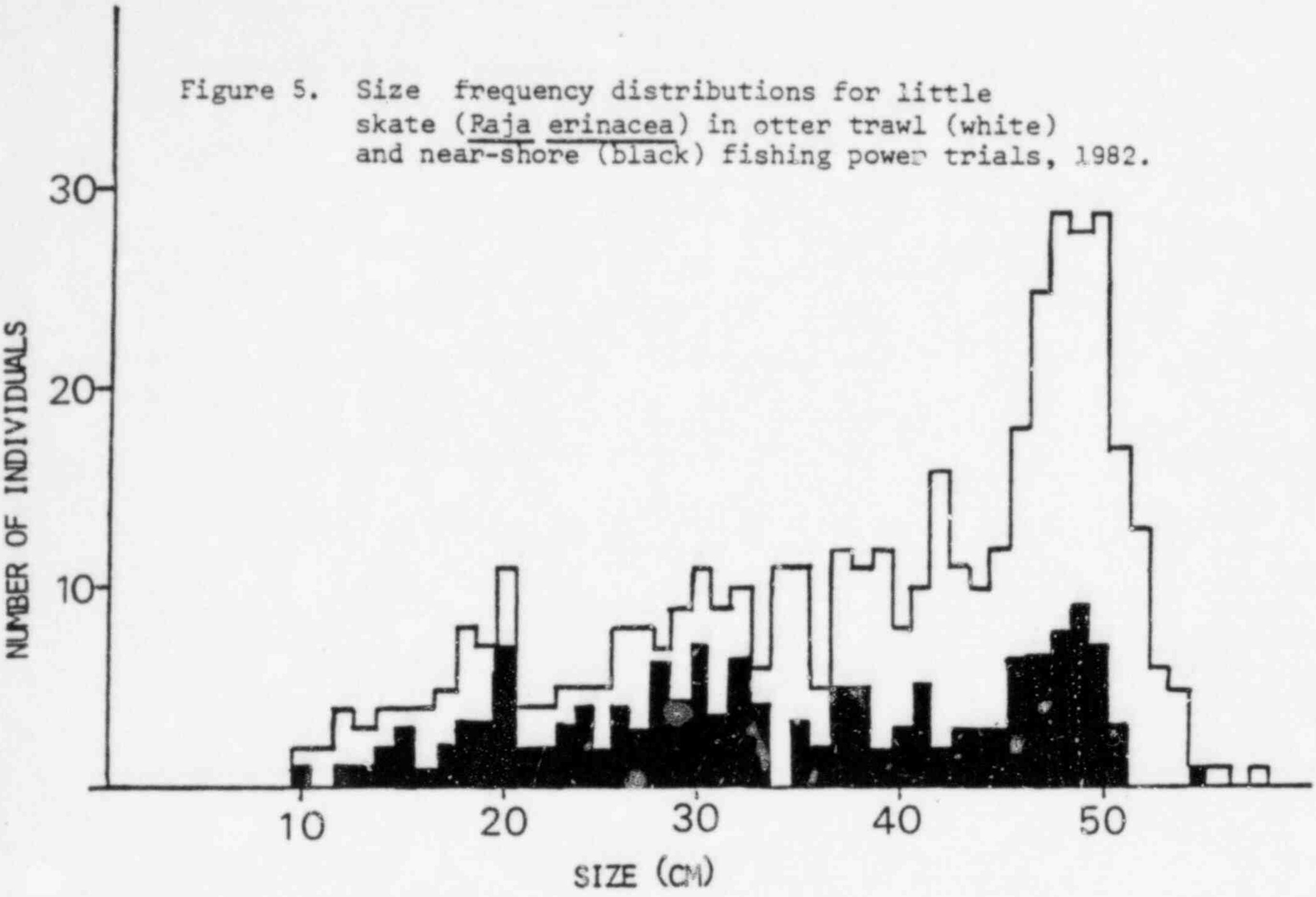


Figure 5. Size frequency distributions for little skate (*Raja erinacea*) in otter trawl (white) and near-shore (black) fishing power trials, 1982.

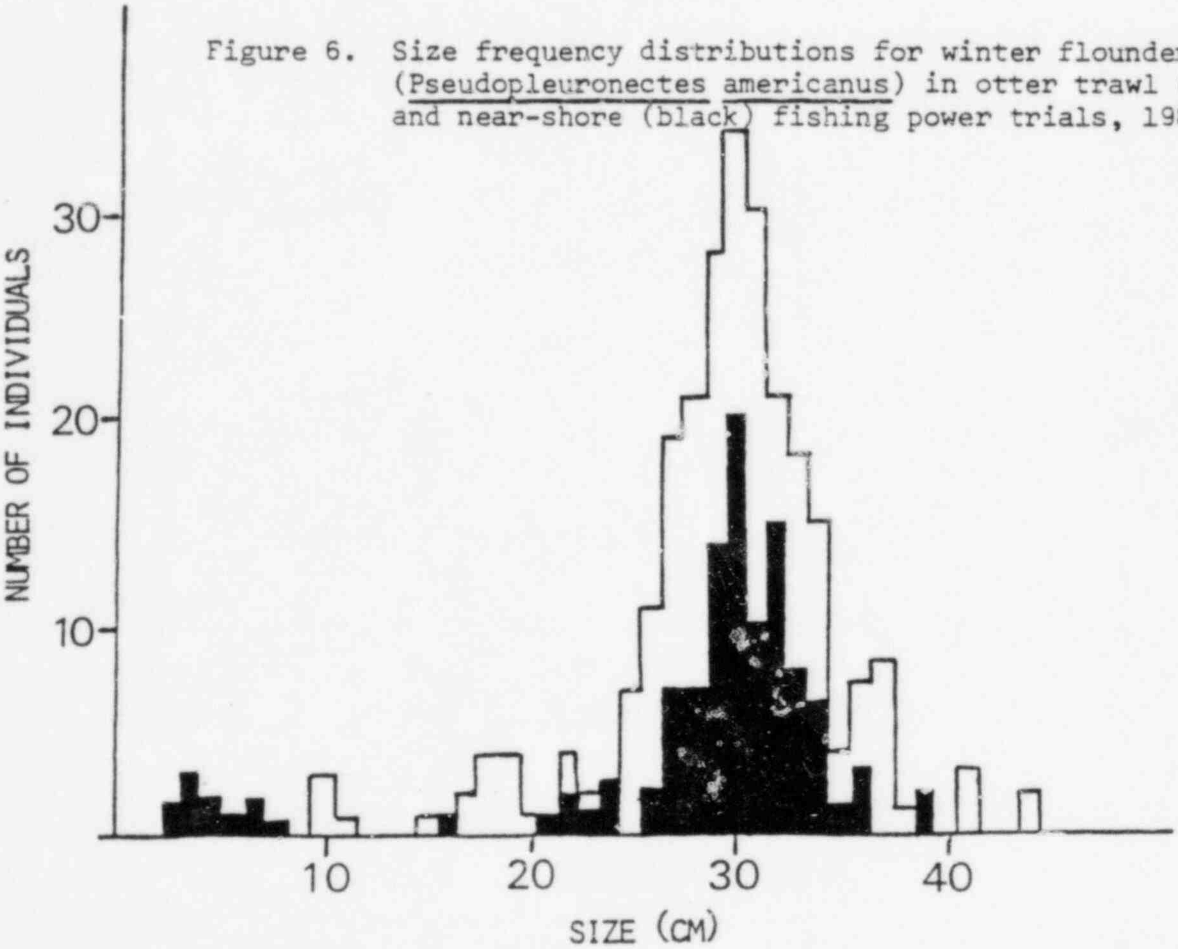


Figure 6. Size frequency distributions for winter flounder (*Pseudopleuronectes americanus*) in otter trawl (white) and near-shore (black) fishing power trials, 1982.

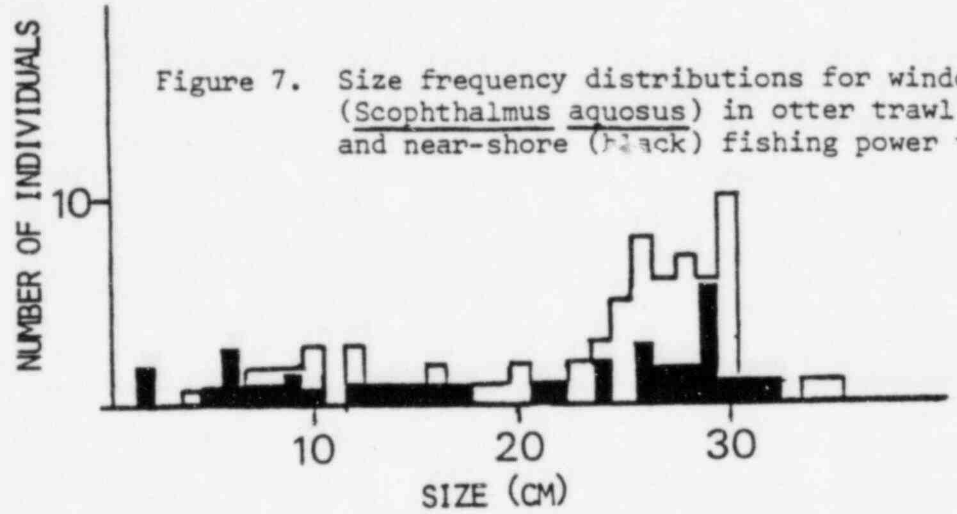


Figure 7. Size frequency distributions for windowpane (Scophthalmus aquosus) in otter trawl (white) and near-shore (black) fishing power trials, 198

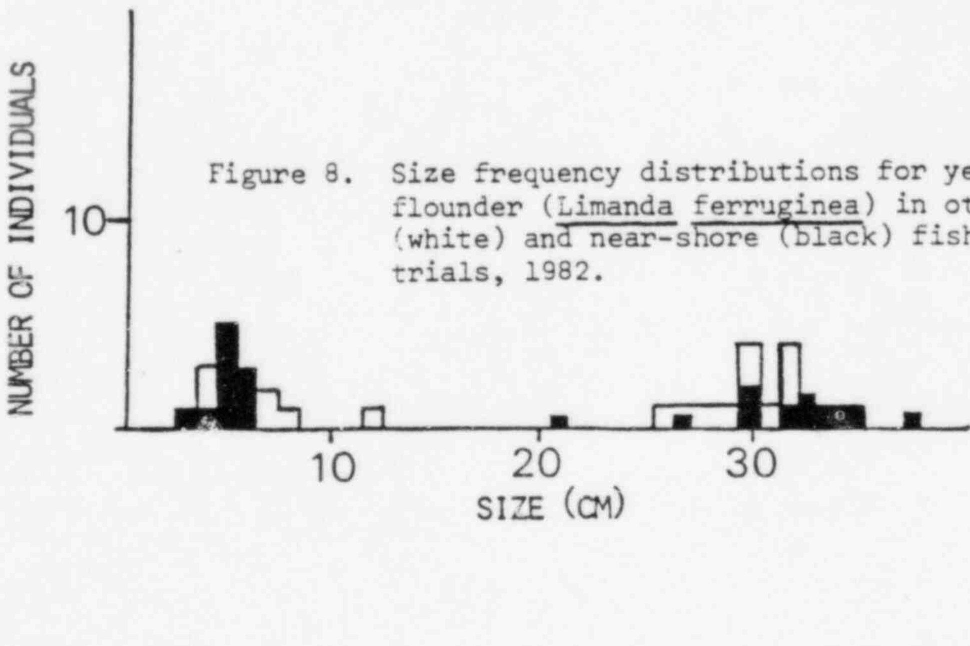


Figure 8. Size frequency distributions for yellowtail flounder (Limanda ferruginea) in otter trawl (white) and near-shore (black) fishing power trials, 1982.

Table 20. Inter-vessel factors* for predominant species by comparative tow.

Species	Tow # 1	2	3	4	5	6	7	8	9	10	11	12	13
winter flounder	3.2	1.0		1.0		2.5		1.0	3.0	2.2	1.5	3.0	3.1
windowpane	0.5	0.5	2.0	0.5		3.0		2.0	0.5	5.5	1.4	4.0	3.0
yellowtail flounder										4.5	1.6	1.8	0.3
little skate	2.9	4.0	1.7	0.7	4.7	2.0		3.5	1.6	2.6	2.7	2.7	7.8
winter skate										1.0			4.0
butterfish											4.0	1.0	
Atlantic cod											2.5	2.0	
rainbow smelt										0.7	2.0	0.8	0.2
white hake										2.7	2.0	4.0	3.0
scup						5.1		4.5	29.0				
summer flounder		4.0	3.0										

$$* \frac{\text{Number of fish captured/otter trawl tow.}}{\text{Number of fish captured/near-shore trawl tow.}}$$

PELAGIC AND BENTHI-PELAGIC FISHES

Two gill net stations were again sampled (Fig. 9) in 1982, one set being made at each site on a monthly basis, weather permitting. Set duration was overnight, with the two stations being sampled on consecutive nights whenever possible. The end of the net positioned closest to the power plant's thermal discharge was reversed on alternate sets to reduce sampling bias.

Data records this year included length measurements of skates, sculpins, searobins and others deemed as "trash fish" (those of little or no commercial or recreational value). In addition, hakes (red and white) and skates were identified to species level rather than being grouped by genus as formerly done.

Sampling was highlighted by the capture of two species new to project collections. In May, a 5.5 m (18 ft) male basking shark (*Cetorhinus maximus*) was netted at Station 1. Approximately three years old (Bigelow and Schroeder 1953) and estimated at between 680-907 kg (1500-2000 lb), this shark caused the destruction of the entire 15.2 cm mesh panel and up to 50% of the adjoining panels. This necessitated replacement of the entire net (Lawton et al. 1981). In November at Station 2, a female Atlantic sturgeon (*Acipenser oxyrhynchus*) was taken in the 15.2 cm mesh panel. This individual was 82.8 cm in length and weighed 2.6 kg.

Comprising 29 species, 1,635 fish (from seven panels of 3.8-15.2 cm mesh) were caught at Station 1 during 10 sets (Tables 21 and 22). Eleven sets at Station 2 yielded 1,487 fish (seven panels), representing 31 species (Tables 21 and 22). Adverse wind conditions resulted in a two-day set at Station 2 in May; respective data were excluded from totals or calculations of catch-per-unit-effort. As in 1981, a large by-catch of rock crabs (*Cancer irroratus* and *C. borealis*) was noted at Station 2. Also at the latter location, relatively

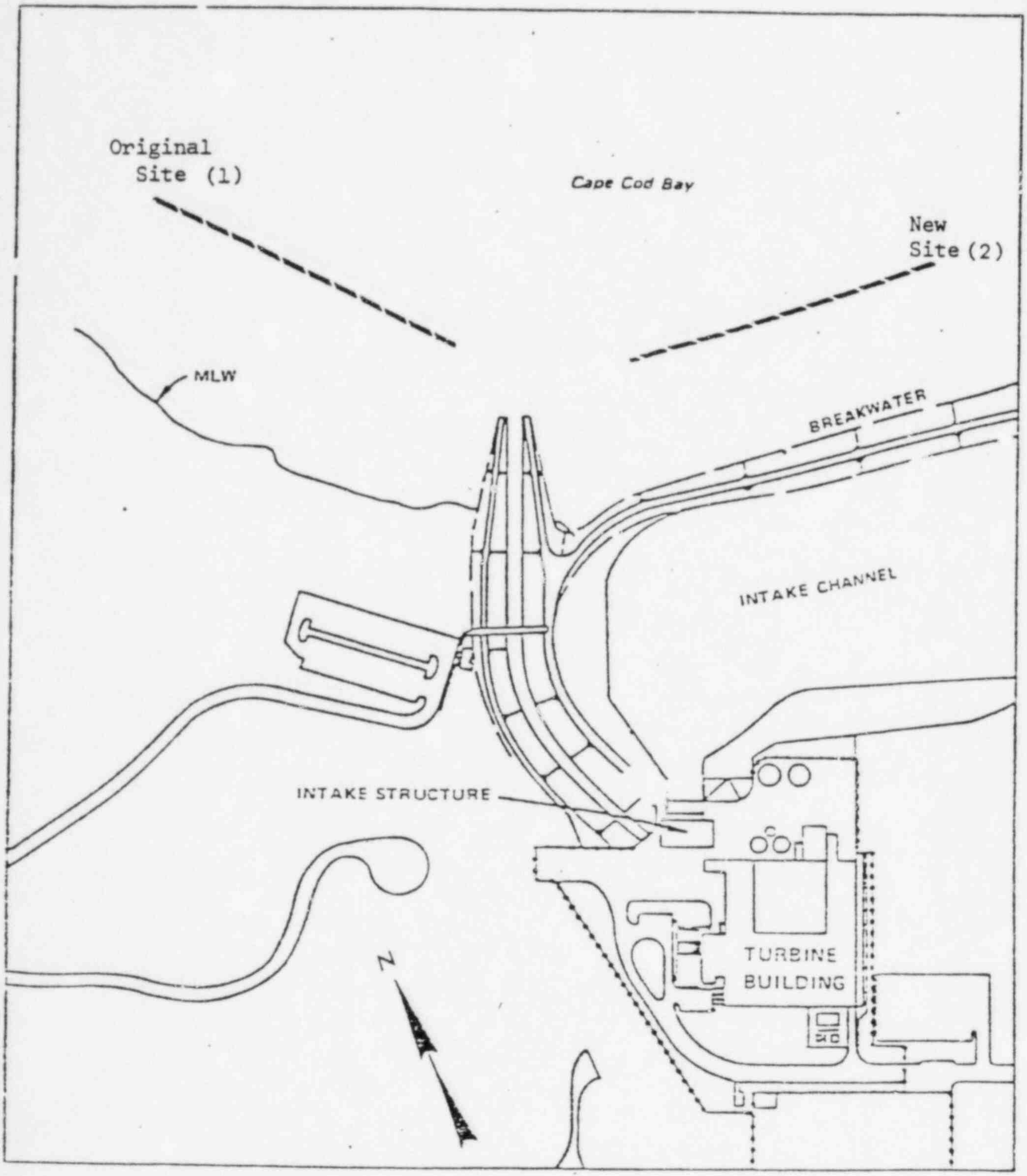


Figure 9. Gill net station locations in the vicinity of PNPS, 1982.

large numbers of sub-legal lobsters were taken, particularly in June.

Data from the five original (3.8-8.9 cm mesh) and two larger panels (11.4-15.2 cm mesh) were pooled separately, and mean catch per set, i.e., catch per unit effort (CPUE), computed for all species combined for each station. Mean catch estimates were also calculated by species (Tables 21 and 22). For all species combined (five panels), mean CPUE was 150.5 at Station 1, which is substantially lower than the 1981 value of 224.7. This difference reflects the reduced numbers of pollock (Pollachius virens) and Atlantic herring (Clupea harengus harengus) captured this year at that site. Mean CPUE (five panels) at Station 2 was 127.5, a slight decrease from last year's estimate of 138.8. For the two larger meshes, CPUE's (pooled species) of 13.0 and 7.7 were obtained at Stations 1 and 2, respectively. In 1981, mean CPUE was 11.3 at Station 1 and 22.1 at Station 2. The marked difference between years at Station 2 is due in part to the reduced catches of Atlantic mackerel (Scomber scombrus) and northern searobin (Prionotus evolans) in 1982.

We observed in 1981 that data from Stations 1 and 2 were quite dissimilar in that there were marked differences in catch indices for most species. As a quantified means of comparing the two stations for all species captured, percent similarity (Whittaker and Fairbanks 1958) was calculated for 1981 and 1982 by mesh size groups (five mesh and two mesh). Percent similarity is an index combining "...information both on the species present and their relative abundances." It "...ranges from 0 when two samples contain no species in common, to 100, when the two samples are identical in both species and individual abundances." (Haedrich 1975). Percent similarity is calculated:

$PS = 100 - 0.5\ \Sigma\ |a-b| = \Sigma\ \min\ (a,\ b)$; where "a and b are, for a given species, the percentages of samples A and B which that species represents"

(Whittaker and Fairbanks 1958).

Between Stations 1 and 2 for the five-mesh panels, percent similarity was 68.8% in 1981 and 62.8% in 1982. For the two larger panels, PS was 33.2% in 1981 and 25.2% in 1982. These values indicate considerable dissimilarity of catches between stations, especially in the larger panels. However, catch differences were fairly constant from one year to the next.

The most abundant species captured at both Stations 1 and 2 was pollock. Catch was lower than in previous years, but nevertheless, pollock accounted for over one-third (36.4% at Station 1 and 37.6% at Station 2) of all the fish gill netted (pooled species) at both stations. Mean annual CPUE at Station 1 (54.8) was the lowest index value recorded the last six years (Table 23). However, based on long-term records, abundance fluctuations appear to result from natural variability. Mean CPUE at Station 2 was 47.9, a slight increase from last year's level (42.0).

Length-frequency data for pollock, from pooled seven-panel catches, were plotted by station for 1981 and 1982 (Figs. 10 and 11). There was good agreement in the 1981 data between stations, with peak numbers of pollock caught in the 230-250 mm length increment. Catch data for 1982 were more evenly distributed over the entire size range, although data at both stations show a small mode at the 170-190 mm interval. Length frequencies between years, by station, are noticeably dissimilar, in that the 1982 frequencies are bimodel, lying to either side of the 1981 mode at both stations. Although none of the fish were aged, a comparison with age-length data from Bigelow and Schroeder (1953) suggests that we sampled three age classes of pollock (1-3 years-olds). Older fish are pro-

Table 21. Gill net catch data (five panels of 3.8-8.9 cm mesh) at two sites in the vicinity of PNPS from January-December, 1982.

Species	Number	Percent of total catch*	Size range (mm)	Mean catch/set (C.P.U.E.)
pollock	548 (527)	36.4 (37.6)	123-418 (100-473)	54.8 (47.9)
cunner	388 (20)	25.8 (1.4)	109-330 (72-256)	38.8 (1.8)
Atlantic herring	133 (472)	8.8 (33.7)	135-307 (130-361)	13.3 (42.9)
Atlantic cod	89 (27)	5.9 (1.9)	235-670 (210-620)	8.9 (2.5)
Atlantic mackerel	66 (26)	4.4 (1.9)	200-425 (190-412)	6.6 (2.4)
northern searobin	47 (42)	3.1 (3.0)	226-361 (220-340)	4.7 (3.8)
tautog	44 (0)	2.9 (0.0)	188-366	4.4 (0.0)
longhorn sculpin	34 (46)	2.3 (3.3)	260-378 (262-383)	3.4 (4.2)
alewife	30 (16)	1.9 (1.1)	80-278 (168-278)	3.0 (1.5)
silver hake	23 (66)	1.5 (4.7)	220-402 (120-432)	2.3 (6.0)
Atlantic menhaden	19 (15)	1.3 (1.1)	250-297 (116-325)	1.9 (1.4)
sea raven	18 (3)	1.2 (0.2)	260-432 (198-432)	1.8 (0.3)
winter flounder	15 (14)	1.0 (1.0)	220-399 (182-433)	1.5 (1.3)
rainbow smelt	13 (34)	0.9 (2.4)	190-230 (172-285)	1.3 (3.1)
Atlantic tomcod	8 (1)	0.5 (0.1)	215-253 (260)	0.8 (0.1)
striped bass	8 (6)	0.5 (0.4)	376-425 (405-455)	0.8 (0.5)
butterfish	6 (0)	0.4 (0.0)	115-140	0.6 (0.0)
red hake	5 (5)	0.3 (0.4)	381-491 (341-431)	0.5 (0.5)
smooth dogfish	4 (21)	0.3 (1.5)	505-962 (529-772)	0.4 (1.9)
grubby	2 (0)	0.1 (0.0)	115-125	0.2 (0.0)
American shad	1 (0)	0.1 (0.0)	305	0.1 (0.0)
hickory shad	1 (0)	0.1 (0.0)	363	0.1 (0.0)
black sea bass	1 (4)	0.1 (0.3)	320 (240-342)	0.1 (0.4)
blueback herring	1 (0)	0.1 (0.0)	196	0.1 (0.0)
bluefish	1 (4)	0.1 (0.3)	505 (158-160)	0.1 (0.4)
little skate	0 (17)	0.0 (1.2)	(231-542)	0.0 (1.5)
spiny dogfish	0 (17)	0.0 (1.2)	(592-1028)	0.0 (1.5)
windowpane	0 (9)	0.0 (0.6)	(185-321)	0.0 (0.8)
fourspot flounder	0 (3)	0.0 (0.2)	(227-293)	0.0 (0.3)

Table 21. Gill net catch data (five panels of 3.8-8.9 cm mesh) at two sites in the vicinity of PNPS from January-December, 1982. (continued)

Species	Number	Percent of total catch*	Size range (mm)	Mean catch/set (C.P.U.E.)
yellowtail flounder	0 (2)	0.0 (0.1)	(326-331)	0.0 (0.2)
coho salmon	0 (1)	0.0 (0.1)	(386)	0.0 (0.1)
scup	0 (1)	0.0 (0.1)	(180)	0.0 (0.1)
winter skate	0 (2)	0.0 (0.1)	(350-413)	0.0 (0.2)
white hake	0 (1)	0.0 (0.1)	(215)	0.0 (0.1)
Total	1505 (1402)			150.5 (127.5)

( ) Numbers in parentheses represent fish captured at Station 2.
* From five panels of 3.8-8.9 cm mesh

Table 22. Gill net catch data (two panels of 11.4-15.2 cm mesh) at two sites in the vicinity of PNPS from January-December, 1982.

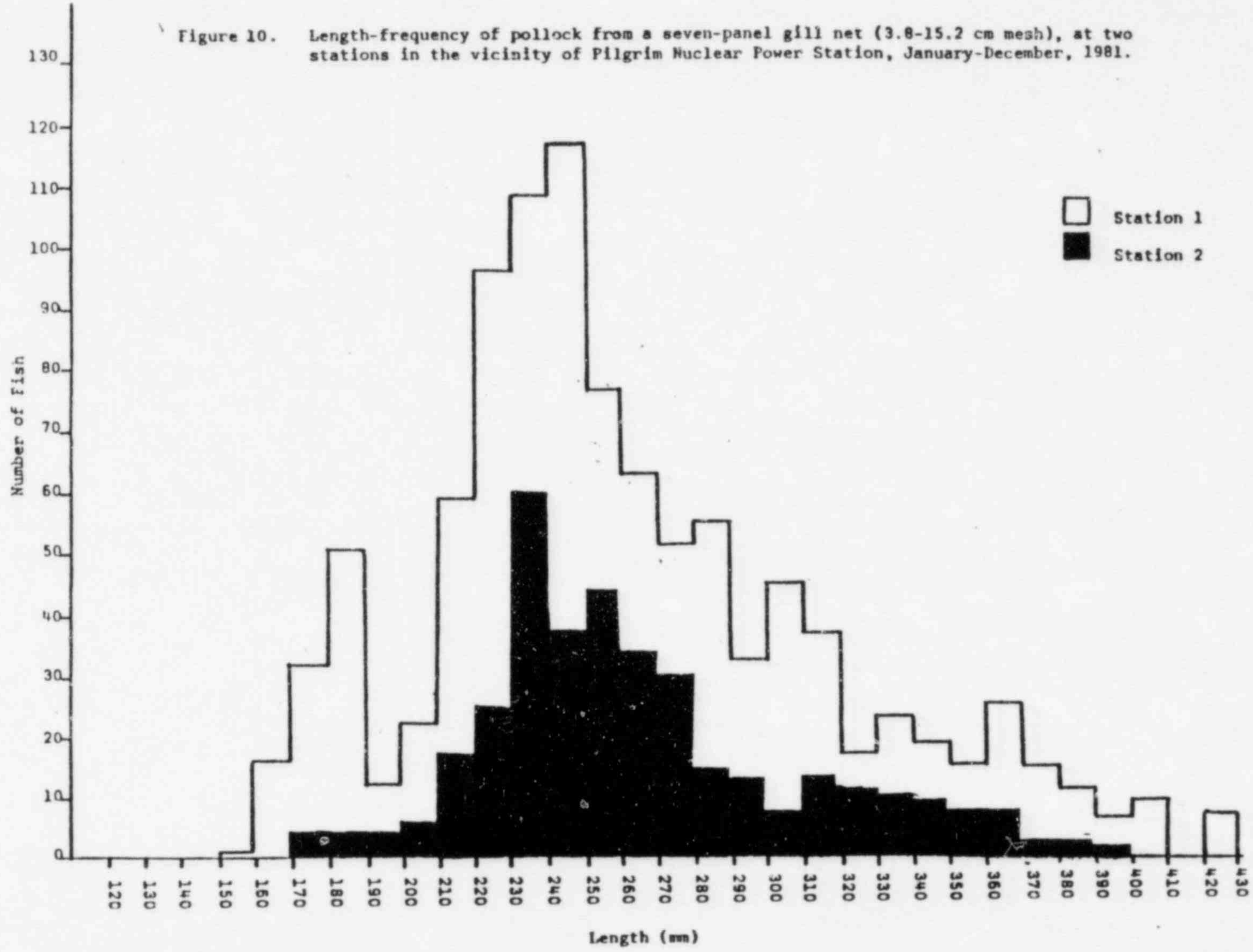
Species	Number	Percent of total catch*	Size range (mm)	Catch/set (C.P.U.E.)
Atlantic cod	32 (1)	24.6 (1.2)	358-853 (m)	3.2 (0.1)
tautog	26 (1)	20.0 (1.2)	320-512 (460)	2.6 (0.1)
winter flounder	20 (9)	15.4 (10.8)	222-356 (223-325)	2.0 (0.8)
sea raven	13 (1)	10.0 (1.2)	300-381 (348)	1.3 (0.1)
pollock	11 (0)	8.5 (0.0)	142-348	1.1 (0)
smooth dogfish	10 (6)	7.6 (7.2)	927-1172 (560-1155)	1.0 (0.5)
Atlantic mackerel	8 (1)	6.1 (0.0)	352-407 (306)	0.8 (0.1)
longhorn sculpin	2 (1)	1.5 (1.2)	318-349 (m)	0.2 (0.1)
northern searobin	2 (0)	1.5 (0.0)	285	0.2 (0.0)
basking shark	1 (0)	0.8 (0.0)	5500	0.1 (0.0)
cunner	1 (0)	0.8 (0.0)	270	0.1 (0.0)
scup	1 (0)	0.8 (0.0)	300	0.1 (0.0)
silver hake	1 (4)	0.8 (4.8)	402 (315-415)	0.1 (0.4)
spiny dogfish	1 (25)	0.3 (30.1)	968 (898-1115)	0.1 (2.3)
summer flounder	1 (2)	0.8 (2.4)	431 (403-461)	0.1 (0.2)
little skate	0 (11)	0.0 (13.3)	(336-568)	0.0 (1.0)
windowpane	0 (10)	0.0 (12.0)	(210-330)	0.0 (0.9)
Atlantic herring	0 (6)	0.0 (7.2)	(283-316)	0.0 (0.5)
Atlantic menhaden	0 (2)	0.0 (2.4)	(290-292)	0.0 (0.2)
striped bass	0 (1)	0.0 (1.2)	(500)	0.0 (0.1)
Atlantic sturgeon	0 (1)	0.0 (1.2)	(828)	0.0 (0.1)
black sea bass	0 (1)	0.0 (1.2)	(245)	0.0 (0.1)
fourspot flounder	0 (1)	0.0 (1.2)	(335)	0.0 (0.1)
yellowtail flounder	0 (1)	0.0 (1.2)	(359)	0.0 (0.1)
Total	130 (85)			13.0 (7.7)

( ) Numbers in parentheses are fish captured at Station 2.
m From two panels of 11.4-15.2 cm mesh.
* Mutilated - unable to measure.

Table 23. Mean annual catch per standard gill net (five panels of 3.8 - 8.9 cm mesh) set (CPUE) for selected species collected northwest (Station 1) of PNPS, 1971-1982.

Species	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
pollock	67.9	119.8	109.1	41.6	22.1	57.2	141.8	91.3	86.9	135.2	110.7	54.8
cunner	18.9	18.6	21.1	18.9	26.4	27.6	42.7	44.0	38.6	44.3	40.7	38.8
Atlantic herring	14.2	1.5	4.6	19.9	17.4	96.1	80.0	22.3	56.0	14.7	44.4	13.3
alewife	44.3	10.8	15.3	29.6	4.1	12.2	7.4	14.5	4.7	6.1	1.3	3.0
Atlantic mackerel	13.9	5.0	6.3	2.4	5.7	1.6	2.5	8.7	3.7	6.4	2.2	6.6
Atlantic cod	8.9	14.2	9.6	7.9	6.1	4.4	3.0	2.8	6.5	4.5	4.1	8.9
butterfish	0.9	0	0	0.4	0	1.0	0.1	1.5	1.2	4.2	0.7	0.6
silver hake	0.3	0.1	0.4	8.4	5.1	21.8	13.4	0	0	2.5	0.7	2.3
tautog	0.7	0.6	1.2	1.0	0.4	1.2	0.6	0.7	3.1	1.9	1.6	4.4
blueback herring	2.1	0.2	5.6	0.8	0.6	2.1	2.9	3.5	4.9	0.8	0.7	0.1
rainbow smelt	0.1	0.1	0.2	1.9	0.5	0.9	0.5	0.7	1.6	0.7	0.6	1.3
Atlantic menhaden	1.8	0.7	1.9	4.9	4.1	6.4	2.7	6.4	8.1	0.5	1.8	1.9
Atlantic tomcod	0.5	0.2	0.1	0	0.1	0.4	0.9	2.6	1.8	0.4	0.2	0.8
bluefish	0.1	0.2	0.4	6.6	4.4	0.6	0.8	0.9	3.2	0.3	0.4	0.1

Figure 10. Length-frequency of pollock from a seven-panel gill net (3.8-15.2 cm mesh), at two stations in the vicinity of Pilgrim Nuclear Power Station, January-December, 1981.



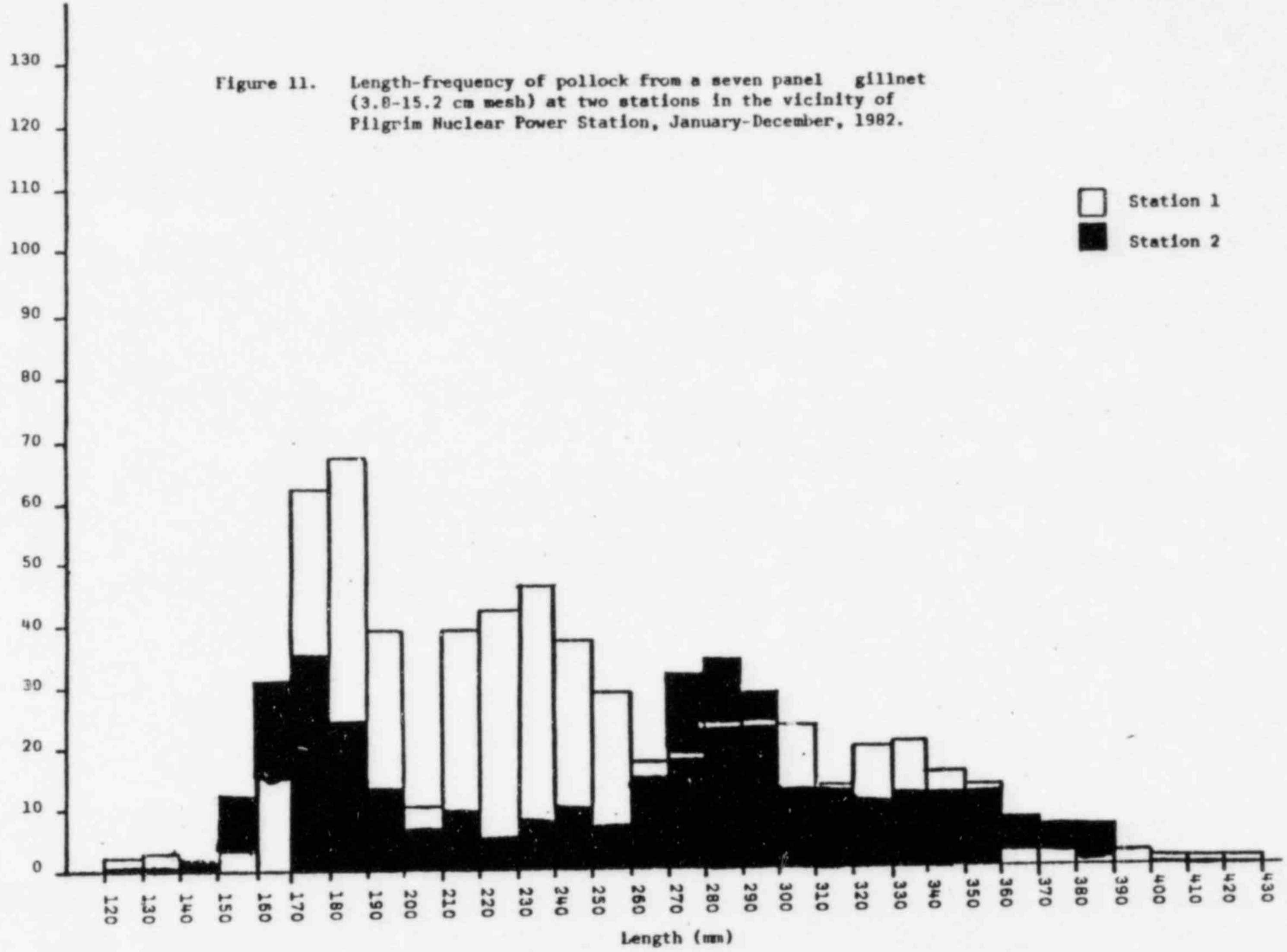


Figure 11. Length-frequency of pollock from a seven panel gillnet (3.8-15.2 cm mesh) at two stations in the vicinity of Pilgrim Nuclear Power Station, January-December, 1982.

bably not common in the shallow study area because of their preference for deeper, colder water (Steele 1963).

Cunner (Tautogolabrus adspersus) ranked second (25.8% of the total catch) in catch abundance at Station 1, but only tenth at Station 2 (1.4% of total). A substantial spatial difference was also noted in 1981, with greater numbers also caught at Station 1. Lawton et al. (1981) believed this was related to habitat preference.

Cunner were sampled during all four seasons but were most abundant in late spring and summer. Low numbers captured during colder months probably reflect an offshore movement and their sedentary nature in winter (Bigelow and Schroeder 1953).

Third in total catch at Station 1 (8.8%) and second at Station 2 (33.7%) was the Atlantic herring. A mean annual CPUE of 13.3 at Station 1 is a marked decrease from the 1981 level (44.4). Water temperatures were higher (≈ 4.5 C) during the fall months (October-December) of 1982, usually a time of high catches; this may have influenced local abundance of this cold-water species. However, time-series data reveal that abundance of this species fluctuates greatly. Stock fluctuations were also reported by Bigelow and Schroeder (1953) for the Gulf of Maine, at large. A comparisor with age-length data from Draganik and Zukowski (1967) suggests that we sampled as many as eight year-classes. Size data from Georges Bank ranged from 210 mm (Age I) to 339 mm (Age VIII). Our ranges at Stations 1 and 2 were 135-307 mm (FL) and 130-361 mm (FL), respectively.

Atlantic cod (Gadus morhua) were fourth in total catch (5.9%) at Station 1 and seventh (1.9%) at Station 2. Mean catch per set was 8.9 and 2.5 at Stations 1 and 2, respectively. Both values are slightly higher than last year. As in

1981, larger cod were taken at Station 1 (Table 21). Cod were netted from April-November, with the greatest numbers caught from September-November.

At a mean annual CPUE of 6.6, Atlantic mackerel (Scomber scombrus) ranked fifth in total catch (4.4%) at Station 1 and eighth (1.9%) at Station 2, where CPUE was 2.4. Catch per set at Station 2 decreased substantially from last year's index of 17.6. Catches were highest from June-July and October-November, which corresponds with their northern and southern migrations, respectively, in Cape Cod B Using age-length data from Moores et al. (1975), we probably captured 1-8 year old mackerel.

Winter flounder (Pseudopleuronectes americanus) were slightly more abundant at Station 2 in 1981 but were collected at similar levels at both stations in 1982, when mean CPUE was 1.5 and 1.3 at Stations 1 and 2, respectively. The index value at Station 2 decreased 50% from last year. However, fluctuations are common, and the gill netting of winter flounder has always been sporadic.

The two larger panels (11.4-15.2 cm mesh) were added to our experimental gill net in 1979 to sample larger individuals that might be present in the immediate area of the power station but were not representatively caught by the original five-panel net. Comparison of length data from each of the two-panel groups supports this contention. Catch composition varied between panels, but species found to be common in the catches of the five smaller panels were also common in the two larger panels. In addition, CPUE estimates indicated that trends in relative abundance by season and year were the same for all panels.

A summary of the collection totals from Station 2 for 1981 and 1982 appears in Table 24. Station 2 will not be sampled in 1983 because of the excessive damage caused to the net by the capture of rock crabs. Sampling will revert to biweekly sets made at Station 1 only.

Table 24. Gill net collection totals at Station 2 for the five (3.8-8.9 cm) and two (11.4-15.2 cm) mesh panel groups, 1981-82.

Species	Number: 5 mesh	Number: 2 mesh	Size range (mm): 5 mesh		Size range (mm): 2 mesh
pollock	1051	8	100-473		253-325
Atlantic herring	623	16	110-364		264-327
Atlantic mackerel	184	31	190-436		306-404
northern searobin	135	38	220-340	**	
cunner	91	0	72-256		
hake spp.*	80	9	196-550		332-525
silver hake	78	4	120-470		315-415
longhorn sculpin	76	4	262-383	**	
rainbow smelt	46	0	172-285		
winter flounder	38	37	142-453		223-325
Atlantic cod	37	5	210-620		305-660
skate spp.*	35	34	231-542	**	336-568
smooth dogfish	31	13	529-772	**	560-1155
alewife	26	1	142-278		274
Atlantic menhaden	20	2	116-325		290-292
windowpane	14	24	185-321	**	210-330
fourspot flounder	13	7	227-415		270-375
sea raven	10	9	198-432	**	348
bluefish	9	0	158-485		
yellowtail flounder	8	1	160-331		359
striped bass	8	5	311-455		348-500
butterfish	6	0	100-160		
black sea bass	5	1	240-342		245
blueback herring	3	0	160-250		
Atlantic tomcod	2	0	243-260		
scup	2	0	163-180		
tautog	1	6	311		361-543
spiny dogfish	0	26			898-1115
summer flounder	0	2			403-461
Atlantic sturgeon	0	1			828
lumpfish	0	1			479
Total	2632	284			

* Not identified to species in 1981.
** 1982 measurements only; species not measured in 1981.

In general, sampling at Station 2 yielded fewer numbers of fish but more species. Mean lengths of species collected at Station 2 were generally smaller than corresponding measurements at Station 1. Seasonal trends in abundance were essentially the same for both stations. Greater numbers of flatfishes and rock crabs were captured at Station 2, which may reflect habitat differences, in that this area was less rocky than Station 1.

Data collected by gill net through 1982 suggest that fluctuations occur in local species abundance and these are related to natural variability.

FISHES OF THE NEARSHORE COMMUNITY

Haul seining, initiated in 1981, was continued in 1982 to sample shore-zone finfish in the vicinity of Pilgrim Nuclear Power Station. This sampling technique complements other sampling methods and provides representative data on forage species and the juvenile stages of sport and commercial fishes which inhabit the intertidal and shallow subtidal zones. Species occurring in the nearshore area are important components of community structure. As an effective means of sampling shallow water habitats, haul seining countervails gear selectivity of the nets employed in trawling and gill netting.

Four stations (Fig.12), representing typical shore-zone habitats in the study area, were systematically sampled weekly during segments of three seasons: spring (March-April), summer (August-September), and autumn (November-December). The temporal selection of field sampling coincided with the traditional periods of highest impingement of fish at Pilgrim Station. Gray's Beach (Station 1) in Plymouth, Kingston, Duxbury Bay complex, an estuarine location, is a sandy beach bordered by salt marsh grass (Spartina alterniflora) with exposed mud flats at low tide. Warren Cove (Station 2) and White Horse Beach (Station 4), both in Plymouth, are open coastal sand beaches. Pilgrim Station Intake embayment (Station 3) is a man-made enclosure bordered by breakwaters and rip-rap. Seining at the latter site was conducted at the head of the embayment, proximal to the power plant's intake screens.

We adopted a standardized quantitative seining technique, modified after Conover and Ross (1982), requiring 3-4 people and employing a 45.7 x 1.8 m haul seine with a 1.8 x 1.8 x 1.8 m pocket of 0.48 cm square mesh (twine #63). The net was set as follows: 13.7 m of net were drawn together at one end and walked out perpendicular from shore to a depth of approximately 1.1 m with the

rest of the net trailing behind. The central 18.3 m section, containing the bag, was then stretched parallel to the shoreline while the other end was secured ashore. At this point, an attached lead weight and float was dropped at the newly formed corner, and this end of the net was quickly brought to shore thus enclosing a rectangular area completed by the shoreline. Replicate hauls were made at each station to address data variability, and mean catches were calculated.

The surface area (m^2) of water seined each haul was estimated considering the linear distance of the net from shore at inception of a set. Fish were identified, enumerated, and measured. If catches were unusually large, all fish were counted, but length data were obtained from a subsample of at least 100 individuals of each species caught. Density estimates (no. per m^2 surface area) were calculated by dividing species catch by the surface area seined.

Seining was conducted at different tidal stages. Water temperature and salinity of the nearshore water column (≈ 1 m deep) were measured using a YSI (Model 33) SCT meter at the time of sampling. Temperatures ranged from 1.0 C in March to 22.0 C in August. Salinities ranged from 19-34 ‰, which reflected the influence of both the ocean and watershed drainage. Lowest salinities occurred on ebb tides.

During 26 sampling dates, we seined a total of 22 finfish species (2 more than in 1981) and 8 species of invertebrates (Table 25). Overall, diversity and abundance were again greatest in summer. Three species, not seined last year, were the tautog (Tautoga onitis), northern kingfish (Menticirrhus saxatilis), and haddock (Melanogrammus aeglefinus). The capture of a large haddock (540 mm TL; age ≈ 7 yrs) in early December in Warren Cove was a most unusual occurrence. We have caught few haddock (small juveniles)

Table 25. Numerical rank, catch, percentage composition, and size range of shore-zone fishes captured by haul seine at four stations in the environs of Pilgrim Nuclear Power Station in 1982.

Rank	Species	Catch	% of Catch	Size Range (mm)
1	Atlantic silverside	3,701	65.3	18-162 (TL)
2	bay anchovy	1,059	18.7	35- 77 (FL)
3	sand lance spp.*	580	10.2	75-145 (TL)
4	northern puffer	119	2.1	12- 50 (TL)
5	winter flounder	79	1.4	30-235 (TL)
6	mummichog	55	1.0	26- 99 (TL)
7	windowpane	18	0.3	34-258 (TL)
8	rainbow smelt	11	0.2	63-128 (TL)
9	northern pipefish	10	0.2	31-169 (TL)
10	alewife	9	0.2	31- 94 (FL)
11	Atlantic menhaden	7	0.1	32- 68 (FL)
12	Atlantic tomcod	6	0.1	72-156 (TL)
13	striped killifish	5	0.1	55- 76 (TL)
14	cunner	3		20- 24 (TL)
15	blueback herring	2		32- 63 (FL)
	unidentified Carangid or Pomatomid	2		40- 45 (FL)
16	Atlantic herring	1		112 (FL)
	American eel	1	0.1	520 (TL)
	haddock	1		560 (TL)
	tautog	1		25 (TL)
	northern kingfish	1		42 (TL)
	white hake	1		34 (TL)

* Not separated by species; (TL) = total length; (FL) = fork length.

during 12 years of fisheries investigations in the vicinity of Pilgrim Station and never in such shallow water.

The number of finfish species caught by station ranged from 8 in Pilgrim's Intake embayment to 14 in Warren Cove. We recorded 13 species at Gray's Beach as compared to 6 species seined there in the early 1970's by Iwanowicz et al. (1974). The total number of fish caught (pooled species) was highest at Gray's Beach followed by White Horse Beach, primarily due to the abundance of the Atlantic silverside at the former site and Atlantic silverside, bay anchovy, and sand lance spp. at the latter location. It should be noted, however, that subsequent to the end of September, maintenance dredging operations in the Intake embayment prevented autumn sampling there.

Seasonally, the number of species (pooled station data) captured was lowest in spring (7) and highest in summer (18); no winter sampling was conducted. The total number of fish caught also peaked in summer when warmest temperatures prevailed inshore (as high as 22 C). Species occurring at all collecting stations were: Atlantic silverside (Menidia menidia), alewife (Alosa pseudoharengus), Atlantic menhaden (Brevoortia tyrannus) and winter flounder (Pseudopleuronectes americanus). Both cyprinodontids, viz. mummichog (Fundulus heteroclitus) and striped killifish (Fundulus majalis), were taken only at Gray's Beach, apparently due to their estuarine/marsh dependence (Valeila et al. 1977).

Exploratory day/night seining revealed overall that catches were dissimilar, and specifically, catches of Atlantic silverside and green crab (Carcinus maenas) were substantially higher at night. Size differences were apparent for Atlantic herring (Clupea harengus harengus) and northern kingfish, with larger individuals caught after dark. Possibly these differences resulted from diel changes in species distribution and/or were related to gear avoidance.

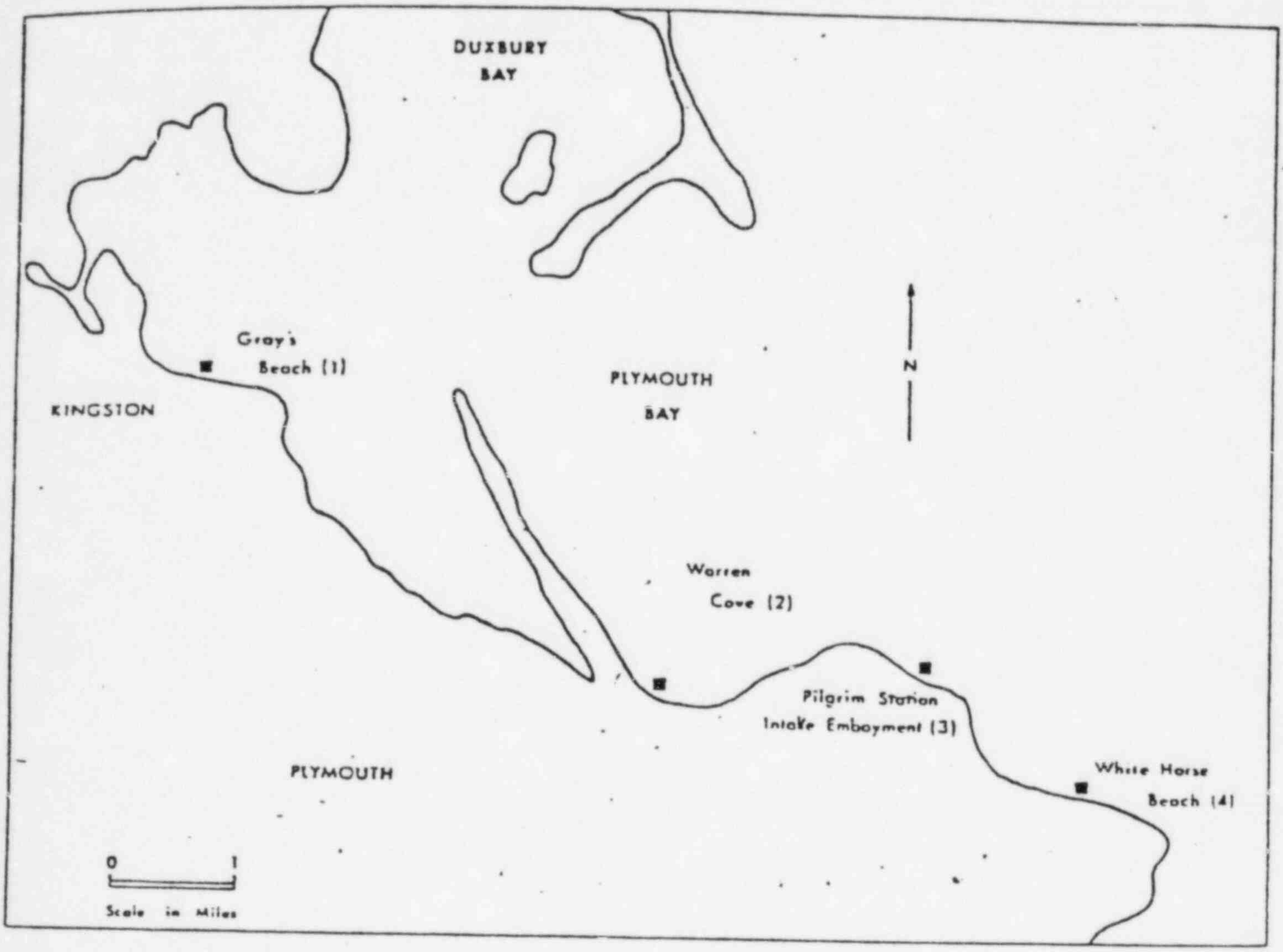


Figure 12. Haul seine station locations in the vicinity of PNPS, 1982.

The Atlantic silverside was the most abundant species encountered, comprising 65.3% of the total haul seine catch (Table 25). Fish ranged in size from 18-162 mm (TL), which included young-of-the-year and adults. As in 1981, station totals for this species were highest at Gray's Beach (Station 1) and lowest in Warren Cove (Station 2). In 1982, annual mean densities in the Intake embayment and at White Horse Beach were identical (Table 26). The abundance of juveniles (some just exceeding the post-larval size of 12-15 mm) at Gray's Beach in August indicates that spawning occurs in Plymouth, Kingston, Duxbury Bay. There is a protracted spawning season for silversides which extends through July in the Gulf of Maine (Bigelow and Schroeder 1953); eggs are demersal and adhere to intertidal vegetation within salt marshes (Conover and Ross 1982). Iwanowicz et al. (1974) reported that the salt marshes within Plymouth, Kingston, Duxbury Bay provide spawning and nursery habitat for many species of marine biota.

Seasonally, silversides were most abundant in the study area during summer ($\bar{x}$ density = 0.27 per m^2) followed closely by fall ($\bar{x}$ density = 0.24 per m^2). Densities declined in December (Table 26) concomitant with decreasing water temperatures. Howe and Germano (1982) captured relatively large numbers in mid-December, 1981, ranging in size from 60-160 mm (TL), from bottom trawls of Cape Cod Bay in up to 46 m of water and approximately 9.3 km off the Cape Cod shoreline. Conover and Murawski (1982) demonstrated that populations of this nearshore species north of Cape Hatteras undergo an offshore winter migration. Silversides ($\geq$ 70 mm TL) were first captured in the Plymouth area in 1982 when water temperatures warmed to about 6-8 C in the spring. Overwintering losses (1981-1982) were apparently substantial as indicated by a mean adult density of 0.007 per m^2 obtained that spring. Conover and Ross

Table 26. Density of Atlantic silversides (no. per m^2 surface area) collected in the off-site waters of Pilgrim Nuclear Power Station by haul seine in 1982.

Date	Gray's Beach (Sta. 1)	Warren Cove (Sta. 2)	Intake (Sta. 3)	White Horse Beach (Sta. 4)
3/4	0.00 (0)	0.00 (0)	0.00 (0)	-
3/12	0.01 (2)	0.00 (0)	0.00 (0)	0.00 (0)
3/18	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)
3/26	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)
4/1	0.01 (2)	0.00 (0)	0.02 (2)	0.11 (28)
4/9	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)
4/16	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)
4/23	0.00 (0)	0.02 (4)	0.00 (0)	0.00 (0)
4/30	0.08 (19)	0.01 (2)	0.00 (0)	0.00 (0)
8/3	0.27 (67)	-	0.04 (9)	-
8/13	0.53 (134)	-	0.06 (14)	-
8/19	0.74 (186)	0.01 (1)	0.00 (0)	0.26 (64)
8/27	1.20 (403)	0.01 (2)	0.01 (1)	0.73 (184)
9/3	0.07 (22)	0.00 (0)	0.63 (106)	0.03 (11)
9/13	1.26 (317)	0.04 (10)	0.70 (175)	0.01 (2)
9/24	0.29 (151)	0.01 (1)	0.02 (5)	0.13 (110)
10/1	0.26 (64)	0.08 (29)	*	0.01 (2)
11/5	1.61 (404)	0.04 (9)	*	0.27 (69)
11/12	1.53 (384)	0.38 (138)	*	0.14 (64)
11/19	0.41 (102)	-	*	-
11/24	0.46 (212)	0.10 (25)	*	0.04 (12)
12/2	0.07 (28)	0.06 (16)	*	0.02 (6)
12/8	0.13 (39)	0.01 (2)	*	-
12/14	0.03 (7)	0.01 (2)	*	0.06 (14)
12/22	0.03 (7)	0.00 (0)	*	-
12/31	0.00 (0)	0.18 (30)	*	0.01 (2)
$\overline{x}$ (Total)	0.35 (2,500)	0.04 (271)	0.09 (312)	0.09 (568)
Standard deviation	0.50	0.09	0.22	0.17

( ) Numbers in parentheses represent the mean catch in numbers for duplicate sets.

\- No haul made because of strong surf.

* No sampling conducted because of dredging operations.

(1982) reported losses of 99% in the Atlantic silverside population of Essex Bay over the winter of 1977-78; adult density was .009 ± .002 per m^2 in May, 1978. The annual abundance of silversides in our study area in 1982, when the overall study mean density was 0.16 per m^2, was much less than in 1981 when density averaged 2.07.

Bay anchovy (Anchoa mitchilli), ranging in size from 35-77 mm (FL), ranked second in total seine catch (18.7%). They occurred at each station except in the Intake embayment; catches were highest at White Horse Beach. Abundance peaked in summer when water temperatures ranged from 13.0-22.0 C. This schooling species is a summer straggler to the Gulf of Maine waters from the south (Bigelow and Schroeder 1953).

Sand lance (Ammodytes spp.) ranked third (10.2%) in numerical abundance (Table 25). Ranging in size from 75-145 mm (TL), sand lance were collected each season sampled. However, none were caught at Gray's Beach. Iwanowicz et al. (1974) did not capture this species at stations located throughout Plymouth, Kingston, Duxbury Bay. Overall abundance was greatest in autumn on the sandy foreshore at White Horse Beach. Summer catches were also high in Warren Cove.

Ranking fourth in overall catch (2.1%) was the northern puffer (Sphoeroides maculatus), a species not commonly encountered north of Cape Cod. In 1981, we seined only 6 specimens (18-52 mm TL), while 12 years of bottom trawling in the vicinity of Pilgrim Station has produced only 4 puffers. In 1982, our catch (Table 25) consisted of all juveniles (young-of-the-year), which ranged in size from 12-50 mm (TL). They occurred only in summer and at all sites except Gray's Beach; abundance was highest in the Intake at Pilgrim Station. An inshore species, northern puffer spawn demersal, adhesive eggs in

shoal water close to shore from early June through summer off southern Massachusetts (Bigelow and Schroeder 1953).

Winter flounder, as in 1981, ranked fifth in overall seine totals (Table 25). Based on length data (30-235 mm TL) and the age-length work of Berry et al. (1965), it appears we sampled three year-classes (0-II) in this survey. Greatest numbers were caught in Warren Cove and at Gray's Beach during summer. Our bottom trawl catches from 1970-1982 indicate that peak abundance of this flatfish occurs in Warren Cove in summer.

The mummichog was collected only at Gray's Beach; catches were substantially reduced from last year when this species ranked second in seine hauls. Rainbow smelt (Osmerus mordax) were taken at Gray's Beach and in Warren Cove and northern pipefish (Syngnathus fuscus) at White Horse Beach and in the Intake in relatively small numbers. Of the invertebrates seined, shrimp (Crangon spp.), by far, predominated at all stations.

UNDERWATER FINFISH OBSERVATIONS

The 1982 underwater finfish observational study commenced on 6 May and continued through 26 November. Biologist-divers, utilizing SCUBA, made biweekly observations at six stations (Fig. 13) from May to mid-August and mid-September through November. From the mid-August through mid-September interim (the period of highest ambient temperatures), weekly observations were made. Diving was restricted to a two-hour period before and after high tide.

Dive stations were identical to those of last year, (Lawton et at. 1981). Stations designated 'S', 'D', and 'C', were located in the 'stunted', 'denuded' and 'control' zones, respectively (Boston Edison Company 1980). Plates 1-6 depict typical scenes viewed by divers during operations.

Eight finfish species were noted during observational dives (Table 27). Surface and bottom water temperatures ranged from 11.0-28.0 C and 9.0-27.8 C, respectively (Table 28). As in past years, water temperatures were generally highest from late August to mid-September.

Finfish composition varied spatiotemporally. Approximately 2,100 finfish were observed which is similar to last year's total of 2,230 fish. Of the fish recorded, 43% were encountered in the 'denuded zone', 22% in the 'stunted zone' and 35% in the 'control zone'. Distribution of fish was identical to past years when more were observed in the 'denuded zone' than the other zones. Numbers of fish observed at the offshore 'denuded' station (D_1) were approximately 16% lower than the nearshore station (D_2). Contrasting with results obtained last year, the numbers of fish occurring at the offshore stations ($S_1$and C_1) were 24 and 26% higher than at respective nearshore stations (S_2 and C_2).

