

**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. 49 (January-June, 1990)

By

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**September 1, 1990
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I. EXECUTIVE SUMMARY

Commercial Lobster Pot-Catch Fishery

From May to June (spring) of 1990, data were obtained from the trap catch of one commercial lobsterman who fishes in the vicinity of Pilgrim Nuclear Power Station. Sample size included a total of 712 pots hauled and 1749 American lobster (*Homarus americanus*) captured. Of the total catch, 11% of the lobster were legal in size (CL \geq 82.55 mm). Legal catch rate for the overall inshore area averaged 0.26 legals per pot-haul for the second year in a row.

Controlled Research Lobster Fishing

Fourteen sampling trips were completed in June, with data procured from 620 trap-hauls. Of the 1747 lobster sampled in the study area, 8% were legal in size (\geq 82.55 mm CL). Legal catch rate averaged 0.20 lobster per trap-haul in the discharge area and for the study area as a whole.

Nearshore Benthic Finfish

A bottom trawl survey of groundfish in the Pilgrim area was conducted January to June 1990. A total of 344 finfish representing 13 species was collected in 62 trawl tows. Overall catch per unit effort (CPUE) for all stations and species pooled was 5.5 fish/tow, as compared to last year's mean of 8.2. Numerically dominant species in the catch were winter flounder (*Psuedopleuronectes americanus*), windowpane (*Scophthalmus aquosus*), and little skate (*Raja erinacea*). CPUE of winter flounder was highest in the Intake, while windowpane catch rate was highest in Warren Cove. Little skate were most abundant at Priscilla Beach. Ocean pout (*Macrozoarces*

americanus) ranked fourth, but were not captured in great abundance.

Pelagic and Benthic-pelagic Fishes

Gill-net sampling was conducted approximately monthly in the environs of Pilgrim Station during the first half of 1990. The dominant species captured in order of abundance were pollock (*Pollachius virens*), striped bass (*Morone saxatilis*), Atlantic herring (*Clupea harengus harengus*), alewife (*Alosa pseudoharengus*), and cunner (*Tautoglabrus adspersus*). The overall catch per unit of effort for all species pooled was substantially down from the level of the last three years. Of note, the numbers of striped bass were markedly up while the local cunner population continued to show signs of declining abundance.

Shorezone Fishes

Sampling of the shore zone for fish using 45.7 m haul seines began in June. Two open coastal sites (Warren Cove and Manomet Point) and two sheltered locations (Long Point barrier beach and the Pilgrim Station Intake embayment) were monitored. Eight finfish species were seined, with sand lance (*Ammodytes spp.*) and northern pipefish (*Syngnathus fuscus*) comprising 87% of the catch that month. Sand lance were taken predominantly (62% of species total) in the Intake embayment at Pilgrim Station, whereas all of the pipefish were seined at Long Point, which is at the mouth of Plymouth Harbor.

Diversity, as to the number of species sampled at a location, was relatively high in the Intake where seven species were captured. Catch per unit of effort was highest there and lowest at Manomet Point.

Underwater Finfish Observations

Biweekly observational dives were performed in May and June 1990 at six stations in and around the Pilgrim Station discharge canal. Four species of finfish were sighted, with striped bass, bluefish (*Pomatomus saltatrix*), and tautog (*Tautoga onitis*) comprising 94% of the total observed. Cunner local abundance remained depressed. Distributionally, 99% of all fish were observed in the "denuded" zone. Continued recolonization of the denuded area by Irish moss (*Chondrus crispus*) was observed by project divers.

Sportfishing

Sportfishing at Pilgrim Shorefront was monitored in late May and during June. In May, four fish species were caught (striped bass, cunner, winter flounder, and tautog), with striped bass comprising 69% of the sportfish catch. Overall, however, the catch rate (pooled species) was relatively low, averaging 0.4 fish per angler-trip. In June, angling effort increased as did the total catch. The monthly catch rate increased slightly to 0.6 fish per angling-trip. Bluefish (40%), striped bass (38%), winter flounder (22%), and cod (negligible percent) comprised the catch of 240 fish. The landings of bass and bluefish were much greater than from 1986 to 1988 when Pilgrim Station was in an extended outage and in 1989 when the plant gradually returned to full operational status.

Cunner Capture-Tagging Program

A pilot study was conducted this spring on tagging cunner with the intent of a full scale effort in 1991. As part of our

observational diving program, this work should generate information on the mobility and dispersion of cunner as related to the influence of the thermal discharge. We selected the Floy plastic anchor tag to mark cunner. Our initial work was to investigate the best way to catch numbers of cunner in good condition, perfect our tagging technique, and assess tag retention, fish survival after tagging, and tag visibility underwater. In light of the findings from our preliminary work, it appears that the anchor tag will be suitable for our tagging operations next year.

II. INTRODUCTION

Monitoring of the marine environment in the vicinity of the Pilgrim Nuclear Power Station is ongoing to assess environmental change induced by plant operation. Ecological investigations conducted by the power plant team of the Massachusetts Division of Marine Fisheries (DMF) focus on marine fisheries resources in the off-site waters of western Cape Cod Bay. DMF is funded by Boston Edison Company under Purchase Order No. 67252 in 1990.

Sampling data collected from reference and surveillance sites for January to June 1990 are summarized in this report. Measurements, counts, percentages, and indices of relative abundance are employed to flag any trends or relationships in the data spatially and/or temporally.

Operational status, as regards the seawater circulating pumps, was as follows: one pump was in operation during most of March and April, while both pumps were generally operated during the other four months. As to waste heat, the thermal output ranged (as estimated by Net % MDC) from ~0% in April (plant outage) to 100% capacity in January, February, and June (67% for the 6-month period).

