ECOLOGICAL STUDIES FOR THE OYSTER CREEK GENERATING STATION

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FIN- AND SHELLFISH

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INTRODUCTION

The Oyster Creek Generating Station (OCGS) of Jersey Central Power and Light Co. is a 620 MWE boiling water reactor which has been in commercial operation since December 1969. It is located 3.2 km inland from Barnegat Bay in Lacey Township, New Jersey. The south branch of Forked River and Oyster Creek have been modified as an intake and discharge canal, respectively (Fig. 1). When OCGS is in operation, the flow in the south branch of Forked River is always upstream toward OCGS, and the flow in Oyster Creek is always downstream toward Barnegat Bay. Tidal range at the mouth of Oyster Creek is 0.15 m (U. S. Atomic Energy Commission, AEC 1974). Barnegat Bay is a relatively large (surface area 16,714 ha), shallow (average depth (1.5 m) estuary (AEC 1974). Interchange of water between the Atlantic Ocean and the Bay is limited and occurs through Barnegat Inlet which is narrow (Makai 1973, Carpenter 1963). Normal tidal range in Barnegat Bay is 0.3 m (Makai 1973).

Samples were taken primarily in the middle portion of Barnegat Bay from Good Luck Point in the north to Gulf Point in the south (surface area 9,816 ha). The eastern study area contains extensive shoal areas (depth 0.2 to 0.9 m); the central and western Bay is deeper and ranges from 1.2 to 3.7 m (National Oceanic and Atmospheric Administration 1976).

Several studies of Barnegat Bay and OCGS have been conducted. Makai (1973) reported on the physicochemical parameters of upper Barnegat Bay, and Halgren (1973) conducted a study on the usage of the upper Bay. Wurtz (1965), Marcellus (1972), and McClain (1973) reported on the fishes of the

Bay. Wurtz (1972) also reported preliminary findings on impingement of fishes and crabs at OCGS. Rutgers University conducted studies of the benthic invertebrates and benthic algae (Loveland et al. 1966-1972, 1974); this work was reviewed by Vouglitois (1976).

Since 8 September 1975, Ichthyological Associates, Inc. has conducted studies to determine and assess the biological impact of OCGS and its discharges and has implemented an ecological survey of fin- and shellfish populations in Barnegat Bay, Oyster Creek, and Forked River. Life history studies of fishes and macroinvertebrates designated as important by the U. S. Nuclear Regulatory Commission (NRC) and the U. S. Environmental Protection Agency (EPA) were conducted. This document summarizes information collected from September 1975 through August 1976. Data from individual collections were presented previously (Ichthyological Assoc., Inc. 1976 a, b; Tatham et al. 1977a, b) and may be obtained at cost. Volume one covers the water quality program and investigations of fin- and shellfish populations and volume two zoo- and ichthyoplankton investigations. The common and scientific names of fishes and invertebrates used in this report are given in Tables 1-3.

WATER QUALITY

Thomas R. Tatham

Introduction

Water temperature, salinity, pH, dissolved oxygen, and water clarity were taken with each biological collection and test. Free and total chlorine were determined for each temperature shock test and for samples in the area of the condenser discharge. These data were used to describe the physicochemical regimes in Barnegat Bay, Forked River, and Oyster Creek.

Materials and Methods

Water temperature and dissolved oxygen were measured with a YSI oxygen meter (Model 57A). Salinity was determined with an American Optical hand refractometer. The pH was measured in the field with a Photovolt pH meter (Model 126A) and in the lab with a Corning pH meter (Model 610A). Free and total chlorine were determined with a Fischer - Porter amperometric titrator located in the laboratory trailer at OCGS. Water clarity was measured with a 20-cm Secchi disc only during daylight. Procedures for the use and calibration of these instruments were presented previously (Ichthyological Assoc., Inc. 1976a).

Surface and bottom water chemistry was taken with impingement and all trawl and gill net collections. Bottom water samples were obtained with a 1.7- or 5-liter Niskin bottle. Only surface chemistry was taken with seine collections. During impingement sampling, surface chemistry was taken

with each collection but bottom chemistry with only the first and last collection. If a substantial difference existed between the first surface and bottom chemistry, however, both chemistries were taken with each subsequent collection. Only surface chemistry was taken at the condenser discharge because water discharged from OCGS was thoroughly mixed.

In the field, water chemistry was generally taken between replicate collections or, for unreplicated sets of the gill net, at the beginning of the collection. Chemistry associated with impingement and entrainment samples was usually taken during the collection period. To determine instrument variability, the first and last water chemistry of any sampling date was replicated by taking a second reading from the same water sample. The standard deviation of water temperature and dissolved oxygen was 0.1 C and 0.1 ppm, respectively (Lynch et al. 1977).

The change in the temperature of water circulated through OCGS was determined from operating parameters supplied by Jersey Central Power and Light Co. The change in the dissolved oxygen value of water passed through the OCGS condenser was determined with a paired t-test ($P \leq 0.05$) on water chemistries taken during entrainment sampling in November 1975 and July 1976.

Results and Discussion

The mean monthly water temperature, salinity, pH, dissolved oxygen value, and Secchi disc reading at stations in Forked River, Oyster Creek, and Barnegat Bay were summarized from water chemistries associated with fisheries collections.

With the exception of the stations in the OCGS thermal plume, there was little variation in the mean monthly temperature among stations in the

western portion of Barnegat Bay and the mouth of four tributary creeks (Table 4). The difference in temperature among stations rarely exceeded 1 C. The temperature in the OCGS thermal plume east of the U. S. Route 9 highway bridge averaged about 2.4 C greater than the temperature in the Bay from September through December 1975 and about 3.4 C greater than the Bay temperature from March through August 1976. The temperatures in Oyster Creek and Forked River were similar during January and February when OCGS was shut down. The mean monthly temperatures in the Bay and Forked River declined from September (19.2-20.8 C) through January (-1 to 1.5 C) and then increased to a maximum (24.3-25.6 C) in August. Makai (1973) reported a maximum temperature of 26.9 C in Barnegat Bay during August and September 1972; the minimum temperature (0.9 C) was recorded in February.

A substantial difference ($\geq$ 0.5 C) between the mean monthly surface and bottom temperature was most common at the station in the mouth of Forked River and Cedar, Stouts, and Double creeks. Mean surface temperature at stratified stations averaged 1.4 C warmer than the bottom temperature. These differences were most common from April through June. Temperature stratification was less common during other months. Makai (1973) also found temperature stratification throughout the Bay.

A difference between the mean monthly surface and bottom temperature at stations in the OCGS thermal plume was noted. During December, surface temperature in Oyster Creek was 0.9 to 3.0 C cooler than bottom temperature. The surface water temperature off the mouth of Oyster Creek was frequently warmer than the bottom temperature. This phenomenon resulted in part from the deflection of the thermal plume in Oyster Creek to the surface of the Bay

by a ledge of sediment at the Creek mouth (M. B. Roche, personal communication).

The mean monthly increase in the temperature of water circulated through the OCGS condensers (Δ T) ranged from 4.9 C in March to 9.7 C in August (Table 5). The ΔT's would have been higher if OCGS operated at full rated capacity throughout the month. Several shutdowns and periods of operation at reduced capacity resulted in a lower mean monthly ΔT.

Generally, a north to south gradient of salinities was found in the western portion of Barnegat Bay (Table 6). The lowest salinity was always found at the mouth of Cedar Creek, the northernmost station. The greatest salinity was always found at the southernmost stations: Barnegat Inlet, the mouth of Double Creek, or the Bay off Waretown. Similar findings were reported by Makai (1973) and Carpenter (1963). The mean monthly salinity at the mouth of Double Creek (22.0-29.1 ppt) averaged 6.4 ppt (4.6-7.8 ppt) greater than the salinity at the mouth of Cedar Creek (14.8-24.6 ppt). The salinity at the other stations was intermediate and generally similar. The mean monthly salinity at the mouth of Oyster Creek (19.3-26.9 ppt) averaged 3.7 ppt (2.1-5.1 ppt) greater than the salinity at the mouth of Cedar Creek and 2.6 ppt (1.6-4.9 ppt) less than that at the mouth of Double Creek.

Mean monthly salinity in Forked River (Sta. 4, 6) was almost always 0.3 to 2.3 ppt greater than the salinity at the corresponding station (17, 15) in Oyster Creek. These differences occurred in all months including January and February when only the dilution pumps were in operation. Water flows up the south branch of Forked River, through OCGS or the dilution pumps, and down Oyster Creek. Between the stations in Forked River and those in Oyster Creek, fresh water is added from both the headwaters of the south branch of Forked River and Oyster Creek.

The mean monthly salinity at all Bay and creek stations generally decreased from September through January and increased from February through July. Salinity decreased slightly during August, probably due to rain from Hurricane Belle on 9 August.

A difference ($\geq$ 0.5 ppt) between surface and bottom salinity was noted at both Bay and creek mouth stations. Stratification was most frequent (10 of 12 months) at the mouth of Cedar Creek. It occurred equally at creek mouths (22.9% of these mean monthly salinities) and in the Bay (22.2%) but somewhat less (16.7%) in Forked River and Oyster Creek. Salinity stratification was most common during October (5 of 11 stations), January (7 of 11), and March (7 of 11). Little stratification was observed during December (1 of 11) and from April through August (7 of 55). Carpenter (1963) suggested that salinity stratification tended toward a two layer circulation pattern in areas of Barnegat Bay deeper than 1.5 m.

The mean monthly pH ranged from 6.9 to 8.6 (Table 7). Makai (1973) reported that pH in the Bay ranged from 6.4 to 8.4. Over the year, there was no apparent trend in pH. The highest value was often found in Barnegat Inlet.

The dissolved oxygen level was similar among the creek mouth and Bay stations (Table 8). The greatest values (11-12 ppm) were recorded during the coldest months (January and February) and the lowest (6-8 ppm) during the warmest months (July and August). Makai (1973) reported similar maximum and minimum values during the same months. He found that vertical stratification in the Bay did not exceed 2.9 ppm.

No apparent difference in mean monthly dissolved oxygen level was found between Oyster Creek (Sta. 15) and Forked River (6). Similarly, the

dissolved oxygen value of water before and after circulation through the condensers at OCGS was not significantly different. Neither Jacobsen (1976) nor Adams (1969) found a change in the dissolved oxygen concentration of water passed through the condensers of power plants. Markowski (1959) noted a slight change in dissolved oxygen level after condenser passage, and Trembley (1960) reported losses of dissolved oxygen as high as 4.5 ppm.

The greatest mean monthly Secchi disc transparency was consistently found in the southern part of the study area: Barnegat Inlet (7 of 12 months), the mouth of Double Creek (3 of 12), and the Bay off Waretown (2 of 12). Some 50% of the lowest mean monthly transparencies were from stations in Oyster Creek or just off the mouth of the Creek (Table 9). Generally, the greatest values (90-187 cm) were found from November through January and during April. The lowest values (62-113 cm) were recorded during July and August.

IMPINGEMENT ON THE TRAVELING SCREENS

Gerald J. Miller

Introduction

Little data were previously available to determine the magnitude and assess the impact of the impingement of fishes and macroinvertebrates on the traveling screens at OCGS. The objectives of this study were to determine the species composition and abundance of organisms impinged on the traveling screens at OCGS, their survival rate when returned to the discharge canal, and any impact on populations in the receiving water.

Materials and Methods

Impingement samples were taken from the sluiceway after the last traveling screen and from the sluiceway pit (Fig. 2). Samples were taken three days a week during four periods. Period 1 was from sunrise to 6 h before sunset, period 2 was from 6 h before sunset to sunset, period 3 was from sunset to 6 h after sunset, and period 4 was from 6 h after sunset to sunrise. In 1975, periods 2 and 3 were sampled twice a week, and all four periods were sampled consecutively during 24 h. In 1976, period 3 was sampled three times a week, period 4 was sampled twice, and all four periods were sampled consecutively during 24 h. Since most impingement occurred at night (Thomas and Miller 1976), this increased frequency of sampling during period 4 was designed to give a better estimate of total weekly impingement. Sampling frequency during daylight hours was decreased, and periods 1 and 2 were sampled once or, on an alternating basis, twice a week.

