BOSTON EDISON
Pilgrim Nuclear Power Station
Rocky Hill Road
Plymouth, Massachusetts 02360

October 17, 1995
BECo 95-085

NPDES Program Operations Section (WCP)
Environmental Protection Agency
P.O. Box 8127
Boston, MA 02114

NPDES PERMIT MARINE ECOLOGY MONITORING REPORT

Dear Sirs:

In accordance with Part I, Paragraphs A.8.b. & e, and Attachment A, Paragraph I.F, of the Pilgrim Nuclear Power Station NPDES Permit No. MA0003557(Federal) and No. 359 (State), Semi-Annual Marine Ecology Report No. 46 is submitted. This covers the period from January through June, 1995.

H. V. Oheim
General Manager -
Technical Support

Attachment: Semi-Annual Marine Ecology Report No. 46

HVO/RDA/nas/ECOLRPT

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BOSTON EDISON
Pilgrim Nuclear Power Station
Rocky Hill Road
Plymouth, Massachusetts 02360

October 17, 1995
BECo 95-085

Mass. Department of Environmental Protection
Regulatory Branch - 7th Floor
One Winter Street
Boston, MA 02108

NPDES PERMIT MARINE ECOLOGY MONITORING REPORT

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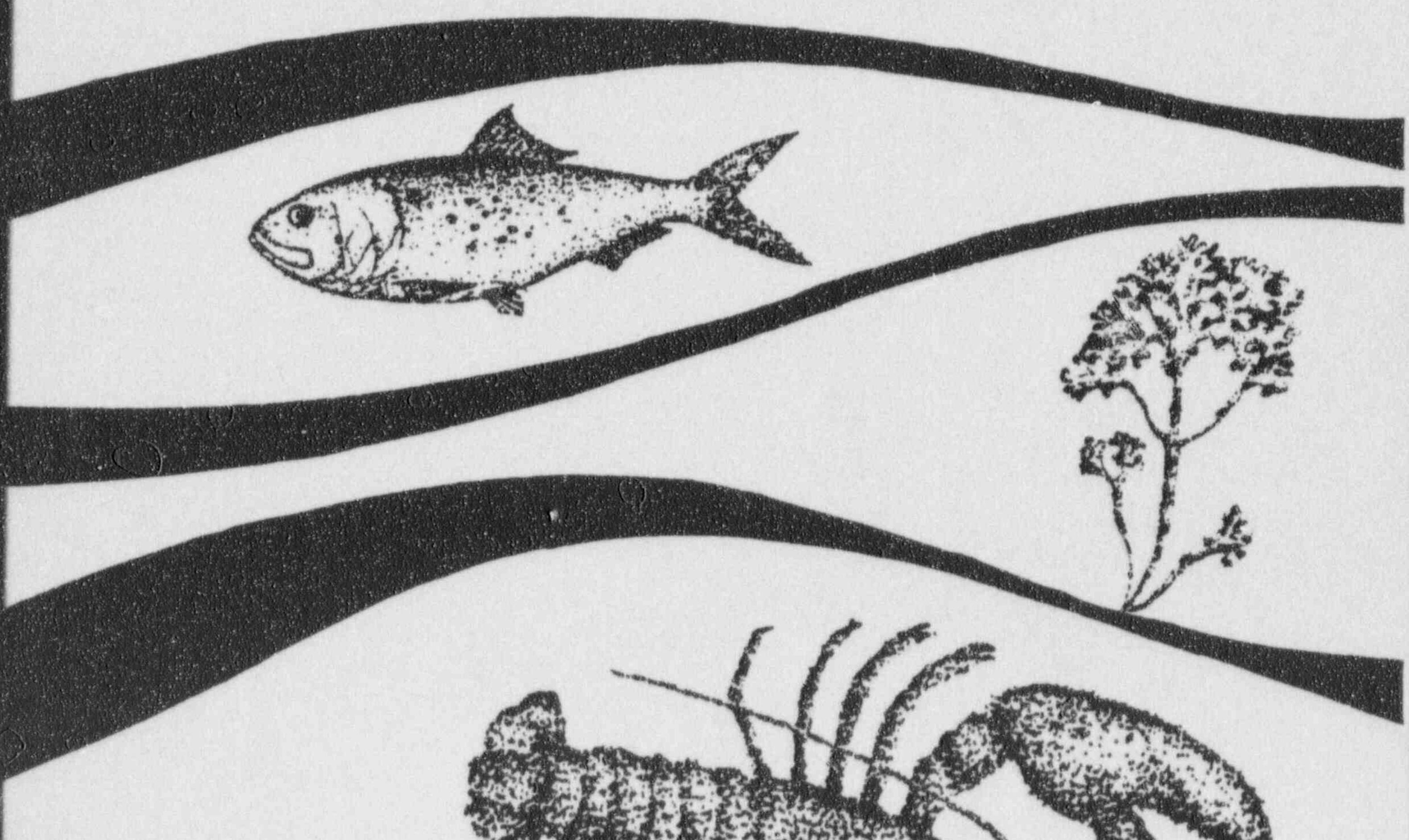
HVO/RDA/nas/ECOLRPT

marine ecology studies
Related to Operation of Pilgrim Station

SEMI-ANNUAL REPORT NUMBER 46
JANUARY 1995 – JUNE 1995



BOSTON EDISON COMPANY
REGULATORY AFFAIRS DEPARTMENT

Boston Edison

MARINE ECOLOGY STUDIES

RELATED TO OPERATION OF PILGRIM STATION

SEMI-ANNUAL REPORT NO. 46

REPORT PERIOD: JANUARY 1995 THROUGH JUNE 1995

DATE OF ISSUE: OCTOBER 31, 1995

Compiled and Reviewed by: Robert D. Anderson
Robert D. Anderson
Principal Marine Biologist

Regulatory Affairs Department
Boston Edison Company
Pilgrim Nuclear Power Station
Plymouth, Massachusetts 02360

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SUMMARY

Highlights of the environmental surveillance and monitoring program results obtained over this reporting period (January - June 1995) are presented below. (Note: PNPS was in high power operation during most of this period with the exception of RFO #10 from April - early June.)

Marine Fisheries Monitoring:

1. Wilcox and Yankee trawl catch from January - June 1995, outside and inside Plymouth, Kingston, Duxbury Bay, recorded several benthic fish species. Winter flounder stock assessment work was performed to determine population parameters with 2,066 fish marked so far in 1995. Twenty-four recaptures have been recorded to date. Techniques for sampling young-of-the-year winter flounder for spawning success/year class strength studies included diving observations and beach seining.

2. In 1995 fish observational dive surveys fish species were observed in the discharge area. No fish showed abnormal behavior and no gas bubble disease symptoms were observed on routine observational dives to date.

3. Rainbow smelt egg restocking of the Jones River (Kingston), to mitigate for the high PNPS smelt impingement in December 1993, accounted for 1,200,000 fertilized eggs being transplanted for hatching to supplement the River's spawning population of this species. This effort was also accomplished in the early Spring 1994 when 600,000 smelt eggs were stocked from other areas to the Jones River.

4. The cunner tagging study concentrated on mark/recapture for population estimation as well as recruitment dynamics. Tagged cunner (746) were released in June 1995, and 103 were recaptured.

Impingement Monitoring:

1. The mean January - June 1995 impingement collection rate was 4.36 fish/hr. The rate ranged from 0.59 fish/hr (June) to 9.75 fish/hr (March) with Atlantic silverside comprising 74.1% of the catch, followed by rainbow smelt, 10.5%, blueback herring, 3.4%, and winter flounder, 2.8%.

2. For March 1995, when the fish impingement rate was 9.75, Atlantic silverside accounted for 96% of the fishes collected. Fish impingement rate was notably higher in 1989-1995 than in 1988 (0.30), primarily because Pilgrim Station had much less circulating water pump capacity than normal that year.

3. The mean January - June 1995 invertebrate collection rate was 1.99+/hr with jellyfish (undetermined numbers), sevenspine bay shrimp (63.0%) and sand worms (19.6%) dominating the catch. Fifteen American lobsters were caught.

4. Impinged fish initial survival at the end of the Pilgrim Station intake sluiceway was approximately 56% for static washes and 50% for continuous washes.

Benthic Monitoring

Early May and June 1995 mappings of the discharge effluent, near-shore acute impact zones were performed. Negligible Chondrus (Irish moss) growth in the denuded zone was evident for both April (1,198m^2) and June (1 405m^2) indicating continuing impact since the 1986 - 1988 PNPS outage. In June a dense mat of juvenile blue mussels (5-15mm length) blanketed large portions of the Chondrus sparse/stunted zones as was also apparent in June of 1990 and 1992-1994, possibly because of consistent thermal discharge during these periods.

Entrainment Monitoring:

1. A total of 32 species of fish eggs and/or larvae were found in the January - June 1995 entrainment collections: 14 eggs, 27 larvae.

2. Egg collections for January - April 1995 (winter-early spring spawning) were dominated by Atlantic cod, American plaice, winter and yellowtail flounder eggs. May and June (late spring - summer spawning) egg samples were most representative of Atlantic mackerel and labrids.

3. Larval collections for January - April 1995 were dominated by rock gunnel, grubby and sand lance. For May and June larvae, sand lance, mackerel, winter flounder and radiated shanny dominated.

4. No lobster larvae were collected in the entrainment samples for January - June 1995.

5. On several occasions unusually high densities of ichthyoplankton were found, involving sand lance, Atlantic herring, Atlantic mackerel larvae; and Atlantic menhaden, as well as labrid, eggs and larvae.

6. Labrid entrainment sampling, net mesh size efficiency comparisons were conducted showing 0.202 mm mesh significantly more efficient in capturing eggs than 0.333 mm mesh. Larval cunner results were variable.

INTRODUCTION

A. Scope and Objective

This is the forty-sixth semi-annual report on the status and results of the Environmental Surveillance and Monitoring Program related to the operation of Pilgrim Nuclear Power Station (PNPS). The monitoring programs discussed in this report relate specifically to the Western Cape Cod Bay ecosystem with particular emphasis on the Rocky Point area. This is the thirty-fourth semi-annual report in accordance with the environmental monitoring and reporting requirements of the PNPS Unit 1 NPDES Permit from the U.S. Environmental Protection Agency (#MA0003557) and Massachusetts Division of Water Pollution Control (#359). 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. Amendment #67 (1983) to the PNPS Tech. Specs. deleted Appendix B non-radiological water quality requirements as the NRC felt they are covered in the NPDES Permit.

The objectives of the Environmental Surveillance and Monitoring Program are to determine whether the operation of the 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 the Pilgrim Administrative-Technical Committee (PATC) which was chaired by a member of the Mass. Division of Water Pollution Control in 1995 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 Mass. Office of Coastal Zone Management, the U.S. Environmental Protection Agency and Boston Edison Company. Copies of the Minutes of the Pilgrim Station Administrative-Technical Committee meetings held during this reporting period are included in Section IV.

B. Marine Biota Studies

1. Marine Fisheries Monitoring

A modified version of the marine fisheries monitoring, concentrating on indicator species populations' impacts, is being conducted by the Commonwealth of Massachusetts, Division of Marine Fisheries (DMF).

The occurrence and distribution of primarily cunner and winter flounder around Pilgrim Station and in adjacent areas are being determined. Population parameters and related life history statistics are being studied to address Pilgrim Station impacts from entrainment of ichthyoplankton, and impingement of juveniles and adults.

Smelt eggs were stocked in the Jones River (Kingston) in March/April 1995, as was done in 1994, to mitigate for the large impingement of 5,000+ rainbow smelt on Pilgrim Station intake screens in December 1993. Mitigation for another 5,000 + smelt impingement at Pilgrim in December 1994 is being considered.

A finfish observational dive program was initiated in June 1978. SCUBA gear is utilized on biweekly dives from May-October at 6 stations in the PNPS thermal plume area.

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

2. Benthic Monitoring

The benthic monitoring described in this report was conducted by ENSR Consulting and Engineering, Woods Hole, Massachusetts.

Benthic thermal plume analyses were completed and a final report submitted by EG&G (June 1995) to help recommend the most applicable future benthic studies to be performed. Qualitative transect sampling off the discharge canal to determine the extent of the denuded and stunted zones is conducted four times a year (March, June, September and December). Results of the benthic monitoring reported during this period are discussed in Section IIIB.

3. Plankton Monitoring

Marine Research, Inc. (MRI) of Falmouth, Massachusetts, has been monitoring entrainment in Pilgrim Station cooling water of fish eggs and larvae, and lobster larvae (from 1973-1975 phytoplankton and zooplankton were also studied). 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 basis of the program results. Plankton monitoring in 1995 emphasized consideration of ichthyoplankton entrainment and selected species adult equivalency analyses. Results of the ichthyoplankton entrainment monitoring for this reporting period are discussed in Section IIIC.

4. Impingement Monitoring

The Pilgrim Station impingement monitoring and survival program speciates, quantifies and determines viability of the organisms carried onto the four intake traveling screens. 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 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. Special fish survival studies conducted from 1980-1983 to determine its effectiveness in protecting marine life were terminated in 1984, and a final report on them appears in Marine Ecology Semi-Annual Report #23.

Results of the impingement monitoring and survival program for this reporting period are discussed in Section IIID.

C. Station Operation History

The daily average, reactor thermal power levels from January through June 1995 are shown in Figure 1. As can be seen, PNPS was in a normal operating stage except for April - early June during RFO #10. Cumulative capacity factor from 1973 - 1994 is 50.9%. Capacity factors for the past 15 years are summarized in Table 1.

E. 1995 Environmental Programs

A planning schedule bar chart for 1995 environmental monitoring programs related to the operation of Pilgrim Station, showing task activities and milestones from December 1994 - June 1996, is included.

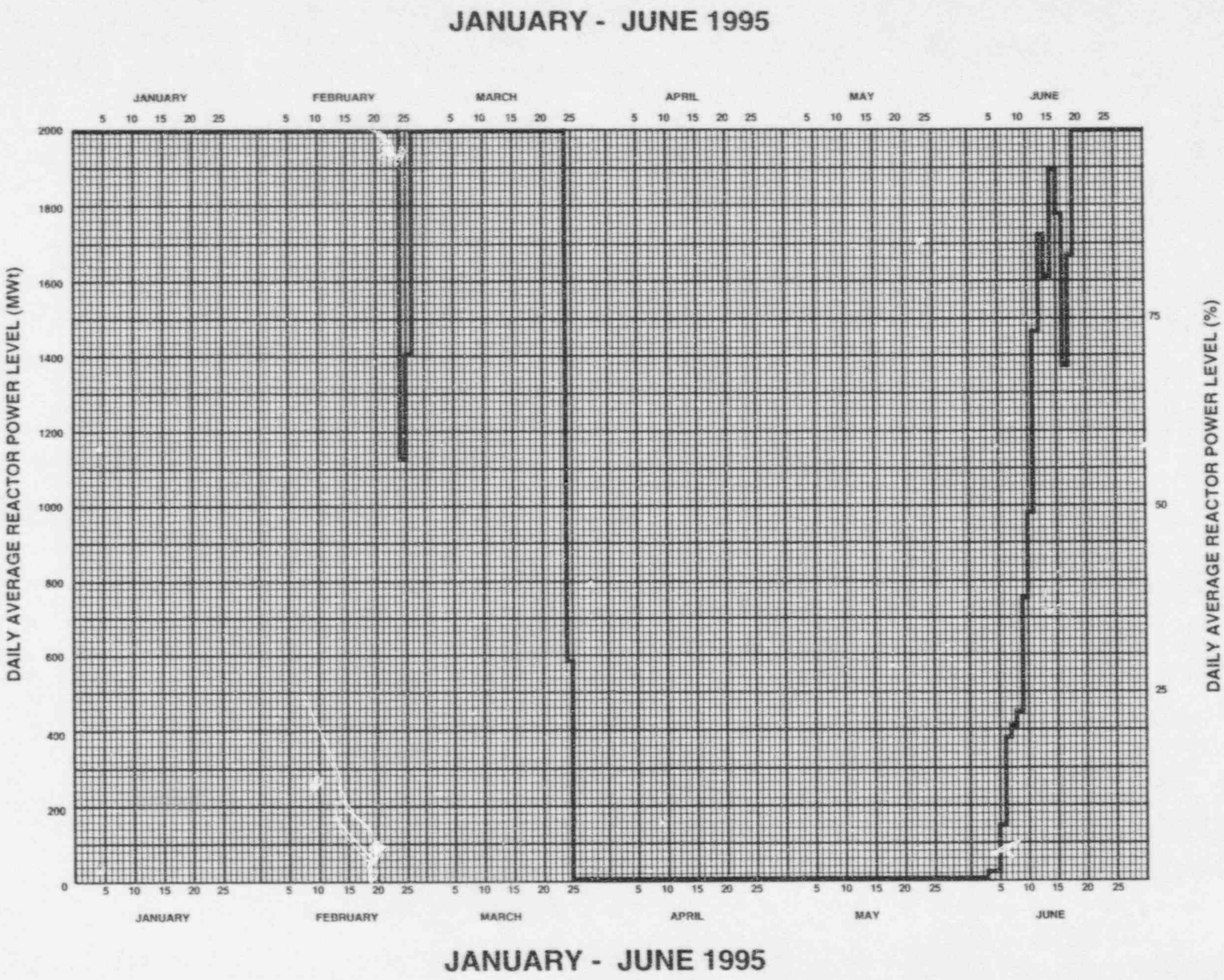


Figure 1. Daily Average Reactor Thermal Power Level (MWt and %) from January - June 1995 for Pilgrim Nuclear Power Station