III. RESULTS AND DISCUSSION

1. COMMERCIAL LOBSTER POT CATCH FISHERY

Seasonal monitoring of the commercial lobster fishery around Pilgrim Station was continued in 1990. We began sampling the catch of our cooperating lobsterman in early May and continued through June with a total of 1749 lobster caught from 712 pot-

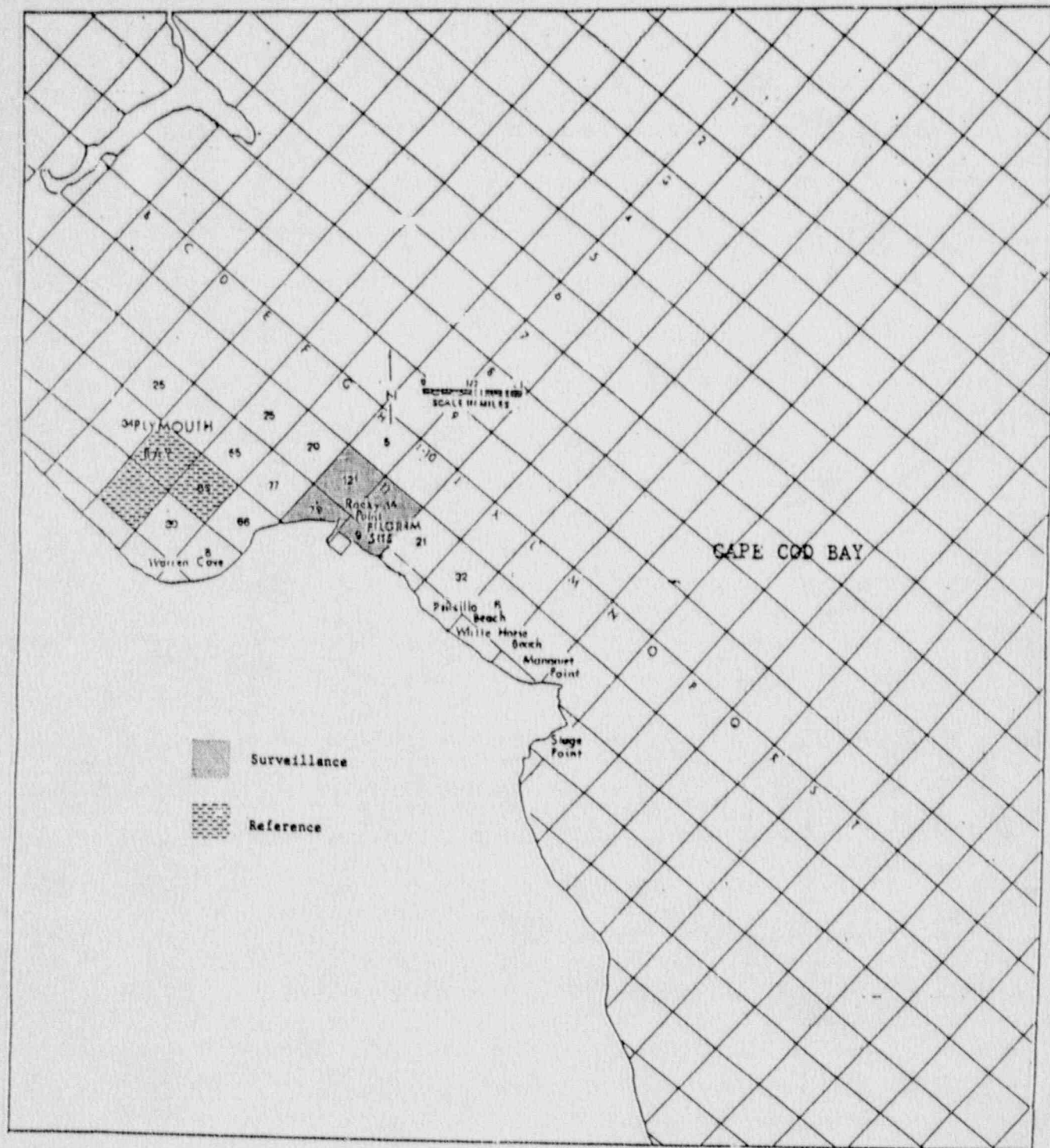


Figure 1. Number of lobster pots sampled per quadrat for commercial lobster study in the Pilgrim area, May-June, 1990.

hauls. Figure 1 depicts the distribution of pots sampled by designated quadrat.

The sampled catch included 186 legal (≥ 82.55 mm carapace length - CL) lobster, representing 11% of the total catch, for a mean catch rate in the study area of 0.26 legals per pot-haul over the two months, the same rate as last year. This constancy in catch rate existed for the Cape Cod Bay lobster fishery as a whole (Bruce Estrella, personal communication)¹.

The mean legal catch rate for reference quadrats (E-13 & 14, F-13) of 0.21 (18 legal lobster per 85 pot-hauls) is equal to the 1989 rate for the same period. The spring catch rate for the surveillance quadrats (H-11 & 12, I-11 & 12) was 0.27, also equivalent to last spring's rate.

2. CONTROLLED RESEARCH LOBSTER FISHING

In June 1990 we began the fifth year of the research lobster trap study in the environs of Pilgrim Nuclear Power Station (Figure 2). Fourteen sampling days were completed in which 1747 lobster were caught in 620 trap-hauls. The incidence of null pots (pots with zero lobster) was 11%. The lobster sampled were predominantly (92%) sublegal in size (< 82.55 mm CL). A total of 127 legal-sized (≥ 82.55 mm CL) lobster was sampled. The catch ratio of sublegal to legal lobster was 12.8:1. The mean catch rate for all lobster sampled was 2.8 lobster/trap-haul for the study area. Overall catch rates for legal and sublegal lobster were 0.20 and 2.61

¹B. Estrella, Senior Marine Fisheries Biologist, Coastal Lobster Investigations, Massachusetts Division of Marine Fisheries, Sandwich, MA.