A 10.7-mm mesh wire basket (45.7 x 50.8 x 61.0 cm) was used to collect organisms from the sluiceway (Sta. 8) to determine the condition of impinged organisms (Fig. 3). A 10.7-mm mesh wire basket (101.6 x 101.6 x 121.9 cm) was used to collect organisms from the pit (Sta. 9) to determine the number of impinged organisms (Fig. 3). The pit sampler was lowered into place after the screens were washed at the beginning of the sampling period. Subsequently, the screens washed automatically either every 2 h or more often if the pressure differential across the screens reached a critical level. The screen wash involved one complete revolution of the screens and lasted from 10 to 11 min. After the screens had washed for 1 min, the sluiceway sampler was inserted. After 1 min or less, depending on the mass of organisms present, it was removed and the organisms were placed on a 3.9-m^2 table. The sluiceway sampler was replaced, and the procedure repeated. A maximum of six, 1-min samples were taken during each screen wash. The rest of the sample passed into the pit sampler; at the end of the screen wash it was removed and the specimens were processed.

Collections from the sluiceway sampler were rapidly processed on the table. Fishes were placed into a 45-liter insulated cooler filled with water, and crabs were placed into 10-liter plastic buckets. The condition of the organisms was determined 5 to 10 min after the end of the screen wash. Live denoted a specimen which had no apparent damage and which was swimming normally. Damaged specimens were alive (opercular movement in fishes) but showed external damage or abnormal behavior. Dead specimens showed no movement (opercular movement in fishes) or sign of life.

When the screens washed frequently or continuously, it was not possible to collect all impinged organisms. The total impingement during a period was then extrapolated from collections taken during the portion of the period that was sampled. Estimated weekly impingement during a

period was calculated by multiplying the actual or extrapolated number of specimens impinged during a period by 7 and by dividing this number by the number of times that period was sampled during the week. The total weekly impingement was the sum of the estimated weekly impingement for each period.

Number and weight of abundant species were estimated volumetrically. After all other species were removed from the sample, it was thoroughly mixed, and a known volume removed. Number and weight of the abundant species in this subsample were determined and used to estimate the number and weight in the total sample.

All specimens, or a representative subsample, of important fishes and the sand shrimp were preserved for life history studies. A representative subsample of the blue crab was analyzed for length, weight, sex, and stage of maturity immediately after collection, and the crabs were released.

A stepwise multiple regression analysis was used to determine the statistical significance of differences in the number of specimens impinged per hour (dependent variable) due to water temperature, salinity, dissolved oxygen, pH, time of day, wind speed, wind direction, number of screens washing, and water flow (independent variables). Time of day was recorded so that the period of greatest impingement had the largest value (period 2 = 1, period 1 = 2, period 4 = 3, and period 3 = 4). Wind speed was recorded so that the greatest speed had the highest value: calm = 1, light (1-9 mph) = 2, moderate (10-25 mph) = 3, and heavy (25+ mph) = 4. Wind direction was recorded as N(1), NE(2), E(3), SE(4), S(5), SW(6), W(7), and NW(8). The natural logarithmic transformation of the dependent variable reduced skewness, approximated normality, and changed any curvilinear relationships to linear (Sokal and Rohlf 1969). A tolerance value of 0.001 was used, and the F value for inclusion and deletion was 4.0 (Hewlett-Packard 1974).

Results

A total of 941 collections was taken during 42 weeks from 8 September 1975 through 3 September 1976. No collections were taken from 24 December through 7 March because OCGS was shut down. Some 431 collections were made during the day (189 in period 1 and 242 in period 2) and 510 at night (357 in period 3 and 153 in period 4). Each collection represented the organisms impinged for a duration of from 7 min to 7 h 32 min.

Some 1,981,057 specimens, weighing 10,874 kg, of 130 taxa were collected. The total estimated impingement for the 42-week period was 10,104,320 specimens weighing 58,234 kg (Table 10). Fishes accounted for an estimated 1,948,852 specimens (10,500 kg) of 90 taxa, and invertebrates accounted for an estimated 8,155,468 specimens (47,734 kg) of 40 taxa. Fishes comprised 19% of the number of the estimated organisms impinged and 18% of the weight.

The most numerous fishes were the bay anchovy (84% of the estimated fish impinged), Atlantic silverside (3%), northern pipefish (2%), and blueback herring (1%). The most important fishes by weight were the bay anchovy (42% of the estimated fish biomass impinged), Atlantic menhaden (11%), summer flounder (9%), and winter flounder (3%). The most numerous invertebrates were the blue crab (57% of the estimated invertebrates impinged), sand shrimp (39%), and grass shrimp (4%). The most important invertebrates by weight were the blue crab (90% of the estimated invertebrate biomass impinged), sand shrimp (6%), and horseshoe crab (3%).

Some 81% of the fishes impinged were taken from 28 March through 29 June; most were bay anchovy. Some 95% of all bay anchovy impinged were collected from 21 March through 29 May. For the Atlantic silverside, 77% were impinged from 21 through 27 December and from 7 March through 3 April. Some 66% of the northern pipefish were impinged from 30 November

through 27 December and from 7 March through 10 April. Most (75%) Atlantic menhaden were impinged from 30 November through 27 December and from 18 through 24 July. Some 59% of the winter flounder were impinged from 13 June through 3 July; most of these were young (age 0+). Most (58%) summer flounder were impinged from 19 October through 27 December and from 16 May through 19 June.

A total of 48% of the invertebrates was impinged from 23 May through 21 August. The blue crab comprised most of these specimens; 71% of all blue crab were impinged from 2 May through 21 August. Most (99%) sand shrimp were collected from 30 November through 27 December and from 7 March through 26 June. Most grass shrimp (83%) were impinged from 21 April through 3 July. Horseshoe crab was most abundant (75%) from 18 April through 19 June.

When 42, 24-h sampling periods were analyzed, only 13.6% of the fishes and invertebrates were impinged during daylight hours. Most (86.4%) were impinged at night. In the 6 h after sunset, 65.5% of the organisms (69% of the invertebrates and 50.5% of the fishes) were impinged (Table 11).

Some 53,054 specimens were examined for condition; 52.3% were live, 19.3% damaged, and 28.4% dead (Table 12). Many species passed from the screens in good condition. Only 4% of the northern pipefish, 10% of the northern puffer, 8% of the blue crab, and 13% of the sand shrimp were dead (Table 13). Specimens of the bay anchovy (77% dead), spot (69%), bluefish (61%), and weakfish (59%) comprised 62% of the dead specimens. The greatest mortalities were recorded in April (59%) and May (52%) due to the large number and high mortality of the bay anchovy.

Seasonal variation in mortality was noted for some species. Generally, mortality of these species was lower during late fall and early spring. Mortality of the bay anchovy decreased from September through December and increased from March through August. The mortality of the

blueback herring, Atlantic menhaden, and Atlantic silverside increased from March through May. Weakfish mortality decreased from September through November. Mortality of the sand shrimp decreased from October through December and also from March through June (Table 13).

Based on 24-h samples, approximately 36% of the organisms impinged during the day were dead and 46% live. Specimens collected at night showed somewhat improved survival (53%) and decreased mortality (27%).

The total impingement estimate by week was also expressed as the number of specimens impinged per hour and per million gallons of cooling water flow (Table 14). The most (7,005) specimens collected per hour were taken from 13 through 19 June and the least (39) from 2 through 8 November. The average number per hour for the 42 weeks was 1,432 specimens. The most (254) specimens collected per million gallons of cooling water flow also occurred from 13 through 19 June and the least (2) from 12 through 18 October. The average number impinged per million gallons of cooling water flow was 61 specimens.

Northeast winds (particularly storm conditions) coincided with greater impingement. Between September and December, 15% of the collections were made during northeast winds whereas 29% of the specimens and 31% of the biomass were taken then (Thomas and Miller 1976). The number impinged increased almost 10 times between 8 October (southwest winds) and 9 October (northeast winds). An approximate tenfold increase was also found between 20 November (north wind) and 24 November when the wind was from the northeast (Figs. 4 and 5).

Of the estimated 10,104,320 specimens impinged on the screens, 99% were of 10 species. These are discussed in order of their numerical abundance.

1. A total of 705,382 blue crab (estimated total of 4,617,069) was impinged; most (71%) were taken from 2 May through 21 August. It comprised 46% of the total estimated number of specimens impinged and 74% of the total weight. About 83% were taken at night. It had a mortality rate of 8%. Some 29% were damaged, and most of these were missing one or more appendage. Individuals with missing appendages are common in nature, and limbs can be regenerated.

2. A total of 749,910 sand shrimp (estimated total of 3,201,475) was impinged; some 42% of the specimens were taken from 30 November through 27 December. It comprised 32% of the total estimated number of specimens collected and 5% (ranked third) of the total weight. It had a mortality rate of 13%. Some 94% were impinged at night.

3. A total of 384,589 bay anchovy (estimated total of 1,643,467) was impinged; most (95%) were taken from 21 March through 29 May. It comprised 16% of the estimated number of specimens collected and 8% (ranked second) of the weight. Some 77% were dead and only 8% live. Sixty-one percent were taken at night.

4. A total of 69,114 grass shrimp (estimated total of 327,247) was impinged; most (83%) were taken from 21 April through 3 July. It had a mortality rate of 7%. About 94% were taken at night.

5. A total of 16,524 Atlantic silverside (estimated total of 58,138) was impinged; most (77%) were taken from 21 through 27 December and from 7 March through 3 April. It had a mortality rate of 40%. Some 55% were taken at night.

6. A total of 9,907 northern pipefish (estimated total of 34,810) was impinged; most (66%) were impinged from 30 November through 27 December and from 7 March through 10 April. It had a 4% mortality rate. About

77% of those impinged were taken at night.

7. A total of 7,608 blueback herring (estimated total of 26,409) was impinged; 65% were taken from 21 through 27 December. It had a 44% mortality rate. Most (80%) were taken at night. Most fish were young (mean weight=9 g).

8. A total of 4,693 striped searobin (estimated total of 22,434) was impinged. Most (78%) were taken from 15 August through 4 September, and about 95% were impinged at night. It had a 27% mortality rate.

9. A total of 4,527 Atlantic menhaden (estimated total of 18,191) was impinged; most (56%) were taken from 30 November through 27 December. It comprised 2% (ranked fourth) of the total weight. It had a 31% mortality rate but 62% were damaged. Some 71% were taken at night.

10. A total of 1,659 bluefish (estimated total of 12,283) was impinged; 76% were taken from 23 May through 19 June. It had a mortality rate of 61%. Sixty-two percent of the bluefish were impinged at night.

Multiple regression analysis was used to relate impingement to environmental and physical factors (Table 15). Time of day, cooling water flow, and water temperature accounted for 56% of the variation in the impingement of all specimens. Thirteen species of fishes and invertebrates were analyzed separately, and time of day, water flow, water temperature, and number of screens washing were most frequently related to impingement. The blue crab had the most variation explained; water flow, time of day, and water temperature accounted for 67% of the variation in impingement. The environmental factors explained 8 to 68% of the variation in impingement for the other species.

The sign of the regression coefficients indicated that the impingement of all specimens increased as water flow, number of screens washing, wind speed, and time of day (day to night) increased. Conversely,

impingement increased as dissolved oxygen (April-September) and water temperature decreased (December). The impingement of the individual species generally increased as water temperature decreased and as time of day (day to night), wind speed, and water flow increased. The blue crab and winter flounder were exceptions because their impingement increased as water temperature increased.

Discussion

Most fishes were impinged when water temperature was seasonally increasing or decreasing. The estimated number of fishes impinged was greatest from March through June and in December. Changing water temperature probably influenced the movement of specimens either into, out of, or within the Bay. Texas Instruments, Inc. (1974) reported that temperature influenced impingement at the Indian Point Nuclear Generating Station on the Hudson River by affecting the distribution of fishes within the River; impingement appeared to be directly due to relative species abundance and only indirectly to physicochemical parameters. Low water temperature, particularly from October through December, may also reduce the ability of fishes to avoid impingement. Grimes (1975) believed that high impingement during winter probably reflected a cold-induced sluggishness in fishes and not simply an increase in abundance. The greatest number of invertebrates was impinged from March through August and in December. The blue crab was active in Barnegat Bay primarily from May through October, and its impingement increased as water temperature increased.

Most impingement (86.4%) occurred at night. Of the ten most abundant species, the Atlantic silverside had the smallest percentage of specimens (55%) impinged at night. Grimes (1975) found that the

mean catch per hour on the screens at a generating station on the Crystal River in Florida was significantly greater during darkness. Texas Instruments, Inc. (1975) indicated that the greatest impingement at the Indian Point Nuclear Generating Station on the Hudson River occurred between 2200 and 0600 h. In a comparison of night, afternoon, and morning collections from the screens at the P. H. Robinson Generating Station in Texas, Landry and Strawn (1974) showed that the mean impingement catch during 9 of 13 months was greatest at night and least during the afternoon.