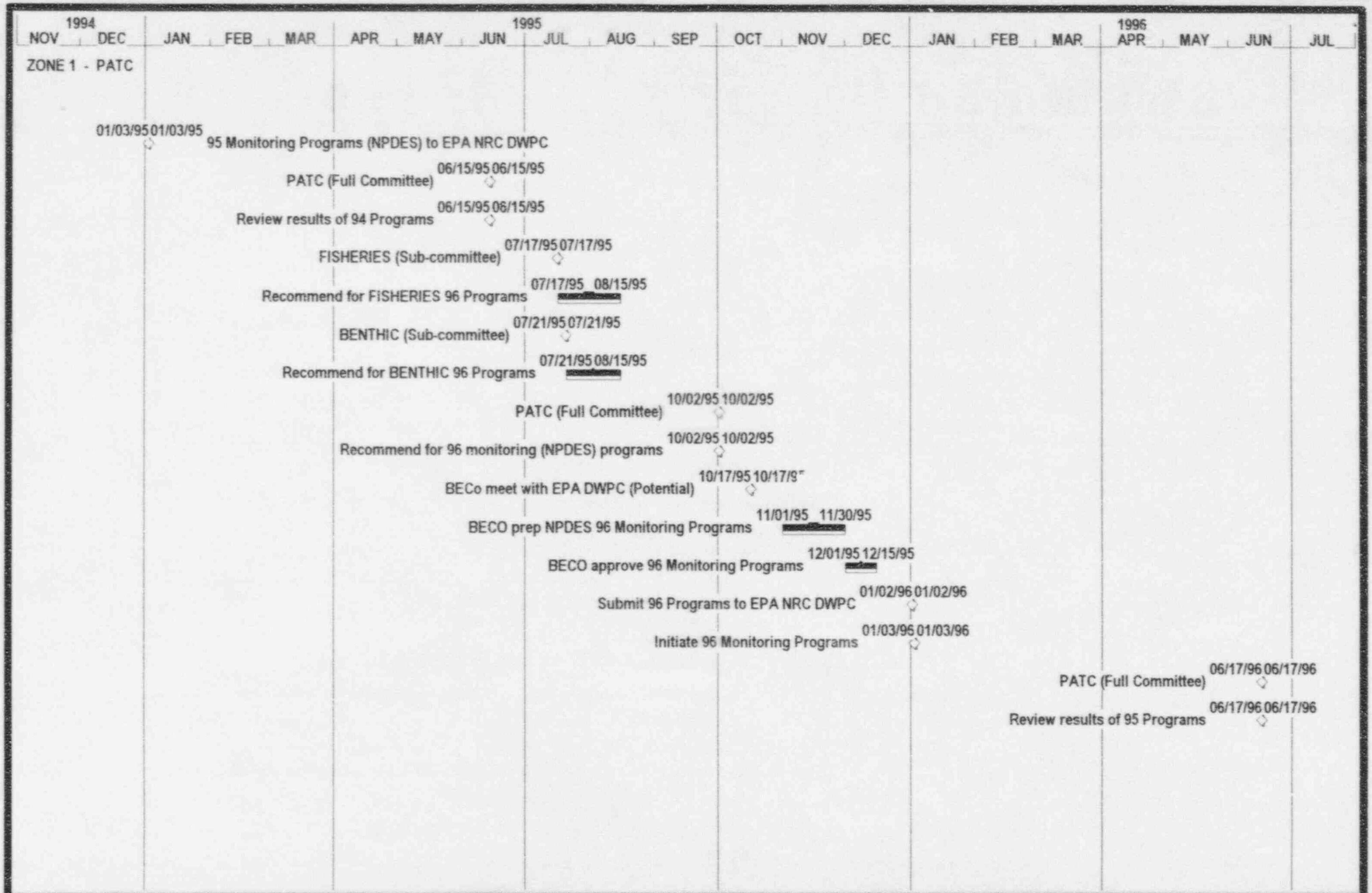
Table 1. PILGRIM NUCLEAR POWER STATION UNIT 1 CAPACITY FACTOR USING MDC NET%
(Roughly approximates thermal loading to the environment: 100%=32 Degrees F Δ T)

Month	1994 *	1993	1992	1991	1990	1989	1988 *	1987 *	1986	1985	1984 *	1983	1982	1981	1980
January	98.8	99.0	96.6	95.4	99.4	0.0	0.0	0.0	79.5	54.0	0.0	98.0	0.0	85.7	11.8
February	72.5	96.7	99.4	88.9	97.4	0.0	0.0	0.0	97.7	59.3	0.0	90.0	0.0	67.0	0.0
March	79.5	83.2	80.4	84.6	30.0	10.7	0.0	0.0	26.9	81.8	0.0	97.3	0.0	65.6	0.0
April	63.3	6.4	53.5	92.7	5.4	10.5	0.0	0.0	11.9	90.8	0.0	89.7	44.1	90.7	0.0
May	94.5	0.4	97.8	0.0	77.9	4.6	0.0	0.0	0.0	94.3	0.0	97.3	80.1	94.6	20.8
June	97.2	77.5	97.8	0.0	96.3	16.4	0.0	0.0	0.0	85.0	0.0	66.2	87.5	95.0	83.1
July	97.6	80.3	97.4	0.0	55.1	28.6	0.0	0.0	0.0	96.9	0.0	80.5	97.2	59.8	87.7
August	88.2	86.9	97.4	28.5	94.5	50.8	0.0	0.0	0.0	96.5	0.0	83.1	75.7	72.1	78.7
September	0.0	84.8	94.1	96.4	21.6	52.5	0.0	0.0	0.0	71.4	0.0	86.5	68.3	75.4	93.4
October	0.0	98.0	72.8	94.2	98.7	30.1	0.0	0.0	0.0	95.4	0.0	79.0	39.9	0.0	74.9
November	0.2	80.0	13.7	[illegible]	96.8	66.0	0.0	0.0	0.0	88.1	0.0	78.6	88.9	0.0	68.4
December	87.7	94.8	65.2	98.1	94.5	77.1	0.0	0.0	0.0	99.1	0.7	18.1	87.1	0.0	99.6
ANNUAL%	65.2	74.0	80.6	58.4	72.3	28.9	0.0	0.0	17.5	84.4	0.1	80.3	56.0	58.7	51.7

CUMULATIVE CAPACITY FACTOR (1973 - 1994) = 50.9%

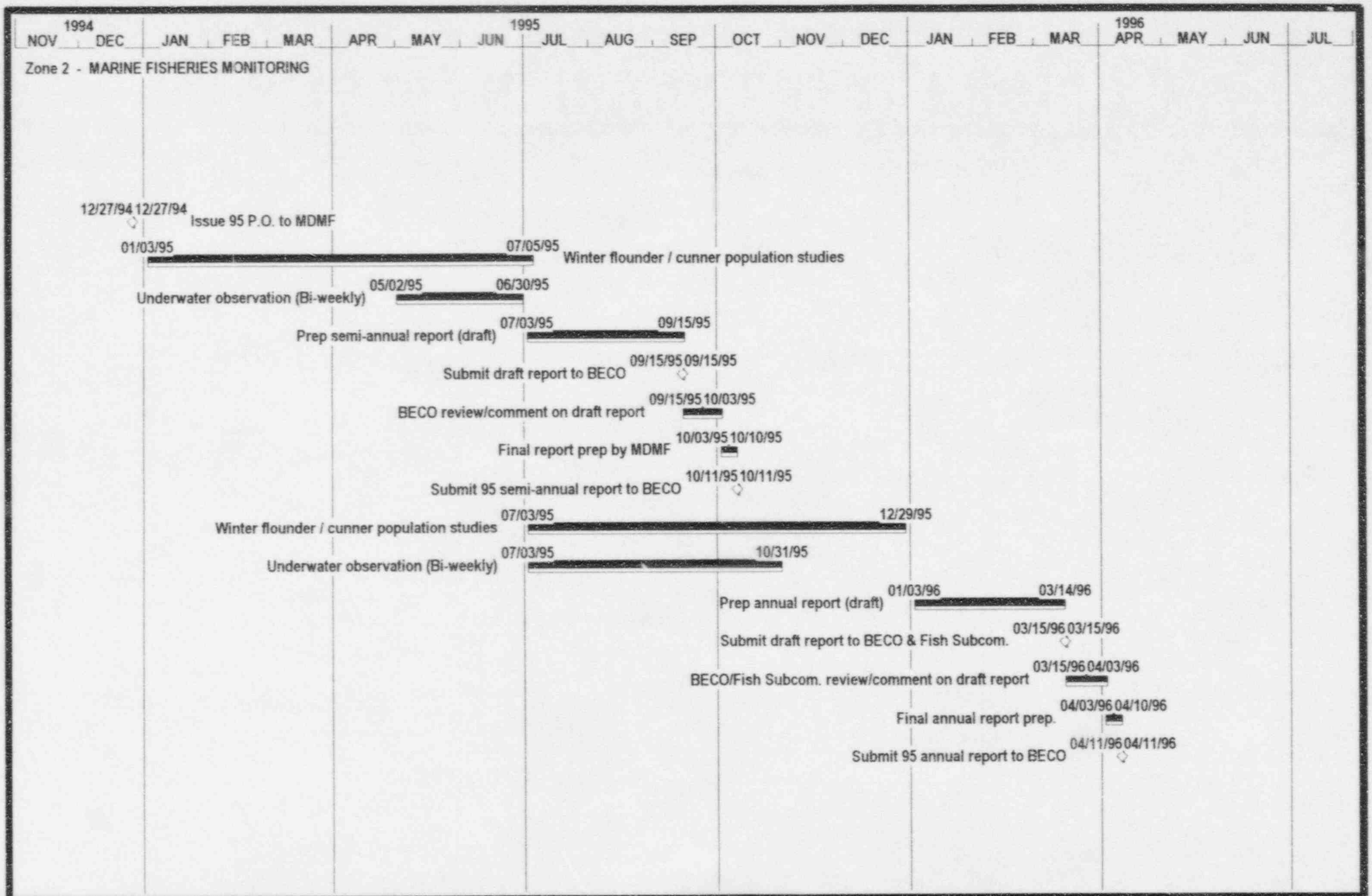
________________ = OUTAGES > 2 MONTHS

* = NO CIRCULATING SEAWATER PUMPS IN OPERATION FROM 27 MARCH - 13 AUGUST, 1984
= NO CIRCULATING SEAWATER PUMPS IN OPERATION FROM 18 FEBRUARY - 8 SEPTEMBER, 1987
= NO CIRCULATING SEAWATER PUMPS IN OPERATION FROM 14 APRIL - 5 JUNE, 1988
= NO CIRCULATING SEAWATER PUMPS IN OPERATION FROM 9 OCTOBER - 16 NOVEMBER, 1994



PNPS 1995 ENVIRONMENTAL PROGRAMS

(NPDES PERMIT #MA 0003557)



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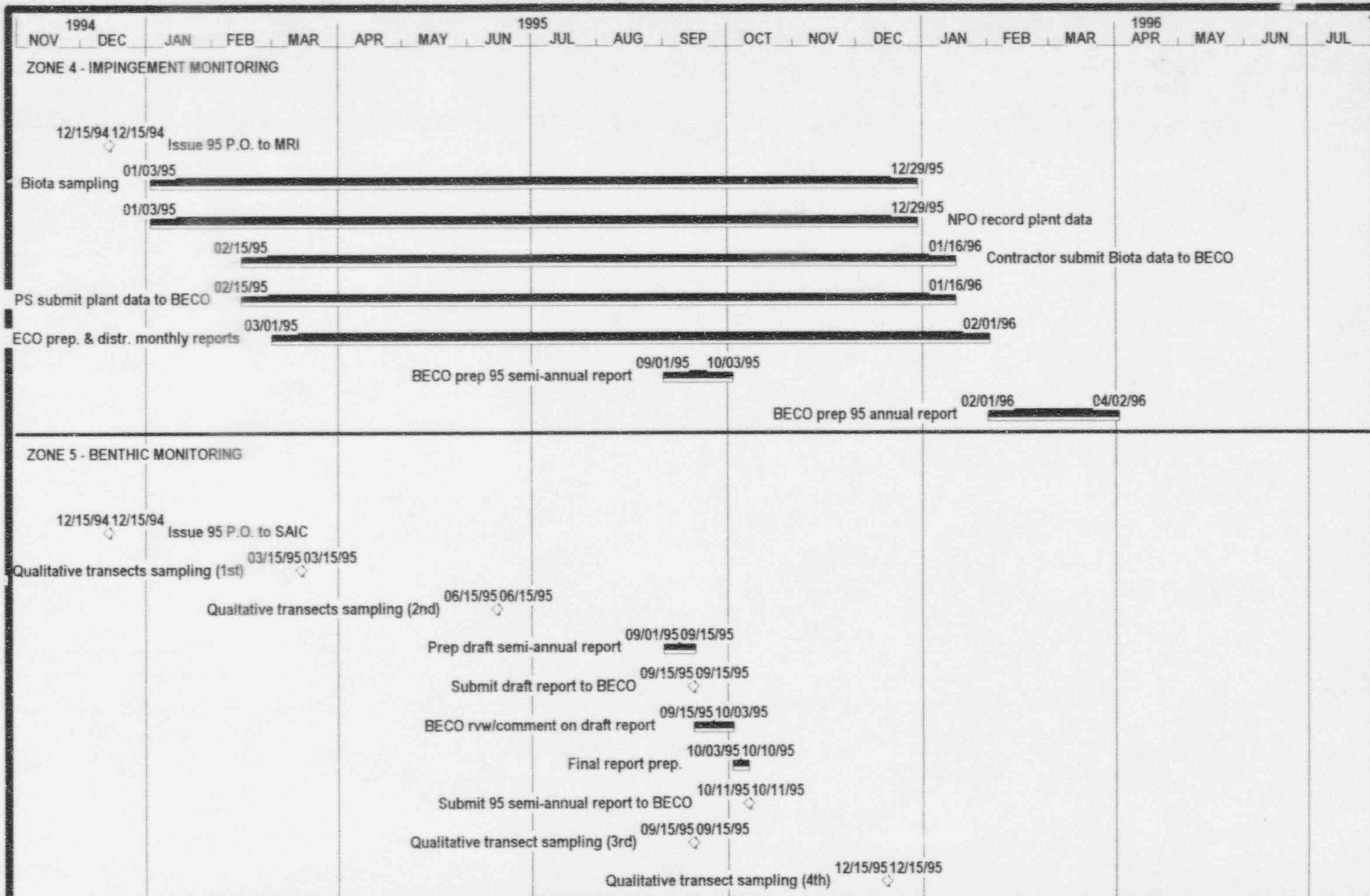

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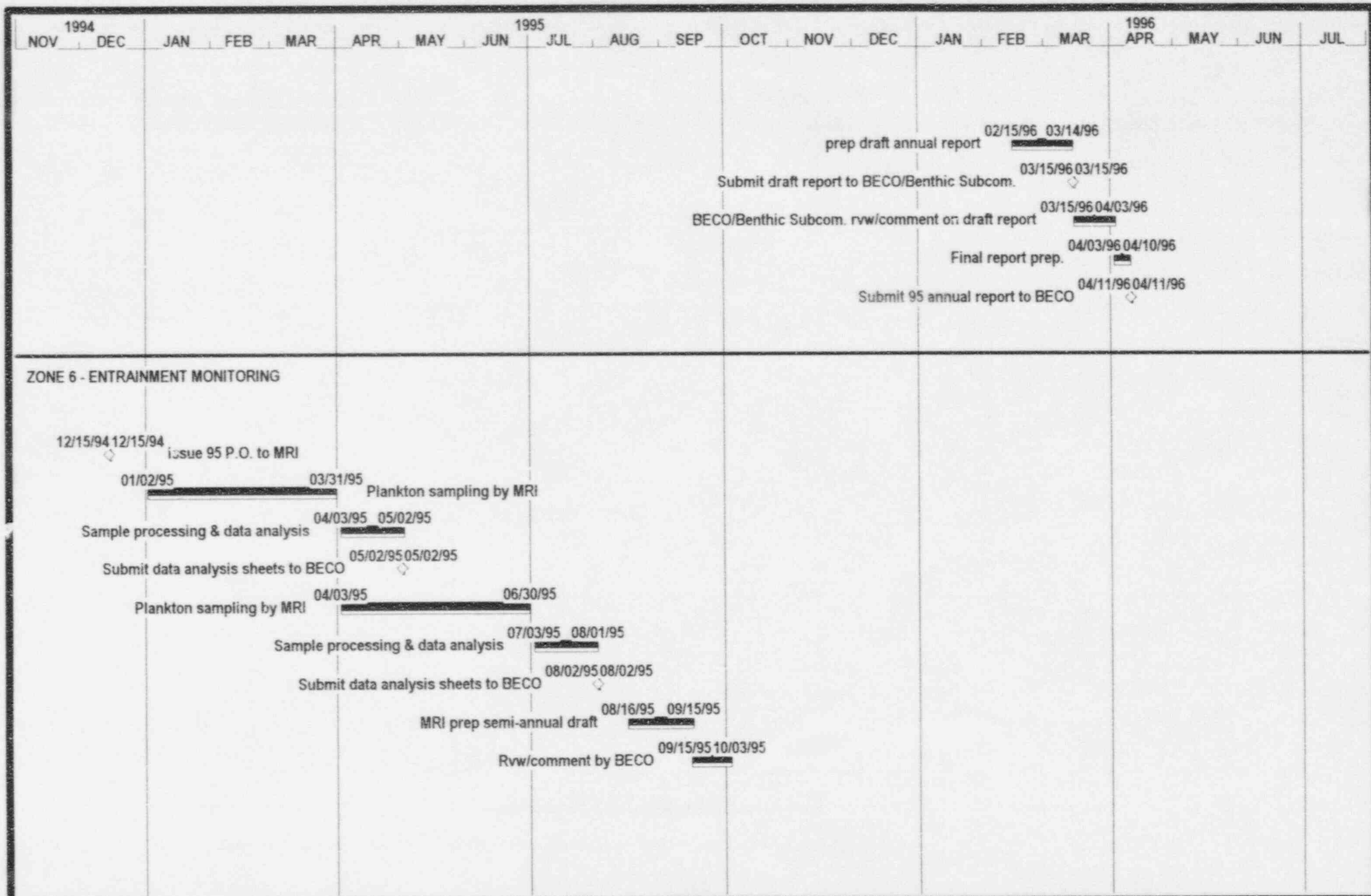

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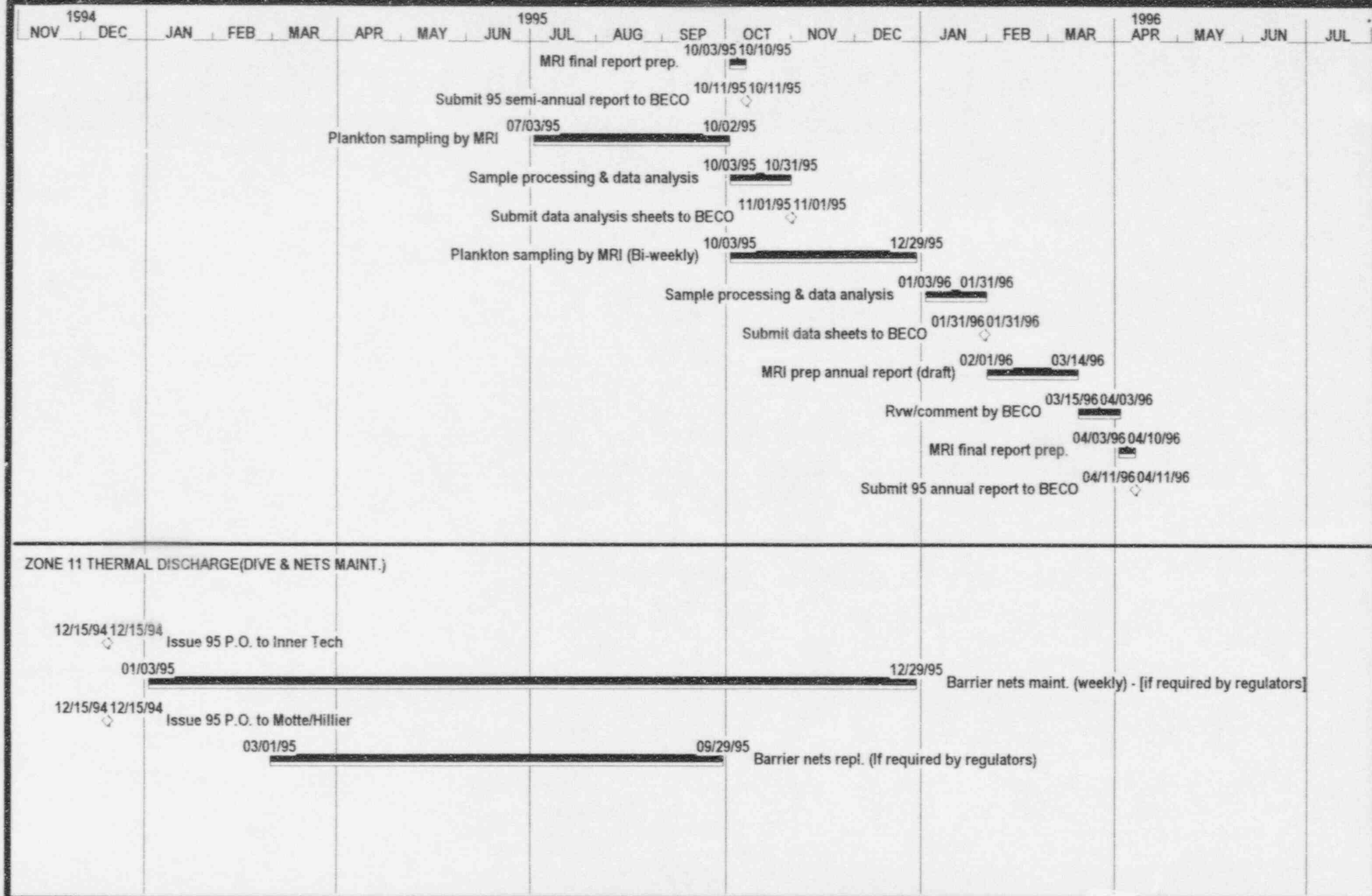