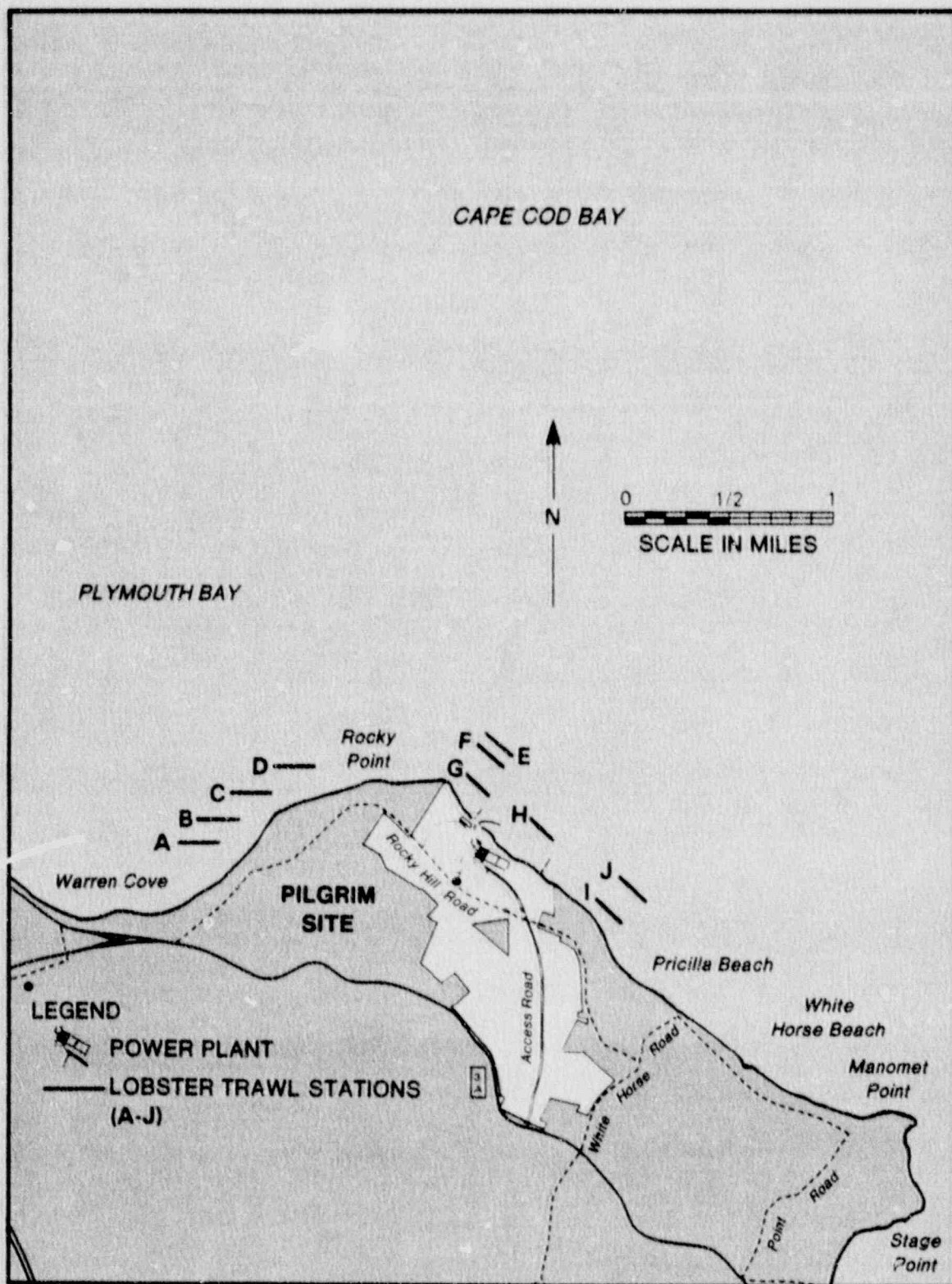


Figure 2. Location of experimental lobster gear (5-pot trawls) for Marine Fisheries Studies.

lobster/trap-haul, respectively.

A graphic comparison of June's lobster catch rates at the three sampling locations (Figure 3) suggests that Rocky Point differed from the other two sampling areas (Discharge and Priscilla Beach) in sublegal catch. The legal catch rates were 0.19 at Rocky Point, 0.20 at the discharge area and 0.25 at Priscilla Beach. With only one month's data, it is presumptuous to assign significance to the higher legal catch rate obtained at Priscilla Beach at this time.

3. NEARSHORE BENTHIC FINFISH

Our nearshore bottom trawl survey for 1990 commenced in mid-January and continued through June. Station locations (Figure 4) included Warren Cove, off Priscilla Beach, in the area of the Discharge, and in the Intake embayment at Pilgrim Station. Sampling was conducted monthly during January through March thence biweekly through June. Catches for tows greater than or equal to 10 minutes, but less than the standard 15 minute duration, were multiplied by an expansion factor (15 minutes/actual tow minutes) to standardize sampling effort. Any tow of less than 10 minutes was rejected a priori.

A total of 344 finfish comprising 13 species was collected

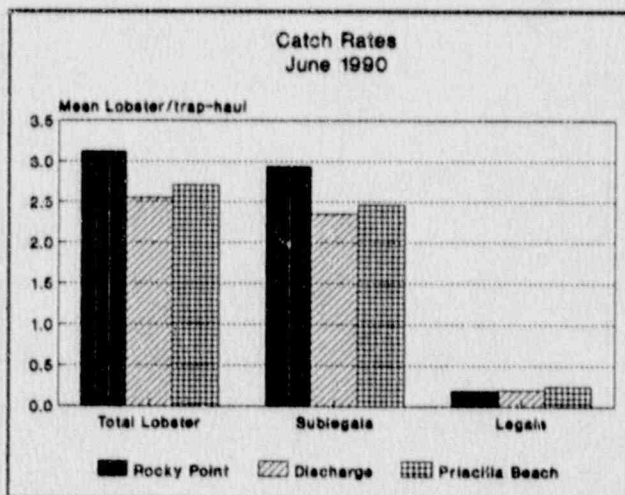


Figure 3. Catch rates of total, sublegal, and legal lobster in the research lobster traps fished in the area around Pilgrim Station, June, 1990.