Water flow was primarily related to the number of circulating pumps in operation. Only three circulating water pumps operated from September through December while four pumps usually operated from March through August. Although the estimated number of fish impinged during March and April was 10 times greater than the number impinged from September through December, it was difficult to discern how much was attributable to increased water flow and how much to differences in abundance of organisms in front of the screens. At the P. H. Robinson Generating Station, Chase (1975) reported that more specimens were collected from the screens at Units 3 and 4 than from Units 1 and 2. He believed this difference was caused in part by a greater volume of water and a greater average maximum approach velocity at Units 3 and 4.

The number of screens washing accounted for much of the explained variation in the impingement of the winter flounder and bluefish. A decrease in the number of screens washing increased impingement possibly due to subsequent higher intake velocities at the other screens.

The condition of organisms by time period indicated the percent of dead specimens was less and the percent of live organisms greater at

night than during the day. Lower mortality of fishes at night may reflect the ability of healthy organisms to avoid the screens during the day while weaker organisms could not avoid the screens and were impinged. Less screen avoidance at night by all organisms could have resulted in greater impingement of healthy organisms and thus a reduced mortality rate. Landry and Strawn (1974) found that the greatest impingement and the least damage occurred at the 2200 h sample, while daytime samples had the lowest impingement but the most damage.

This study showed a greater number of specimens impinged per hour than the preliminary assessment of impingement made by the AEC. Their impingement rates were based on collections taken at the OCGS traveling screens from 11 April through 1 July 1971. The AEC (1974) estimated that 24 fish and 147 blue crab were impinged per hour. From 11 April to 26 June 1976, 808 fish, 1,316 blue crab, and a total of 3,120 organisms were estimated to have been impinged per hour. The very low AEC estimate may have been due to year class variation (i.e. bay anchovy and blue crab may have been more abundant in 1976) and to the limited sampling program in 1971.

The species composition of fishes and invertebrates impinged at OCGS from 11 April to 1 July 1971 (AEC 1974) was similar to that from 11 April to 26 June 1976. The blue crab, winter flounder, bay anchovy, northern pipefish, and Atlantic silverside were the dominant species during both years. Besides these species, the sand shrimp and grass shrimp were abundant in 1976; these invertebrates were not mentioned in the AEC study and may have been disregarded by the investigators.

SCREEN WASH FLUME PASSAGE

Randall P. Rode and Michael F. Boyle

Introduction

Organisms impinged on the traveling screens of the condenser water intake are washed into the discharge canal through a 76-cm diameter flume (Fig. 2). The flume is approximately 23 m in length and empties into the canal about 50 m from the discharge of the condensers. Impinged fishes and macroinvertebrates were sampled before they entered and after they traversed the flume to determine the effects of passage. Delayed mortality of these organisms was examined in a separate study.

Materials and Methods

From October 1975 through August 1976, collections were taken at night every 2 weeks. Before the flume, organisms were collected from the sluiceway in front of the screens with a 45.7- x 50.8- x 61-cm sluiceway sampler (Fig. 3) As many as five, 1-min samples were taken during the 10- to 11-min screen wash. Specimens were rapidly processed on a 3.9-m^2 table, and fishes and crabs were placed in separate 45-liter coolers. Organisms were identified, and their condition was recorded as live, dead, or damaged (See page 10).

From October through December, the screen wash flume sampler was placed over the end of the flume discharge and held in place by a line tied to the bulkhead. The sampler was a 0.9- x 0.9- x 1.2-m frame of aluminum tubing covered with 9.5-mm mesh netting that had a 76-cm diameter opening in one side. All portions of the wash not collected

with the sluiceway sampler were collected after passage through the flume. This sampler proved unwieldy and after January, specimens were collected by holding a 45.7- x 50.8- x 61-cm sluiceway sampler at the opening of the discharge pipe. Specimens were rapidly sorted, and fishes and crabs were placed in separate 45-liter insulated coolers. Organisms were identified, and their condition was recorded as live, dead, or damaged.

Results and Discussion

Some 698 specimens were collected from the sluiceway, and specimens were taken at the discharge of the screen wash flume.

The blue crab was the most numerous (n = 191) macroinvertebrate (Table 16). Due to their abundance, crabs collected during March and April were not enumerated. Blue crab collected after the flume had greater damage (19%) than those collected before the flume (6%). No mortality was observed (Table 17). During regular sampling at the traveling screens, a somewhat greater percentage of dead (8%) and damaged (29%) blue crab was observed.

The bay anchovy (n = 781) was the most numerous fish taken and comprised 65% of the fishes collected. Some 90% of the bay anchovy were collected during March and April. The percent of dead and damaged bay anchovy collected at the sluiceway (70% dead, 28% damaged) and at the discharge of the flume (75%, 20%) was similar. Impingement collections indicated that 77% of the bay anchovy impinged on the traveling screens were dead, and 14% were damaged.

The Atlantic silverside (n = 113) accounted for 9% of the fishes taken. Some 48% of the Atlantic silverside collected before the

sluiceway and 29% collected at the discharge of the flume were dead or damaged. During regular impingement sampling, 66% of the Atlantic silverside impinged were dead or damaged.

The northern pipefish (n = 40) accounted for 3% of the fishes taken. The Atlantic menhaden, spot, and winter flounder were also common. None of these species had substantial differences in mortality before and after passage through the screen wash flume. Too few individuals of these species were collected to make meaningful comparisons to impingement mortality estimates.

Although sample size was small, no additional immediate mortality or damage of fishes and macroinvertebrates passed through the screen wash flume was apparent. More accurate estimates of species abundance, composition, and condition of impinged organisms were presented in the section covering impingement on the traveling screens (See page 9).

On two occasions, large schools of mummichog were observed around the end of the flume discharge. These specimens were probably not impinged on the traveling screens but were residing in or around the flume discharge.

TEMPERATURE SHOCK STUDIES

Kurt R. Powers

Introduction

The objective of this program was to determine the effect of the transfer of fishes and macroinvertebrates from ambient water in Forked River to the heated discharge of OCGS. Mortality and loss of equilibrium associated with the temperature change (ΔT's) experienced at OCGS from October 1975 through August 1976 were determined. Most tests were run on the Atlantic menhaden, bay anchovy, northern pipefish, winter flounder, and blue crab; these species were designated as important species by the NRC. Limited work was also done with other species.

Materials and Methods

A 15.2- x 3.0-m mobile experimental laboratory at OCGS was situated between the discharge of the condensers and of the dilution pumps (Fig. 2). Floating pumps located in each discharge supplied the laboratory with heated and ambient water, respectively.

The experimental laboratory was divided into a holding facility, a testing facility, and a work area. The holding facility consisted on one, 900-liter circular fiberglass tank; three, 200-liter oval fiberglass tanks; and a mechanical-biological filter. The first section of the filter consisted of a 0.5- x 0.75- x 0.75-m box containing an upper layer of 5- to 20-mm pebbles, a second layer of 1- to 3-mm quartz pebbles, and a lower layer of

of fine sand. In addition to bacteria, a few filter and detritus feeders (the sand shrimp, silversides, and killifishes) were stocked in the box as biological components. The second section of the filter was a box of the same dimensions as the mechanical-biological portion and collected the filtered water. It contained a pH buffer and a carbon column to remove harmful gases. Water was pumped through the carbon column at a rate of 2 liters/min. The pH buffer was finely crushed clam (Mercenaria) shells spread over the bottom in a thin layer. It maintained the pH at 7.8, the approximate pH (7.6-8.1) of ambient water.

Temperature shock studies were performed in the testing facility. Two, 0.66- x 0.75- x 2.44-m plywood tanks served as water baths for the control and experimental aquaria. Six, 56-liter glass aquaria in each water bath served as test chambers. Ambient and heated water were available in each aquarium.

Experimental aquaria were supplied with heated water under either flow-through or closed-cycle circulation. The control aquaria and holding facilities were provided with ambient water under flow-through circulation. Water was taken from either the condenser or the dilution pump discharge, circulated through the lab, and returned to the discharge canal. The closed system contained approximately 1,800 liters of water which circulated through the filter and the experimental aquaria. The water in the water bath overflowed through a standpipe and was gravity returned to the filter. Water was heated by two, 1000-watt Vycor immersion heaters in each water bath and by two heaters in the filter. Heaters were controlled by YSI temperature controllers (± 0.5 C). Further temperature control in the water baths was provided by two Frigid Unit refrigeration units regulated by the

the same YSI temperature controllers. The closed system was used when OCGS was shut down.

Specimens were collected with various gear. A 4.9-m, semiballoon trawl with the codend modified to reduce the stress of collection was used to collect Atlantic menhaden, northern pipefish, white perch, and winter flounder. A 12.2- x 1.5-m beach seine was used to collect bay anchovy, Atlantic silverside, fourspine stickleback, and northern pipefish. A 1- x 1- x 1.2-m pit sampler with 10.7-mm wire mesh (Fig. 3) was used to collect northern pipefish, blue crab, and sand shrimp from washes of the traveling screens. The dilution pump sampler (Fig. 3) was used to collect winter flounder and sand shrimp. A 1.5-m diameter cast net was employed to collect Atlantic menhaden, bluefish, and spot. A 1-m diameter lift net was used to collect blueback herring and bay anchovy. A dip net was used to collect Atlantic menhaden from the dilution pump discharge.

All specimens were brought to the laboratory in 45-liter insulated coolers to minimize temperature change during transport. Air was supplied to the coolers with battery operated air pumps when transport time exceeded 5 min. Fish were acclimated at 3 C or less per hour to laboratory conditions. to prevent temperature, salinity, or pH shock and were maintained in the holding facility at ambient temperature under flow-through conditions.

Specimens were fed preferentially on a variety of foods: chopped fish, brine shrimp, and commercially prepared flake (Tetramin) or pelleted (Purina #4 floater) food. Organisms were not fed during or 24 h prior to a test.

For delicate species (the Atlantic menhaden, blueback herring, bay anchovy, and Atlantic silverside), handling during collection and testing was minimized by transporting these organisms with a 4-liter plastic scoop from the collection gear to the coolers and from the holding tanks to the test chamber.

All organisms were held at least four days prior to testing, and stressed individuals were not tested.

An equal number of specimens was placed in each aquarium. The number of specimens per test varied according to their size and availability. Organisms were removed from the holding facility and placed directly into the control or experimental aquaria. The degree of temperature shock depended upon the heat rejection (Δ T = 3.6-14.8 C) of OCGS or the temperature in the closed system (Δ T = 11.2-24.6 C). Observations were made continuously for the first hour, hourly up to 8 h, and three times daily to 96 h. Temperature, dissolved oxygen, salinity, total chlorine, and pH were determined at each observation. Mortality, loss of equilibrium, and any other event considered significant were noted at each observation. Mortality of fish was defined as lack of opercular movement for a period of 5 min. Mortality of the blue crab and sand shrimp was defined as the lack of movement or sign of life. Inability of an organisms to maintain normal orientation was considered loss of equilibrium. The percent mortality at each observation was adjusted if mortality occurred in the control. Adjusted experimental mortality was calculated as the actual experimental mortality minus the control mortality. Tests were considered invalid if more than 20% of the organisms in the control died for reasons other than cannabalism or minor mechanical failure of the experimental system.

Results

Temperature shock tests are summarized in Table 18.

The blue crab was tested at an ambient temperature of 3.8 to 24.3 C and tolerated all but the most extreme shock temperature (Table 19). Substantial

(> 20%) mortality occurred in two bioassays. At a test temperature of 34.0 C, the adjusted experimental mortality was 30%. The adjusted mortality (90%) at a test temperature of 37.0 C was sufficient to generate an LT_{50} of 57 h. Most mortality in other tests was due to cannabalism.

The Atlantic menhaden was tested extensively from May through August at an ambient temperature of 4.8 to 26.0 C (Table 20). At an ambient temperature of 15.8 and 18.2 C, no mortality was observed. Substantial (> 20%) mortality occurred at ambient temperatures above 19 C and test temperatures above 28.0 C. Complete mortality was consistently observed when the test temperature exceeded 31.0 C; the LT_{50} values were less than 1 h. At the highest temperature (ambient temp = 26.0 C; test temp = 37.0 C; ΔT = 11.0 C), the LT_{50} was less than 3 min, and complete mortality occurred in approximately 8 min. During one test, the control organisms received a cold shock (acclimation temp = 6.5 C, control temp = 1.5 C) as the ambient temperature dropped sharply. Complete mortality of the control specimens occurred but specimens exposed to increased temperature (test temp = 17.7 C) had only 20% mortality.