This year's findings agree, in general, with those of the past; finfish appear to concentrate directly in the path of the thermal effluent. Pollock was

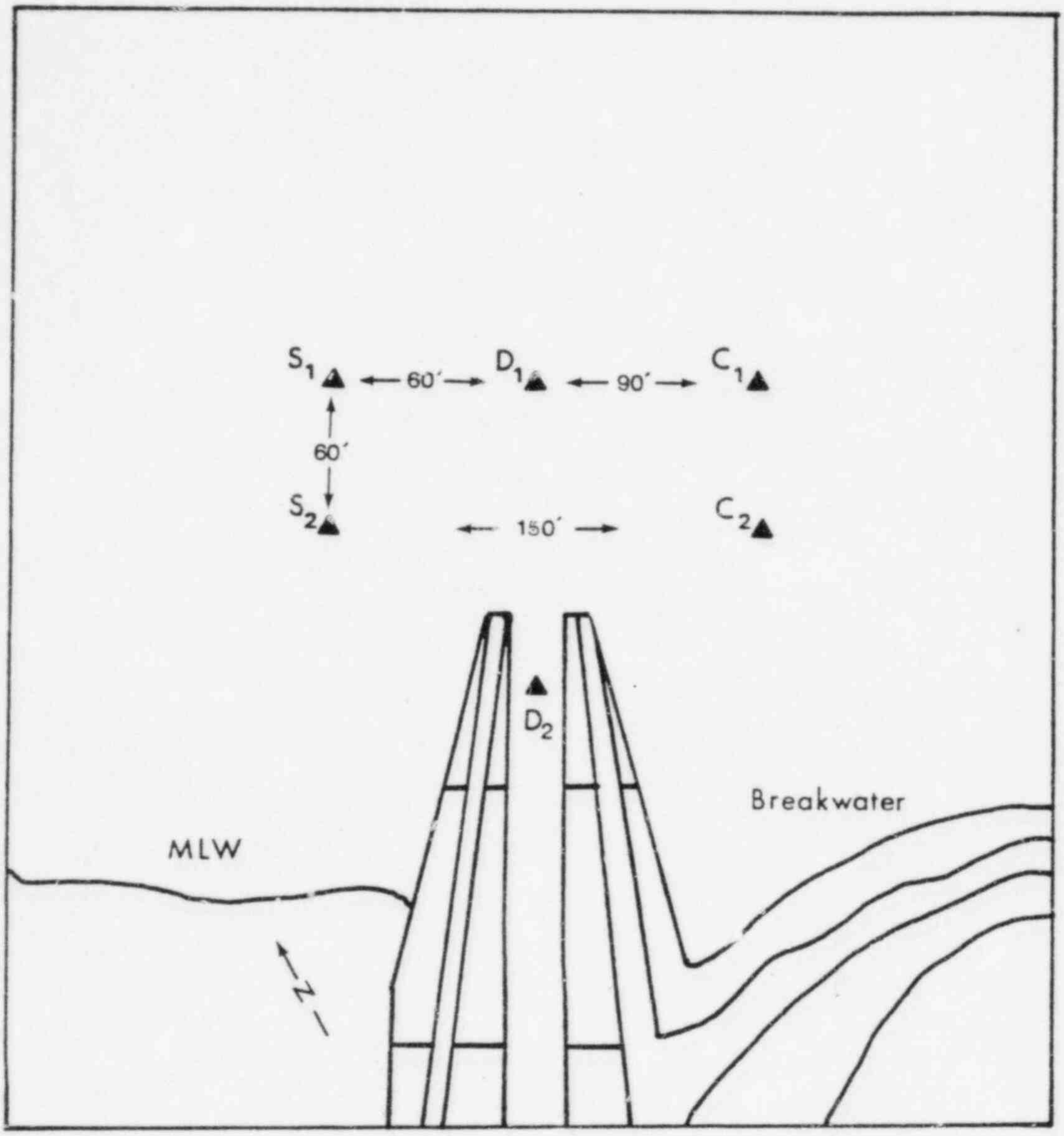


Figure 13 . Finfish observational diving stations at PNPS discharge, 1982.

Plate 1. Divers making observations at a 'control' station, located outside the influence of the thermal discharge. (Photo by P. Brady)

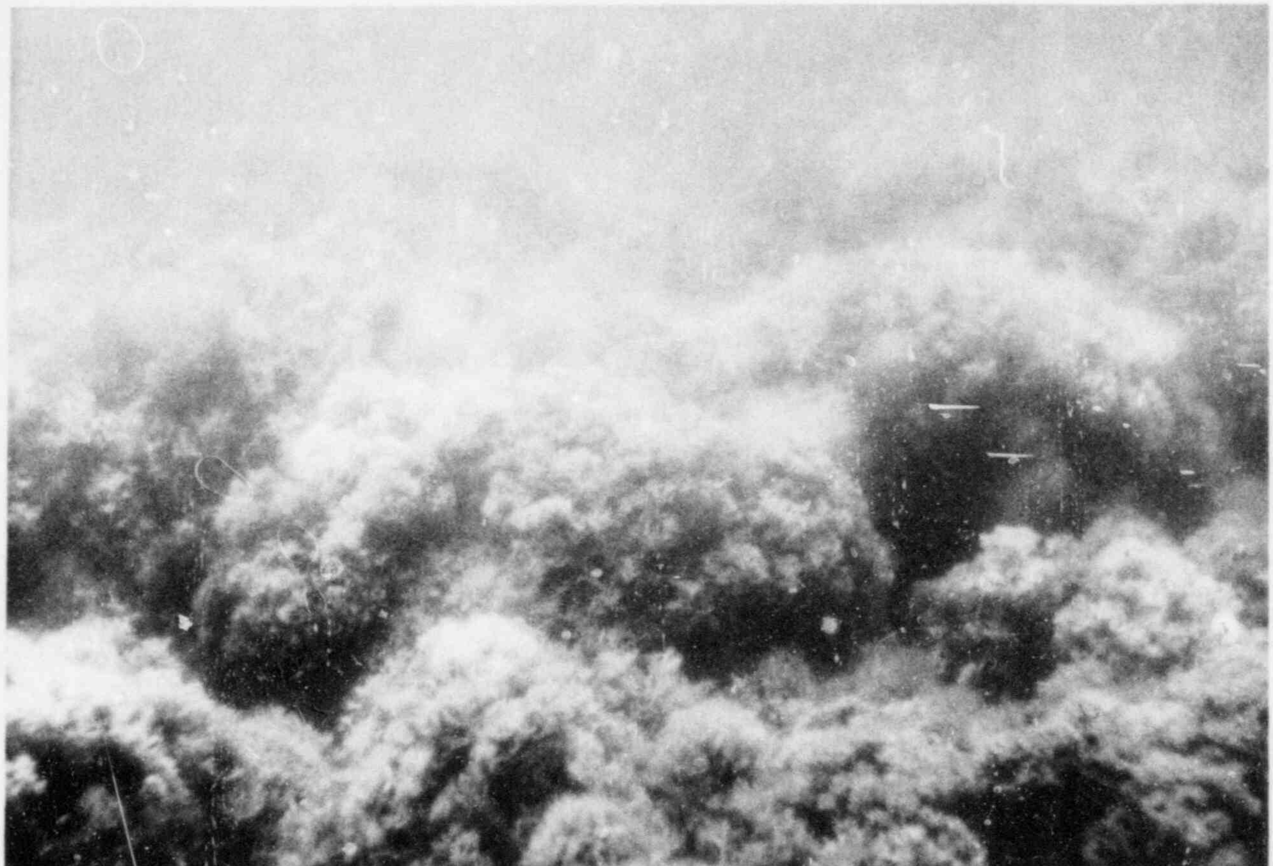


Plate 2. A 'carpet' of Irish moss, with accompanying epiphytes, extends over the rocky bottom at a 'control' site. (Photo by P. Brady)

Plate 3. A longhorn sculpin (Myoxocephalus octodecemspinosus) watches while divers complete observations at a station in the 'stunted' zone. (Photo by P. Brady)

Plate 4. Starfish (Asterias spp.) observed during many dives, graze on new mussel sets in the 'stunted' zone. (Photo by P. Brady)

Plate 5. A horseshoe crab (Limulus polyphemus) and several cunner (<u>Tautogolabrus adspersus</u>) are sighted at Station D_2 (discharge). (Photo by P. Brady)

Plate 6. Cunner often occur in large numbers in the 'denuded' zone, and are pictured actively feeding on suspended particles emanating from the discharge canal. (Photo by P. Brady)

Table 27. Percent occurrence of finfish species at each observational station from 6 May 26 November, 1982.

Species	Stations - Percent Occurrence					
	S_1	S_2	D_1	D_2	C_1	C_2
Tautogolabrus adspersus (cunner)	14.1	10.3	19.7	27.8	12.9	15.2
Pollachius virens (pollock)	20.0	5.6	4.7	9.1	51.2	9.3
Tautoga onitis (tautog)	9.6	0.7	22.2	63.7	2.2	1.5
Morone saxatilus (striped bass)	-	-	-	30.8	-	69.2
Gadus morhua (Atlantic cod)	-	-	83.3	-	16.7	-
Psuedopleuronectes americanus (winter flounder)	25.0	-	-	25.0	25.0	25.0
Myoxocephalus octodecemspinosus (longhorn sculpin)	-	50.0	-	-	50.0	-
Menidia spp. (silversides)	-	-	54.5	-	45.5	-

Table 28. Surface and bottom water temperatures (C) at each observational station, 6 May-26 November, 1982.

Date	Surface water temperatures						Bottom water temperatures					
	S_1	S_2	D_1	D_2	C_1	C_2	S_1	S_2	D_1	D_2	C_1	C_2
5/6	18.0	17.5	18.0	21.0	18.0	16.0	11.0	11.0	10.0	11.0	11.0	12.0
6/21	-	-	22.2	22.2	-	-	14.4	14.4	14.4	16.7	14.4	14.4
6/30	21.0	16.0	22.0	22.0	22.0	22.0	14.0	12.0	16.0	16.0	16.0	16.0
7/8	19.0	19.0	21.0	20.0	19.0	21.0	12.5	11.0	15.0	15.0	14.0	16.0
7/19	19.0	23.5	23.0	26.0	21.0	23.0	10.0	12.0	13.0	14.0	13.0	14.0
8/2	25.0	27.0	28.0	27.0	28.0	23.0	17.0	16.0	16.5	17.0	17.0	17.0
8/19	22.0	22.0	21.0	23.0	18.0	18.0	17.5	17.0	17.0	18.0	17.0	17.0
8/23	21.0	25.0	25.0	27.0	21.0	20.0	16.0	16.0	16.0	24.0	16.0	16.0
8/30	21.0	24.0	24.0	26.0	21.0	20.0	16.0	17.0	17.0	20.0	15.0	17.0
9/9	19.0	18.0	20.0	24.0	21.0	21.0	16.7	16.7	25.5	27.8	15.6	15.6
9/20	17.0	23.0	18.0	20.0	18.0	17.0	16.0	17.0	17.0	22.0	20.0	20.0
10/4	16.0	18.0	-	-	-	-	16.7	15.6	16.7	22.2	16.7	16.7
10/14	11.0	13.0	11.0	12.0	11.0	12.0	9.0	12.0	10.0	12.0	11.0	11.0
11/26	19.0	20.0	22.0	25.0	22.0	21.0	15.0	15.0	20.0	22.0	18.0	18.0

Table 29. Approximate number of finfish that occurred at each observational station from 6 May to 26 November, 1982.

Sta.	6 May	21 June	30 June	8 July	19 July	2 Aug	19 Aug	23 Aug	30 Aug	9 Sept	20 Sept	4 Oct	26 Nov	Approximate total for all dates combined
							Cunner							
S_1	***	8	27	31	12	9	43	15	12**	15	29	1	0	202
S_2	***	2	13**	2	14	21	53	19	13**	9	1	0	1	148
D_1	***	25	25	32	10	31	40	19	45**	0	13	43	0	283
D_2	***	35	125	93	29	25	27	24	15**	3	23	1	0	400
C_1	***	6**	22	14	16	19	30+**	17	15**	27+	9	9	1	185+
C_2	***	5**	10	15	11	22	48	28	10**	10	47	13	0	219
							Pollock							
S_1	***	0	0	1	58	6	0	0	0**	0	30+	0	0	87+
S_2	***	0	3**	1	7	0	0	0	0**	0	10+	0	3	24+
D_1	***	0	0	0	20	0	0	0	0**	0	0	0	0	20
D_2	***	0	0	0	25	0	0	0	0**	0	11+	0	3	39+
C_1	***	4**	4	0	48	1	8	25+	4**	0	125+	1	0	220+
C_2	***	8**	5	0	0	1	1	8	11**	0	1	3	2	40
							Tautog							
S_1	***	0	0	0	0	0	1	12	0**	0	0	0	0	13
S_2	***	0	0**	0	0	0	0	1	0**	0	0	0	0	1
D_1	***	1	3	0	0	1	0	0	10**	15	0	0	0	30
D_2	***	6	9	7	0	25	2	10	13**	1	3	10	0	86
C_1	***	0**	1	0	0	0	0	0	2**	0	0	0	0	3
C_2	***	2**	0	0	0	0	0	0	0**	0	0	0	0	2

Sta.	6 May	21 June	30 June	8 July	19 July	2 Aug	19 Aug	23 Aug	30 Aug	9 Sept	20 Sept	4 Oct	26 Nov	Approximate total for all dates combined
							Striped bass							
S_1	***	0	0	0	0	0	0	0	0**	0	0	0	0	0
S_2	***	0	0**	0	0	0	0	0	0**	0	0	0	0	0
D_1	***	0	0	0	0	0	0	0	0**	0	0	0	0	0
D_2	***	3	0	0	0	0	0	0	0**	0	0	1	0	4
C_1	***	0**	0	0	0	0	0	0	0**	0	0	0	0	0
C_2	***	0**	0	0	0	0	0	0	0**	0	0	0		9
							Atlantic cod							
S_1	***	0	0	0	0	0	0	0	0**	0	0	0	0	0
S_2	***	0	0**	0	0	0	0	0	0**	0	0	0	0	0
D_1	***	0	5	0	0	0	0	0	0**	0	0	0	0	5
D_2	***	0	0	0	0	0	0	0	0**	0	0	0	0	0
C_1	***	0**	1	0	0	0	0	0	0**	0	0	0	0	1
C_2	***	0**	0	0	0	0	0	0	0**	0	0	0	0	0

Sta.	6 May	21 June	30 June	8 July	19 July	2 Aug	19 Aug	23 Aug	30 Aug	9 Sept	20 Sept	4 Oct	26 Nov	Approximate total for all dates combined
							Winter flounder							
S_1	***	0	0	0	0	1	0	0	0**	0	0	0	0	1
S_2	***	0	0**	0	0	0	0	0	0**	0	0	0	0	0
D_1	***	0	0	0	0	0	0	0	0**	0	0	0	0	0
D_2	***	0	0	1	0	0	0	0	0**	0	0	0	0	1
C_1	***	0**	0	1	0	0	0	0	0**	0	0	0	0	1
C_2	***	0**	0	0	0	0	0	0	0**	0	1	0	0	1
							Longhorn sculpin							
S_1	***	0	0	0	0	0	0	0	0**	0	0	0	0	0
S_2	***	0	0**	0	0	0	0	0	1**	0	0	0	0	1
D_1	***	0	0	0	0	0	0	0	0**	0	0	0	0	0
D_2	***	0**	0	0	0	0	0	0	0**	0	0	0	0	0
C_1	***	0**	0	0	0	0	0	0	0**	0	0	1	0	1
C_2	***	0**	0	0	0	0	0	0	0**	0	0	0	0	0
							Silverside spp.							
S_1	***	0	0	0	0	0	0	0	0**	0	0	0	0	0
S_2	***	0	0**	0	0	0	0	0	0**	0	0	0	0	0
D_1	***	0	0	0	0	0	0	0	0**	0	60+	0	0	60+
D_2	***	0	0	0	0	0	0	0	0**	0	0	0	0	0
C_1	***	0**	0	0	0	0	0	0	0**	0	50+	0	0	50+
C_2	***	0**	0	0	0	0	0	0	0**	0	0	0	0	0

* No observation at this station on this date.
** Single diver observation.
*** No fish seen by either diver.

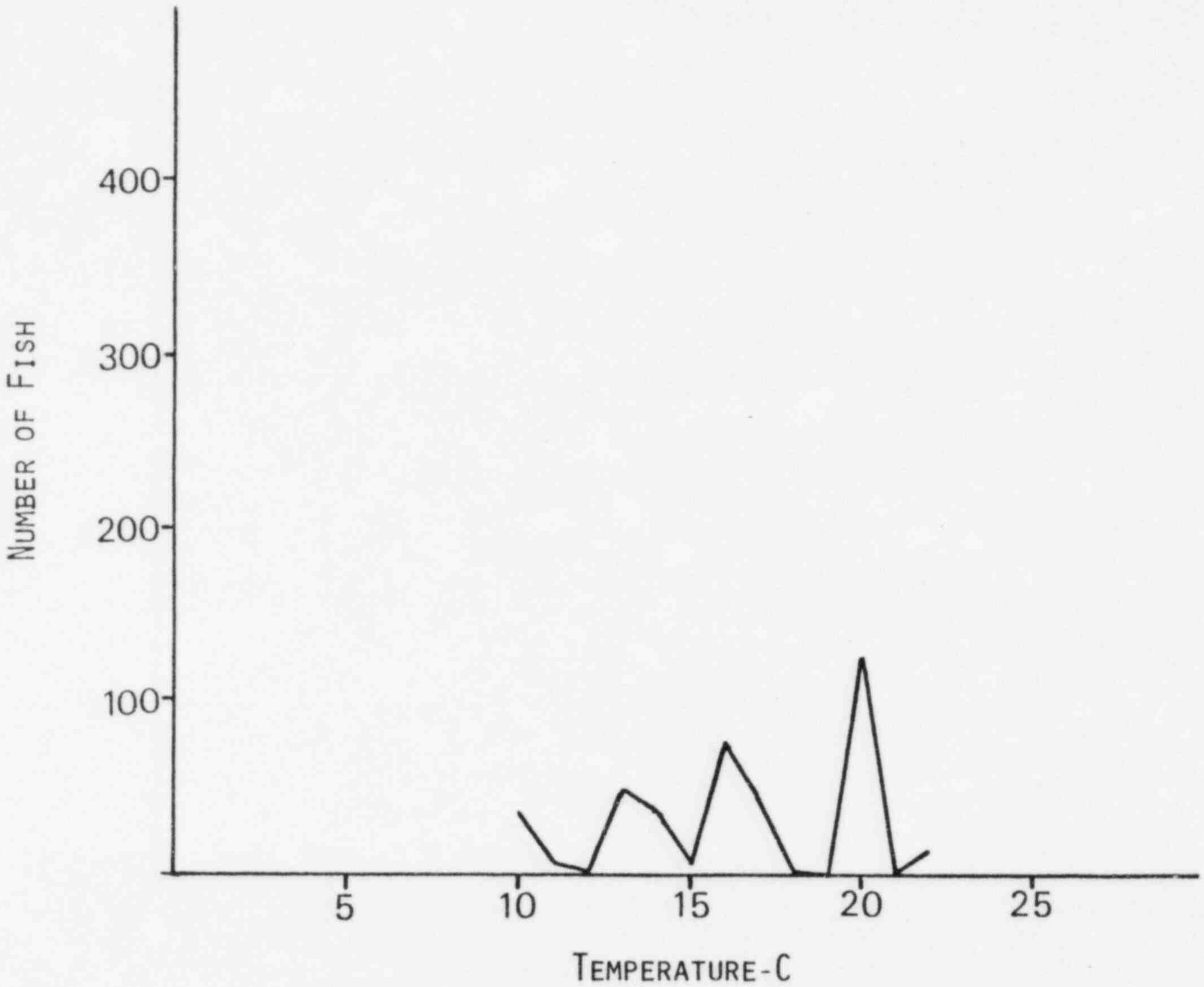


Figure 14 . Number of pollock at bottom water temperatures during underwater observations, 1982.

Table 30. Abundance, size ranges and temperatures associated with the occurrence of all species observed during underwater finfish observations, 1982.

Species	Station where most abundant	Total number observed	Size range (cm)	Bottom temperature range (C)
Cunner	D_2	2,096	∿ 3-25	10.0-27.8
Pollock	C_1	395	∿ 8-38	10.0-22.0
Tautog	D_2	135	∿15-51	14.4-24.0
Silverside spp.	D_1	110	∿10	14.0-20.0
Striped bass	D_2	8	∿20	16.7-22.2
Atlantic cod	D_1	6	∿15	14.4
Winter flounder	-	3	∿10-30	14.0-20.0
Longhorn sculpin	-	2	∿25-36	16.7-17.0

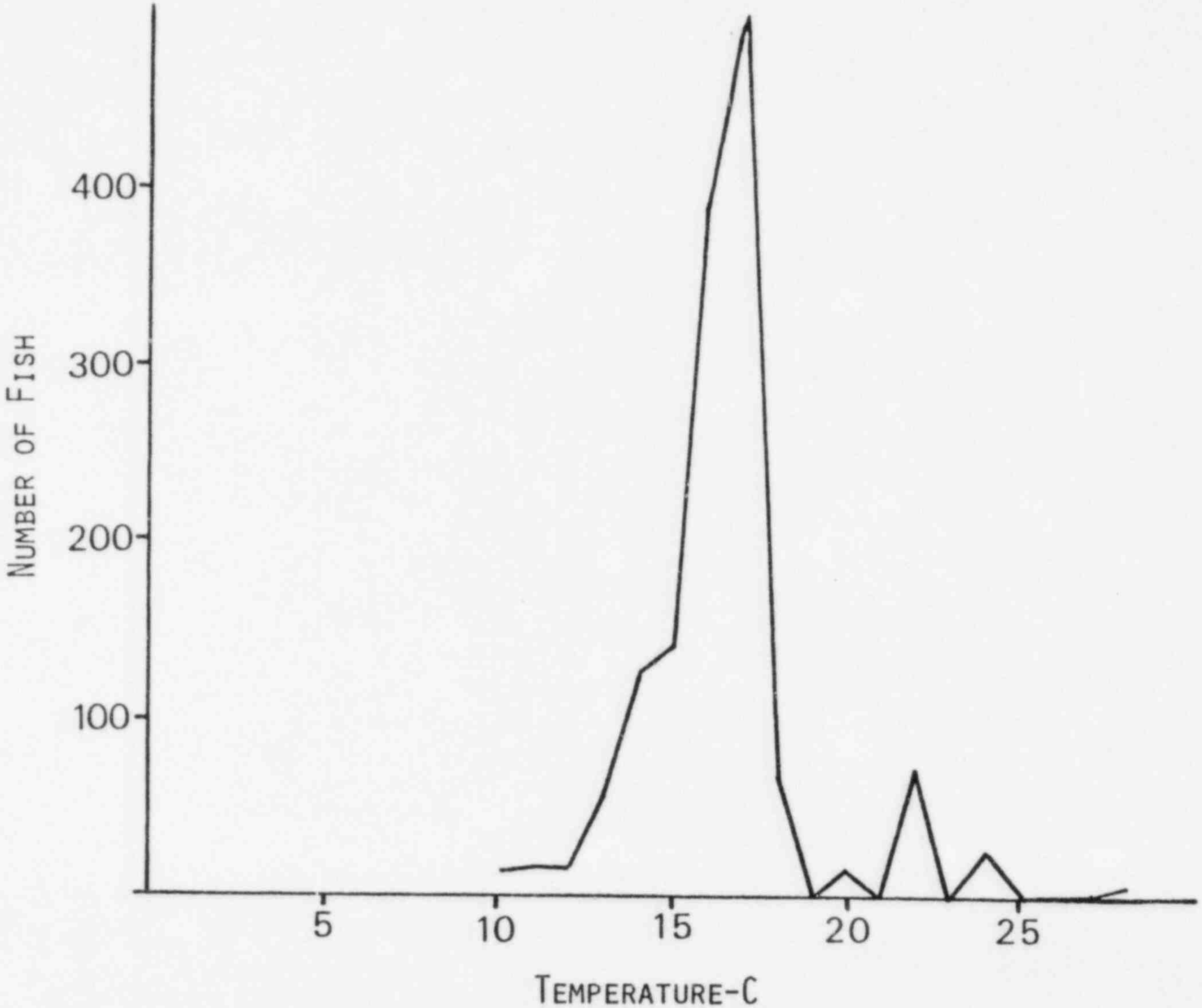


Figure 15. Number of cunner observed at bottom water temperatures during underwater observations, 1982.

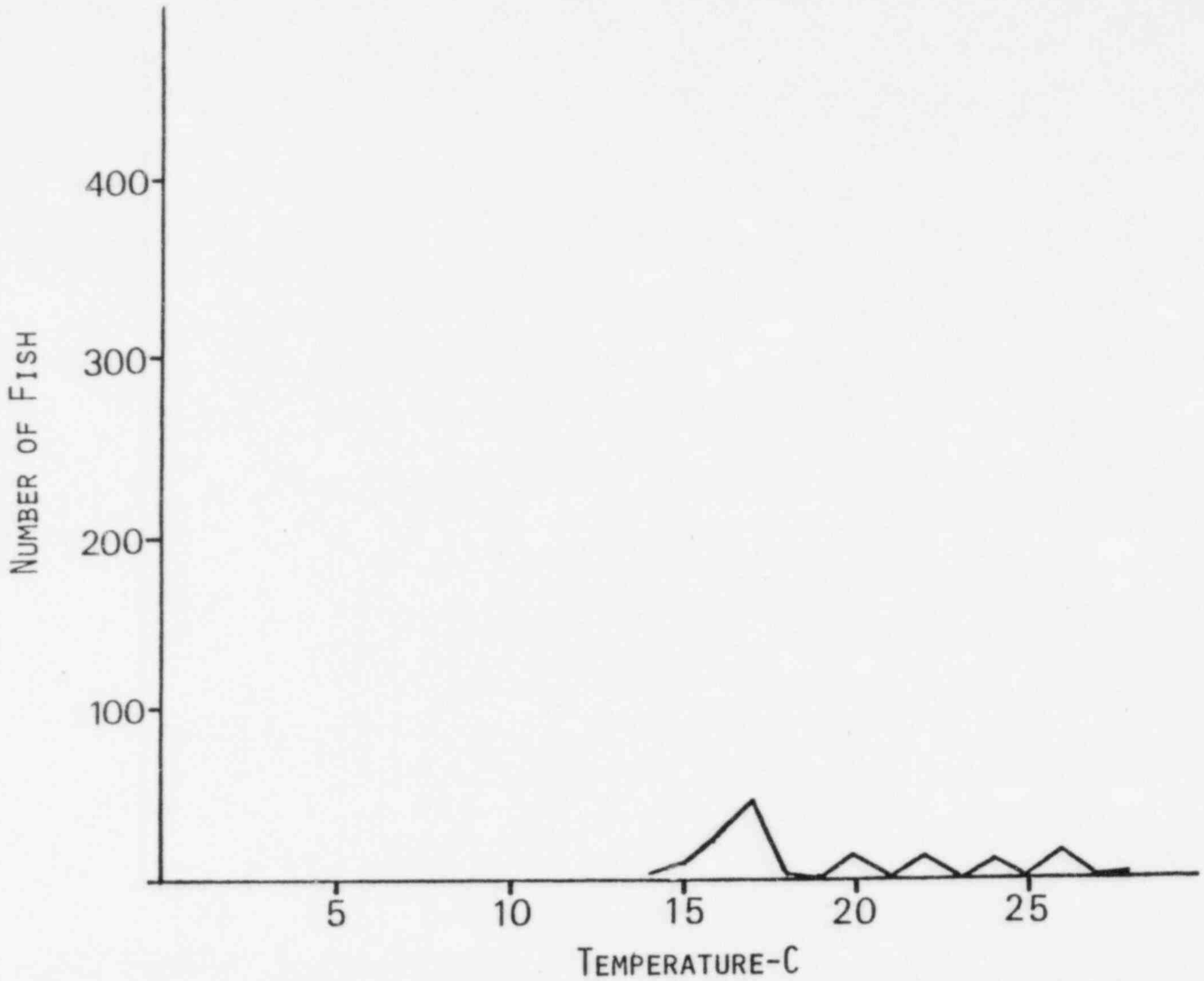


Figure 16. Number of tautog at bottom water temperatures during underwater observations, 1982.

an exception in 1982. Contrary to past data, pollock were more abundant in the 'control and stunted' zones (Table 29). Only 10% were sighted in the 'denuded' zone; 66% and 24% were in the 'control and stunted' zones, respectively. Pollock demonstrated no particular temperature preference within the temperature regime experienced (Fig. 14). They occurred at temperatures ranging from 10-22 C and ranked second in overall abundance (Table 30).

Cunner were numerically dominant in the study area. Most were observed at temperatures of 16-17 C (Fig. 15). Abundance was greatest at Station D_2, where 48% were observed. Tautog were also most abundant at 16-17 C (Fig. 16); sixty-four percent were encountered at station D_2.

The remaining species occurred as incidental sightings. Striped bass appeared in spring and fall during their north/south migrations. For the first time in the study, young-of-the-year Atlantic cod were sighted. All finfish sighted by divers in 1982 appeared to be in good condition, and were active; frequently, feeding fish were observed. There was no evidence of adverse temperature or gas bubble disease effects.

An unusual phenomenon was noted during June and July. Large quantities of a presumed fungal or bacterial growth were present on the bottom in the observational area. Appearing as white 'streaks', this material was oriented perpendicular to the discharge water current. Dead mussels were observed beneath the substance. When attempts were made to procure a sample for identification, the material disintegrated. On a later dive, only minute quantities could be found. At first, we believed this event to be singular to the discharge area. However, this material was observed in the intake channel several weeks later by divers collecting special sediment cores for radiological analysis. If this recurs in 1983, we will again attempt to obtain an intact sample for identification.

SUMMARY

An additional 3,374 lobster pots, containing 7,794 lobsters of which 28% were of legal size, were sampled in 1982. Overall catch rate (legal and sublegal) was 2.3. Ovigerous females comprised 1.8% of the total catch and 2.9% of all captured females. Mean catch rate for legal lobsters was the second highest obtained since study commencement and was similar to the three year pre-operational mean.

During 1982, commercial rakers expended 1,037 hrs of effort, harvesting 201,131 lbs (wet weight) of Irish moss from the study area at a mean rate of 194.0 lbs/hr. Though total effort and landings were the second and third lowest recorded during the entire study, seasonal harvest rate (pooled data) ranked fourth. During the preoperational and operational years there has been a fairly consistent ratio of harvest rate between Zone 5 (surveillance) and Zone 1 (reference). The 12-year mean harvest rate in the surveillance zone exceeded the study's seasonal mean rate (total pounds, wet weight/total effort, hrs) for the same period by 7.6 lbs/hr. Landings in the surveillance zone increased 23.6% from last season.

Fifty-seven bottom trawl tows, utilizing a half-Yankee net, collected 2,785 fish comprising 26 species. Fish abundance (pooled species) was highest at Station 1 in Warren Cove, where 32% of the total trawl catch was obtained. Winter flounder were numerically dominant, comprising 47.8% of the annual catch. Decreases in catch-per-unit-effort were noted for winter flounder, skate spp., windowpane, and yellowtail flounder, while small increases were recorded for longhorn sculpin and ocean pout. Catch per tow of lobsters was again high this year, which further substantiates that there has been a recent increase in abundance of lobsters on sand substrate.

Small vessel trawling utilizing a half-Wilcox net, collected an estimated 2,421 fish in 79 tows at stations bracketing the power plant. Of the 26 species caught, 5 were prevalent. Winter flounder were numerically dominant, with catch and catch per tow being highest at Station 1 in Warren Cove. At Station 3 (discharge area), yellowtail flounder were captured in greatest numbers as in 1981. Catch/tow for all species combined was highest at Station 2 (9 m depth contour) and lowest at Station 1, ranging from 29.0 to 35.2.

Fishing power trials were conducted this year prior to discontinuing long-term otter trawl sampling. Of the 37 daytime paired tows attempted during September and October at two separate locations in Cape Cod Bay, 26 were suitable for comparison. With the larger half-Yankee trawl, we captured 27 fish species and with the smaller half-Wilcox trawl, 20. Number of fish taken in the former was nearly three times greater than by the latter. Two species were sampled only by the half-Wilcox net, while seven were captured exclusively in the half-Yankee trawl. Inter-vessel/gear comparison factors were variable, eg., 0.5 to 5.5 for windowpane and 5.1-29.0 for scup. It appears that when the distribution of fish is contagious, a small number of tows is of limited value in deriving accurate and meaningful inter-vessel/gear comparisons.

Twenty-one gill net sets made at two sites this year sampled 3,122 fish. There were 29 species recorded from Station 1 and 31 from Station 2. Mean catch per set for all species combined (five panels) was 150.5 at Station 1, or a 33% decline from 1981, and 127.5 at Station 2, representing a 8.1% decrease from last year. Pollock was again the dominant species captured. Two new species to our fisheries studies, collected this year were a 5.5 m (18 ft) basking shark (Cetorhinus maximus), and a 82.8 cm Atlantic sturgeon (Acipenser oxyrhynchus). Percent similarity, comparing catches from the smaller five mesh

panels for Station 1 and 2, was 68.8% and 62.8% for 1981 and 1982, respectively. Similarity of catch was 33.2% and 25.2% for the two larger-mesh panels for the same years.

Seine collections in the nearshore zone produced 22 species of finfish and 8 species of invertebrates. Atlantic silverside was again the dominant species comprising 65.3% of the total catch. An unusual occurrence was the capture of a large haddock (54.0 cm) from Warren Cove in early December. Larger numbers of the northern puffer, an uncommon species north of Cape Cod, were seined in summer; their abundance was highest in the Pilgrim Station intake embayment.

Biologist-divers, utilizing SCUBA, made underwater finfish observations at six stations from 6 May-26 November. Eight finfish species were noted. Of the approximate 2,100 fish observed, 43% were encountered in the immediate path of the thermal discharge, referred to as the 'denuded zone'; 22% in the designated 'stunted zone'; and 35% in the 'control zone'. Cunner were numerically dominant; pollock ranked second. Atlantic cod were sighted for the first time in the dive study. Of the fish observed, no overt symptoms of gas bubble disease, abnormal physical appearance, or aberrant behavior were apparent.

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Appendix A.

Summary of Lobster Pot Catch
Data

January - December, 1982.

# of Sampling days	# of Pots	Total catch	Male	Female	Legals	Sub-legals	Eggers	Legals /pot	Catch /pot	Ratio Legals	:	Sub-legals	:	Eggers
1	4	9	4	5	2	F-10 7	0	0.5	2.3	1.0	:	3.5	:	0.0
1	10	9	6	3	2	F-11 7	0	0.2	0.9	1.0	:	3.5	:	0.0
1	14	58	30	28	3	F-12 55	0	0.2	4.1	1.0	:	18.3	:	0.0
2	15	9	2	7	2	F-13 7	0	0.1	0.6	1.0	:	3.5	:	0.0
4	41	77	30	47	17	F-14 59	1	0.4	1.9	1.0	:	3.5	:	0.1
3	29	61	33	28	14	F-15 46	1	0.5	2.1	1.0	:	3.3	:	0.1
5	31	81	25	56	15	G-10 66	0	0.5	2.6	1.0	:	4.4	:	0.0
6	72	293	116	177	58	G-11 235	0	0.8	4.1	1.0	:	4.0	:	0.0
4	27	114	45	69	20	G-12 94	0	0.7	4.2	1.0	:	4.7	:	0.0
4	20	44	26	18	11	G-13 33	0	0.6	2.2	1.0	:	3.0	:	0.0
5	50	145	63	82	24	G-14 119	2	0.5	2.9	1.0	:	5.0	:	0.0
2	13	29	14	15	4	G-15 25	0	0.3	2.2	1.0	:	6.2	:	0.0

# of Sampling days	# of Pots	Total catch	Male	Female	Legals	Sub-legals	Eggers	Legals /pot	Catch /pot	Ratio Legals	:	Sub-legals	:	Eggers
5	47	142	50	92	20	H-10 121	1	0.4	3.0	1.0	:	6.0	:	0.0
4	54	119	49	70	20	H-11 97	2	0.4	2.2	1.0	:	4.8	:	0.1
3	35	74	37	37	24	H-12 48	2	0.7	2.1	1.0	:	2.0	:	0.1
2	16	31	10	21	11	I-9 19	1	0.7	1.9	1.0	:	1.7	:	0.1
1	9	29	11	18	6	I-10 23	0	0.7	3.2	1.0	:	3.8	:	0.0
3	21	30	19	11	6	I-11 24	0	0.3	1.4	1.0	:	4.0	:	0.0
2	10	8	3	5	2	I-12 6	0	0.2	0.8	1.0	:	3.0	:	0.0
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
1	8	4	3	1	4	J-7 0	0	0.5	0.5	1.0	:	0.0	:	0.0
1	9	1	1	0	1	J-8 0	0	0.1	0.1	1.0	:	0.0	:	0.0
4	33	103	31	72	28	J-9 70	5	0.8	3.1	1.0	:	2.5	:	0.2

# of Sampling days	# of pots	Total catch	Male	Female	Legals	Sub-legals	Eggers	Legals /pot	Catch /pot	Ratio Legals	:	Sub-legals	:	Eggers
2	10	20	9	11	4	J-10 15	1	0.4	2.0	1.0	:	3.8	:	0.2
1	20	39	16	23	10	J-11 29	0	0.5	2.0	1.0	:	2.9	:	0.0
1	3	7	3	4	3	J-12 4	0	1.0	2.3	1.0	:	1.3	:	0.0
1	96	219	82	137	135	K-2 84	0	1.4	2.3	1.0	:	0.6	:	0.0
1	32	26	5	21	5	K-3 19	2	0.2	0.8	1.0	:	3.8	:	0.4
3	34	43	18	25	17	K-8 26	0	0.5	1.3	1.0	:	1.5	:	0.0
6	196	304	104	200	111	K-9 184	9	0.6	1.6	1.0	:	1.7	:	0.1
6	141	212	88	124	85	K-10 127	0	0.6	1.5	1.0	:	1.5	:	0.0
4	29	39	18	21	13	K-11 26	0	0.4	1.3	1.0	:	2.0	:	0.0
2	16	12	4	8	10	L-8 2	0	0.6	0.8	1.0	:	0.2	:	0.0
4	81	123	47	76	47	L-9 74	2	0.6	1.5	1.0	:	1.6	:	0.0
3	38	59	19	40	20	L-10 38	1	0.5	1.6	1.0	:	1.9	:	0.1

# of Sampling days	# of pots	Total catch	Male	Female	Legals	Sub-legals	Eggers	Legals /pot	Catch /pot	Ratio Legals	:	Sub-legals	:	Eggers
						L-11								
1	7	17	8	9	9	8	0	1.3	2.4	1.0	:	0.9	:	0.0
						M-5								
1	16	58	21	37	32	26	0	2.0	3.6	1.0	:	0.8	:	0.0
						M-6								
2	42	168	61	107	54	111	3	1.3	4.0	1.0	:	2.1	:	0.1
						M-8								
1	8	17	5	12	3	14	0	0.4	2.1	1.0	:	4.7	:	0.0
						M-10								
2	30	72	25	47	25	45	2	0.8	2.4	1.0	:	1.8	:	0.1
						N-5								
2	48	213	65	148	62	143	8	1.3	4.4	1.0	:	2.3	:	0.1
						N-6								
2	47	122	40	82	46	73	3	1.0	2.6	1.0	:	1.6	:	0.1
						N-7								
1	24	35	13	22	23	11	1	1.0	1.5	1.0	:	0.5	:	0.0
						N-8								
3	32	75	26	49	31	43	1	1.0	2.3	1.0	:	1.4	:	0.0
						N-9								
2	32	59	23	36	21	38	0	0.7	1.8	1.0	:	1.8	:	0.0
						N-10								
4	93	160	49	111	63	92	5	0.7	1.7	1.0	:	1.5	:	0.1
						N-11								
1	2	5	3	2	0	5	0	0.0	2.5	0.0	:	0.0	:	0.0

# of Sampling days	# of pots	Total catch	Male	Female	Legals	Sub-legals	Eggers	Legals /pot	Catch /pot	Ratio Legals	:	Sub-legals	:	Eggers
1	2	2	0	2	1	N-12 1	0	0.5	1.0	1.0	:	1.0	:	0.0
1	16	53	18	35	23	O-5 30	0	1.4	3.3	1.0	:	1.3	:	0.0
2	56	171	48	123	46	O-6 115	10	0.8	3.1	1.0	:	2.5	:	0.2
3	89	176	58	118	42	O-8 125	9	0.5	2.0	1.0	:	3.0	:	0.2
2	96	133	32	101	48	O-9 79	6	0.5	1.4	1.0	:	1.6	:	0.1
4	77	119	44	75	44	O-10 74	1	0.6	1.5	1.0	:	1.7	:	0.0
2	28	19	7	12	4	O-11 14	1	0.1	0.7	1.0	:	3.5	:	0.3
3	14	13	4	9	3	O-12 9	1	0.2	0.9	1.0	:	3.0	:	0.3
1	9	12	4	8	7	O-13 5	0	0.8	1.3	1.0	:	0.7	:	0.0
2	12	37	13	24	14	P-8 23	0	1.2	3.1	1.0	:	1.6	:	0.0
1	8	30	8	22	9	P-9 21	0	1.1	3.8	1.0	:	2.3	:	0.0
1	6	12	3	9	1	P-10 11	0	0.2	2.0	1.0	:	11.0	:	0.0

# of Sampling days	# of pots	Total catch	Male	Female	Legals	Sub-legals	Eggers	Legals /pot	Catch /pot	Ratio Legals	: Sub-legals	: Eggers
3	44	47	12	35	19	P-11 28	0	0.4	1.1	1.0	: 1.5	: 0.0
3	44	43	8	35	17	P-12 25	1	0.4	1.0	1.0	: 1.5	: 0.1
3	26	38	18	20	21	Q-10 17	0	0.8	1.5	1.0	: 0.8	: 0.0
3	30	38	11	27	12	Q-12 24	2	0.4	1.3	1.0	: 2.0	: 0.2
2	7	1	0	1	1	Q-13 0	0	0.1	0.1	1.0	: 0.0	: 0.0
4	142	240	96	144	96	R-9 139	5	0.7	1.7	1.0	: 1.4	: 0.1
3	59	106	38	68	39	R-11 65	2	0.7	1.8	1.0	: 1.7	: 0.1
1	3	3	1	2	1	R-12 2	0	0.3	1.0	1.0	: 2.0	: 0.0
1	5	3	0	3	1	R-13 1	1	0.2	0.6	1.0	: 1.0	: 1.0
2	24	43	13	30	23	S-9 18	2	1.0	1.8	1.0	: 0.8	: 0.1
2	49	84	25	59	31	S-10 50	3	0.6	1.7	1.0	: 1.6	: 0.1
1	8	19	7	12	7	S-11 12	0	0.9	2.4	1.0	: 1.7	: 0.0

# of Sampling days	# of pots	Total catch	Male	Female	Legals	Sub-legals	Eggers	Legals /pot	Catch /pot	Ratio Legals	:	Sub-legals	:	Eggers
						Cole's Hole								
12	733	2394	923	1471	467	1893	34	0.6	3.3	1.0	:	4.1	:	0.1
						Fonces Ledge								
3	108	331	129	202	84	238	9	0.8	3.1	1.0	:	2.8	:	0.1

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BENTHIC ALGAL AND FAUNAL STUDIES AT THE PILGRIM NUCLEAR POWER STATION

August, 1982 - March, 1983

James A. Blake
Richard A. McGrath
Judith A. Scanlon
John W. Williams

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EXECUTIVE SUMMARY

This report presents the results of benthic studies conducted from August, 1982 to March, 1983 in conjunction with operation of Pilgrim Nuclear Power Station (PNPS). Quantitative samples were collected on September 24, 1982 and transect mappings were conducted on September 24 and December 1, 1982. These investigations represent the most recent phase of an extensive long-term effort by Boston Edison to assess the impact of PNPS on the inshore benthic community of Cape Cod Bay.

The benthic monitoring program has been refined in scope during the past several years by the Pilgrim Administrative - Technical Committee in conjunction with Boston Edison Company and presently comprises the following components:

- semi-annual quantitative sampling at the Effluent, and at the Rocky Point and Manomet Point control sites, and
- quarterly mapping of the near-field acute impact zones via diver observation.

A variety of analytical techniques were employed to assess community structure. Specific data on algal biomass, dominant fauna and density of selected species were also investigated. Both spatial (with control sites) and temporal (with previous samplings) comparisons were used to examine the data for any evidence of PNPS effects.

Field collection and laboratory analysis techniques were in most cases identical with techniques used by former contractors. Comparability of methodology was insured by the continuation of some personnel who have had a long history with the program and by the use of previous investigators as consultants. Every effort was made to ensure that the long-term comparability of the data base would not be compromised due to a change in contractors. We have carefully noted any changes in techniques which were deemed advisable.

As in previous samplings, five replicate 33 cm^2 benthic samples were collected with SCUBA at three sites: Effluent, Manomet Point and Rocky Point. Samples were preserved in the field and returned to the laboratory where the faunal and algal fractions were separated and analyzed. Data analysis was conducted on the Woods Hole Oceanographic Institution computer using software which had previously been used to analyze PNPS data.

The diver-transect study was conducted with particular care so as to ensure comparability with previous work. Previous contractors participated in the initial survey and were consulted regularly on particular technical points. Methods were therefore identical with previous years, involving a fixed line stretched offshore along the discharge centerline and a moveable line pe-pendicular to this which was traversed by divers who noted the boundaries of the stunted and denuded algal zones.

There have been some minor changes in faunal taxonomy as a result of analysis of the September, 1982 samples. We are not presently sure which of the newly-identified species are in fact new to the area and which were perhaps overlooked by previous taxonomists. This will become clearer with subsequent samplings, examination of previous voucher specimens, and consultation with systematists. In any event, none of the major species are involved, and those taxonomic discrepancies are not of sufficient importance to change any of the previous conclusions.

The Effluent station had significantly fewer numbers of species in September, 1982. This has been the typical pattern for this parameter in recent years and appears to be related to reduced habitat stability due to the hydrodynamic rather than the thermal effects of the PNPS discharge.

Faunal densities, however, were higher at the Effluent than at the control sites, though not significantly so. Few mussels (Mytilus edulis) were found at the Effluent and the elevated densities were due primarily to the amphipods Jassa falcata and Corophium spp.

Patterns of dominant species during September were essentially similar at all three sites though some differences are notable. Chief among these is the depressed dominance of mussels, especially at Effluent where Mytilus was only the fourth most abundant species comprising 6.62% of the fauna. This species is typically an overwhelming dominant at all sites and particularly so at Effluent where conditions appear optimal for settlement. Mussels are known to vary greatly from year to year in reproductive success and this may account for the observed distribution pattern.

Shannon-Wiener diversities were markedly lower at Effluent than at the two control sites. Examination of the data indicated that this was due to the combined effects of lowered species richness and strong dominance of Jassa falcata. Both of these factors result in lowered Shannon-Wiener values. Depressed diversity values at Effluent are seen commonly in previous data.

Classification (cluster) analysis was used to identify broad patterns of similarity in the data. All stations were generally distinct from each other and the replicates from a station tended to cluster together. Rocky Point and Manomet Point were shown to be more similar to each other in faunal composition than either was to the Effluent. The distinct clustering of the Effluent Station is due to the unusual dominance of amphipods and the reduced importance of Mytilus, in the rank order of dominance. In addition, among the 15 dominant species at Effluent Station, 6 species are not dominant at Rocky Point and Manomet Point. The differences observed at the Effluent Station is unquestionably due to the integrated effects of the PNPS discharge at the sampling site.

No additional algal species were identified from the September, 1982 sampling and the algal systematics were identical with those used in previous years. Abundant species throughout the sampling area continued to be Chondrus crispus and Phyllophora spp., with Chondrus being more dense at most sites.

Gracilaria foliifera and Codium fragile tomentosoides, two warm-water algae, were again found in the discharge canal and immediately beyond the ends of the discharge jetties. These species do not normally occur in open coastal situations north of Cape Cod and their occurrence is partly due to the presence of heated effluent from PNPS.

Algal community overlap values were similar at all three sampling sites and indicated comparable habitat homogeneity.

Algal biomass was determined separately for six different algal categories. Although there was considerable variability, greatest biomass was found at the Effluent, and Rocky Point appeared to support considerably less biomass than the other two sites. None of the observed differences were found to be statistically significant, however. The previous pattern of decreased Chondrus biomass and decreased Chondrus/Phyllophora biomass ratio at Effluent, believed to be due to scour from the PNPS discharge, was not repeated in the September, 1982 data.

Comparison of the present algal biomass data with data collected in August, 1981 indicated significant differences for Chondrus epiphytes, Phyllophora spp. and total biomass, respectively. Of these, only Chondrus epiphytes showed a significant site x time interaction which would be indicative of differential effects at Effluent since the previous year. The importance of this observation is not presently known.

The Chondrus/Phyllophora condition index study indicated that Phyllophora was more heavily colonized, presumably due to its ability to tolerate epiphyte-induced

stress. Epiphytization and condition values were highest at Manomet Point and similar at Rocky Point and Effluent.

The extent and configuration of the near-field acute impact zones were measured twice during this reporting period, September and December, 1982. Results were generally comparable to previous surveys, indicating a denuded zone of approximately 1000 m^2 and a total impact area of 2200 m^2. The impacted area was again found to be more extensive to the northwest (left) of the discharge.

With data now available from eight mappings, we believe we may be seeing some indication of a seasonal pattern in the size of the impacted area (Figure 12). There is a tendency for the impacted area to increase in total area during the spring and summer months and to be more restricted during the colder months of the year. Additional data are required to evaluate this hypothesis.

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James A. Blake
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INTRODUCTION

This report presents the results of the most recent series of benthic monitoring surveys performed at the Pilgrim Nuclear Power Station (PNPS). The monitoring surveys are part of a long-term effort by Boston Edison Company to assess the impact of the thermal effluent from the 655 MW^e nuclear steam-electric generating station on the inshore benthic community. PNPS is located on the northwest shore of Cape Cod Bay, five miles southeast of Plymouth Harbor, Massachusetts. The quantitative algal and faunal data presented and analyzed in this report were derived from field collections conducted in September, 1982. Qualitative transect data were collected on September 24, and December 1, 1982.

The specifications for times of sampling and procedures follow guidelines established by the Pilgrim Administrative Technical Committee (PATC) and adopted by the Boston Edison Company. The program was modified in the summer of 1981 to include: 1) Semi-annual (August, March) benthic sampling (quarterly samples were taken from September, 1974 to June 11, 1981); 2) Three quantitative sampling sites (Manomet Point, Rocky Point and Effluent Station); 3) Five replicate samples ($0.33m^2$) from each of the 3 stations (three replicates were taken from September, 1974 through June, 1980; six replicates were taken from September, 1980 through June, 1981); and 4) Diver-conducted

transect surveys to be performed quarterly (August, December, March, June) from December, 1981 to assess localized effects of PNPS cooling water discharge on near-field benthic communities.

A variety of analytical techniques were employed in this program to assess community structure. In addition, specific data on algal biomass, dominant fauna and densities of selected species were also investigated. Where appropriate, biological interpretation of observed results are incorporated. All data were analyzed and compared with data from previous samplings and with control station results.

Field collections were supervised by Mr. John Williams. Sorting and identification of algal and faunal samples was supervised by the Project Manager, Dr. James A. Blake. Data analysis was supervised by Mr. Richard McGrath. Algal taxonomy and analysis were performed by Ms. Judy Scanlon, with the consultation of Mr. Walter Grocki. Other key personnel included: Ms. Maggie Dutch, Mr. Dale Davis, Mr. Mark Curran, Mr. Jim Cammarata, Ms. Sandra Weiss, Mr. Bill Johnson, Ms. Elizabeth Garlo, Mr. Phillip Nimerskern and Mr. Paul Banas.

METHODS

QUANTITATIVE ALGAL AND FAUNAL SAMPLING

The field procedures basically follow some techniques initiated by Battelle in 1972. Present procedures adhere closely to the most recent modifications initiated by Taxon, Inc. in subsequent years, especially since 1974.

Benthic Sampling Stations

Quantitative benthic samples were collected on September 24, 1982 at three stations: Manomet Point, Rocky Point and Effluent (Figure 1). The first two stations served as southern and northern controls respectively, while the Effluent Station represented the area of most immediate potential impact. All stations were located at a depth of 10 feet (MLW). The Effluent Station is located directly seaward of the center

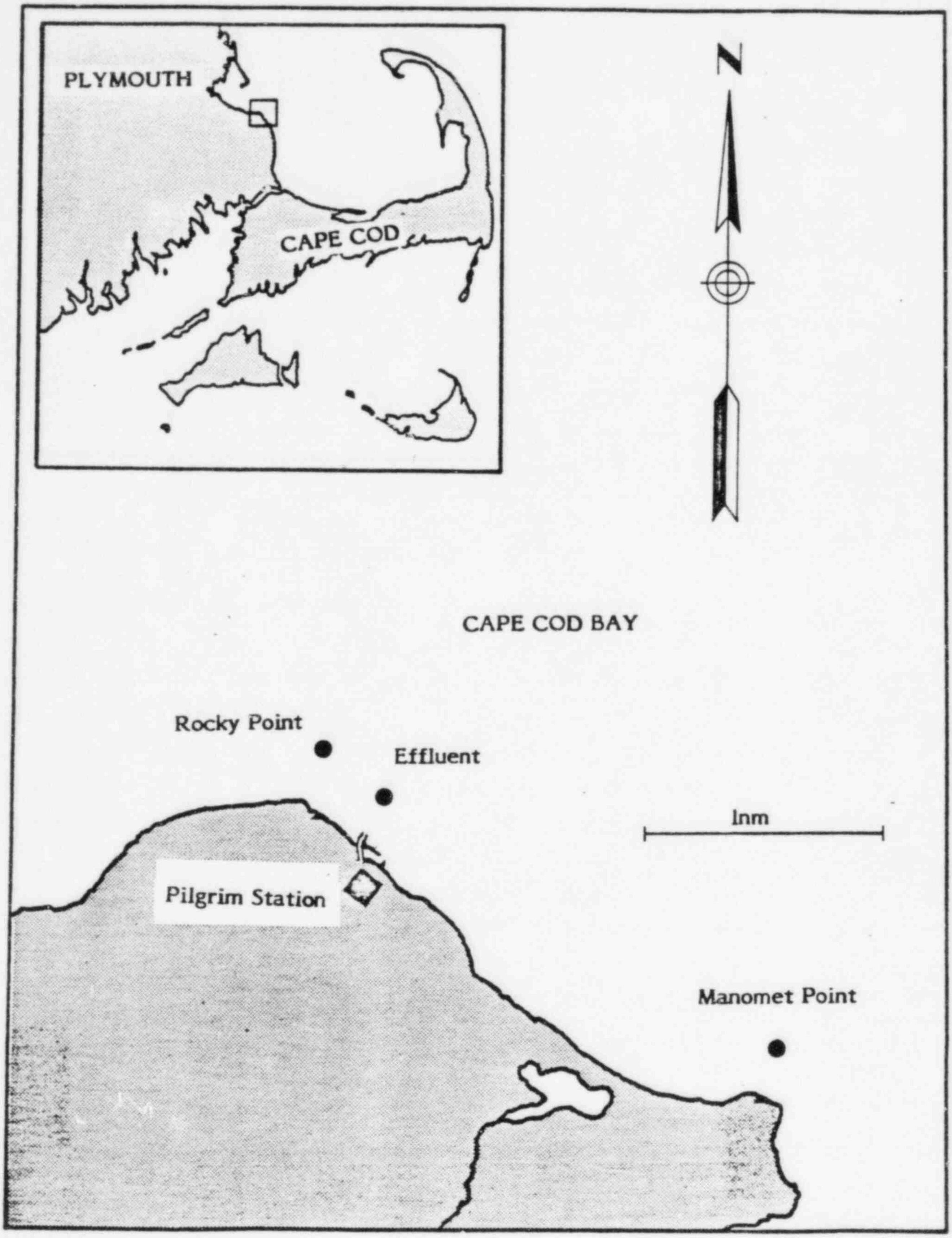

FIGURE 1. LOCATION OF THE ROCKY POINT, EFFLUENT, AND MANOMET POINT ROCK-SUBSTRATUM SUBTIDAL (10' MLW) STATIONS

line of the discharge canal. The Rocky Point control station is located approximately 0.25 nautical miles (nm) northeast of the Effluent site. The Manomet Point Station is located approximately 2 nautical miles (nm) southeast of the Effluent Station.

Precise station locations depend upon line-of-sight techniques, with highly visible structures located on the shore. These reference points are coordinated with fathometer readings to provide precise station location. The Rocky Point Station was located by lining up the microwave relay tower with the off-gas stack. The Effluent Station was identified as the center line between the two discharge jetties. The Manomet Point Station was located 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 20-50 m of the originally established station locations.

Collection Techniques

All sampling was performed by a team of SCUBA divers. Sampling equipment consisted of an airlift sampling device and a 0.33 cm^2 metal pipe-frame quadrate (Figure 2). The pipe-frame 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. The Battelle research vessel, R/V Mya was used as a base from which the divers operated. At Manomet Point, a small boat was required to assist the divers, due to large rocks in the area which forced the Mya to anchor slightly seaward of the station.

Upon arriving at the sampling location, divers descended to the bottom with the sampling equipment and randomly chose large, flat-surfaced rocks or boulders for sampling. Small rocks with less than half the surface area of the quadrate were eliminated from sampling consideration due to their increased susceptibility to movement or dislodgement during stormy weather. Such rocks were considered to have a less stable resident community. The quadrate was placed on the surface of a rock and the airlift device was positioned a few inches above the quadrate by one diver, while a second diver began scraping the quadrate with a sharp bladed tool (Red Devil Paint Scraper). The algae and resident fauna were carried by suction up the airlift into a bag (Nitex, 0.5 mm mesh) at the opposite end. When the quadrate had been scraped clean, the bag was removed and sealed. A new bag was then attached while one diver took the filled sample bag to the surface to a biologist waiting in the boat. In some cases, 2 or 3 bags would be collected

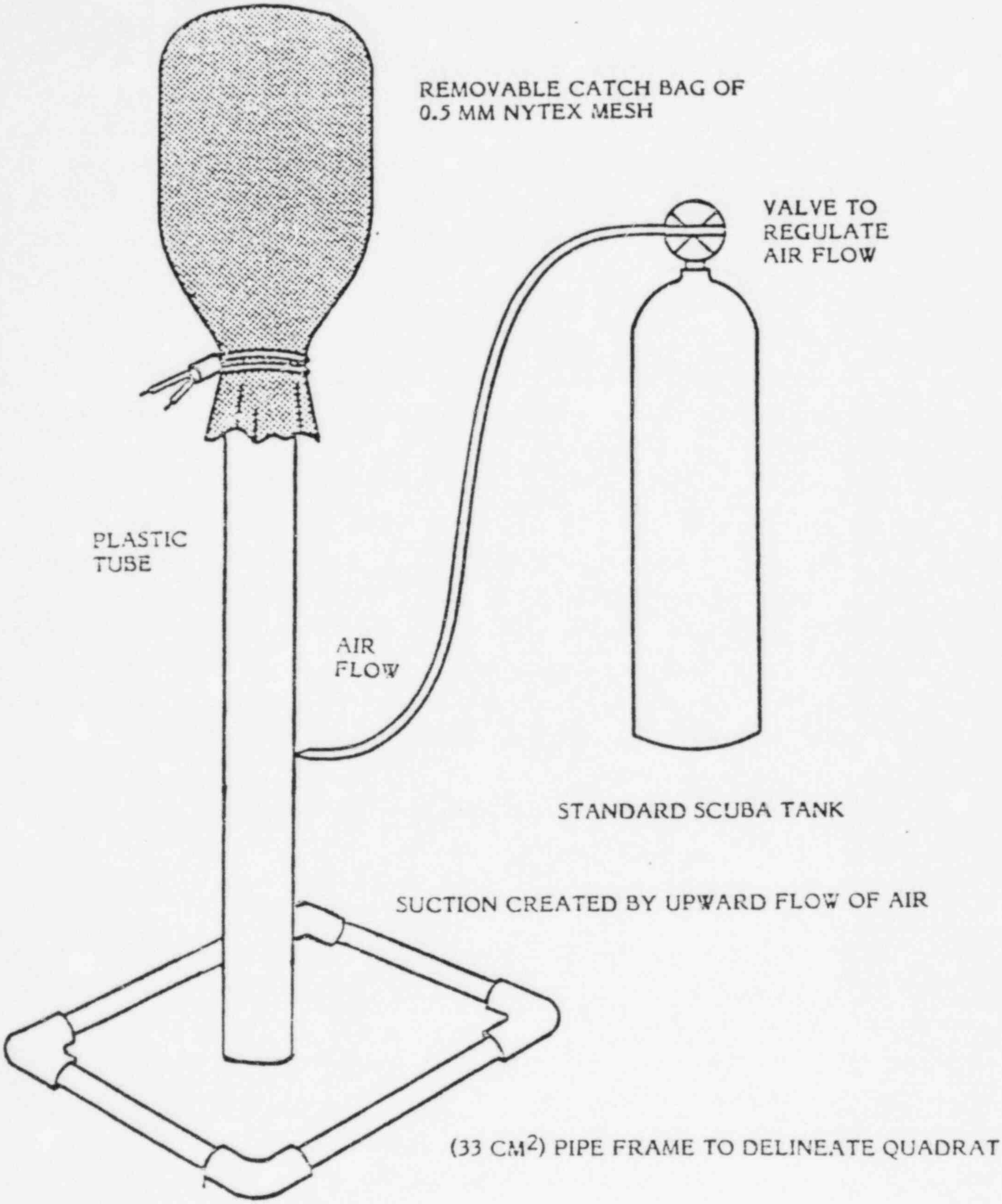

FIGURE 2. ROCK SUBSTRATUM AIRLIFT SAMPLING DEVICE

and returned at once, depending upon convenience. Five replicate samples were taken at each station.

On board the Mya, each sealed bag was placed in a wet box containing fresh seawater. While underway to the next station, the contents of each bag were transferred to a one-gallon plastic jar, labelled and preserved with 10% formalin. Two handfulls of Borax were added as a buffering agent to prevent softening of mollusc shells.

Faunal Processing

In the laboratory, the algal and faunal components were separated by washing the animals off the algae onto a 0.5 mm mesh screen. The fauna was then preserved in 70% ethanol. The algae were returned to 5% formalin.

Each faunal sample was then divided in one-quarter aliquots prior to sorting. One aliquot from each replicate was processed and the rest archived. A solution of Rose Bengal stain was added to each faunal aliquot prior to sorting. Animals were sorted into major groups by the sorter or to the lowest possible taxon depending upon the individual sorter. Major groups were then assigned to identifiers as follows: polychaetes, echinoderms, cnidarians, nemerteans and turbellarians to J. Blake, arthropods to J. Cammarata, S. Weiss and L. Garlo; molluscs to M. Curran and P. Nimeskern. J. Blake, L. Garlo and P. Nimeskern are senior level taxonomists and certify that all identifications follow the latest nomenclature.