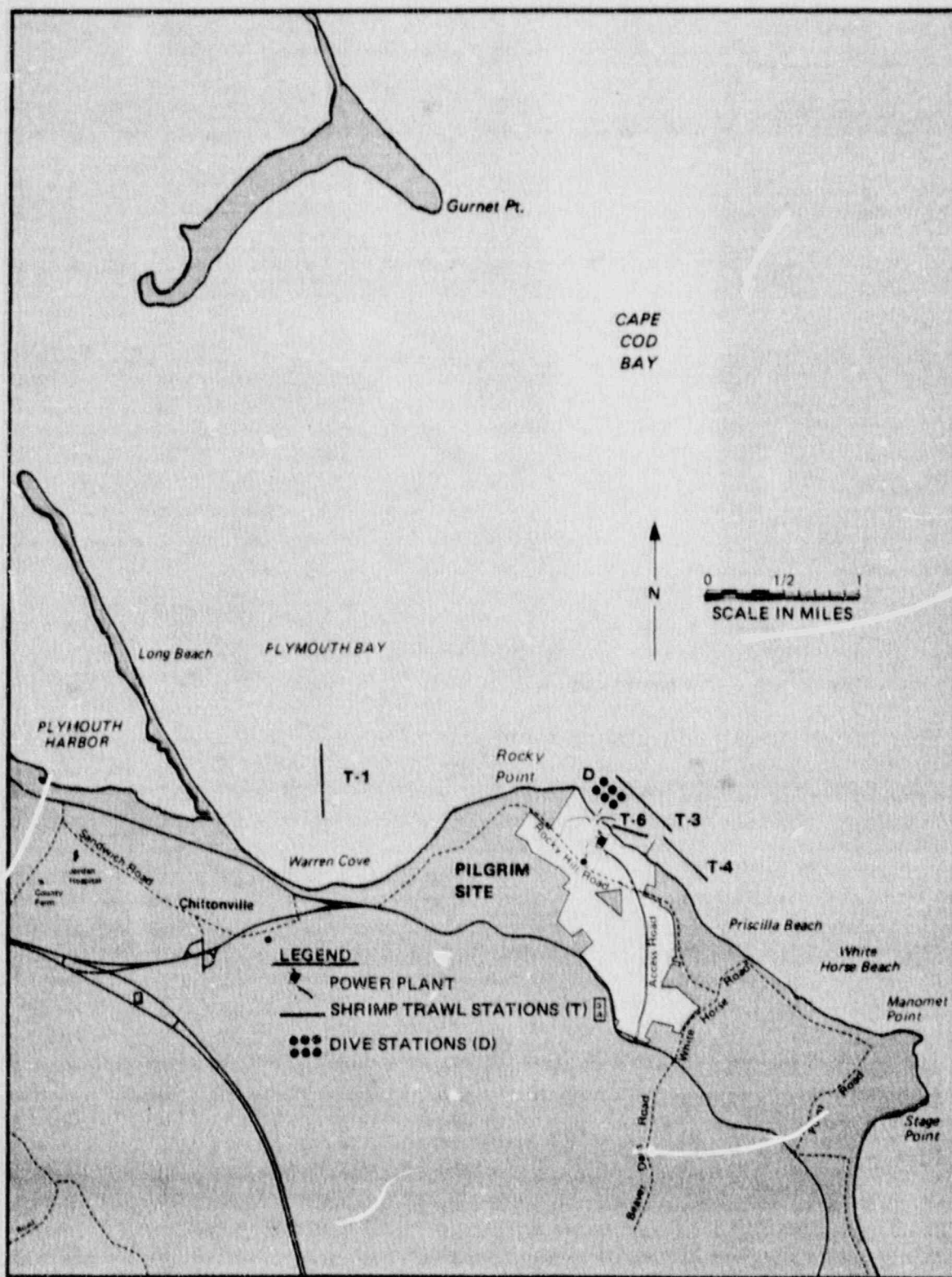


Figure 4. Location of Shrimp Trawl and Dive Sampling Stations for Marine Fisheries Studies.

during 62 tows in the study area (Table 1). Nineteen species and 473 finfish were collected in 58 tows for the same period in 1989. CPUE (mean catch per standard 15 minute tow) for all stations and species pooled was 5.5 fish/tow, as compared to last year's mean of 8.2 fish/tow.

CPUE for all species pooled ranged from 7.2 in the Intake to

Table 1. Expanded trawl catch¹ and percent composition of finfish captured by nearshore trawling in the vicinity of Pilgrim Station, January-June, 1990.

Species	Warren Cove	Pilgrim Discharge	Priscilla Beach	Pilgrim Intake	Total	% of Catch
Winter Flounder	35	31	24	49	139	40.4
Windowpane	26	13	17	17	73	21.2
Little Skate	5	10	29	26	70	20.3
Ocean pout	6	6	3	7	22	6.4
Other spp. ²	5	10	16	9	40	11.6
Pooled Species						
Number of species	9	7	9	9	13	
Number of tows	16	15	16	15	62	
Total # fish	77	70	89	108	344	
Catch/tow	4.8	4.7	5.6	7.2	5.5	
Percent catch	22.4	20.3	25.9	31.4		

¹Catch rates were expanded for tows less than the standard 15-minute duration.

²Represent combined totals from 9 species of low catch.

4.7 at the Discharge site (Table 1). For the same sampling period in 1989, CPUE was greatest off the Discharge (9.1) and lowest in the Warren Cove (7.0). Four species: winter flounder (*Pseudopleuronectes americanus*), windowpane (*Scophthalmus aquosus*), little skate (*Raja erinacea*), and ocean pout (*Macrozoarces americanus*) comprised 88% of the total catch through the first half of 1990.

Winter flounder was numerically dominant (40.4%) in trawl

samples. Relative abundance was highest in the Intake at 3.3 fish/tow and lowest at Priscilla Beach at 1.5 (Table 2). An overall winter flounder abundance index (catch/tow) of 2.2 is essentially the same as last year's value of 2.0.

Windowpane ranked second at 21.2% of the total. Relative abundance ranged from 1.6 in Warren Cove to 0.9 at the Discharge

Table 2.

Expanded trawl catch data (total length and catch per unit effort) for dominant demersal community finfish occurring in the vicinity of Pilgrim Station, January-June, 1990.