The bay anchovy was tested at an ambient temperature of 5.6 to 24.5 C (Table 21). From October through December, bay anchovy tolerated a ΔT of 2.6 to 12.2 C. From April through June, substantial (> 50%) mortality occurred when the ambient temperature exceeded 15.7 C, the test temperature exceeded 25.2 C, and the ΔT was greater than 5.1 C. At the most extreme temperature (ambient temp = 22.5 C; test temp = 37.3 C; ΔT = 14.8 C), the bay anchovy had an LT_{50} of less than 1 min. Testing of the bay anchovy was hampered by substantial (38.9-65.0%) control mortality in several tests. Because of the delicate nature of this fish, clearly defined limits of low (< 20%) mortality could not be determined.

The northern pipefish was tested at an ambient temperature of 1.0 to 15.0 C (Table 22). During December (ambient temp = 5.6 and 7.7 C), little ($<$ 5.0%) mortality was observed at a test temperature of 15.4 and 19.8 C. From March through May, tests at an ambient temperature of 10.8 to 17.0 C and a shock temperature of 19.6 to 25.7 C resulted in mortality ranging from 20 to 44%. One test (ambient temp = 7.0 C; test temp = 15.6 C; ΔT = 7.7 C) resulted in 63.5% mortality. Under flow-through conditions, many experimental specimens were affected by gas bubble disease. These specimens exhibited loss of equilibrium, and mortality often followed. In all tests with substantial (20-100%) mortality, a large (60-89%) percentage of the specimens were affected with gas bubble disease.

Most of the winter flounder bioassays were done under closed-cycle circulation. At an ambient temperature of 7.6 C or less, a ΔT of 16.0 C produced little (6.6-7.1%) mortality of adults (Table 23). At an ambient temperature of 10.1 C and a ΔT of 16.0 C, complete mortality of adult winter flounder occurred. The LT_{50} value was 54 min. All ΔT's above 16.0 C resulted in greater than 70% mortality regardless of acclimation temperature. One test (ambient temp = 19.6 C, test temp = 32.9 C) of young of the winter flounder was performed in July under flow-through conditions. Complete mortality with an LT_{50} of less than 2 min resulted (Table 18).

Other fishes and macroinvertebrates were also tested (Tables 24-30). In most cases, they were only tested at a few temperatures and not over the entire range at which they normally occur.

Young of the bluefish (35.7-181.3 mm) acclimated to an ambient temperature of 19.0 to 26.7 C were tested at a temperature from 27.9 to 37.3 C and a ΔT of 8.9 to 10.6 C (Table 29). Mortality was greater than 85% in all tests and was usually 100%. The most extreme temperature tested

(ambient temp = 26.7 C; test temp = 37.3 C; ΔT = 10.6 C) resulted in an LT_{50} of 1 min. At the least extreme temperature (ambient temp = 19.0 C; test temp = 27.9 C; ΔT = 8.9 C), the lowest (86.9%) mortality occurred.

The spot was tested at an ambient temperature of 25.2 C, a test temperature of 36.0 C, and a ΔT of 10.8 C (Table 30). An LT_{50} of 52 min was observed.

Discussion

Fishes and macroinvertebrates exhibited varying degrees of thermal tolerance, and this tolerance to temperature shock often varied seasonally. Little mortality was observed from October through December at OCGS discharge temperatures.

During March and April, some fishes, such as the fourspine stickleback and blueback herring, were relatively unaffected by the temperature shock experienced at OCGS. The bay anchovy and northern pipefish, however, had significant mortalities. Similar bioassays conducted from October through December resulted in substantially different results. The bay anchovy (mean length = 41.4 mm) tested during October (test no. 75-04) had no mortality while larger (61.0 mm) specimens tested during April (76-32) had 74% mortality (Table 18). Similar bioassays of the northern pipefish indicated that specimens tested during December (75-11) had significantly less mortality (5.0%) than those tested during April (76-25, 62.5% mortality). In addition, most of the northern pipefish tested from March through May were affected by gas bubble disease. Fish tested from March through May were acclimatizing to increasing water temperature while fish tested during December were acclimatizing to declining water temperature. Meldrim and Gift (1971) demonstrated that the avoidance temperatures of white perch acclimated to decreasing water temperatures were significantly different

than those of fish acclimated to increasing water temperature. The population of the bay anchovy present in Barnegat Bay during April and May had a significantly poorer condition factor (weight/length^3) than fish tested from October through December. Mortality of control fish from October through December was usually low (0-5.1%); however, substantial (10.5-65%) mortality occurred among control specimens during April and May.

Fishes tested from May through August did not tolerate discharge temperatures greater than 33 C. Most marine fishes do not survive above 35 C (de Sylva 1969). Fishes tested at or above 35 C had LT_{50} values of 1 to 57 min. At a test temperature of 30 to 34.9 C, the LT_{50} values were 1.6 min to 49 h.

The blue crab tolerated test temperatures of 34.0 C and below with less than 20% mortality but substantial mortality of juveniles occurred at 37 C. Gift and Westman (1971) reported an avoidance temperature of 37.5 C for juvenile blue crab and an avoidance breakdown temperature of 39.2 C. Tagatz (1969) reported 48-h thermal tolerance limits of 38.7 C for adults and 39.0 C for juveniles.

The Atlantic menhaden exhibited significant ($>$ 20%) mortality at test temperatures above 28.2 C (Δ T = 9.2 C). Complete mortality was observed in all bioassays where the test temperature exceeded 31.0 C. The temperature of the inadvertant cold shock bioassay (1.5 C) was below the lethal limit (3.5 C) of young Atlantic menhaden (Reintjes 1975), and 100% mortality was observed.

The bay anchovy had high mortalities during June (test temp = 31.2 - 37.3 C). LT_{50} values indicated that bay anchovy acclimated to an ambient temperature of 22.0 to 24.5 C survived less than 6 h when transferred directly into condenser discharge water. Wyllie et al. (1976) found that bay anchovy acclimated at 15 and 20 C avoided a temperature of 27.6 and 30.8 C, respectively.

Adult winter flounder withstood the temperature shock they would normally experience during February and March at OCGS; however, as the ambient temperature increased above 10.1 C, their tolerance to temperature shock decreased. Young of the winter flounder were tested once during July and did not tolerate a test temperature of 32.9 C. Gift and Westman (1971) concluded that thermal tolerance of winter flounder varied with size. Their studies performed at an ambient temperature of 19.6 C showed that young had an avoidance temperature of approximately 24.4 C. Age 1+ winter flounder, tested during the same period, had a lower avoidance temperature of 23.2 C.

The northern pipefish tolerated a test temperature during December of 15.4 and 19.8 C (Δ T = 9.8 C and 12.1 C) with little (5.0%) mortality. From January through May, a test temperature of 15.6 to 25.7 C (Δ T = 7.7-9.4 C) produced substantial (20-62.5%) mortality. A significant loss of equilibrium, attributed to gas bubble disease, was observed in these fish prior to mortality.

The Atlantic silverside tolerated test temperatures below 28.0 C and Δ T's of 10.5 C or less. Substantial ($>$ 20%) mortality was observed when the test temperature was 34.9 C and the Δ T 12.1 C. Gift and Westman (1971) reported that the mean avoidance temperature was 30.0 C and the mean avoidance breakdown temperature was 34.3 C.

Young bluefish subjected to the temperature shock (test temp = 27.9-37.3 C) encountered at OCGS from June through August had a mortality greater than 85%. Gift and Westman (1971) reported that the mean avoidance temperature for young bluefish was 30.8 C and the upper avoidance breakdown temperature ranged from 33.3 C to 33.6 C.

DILUTION PUMP PASSAGE

Randall P. Rode and Michael F. Boyle

Introduction

The dilution pump intakes are preceded only by trash racks, and large fishes and invertebrates are entrained through the pumps. Collections were made in the dilution pump discharge to determine the species composition, abundance, and condition of fishes and macroinvertebrates passed through the pumps. Delayed mortality of these organisms was examined in a separate study.

Materials and Methods

The dilution pump sampler consisted of a galvanized steel frame (91 cm long) which opened from a 1.2-m^2 mouth to 1.5-m^2; a section of 38-mm stretch mesh netting 3.35 m long; and a 97- x 128- x 97-cm aluminum frame live box with 9.5-mm mesh netting (Fig. 3).

Samples were taken at the dilution pump discharge once every 2 weeks. During 1975, duration of sampling was generally 1 h but varied from 0.5 to 2 h depending on the number of organisms collected. In 1976, each sampling period began 1 h before sunset and consisted of four, consecutive 1-h collections. The sampling period corresponded to the time of greatest impingement on the traveling screens.

A boom was used to lower the sampler into the water. Generally, it was fished near the bottom, although the live box floated at the surface. After collection, crabs and fish were taken from the live box and placed in separate, insulated coolers. Their condition was recorded as live, dead, or damaged (see page 10).

The number of individuals of abundant fishes and macroinvertebrates passed through the dilution pumps each month was compared to the number of specimens impinged on the traveling screens. Impingement sampling periods that most closely corresponded to the day and hour of dilution pump sampling were chosen for comparison. Both the number of organisms collected in the dilution pump sampler and the number impinged were expressed in terms of water volume (n/million gal) sampled by the dilution pump sampler and traveling screens, respectively. Total flow through the traveling screens for the time sampled was determined from OCGS records. Volume sampled by the dilution pump sampler was calculated from the flow rate in the mouth of the sampler, the area of the mouth of the sampler, and the duration of each sample. The flow rate was measured periodically by a General Oceanics Flowmeter (Model 2030) mounted in the mouth of the sampler.

Results and Discussion

From September 1975 through August 1976, 98 collections yielded 3,911+ specimens of 36 taxa (Table 31). The immediate mortality and damage of fishes and macroinvertebrates passed through the dilution pumps were generally less than that of specimens impinged on the traveling screens.

The blue crab was collected during all months except from December through February. Most (n = 638) were collected during July. The blue crab had relatively little mortality (4%) but 23% of the specimens were damaged (Table 32). Condition did not appear to vary seasonally. Crabs impinged on the traveling screens suffered slightly greater mortality (8%) and damage (29%).

The sand shrimp was first collected during December when it was the dominant macroinvertebrate. It remained abundant from January through April. Although 19% were dead during December, mortality in the other months was

only 2%; 3% were damaged and 95% live. The large mortality during December was partially attributed to a small sample size and to an extremely cold air temperature which affected the specimens after they were removed from the sampler. Sand shrimp impinged on the traveling screens had greater mortality (13%) and damage (9%).

The bay anchovy (45% of all fishes, n = 582), spot (24%, 310), striped cusk-eel (7%, 88), winter flounder (5%, 67), and Atlantic menhaden (5%, 63) were the most numerous fishes (Table 31).

Most (98%) of the bay anchovy were collected from March through June. Some 39% of the bay anchovy (n = 145) passed through the dilution pumps were dead and 15% were damaged (Table 32). Immediate mortality (77%) of bay ancnovy impinged on the traveling screens was greater. No difference was noted between the percentage of damaged bay anchovy collected from the screens (14%) and passed through the dilution pump (15%).

The spot (n = 310) was collected from June through August; 38% were dead, 50% live, and 12% damaged. Spot had greater immediate mortality after impingement (69%) than after passage through the dilution pump.

The winter flounder was collected from December through May. Some 97% of the winter flounder (n = 39) passed through the dilution pumps were live and undamaged. Winter flounder showed little (3%) damage and no mortality after passage through the dilution pumps. Some 22% of those impinged on the traveling screens, however, were dead, and 20% were damaged.

The Atlantic menhaden was collected during all months except September, January, February, and April. Mortality of Atlantic menhaden (n = 52) was 15%; 27% were damaged and 58% live. The striped cusk-eel (n = 82) was collected primarily from June through August and had little (6%) mortality; 63% were live and 31% damaged. Both the Atlantic menhaden and striped cusk-

eel had greater mortality and damage after impingement than after dilution pump passage.

Some portion of the immediate mortality was undoubtedly caused by the dilution pump sampler and subsequent handling of the specimens. The relatively little mortality and damage of large individuals of the tautog, winter flounder, and blue crab suggested that some of the mortalities and damage to fishes such as the bay anchovy and spot may have been attributable to the collection procedure. The bay anchovy is a delicate fish that is difficult to handle and maintain in the laboratory. Other delicate fishes such as the Atlantic menhaden, however, showed relatively little mortality and damage; these fishes may have been less susceptible to collection and handling stress when they were collected.

Only one macroinvertebrate and five fishes were abundant enough for meaningful comparisons between the number of organisms collected in the dilution pump discharge and impinged on the traveling screens (Table 33). A comparison of the blue crab catch was made for seven months. In October and November 1975, two to three times as many were passed through the dilution pumps as were impinged on the traveling screens. In March and from May through August 1976, this trend reversed, and from 1.4 to 4.1 times as many blue crabs were impinged. Seven of 10 monthly comparisons indicated more fishes were impinged than passed through the dilution pumps, and three of 10 comparisons showed the reverse.