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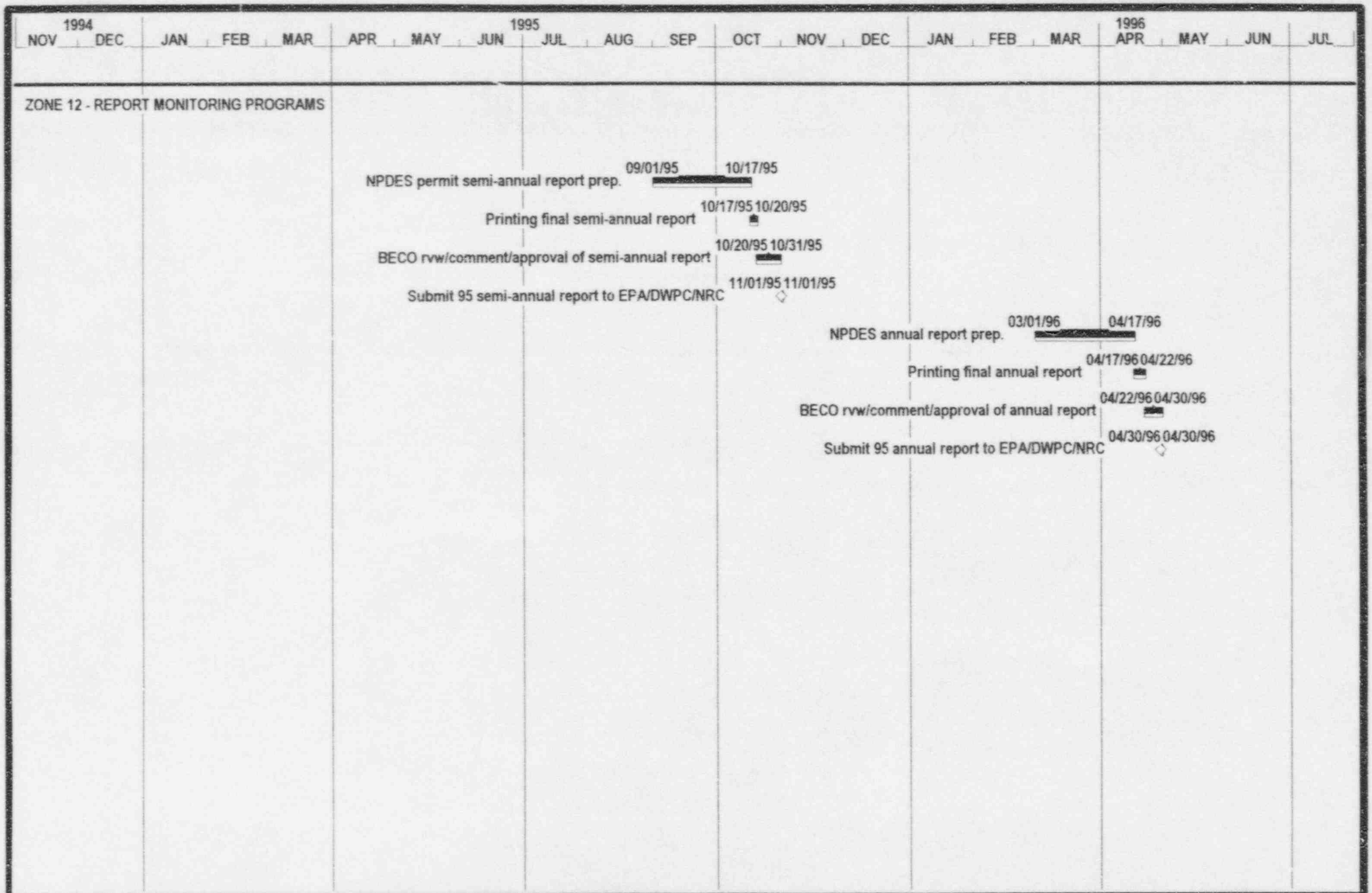

PNPS 1995 ENVIRONMENTAL PROGRAMS

(NPDES PERMIT #MA 0003557)

SEMI-ANNUAL REPORT
ON
MONITORING TO ASSESS IMPACT
OF
PILGRIM NUCLEAR POWER STATION
ON MARINE FISHERIES RESOURCES
OF WESTERN CAPE COD BAY

Project Report No. 59 (January to June 1995)

By

Robert Lawton, Brian Kelly,
Vincent Malkoski, John Chisholm,
Paul Nitschke, John Boardman,
and Erin Casey

October 1, 1995
Massachusetts Department of Fisheries,
Wildlife, and Environmental Law Enforcement
Division of Marine Fisheries
100 Cambridge Street
Boston, Massachusetts 02202

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I. EXECUTIVE SUMMARY

Winter Flounder Studies and Other Groundfish

Our primary objectives are to determine the discreteness (boundaries) of the local winter flounder (*Pleuronectes americanus*) population and to estimate absolute abundance. This information will be used to assess impact of larval flounder entrainment at Pilgrim Station. Secondarily, we are endeavoring to maintain catch records of other groundfish in the area; results will appear in the 1995 annual report.

Using the small Wilcox net, we completed 39 bottom trawl tows. Twenty-one tows were made inside Plymouth, Kingston, Duxbury Bay with the remainder located along the Plymouth shoreline in the inshore sector of western Cape Cod Bay. We tagged (Petersen disc) 19 winter flounder (6 inside PKDB and 13 outside the estuary). No tagged flounder were recaptured with this gear.

Our survey of spawning success and resultant year-class strength of winter flounder is on-going; results will appear in the 1995 annual report.

We contracted a commercial fishing vessel, the F/V *Frances Elizabeth*, to sample winter flounder from the deeper nearshore waters for density extrapolation and as a source of tagging fish. The boundaries of the sampling area were the waters between High Pines Ledge to the Mary Ann buoy from the nearshore out to the 36.6 m (120 foot) (MLW) depth contour.

Between 14 and 26 April, 1995, we completed 58 tows within the study area. A total of 2,882 winter flounder was captured, of which 2,047 were tagged. Twenty-four of these tagged fish were recaptured during our two-week sampling period.

Cunner Studies

We have studied the distribution and movement patterns of adult cunner (*Tautogolabrus adspersus*) off Pilgrim Station and are now working to estimate adult population size and recruitment dynamics of cunner in the Pilgrim area. Cunner fecundity by age and length has been investigated in the Pilgrim Station area, highlights of which will appear in the next annual report. Cunner are caught in baited fish traps, and cunner 90 mm or larger in total length (TL) are marked with Floy T-bar anchor tags and released in the capture area. This June, 1,197 cunner were captured, of which 746 were tagged. As for recaptures, 103 tagged fish were taken.

Smelt Restocking

To compensate for recent impingement of rainbow smelt (*Osmerus mordax*) at Pilgrim Station, the Massachusetts Division of Marine Fisheries was funded for restoration work by Boston Edison Company. The objectives were to augment instream reproduction of smelt and to enhance the quality of spawning habitat in the Jones River, which hosts the major smelt spawning run in the area. We stocked 1.2 million smelt eggs into the Jones River during the spring of 1995. To address spawning habitat enhancement and ultimate egg survival, we placed an additional 75 egg collecting trays into the Jones River, filled with sphagnum moss, to collect eggs spawned there naturally. Smelt egg deposition is higher on vegetation, while egg survival to hatching is up to ten times greater on plant substrate than on hard bottom.

II. INTRODUCTION

Ecological monitoring of the marine environment off Pilgrim Nuclear Power Station is conducted to assess impact of power plant operation. Investigations are conducted by the Power Plant Team of the Massachusetts Division of Marine Fisheries (MDMF), focusing on three indicator finfish species in the nearshore waters of western Cape Cod Bay. Funded by Boston Edison Company under Purchase Order No. LSP001698 in 1995, this work is ongoing.

In this report, methodology and progress on sampling programs conducted from January through June 1995 are discussed. Measurements, counts, indices, and visual observations are used in reporting preliminary results and accomplishments for the first half of 1995.

III. METHODS AND PRELIMINARY FINDINGS

1. WINTER FLOUNDER STUDIES AND OTHER GROUNDFISH

Small Vessel Trawling

Following the sampling protocol established in 1994 (Lawton et al. 1995), we completed 39 bottom trawl tows using a Wilcox trawl (9.8-m sweep, 7-m headrope, 10.2-cm wings, 13-cm cod-end mesh fitted with a 6.4-mm stretch mesh liner). Twenty-one tows were made inside Plymouth, Kingston, Duxbury Bay (PKDB), with the other 18 located along the Plymouth shoreline in the inshore sector of western Cape Cod Bay (Figure 1). Slightly more than half the trawls were randomly selected, with the unit of effort standardized at a 400-m towing distance. Locations of the remaining tows were haphazardly selected, and the unit of effort was 15 minutes of bottom towing time. The latter effort placed emphasis on towing areas believed to hold concentrations of winter flounder.

Our primary objectives are to determine the discreteness (boundaries) of the local winter flounder population and to estimate absolute abundance. This information will be used to assess impact of larval flounder entrainment at Pilgrim Station. Secondarily, we are endeavoring to maintain catch records of other groundfish in the area. A summary of catch data (species in addition to winter flounder) will appear in the annual report. Winter flounder from all tows were used as a source of tagging fish for our capture-recapture program.

During the spawning season, we tagged (Petersen disc) 19 winter flounder (6 inside PKDB and 13 outside the estuary). In

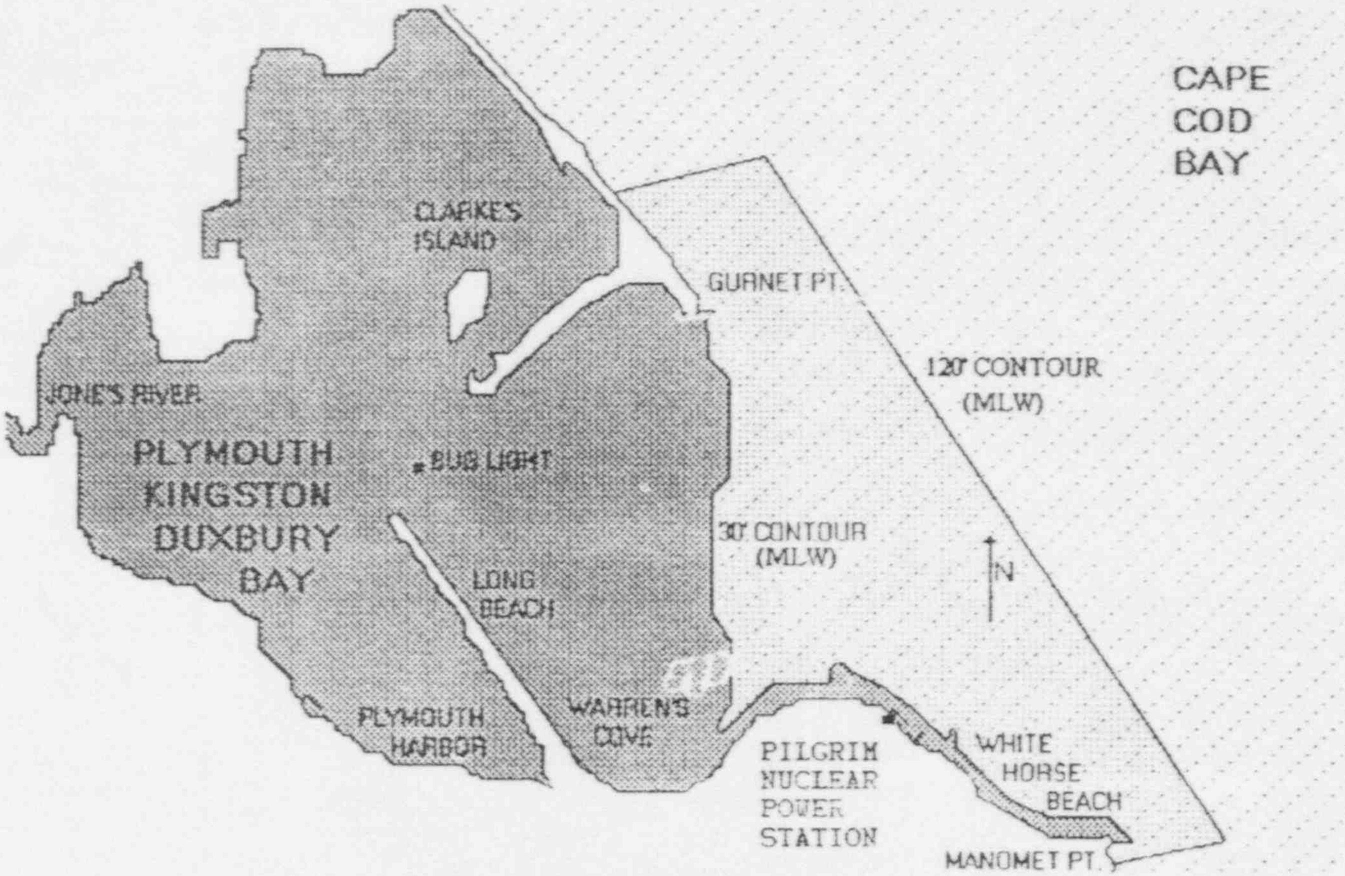

Figure 1. Study area inside and outside the estuary sampled by bottom trawls for groundfish, with major emphasis on winter flounder, January - June, 1995 (not drawn to scale).

1994, we had tagged 226 flounder (27 inside and 199 outside the estuary). Trawling for marked fish will be resumed this fall, and tagging will again be conducted in the late winter/early spring of 1996.

In addition, an independent estimate of population size will be generated when all data have been collected for 1995 using an area-swept approach (density extrapolation).

Juvenile Winter Flounder Survey

The survey of spawning success and resultant year-class strength of winter flounder is on-going; results will appear in the 1995 annual report. Beach seining and SCUBA transect swims are to be conducted through August inside and outside (seining only) PKDB.

Large Vessel Trawling

In April, we contracted a commercial fishing vessel, the F/V *Frances Elizabeth*, to sample winter flounder for density extrapolation and as a source of tagging fish. The boundaries of the sampling area were the waters between High Pines Ledge to the Mary Ann buoy from the nearshore out to the 36.6 m (120 foot) (MLW) depth contour. Our outer depth boundary was selected based on data from the Division's Resource Assessment coastal trawl program. The gear used was a Yankee otter trawl (18.5-m sweep and 14.8-m headrope, with 15.24-cm stretch mesh and a 7.62-cm mesh liner). The net was fished with 12.9-m legs and 60.9-m ground cables. The trawl doors were steel, measuring 1.85 m X 1.1 m and weighing 990 kg each.

Warp length varied with depth of water fished; the range was from 73.85 to 92.31 m.

The catch from each tow was processed as during small vessel trawling (i.e., winter flounder length measurements, sex, and evidence of maturity were recorded, and Petersen disc tags attached to flounder greater than or equal to 20 cm in total length).

Between 14 and 26 April, 1995, we completed 58 tows within the study area. Tow duration averaged 30 minutes, while tow length averaged 1.58 km. A total of 2,882 winter flounder was captured, of which 2,047 were tagged. Twenty-four of these tagged fish were recaptured during our two-week sampling period. Tagging will be resumed in the spring of 1996.

Results of tagging winter flounder to define the population and to estimate absolute abundance along with relative abundance indices for other groundfish will appear in the next annual report.

2. CUNNER POPULATION STUDIES

We formerly studied movement patterns and distribution of adult cunner in the vicinity of Pilgrim Station via mark and recapture, with particular emphasis on their behavioral responses to the discharge current. One of our objectives now is to estimate cunner numbers and survival in the local population. A Floy T-bar anchor tag is used to mark cunner. The tag is embedded in the dorsal musculature via a tagging gun. To procure cunner, baited traps are fished overnight, in that they most actively forage at dusk and dawn. Each fish is measured, and a numbered tag is placed in the dorsal musculature of all individuals 90 mm in total length or greater (adults). All cunner are mature by this size. Fish are released at the site of capture. We are conducting a multiple census of capture and recapture. Recovery information is obtained using the baited fish traps and by visual diving observations. This allows for multiple recaptures.

A paper on age structure and age/length relationship of cunner from the Pilgrim area presently is being prepared for publication in the open literature. The principal findings of this work will appear in the 1995 annual report. In addition, recruitment dynamics of cunner in the Pilgrim area are being examined as part of a larger effort to assess entrainment impact of cunner eggs and larvae at Pilgrim Station. Fecundity by age and length has been investigated for cunner in the environs of Pilgrim Station. These data are needed for the Adult Equivalency model to equate eggs and larvae entrained to equivalent adults. Highlights of the recruitment and fecundity work also will appear in the next annual report.

Our marking efforts through June resulted in the capture of 1,197 cunner in the immediate Pilgrim area, of which 746 were tagged. As to spatial breakdown, 80 cunner were caught seaward of the outer intake breakwater at Pilgrim Station, of which 58 were tagged. Within the Pilgrim Intake, 7 sampling outings yielded 886 cunner captured, of which 532 were tagged. At White Horse Beach, 231 cunner were caught and 156 tagged during three tagging events. A total of 103 recaptures of fish tagged this year was recorded in

June: 3 from off the outer breakwater, 92 from the Intake, and 8 from White Horse. Work is ongoing through the fall to generate estimates of absolute abundance.

