MARINE ECOLOGY STUDIES

RELATED TO OPERATION OF PILGRIM STATION

SEMI-ANNUAL REPORT No. 66

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Compiled and Reviewed by:

Environmental Protection Group

Entergy Nuclear — Pilgrim Station
Plymouth, Massachusetts 02360

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SECTION

INTRODUCTION

A. Scope and Objective

This is the sixty-sixth (66) report, provided semi-annually, on the status and results of environmental surveillance and monitoring programs related to the operation of Pilgrim Nuclear Power Station (PNPS). The monitoring efforts discussed in this report relate specifically to the Western Cape Cod Bay ecosystem with particular emphasis on the Rocky Point area. This report is submitted in accordance with the environmental monitoring and reporting requirements of the PNPS NPDES Permit from the U.S. Environmental Protection Agency (#MA0003557) and Massachusetts Department of Environmental Protection (#359).

The objectives of the Environmental Surveillance and Monitoring Program are to determine whether the operation of PNPS results in measurable effects on the marine ecology and to evaluate the significance of any observed effects. If an effect of significance is detected, steps are taken to correct or mitigate any potential impacts.

The efforts described in this report represent a continuation of monitoring conducted at PNPS in the past by Entergy (and before that, by Boston Edison Company). This program was submitted to U.S. EPA and MA DEP for review in December 2004 and was subsequently approved. Note that in March 2002, Entergy Nuclear Operations, Inc. became the operator of Pilgrim Station, although Entergy Nuclear Generation Co. is still the owner. This change had virtually no effect on the Marine Environmental Monitoring Programs at PNPS or the personnel associated with them.

B. Marine Biota Studies

1. Marine Fisheries Monitoring

Marine Fisheries studies in 2005 focused on winter flounder population parameters to develop an understanding of any PNPS impact on this indicator species. Population estimates and adult equivalency analyses are conducted on this key species to help assess the impact of PNPS entrainment.

Results of the marine fisheries monitoring during the reporting period are presented in Section 3.1. Winter flounder are studied by trawling techniques.

Entergy has conducted efforts to support fisheries enhancement in 2000 through 2004 and did so again in 2005. Winter flounder were spawned and reared in a hatchery from January to May, and then released near the Plymouth Harbor Yacht Club in mid-May 2005.

Field results to-date have been very favorable. As of late September, 220 tagged-fish have been recaptured. Long-term survival experiments (pen studies) were conducted from June to October. Because this activity continued past June, it will be documented separately and included in our annual report.

2. Benthic Monitoring

No benthic monitoring was performed during this period.

3. Entrainment Monitoring

PNPS has been monitoring entrainment of fish eggs and larvae, and lobster larvae in the plant's cooling water for more than twenty-five years (in 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 Marine Research, Inc. (MRI) in conjunction with Pilgrim environmental personnel, and reviewed and approved by U.S. EPA and MA DEP on the basis of the program results. Plankton monitoring in 2005 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 3.2.

4. Impingement Monitoring

The PNPS impingement monitoring and survival program identifies, quantifies and determines viability of the organisms carried onto the four intake traveling screens. Marine Research, Inc. conducted impingement sampling with results reported to Entergy's Environmental Protection Dept.

Results of the impingement monitoring for this reporting period are discussed in Section 3.3.

C. Station Operation History

Monthly average capacity factors for the first half of 2005 are shown below. During this period, one thermal backwash for biofouling control was performed (June 28th). PNPS was operated at or near full power during the first six months of 2005, with the exception of one planned shutdown. Beginning on April 18, and ending on May 13, 2005 (24½ days), Pilgrim had a planned refueling outage (RFO-15). During this outage both circulating (condenser cooling) water pumps were secured for 18 days (April 20th to May 8th).

The monthly average amount of sea water used for plant cooling water as well as the average discharge water temperatures are also shown below. Flow volume is given as percent of total possible discharge flow from both the circulating water and salt service water systems. The nominal capacities for these intake pumps are: 155,500 gal/min. for each circulating water pump [2] and 2500 gal/min. for each salt service water pump [5]. To estimate annual entrainment, the average flow value is assumed to be 320,335 gal/min. (99% of maximum possible cooling water flow).

2005 MONTH	CAPACITY FACTOR	DISCHARGE TEMP. (°F)	DISCHARGE FLOW (%)
January	99.0	65.4	97.5
February	98.1	63.4	97.7
March	97.0	63.9	97.7
April	49.5	56.9	58.9
May	60.4	75.7	68.7
June	99.0	81.6	97.8

SUMMARY

Results of the January-June 2005 Environmental Surveillance and Monitoring Program at Pilgrim are highlighted below.

Section 3.1-Marine Fisheries Monitoring:

1. Trawls for winter flounder stock assessment were performed for the eleventh consecutive year. The "area-swept" study consisted of 75 tows in northwestern Cape Cod Bay to estimate this species' population (instantaneous abundance).

2. Winter flounder population size (instantaneous abundance) was estimated using an area/density approach, based on the area-swept densities over the entire study area.

3. Adjusted estimates of winter flounder abundance in the study area for 2005 were 126,118 adults and 229,156 total winter flounder.

Section 3.2-Entrainment Monitoring:

1. A total of 35 species of fish were represented in the January-June samples.

2. Winter-early spring samples were dominated by the Atlantic cod and witch flounder egg group and American plaice eggs along with sand lance, rock gunnel and grubby larvae.

3. Late spring-summer collections taken in May and June were dominated by labridae-*Limanda*, and Atlantic mackerel eggs along with radiated shanny, winter flounder, cunner and rockling larvae.

4. A review of January-June 2005 egg and larval densities suggested that, in most cases, numbers were consistent with those recorded from 1981 through 2004. An exception was noted in the June labridae-*Limanda* eggs, which had a lower mean density than previous years.

5. Fourteen (14) stage 1 and one (1) stage 2 lobster larvae were collected in entrainment samples for the January-June 2005 period.

Section 3.3-Impingement Monitoring:

1. In 202.2 collection hours, a total of 490 fish comprising 25 species were collected from January-June 2005, resulting in a mean impingement rate of 2.61 fish/hour.

2. Impingement rates ranged from 6.72 fish/hour in April to 0.05 fish/hour in June.

3. Atlantic silversides (*Menidia menidia*), rainbow smelt (*Osmerus mordax*), pollock (*Pollachius virens*), winter flounder (*Pseudopleuronectes americanus*), Atlantic herring (*Clupea harengus*). grubby (*Myoxocephalus aenaeus*), and Atlantic menhaden (*Brevoortia tyrannus*) accounted for 56.6, 11.8, 6.7, 6.5, 4.9, 2.7, and 2.2%, respectively, of the six month total.

4. From January to June 2005, 379 invertebrates representing 12 species were sampled yielding an impingement rate of 1.87 invertebrates per hour (Table 3). Sevenspine bay shrimp (*Crangon septemspinosa*) accounted for 68.3% of the six-month total.

Pilgrim Nuclear Power Station
Marine Ecology Studies
Semi-Annual Report # 66

Section 3.1

Marine Fisheries Monitoring

WINTER FLOUNDER

AREA-SWEPT ESTIMATE

WESTERN CAPE COD BAY 2005

Submitted to

Entergy Nuclear Operations, Inc.

Pilgrim Nuclear Power Station

Plymouth, Massachusetts

by

Marine Research, Inc.

Falmouth, Massachusetts

October 24, 2005

Introduction

Field studies around Pilgrim Nuclear Power Station (PNPS) have demonstrated the water withdrawal affects of plant operations, specifically the entrainment of fish eggs and larvae, and impingement of adult and juvenile fish and invertebrates. The environs around PNPS serve as spawning, nursery, and feeding grounds for winter flounder (*Pseudopleuronectes americanus*) and this species is valuable both commercially and recreationally. From 1995 through 1999 the Massachusetts Division of Marine Fisheries (MDMF) estimated the size of the winter flounder population in waters off Pilgrim Station. This study has been continued by Marine Research, Inc. (MRI) since 2000, the 2005 work being presented here.

Methods and Materials

The study area, sampling methodology, and analytical calculations were the same as those used in the Massachusetts Division of Fisheries studies conducted in 1999 and by Marine Research, Inc. (MRI) from 2000 through 2004. Consistent with the past four years, tow duration was 30 minutes and tows less than 20 minutes were not included in calculations. Eighty-four tows were planned for 2005 consistent with previous years. The sampling area extended from Humarock, Marshfield southeastward to the Mary Ann buoy, Manomet, from nearshore (9.2 m MLW) out to the 36.6 m (MLW) depth contour (Figure 1; Lawton et al. 2000). Since there is spatial variation in winter flounder abundance by depth (Lawton et al. 1995), stratified estimates of abundance were used to improve precision.

The 55-foot F/V *Frances Elizabeth* was contracted to sample winter flounder using a Yankee otter trawl with 18.3 m sweep and 14.6 m headrope with 15.2 cm stretch mesh body and a 7.6 cm square mesh cod end with a 4.5 cm mesh liner; it was fished with 12.8 m legs and 73.2 m ground cables. The trawl doors were steel measuring 1.8 m x 1.2 m and weighing 205 kg each.

Beginning and end latitude and longitude, start and end times, and boat speed were recorded during each tow. Tow tracks were plotted with Nobeltec Visual Navigation Suite. All winter flounder were measured to the nearest centimeter total length (TL), sexed by assessing the reproductive state and maturity. This included checking for the presence of ripe eggs or sperm and for the presence of ctenoid scales on the left (blind) side of the caudal peduncle. Ctenoid scales often occur on mature males. Prior to being released all fish were examined for tags (MDMF tagging study 1994 to 1998; Lawton et al. 2000).