DELAYED MORTALITY STUDIES

Randall P. Rode and Michael F. Boyle

Introduction

After impingement on the traveling screens or passage through the dilution pumps, organisms are passed into the discharge canal and are usually subjected to increased temperature. A delayed mortality study was conducted to examine the latent effects of impingement, screen wash flume passage, dilution pump passage, and exposure to the heated discharge.

Materials and Methods

During September and October 1975, fishes and blue crab collected before and after the screen wash flume and from the dilution pump sampler were placed in a floating 0.9- x 0.9- x 1.2-m aluminum frame live box with 9.5-mm mesh netting (Fig. 3). The live box was drifted down the canal to the Route 9 bridge where is was held for 0.5 h. The duration of canal passage ranged from 90 to 160 min. Too few fishes were collected to provide an adequate control

After October, canal passage was discontinued because examination of organisms in the live box was difficult at night. Large fish were placed in floating 0.9- x 0.9- x 1.2-m live boxes or in a 900-liter circular holding tank. Small fish, blue crab, and sand shrimp were placed in 23- x 30- x 50-cm screened, wooden live boxes held in the circular holding tank. Large individuals of the blue crab were kept in 0.5- x 0.7- x 1.2-m lobster pots enclosed by 9.5-mm wire mesh. After January, fishes and

macroinvertebrates were also held in 24- x 20- x 40-cm live boxes floated in the circular tank and in a 60- x 80- x 240-cm wooden holding tank divided into eight, 40- x 60-cm compartments. Specimens were held under flow-through conditions in ambient water and in heated water which was pumped from the discharge canal approximately 50 m from the condenser discharge.

Condition of fishes and blue crab was recorded as live, dead, or damaged (See page 10). Condition was determined immediately after collection and, thereafter, twice daily for 48 to 96 h.

Results and Discussion

Some 122 sand shrimp were tested for the delayed effects of dilution pump passage; 6% were dead and 5% damaged after being held for 96 h under ambient conditions (Table 32). None were held in condenser discharge water.

The delayed mortality of blue crab impinged on the traveling screens (3% dead, n = 30), passed through the screen wash flume (4%, 119), or passed through the dilution pumps (2%, 213) and held at ambient temperature was low (Tables 17, 32). No mortality occurred when four impinged blue crab collected before the screen wash flume or three specimens passed through the dilution pumps were held at a condenser discharge temperature of 27.9 to 35.1 C. Two of 11 specimens held at 32.0 to 35.9 C after passage through the screen wash flume died.

The delayed mortality of Atlantic menhaden impinged on the traveling screens or passed through the dilution pumps was great regardless of the temperature at which they were held (Tables 17, 32). Individuals collected before the screen wash flume (n = 17) and after passage through the dilution pumps (30) and held at ambient temperature had a delayed mortality of 88% and 73%, respectively. All Atlantic menhaden passed

through either the dilution pumps (18) or the screen wash flume (6) and held at a condenser discharge temperature of 32.0 to 35.9 C died.

All bay anchovy collected before the screen wash flume (n = 109) were dead after 96 h regardless of the temperature at which they were maintained (Table 17). Some 75% of the 44 bay anchovy collected at the flume discharge and held at ambient temperature were dead; 100% mortality occurred in the 40 specimens held at condenser discharge temperature. Bay anchovy (n = 70) passed through the dilution pumps and held at ambient temperature had a mortality of 89%; all 16 held at condenser discharge temperature died (Table 32).

Some 53% of the 36 Atlantic silverside collected before the sluiceway and held in ambient water were dead. None were held at condenser discharge temperature. Atlantic silverside (n = 15) collected at the flume discharge and held at ambient temperature had 20% mortality; two of six specimens held at the condenser discharge temperature were dead. Five of 12 Atlantic silverside passed through the dilution pumps died when held at ambient temperature. None were held at condenser discharge temperature.

Three spot collected at the sluiceway and held at ambient temperature had no mortality or damage while all five held at a condenser discharge temperature of 32.0 to 35.9 C died. One of three spot collected at the flume discharge and held at ambient temperature, and six of seven held at condenser discharge temperature died. Some 17% of the 72 spot passed through the dilution pumps and held at ambient temperature were dead, and 53% of the 80 specimens held in condenser discharge water died.

All four American eel passed through the dilution pumps died when held at a condenser discharge temperature of 36.0 to 37.2 C but none of the five specimens held at ambient temperature died. Similarly the striped cusk-eel experienced 91% mortality (n = 23) when held at condenser discharge temperature but only 8% mortality (25) when held at ambient temperature. Winter flounder (n = 39) experienced 3% mortality when held at ambient temperature. No test was conducted at condenser discharge temperature.

The delayed mortality of the American eel, striped cusk-eel, and spot either impinged on the traveling screens at OCGS or passed through the dilution pumps and held at condenser discharge temperature was substantially greater than those held at ambient temperature. There was no apparent difference in the mortality of fishes impinged at OCGS or passed through the dilution pumps. The delayed mortality of specimens held at ambient temperature was 9 to 17%. Fishes which had substantial delayed mortality when held at ambient temperature, such as the bay anchovy (88%), Atlantic menhaden (73-88%) and Atlantic silverside (20-43%), also had high immediate mortality after impingement on the traveling screens (Table 12). The high mortality of specimens held at ambient temperature suggested that the stress of collecting, handling, and holding these species may have contributed greatly to their mortality.

SURVEYS OF THE POPULATION OF SELECTED FISHES AND BLUE CRAB IN BARNEGAT BAY

Donald J. Danila

Introduction

Surveys designed to estimate the population of the winter flounder, bay anchovy, northern pipefish, and blue crab in Barnegat Bay were conducted. These estimates were used with other data to assess the impact of OCGS on these species.

Materials and Methods

Most samples were taken with a 4.9-m semiballoon otter trawl. It had a 4.9-m headrope, 5.8-m footrope, and 61- x 30.5-cm doors. The nylon trawl had a 3.8-cm stretch mesh body and a 3.2-cm stretch mesh codend fitted with a 1.3-cm stretch mesh inner liner. It was hauled for 5 min at 1,600 RPM from a 6.4-m MonArk work boat. In addition, a 2.7-m semiballoon otter trawl was used during some surveys. It had a 2.7-m headrope, 3.4-m footrope, and 40.6- x 26.7-cm doors. The nylon body had 3.8-cm stretch mesh and an inner liner of 0.6-cm stretch mesh in the codend. It was slowly towed from a 4.3-m outboard motor powered Starcraft at a standard throttle setting.

The distance covered in a haul was determined from the time it took to run out a line attached to a sea anchor; this anchor was deployed from the stern of the boat as trawling proceeded. Distance traveled was determined by the formula: Distance (m) = (length of line/number of sec to deploy line) x (300 sec). Since the effective fishing width of the net is 2/3 the length of the headrope (S. Marinovich, personal communication), the area of the

bottom covered was the distance traveled times 3.3 m (4.9-m trawl) or 1.8 m (2.7-m trawl). An average haul of the 4.9-m trawl covered 1,030 m^2, and the 2.7-m trawl covered 211 m^2.

Barnegat Bay from Goodluck Point to Gulf Point (19.2 km) was considered the survey area. The Bay between these two points forms a basin somewhat constricted at both ends with OCGS roughly in the center. The bay anchovy survey, however, was conducted only in the area from Stouts Creek to Barnegat Lagoons (10 km) because the bay anchovy was expected to be common and their distribution extremely contagious. The large number of samples in a smaller area was an attempt to reduce sample variance. The shallow, eastern portions of the Bay were included only in the northern pipefish and blue crab surveys.

A stratified random sample model was employed (Mackett 1973). The Bay was subdivided into strata based on expected catches, and the area of each stratum was calculated with a Lietz Polar Planimeter (Model 3651-30). The Bay was also subdivided into 0.9-km^2 grids, and the location of samples within a stratum was allocated to grids by use of a random number table. Five min tows were taken at random locations in each grid. The 4.9-m trawl was used at all stations except in the shallow, eastern Bay where the 2.7-m trawl was used.

Population size and confidence limits were determined according to Mackett (1973). In the analyses it became obvious that several factors introduced large sources of variability,and in some cases it was necessary to redefine strata in order to reduce sample variance. All data were examined for a contagious distribution which resulted from the tendency of fish to aggregate. In general, the procedures of Clarke (1974) and Saila

and Gaucher (1966) were followed to test the applicability of fitting the negative binomial distribution to the data.

The mean, standard deviation, coefficient of variation, skewness, and kurtosis of the raw data were calculated. The index of dispersion was determined (Steel and Torrie 1960). If contagion was evident then the negative binomial distribution was fitted to the data by the maximum likelihood equation of Bliss and Fisher (1953), and the contagion coefficient (k) was determined. The U statistic (Poole 1974) and a chi-square goodness of fit test were used to determine the goodness of fit to the negative binomial. If the negative binomial distribution fit the data, a ln (X + 1 + 0.5 k) transformation was used (Anscombe 1948). The mean, standard deviation, coefficient of variation, skewness, and kurtosis were again determined for the transformed data. A chi-square goodness of fit test was applied to determine if the transformed distribution was normal.

Results

The dates of the surveys, sampling gear used, and number of samples taken are summarized in Table 34.

Winter Flounder

A 7-day delay occurred between the third and fourth survey dates, and the number of winter flounder taken on the fourth survey day was about half the number taken on each of the first three days. This decline may have represented an actual decrease in the population due to emigration of adults from the Bay during the interval. Consequently, only the first three sampling days (120 samples) were included in the population estimate. There

appeared to be a gradient in the density of winter flounder between the northern and southern portions of the open Bay. The strata were defined as the Bay north of Forked River, the Bay south of Forked River, the Inlet area (Oyster Creek and Double Creek channels), and the creeks (including Oyster Creek and Forked River).

Results of the analysis are given in Table 35. The data fitted a negative binomial distribution and were transformed. The transformed distribution reduced skewness and the coefficient of variation considerably but was somewhat platykurtic. The transformation and restratification provided smaller confidence limits and greater precision in the estimate (Mackett 1973). The estimated population was 91,000 ± 8,400. The average number of winter flounder per 1,000 m^2 of bottom area was 1.32. Saila (1961b) estimated densities of 26.19 and 5.68 per 1,000 m^2 for yearlings (age 1+) and older winter flounder, respectively, for Charlestown and Green Hill ponds in Rhode Island. However, densities of winter flounder are generally expected to be greater in more northern waters. Additionally, the winter flounder populations in southern New Jersey have apparently declined during the past few years (Thomas et al. 1975; Danila and Howells, in preparation).

The population estimate was considered very conservative. The estimated biomass (17,500 kg) was less than the commercial landings reported from Barnegat Bay from December 1975 through May 1976 (20,000 kg). The survey was apparently made during the annual emigration of adults from the Bay. The accuracy of the estimate was also biased by vulnerability to capture, gear selectivity, and accessibility of the fish (Cochran 1963). Undoubtedly some winter flounder were in areas, such as the shallow, eastern portion of the Bay, that were not sampled, and avoidance of the trawl occurred to some unknown degree.

Bay Anchovy

Unfavorable weather forced the cancellation of the last sampling day, and only 90 of the 120 proposed samples were taken. In addition, it became evident during the survey that the number taken was much smaller than expected and that sampling occurred after the population maximum in April.

After the data were examined, three strata were redefined based on total catch. Most specimens were collected in the southern portion of the survey area. Although the catch frequency was highly negatively skewed and contagious, criteria for a negative binominal distribution were not met, and the data were not transformed.

The estimated population of 1,932,000 ± 755,000 must be considered a low estimate (Table 36). Sampling efficiency was unknown. At the time of the survey, the number of bay anchovy had declined after the first large contingent entered the Bay in April, and no young had been recruited into the population.

Northern Pipefish

Since the northern pipefish was expected to be found in eelgrass beds, most samples were taken from the shallow, eastern side of the Bay where eelgrass is common. A few samples were also taken from non-vegetated, sandy areas, particularly near the Inlet. Samples from these areas were taken with a 2.7-m trawl. The remainder of the Bay was divided into two strata and was sampled with a 4.9-m trawl. The relative efficiency in catch between the two trawls was not known, so an estimate was made for each gear.

The catches were highly negatively skewed but did not meet criteria for a negative binomial distribution. An estimate of 383,000 ± 179,000 was determined for the eastern Bay (Table 37). The mean catch for the sand

bottom areas was actually greater than areas with eelgrass. Catches were smaller in the western and central Bay. Several large catches produced large sample variance and, consequently, the population estimated to be 45,000 had a large confidence interval of ± 44,000. The total of both strata indicated a population of approximately 428,000 northern pipefish in the Bay.