Species counts did not include bryozoa, colonial hydroids and spirorbid worms as they are attached epifauna on the algae and their presence in the faunal fraction is an underestimate of their abundance. These epifauna were noted during the algal processing (see below).

Species exhibiting very high densities such as Mytilus edulis juveniles were subsampled from the residue rather than expending the labor needed to remove them in toto from the processed aliquot.

Research quality stereomicroscopes and compound microscopes were used by all personnel during the identification process.

Algal Processing

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

(See Appendix 1). The relative abundance of each indicator or 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. 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. Additional points of interest such as reproductive states of various algal species encountered, algal species present in addition to the 38 indicator species, and similarities and differences between each replicate sample were also recorded. Two voucher collections were established. One is preserved in 5% formalin. The second is a set of permanent slide mounts. The slides include reproductive structures and other characteristics useful for identification.

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 encrusting hydrozoans, bryozoans, spirorbid worms and mussel spat (Mytilus edulis). 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 three replicate samples.

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.

Sediment Grain Size

A sample of sediment was taken from each of the Effluent Station replicates. The amount of sand was conspicuous at this station. The sample was dried and passed through a 1∅ nested series of Standard Sieves on a Roto-Tap Shaking Device. The contents of each sieve were weighed and tabulated as a cumulative of the total pre-sieved weight.

QUALITATIVE TRANSECT SURVEY

SCUBA observations along the axis of the discharge canal were conducted on September 24, 1982 and December 1, 1982.

A line was extended across the mouth of the discharge canal at the mean high water mark on the ends of the discharge jetties. A weighted transect line, marked at 10 m intervals was then attached to the center of this line and deployed along the central axis of the discharge canal for 200 m offshore. A third line, marked at one meter intervals, was extended perpendicularly to the transect line by divers on the bottom, and oriented at 90° with a compass. A SCUBA diver then transversed this third line underwater and recorded changes in algal cover over the distance from the center line through the denuded and stunted areas to where the algal cover became normal. These observations were made at 10 m intervals on each side of the center line until the offshore limit of the stunted zone was encountered. Observations were the same as those conducted for the 1981 Transect Program.

According to BECo (1982 a-b), the distinction between "denuded" and "stunted" is based on Chondrus crispus. The denuded zone is 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 are typical for the depth and substratum in question. In order to ensure that Battelle divers were making the same judgements as to changes in algal cover, as previously made by Taxon, Inc. biologists, Mr. Walter Grocki demonstrated the procedure to Battelle divers during a preliminary sampling trip on September 17, 1982.

DATA ANALYSIS

Data analysis was performed on the VAX - 11/780 computer at Woods Hole Oceanographic Institution (WHOI). All data were coded onto specially designed project coding sheets as the samples were processed. Data were entered onto 5¼" diskettes on a VT-180 microcomputer located at BNEMRL and subsequently transmitted to magnetic disk at WHOI.

Following transmittal, a hard copy of the raw data was generated at BNEMRL's remote terminal and verified against the original coding sheets. All keypunching errors were corrected at this point. Auditing software was then employed to further examine the data for errors.

Analytical software comprised a suite of programs developed at WHOI specifically for the analysis of benthic data. In addition to a variety of data-management and modification utilities, these include primarily the programs PRARE1 and SPSTCL. PRARE1 summarizes the data for each sample, calculates a variety of diversity-related indices, and generates a rarefaction curve. SPSTCL is a multivariate classification package which allows a wide variety of user-specified options for similarity indices and clustering strategies.

Analytical Techniques

Rank Order of Abundance. The individual species comprising the fauna at each station are rank ordered by abundance for each replicate. The most dominant species are listed first, followed in order by less dominant forms. The contribution of each species to the overall total percent of the fauna is denoted by an increasing cumulative percentage starting with the most dominant species and ending with the most rare. Basic statistical treatments including calculation of means, standard deviations, standard error and extrapolation to an abundance per m^2 are performed on each replicate sample in order to obtain the rank order for each station.

Diversity Measures (Community Parameters). At least two measures of diversity are calculated for each sample and station, including the Shannon-Wiener information index, H', as well as evenness (Pielou's J) and species richness. In addition, rarefaction curves according to the method of Hurlbert (1971) are calculated. It can be shown that

Shannon's H' is a biased estimator, and for small samples will underestimate the true population information (Smith and Grassle, 1977). Hurlbert's expected species index of diversity has an unbiased estimator and is thus particularly useful when small and unequal sample size must be compared. Rarefaction curves will not be presented until the October report.

Similarity Measures. The most direct measure of faunal similarity between field samples is the number of species in common. The concept of species shared is biologically meaningful and can be readily visualized in terms of species distribution. We used the measure of similarity developed by Grassle and Smith (1976), the Normalized Expected Species Shared (NESS). This measure is based on the expected number of species shared between random samples of size, m, drawn from a population. The NESS is sensitive to the less common species in the populations to be compared. Confidence intervals can be calculated for this index using the two sample jackknife estimator (Smith, Grassle and Kravitz, 1979).

The classic Bray-Curtis similarity measure, the most widely used clustering technique, was also used (Boesch, 1977). These values can be calculated for stations (Q Type) and by species (R Type). For the present report, only the Q Type value was calculated.

In developing similarity values for station pairs (Effluent station with Rocky Point; Effluent Station with Manomet Point; Rocky Point with Manomet Point), clustering algorithms, such as flexible sorting and group averaging are applied to the similarity matrix, and a cluster diagram or dendrogram is generated. This provides a graphical means of visualizing station relationships based on similarity. The significance of differences between stations and sampling periods is then tested with analysis of variance.

Time-Series Analysis. New results were compared with important components of the 8-year data base to observe long-term effects of thermal discharge on the benthic community. The simplest manner in which to compare long-term data of this sort is to compare changes in species composition over time. Changes in rank of dominants may indicate that perturbation of the community has occurred, or may be merely indicative of natural population cycles. In the August, 1981 samples, Mytilus edulis and Caprella penantis were the most dominant faunal species at all three stations. In the same samples, however, two other highly placed dominants at Rocky Point and Manomet Point,

Hiatella arctica and Margarites umbilicus, were greatly reduced in numbers at the Effluent site. The past data base is valuable to see if this relationship and others has always existed or if it is related to operation of PNPS, as suspected.

RESULTS

FAUNAL STUDIES

Systematics

Following the change in contractors from Taxon, Inc. to Battelle, there have been a few changes in the names applied to some taxa. With two exceptions, however, none of the common indicator or dominant faunal components are affected. One minor change is with the species previously called Nicolea venustula, a terebellid polychaete. We have decided that this species should properly be called N. zostericola since it has 15 instead of 17 thoracic setigerous segments. The caprellid amphipod, Aeginina longicornis found in previous years was not identified by our crustacean taxonomist Elizabeth Garlo. Instead, Caprella linearis, a superficially similar species was identified. At the moment we are unsure whether A. longicornis has been replaced, or whether there is a disagreement among amphipod identifiers, although the latter appears unlikely due to differences in morphology. We plan to have Dr. Les Watling of the University of Maine examine our specimens and the reference specimens from Taxon in order to resolve the issue.

Among the Mollusca, several species have been identified which appear to be newly reported for the program. These include the bivalves Mysella planulata and Spisula solidissima and the gastropods Facelina bostoniensis, Doto coronata, Anachis avara, Odostomia gibbosa and Nassarius vibex. Cingula aculea is the same as Taxon's Onoba aculea and Turbonilla sumneri is possibly the same as T. interrupta. Our Anomia squamula is a senior synonym of A. aculeata.

Several very interesting species of Polychaeta have been identified. Caulleriella bioculata occurred at both the Rocky Point and Manomet stations and represents the first record of the species from North America. Previously known from European waters, C. bioculata is the type-species of its genus. Representative specimens will be archived in

the National Museum of Natural History, Smithsonian Institution. A new species of Cirratulidae has been discovered, which is possibly referrable to the genus Chaetozone. Two species of Polydora have been identified including P. socialis and P. giardi. The latter species resolves a long standing taxonomic problem. Blake (1971) suggested that P. anoculata Moore, 1909 from Woods Hole, might be a junior synonym of P. giardi Mesnil, 1897 known from widely distributed areas. Little material was available at the time to resolve the issue. The new specimens clearly indicate that the characters of the widespread P. giardi are present and that P. anoculata must be sunk into synonymy.

Two species, Harmothoe extenuata and H. imbricata, have been separated from what was previously called H. imbricata. The two forms may be readily distinguished by the lateral placement of the anterior eyes in the former and their forward location in the latter (Pettibone, 1963).

Species Richness

Species Richness for the September, 1982 sampling is presented in Table 1. Data are presented as total numbers of species for each replicate, with a mean ($\bar{x}$) value from all replicates and a cumulative value for the entire station.

Manomet Point and Rocky Point had the most species with an average of 55 and 54.6 respectively. Effluent Station had the fewest species with an average of 41.6 per replicate. Manomet Point had a cumulative total of 89 species and Rocky Point had 83. Effluent had 75 species.

The observed differences in mean number of species per replicate were tested with a one-way analysis of variance (ANOVA) (Sokal and Rohlf, 1969). The results of this test showed that the Effluent Station had significantly fewer species than Manomet and Rocky Point ($p < .001$). There was no difference between the two control stations.

This pattern was nearly the same as observed in previous sampling periods and represents a typical pattern observed in previous years (BECo, 1981a-b; 1982a-b). The patterns for variation in species richness since September, 1979 are shown in Figure 3. the species totals have increased from the lows recorded in March, 1982.

TABLE 1. FAUNAL SPECIES RICHNESS, FAUNAL DENSITY WITH AND WITHOUT <u>MYTILUS</u> <u>EDULIS</u>, SEPTEMBER, 1982.

Station/ Replicate No.	Species Richness (No.of Species)	Density	Density w/o Mytilus
Effluent			
1	40	39,376	36,220
2	42	12,852	11,288
3	48	7,716	7,464
4	41	10,616	10,276
5	37	39,364	37,392
$\bar{x}$	41.6	21,985	20,528
m^2	--	197,865	184,752
Total No. Species	75	--	--
Manomet Point			
1	52	6,944	5,660
2	53	8,232	6,844
3	58	14,240	11,804
4	56	16,192	12,916
5	56	8,068	6,584
$\bar{x}$	55	10,735	8,762
m^2	--	96,616	78,845
Total No. Species	89	--	--
Rocky Point			
1	56	8,844	7,364
2	54	14,244	12,476
3	56	9,712	8,040
4	53	7,472	6,512
5	54	9,476	8,304
$\bar{x}$	54.6	9,950	8,539
m^2	--	89,546	76,853
Total No. Species	83	--	--

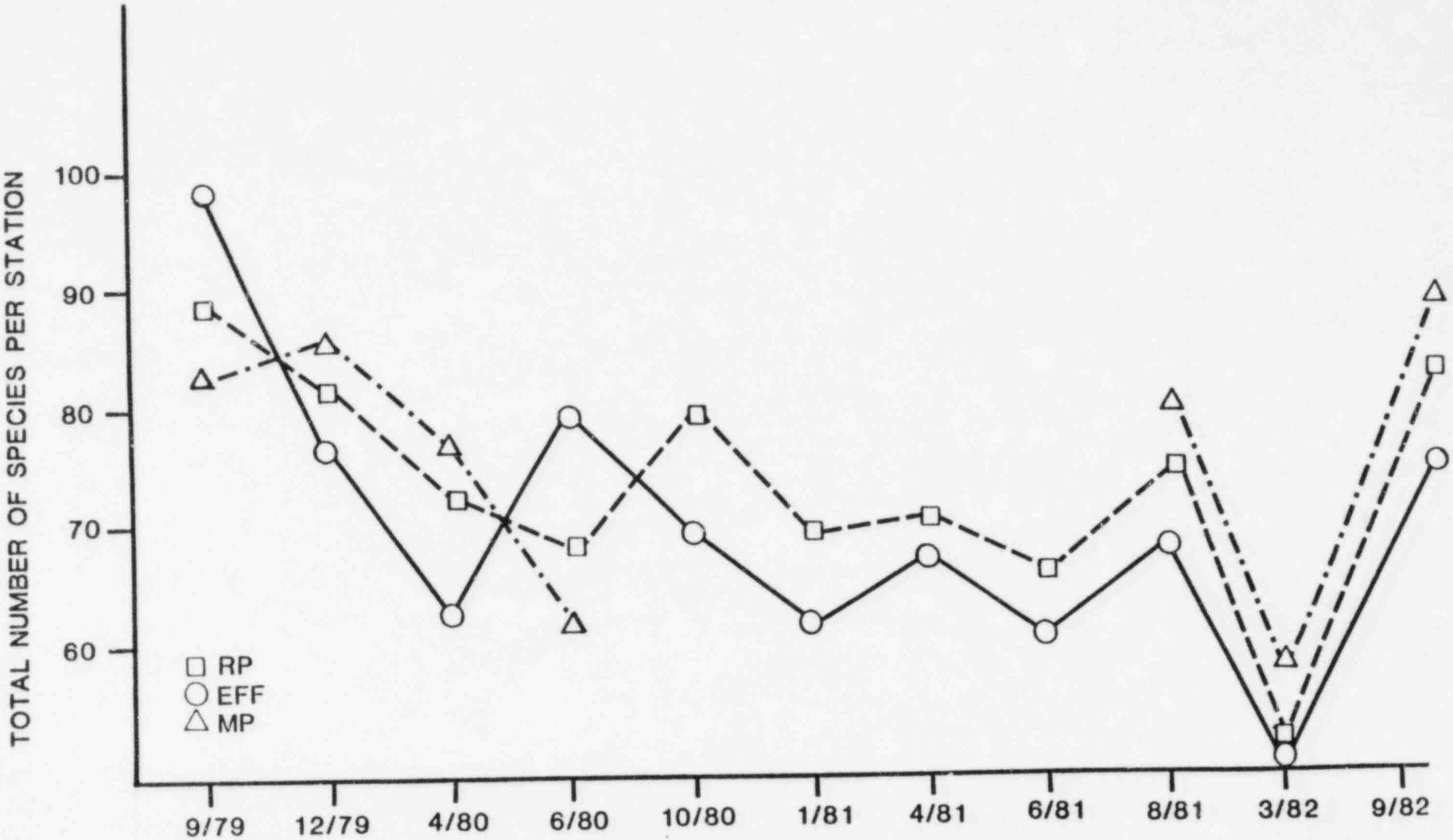

FIGURE 3. SPECIES RICHNESS FOR THE PERIOD SEPTEMBER, 1979 THROUGH SEPTEMBER, 1982.

Faunal Density

Densities of benthic macrofauna per replicate and per square meter at each station are presented in Table 1 and Figures 4, 5, and 6. Results are presented with and without mussels (Mytilus edulis). Densities of each species are given in Appendices 2,3, and 4.

The greatest densities are recorded at the Effluent Station with individual replicates ranging from 7,716 to 39,376 ($\bar{x}$= 21,985) individuals per sample. Removal of Mytilus had little impact on the totals, since they only represented 6.2% of the total fauna.

Faunal densities at Manomet Point and Rocky Point were lower. At Manomet Point, replicate densities ranged from 6,944 to 14,240 ($\bar{x}$ = 10,735) individuals per sample. This is calculated to be 96,616 individuals per m^2. At Rocky Point, replicate densities ranged from 7,472 to 14,244 ($\bar{x}$ = 9,950) individuals per sample. This is 76, 853 per m^2. Removal of mussels at Manomet Point and Rocky Point was important since they represent 18.38% and 14.17% of the fauna, respectively. Effluent Station faunal densities were controlled by amphipods, especially Jassa falcata (54.14%), Corophium bonelli (15.22%) and C. acutum (8.78%).

The differences in faunal densities were examined with a one-way analysis of variance (ANOVA) for overall density and for density without mussels. Results of these tests were not significant.

Species Dominance

The 15 numerically dominant species at each station for the September, 1982 sampling are shown in Table 2. The Effluent Station is different from the Rocky Point and Manomet Point Stations. However, there are also differences between the two latter stations.

Effluent Station is dominated by three amphipods, Jassa falcata, Corophium bonelli and C. acutum, which comprise 78.14% of the total density. Jassa falcata alone accounts for over one-half of the total number of individuals. Mytilus edulis only comprises 6.62% of the total fauna and is ranked fourth. All of the 15 top species make up 97.63% of the total density with the remaining 60 species comprising only 2.37%. At Rocky Point, Corophium bonelli is the most abundant species, with Jassa falcata dropping to sixth in the rank order. Mytilus edulis is second in abundance. After the first 15 species, the remaining 68 species comprise 13.07% of the total. At Manomet Point, Mytilus edulis is

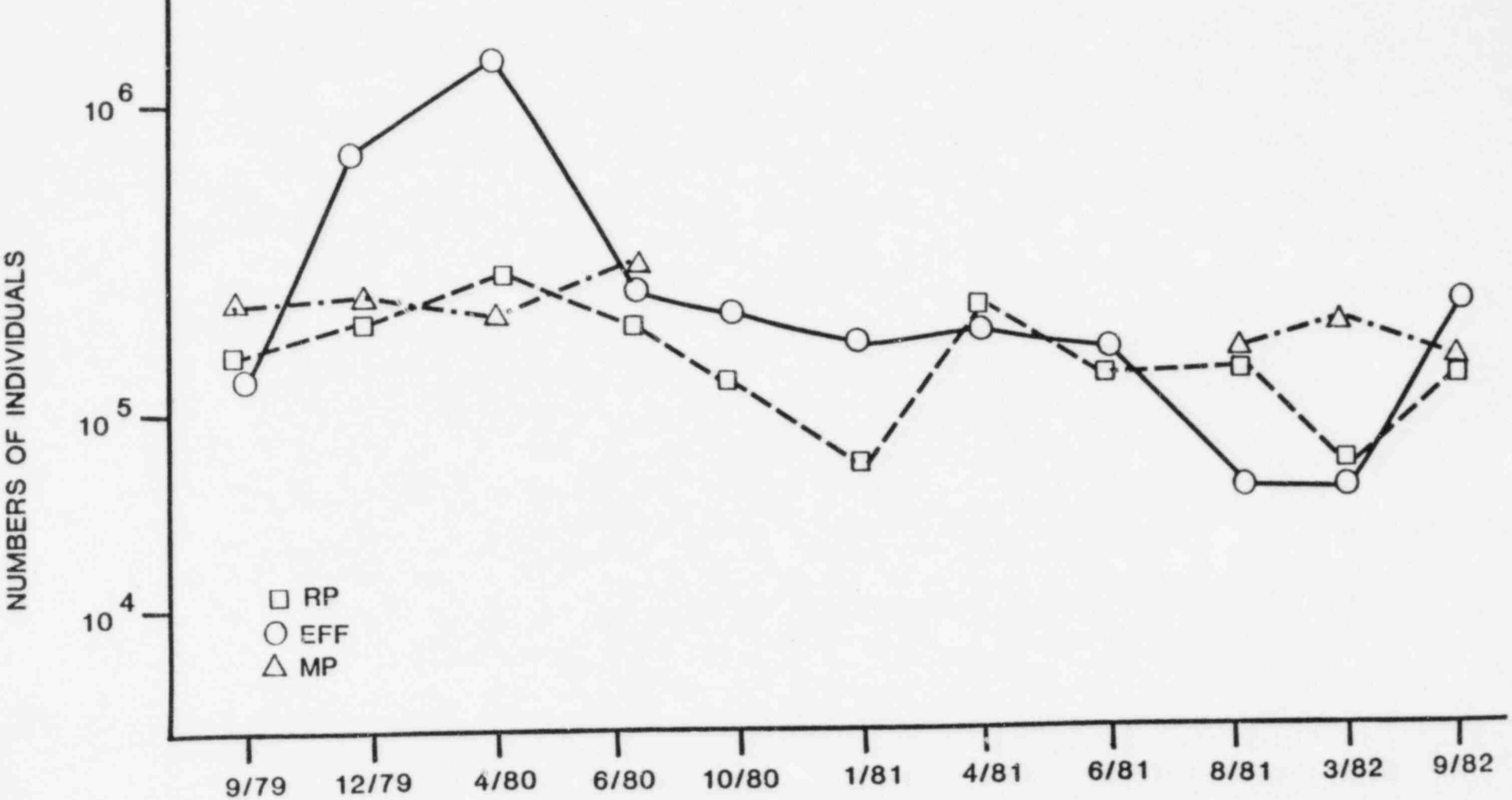

FIGURE 4. FAUNAL DENSITIES (m^2) FOR THE PERIOD SEPTEMBER, 1979 THROUGH SEPTEMBER, 1982.

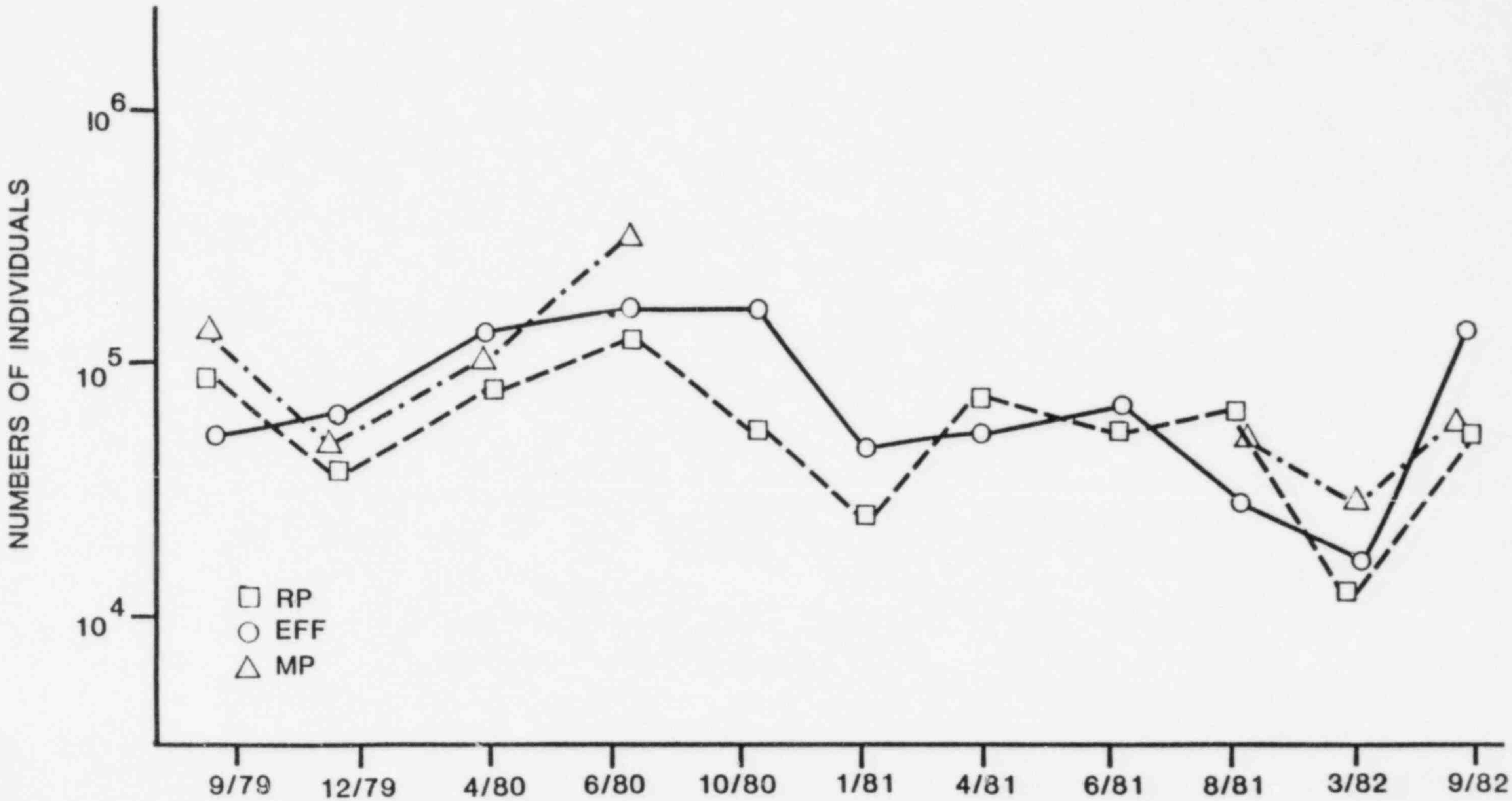

FIGURE 5. FAUNAL DENSITIES (m^2) EXCLUDING MYTILIS EDULIS FOR THE PERIOD SEPTEMBER, 1979 THROUGH MARCH, 1982.

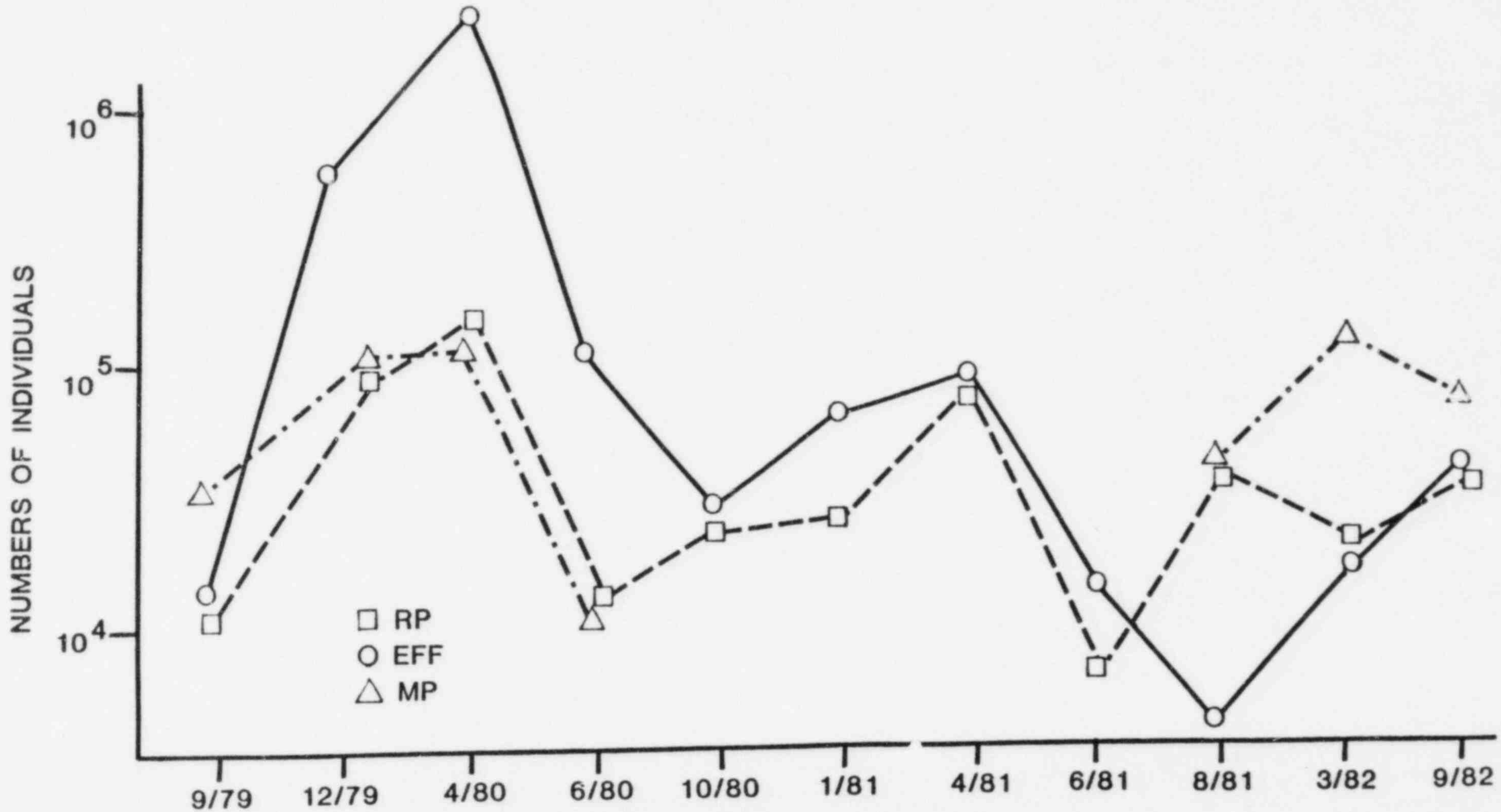

FIGURE 6. MYTILUS EDULIS DENSITIES (m^2) FOR THE PERIOD SEPTEMBER, 1979 THROUGH SEPTEMBER, 1982.

TABLE 2. RANK ORDER OF ABUNDANCE FOR THE DOMINANT 15 SPECIES, SEPTEMBER, 1982.

Station/Species	Number ($\bar{x}$/replicate)	Percent
Effluent		
Jassa falcata	11,903	54.14
Corophium bonelli	3,347	15.22
Corophium acutum	1,930	8.78
Mytilus edulis	1,457	6.62
Calliopus laevisculus	811.2	3.68
Caprella penantis	745.6	3.39
Acarina sp.	568.0	2.58
Dexamine thea	268.0	1.22
Idothea phosphorea	196.0	0.89
Asterias forbesii	77.6	0.35
Lacuna vincta	69.6	0.31
Idotea baltica	64.8	0.29
Aeolidia papillosa	60.8	0.27
Metridium senile	51.2	0.23
Mysella planulata	50.4	0.22
Total of 15 Species	21,600.4	97.63%
Remaining fauna — 60 spp.	384.4	2.37%
Total Fauna — 75 spp.	21,984.8	100.0%
Manomet Point		
Mytilus edulis	2,776.8	25.86%
Jassa falcata	1,766.4	16.45
Acarina sp.	746.4	6.95
Pleusymtes glaber	636.0	5.92
Ischyroceros anguipes	529.6	4.93
Corophium acutum	513.6	4.78
Caprella penantis	464.8	4.32
Margarites helicinia	380.8	3.54
Corophium borelli	377.6	3.51
Calliopus laevisculus	304.0	2.83
Nicolea zostericola	248.8	2.31
Dexamine thea	240.8	2.24
Hiatella arctica	217.6	2.02
Caprella linearis	176.8	1.64
Idotea phosphorea	172.0	1.60
Total of 15 Species	9,552.0	88.90
Remaining fauna — = 74 spp.	1,183.2	11.10%
Total Fauna — 89 spp.	10,735.2	100.0%
Rocky Point		
Corophium bonelli	1,612.8	16.20
Mytilus edulis	1,410.4	14.17
Dexamine thea	1,049.6	10.54
M[illegible]arites helici[illegible]	632.0	6.35
Ca[illegible]ella penantis	604.8	6.07
Jassa falcata	600.0	6.03
Corophium acutum	493.6	4.96
Acarina sp.	473.6	4.75
Pleusymtes glaber	403.2	4.05
Lacuna vincta	300.0	3.01
Hiatella arctica	257.6	2.58
Ischyrocerus anguipes	2[illegible].0	2.45
Cingula aculeus	218.4	2.19
Calliopius laevisculus	182.4	1.83
Nicolea zostericola	174.4	1.75
Total of 15 Species	8,656.8	86.93
Remaining fauna — 68 spp.	1,292.8	13.07%
Total Fauna — 83 spp.	9,949.6	100.0%

the most abundant species, with 25.86% of the total. Jassa falcata is second with 16.45%. Nine species of amphipods in the top 15 comprise 46.62% of the total. The remaining 74 species of the station account for 11.1%.

The patterns of dominance observed in these September, 1982 samples depart from the patterns seen in August, 1981 where Mytilus edulis and Caprella penantis were ranked first and second at all three stations (BECo, 1981b). In 1982, Mytilus ranked first only at Manomet Point. Caprella penantis ranked from fifth to seventh at all three stations.

The samples of March, 1982 again showed Mytilus edulis as the single most abundant species at all three stations. Jassa falcata was second at Manomet Point and Effluent, but ranked seventh at Rocky Point.

In summary, amphipods were far more abundant than mussels in the September, 1982 samples. This pattern departs from the last two sampling periods (August, 1981; March, 1982) where Mytilus was dominant (BECo, 1981b; 1982a-b).

Species Diversity

Shannon-Wiener diversity (H') and eveness (Pielou's J') were calculated for each replicate and for the combined data of each station. These values are presented in Table 3 for the entire community and in Table 4 for the community excluding Mytilus edulis. The exclusion of M. edulis has been used in previous studies due to the usual disproportionate influence this numerical dominant usually has one on these indices. In the September, 1982 data, however, Mytilus populations were not as high as in previous sampling periods (see above) and the values are probably influenced more by elevated amphipod densities.

The highest diversity and eveness values are found at the Manomet and Rocky Point Stations. Values at Effluent are significantly lower. This data corresponds to the lower species richness data also evident at Effluent Station.

The lower diversity values at Effluent Station are undoubtedly due to the dominance of three amphipod species which comprise over 78% of the total number of individuals.

The September, 1982 values may be compared with March, 1982 (BECo, 1982a) where overall diversities were low at all stations. Manomet Point which had the lowest diversities in March are all now very high, while diversity at Effluent Station has remained low.

TABLE 3. INFORMATION THEORY DIVERSITY VALUES (SHANNON-WIENER) BY REPLICATE AND FOR M^2 DATA, SEPTEMBER, 1982.

			Replicate		Manomet Point	
	H'	J'	H'	J'	H'	J'
1	4.04	0.71	4.23	0.73	2.03	0.38
2	4.21	0.74	4.14	0.72	2.56	0.47
3	3.95	0.67	3.88	0.67	3.30	0.59
4	3.71	0.64	4.34	0.76	2.76	0.51
5	4.17	0.72	4.08	0.71	2.14	0.41
m^2	4.22	0.65	4.27	0.67	2.41	0.39

TABLE 4. INFORMATION THEORY DIVERSITY VALUES (SHANNON-WIENER) EXCLUDING *MYTILUS EDULIS* BY REPLICATE AND M^2 DATA, SEPTEMBER, 1982.

Replicate	Manomet Point		Rocky Point		Effluent	
	H'	J'	H'	J'	H'	J'
1	4.11	0.72	4.30	0.74	1.76	0.33
2	4.29	0.75	4.10	0.72	2.31	0.43
3	3.98	0.68	3.89	0.67	3.20	0.58
4	3.75	0.65	4.34	0.76	2.64	0.50
5	4.27	0.74	4.04	0.71	1.95	0.38
m^2	4.33	0.67	4.29	0.68	2.20	0.35

Similarity Measures

Number of species in common is a direct measure of faunal similarity between samples. The concept of species shared can be readily visualized in terms of species distribution. Cluster analyses were conducted using both the NESS Similarity measure developed by Grassle and Smith (1976) and the Bray-Curtis method (Boesch, 1977). The NESS (Normalized Expected Species Shared) is more sensitive to the rare species in populations.

The results are presented in Figure 7 for NESS and Figure 8 for Bray-Curtis. The Effluent Station is distinctly separated from the Manomet Point and Rocky Point stations by both techniques. Manomet Point and Rocky Point separate at lower levels of similarity. All five replicates each of Manomet Point and Rocky Point cluster closely together with their respective stations using NESS. Using Bray-Curtis, however, Rocky Point replicate 2 clusters with the five Manomet Stations. That particular replicate, upon inspection, had higher numbers of Jassa falcata than the other four. This amphipod was the second ranking species in the dominance hierarchy at Manomet, but only ranked sixth at Rocky Point. The NESS method apparently did not place undue weight upon that single anomaly in one replicate, but dealt with overall population similarities of the two stations.

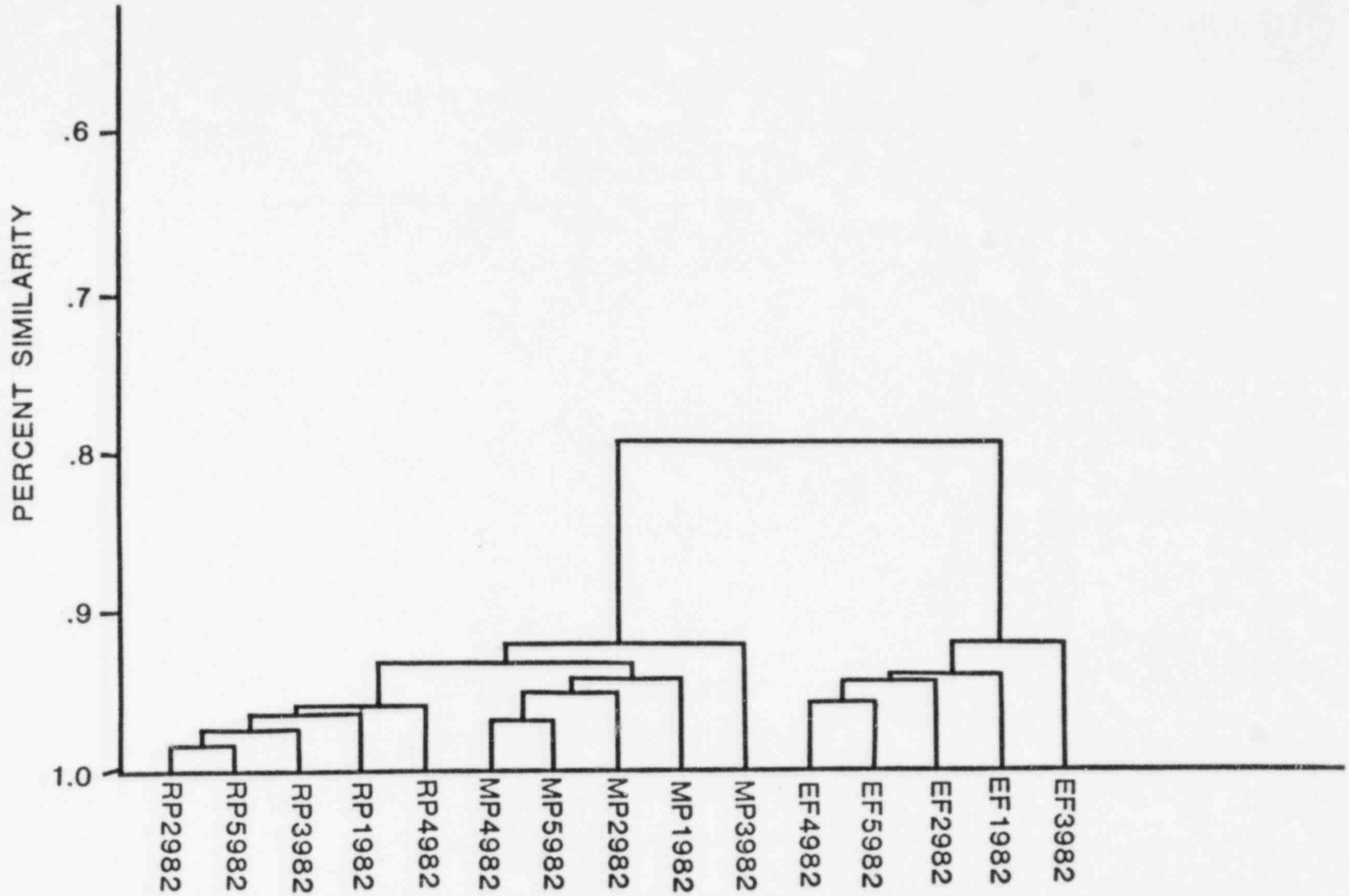

FIGURE 7. REPLICATES OF MANOMET POINT , ROCKY POINT AND EFFLUENT STATIONS CLUSTERED BY NESS

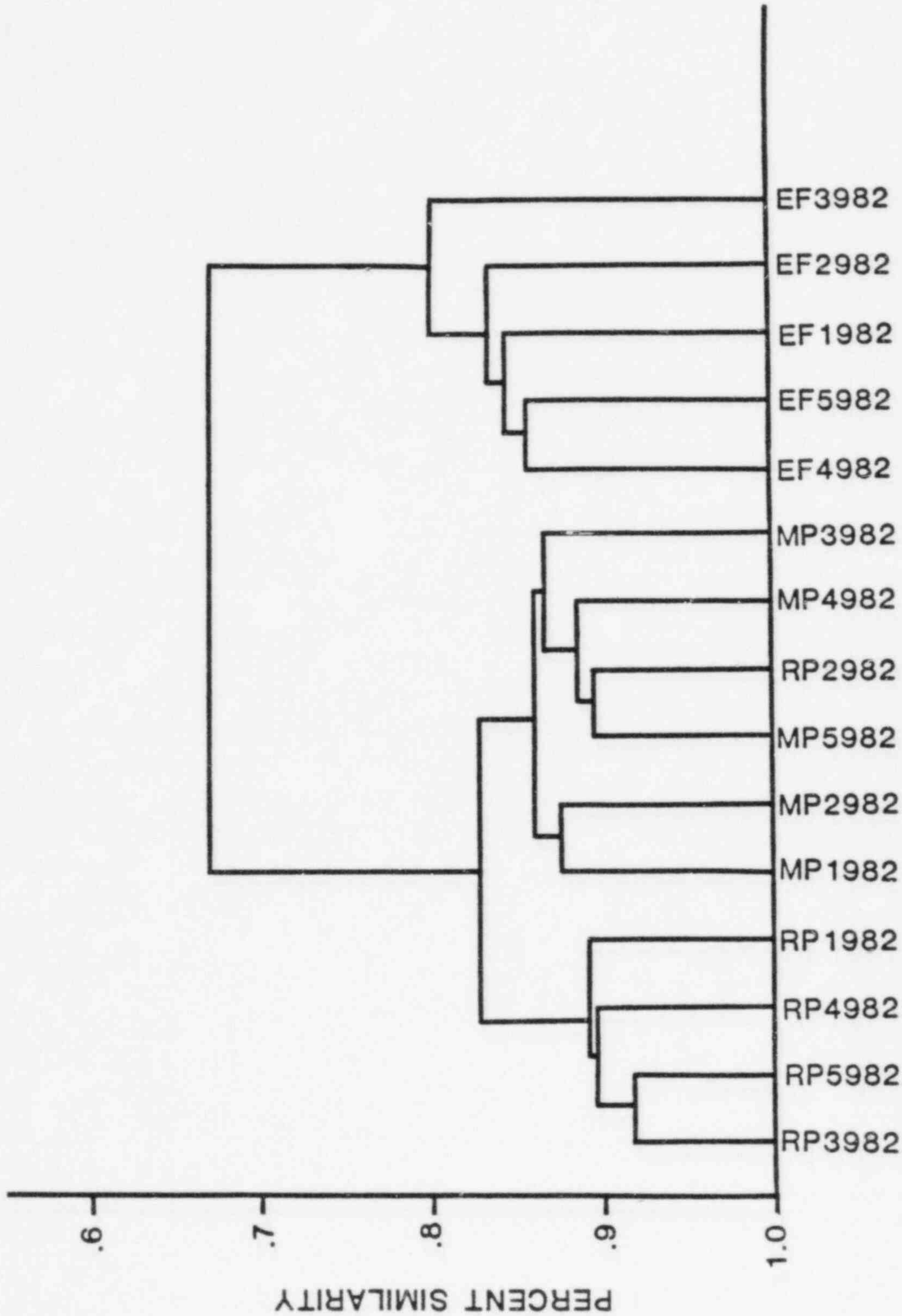

FIGURE 8. REPLICATES OF MANOMET POINT , ROCKY POINT AND EFFLUENT STATIONS CLUSTERED BY BRAY-CURTIS

ALGAL STUDIES

Systematics

No additions to the cumulative algal species list presented in BECo Report No. 16 (BECo, 1980) have been made as a result of the September, 1982 sample analyses. Species identifications and taxonomic determinations were based on the works of Bold and Wynne (1978), Dawson (1966), Parke and Dixon (1976), South (1976), and Taylor (1962).

Algal Community Description

Throughout the Manomet Point, Rocky Point, and Effluent survey areas, the rock and cobble substratum was heavily colonized by red macroalgae. The most abundant species were Chondrus crispus and Phyllophora spp., both representatives of the Order Gigartinales. Chondrus densities appeared similar at all three sampling areas. Phyllophora spp. was present at all three sample areas, but was less dense than Chondrus. Additional benthic macroalgal species were also represented within the three sampling areas. The most noticeable red algae were Polyides rotundus, Ahnfeltia plicata, and Corallina officinalis.

The most conspicuous brown algae were isolated specimens of Laminaria spp. Green algae within the sampling area included mostly Chaetomorpha sp. filaments and scattered Ulva lactuca. While each of these taxa were occasionally observed to form well defined populations, their most common mode of occurrence was either as isolated individuals, or as weakly developed populations occurring within the Chondrus and Phyllophora.

Gracilaria folifera blanketed the rocks within the Effluent Canal, decreasing to sparse patches at a distance of 50 meters from the jetties. Also common in clumps among the Gracilaria was the introduced green alga Codium fragile tomentosoides. Since its introduction in Long Island Sound in 1957, Codium has spread to the south side of Cape Cod. In recent years, Codium has been documented in Cape Cod Bay and presently a local population exists year round in Duxbury Bay (Carlton and Scanlon, MS.). The shallower stunted zone interface was dominated by sparse Chondrus and the brown alga Fucus spp.

The epiphytic algal population encompassed a large number of species and constituted an important component of the algal community. Chondrus and Phyllophora

served as the primary host species although Polyides rotundus was also epiphytized at Rocky Point, where it was most abundant. Epiphytic species are prevalent year round, but attain their maximum development during summer and early autumn. During this time, the dominant epiphytic species include Spermothamnion repens, several species of Polysiphonia, Cystoclonium pupureum and Ceramium rubrum. While all species were common at all three sampling stations, Ceramium dominated at the warmer Effluent Station whereas Spermothamnion and Polysiphonia were more abundant at the Rocky Point and Manomet Point Stations. Based upon previous BECo reports, the primary winter spring epiphytes are expected to include Phycodrys rubens, Callophyllis cristata, Membranoptera alata, and Rhodomela confervoides.

Algal Community Overlap

Community overlap was calculated using Jaccard's Coefficient of Community (Greig-Smith, 1964) to measure quantitatively the extent of similarity in algal species composition between the Manomet Point, Effluent, and Rocky Point stations. The coefficient 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. Species occurrence records of 38 carefully selected indicator species were used for all community overlap calculations. Specific criteria employed in the selection of the indicator species have been described in the Methods section of this report.

Results of community overlap comparisons between replicate samples of each station for the September, 1982 collecting period are presented in matrix form in Figs. 9a-c. Ranges of replicate overlap values were 65% - 90% at Manomet Point and Rocky Point Stations, and 70% - 95% at the Effluent. The mean replicate overlap value for the three stations showed a close degree of correspondence; the respective values for Manomet Point, Rocky Point and Effluent were 79.6%, 77.6% and 82.9%. Similar ranges and means of these values at the three stations indicates that the algal species composition of each was similarly homogeneous.

	1	2	3	4	5
1		19	16	18	17
2	82.6		18	19	18
3	66.7	81.8		17	18
4	81.8	90.5	81.0		17
5	70.8	78.3	85.7	77.3	

NUMBER OF SPECIES SHARED

PERCENT OVERLAP

A. MANOMET POINT STATION

	1	2	3	4	5
1		17	21	20	19
2	63.0		19	18	17
3	70.0	79.2		21	21
4	74.1	85.7	84.0		20
5	67.9	77.3	84.0	90.9	

NUMBER OF SPECIES SHARED

PERCENT OVERLAP

B. ROCKY POINT STATION

	1	2	3	4	5
1		20	22	18	20
2	83.3		20	17	19
3	95.7	87.0		18	21
4	75.0	73.9	78.3		18
5	95.7	79.2	91.3	69.2	

NUMBER OF SPECIES SHARED

PERCENT OVERLAP

C. EFFLUENT STATION

Overlap between stations

Station Pair	Number of Shared Species August 1982	Community Overlap August 1982
Manomet Point-Rocky Point	23	79.31%
Manomet Point-Effluent	20	68.97%
Rocky Point-Effluent	23	76.67%

FIGURE 9. ALGAL COMMUNITY OVERLAP (JACARD'S COEFFICIENT OF COMMUNITY) AND NUMBER OF SPECIES SHARED BETWEEN REPLICATE PAIRS AT THE MANOMET POINT, ROCKY POINT AND EFFLUENT SUBTIDAL STATIONS (10' MLW), SEPTEMBER, 1982.

Algal Biomass

Algal biomass was determined for benthic (Chondrus crispus, Phyllophora spp., and remaining benthic species) and epiphytic (epiphytes of Chondrus and epiphytes of Phyllophora) algal fractions. Total algal biomass was also determined for each replicate.

Chondrus crispus Biomass. Chondrus crispus biomass values for Manomet Point, Effluent, and Rocky Point Stations for September, 1982 are presented in Table 5. The Effluent Station produced the highest mean Chondrus biomass (474.19 g/m^2) followed closely by Manomet Point (465.44 g/m^2). Rocky Point mean biomass was the lowest of the three stations (325.85 g/m^2), 31% lower than the Effluent value, and 30% lower than the Manomet Point value.

An examination of the replicate biomass values for the three stations show the range of individual biomass to be greatest at Effluent (56.25--990.27 g/m^2). Ranges at Rocky Point and Manomet Point were lower, 225.72-574.38 g/m^2, and 189.72-594.90 g/m^2 respectively. This year's Chondrus biomass has more than doubled over the August, 1981 value at the Effluent Station. Table 5 shows that the mean Chondrus biomass constituted the same percentage at both Effluent and Manomet Point Stations (54%). Rocky Point Chondrus biomass consisted of 48% of the total algae present. The ratio of Chondrus/Phyllophora biomass at Rocky Point, Effluent, and Manomet Point was similar with ratios of 1.9:1, 1.8:1, and 1.5:1, respectively.

A one-way analysis of variance (ANOVA) was performed on replicate sample data from September, 1982 to test for significant differences in Chondrus biomass between the three stations. Results of the ANOVA are included in Table 6, and indicate no significant differences between stations.

Previous BECo semi-annual reports have advanced the hypothesis that sand scour at the Effluent site may be primarily responsible for a decreased Chondrus biomass observed from October, 1975 to August, 1981. Chondrus is relatively delicate and is considered to be particularly susceptible to the effects of scouring (Prince, 1971). These include inhibition of germination and abrasion-induced dislodging of established plants (Newroth, 1970), both of which could contribute to locally-depressed biomass.

The September, 1982 data do not repeat the previous pattern of decreassed biomass at the Effluent Station. However, variation in Chondrus biomass was higher at this site and may reflect selective scouring effects at some replicate sampling sites.

TABLE 5. DRY WEIGHT BIOMASS VALUES (g/m^2) FOR CHONDRUS CRISPUS, PHYLLOPHORA spp., EPIPHYTES, THE REMAINING BENTHIC SPECIES, AND TOTAL ALGAL BIOMASS FOR MANOMET PT., ROCKY PT., AND EFFLUENT SUBTIDAL (10'mlw) STATIONS FOR SEPTEMBER, 1982.

Station Rep.	Chondrus Crispus		Phyllophora spp.		Remaining Benthic Species		Epiphytic Species (Total)		Total Algal Biomass
MANOMET PT.									
1	521.55	(60%)	218.88	(25%)	3.78	(0.4%)	121.68	(14%)	865.89
2	448.65	(55%)	235.08	(29%)	36.63	(5%)	90.00	(11%)	810.36
3	572.40	(60%)	324.45	(34%)	1.08	(0.1%)	53.64	(6%)	951.57
4	189.72	(23%)	540.36	(66%)	8.19	(1%)	75.51	(9%)	813.78
5	594.90	(66%)	228.60	(25%)	8.73	(1%)	71.10	(8%)	903.33
$\bar{X}$	**465.44**	**(54%)**	**309.47**	**(36%)**	**11.68**	**(1%)**	**82.39**	**(9%)**	**868.99**
ROCKY PT.									
1	272.25	(38%)	145.17	(20%)	188.28	(26%)	113.22	(16%)	718.92
2	574.38	(67%)	196.11	(23%)	3.15	(0.4%)	79.11	(9%)	852.75
3	225.72	(37%)	126.90	(21%)	174.87	(29%)	78.03	(13%)	605.52
4	280.80	(48%)	170.10	(29%)	58.59	(10%)	72.54	(13%)	582.03
5	276.12	(45%)	190.17	(31%)	12.10	(2%)	129.96	(21%)	608.35
$\bar{X}$	**325.85**	**(48%)**	**165.69**	**(25%)**	**87.40**	**(13%)**	**94.57**	**(14%)**	**673.51**
EFFLUENT									
1	990.27	(77%)	247.32	(19%)	4.68	(0.4%)	50.67	(4%)	1292.94
2	889.29	(84%)	123.66	(12%)	0.45	(.04%)	46.35	(4%)	1059.75
3	84.15	(14%)	235.35	(39%)	124.38	(21%)	163.80	(27%)	607.68
4	56.25	(10%)	374.22	(69%)	14.40	(3%)	99.99	(18%)	544.86
5	351.00	(39%)	285.30	(31%)	188.10	(21%)	85.32	(9%)	909.72
$\bar{X}$	**474.19**	**(54%)**	**253.17**	**(29%)**	**66.40**	**(8%)**	**89.23**	**(10%)**	**882.99**

TABLE 6. 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 SEPTEMBER, 1982 COLLECTIONS.

September, 1982 Biomass category	d.f.	f-value	Level of Significance
Chondrus crispus	2/12	0.4296	not significant
Phyllophora spp.	2/12	2.8608	not signficant
Remaining benthic species	2/12	1.4961	not significant
Epiphytes of Chondrus	2/12	0.1232	not significant
Epiphytes of Phyllophora	2/12	1.0773	not significant
Total algal biomass	2/12	1.8042	not significant

Phyllophora spp. Biomass. Phyllophora spp. biomass is given in Table 5. The data show that Manomet Point had the highest mean biomass (309.47 g/m^2) and Rocky Point the lowest (165.69 g/m^2), with Effluent having 253.17 g/m^2. Rocky Point biomass was 46% lower than at Manomet Point, and 35% lower than at the Effluent. Chondrus biomass at Effluent was only 18% lower than at the Manomet Point Station. In all individual replicates at Manomet Point, and four out of five replicates at the Effluent, Phyllophora biomass exceeded 200.00 g/m^2. At Rocky Point, individual replicate biomass approached, but never exceeded 200.00 g/m^2. The individual replicate biomass high and low ranges at Manomet Point, Rocky Point, and Effluent were 218.88 -540.36 g/m^2, 126.90 - 196.11 g/m^2, and 123.66 - 374.22 g/m^2 respectively. As shown in Table 5, Phyllophora constituted 36% of the total algae present at Manomet, 25% at Rocky Point, and 29% at the Effluent.

A one-way ANOVA was performed on the replicate sample data of September, 1982 to test for significant Phyllophora biomass differences between stations. As seen in Table 6, there were no significant differences.

Since similar Chondrus/Phyllophora ratios exist at all three stations, it can be assumed that the PNPS Unit I discharge current at the Effluent Station did not affect the Chondrus and Phyllophora growth this year as has been hypothesized in past reports. It has been thought that the course sand substratum combined with the scouring of holdfasts by increased sediment deposition occurring at the discharge plume created conditions which favored Phyllophora growth, a more hardy alga, over Chondrus. This is the first time since September, 1979 that Phyllophora has not been most abundant at the Effluent Station.

Biomass of Remaining Benthic Species. The algal biomass category designated as "remaining benthic species" comprises all benthic algae excluding Chondrus, Phyllophora, Laminaria spp. and algal epiphytes. For all stations, the dominant algal species were Polyides rotundus, Ahnfeltia plicata, Corallina officinalis, Chaetomorpha linum and Ulva lactuca.

Biomass data for the RBS are presented in Table 5. Rocky Point produced the highest RBS biomass (87.40 g/m^2) Manomet Point the lowest (11.68 g/m^2) and Effluent the intermediate level (66.40 g/m^2). Higher Chondrus and Phyllophora biomass at the Manomet Point Station are directly related to the low RBS biomass due to competition for similar resources (primarily space) among these species.

The Manomet Point biomass value was 87% lower and Effluent biomass 24% lower than the Rocky Point value. Elevated Rocky Point biomass was due to the abundance of Polyides rotundus. No Polyides was found at Manomet Point. Individual replicate ranges for Rocky Point and Effluent were 12.10-188.28 g/m^2 and 0.45-188.10 g/m^2, respectively. Manomet Point had a lower range of 1.08-36.63 g/m^2, and the RBS comprised only 1% of the total algae present at that station. RBS made up 13% of the total algae at Rocky Point, and 8% at the Effluent. A one-way ANOVA was performed on the September, 1982 data and showed no significant differences between stations (Table 6).

Epiphytic Algal Biomass. Total epiphytic biomass for September, 1982 is included in Table 5. Epiphytes were usually more abundant on Phyllophora than on Chondrus at all three stations, with the highest amount of algal epiphytes occurring at Rocky Point. Colonization values for both host species are presented in Table 8. Epiphytes additionally colonized Polyides rotundus which increased the total epiphyte biomass at the Rocky Point Station where Polyides was abundant. Mean epiphytic biomass was similar at Manomet Point, Rocky Point and Effluent with values of 82.39 g/m^2, 94.57 g/m^2, and 89.23 g/m^2 respectively, and ranged from 9% to 14% of the total algae present. A one-way ANOVA was performed on the September, 1982 data and showed no signficant differences between stations.

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 wirey 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 also showed that Phyllophora was more heavily epiphytized than Chondrus.

Total Algal Biomass. Total mean algal biomass for each station, and values for individual replicates are given in Table 5. During previous fall sampling periods, (September, 1979, October, 1980 and August, 1981), Manomet Point produced the highest total mean algal biomass. For the current September, 1982 report, the highest total algal biomass was produced at the Effluent Station (882.99 g/m^2). Manomet Point was very similar with a total algal biomass of 868.99 g/m^2. Rocky Point had the lowest value with a total production of 673.5 g/m^2. The Manomet Point value was .02% lower and Rocky

Point 24% lower than the Effluent value. Individual replicate ranges at Manomet Point, Rocky Point and Effluent were 810.36-951.57 g/m^2, 582.03-852.75 g/m^2, and 544.86-1292.94 g/m^2 respectively, with the lowest range occurring at Manomet Point. At all three stations, individual replicate biomass values exceeded 500 g/m^2. During the August, 1981 sampling period only one replicate at the Effluent Station exceeded 600 g/m^2. Currently, four out of five replicates show biomass values over 600 g/m^2, two of which exceed 1000 g/m^2.

A one-way ANOVA was performed on the September, 1982 data and showed no significant differences between stations (Table 6).

Two-Way ANOVA for Algal Biomass. The relative effects of location and time on the various algal biomass parameters were examined via a two-way ANOVA using subprogram ANOVA of the Statistical Package for the Social Sciences (Nie, et al., 1975). Biomass parameters examined included total algae, Chondrus crispus, Phyllophora spp., remaining benthic algae, epiphytes of Chondrus sp., and epiphytes of Phyllophora spp. The ANOVA values for those analyses resulting in significant differences are included in Table 7.

For Chondrus crispus, Phyllophora epiphytes, and remaining benthic species, no significant differences were indicated for the effects of site and time. For Chondrus epiphytes, however, both main effects and the site x time interaction were very highly significant ($p < .001$). Examination of the algal biomass data (Table 5) indicates that epiphyte biomass decreased from August, 1981 to September 1982 at Rocky Point and Manomet Point, but increased at Effluent over the same period.

The ANOVA for Phyllophora spp. biomass was also significant for main effects (Table 7), but was not significant for interaction. Inspection of Table 5 indicates that biomass increased at all stations from August, 1981 to September, 1982 and was significantly less at Rocky Point for both collections.

A similar result was produced by the ANOVA for total algal biomass, but the reasons for the observed patterns of significance were different from those described above for Phyllophora spp. Manomet Point had significantly greater total algal biomass over this period and the September, 1982 sampling was significantly greater than August, 1981. The interaction effect for this parameter was nearly significant ($p = .059$) due to a marked increase in total algal biomass at Effluent from 1981 to 1982. Although all three stations increased over this period, the increase at Effluent was considerably greater than that seen at Manomet Point or Rocky Point.

TABLE 7: RESULTS OF TWO-WAY ANOVAS INDICATING SIGNIFICANT DIFFERENCES FOR ALGAL BIOMASS PARAMETERS.

Chondrus crispus Epiphytes:

SOURCE OF VARIATION	DF	SS	MS	P
Location	2	3,428	1,714	<.001
Time	1	1,973	1,973	<.001
Location x Time	2	3,555	1,777	<.001
Error	24	2,148	89.5	
Total	29	11,104	383	

Phyllophora spp.:

SOURCE OF VARIATION	DF	SS	MS	P
Location	2	75,122	37,561	< .01
Time	1	88,419	88,419	<.001
Location x Time	2	11,478	5,739	.340
Error	24	122,110	5,088	
Total	29	297,129	10,246	

Total Algal Biomass:

SOURCE OF VARIATION	DF	SS	MS	P
Location	2	237,472	118,736	<.05
Time	1	252,533	252,533	<.01
Location x Time	2	175,539	87,769	.059
Error	24	665,544	27,434	
Total	29	1,323,970	45,654	

Chondrus/Phyllophora Condition Index Study

Colonization values for Chondrus and Phyllophora for September, 1982 are presented in Table 8. Condition Index Values are presented in Table 9. An inspection of the data indicates that Phyllophora was more heavily colonized with both epiphytes and encrusting fauna than was Chondrus. The higher Phyllophora infestation values reflect a greater capability of tolerating increased stresses associated with heavy plant and animal colonization.

Epiphytic and epifaunal colonization values were highest at Manomet Point. Values are generally similar at Rocky Point and Effluent Stations. These results differ from those of August, 1981 where epiphytic colonization values for Chondrus were highest at Rocky Point and lowest at Effluent (BECo, 1982b); epiphytic colonization values for Phyllophora were similar at all three stations. Faunal colonization values of Chondrus in August, 1981 were highest at Effluent and lowest at Rocky Point. Values for all stations were generally similar in September, 1982 to what they have been in the past. There does not appear to be any direct correlation between epiphytic and epifaunal colonization and the PNPS discharge.