3. SMELT RESTOCKING

We completed the second year's work of a two-year stocking program of rainbow smelt (*Osmerus mordax*) in the Jones River, a tributary to nearby Plymouth, Kingston, Duxbury Bay. This is a remedial measure to compensate for an estimated 9,500 smelt impinged at Pilgrim Nuclear Power Station in 1993. There is compelling evidence that smelt frequenting the area of the power plant are members of a local sea-run population natal to PKDB, with the Jones River providing the major smelt-spawning ground. The local population has been depressed for years, and the magnitude of recent fish kills at Pilgrim Station could seriously impact smelt.

The overall goal of our stocking has been to enhance the smelt run in the Jones River, i.e., to increase the number of adults in the local stock. The objectives of this restoration were to augment instream reproduction in the Jones River and to enhance the quality of spawning habitat on the run. To address the first objective, we stocked 1.2 million smelt eggs (conservative estimate) into the Jones River during the spring of 1995. These eggs came from two genetically isolated, wild, anadromous smelt populations - one from the Weweantic River in Wareham and the other from Back River, Weymouth.

We monitored pH and temperature in each of the three systems during the spawning period. The results obtained from the Back and Weweantic Rivers revealed that pH and temperature values were similar to the Jones River readings. These two environmental variables should not have had any adverse effects on the transplanted eggs.

Within the two source streams, a total of 96 egg collecting trays [each tray consisted of a 35.6 x 45.7 cm (14 x 18 inch) weighted wooden frame, enclosed with chicken wire and filled with unprocessed sphagnum moss, as substrate for egg deposition] was deployed to collect smelt eggs for transplanting into the Jones River. The resulting larvae from hatchout were expected to imprint on the waters of PKDB and as adults to home to this estuary, ascending the Jones River and possibly other tributaries flowing into this system to spawn.

To address the second objective - that of spawning habitat enhancement - and to increase the efficacy of our egg stocking, we employed plant substrate which possessed high relief and surface area, i.e., egg trays filled with sphagnum moss. Transplanted eggs were placed in riffle areas on the Jones River spawning ground. In addition to moving eggs from one river system to another, we placed 75 trays in the Jones River to collect eggs spawned there naturally. This was done to improve instream egg survival and ultimate hatching success. The sphagnum in the trays provides a three dimensional surface and concentrates eggs in higher densities than on natural hard bottom (e.g., sand, gravel, and cobble). The only surface competing for higher egg sets and improved survival is attached endemic aquatic flora (macroscopic river plants), which on the Jones River smelt spawning ground comprise less than one-quarter of the available habitat.

The trays were checked every few days to service them and to monitor egg development. Any algae were removed from the trays using the hook-end of a boat pole. Fouling algae were gently pulled from the trays and discarded downstream. We endeavored to minimize egg disturbance during this process. Macro-algae have become a nuisance the last few years in the area where much of the smelt spawning occurs. These included a chain-forming diatom - *Fragilaria* spp.. Other diatoms present were *Synedra* spp., *Gomphonema* spp., and *Achnanthes* spp.. Three genera of filamentous green algae also occurred - *Draparnaldia*, *Vlothrix*, and *Stigeoclonium*. Eggs that settle on the algae become entangled in long hair-like filaments. There is reduced water flow not only with the entangled eggs but also to eggs which had settled on moss. A reduction in water flow may hinder egg development and survival. Sutter (1980) found that smelt egg deposition was greater in areas of high river flow and on river plants. Furthermore, the survival of eggs to hatching on vegetation was about 10% as compared to 1% on other hard surfaces. Saunders (1981) ran a sensitivity analysis, finding that the most sensitive parameter affecting subsequent smelt population growth was egg survival.

Our portable egg trays in the Jones River increased the amount of available plant material for egg deposition. Sphagnum has spaces between its plant fibers giving a depth dimension and thus providing 3-dimensional habitat. Fertilized smelt eggs that land on the trays can attach to the moss at the surface or within the interstices, creating a micro-environment that offers protection, reducing egg "turnover" (loss), yet is well aerated. Water seeps through the porous surface delivering oxygen to the developing embryos and washing away metabolic wastes.

We will again add plant substrate to the Jones River smelt spawning ground in 1996. In addition, we will monitor the run for the abundance of spawning smelt and egg densities.

IV. ACKNOWLEDGMENTS

The authors thank Marine Research, Inc. for identifying macroalgae collected in the Jones River. We appreciate the guidance of Robert D. Anderson of Boston Edison Company, W. Leigh Bridges of the Division, and the Pilgrim Administrative-Technical Committee, specifically for their input and direction on study programs and on project reports.

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FINAL
SEMI-ANNUAL REPORT
Number 46

BENTHIC ALGAL MONITORING AT THE PILGRIM NUCLEAR POWER STATION (QUALITATIVE TRANSECT SURVEYS)

January-June 1995

to

BOSTON EDISON COMPANY
Regulatory Affairs Department
Pilgrim Nuclear Power Station
Plymouth, Massachusetts 02360

From

ENSR
89 Water Street
Woods Hole, MA 02543
(508) 457-7900

27 September 1995

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EXECUTIVE SUMMARY

This report presents results of qualitative surveys of benthic algae in the thermal effluent of the Pilgrim Nuclear Power Station (PNPS) that were completed in May and June 1995. These investigations represent the most recent phase of long-term efforts to monitor effects of the thermal effluent on the benthic algal communities within and just offshore of the PNPS discharge canal. Field survey techniques were identical to those used in previous investigations.

The underwater profile of the jetties has changed somewhat over the years. Storms have moved some boulders away from the jetty to positions closer to the central transect line. For the sake of maintaining consistency in calculations of the area of the *Chondrus* denuded zone, the same base dimensions of the jetty that have been used in figures for this report for many years, are continued for the current surveys. However, as a reminder that the condition of the jetty is by no means static, those boulders closest to the transect line that are encountered by the divers at the 30-m mark are indicated in both the May and June figures.

The qualitative transect studies performed to evaluate the *Chondrus crispus* community in the thermal plume area indicated that in early May and late June 1995 the condition of the denuded and total affected areas was typical of that seen in years prior to 1995 when the power plant was in full or nearly full operation, even though the plant was down for refueling in April and May. The denuded area (1198 m^2), in early May, was well within the size range seen in earlier spring surveys taken when the plant was in operation (765 m^2 in April 1986 to 1321 m^2 in March 1991). By June, the denuded zone had increased 17% to 1405 m^2, again an area well within the size range seen in previous summer surveys. As in many prior summer surveys (1990, 1992, 1993, and 1994) the divers saw a dense mat of juvenile (5-15 mm in length) blue mussels (*Mytilus edulis*) with an associated high density of the predatory starfish *Asterias forbesi*.

1.0 INTRODUCTION

This report represents a continuation of long-term (22 yr) benthic studies at Pilgrim Nuclear Power Station (PNPS) that are intended to monitor the effects of the thermal effluent. The 1995 monitoring program is identical to that performed from 1992 through 1994 and consists of qualitative SCUBA surveys of algal cover in the thermal plume of the effluent within and beyond the discharge canal (Figure 1). Surveys are conducted quarterly during April, June, September, and December. This Semi-Annual Report includes qualitative observations recorded in early May and late June 1995. Work was performed under Boston Edison Co. (BECo) Purchase Order LSP003397 in accordance with requirements of the PNPS NPDES Permit No. MA 0003557.

2.0 METHODS

The qualitative algal survey is performed by SCUBA divers in the same location and with the same techniques that have been used since the present monitoring program began, approximately 14 years ago. The effluent area is surveyed by two or three SCUBA-equipped biologists operating from a small boat. To ameliorate the effect of the powerful outflowing current upon the divers it is critical that the survey occur near the time of high tide; the divers generally begin the survey at or within an hour of high tide and are finished an hour later. For the qualitative transect survey, SCUBA observations are made along the axis of the discharge canal. A line is stretched across the mouth of the discharge canal (Figure 2). A weighted central transect line (CTL), marked at 10-m intervals, is then attached to the center of this line and deployed along the central axis of the canal to a distance of 100 m offshore. Using a compass, divers extend a 30-m measuring line, marked at 1-m intervals, perpendicular to the CTL at each 10-m mark. A diver swims along this third line, recording changes in algal cover from the CTL through the denuded and stunted *Chondrus* areas, until the algal cover looks normal.

The terminology established by Taxon (1982) and followed in subsequent years uses the growth morphology of *Chondrus crispus* to distinguish between "denuded" and "stunted" zones. The **denuded zone** is the area in which *Chondrus* occurs only as stunted plants restricted to the sides and crevices of rocks. In this area, *Chondrus* is found on the upper surfaces of rocks only where the microtopography of the rock surfaces creates small protected areas. In the **stunted zone**, *Chondrus* grows on the upper surfaces of rocks but is noticeably inferior in height, density, and frond development compared to plants growing in unaffected areas. In 1991 the divers began to discriminate between a stunted zone and a "sparse" zone. The **sparse zone** is an area with normal-looking *Chondrus* plants that are very thinly distributed. The **normal zone** begins at the point where *Chondrus* height is fully developed and density reaches the ambient concentration.

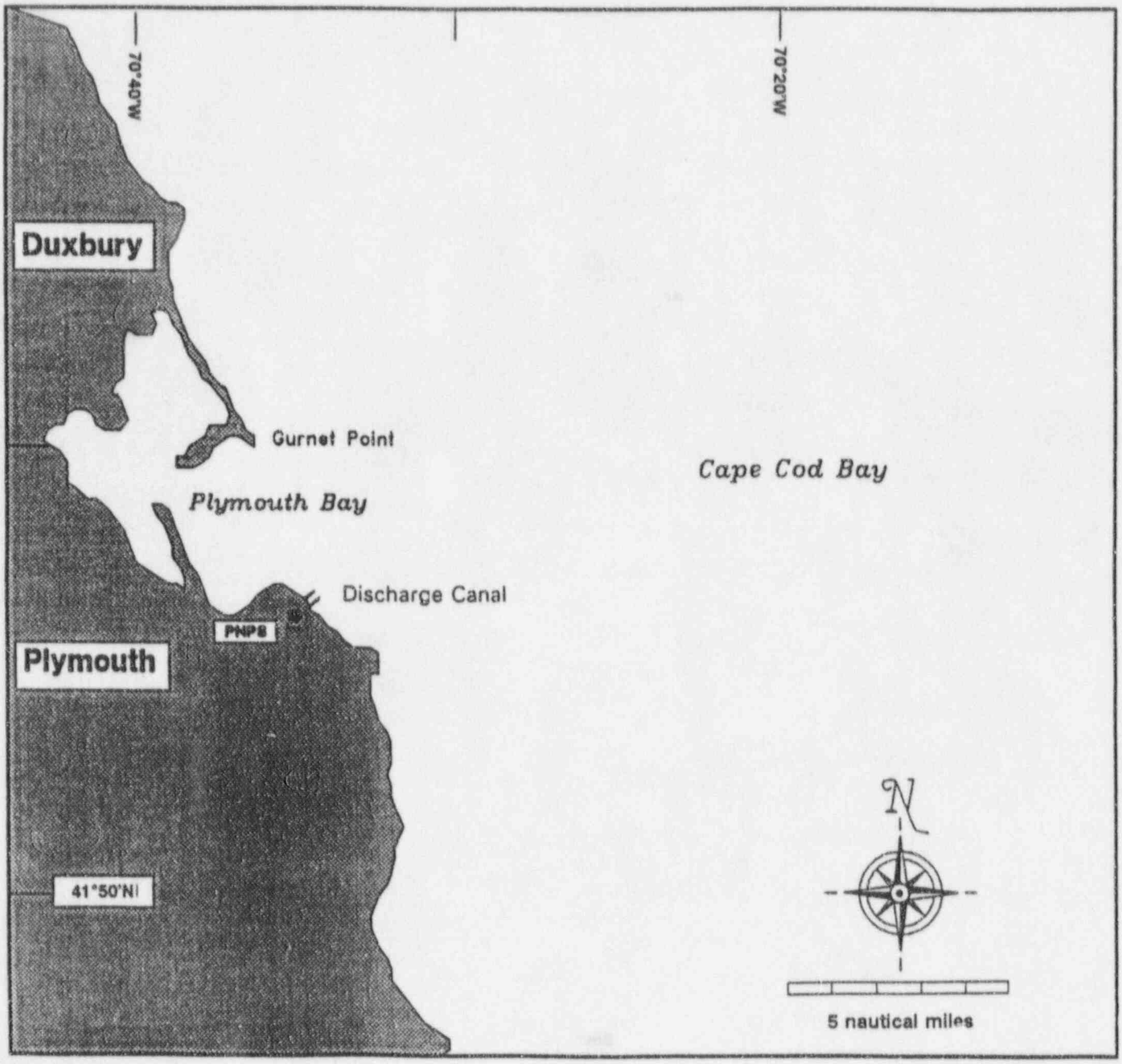


Figure 1. Location of Pilgrim Nuclear Power Station Discharge Canal.

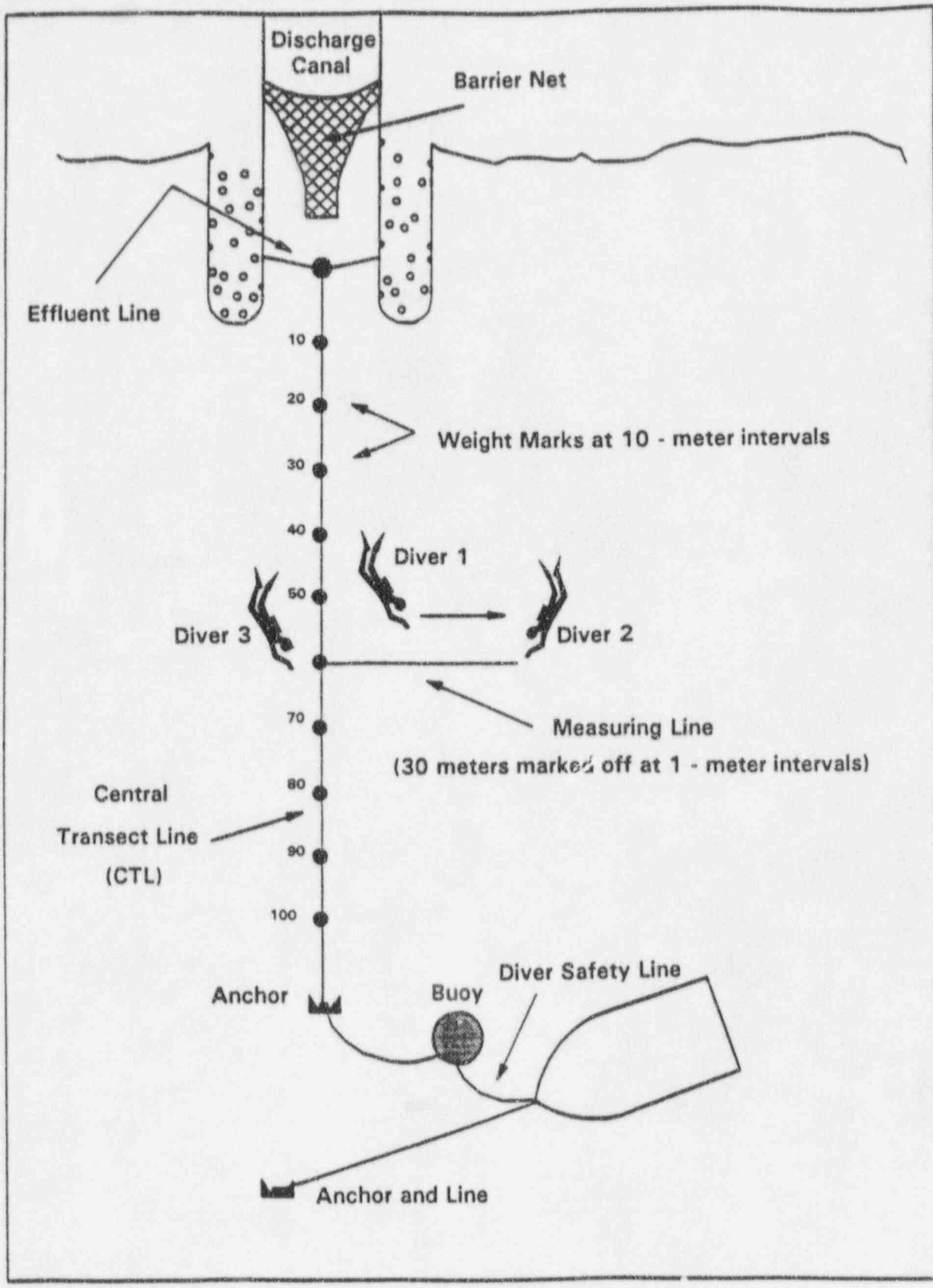


Figure 2. Design of Qualitative Transect Survey.

The dive team must keep in mind while taking measurements that the shallow depths northwest of the discharge canal hamper normal *Chondrus* growth. In addition to evaluating algal cover, the divers record any unusual occurrences or events in the area, such as unusually strong storms, and note the location of any distinctive algal or faunal associations.