Blue Crab

The Bay was divided into deeper areas that were sampled with the 4.9-m trawl and shallower areas in the eastern Bay that were sampled with the 2.7-m trawl. Catches were plotted and strata were created in each division based on the distribution of catch and the concentration of various life history stages in the different areas.

Five strata were created in the eastern Bay. The catch frequency for this area was normally distributed, and no transformation of the data was necessary. Mean and variance of the catch for each stratum was calculated, and the total population for the eastern Bay was 3,860,000 ± 425,000 (Table 38).

Catches with the 4.9-m trawl were considerably smaller than those with the 2.7-m trawl. Although the data were negatively skewed, criteria for a negative binomial transformation were not met. A total population of only 195,000 ± 52,000 was determined for an area 2.5 times larger than the eastern Bay. This appeared to be a significant underestimate. Although real differences in abundance between the two areas may have existed, the extremely low estimate in the central and western Bay was probably due to gear avoidance. Swimming blue crabs may have avoided the trawl in the deeper areas of the Bay. Many immature blue crabs may have been in the

shore zone and therefore were not sampled by the 4.9-m trawl. In contrast, the 2.7-m trawl usually fished from surface to bottom in shallow water, and there may have been less gear avoidance.

A summary of the life history stages taken during the survey is given in Table 39. The findings were consistent with those of other studies and indicated the validity of the data. Most (90%) crabs were immature. Garlo et al. (1974) found 87% of the blue crab taken in Great Bay, New Jersey were immature. Less than 10% of the immature and adult crabs were molting or had recently molted (paper shell). Some 67% of mature females carried eggs; 29% of these had well-developed (black) eggs and 71% less-developed (orange) eggs. Garlo et al. (1974) found that gravid females were most common in Great Bay in June and July.

The distribution of various life history stages also followed recognized patterns. Most egg-bearing females were found near the Inlet. Most of the paper shell immature, molting immature, and mature male crabs were found in the northernmost stratum where salinity was lower.

Discussion

Variability in population estimates resulted in large confidence intervals. Obvious bias in catch between areas and different sized trawls was evident in the blue crab survey. A real decrease may have occurred during the winter flounder survey and accounted for the small number taken during the last day. The bay anchovy survey was apparently done after the adult population had declined and before young were recruited into the catch.

Loesch et al. (1976) reported the results of mark-recapture experiments to determine the sampling efficiency of a 4.9-m otter trawl. They concluded

that efficiency varied by species and was low enough that large underestimates of biomass may have occurred. Efficiency was determined to be 33 to 50% for the brown shrimp, 25% for the Atlantic croaker, and 6% for the spot. In addition, they determined that the effective fishing width of the 4.9-m trawl was 2.5 m, not the 3.3 m used in this study. A smaller trawl width would increase the population estimates. Consequently, the population determined for the four species can be considered to be relatively conservative.

REPLICATE TRAWL STUDIES

Donald J. Danila

Introduction

A replicate trawl program was undertaken to assess the variability in the catch of fishes and macroinvertebrates between successive hauls with the 4.9-m trawl.

Materials and Methods

Eight or, or some cases, seven replicate hauls of a 4.9-m semiballoon trawl were made at both the mouth of Oyster Creek and Forked River on 11 August 1975 and on 27 May, 28 June, 2 July, and 5 August 1976. At the completion of every haul all fishes, sand shrimp, and blue crab were enumerated, and the boat returned to the starting point as soon as possible to begin the next haul.

For the total species of fish and total number of specimens collected, a mean for the eight hauls was determined for each area on each day. A subsample of two of the eight hauls was selected randomly without replacement 100 times. The 100 subsample means were compared with the sample mean, and the number of times the subsample mean fell within 25% of the sample mean was computed. This procedure was repeated for subsample sizes of three through seven.

Results and Discussion

A summary of statistics applied to replicate trawl collections is given in Table 40. The number of fishes taken in each replicate series varied the least and had the smallest coefficient of variation. The total fish catch and the catch of the bay anchovy, the dominant fish, usually varied considerably.

At times, a small number of spot, blue crab, and sand shrimp was taken. The northern pipefish, crevalle jack, lookdown, and weakfish were taken in more than half the tows only once. All other fishes were rare.

The effect of anomalous hauls of a particular species is illustrated by eliminating single large catches of the spot and bay anchovy taken on 2 July. The coefficient of variation in the catch was reduced from 63% to 31% for the spot and from 56% to 29% for the bay anchovy.

Results of the analyses showed that as the size of the subsample increased the subsample mean more frequently approached the sample mean (Table 41). The average percentage of time a subsample mean fell within 25% of the mean of the sample was determined for each subsample size. For fishes, three hauls produced the mean number of species (within 25%) 74.8% of the time. It increased to 89.4% for four hauls.

Since the catch of all fishes, bay anchovy, spot, and blue crab was more variable, larger subsample sizes were needed to consistently approach within 25% of the sample mean. For a subsample size of four, the subsample mean approached within 25% of the sample mean from 52.1% (blue crab) to 77.6% (total fish specimens) of the time. For a subsample size of seven, all subsample means fell within 25% of the mean at least 9 out of 10 times.

All categories were combined, and the percentage of time the subsample mean fell within 25% of the sample mean was plotted against subsample size (Fig. 6). A steady increase occurred up to a subsample size of four; after four subsamples the increase was more gradual.

The variability in sampling by trawl was considerable. Two trawl hauls were made at regular sampling stations. On the average, the mean of two hauls at a station came within 25% of a larger sample mean 62.4% of the time for fish species and 44.5% of the time for fish specimens.

EFFECTS OF THE THERMAL PLUME ON FISHES IN WESTERN BARNEGAT BAY IN THE VICINITY OF OYSTER CREEK

Donald J. Danila

Introduction

This report analyzes and discusses data collected from September 1975 through August 1976. The species composition, distribution, and abundance of fishes and two important macroinvertebrates, the sand shrimp and blue crab, are discussed. The attraction or avoidance of organisms to the OCGS heated discharge in Oyster Creek and the thermal plume in Barnegat Bay is examined. Relative abundance and distribution of important species is compared with historical data.

Materials and Methods

Sampling with trawl, seine, and gill net was done in Forked River, Oyster Creek, and western Barnegat Bay from Cedar Creek to Double Creek, approximately 8 km to the north and to the south of Oyster Creek. An additional station was located in Oyster Creek Channel, near Barnegat Inlet (Fig. 1).

For comparative purposes the sampling stations were grouped into four areas: Oyster Creek (Sta. 15, 17, 19), Forked River (3, 4, 6), Waretown (20, 21), and the mouth of three other (Cedar, Stouts, and Double) creeks (1, 2, 23). The stations at Barnegat Beach (22) and Oyster Creek Channel (24) were not included in any group.

A 4.9-m trawl was used at eleven stations (Table 42). The trawl and its operation have been described (See page 40). An average haul covered

1,030 m^2. All stations were sampled during daylight on the same day twice a month. Once a month, the stations at the mouth of Oyster Creek (Sta. 17), at the mouth of Forked River (4), and in the adjacent Bay (19, 3) were sampled again at night, beginning 1 h after sunset. At each station, two successive 5-min hauls were made in the direction of either the current (usually in the creeks and Sta. 24) or the wind (usually in the Bay). Upon completion of the first haul, the boat returned to the starting point to repeat the haul as soon as the first collection was processed.

A 12.2- x 1.5-m nylon seine (0.6-cm stretch mesh) with a 1.5-m bag in the center was used at seven stations (Table 43). All stations were sampled during daylight on the same day twice a month. Once a month, the stations at the mouth of Forked River, the mouth of Oyster Creek, and at Sands Point Harbor (Sta. 20) were repeated at night, beginning 1 h after sunset. Two hauls were made at each station. To set the net, one brail was held at the water's edge, and the other was walked along and parallel to shore until the net was taut. The net was then swept in a semicircle with one end held stationary on shore. The maximum area covered was 233 m^2 $\left[1/2\ \pi(12.2\ m^2)\right]$. After the first catch was processed, the haul was repeated in an adjacent, undisturbed area.

Seven gill net stations were sampled during daylight on the same day once a month (Table 44). The 91.4- x 1.8-m gill net consisted of 3, 30.5-cm panels of 38-, 70-, and 89-mm monofilament stretch mesh. The net was anchored at each station and was generally set perpendicular to the main channel of the creek or shoreline of the Bay. The net was floated and fished either at the surface or, in shallow water, from surface to bottom. It was retrieved after 1 h, and the catch processed.

In trawl or seine samples with large amounts of detritus and macroalgae,

an estimate of abundant organisms was made by counting their number in a known volume of the sample. This number was multiplied by the total volume of the sample to estimate the total number of these organisms collected. Fish tangled in the net were removed by hand, counted, and added to the total.

All individuals of important species, or a subsample of at least 50 individuals from each of the four areas, and all uncommon fishes were initially preserved in buffered 10% formalin. Fishes other than the important species were identified, counted (or their abundance estimated), and either discarded or preserved. Specimens were stored in 40% isopropanol for the voucher collection or life history studies.

Invertebrates other than the sand shrimp and blue crab were identified in the field to the lowest practical taxon. Their number was counted or estimated, and relative abundance was categorized as rare (1-10 individuals or colonies), occasional (11-100), common (101-1,000), and abundant (1,000+).

A Hewlett-Packard 9830A programmable calculator was used for most statistical analyses and data compilation. A two-way analysis of variance (ANOVA) was used to test for differences in the catches of species with a particular gear among stations and sampling dates. For paired day-night samples, a three-way ANOVA was used to test for differences in catch among stations, dates, and time of day. The significance level of parametric tests was the 95% level ($P \leq 0.05$). Certain constraints of the Hewlett-Packard ANOVA statistical package limited the scope of the analyses of trawl data. The total number of samples that could be analyzed was limited to ≤ 220; therefore, a maximum of 5 months of trawl data could be used in an ANOVA. The data had to be equally distributed among the stations; thus, January was not included in the analyses because some stations were not sampled due to ice in the Bay.

ANOVA was limited to relatively common species. Prior to analysis, data were transformed by a log (X+1) transformation. This transformation reduced the skewness which had marked effects on the significance level of F-tests, approximated normality, and made variances homogeneous (Sokal and Rohlf 1969). Upon completion of ANOVA, Barlett's test for homegeneity of variances was applied, and if heterogeneity was indicated, the results were discounted. When significant differences were indicated, the Student-Newman-Kuels multiple range test was used to determine significant differences among the means of the main effects (Sokal and Rohlf 1969). No analysis was made on any interaction effects.

A stepwise multiple linear regression analysis was used to develop an equation that related catch with water temperature, salinity, oxygen, tide height, tide direction, OCGS water flow, and OCGS heat rejection. Tide height and direction were coded as discrete variables. Catch data by gear were transformed to natural logarithms to reduce skewness, approximate normality, and change curvilinear relationships to linear ones (Sokal and Rohlf 1969). Only relatively common species had a sufficient number of observations to be used in multiple regression models. Independent variables were added to or deleted from the model until tolerance values (initialized at 0.001) were too small or F values (initialized at 4.0) were insufficient for further computation (Hewlett-Packard 1974).

Results

The number of specimens of each species collected for all sampling gears by month is given in Table 45. A total of 85,641 fishes (65 species) and 35,388 sand shrimp and blue crab was taken in 1,097 collections.

Total catch of fish by month varied from 354 in January to 22,505 in

April. The fewest sand shrimp and blue crab were taken in September (332) and the most in December (12,577). In general, the fewest fish were collected during the coldest months (December-February). Catches from March, May, June, and August were similar in number; large increases occurred from March to April and from June to July.

Fewest fishes (13-23 species) were taken from January through March and the most (44) in August. The number of fishes collected during the other months ranged from 31 to 36.

The total catch by trawl for each month is given in Table 46. Most fishes were taken in August (31 species) and fewest in January (11) and February (13). Some 20 to 28 fishes were taken in the other months.

The 50,195 fish taken were dominated by the bay anchovy (76.7% of total fish collected by trawl), fourspine stickleback (8.7%), Atlantic silverside (4.8%), and spot (4.3%). The other 49 fishes comprised the remaining 4.5% of the catch, and more than 25% of these specimens were from several large collections of the Atlantic herring and sand lance. Although less common, the American eel, Atlantic menhaden, oyster toadfish, mummichog, tidewater silverside, northern pipefish, white perch, tautog, naked goby, summer flounder, winter flounder, and hogchoker were taken in at least 9 months. In addition, 22,942 sand shrimp and blue crab were taken. The sand shrimp was the dominant macroinvertebrate in 8 of the 12 months.