Winter flounder population size (instantaneous absolute abundance) was estimated using an area/density approach, based on the area-swept densities over the entire study area. Calculations were completed using the same procedures employed in 1999 by Lawton et al. (2000). Trawl gear efficiency was unknown and assumed to be 50% consistent with previous estimates. Density was determined by dividing the number

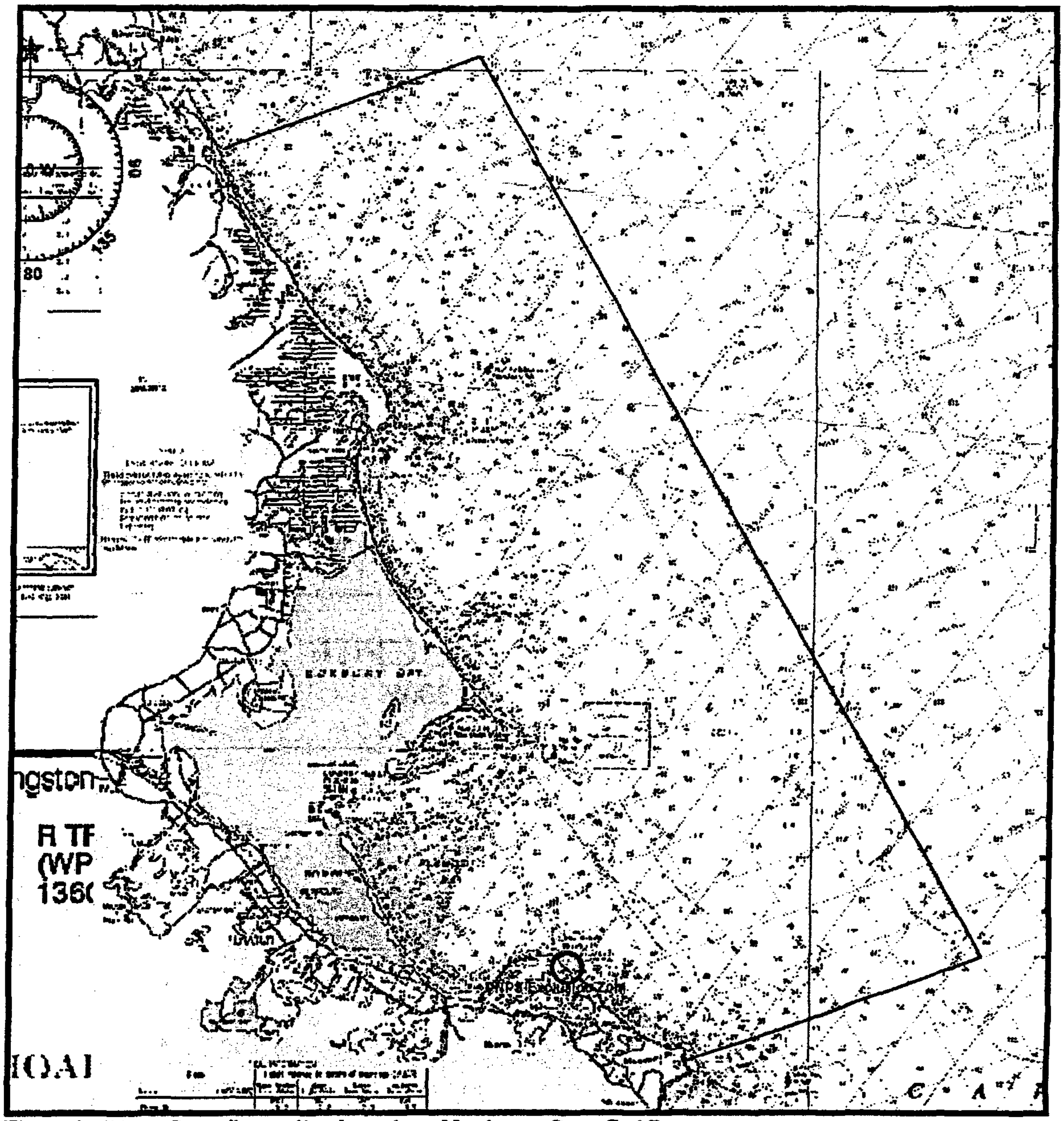


Figure 1. "Area-Swept" sampling boundary, Northwest Cape Cod Bay.

of winter flounder per tow by the area of bottom covered. Bottom area was based on tow length and tow width. Tow length was taken from the tracks generated by the Nobeltec software. Tow width was estimated using the trawl doors' spread on the bottom. Spread was determined by measuring the between-wire width at the blocks and at six feet aft of the blocks and extrapolated to account for the wire out (usually 450 feet) yielding a typical door spread of 175 feet (54 meters). Door spread was used because of the "herding" action caused by the sediment cloud generated by the doors and legs while towing (Somerton 2003, Somerton and Weinberg 2001, Lawton et al. 2000, Ramm and Ziao 1995, Dickson 1993a and Dickson 1993b). Catch per unit area was calculated for each tow. Computed estimates for adult winter flounder ($\geq$280 mm TL; Witherell and Burnett 1993) and for all sizes pooled were doubled to account for assumed catch efficiency. Density estimates were multiplied by total acreage (2.674×10^8 m^2)[1] in the study area to calculate absolute abundance.

Results and Discussion

In 2005, 4,206 winter flounder were taken in 75 tows completed between April 13 and May 4 yielding a mean catch of 56 fish per tow (catch per unit effort, CPUE). The CPUE for 2005 was lower than all previous years except for 1995 (Figure 2). The relative low abundance observed in 1995, 1996 and 1999 may be attributed to the use of a different fishing vessel with possibly different catch efficiencies (Figure 3).

Unadjusted estimates of winter flounder abundance in the study area for 2005 were 63,059 adults and 114,578 total winter flounder. These estimates were doubled to account for trawl efficiency which was assumed to be 50%; the adjusted numbers were 126,118 and 229,156, respectively (Table 1). Winter flounder absolute abundance estimates for adults and total winter flounder were below average in 2005 based on the 1995 - 2004 time series, 42% and 41% of their respective means of 303,358 and 556,771.

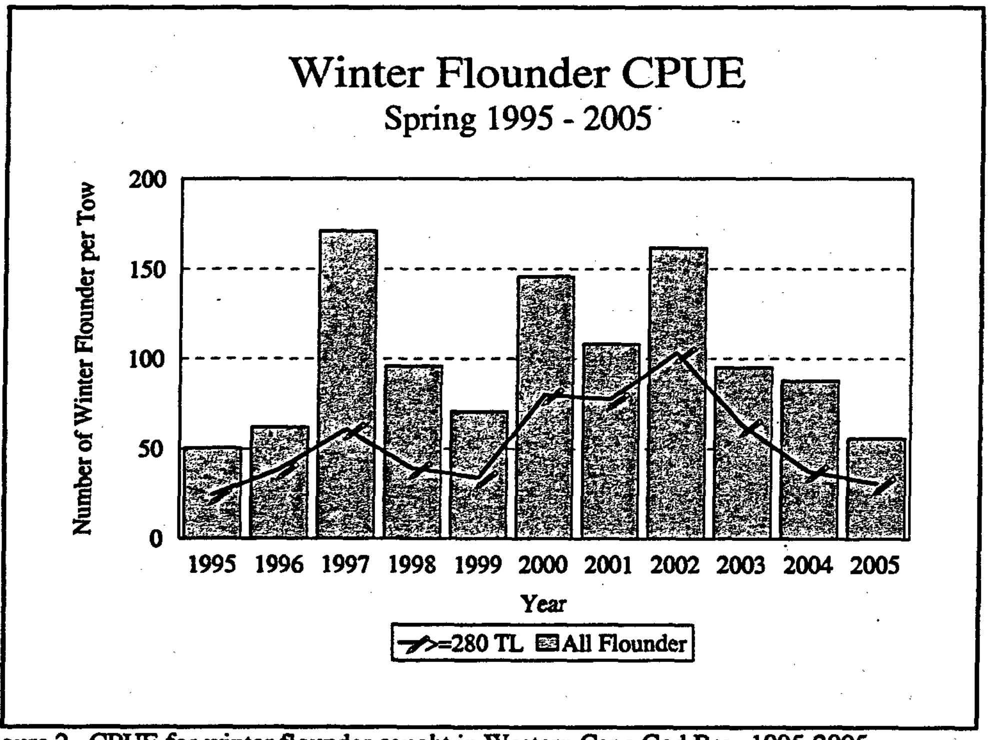


Figure 2. CPUE for winter flounder caught in Western Cape Cod Bay, 1995-2005.

[1] In 1995 and 1996 an acreage figure of 1.526×10^8 m^2 was originally used. Beginning with 1997 this larger value was employed. The 1995 and 1996 estimates were corrected accordingly.

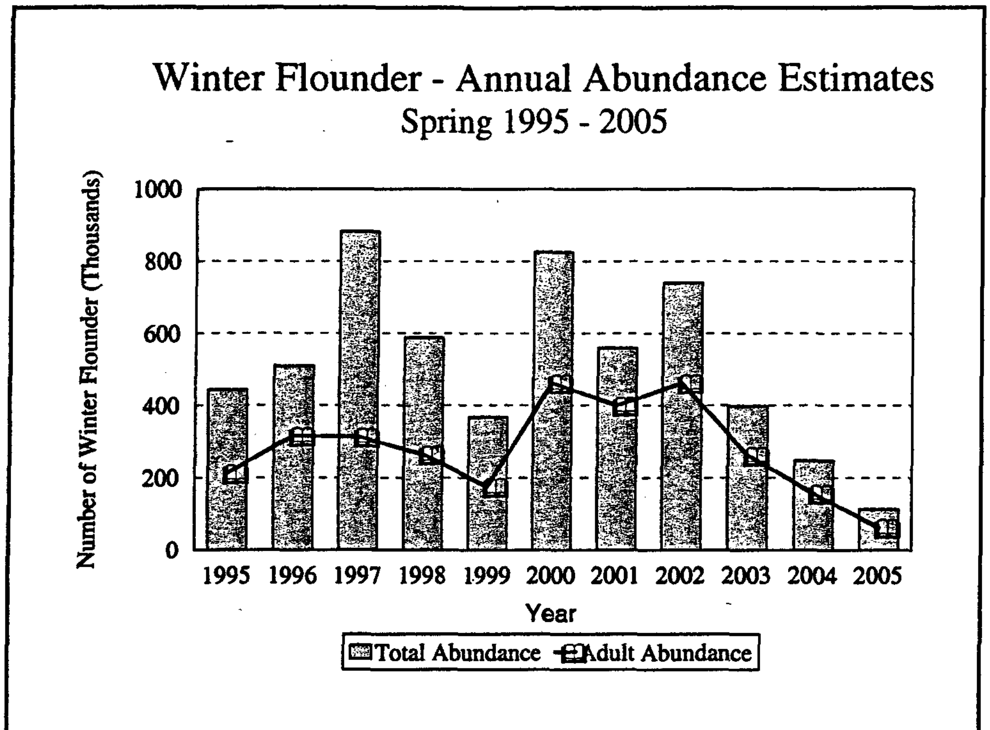
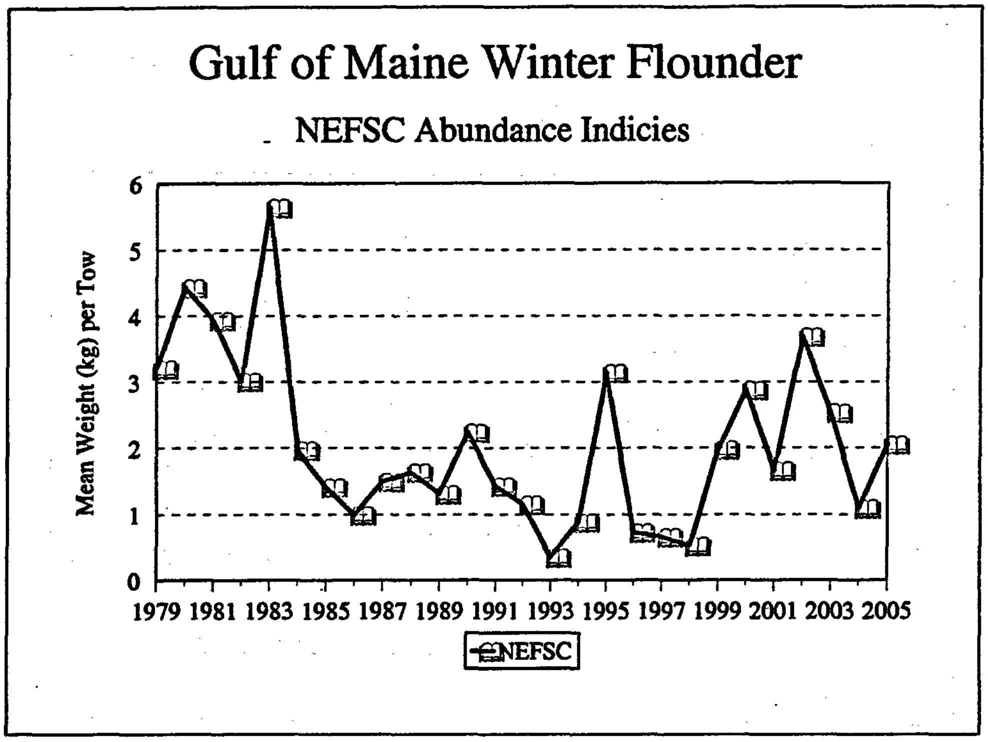