TABLE 8. COLONIZATION VALUES FOR CHONDRUS CRISPUS AND PHYLLOPHORA spp. FOR THE MANOMET POINT, EFFLUENT, AND ROCKY POINT SUBTIDAL (10' mlw) STATIONS FOR SEPTEMBER, 1982

A) CHONDRUS CRISPUS

Replicate	Algal Colonization			Faunal Colonization		
	Manomet Pt.	Rocky Pt.	Effluent	Manomet Pt.	Rocky Pt.	Effluent
1	3	2	1	3	2	1
2	2	3	1	3	3	1
3	2	1	2	2	1	1
4	1	2	1	2	1	1
5	2	1	2	3	1	3
TOTAL	10	9	7	13	8	7

B) PHYLLOPHORA spp.

Replicate	Algal Colonization			Faunal Colonization		
	Manomet Pt.	Rocky Pt.	Effluent	Manomet Pt.	Rocky Pt.	Effluent
1	3	3	1	4	4	4
2	3	2	2	4	3	3
3	2	2	3	3	3	2
4	3	2	3	4	2	3
5	3	2	2	4	3	3
TOTAL	14	11	11	19	15	15

TABLE 9: CONDITION INDEX VALUES FOR CHONDRUS CRISPUS AND PHYLLOPHORA SPP. FOR THE MANOMET POINT, ROCKY POINT, AND EFFLUENT SUBTIDAL (10' MLW) STATIONS FOR SEPTEMBER, 1982.

Chondrus crispus
Condition Index

Station	Collecting Period September, 1982
Manomet Point	23
Rocky Point	17
Effluent	14

Phyllophora spp.
Condition Index

Station	Collecting Period September, 1982
Manomet Point	33
Rocky Point	26
Effluent	26

SEDIMENT GRAIN SIZE ANALYSIS

Four of five replicates at the Effluent Station contained large amounts of sand. Analysis of the particle size distribution is presented in Table 10). All of the large particles (> .500 mm) are Mytilus edulis shell fragments. The 0.250 mm fraction is a mixture of shell fragments and quartz sand grains. The 0.125 mm fraction is mostly sand grains with a few shell splinters. The 0.63 mm fraction is mostly minute sand grains, shell splinters and miscellaneous organic debris.

The source of this sediment is undoubtedly a combination of destruction of Mytilus edulis shells in the area and transport and entrapment of sand particles. Sediment concentrations of this sort are not present at the Rocky Point and Manomet Point Stations. It is not known at this time if the occurrence at the Effluent Station is related to the warm water discharge, but must in some manner, be related to the destruction of mussel shells.

TABLE 10. PARTICLE SIZE DISTRIBUTION FOR SEDIMENT SAMPLES COLLECTED AT EFFLUENT STATION SEPTEMBER, 1982.

Replicate	ØSize	Diameter (mm)	Corrected Weight (g)	Cumulative Weight (g)	Cumulative Percent	Individual Percent
1	-	>2	14.5393	14.5393	40.37	40.37
	0	1-2	7.4900	22.0293	61.17	20.80
	1	0.5-1	7.5421	29.5714	82.11	20.94
	2	0.25-0.5	5.5120	35.0834	97.42	15.31
	3	0.125-0.25	0.8441	35.9275	99.76	2.34
	4	0.063-0.125	0.0856	36.0131	100.00	0.24
3*	-	>2	12.5465	12.5465	24.72	24.72
	0	1-2	6.5130	19.0595	37.56	12.83
	1	0.5-1	10.6165	29.6760	58.48	20.92
	2	0.25-0.5	18.2945	47.9705	94.53	36.05
	3	0.125-0.25	2.5345	50.5050	99.53	4.99
	4	0.063-0.125	0.2405	50.7455	100.00	0.47
4	-	>2	17.8939	17.8939	41.20	41.20
	0	1-2	9.3356	27.6295	63.61	22.41
	1	0.5-1	12.2471	39.8766	91.81	28.20
	2	0.25-0.5	2.5250	42.4016	97.62	5.81
	3	0.125-0.25	0.9241	43.3257	99.75	2.13
	4	0.063-0.125	0.1089	43.4346	100.00	0.25
5	-	>2	11.1560	11.1560	30.62	30.62
	0	1-2	8.5159	19.6719	53.99	23.37
	1	0.5-1	7.8008	27.4727	75.39	21.41
	2	0.25-0.5	8.1207	35.5934	97.68	22.29
	3	0.125-0.25	0.7403	36.3337	99.71	2.03
	4	0.063-0.125	0.1056	36.4393	100.00	0.29

* Replicate No. 2 was free of sediment.

QUALITATIVE TRANSECT SURVEY

The quarterly transect surveys were initiated in January, 1980 and have now been conducted seven times. A full review of these studies will be developed for the Annual Report in October. The results presented here discuss results of the two most recent transects performed in September and December, 1982.

September, 1982 Transect Survey

The extent of the denuded and stunted areas immediately offshore from the PNPS discharge is shown in Fig. 10. The denuded area is defined as being essentially devoid of Chondrus crispus, while the stunted area is identified as having Chondrus, but of a low height.

In September, the denuded zone extended to about 84 m offshore as measured from the mean high water mark on the discharge canal jetties. The denuded area extended further westward (left) of the center line of the transect reaching a maximum extent of 15 m in that direction. To the right, the denuded zone was more or less continuous out to the 80 m mark, extending no more than 6-9 m from the center line. The total denuded area was estimated at 1193 m^2.

Beyond the denuded zone, the stunted Chondrus generally followed the contour of the denuded zone, but bulged westward 25 m at the 30 and 60 m marks. The total area encompassed by the denuded and stunted zones covered approximately 2328 m^2.

December, 1982 Transect Survey

For December, the overall configuration of the denuded zone was similar to that seen in September, except for 15 m bulges on the westerly side at the 20 and 50 m marks (Fig. 11). The easterly side was again relatively constant, only extending 5-6 meters from the center line. The denuded zone extended out about 73 m along the center line, and encompassed a total area of about 856 m^2.

The stunted zone was characterized by a large westerly bulge located between the 30 and 60 m marks and extending outward for 35 m. The area occupied by this bulge was

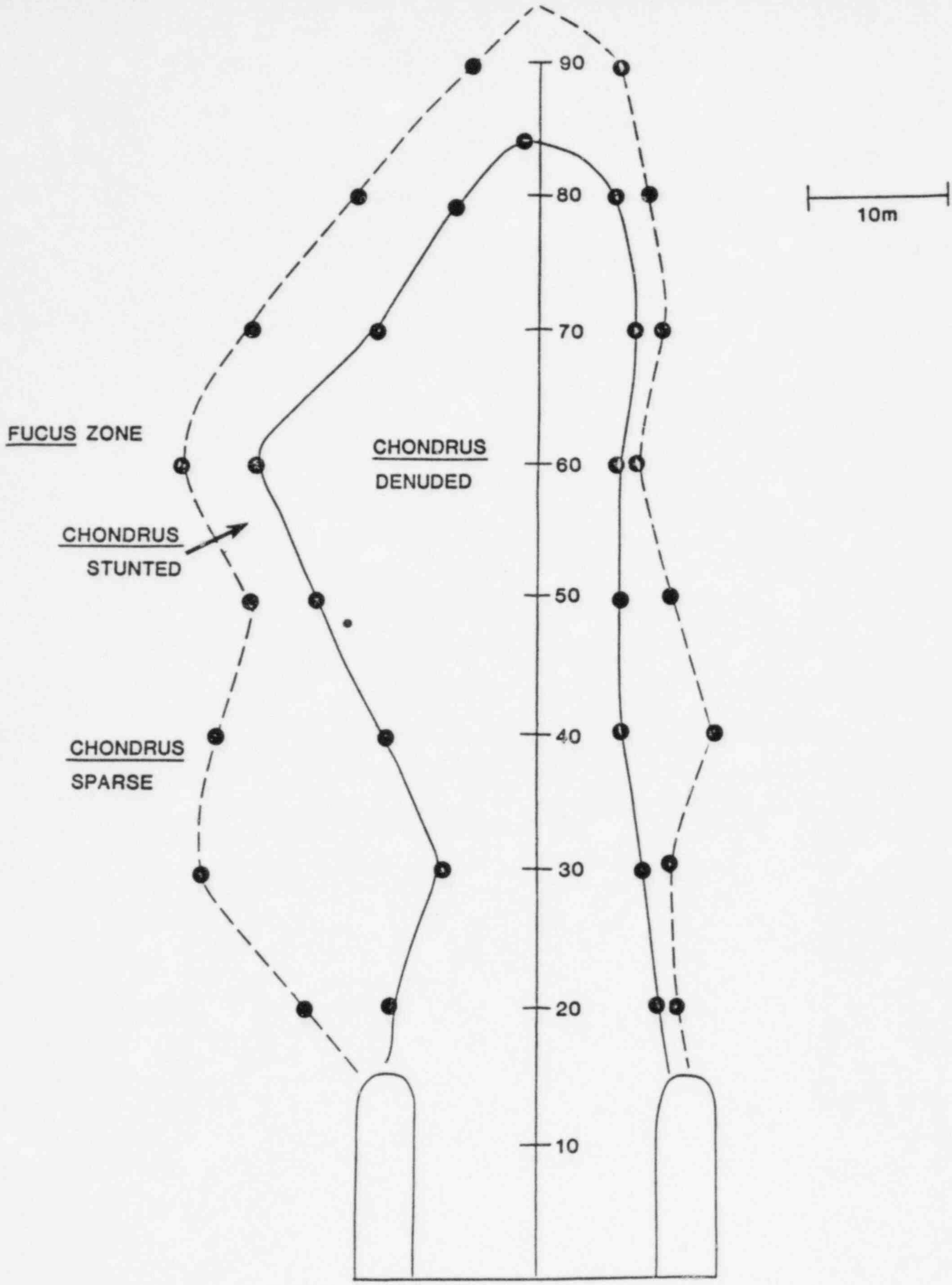

FIGURE 10. PILGRIM STATION, SEPTEMBER 24, 1982. CONFIGURATION OF THE CHONDRUS CRISPUS COMMUNITY IN THE VICINITY OF THE DISCHARGE CANAL.

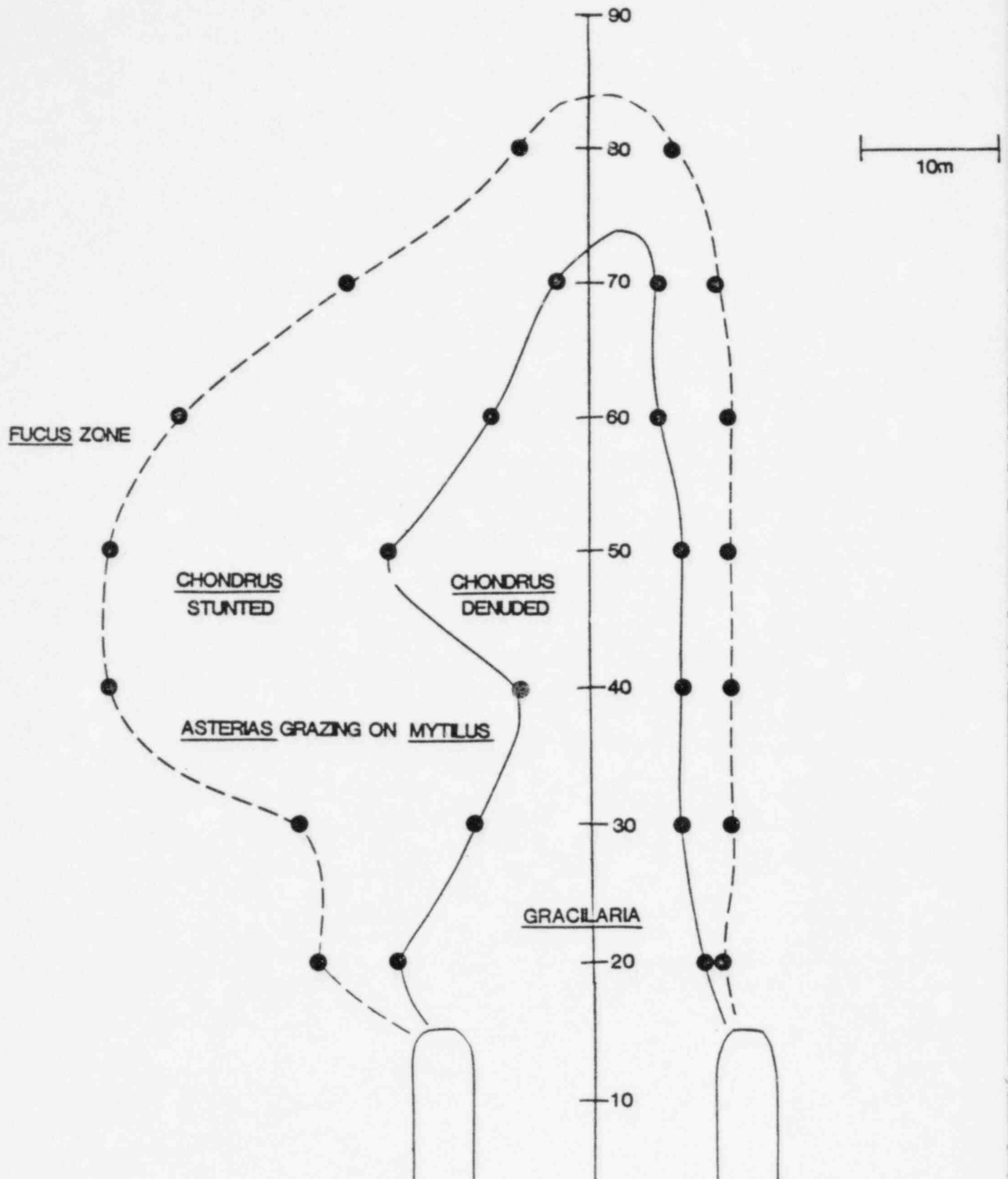

FIGURE 11. PILGRIM STATION, DECEMBER 1, 1982. CONFIGURATION OF THE CHONDRUS CR
COMMUNITY IN THE VICINITY OF THE DISCHARGE CANAL

shallow and the rocks were covered with juvenile Mytilus edulis which were being preyed upon by starfish (Asterias). The stunted zone was uniform on the easterly side, extending no more than 10 m from the center line. The stunted zone was identified outward to 85 m along the transect and encompassed a total area with the denuded zone of 2082 m^2.

Remarks

Data is now available from eight near-field mappings of the discharge area (Fig. 12). The data for 1982 is now complete. Except for the August, 1980 transect survey, the extent of the stunted and denuded areas have tended to increase and decrease roughly parallel with one another.

There is a tendency for the impacted area to increase in total area in spring and summer months and to be more restricted in the colder months. The condition of August, 1980 reflects the same pattern, if the stunted and denuded zones are taken together. It is possible that an enhancement effect is operative during winter months, where the impacted zone is reduced because of rapid cooling of the discharge water through mixing with cold seawater. Just enough warming effect is left in the stunted areas to promote good growth. In the summer months, the water does not cool as fast, and its effect is more extensive, with the algal growth inhibited.

In order to test this hypothesis, one approach would be to design an experiment to be conducted concurrently with the transect survey which would carefully document temperature changes over tidal cycles in correlation with current measurements. With this data and with Chondrus culture information from the literature, it should be possible to develop a model to predict how Chondrus responds to seasonal changes in warm water discharge in the nearfield area.

A transect dive was made on December 1, just one week following cessation of a dredging operation in the intake basin. Sediment stirred up during the dredging operation was passed through the cooling system and out the effluent canal, where a distinct plume was observed (Anderson, personal communication). Battelle divers reported no evidence of scouring or unusual sedimentation during this dive.

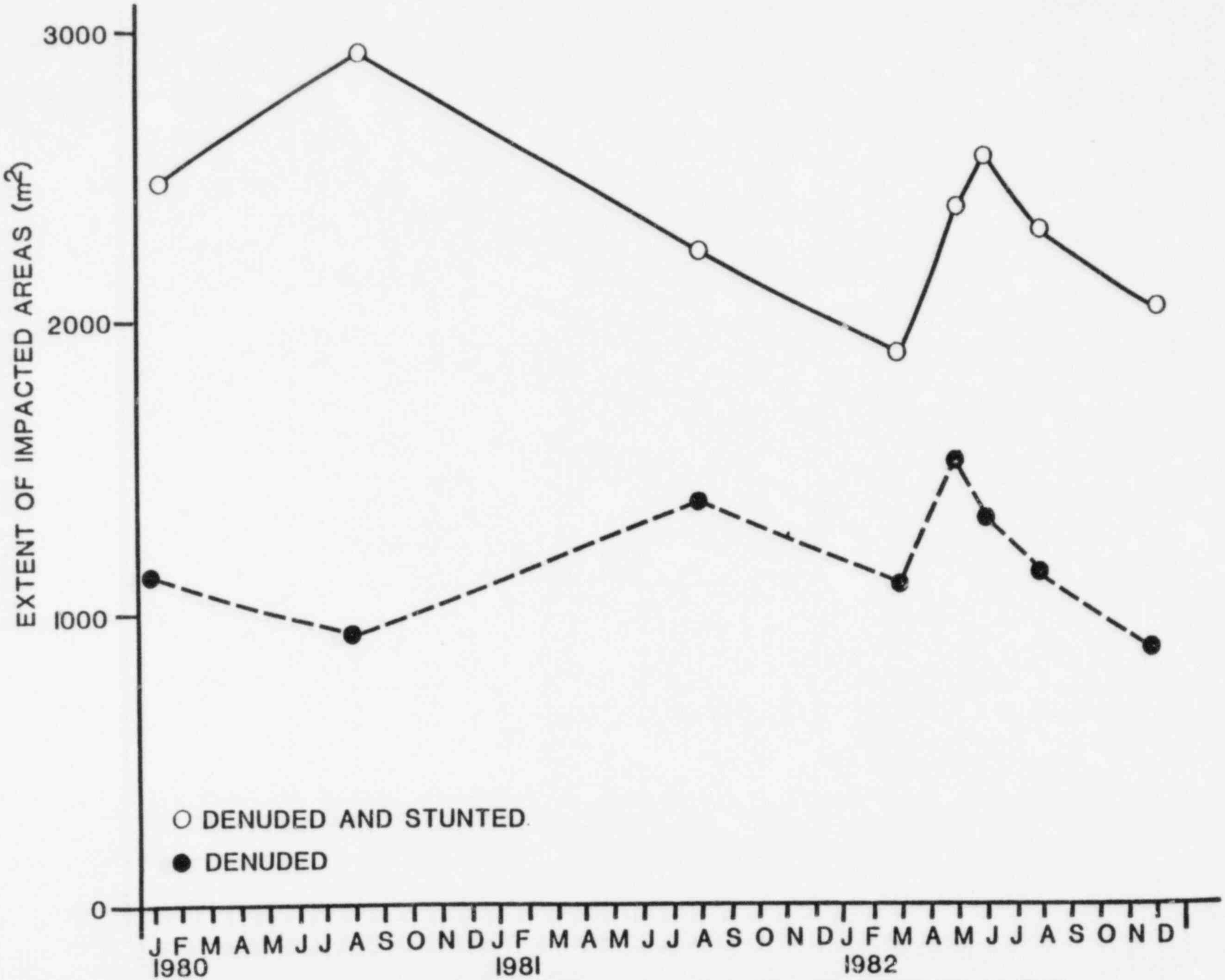

FIGURE 12. MEASUREMENTS OF DENUDED AND STUNTED AREAS IN THE

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APPENDIX 1

APPENDIX I. ALGAL SPECIES COLLECTED FROM THE REPLICATE SAMPLES OF THE EFFLUENT, ROCKY POINT, AND MANOMET POINT SUBTIDAL (10' MLW) STATIONS FOR THE SEPTEMBER, 1982 COLLECTING PERIOD.

Division Species	Effluent					Rocky Point					Manomet Point				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
CHLOROPHYTA (green algae)															
Bryopsis plumosa									R						
Chaetomorpha linum	C	O	O	C	O	O	O	O	C	C	R	C	O	O	O
C. melagonium	R	R	O	O	O	O	C	O	C	C	C	C	O	O	C
Enteromorpha flexuosa	A	A	A	C	C	R		R		R					
Rhizoclonium riparium	C	C	O	O	R	R	R	R	R	R	R	R	R	R	R
Ulva lactuca	R	R	R	R	R	R		R	O	O	R	R	R	O	R
PHAEOPHYTA (brown algae)															
Chordaria flagelliformis															
Desmarestia aculeata						R							R		
D. viridis															
Laminaria digitata						R		R			R	R		R	
L. saccharina						R		R			R	R		R	
Sphacelaria cirrosa	A	O	O	O	C	A	O	R	R	R	R				R
RHODOPHYTA (red algae)															
Ahnfeltia plicata	O	R	A	C	A	C	R	O	O	C		R	R		R
Antithamnion americanum	R		R		O	O	R	R	O		R	R	R	R	R
Bonnemaisonia hamifera						R									
Callophyllis cristata															
Ceramium rubrum	A	A	A	A	C	A	C	O	C	C	O	C	C	C	C
Chondrus crispus	A	A	R	R	O	O	C	R	O	O	C	C	C	R	C
Corallina officinalis	R	R	R	O	O	R	R	O	O	O	R	O	R	O	O
Cystoclonium purpureum	O	O	R	O	O	C	C	O	O	O	O	C	C	C	C
Gracilaria foliifera	R	R	R		R										
Gymnogongrus crenulatus											R				
Membranoptera alata	R				R	R									
Palmaria palmata															
Phycodrys rubens		R					R	R	R	R	O	O	R	C	R
Phyllophora truncata	O	O	O	O	O	O	O	O	O	O	O	O	O	A	O
P. pseudoceranoides	O	O	R	O	O	O	O	O	O	O	O	O	O	O	O
P. traillii											R	R			
Plumaria elegans															
Polyides rotundus	R		C	A	C	A		A	C	O					
Polysiphonia elongata				R											
P. fibrillosa	R	C	R			A	O	O	O	R	O	O	O	O	O
P. harveyi	O	C	C	A	A	A	C	C	C	C	A	A	A	A	A
P. nigrescens	R	O	O	O	O	C	O	R	R	O		R	R	F	R
P. urceolata	O	O	O	C	C	C	C	R	C	O	R	R	R	R	R
Rhodomeia confervoides	R	R	R		R	R		R	R	R					R
Spermothamnion repens	O	O	C	C	C	C	C	C	C	C	O	O	C	C	O
Replicate species richness	23	21	22	19	22	26	18	25	21	21	21	21	19	19	20
Station species richness			25					28					24		

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

APPENDIX 2

APPENDIX 2. REPLICATE (TOTAL NUMBERS OF INDIVIDUALS PER SPECIES) AND STATION (NUMBERS OF INDIVIDUALS PER SPECIES PER M^2) FAUNAL DATA FOR EFFLUENT STATION SEPTEMBER, 1982.

PHYLUM	Replicate					Station
Species	1	2	3	4	5	(No./m^2)
COELENTERATA						
Haliclystis salpinx	--	--	--	--	--	--
Metridium senile	68	52	12	56	68	460.8
PLATYHELMINTHES						
Notoplana atomata	--	4	--	--	--	7.2
NEMERTEA						
Nemertea sp.	--	96	--	8	24	230.4
MOLLUSCA						
Acmaea testudinalis	--	4	--	--	--	7.2
Aeolidia papillosa	72	56	72	36	68	547.2
Alvania pseudoareolata	--	--	--	--	--	--
Anachis avara	--	--	--	--	--	--
Anachis translirata	--	--	--	--	--	--
Anomia simplex	--	--	--	--	--	--
Anomia sp.	--	--	--	--	--	--
Anomia squamula	--	--	--	--	--	--
Cerastoderma pinnulatum	--	--	--	--	--	--
Cingula aculeus	--	4	--	--	--	7.2
Crepidula fornicata	32	24	4	20	16	172.8
Diaphana minuta	--	--	--	--	--	--
Doto coronata	--	8	--	--	--	14.4
Ensis directus	--	--	--	--	--	--
Facelina bostoniensis	--	--	--	--	--	--
Hiatella arctica	16	16	--	16	--	86.4
Ishnochiton ruber	--	--	--	--	--	--
Lacuna vincta	80	--	--	16	40	244.8
Mysella planulata	120	56	4	28	44	252.0
Margarites helicinia	32	--	--	--	--	57.6
Mitrella lunata	48	--	8	4	16	15.2
Modiolus modiolus	--	--	--	--	--	--
Mytilus edulis	3,156	1,564	252	340	1,972	13,111.2
Mytilus sp.	--	--	--	--	--	--
Nassarius vibex	--	--	--	8	--	14.4
Odostomia gibbosa	--	--	--	--	--	--
Omalogyra atomus	--	--	--	--	--	--
Onchidoris aspera	12	--	4	4	8	50.4
Pandora sp.	--	--	--	--	--	--
Spisula solidissma	--	--	--	--	--	--
Tellina agilis	12	4	8	--	--	43.2
Turbonilla sumneri	--	4	--	--	--	7.2
ANNELIDA						
Amphitrite johnsoni	--	--	--	--	--	--
Aricidea catherinae	--	--	4	--	--	7.2
Asabellides oculata	--	--	--	--	--	--

PHYLUM Species	Replicate 1	 2	 3	 4	 5	Station (No./m²)
Autolytus cornutus	--	--	--	4	--	7.2
Autolytus prismaticus	--	--	--	--	--	--
Capitella capitata	8	4	140	16	20	338.4
Caulleriella bioculata	--	--	--	--	--	--
Cirratulidae sp. A	--	--	--	--	--	--
Dodecaceria sp.	24	4	--	--	--	50.4
Eteone longa	--	--	4	--	4	14.4
Eulalia bilineata	--	--	8	16	--	43.2
Eulalia viridis	28	8	--	--	40	76.0
Eumida sanguinea	--	--	12	--	--	21.6
Harmothoe extenuata	8	--	--	4	4	28.8
Harmothoe imbricata	24	8	12	--	12	100.8
Lepidonotus squamatus	4	4	8	8	4	50.4
Naineris quadricuspida	--	--	--	--	4	7.2
Nephtys bucera	--	--	12	--	--	21.6
Nephtys picta	--	--	--	--	--	--
Nephtys sp. (juv.)	--	--	--	--	--	--
Nereis pelagica	8	4	16	4	12	79.2
Nicolea zostericola	16	--	8	--	--	43.2
Oligochaeta sp.	--	--	4	--	--	7.2
Pectinaria granulata	--	--	4	--	--	7.2
Peloscolex apectinatus	--	--	4	--	--	7.2
Pholoe minuta	32	--	24	8	24	158.4
Phyllodoce maculata	4	20	4	28	64	216.0
Polycirrus sp. A	--	--	4	--	4	14.4
Polydora giardi	--	--	--	--	4	7.2
Polydora socialis	--	4	--	--	--	7.2
Polygordius sp.	--	--	52	4	--	100.8
Potamilla sp.	--	--	--	--	--	--
Potamilla reniformis	--	--	--	--	--	--
Pygospio elegans	--	--	--	--	--	--
Sabellaria vulgaris	--	4	--	--	--	7.2
Spio cf. armata	--	--	--	--	--	--
Schistomeringos caeca	--	--	4	--	--	7.2
Terebellidae	--	--	--	--	--	--
Tharyx acutus	--	--	16	--	--	28.8
Tubifex pseudogaster	--	--	4	--	--	7.2
Typosyllis sp.	--	--	--	--	--	--
ARTHROPODA						
Acarina sp.	620	328	248	860	784	5,112.0
Achelia scabra	--	--	--	--	--	--
Achelia spinosa	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Ampithoe rubricata	8	8	--	16	4	64.8
Anoplodactylus lentus	--	--	--	--	--	--
Brachyura (megalopa)	8	--	--	4	4	28.8
Calliopius laevisculus	1,608	348	388	508	1,204	7,300.8
Cancer irroratus	32	4	52	20	56	295.2
Caprella linearis	4	8	20	16	20	122.4
Caprella penantis	408	348	1,552	628	784	6,696.0
Caridea indet.	--	--	--	--	--	--

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m^2)
Corophium acutum	3,296	680	588	672	4,416	9,652.0
Corophium bonelli	3,936	1,540	2,124	2,260	6,876	16,736.0
Crangon septemspinosa	--	--	--	--	--	--
Decapoda indet.	--	--	--	--	--	--
Dexamine thea	288	--	384	240	148	1,908.0
Diastylis sculpta	--	--	--	--	--	--
Diastylis sp.	--	--	8	4	--	21.6
Edotea trilobata	4	--	--	--	--	7.2
Eualus pusiolus	--	--	--	--	--	--
Idotea balthica	132	24	36	48	84	583.2
Idotea phosphorea	252	200	112	120	296	1,764.0
Ischyrocerus anguipes	--	16	32	8	80	27.2
Jaera marina	8	--	--	--	--	14.4
Jassa falcata	24,840	6,792	1,304	4,500	22,080	107,128.0
Lamprops quadriplicata	--	--	--	--	--	--
Nantantia indet.	--	--	--	--	--	--
Pagurus acadianus	--	--	--	--	4	7.2
Pagurus sp.	--	--	4	--	--	7.2
Phoxocephalus holbolli	4	--	4	--	--	14.4
Pleusymtes glaber	--	4	4	--	--	14.4
Pontogeneia inermis	--	--	12	4	--	21.6
Proboloides holmesi	28	--	--	8	--	64.8
Stenopleustes inermis	--	--	--	--	--	--
Tanystylum orbiculare	--	--	--	--	--	--
Rhepoxynius hudsoni	--	--	12	--	--	21.6
ECHINODERMATA						
Amphipholis squamata	--	4	--	4	--	14.4
Asterias forbesi	104	108	52	60	64	698.4
Echinarachius parma	--	--	--	--	--	--
Henricia sanguinolenta	--	--	--	--	--	--
Ophiopholis aculeata	4	4	-	4	-	21.6
Strongylocentrotus droebachiensis	--	--	--	--	--	-
CHORDATA						
Colonial Ascidacea	--	--	--	--	--	--
Solitary Ascidacea	--	--	--	--	--	--

APPENDIX 3

APPENDIX 3. REPLICATE (TOTAL NUMBERS OF INDIVIDUALS PER SPECIES) AND STATION (NUMBERS OF INDIVIDUALS PER SPECIES PER M^2) FAUNAL DATA FOR MANOMET POINT SEPTEMBER, 1982.

PHYLUM Species	Replicate 1	 2	 3	 4	 5	Station (No./m^2)
COELENTERATA						
Haliclystis salpinx	--	--	--	--	4	7.2
Metridium senile	--	--	--	--	--	--
PLATYHELMINTHES						
Notoplana atomata	--	--	4	8	--	21.6
NEMERTEA						
Nemertea sp.	12	36	24	12	--	151.2
MOLLUSCA						
Acmaea testudinalis	--	--	--	16	4	36
Aeolidia papillosa	--	--	--	--	--	--
Alvania pseudoareolata	--	--	--	--	--	--
Anachis avara	--	--	--	8	--	14.4
Anachis translirata	--	--	--	--	--	--
Anomia simplex	12	--	12	8	--	57.6
Anomia sp.	--	8	--	--	--	14.4
Anomia squamula	--	--	--	--	--	--
Cerastoderma pinnulatum	4	40	8	48	32	244.8
Cingula aculeus	36	16	20	8	12	165.6
Crepidula fornicata	4	8	9	20	8	86.4
Diaphana minuta	--	4	--	--	4	14.4
Doto coronata	--	--	--	--	8	14.4
Ensis directus	--	--	--	--	--	--
Facelina bostoniensis	20	8	28	4	8	122.4
Hiatella arctica	116	280	140	108	144	1,418.4
Ishnochiton ruber	--	--	--	4	4	14.4
Lucuna vincta	220	92	176	112	84	1,231.2
Mysella planulata	--	24	--	24	4	93.6
Margarites helicinia	184	272	400	432	120	2,534.4
Mitrella lunata	68	--	8	44	20	252.0
Modiolus modiolus	40	52	40	56	60	446.4
Mytilus edulis	1,284	1,388	2,436	3,268	1,484	17,748.0
Mytilus sp.	--	1,560	2,456	--	--	7,228.8
Nassarius vibex	--	--	--	--	--	--
Odostomia gibbosa	--	--	--	--	--	--
Omalogyra atomus	--	--	--	--	--	--
Onchidoris aspera	32	92	100	44	44	561.6
Pandora sp.	--	12	--	--	--	21.6
Spisula solidissma	4	12	--	12	4	57.6
Tellina agilis	4	40	--	88	12	259.2
Turbonilla sumneri	--	--	--	4	--	7.2
ANNELIDA						
Amphitrite johnsoni	--	--	--	--	--	--
Aricidea catherinae	--	--	--	--	--	--
Asabellides oculata	4	8	8	--	12	58.5

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m^2)
Autolytus cornutus	--	--	4	--	--	7.2
Autolytus prismaticus	--	--	4	--	--	7.2
Capitella capitata	--	8	8	8	--	43.2
Caulleriella bioculata	4	12	28	--	28	129.6
Cirratulidae sp. A	--	--	--	--	4	7.2
Dodecaceria sp.	4	4	12	--	4	43.2
Eteone longa	--	--	--	--	--	--
Eulalia bilineata	--	--	--	16	8	43.2
Eulalia viridis	12	4	20	--	--	64.8
Eumida sanguinea	--	12	--	--	--	21.6
Harmothoe extenuata	16	28	24	4	20	165.6
Harmothoe imbricata	20	48	36	12	44	288.0
Lepidonotus squamatus	8	8	--	4	8	50.4
Naineris quadricuspida	--	4	12	--	--	28.8
Nephtys bucera	--	--	--	--	--	--
Nephtys picta	--	--	--	--	--	--
Nephtys sp. (juv.)	--	--	52	--	--	93.6
Nereis pelagica	8	20	--	28	8	115.2
Nicolea zostericola	292	220	320	296	408	2,764.8
Oligochaeta sp.	--	--	--	--	--	--
Pectinaria granulata	--	--	--	--	--	--
Peloscolex apectinatus	--	--	--	--	--	--
Pholoe minuta	--	--	4	--	12	28.8
Phyllodoce maculata	4	8	8	4	--	43.2
Polycirrus sp. A	4	--	--	--	--	7.2
Polydora giardi	4	--	20	--	8	57.6
Polydora socialis	4	4	4	8	--	36.0
Polygordius sp.	--	--	--	--	--	--
Potamilla sp.	--	--	4	--	--	7.2
Potamilla remiformis	--	--	--	--	4	7.2
Pygospio elegans	--	--	--	--	4	7.2
Sabellaria vulgaris	--	--	4	4	--	14.4
Spio cf. armata	--	--	--	--	--	--
Schistomeringos caeca	--	--	--	--	--	--
Terebellidae	--	--	4	--	--	7.2
Tharyx acutus	--	--	--	--	--	--
Tubifex pseudogaster	--	--	--	--	--	--
Typosyllis sp.	--	--	--	--	--	--
ARTHROPODA						
Acarina sp.	136	244	1,064	1,264	1,024	6,717.6
Achelia scabra	--	--	--	--	--	--
Achelia spinosa	--	--	--	--	--	--
Amphipoda	--	--	--	1	--	1.8
Ampithoe rubricata	76	84	64	72	60	640.8
Anoplodactylus lentus	--	--	--	--	4	7.2
Brachyura indet.	--	--	--	--	--	--
Calliopius laevisculus	260	124	396	308	432	2,736.0
Cancer irroratus	12	8	8	12	8	86.4
Caprella linearis	40	60	256	284	244	1,591.2
Caprella penantis	476	224	836	344	444	4,183.2
Caridea indet.	--	4	--	--	--	7.2

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m²)
Corophium acutum	296	240	544	1,256	232	4,622.4
Corophium bonelli	288	532	248	640	180	3,398.4
Crangon septemspinosa	--	--	--	--	--	--
Decapoda indet.	--	--	--	--	--	--
Dexamine thea	120	304	296	316	168	2,167.2
Diastylis sculpta	4	--	8	--	8	36.0
Diastylis sp.	--	--	--	--	--	--
Edotea triiobata	--	--	8	--	--	14.4
Eualus pusiolus	--	--	12	16	16	79.2
Idotea balthica	4	--	8	12	24	86.4
Idotea phosphorea	136	148	124	264	188	1,548.0
Ischyrocerus anguipes	564	228	748	712	396	4,766.0
Jaera marina	--	--	--	--	--	--
Jassa falcata	1,156	544	2,008	4,160	964	15,898.0
Lamprops quadriplicata	--	--	--	--	--	--
Natantia indet.	--	4	4	4	--	21.6
Pagurus acadianus	--	--	--	--	--	--
Pagurus sp.	--	--	--	--	--	--
Phoxocephalus holbolli	--	--	--	4	--	7.2
Pleusymtes glaber	712	516	772	628	552	5,724.0
Pontogeneia inermis	--	52	148	144	168	921.6
Proboloides holmesi	20	12	132	140	116	756.0
Stenopleustes inermis	60	--	--	--	--	108.0
Tanystylum orbiculare	--	--	--	--	--	--
Rhepoxynius hudsoni	--	--	--	--	--	--
ECHINODERMATA						
Amphipholis squamata	4	48	20	24	28	223.2
Asterias forbesi	36	52	60	56	44	446.4
Echinarachius parma	--	--	--	20	--	36.0
Henricia sanguinolenta	4	--	--	--	--	7.2
Ophiopholis aculeata	12	24	12	12	16	136.8
Strongylocentrotus droebachiensis	48	48	20	--	24	252
CHORDATA						
Colonial Ascidacea	12	--	--	--	--	21.6
Solitary Ascidacea	4	--	--	--	--	7.2

APPENDIX 4

APPENDIX 4. REPLICATE (TOTAL NUMBERS OF INDIVIDUALS PER SPECIES) AND STATION (NUMBERS OF INDIVIDUALS PER SPECIES PER M^2) FAUNAL DATA FOR ROCKY POINT, SEPTEMBER, 1982.

PHYLUM	Replicate					Station
Species	1	2	3	4	5	(No./m^2)
COELENTERATA						
Haliclystis salpinx	--	12	--	8	--	36.0
Metridium senile	--	--	--	4	--	7.2
PLATYHELMINTHES						
Notoplana atomata	--	4	4	--	--	14.4
NEMERTEA						
Nemertea sp.	120	136	40	--	56	633.6
MOLLUSCA						
Acmaea testudinalis	--	12	4	12	--	50.4
Aeolidia papillosa	--	--	--	--	--	--
Alvania pseudoareolata	12	16	8	20	16	129.6
Anachis avara	--	--	--	--	--	--
Anachis translirata	--	--	--	--	--	--
Anomia simplex	4	--	16	--	--	36.0
Anomia sp.	--	--	--	--	--	--
Anomia squamula	--	--	--	--	8	14.4
Cerastoderma pinnulatum	16	20	20	12	12	144.0
Cingula aculeus	264	64	376	196	192	1,965.6
Crepidula fornicata	16	12	16	36	28	194.4
Diaphana minuta	8	20	4	8	8	86.4
Doto coronata	--	--	--	--	--	--
Ensis directus	--	--	4	--	--	7.2
Facelina bostoniensis	4	8	--	4	8	43.2
Hiatella arctica	356	304	268	136	224	2,318.4
Ishnochiton ruber	--	4	12	--	--	28.8
Lacuna vincta	620	196	192	248	244	2,700.0
Mysella planulata	88	16	28	4	60	352.8
Margarites helicinia	364	984	616	564	632	5,688.0
Mitrella lunata	32	48	28	16	48	309.6
Modiolus modiolus	48	12	60	56	24	360.0
Mytilus edulis	1,480	1,888	1,672	960	1,172	12,909.6
Mytilus sp.	--	--	--	--	--	--
Nassarius vibex	--	--	--	--	--	--
Odostomia gibbosa	--	--	--	--	4	7.2
Omalogyra atomus	12	--	4	--	8	43.2
Onchidoris aspera	80	120	72	180	88	972.0
Pandora sp.	--	--	--	--	--	--
Spisula solidissma	8	--	--	--	--	14.0
Tellina agilis	44	--	12	16	8	80.0
Turbonilla sumneri	--	--	--	--	--	--
ANNELIDA						
Amphitrite johnsoni	--	--	--	4	--	7.2
Aricidea catherinae	--	--	--	--	--	--
Asabellides oculata	4	--	--	4	8	28.8

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m²)
Autolytus cornutus	--	--	--	--	--	--
Autolytus prismaticus	--	--	--	--	--	--
Capitella capitata	20	--	--	--	--	36.0
Caulleriella bioculata	--	--	8	--	--	14.4
Cirratulidae sp. A	--	--	--	--	--	--
Dodecaceria sp.	4	4	--	--	4	21.6
Eteone longa	--	--	--	--	--	--
Eulalia bilineata	--	28	--	32	--	108.0
Eulalia viridis	--	--	4	--	8	21.6
Eumida sanguinea	--	--	--	--	--	--
Harmothoe extenuata	32	32	--	12	12	158.4
Harmothoe imbricata	64	68	32	68	44	496.8
Lepidonotus squamatus	--	8	4	12	8	57.6
Naineris quadricuspida	8	--	4	--	--	21.6
Nephtys bucera	--	--	--	--	--	--
Nephtys picta	--	--	4	--	--	7.2
Nephtys sp. (juv.)	4	--	--	--	--	7.2
Nereis pelagica	24	36	24	16	36	244.8
Nicolea zostericola	176	324	124	136	288	1,886.4
Oligochaeta sp.	--	--	--	--	--	--
Pectinaria granulata	--	--	--	--	--	--
Peloscolex apectinatus	--	--	--	--	--	--
Pholoe minuta	160	28	72	32	32	583.2
Phyllodoce maculata	16	4	8	4	20	93.6
Polycirrus sp. A	--	--	--	--	--	--
Polydora giardi	--	4	--	--	--	7.2
Polydora socialis	--	--	--	4	--	7.2
Polygordius sp.	--	--	--	--	--	--
Potamilla sp.	--	--	--	--	--	--
Potamilla reniformis	--	--	--	--	4	7.2
Pygospio elegans	--	--	--	--	--	--
Sabellaria vulgaris	--	--	--	--	4	7.2
Spio cf. armata	--	--	4	--	--	7.2
Schistomeringos caeca	--	--	--	--	--	--
Terebellidae	--	--	--	--	--	--
Tharyx acutus	--	4	--	--	--	7.2
Tubifex pseudogaster	--	--	--	--	--	--
Typosyllis sp.	4	--	--	--	--	7.2
ARTHROPODA						
Acarina sp.	344	924	260	200	384	3,801.6
Achelia scabra	--	--	--	--	--	--
Achelia spinosa	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Ampithoe rubricata	20	40	20	20	12	201.6
Anoplodactylus lentus	--	--	--	--	--	--
Brachyura indet.	--	--	--	--	--	--
Calliopius laevisculus	168	328	124	148	144	1,641.6
Cancer irroratus	12	4	12	16	--	79.2
Caprella linearis	64	252	96	160	136	1,274.4
Caprella penantis	756	740	312	652	564	5,443.7
Caridea indet.	--	--	--	--	--	--

PHYLUM Species	Replicate 1	2	3	4	5	Station (No./m^2)
Corophium acutum	144	1,196	396	356	376	4,442.4
Corophium bonelli	808	1,540	2,500	904	2,312	14,515.2
Crangon septemspinosa	--	--	--	--	--	--
Decapoda indet.	--	--	4	--	--	7.2
Dexamine thea	1,428	1,404	708	824	884	9,446.4
Diastylis sculpta	4	--	--	--	--	7.2
Diastylis sp.	--	--	4	--	4	14.4
Edotea trilobata	4	4	--	4	--	21.6
Eualus pusiolus	16	16	8	24	56	216.0
Idotea balthica	16	72	4	4	24	216
Idotea phosphorea	56	416	52	60	144	1,310.4
Ischyrocerus anguipes	96	532	168	212	212	2,196
Jaera marina	--	--	--	--	--	--
Jassa falcata	184	1,844	340	284	348	5,400.0
Lamprops quadriplicata	--	--	--	--	--	--
Natantia indet.	--	--	--	--	--	--
Pagurus acadianus	--	--	--	--	--	--
Pagurus sp.	--	--	--	--	--	--
Phoxocephalus holbolli	68	4	48	60	20	360.0
Pleusymtes glaber	246	380	496	484	340	3,502.8
Pontogeneia inermis	152	100	80	136	108	1,036.8
Proboloides holmesi	--	--	--	--	--	--
Stenopleustes inermis	--	--	--	--	--	--
Tanystylum orbiculare	--	--	--	--	--	--
Rhepoxynius hudsoni	--	--	--	--	--	--
ECHINODERMATA						
Amphipholis squamata	20	20	16	12	36	187.2
Asterias forbesi	24	32	12	--	20	115.2
Echinarachius parma	--	--	--	--	--	--
Henricia sanguinolenta	--	--	--	4	4	14.4
Ophiopholis aculeata	4	32	12	40	8	172.8
Strongylocentrotus droebachiensis	40	12	24	48	12	244.8
CHORDATA						
Colonial Ascidacea	--	8	--	--	--	14.4
Solitary Ascidacea	--	--	--	--	--	--

NUC72-A

INVESTIGATIONS OF ENTRAINMENT OF ICHTHYOPLANKTON AT PILGRIM NUCLEAR POWER STATION 1982

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April 1983

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*Appendix available upon request

FIGURES

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*Appendix available upon request.

1982 ENTRAINMENT STUDY

SUMMARY

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

Eggs and/or larvae of 37 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 August 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 - October. Hake (*Urophycis* spp.) and rockling (*Enchelyopus cimbrius*) were abundant in June - September. Menhaden (*Brevoortia tyrannus*) were most abundant in September.

Larval collections were dominated by sand lance (*Ammodytes* sp.) during the months of January through March and December. 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. Cunner were abundant June - August, rockling in May, and July - September, and hake from August - October. Atlantic mackerel were most abundant in June, and menhaden in September - October. 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) during 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.

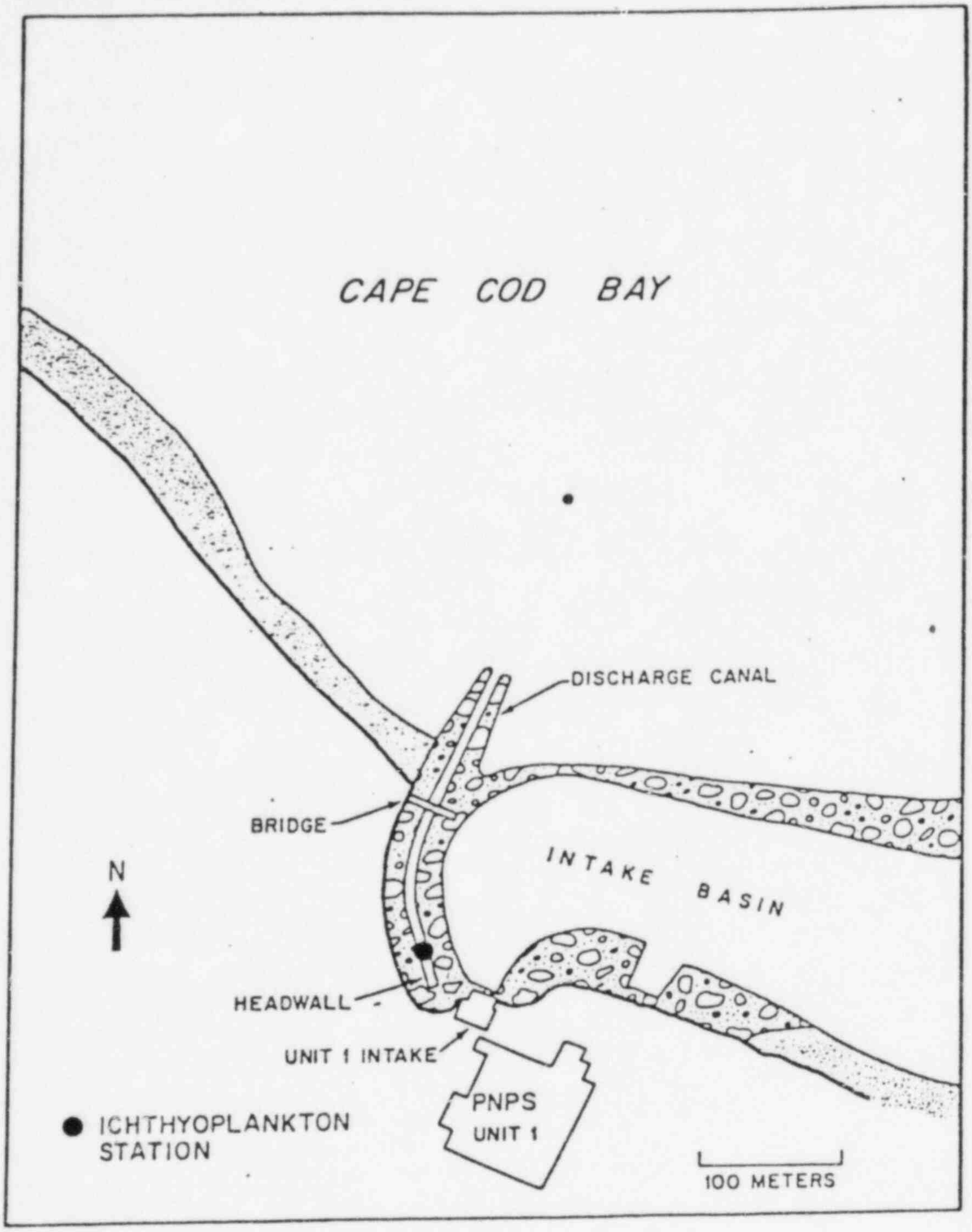

Figure 1: Entrainment sampling station in PNPS discharge canal.

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.

Several 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 in 1982 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 1974-1982 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 1975-1982.

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, of 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.

July: Fourteen of the 18 species found in July were represented by eggs. Labrid eggs clearly dominated among these, as they did in June, accounting for 94% of the total (if yellowtail flounder eggs are considered to have been absent from the labrid-Limanda grouping; see footnote for June). Mean densities for both labrid and labrid - Limanda eggs combined ranged from 120.4 to 2,126 per $100m^3$. Flounder, rockling, hake, cusk and bay anchovies counted for most of the remaining eggs in the samples.

Rockling were most abundant among the 10 species of larvae collected. They accounted for 34% of the month's larval catch with weekly mean densities ranging between 0.6 and 2.6 per $100m^3$. Cunner was in a close second place comprising 31% of the catch. Northern pipefish, tautog (*Tautoga onitis*), anchovy and radiated shanny composed most of the remaining larvae. The number of species collected was down from the 20 of the previous year.

August: Fifteen species were represented by eggs. Labrids retained their dominant position from July, accounting for 78% of the larvae. Windowpane, hake, rocking and butterfish when totaled together, accounted for 18.7% of the egg catch. The windowpane group was less well represented than in August 1981, with only 7% of the catch. The weekly labrid mean density, per $100m^3$ of water, ranged from 743 on August 3 to 0.4 on August 31.

The number of species represented by larvae was 16. Cunner, rockling and hake accounted for 56, 26, and 6% of the month's larval catch, respectively. Weekly mean densities, per 100m^3 of water, for these species ranged from 1.7 to 25.1 for the cunner, 0.4 to 10.4 for the rockling, and 0 to 2.2 for hake. The mean number of larvae for the month increased from 3.7 in July to 11.3 in August (see Table 3).

Sept: Thirteen species were represented by eggs in this month's collections. In contrast to Sept. 1981, Atlantic menhaden composed 81% of the catch. Windowpane, hake and rockling combined accounted for 16% of the month's catch assuming no fourspot flounder or butterfish eggs were taken among the Enchelyopus - Urophycis - Peprilus and Paralichthys - Scophthalmus egg groups. Weekly densities ranges, per 100m^3 of water, were from 0 to 2,533 for menhaden, 39-312 for the windowpane group, 0 to 28.9 for rockling eggs and 0.6 to 44.1 for the hakes. The remaining eggs were those of goosefish and searobin. The mean numbers of eggs were considerably higher than in September 1981.

Larval collections contained 13 species. Hake composed 33% of the catch, followed by rockling with 20% and menhaden with 20%. These were followed by windowpane which represented 17%. Hake weekly mean densities ranged from 0.6 to 14.4 per 100m^3 of water. Cunner, fourspot flounder and the northern pipefish accounted for most of the remaining catch. A small number of butterfish and anchovy were also found.

October: The number of species represented by eggs was five out of a total of seven species. Windowpane ranked first with 63% of the catch, with rockling, menhaden, and hake and two other species incidental. Monthly mean densities, per $100m^3$ of water, were 1.3 for windowpane, 0.3 for rockling, 0.2 for menhaden and 0.2 for the Enchelyopus - Urophycis -Peprilus group.

Five species of larvae were found in the October collections. Hake, menhaden, and tautog accounted for 92% of the catch with monthly mean densities of 1.7, 0.5 and 0.2 per $100m^3$, respectively. Windowpane were also represented.

November: The Atlantic cod were the only eggs in this month's egg collections. The mean density of cod eggs per $100m^3$ was 0.4 and there was just one collection in November on the 9th.

No larvae were collected in November.

December: Only cod eggs and labrid eggs were identified in the December egg collections with cod accounting for 96% of the catch and labrid eggs for the remainder. Mean densities per $100m^3$ recorded on December 7 and 21 were 0.4 and 3.6, respectively for cod, and 0.2 on December 7 only for labrids.

Three species were found among the larvae. Sand lance accounted for 94% of the total with mean densities per $100m^3$ of water of 24.7 on December 21. Cod (3%) and menhaden (3%) composed the remainder of the larval catch.

Table 2 summarizes by year all species by eggs and larvae collected in the PNPS discharge canal from 1974-1982. Monthly mean densities for the numerically dominant species of eggs and larvae taken in 1982 are summarized in Table 3. Similar data for 1975 through 1979 were also tabulated for comparision 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.

B. Lobster Larvae Entrained

In the period 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:	1 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.

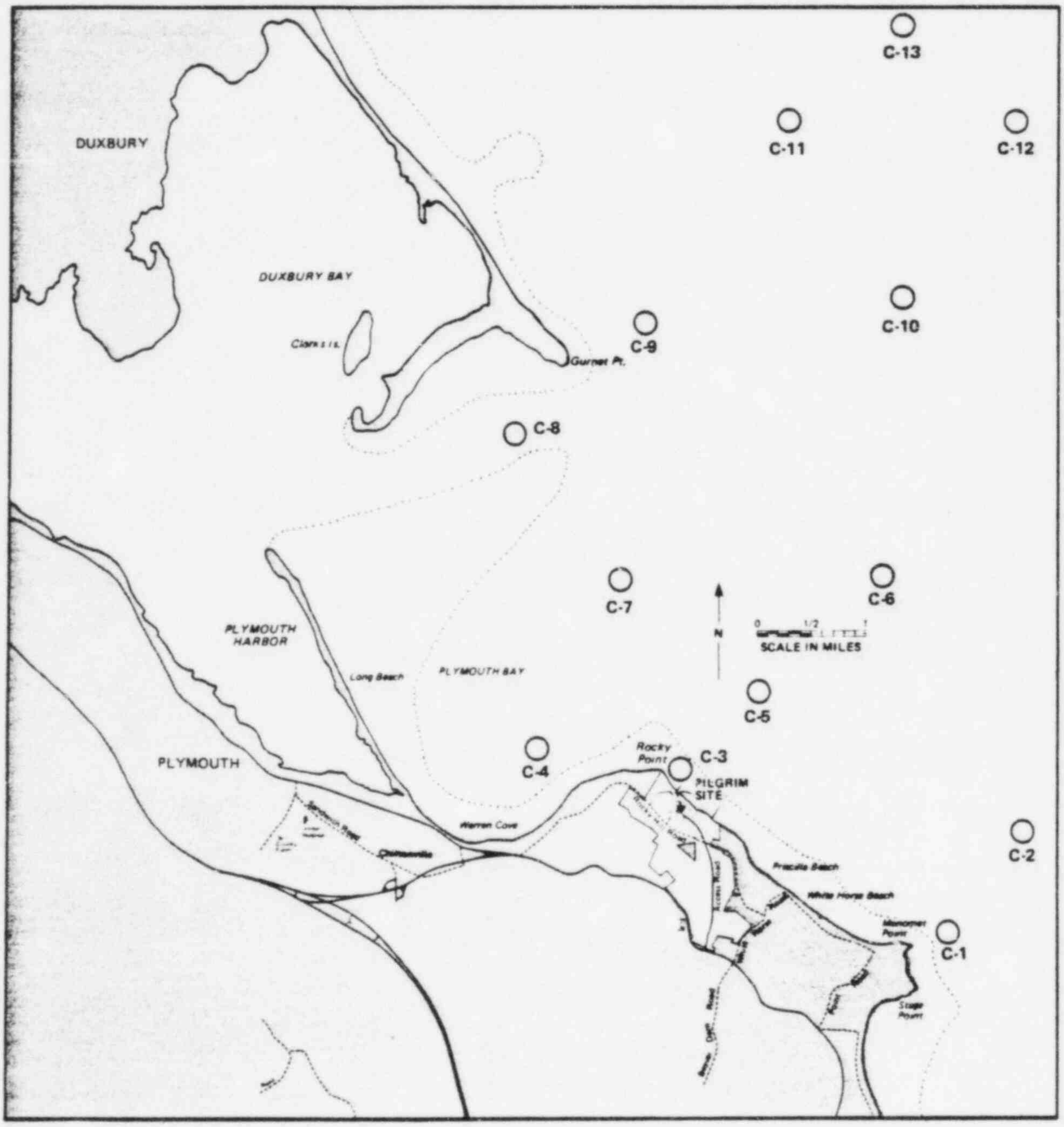

Figure 2. Location of Entrainment Contingency Plan Sampling Stations, C.

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 five times in 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 - December 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 - December 1982 were very similar to previous years.

NUC72-A

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	Jul	Aug	Sep	Oct	Nov	Dec
Atlantic menhaden	*Brevoortia tyrannus*						E/L	E/L	E/L	E/L	E/L		L
Atlantic herring	*Clupea harengus harengus*	L		L	L	L							
Anchovy	*Anchoa spp.*						E	L	L	L			
Bay Anchovy	*Anchoa mitchilli*							E	E/L				
Rainbow Smelt	*Osmerus mordax*				L		L						
Goosefish	*Lophius americanus*						E		L	E			
Cusk	*Brosme brosme*					E	E						
Fourbeard rockling	*Enchelyopus cimbrius*				E	E/L	E/L	E/L	E/L	E/L	E		
Atlantic cod	*Gadus morhua*	E	E	E	E/L	E/L	E/L	E				E	E/L
Atlantic Tomcod	*Microgadus tomcod*		L	L	L								
Silver hake	*Merluccius bilinearis*					E	E	E	E	E/L			
Pollock	*Pollachius virens*												
Hakes	*Urophycis* spp.						E	E	E/L	E/L	L		
Silversides	*Menidia* spp.								E				
Northern pipefish	*Syngnathus fuscus*						J*	J	J	J			
Wrasses	Labridae					E	E	E	E	E			
Tautog	*Tautoga onitis*						L	L	L		L		
Cunner	*Tautogolabrus adspersus*						L	L	L	L	L		
Goby	*Gobiosoma ginburgi*								L				

*J = Juvenile

Table 1 (Continued).

Species		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Radiated shanny	*Ulvaria subbifurcata*				L	L	L	L		L			
Rock gunnel	*Pholis gunnellus*	L	L	L	L	L							
Snakeblenny	*Lumpenus lumpretaeformis*												
Sand lance	*Ammodytes* sp.	L	L	L	L	L							
Wrymouth	*Cryptaeanthodes maculatus*			L	L								
Atlantic mackerel	*Scomber scombrus*					E/L	E/L	E					
Butterfish	*Peprilus triacanthus*					E				L			
Searobin	*Prionotus* spp.						E	E	E	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* spp.			L		L	L						
Fourspot flounder	*Paralichthys oblongus*					E		L	L	L			
Windowpane	*Scophthalmus aquosus*				E	L	L	L	L	L	L		
Witch flounder	*Glyptocephalus cynoglossus*				E	E	E/L	E/L	E	E			
American plaice	*Hippoglossoides platessoides*				E/L	E/L							
Yellowtail flounder	*Limanda ferruginea*				E	E/L	E/L		E/L				
Winter flounder	*Pseudopleuronectes americanus*	L		E	E/L	E/L	L	L					
Smooth flounder	*Liopsetta putnami*				L								
Hogchoker	*Trinectes maculatus*									E			

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/L
Bay anchovy	Anchoa mitchilli				E	E	E			E/L
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/L
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/L
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/L

*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	E
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					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/L
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	E
Northern puffer	Sphoeroides maculatus				L					
Smooth Flounder	Liopsetta putnami								L	E/L

Table 3: Mean monthly densities of the numerically dominant fish eggs and larvae entrained at the Pilgrim Nuclear Power Station, January-December, 1975-1982. The total column represents the total for all 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	1981	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	MARCH 1981	MARCH 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 / Rang

	APRIL 1975	1976+	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 states 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	10.1 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.

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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	[illegible]
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.