Some 34,865 fish and 10,285 sand shrimp and blue crab were taken by seine during the year (Table 47). Fewest fishes (6-13 species) were taken from November through March. A similar number of species (17-20) was taken in September and October and from April through June. The largest number of fishes was taken in July (28) and August (35).

The bay anchovy (47.2% of the total fish collected by seine) and Atlantic silverside (44.8%) dominated the catch. Mummichog, tidewater silverside,

fourspine stickleback, and spot comprised an additional 5.3%. The remaining 2.7% was made up of 42 species.

The Atlantic menhaden (n = 276) and bluefish (127) made up 71.3% of the fish taken by gill net (Table 48). Fifteen other fishes (162) and the blue crab (177) were also taken.

Results of the two-way ANOVA are summarized in Table 49, and the three-way ANOVA in Table 50. When significant differences were found, the Student-Newman-Keuls multiple range test was used to determine differences among mean catches for station or date (Tables 51, 52). For both ANOVA, a significant difference between replicates was found in 5 of 19 cases; the first haul was always larger than the second.

The Atlantic menhaden was collected in all months except February. Most (90.2%) specimens were taken by gill net. Although the largest catch (n = 67) was made in December, only one specimen was collected in January. The catch by gill net from March through August was significantly different by station and date. The largest mean catch was from the mouth of Cedar Creek. Fewest were taken at the station nearest OCGS in Oyster Creek and Forked River. The catch was similar (35-42) during April and from June through August but only 15 Atlantic menhaden were taken in May and 12 in March.

Almost all bay anchovy were taken from September through November and from April through August by trawl (70% of all specimens) and seine (30%). It was most abundant in April (n = 17,642) and October (10,090). Some 90.2% of the bay anchovy taken in April were from two large trawl collections and four large seine collections taken at the mouth of Oyster Creek.

From September through December, the bay anchovy was most abundant in trawl hauls at the mouth of the other three creeks and Forked River followed by the Bay station off Forked River and Oyster Creek (Table 51). Fewest were

taken at the station nearest OCGS in both Oyster Creek and Forked River. It was most abundant in October and early November and least abundant during late November and December. The largest mean catches by seine were from the station at the mouth of Oyster Creek and Cedar Creek. Largest collections there were from late September and late October.

From April through August, the bay anchovy was most common in day seine hauls at the mouth of Oyster Creek and at Barnegat Beach. Fewest were collected at the mouth of Stouts Creek. Most were taken in early July and early August; the fewest in late April and May.

Significantly more bay anchovy were taken by trawl during the day and by seine during night in paired day-night hauls (Table 50). Largest mean trawl catches from March through August were from the mouth of Forked River and Oyster Creek. The largest mean seine catch from April through August was from the mouth of Oyster Creek followed by Sands Point Harbor and the mouth of Forked River (Table 52).

Most (98.1%) mummichog were taken by seine. It was collected throughout the year. The catch was variable and ranged from 10 to 89 specimens per month.

The Atlantic silverside was taken in all months by seine but the catch was variable. It was common from September through December but few specimens were taken in January and February. It was most abundant in March (n = 2,261) and April (3,648). The catch was small in May (332) and June (535) but increased in July (1,927), probably due to recruitment of young. From September through December, most Atlantic silverside were taken by seine at Sands Point Harbor. Little difference occurred among the mean catch at other seine stations.

In collections taken by trawl, the Atlantic silverside was most predominant in November (1,355) and December (773). Largest mean catches by

trawl from November and December were at Stouts Creek mouth and in the Bay off Forked River and off Waretown. Fewest were taken at the station in Oyster Creek and Forked River nearest OCGS and in Oyster Creek Channel (Table 51).

During November and December, the mean catch of the Atlantic silverside in seine and trawl collections at the same station indicated that the relative abundance was similar among stations. However, on dates when the mean catch for seine collections was large, it was small for trawl collections and vice versa; the exception was in early December when both were small. This suggested that during early winter, when water temperature fluctuated rapidly from day to day, Atlantic silverside probably moved into and out of the shore zone as conditions became more or less favorable.

No difference in catch of the Atlantic silverside was found between day and night collections (Table 50). The largest mean catch of the Atlantic silverside in paired day-night seine hauls from January through August was from the mouth of Oyster Creek. No difference was found in the catch between Sands Point Harbor and the mouth of Forked River. The largest mean catch was taken in March followed by July and April.

When the bay anchovy and Atlantic silverside were taken together by seine and trawl during 1975, a large mean catch of one species corresponded to a smaller mean catch of the other. The two species were apparently mutually exclusive to some degree.

Almost all (99.5%) specimens of the tidewater silverside were taken by seine from December through August. Some 82.8% were taken from February through April.

The fourspine stickleback was taken by trawl (91%) and seine (9%). It was most abundant in trawl catches at times of the year when the bay anchovy was absent or relatively uncommon. Some 81.9% taken by trawl were collected from March (n = 2,592) and February (991). Largest mean catches

in those months were from Double Creek mouth followed by the Bay off Forked River. Smallest mean catches were from the Oyster Creek stations and Oyster Creek Channel (Table 51). It was taken by seine in all months except June, and the catch varied from 7 to 82 specimens per month.

The northern pipefish was common in all months except January and February and was taken by trawl (64.9% of all specimens) and seine (35.1%). More specimens were taken by seine than trawl from July through September. Largest catches by trawl were in November and December and from March through May.

The bluefish was taken by gill net (63.5% of all specimens), trawl (24.5%), and seine (12.0%). None were taken from January through April. All 12 specimens from December were taken by trawl at the mouth of Oyster Creek. Most specimens taken by gill net were collected in September (21), May (51), and August (37). No significant differences in catch were found by station or date for gill net collections from May through August (Table 49).

Only two specimens of the spot were taken from September through November, and none were collected from December through April. It was most common in seine catches in June (n = 163) and July (197). Many were taken by trawl in June (556), July (1,130), and August (452). The spot was common in gill net catches in July (23) and August (33).

The spot had the largest mean catches by trawl at the three Oyster Creek stations, Double Creek mouth, and Oyster Creek Channel; little differences were found among the other stations. The largest mean catch by seine was at Double Creek mouth and the smallest at the mouth of Cedar and Stouts creeks (Table 51).

Significantly larger catches of spot were made at night in paired day-night seine hauls. No differences were found among stations. Significantly larger catches were made in June and July than in May and

August.

The winter flounder was collected throughout the year. Largest catches were in December (n = 40), March (47), and August (49). Most (78.4%) were taken by trawl. Some 53.3% of those collected from May through August were young taken by seine. Some 76% of the winter flounder collected in paired day-night seine and trawl hauls were taken at night.

The sand shrimp was the second most numerous organism collected. The number taken by trawl increased from October (n = 409) to a maximum in December (9,859). Relatively few (399) were taken in January but many (1,044-4,234) were collected from February through May. It was uncommon (2-141) from June through September.

Most sand shrimp collected by seine were also taken in the colder months. Largest collections were made in December (2,560) and March (2,352). Fewest were taken from May through July, although their numbers increased in August.

In catches of paired day-night trawl hauls from October through December, the number of sand shrimp was not significantly different among stations. Significantly more were taken in December than during October or November (Table 52). From February through May, the smallest mean catch was at the mouth of Oyster Creek; no difference existed among the other three stations.

In paired day-night hauls by trawl and seine, significantly more sand shrimp were taken at night (87.7% of total catch) than day. The catch in paired day-night seine hauls was not significantly different among stations from January through August. The largest mean catch by month was made in March and the smallest in June.

The blue crab was taken during most of the year. Most were collected by trawl (57.5% of all specimens) from March through August; the largest

catch (n = 500) was in May. It increased in abundance in seine collections (38.2%) from March to a maximum (540) in August. It decreased in abundance from September through December and was not taken in January and February. The blue crab was common in gill net collections (4.3%) from June through August but none were taken from November through March.

From September through December, the largest mean catch of the blue crab in trawl hauls was at the mouth of Double Creek. Smallest mean catches were from the stations in the Bay off Forked River and Waretown and in Oyster Creek Channel (Table 51).

Catches of the blue crab by seine from May through August were generally similar among stations. Most specimens were caught in late July and August and fewest in early May.

The mean catch of the blue crab in paired day-night trawl hauls from March through August was significantly larger at night (Table 50). Largest mean catches were at the two Oyster Creek stations (Table 52). It was most abundant in May and least abundant in April. No difference existed among the other months.

Results of the multiple regression analyses are given in Table 53. In six cases no coefficient of determination (r^2) was calculated as the data did not meet the test criteria. The r^2 values in 10 analyses ranged from 0.047 to 0.188. In only 3 of the 19 analyses was the r^2 value greater than 0.35. For Atlantic silverside taken by trawl (r^2=0.354), significant variables included OCGS heat rejection and water flow. As the heat rejection increased and water flow decreased, catch increased. The catch of blue crab taken by trawl (r^2=0.363) increased as water temperature, tide direction, and salinity increased. For blue crab taken by gill net (r^2=0.454), the only significant variable was water temperature. Catch increased as temperature increased.

Discussion

The temporal distribution and abundance of fishes and macroinvertebrates in western Barnegat Bay were generally similar to that reported in previous studies of the Bay (McClain 1973, Marcellus 1972) and in studies of nearby estuaries (Thomas and Milstein 1973; Thomas et al. 1974, 1975). Although species assemblages and distributions differed somewhat, the population structure and movements of fishes in Barnegat Bay were similar to other estuaries in the northeastern United States (de Sylva et al. 1962, Pearcy and Richards 1962, Daiber and Abbe 1967, Richards and Castagna 1970, McErlean et al. 1973, Oviatt and Nixon 1973, Jeffries and Johnson 1974). Most investigators found that estuarine fish populations were dominated numerically by relatively few species. The population of fishes in Barnegat Bay consisted mostly of forage fishes and juveniles of species which utilized the estuary as a nursery. Adult marine fishes typically entered the estuary on occasion to spawn or feed but generally were found in the ocean. At times, resident species made up a smaller component of the fishes in the estuary than did seasonal migrants. Comparisons of this study and several previous surveys of fishes in Barnegat Bay were primarily qualitative because of the different sampling gears, techniques, frequencies, and stations among the studies.

McClain (1973) conducted a trawl and seine survey from December 1971 through November 1972. It included the central and northern portions of the present study area. Almost 29,000 specimens of 49 species were taken. The most abundant fishes were the bay anchovy, Atlantic silverside, tidewater silverside, winter flounder, and fourspine stickleback. No spot were taken. The sand lance and tidewater silverside made up a larger proportion of his seine catches than in the present study. He found that the winter flounder was more abundant, and it was the third most numerous

species taken by trawl. The Atlantic silverside was taken more frequently by trawl from May through October.

Marcellus (1972) undertook an extensive seine survey from 1966 through 1970, three years before and one year after OCGS began operation. The size of the seine used and techniques employed were similar to those of this study. Major differences between the studies included stations sampled, sampling frequencies, and the lack of night samples in Marcellus' study. The annual mean number of fishes taken per collection (n/coll.) was similar between the two studies. It was 83.8 (53.7-125.7) in Marcellus's study and 86.3 in this study.

A comparison of the ten most abundant species in this and in Marcellus' (1972) study showed that the bay anchovy, spot, and crevalle jack were more abundant in 1975-1976, and the silver perch, northern puffer, fourspine stickleback, tidewater silverside, winter flounder, and Atlantic herring were more abundant in 1966-1970 (Table 54). The bay anchovy comprised a larger proportion of the catch in 1975-1976. Although differences in salinity, topography, sediments, and other factors at seining sites may have accounted for some of these differences, the changes noted apparently represented real differences in the relative abundance and success of year classes between the two periods. Marcellus noted 50 to 100% fluctuations in abundance from year to year. In addition, he reported the largest n/coll. in summer, whereas the largest n/coll. in this study was from April, July, March, and September. He took 62 species, 23 of which were not taken in the present study. Ten of the 48 fishes taken by seine in 1975-1976 were not taken by Marcellus.

A haul seine survey taken from October 1966 through September 1968 by Wurtz (1969) was summarized by the AEC (1974). It appeared to be similar

to Marcellus (1972) but no station data, sampling frequency, or gear description were given.

Dorfman et al. (1976), in a study of paired seine stations in Oyster Creek and Forked River from October 1973 through November 1974, reported that the Atlantic silverside comprised more than half of the catch in both areas.

Thomas and Milstein (1974) reported the results of some 14 trawl collections made in Barnegat Bay and Forked River from 1929 to 1933. Since no field data were available, only qualitative changes in species occurrence and abundance were noted. The most significant changes were in the complete or near disappearance of the tomcod (49.5% of the specimens collected from 1929 to 1933; none in 1975-1976) and the Atlantic croaker (21.0% in 1929-1933; 0.1% in 1975-1976). Neither species was reported by McClain (1973).