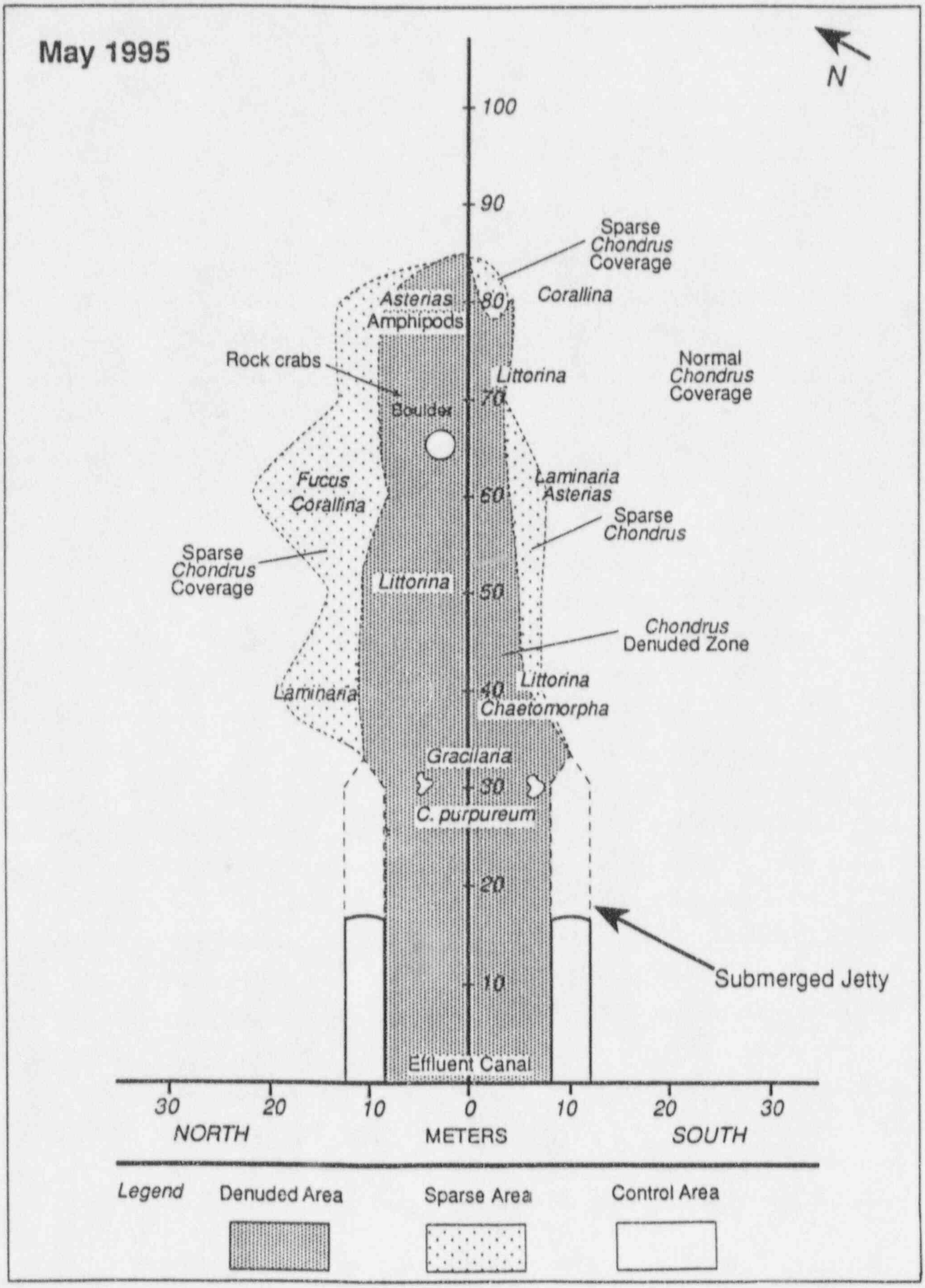
3.0 RESULTS

Qualitative transect surveys of acute nearfield impact zones began in January 1980 and have been conducted quarterly since 1982. Two surveys were performed (May 2 and June 30) during the current reporting period, bringing the total number of surveys conducted since 1980 to 58. Results of surveys conducted from January 1980 to June 1983 were reviewed in Semi-Annual Report 22 to BECo (BECo, 1983). A summary of surveys conducted between 1983 and 1994, including a review of the four surveys performed in 1994, was presented in Semi-Annual Report No. 45 (BECo, 1995). Detailed results of the mapping surveys conducted in May and June 1995 are presented in the next two sections.

3.1 MAY 1995 TRANSECT SURVEY

The denuded and sparse *Chondrus crispus* areas mapped on May 2, 1995, immediately offshore of the PNPS are shown in Figure 3. A large boulder that is nearly exposed at mean low water, and that is used as a landmark by both the ENSR and Massachusetts Division of Marine Fisheries dive teams, is plotted in the figure. The denuded zone is essentially devoid of *Chondrus*, whereas sparse zones have normal-looking *Chondrus* that is thinly distributed.

In May 1995, rocks within the *Chondrus* denuded zone essentially were bare with only a very few algal plants attached. As has been often seen in past surveys, algal density beyond the *Chondrus* denuded zone was greater south of the central transect line than north; most vegetation was located along the south side of the central transect line from the 30-m to 60-m marks. The area (approximately 1198 m^2) of the *Chondrus* denuded zone was slightly larger (3%) in May than in February 1995. The typical asymmetrical distribution of the denuded zone around the central transect line was seen; 65% of the denuded *Chondrus* area was north of the transect line and at its furthest extent the denuded zone extended 11 m north of the line from the 40-m to 50-m marks. The denuded region extended 84 m along the transect line, 6 m less than seen in the February 1995 or April 1994 surveys. Compared to April 1994, the denuded zone was 7% larger in area in May 1995. The divers classified no area as a stunted zone but did define a sparse *Chondrus* zone that had decreased in size from February 1995 (595 m^2) to about 450 m^2. Although the sparse *Chondrus* zone measured in May 1995 was more than twice the area of the sparse zone seen in April 1994 it still fell midway


May 1995
N
100
90
Sparse
Chondrus
Coverage
Corallina
Asterias
80
Amphipods
Rock crabs
Littorina
Normal
Chondrus
Coverage
70
Boulder
Fucus
Corallina
Laminaria
Asterias
60
Sparse
Chondrus
Sparse
Chondrus
Coverage
Littorina
50
Chondrus
Denuded Zone
Littorina
Laminaria
40
Chaetomorpha
Gracilaria
30
C. purpureum
20
Submerged Jetty
10
Effluent Canal
30 20 10 0 10 20 30
NORTH
METERS
SOUTH
Legend
Denuded Area
Sparse Area
Control Area

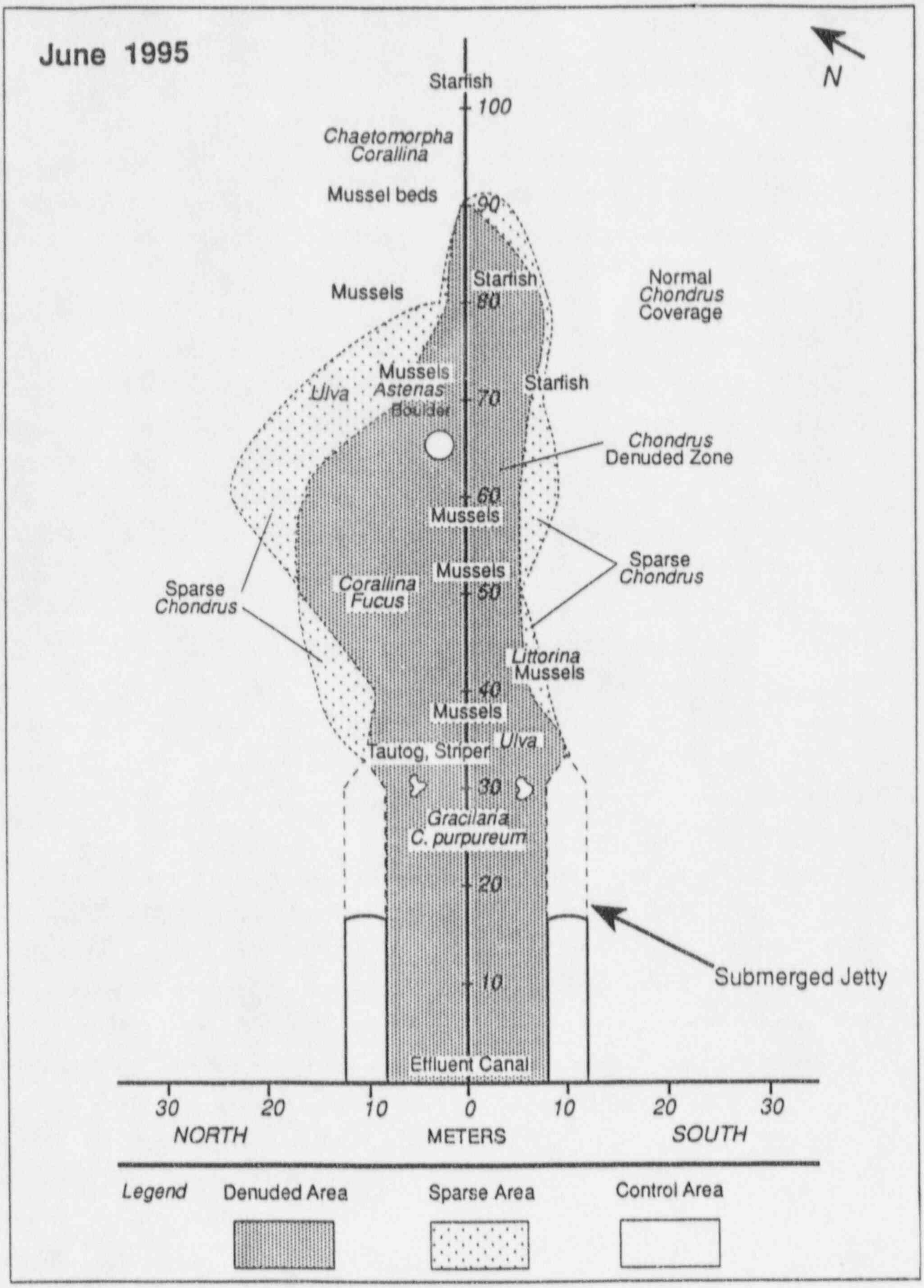
within the range (90 - 901 m²) encountered during prior spring surveys. The sparse zone occurred as a narrow band along the southeast side of the denuded zone from the jetty to the 70-m mark on the transect line. However, to the northwest, the sparse area reached beyond the 80-m mark on the transect line and extended 14 meters beyond the denuded zone at the 60-m mark. The total affected area (1648 m²) was slightly smaller (6%) that it had been in February 1995 but was 27% larger than in April 1994 and indeed had not been as large in earlier spring surveys since March 1984.

The divers noted biological features such as algal species typically found in warm or cold water and obvious benthic animals. *Gracilaria*, an alga indicative of warmer water, was seen only within the discharge canal and extending along the transect line to the 40-m mark. The kelp, *Laminaria*, an indicator of cold water, was observed at several sites from the 40-m to 60-m marks within the study area. Blue mussels, *Mytilus edulis*, were present only sporadically as were their predators the starfish *Asterias forbesi*. The gastropods, *Littorina littoria*, were very common throughout most of the area. Two species of crabs were seen, *Cancer irroratus* and the common green crab, *Carcinus maenas*. No fish were seen. There was no current at the 30-m station at the central transect line.

3.2 JUNE 1995 TRANSECT SURVEY

Results of the divers' survey for June 30, 1995 are mapped in Figure 4. There was a dense array of juvenile (5-15 mm in length) blue mussels (*Mytilus edulis*), as there has been in many prior June surveys (1990, 1992, 1993, and 1994). The area affected by the dense mussel settlement was along the central transect line from the 40-m mark seaward to the 90-m mark. Mussel density was so high that surfaces of large rocks were completely covered.

The *Chondrus* denuded zone extended 90 m along the central transect line. The area (1405 m²) of the denuded zone was larger (17%) than that measured two months earlier, in May, 1995 and larger (15%) than that seen in June 1994. The asymmetrical distribution of the denuded zone around the transect line, with more area denuded of *Chondrus* north than south of the line, followed the pattern seen during most surveys for the past five years. The denuded zone extended furthest from the transect line at the 50-m mark to the northwest, reaching 15 m from the line and at the 80-m mark to the southeast, reaching 7.5 m from the line. The area occupied by sparsely distributed *Chondrus* plants (367 m²) was smaller (23%) than the sparse *Chondrus* area seen in early May (450 m²) and one-third larger than seen a year earlier in June 1994 (249 m²). The sparse area, irregularly distributed on both sides of the denuded *Chondrus* zone with more than two-thirds of the zone to the north, contributed to the asymmetrical pattern of the affected zone. The total


June 1995
N
Starfish
100
Chaetomorpha
Corallina
Mussel beds
90
Mussels
Starfish
80
Normal
Chondrus
Coverage
Mussels
Ulva
Astenas
Boulder
Starfish
70
Chondrus
Denuded Zone
60
Mussels
Sparse
Chondrus
Mussels
Corallina
Fucus
50
Sparse
Chondrus
Littorina
Mussels
40
Mussels
Ulva
Tautog, Striper
30
Gracilaria
C. purpureum
20
Submerged Jetty
10
Effluent Canal
30
20
10
0
10
20
30
NORTH
METERS
SOUTH
Legend
Denuded Area
Sparse Area
Control Area

affected area (1772 m^2) was slightly larger than in May 1995 and midway in areal dimension between the sizes measured in June 1993 (2058 m^2) and June 1994 (1472 m^2).

Sea lettuce, *Ulva lactuca*, was more common than it had been in the last few years, and along with *Gracilaria* and *Chaetomorpha purpureum*, dominated the flora at the head of the effluent canal. Rockweed, *Fucus*, was present from 10 to 15 meters north of the transect line between the 50-m and 60-m marks. The divers saw no specimens of *Laminaria*. Four adult fish were seen, two winter flounder (*Pleuronectes americanus*) and near the end of the jetties, one tautog (*Tautoga*) and one striper.

4.0 DISCUSSION

The configuration of the *Chondrus crispus* denuded zone that may extend as far as 100 m beyond the discharge canal is readily apparent to SCUBA divers and is easily mapped for the qualitative transect survey. The stunted and sparse zones are somewhat less obvious but in May and June 1994 were readily delineated. In June 1995, a dense mussel mat, similar to that seen in June 1990, 1992, 1993, and 1994 was present. For May and June 1995, the areas of the denuded and total affected zones were well within those seen in past years when the power plant was in full or nearly full operation. The two month refueling outage that occurred in April and May, 1995 had no discernible effect on lessening the size of the affected *Chondrus* region.

5.0 LITERATURE CITED

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Taxon. 1982. Benthic studies in the vicinity of Pilgrim Station. In: Marine Ecology Studies Related to Operation of Pilgrim Station. Semi-Annual Report No. 19.

ICHTHYOPLANKTON ENTRAINMENT MONITORING

AT PILGRIM NUCLEAR POWER STATION

JANUARY - JUNE 1995

Submitted to

Boston Edison Company

Boston, Massachusetts

by

Marine Research, Inc.

Falmouth, Massachusetts

September 29, 1995

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SECTION I

SUMMARY

Entrainment sampling at PNPS during the first half of 1995 was completed on six occasions per month during January and February, scheduled for three times per week from March through June. Due to a refueling and maintenance outage from late March to early June, several sampling occasions were missed because both main water system pumps were out of service; one of two pumps was operating when samples were taken. Standard netting was 0.333-mm mesh except during the larval flounder season when 0.202 mesh was used. On three dates in June 0.333/0.202 comparison samples were taken to study extrusion of cunner eggs and larvae by 0.333 mesh netting.

Over the first six months of the year 32 species were represented in PNPS samples. Winter-early spring collections (January-April) were dominated by American plaice, winter flounder, yellowtail flounder, and Atlantic cod eggs as well as sand lance, grubby, and rock gunnel larvae. Collections in May and June, which together with July encompass late spring-summer, were dominated by Atlantic mackerel and tautog/cunner eggs plus radiated shanny, winter flounder, sand lance, and mackerel larvae.

Comparison of January-June 1995 egg and larval densities with those recorded from 1985 through 1994 suggested that larval sand lance were abundant in February, unusually so on three dates. Larval Atlantic herring were also numerous in March and April,

exceeding the unusually high level on four dates. Atlantic menhaden and Atlantic mackerel larvae were abundant in June, reaching their high density notification level on five and six consecutive dates, respectively.

No lobster larvae were noted in the collections through the month of June; only five have been collected through June since 1974.

Paired sample comparisons indicated that tautog/cunner eggs were significantly more abundant in 0.202-mesh samples compared with 0.333-mesh samples, the collection ratio being 1.4:1. Results were variable for the youngest (stage 1 and 2), larval cunner data suggesting that consistent extrusion does not occur. Collections of larger stage 3 cunner averaged somewhat higher in the bigger mesh although the difference was not significant.

SECTION II

INTRODUCTION

This progress report briefly summarizes results of ichthyoplankton entrainment sampling conducted at the Pilgrim Nuclear Power Station (PNPS) from January through June 1995 by Marine Research, Inc. (MRI) for Boston Edison Company (BECo) under Purchase Order No. LSP001616. As a result of studies completed in 1994, conversion from 0.333 to 0.202-mm mesh was initiated from late March through late May 1995 to improve retention of early-stage larval winter flounder. Extrusion of young larval cunner was also a concern at PNPS based on limited data gathered in 1994. Additional 0.333 and 0.202-mm mesh samples were therefore taken in June 1995 to improve that data base. A more detailed annual report covering all 1995 data will be prepared following the July-December collection periods.

SECTION III

METHODS AND MATERIALS

Monitoring

Entrainment sampling at PNPS has historically been completed twice per month during January and February, weekly during March through June. Following a PNPS fisheries monitoring review workshop in early 1994, the sampling regime was modified beginning April 1994. In January and February during two alternate weeks each month single samples were taken on three separate occasions. Beginning with March single samples were taken three times every week. To minimize costs, sampling was linked to the impingement schedule so that collections were made Monday morning, Wednesday afternoon, and Friday night regardless of tide. All sampling was completed with a 60-cm diameter plankton net streamed from rigging mounted approximately 30 meters from the headwall of the discharge canal (Figure 1). Standard mesh was 0.333-mm except from late March through late May when 0.202-mm mesh was employed to improve retention of early-stage larval winter flounder (Pleuronectes americanus). Sampling time in each case varied from 8 to 35 minutes depending on tide, higher tide requiring a longer interval due to lower discharge stream velocities. In most cases, a minimum quantity of 100 m^3 of water was sampled although at astronomical high tides it proved difficult to collect this amount even with long sampling intervals. Exact filtration volumes were calculated using a General Oceanics Model 2030R digital flowmeter mounted in

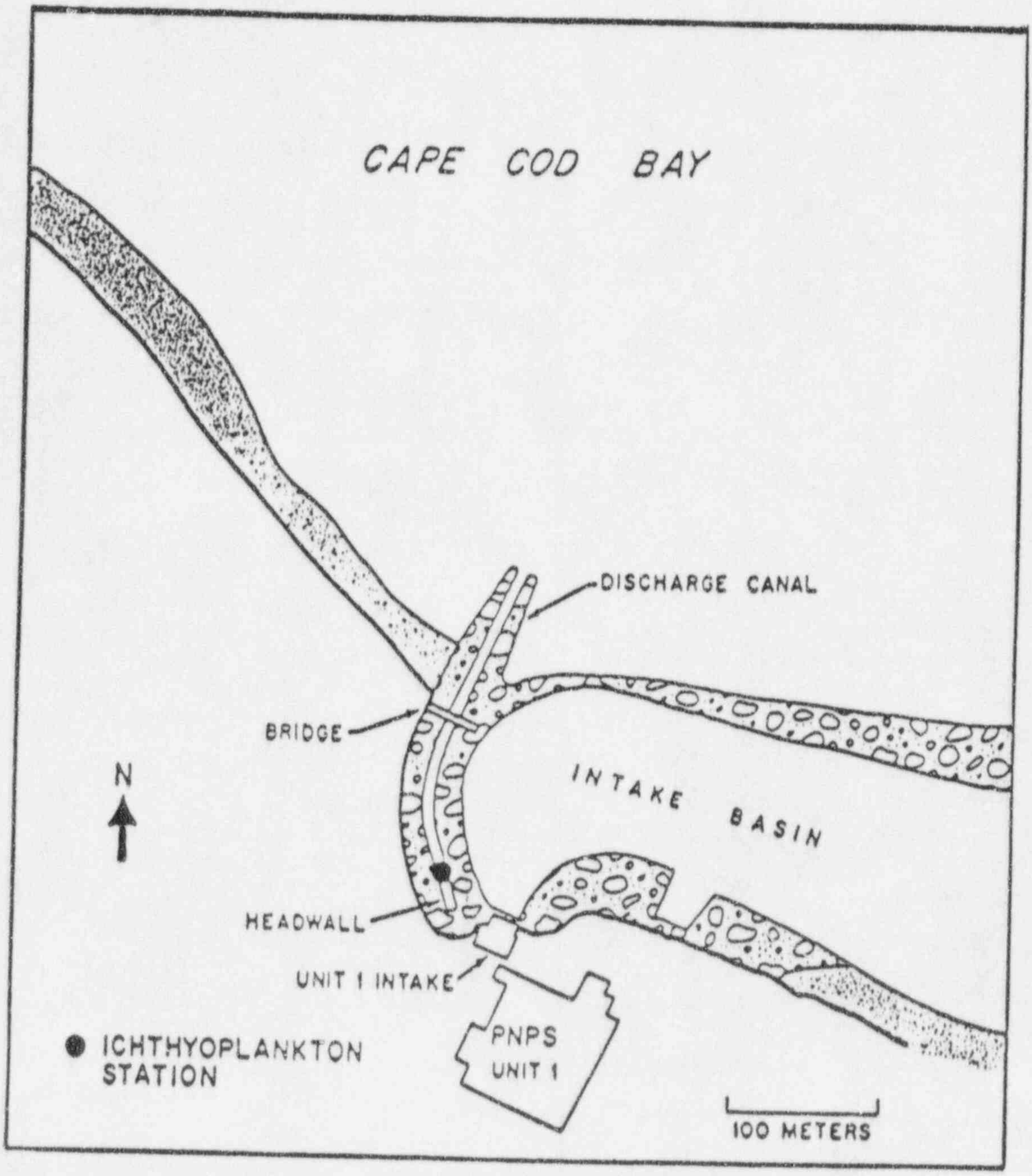

Figure 1. Entrainment sampling station in PNPS discharge canal.

the mouth of the net. Near times of high water a 2030 R2 rotor was employed to improve sensitivity at low velocities.