	Winter flounder	Windowpane	Little skate
STATION 1 - WARREN COVE			
Mean catch/tow	2.2	1.6	0.3
Mean size (cm)	31.3	26.0	39.8
Size range (cm)	9-43	18-34	30-48
STATION 3 - PILGRIM DISCHARGE			
Mean catch/tow	2.1	0.9	0.7
Mean size (cm)	30.9	20.7	37
Size range	10-39	14-31	22-48
STATION 4 - PRISCILLA BEACH			
Mean catch/tow	1.5	1.1	1.8
Mean size (cm)	28.8	26.9	37.9
Size range	9-39	22-30	25-51
STATION 6 - PILGRIM INTAKE			
Mean catch/tow	3.3	1.1	1.7
Mean size (cm)	28.3	23.3	39.5
Size range	9-43	12-28	25-51

(Table 2). Total windowpane abundance increased slightly from 0.8 for the first half of last year to 1.2 in 1990.

Little skate ranked third, comprising 20.3% of the trawl catch. CPUE was highest off Priscilla Beach at 1.8 and lowest in Warren Cove at 0.3 (Table 2). The overall half-year little skate relative abundance index (1.1) declined from 2.0 in 1989.

Comprising 6.4% of the trawl catch, ocean pout was fourth in

the dominance hierarchy. Although common to the Pilgrim Station area, ocean pout has displayed depressed local abundance in recent years.

4. PELAGIC AND BENTHI-PELAGIC FISH

Our gill-net catch totaled 359 fish, comprising 19 species (Figure 5), in 5 overnight sets.

At approximately monthly intervals during the first half of 1990, sampling was conducted at one location in the Pilgrim Station discharge (Figure 6). Comprising 87% of the catch, the top five species in number caught were pollock (*Pollachius virens*), striped bass (*Morone saxatilis*),

Atlantic herring (*Clupea harengus harengus*), alewife (*Alosa pseudoharengus*), and cunner (*Tautoglabrus adspersus*). All but the striped bass have been among the dominants in the gill-net catch over the years at the power plant.

The mean catch per standard gill-net set (catch per unit effort-CPUE) for all species pooled was 72 fish. This catch rate is noticeably down from the first half of 1989 (CPUE = 117), 1988 (315), and 1987 (356).

Pollock comprised 48% of the catch and generally has been the dominant fish captured by gill net in the Pilgrim area. Unprecedentedly, striped bass ranked second at 16% of the catch.

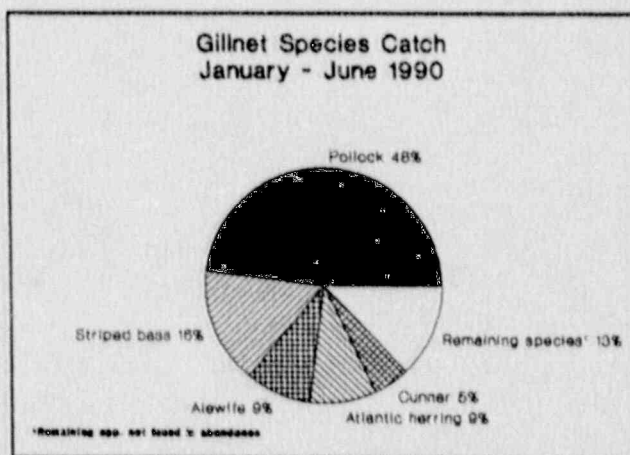


Figure 5. Gill net catch data (7 panels of 3.8-15.2 cm mesh) from the vicinity of Pilgrim Station, January-June, 1990.