Figure 3. Estimated annual abundance of winter flounder in Western Cape Cod Bay, 1995-2005.

Recent estimates of fishing mortality suggest that it is relatively low with an estimated exploitation rate of 12% in 2001 and 2002. The Gulf of Maine stock is not considered to be in an overfished state and overfishing is not believed to be taking place at the present time (NEFSC 2003, NEFSC 2005). The low 2005 area swept estimate is likely the result, at least in part, to the natural and fishing induced decline in the strong 1997 and 1998 year classes. A review of the NOAA Northeast Fisheries Science Center (NEFSC) spring abundance index has also shown a sharp drop in the Gulf of Maine stock from 2002 (3.7 kg per tow) to 2004 (1.1 kg per tow). The MDMF resource assessment time series for the northern flounder stock extending from the New Hampshire border to Cape Cod (Howe et al. 1994) has also dropped from 35.6 kg per tow in 2000 to 12.2 kg per tow in 2004 (Figure 4; NEFSC 2005). These data suggest that the decline observed in Western Cape Cod Bay is not local to the PNPS area.

It is important to note that the assumed trawl efficiency value of 50% almost certainly varies from year to year and was selected to be conservative. It is probably lower than 50% particularly for small fish which would result in higher population estimates than those presented. For example, Kuipers (1975) reported efficiency of 28% for a beam trawl which is typically more efficient than an otter trawl. Harden-Jones et al. (1977) cited in Gunderson (1993) used sonar to estimate that 44% of plaice positioned between the trawl doors were captured. Mearns and Allen (1978) reported efficiencies of 10 to 50% for a small otter trawl. Kjelson and Colby reported a range of efficiencies from 9 to 51%, Grosslien and Laurec (1982) efficiencies of 26 to 38%, and Walsh (1992) values that ranged from as low as 5% for small flounder to 75% for adults.



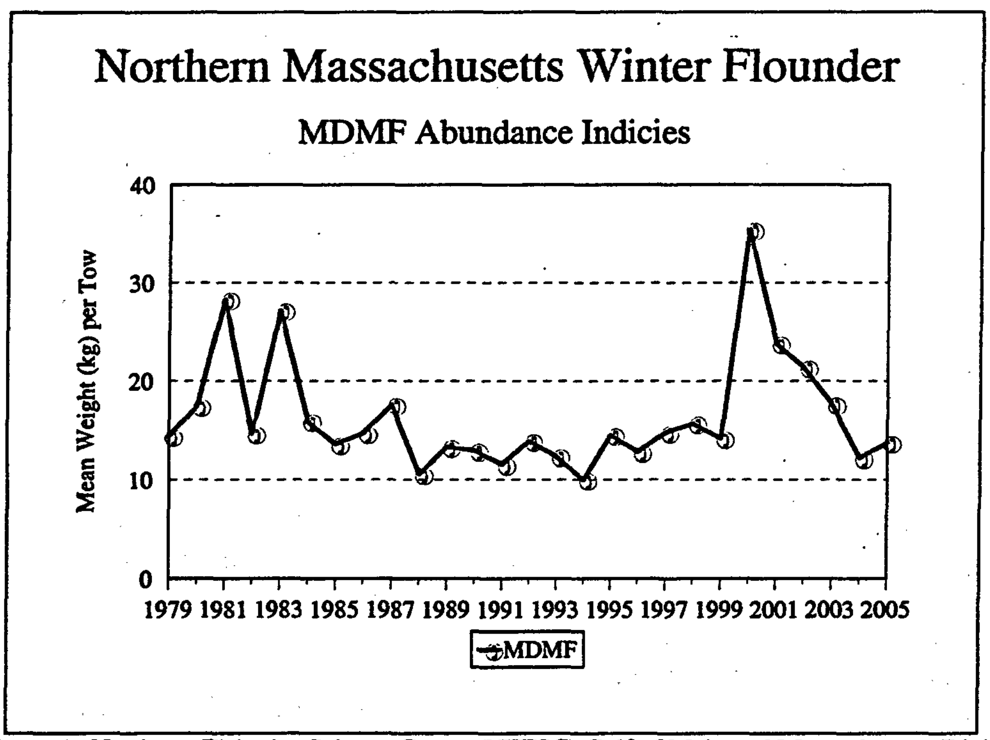


Figure 4. Northeast Fisheries Science Center (NEFSC) Gulf of Main and Massachusetts Division of Marine Fisheries (MDMF) northern stock spring abundance indices for winter flounder stocks, mean weight (kg) per tow, 1979-2005.

The Coastal Lobster Investigations Project of the Massachusetts Division of Marine Fisheries maintains temperature monitors in the vicinity of Plymouth at three depth strata (40, 60 and 110 feet). These data along with surface water temperature from National Data Buoy Center Station 44013 (Boston Buoy; available at http://www.ndbc.noaa.gov/station_page.php?station=44013) were plotted from April 1 through May 15 for 2000 to 2005 (Figure 5). Included on these plots is the daily winter flounder catch per tow for each sampling day in Western Cape Cod Bay. These figures show that bottom water in 2005 was colder than the previous five years. From April 21 to 25 there was more than a 3° C drop in water temperature at the 40-foot, 60-foot and 110-foot monitors. Cool water temperatures in general and this decline in bottom water temperature may have delayed the inshore migration of mature winter flounder.

Length frequency data for 2005 exhibited a bimodal distribution (Figure 6). The majority of fish sampled were age 3 and 4 representing the 2002 and 2001 year classes, respectively (Witherell and Burnett 1993). The second mode was age 2 fish. As in previous years, due to the selectivity of the net and the 4.5 mm cod-end liner, the number of age 2 and younger fish was probably under sampled (Lawton et al. 2000).

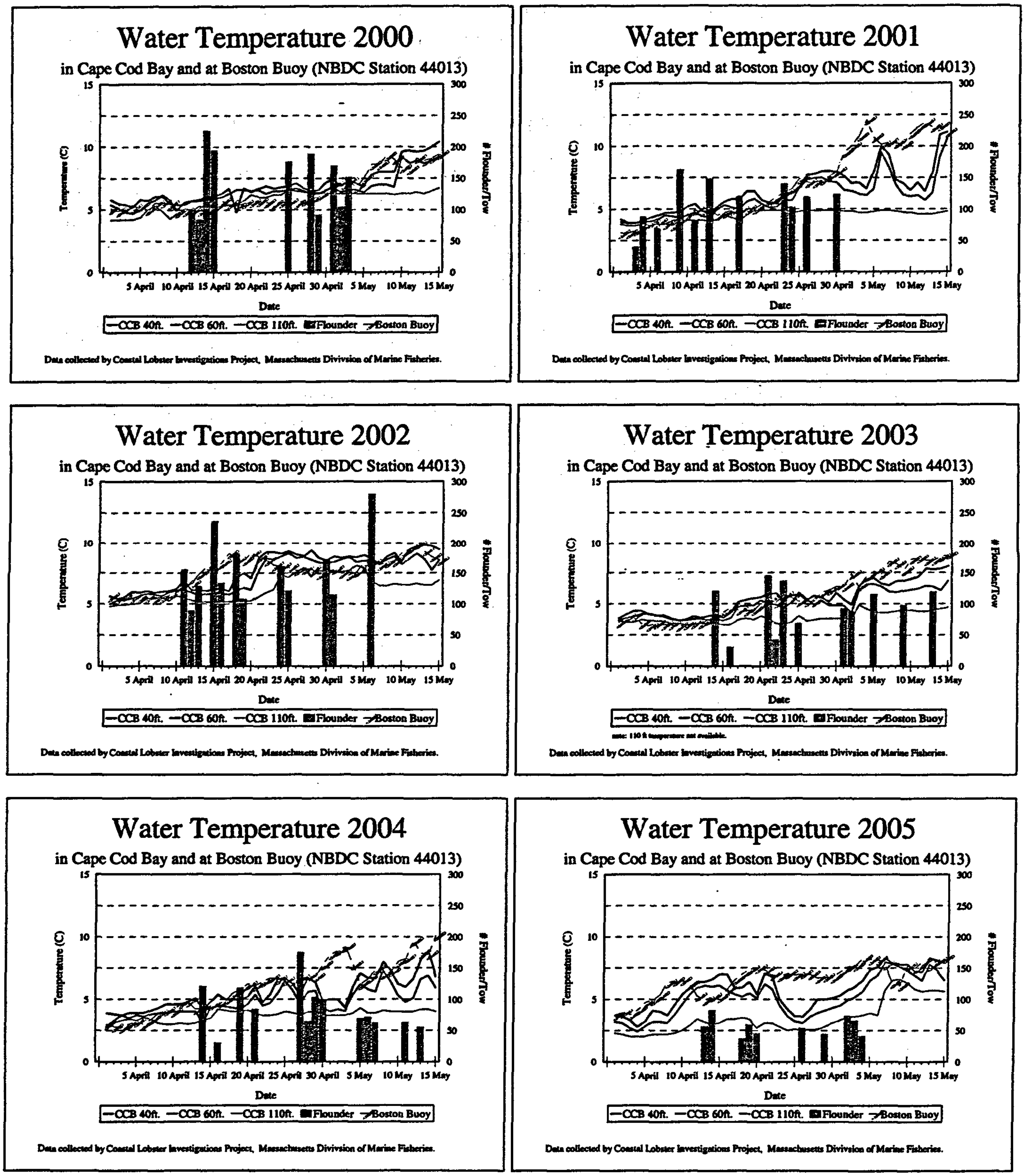


Figure 5. Mean daily water temperatures (April 1 to May 15) in Cape Cod Bay (at three depth strata) and at Boston Buoy (NBDC Station 44013) surface and daily catch per tow, 2000 to 2005.