Table 3 (continued). Format: Mean / Range

	JULY 1975	1976	1977	1978	1979
EGGS					
Gadidae-*Glyptocephalus*	0.6 / 0-2	0	2.9 / 0-9	0.8 / 0-2	0.6 / 0-4
Gadidae*	0	0	2.1 / 0-13	0.2 / 0-2	0.2 / 0-0.
Enchelyopus-*Urophycis*-*Peprilus*	26.6 / 2-132	271.8 / 3-943	656.3 / 10-2858	389.2 / 50-1445	17.5 / 4-49
*Enchelyopus cimbrius***	1.7 / 0-10	5.2 / 0-10	6.0 / 0-14	3.1 / 0-9	7.1 / 0-18
Urophycis spp.	0.7 / 0-2	27.9 / 0.7-70	34.7 / 0-113	74.9 / 5-184	10.2 / 0-38
Labridae-*Limanda*	2972.0 / 182-9861	2588.1 / 75-6817	2793.4 / 814-8537	3275.8 / 482-8086	1430.4 / 154-690
Labridae	44.3 / 0-170	232.6 / 39-460	223.6 / 11-791	210.8 / 93-386	54.1 / 12-126
Scomber scombrus	0.1 / 0-1	7.2 / 0-20	9.2 / 0-35	13.3 / 0-49	2.1 / 0-9
Paralichthys-*Scophthalmus*	7.7 / 0-23	17.8 / 0-29	43.5 / 2-118	92.7 / 20-271	13.3 / 2-27
Total	3056.9 / 192-10041	3235.4 / 303-4115	3936.2 / 962-12306	4117.3 / 677-8711	4624.2 / 207-711
LARVAE					
Clupea harengus harengus	0	0	0	0	0
Enchelyopus cimbrius	6.4 / 0-27	5.8 / 0-25	34.3 / 25-42	1.1 / 0-3	3.2 / 0-8
Tautogolabrus adspersus	5.2 / 0-15	30.8 / 0-124	20.1 / 0-155	11.2 / 0-110	8.9 / 0-39
Ulvaria subbifurcata	0	0	0	0	0
Pholis gunnellus	0	0	0	0	0
Ammodytes sp.	0	0	0	0	0
Scomber scombrus	0	3.0 / 0-12	2.4 / 0-13	5.9 / 0-52	0.4 / 0-2
Myoxocephalus spp.	0	0	0	0	0.06 / 0-0.
Liparis spp.	0	0.3 / 0-2	0	0.1 / 0-1	0.04 / 0-0
Pseudopleuronectes americanus	0	0.1 / 0-0.8	0.1 / 0-0.8	0.2 / 0-2	0.1 / 0-0.
Total	19.1 / 0-42	50.6 / 10-153	69.5 / 4-275	30.9 / 4-211	47.6 / 0-57

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

Table 3 (continued). Format: Mean / Range

	JULY 1980	JULY 1981	JULY 1982
EGGS			
Gadidae-Glyptocephalus	0.6 0-2.2	0.2 0-0.88	0.734 0-3.57
Gadidae*	1.7 0-7.5	0	0
Enchelyopus-Urophycis-Peprilus	121.6 20-495	67.6 4.2-202.6	0.203 0.6-1.2
Enchelyopus cimbrius**	31.3 2.9-121.5	4.1 1.7-15.0	6.16 0.5-19.9
Urophycis spp.	30.2 6.6-61.2	79.4 3.3-257.6	3.1 0-13.9
Labridae-Limanda	1320.6 262.7-2456	0	778.7 117.5-2053.2
Labridae	336 3.3-699.7	473.0 3.1-1868.0	33.7 2.9-72.9
Scomber scombrus	32.3 0-100.1	47.6 46.0-144.4	0.4 0-1.9
Paralichthys-Scophthalmus	38.8 11.7-92.5	56.9 08.-172.6	19.1 2.1-71.5
Total	1999.7 1099-3867	4615.2 74.9-13508.[illegible]	859.8 148.2-2132.3
LARVAE			
Clupea harengus harengus	0	0	0
Enchelyopus cimbrius	23.9 1.6-89.1	11.5 .0.8-43.1	1.3 0-4.1
Tautogolabrus adspersus	107.7 1.6-305.1		1.2 0-3.5
Ulvaria subbifurcata	0	.2009 0-1.6	0.1 0-0.9
Pholis gunnellus	0	0	0
Ammodytes sp.	0	0	0
Scomber scombrus	5.9 0-32.7	9.7 0.9-50.7	0
Myoxocephalus spp.	0	0	0
Liparis spp.	0	0	0
Pseudopleuronectes amerianus	0.2 0-3	0	0.1 0-0.75
Total	157.6 27.6-376.7	660.2 11.2-2996.0	3.72 0.7-8.0

Table 3 (continued). Format: Mean / Range

	1975	1976	AUGUST 1977	1978	1979
EGGS					
Gadidae-Glyptocephalus	0.1 0-0.9	0.4 0-2	0.7 0-1	0.9 0-2	0.2 0-1
Gadidae*	0	0.2 0-1	0.3 0-1	0.06 0-0.7	0.09 0-0.
Enchelyopus-Urophycis-Peprilus	4.8 1-14	104.9 10-318	17.4 13-21	206.4 5-490	132.6 2-502
Enchelyopus cimbrius**	2.0 0-4	10.9 2-26	2.3 2-3	12.8 0-56	10.5 0.5-36
Urophycis spp.	2.2 0-8	39.9 3-76	15.4 9-25	80.1 0-250	18.3 0.8-39
Labridae-Limanda	202.7 0.5-896	30.2 1-90	22.0 17-31	531.9 0-2334	133.6 0.8-533
Labridae	2.6 0-6	9.7 0-20	20.3 14-31	19.6 0-88	16.2 0-72
Scomber scombrus	0	0	0	1.0 0-7	0.2 0-0.5
Parlichthys-Scophthalmus	22.9 8-48	37.0 13-69	6.5 4-10	37.6 1-96	46.4 10-86
Total	239.96 21-920	249.5 57-584	114.9 101-128	899.6 30-2445	369.8 22-119
LARVAE					
Clupea harengus harengus	0	0	0	0	0
Enchelyopus cimbrius	1.0 0-3	12.6 0-25	1.6 1-2	1.9 0-13	1.7 0.5-4
Tautogolabrus adspersus	2.8 0-15	25.4 2-62	0.3 0-1	0.4 0-3	4.7 0-10
Ulvaria subbifurcata	0	0	0	0	0
Pholis gunnellus	0	0	0	0	0
Ammodytes sp.	0	0	0	0	0
Scomber scombrus	0			0	0.07 0-1
Myoxocephalus spp.	0	0	0	0	0
Liparis spp.	0	0	0.3 0-1	0	0
Pseudopleuronectes americanus	0	0.4 0-2	0	0	0
Total	20.5 0-17	52.8 8-126	3.9 2-8	7.0 0-29	14.8 5-28

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

Table 3 (continued). Format: Mean / Range

	AUGUST 1980	1981	1982
EGGS			
Gadidae-Glyptocephalus	0.3 / 0-1.3	0	0
Gadidae*	0	0	0
Enchelyopus-Urophycis-Peprilus	43.2 / 3.3-158.7	20.0 / 1.3-69.0	11.9 / 0-55.5
Enchelyopus cimbrius**	8.9 / 2.1-19.6	1.9 / 0-8.1	2.7 / 0-7.4
Urophycis spp.	38.8 / 11.1-72.8	8.2 / 0-22.0	11.8 / 0-64.9
Labridae-Limanda	283.5 / 12.6-1196	4.5 / 0-20.2	147.6 / 0-857.1
Labridae	42.6 / 0.8-186.5	4.3 / 0-13.0	12.5 / 0-77.9
Scomber scombrus	0	0	0
Parlichthys-Scophthalmus	17.6 / 2.1-31.4	21.0 / 0-62.5	14.6 / 1.8-29.9
Total	444.4 / 23.1-1202	70.4 / 17.7-169.1	204 / 3.5-1092.2
LARVAE			
Clupea harengus harengus	0	0	0
Enchelyopus cimbrius	13.7 / 0-44.8	3.3 / 0.63-17.0	25.7 / 0-13.2
Tautogolabrus adspersus	40.6 / 2.2-206	0	0
Ulvaria subbifurcata	0	0	0
Pholis gunnellus	0	0	0
Ammodytes sp.	0	0	0
Scomber scombrus	0.02 / 0-1.8	0	0
Myoxocephalus spp.	0	0	0
Liparis spp.	0	0	0
Pseudopleuronectes americanus	0	0	0
Total	70.8 / 0.5-19.0	17.2 / 5.1-58.6	11.3 / 1.2-49.9

Table 3 (continued). Format: Mean/Range

	SEPTEMBER 1975+	1976	1977	1978	1979
EGGS					
Gadidae-Glyptocephalus	0	0		0.1 / 0-1	0.06 / 0-0.
Gadidae*	0	0		0	0
Enchelyopus-Urophycis-Peprilus	10.7 / 4-20	10.1 / 1-23		18.7 / 2-32	13.9 / 0.5-36
Enchelyopus cimbrius**	30.7 / 19-39	9.3 / 0-29		6.1 / 0-24	5.4 / 0-12
Urophycis spp.	5.7 / 1-8	10.0 / 0-42		13.0 / 0-32	7.4 / 0-23
Labridae-Limanda	2.9 / 0-6	0.7 / 0-3		1.3 / 0-6	0.5 / 0-2
Labridae	1.4 / 0-4	0.2 / 0-0.9		0.5 / 0-3	0
Scomber scombrus	0	0		0	0
Parlichthys-Scophthalmus	22.4 / 3-50	47.0 / 1-203		23.9 / 4-81	13.6 / 2-26
Total	75.6 / 29-126	94.4 / 10-334		65.3 / 9-154	50.1 / 11-110
LARVAE					
Clupea harengus harengus	0	0		0.1 / 0-1	0
Enchelyopus cimbrius	3.1 / 1-8	18.0 / 1-67		0.7 / 0-3	1.1 / 0-5
Tautogolabrus adspersus	0.9 / 0-2	0.2 / 0-0.9		0.5 / 0-2	0
Ulvaria subbifurcata	0	0		0	0
Pholis gunnellus	0	0		0	0
Ammodytes sp.	0	0		0	0
Scomber scombrus	0	0		0	0
Myoxocephalus spp.	0	0		0	0
Liparis spp.	0	0		0	0
Pseudopleuronectes americanus	0	0		0	0
Total	13.6 / 6-20	35.2 / 5-130		33.2 / 1-169	2.2 / 0-7

*Represents all three egg stages from January through February.
**Represents all three egg states from January through March.
+0.505 samples only.

Table 3 (continued). Format: Mean / Range

	SEPTEMBER 1980	1981	1982
EGGS			
Gadidae-*Glyptocephalus*	0.14 / 0-1.2	0.05 / 0-0.63	0.05 / 0-0.6
Gadidae*	0	0	0
Enchelyopus-*Urophycis*-*Peprilus*	27.1 / 0.8-85.4	4.4 / 0-1.4	22.7 / 0-76.8
*Enchelyopus cimbrius***	14.9 / 0-59.1	1.9 / 0-7.6	4.5 / 0-28.9
Urophycis spp.	37.3 / 0-238.1	0.4 / 0-1.9	11.9 / 0.6-44.1
Labridae-*Limanda*	1.6 / 0-7.0	0	8.9 / 0-44.7
Labridae	1.2 / 0-5.8	0.6 / 0-0.7	1.5 / 0-7.1
Scomber scombrus	0	0	0
Parlichthys-*Scophthalmus*	25.0 / 3.1-73.2	5.4 / 0.7-10.1	117.5 / 38.9-312.5
Total	107.5 / 64-436.2	8.9 / 0-20.8	934.6 / 58.7-2729.6
LARVAE			
Clupea harengus harengus	0	0	0
Enchelyopus cimbrius	5.3 / 0-30.3	0.7 / 0-3.3	2.6 / 0-12.0
Tautogolabrus adspersus	4.9 / 0-27.0	0	0.2 / 0-1.3
Ulvaria subbifurcata	0	0	0.05 / 0-0.6
Pholis gunnellus	0	0	0
Ammodytes sp.	0	0	0
Scomber scombrus	0	0	0
Myoxocephalus spp.	0	0	0
Liparis spp.	0	0	0
Pseudopleuronectes americanus	0	0	0
Total	18.8 / 0.8-89.2	9.6 / 0-30.0	12.7 / 0.9-35.3

Table 3 (continued). Format: Mean / Range

	OCTOBER 1975	1976	1977	1978	1979
EGGS					
Gadidae-Glyptocephalus		0.8 0-2		0.2 0-1	1.3 0-5
Gadidae*		0		0.3 0-1	0.2 0-0.7
Enchelyopus-Urophycis-Peprilus		0		2.0 0-8	1.2 0-3
*Enchelyopus cimbrius***		0		3.2 0-16	2.5 0-6
Urophycis spp.		0		0.1 0-1	0.1 0-0.
Labridae-*Limanda*		0		0.1 0-1	0
Labridae		0		0.1 0-1	0
Scomber scombrus		0		0	0
Parlichthys-Scophthalmus		0		0.3 0-2	2.5 0-8
Total		0.8 0-2		6.5 2-22	8.6 2-19
LARVAE					
Clupea harengus harengus		0.2 0-0.8		0	0
Enchelyopus cimbrius		0		1.9 0-6	3.9 0-10
Tautogolabrus adspersus		0		0	0
Ulvaria subbifurcata		0		0	0
Pholis gunnellus		0		0	0
Ammodytes sp.		0		0	0
Scomber scombrus		0		0	0
Myoxocephalus spp.		0		0	0
Liparis spp.		0		0	0
Pseudopleuronectes americanus		0		0	0
Total		1.0 0-2		3.5 0-15	6.2 2-1

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

Table 3 (continued). Format: Mean / Range

	OCTOBER 1980	1981	1982
EGGS			
Gadidae-*Glyptocephalus*	0	0.2 / 0-1.2	0.09 / 0-0.8
Gadidae*	0	0	0
Enchelyopus-*Urophycis*-*Peprilus*	0.5 / 0-0.9	2.1 / 0-4.2	0.2 / 0-0.6
*Enchelyopus cimbrius***	1.7 / 0-3.4	1.4 / 1.8-4.6	0.3 / 0-1.3
Urophycis spp.	1.1 / 0-2.1	0.6 / 0.6-2.4	0
Labridae-*Limanda*	0	0.2 / 0-0.6	0
Labridae	0	0	0
Scomber scombrus	0	0	0
Parlichthys-*Scophthalmus*	0.8 / 0-1.5	3.3 / 4.7-7.7	1.3 / 0-4.1
Total	22.9 / 0-52.1	7.9 / 0-17.4	2.1 / 0-4.1
LARVAE			
Clupea harengus harengus	0	0	0
Enchelyopus cimbrius	0.8 / 0.6-1.9	1.1 / 1.9-2.4	0
Tautogolabrus adspersus	0	0	0.1 / 0-0.5
Ulvaria subbifurcata	0	0	0
Pholis gunnellus	0	0	0
Ammodytes sp.	0	0	0
Scomber scombrus	0	0	0
Myoxocephalus spp.	0	0	0
Liparis spp.	0	0	0
Pseudopleuronectes americanus	0	0	0
Total	7.3 / 0-16.2	3.7 / 0-8.9	2.7 / 0-6.5

Table 3 (Continued).

Format: Mean / Range

	NOVEMBER 1975	1976	1977	1978	1979
EGGS					
Gadidae-*Glyptocephalus*	29.6 / 16-48	1.6 / 1-3	4.6 / 1-8	1.7 / 0-4	6.8 / 2-10
Gadidae*	2.8 / 1-6	1.0 / 0.4-2	2.2 / 0.5-5	11.0 / 1-26	3.8 / 0.9-7
Enchelyopus-*Urophycis*-*Peprilus*	0.1 / 0-0.6	0	0	0.1 / 0-0.5	0
*Enchelyopus cimbrius***	0	0	0	0.1 / 0-0.5	0
Urophycis spp.	0	0	0	0	0
Labridae-*Limanda*	0	0	0	0	0
Labridae	0	0	0	0	0
Scomber scombrus	0	0	0	0	0
Parlichthys-*Scophthalmus*	0	0	0	0	0
Total	32.5 / 18-51	2.6 / 1-4	20.3 / 2-13	13.0 / 2-7	10.6 / 4-17
LARVAE					
Clupea harengus harengus	0.4 / 0-1	0	2.0 / 0-5	0.2 / 0-0.5	0.3 / 0-0.4
Enchelyopus cimbrius	0	0	0	0.7 / 0-2	0.07 / 0-0.4
Tautogolabrus adspersus	0	0	0	0.2 / 0-1	0
Ulvaria subbifurcata	0	0	0	0	0
Pholis gunnellus	0	0	0	0	0
Ammodytes sp.	0	0	0	0	0
Scomber scombrus	0	0	0	0	0
Myoxocephalus spp.	0	0	0	0	0
Liparis spp.	0	0	0	0	0
Pseudopleuronectes americanus	0	0	0	0	0
Total	0.7 / 0-1	0.1 / 0-0.4	2.0 / 0-5	3.0 / 2-5	0.6 / 0.4-

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

Table 3 (Continued). Format: Mean / Range

	NOVEMBER 1980	NOVEMBER 1981	NOVEMBER 1982
EGGS			
Gadidae-Glyptocephalus	1.1 / 1.6-2.8	0	0
Gadida·*	0.6 / 0-2.3	0	0.4 / 0-0.6
Enchelyopus-Urophycis-Peprilus	0	0	0
Enchelyopus cimbrius**	0	0	0
Urophycis spp.	0	0	0
Labridae-Limanda	0	0.2 / 0-0.7	0
Labridae	0	0	0
Scomber scombrus	0	0	0
Parlichthys-Scophthalmus	0	0	0
Total	1.7 / 0-4.8	7.9 / 5.5-10.5	0.4 / 0-0.6
LARVAE			
Clupea harengus harengus	0	0.3 / 0-0.8	0
Enchelyopus cimbrius	0.25 / 0-0.7	0.5 / 0.4-0.6	0
Tautogolabrus adspersus	0	0	0
Ulvaria subbifurcata	0	0	0
Pholis gunnellus	0	0	0
Ammodytes sp.	0	0	0
Scomber scombrus	0	0	0
Myoxocephalus spp.	0	0	0
Liparis spp.	0	0	0
Pseudopleuronectes americanus	0	0	0
Total	0.5 / 0-1.5	13.5 / 0.5-26.3	0

Table 3 (Continued). Format: Mean / Range

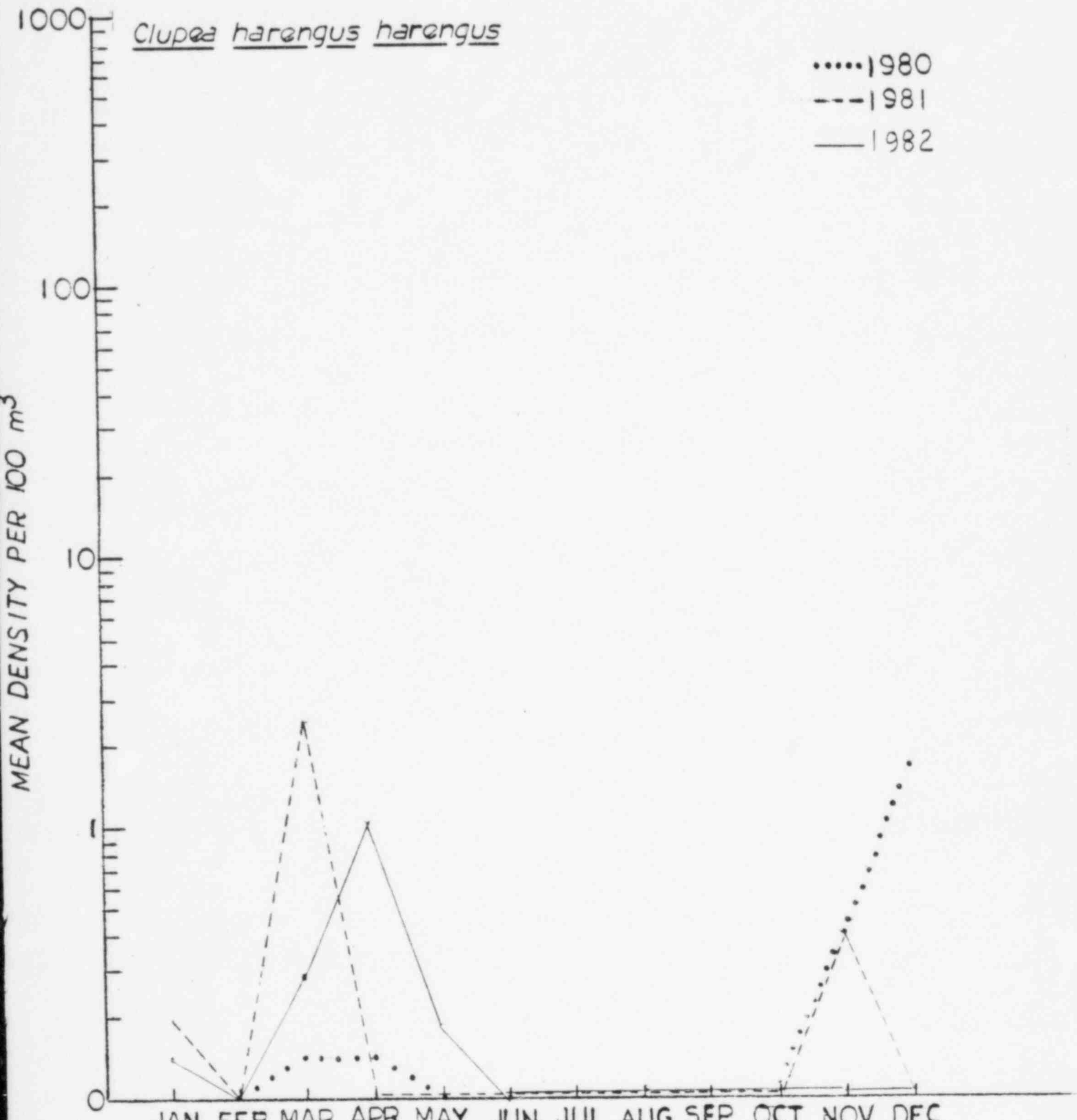
	DECEMBER 1975	1976	1977	1978	1979
EGGS					
Gadidae-Glyptocephalus	0	0	0	0	0
Gadidae*	6.7 1-12	0.9 0-3	2.3 1-3	2.8 1-6	4.4 3-8
Enchelyopus-Urophycis-Peprilus	0	0	0	0	0
Enchelyopus cimbrius**	0	0	0	0	0
Urophycis spp.	0	0	0	0	0
Labridae-Limanda	0	0	0	0	0
Labridae	0	0	0	0	0
Scomber scombrus	0	0	0	0	0
Parlichthys-Scophthalmus	0	0	0	0	0
Total	6.7 1-12	0.9 0-3	3.7 2-10	2.8 1-6	4.5 3-9
LARVAE					
Clupea harengus harengus	1.8 1-4	0	2.2 0-5	0.7 0-2	0
Enchelyopus cimbrius	0	0	0	0	0.15 0-0.
Tautogolabrus adspersus	0	0	0	0	0
Ulvaria subbifurcata	0	0	0	0	0
Pholis gunnellus	0	0	0	0	0
Ammodytes sp.	0	0.6 0-1	0	0.1 0-0.4	9.8 0-2
Scomber scombrus	0	0	0	0	0
Myoxocephalus spp.	0	0	0	0	0
Liparis spp.	0	0	0	0	0
Pseudopleuronectes americanus	0	0	0	0	0
Total	2.5 2-7	0.8 0-2	2.5 0-5	1.3 1-2	10.2 0-24

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

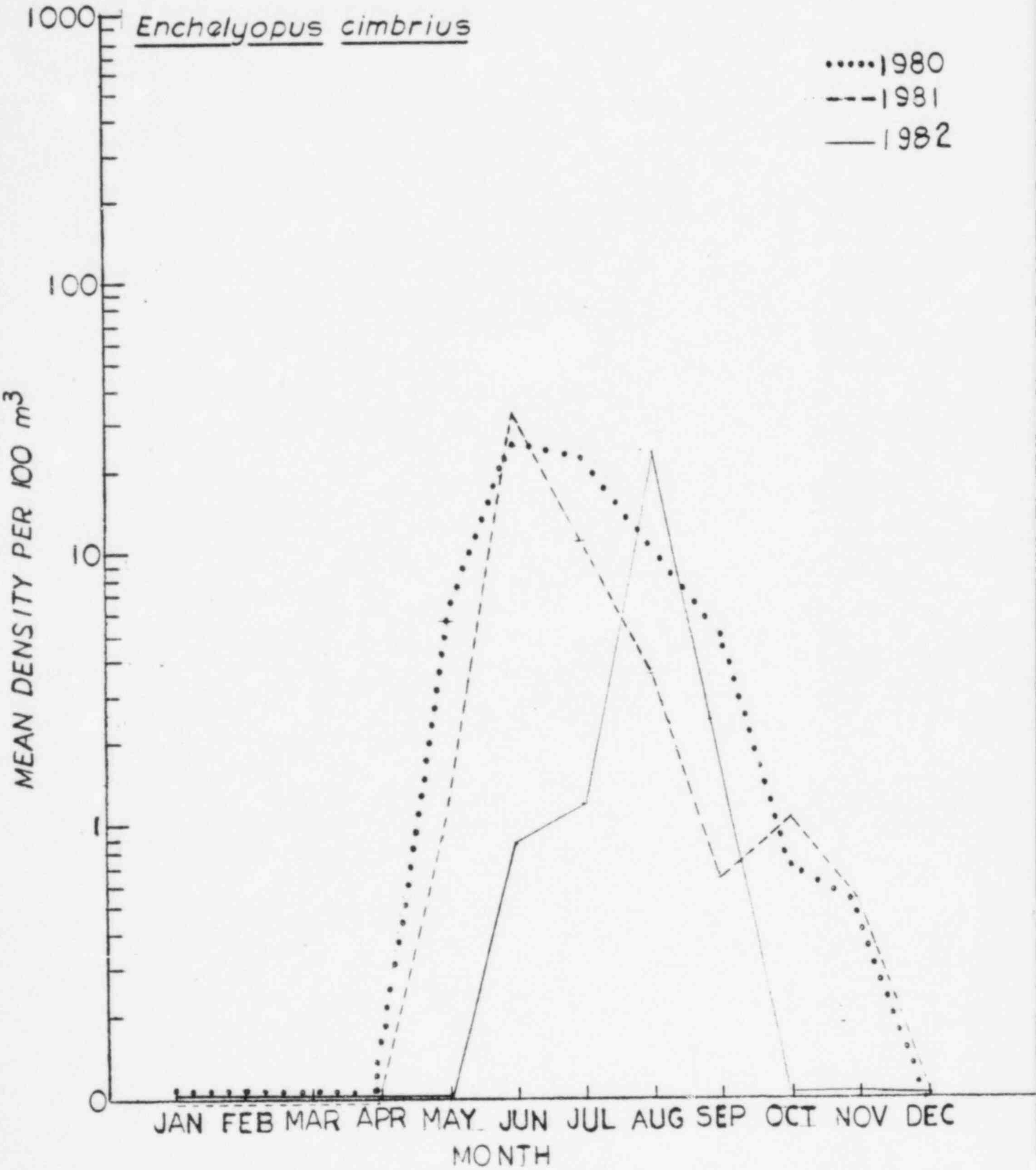
Table 3 (Continued). Format: Mean / Range

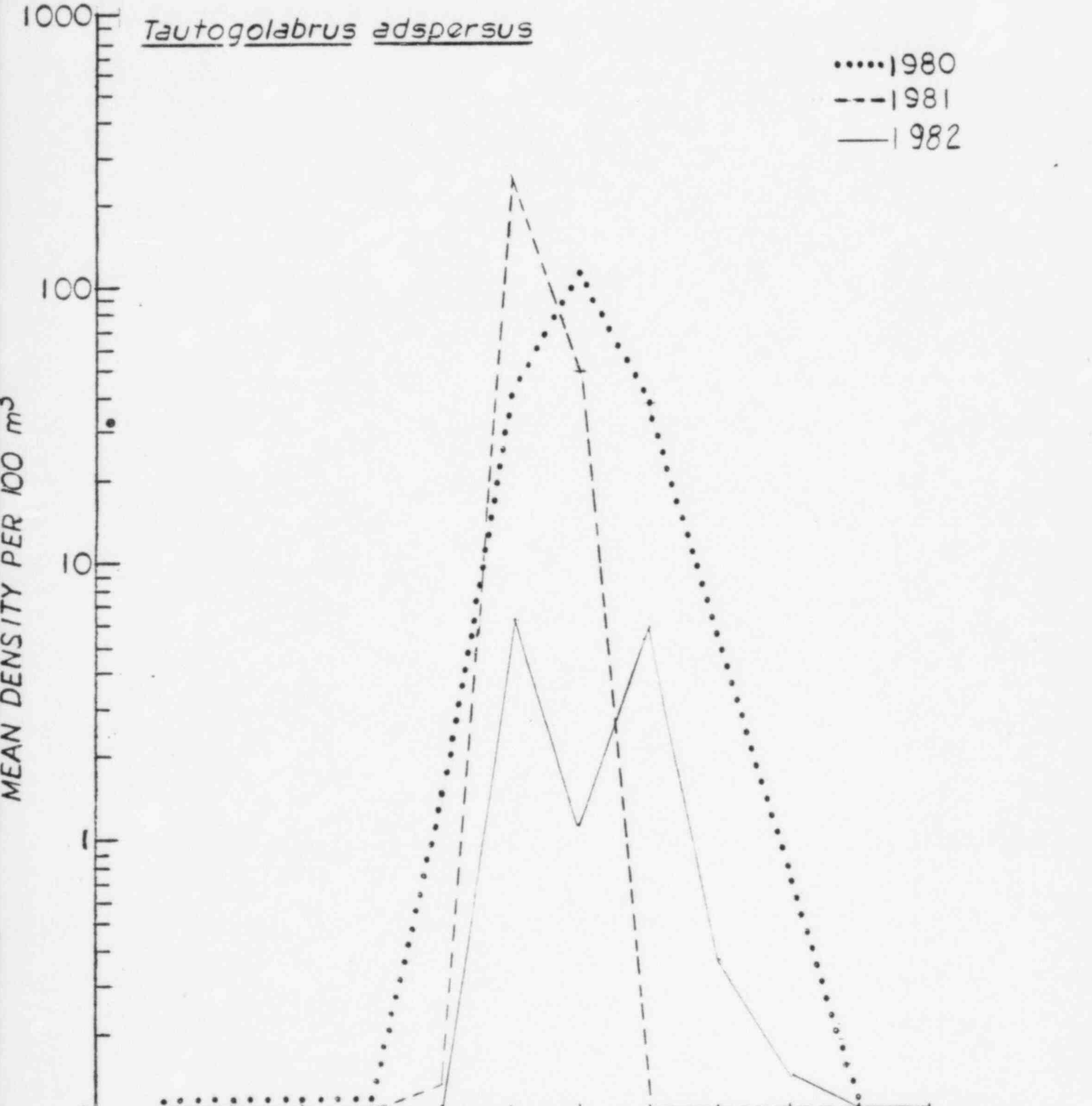
	DECEMBER 1980	DECEMBER 1981	DECEMBER 1982
EGGS			
Gadidae-*Glyptocephalus*	0	0	0
Gadidae*	0.5 / 0-1.8	0	1.5 / 0-4.5
Enchelyopus-*Urophycis*-*Peprilus*	0	0	0
*Enchelyopus cimbrius***	0	0	0
Urophycis spp.	0	0	0
Labridae-*Limanda*	0	0	0
Labridae	0	0	0.1 / 0-0.6
Scomber scombrus	0	0	0
Parlichthys-*Scophthalmus*	0	0	0
Total	19.7 / 0-42.1	2.5 / 1.2-4 2	1.6 / 0-4.5
LARVAE			
Clupea harengus harengus	1.6 / 2.1-4.6	0	0
Enchelyopus cimbrius	0	0	0
Tautogolabrus adspersus	0	0	0
Ulvaria subbifurcata	0	0	0
Pholis gunnellus	0	0	0
Ammodytes sp.	1.1 / 0-2.4	0	8.4
Scomber scombrus	0	0	0
Myoxocephalus spp.	0	0	0
Liparis spp.	0	0	0
Pseudopleuronectes americanus	0	0	0
Total	4.1 / 2.1-6.3	0.3 / 0-0.6	8.9 / 0.6-40.2

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, 1982.

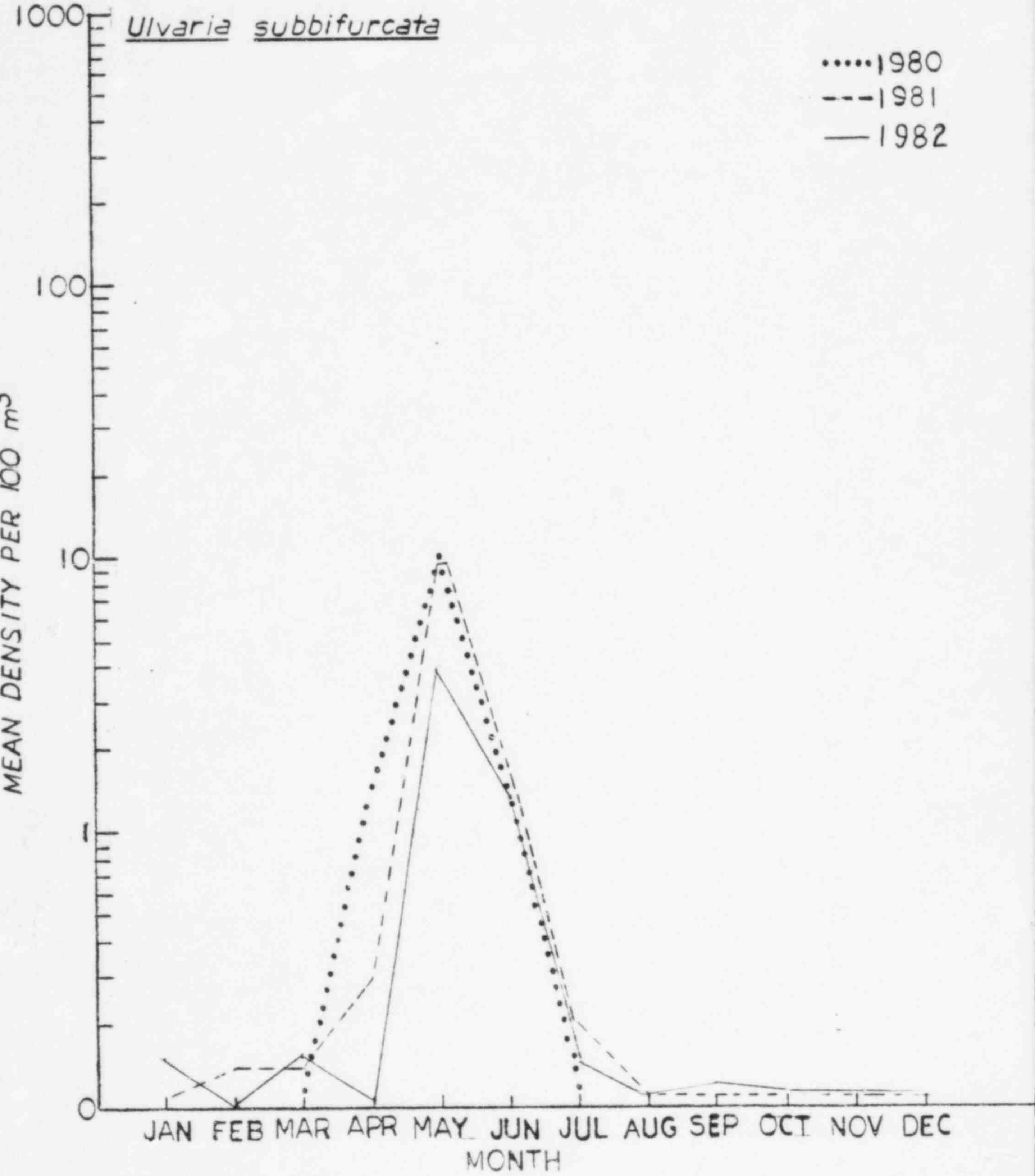


Clupea harengus harengus
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m^3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

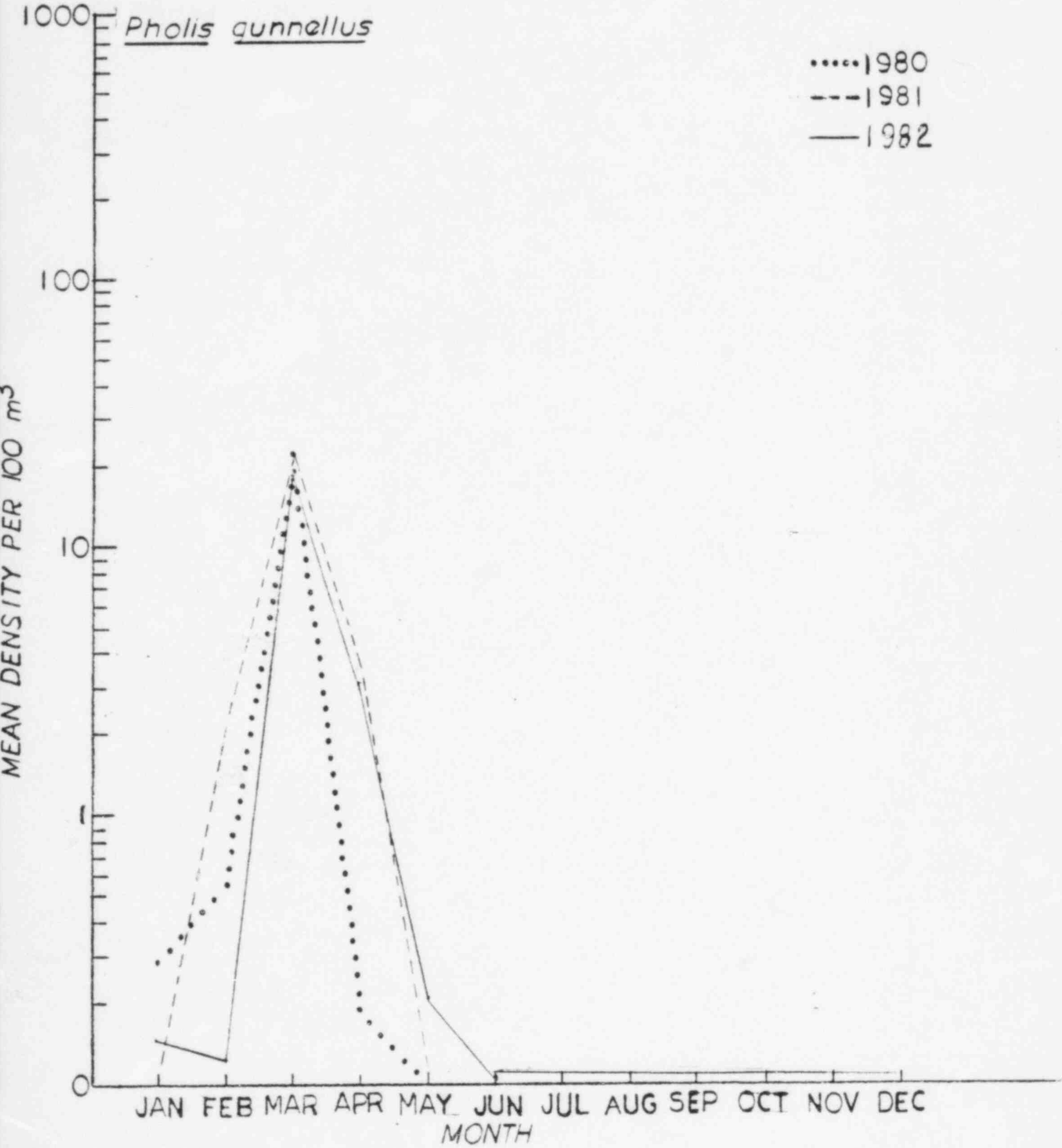

Enchelyopus cimbrius
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m^3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

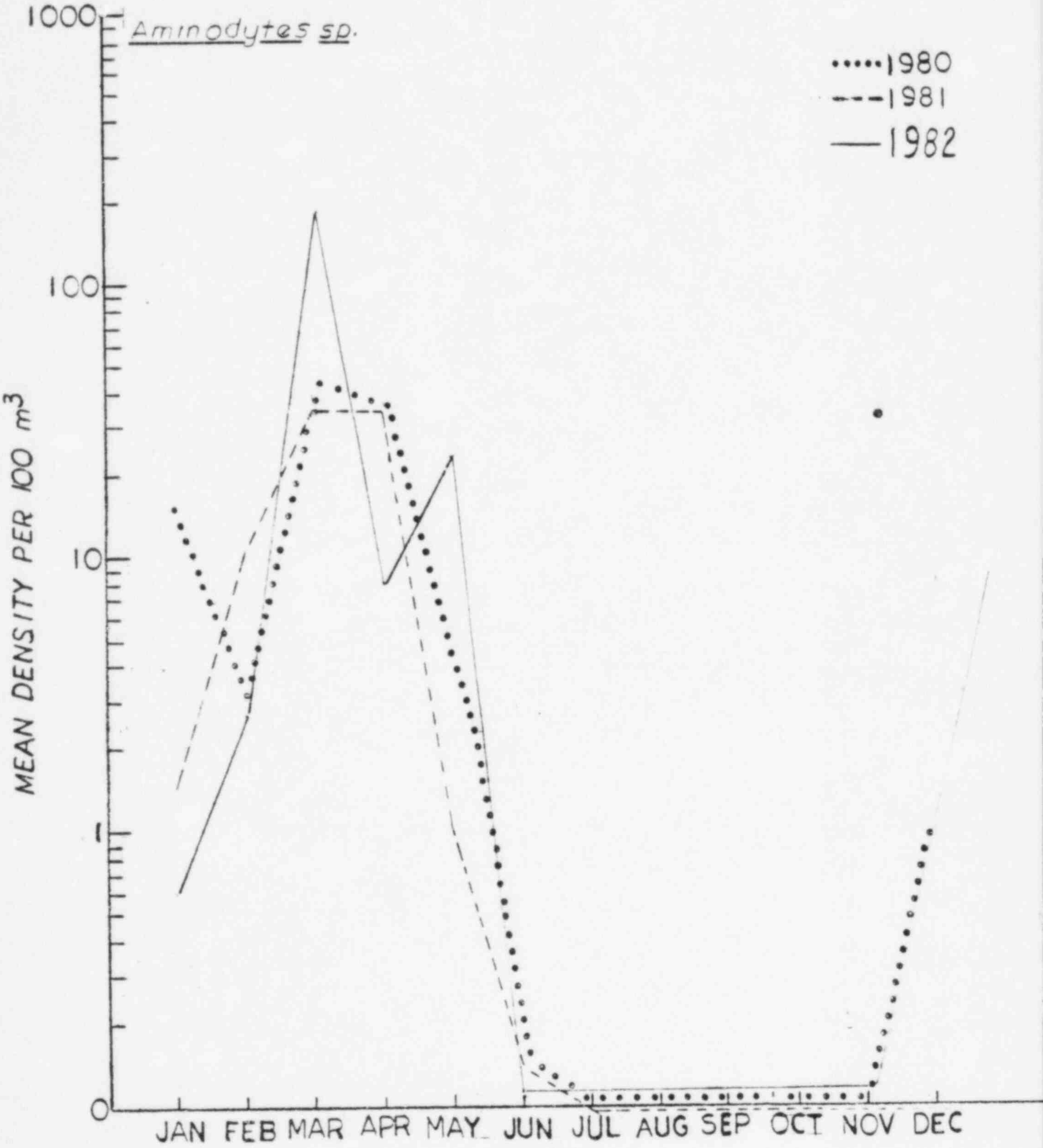


Tautogolabrus adspersus
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

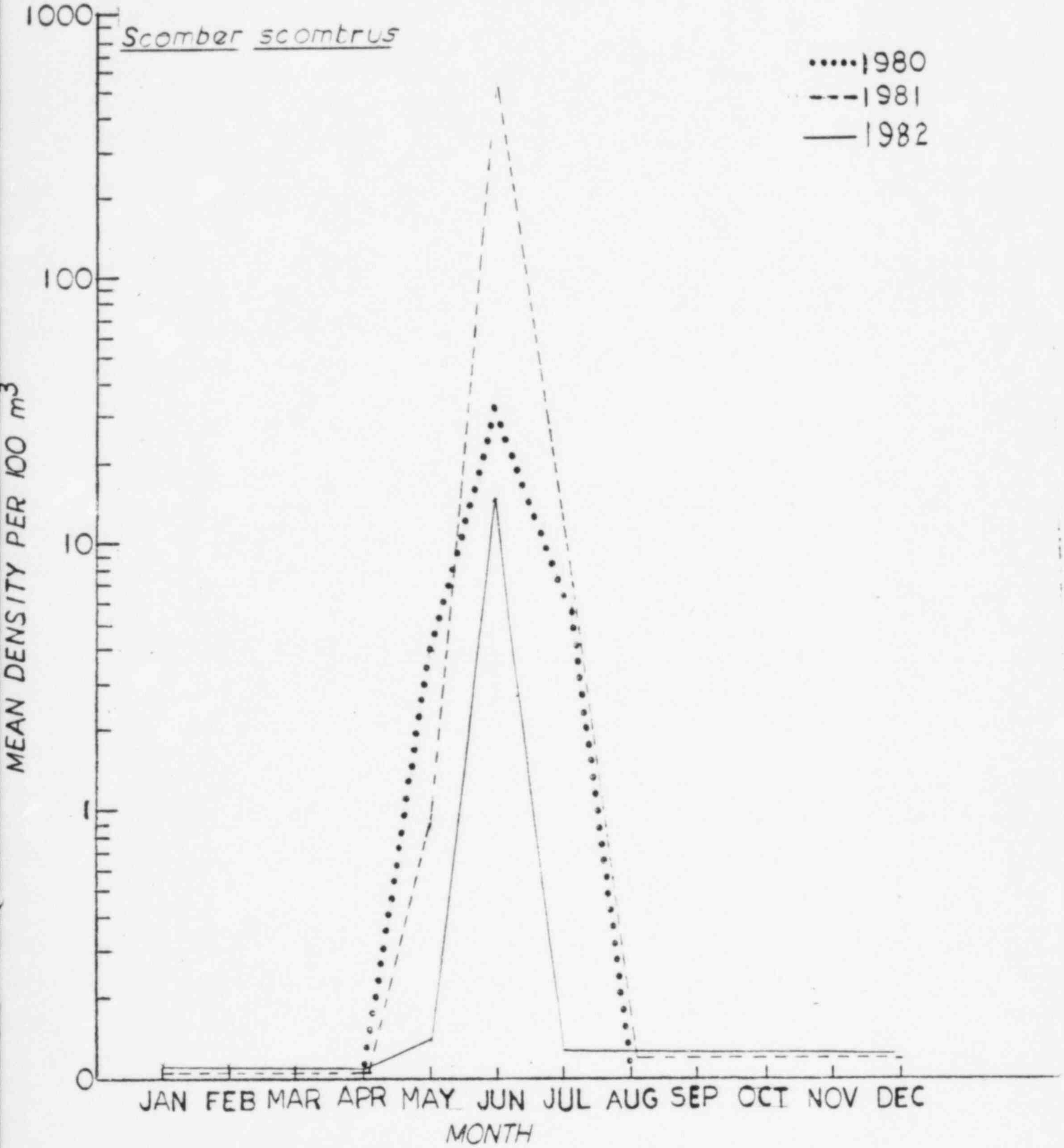


Ulvaria subbifurcata
1980
1981
1982
MEAN DENSITY PER 100 m3
1000
100
10
1
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

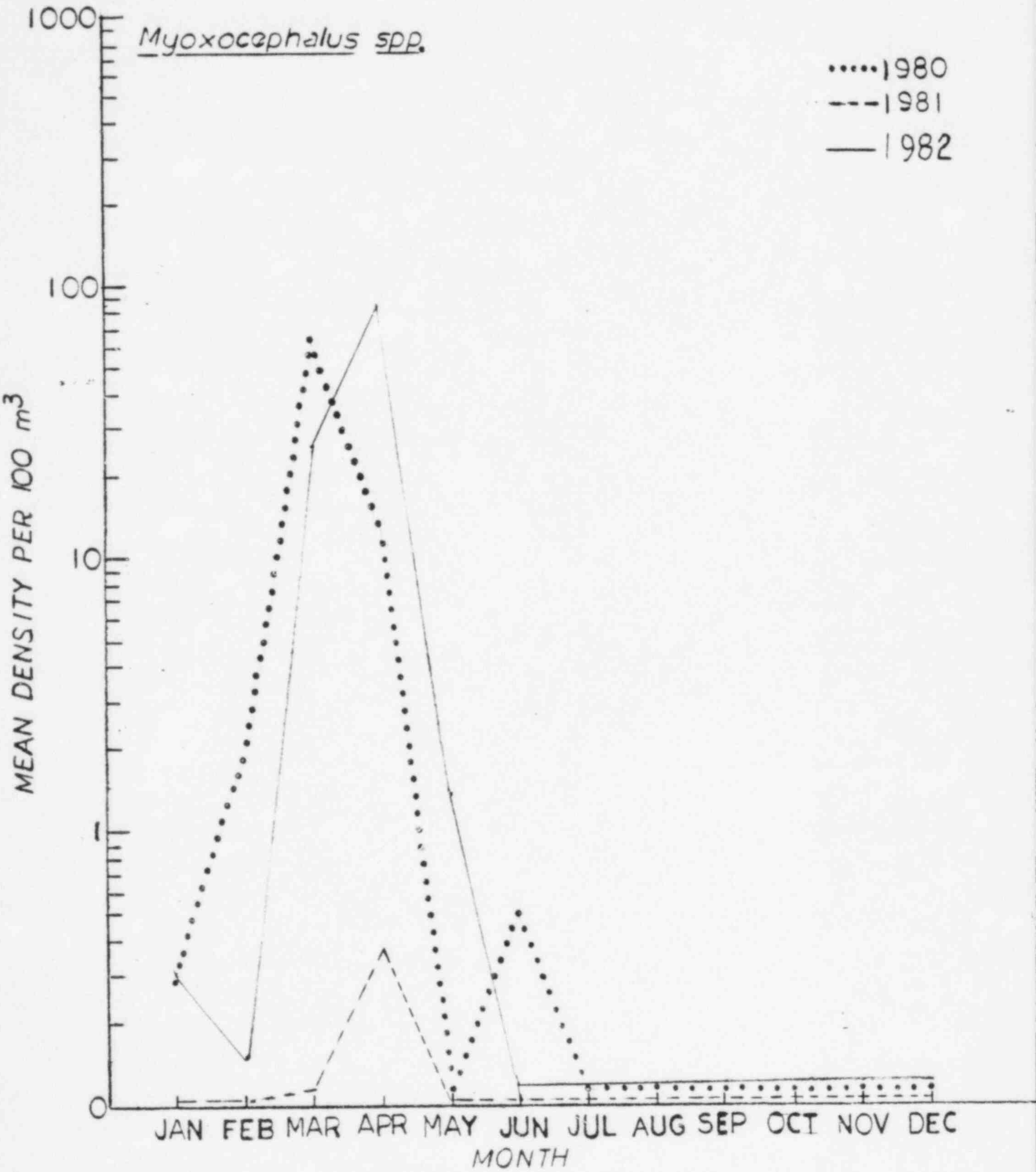

Pholis gunnellus
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

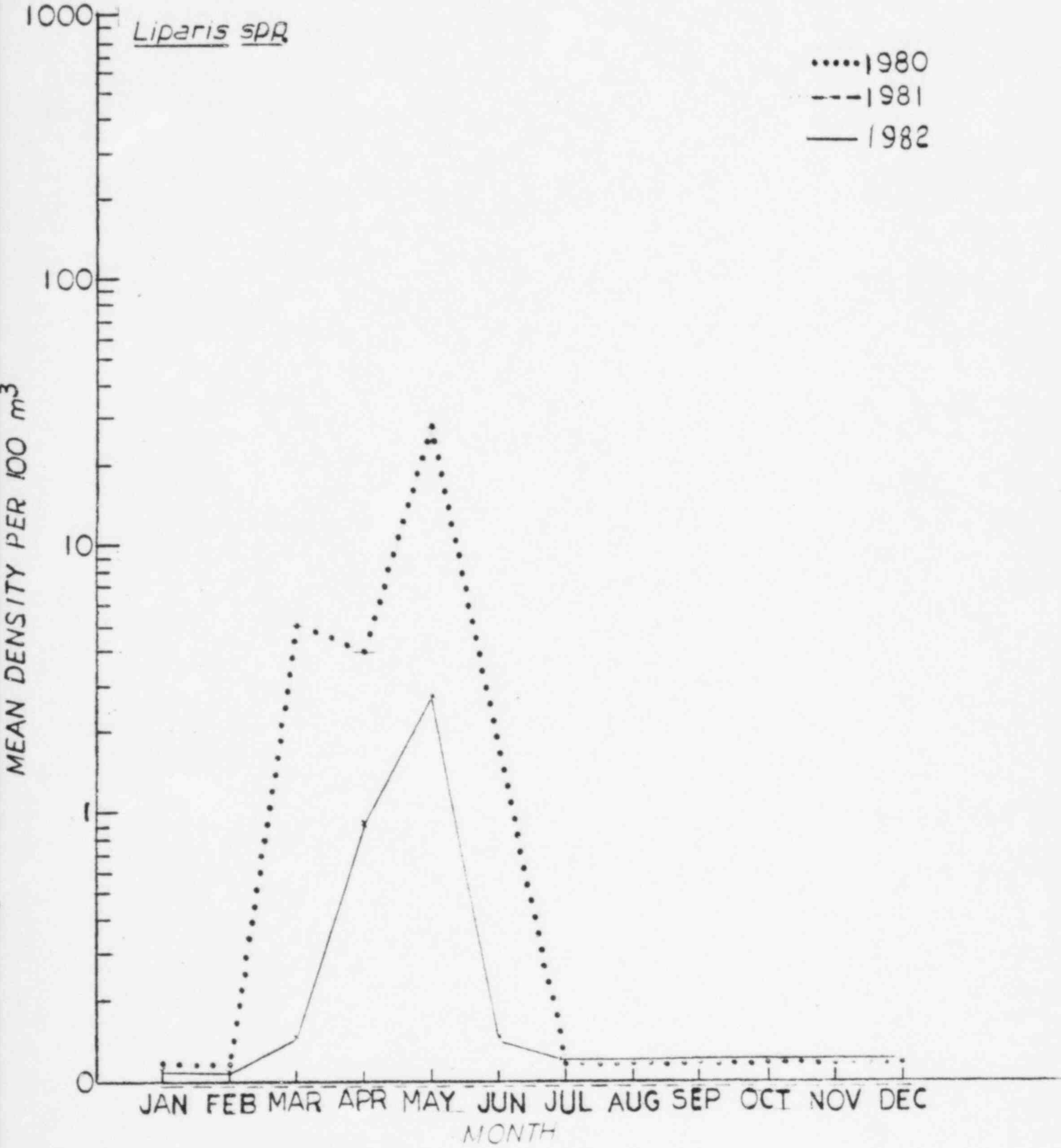


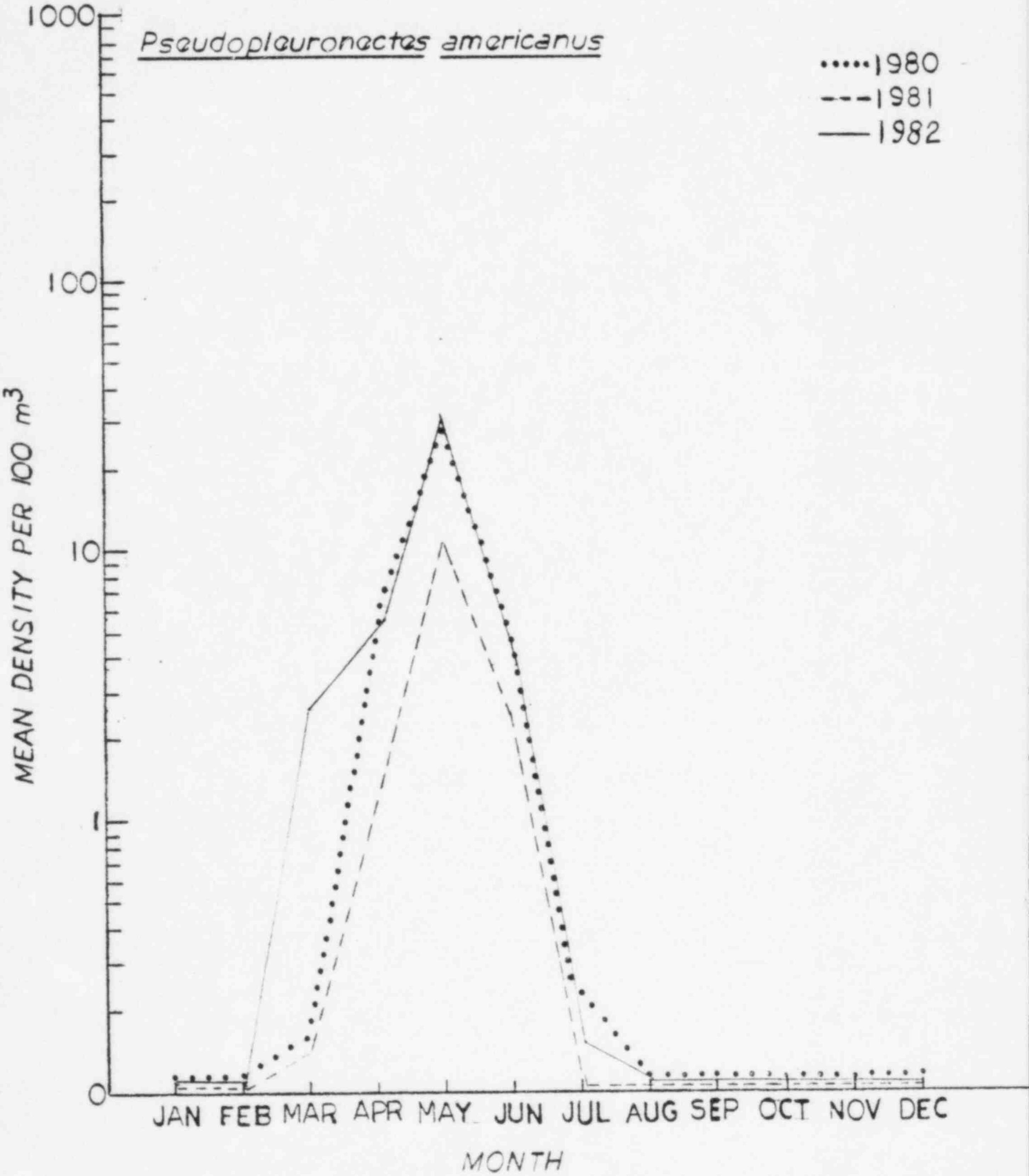
Aminodytes sp.
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m^3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH



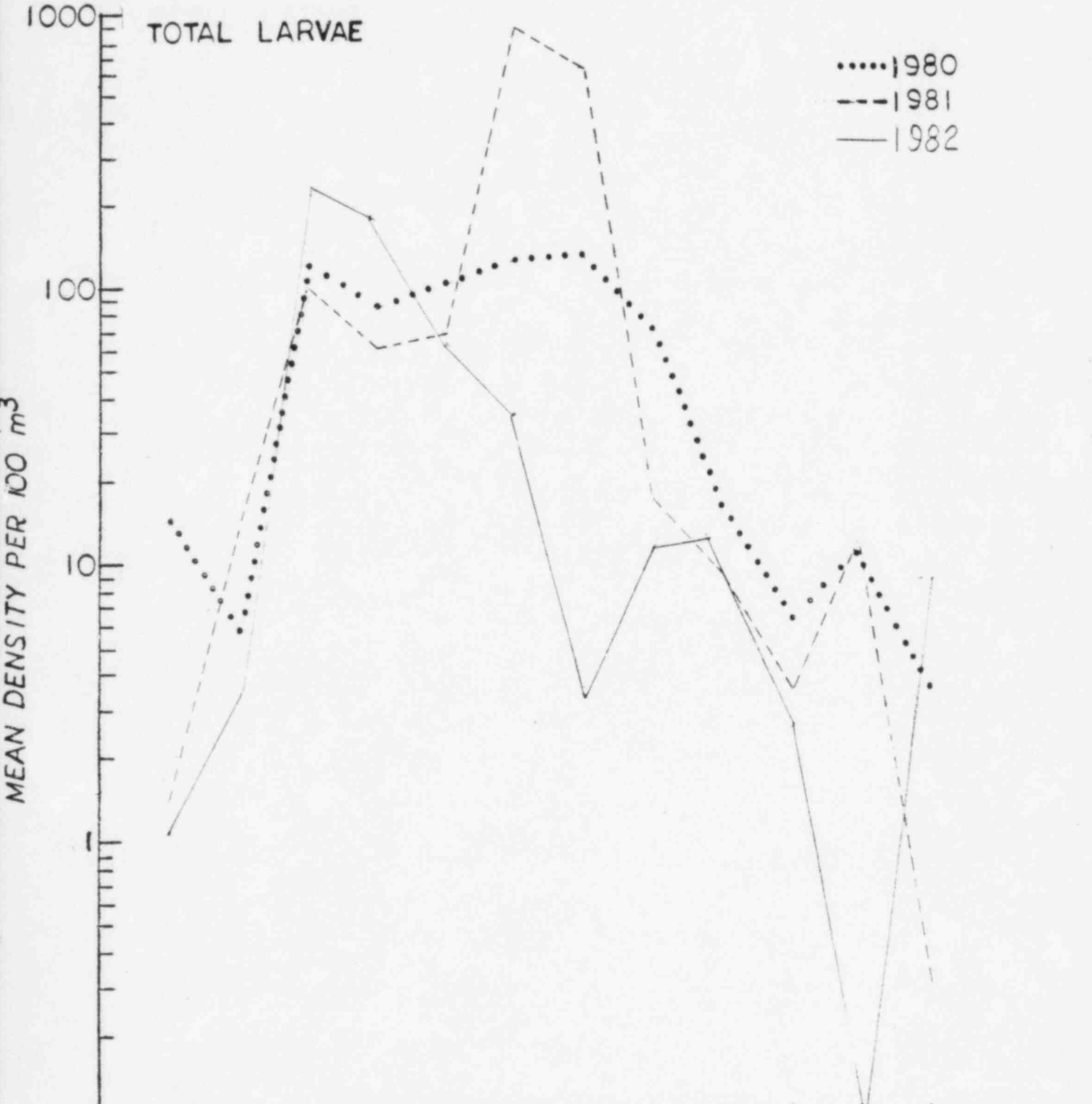
Scomber scombrus
1980
1981
1982
1000
100
10
1
0
MEAN DENSITY PER 100 m3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH


Myoxocephalus spp.
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


Liparis spp.
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



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 m^3
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

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, 1974-1982.