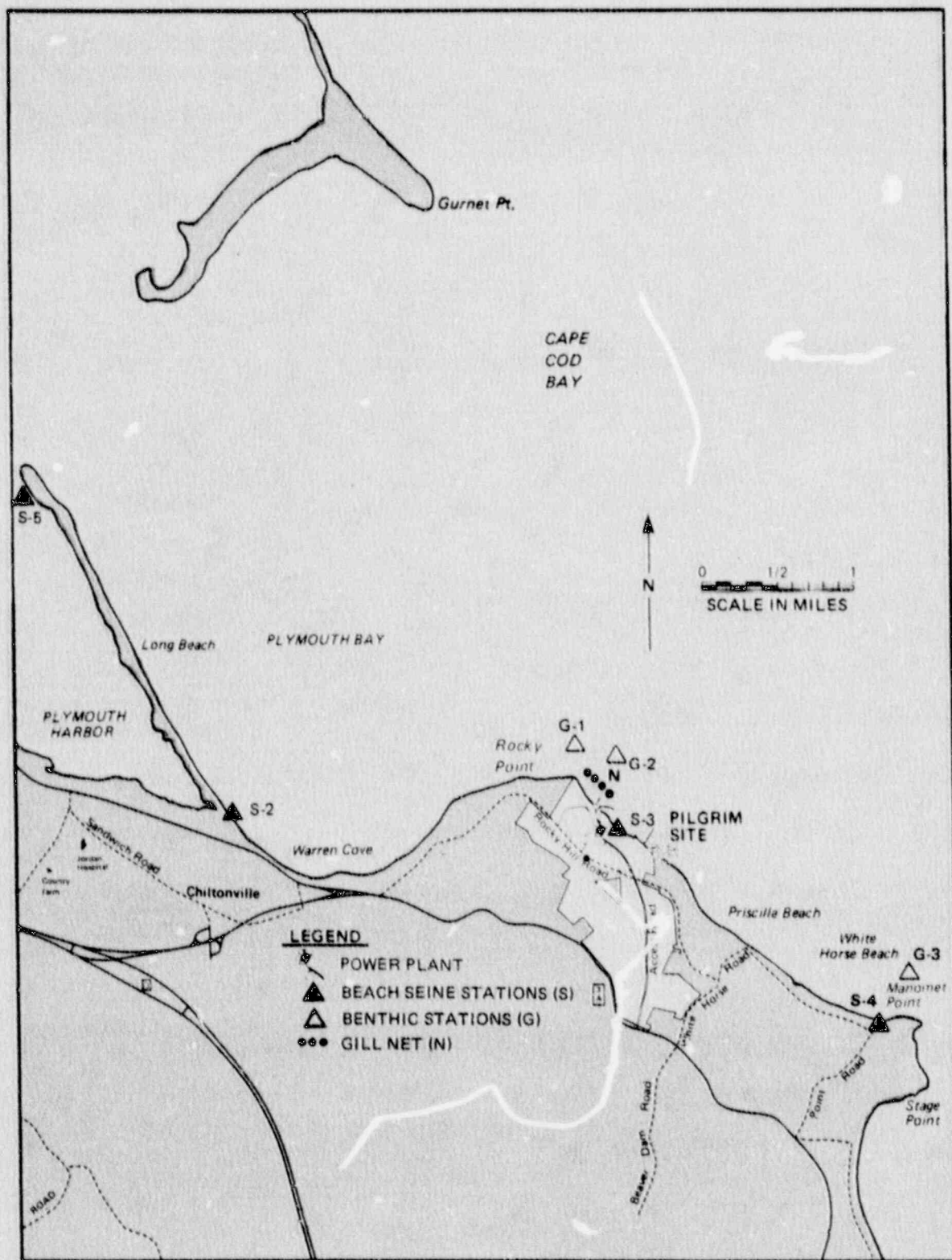


Figure 6. Location of Beach Seine and Gill Net Sampling Stations for Marine Fisheries Studies, and Benthic Studies Sampling Stations

The numbers of bass appearing in Massachusetts waters the last few years have increased as a result of coastal management conservation measures. Specifically, the number found in the thermal discharge (as evidenced by gill-net sampling, creel survey, and diving observations) at Pilgrim Station in the first half of 1990 is markedly up concomitant with the plant being fully operational. Alewife and Atlantic herring were tied for third at 9% of the catch. Cunner (5%) dropped in the hierarchy of catch from third to fifth. The local stock of cunner has shown signs of declining abundance over the past decade.

5. SHOREZONE FISHES

Fifteen sets of the 45.7 m haul seines were made at four stations (Figure 6) sampled within ± 3 hours of low tide. A total of 247 fish comprising 8 species was sampled (Table 3). The average catch per unit of effort was 16.0 fish per haul seine.

Table 3. Haul-seine of shore-zone fishes in number of fish, species composition (% number), and catch per unit of effort (catch per standard seine haul) at sampling stations in the environs of Pilgrim Nuclear Power Station during June 1990.

Species	Warren Cove	Pilgrim Intake	Manomet Point	Long Point	Total Catch	Percent of Total Catch
Sand lance (spp. ¹)	77	126	0	0	203	82.2
Northern pipefish	0	0	0	12	12	4.9
Atlantic tomcod	0	1	0	9	10	4.0
Winter flounder	1	4	2	2	9	3.6
Grubby	0	6	0	0	6	2.4
Windowpane	0	2	0	1	3	1.2
Atlantic silverside	0	3	0	0	3	1.2
Bay anchovy	0	1	0	0	1	0.4
Total no. of fish	78	143	2	24	247	
Number of sets	4	3	4	4	15	
Catch/set (pooled species)	20	48	1	6	16	
Total no. of species	2	7	1	4	8	
Percent of total catch (by station)	31.6	57.9	0.8	9.7	100.0	

¹Not identified as to species

¹ 45.7 m long x 3.0 m deep seine; other sites sampled by 45.7 m x 1.8 m seine

For the same time period and sampling effort last year, we collected 10 species (5 species in common), but the average catch was twice as high at 32.0 fish per set. Surface water temperature and salinity at the time of sampling this June ranged from 11 to 16.5 C and 28 to 32 ppt, respectively. June water temperatures were once again higher at Long Point (Station S-5) than at the other sampling locations.

Sand lance (*Ammodytes spp.*) comprised 82.2% of the seine catch in June. This species accounted for 80.4% of June's seine catch last year. Sixty-two percent of the sand lance catch in June this year was taken in the Intake embayment. In fact, over 50% of the total seine catch (species pooled) was obtained at this site. Northern pipefish (*Syngnathus fuscus*) ranked second in overall catch (4.9%), followed by juvenile Atlantic tomcod (*Microgadus tomcod*) and juvenile winter flounder. Northern pipefish occurred exclusively at Long Point. Last year tomcod comprised 11% of the total catch.

Diversity, as measured by the number of species present in a community (the only truly objective measure of diversity), was highest in June at the Pilgrim Intake embayment where seven species were captured (Table 3). Catch per unit of effort (pooled species), as an index overall relative abundance, was highest in the Intake and lowest at Manomet Point. It is unrealistic to comprehensively analyze community species diversity and relative abundance based on only one month's data.

6. UNDERWATER FINFISH OBSERVATIONS

Biweekly observational SCUBA dives were made at six stations in and around the discharge canal in May and June, 1990 (Figure 4). Four species of finfish (Figure 7) were recorded, as well as such invertebrate species as blue mussel (*Mytilus edulis*), American lobster (*Homarus americanus*), starfish (*Asterias* spp.), and rock and jonah crabs (*Cancer irroratus* and *C. borealis*). Macro-algal species sighted included kelp (*Laminaria* spp.) and Irish moss (*Chondrus crispus*).

Observations of the benthos revealed a virtual carpet of blue mussels extending from inside the discharge canal out to the large boulder at Station D₁. By late June, the mussel bed had attracted large numbers of starfish to the "denuded" zone. Several species of macro-algae (especially kelp) flourished throughout the discharge area, vying with the mussels for exposed rock surfaces. The recolonization of the "denuded" area by Irish moss continued to the extent that moss was observed growing up inside the mouth of the discharge canal.