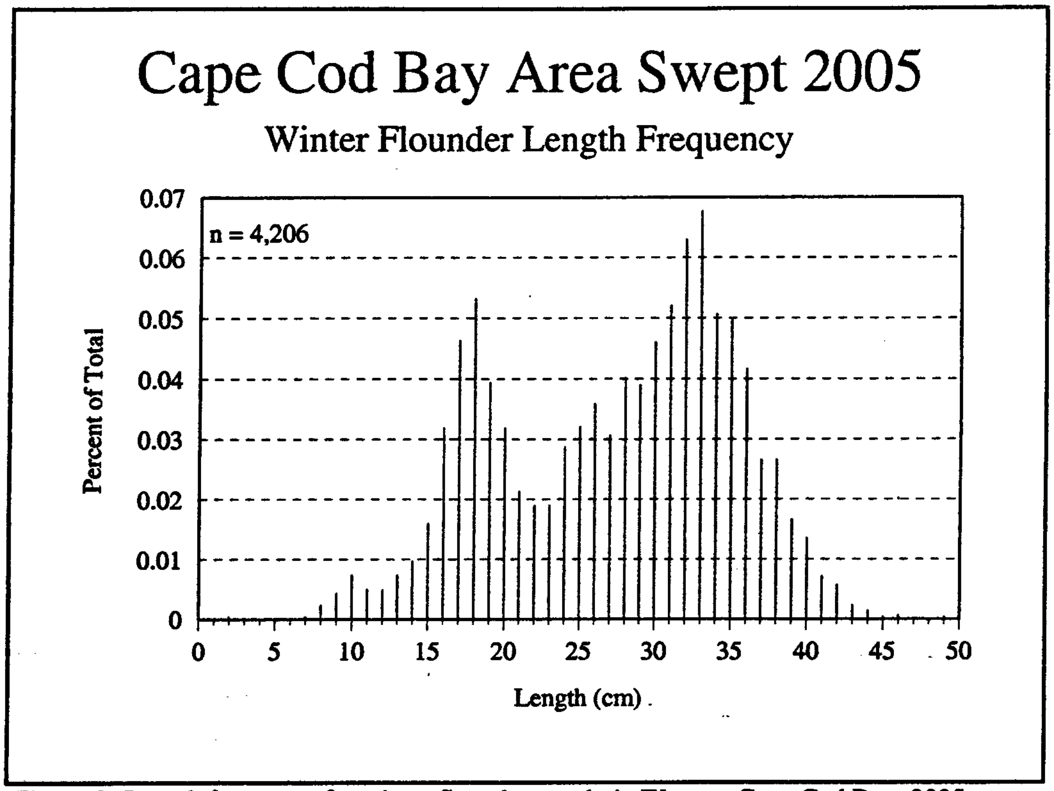


Figure 6. Length frequency for winter flounder caught in Western Cape Cod Bay, 2005.

Table 1. Estimated abundance (stratified by depth) of winter flounder in the study area (2.674×10^8 m^2 at MLW) with 95% confidence limits, Spring 1995-2005.

Year	Category	Number of flounder	Lower 95% CL	Upper 95% CL
1995	Flounder ≥280 mm TL	212,989	210,637	215,341
	All Flounder	444,850	437,438	452,261
1996	Flounder ≥280 mm TL	316,986	314,365	319,607
	All Flounder	510,306	506,378	514,235
1997	Flounder ≥280 mm TL	313,959	308,896	319,021
	All Flounder	882,889	887,834	887,945
1998	Flounder ≥280 mm TL	264,812	242,779	286,825
	All Flounder	588,450	553,330	623,570
1999	Flounder ≥280 mm TL	176,271	172,306	180,236
	All Flounder	367,908	360,826	374,989
2000	Flounder ≥280 mm TL	464,176	450,222	478,126
	All Flounder	826,548	807,952	845,144
2001	Flounder ≥280 mm TL	400,812	330,709	470,914
	All Flounder	559,713	471,109	648,316
2002	Flounder ≥280 mm TL	476,263	429,430	523,096
	All Flounder	741,108	725,285	756,932
2003	Flounder ≥280 mm TL	262,604	223,957	301,247
	All Flounder	398,528	387,156	409,898
2004	Flounder ≥280 mm TL	157,532	154,555	160,509
	All Flounder	247,411	242,226	252,596
2005	Flounder ≥280 mm TL	126,117	124,107	128,127
	All Flounder	229,156	226,144	232,169

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Pilgrim Nuclear Power Station
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Semi-Annual Report # 66

Section 3.2

Entrainment Monitoring

ICHTHYOPLANKTON ENTRAINMENT MONITORING

AT PILGRIM NUCLEAR POWER STATION

JANUARY - JUNE

2005

Submitted to

Entergy Nuclear Generation Company

Pilgrim Nuclear Power Station

Plymouth, Massachusetts

by

Marine Research, Inc.

Falmouth, Massachusetts

October 11, 2005

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*Available upon request.

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SECTION I

SUMMARY

Entrainment sampling at PNPS during the first half of 2005 was completed on five occasions during January and six in February. Sampling then occurred three times per week from March through June, except during the maintenance outage from April 18 to May 10, and on two storm occasions, March 11 and May 25.

A total of 35 species of fish were represented in the January - June samples. Winter-early spring samples were dominated by the Atlantic cod and witch-flounder egg group and American plaice eggs along with sand lance, grubby and rock gunnel larvae. Late spring-summer collections taken in May and June were dominated by labridae-*Limanda* and Atlantic mackerel eggs along with winter flounder, cunner, rockling, and radiated shanny larvae.

A review of January-June 2005 egg and larval densities suggested that, in most cases, numbers were consistent with those recorded from 1981 through 2004. An exception was noted in the June labridae-*Limanda* eggs which had a lower monthly mean density than previous years. Several unusually high densities were also recorded during the January-June 2005 period although they did not result in remarkable monthly mean densities relative to the PNPS time series.

Fourteen stage 1 and one stage 2 lobster larvae were found during the January-June 2005 entrainment sampling period. Previously, a total of 46 lobster larvae have been collected at PNPS dating back to 1974.

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 2005 by Marine Research, Inc. (MRI) for Entergy Nuclear Generating Company under Contract No. 4500538686. A more detailed annual report covering all 2005 data will be prepared following the July-December monitoring period.

SECTION III
METHODS AND MATERIALS

Monitoring

Entrainment sampling at PNPS, begun in 1974, was originally completed twice per month during January and February, October-December; weekly during March through September; in triplicate at low tide. Following a PNPS fisheries monitoring review workshop in early 1994, the sampling regime was modified beginning April 1994. The revised program exchanged replication for improved temporal coverage. In January, February, and October through December during two alternate weeks each month single samples were taken on three separate occasions. Beginning with March and continuing through September single samples were taken three times every week. During autumn and winter months when sampling frequency was reduced, sampling was postponed during onshore storms due to heavy detrital loads. The delayed sample was taken during the subsequent week, six samples ultimately being taken each month.

To minimize costs, sampling was linked to the impingement monitoring program so that collections were made Monday morning, Wednesday afternoon, and Friday night regardless of tide (see Impingement Section). 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 *(Pseudopleuronectes americanus).* Sampling time in each case varied from 8 to 30 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 astronomically high tides it proved difficult to collect this amount even with long sampling intervals since the net would not inflate in the low current velocity near high tide. Exact filtration volumes were calculated using a General Oceanics Model 2030R digital flowmeter mounted in the mouth of the net. Near times of high water a 2030 R2 rotor was employed to improve sensitivity at low velocities.

All samples were preserved in 10% Formalin-seawater solutions and returned to the laboratory for microscopic examination. A detailed description of the analytical procedures including developmental staging and a description of egg groupings 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).

Samples were examined in their entirety for larval American lobster (*Homarus americanus*). When collected these were staged following Herrick (1911).

<u>Unusual Entrainment Values</u>

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 effect 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, regulatory personnel requested additional entrainment sampling, 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 has been relatively easy to discern without additional sampling effort.

"Unusually abundant" was defined within monthly periods to deal with the large seasonal variation so readily apparent with ichthyoplankton and allowed tracking densities as each species' season progressed. On a month-by-month basis, for each of the numerically dominant species, all previous mean densities over three replicates (1974-1993; updated each year) were examined and tested for normality following logarithmic transformation. Single sample densities obtained from 1994-2004 were added to the pool within each month. Where data sets (for example, mackerel, *Scomber scombrus* 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] Log densities were back-transformed to make them easier to interpret thus providing geometric means. 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, 1986, 1996, NUSCO 1993, Smith 1988). 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.,

[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 range of the mean ± 2.58s. 99.5% of all normally distributed values lie below a value equal to the mean + 2.58s.

relatively greater densities were necessary to trigger notification). Species of commercial, 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, 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 2005 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.