	1974	1975	1976	1977	1978	1979	1980	1981	1982
April									
Mean	46.0	34.6	27.7	40.5	44.5	34.9	39.6	22.0	33.0
Maximum	84	75	44	87	82	62	73	39	58
Minimum	30	17	19	25	24	14	21	9	18
May									
Mean	33.3	18.8	21.6	33.4	48.2	50.2	22.3	12	20.1
Maximum	62	28	33	120	95	128	49	23	35
Minimum	18	11	16	14	19	22	12	8	12

*U.S.G.S. 1975-1982

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Final Report

Larval Winter Flounder Studies in Plymouth Harbor, Kingston, Duxbury Bay, and Green Harbor River Estuaries - 1982

Submitted to

Boston Edison Company

Boston, Massachusetts

by

Marine Research, Inc.

Falmouth, Massachusetts

November 30, 1982

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Figures

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Appendix

I. Introduction

Entrainment studies at the Pilgrim Nuclear Power Station (PNPS) and abundance and distribution studies of larval winter flounder (Pseudopleuronectes americanus) in Plymouth Bight have, in the past, assumed that all flounder in the collections originated in Plymouth Harbor, Kingston and Duxbury Bay (PHKDB). Since winter flounder are considered to be estuarine spawners (Bigelow and Schroeder 1953; Smith et al. 1975), the Green Harbor River, the nearest estuary to PNPS other than PHKDB may also contribute larval flounder to the waters potentially under the influence of the plant. The absence of estuaries within a reasonable distance to the south of PNPS and the fact that net drift in Cape Cod Bay is southeast along the western shore further support this hypothesis.

A sampling program was conducted in the spring of 1982 to compare numbers of larval flounder flushed into Cape Cod Bay from PHKDB with those from the Green Harbor River estuary (GHR) located approximately 5 nautical miles to the north. In conjunction with the larval sampling, tidal flushing volumes of the two estuaries were compared so that total numbers of larvae potentially reaching Cape Cod Bay could be estimated for both sites.

In addition to the PHKDB and GHR larval flounder program, independent, supplementary studies were conducted in 1982 to estimate the approximate age of winter flounder eggs entrained at PNPS. These studies were completed in response to a question raised by the Pilgrim Advisory Technical Committee concerning the origin of flounder eggs collected in the discharge canal. Specifically, did these eggs drift from PHKDB (or GHR), or does coastal spawning appear to occur closer to the plant? Based on a net drift of 0.04 ft/sec (Stone and Webster 1975), it would require 7 days (168 hours) for an egg to drift from the mouth of PHKDB to PNPS (MRI 1978) and 15 days from GHR to PNPS. Any eggs at the plant found to be younger than 7 days would theoretically have originated from spawning nearer the plant.

To address this question a developmental time series was obtained for winter flounder by rearing eggs at four temperatures covering the range observed at PNPS and PHKDB during the spawning season.

II. Methods

A. Larval Sampling

Sampling in 1982 was conducted at two stations, one located at the mouth of PHKDB, the other at the mouth of GHR (Figures 1 - 3). Collections were made simultaneously at both stations using two boats. At each station duplicate tows were made during daylight ebb tides with a 0.333-3/4 m Tucker net one hour after high water, three hours after high water, and one hour before low water. At the relatively deep station in PHKDB (approximately 21 m at MLW) tows were oblique from bottom to surface. In GHR where depths ranged from 1.5 to 2.4 m at MLW tows were made at mid-depth. All tows were made at 2 to 2.5 k for 5 to 8 minutes. Net-mounted flowmeters (General Oceanics 2030) provided filtration volumes which ranged from about 125 to 250 m^3 per tow.

Sampling was completed on nine dates in 1982. The original design specified two sampling dates in March, three in April and in May, and one in early June. The unusual blizzard and high wind period which occurred from April 6-8 forced a delay which permitted only two sampling periods in April; as a result four periods were completed in May. From April 20 to June 1 collections were made during seven consecutive weeks.

Temperature ($\pm$ 0.1 C) and salinity ($\pm$ 0.1 °/oo) were recorded after each set of duplicates was taken using either a Beckman RS-5 portable salinometer or a Hydrolab digital model 4041. Readings were made at surface, mid-depth, and bottom at each station.

In addition to the larval sampling, comparative estimates were necessary of the amount of water flushed from each estuary on ebb tides. For PHKDB, data were available from Iwanowicz et al. (1974). Since none were available

for GHR, current measurements were recorded throughout each sampling day using an Endeco model 110 current meter. Current meter readings (± 0.05 k) were made before and after each collection period at the surface, mid-depth, and bottom in the narrowest part of the channel just downstream of the sampling station (Figure 3). On each occasion when current was determined, the width of the channel was measured with an optical range finder.

Plankton samples were preserved in 10% formalin-seawater solutions and returned to the laboratory for microscopic analysis. Generally entire samples were sorted for larval winter flounder. In 14% of the cases aliquot subsamples were taken using a plankton splitter because larval flounder were particularly abundant or the samples were exceptionally heavy with zooplankton and detritus. The contribution of subsampling error to total sampling error from all sources is generally not large (MRI 1974) and may be maintained at a low level if the number of specimens in an aliquot increases as the aliquot fraction grows smaller (e.g., 100 larvae of a species should be present in a one-half split, 200 in a one-quarter split, etc.).

All larval flounder were classified into arbitrary developmental stages and counted. The stages are defined below along with an approximate size range observed in each case.

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 (2.6-4.0 mm TL).

Stage III - from the end of stage II until the left eye migrates past the midline of the head during transformation (3.5-8.0 mm TL).

Stage IV - from the end of stage III to juvenile stage (7.3-8.2 mm TL).

Based on the laboratory counts and flowmeter-derived filtration volumes, larval densities were expressed in numbers per 100 m^3 of water.

B. Supplementary Winter Flounder Egg Studies

One ripe male and one gravid female with freely flowing eggs were collected from the PNPS screenwash sluiceway on May 5, 1982. Eggs and milt were manually expressed from the fish, mixed on site in ambient seawater (9.5 C; 31.0 ‰), and the fertilized eggs were transferred to our laboratory. Eggs were then divided into aerated, 1 liter, glass beakers containing ambient seawater, and the beakers were placed in constant temperature ($\pm$ 0.5 C) water baths set at 3, 8, 12, and 15 C incubation temperatures. Every two or three days 75-90% of the water in each beaker was exchanged with fresh PNPS intake water filtered to 0.8 μ and adjusted to the appropriate temperatures. Each day until hatching at approximately 0800 and 1630 about 50 eggs were removed from each bath and preserved in 5% buffered formalin. These eggs of known age were then compared with flounder eggs obtained from the PNPS discharge canal to determine if any eggs collected at PNPS were less than seven days old.

III. Results

A. Larval Sampling

Based on calculations presented by Iwanowicz et al. (1974), Plymouth Harbor Kingston and Duxbury Bay, have a mean high water surface area of 4069.8 hectares (10 056.7 acres) and a mean low water surface area of 2211.6 hectares (5464.8 acres). Based on mean depth values of 3.3 m (10.9 ft) at mean high water and 2.1 m (6.8 ft) at mean low water, 89584210 m^3 (3163636476 ft^3) of water flow from PHKDB each tide.

Using the same chart as Iwanowicz et al. (C&GS chart 245, now NOAA chart 13253), we made similar computations for the Green Harbor River estuary using a polar planimeter and depth observations made during the sampling program. Based on these, GHR has an approximate MHW surface area of 21.3 hectares (52.6 acres) and a MLW surface area of 9.8 hectares (24.2 acres). With an average

MHW depth of 2.2 m (7.1 ft) and average MLW depth of 1.1 m (3.5 ft), an average of 356000 m^3 (12572021 ft^3) of water flow from the estuary on each ebb tide, or about 0.4% of the volume leaving PHKDB.

The current meter readings provided an alternate method of calculating the water discharged from GHR. Flow rates averaged over the nine sampling dates for each of the three sampling periods resulted in an estimate of 445000 m^3 (15715027 ft^3) of water discharging from the estuary on ebb tides, or about 0.5% of the volume leaving PHKDB. Calculations of larval flounder densities flushed from the estuary were based on the higher, current meter value primarily because tide gates are present under Route 139 where it passes over GHR (Figure 3), and their effect on the flushing volume is unclear at this time.

Larval winter flounder densities, per 100 m^3 of water, by developmental stage, date, station, sample set, and replicate are presented in Appendix Table 1. Mean densities recorded on each date at both sites are shown in Table 1. These densities were in turn multiplied by the ebb tide water volume estimates obtained for each estuary. Finally the numbers of larvae discharged from GHR were expressed as a percent of the numbers discharged from PHKDB.

With the exception of March 19 when a small number of larvae were taken in GHR while none were found in PHKDB, GHR contributed less than 1% of the larval flounder to Cape Cod Bay that PHKDB contributed.

The presence of larval flounder in GHR samples before they appeared in PHKDB suggests that spawning or hatching may have begun there somewhat earlier. This is supported by the greater percentage of stage II larvae in GHR early in the season (Table 2). Temperature records at both sites (Table 3) indicate that, while GHR surface water temperatures were generally higher than those in PHKDB, mid- and bottom temperatures where the eggs develop were generally similar. The observed differences in first occurrence and stage distribution may simply reflect differences in size and circulation patterns of the two

estuaries; larvae probably have varying drift rates between spawning ground and the entrance to each estuary.

B. Supplementary Winter Flounder Egg Studies

Winter flounder eggs were successfully reared in large numbers through hatching at 3, 8, and 12 C. Development proceeded normally at 15 C, but 100% mortality occurred following the third day. Although Breder (1922) reported rearing winter flounder eggs to hatching at 20.6 C, Williams (1975) listed 15 C as the upper lethal temperature with some viable hatching occurring to 18 C. Rogers (1976) reported a viable hatching rate of 32% at 14 C and 30 $^{o}/_{oo}$, so it is likely that 15 C exceeded the lethal temperature for the particular group of eggs used in our experiment. Table 4 summarizes the time series for each temperature, presenting elapsed time in hours and days to each stage. Since the eggs had reached the two-cell stage during the time necessary to transfer them from field to the water baths, studies and elapsed time began at that point. In cases where no time is presented for a particular stage, the eggs developed beyond that point between sampling occasions.

Information available in the literature (see Rogers 1976) indicates that a single batch of winter flounder eggs hatches over a long period of time. The PNPS rearing studies indicated that the staggering of development among eggs fertilized at the same time begins at or near the end of gastrulation and becomes quite dramatic once the early embryo forms. The data in Table 4 indicate the wide range in development times beyond that point. Some eggs continue to develop while others appear to slow or stop for periods of perhaps six or more days (3 C). Viewed within the goals of this study, an egg collected at 3 C with an embryo just encircling the yolk could be as young as 10 or as old as 15.6 days.

During the March-May period when winter flounder eggs are generally taken at PNPS, 79 eggs were found in entrainment samples utilized for the aging studies. (Others were collected but were reared under another phase of the

study - see MRI 1982.) Among the 79 eggs, 35 (44.3%) were dead and did not offer any useful information. Table 5 summarizes the numbers of eggs taken by date and lists the approximate ages of all the live eggs in each case. Eggs were aged using the 3 C (March 24, 31) and 8 C (all others) laboratory-reared series based on PNPS intake water temperature records.

As shown in Table 5, 18 (40.9%) of the live eggs taken during the study appeared to be considerably younger than 7 days (168 hours) even allowing for the fact that in all but one case (May 11) field temperatures were somewhat lower than the laboratory temperature used to age the eggs. For example, if the eggs collected at 6.1 (April 7) and 6.7 C (April 29, May 4) were aged using the considerably longer 3 C developmental series, only the single egg on May 4 would exceed seven days in age. Many of the other eggs could have been less than seven days in age but, due to the wide range in development times among the older eggs, results are uncertain.

Results of these studies certainly suggest that some winter flounder eggs are spawned outside the Plymouth Harbor, Kingston and Duxbury Bay estuary nearer the station. The alternate hypothesis is that some eggs may drift from the estuary to PNPS in much less time than the estimated seven days. The larval flounder studies completed in 1975 (MRI 1976) suggested that larvae might, under some tidal conditions, pass over Browns Bank and through the narrow channel between the Bank and the tip of Plymouth Beach. It is reasonable to assume that this route would result in a more rapid passage to PNPS than if an egg followed the channel out of the estuary. This shorter route may be offset to some extent by the fact that the seven-day estimated passage time was assumed to begin at the mouth of PHKDB and not inside the estuary where spawning was expected to occur. In any event, given that some eggs found at the plant appeared to be under 3 days old and several were about 1 day old, it would appear doubtful, based on present information, that they originated from PHKDB.

IV. Summary

A. Larval Sampling

Larval winter flounder sampling in 1982 was designed to test the assumption that all winter flounder larvae entrained at the Pilgrim Nuclear Power Station (PNPS) originate from Plymouth Harbor, Kingston and Duxbury Bay (PHKDB). This assumption was made in impact modeling studies by MIT and Stone and Webster Engineering Corporation (Pagenkopf et al. 1976; Chau and Pearce 1977; Stone and Webster 1975) and Marine Research, Inc. (MRI 1978). Concurrent ebb tide sampling was completed on nine dates between mid-March and early June at the mouth of PHKDB and the Green Harbor River (GHR), the nearest estuary to PNPS other than PHKDB. Over nine collection dates larval flounder densities, per 100 m^3 of water, in PHKDB ranged from 0 (March 19) to 73.9 (March 26) with a mean of 34.8. In GHR they ranged from 0.2 (March 19) to 36.8 (March 26) with a mean of 15.0 per 100 m^3 of water. Based on tidal flushing volumes of 89584210 m^3 for PHKDB ebb tides (Iwanowicz et al. 1974) and 445000 m^3 for GHR (determined with 1982 current meter readings), the number of larval flounder drifting into Cape Cod Bay from GHR was less than 1% of the number drifting from PHKDB (range = 0.04-0.8%).

These values suggest that assuming PHKDB to be the sole source of larval flounder entrained at PNPS has in general been valid. Assuming near shore drift patterns carry larval flounder from GHR to PNPS and that these larvae survive the drift period, some are probably entrained. However, the 1982 sampling program indicated that, compared with numbers of larval flounder from PHKDB, this number is probably quite small. Since it is usually wise to maintain a conservative approach to power plant impact assessment, attributing all larval flounder impact to PHKDB appears to have been appropriate.

B. Supplementary Winter Flounder Egg Studies

In conjunction with 1982 ichthyoplankton entrainment sampling, supplementary studies were completed to estimate the age of winter flounder eggs collected at PNPS. These developed in response to a question concerning the source of flounder eggs at PNPS; specifically do these eggs drift from PHKDB (or GHR), or does coastal spawning appear to occur closer to PNPS? Based on available drift data, any entrained flounder eggs less than 7 days old could not have originated from PHKDB and must therefore have been spawned nearer the plant. To age entrained eggs, winter flounder eggs were reared at 3, 3, 12, and 15 C and fixed at known intervals for comparison with field samples.

Results of these studies indicated that 40.9% of the live eggs (n = 44) collected at PNPS appeared to be considerably younger than 7 days. A total of 16 eggs (36.4%) were in fact less than 3 days old and 7 of these (15.9%) were about 1 day old. These data strongly suggest that some flounder spawning occurs nearer PNPS than inside PHKDB.

Studies conducted in 1982 indicated that live winter flounder eggs collected in the intake and discharge water at PNPS and returned to the laboratory produce viable larvae (MRI 1982). Therefore eggs found outside PHKDB presumably contribute to larval entrainment. If significant coastal spawning occurs, attributing all plant impacts to PHKDB populations would be conservative as mentioned above in the case of GHR.

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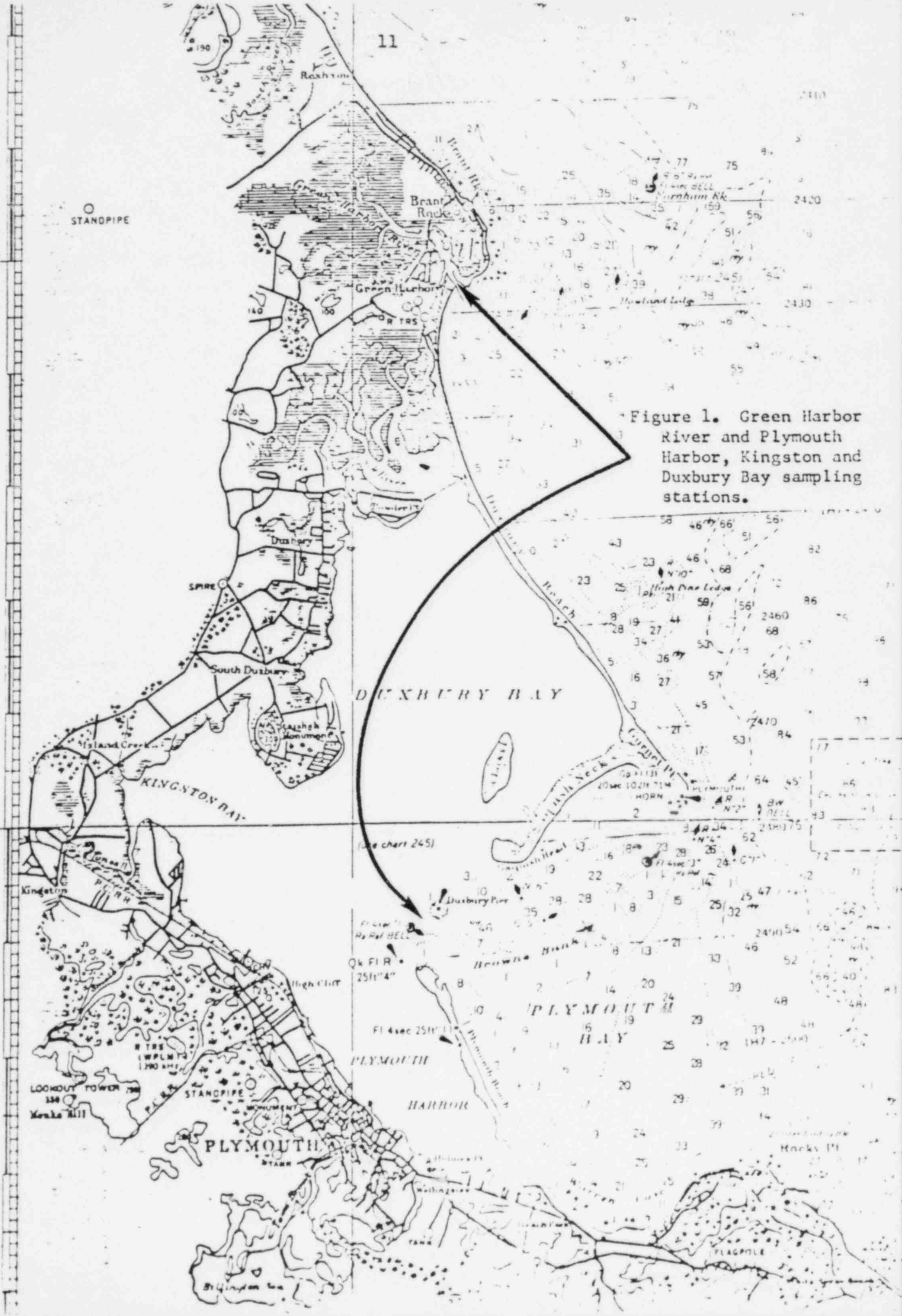

Figure 1. Green Harbor River and Plymouth Harbor, Kingston and Duxbury Bay sampling stations.

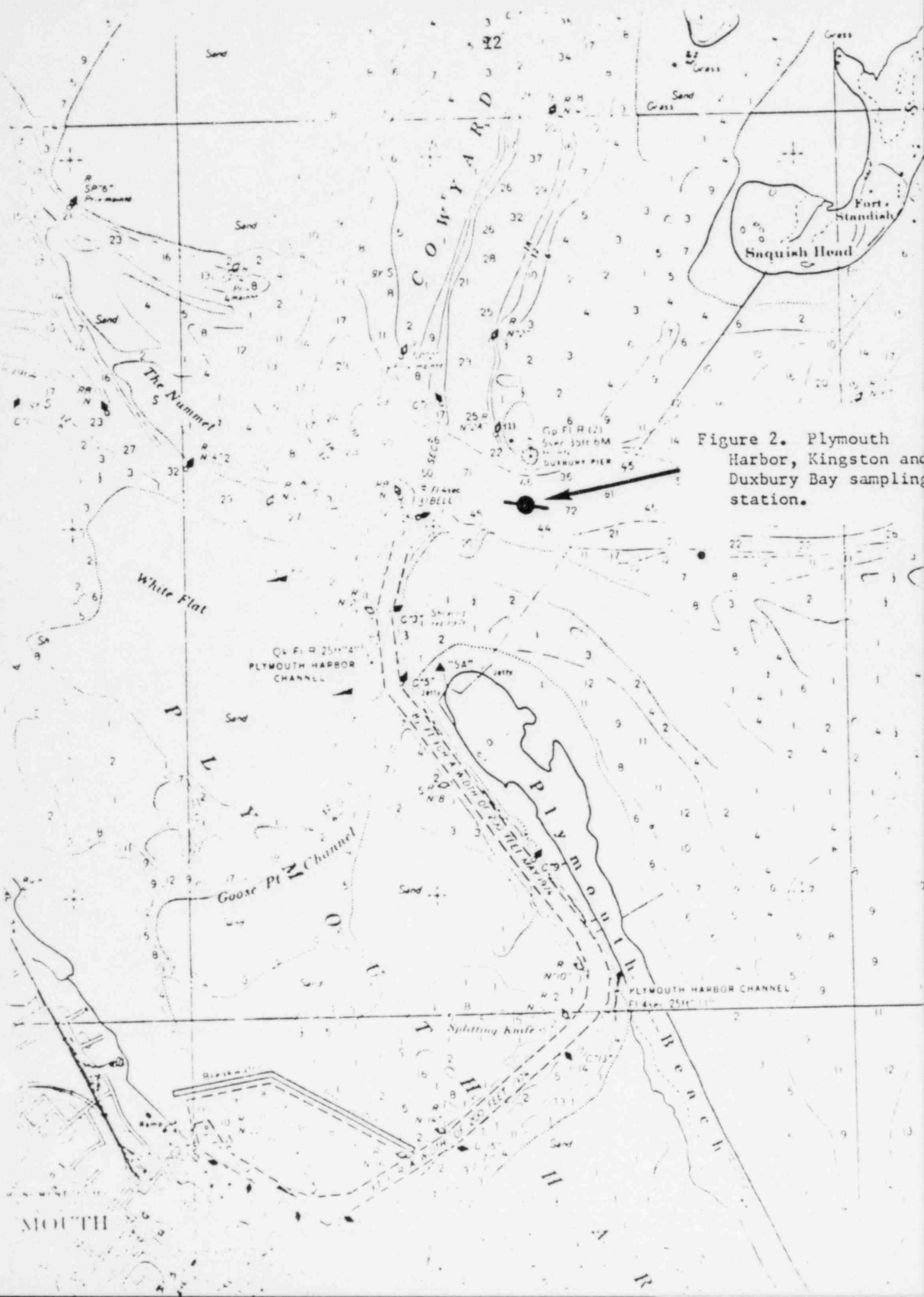

Figure 2. Plymouth Harbor, Kingston and Duxbury Bay sampling station.

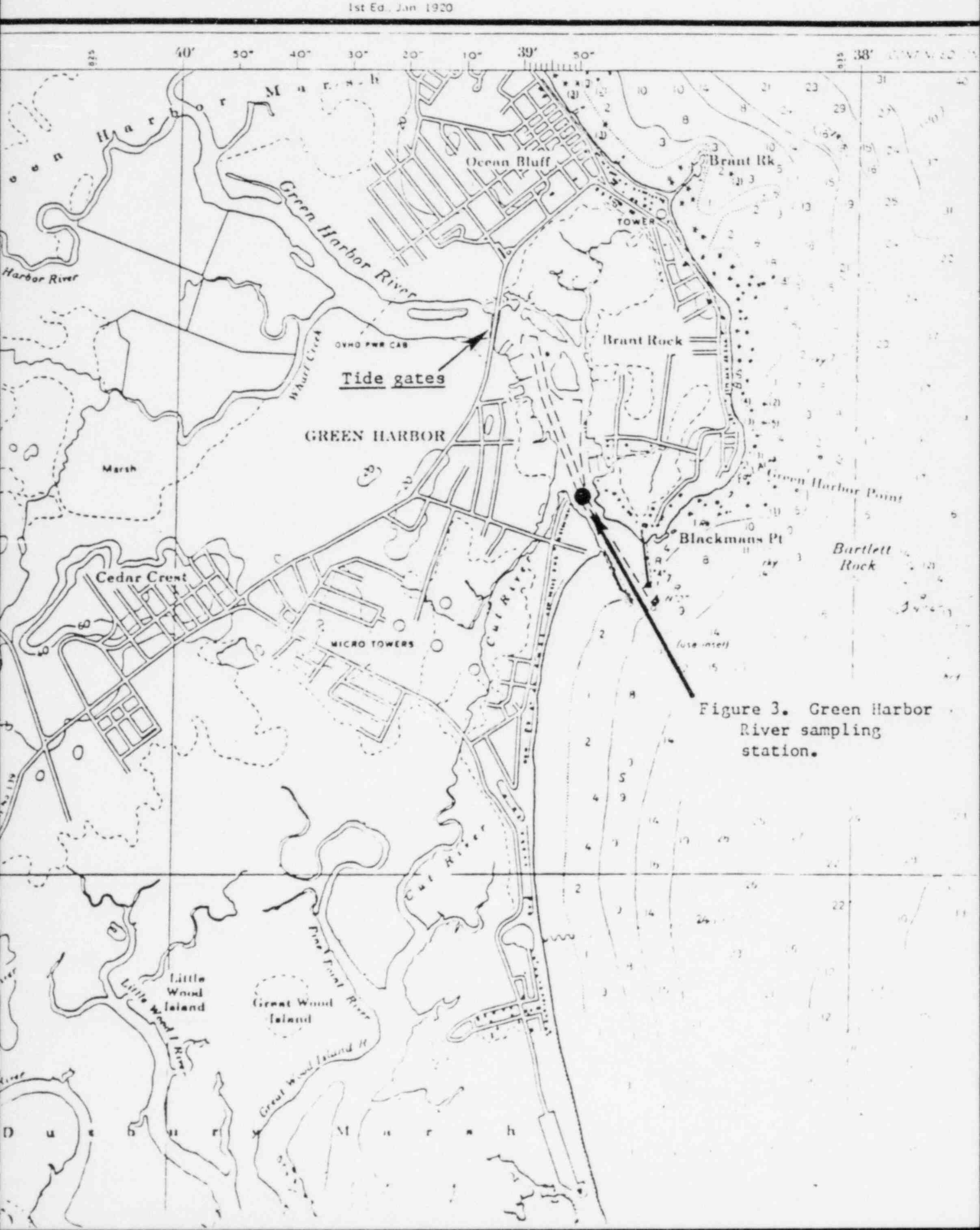

Figure 3. Green Harbor River sampling station.

Table 1. Mean larval winter flounder densities recorded at the entrance to PHKDB and GHR during ebb tides on nine dates in 1982. Numbers of larvae discharged to Cape Cod Bay during one tidal cycle were based on flushing volumes of 89,584,210 m^3 for PHKDB and 445,000 m^3 for GHR.

Date (1982)	Mean Density PHKDB	Mean Density GHR	Total Discharged ($x 10^3$) PHKDB	Total Discharged ($x 10^3$) GHR	Percent Contributed by GHR
March 19	0	0.2	0	0.9	100
March 26	73.9	36.8	66,202.7	163.8	0.2
April 20	6.0	9.5	5,375.0	42.3	0.8
April 26	13.0	20.0	11,645.9	89.0	0.8
May 3	43.4	22.0	38,879.5	97.9	0.3
May 10	70.1	19.5	62,798.5	86.8	0.1
May 18	43.5	18.3	38,969.1	81.4	0.2
May 25	60.2	4.7	53,929.7	20.9	0.04
June 1	3.4	3.7	3,045.9	16.5	0.5

Table 2. Percent of total winter flounder larvae classified among developmental stages I, II, and III from collections made at the entrance to PHKDB and GHR.

Date (1982)	Stage I		Stage II		Stage III	
	PHKDB	GHR	PHKDB	GHR	PHKDB	GHR
March 19	*	65.2	*	34.8	*	0
March 26	93.0	30.4	7.0	69.1	0	0.5
April 20	27.0	0	69.8	98.4	3.0	1.5
April 26	6.3	0	91.1	93.4	2.6	6.6
May 3	0	0.3	54.2	61.3	45.8	38.4
May 10	2.4	1.0	13.4	1.7	84.2	97.3
May 18	1.9	0	40.7	8.3	57.2	91.4
May 25	0	5.5	11.1	14.6	87.5	77.0
June 1	2.8	3.5	97.4	94.9	0	1.6

*No larval flounder were present.

Table 3. Temperature (^{o}C) and salinity ($^{o}/oo$) recorded at surface, mid-depth, and bottom at the entrance to PHKDB and GHR on nine dates in 1982.

		Temperature (^{o}C)			Salinity ($^{o}/oo$)		
		Surface	Mid	Bottom	Surface	Mid	Bottom
March 19	PHKDB	2.8	2.8	2.7	32.1	32.2	32.2
	GHR	4.2	2.5	2.3	22.6	31.7	31.2
March 26	PHKDB	4.7	4.4	4.0	32.1	32.1	32.3
	GHR	6.0	4.3	4.5	29.6	32.0	32.0
April 20	PHKDB	7.5	7.3	7.2	31.9	31.9	31.9
	GHR	6.9	5.0	5.9	28.9	33.0	32.0
April 26	PHKDB	6.4	6.3	6.0	30.3	30.6	30.6
	GHR	8.2	7.6	7.4	*	*	*
May 3	PHKDB	7.8	7.3	6.9	32.1	32.5	32.4
	GHR	10.1	8.1	8.2	29.8	29.8	30.4
May 10	PHKDB	9.4	8.3	8.2	32.6	32.2	32.2
	GHR	8.8	8.4	8.3	29.3	30.5	30.0
May 18	PHKDB	11.5	12.8	12.2	30.8	30.9	30.8
	GHR	13.2	12.7	11.6	27.9	29.0	29.6
May 25	PHKDB	11.8	10.5	10.5	30.8	31.6	32.0
	GHR	12.3	10.3	10.1	29.2	29.7	29.8
June 1	PHKDB	12.7	12.5	12.5	30.8	30.8	30.9
	GHR	13.2	13.0	13.1	28.2	28.5	29.4

*Conductivity meter malfunctioned.

Table 4. Elapsed time in hours and days ( ) during development of winter flounder eggs at four water temperatures (C).

Stage	Temperature (C) 3	8	12	15
early to mid-blastula	15 (0.6)	15 (0.6)	-	
mid to late blastula	24 - 39 (1.0-1.6)	24 (1.0)	15 (0.6)	15 - 24 (0.6-1.0)
early gastrulation	48 (2.0)	-	-	-
germ ring ¼ to ½ around yolk	62 (2.6)	-	-	-
germ ring ½ to 3/4 around yolk	72 (3.0)	39 (1.6)	24 (1.0)	24 (1.0)
germ ring 3/4 around to fully around	87 - 168 (3.6-7.0)	48 - 62 (2.0-2.6)	-	-
embryonic axis visible	135 - 144 (5.6-6.0)	62 - 72 (2.6-3.0)	39 - 62 (1.6-2.6)	39 - * (1.6-)
head visible	144 - 192 (6.0-8.0)	72 - 87 (3.0-3.6)	-	48 - * (2.0-)
embryo 9/12 around yolk	159 - 192 (6.6-8.0)	96 - 120 (4.0-5.0)	-	-
embryo 10/12 around yolk	168 - 240 (7.0-10.0)	-	48 - 144 (2.0-6.0)	62 - * (2.6-)
embryo 11/12 around yolk	207 - 335 (8.6-14.0)	111 - 264 (4.6-11.0)	62 - 159 (2.6-6.6)	
embryo fully around yolk	240 - 375 (10.0-15.6)	120 - 264 (5.0-11.0)	72 - 159 (3.0-6.6)	
tip of tail reaches front edge of eye	255 - 399 (10.6-16.6)	135 - 264 (5.6-11.0)	87 - 159 (3.6-6.6)	
tip of tail reaches beyond rear of eye	288 - 399 (12.0-16.6)	144 - 264 (6.0-11.0)	-	
tip of tail distinctly pointed	312 - 686 (13.0-28.6)	168 - 288 (7.0-12.0)	96 - 159 (4.0-6.6)	
finfold becoming clearly defined	360 - 686 (15.0-28.6)	168 - 288 (7.0-12.0)	-	
hatching imminent	384 - 740** (16.0-30.8)	192 - 375** (8.0-15.6)	96 - 159 (4.0-6.6)	
hatching	399 - 740** (16.6-30.8)	207 - 375** (8.6-15.6)	111 - 184** (4.6-7.7)	

*Development appeared to cease at approximately 72 hours.

**Hatching largely completed.

Table 5. Approximate ages in hours and days ( ) for winter flounder eggs collected in the PNPS discharge canal, March-May 1982.

Date	Total Number	Age Hours	(Days)	No. Eggs	Water Temp. (C)
March 24	6	<15	(0.6)	2	2.8
		24-39	(1.0-1.6)	1	
		62	(2.6)	3	
March 31	3	<15	(0.6)	1	2.2
		-		2 (dead)	
April 7	12	24	(1.0)	3	6.1
		111-264	(4.6-11.0)	1	
		120-264	(5.0-11.0)	2	
		168-288	(7.0-12.0)	2	
		192-375	(8.0-15.6)	1	
				3 (dead)	
April 13	2	-		2 (dead)	7.8
April 27	1	-		1 (dead)	7.8
April 29	45	<39	(1.6)	2	6.7
		48-62	(2.0-2.6)	4	
		111-264	(4.6-11.0)	8	
		135-264	(5.6-11.0)	3	
		192-375	(8.0-15.6)	4	
				24 (dead)	
May 4	2	96-120	(4.0-5.0)	1	6.7
				1 (dead)	
May 11	8	96-120	(4.0-5.0)	1	8.9
		111-264	(4.6-11.0)	1	
		135-264	(5.6-11.0)	1	
		192-375	(8.0-15.6)	3	
				2 (dead)	

Appendix Table 1. Population densities, per 100 m^3 of water, for larval winter flounder classified by four arbitrary developmental stages on nine dates in 1982 for Plymouth Harbor, Kingston, Duxbury Bay and Green Harbor River estuaries.

TIME CODE 1 19 MARCH 1982

Densities in Numbers of Plankton per 100 Cubic Meters

Locality	PLYMOUTH HARBOR - DUXBURY BAY				GREEN HARBOR			
Set	I	II	III	MEAN	I	II	III	MEAN
Larvae-#-Species								
P. AMERICANUS STAGE 1 I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 1 II	0.00	0.00	0.00	0.00	0.00	0.45	0.47	0.31
AVERAGE P. AMERICANUS STAGE 1	0.00	0.00	0.00	0.00	0.00	0.22	0.23	0.15
P. AMERICANUS STAGE 2 I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 2 II	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.16
AVERAGE P. AMERICANUS STAGE 2	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.08
TOTAL I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL II	0.00	0.00	0.00	0.00	0.00	0.45	0.94	0.46
AVERAGE TOTAL	0.00	0.00	0.00	0.00	0.00	0.22	0.47	0.23
TOTAL	0.00	0.00	0.00	0.00	0.00	0.45	0.94	0.46

Roman Numerals Designate Replicate Tows at a Station

TIME CODE 2 26 MARCH 1982

Densities in Numbers of Plankton per 100 Cubic Meters

Locality	PLYMOUTH HARBOR - DUXBURY BAY				GREEN HARBOR			
Set	I	II	III	MEAN	I	II	III	MEAN
Larvae-#-Species								
P. AMERICANUS STAGE 1 I	22.36	63.56	129.70	71.87	0.73	21.19	0.00	7.31
P. AMERICANUS STAGE 1 II	10.25	111.99	74.27	65.50	1.78	19.07	24.45	15.10
AVERAGE P. AMERICANUS STAGE 1	16.30	87.78	101.99	68.69	1.25	20.13	12.22	11.20
P. AMERICANUS STAGE 2 I	1.24	4.38	5.90	3.84	0.00	0.00	151.45	50.48
P. AMERICANUS STAGE 2 II	0.60	0.00	18.91	6.50	0.00	1.19	0.00	0.40
AVERAGE P. AMERICANUS STAGE 2	0.92	2.19	12.40	5.17	0.00	0.60	75.73	25.44
P. AMERICANUS STAGE 3 I	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.35
P. AMERICANUS STAGE 3 II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE P. AMERICANUS STAGE 3	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.17
TOTAL I	23.60	67.95	135.59	75.71	0.73	21.19	152.49	58.14
TOTAL II	10.85	111.99	93.18	72.01	1.78	20.26	24.45	15.50
AVERAGE TOTAL	17.23	89.97	114.39	73.86	1.25	20.73	88.47	36.82
TOTAL	34.45	179.94	228.77	147.72	2.51	41.46	176.94	73.63

Roman Numerals Designate Replicate Tows at a Station

TIME CODE 3 20 APRIL 1982

Densities in Numbers of Plankton per 100 Cubic Meters

Locality	PLYMOUTH HARBOR - DUXBURY BAY				GREEN HARBOR			
Set	I	II	III	MEAN	I	II	III	MEAN
Larvae-#-Species								
P. AMERICANUS STAGE 1 I	2.44	1.11	6.16	3.24	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 1 II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE P. AMERICANUS STAGE 1	1.22	0.55	3.08	1.62	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 2 I	2.44	2.21	0.00	1.55	12.54	3.28	7.15	7.66
P. AMERICANUS STAGE 2 II	0.00	1.80	18.64	6.81	11.15	11.99	9.90	11.01
AVERAGE P. AMERICANUS STAGE 2	1.22	2.00	9.32	4.18	11.85	7.63	8.53	9.33
P. AMERICANUS STAGE 3 I	0.00	1.11	0.00	0.37	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 3 II	0.00	0.00	0.00	0.00	0.00	0.86	0.00	0.29
AVERAGE P. AMERICANUS STAGE 3	0.00	0.55	0.00	0.18	0.00	0.43	0.00	0.14
TOTAL I	4.89	4.42	6.16	5.16	12.54	3.28	7.15	7.66
TOTAL II	0.00	1.80	18.64	6.81	11.15	12.84	9.90	11.30
AVERAGE TOTAL	2.44	3.11	12.40	5.99	11.85	8.06	8.53	9.48
TOTAL	4.89	6.22	24.81	11.97	23.69	16.12	17.05	18.95

Roman Numerals Designate Replicate Tows at a Station

TIME CODE 4 26 APRIL 1982

Densities in Numbers of Plankton per 100 Cubic Meters

Locality	PLYMOUTH HARBOR - DUXBURY BAY				GREEN HARBOR			
Set	I	II	III	MEAN	I	II	III	MEAN
Larvae-#-Species								
P. AMERICANUS STAGE 1 I	1.40	0.67	2.87	1.65	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 1 II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE P. AMERICANUS STAGE 1	0.70	0.34	1.44	0.82	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 2 I	15.45	8.07	1.91	8.48	13.68	30.36	11.86	18.63
P. AMERICANUS STAGE 2 II	9.52	20.00	16.26	15.26	12.62	22.83	20.60	18.68
AVERAGE P. AMERICANUS STAGE 2	12.49	14.03	9.09	11.87	13.15	26.59	16.23	18.66
P. AMERICANUS STAGE 3 I	0.00	0.67	0.00	0.22	4.10	0.00	0.00	1.37
P. AMERICANUS STAGE 3 II	1.36	0.00	0.00	0.45	0.00	0.00	3.75	1.25
AVERAGE P. AMERICANUS STAGE 3	0.68	0.34	0.00	0.34	2.05	0.00	1.87	1.31
TOTAL I	16.85	9.41	4.78	10.35	17.78	30.36	11.86	20.00
TOTAL II	10.88	20.00	16.26	15.71	12.62	22.83	24.34	19.93
AVERAGE TOTAL	13.87	14.71	10.52	13.03	15.20	26.59	18.10	19.97
TOTAL	27.74	29.41	21.04	26.07	30.40	53.19	36.20	39.93

Roman Numerals Designate Replicate Tows at a Station

TIME CODE 5 3 MAY 1982

Densities in Numbers of Plankton per 100 Cubic Meters

Locality	PLYMOUTH HARBOR - DUXBURY BAY				GREEN HARBOR			
Set	I	II	III	MEAN	I	II	III	MEAN
Larvae-#-Species								
P. AMERICANUS STAGE 1 I	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.13
P. AMERICANUS STAGE 1 II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE P. AMERICANUS STAGE 1	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.06
P. AMERICANUS STAGE 2 I	17.30	36.95	22.64	25.63	14.29	15.02	6.41	11.91
P. AMERICANUS STAGE 2 II	18.86	34.98	10.38	21.40	19.75	15.30	10.30	15.12
AVERAGE P. AMERICANUS STAGE 2	18.08	35.97	16.51	23.52	17.02	15.16	8.3[illegible]	13.51
P. AMERICANUS STAGE 3 I	17.99	21.87	13.27	17.71	3.43	9.32	10.18	7.65
P. AMERICANUS STAGE 3 II	13.20	12.56	40.21	21.99	18.62	4.78	4.41	9.27
AVERAGE P. AMERICANUS STAGE 3	15.60	17.21	26.74	19.85	11.03	7.05	7.30	8.46
TOTAL I	35.29	58.82	35.91	43.34	17.71	24.34	16.97	19.68
TOTAL II	32.06	47.53	50.58	43.39	38.37	20.09	14.71	24.39
AVERAGE TOTAL	33.67	53.18	43.25	43.37	28.04	22.21	15.84	22.03
TOTAL	67.35	106.36	86.49	86.73	56.09	44.43	31.69	44.07

Roman Numerals Designate Replicate Tows at a Station

TIME CODE 6 10 MAY 1982

Densities in Numbers of Plankton per 100 Cubic Meters

Locality	PLYMOUTH HARBOR - DUXBURY BAY				GREEN HARBOR			
Set	I	II	III	MEAN	I	II	III	MEAN
Larvae-#-Species								
P. AMERICANUS STAGE 1 I	0.00	1.10	4.02	1.71	0.32	0.39	0.00	0.24
P. AMERICANUS STAGE 1 II	0.59	0.00	4.41	1.66	0.43	0.00	0.00	0.14
AVERAGE P. AMERICANUS STAGE 1	0.29	0.55	4.21	1.69	0.38	0.19	0.00	0.19
P. AMERICANUS STAGE 2 I	6.33	9.32	9.19	8.28	0.64	0.00	0.29	0.31
P. AMERICANUS STAGE 2 II	8.83	15.12	7.71	10.55	0.43	0.35	0.31	0.37
AVERAGE P. AMERICANUS STAGE 2	7.58	12.22	8.45	9.42	0.54	0.17	0.30	0.34
P. AMERICANUS STAGE 3 I	33.97	38.36	105.69	59.34	4.81	11.66	41.29	19.25
P. AMERICANUS STAGE 3 II	55.33	34.71	85.90	58.65	12.17	4.16	39.99	18.77
AVERAGE P. AMERICANUS STAGE 3	44.65	36.54	95.79	58.99	8.49	7.91	40.64	19.01
TOTAL I	40.30	48.77	118.90	69.32	5.77	12.04	41.58	19.80
TOTAL II	64.74	49.83	98.02	70.86	13.04	4.50	40.30	19.28
AVERAGE TOTAL	52.52	49.30	108.46	70.09	9.40	8.27	40.94	19.54
TOTAL	105.04	98.60	216.91	140.19	18.81	16.54	81.88	39.08

Roman Numerals Designate Replicate Tows at a Station

TIME CODE 7 18 MAY 1982

Densities in Numbers of Plankton Per 100 Cubic Meters

Locality	PLYMOUTH HARBOR - DUXBURY BAY				GREEN HARBOR			
Set	I	II	III	MEAN	I	II	III	MEAN
P. AMERICANUS STAGE 1 I	0.00	0.57	0.00	0.19	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 1 II	0.00	4.44	0.00	1.48	0.00	0.00	0.00	0.00
AVERAGE P. AMERICANUS STAGE 1	0.00	2.51	0.00	0.84	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 2 I	6.71	17.08	12.22	12.01	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 2 II	16.97	37.33	15.88	23.39	1.28	0.38	7.47	3.04
AVERAGE P. AMERICANUS STAGE 2	11.84	27.21	14.05	17.70	0.64	0.19	3.73	1.52
P. AMERICANUS STAGE 3 I	54.78	14.24	10.48	26.50	13.97	44.68	8.20	22.28
P. AMERICANUS STAGE 3 II	36.06	24.89	8.98	23.31	14.70	17.82	0.93	11.15
AVERAGE P. AMERICANUS STAGE 3	45.42	19.56	9.73	24.90	14.33	31.25	4.57	16.72
P. AMERICANUS STAGE 4 I	0.00	0.00	0.58	0.19	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 4 II	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.13
AVERAGE P. AMERICANUS STAGE 4	0.00	0.00	0.29	0.10	0.00	0.19	0.00	0.06
TOTAL I	61.49	31.89	23.28	38.89	13.97	44.68	8.20	22.28
TOTAL II	53.02	66.67	24.86	48.18	15.97	18.57	8.40	14.32
AVERAGE TOTAL	57.25	49.28	24.07	43.54	14.97	31.63	8.30	18.30
TOTAL	114.51	98.56	48.14	87.07	29.95	63.26	16.60	36.60

Roman Numerals Designate Replicate Tows at a Station

TIME CODE 8 25 MAY 1982

Densities in Numbers of Plankton per 100 Cubic Meters

Locality	PLYMOUTH HARBOR - DUXBURY BAY				GREEN HARBOR			
Set	I	II	III	MEAN	I	II	III	MEAN
P. AMERICANUS STAGE 1 I	0.00	0.00	0.00	0.00	0.7[illegible]	0.83	0.00	0.52
P. AMERICANUS STAGE 1 II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE P. AMERICANUS STAGE 1	0.00	0.00	0.00	0.00	0.36	0.41	0.00	0.26
P. AMERICANUS STAGE 2 I	3.43	6.62	0.56	3.54	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 2 II	15.38	6.77	7.27	9.81	0.82	0.41	2.94	1.39
AVERAGE P. AMERICANUS STAGE 2	9.41	6.70	3.91	6.67	0.41	0.20	1.47	0.69
P. AMERICANUS STAGE 3 I	37.14	68.98	36.35	47.49	2.18	6.20	1.99	3.46
P. AMERICANUS STAGE 3 II	59.26	53.05	61.39	57.90	4.09	6.95	0.42	3.82
AVERAGE P. AMERICANUS STAGE 3	48.20	61.02	48.87	52.70	3.14	6.58	1.20	3.64
P. AMERICANUS STAGE 4 I	0.00	0.00	1.68	0.56	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 4 II	0.00	1.13	2.42	1.18	0.00	0.82	0.00	0.27
AVERAGE P. AMERICANUS STAGE 4	0.00	0.56	2.05	0.87	0.00	0.41	0.00	0.14
TOTAL I	40.57	75.61	38.59	51.59	2.91	7.03	1.99	3.98
TOTAL II	74.64	60.95	71.08	68.89	4.91	8.18	3.36	5.48
AVERAGE TOTAL	57.61	68.28	54.84	60.24	3.91	7.60	2.67	4.73
TOTAL	115.22	136.56	109.67	120.48	7.82	15.20	5.34	9.46

Roman Numerals Designate Replicate Tows at a Station

TIME CODE 9 1 JUNE 1982

Densities in Numbers of Plankton per 100 Cubic Meters

Locality	PLYMOUTH HARBOR - DUXBURY BAY				GREEN HARBOR			
Set	I	II	III	MEAN	I	II	III	MEAN
P. AMERICANUS STAGE 2 I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P. AMERICANUS STAGE 2 II	0.00	0.58	0.00	0.19	0.00	0.77	0.00	0.26
AVERAGE P. AMERICANUS STAGE 2	0.00	0.29	0.00	0.10	0.00	0.39	0.00	0.13
P. AMERICANUS STAGE 3 I	1.10	1.79	1.85	1.58	3.43	5.80	0.00	3.08
P. AMERICANUS STAGE 3 II	2.26	4.03	9.05	5.11	2.22	6.17	3.66	4.02
AVERAGE P. AMERICANUS STAGE 3	1.68	2.91	5.45	3.35	2.83	5.98	1.83	3.55
P. AMERICANUS STAGE 4 I	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.13
P. AMERICANUS STAGE 4 II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE P. AMERICANUS STAGE 4	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.06
TOTAL I	1.10	1.79	1.85	1.58	3.43	6.18	0.00	3.21
TOTAL II	2.26	4.60	9.05	5.30	2.22	6.94	3.66	4.27
AVERAGE TOTAL	1.68	3.20	5.45	3.44	2.83	6.56	1.83	3.74
TOTAL	3.36	6.39	10.90	6.88	5.65	13.12	3.66	7.48

Roman Numerals Designate Replicate Tows at a Station

NUC6-N1

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

Prepared by: Robert D. Anderson

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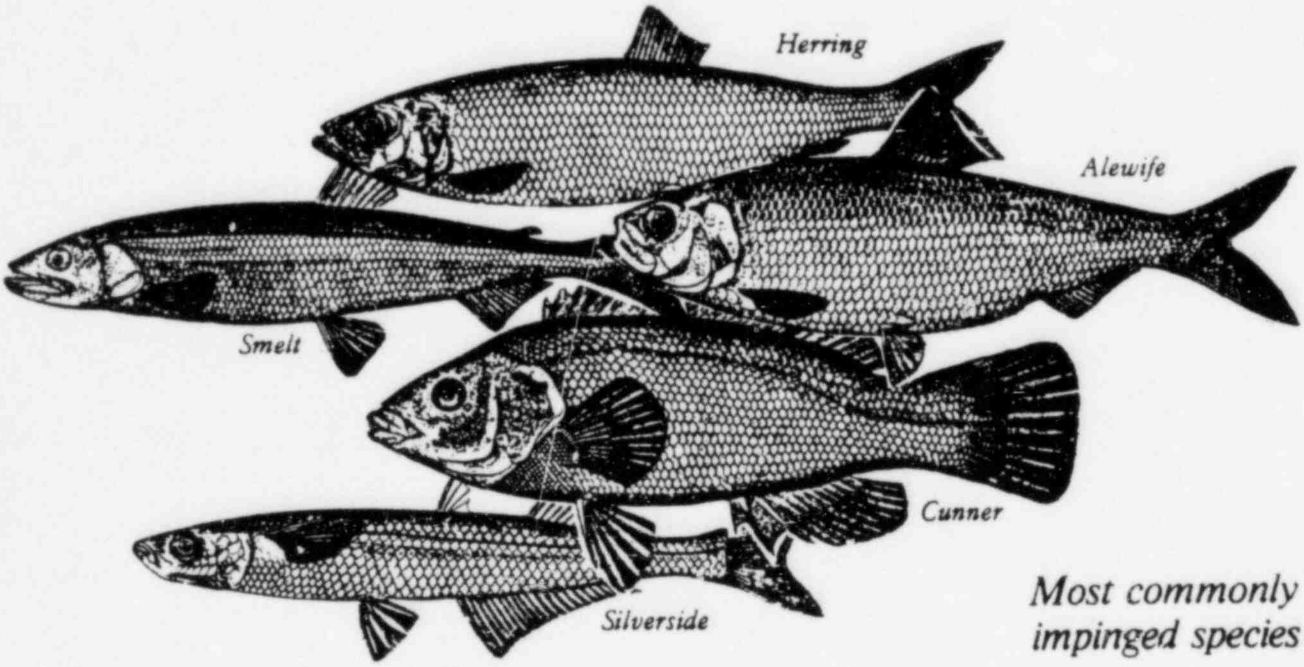
Boston Edison Company

April 1983



Most commonly impinged species

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SECTION 1

SUMMARY

Fish impingement averaged 0.93 fish/hour during the period January-December 1982. Atlantic silverside (Menidia menidia) accounted for 20.7% of the fishes collected. Bay Anchovy (Anchoa mitchilli), cunner (Tautogolabrus adspersus), rainbow smelt (Osmerus mordax) and threespine stickleback (Gasterosteus aculeatus) accounted for 11.5, 9.8, 9.4 and 6.7%, respectively, of the fishes impinged. Peak impingement months were September and December when the bay anchovy/cunner and Atlantic silverside/rainbow smelt, respectively, were most represented.

At full-load yearly (January-December) operation of Pilgrim Nuclear Power Station (PNPS) the estimated maximum impingement was 8,173 fishes (536 lbs.). The PNPS capacity factor was 56.0% from January-December 1982.

The collection rate (no./hr.) for all invertebrates captured from January-December 1982 was 1.33. The long-finned squid (Loligo pealei), and horseshoe crab (Limulus polyphemus), accounted for 40.8 and 33.6%, respectively, of the invertebrates impinged. Mixed species of algae collected on intake screens amounted to 3,606.3 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-December 1982.

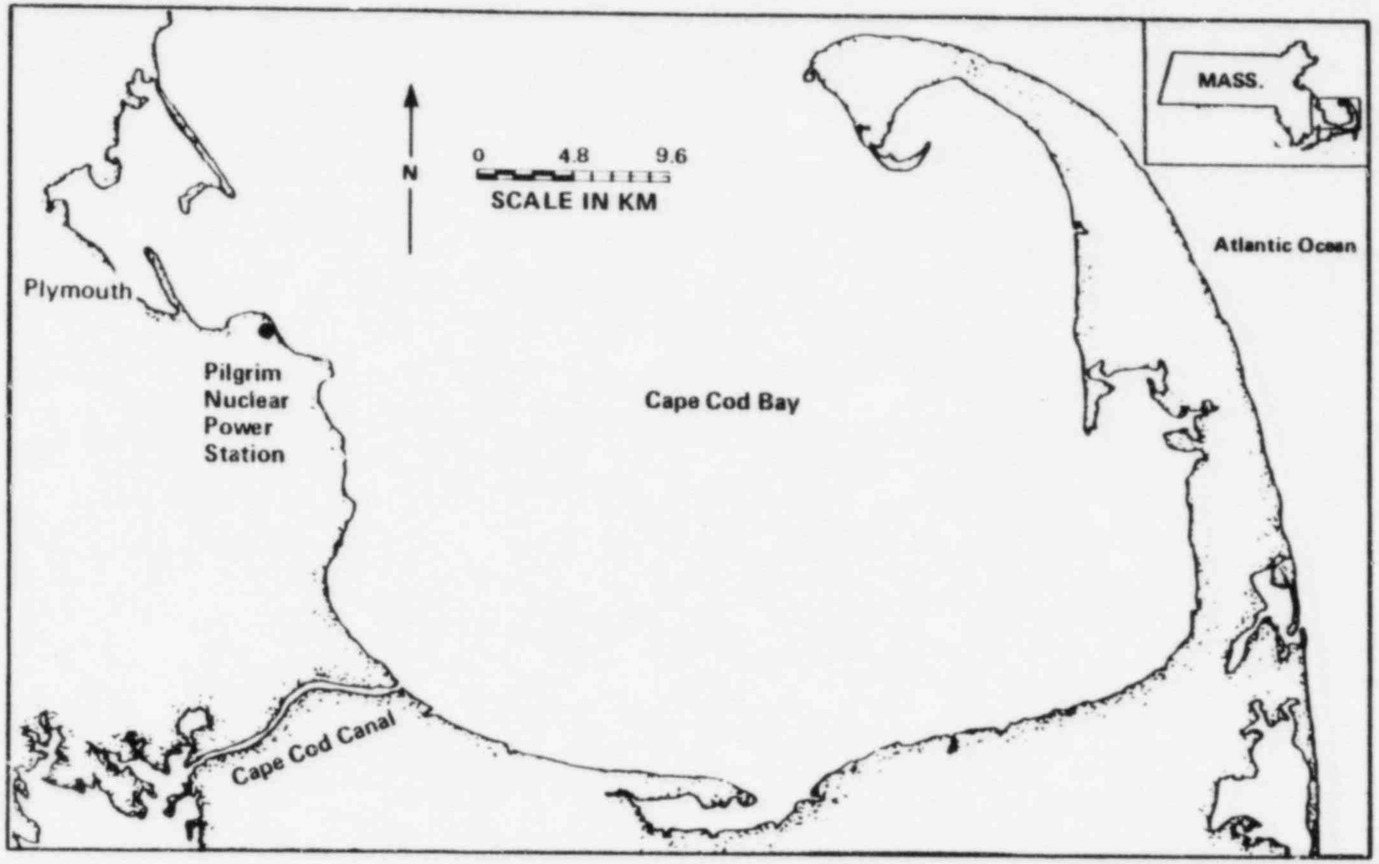

Figure 1. Location of Pilgrim Nuclear Power Station

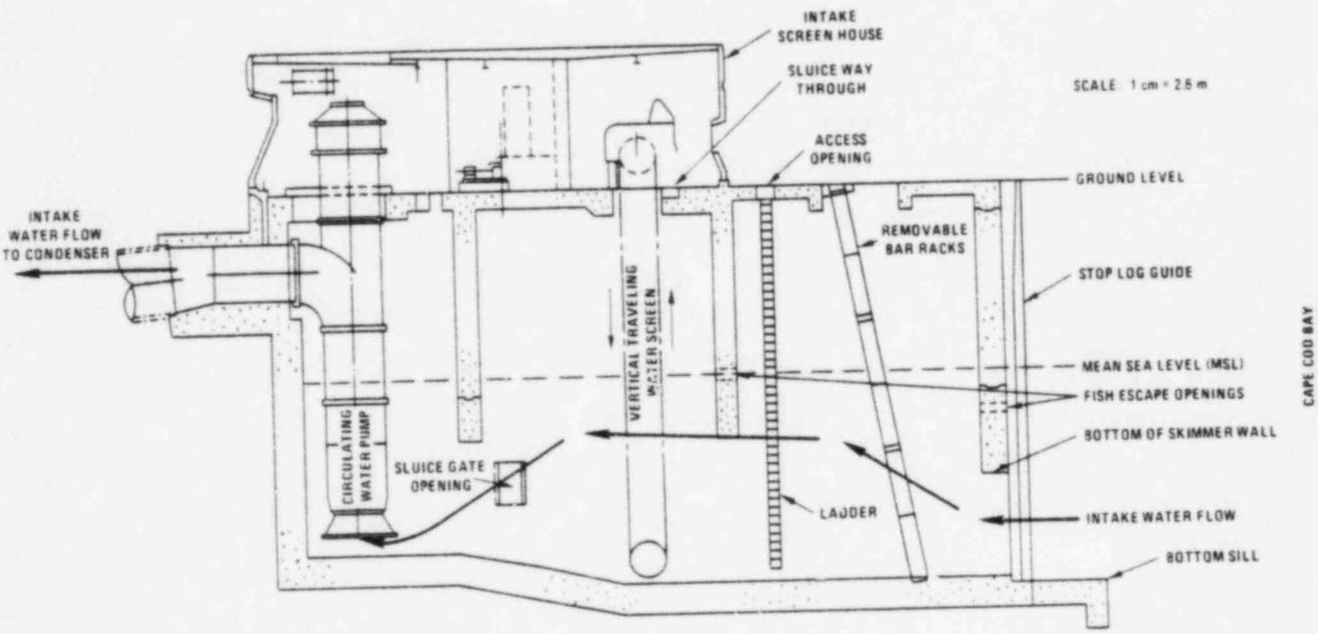

Figure 2. Intake Structure of Pilgrim Nuclear Power Station

SECTION 3

METHODS AND MATERIALS

Three screen washings each week were performed from January-December 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 30 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. A Station refueling outage from January - March 1982 curtailed impingement sampling when circulating water pumps were not operational.

Water nozzles directed at the screens washed impinged organisms and debris into a sluiceway that flowed into a trap. The original trap used 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 half 18" corrugated metal pipe with fine mesh plankton netting attached.

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 687 collection hours, 641 fishes of thirty-eight species (Table 1) were collected from Pilgrim Nuclear Power Station intake screens from January-December 1982. The collection rate was 0.93 fish/hour. Atlantic silverside (Menidia menidia) was the most abundent species accounting for 20.7% of all fishes collected (Table 2). Bay anchovy (Anchoa mitchilli), cunner (Tautogolabrus adspersus), rainbow smelt (Osmerus mordax) and threespine stickleback (Gasterosteus aculeatus) accounted for 11.5, 9.8, 9.4 and 6.7% of the total number of fishes collected and identified to lowest taxon.

Atlantic silversides occurred predominantly in monthly samples in March, April and December, with the largest number (49) captured in March. Hourly collection rates for Atlantic silversides ranged from 0 to 0.92. Silversides impinged in March, April and December accounted for 89.5% of all this species captured in impingement collections from January-December 1982. Atlantic silversides averaged 105 mm total length and 6 grams in weight. Silverside impingement indicated no relationship to tidal stage or diel factors. It is not unusual for silversides to dominate the impingement catch in March and April as happened in 1982, but a review of historical data shows it to be unprecedented for them to dominate in December. They are generally one of the major impinged species collected annually (Table 3).