The total number of finfish observed (346) was larger than for May and June of 1989 (200 fish), despite the relatively small number of cunner (17) this spring. Striped bass was the most

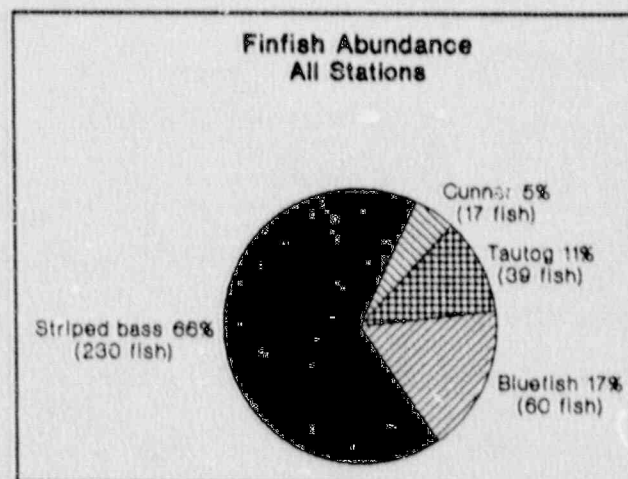


Figure 7. Finfish abundance as observed by divers in the area around the Pilgrim Station discharge canal, January-June, 1990.

commonly sighted species, present in large numbers (70+ fish) on three of the four dives. Bluefish ranked second in number recorded, even though they were observed on only one occasion. Tautog was third, with 39 fish recorded which is similar to 1989 sightings (27). The low number of cunner is consistent with a trend of depressed local abundance.

Of the fish observed, 99% were found in the "denuded" zone (Figure 8), with the remaining fish (5 cunner) seen in the "control" zone. This pattern of

distribution is not surprising given that striped bass and bluefish comprised 84% of the total, for these fish have a known affinity for the fast-moving water of the thermal effluent. Past observations (Lawton et al. 1990) revealed that tautog also show a marked preference for the "denuded" zone, perhaps due to the

abundance of blue mussels and structure provided by the boulders in that area.

7. SPORTFISHING

Catch data on the shore-based sportfishery at Pilgrim Station Shorefront were collected by seasonal Boston Edison Company (BECO) public relations personnel stationed at the Shorefront. Anglers

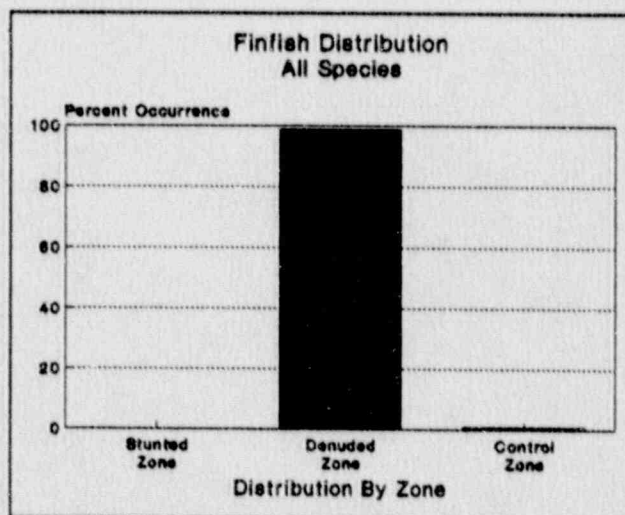


Figure 8. Finfish distribution as noted by divers in the area around the Pilgrim Station discharge canal, January-June, 1990.

are interviewed at an access point. A sample data interview form used in this on-site creel survey is found in Figure 9. Daily effort (number of angler-trips) and catch by species are especially important information with which to derive an index of the fishery off Pilgrim Station. This cooperative venture with BECo enables us to continue monitoring sportfish at the station.

The Shorefront was again opened to the public in 1990 on April 1. The area routinely remains open through November. During daylight hours, rod-and-reel fishermen have access to the outer breakwater, both discharge jetties, and the sandy beach and rip-rap at the head of the intake. The creel survey began on Saturday, May 19th and continued on weekends through mid-June. The collection of daily information began on June 20.

As to plant operation during the first three months of fishing this year, during April only one circulating seawater pump was operated most of the time, which reduced the discharge flow by 50%; whereas, in May and June both pumps were run most often in concert, producing a strong current. Thermal output ranged from ~0% in April to about 100% in June.

No creel data were collected systematically from April through May 18, but we observed few anglers fishing at the Shorefront throughout April. During the last two weekends of May, including Memorial day (five sampling days), 103 angler-trips were recorded at the Shorefront. Both casting artificial lures and bottom fishing with natural bait were conducted.

Interviewer's Initials		Sheet #
<div style="border: 1px solid black; width: 80px; height: 20px; display: inline-block;"></div>		1990
Recreational Fish Survey - PNPS Shorefront		
	Date	
	Weather	
	Wind Direction and Speed	
	Number of Anglers for the Day	
	Fishing Locations	
	Hours the Shorefront was open and fishing allowed (e.g., 6 am - 5:30 pm)	
Species	Total Number Caught for Day	
Flounder (Flatfish)		
Striped Bass		
Bluefish		
Cod		
Pollock		
Tautog		
Mackerel		
Cunner (Sea Perch)		
Other		
Comments:		

Figure 9. Creel data form used at Pilgrim Shorefront to record sportfishing information.

Four species of finfish, totaling 42 fish, reportedly were caught in May. Striped bass (69%), cunner (21%), winter flounder (7%) and tautog (2%) comprised the catch. The striped bass were caught in the discharge current. The catch rate (pooled species) averaged 0.4 fish/angler-trip or 8.4 fish/sampling day.

In June, 16 days were sampled: 9 weekend days and 7 week days. A total of 367 angler-trips was recorded at the Shorefront during June's sampling. The catch was comprised of four species of fish: two pelagics - bluefish (40%) and striped bass (38%) and two groundfish - winter flounder (22%) and Atlantic cod (*Gadus morhua*) (negligible percent). The catch rate averaged 0.6 fish/angler-trip or 15 fish/day. Most of the flounder were caught in the intake, while the bass and bluefish were hooked in the discharge. The catches of bass and bluefish were much greater than for the years 1986-1988, when the plant was off-line or in 1989 when the plant gradually returned to full operational status. The discharge of a well-defined heated current attracts and holds game fish, making them available to shore fishermen. Areas of moving water are prime feeding locations for certain species of game fish, which seek out locations where forage fish are tumbled about by the accelerated flows. The velocity of the water in many rip-currents makes bait fish vulnerable to predation by bluefish, striped bass, Atlantic mackerel (*Scomber scombrus*), etc.