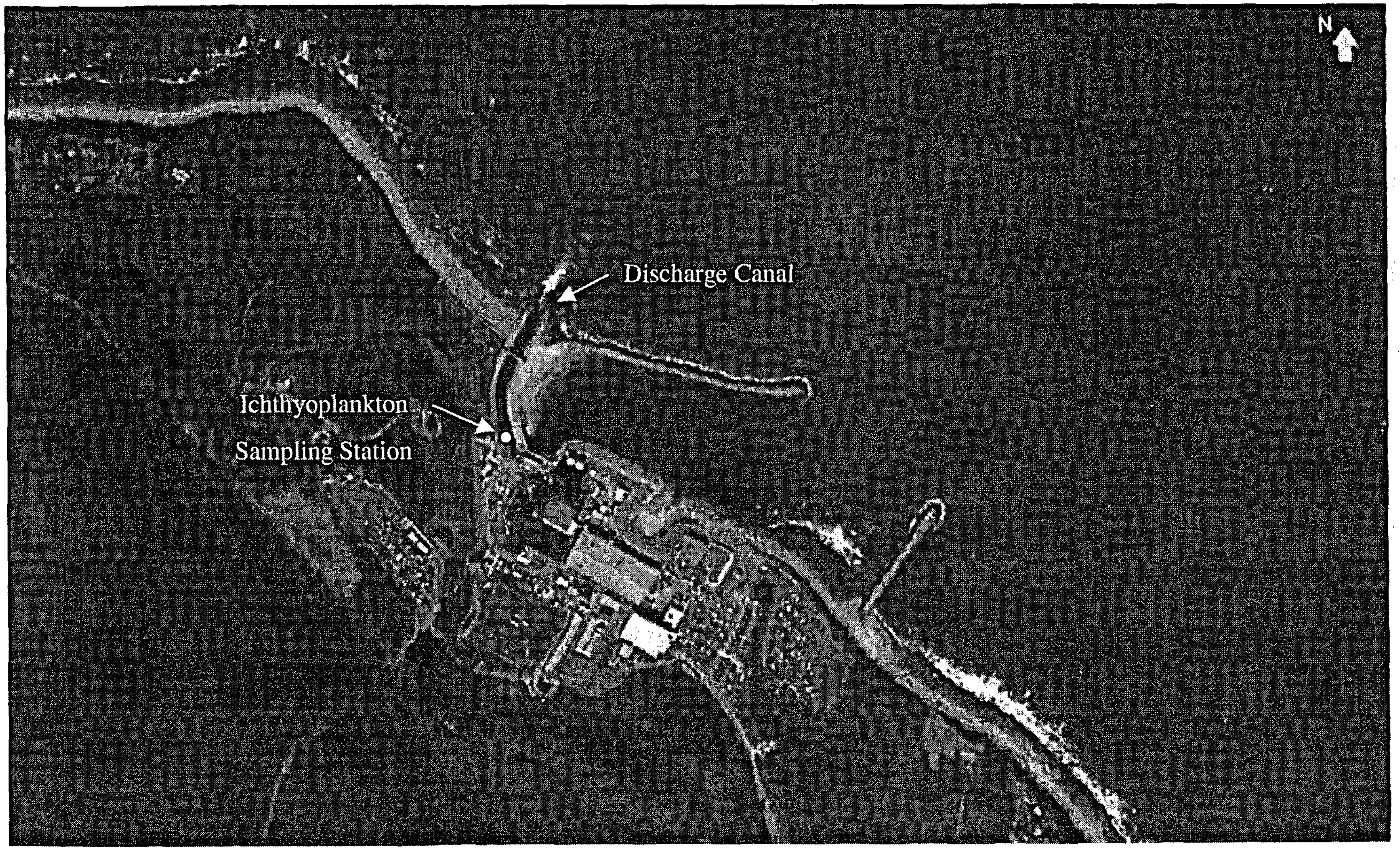

Figure 1. Aerial photograph of the entrainment sampling station in the PNPS discharge canal.

Table1. PNPS ichthyoplankton entrainment values for 2005 by species category and month used to determine unusually high densities. See text for details.

Densities per 100 m³ of water:	Long-term Mean[1]	Mean + 2 std.dev.	Mean + 2.58 std.dev.	Previous High (Year)
<u>January</u>				
LARVAE				
Atlantic herring[2]	0.2	1		38.0 (1999)
Sculpin	0.9		2	9.7 (1999)
Rock gunnel	4.0		7	78.1 (2002)
Sand lance[2]	5	11		337.0 (1996)
<u>February</u>				
LARVAE				
Atlantic herring[2]	0.5	0.7		8.0 (2002)
Sculpin	2		65	183.1 (1998)
Rock gunnel	5		177	133.0 (1999)
Sand lance[2]	16	29		372.9 (1995)
<u>March</u>				
EGGS				
American plaice[2]	2	3		19.0 (1977)
LARVAE				
Atlantic herring[2]	2	3		28.5 (1997)
Sculpin	17		608	454.1 (1995)
Seasnails	0.6		1	14.4 (1980)
Rock gunnel	10.7		723	882.2 (1997)
Sand lance[2]	7	164		708.0 (2002)
Winter flounder[2]	0.4	0.7		16.2 (1997)
<u>April</u>				
EGGS				
American plaice[2]	3	32		70.3 (1978)
LARVAE				
Atlantic herring[2]	1	2		38.3 (1999)
Sculpin	15		391	386.2 (1985)
Seasnails	6		8	98.1 (1974)
Radiated shanny	5		7	59.6 (1974)
Rock gunnel	4		142	121.1 (1992)
Sand lance[2]	21	998		2590.6 (1994)
Winter flounder[2]	7	12		198.3 (1994)

Table 1 (continued).

Densities per 100 m³ of water:	Long-term Mean[1]	Mean + 2 std.dev.	Mean + 2.58 std.dev.	Previous High (Year)
May				
EGGS				
Labrids[2]	36	3514		34050.0 (1974)
Atlantic mackerel[2]	18	4031		19203.0 (1995)
Windowpane[2]	9	147		319.0 (2000)
American plaice[2]	2	15		87.2 (2003)
LARVAE				
Atlantic herring	0.7	1.1		10.5 (1975)
Fourbeard rockling	4.1		8	104.5 (1997)
Sculpin	3		4	78.3 (1997)
Seasnails	7		208	164.4 (1974)
Radiated shanny	7		236	266.9 (1998)
Sand lance[2]	37	59		639.1 (1996)
Atlantic mackerel	2	4		377.6 (1998)
Winter flounder[2]	9	123		573.8 (1998)
June				
EGGS				
Atlantic menhaden[2]	14	22		799.7 (1998)
Searobins	2		3	128.0 (1987)
Labrids[2]	958	21599		37282.0 (1995)
Atlantic mackerel[2]	63	3515		8193.2 (1990)
Windowpane[2]	27	261		355.5 (1998)
American plaice[2]	1	3		35.0 (1980)
LARVAE				
Atlantic menhaden[2]	6	10		495.9 (1981)
Fourbeard rockling	9		634	224.0 (1992)
Hake	0.3		1	50.6 (1998)
Cunner[2]	54	87		2215.6 (1998)
Radiated shanny	7		10	262.2 (1996)
Atlantic mackerel[2]	91	155		2700.0 (1981)
Winter flounder[2]	10	106		813.5 (1998)

SECTION IV
RESULTS

Population densities per 100 m^3 of water for each species listed by date, station, and replicate are presented for January-June 2005 in Appendix A (available upon request). The occurrence of eggs and larvae of each species by month appears in Table 2. Species occurring in egg groups, such as *Paralichthys-Scophthalmus,* were indicated as collected only if late-stage eggs were specifically identified and/or larvae were present in that month.

Ichthyoplankton entrained during January through April generally represent winter-early spring spawning fishes. Many of these species employ a reproductive strategy that relies on demersal, adhesive eggs not normally entrained. As a result, more species are typically represented by larvae than by eggs during the early portion of the year. Over both life stages the number of species represented in the catch increased from 6 in January to 17 in April. Egg collections in winter-early spring were numerically dominated by the Atlantic cod - witch-flounder egg group, and American plaice eggs. These species accounted for 83 and 8% of the total egg catch during the period, respectively. The cod - witch flounder egg group was entrained from January through April with monthly geometric mean densities of 2.1, 1.3, 0.7, and 1.3 eggs per 100 m^3 of water, respectively. Atlantic cod was the prevalent species in this group from January through March based on the proportion of late-stage eggs. American plaice eggs were entrained in March and April with monthly geometric mean densities of 0.1 and 0.7 eggs per 100 m^3 of water, respectively.

In the winter-early spring 13 species of larval fish were collected from the discharge canal. The sand lance, grubby (*Myoxocephalus aenaeus*) and rock gunnel (*Pholis gunnellus*) made up the majority of the larval fish collected from January to April, contributing 82, 9, and 5% of the total captured. Sand lance was the predominant larval species throughout the time period; they were most abundant during March and April, with monthly geometric mean densities of 36.4 and 27.1 larvae per 100 m^3 of water. They comprised 87 and 80% of the total collected in March and April, respectively. Grubby had peak numbers in March with a monthly mean density of 9.8 per 100 m^3, comprising 6.5% of all larvae collected. The rock gunnel peak density also occurred in March with a geometric mean density of 6.4 fish per 100 m^3.

May and June (along with July) represents the late spring-summer ichthyoplankton season, typically the most active reproductive period among temperate fishes. The eggs of 16 fish species were collected during this season. Of those collected labrid (tautog/cunner)-yellowtail flounder (grouped together) and Atlantic mackerel eggs were the dominant species, comprising 74 and 17% of the total egg catch, respectively. Fourspot flounder-windowpane eggs (*Paralicthys-Scophthalmus*) were also found in abundance, making up an additional 3% of the late spring-summer eggs. Early and middle-stage tautog, cunner, and yellowtail flounder eggs were abundant in May and June with respective monthly mean densities of 24.9 and 159.3 eggs per 100 m^3. Based on the proportion of late stage eggs most of the labrid-yellowtail eggs were assumed to be those of tautog or cunner. Geometric mean monthly densities for Atlantic mackerel were 5.9 and 16.2 eggs per 100 m^3 for May and June, comprising 22 and 16% of the monthly total eggs collected, respectively. Fourspot flounder-windowpane monthly mean densities were 4.9 in May and 8.6 eggs per 100 m^3 of water in June.

Larval collections in late spring-summer contained 25 species, with 13 collected in May and 20 collected in June. Winter flounder was the dominant species during this period, making up 50.5% of the total collected for May and June combined. Monthly geometric mean densities of winter flounder were 5.7 and 10.3 larvae per 100 m^3 of water for May and June, respectively. Cunner ranked second among numerical dominants during this period, making up 14% of all larvae collected. Cunner abundance was highest in June with a monthly mean density of 4.3 larvae per 100 m^3 of water, accounting for 20% of that monthly total. Fourbeard rockling ranked third, accounting for 8% of the larvae collected during the spring-summer period. Abundance was highest in June with a monthly mean density of 3.7 larvae per 100 m^3 of water. The fourth numerically dominant species was the radiated shanny (*Ulvaria subbifurcata*), accounting for 7% of the larvae collected during May and June combined. Monthly mean densities were 1.3 and 2.0 larvae per 100 m^3 of water, respectively.