PNPS was taken out of service in late March for refueling and maintenance which lasted until early June. During this period only one of two main circulating water system pumps was in use on an intermittent basis. Sampling followed the above regime unless both pumps were out of service in which case no sample could be taken.

All samples were preserved in 10% Formalin-seawater solutions and returned to the laboratory for microscopic examination. A detailed description of the analytical procedures appears in MRI (1988). As in past years, larval winter flounder were enumerated in four developmental stages as follows:

Stage 1 - from hatching until the yolk sac is fully absorbed (2.3-2.8 mm TL).

Stage 2 - from the end of stage 1 until a loop or coil forms in the gut (2.6-4 mm TL).

Stage 3 - from the end of stage 2 until the left eye migrates past the midline of the head during transformation (3.5-8 mm TL).

Stage 4 - from the end of stage 3 onward (7.3-8.2 mm TL).

Similarly larval cunner (Tautogolabrus adspersus) were enumerated in three developmental stages:

Stage 1 - from hatching until the yolk sac is fully absorbed (1.6-2.6 mm TL).

Stage 2 - from the end of stage 1 until dorsal fin rays become visible (1.8-6.0 mm TL).

Stage 3 - from the end of stage 2 onward (6.5-14.0 mm TL).

Notification Provisions

When the Cape Cod Bay ichthyoplankton study was completed in 1976, provisions were added to the entrainment monitoring program to identify unusually high densities of fish eggs and larvae. Once identified and, if requested by regulatory personnel, additional sampling could be conducted to monitor the temporal and/or spatial extent of the unusual occurrence. An offshore array of stations was established which could be used to determine whether circumstances in the vicinity of Rocky Point, attributable to PNPS operation, were causing an abnormally large percentage of ichthyoplankton populations there to be entrained or, alternatively, whether high entrainment levels simply were a reflection of unusually high population levels in Cape Cod Bay. The impact attributable to any large entrainment event would clearly be greater if ichthyoplankton densities were particularly high only close to the PNPS shoreline. In past years when high densities were identified, additional entrainment sampling was requested by regulatory personnel and the unusual density in most cases was found to be of short duration (<2 days). With the change in 1994 to Monday, Wednesday, Friday sampling the temporal extent of any unusual density can be more clearly discerned without additional sampling effort.

Until 1994 "unusually abundant" was defined as any mean density, calculated over three replicates, which was found to be 50% greater than the highest mean density observed during the same month from 1975 through to the current year. Restricting comparisons to monthly periods damped the large seasonal variation so readily apparent with ichthyoplankton. Starting with 1994 "unusually abundant" was redefined. On a month-by-month basis for each of the numerically dominant species all previous mean densities over three replicates (1974-1993; to be updated each year) were examined and tested for normality following logarithmic transformation. Where data sets (for example, mackerel eggs taken in June) fit the lognormal distribution, then "unusually large" was defined by the overall log mean density plus 2 or 2.58 standard deviations.[1] In cases where data sets did not fit the lognormal distribution (generally months when a species was frequently but not always absent, i.e., many zeros occurred), the mean and standard deviation was computed using the delta-distribution (see for example Pennington 1983). The same mean plus standard deviation guideline was applied.

The decision to rely on 2 standard deviations or 2.58 standard deviations was based on the relative importance of each species. The more critical criterion was applied to species of commercial, recreational, or biological interest, the less critical to the remaining species (i.e., relatively greater densities were necessary to trigger notification). Species of commercial,

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[1]Normal distribution curve theory states that 2.5% of the measurements in a normally distributed population exceed the mean plus 1.96 standard deviations (= s, we rounded to 2 for simplicity), 2.5% lie below the mean minus 1.96 standard deviations. Stated another way 95% of the population lies within that range and 97.5% lies below the mean plus 1.96s. Likewise 0.5% of measurements exceed the mean plus 2.58s, 99% lie within the range of the mean ± 2.58s, 99.5% lie above the mean + 2.58s.

recreational, or biological interest include Atlantic menhaden (Brevoortia tyrannus), Atlantic herring (Clupea harengus), Atlantic cod (Gadus morhua), tautog and cunner (the labrids; Tautoga onitis/Tautogolabrus adspersus), sand lance (Ammodytes sp.), Atlantic mackerel (Scomber scombrus), windowpane (Scophthalmus aquosus), American plaice (Hippoglossoides platessoides), and winter flounder. Table 1 provides summary data for each species of egg and larva by month within these two categories showing the 1995 notification level.

A scan of Table 1 will indicate that, in cases where the long-term mean amounts to 1 or 2 eggs or larvae per 100 m^3, the critical level is also quite small. This situation occurred during months when a given species was obviously uncommon and many zeros were present in the data set with an inherent small standard deviation. The external reference distribution methodology of Box et al. (1975) was also employed. This procedure relies on a dotplot of all previous densities for a species within month to produce a reference distribution. Densities exceeding either 97.5 or 99.5% of the reference set values were considered unusually high with this procedure.

Mesh Extrusion

To potentially improve enumeration of cunner eggs and larvae in PNPS entrainment samples, preliminary sampling was conducted in 1994 to see if eggs and young larvae are extruded through the standard 0.333-mm mesh netting. The smallest stage 1 larvae were not present in 1994 and slightly larger stage 2 larvae were uncommon. The limited data available suggested that substantial extrusion can occur. Therefore on three occasions in June 1995 collections were made in triplicate with both 0.333 and 0.202-mm mesh nets. Dates were selected based on previous samples and historical data to correspond to the likely period of occurrence of small, early-stage cunner. All samples were taken at low water when velocity and potential extrusion would be greatest, each collection six to eight minutes in duration. Nets were alternately attached to the rigging until six samples had been taken. Methodology followed that described for the routine sampling.

Table 1. PNPS ichthyoplankton entrainment notification levels for 1995 by species category and month. See text for details.

Densities per 100 m³ of water:	Long-term Mean[1]	Mean + 2 std.dev.	Mean + 2.58 std.dev.
January			
LARVAE			
Atlantic herring[2]	0.2	1	
Sculpin			
Rock gunnel	0.8		1.4
Sand lance[2]	5	11	
February			
LARVAE			
Atlantic herring[2]	0.1	0.8	
Sculpin	2		65
Rock gunnel	3		99
Sand lance[2]	9	16	
March			
EGGS			
American plaice[2]	2	3	
LARVAE			
Atlantic herring[2]	0.9	1.3	
Sculpin	17		608
Seasnails	0.6		1
Rock gunnel	10.7		723
Sand lance[2]	7	164	
Winter flounder[2]	0.4	0.7	
April			
EGGS			
American plaice[2]	3	32	
LARVAE			
Atlantic herring[2]	1	2	
Sculpin	15		391
Seasnails	6		10
Radiated shanny	3		6
Rock gunnel	4		142
Sand lance[2]	21	998	
Winter flounder[2]	7	12	
May			
EGGS			
Labrids[2]	36	3514	
Mackerel[2]	16	3405	
Windowpane[2]	9	147	
American plaice[2]	2	15	

Table 1 (continued).

Densities per 100 m³ of water:	Long-term Mean[1]	Mean + 2 std.dev.	Mean + 2.58 std.dev.
<u>May</u>			
LARVAE			
Atlantic herring	0.7	1.1	
Fourbeard rockling	2		5
Sculpin	3		4
Radiated shanny	7		236
Sand lance[2]	22	32	
Winter flounder[2]	9	123	
<u>June</u>			
EGGS			
Atlantic menhaden[2]	4	6	
Searobins	3		4
Labrids[2]	958	21599	
Mackerel[2]	63	3515	
Windowpane[2]	27	261	
American plaice[2]	1	2	
LARVAE			
Atlantic menhaden[2]	6	10	
Fourbeard rockling	9		634
Cunner[2]	6	265	
Radiated shanny	1		15
Mackerel[2]	50	83	
Winter flounder[2]	2	20	

[1]Geometric or Delta Mean.

[2]Species of commercial, recreational, or biological interest for which a more critical notification level will be used.

SECTION IV

RESULTS

Monitoring

Population densities per 100 m^3 of water for each species listed by date, station, and replicate are presented for January-June 1995 in Appendix A (available upon request). The occurrence of eggs and larvae of each species by month appears in Table 2.

Ichthyoplankton entrained during January through April generally represent winter-early spring spawning fishes. Many of these employ a reproductive strategy relying on demersal, adhesive eggs which are not normally entrained. As a result, more species are typically represented by larvae than by eggs. Over both life stages 7 species were represented in the January collections, 8 were represented in February, 11 in March, and 15 in April. Egg collections over the season as a whole contained six species, American plaice , winter flounder, yellowtail flounder (Pleuronectes ferrugineus), and Atlantic cod contributing the majority. Plaice eggs were present in March and April accounting for 10 and 45% of those months' egg totals with monthly geometric means of 0.1 and 3.8, respectively. Winter flounder eggs were also taken only in March and April. Their monthly geometric mean densities of 0.2 and 1.5 per 100 m^3 of water accounted for 10 and 41% of their respective monthly totals. Yellowtail eggs were present in January and April, cod eggs in January, March, and April. Monthly mean densities were less than 0.7 per 100 m^3 in each case.

Since they are demersal and adhesive, winter flounder eggs are not typically entrained by water intake systems. Their numbers in PNPS samples are therefore not considered representative of numbers in the surrounding area. Those that were taken were probably dislodged from the bottom by currents and perhaps other fish and large invertebrates.

Larval collections during the winter-early spring season contained 14 species overall. Sand lance ,grubby (Myoxocephalus aenaeus), and rock gunnel (Pholis gunnellus) contributed the most individuals. Sand lance were taken during each weekly sampling period accounting for 40% of the total larval catch in January, 76% in February, 41% in March, and 44% in April; monthly geometric mean densities amounted to 1.3, 29.6, 26.2, and 44.2 per 100 m^3 respectively. Larval grubby first appeared in February and increased in number into April. They accounted for 7% of all larvae in February with a monthly geometric mean of 4.4 per 100 m^3, 17% of all larvae in March with a mean of 13.6, and 28% of all larvae in April with a mean of 31.3 per 100 m^3. Rock gunnel were present each week with the exception of the first week in January. They represented an additional 48% of the February total with a geometric mean density of 6.4, 29% of the March total with a mean of 8.2, and 18% of April's total with a mean of 8.9 per 100 m^3 of water.

May and June collections (along with July) encompass the late spring-summer ichthyoplankton period. Egg and larval densities, particularly among species with pelagic eggs, increase with expanding day length and rising water temperature. Considering both life stages, 18 species were represented in the May collections, 20 were represented in June. Atlantic mackerel were numerically dominant among eggs in May, ranking second in June. In May, with a monthly geometric mean of 73.2 per 100 m^3, mackerel eggs represented 70% of total while corresponding values for June were 24.6 per 100 m^3 and 10% of total, respectively. Tautog/cunner eggs exchanged with mackerel, contributing 23% of all eggs in May at a density of 27.6 per 100 m^3 and 89% of all eggs in June at a geometric mean density of 1179.3 per 100 m^3.

Larval densities over the two-month period were dominated numerically by radiated shanny (Ulvaria subbifurcata), winter flounder, sand lance, and mackerel. Radiated shanny were abundant only in May when a geometric mean density of 29.5 per 100 m^3 represented 47% of all larvae. Winter flounder accounted for 17% of the May larval catch, less than 1% of the June total; respective geometric mean densities were 17.3 and 1.3 per 100 m^3. Sand lance, a numerical dominant during the colder months, remained numerous in early May, dropping from the collections by June. Overall they represented 7% of the May total with a geometric mean density of 2.3 per 100 m^3 of water. Larval Atlantic mackerel contributed little to the collections in May (monthly mean = 0.3 per 100 m^3) but represented 73% of the June total with a monthly geometric mean density of 76.8 per 100 m^3.

Appendix B lists geometric mean monthly densities along with 95% confidence limits for each of the numerical dominants collected over the January-June period dating back to 1985. Geometric means are reported because they more accurately reflect the true population mean when the distribution of sample values are skewed to the right as is commonly the case with plankton data. Generally low values obtained for both eggs and larvae during April-June 1987 were shaded because low through-plant water volumes during those months probably affected densities of ichthyoplankton (MRI 1994). Shaded values were omitted from the following discussion. Entrainment data collected from 1975-1984 remain in an outdated computer format requiring conversion before geometric mean densities can be generated. These years were therefore excluded from comparison. Because densities of each ichthyoplankton species rise from and fall to zero over the course of each respective season, inter-year comparisons are most conveniently made within monthly periods. A general review of the data through the first six months of 1995 suggests the following:

- Larval sand lance were relatively abundant in February, the 1995 monthly mean exceeding all previous February mean values dating back to 1985. During the week of February 20 all three samples collected (Monday, Wednesday, Friday) surpassed the unusually high criterion for the month (Table 3). On February 24, the observed density of 373 larvae per 100 m^3 exceeded the previous February high of 96 per 100 m^3.
- Recent stock size data suggest that the Atlantic herring stock is increasing following reductions in foreign fishing pressure (Smith and Sherman 1993, Sherman 1994, NOAA 1995). Larval

collections in March and April 1994 were relatively high perhaps reflecting stock size changes. In 1995 values were also relatively high for these two months but not exceptionally so over each month as a whole. Unusually high values were observed on March 24, April 5, 13, and 15, the value on March 24 exceeding all previous March values (Table 3).

- American plaice eggs were numerous in May 1995 with a monthly geometric mean density of 5.8 per 100 m^3 which exceeded all previous May monthly means dating back to 1985.
- Larval fourbeard rockling (Enchelyopus cimbrius) were relatively abundant in May and June, the 1995 respective monthly means of 2.4 and 26.7 per 100 m^3 exceeding the previous highs of 1.8 (1986, 1991) and 16.3 (1989) per 100 m^3.
- Winter flounder larvae were relatively numerous in May with a geometric mean density of 17.3 per 100 m^3. This value exceeded that for 1994 (16.8 per 100 m^3), the previous high dating back to 1985. No unusually high densities were recorded during the period however.
- Atlantic menhaden larvae were abundant in June. Over the month as a whole they showed a geometric mean densit'' of 6.3 per 100 m^3, exceeding the 4.7 per 100 m^3 noted in 1985, the previous high. On five occasions from June 16 through June 26, 1995, densities were unusually high for the month of June (Table 3). The highest density recorded during the period (59 per 100 m^3) surpassed 98% of all previous June values.

- Lastly Atlantic mackerel larvae were abundant in June. The 1995 monthly mean of 76.8 per 100 m^3 exceeded the previous high of 37.8 per 100 m^3 noted in 1989. Densities recorded on six dates from June 12 through 23 each exceeded the unusually-high criterion with four of the six exceeding 99% of all previous values (Table 3). Like Atlantic herring, mackerel spawning stock biomass has rebounded over the last decade (NOAA 1995) presumably with concurrent increases in egg and larval production.

Although monthly values did not prove to be remarkable, three single observations, two for Atlantic mackerel eggs and one for tautog/cunner eggs were noted to be unusually high. For mackerel one observation occurred May 26, one June 9. The May value of 19203 eggs per 100 m^3 exceeded the previous high value for that month of 14967 per 100 m^3 (Table 3). This also proved to be the case for tautog/ cunner eggs. On June 21 a density of 37283 per 100 m^3 was recorded, exceeding the previous June high of 31833 eggs per 100 m^3 noted in 1974.

No lobster larvae (Homarus americanus) were encountered through the end of June, a total of five having been taken through that month dating back to 1974.

Mesh Extrusion

Densities per 100 m^3 of water for tautog/cunner eggs and cunner larvae by stage for both 0.333 and 0.202-mm mesh collections completed in both 1994 and 1995 appear in Table 4. Paired sample t-tests on log-transformed data indicated tautog/cunner eggs were significantly more abundant in the 0.202-mesh samples ($p < 0.004$; $n = 21$ pairs). Since the data were highly skewed by high densities on June 28, 1995, geometric means were calculated over the 21 samples within each mesh category. The ratio of these was 1.40:1.

Results for larval cunner were variable making meaningful conclusions difficult to reach. The smallest stage 1 individuals were present in five sample pairs. On June 16 cunner stage 1 densities were consistently higher in the 0.333 samples while the reverse was true on June 26 (paired t, $n = 5$, $p = 0.61$). Geometric means within mesh over all samples were 9.1 for 0.333, 14.8 for 0.202, providing a ratio of 1.64:1. For somewhat larger stage 2 larvae comparative data were available for nine pairs; 0.202-mesh densities were greater in six of the nine (paired t-test $p = 0.94$). Respective geometric means were 10.0 and 9.7 per 100 m^3. Summing stage 1 and 2 densities and calculating geometric means over all pairs indicated that densities were essentially identical in the two meshes (11.7 vs 11.6, paired $t = 0.96$). Collections of larger stage 3 cunner averaged somewhat higher in the larger mesh (7.1 vs 5.7 per 100 m^3 of water, paired $t = 0.51$). These data suggest that small larval cunner are not consistently extruded through 0.333 mesh. Pairs showing greater densities in the larger mesh may have resulted from random error inherent in a system with naturally high variability among ichthyoplankters or perhaps to clogging of the finer mesh. The 0.202-mm mesh visibly collects greater amounts of small planktonic forms such as diatoms and, although not clearly detectable in the flowmeter data, greater back pressure may reduce collection of some larvae.