Table 1. Monthly Impingem.nt For All Fishes Collected From Pilgrim Station Intake Screens, January - December 1982

Species	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Tota
Atlantic silverside	1		49	35	3			1		3	6	35	13
bay anchovy						24	7	1	25	10	7		7
cunner				1	12	11	12	1	25	1			6
rainbow smelt				3	2		3		1	5	22	24	6
threespine stickleback					37				5		1		4
pollock				1	1	2	10	1	3	4	10	5	3
winter flounder			1	2	9						5	10	2
alewife				2	2	8	2	3	1		4	3	2
blueback herring						10			1		8	5	2
northern puffer						1			19				2
Atlantic menhaden						4			6	2	3		
Atlantic tomcod	1		1						2	2	3	5	
grubby	1	2		1	3	1	1			2	1	1	
lumpfish								1	2	3		6	
white hake					3				5		2		
Atlantic herring	1									2		6	
windowpane					1	1				1	1	5	
scup									7	1			
northern pipefish				1	1			1		4			
northern searobin					4	1	1		1				
pearlside												7	
sand lance sp.							1		1		1		
bluefish											2		
mummichog					2								
radiated shanny			1									1	
summer flounder						1	1						
tautog					1						1		
American eel						1							
American sand lance						1							
Atlantic cod				1									
fourspot flounder					1								
hogchoker							1						
little skate						1							
longhorn sculpin											1		
red hake			1										
shorthorn sculpin				1									
silver-rag											1		
winter skate					1								
TOTALS	4	2	53	48	83	67	39	9	104	40	79	113	6
Collection Time (hrs.)	16	8	22	65	72	58	101	71	83	33	89	69	6
Collection Rate (#/hr.)	0.25	0.25	2.41	0.74	1.15	1.16	0.39	0.13	1.25	1.21	0.89	1.64	0

(NUC6-C10)

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

Species	Number	Length Range	Mean Length	Weight Range	Mean Weight	Percent of Total Fish
tlantic silverside	133	70-140	105	2-12	6	20.7
ay anchovy	74	36-98	73	0.4-6	3	11.5
unner	63	7-195	99	4-190	26	9.8
ainbow smelt	60	64-215	109	2-54	8	9.4
hreespine stickleback	43	50-69	58	1-3	3	6.7
ollock	37	58-350	150	4-318	56	5.8
inter flounder	27	50-355	178	1-589	136	4.2
lewife	25	8-290	147	5-250	45	3.9
lueback herring	24	80-203	153	4-54	27	3.7
orthern puffer	20	42-119	64	1-41	9	3.1
tlantic menhaden	15	55-245	113	2-157	37	2.3
tlantic tomcod	14	98-260	137	7-125	28	2.2
rubby	13	54-135	93	3-40	16	2.0
umpfish	12	27-55	40	1-7	2	1.9
hite hake	10	58-192	121	2-39	19	1.6
tlantic herring	9	60-240	145	3-76	24	1.4
indowpane	9	35-310	118	1-383	65	1.4
cup	8	43-70	52	1-5	2	1.2
orthern pipefish	7	140-194	163	1-8	2	1.1
orthern searobin	7	58-315	240	4-377	173	1.1
earlside	7	46-56	50	2-3	3	1.1
and lance sp.	3	85-210	130	3-27	12	0.5
luefish	2	90-115	102	6-11	9	0.3
ummichog	2	80-95	88	12	12	0.3
adiated shanny	2	115-120	118	15-17	16	0.3
ummer flounder	2	320-365	342	339-630	484	0.3
autog	2	130-320	225	39-610	324	0.3
merican eel	1	320	320	-	-	0.2
merican sand lance	1	175	175	18	18	0.2
tlantic cod	1	215	215	99	99	0.2
ourspot flounder	1	382	382	515	515	0.2
ogchoker	1	114	114	36	36	0.2
ittle skate	1	450	450	700	700	0.2
onghorn sculpin	1	280	280	289	289	0.2
ed hake	1	90	90	4	4	0.2
horthorn sculpin	1	290	290	350	350	0.2
ilver-rag	1	135	135	34	34	0.2
inter skate	1	490	490	770	770	0.2

Table 3. Annual Impingement Collections (1973-1982) For the 10 Most Abundant Fishes From Pilgrim Station Intake Screens During January - December 1982

Species	Number of Impinged Fishes Collected From January - December										
	1973	1974[1]	1975	1976	1977[2]	1978	1979	1980	1981	1982	Totals
Atlantic silverside	515	4	107	114	473	722	1,173	14	5,466	133	8,721
bay anchovy				3	9	12		1		74	99
cunner	99	10	28	285	154	61	22	116	55	63	893
rainbow smelt	291	34	6	103	273	3,019	87	95	13	60	3,981
threespine stickleback	9+			1	4	9	26	4	7	43	103
pollock	12	3		42	23		39	3		37	159
winter flounder	16**	1	4	29	64	34	34	15	15	27	239
alewife	596*	253*	28*	2,061	15	131	28	8	11	25	3,156
blueback herring	596*	253*	28*	23	19	64	20	5	15	24	1,047
northern puffer	1		3	48		3	2	15	79	20	171
Totals	2,135	558	204	2,709	1,034	4,055	1,431	276	5,661	506	18,569
Collection Time (hrs)	2,096.0	1,464.0	1,336.0	2,022.0	1,515.0	1,442.0	494.25	603.75	574.5	687.0	12,234.5
Collection Rate (#/hr)	1.02	0.38	0.15	1.34	0.68	2.81	2.90	0.46	9.85	0.74	1.52

*Herrings (clupeids) identified as a general category in 1973 - 1975 were split among alewife, blueback herring and Atlantic menhaden.

**Flounders identified as a general category in 1973 were split among windowpane, winter flounder and fourspot flounder.

+Sticklebacks identified as a general category in 1973 were split among threespine stickleback and fourspine stickleback.

[1]No collections were made from March - July 1974.

[2]No collections were made in September 1977.

There were no large impingement mortalities (1000+ specimens) at Pilgrim Station in 1982 (Table 4). Of the ten documented fish incidents since operation commenced, most (6) have involved impingement as the causative agent. However, at least in two of these the possibility of pathological influence has been implicated as indirectly contributing to the mortalities. They were the Atlantic herring (tubular necrosis) and rainbow smelt (piscine erythrocytic necrosis) impingement incidents in 1976 and 1978, respectively.

Bay anchovy occurred predominantly in June and September with the largest annual number (74) captured, by far, since Pilgrim operation (Table 3). Hourly collection rates for bay anchovy ranged from 0 to 0.41 specimens. It is unusual for this species to be a dominant in the impingement catch on an annual basis, but a review of the data shows they generally are impinged most during the warmer months.

Cunner dominated the impingement catch in September (25 specimens) when the highest collection rate was 0.30 fish/hour. Historically cunner impingement at Pilgrim Station has been greatest during summer months (June-August). This species annually is one of the dominants (Table 3), ranking approximately fifth over the last 10 years.

Rainbow smelt were impinged most in November and December. They are characteristically impinged in greatest numbers during the Winter period and rank approximately second in numbers collected at Pilgrim Station.

Table 4. Approximate Number and Cause for Most Notable Fish Mortalities at Pilgrim Nuclear Power Station, 1973-1982

Date	Species	Number	Cause
April 9-19, 1973	Atlantic Menhaden	43,000	Gas Bubble Disease
August/September, 1973	Clupeids	1,600	Impingement
April 2-15, 1975	Atlantic Menhaden	5,000	Gas Bubble Disease
August 2, 1975	Atlantic Menhaden	3,000	Thermal Stress
August 5, 1976	Alewife	1,900	Impingement
November 23-28, 1976	Atlantic Herring	10,200	Impingement
August 21-25, 1978	Clupeids	2,300	Thermal Stress
December 11-29, 1978	Rainbow Smelt	6,200	Impingement
March/April, 1979	Atlantic Silverside	1,100	Impingement
September 23-24, 1981	Atlantic Silverside	6,048	Impingement

Threespine stickleback dominated May impingement collections. This species is generally not impinged in large numbers being characteristically an estuarine inhabitant. Pollock (Pollachius virens) were more prevalent in July and November sampling. They are historically not impinged in large numbers either.

Blueback herring (Alosa aestivalis) and alewife (Alosa pseudoharengus) dominated the Clupeid impingement catch in 1982. This is generally typical based on past impingement records when blueback herring, and particularly alewife have been abundant in impingement samples. Winter flounder (Pseudopleuronectes americanus) maintained its position as one of the more abundant species impinged over the years. Northern puffer (Sphoeroides maculatus) was the tenth most abundant species impinged in 1982, but it was second in 1981. In the years 1976 and 1980-1982, when respectable numbers of northern puffer were collected (Table 3) the month of greatest occurrence was always September. Monthly impingement rates for the five dominant species are illustrated in Figure 3.

Projected fish impingement rates were calculated assuming 100% operation of Pilgrim Nuclear Power Station during the period January-December 1982. Table 5 presents hourly, daily and yearly impingement rates for each species captured (rates are rounded to significant figures). For all fishes combined the respective rates are 0.93, 22.39 and 8,173. The yearly rate of 8,173 fishes impinged is 32% of the 10-year (1973-1982) mean annual projection of 25,214

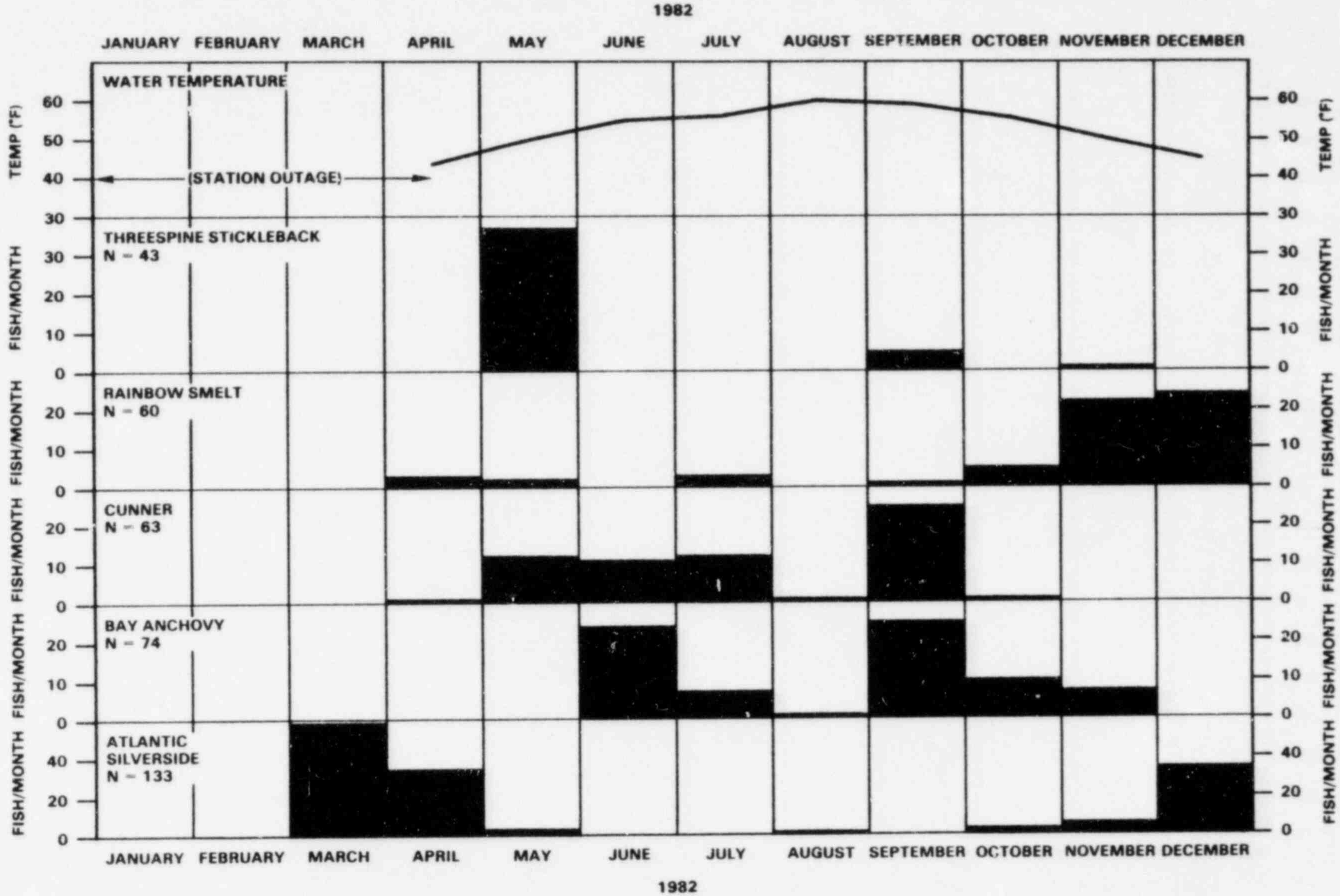

Figure 3. Trends of Intake Water Temperature, and Number of Fish Captured by Month from Pilgrim Station Intake Screens for the Five Most Abundant Species Collected, January - December 1982.

Table 5. Impingement Rates Per Hour, Day and Year For All Fishes Collected From Pilgrim Station Intake Screens During January - December 1982, Assuming 100% Operation of Pilgrim Unit 1

Species	Rate/Hr.	Rate/Day	Rate/January-December 1981	Dominant Season Of Occurrence
Atlantic silverside	0.19	4.65	1,696	March - April
bay anchovy	0.12	2.59	944	June & September
cunner	0.09	2.20	803	September
rainbow smelt	0.09	2.10	765	November - December
threespine stickleback	0.06	1.50	548	May
pollock	0.05	1.29	472	July & November
winter flounder	0.04	0.94	344	May & December
alewife	0.04	0.87	319	June
blueback herring	0.03	0.84	306	June
northern puffer	0.03	0.70	255	September
Atlantic menhaden	0.02	0.52	191	September
Atlantic tomcod	0.02	0.49	179	December
grubby	0.02	0.45	166	May
lumpfish	0.02	0.42	153	December
white hake	0.01	0.35	128	September
Atlantic herring	0.01	0.31	115	December
windowpane	0.01	0.31	115	December
scup	0.01	0.28	102	September
northern pipefish	0.01	0.24	89	October
northern searobin	0.01	0.24	89	May
pearlside	0.01	0.24	89	December
sand lance sp.	0.004	0.10	38	--
bluefish	0.003	0.07	26	November
mummichog	0.003	0.07	26	May
radiated shanny	0.003	0.07	26	March & December
summer flounder	0.003	0.07	26	June - July
tautog	0.003	0.07	26	May & November
American eel	0.001	0.03	13	June
American sand lance	0.001	0.03	13	June
Atlantic cod	0.001	0.03	13	April
fourspot flounder	0.001	0.03	13	May
hogchoker	0.001	0.03	13	July
little skate	0.001	0.03	13	June
longhorn sculpin	0.001	0.03	13	November
red hake	0.001	0.03	13	March
shorthorn sculpin	0.001	0.03	13	April
silver-rag	0.001	0.03	13	November
winter skate	0.001	0.03	13	May
Totals	0.93	22.39	8,173	

*Rates have been rounded to significant figures.

fishes. This is one of the lowest yearly fish impingement rates during the operating life of Pilgrim Station. It is attributed partially to the Station outage from January - March when sampling was limited, and possibly population variances of the dominant species.

Comparison with fish impingement rates at other power plants in the northeast United States shows Pilgrim Nuclear Power Station to be relatively low in this area of impact over the 10-year period (1973-1982) it has been operating. Anderson et al. (1975) documented higher annual impingements at seven other northeast power plants in the early 1970's. Maine Yankee Atomic Power Company (1978) Nuclear Generating Station had a mean impingement rate of approximately 58 fishes/hr. from late 1972 - late 1977, while over the same period of time Pilgrim Station's rate was slightly greater than 2 fishes/hr. In a survey of estuarine and coastal power plants in the United States, Stupka and Sharma (1977) showed annual impingement rates at numerous locations for dominant species, and compared to these even expanded rates at Pilgrim Station (assuming 100% annual operation) are lower than at most other sites.

Monthly intake water temperatures recorded during impingement collections at Pilgrim Station were generally higher from April-December (except July) 1982 than the comparable mean monthly temperatures for the interval 1976-1982 (Table 6). Therefore, overall 1982 was characterized by warm water temperatures.

Table 6. Monthly Means of Intake Temperature (°F) Recorded During Impingement Collections at Pilgrim Nuclear Power Station, 1976-1982

Month	Year							$(\bar{X})$
	1982	1981	1980	1979	1978	1977	1976	1976-1982
January	*	31.95	*	36.75	34.47	31.85	*	33.75
February	*	32.68	*	30.36	32.88	30.86	*	31.69
March	*	39.04	*	35.51	34.98	36.36	42.59	37.70
April	43.60	37.60	41.77	39.92	40.67	42.88	49.02	42.21
May	49.73	45.99	48.18	49.56	47.22	50.75	52.58	49.14
June	55.10	52.74	49.49	54.39	50.04	54.21	52.13	52.59
July	55.98	61.01	52.78	55.56	56.03	56.98	58.51	56.69
August	60.23	63.68	58.02	56.73	60.48	*	61.62	60.13
September	59.04	63.70	55.89	53.75	58.59	*	58.94	58.32
October	55.60	*	54.64	51.94	52.80	*	54.21	53.84
November	50.36	*	46.33	48.75	49.22	47.33	45.38	47.89
December	44.55	*	39.34	40.86	40.41	39.78	38.18	40.52

* Temperatures were incompletely recorded during PNPS outages in these months.

In general, 1976 displayed relatively warm water temperatures, 1977/1978/1981 were average years, and 1979/1980 were cold water years. Pilgrim Station intake temperatures approximate ambient water temperature. Despite the relatively warm water temperatures in 1982, a fairly even distribution of both cold water species (e.g., rainbow smelt, pollock and winter flounder) and warm water species (e.g., bay anchovy, cunner and threespine stickleback) were impinged. The most apparent effect of the warmer then average water temperatures appeared to be the largest numbers of bay anchovy and threespine stickleback collected since Pilgrim operation.

4.2 Invertebrates

In 687 collection hours, 914+ invertebrates of sixteen species (Table 7) were collected from Pilgrim Station intake screens from January-December 1982. Jellyfish were collected in large undertermined numbers from August-November. The collection rate was 1.33 invertebrates/hour. Two species, the long-finned squid (*Loligo pealei*) and horseshoe crab (*Limulus polyphemus*) accounted for 40.8 and 33.6%, respectively, of the total number of invertebrates collected. An unusual occurrence was the collection of no blue mussels (*Mytilus edulis*) which have dominated past impingement samples.

The greatest collections of long-finned squid were in September. Squid have been mostly impinged during the summer months since 1976. Horseshoe crabs appeared typically in greatest numbers from May-July which is their spawning season. Thirty-two specimens of the commercially important American lobster (*Homarus americanus*) were captured in the period May-September. The lobsters

Table 7. Monthly Impingement For All Invertebrates Collected From Pilgrim Station Intake Screens, January - December 1982

Species	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
jellyfish								*	*	*	*		
long-finned squid					2	7	25	22	315	2			373
horseshoe crab					110	120	62	10	5		1		308
rock crab				1	10	11	4	1	5	6	16	7	61
sand shrimp	2	2	47	6									57
green crab			10	2	6	1	1	2	5	4	1	1	33
American lobster					12	4	3	12	1				32
common starfish			5	1	8		1	2	2	3	2		24
lady crab						1	1		6	4		1	13
mantis shrimp											5		5
green sea urchin						2					1		3
purple sea urchin					1								1
ribbon worm	1												1
short-finned squid								1					1
unidentified crab	1												1
unidentified worm	1												1
TOTALS	5	2	62	10	149	149	97	50	339	19	26	9	914
Collection Time (hrs.)	16	8	22	65	72	58	101	71	83	33	89	69	687
Collection Rate (#/hr.)	0.31	0.25	2.82	0.15	2.07	2.52	0.96	0.70	4.08	0.58	0.29	0.13	1.33

* Large undetermined numbers

ranged in size from 34-90 mm carapace length and 25-220 gms. This equals 408 lobsters impinged on an annual basis at 100% operation of Pilgrim Station. It is the highest annual rate of lobster impingement since Pilgrim Station operation.

Approximately 3,606.3 pounds of mixed algae species were collected during impingement sampling for a rate of 5.25 pounds/hr.

SECTION 5

CONCLUSIONS

1. The average Pilgrim I collection rate for the period January-December 1982 was 0.93 fish/hour. Low impingement rate may have been affected, in part, by a Station outage from January-March 1982 when variable circulating water pump operation was in effect.

2. At full-load (conservative assumption) yearly operation the estimated maximum January-December 1982 impingement rate was 8,173 fishes (536 lbs.). This projected annual fish impingement rate is one of the lowest in the 10-year operating history of Pilgrim Station.

3. Thirty-eight species of fish were recorded in 687 impingement collection hours.

4. The major species collected and their relative percentages of the total collections were Atlantic silverside, 20.7%; bay anchovy, 11.5%; cunner, 9.8%; rainbow smelt, 9.4%; and threespine stickleback 6.7%.

5. Peaks in impingement collections occurred in March, April and December for Atlantic silverside. Atlantic silverside hourly impingement rate varied from 0 to 0.92.

6. Atlantic silverside indicated no relationship to tidal stage or diurnal periodicity.

7. Intake water temperatures, which reflect ambient water temperatures, were relatively high from April-December 1982, compared to the seven year monthly averages for 1976-1982.

8. The hourly collection rate for invertebrates was 1.33 with long-finned squid representing, 40.8%; horseshoe crab, 33.6% of the catch. No blue mussels were collected.

9. Thirty-two American lobsters were collected during impingement sampling which equates to 408 lobsters/year impinged. This is the highest impingement rate for lobsters since Pilgrim Station operation.

SECTION 6
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Assessment of Finfish Survival at Pilgrim Nuclear Power Station 1982

Submitted to

Boston Edison Company

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by

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I. Introduction

This report describes the results of studies conducted at the Pilgrim Nuclear Power Station to assess survival of finfish impinged on the plant's revolving intake screens. These 1982 investigations, completed under Boston Edison Company Purchase Order No. 69684, represent a continuation of work begun in 1980 following construction of a concrete sluiceway designed to return fish surviving impingement to Cape Cod Bay waters. Studies were designed to examine mortality induced by the screenwash system and by the sluiceway itself. Data obtained in 1980 and 1981 are summarized in this report along with the 1982 data.

II. Methods

A. General

To determine impingement survival rates during routine plant operations fish washed off the traveling screens were sampled at the end of the sluiceway (Figure 1). Special nets were constructed of 3/16-inch (4.8 mm) "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 (1.5 m) diameter, circular holding pools located about 20 feet (6.1 m) from the end of the sluiceway and supplied with continuous running ambient 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 screenwash 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 1980 and 1981; 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.

In 1982 when the service water system was chlorinated continuously at PNPS, sodium thiosulfate was used to neutralize any residual chlorine in the screenwash water. Any time the screens were operated during fish survival studies in 1982, MRI personnel insured that the sodium thiosulfate delivery

pumps were operating and the system was routinely checked by titration to insure that no detectable chlorine was present in the sluiceway.

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.

B. Sluiceway Introduction Studies 1980, 1981

To assess mortality induced by the sluiceway itself samples of fish were introduced to the sluiceway in the screenhouse just downstream of the screens while the wash system was in operation. Fish were obtained from local waters by beach seine, otter trawl, or baited lift net (cunner, *Tautogolabrus adspersus*, and pollock, *Pollachius virens*) and transferred to PNPS in 32-50 gal (121-189 l) plastic, aerated containers. Introduced fish were then collected at the end of the sluiceway by a second person in a manner identical to that used for fish washed off the screens. They were transferred immediately to a separate holding pool and otherwise treated as described above for naturally impinged fish. However, due to variability in collection times, introduced fish were held from 47 to 70 hours. They were not fed during the study.

Sluiceway introduction studies were conducted during September, November, and December 1980 and April, May, June, August, September, and November 1981. The beach seine, used to obtain many of the introduced fish, measured 100 by 6 feet (30.5 x 1.8 m) and was made of ¼-inch (6.4 mm) "delta" mesh. It was used at several locations along the Plymouth Harbor side of Plymouth Beach, along the town beach in Plymouth center, and along the north side of the PNPS intake. Other fish such as winter flounder (*Pseudopleuronectes americanus*) and sculpin (*Myoxocephalus* spp.) were obtained with a small otter trawl in

Plymouth Harbor-Kingston, Duxbury Bay or larger gear operated by the Massachusetts Division of Marine Fisheries off PNPS. Cunner and pollock were obtained in Sandwich, Massachusetts, along the southeast side of the Cape Cod Canal using a baited 28-inch (0.71 m), 3/16-inch (4.8 mm) mesh lift net.

C. Screen Introduction Studies 1982

To obtain information on sources of impingement mortality, studies were conducted in 1982 which involved the release of live fish in front of the PNPS intake screens while in continuous wash mode. Fish were introduced through an access opening located just upstream of the traveling screens (Figure 2) in a specially designed container 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 and sluiceway-introduced fish. As in the latter case, holding periods varied from 44 to 70 hours due to variations in collection time.

These introduction studies were conducted in April-June and August-November 1982. Fish were obtained and transferred as described under the sluiceway introductions.

D. Controls

In early 1980 when the survival program first began, fish were collected by beach seine, otter trawl, and lift net as described above and transferred to the holding pools to confirm that those facilities did not represent a source of mortality. In late 1980, 1981, and 1982 when sluiceway and screen introduction studies were conducted, subsamples of those fish were held as

controls whenever possible. In the case of uncommon species no controls were held since we chose to obtain treatment data in those instances. In 1982 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 (0.15 to 0.3 m/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 considered to be marginal in size, no controls were held if previous control data for that particular species indicated little or no mortality among controls.

II. Results

A. Routine Screenwash Survival

Sluiceway collections, made during the routine screenwash program established at PNPS which contributed to the survival assessment program in 1982, are summarized in Table 1. A total of 450 fish were obtained, 259 under static or 8-hour cycles and 191 under continuous wash cycles. Represented among these were 34 species. The six most common were Atlantic silversides (*Menidia menidia*), rainbow smelt (*Osmerus mordax*), threespine sticklebacks (*Gasterosteus aculeatus*), cunner, bay anchovy (*Anchoa mitchilli*), and winter flounder. These species represented 18.7, 12.0, 9.6, 8.7, 7.6, and 4.9% of the total catch, respectively, for a combined total of 61.5%. Silversides were most common in March and December; smelt were most common in November and December; threespine sticklebacks in May; cunner and anchovy in September; and flounder in May, November, and December.

Three years of impingement survival data, 1980-1982, are combined and summarized in Table 2 and Figure 3. Among the 1058 fish taken representing 43 species, six species accounted for 65.7% of the total collected. Cunner represented 16.8%, Atlantic silversides 15.2%, rainbow smelt 14.4%, northern

puffer (Sphoeroides maculatus) 10.9%, threespine stickleback 4.8%, and winter flounder 3.6%. These data exclude a relatively large impingement period for Atlantic silversides (n = 4825, Table 2) which occurred on September 23, 24, 1981, because that single incident represented an unusual monospecific occurrence which exceeded the three-year total of all other samples by a factor of four.

Combining all 43 species over three years (but again excluding the high silverside mortality in September 1981), initial finfish survival at Pilgrim Station was 8.2% under 8-hour wash cycles and 30.0% under continuous wash cycles (Table 2). Among the six dominant species (Figure 3) initial survival under 8-hour cycles ranged from 1.8% among smelt (n = 112) to 13.6% among puffer (n = 105). Under continuous wash cycles survival for the dominant species ranged from 0% among threespine sticklebacks (n = 3) to 70.0% among cunner (n = 20).

It is quite clear that initial survival rates were higher under continuous wash operation than under the 8-hour static wash cycles; this was true even for species with relatively small sample sizes. Using Z tests for the difference between proportions (Zar 1974) among the six dominant species, significant differences between initial 8-hour cycle and initial continuous wash cycle survival were detected among cunner ($p < 0.001$, $Z = 7.953$) and silversides ($p < 0.001$, $Z = 4.501$). Among rainbow smelt survival was about equal in both categories (1.8 and 2.5%, respectively). Among puffer, sticklebacks, and winter flounder, statistically significant differences were not detected, probably due to the small sample sizes under continuous wash operation (Table 2). Significant differences were also apparent for all other species besides the dominant ones ($p < 0.001$, $Z = 3.308$) and for all species combined ($p < 0.001$, $Z = 8.703$).

Survival rates declined following the 56-hour holding periods. Pooling all fish, survival was 4.0% under 8-hour cycles, 11.9% under continuous wash cycles (Table 2). Among the six dominant species, survival ranged from 0% (silversides, n = 116; smelt, n = 112) to 9.1% (winter flounder, n = 16) under 8-hour cycles and 0% (silversides, n = 45; smelt, n = 40; threespine stickleback, n = 3) to 25.0% (flounder, n = 16) under continuous wash cycles. As noted above under initial survival results, higher latent survival rates were generally noted under continuous wash cycles. These differences were statistically significant among cunner ($p < 0.01$, $Z = 2.696$), all fish combined ($p < 0.001$, $Z = 4.437$), and all species excluding the six dominants ($p < 0.01$, $Z = 2.880$) based on the test for differences between proportions. Silversides and smelt displayed 100% mortality in both categories. No difference could be detected among puffer, sticklebacks, or winter flounder, again probably due to the small sample sizes under continuous wash operation (Table 2).

Data collected in 1982 were compared with combined data for 1980 and 1981 to see if any increase in survival occurred in 1982 as a result of the low-pressure screenwash nozzles installed early in that year. Survival rates before (1980 and 1981) and after (1982) installation of the low-pressure nozzles are shown in Table 3 for all categories where sample sizes were relatively large. Cunner and northern puffer showed greater survival rates in 1982 than in 1980-1981 in both initial and delayed categories under static wash cycles; data were insufficient to compare results for these species under continuous wash cycles. Under the static wash cycles survival in 1982 was significantly higher among cunner (initial = $p < 0.05$, $Z = 2.501$; delayed = $p < 0.05$, $Z = 2.368$). Results were not significantly different among puffer (initial = $p > 0.05$, $Z = 1.940$; delayed = $p > 0.05$, $Z = 0.967$). In all remaining categories survival was generally greater in 1980-81 and in fact was significantly greater in four cases (8-hour cycles, initial survival - all others, $p < 0.01$, $Z = 3.068$; continuous

wash cycles, initial survival - all others, $p < 0.05$, $Z = 2.820$; delayed survival - all others, $p < 0.05$, $Z = 2.568$; all fish, $p < 0.05$, $Z = 2.554$). Based on these results it is difficult to reach any firm conclusions without additional data although the cunner and puffer results suggest that some species-specific improvement in survival may have occurred. No explanation is apparent in those cases where survival was greater in 1980-1981.

B. Sluiceway Introduction Studies 1980, 1981

The numbers of fish introduced to the sluiceway in 1980 and 1981, collected at the downstream end and held for 50-90 hours, are summarized by species in Table 4. Survival in these studies was generally quite high (86-100%), indicating that little mortality occurred as a result of passage down the sluiceway. Exceptions occurred among rainbow smelt and Atlantic silversides which showed survival rates of 0 and 50%, respectively. The smelt results were based on very few fish (n = 12) while the silverside data were based on five samples introduced on five dates (one in 1980, four in 1981). The range in survival over the five dates was large: 10% (April 23, 1981; n = 66) to 91.2% (June 10, 1981; n = 91). Survival among control fish was 100% on both these dates so the fish were apparently in good condition, and mean lengths were similar: 95.6 mm on April 23, 90.3 mm on June 10.

In May 1981 the program was modified slightly to determine if possible why silverside mortality was relatively high during some trials. In spite of efforts to minimize sluiceway, net-induced mortality (see Methods), water velocity at the end of the sluiceway was sufficiently high that net injury could have been significant. Flow rate measured at the downstream end of the sluiceway with a General Oceanics 2030 flowmeter (June 10, 1981) was found to be 455 cm/sec (15 ft/sec). Fish were therefore subjected to a great deal of pressure and presumably stress while in the sampling net for even a short period. Fish may also have been injured by hitting the sidewall of the

sluiceway while traversing the sharp bend just above the downstream end (Figure 1). Just before the final sharp bend where the slope is low, water velocity was recorded at 204 cm/sec (7 ft/sec). Therefore to examine for mortality induced by the bend or the sampling gear, beginning in late May 1981 collections were made at both locations whenever sufficient numbers of fish were available. Results of these trials are shown in Table 5. These data indicate that, with the exception of cunner which showed 100% survival at both sampling locations, survival was higher at the upstream, low velocity point. Improvement in survival was 27% for the mummichog (Fundulus heteroclitus) and averaged about 8% for silversides. (Additional mummichogs were collected for a second trial with that species on September 1, 1981, but the sluiceway was found to be inoperable on that date.) If the sampling gear was the primary source of injury, these data suggest that for some species survival rates were somewhat underestimated for collections made at the downstream end of the sluiceway. Based on these results, all collections in 1982 were made in the 7 ft/sec area.

C. Controls

Table 6 summarizes the control data obtained in 1980 and 1981 to test the effectiveness of the holding pools and the field collection and transportation methods. With the exception of the clupeids, survival among the control fish was generally high, ranging from 95% among Atlantic silversides to 100% among many other species. These data indicated that our methods introduced little or no additional mortality in the studies. Survival among clupeids ranged from 52% among menhaden (Brevoortia tyrannus) to 79% among alewives (Alosa pseudoharengus). Since small clupeids are well known for being sensitive to handling stress, the relatively high mortality among these fish was not unexpected.

No adjustments were made to the 1980 and 1981 data as a result of the generally high survival rate among control fish. Adjustment among clupeids would have been warranted but only six were collected alive during the two years of study, and none of them survived the holding periods.

D. Screen Introduction Studies 1982

Table 7 summarizes the numbers of fish by species released in front of the screens on 12 dates during the 1982 studies. An additional 1500 fish were collected on five dates as part of the introduction studies but either could not be released due to problems at the plant or were released but were lost along with the holding pools during two severe storms.

Following release and subsequent impingement, Atlantic silversides, cunner, and winter flounder provided the greatest data base. Pooled over all dates, these species showed survival rates of 19.9, 100, and 99.5%, respectively, following one-hour holding periods. After 44 to 70-hour holding periods survival dropped to 68.7% among flounder and 4.3% among silversides. Survival among cunner remained at 100%. No adjustment for survival among controls was necessary for winter flounder or cunner since both showed latent survival rates of 100%. However, since Atlantic silversides showed a pooled control survival rate of 88.5% following 44 to 70-hour holding periods (Table 7), the method of Tattersfield and Morris (1923) and King et al. (1977) was used to adjust the latent survival rate for that species to 4.9% (i.e., adjusted survival = treatment survival/control survival).

Results for winter flounder, cunner, and silversides are shown in more detail in Tables 8 and 9 where data are presented by replicate. The 317 winter flounder introduced in front of the screens were collected and released on eight sampling dates. Over those eight dates latent survival ranged from 2.2 to 100%. Relative to the other dates where survival was fairly consistent, ranging from 72.2 to 100%, the value of 2.2% obtained on September 24 was

unusually low; control survival on that date was 100%. On September 24 we experienced a two-hour delay at the screenhouse due to chlorination operations. During the delay the fish were aerated continuously and water was exchanged periodically with fresh ambient seawater. Control fish were subsampled at the end of the day from those transported into the plant so they were actually held in the barrels for an additional 0.5 hour. Nevertheless the exceptionally low survival rate among introduced fish on that date suggests that the long holding period followed by impingement and screenwash exceeded the tolerance of those fish.

Cunner were introduced on three dates (Table 8). Survival was 100% in all cases including controls.

Silverside latent survival rates observed on seven dates were relatively low ranging from 0 to 34.8% (Table 9). Although silversides were subjected to the same problem on September 24 described above for winter flounder, 100% mortality was also realized on two additional dates. This species generally appears to be sensitive to impingement. In some of the introduced samples a portion of the fish (e.g., 21.2%, October 27) were dead when collected at the end of the sluiceway which rarely occurred among other species. Tissue damage was also frequently noticed on these fish. For example, on September 24, 67.3% of the fish showed hematomas around the brain and eyes; this type of injury may occur among other species as well but be particularly noticeable on silversides because their dorsal tissue is relatively clear. Also because of their generally small size and attenuated shape, silversides are susceptible to penetration of the 3/8-inch screen mesh which may explain the more severe injuries.

The recovery rate data presented in Tables 7-9 were interesting because they indicated that apparently healthy fish could avoid impingement even when released immediately in front of the screens. Recovery rates among species

with sample sizes of at least 25 ranged from 0% for pollock (n = 25) to 62% among winter flounder (n = 317). Based on the replicates for flounder, cunner, and silversides (Tables 8, 9) recovery rates were also variable within species, ranging from 55.1 to 82.1 for flounder (excluding August 18 when n = 1), 4.9 to 21.2% among cunner, and 2.8 to 75.6% among silversides.

Table 10 summarizes some observations which were made regarding elapsed time between the release of samples of fish and their appearance at the end of the sluiceway and also the time between the last release and the last collection at the end of the sluiceway. For example, if on day X the first subsample of 20 silversides was released in front of the PNPS screens at 1200 and the first silverside appeared in the sluiceway collections at 1208, eight minutes elapsed before that fish was impinged, washed from the screens, and traveled down the sluiceway. If on day X the last subsample of 20 silversides was released at 1300 and the last silverside appeared in the collections at 1405, 65 minutes elapsed during which time that fish must have avoided impingement for most of that period; if that fish had been introduce in an earlier subsample, considerably more time than 65 minutes would have elapsed.

These data indicate that a minimum of about six minutes elapses before an impinged fish is returned to Cape Cod Bay. The shortest observed time was three minutes presumably because those particular fish were impinged immediately after release and were probably near the surface where screen travel time is shortest. The longer time interval between last release and last collection indicates that fish avoid impingement for periods of one hour or more presumably by swimming in front of the screens. For example, on September 17 most of the silversides recovered at the end of the sluiceway were collected one hour after the last subsample was introduced. These fish were in poor condition and died in less than one hour. Presumably they swam in front of the screens until exhausted and then became impinged.

Additional observations were made which suggested that fish which were not recovered within approximately an hour of release, escaped from the intake structure entirely. Six of the sampling dates (April, August, September) were scheduled on Fridays so that a screenwash collection would again be made during the regularly scheduled 0030 wash period. On two of the six dates the screens were inoperative during the scheduled 0030 wash. In no instance during the remaining four dates were fish introduced Friday afternoon (approximately 8 hours prior to the 0030 wash) found in the subsequent 0030 wash collection.

E. One-Hour Mortality

Mortality was determined one hour after collection in addition to the initial and 56-hour points as mentioned under Methods. Throughout the routine screenwash phase of the survival study, mortality occurring at one hour amounted to 17.1% of the 140 fish collected alive or 30.8% of all live fish dying during the holding periods from 1980-1982.

Among the control and sluiceway-introduced fish, most of the observed one-hour mortality occurred among the clupeids. Among alewives and menhaden 87.5 and 100%, respectively, of the fish which did not survive either the control or introduction studies died during the first hour of the holding period. One-hour mortality was also relatively high among rainbow smelt; 33% of those which died during the experiments did so in the first hour.

Among the fish introduced directly in front of the screens in 1982, one-hour mortality was relatively high among Atlantic silversides (see Table 9); of 540 fish that died following introduction, 452 (83.7%) did so during the first hour. Threespine sticklebacks and bluefish (*Pomatomus saltatrix*) also showed high one-hour mortality although sample sizes were small in both cases. Among sticklebacks 87.5% (n = 11) of those dying following release and impingement did so during the first hour, and among bluefish 100% (n = 2) did so.

IV. Discussion

Comparisons of screenwash survival rates between the Pilgrim Station and other power plants is complicated by the fact that there are probably as many different intake velocities and screenwash systems as there are power plants. Nevertheless, to the extent that data are available, general comparisons with other plants are useful in assessing data obtained at PNPS.

For example, at the Manchester Street Station in Providence, Rhode Island, survival studies were conducted under continuous, 2, 4, 8, and 12 to 18 hour wash cycles (MRI 1980). A total of 26 species were taken but collections were dominated by mummichogs, striped killifish (Fundulus majalis), winter flounder, and windowpane (Scophthalmus aquosus). Over all species of fish (sample sizes for individual species were low), survival following a 24-hour holding period ranged from 55.7% under continuous wash to 31.3% under 8-hour cycles; these two cycles being most comparable to the PNPS schedule. Under 2, 4, and 12 to 18-hour wash cycles, survival was 37.0, 46.9, and 26.5%, respectively, following 24-hour holding periods. Not included with these data were the alewife, blueback herring (Alosa aestivalis), and bluegill (Lepomis macrochirus), which did not survive impingement under any circumstances.

The same sampling regime was utilized at Brayton Point Station in Somerset, Massachusetts (MRI 1982). Winter flounder and Atlantic silversides contributed most to the Brayton Point data base. Among flounder, survival following 24-hour holding periods ranged from 90.2 to 94.4% under continuous, 2, 4, and 8-hour wash cycles; a decline to 83.0% occurred under 12-hour cycles. Latent survival among Atlantic silversides was low at 2, 4, 8, and 12-hour cycles (9.5-1.3%), but increased to 47.3% under continuous wash cycles. Other species taken during the Brayton studies which were also taken at PNPS included alewives, blueback herring, Atlantic menhaden, Atlantic herring (Clupea harengus harengus)--all grouped as clupeids because of small sample sizes, silver hake (Merluccius

bilinearis), Atlantic tomcod (Microgadus tomcod), and windowpane. Survival among these taxa under continuous and 8-hour cycles, those most comparable to PNPS, was 11.1 (n = 9) and 0% (n = 18), respectively, for tomcod, 83.3 (n = 18) and 65.5% (n = 87), respectively, for windowpane. Clupeids showed 0% survival under both wash cycles with sample sizes of only n = 5 and n = 18, respectively. A survival rate of 12.5% was recorded under 4-hour wash cycles (n = 8). Silver hake did not survive under any wash cycles where data were available (continuous, n = 12; 4-hour, n = 5; 12=hour, n = 43).

Continuous wash studies at several screen rotation periods conducted at Mystic Station in Boston, Massachusetts, provided comparative survival data with 96-hour holding periods for rainbow smelt, alewife-blueback herring, and winter flounder (Stone and Webster 1981). Among small smelt (probably age II) survival ranged from 22.5% at low screen speeds to 66.7% at high screen speeds. Survival was lower among larger smelt (probably age III); 11.0% at low speed, 40.0% at high speed. Alewives were also taken in two size classes; survival among young-of-the-year fish ranged from 6.7% at low speed to 48.1% at high speed, while among larger fish it ranged from 0.8% at low speed to 0.5% at high speed. Winter flounder survival was high among all sizes, ranging from 96.8% at low screen speed to 98.6% at high screen speed.

King et al. (1977) summarized fish survival studies at three Hudson River power plants under continuous, 2, and 4-hour wash cycles. For juvenile white perch (Morone americana) at the Bowline Point Plant, latent survival (96-hour) was 56% in a continuous wash mode and 19% in a 4-hour wash mode. These data were not adjusted for control survival which, based on the limited data presented, appeared to be relatively low. At the Roseton Plant latent (84-hour) white perch survival in a continuous wash mode was 29 and 60% in two separate studies compared with 23 and 36% for 4-hour wash modes. These data were adjusted for control survival and were collected with a wash water

pressure of 50 psi. Data were collected on the Atlantic tomcod at the Roseton Plant; however, screen wash pressure data were unavailable. Survival under a continuous wash mode was 81% compared with 72% under a 2-hour wash mode after adjustment for controls. Similar data were collected at the Danskammer Point Plant for juvenile white perch and tomcod. Adjusted survival (84-hour latent) for white perch in two studies was 40 and 61% under continuous wash and, based on one study (April-May), 9% under a 4-hour wash cycle. Adjusted survival among tomcod was 83% under continuous wash and 87% under a 2-hour cycle.

Survival studies at the Oyster Creek Station in New Jersey were summarized by Tatham et al. (1977). Long-term survival (48-hour) with 2-hour wash cycles ranged from 5% for Atlantic menhaden to 98% for striped searobin (Prionotus evolans). Other values included 79% for northern pipefish (Syngnathus fuscus), 67% for winter flounder, 35% for Atlantic silversides, and 9% for bay anchovy. Initial survival improved under continuous wash cycles (no delayed mortality data were presented). For example, initial survival among menhaden increased from 9% with intermittent screen rotation to 25% under continuous rotation.

Species-specific comparisons between PNPS results and the work reviewed above are limited because either species were not comparable or PNPS sample sizes were insufficient. Comparisons can be made for winter flounder between PNPS, Manchester Street, and Brayton Point Stations, keeping in mind that few fish were taken at PNPS. For this species latent percent survival was lowest at PNPS under both continuous and 8-hour wash cycles:

	PNPS		Manchester St.	Brayton Point
Wash Cycle	Initial	Latent	Latent	Latent
Continuous	43.8	25.0 (n=16)	48.4 (n=31)	90.2 (n=123)
8-hour	13.6	9.1 (n=22)	39.5 (n=38)	94.4 (n=447)

Since latent survival was determined following 56 hour at PNPS versus 24 hours at the other two stations, both initial and latent values are shown for PNPS.

As indicated, even initial values at PNPS were lower than latent values at either Manchester Street or Brayton Point.

Survival data among Atlantic silversides are comparable for PNPS and Brayton Point although, as mentioned above, holding periods were longer at PNPS. For this species survival rates (%) compare as follows:

	PNPS		Brayton Point
Wash Cycle	Initial	Latent	Latent
Continuous	33.3	0 (n=45)	47.3 (n=203)
8-hour	5.2	0 (n=116)	2.3 (n=262)

Some comparison can be made among rainbow smelt impinged at PNPS and Mystic Station. Latent survival under continuous wash modes was higher at Mystic Station (48.3% at 96 hours among small smelt, n = 60, intermediate screen speed) than at PNPS (0% at 56 hours, n = 40) for similar size fish and similar screen speeds. The higher survival at Mystic Station may be attributable to modifications to the fish and debris trays and troughs which helped protect fish during the wash regime.

V. Summary

Initial finfish impingement survival determined at the end of the PNPS sluiceway during routine plant operations using continuous and 8-hour wash cycles was 13.2% (n = 1058) during studies conducted from 1980-1982. Considered separately initial survival was 8.2% (n = 815) under 8-hour wash cycles and 30.0% (n = 243) under continuous wash cycles. Following 56-hour holding periods overall survival declined to 5.9% or 4.0% under 8-hour cycles, 11.9% under continuous wash cycles. Among cunner (n = 158), Atlantic silversides (n = 116), rainbow smelt (n = 112), northern puffer (n = 22), threespine sticklebacks (n = 48), and winter flounder (n = 22), the six most abundant species, latent survival amounted to 5.1, 5.2, 1.8, 6.7, 4.2, and 13.6% respectively under 8-hour wash cycles. Under continuous wash cycles latent

survival was 3.2% among cunner, 0% among silversides and smelt, 5.7% among puffer, 2.1% among sticklebacks, and 9.1% among flounder. These values do not include 4825 Atlantic silversides lost to impingement during a single 27-hour period in September 1981.

In many cases where sample sizes were sufficiently large, survival was found to be significantly higher under continuous wash cycles when compared with 8-hour wash cycles.

Samples of fish collected near PNPS by beach seine and otter trawl in 1980 and 1981 were introduced to the sluiceway and collected at the downstream end to assess mortality induced by passage down the system. Survival based on these studies was 100% in many cases. Exceptions occurred among rainbow smelt (0%, n = 12), Atlantic silversides (50%, n = 282), and mummichogs (86%, n = 49). Based on paired samples survival improved by 4 to 27% when silversides and mummichogs were collected further up the sluiceway where the flow rate was about half that at the downstream end.

In 1982 samples of fish were collected as in 1980-1981, released in front of the screens while the wash system was in operation, and collected at the downstream end of the sluiceway following impingement. Latent survival among Atlantic silversides, cunner, and winter flounder in those experiments was 4.9, 100, and 68.7%, respectively; the silverside data were adjusted for control survival which was 88.5%.

Recovery rates among fish introduced ahead of the screens ranged from 0% among pollock (n = 25) to 62% among winter flounder (n = 317) and was found to be quite variable between samples of the same species. These data indicate that apparently healthy fish could avoid impingement even when released just ahead of the screens with no acclimation period.

Table 11 summarizes results obtained during these survival studies for the six numerically dominant species as determined during the routine impingement

phase of the studies, cunner, Atlantic silversides, rainbow smelt, northern puffer, threespine stickleback, and winter flounder. Most noticeable perhaps among these data is the fact that latent, natural continuous-wash survival was lower than latent survival among fish introduced under a continuous-wash regime. This suggests that fish which are naturally impinged during routine plant operations may be in poor physiological condition prior to impingement.

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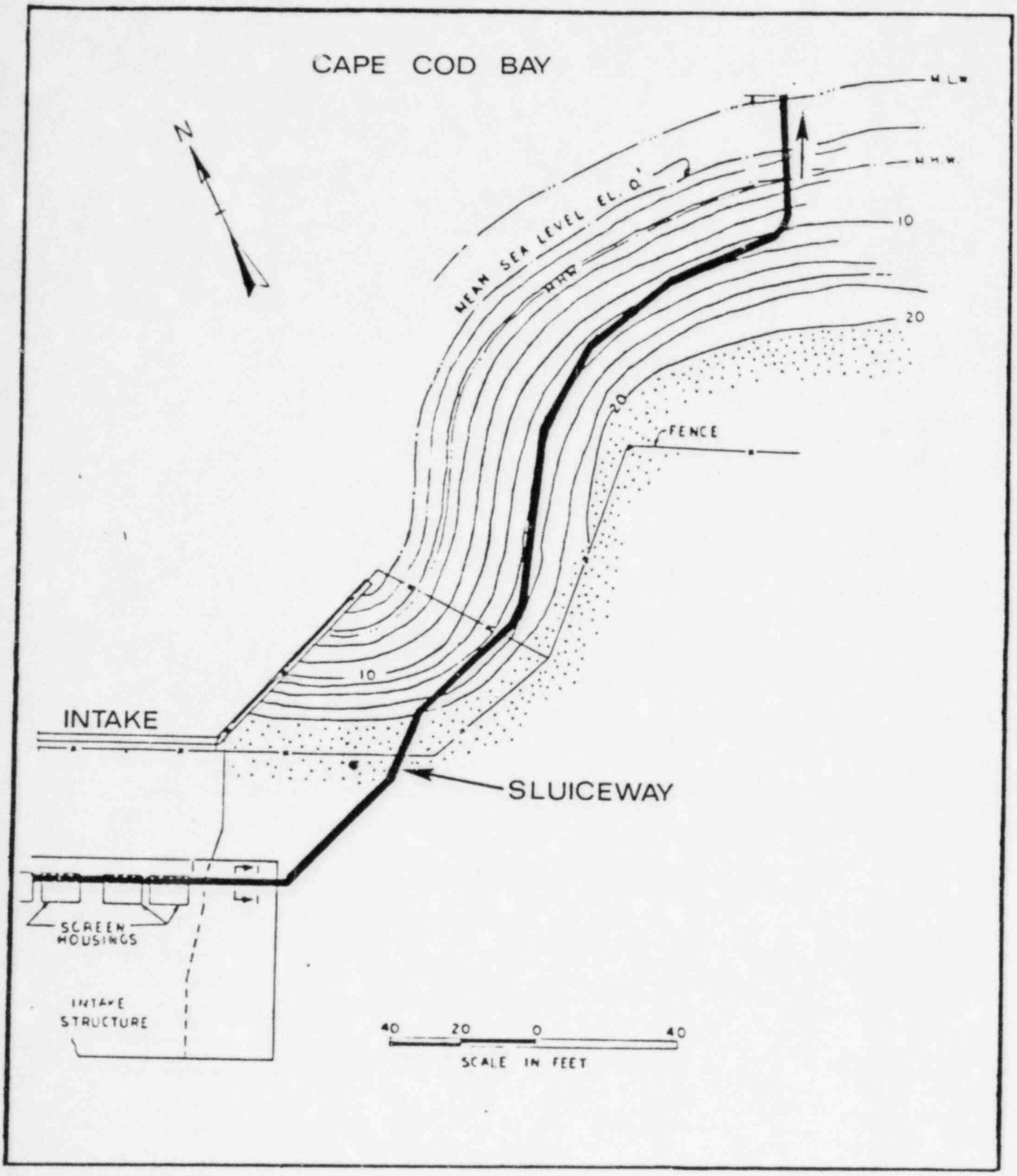

Figure 1: The PNPS sluiceway designed to return impinged fish to ambient temperature water in Cape Cod Bay. The sampling area of the sluiceway ranged between mean low water (MLW) and mean high water (MHW) depending on the tide.

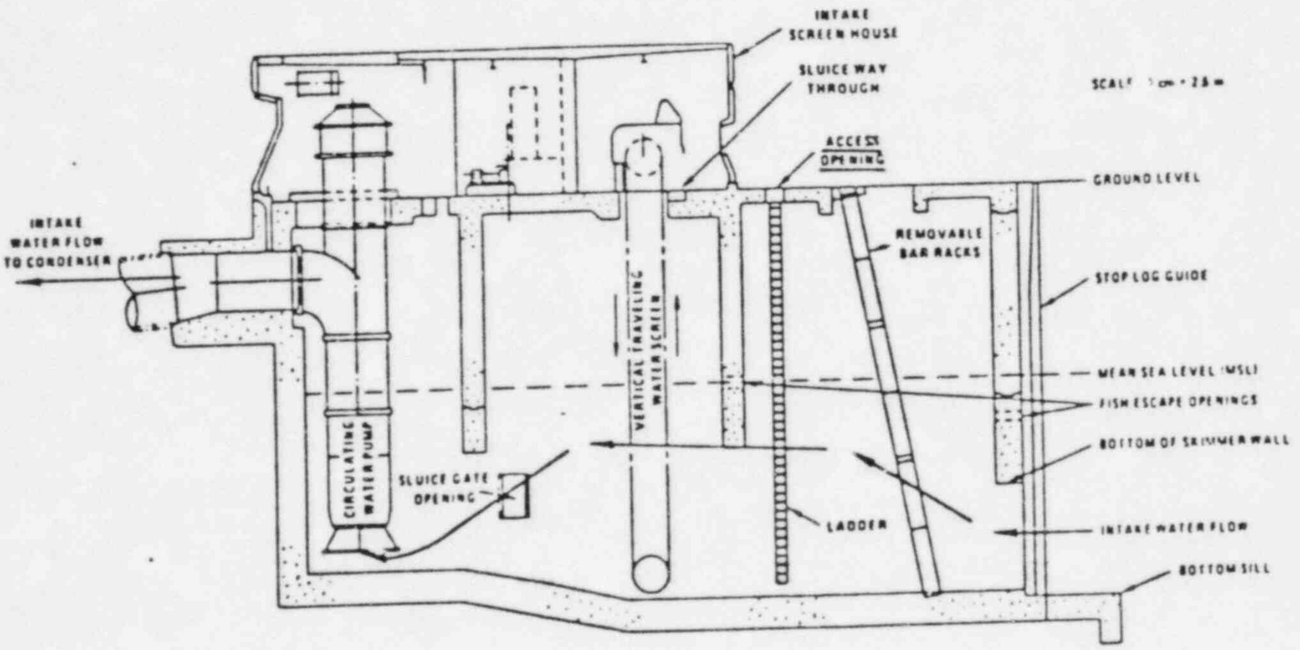

Figure 2. Diagram of the PNPS seawater intake system (illustration provided by Boston Edison Company).

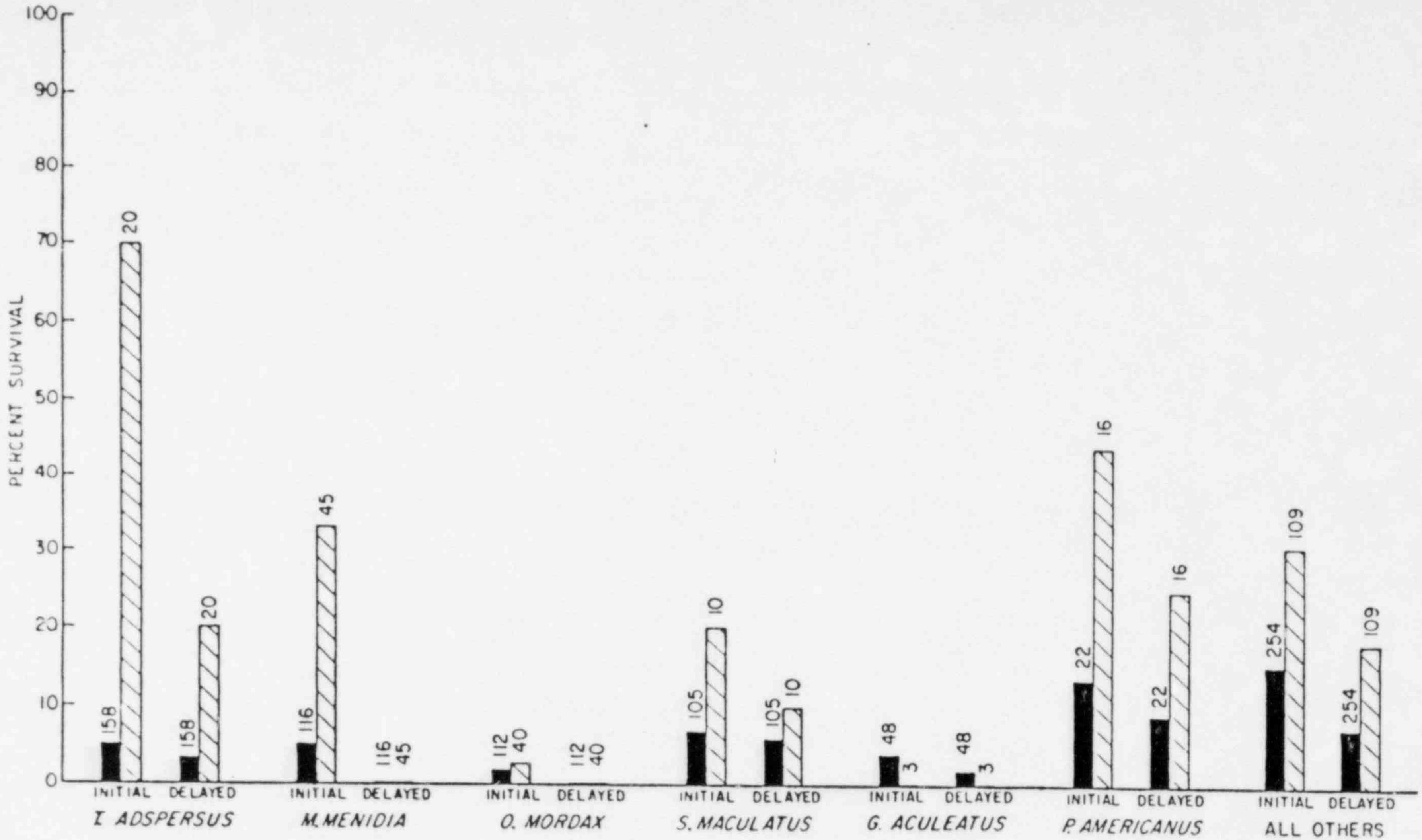

Figure 3. Percent survival for the six most abundant species of finfish plus all other fish combined collected on the PNPS traveling screens 1980-1982. Solid bars represent 8-hour wash cycles; striped bars, continuous wash cycles. Numbers above each bar represent the sample size.

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 assessment program, 1982.

Species	Total length (mm)		Number Collected		Number (%) Collected Alive		Number (%) Surviving 56 hours	
	Mean	Range	8-hour cycles	Contin. cycles	8-hour cycles	Contin. cycles	8-hour cycles	Contin. cycles
Winter skate (*Raja ocellata*)	490	-	1	0	0	0	-	-
American eel (*Anguilla rostrata*)	101	-	0	1	0	1(100)	-	0
Blueback herring (*Alosa aestivalis*)	135	80 - 180	6	7	1	0	0	-
Alewife (*A. pseudoharengus*)	140	64 - 290	9	5	0	1(20)	-	0
Menhaden (*Brevoortia tyrannus*)	72	56 - 91	9	0	0	0	-	-
Atlantic herring (*Clupea harengus h.*)	144	125 - 167	2	5	0	0	-	-
Bay anchovy (*Anchoa mitchilli*)	61	36 - 90	19	15	0	1	-	0
Rainbow smelt (*Osmerus mordax*)	105	64 - 215	27	27	0	0	-	-
Pearlside (*Maurolicus muelleri*)	50	46 - 56	0	7	0	0	-	-
Atlantic cod (*Gadus morhua*)	215	-	0	1	0	0	-	-
Atlantic tomcod (*Microgadus tomcod*)	137	98 - 260	4	9	0	4(44)	-	4(44)
Pollock (*Pollachius virens*)	183	102 - 350	14	12	0	2(17)	-	0
Red hake (*Urophycis chuss*)	90	-	0	1	0	0	-	-
White hake (*U. tenuis*)	128	58 - 192	9	0	0	0	-	-
Mummichog (*Fundulus heteroclitus*)	88	80 - 95	2	0	1(50)	0	0	-
Atlantic silverside (*Menidia menidia*)	103	70 - 140	48	36	1(2)	12(33)	0	0
Threespine stickleback (*Gasterosteus aculeatus*)	58	50 - 69	41	2	1(2)	0	0	-
Northern pipefish (*Syngnathus fuscus*)	155	140 - 170	1	1	0	1(100)	-	1(100)
Bluefish (*Pomatomus saltatrix*)	90	-	1	0	0	0	-	-
Scup (*Stenotomus chrysops*)	52	43 - 70	4	4	1(25)	1(25)	0	0

Table 1 (continued).

Species	Total length (mm)		Number Collected		Number (%) Collected Alive		Number (%) Surviving 56 hours	
	Mean	Range	8-hour cycles	Contin. cycles	8-hour cycles	Contin. cycles	8-hour cycles	Contin. cycles
Tautog (*Tautoga onitis*)	225	130 - 320	2	0	0	0	-	-
Cunner (*Tautogolabrus adspersus*)	102	50 - 195	22	17	4(18)	12(71)	3(14)	2(12)
Radiated shanny (*Ulvaria subbifurcata*)	118	115 - 120	1	1	0	0	-	-
Sand lance (*Ammodytes* sp.)	153	95 - 210	2	0	1(50)	0	1(50)	-
Silver-rag (*Ariomma bondi*)	135	-	1	0	0	0	-	-
Northern searobin (*Prionotus carolinus*)	235	58 - 315	5	0	0	0	-	-
Grubby (*Myoxocephalus aenaeus*)	104	66 - 135	3	4	2(67)	2(50)	2(67)	1(25)
Longhorn sculpin (*M. octodecemspinosus*)	280	-	1	0	0	0	-	-
Shorthorn sculpin (*M. scorpius*)	290	-	0	1	0	0	-	-
Lumpfish (*Cyclopterus lumpus*)	34	27 - 50	2	5	0	3(60)	-	0
Fourspot flounder (*Paralichthys oblongus*)	382	-	1	0	0	0	-	-
Windowpane (*Scophthalmus aquosus*)	105	35 - 310	1	7	0	5(71)	-	5(71)
Winter flounder (*Pseudopleuronectes americanus*)	186	50 - 355	8	14	1(13)	6(43)	1(13)	3(21)
Puffer (*Sphoeroides maculatus*)	61	42 - 96	13	9	3(23)	1(11)	2(15)	1(11)
Total			259	191	16(6)	52(27)	9(3)	17(9)

Table 2. Total number of fish collected, number and percentage alive, and number and percentage surviving a 56-hour holding period by species in the INPS sluiceway under static (8-hour) and continuous wash cycles, 1980-1982.