8. CUNNER CAPTURE-TAGGING PROGRAM

Background

In order to make our observational diving program more

quantitative, we have proposed to individually tag cunner (coastal resident groundfish) and follow their movements and distribution in relation to the thermal discharge current and resultant zones of impact at Pilgrim Station. This effort is planned for next year; however, we have been conducting preliminary work this year. The study should generate information on the mobility and dispersion of cunner as related to their susceptibility to the impact of the thermal discharge current.

The cunner is a small labrid that inhabits inshore temperate reefs, i.e., rocky areas and other structures, including piers, pilings, and shipwrecks, which serve as refuge areas. Found in marine waters along the western North Atlantic coast from Newfoundland to New Jersey, cunner are especially abundant in the Massachusetts Bay region, including Cape Cod Bay. They form discrete localized populations which exhibit only seasonal inshore/offshore movements controlled by water temperature.

The U.S. Environmental Protection Agency and the Massachusetts Division of Water Pollution Control selected cunner as one of thirteen representative important species (RIS) to assess environmental impact of Pilgrim Station on the local marine ecosystem. A species that occurs in localized populations, such as the cunner, makes a potentially good indicator organism to detect perturbation in the environment. A discrete population unit is more likely to be measurably impacted by a point-source of pollution than a species, such as the Atlantic menhaden (*Brevoortia tyrannus*), whose stock is composed of essentially one interbreeding

population throughout its extensive geographical range.

Cunner occupy small home ranges for extensive periods of time, which exposes them to potential effects of inshore pollutants. This makes them appropriate candidates for monitoring short and long-term changes in local environmental conditions. Cunner are especially vulnerable at night since low responsiveness, characteristic of the sleep state of labrids, reduces their ability to avoid environmental stresses that may occur after dark.

Gill-net sampling, diving observations, and creel surveys have revealed that cunner are abundant members of the groundfish community in the environs of Pilgrim Station. The intake embayment with its two breakwaters and the discharge jetties provide structure for a temperate-water reef community. The large boulders serve both as substrate for attached flora and fauna that provide a food source for cunner and as shelter (home sites) for the fish especially during the cunner's nocturnal sleep phase. As cunner feed both benthically and in the water column, besides foraging on the benthos, when the circulating seawater pumps are operating at Pilgrim Station, cunner are attracted to the discharge current on flood tides presumably to feed on suspended food items carried in the effluent water.

The potential sources of Pilgrim Station impact on cunner are entrainment of their pelagic eggs and larvae in the circulating seawater system, entrapment in the intake structure of juveniles and adults, and impingement on the travelling water screens of the latter two life stages. The circulating water discharge laden with

waste heat and containing chlorine can affect cunner in the receiving waters.

Tagging

After reviewing the open literature on cunner life history and the tagging of fish in general, we selected for our needs the Floy plastic anchor tag to mark cunner. The tags are applied into the musculature with a tagging gun. We selected the left side of the fish just below the dorsal fin as the location for tagging.

We began preliminary tagging operations in November 1989 at the Woods Hole Oceanographic Institute (WHOI), where known numbers of cunner were located under a pier and were readily accessible to capture from shore. Our intent was to assess tag retention, fish survival, and visibility of the tag below the water's surface. We captured 11 cunner (10-19 cm total length - TL) by potting, tagged 5 of them (16-19 cm TL) leaving six untagged as a control, and held all 11 in a holding car placed in a small boat well off the WHOI pier. Although there was some escapement, there was no evidence of mortality in any of the fish after four days when the fish were released.

We continued experimental tagging operations in May 1990 at WHOI. A dive was made in mid-May to test the visibility of different colored tags. The divers took different color tags to a depth of 15.2 m (50 ft) to simulate conditions of less than optimum visibility. With a visibility of 3 m (9.8 ft), as measured by secchi disk, the hand-held red and blue tags were easily seen, but the orange, pink, and yellow ones were not. The last three colors

were indistinguishable from each other.

In mid-May, we trapped and tagged 16 cunner. Six (15-16 cm TL) were placed in an aquarium, that contained clay pots and PVC pipe for structure, at the National Marine Fisheries Service headquarters in Woods Hole along with 2 untagged cunner as a control. Ten tagged cunner and two control fish (14-18 cm TL) were also placed in a holding car in a small boat well at the WHOI pier. All the fish that were held were fed fish or crushed mussels on a regular basis, and direct observations were made of their condition and behavior. The fish in the tank exhibited territorial behavior which included occupying and defending a structure by chasing off and nipping at intruders.

The fish in the holding car were held for 18 days and were released under the WHOI pier. All were doing well, although one of the tagged fish had lost its tag. In mid-June, an angler caught one of the tagged cunner under the pier. During the last week in June, while SCUBA diving under the pier, we observed four tagged cunner which appeared to be normally responsive.

The fish in the aquarium were held for 86 days with no loss of tags or mortality incurred. We would conclude from our preliminary work thus far that the anchor tag will be suitable for our study next year. However, we do not know if there will be differential mortality due to the conspicuousness of the tags when the fish are in their natural environment. Continued evaluation will occur this summer and fall, 1990.

IV. ACKNOWLEDGMENTS

The authors acknowledge the contribution of Neil Churchill, a staff member of the Division, who assisted in diving operations. We thank Chris Kyranos for allowing us to sample his commercial lobster catch, and Raymond Dand and Robert Ellenberger for collecting creel data at the Pilgrim Shorefront. A special thanks to Kim Trotto of the Division for word-processing various sections of this report. Finally, we appreciate the roles of Robert D. Anderson of Boston Edison Company, W. Leigh Bridges of the Division, and the Pilgrim Administrative-Technical Committee for their input on study programs and editorial comments on project reports.

VI. LITERATURE CITED

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