Table 2. Species of fish eggs (E) and larvae (L) obtained in ichthyoplankton collections from the Pilgrim Nuclear Power Station discharge canal, January-June 1995.

Species		Jan	Feb	Mar	Apr	May	June
American eel	*Anguilla rostrata*				L		
Atlantic menhaden	*Brevoortia tyrannus*						E/L
Atlantic herring	*Clupea harengus*	L		L	L	L	
Rainbow smelt	*Osmerus mordax*					L	
Fourbeard rockling	*Enchelyopus cimbrius*				E	E/L	E/L
Atlantic cod	*Gadus morhua*	E	L	E/L	E	E/L	E/L
Haddock	*Melanogrammus aeglefinus*			E			
Silver hake	*Merluccius bilinearis*						E/L
Atlantic tomcod	*Microgadus tomcod*	L	L				
Hake	*Urophycis* spp.						E/L
Goosefish	*Lophius americanus*						E
Silversides	*Menidia* spp.						L
Searobins	*Prionotus* spp.						E
Sea raven	*Hemitripterus americanus*			L			
Grubby	*Myoxocephalus aenaeus*		L	L	L	L	L
Longhorn sculpin	*M. octodecemspinosus*		L	L	L		
Shorthorn sculpin	*M. scorpius*		L	L	L	L	
Lumpfish	*Cyclopterus lumpus*				L		
Seasnail	*Liparis atlanticus*				L	L	L
Wrasses	Labridae					E	E
Tautog	*Tautoga onitis*						L
Cunner	*Tautogolabrus adspersus*						L
Radiated shanny	*Ulvaria subbifurcata*					L	L
Rock gunnel	*Pholis gunnellus*	L	L	L	L	L	
Wrymouth	*Cryptacanthodes maculatus*	L	L		L	L	
Sand lance	*Ammodytes* sp.	L	L	L	L	L	
Atlantic mackerel	*Scomber scombrus*					E/L	E/L
Windowpane	*Scophthalmus aquosus*					E	E/L
American plaice	*Hippoglossoides platessoides*			E	E	E/L	E/L
Winter flounder	*Pleuronectes americanus*			E	E/L	E/L	L
Yellowtail flounder	*P. ferrugineus*	E			E	E	E/L

Table 3. Ichthyoplankton densities (number per 100 m^3) for each sampling occasion during months when notably high densities were recorded, January-June 1995. Densities marked by + were unusually high based on values in Table 1. Number in parentheses indicates percent of all previous values during that month which were lower.

Sand lance larvae

Feb.	6	11.7
	8	4.6
	10	14.5
	20	31.3 + (97)
	22	49.7 + (97)
	24	372.9 + (100)

Previous high: 95.8 (1985)
Notice level: 16

Atlantic herring larvae

March	6	0.8
	8	0
	10	0.6
	13	0
	15	0
	17	0.9
	20	0
	22	0
	24	12.6 + (100)
	27	8.0
	29	1.3
	31	n.s.[1]

Previous high: 9.1 (1983)
Notice level: 1

April	3	n.s.
	5	4.5 + (90)
	7	0
	10	n.s.
	13	5.5 + (90)
	15	5.6 + (90)
	17	0.8
	19	n.s.
	21	n.s.
	24	n.s.
	26	n.s.
	28	n.s.

Previous high: 13.8 (1994)
Notice level: 2

Atlantic mackerel

		Eggs	Larvae
May	1	n.s.	n.s.
	3	n.s.	n.s.
	5	0	0
	8	n.s.	n.s.
	10	n.s.	n.s.
	12	1.9	0
	15	n.s.	n.s.
	17	134.7	0
	19	12.2	0
	22	24.7	0
	24	n.s.	n.s.
	26	19203 + (100)	4.0
	29	557.0	0
	31	139.0	0
Previous high:		14967 (1989)	26.4 (1991)
Notice level:		3405	--
June	2	337.7	1.5
	5	346.0	0.7
	7	480.6	0.8
	9	4754.0 + (98)	15.3
	12	2242.7	1965.4 + (99)
	14	20.5	601.1 + (99)
	16	144.9	1034.3 + (99)
	19	12.9	207.3 + (93)
	21	0	535.3 + (99)
	23	0	141.6 + (93)
	26	0	62.1
	28	0	35.5
	30	0	21.2
Previous high:		8193 (1990)	2700 (1981)
Notice level:		3515	83

Table 3 (continued).

Tautog/Cunner eggs			Atlantic menhaden larvae		
June	2	225.9	June	2	0
	5	242.9		5	0
	7	406.1		7	0
	9	1710.8		9	1.5
	12	281.4		12	8.2
	14	10510.5		14	0
	16	1363.9		16	19.9 + (92)
	19	107.2		19	58.6 + (98)
	21	37282.5 + (100)		21	38.0 + (96)
	23	2787.7		23	25.5 + (92)
	26	385.7		26	10.0 + (89)
	28	17446.7		28	7.7
	30	639.9		30	8.0

Previous high: 31833 (1974) Previous high: 495.9 (1981)
Notice level: 21599 Notice level: 10

[1]n.s. = No sample taken due to circulating water pump shutdown.

Table 4. Densities per 100 m^3 of water for tautog/cunner eggs and cunner larvae taken with 0.333 and 0.202-mm mesh netting on four 1994 dates and three 1995 dates.

	Date	Replicate	Mesh 0.333	Mesh 0.202	Ratio	p[1]
EGGS	1994					
	May 4	1	2.9	16.1	5.55	
		2	3.2	9.0	2.81	
		3	5.3	4.4	0.83	
	May 9	1	1.1	3.9	3.55	
		2	4.7	4.9	1.04	
		3	1.8	2.9	1.61	
	July 21	1	1194	1330	1.11	
		2	1028	1462	1.42	
		3	1377	2259	1.64	
	August 8	1	134	110	0.82	
		2	134	172	1.28	
		3	134	152	1.13	
	1995					
	June 16	1	1364	1959	1.44	
		2	1405	1514	1.08	
		3	1609	1299	0.81	
	June 26	1	386	675	1.75	
		2	631	675	1.07	
		3	515	570	1.11	
	June 28	1	17447	17658	1.01	
		2	16432	24925	1.52	
		3	21671	26357	1.22	
Geometric mean			207	290	1.40	0.004
95% confidence limits			50-859	76-1101	1.20-1.63	
LARVAE						
Cunner	1994					
Stage 1	May 4	All	0	0	-	
	May 9	All	0	0	-	
	July 21	All	0	0	-	
	August 8	All	0	0	-	
	1995					
	June 16	1	59.7	25.0	0.42	
		2	30.7	18.4	0.60	
		3	69.3	39.7	0.57	
	June 26	1	0.6	5.4	9.82	
		2	0.8	7.3	8.80	
		3	0	0	-	
	June 28	All	0	0	-	
Geometric mean			9.1	14.8	1.64	>0.05
95% confidence limits			0.6-138	6-39	0.3-10	

Table 4 (continued).

	Date	Replicate	Mesh 0.333	0.202	Ratio	p[1]
	1994					
Stage 2	May 4	All	0	0	-	
	May 9	All	0	0	-	
	July 21	1	0	2.5	-	
		2	1.1	7.8	7.09	
		3	2.1	0	-	
	August 8	1	0.7	0	-	
		2	0	0	-	
		3	0	0	-	
	1995					
	June 16	1	56.8	60.0	1.06	
		2	36.3	12.3	0.34	
		3	72.2	34.0	0.47	
	June 26	1	16.6	43.5	2.62	
		2	56.2	90.7	1.61	
		3	85.9	36.3	0.42	
	June 28	1	1.5	10.4	6.75	
		2	4.5	14.0	3.13	
		3	14.4	0	-	
Geometric mean			10.0	9.7	1.03	>0.05
95% confidence limits			3-28	3-27		
	1994					
Stage 1 & 2	May 4	All	0	0	-	
	May 9	All	0	0	-	
	July 21	1	0	2.5	-	
		2	1.1	7.8	7.09	
		3	2.1	0	-	
	August 8	1	0.7	0	-	
		2	0	C	-	
		3	0	0	-	
	1995					
	June 16	1	116.5	85.0	0.73	
		2	67.1	30.7	0.46	
		3	141.5	73.7	0.52	
	June 26	1	17.2	48.9	2.85	
		2	56.2	98.0	1.74	
		3	85.9	36.3	0.42	
	June 28	1	1.5	10.4	6.75	
		2	4.5	14.0	3.13	
		3	14.4	0	0	
Geometric mean			11.7	11.6	0.99	>0.05
95% confidence limits			3-36	3-35		

Table 4 (continued).

	Date	Replicate	Mesh 0.333	Mesh 0.202	Ratio	p'[1]
	1994					
Stage 3	May 4	All	0	0	-	
	May 9	All	0	0	-	
	July 21	1	0	0	-	
		2	1.1	0	-	
		3	2.1	2.3	1.10	
	August 8	1	12.2	13.4	1.10	
		2	13.5	7.3	0.54	
		3	2.9	5.1	1.76	
	1995					
	June 16	All	0	0	-	
	June 26	1	3.9	14.5	3.74	
		2	24.8	7.3	0.29	
		3	28.1	12.7	0.45	
	June 28	All	0	0	-	
Geometric mean			7.1	5.7	0.80	>0.05
95% confidence limits			3-17	2-13		

[1]p = paired t-test

SECTION V

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APPENDIX A*. Densities of fish eggs and larvae per 100 m^3 of water recorded in the PNPS discharge canal by species, date, and replicate, January-June 1995.

*Available upon request.

APPENDIX B*. Geometric mean monthly densities and 95% confidence limits per 100 m^3 of water for the dominant species of fish eggs and larvae entrained at PNPS, January-June 1985-1995.

Note the following:

When extra sampling series were required under the contingency sampling regime, results were included in calculating monthly mean densities.

Shaded columns for certain months in 1987 delineate periods when sampling was conducted with only salt service water pumps in operation. Densities recorded at those times were probably biased low due to low through-plant water flow (MRI 1994).

*Available upon request.

IMPINGEMENT OF ORGANISMS AT PILGRIM NUCLEAR POWER STATION

(January - June 1995)

Prepared by:

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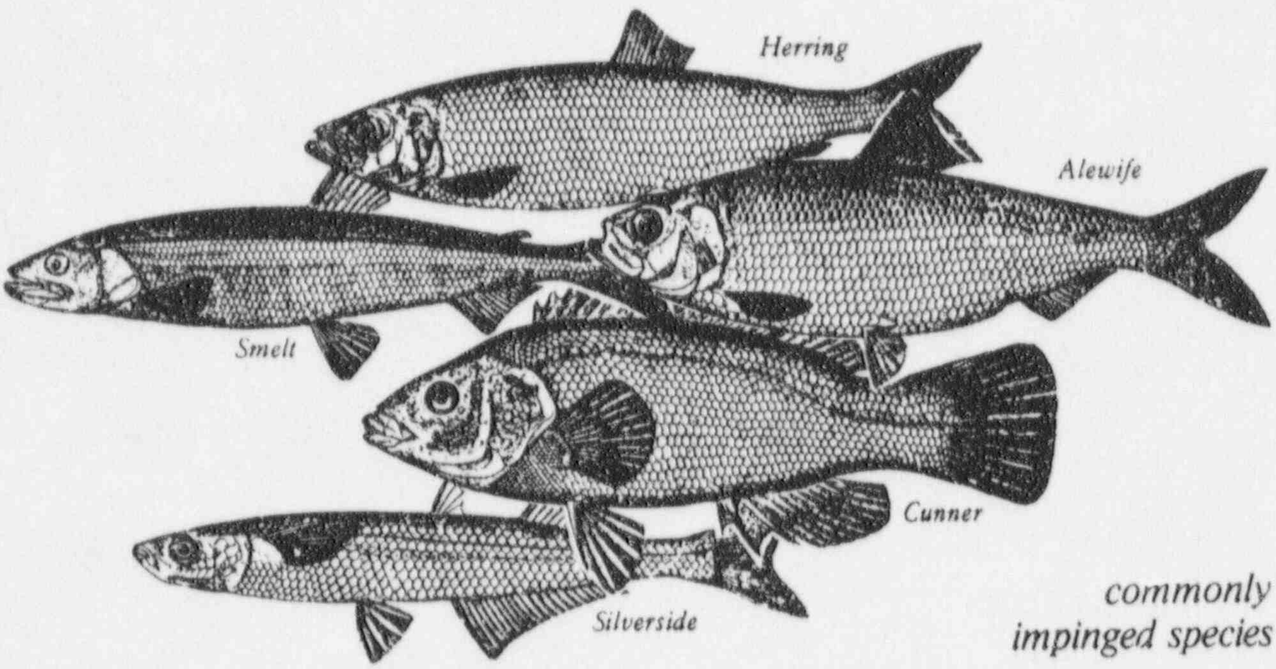
October 1995



commonly
impinged species

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SECTION I

SUMMARY

Fish impingement averaged 4.36 fish/hour during the period January-June 1995. Atlantic silverside (Menidia menidia), rainbow smelt (Osmerus mordax), blueback herring (Alosa aestivalis) and winter flounder (Pleuronectes americanus) accounted for 91% of the fishes collected. Initial impingement survival for all fishes from static screen wash collections was approximately 56% and from continuous screen washes 50%.

The collection rate (no./hr.) for all invertebrates captured from January-June 1995 was 1.99+. Jellyfish, sevenspine bay shrimp (Crangon septemspinosa) and sand worms (Nereis sp.) accounted for 83%+ of the invertebrates impinged. Mixed species of algae collected on intake screens amounted to 1,798 pounds.

The relatively high fish impingement rates from January-June 1993 (2.58), 1994 (3.34) and 1995 (4.36), reflect circulating water pumps operating regularly during most of these periods, and high numbers of silversides impinged in early spring of each year. The invertebrate impingement was not as reflective of increased intake flow.

The Pilgrim Nuclear Power Station capacity factor was 55% from January - June 1995.

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 670 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 (USEPA) and No. 359 (Mass. DEP) for Pilgrim Nuclear Power Station, Unit I. The report describes impingement of organisms and survival of fishes carried onto the vertical travelling water screens at Unit I. It presents analysis of the relationships among impingement, environmental factors, and plant operational variables.

This report is based on data collected from screen wash samples during January-June 1995.

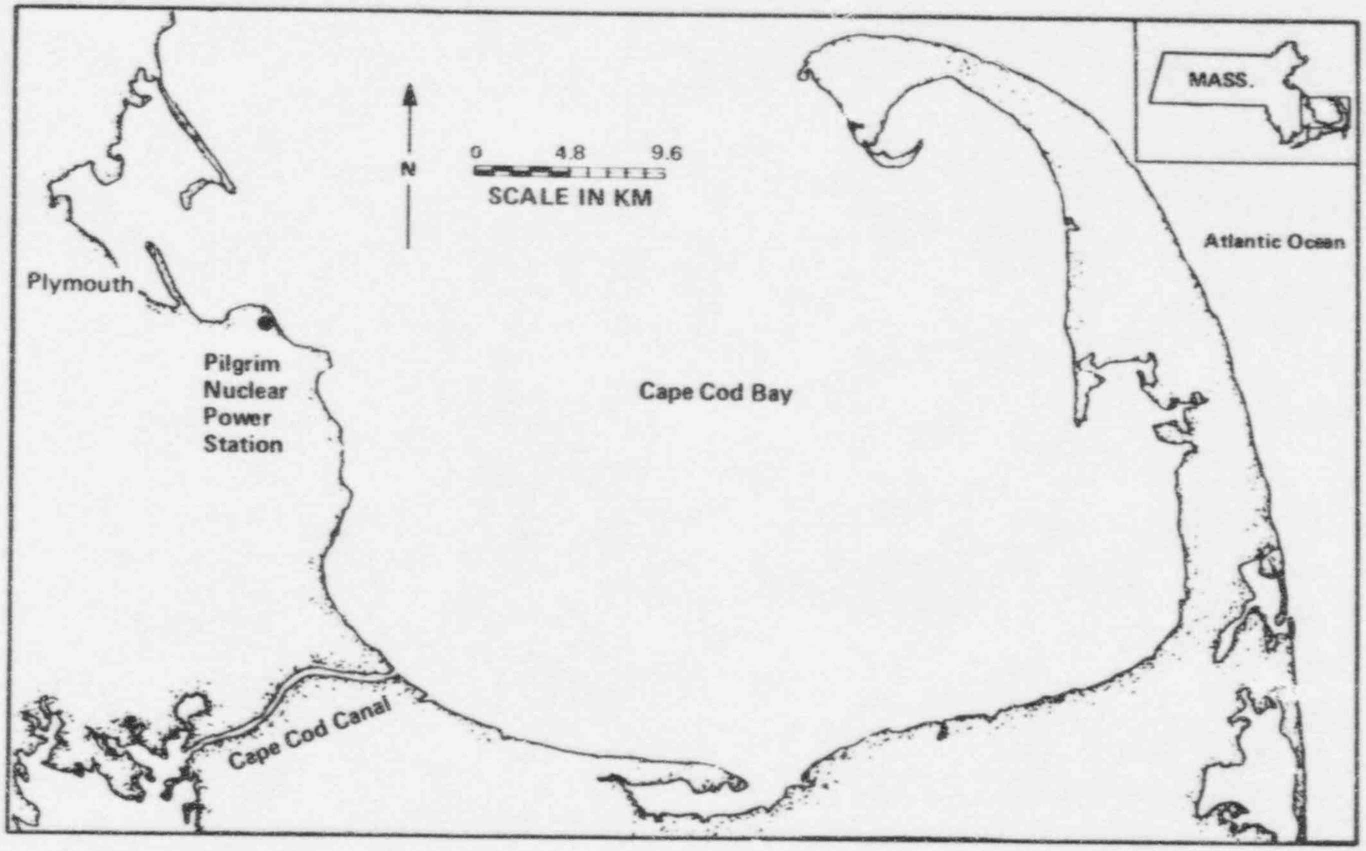

Figure 1. Location of Pilgrim Nuclear Power Station.