Species	Number Collected		Number (%) Collected Alive		Number (%) Surviving 56 hrs.		Total Length (mm)	
	8-hour cycles	Continuous cycles	8-hour cycles	Continuous cycles	8-hour cycles	Continuous cycles	Mean	Range
Cunner (*Tautogolabrus adspersus*)	158	20	8(5)	14(70)	5(3)	4(20)	106	47 - 209
Atlantic silverside (*Menidia menidia*)	116	45	6(5)	15(33)	0	0	98	50 - 140
	4825	0	0	-	-	-	89	75 - 136
Rainbow smelt (*Osmerus mordax*)	112	40	2(2)	1(3)	0	0	99	64 - 220
Northern puffer (*Sphoeroides maculatus*)	105	10	7(7)	2(20)	6(6)	1(10)	77	37 - 115
Threespine stickleback (*Gasterosteus aculeatus*)	48	3	2(4)	0	1(2)	-	59	50 - 73
Winter flounder (*Pseudopleuronectes americanus*)	22	16	3(14)	7(44)	2(9)	4(25)	194	50 - 384
Bay anchovy (*Anchoa mitchilli*)	20	15	0	1(7)	-	0	62	36 - 90
Blueback herring (*Alosa aestivalis*)	24	7	2(8)	0	0	-	123	66 - 180
Alewife (*Alosa pseudoharengus*)	25	6	2(8)	1(17)	0	0	137	64 - 306
Pollock (*Pollachius virens*)	17	12	0	2(17)	-	0	187	102 - 350
Atlantic menhaden (*Brevoortia tyrannus*)	28	0	1(4)	-	0	-	94	47 - 131
Grubby (*Myoxocephalus aenaeus*)	15	9	7(47)	7(78)	7(47)	6(67)	91	55 - 155
Atlantic tomcod (*Microgadus tomcod*)	9	12	2(22)	6(50)	2(22)	6(50)	148	98 - 260
White hake (*Urophycis tenuis*)	15	1	0	1(100)	-	0	132	58 - 229
Windowpane (*Scophthalmus aquosus*)	5	11	2(40)	5(45)	2(40)	5(45)	108	35 - 310
Scup (*Stenotomus chrysops*)	11	4	1(9)	1(25)	0	0	62	43 - 138
Atlantic herring (*Clupea harengus h.*)	9	5	2(22)	0	0	-	170	55 - 284
Northern searobin (*Prionotus carolinus*)	13	1	2(15)	0	1(8)	-	234	58 - 315
Northern pipefish (*Syngnathus fuscus*)	7	4	0	3(75)	-	2(50)	163	58 - 245

Table 2 (continued).

Species	Number Collected 8-hour cycles	Number Collected Continuous cycles	Number (%) Collected Alive 8-hour cycles	Number (%) Collected Alive Continuous cycles	Number (%) Surviving 56 hrs. 8-hour cycles	Number (%) Surviving 56 hrs. Continuous cycles	Total Length (mm) Mean	Total Length (mm) Range
Lumpfish (Cyclopterus lumpus)	4	6	1(25)	4(67)	0	0	35	27 - 50
Fourspot flounder (Paralichthys oblongus)	10	0	5(50)	-	3(30)	-	294	190 - 382
Sand lance (Ammodytes sp.)	8	1	7(88)	1(100)	1(13)	0	147	95 - 210
Silver hake (Merluccius bilinearis)	7	1	0	0	-	-	210	81 - 326
Pearlside (Maurolicus muelleri)	0	7	-	0	-	-	50	46 - 56
American eel (Anguilla rostrata)	2	2	0	2(100)	-	1(50)	365	101 - 510
Radiated shanny (Ulvaria subbifurcata)	3	1	2(67)	0	1(33)	-	120	115 - 125
Spiny dogfish (Squalus acanthias)	2	0	0	-	-	-	587	234 - 940
Winter skate (Raja ocellata)	2	0	1(50)	-	1(50)	-	293	95 - 490
Atlantic cod (Gadus morhua)	1	1	0	0	-	-	148	80 - 215
Red hake (Urophycis chuss)	1	1	0	0	-	-	243	90 - 395
Hake (Urophycis sp.)	2	0	0	-	-	-	96	-
Mummichog (Fundulus heteroclitus)	2	0	1(50)	-	0	-	88	80 - 95
Northern kingfish (Menticirrhus saxatilis)	2	0	0	-	-	-	169	156 - 182
Tautog (Tautoga onitis)	2	0	0	-	-	-	225	130 - 320
Fourspine stickleback (Apeltes quadracus)	0	1	-	0	-	-	59	-
Bluefish (Pomatomus saltatrix)	1	0	0	-	-	-	90	-
Rock gunnel (Pholis gunnellus)	1	0	1(100)	-	1(100)	-	190	-
Atlantic mackerel (Scomber scombrus)	1	0	0	-	-	-	82	-
Silver-rag (Ariomma bondi)	1	0	0	-	-	-	135	-
Butterfish (Peprilus triacanthus)	1	0	0	-	-	-	76	-

Table 2 (continued).

Species	Number Collected		Number (%) Collected Alive		Number (%) Surviving 56 hrs.		Total Length (mm)	
	8-hour cycles	Continuous cycles	8-hour cycles	Continuous cycles	8-hour cycles	Continuous cycles	Mean	Range
Longhorn sculpin (*Myoxocephalus octodecemspinosus*)	1	0	0	-	-	-	280	-
Shorthorn sculpin (*Myoxocephalus scorpius*)	0	1	-	0	-	-	290	-
Summer flounder (*Paralichthys dentatus*)	1	0	0	-	-	-	295	-
Orange filefish (*Aluterus schoepfi*)	1	0	0	-	-	-	191	-
Total*	815	243	67(8)	73(30)	33(4)	29(12)		

*Total does not include the silverside data from the high mortality period of September 23, 24, 1981.

Table 3. Comparison of impinged finfish survival rates at PNPS before (1980-81) and after (1982) installation of low-pressure spray wash nozzles.

	Initial Survival		Delayed Survival	
Species	1982	1980-81	1982	1980-81
8-hour Static Cycles				
T. adspersus	18.2 n = 22	2.9 n = 136	13.6 n = 22	1.5 n = 136
O. mordax	0 n = 27	2.4 n = 85	0 n = 27	0 n = 85
M. menidia	2.1 n = 48	7.4 n = 68	0 n = 48	0 n = 68
S. maculatus	23.1 n = 13	4.3 n = 92	15.4 n = 13	4.3 n = 92
G. aculeatus	2.4 n = 41	14.3 n = 7	0 n = 41	14.3 n = 7
All Others	6.5 n = 108	20.8 n = 168	3.7 n = 108	10.1 n = 168
All Fish	6.2 n = 259	9.2 n = 556	3.5 n = 259	4.3 n = 556
Continuous Cycles				
O. mordax	0 n = 27	7.7 n = 13	0 n = 27	0 n = 13
M. menidia	33.3 n = 36	33.3 n = 9	0 n = 36	0 n = 9
All Others	25.2 n = 111	55.6 n = 27	13.5 n = 111	37.0 n = 27
All Fish	27.2 n = 191	40.4 n = 52	8.9 n = 191	23.1 n = 52

Table 4. Sample size, percent survival, and total length data (mm) for fish introduced at the head of the PNPS sluiceway, collected at the downstream end, and held for 50 to 90 hours, 1980 and 1981.

Species	Number Introduced	Number (%) Surviving	Total Length (mm) Mean	Range	Number of Trials
Little skate (Raja erinacea)	1	1(100)	230	-	1
Atlantic menhaden (Brevoortia tyrannus)	1	0	55	-	1
Rainbow smelt (Osmerus mordax)	12	0	99	86 - 116	2
Mummichog (Fundulus heteroclitus)	49	42(86)	86	52 - 131	2
Atlantic silverside (Menidia menidia)	282	141(50)	99	50 - 139	5
Threespine stickleback (Gasterosteus aculeatus)	4	3(75)	59	56 - 73	1
White perch (Morone americana)	5	5(100)	226	126 - 302	1
Cunner (Tautogolabrus adspersus)	74	73 (99)	142	76 - 206	2
Sea raven (Hemitripterus americanus)	2	2(100)	300	266 - 303	1
Longhorn sculpin (Myoxocephalus octodecemspinosus)	19	19(100)	297	260 - 326	2
Windowpane (Scophthalmus aquosus)	6	6(100)	242	189 - 270	1
Yellowtail flounder (Limanda ferruginea)	25	25(100)	255	190 - 340	2
Winter flounder (Pseudopleuronectes americanus)	70	70(100)	104	64 - 396	4

Table 5. Results of sluiceway introduction trials conducted in 1981 in which fish were collected in relatively low and high velocity areas of the sluiceway and held for approximately 56 hours (see text for clarification).

Species	Short Sluice			Long Sluice			Date
	n	Number (%) Surviving	Mean TL	n	Number (%) Surviving	Mean TL	(1981)
Alewife (*Alosa pseudoharengus*)	20	0	57	-	-	-	August 14
Mummichog (*Fundulus heteroclitus*)	24	24(100)	70	11	8(73)	70	June 10
Atlantic silverside (*Menidia menidia*)	33	33(100)	98	20	17(85)	101	May 22
	31	30(97)	93	91	83(91)	90	June 10
	37	13(35)	110	48	15(31)	107	August 14
Cunner (*Tautogolabrus adspersus*)	37	37(100)	152	32	32(100)	153	September 16

Table 6. Number, percent survival after 55 to 100-hour holding periods, and total length data (mm) for control fish used in survival studies at the PNPS sluiceway, 1980-1981.

Species	Number Held	Number (%) Surviving	Total Length (mm) Mean	Total Length (mm) Range	Number of Trials
Little skate (*Raja erinacea*)	8	8(100)	283	230 - 329	1
Blueback herring (*Alosa aestivalis*)	4	3(75)	83	56 - 145	2
Alewife (*A. pseudoharengus*)	19	15(79)	58	49 - 71	2
Atlantic menhaden (*Brevoortia tyrannus*)	23	12(52)	65	46 - 71	3
Rainbow smelt (*Osmerus mordax*)	1	1(100)	158	-	1
Pollock (*Pollachius virens*)	10	10(100)	43	38 - 47	2
Mummichog (*Fundulus heteroclitus*)	313	312(99)	82	46 - 132	7
Striped killifish (*F. majalis*)	9	9(100)	76	70 - 94	2
Atlantic silverside (*Menidia menidia*)	684	650(95)	96	56 - 150	11
Threespine stickleback (*Gasterosteus aculeatus*)	2	1(50)	57	53 - 60	2
White perch (*Morone americana*)	1	0(0)	67	-	1
Bluefish (*Pomatomus saltatrix*)	2	2(100)	93	86 - 99	1
Cunner (*Tautogolabrus adspersus*)	125	125(100)	131	91 - 171	3
Longhorn sculpin (*Myoxocephalus octodecemspinosus*)	23	23(100)	300	272 - 330	3
Windowpane (*Scophthalmus aquosus*)	9	9(100)	275	240 - 301	2
Yellowtail flounder (*Limanda ferruginea*)	25	24(96)	280	154 - 349	3
Winter flounder (*Pseudopleuronectes americanus*)	118	117(99)	189	36 - 435	6

Table 7. Species of fish released in front of the PNPS traveling screens, number recovered, survival rates, including control samples, and total length data, 1982.

Species	Number Introduced	Number (%) Recovered	Number (%) Alive 1 hr	Number (%) Alive 44+ hrs	% Control Survival (n)	Total Lengths (mm) Recovered Mean	Recovered Range	Controls Mean	Controls Range
Atlantic silverside (*Menidia menidia*)	1360	564(41)	112(20)	24(4)	88 (n=408)	103	68 - 133	96	70 - 142
Cunner (*Tautogolabrus adspersus*)	387	59(15)	59(100)	59(100)	100 (n=14)	123	71 - 157	126	100 - 155
Winter flounder (*Pseudopleuronectes americanus*)	317	195(62)	194(99)	134(69)	100 (n=60)	121	52 - 356	110	54 - 360
Mummichog (*Fundulus heteroclitus*)	118	2(2)	2(100)	2(100)	100 (n=73)	*	*	97	83 - 107
Sand lance (*Ammodytes* sp.)	55	1(2)	0	-	100 (n=35)	106	-	110	100 - 123
Pollock (*Pollachius virens*)	25	0	-	-	-	-	-	-	-
Windowpane (*Scophthalmus aquosus*)	17	12(71)	12(100)	10(83)	-	137	82 - 285	-	-
Little skate (*Raja erinacea*)	14	10(71)	10(100)	**	-	**	**	-	-
Threespine stickleback (*Gasterosteus aculeatus*)	11	11(100)	4(36)	3(27)	-	54	40 - 61	-	-
Northern pipefish (*Syngnathus fuscus*)	8	3(38)	3(100)	3(100)	-	160	155 - 165	-	-
Grubby (*Myoxocephalus aenaeus*)	8	6(75)	6(100)	4(67)	100 (n=1)	102	63 - 130	128	-
Bluefish (*Pomatomus saltatrix*)	6	2(33)	0	-	-	69	62 - 76	-	-

Table 7 (continued).

Species	Introduced	Number (%) Recovered	Number (%) Alive 1 hr	Number (%) Alive 44+ hrs	% Control Survival (n)	Total Lengths (mm) Recovered Mean	Range	Controls Mean	Range
Atlantic tomcod (*Microgadus tomcod*)	5	3(60)	3(100)	1(33)	-	172	-	-	-
Red hake (*Urophycis chuss*)	3	2(67)	2(100)	2(100)	-	81	71 - 90	-	-
Rainbow smelt (*Osmerus mordax*)	2	0	-	-	-	-	-	-	-
Sea raven (*Hemitripterus americanus*)	1	0	-	-	-	-	-	-	-
Longhorn sculpin (*Myoxocephalus octodecemspinosus*)	1	0	-	-	-	-	-	-	-

*Fish decomposed due to insufficient formalin.

**All skates were missing, apparently removed by someone since screen covers were in place.

number recovered, and survival rates, by date 1982.

Date (1982)	Number Introduced	Number (%) Recovered	Number (%) Alive 1 hr	Number (%) Alive 44+ hrs	Control Survival 44+ hrs
Winter flounder					
April 16	28	23 (82.1)	23 (100)	23 (100)	-
April 30	67	38 (56.7)	38 (100)	32 (84.2)	-
May 14	69	38 (55.1)	36 (94.7)	31 (81.6)	100% (n = 21)
Aug 13	25	18 (72.0)	18 (100)	13 (72.2)	-
Aug 18	1	1 (100)	1 (100)	1 (100)	-
Sept 24	68	45 (66.2)	45 (100)	1 (2.2)	100% (n = 20)
Oct 27	2	0	-	-	-
Nov 8	57	33 (57.9)	33 (100)	33 (100)	100% (n = 19)
Cunner					
June 21	236	50 (21.2)	50 (100)	50 (100)	100% (n = 14)
Sept 10	82	4 (4.9)	4 (100)	4 (100)	-
Oct 27	69	5 (7.2)	5 (100)	5 (100)	-

Table 9. Numbers of Atlantic silversides released in front of the PNPS traveling screens, number recovered, and survival rates, by date 1982.

Date (1982)	Number Introduced	Number (%) Recovered	Number (%) Alive 1.hr	Number (%) Alive 44+ hrs	Control Survival 44+ hrs	Adjusted % Latent Survival
April 30	67	18 (26.9)	10 (55.6)	2 (11.1)	100% (n = 30)	11.1
May 5	264	203 (76.9)	12 (5.9)	0	95.1 (n = 41)	0
May 14	37	23 (62.2)	14 (60.9)	8 (34.8)	-	34.8
June 2	*	-	-	-	99.3 (n = 149)	-
Aug 18	71	2 (2.8)	0	0	76.0 (n = 25)	0
Sept 17	287	217 (75.6)	42 (19.4)	14 (6.5)	80.0 (n = 30)	8.1
Sept 24	463	49 (10.6)	2 (4.1)	0	65.6 (n = 93)	0
Oct 27	171	52 (30.4)	32 (61.5)	0	100 (n = 40)	0

*Screens inoperative, therefore all fish held as controls.

Table 10. Mean elapsed time between release of fish and first appearance at the end of the sluiceway and last release and last appearance at the end of the sluiceway, 1982 (see text for details).

Species	Mean Elapsed Time (min) First Release to Collection	Mean Elapsed Time (min) Last Release to collection
Winter skate	8*	41*
Atlantic silverside	6	66
Bluefish	25*	-
Cunner	10	10
Windowpane	29	11
Winter flounder	6	46

*One observation only.

Table 11. Survival summary for the six numerically dominant species obtained during the PNPS sluiceway survival studies, 1980-1982. Initial and latent percent survival is shown for sluiceway introductions, screen introductions, and those naturally impinged on the screens.

	Sluiceway Introduction Survival		Screen Introduction Survival		Natural Impingement Survival			
	Initial	Latent	Initial	Latent	Initial	Latent	Initial	Latent
Species			Continuous washes		8-hour washes		Continuous washes	
Cunner	100	99	100	100	5	3	70	20
Atlantic silverside	96	50	20	5*	5	0	33	0
Rainbow smelt	67	0	-	-	2	0	3	0
Northern puffer	-	-	-	-	7	6	20	10
Threespine stickleback	75	75	36	27	4	0	2	0
Winter flounder	100	100	99	69	14	9	44	25

*Adjustment made for control survival.

SUMMARY REPORT:
FISH SPOTTING OVERFLIGHTS
IN WESTERN CAPE COD BAY
IN 1982

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April 1983

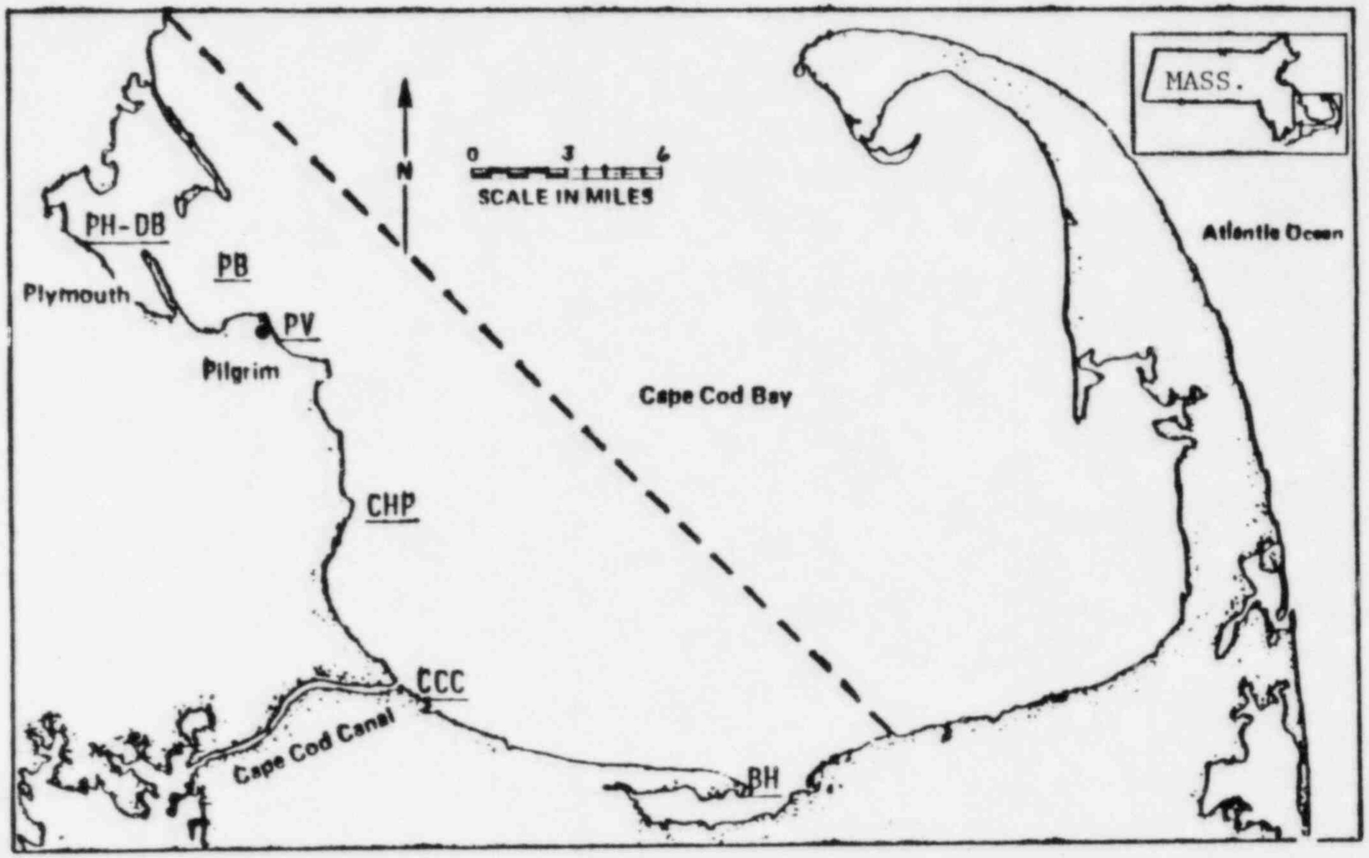
SUMMARY REPORT: FISH SPOTTING OVERFLIGHTS IN WESTERN CAPE COD BAY IN 1982

Fish spotting overflights were made north, south and in the vicinity of Pilgrim Nuclear Power Station (PNPS) during 1982. Five main groupings of fish were noted by the overflight pilot who was trained to spot fish for commercial fishing operations. The five groupings are herring, consisting primarily of Atlantic herring (Clupea harengus harengus), alewife (Alosa pseudoharengus) and/or blueback herring (Alosa aestivalis); Atlantic menhaden (Brevoortia tyrannus); pollock (Pollachius virens); Atlantic mackerel (Scomber scombrus); and baitfish, consisting primarily of any species too small to identify but most likely being composed of Atlantic silverside (Menidia menidia), rainbow smelt (Osmerus mordax), sand lance (Ammodytes spp.) or the juveniles of other species.

Figure 1 shows the general area covered by the PNPS fish overflight program, although reports of fish concentrations are received from further north, or south also. This summary report is meant for general information purposes only, as it is not possible to quantify with reasonable accuracy the data from this qualitative a program. Nevertheless, this program is very valuable and useful in being responsive to NPDES Permit requirements, documenting barrier net effectiveness by confirming large quantities of fishes in the Pilgrim area, and alerting BECo. personnel of the potential for a discharge-related fish mortality.

Table 1 summarizes location, approximate poundage and seasonal information for the five groupings of fishes defined above. Below are some interpretive

Figure 1. FISH SURVEILLANCE OVERFLIGHTS (Critical Area)



PH-DB	Plymouth Harbor-Duxbury Bay
PB	Plymouth Bay
PV	Pilgrim Vicinity
CHP	Center Hill Point
CCC	Cape Cod Canal
BH	Barnstable Harbor

Note: Critical surveillance area is west of the dashed line in the vicinity of the specific locations noted. Generic observations should also be made in the course of the plane's flight to and from the critical area.

NUC6-H9

TABLE 1. Approximate Location, Relative Species Poundage and Seasonality from Fish Observation Overflights in the Western Cape Cod Bay Area in 1982

LOCATION	SPECIES	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
	Herring	140,000	100,000+		2,000,000	600,000					200,000	1,060,000+	1,190,000+
	Menhaden					1,070,000+	2,035,000	5,000,000+	6,625,000+	2,015,000+	5,590,000+	200,000	
North of	Pollock											220,000	130,000
Pilgrim	Baitfish								50,000				
	Mackerel												
	Herring		1,037,000										
Pilgrim	Menhaden								50,000				
Vicinity	Pollock				7,000	2,000		2,000					
	Baitfish												
	Mackerel												
	Herring		100,000+									250,000	675,000
South of	Menhaden					25,000	75,000	650,000			450,000+	300,000	
Pilgrim	Pollock												10,000
	Baitfish												
	Mackerel						50,000						
	Herring	140,000	1,237,000+		2,000,000	600,000					200,000	1,310,000+	1,865,000+
	Menhaden					1,095,000+	1,110,000	5,650,000+	6,675,000+	2,015,000+	6,040,000+	500,000	
Totals	Pollock				7,000	2,000		2,000				220,000	140,000
	Baitfish								50,000				
	Mackerel						50,000						

comments based on general trends illustrated by fish observation data for the five predominant fish groups in 1982:

1. Herring - This is a mixed species category but probably consists mostly of Atlantic herring. These fish were in the Cape Cod Bay area primarily from Fall through early-Spring, most frequently north of PNPS. The alewife and blueback herring are more prevalent in the spring and summer and the large numbers of herring observed on 14 April and 19/27 May north of Pilgrim most probably represented these species. The majority of pounds of herring observed by fish overflights represents Atlantic herring to a major extent as borne out by commercial catch statistics. On 4 February 1982, 37,000 pounds of Atlantic herring were spotted inside the PNPS intake breakwaters but no fish mortality occurred. In November 1976 over 10,000 Atlantic herring were killed by impingement on PNPS traveling screens.

2. Atlantic Menhaden - This species is of concern at Pilgrim because of past gas bubble disease mortalities in the discharge canal and thermal plume. As can be seen from Table 1, menhaden occur over the entire Cape Cod Bay region in the millions of pounds from Spring through Fall. Overflight pilots are particularly adept at identifying this species as commercial ventures depend heavily on accurate observations for success. The first commercial catch of menhaden north of Cape Cod in 1982 was made on 27 May and by mid-June many had moved north to Maine where most of the commercial fishing became concentrated throughout the Summer. On 15 August, 50,000 pounds of

menhaden were spotted one mile east of the PNPS discharge vicinity but this occurrence proved to be uneventful. On 1 November the last menhaden observed in 1982 were 200,000 pounds in Plymouth Bay and 300,000 pounds around Wellfleet , evidently undertaking their Fall southern migration.

3. Pollock - These fish were identified in greatest numbers during November and December in Plymouth Bay. They were not as prolific as the herring and Atlantic menhaden, and no serious incidents have occurred involving them at PNPS although they have been seen within the intake embayment. In April, May and July 1982 and during previous years, this species showed an affinity for schooling in the intake area. However, they have never been impinged on the PNPS intake screens in proportion to their abundance when schooling.

4. Atlantic Mackerel - These fish support a valuable commercial fishery and were reported in one sighting (50,000 pounds) 2-3 miles south of PNPS. They occur in relatively large numbers usually during the Summer months, and no notable incidents involving them have occurred at Pilgrim Station. They are an off-shore species for the most part but have been observed schooling in the PNPS intake embayment, and on 16 July 1981 several Atlantic mackerel were killed in front of the intake structure as a result of bluefish predation.

5. Baitfish - This category is a catchall and may include large numbers of small unidentified fish. One sighting (50,000 pounds) was made on 15 August inside Plymouth Harbor - Duxbury Bay. These baitfish could have represented the offspring of fishes in the above categories as well as Atlantic silversides, rainbow smelt and sand lance.

NUC6m

SUMMARY REPORT: 1982 INSPECTIONS OF PILGRIM DISCHARGE CANAL AND FISH BARRIER NET

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April 1983

SUMMARY REPORT: 1982 INSPECTIONS OF PILGRIM DISCHARGE CANAL AND FISH BARRIER NET

Pilgrim Station discharge canal dive surveys were initiated in 1976 to describe and document the effectiveness of a barrier net in excluding fishes and any behavioral or physical observations of marine biota inhabiting the canal waters.

Twelve biweekly dive inspections of the Pilgrim discharge canal and barrier net were performed from May-October 1982 in partial fulfillment of the Boston Edison Company's Marine Ecology NPDES (EPA) Permit Program. The dives were made around the time of high tide to take advantage of low current velocities (2 fps) in the discharge canal and the time when fishes would be most likely to inhabit it. Marine life upstream and downstream of the barrier net and functioning of the net were observed. Live marine biota in the discharge canal included the following:

1. Rockweed (Laminaria sp.)
2. Green algae (Enteromorpha sp.)
3. Sea lettuce (Ulva lactuca)
4. Sea anemone (Metridium sp.)
5. Common starfish (Asterias forbesi)
6. Blue mussel (Mytilus edulis)
7. Green crab (Carcinus maenus)
8. Rock crabs (Cancer spp.)
9. Acorn barnacle (Balanus balanoides)
10. Horseshoe crab (Limulus polyphemus)

11. Atlantic silverside (Menidia menidia)
12. Atlantic herring (Clupea harengus harengus)
13. Coho salmon (Oncorhynchus kisutch)

Observations made of the above species revealed no signs of stress or gas bubble disease upon close inspection. No individuals of these species observed upstream of the barrier were likely to have entered the canal due to failure of the net. They were either small enough to get through the 2" mesh of the net, were introduced to the canal artificially (i.e., fishermen, screenwash sluiceway), or entered when the cod end of the net was left open occasionally to allow passage of heavy debris loads. Species taken most by sport fishermen off the ends of the discharge breakwaters included:

1. Striped bass (Morone saxatilis)
2. Bluefish (Pomatomus saltatrix)

Some of these fish were closely examined onshore and showed no signs of gas bubble disease. Large schools of bluefish and other species were apparent in the near-field thermal plume, as evidenced by catches and diving sea gulls. This indicated, and close observation of the barrier net confirmed, that the net was operating successfully when properly deployed.

Each inspection covered six major regions of the canal around the barrier net (Figure 1). To put major observations made during 1982 in perspective, the following qualitative monthly breakdown is presented.

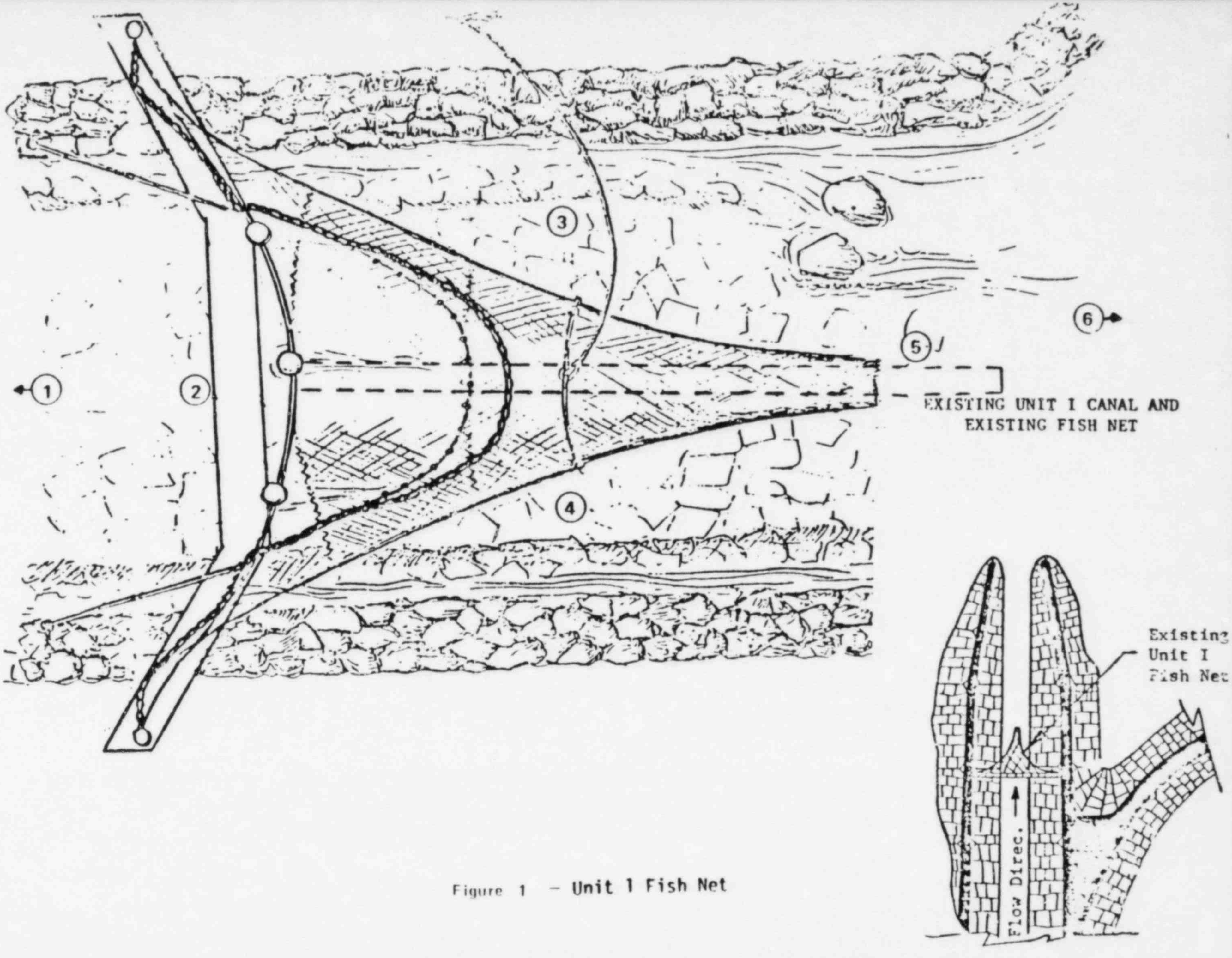

Figure 1 – Unit 1 Fish Net

May

The bottom half of the discharge canal sides had a sparse growth of green algae. Juvenile acorn barnacles covered rock surfaces half way up the canal sides. The bottom of the canal was 50-70% covered with 2" mats of blue mussels ranging from 1/8" - ½" in length. Large strands of sea lettuce were spread between the seed mussel mats. Small common starfish and rock crabs were feeding on mussel clumps. Only scattered numbers of sea anemones and rock crabs were noted. All invertebrates observed were viable and healthy.

The mussel mat persisted on the canal bottom up to the barrier net wings and chain line. A dead Atlantic herring was found wedged between the right net wing and side sill, headed upstream. Evidently this fish tried to get upstream of the barrier net and failed. A small school of Atlantic silversides was observed on the left side of the barrier net. An apparently healthy Coho solmon was observed just below the cod end of the net. No mussels were observed under the barrier net, although downstream of it were seed mussel clumps. The net was maintained in good condition but sportfishing activity was slow, being limited to bottom fishing in the intake area.

June

Tubular green algae covered the lower sides of the discharge canal followed by attached red algae on the bottom. The thick 2-4" mat of ½" blue mussels noted early in May, that covered 80% of the canal bottom, had released and

left the canal by late June. The scarcity of mussels in the canal late in the month accounted for reduced numbers of their predators (common starfish, rock crabs and green crabs) observed. Only a few acorn barnacles were seen and a light growth of sea anemones had begun. This succession of biota is typical when the discharge temperature reaches 85 + °F. No live fishes were noted in the canal the entire month.

A couple of live horseshoe crabs were removed from between the net wing and side sill. One dead striped bass (20" long) was noted upstream of the barrier net but may have washed into the canal from the screenwash sluiceway. The canal bottom was clean beneath the barrier net which was riding in the current well off the bottom. A moderate growth of algae began appearing on the barrier net stimulated by the warmer discharge temperatures but the net remained in good repair. Sportfishing was fairly good with bluefish and striped bass being caught. The Massachusetts Division of Marine Fisheries (DMF) posted the area with signs stating that it was illegal to keep striped bass less than 24 inches long.

July

A moderate growth of green and red algae persisted on the discharge canal sides and bottom, respectively. Occasional green and rock crabs were seen, but all blue mussels and starfish had left the canal. Sea anemones were beginning to cover rock surfaces but not in the extreme densities noted during past summers.

The barrier net was in good condition, having been maintained efficiently. Careful inspections showed no fishes present in the canal as high discharge temperatures (~ 95°F) this time of year effectively exclude many species. No mussels were evident downstream of and under the barrier net and the canal bottom was denuded of algae. Sportfishing on the canal groins slowed down in July with only an occasional bluefish or striped bass being caught.

August

The canal sides and bottom had a lush growth of green and red algae, respectively. Most of the month a minimal growth of sea anemones covered rock surfaces in the discharge canal. No blue mussels, common starfish or green crabs were seen, but numerous rock crabs were noted feeding on dead Atlantic silversides possibly from the screenwash sluiceway. Again, no live fishes were observed the length of the discharge canal.

Sea anemones were prevalent on rock surfaces to the sides of the barrier net but little attached algae was seen. The barrier net was in relatively good condition and the bottom under it was clean. Sportfishermen were taking occasional bluefish. Inspection of sportfishermen's catches revealed no overt symptoms of gas bubble disease or other maladies on fishes.

September

The canal sides and bottom had a dense growth of tubular green and attached red algae, respectively. Rock surfaces were moderately coated with sea anemones leaving a scum-like mat. Occasional rock crabs were seen. No signs

of blue mussels were obvious. Fragments of long-finned squid from the screenwash sluiceway were noted on the canal bottom. The Station was operating at reduced power during this month.

Less algal growth and similar sea anemone density to upstream of the barrier net was noted downstream of it. The net performed well although the bottom of it became overburdened with dense algal growth and cleanings were increased to twice/week. Normally a net replacement would take place in September, but the maintenance divers did such a good job that net life may be extended from 6 months to 1 year. Reports were received of increased bluefish catches by sportfishermen from the ends of the discharge canal, which historically happens in the Fall at Pilgrim Station.

October

Observations in the discharge canal were limited this month by turbid conditions caused by dredging of the intake embayment. However, some inspection was possible.

A moderate growth of red algae persisted on the canal bottom with minimal green algae present on the sides. No invertebrates or fishes were seen in the entire canal because of high turbidity. The west side of the discharge canal revealed a heavy settlement of silt from the dredging and this may have caused mobile marine life to evacuate. The Station operated at a very low power level during most of this month.

The bottom sill had heavy silting around it. The maintenance divers removed rocks under the barrier net which were chaffing and creating holes in it. Sportfishing activity was slow, possibly due to the high turbidity although the DMF caught several small striped bass in their discharge gill net.

(NUC123-E1)

A COMPARISON OF POWER PLANT IMPINGEMENT WITH OTHER TYPES OF SAMPLING GEAR TO SURVEY FINFISH OFF PILGRIM NUCLEAR POWER STATION

By

Robert P. Lawton, Phillips Brady, Christine Sheehan,
Mando Borgatti and Vincent Malkoski

April, 1983

Massachusetts Department of Fisheries,
Wildlife and Recreational Vehicles
Division of Marine Fisheries

(NUC123-E2)

A COMPARISON OF POWER PLANT IMPINGEMENT WITH OTHER TYPES OF SAMPLING GEAR TO SURVEY FINFISH OFF PILGRIM NUCLEAR POWER STATION

To facilitate the description of fish occurrence, distribution, and abundance in the vicinity of Pilgrim Nuclear Power Station, an array of collecting gear has been used over the years to sample a cross-section of species present in the area's diverse habitats. Studies have included an inventory of taxa and determinations of seasonal distribution and estimates of fish abundance. It is unlikely that a particular type of sampling apparatus alone will capture all fish species or all sizes of a species with equal probability. There have been concerted efforts to develop sampling strategies which insure that abundance estimates are well characterized relative to the populations present in the study area.

In 1982, systematic collections were made employing standardized procedures. Physiography of the area strongly influenced the choice of gear and where used. A haul seine was employed in shallow eulittoral areas along the shoreline and bottom trawls (of two different sizes) in deeper waters out to about 12 m (MLW). An anchored gill net, a stationary gear, was fished from surface to bottom (MLW) at sites north and south of the thermal discharge. SCUBA diving operations rendered direct count estimates of finfish in the immediate area of the thermal effluent. Routine intake screen wash collections at Pilgrim Station provide data on the seasonal occurrence of numerically dominant taxa. The following presentation is a comparison of data obtained from impingement collections at Pilgrim Station with that from the aforementioned sampling apparatus.

As to number of species recorded by all means in 1982, impingement and gill net collections led the way with 38 and 37 species, respectively. With both bottom trawls, 26 species were taken, while the seine netted 22 different fishes. SCUBA divers, who are limited by visibility, sampling time, and behaviorial responses of fish to their presence, observed only eight taxa in and tangential to the path of Pilgrim Station's thermal effluent. It is interesting to note that Turner and Johnson (1973) using an array of collecting gear in Newport River, North Carolina captured the greatest variety of fish species by gill net. Long-term data records at Pilgrim Station provide additional insight, revealing that the total number of species impinged on the plant's intake screens from 1973-1980 equals the number collected in surrounding waters by trawl, gill net, and seine combined from 1970-1981.

Impingement collections in 1982 reflected the seasonality of finfish distribution revealed through 13 years of trawl and gill net sampling. Winter (January-March) is the season when fewest species and lowest numbers of finfish occur in the study area. The number of species trawled, gill netted, and impinged was lowest in winter (February), when cold temperatures become a limiting factor. There were more species represented in fall (November) trawl and impingement collections than at any other time; for in autumn, seasonal migrants intermingle with resident benthic fauna. Howe and Germano (1982) conducted a seasonal bottom trawl survey of fisheries resources in Cape Cod Bay and likewise captured more species in autumn.

Spring is also a time of high diversity as reflected in impingement and gill net catches. Over the years, the numbers and species of fish caught by

gill net have peaked in the vernal season. The structure of Pilgrim's demersal fish community, as described by the use of three species diversity indices: species richness (Margalef 1958), Shannon-Weaver (Shannon and Weaver 1963), and Simpson's measure (Simpson 1949), was most diverse in spring and fall as water temperatures steadily increase to a late summer maximum and decline to a winter nadir, respectively (Lawton et al. 1978). At Shoreham, New York on Long Island Sound, GEOMET Technologies, Inc. (1981) found highest diversity in the groundfish community during spring and fall.

Of the dominant demersal fish trawled in the vicinity of Pilgrim Station in 1982, only winter flounder (Pseudopleuronectes americanus) was impinged in any number. From 1973-1981, offshore trawl catches have had little abundance correlation with impingement collections (Anderson, unpublished data). In 1982, cunner (Tautogolabrus adspersus) and pollock (Pollachius virens) were among the top three species both gill netted and observed by SCUBA divers, while ranking third and sixth, respectively, in impingement totals. As to species composition and abundance, haul seine catches agreed most with impingement records. Six of the 10 numerically dominant finfish both seined and impinged were identical, with Atlantic silverside (Menidia menidia) and bay anchovy (Anchoa mitchilli) ranking one and two, respectively. Pilgrim Station's intake is a shoreline structure, and like unto haul seining, is most apt to sample shore fishes inhabiting the intertidal and shallow subtidal zones. These include primarily the juveniles of larger species and both juveniles and adults of smaller forage fish.

While examining seasonality in occurrence and relative abundance of finfish in western Cape Cod Bay as revealed through various sampling regimes,

some interesting findings surfaced. The Atlantic silverside ranked first in overall numerical importance, with highest catches obtained via seining and impingement. A greater size range was seined (18-162 mm TL) than was impinged (70-140 mm TL). An abundance of juveniles (some just exceeding the post-larval size of 12-15 mm) seined in August at Gray's Beach in nearby Plymouth, Kingston, Duxbury Bay (PKDB) suggests that spawning occurs in this estuary. Conover and Ross (1982) reported silverside spawning to be linked to inter-tidal vegetation within salt marches. Thus, the closest spawning grounds to Pilgrim Station is PKDB, which is most likely the source of local recruitment to the Rocky Point area.

Impingement of silversides at the power plant was highest during March-April and December and lowest from mid-spring through summer, which includes the silverside spawning season. According to Bigelow and Schroeder (1953), there is a protracted spawning period extending from May-July in the Gulf of Maine. The density of silversides was far greater in the marsh region of PKDB than in the bay region around the power plant throughout the summer and most of the fall. Declining seine catches in late autumn (December) paralleled dropping water temperatures and heralded an offshore movement of Menidia. There is conclusive evidence that northern populations undergo an offshore winter migration (Conover and Murawski 1982; Howe and Germano 1982). Pilgrim data indicate that silversides were rare or absent from the shore zone in mid-winter.

Bay anchovy ranked second in seine and impingement totals, with the size range of catches being similar. Anchovies were impinged each month from June through November but surprisingly were not seined in the intake embayment.

This schooling species is a summer straggler to the Gulf of Maine from the south (Bigelow and Schroeder 1953). Therefore, it is not surprising that the number seined and impinged peaked in summer when temperatures ranged from 13-22 C.

It is evident that cunner is a dominant member of the finfish community in the immediate vicinity of Pilgrim Station. In 1982, this species ranked first in diver observations, second in gill net totals at one of the two locations sampled, and third in impingement numbers. Few cunner were seined, however, and these were small individuals (20-24 mm TL). More small fish (presumably younger) were impinged (7-195 mm TL) than were observed by divers (30-250 mm TL) or gill netted (72-330 mm TL) indicating the intake embayment was a refuge for younger individuals.

Cunner were present in the study area during portions of all four seasons with highest abundance occurring in late spring and summer according to all sampling methodologies. Low catches in colder months are evidently temperature-related. Olla et al. (1975) observed in late fall, when water temperatures declined to 5-6 C, cunner had moved out of the shallows and became inactive, remaining torpid throughout winter until spring's warming of the water.

Rainbow smelt (Osmerus mordax) was fourth in impingement collections, with the majority entrapped at Pilgrim Station in November and December. Small numbers were trawled and gilled in late fall/early winter, and even smaller

numbers were seined during warmer months. Present in seine and impingement collections were young-of-the-year smelt. A relatively large impingement mortality exceeding 6,000 smelt occurred at Pilgrim Station in December, 1978 (Lawton et al. 1979). Systematic collections from 1973-1982 reveal that smelt was one of the three dominant species impinged, with numbers being highest during colder months (Anderson, unpublished data).

Bigelow and Schroeder (1953) reported that sea-run smelt stocks do not stray far from their natal spawning grounds. In a one-year survey of PKDB, Iwanowicz et al. (1974) captured the largest numbers of smelt in summer while bottom trawling in the deeper channels of the estuary. Smelt concentrate in the fall in harbors and bays where they are harvested by recreational fishermen until early winter; such a fishery occurs in Plymouth Harbor. The spring spawning run into the Jones River, a tributary to PKDB, begins in March and has extended through April (Brady and Lawton 1982). Through the years of plant operation, relatively few smelt have been impinged from February on through the summer months.

Pollock ranked first in gill net catches, second in diver observations, and sixth in fish impinged in 1982. Low numbers were impinged each month from April-December, with slightly more fish collected in autumn. Over the years, pollock gill-net catches have been bimodal, peaking in spring and with a lesser mode in the fall.

In conclusion, it is evident that impingement of fishes on the intake water screens, like fish sampling gear, is a qualitative spatial sampler of

fish species, albeit in a passive mode, and provides data on occurrence and distribution of dominant ichthyofauna. Impingement catch statistics also afford quantitative temporal information on some fish stocks, in that there appears to be a relation between the seasonal abundance of a fish population and the number of fish impinged.

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(NUC123-F1)

OBSERVATIONS ON THE MYTILUS EDULIS COMMUNITY AT THE PILGRIM NUCLEAR POWER STATION

By

James A. Blake

April, 1983
Battelle New England Marine Research Laboratory

(NUC123-F2)

Observations on the *Mytilus edulis* Community

The settlement and growth of *Mytilus edulis* at the three stations is an example of both spatial and temporal distribution. In our latest sampling period (September, 1982), Manomet Point had the densest populations (24,991/ m^2). Effluent and Rocky Point populations were approximately one-half the density of Manomet Point (13,113/m^2 at Effluent; 12,690/m^2 at Rocky Point). Over time, Manomet Point has also had higher mussel densities since sampling at that station was resumed in August, 1981. Mussel densities at Effluent and Rocky Point have generally been similar to one another except that Rocky Point has been steadily decreasing in mussel density since August, 1981 (See Fig. 6, Battelle's Benthic Report).

Part of the spatial variation may be related to patterns of gregarious larval settlement. For example, during our December 1, 1982 diving survey very dense mussel populations were observed on the north side of the Effluent discharge. These populations were not observed in September and did not appear to be widespread over the greater area of the Effluent Station.

Without a more regular sampling of the mussel beds it is difficult to draw many conclusions from our twice a year quantitative samples. Further information could be generated if size frequency data were developed from the archived samples. Then these data could be compared with both numbers of settling larvae collected throughout the spawning season, as well as with growth rate and numbers of juveniles found in the side-stream mussell monitors.

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 55th meeting of the Pilgrim Administrative-Technical Committee

DATE: November 15, 1982

The 55th Administrative-Technical Committee meeting was called to order on 30 September, 1982 at 10:25 A.M. at the Pilgrim Nuclear Station, Information Building, in Plymouth, Massachusetts by Chairman Leger. Nine agenda items were addressed.

I. Minutes of the 54th meeting.

Corrections to the 54th Committee minutes were tendered and are attached as a separate addendum to these minutes.

II. 1982 DMF studies progress report.

Bob Lawton, Phil Brady and Chris Sheehan discussed the 1982 DMF Project Report No. 33, Summary Report No. 14. Committee members were referred to the January-June report for study specifics or more indepth information.

III. 1983 DMF Studies Subcommittee Report.

Jack Finn, chairman of the Marine Fisheries Subcommittee, presented nine subcommittee recommendations for the 1983 studies program.

1. Irish moss harvest study be discontinued.

2. The otter trawl finfish study be discontinued.

3. The lobster pot catch study be continued at the present effort level.

4. The nearshore or (shrimp trawl) study continue. One new sampling station at Plymouth-Duxbury-Kingston Bay will be added. A biweekly sampling schedule will be attempted for sites T1, T3, and T5 with Stations T-2 and T-4 sampled monthly.

5. The shore haul seine study continue with a shift of one sampling station (B-4) from White Horse Beach to the month of Plymouth

Harbor, sampling to be conducted from April through September.

6. The gill net study continue with sampling to return to the previous set location and maintain the present level of effort.

7. The underwater finfish dive study be continued at the present effort level.

8. A new project, mapping of the saturated gas plume in the discharge area was outlined. The objective of this program would be to delineate the area of potential gas bubble disease impact by outlining gas saturation levels of 115% or greater. Sampling will be conducted in the spring and fall, during periods of off-shore winds. Attempts will be made to bracket slack tide periods.

9. Undertake a shorefront creel census.

Items 1-8 were considered conjointly by the full committee. George Kelley recommended the approval of items 1-8 as presented by the fisheries subcommittee. Jack Finn second. Motion passed unanimously.

Item 9 the creel survey was considered separately. Following lengthy discussion, Jack Finn moved the creel survey be conducted. George Kelley second. Motion passed unanimously.

The committee also ranked the projects to be undertaken as follows:

Project	Ranking
Plume dive	1
Lobster study	2
Shrimp trawl	3
Haul seine	4
Gill net	5
Gas plume mapping	6
Creel survey	7

George Kelley moved that the ranking be accepted as outlined by the full committee. Jack Finn second. Motion passed unanimously. Don Miller complimented the fisheries subcommittee on conducting a meaningful and lucid presentation of the fisheries studies for 1983.

IV. Monograph status.

Monograph subcommittee is pursuing two avenues for publication, the American Fisheries Society, and the National Marine Fisheries Service, Special Scientific Report. Tom Horst, of Stone and Webster, is working on an ecosystem synthesis approach to fulfill a requirement of the American Fisheries Society editor. The monograph subcommittee is also following inquiries to NMFS and Carl Synderman, editor of the SSRF documents. It is hoped that the subcommittee will have conclusive results by mid-October and that the manuscript will be submitted to one or the other organizations by the end of December.

V. 1982-1983 Benthic contract.

Lew Scotton reviewed progress on the benthic studies. Prospective contractors have been contacted, and following proposal review by the benthic subcommittee, a contract was awarded to Battelle New England Marine Research Laboratory. Subsequent to committee discussion it was advised that the benthic contractors be invited to attend the next PATC meeting.

Don Miller recommended that each contractor make a short presentation of their study areas. Don also commented positively on the way the benthic work will be conducted and how well, he believes,the new contractors will be able to carry on existing studies.

VI. Mussel control studies.

Lew Scotton reviewed the current status of the mussel control program. The saltwater service system appears free of mussel fouling. Utilization of heat treated backwashes within the circulating water system also appears to be very effective in controlling this problem. Work is continuing on the identification of peak mussel spawning periods and larvae attachment. Efforts also continue to most efficiently measure and monitor chlorine levels within the saltwater service system.

VII. Salmon hatchery update.

Bob Anderson informed P.A.T.C. members that the proposed salmon hatchery project had been cancelled via internal actions of the Boston Edison Company.

VIII. 1983 PNPS monitoring studies.

1. Entrainment

Lew Scotton outlined the 1983 entrainment program conducted by MRI, and recommended its continuation.

George Kelley, moved the entrainment study be continued in 1983. Bob Lawton second. Motion passed unanimously.

2. Impingement

The 1983 impingement study proposal was presented by Bob Anderson. Bob recommended the study be continued at the present level. Following discussion Bob Lawton move the 1983 impingement program be continued. George Kelley second. Motion passed unanimously.

3. Fish overflight surveillance.

This program initiated by BECo in 1976, is an effort to monitor the times when large concentrations of fish might be expected in the vicinity of Pilgrim I plant. The possibility of utilizing a photographic program in conjunction with the overflights was also discussed.

Jack Finn moved that the fish overflights program be continued in 1983. George Kelley second. Motion passed unanimously.

IX. Other business.

The barrier net maintenance program, and fish survival study which commenced in March were briefly discussed. Further information on the survival studies should be available at the next PATC meeting.

X. Adjournment.

Meeting adjourned at 3:00 P.M.

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 54th meeting minutes of the Administrative-Technical Committee

DATE: September 30, 1982

The minutes of the 54th A-T Committee Meeting are corrected as follows:

Page 3, Section VII shall read: Section VI.

Page 3, Section VI, the last sentence, the word eigh-hour shall read eight hour.

Page 4, Section IX shall read: Section XIII.

Page 4, Section X shall read: Section IX.

Administrative-Technical Committee Meeting

September 30, 1982

Bob Leger, Chairman	U.S.E.P.A. (non-voting advisory membe
Phillips Brady, Recording Secretary	Mass. Division of Marine Fisheries
Bob Lawton	Mass. Division of Marine Fisheries
Bob Anderson	BECo
George Kelley	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.
Gerald M. Szal	Mass. DWPC/DEQE

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 56th meeting of the Pilgrim Administrative-Technical Committee

DATE: December 16, 1982

The 56th Administrative-Technical Committee meeting was called to order on 16 December, 1982 at 10:10 A.M. at the Pilgrim Nuclear Station, Information Building, in Plymouth, Massachusetts by Chairman Leger. Following introductions, eight agenda items were addressed.

I. Minutes of the 55th meeting.

Correction to the 55th Committee minutes were tendered and are attached as a separate addendum to these minutes.

II. Benthic study update.

Jim Blake of Battelle, presented the work begun this September, on the benthic community analysis and transect survey studies. A written technical report entitled: "Special Transect Survey of Effluent Canal and Surrounding Areas at Pilgrim Station, Following Cessation of Dredging Operations in the Intake Canal" was distributed to committee members. Work commenced on the 25th of September; processing of community samples is continuing. Community analysis will commence sometime in January, following completion of flora and fauna sorting and identification. To date, a number of new faunal species have been identified. No major differences in algal biomass are evident.

The transect survey confirmed DMF diver reports, as to dredge spoil silt deposition in the vicinity of the discharge. No unusual accumulation of sediments was observed within the observational study area.

The discharge stunted growth zone was reported widely flared to the north, at the 40-50 m transect mark.

Lew Scotton asked that Battelle contact TAXON to acquire and maintain the benthic sample archive collections obtained at Pilgrim Station in previous years.

Don Miller encouraged Battelle to bring out in their semi-annual and annual report discussions, the differences found from previous years' work.

Jim Blake requested a determination by the full committee of when the next transect survey should be conducted. Routine sampling requires a December survey. Jim questioned if the information gathered so closely following the special survey would produce greater insight in the area. He asked if the scheduled December transect dive should be deferred until a later period.

Don Miller felt the effort for the survey could best be utilized by channeling it into indepth analysis of current data.

George Kelley moved that the PATC accept alterations of the Battelle contract, considering the December 1 survey as fulfillment of December sampling. No further transects need be conducted until March, and increased effort will be placed in retrospective data analysis and turbidity factor investigations as outlined by the benthic subcommittee.

Gerald Szal second. Motion passed unanimously.

George Kelley welcomed the Battelle benthic group and voiced committee anticipation of a productive relationship.

III. Winter flounder larvae/intergration proposal for 1983.

Lew Scotton passed out copies of MRI's 1982 "Final Report on Larval Winter Flounder Studies in Plymouth Harbor, Kingston, Duxbury Bay and Green Harbor, River Estuaries - 1982". Collected values suggest that PHKDB may be considered the sole source of larval flounder entrained at PNPS. MRI maintained a conservative approach to power plant impact assessment, by attributing all larval flounder impact to PHKDB. The supplementary winter flounder egg study results indicated 40.9% of the live eggs collected at PNPS were younger than seven days, 36.4% were, in fact, less than three days old, and 15.9% were about one day old, strongly suggesting that some flounder spawning occurs nearer PNPS than inside PHKDB. Eggs collected from PNPS intake and discharge waters produce viable larvae.

IV. Biofouling studies - MRI.

Derek McDonald presented MRI's report on studies to control biofouling within the plant intake structure via five different coating materials. There appears to be a differential level of fouling in relation to depth on all coating types.

Efforts to control mussel sets have shown heat treatment backwashing at temperatures of 105°F for thirty minutes to be very successful. Marginal heat treatments appear effective, and a seven day lag time for mussel death has been noted.

Continuous chlorination of the saltwater service system also appears very effective in controlling fouling within the heat exchangers. Cyclic application of chlorine may be possible in the future.

V. Monograph update.

Bob Anderson critiqued the latest monograph editorial subcommittee meeting. Work is progressing on the ecological synthesis paper. The graphics drafting contract has been awarded; work on diagrams and figures will commence. Publication through the American Fisheries Society continues to be pursed with a submission goal of February 1, 1983. Other possible publishing avenues will continue to be considered. A working meeting of the authors and editors is scheduled for December 21, to finalize all papers and the synthesis section.

Bob Leger suggested that the full A-T Committee meet with the monograph subcommittee in January to present and discuss the monograph document before submission to AFS in February.

VI. Update on dredging.

Bob Anderson and Lew Scotton outlined the intake dredging work conducted during October and November of this year, at Pilgrim Station. Work concluded on the 24th of November. DMF and Battelle divers have reported no heavy siltation buildup throughout the discharge canal or the plume study areas.

VII. Contractor study integration.

Lew Scotton presented the general concept for enhancement of inter-contractor communications. Efforts will be made in the future for all contractors involved at Pilgrim to exchange as much information as possible and attempt to maximize the biological information from the work.

In this effort, contractors were encouraged to communicate with each other on study related observations or problems. Future PATC meetings will be held where invited contractors can present their current findings and evaluations.

BECo representatives also hoped that Pilgrim contractors could schedule, throughout the study year, meetings among themselves.

Tentative dates suggested for contractor meetings were February first and August first, approximately three months before the semi-annual reports are issued.

Bob Lawton moved that the intergrative approach of Pilgrim studies be pursued.

George Kelley second. Motion passed unanimously.

VIII. Other business.

Bob Anderson discussed the sluiceway survival study for 1983. Following extended discussion concerning species type, sample size, and introduction procedures, George Kelley moved that the A-T Committee approve continuation of the

sluiceway study, utilizing fish species for which more data may be needed. Bob Lawton second.

Gerald Szal proposed an amendment to the motion. "That an informational sheet on the study be prepared by MRI and sent to committee members for consideration". Action on the study was tabled until the next PATC meeting. Bob Lawton second. Motion passed Unanimously.

Dick Toner of MRI presented an interrelationship proposal to investigate the fluctuation in abundance of fisheggs and larvae entrained at Pilgrim Station, correlating them with the nutrient input within the area. Following extensive discussion it was determined that a written critique, which A-T members could review, would best serve the project. Further discussion was tabled until the next committee meeting when the proposal will be reconsidered.

IX. Adjournment.

Meeting adjourned at 3:45 P.M.

Administrative-Technical Committee Meeting

December 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 Kelley	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
Vin Malkoski	Mass. Division of Marine Fisheries
Gerald M. Szal	Mass. DWPC/DEQE
Richard Toner	Marine Research Inc.
Michael Scherer	MRI
Jim Blake	Battelle
Judy Scanlon	Battelle
R.A. McGrath	Battelle
Derek McDonald	MRI

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 55th meeting minutes of the Administrative-Technical Committee

DATE: December 16, 1982

The minutes of the 55th Committee Meeting are corrected as follows:

Page 1, Section III, article 5, shall read: 5. The shore haul seine study continue with a shift of one sampling station (B-4) from White Horse Beach to the mouth of Plymouth Harbor, sampling to be conducted weekly from April through September.

Page 2, Section III, article 6, shall read: 6. The gill net study continue with sampling to return to the previous set location and maintain a biweekly level of effort.

Page 2, Section III, article 8, the third sentence shall read: Sampling will be conducted in the spring and fall, during periods of off-shore winds, while the plant is operating at or near 100 percent capacity.

Page 2, Section III, following the motion of Item 9, the sentence shall read: The committee also ranked the projects to be undertaken as follows: (by priority)

Page 2, Section IV, the name of Carl Synderman is corrected to Carl Sindermann.

Page 3, Section V, the second sentence shall read: Prospective contractors were contacted, and following proposal review by the benthic subcommittee, a contract was awarded to Battelle New England Marine Research Laboratory.

Page 3, Section VIII, article 1, the sentence shall read: Lew Scotton outlined the 1982 entrainment program conducted by MRI, and recommended its continuation.