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 1981. 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 1984 and 1987, as well as May-June 1999 were shaded because low through-plant water volumes during those months probably affected densities of ichthyoplankton (MRI 1994). Entrainment data collected from 1975-1981 remain in an outdated computer format requiring conversion before geometric mean densities can be generated. These years were therefore excluded from comparison. Since 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 2005 suggests that in most cases monthly mean densities were consistent with previous years. The following notable observations were made during the first half of the year (Table 3). These will be assessed in greater detail in the annual report particularly as they relate to the annual abundance indices.

- For labridae-*Limanda* eggs June's monthly mean density was 159 eggs per 100 m^3 of water, lower than previous densities in the PNPS time series which ranged from a high of 3,619 in 1989 to a low of 226 eggs per 100 m^3 of water in 1994.
- Atlantic herring larvae were collected at relatively high densities on three occasions in January, two occasions in April, and three occasions in May 2005 (Table 3). In all three months the previous high value was exceeded on one occasion. On March 25 Atlantic herring larvae reached a density of 31 larvae per 100 m^3 of water, exceeding the previous high of 29 larvae per 100 m^3 of water observed in 1997. On April 15 the density of herring larvae reached 83 per 100 m^3 of water exceeding the 1999 record high for the month of 38 larvae per 100 m^3 of water. In May, the previous record of 11 larvae per 100 m^3 of water observed in 1975 was exceeded on May 10, 2005 with a density of 15 larvae per 100 m^3 of water.
- Sand lance larvae were collected at relatively high densities on two occasions in March (Table 3). On March 25 a larval sand lance density of 2,242 larvae per 100 m^3 of water was observed, exceeding the previous high value of 708 larvae per 100 m^3 of water observed in 2002.
- Winter flounder larvae were observed at high densities on two occasions in June, the 3rd and the 8th. On those dates larval densities of 138 and 256 larvae per 100 m^3 of water exceeded 98% and 99% of previous June values, respectively.
- Several other unusually high densities were recorded during the January – June 2005 period although they did not result in remarkable monthly mean densities relative to the PNPS time series (Table 3). These occurred for seasnail larvae (March), American plaice eggs (May), radiated shanny larvae (June), and cunner larvae (June). In the case of

seasnail, plaice, and cunner these involved single observations suggesting that overall seasonal abundance was not likely to have been remarkably high.

Fourteen stage 1 and one stage 2 lobster larvae were found in the entrainment samples collected during the first half of 2005. This represents the highest number of lobster larvae collected during the January - June period. The second highest number collected (N =10) occurred in 2003. Previously, only 46 larvae were collected at PNPS in total dating back to 1974 including a more intensive lobster larvae sampling program in 1976. No direct relationship between prevailing winds or tide at the time of sampling and the number of entrained larval lobster is apparent. However, since night sampling was added in 1995, 94% of the lobster larvae captured were collected during the Friday evening sampling period, representing 75% of the total larvae captured over the 32-year time period. The addition of a nighttime sample period has likely contributed to the increase in the observed number of lobster larvae entrained since adult female lobsters release larvae at night (Ennis 1975, Charmantier et al. 1991).

Additionally, Pilgrim Station established a protection zone around the plant extending seaward from the shorefront for a distance of approximately 1000 feet in October 2001. Within this zone no lobster harvesting is permitted, as a result there may be an increase in nearshore lobster reproductive activity and improvement in the success of larval release.

SECTION V
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Table 2: Species of fish eggs (E) and larvae (L) obtained in ichthyoplankton collections from the Pilgrim Nuclear Power Station Discharge canal, January-June, 2005.

Species		January	February	March	April	May	June
American eel	*Anguilla rostrata*			L	L		
Atlantic menhaden	*Brevoortia tyrannus*						E/L
Anchovy	*Anchoa spp.*						E
River Herring	*Alosa spp.*					L	
Atlantic herring	*Clupea harengus*	L		L	L	L	
Rainbow smelt	*Osmerus mordax*					L	L
Cusk	*Brosme brosme*						E
Fourbeard rockling	*Enchelyopus cimbrius*			E	E	E/L	E/L
Atlantic cod	*Gadus morhua*	E/L	E/L	E/L	E/L	E	E/L
Haddock	*Melanogrammus aeglefinus*				E	E	L
Silver hake	*Merluccius bilinearis*					E	E/L
Atlantic tomcod	*Microgadus tomcod*		L	L			
Hake	*Urophycis spp.*					E	E
Silversides	*Menidia spp.*						L
Northern pipefish	*Syngnathus fuscus*						L
Sea Raven	*Hemitripterus americanus*				L		
Grubby	*Myoxocephalus aenaeus*	L	L	L	L	L	L
Longhorn sculpin	*M. octodecemspinosus*		L				
Shorthorn sculpin	*M. scorpius*			L	L		
Seasnail	*Liparis atlanticus*		L	L	L	L	L
Wrasses	*Labridae*	E			E	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	*Crytacanthodes maculatus*			L	L		
Sand lance	*Ammodytes sp.*	L	L	L	L	L	L
Atlantic mackerel	*Scomber scombrus*					E/L	E/L

Table 2 (continued).

Species		January	February	March	April	May	June
Butterfish	*Peprilus triacanthus*					E	E/L
Windowpane	*Scophthalmus aquosus*					E	E/L
Witch Flounder	*Glyptocephalus cynoglossus*		E	E	E	E	E
American plaice	*Hippoglossoides platessoides*				E	E/L	E/L
Winter flounder	*Pseudopleuronectes americanus*				E/L	E/L	L
Yellowtail flounder	*Limanda ferruginea*				E/	E/L	E/L
Number of species		6	8	12	17	21	25

Table 3. Ichthyoplankton densities (number per 100 m^2 of water) for each sampling occasion during months when notably high densities were recorded, January – June, 2005. Densities marked by + were unusually high based on values in Table 1. Numbers in the last column indicate percent of all previous values during the month which were lower.

Atlantic herring larvae — March

2	0.0		
4	0.0		
7	0.0		
9	0.0		
14	0.8		
16	2.7	+	87
18	8.0	+	95
21	0.0		
23	0.0		
25	30.9	+	100
28	0.0		
30	0.0		

Previous high: 28.5 (1997)
Notice level: 2.0

Sand lance larvae — March

2	2.3		
4	0.0		
7	5.2		
9	1.7		
14	35.6		
16	32.5		
18	77.6		
21	37.7		
23	51.0		
25	2242.0	+	100
28	167.4	+	92
30	9.6		

Previous high: 708.0 (2002)
Notice level: 164.0

Seasnail larvae — May

2	0.0		
4	0.0		
7	0.0		
9	0.8		
14	0.0		
16	0.0		
18	3.6	+	97
21	0.0		
23	0.0		
25	0.0		
28	0.0		
30	0.0		

Previous high: 14.4 (1980)
Notice level: 1.0

Atlantic herring larvae — April

1	2.7		
4	0.0		
6	2.6		
8	4.2	+	84
11	0.0		
13	0.0		
15	83.1	+	100
18	0.0		

Previous high: 38.3 (1999)
Notice level: 3.0

Table 3 (continued).

American plaice eggs

May	10	2.2		
	11	8.6		
	13	0.0		
	16	0.0		
	18	1.4		
	20	40.8	+	98
	23	0.0		
	27	0.0		
	30	0.0		

Previous high: 87.2 (2003)
Notice level: 15.0

Atlantic herring larvae

May	10	15.2	+	100
	11	0.0		
	13	5.3	+	96
	16	0.0		
	18	0.0		
	20	0.8		
	23	1.0		
	27	0.0		
	30	1.6	+	90

Previous high: 10.5 (1975)
Notice level: 1.1

Winter flounder larvae

June	1	2.9		
	3	137.8	+	98
	6	62.8		
	8	256.4	+	99
	10	103.7		
	13	27.1		
	15	0.0		
	17	23.5		
	20	2.4		
	22	0.6		
	24	46.2		
	27	0.0		
	29	2.2		

Previous high: 813.5 (1998)
Notice level: 106.0

Radiated shanny larvae

June	1	2.9		
	3	1.0		
	6	3.1		
	8	1.9		
	10	21.7	+	91
	13	45.0	+	95
	15	0.0		
	17	4.6		
	20	0.0		
	22	0.0		
	24	000		
	27	0.6		
	29	0.0		

Previous high: 262.2 (1996)
Notice level: 10.0

Table 3 (continued).

		Cunner larvae		
June	1	0.0		
	3	0.0		
	6	0.0		
	8	0.0		
	10	0.0		
	13	1.0		
	15	0.0		
	17	0.7		
	20	15.9		
	22	1.2		
	24	28.6		
	27	128.9	+	94
	29	40.6		

Previous high: 2215.6 (1998)
Notice level: 87.0

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 2005.

*Available by 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 1981-2005.

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 1984, 1987, and 1999 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.

Pilgrim Nuclear Power Station
Marine Ecology Studies
Semi-Annual Report # 66

Section 3.3

Impingement Monitoring

IMPINGEMENT OF ORGANISMS on the INTAKE SCREENS

at PILGRIM NUCLEAR POWER STATION

JANUARY - JUNE 2005

Submitted to

Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station

Plymouth, Massachusetts

By

Marine Research, Inc.

Falmouth, Massachusetts

October 21, 2005

Summary

This report describes the monitoring of impinged organisms at Pilgrim Station based on screen wash samples taken from January through June 2005. Three scheduled screen wash periods were monitored each week; however there was no sampling from April 17 to May 10, 2005 due to a scheduled refueling outage. Fish impingement rates averaged 2.61 fish/hour from January to June 2005. Mean monthly impingement rates ranged from 6.72 in April to 0.05 fish/hour in June. Atlantic silversides (*Menidia menidia*), rainbow smelt (*Osmerus mordax*), pollock (*Pollachius virens*), winter flounder (*Pseudopleuronectes americanus*), Atlantic herring (*Clupea harengus*), grubby (*Myoxocephalus aenaeus*), and Atlantic menhaden (*Brevoortia tyrannus*) accounted for 56.6, 11.8, 6.7, 6.5, 4.9, 2.7, and 2.2%, respectively, of the six-month total.

Introduction

Pilgrim Nuclear Power Station (PNPS) is located on the northwestern shore of Cape Cod Bay (Figure 1) with a capacity of 685 megawatts electric. The unit has two circulating water pumps with a capacity of approximately 345 cfs (cubic feet per second = 155,500 gallons per minute each) and five service water pumps (2,500 gallons per minute each) with a combined capacity of 23 cfs. Water is drawn under a skimmer wall, through vertical bar racks spaced approximately three inches on center, and finally through vertical traveling screens of ½ x ¼ inch mesh (Figure 2). There are four vertical screens, two for each circulating water pump.