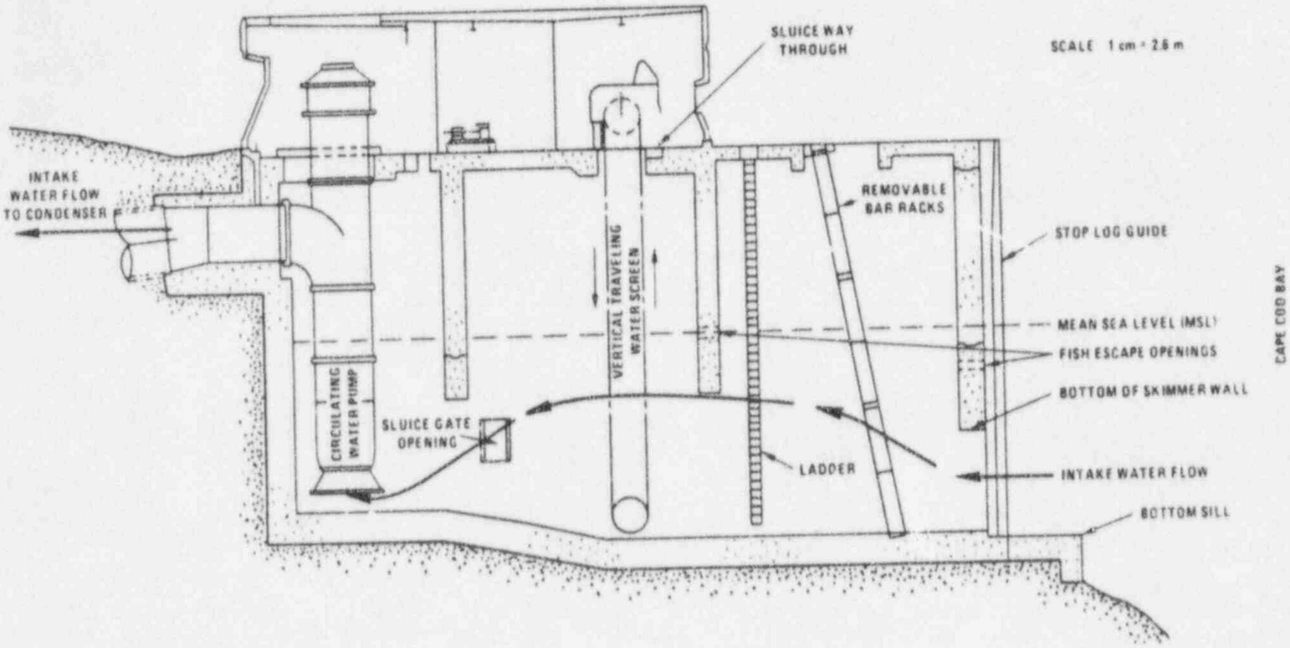

Figure 2: Cross-section of intake structure of Pilgrim Nuclear Power Station.

SECTION 3

METHODS AND MATERIALS

Three screen washings each week were performed from January-June 1995 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.

Water nozzles directed at the screens washed impinged organisms and debris into a sluiceway that flowed into a trap. The trap was made of galvanized screen (3/8-inch mesh) attached to a removable steel frame and it collected impinged biota, in the screenhouse, shortly after being washed off the screens. Initial fish survival was determined for static (8-hour) and continuous screenwash cycles.

Variables recorded for organisms were total numbers, and individual total lengths (mm) and weights (gms) for up to 20 specimens of each species. A random sample of 20 fish or invertebrates 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. Field work was conducted by Marine Research, Inc.

Intake seawater temperature, power level output, tidal stage, number of circulating water pumps in operation, time of day and date were recorded at the time of collections. The collection rate (#/hour) was calculated as number of organisms impinged per collecting period divided by the

(#/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 (1988, 1989, 1991a and 1991b).

SECTION 4

RESULTS AND DISCUSSION

4.1 Fishes

In 318 collection hours, 1,386 fishes of twenty-six species (Table 1) were collected from Pilgrim Nuclear Power Station intake screens during January - June 1995. The collection rate was 4.36 fish/hour. Atlantic silverside (Menidia menidia) was the most abundant species accounting for 74.1% of all fishes collected (Table 2). Rainbow smelt (Osmerus mordax), blueback herring (Alosa aestivalis) and winter flounder (Pleuronectes americanus) accounted for 10.5, 3.4 and 2.8% of the total number of fishes collected. Atlantic silverside were impinged in highest numbers during March. These were primarily adult fish that averaged 97 mm total length. Blueback herring impingement dominated in May, and rainbow smelt and winter flounder were mostly impinged in January. The January-June 1995 fish impingement rate increased from the same period in 1989-1994, when rates varied from 0.52 (1990) to 3.34 (1994). Rates increased the past seven years compared to the 1988 rate (0.30) and this is possibly attributable to greater circulating water pump operating capacity from 1989-1995 and higher silverside impingement numbers, in general, in the springtime period.

4.2. Invertebrates

In 318 collection hours, 632+ invertebrates of 13 species (Table 3) were collected from Pilgrim Station intake screens between January-June 1995. The collection rate was 1.99+ invertebrates/hour. Jellyfish were collected in undetermined numbers. Sevenspine bay shrimp (Crangon septemspinosa) and sand worms (Nereis sp.) accounted for 63.0% and 19.6%, respectively, of the total number of invertebrates enumerated. Green crabs (Carcinus maenus) were fourth in abundance and were impinged predominantly in May.

Table 1. Monthly Impingement For All Fishes Collected From Pilgrim Station Intake Screens, January-June 1995

Species	Jan	Feb.	March	April	May	June	Total
Atlantic silverside	288	39	680	20	1		1,028
Rainbow smelt	138	2	2	3			145
Blueback herring	1		2		38	6	47
Winter flounder	17	6	3	8	4	1	39
Grubby	20	1	2	1	3	4	31
Atlantic tomcod	8		1	2			11
Threespine stickleback	4	1	6				11
Alewife	4		1		1	4	10
Atlantic herring			6			4	10
Cunner					1	7	8
Lumpfish	6		1				7
Atlantic cod		1				4	5
Rock gunnel		1	2	2			5
Radiated shanny	1		2	1			4
Red hake				3		1	4
Windowpane				3		1	4
Northern searobin					3		3
Pollock					1	2	3
Little skate					1	1	2
Mummichog			2				2
Tautog	1		1				2
Atlantic seasnail		1					1
Northern pipefish			1				1
Silver hake		1					1
Striped killifish				1			1
Striped searobin						1	1
TOTALS	488	53	712	44	53	36	1,386
Collection Time (hrs.)	58	60	73	19	47	61	318
Collection Rate (#/hr.)	8.41	0.88	9.75	2.32	1.13	0.59	4.36

Table 2. Species, Number, Total Length(mm), Weight(gms) and Percentage For All Fishes Collected From Pilgrim Station Impingement Sampling, January- June 1995

Species	Number	Length Range	Mean Length	Weight Range	Mean Weight	Percent of Total Fish
Atlantic silverside	1,028	69-138	97	1-12	5	74.1
Rainbow smelt	145	83-215	121	3-61	10	10.5
Blueback herring	47	72-134	94	3-17	5	3.4
Winter flounder	39	50-347	121	1-575	48	2.8
Grubby	31	39-100	67	1-14	5	2.2
Atlantic tomcod	11	96-198	136	8-63	21	0.8
Threespine stickleback	11	61-70	66	2-3	3	0.8
Alewife	10	80-260	139	4-114	24	0.7
Atlantic herring	10	45-62	50	0.4-2	1	0.7
Cunner	8	54-196	116	2-114	42	0.6
Lumpfish	7	39-65	51	2-11	5	0.5
Atlantic cod	5	61-166	89	2-29	8	0.4
Rock gunnel	5	87-153	129	5-10	7	0.4
Radiated shanny	4	76-90	82	3-6	4	0.3
Red hake	4	95-148	119	4-19	9	0.3
Windowpane	4	52-210	128	1-94	34	0.3
Northern searobin	3	220-255	235	104-184	132	0.2
Pollock	3	75-93	82	3-8	5	0.2
Little skate	2	315-377	346	-	-	0.1
Mummichog	2	55-57	56	2	2	0.1
Tautog	2	64-75	70	3-6	5	0.1
Atlantic seasnail	1	75	75	6	6	0.1
Northern pipefish	1	135	135	1	1	0.1
Silver hake	1	125	125	14	14	0.1
Striped killifish	1	-	-	-	-	0.1
Striped searobin	1	266	266	-	-	0.1

Table 3. Monthly Impingement For All Invertebrates Collected From Pilgrim Station Intake Screens, January-June 1995

Species	Jan.	Feb.	March	April	May	June	Totals
Jellyfish						*	*
Sevenspine bay shrimp	171	53	149	24	1		398
Nereis sp.	4	119				1	124
Green crab	12		3	2	14	5	36
Longfin squid					1	22	23
Rock crab	4	4	1	4	3	1	17
American lobster	4	1			7	3	15
Horseshoe crab					2	6	8
Common starfish	1					3	4
Green sea urchin		1			1	1	3
Isopoda				2			2
Glycera sp.			1				1
Lady crab						1	1
TOTALS	196	178	154	32	29	43+	632+
Collection Time (hrs.)66	58	60	73	19	47	61	318
Collection Rate (#/hr.)0.80	3.38	2.97	2.11	1.68	0.62	0.70+	1.99+

* Undetermined numbers

Jellyfish were impinged only during the month of June. The collections of sevenspine bay shrimp occurred primarily from January - March, and sand worms in February. In 1989 from January - June, blue mussels and mussel predators dominated impingement, possibly due to the lack of effective macrofouling controls that year. Fifteen specimens of the commercially important American lobster were captured which is much lower than in 1994, and comparable 1990 and 1991 when 16 and 21 were recorded, respectively, for the same time frame.

Approximately 1,798 pounds of mixed algae species were recorded during impingement sampling, or 5.7 pounds/hour. Like the January-June, 1989 - 1995 fish impingement rates, the algal impingement rate for these years was notably higher than recorded for the same period in 1988.

4.3 Fish Survival

Fish survival data collected while impingement monitoring are shown in Table 4. Static screen was collections provided high numbers of fishes and revealed relatively high impingement survival rates for some species, especially Atlantic silversides. Continuous screen wash collections had lower survival rates, although so few fishes were sampled that they are not a good indicator of continuous wash survival.

Table 4. Survival Summary for the Fishes Collected During Pilgrim Station Impingement Sampling, January-June1995. Initial Survival Numbers Are Shown Under Static (8-Hour) and Continuous Wash Cycles

Species	Number Collected		Number Surviving (Initial)		Total Length (mm)	
	Static Washes	Cont. Washes	Static	Cont.	Mean	Range
Atlantic silverside	1,015	13	642	8	97	69-138
Rainbow smelt	145	0	19	-	121	83-215
Blueback herring	47	0	0	-	94	72-134
Winter flounder	38	1	32	0	121	50-347
Grubby	31	0	26	-	67	39-100
Atlantic tomcod	11	0	7	-	136	96-198
Threespine stickleback	11	0	6	-	66	61-70
Alewife	10	0	4	-	139	80-260
Atlantic herring	10	0	0	-	50	45-62
Cunner	7	1	6	0	116	54-196
Lumpfish	7	0	4	-	51	39-65
Atlantic cod	5	0	0	-	89	61-166
Rock gunnel	5	0	5	-	129	87-153
Radiated shanny	4	0	4	-	82	76-90
Red hake	4	0	2	-	119	95-148
Windowpane	4	0	4	-	128	52-210
Northern searobin	3	0	0	-	235	220-255
Pollock	3	0	0	-	82	75-93
Little skate	1	1	1	0	346	315-377
Mummichog	2	0	2	-	56	55-57
Tautog	2	0	2	-	70	64-75
Atlantic seasnail	1	0	1	-	75	75
Northern pipefish	1	0	1	-	135	135
Silver hake	1	0	0	-	125	125
Striped killifish	1	0	1	-	-	-
Striped searobin	1	0	1	-	266	266
All Species:						
Number	1,370	16	770	8		
(% Surviving)			(56.2)	(50.0)		

SECTION 5

CONCLUSIONS

1. The average Pilgrim impingement rate for the period January-June 1995 was 4.36 fish/hour. The collection rate was notably lower in 1988, than in 1989 - 1995, possibly due to more circulating water pump capacity during the latter years.

2. Twenty-six species of fish were recorded in 318 impingement collection hours.

3. The major species collected and their relative percentages of the total collections were Atlantic silverside, 74.1%; rainbow smelt, 10.5%; blueback herring, 3.4%; and winter flounder, 2.8%.

4. The hourly collection rate for invertebrates was 1.99+ with jellyfish (undetermined numbers), sevenspine bay shrimp (63.0%) and sand worms (19.6%) dominating the catch. Fifteen American lobsters were caught. Impingement rates for invertebrates were higher and algae lower for this period in 1988 (minimum circulating water pumps operating) then in 1989 - 1995.

5. Impinged fish survival was high overall during static screen washes because of relatively high Atlantic silverside survival.

SECTION 6

LITERATURE CITED

American Fisheries Society. 1991a. A list of common and scientific names of fishes from the United States and Canada. Spec. Pub. No. 20: 183 pp.

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MEMORANDUM

TO: Members of the Administrative-Technical Committee, Pilgrim Power Plant Investigations
FROM: John Chisholm, Recording Secretary, Massachusetts Division of Marine Fisheries
SUBJECT: Minutes from the 83rd meeting of the A-T Committee
DATE: June 13, 1995

This meeting of the A-T committee was called to order by chairman Gerald Szal at 9:36

I. Minutes of the 83rd meeting

Carolyn Griswold motioned to accept the minutes; Bob Maietta seconded. The minutes were accepted unanimously with no changes.

II. Pilgrim Station operational review

Bob Anderson presented the latest station operational status to the committee. Overall operation was 65% for 1994 due to the generator problem from September to November. So far in 1995, the plant is operating at 75% capacity. Bob informed the committee that there will be no more mid-cycle outages. The plant will refuel every two years during the months of April and May. This, Bob Lawton explained, fortunately keeps the plant off line during the same period in which winter flounder larvae are in the water column.

Dredging, according to Bob Anderson, will take place next year. It is expected to cost 1.2 million dollars. The project was held up because of traces of Cobalt 60 in some of the sediment samples. However, BECo expects to have the permits by the end of the year. Also, the engineers have considered increasing the power output of the plant. The Delta-t would stay the same, but flow would increase by 13%.

Gerry asked Bob to address two letters that he had received. One was about checking the shroud for cracks and the other, addressed to EPA, notifying them of a new corrosion inhibitor that engineers wanted to use.

III. 1994 Impingement Monitoring Results

Bob Anderson presented the impingement data. The overall rate for 1994 was 6 fish per hour. This is triple the rate of 2 fish per hour which the plant has averaged for the last 20 years. This increase is due to incidents in November and December. In the first incident, 5800 silversides were impinged from November 28 - 29. The second, which occurred in the end of December, involved the impingement of 6100 silversides and 5300 smelt.

IV. 1994 Marine Fish Monitoring Results

Bob Lawton presented the Marine Fisheries monitoring. He began with the smelt restocking efforts. Over a million eggs were moved into the Jones river in the spring of 1995. For next year, Bob recommends putting egg trays in the river to enhance spawning habitat. No eggs will be moved. Money will be needed to fund a seasonal employee to maintain the trays. Bob then described the problems with the yet unidentified alga in the river. Bob Maietta suggested we contact Joan Biskenis to have it identified.
He also suggested Boston Edison fund a pamphlet on making smelt egg trays, similar to the bluebird project run by Fish and Wildlife.

Next Bob Lawton introduced the idea of substitute mitigation. Marine Fisheries suggested using money awarded for impingement incidents to rebuild local fish ladders. Bob Anderson was concerned with attaching a price (value) on the fish. He wanted a letter from Gerry Szal supporting the work. Then a discussion ensued on whether Gerry should endorse this. Gerry said he wanted a monetary figure before he did anything. It was suggested earmarking the work at $10-15,000 for enhancement of the fishery. After more discussion Gerry motioned to "...provide sufficient funds for DMF to continue enhancement of the fishery , for $10,000." Carolyn seconded the motion and it was accepted unanimously.

Bob Lawton then presented the winter flounder work. Tagging efforts utilizing the large commercial fishing vessel resulted in 2050 winter flounder being tagged in the spring of 1995. To achieve good estimates, DMF needs recaptures from fish returning next year to spawn.

As part of the marine fisheries investigations, Paul Nitschke presented the cunner fecundity work. Paul collected 250 fish between 61-182 mm for his fecundity work. His preliminary results estimate 50,000 eggs per year. Paul will also do work on recruitment and post-settlement mortality. Paul distributed his outline and then presented his sampling and analysis protocol.

V. 1994 Benthic monitoring

Isabelle Williams presented the benthic monitoring results. SCUBA surveys are done quarterly to map the impacted bottom area. Divers swim transects perpendicular to the discharge on an axis centered on the discharge canal. In 1994 nothing unusual was reported. The denuded zone was within the range observed in past years. The bottom impact area was 90 meters off by 30 meters. Bob Lawton asked about heat and scouring. Jim Blake said littorinid snails may also affect the denuded area.

VI. 1994 Entrainment Monitoring

Mike Scherer began by reviewing the changes made as a result of the fisheries workshop. In April of 1994 he switched the entrainment sampling to 3 times a week, Monday-Wednesday-Friday. From January to February, sampling is done biweekly from March to September it is done every week. He also reviewed the modifications made to notification levels. As for sampling in 1994, Mike reported higher values for sculpin, sand lance, and radiated shanny. He pointed out that some samples are now taken at night. Cod eggs are down, while mackerel are on the increase. The committee discussed the value of Mike continuing comparisons using the 202 mesh net.

VII. 1995 Marine Fish and Benthic Subcommittees...

The next fisheries subcommittee meeting is scheduled for July 27, 1995. No meeting was scheduled for the benthic group.

VIII. 1994 Benthic Plume Study

Bruce Magnell of EG&G described the array of 59 temperature monitors deployed off of Pilgrim's discharge to map the plume. The full array was deployed and recording from August 26-29. An unexpected generator failure forced the plant to shutdown, which ended the study prematurely. Also, a storm at the beginning of September resulted in the loss of several temperature recorders. In the end, 44 of the 59 recorders were recovered. The results show the greatest offshore effects of the plume on the bottom are at low tide. Benthic organisms in the area would be subject to temperature fluctuations between ambient and the discharge water. The maximum bottom extent of the plume offshore was 170m from the mouth of the discharge canal with an offshore wind. The greatest width was 40m at 80m out from the discharge. The maximum area affected was approximately 1.2 acres.
Although the study was cut short, the temperature monitors were deployed for a few tidal cycles under typical summer conditions.

A-T Committee Meeting Attendance

June 13, 1995

Gerald Szal Chairman	Mass. DEP, Grafton
Robert Lawton	Mass. DMF, Sandwich
Mike Scherer	MRI, Falmouth
Bob Anderson	BECo, Plymouth
Carolyn Griswold	NMFS, Narragansett
Don Miller	EPA, Narragansett
Paul Nitschke	UMASS
Martha Mather	UMASS
Jim Blake	ENSR
Isabelle Williams	ENSR
Robert Maietta	DEP
John Chisholm	Mass. DMF, Sandwich (recording secretary)