This report provides documentation of environmental monitoring and reporting requirements of NPDES Permit No. MA0003557 (USEPA) and No. 359 (MA DEP) at PNPS. It describes the monitoring of impinged organisms at Pilgrim Station based on screen wash samples taken from January through June 2005. A discussion of the relationships among impingement values, environmental factors, and plant operation will be provided in the annual report.

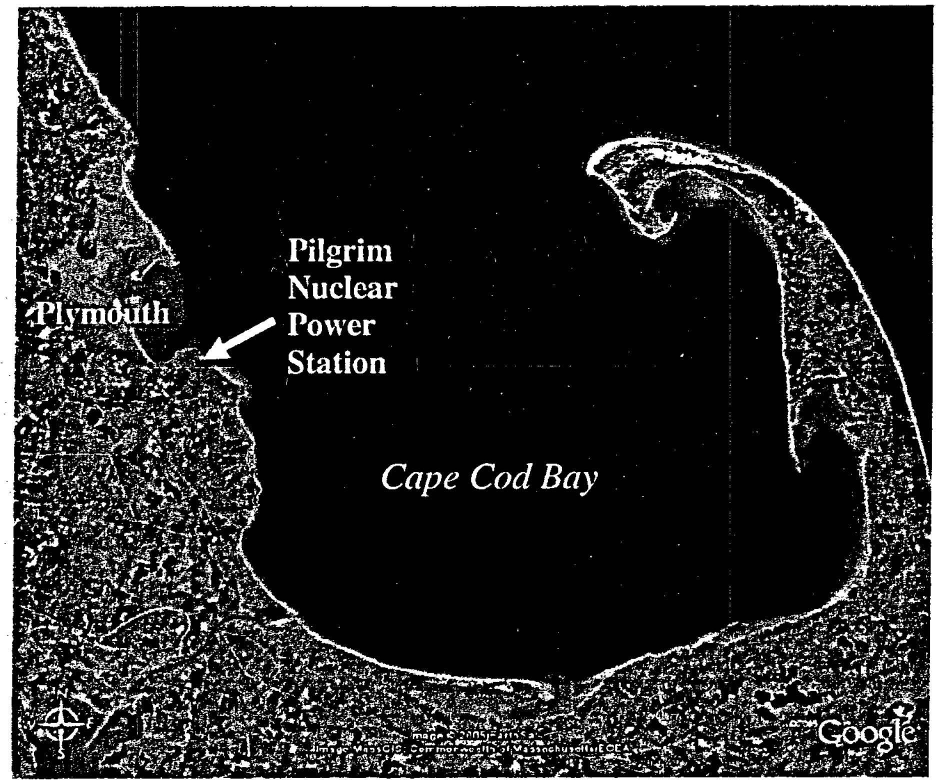

Figure 1. Location of Pilgrim Nuclear Power Station.

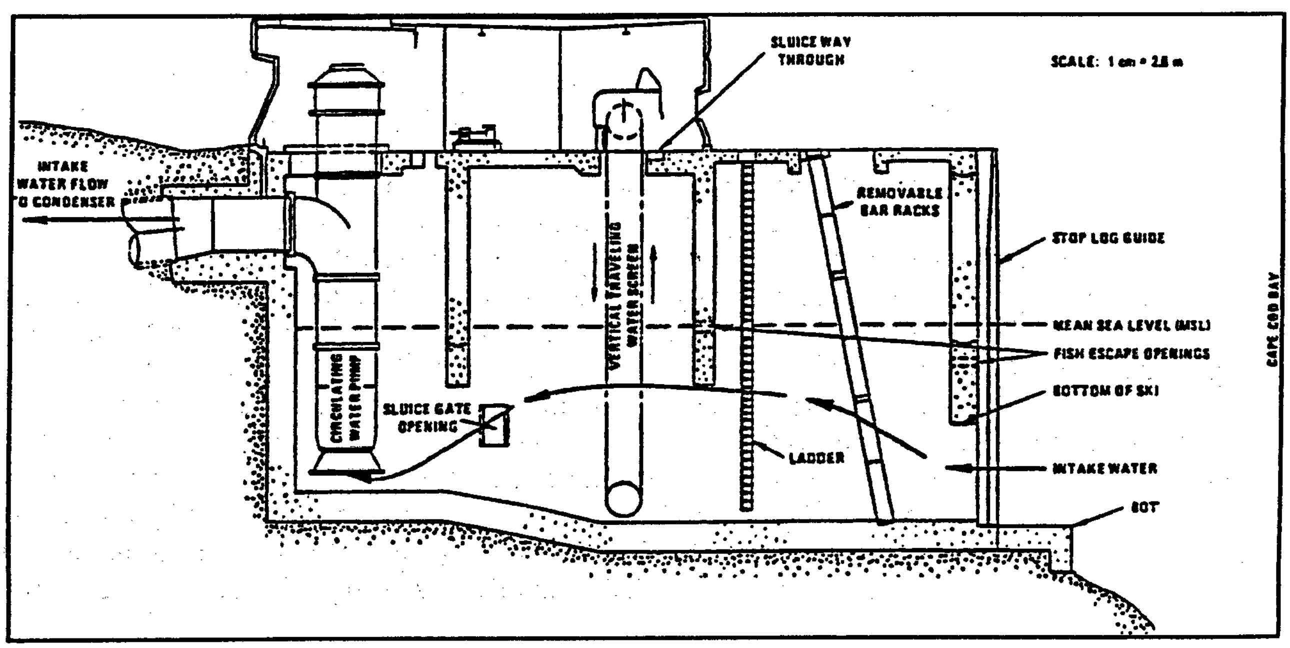

Figure 2. Cross-section of intake structure at Pilgrim Nuclear Power Station.

Methods and Materials

Three scheduled screen wash periods were monitored each week from January to June 2005 although there was no sampling from April 18 to May 9, 2005 due to a scheduled refueling outage. Since the main circulating water pumps were off, no impingement was expected. Monitored screen washes included the 0830 wash on Monday, the 1630 wash on Wednesday, and the 0030 wash on Saturday morning. Each sampling period thus represented a separate, distinct eight-hour period. Prior to each sampling period, the time of the previous screen wash was obtained from a strip chart recorder located in the screen house to permit the current sampling interval to be calculated. Whenever the screens were static upon arrival, a 30-minute sample was collected and, whenever the screens were operating continuously when a biologist arrived, a 60-minute sample was obtained.

Spray nozzles directed at the screens washed impinged organisms and debris into a sluiceway which was sampled by inserting a collection basket made of $^1/_4$–inch stainless steel mesh. All fish were identified and noted as being alive, dead, or injured. Fish that were determined to be alive were measured for total length (mm), and then released. Those determined to be dead or injured were preserved and returned to the laboratory where weights (grams) and total lengths (mm) were recorded for up to 20 specimens of each species. Any impinged invertebrates were identified, measured, and representative specimens were returned to the laboratory where weights were recorded. The impingement rate was calculated by dividing the number of fish and invertebrates collected by the number of hours in the collection period.

Results and Discussion

Fish

In 202.2 collection hours, a total of 490 fish comprising 25 species were collected from January - June 2005 (Table 1, Figure 3). Mean monthly impingement ranged from 6.72 in April, when the plant was operational from April 1 to 16, to 0.05 fish/hour in June. Impingement rate was zero when the plant was off-line and no circulating seawater pumps were running from April 17 to May 9. Atlantic silversides (*Menidia menidia*), rainbow smelt (*Osmerus mordax*), pollock (*Pollachius virens*), winter flounder (*Pseudopleuronectes americanus*), Atlantic herring (*Clupea harengus*), grubby (*Myoxocephalus aenaeus*), and Atlantic menhaden (*Brevoortia tyrannus*) accounted for 56.6, 11.8, 6.7, 6.5, 4.9, 2.7, and 2.2%, respectively, of the six-month total. The highest numbers of Atlantic silversides were impinged in April when 48% of the January to June total of 277 fish was collected. Rainbow smelt were most numerous in February with 76% of the 6-month total (58 fish) collected. Both pollock and Atlantic herring were most abundant in May with 100 and 92% of their respective January-June totals of 33 and 24 fish. Winter flounder were most abundant in January and March (13 and 10 fish, respectively) accounting for 72% of the 6-month total of 32 fish sampled. Grubby were present in the collections from January through April. Atlantic menhaden were sampled primarily in January with 82% of the 11 fish collected over the January to June period.

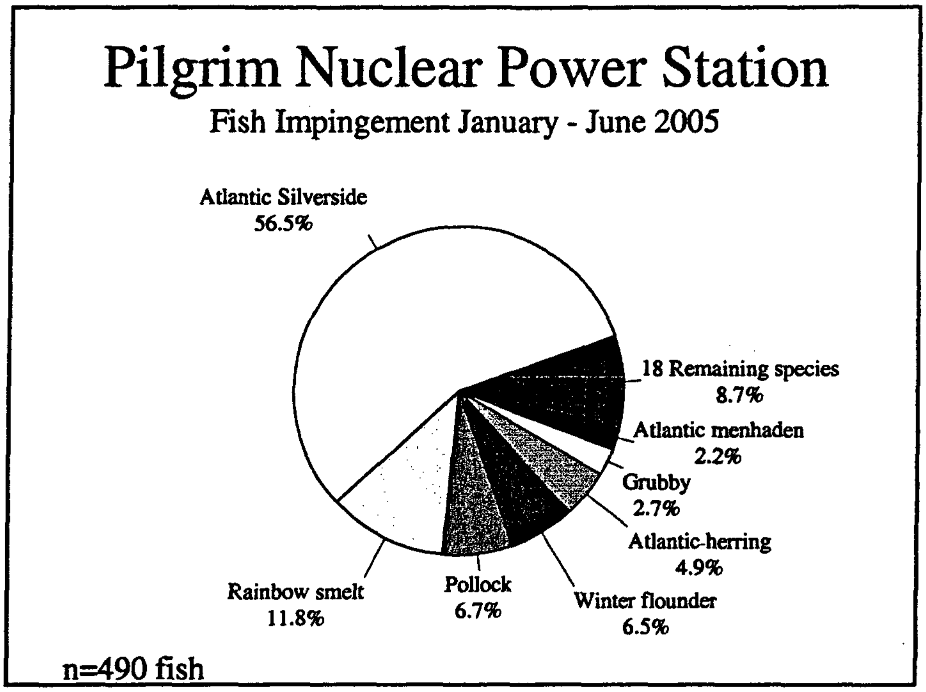

Figure 3. Percent of total for numerically dominant species of fish impinged on the Pilgrim Nuclear Power Station intake screens, January to June 2005.

Total fish were impinged at a mean rate of 2.61 fish/hour from January through June 2005. The highest monthly impingement rate of 6.72 fish/hour was recorded in April which coincided with the high numbers of silversides collected. The mean monthly impingement rate over the first half of 2005 (2.61 fish/hour) was greater than the six-month mean for the 1980 to 2004 time series of 1.70 fish/hour (Figure 4, Table 2).

Invertebrates

From January to June 2005, 379 invertebrates representing 12 species were sampled yielding an impingement rate of 1.87 invertebrates per hour (Table 3). Sevenspine bay shrimp (*Crangon septemspinosa*) accounted for 68.3% of the six-month total. Sevenspine bay shrimp were primarily impinged in March and April when 87% of the 259 animals was collected. American lobster (*Homarus americanus*) and sand worms (*Nereis spp*) accounted for 11.2 and 10.6% of the 6-month catch, respectively. Lobsters were caught primarily in May when 97.7% of the January to June total of 43 individuals was caught. Sand worms were present from January to April 2005, the peak occurring in February.

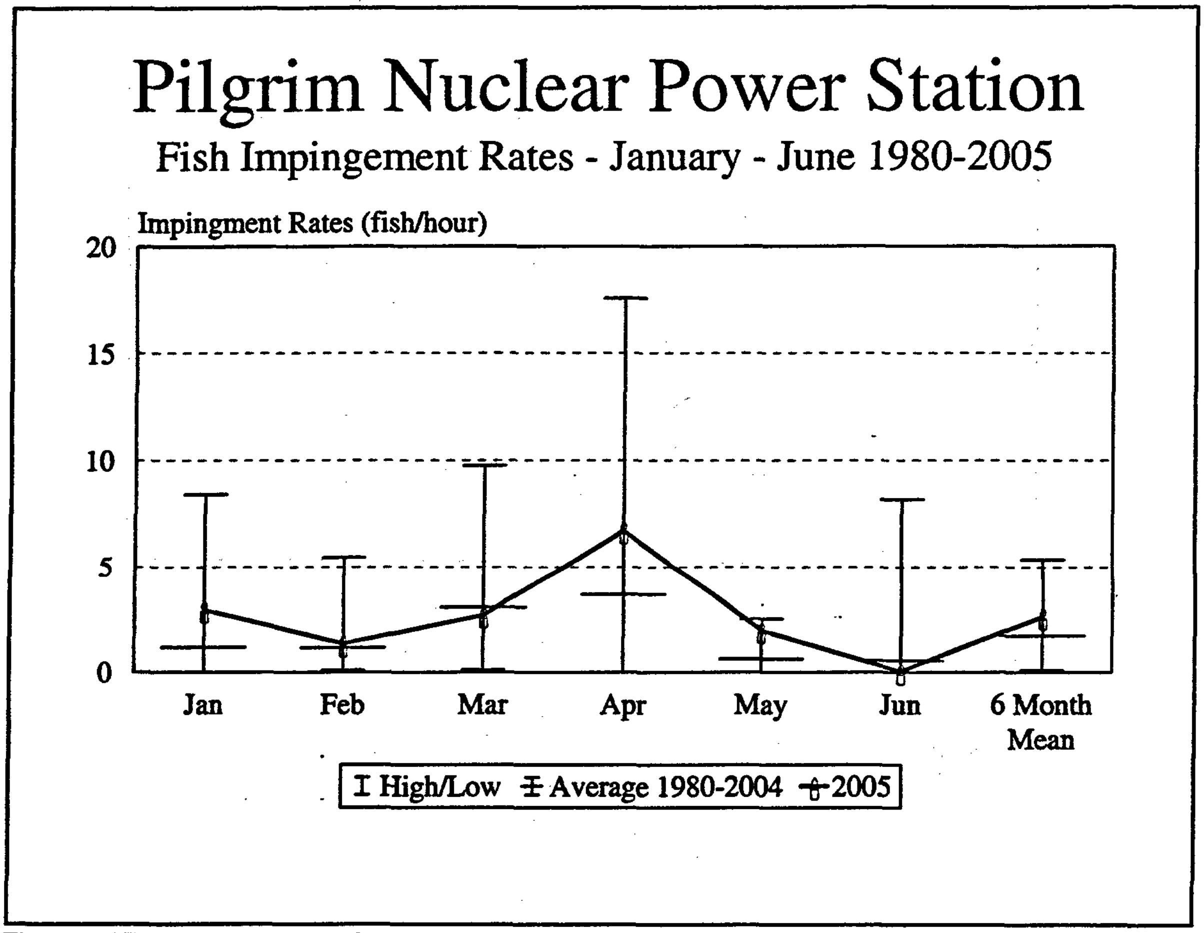

Figure 4. High/low average and grand mean monthly impingement rates for January to June 1980-2004 compared with January to June 2005 monthly mean rates at Pilgrim Nuclear Power Station, total fish.

Table 1. Monthly totals for all fish collected at Pilgrim Station from the intake screens, January - June, 2005.

Species	Jan	Feb	Mar	Apr*	May*	Jun	Total	Percent
Atlantic Silverside *Menidia menidia*	28	12	133	104			277	56.5%
Rainbow Smelt *Osmerus mordax*	10	44	1	2	1		58	11.8%
Pollock *Pollachius virens*					33		33	6.7%
Winter Flounder *Pseudopleuronectes americanus*	13	2	10	7			32	6.5%
Atlantic Herring *Clupea harengus*	1		1		22		24	4.9%
Grubby *Myoxocephalus aenaeus*	3	1	5	4			13	2.7%
Atlantic Menhaden *Brevoortia tyrannus*	9			2			11	2.2%
Cunner *Tautogolabrus adspersus*	2	1	2		2		7	1.4%
Threespine Stickleback *Gasterosteus aculeatus*			5	1			6	1.2%
Atlantic Cod *Gadus morhua*					4	1	5	1.0%
Blackspotted Stickleback *Gasterosteus wheatlandi*	1		2				3	0.6%
Northern Pipefish *Syngnathus fuscus*				3			3	0.6%
Lumpfish *Cyclopterus lumpus*				2	1		3	0.6%
Rock Gunnel *Pholis gunnellus*				3			3	0.6%
Blueback Herring *Alosa aestivalis*			2				2	0.4%
Little Skate *Leucoraja erinacea*					1		1	0.2%
Alewife *Alosa pseudoharengus*					1		1	0.2%
Atlantic Tomcod *Microgadus tomcod*				1			1	0.2%
Mummichog *Fundulus heteroclitus*	1						1	0.2%
Fourspine Stickleback *Apeltes quadracus*				1			1	0.2%
White Perch *Morone americana*			1				1	0.2%
Radiated Shanny *Ulvaria subbifurcata*		1					1	0.2%
Sand Lance *Ammodytes sp.*	1						1	0.2%
Smallmouth Flounder *Etropus microstomus*				1			1	0.2%
Yellowtail Flounder *Limanda ferruginea*					1		1	0.2%
Total Fish	69	61	162	131	66	1	490	
Total Collection Hours	23.48	45.84	60.26	19.50	33.67	19.42	202.17	
Impingement Rate	2.94	1.33	2.69	6.72	1.96	0.05		

* There was no sampling or seawater pumps running from April 18 to May 9, 2005. Impingement rates reported only represent the period when circulating seawater pumps were operational

Table 2. Monthly impingement rates (fish per hour) for all fish collected at Pilgrim Station from the Intake Screens, January - June, 1980-2005.

Year	Jan	Feb	Mar	Apr	May	Jun	Mean
1980	0	0.14	0.57	0.13	0.14	0.21	0.20
1981	0.79	1.88	2.66	6.18	0.32	0.14	2.00
1982	0.25	0.25	2.41	0.74	1.15	1.15	0.99
1983	0.23	0.33	0.71	0.71	0.36	0.15	0.42
1984	0.21	0.18	0.12	0.04	0.06	0.01	0.10
1985	0.4	5.48	2.17	2.36	0.82	0.48	1.95
1986	0.1	0.8	0.63	0.29	0.3	0.97	0.52
1987	0.64	0.11	1.2	0	0.5	0.05	0.42
1988	0.33	0.11	1.13	0.27	0.13	0.04	0.34
1989	0.12	0.25	2	1.41	0.35	0.25	0.73
1990	0.61	1.11	0.44	0.47	0.48	0.1	0.54
1991	0.58	0.57	1.53	2.34	0.33	8.19	2.26
1992	1.30	1.13	1.69	0.75	0.49	0.05	0.90
1993	1.55	0.85	8.06	4.11	0.64	0.28	2.58
1994	1.93	0.73	3.35	10.63	1.00	0.43	3.01
1995	8.41	0.88	9.75	2.32	1.13	0.59	3.85
1996	1.19	0.58	7.00	11.15	2.51	0.22	3.78
1997	0.98	0.48	0.30	2.54	0.26	0.06	0.77
1998	2.42	3.24	5.22	4.19	0.44	0.10	2.60
1999	1.56	2.42	2.71	1.40	1.00	0.00	1.52
2000	3.01	1.98	9.06	17.58	0.47	0.12	5.37
2001	0.41	1.39	4.38	6.22	0.00	0.05	2.08
2002	1.05	2.05	2.36	1.78	0.09	0.05	1.23
2003	0.61	0.83	2.58	1.50	0.66	0.38	1.09
2004	0.68	0.91	4.57	11.91	2.14	0.04	3.37
average	**1.17**	**1.15**	**3.06**	**3.64**	**0.63**	**0.56**	**1.70**
2005	2.94	1.33	2.69	6.72	1.96	0.05	2.61

Table 3. Monthly totals for all invertebrates collected at Pilgrim Station from the intake screens, January - June, 2005.

Species	Jan	Feb	Mar	Apr	May	Jun	Total	Percent
Sevenspine Bay Shrimp								
Crangon septemspinosa	27	6	121	105			259	68.3%
American Lobster								
Homarus americanus					42	1	43	11.3%
Nereis								
Nereis sp.	8	14	9	9			40	10.6%
Cancer Crabs								
Cancer spp.	2	2	1	2	5	7	19	5.0%
Blue Mussel								
Mytilus edulis				4			4	1.1%
Green Crabs								
Carcinus maenas	2				1	1	4	1.1%
Long-finned Squid								
Loligo pealii						3	3	0.8%
Starfish								
Asterias spp.	1		1			1	3	0.3%
Glyceridae								
Glyceridae		1					1	0.3%
Red-lined Worms								
Nephtys spp.	1						1	0.3%
Horseshoe Crab								
Limulus polyphemus						1	1	0.3%
Spider Crabs								
Libinia spp.				1			1	0.8%
Total	14	17	11	16	6	13	379	
Total Collection Hours	23.48	45.84	60.26	19.50	33.67	19.42	202.17	
Impingement Rate	0.60	0.37	0.18	0.82	0.18	0.67	1.87	