In this study, the bay anchovy, Atlantic silverside, fourspine stickleback, and spot comprised 94% of all fishes collected. The bay anchovy alone made up 64.2% of the catch. Sixty-one other fishes accounted for the remaining 6%. The bay anchovy, Atlantic silverside, and fourspine stickleback are relatively short-lived forage fishes.

Both the Atlantic silverside and fourspine stickleback are resident in Barnegat Bay and spend most of their life there. However, many Atlantic silverside move into the ocean during winter when the water temperature in bays is coldest (Thomas and Milstein 1973; Thomas et al. 1974, 1975).

The bay anchovy was present in all months except January and February. Immigration and emigration from the Bay occurred in March and April and during November and December, respectively. Much of its reproductive activity apparently occurred in the Bay.

The spot has usually been found in southern New Jersey estuaries only during summer. Adults spawn offshore in late winter and spring. Young move inshore to the estuaries and grow rapidly from June through September. Populations of spot have had relatively large year to year fluctuations and were abundant in New Jersey only when large year classes occurred (Thomas 1971; Thomas and Milstein 1973; Thomas et al. 1974, 1975).

Both the blue crab and sand shrimp are year-round residents. Their abundance varies seasonally. A significant number of the sand shrimp probably left the Bay in January and February and in July and August to avoid temperature extremes. During these times, catches decreased in the Bay and have been observed to increase in the ocean off nearby estuaries (Thomas and Milstein 1973; Garlo et al. 1974, 1975).

The number of the blue crab taken varied as juveniles, which formed most of the catch, were recruited and became available to the trawl and seine. From late December to early March, the blue crab burrows into bottom sediments, and few were collected.

The other fishes were less abundant although many are important sport or commercial fishes. Many were not sampled in true proportion to their abundance due to gear avoidance (e.g. Atlantic menhaden, bluefish, and mullets), the inability to effectively sample specific habitats (Atlantic needlefish, wrasses, and blennies), or the limited area of the Bay that was sampled regularly (herrings, spotted hake, and summer flounder).

Because the 4.9-m trawl is inefficient (Loesch et al. 1976), the standing crop of fishes and macroinvertebrates was underestimated to an unknown degree. Demersal, slow-moving species were probably the most adequately sampled.

Using a scheme modified by Pearcy and Richards (1962), the fishes of Barnegat Bay were classified into five general assemblages based on their spatial and temporal occurrence and their relative abundance within or

outside the Bay (Table 55).

Resident fishes (20 species) were generally found within the Bay year-round and spent the major portion of their life there. The American eel spawned elsewhere, and only immature winter flounder were resident year-round.

The largest group (24 species) was the warm water migrants. These fishes were present mostly from April through October and accounted for the increase in the number of species collected during these months. Most were young or juveniles that utilized the Bay as a nursery area. Some, such as the bluntnose stingray, entered the Bay to reproduce and feed. One third of the warm water migrants were jacks or drums. Temperature probably was the most important factor which controlled their presence. Their abundance was usually related to success of spawning which, for most species, occurred outside the estuary. Occasionally, individuals of some species, such as the Atlantic menhaden, bay anchovy, or summer flounder, were taken in colder months. In previous years, some Atlantic menhaden, bluefish, and other warm water species remained in the heated discharge of OCGS instead of emigrating from the Bay.

Four species of herrings, the spotted hake, and young of the Atlantic croaker migrated into the Bay during cooler water temperatures. They were present as young or juveniles in November, December, March, and April and were usually absent during other months. Some adults of the alewife were taken and its anadromous spawning runs have been reported in some Bay tributaries (Zich, 1977).

Marine strays (13 species) included those fishes which were most abundant in nearby oceanic waters. They were infrequent in the Bay and did not make up a significant proportion of the fishes.

Two strays from freshwater, the banded killifish and the pumpkinseed, probably represented accidental intrusions.

The distribution of fishes within the Bay was affected by the thermal plume of OCGS in Oyster Creek and in the Bay. It appeared that the warmer water temperature in Oyster Creek attracted fishes in November, December, March, and April. The largest difference in catch between Oyster Creek and Forked River occurred in months when OCGS was in operation and water temperature in the Bay was cool (December, March, and April). Some warm water migrants such as the Atlantic menhaden, bluefish, crevalle jack, and blue runner were attracted to the heated discharge in November. Mortalities of these fishes were noted during three OCGS shutdowns in November and December 1975 (Tatham and Metzger 1976). The cessation of dilution pumping at the time of shutdown of OCGS resulted in a slower cooling of canal water. This may have mitigated the effects of the shutdown to some extent by allowing fishes to acclimate more slowly to the colder temperature. Fish kills, mostly of Atlantic menhaden, occurred because of winter shutdowns of OCGS in January and December 1972 and January 1974 (AEC 1974). The dilution pumps remained running during these kills.

The herrings, bluefish, jacks, drums, and flatfishes were taken more frequently and in greater numbers in Oyster Creek than Forked River. At times the bay anchovy, striped cusk-eel, Atlantic silverside, fourspine stickleback, striped mullet, sand shrimp, and blue crab were more common in Oyster Creek. Some rare fishes, such as the bluntnose stingray, ladyfish, striped anchovy, Atlantic needlefish, mojarras, and gray snapper, were probably attracted to the heated effluent from June through September and were taken almost exclusively in Oyster Creek. The Atlantic menhaden, bluefish, and weakfish were observed from October through May in the immediate vicinity of the OCGS discharge (Danila 1976; G. J. Miller, personal observation).

Fishes and macroinvertebrates showed little avoidance of the thermal

plume within Oyster Creek east of the U. S. Route 9 bridge. From April through August combined, the mean catch by trawl in Oyster Creek (Sta. 15) and at Double Creek (23) was the largest of all stations. Mean catch at other stations in or immediately adjacent to Oyster Creek (17, 19) was similar to that at the mouth of the other three creeks (1, 2, 23) and Forked River (3, 4, 6).

Certain species apparently avoided the thermal plume. After early April, no adult winter flounder and from May through August, few young winter flounder were collected in Oyster Creek. The Atlantic herring and spotted hake also apparently avoided the thermal discharge.

Two fish kills have been reported in Oyster Creek when water temperature exceeded 32.2 C (AEC 1974). No large mortalities were observed in 1975-1976; however, it should be noted that from June through September 1976, OCGS did not operate at its full rated capacity (D. Weigle, personal communication). Maximum water temperature recorded east of the Route 9 bridge was 32.7 C in June.

Marcellus (1972) noted changes in species composition and abundance that he felt were probably due to the thermal discharge from OCGS. He also noted significant increases in the salinity and current regimes in Oyster Creek and Forked River. Dorfman et al. (1976) took 1.5 times more species and 2.3 times more specimens in Oyster Creek than Forked River. They also reported a reduced number of fishes in Oyster Creek in late summer 1974 when water temperature was maximum.

Many factors confounded the analysis of catch data. Large sources of variability are present in trawl (Taylor 1953, Clark 1974), gill net (Moyle and Lound 1960), and seine catches. Single very large collections of several schooling species biased catch statistics and such collections occurred at least once for the Atlantic herring, bay anchovy, Atlantic silverside, and

sand lance. Bias and differences in the relative efficiencies of the sampling gear affected catch data. Differences in the habitats and behavior of species resulted in either over- or underestimates of their abundance. For example, very few Atlantic needlefish were taken but they were observed to be relatively common near the surface of the water from June through September. Significantly more individuals of many species were taken at night. For some species, such as the spot and blue crab, this increase may have represented improved gear efficiency at night because these species were also relatively abundant during the day. However, for others, such as the striped cusk-eel and sand shrimp, the large increase in catch at night was probably the result of diel behavior patterns. Significantly more bay anchovy were taken by trawl during day and by seine at night. This probably was a behavioral phenomenon as schools of bay anchovy were observed to disperse and become more common at the surface and in the shore zone at night. The catch of some species by different gears changed with time. The spot became vulnerable to different gear as it grew larger and its habits changed.

Some significant differences were found between the first and second trawl and seine hauls. In all cases a larger mean catch was taken in the first haul. Despite efforts to seine in adjacent, undisturbed areas and a time delay between trawl and seine hauls, organisms were probably disturbed by the first haul and may have left the immediate vicinity. Large differences probably occurred in the efficiency of the gill net among stations. Operation of the net was affected by strong currents, especially at stations in Forked River and Oyster Creek nearest OCGS.

Usually transformations were used in an attempt to normalize the data for statistical analyses. However, both the statistical and biological variability inherent in the data precluded some analyses,

such as multiple linear regression, and limited others, such as ANOVA.

In general, the species analyzed by ANOVA showed similarities among stations in terms of the catch. Trawl stations at the mouth of Cedar Creek (Sta. 1), Stouts Creek (2), and Forked River (4) were similar, as were those in the Bay off Forked River (3) and off Waretown (21). All Oyster Creek stations (15, 17, 19) were alike. The station off the mouth of Oyster Creek (19) was similar to the station in Forked River nearest OCGS (6). Catches at comparable stations in Oyster Creek and Forked River were not similar. Double Creek mouth (23) and Oyster Creek Channel (24) appeared to be unique.

Less distinguishable differences were found for seine stations. The catch at the mouth of Cedar and Stouts creeks was similar. Catches at Oyster Creek mouth (17) were like those at Cedar Creek mouth and Sands Point Harbor (20). Forked River mouth, Sands Point Harbor, Barnegat Beach (22), and Double Creek mouth (23) were similar.

The results of the multiple regression analyses showed that little variation in catch could be explained in terms of the physicochemical parameters examined. Although it seemed apparent that temperature and other phenomena regulated the distribution and abundance of most species, complex interactions and large sampling variability probably precluded the determination of meaningful predictive equations.

LIFE HISTORY STUDIES

Introduction

Life history studies were undertaken for ten fishes, the sand shrimp, and blue crab. The Atlantic menhaden, bay anchovy, northern pipefish, winter flounder, and blue crab were designated as important species by the NRC. The threespine stickleback, striped bass, bluefish, weakfish, northern kingfish, summer flounder, northern puffer, and sand shrimp were designated as important species by the EPA in mid-October 1975.

Procedures common to all studies are given below. All data were compiled and analyzed with a Hewlett-Packard 9830A programmable calculator.

A representative sample of specimens was examined from four areas: the traveling screens at OCGS, Oyster Creek and the Bay off its mouth, Forked River and the Bay off its mouth, and the mouth of three other (Cedar, Stouts, and Double) creeks and in Barnegat Bay.

Length of all specimens was measured to the nearest mm on a blocked measuring board or with dial calipers. The length of all fishes was measured from the snout to the distal portion of the central rays of the caudal fin. The carapace width (distance between the end of the anterolateral spines) of the blue crab and total length (distance from the anterior end of the spine on the antennal scale to the posterior tip of the telson) of the sand shrimp were determined to the nearest 0.1 mm.

Selected individuals were weighed to the nearest 0.1 g with an Ohaus Autogram or Dial-O-Gram balance. Specimens of the sand shrimp were weighed to the nearest 0.01 g on a Ohaus Cent-O-Gram balance.

All physical anomalies, injuries, external parasites, and diseases were noted. Specimens were categorized as having multiple trauma if they had more than one abnormality.

The length-weight relationship was determined by a geometric mean regression (Ricker 1975). The 95% confidence interval ($P \leq 0.05$) of the regression coefficient was also determined (Simpson et al. 1960).

A t-test was used to test for the difference between mean lengths, mean weights, annuli measurements, condition factors, and regression coefficients (Simpson et al. 1960). A chi-square test was used to test for differences in sex ratios and in day-night catches. The significance level for all statistical tests was the 95% level ($P \leq 0.05$).

The age of selected Atlantic menhaden and most bluefish and weakfish larger than 180 mm was determined by examination of scales for annuli. Scales were removed from specimens, cleaned, and stored in labeled envelopes. Scale impressions were made on acetate slides and were read on an EPOI LP-6 Profile Projector at 10 or 20 X magnification.

Otoliths (left and right sagitta) were used to age winter flounder and summer flounder according to the methodology of Poole (1966) and Smith (1969), respectively. Otoliths were removed, cleaned, and stored either in 3% sodium phosphate (winter flounder) or dry (summer flounder). In most cases the left sagitta was used for ageing. It was immersed in glycerin in a 0.5-mm deep culture slide and examined under 10 X magnification with a dissecting microscope.

The growth of bay anchovy, northern pipefish, northern puffer, and some bluefish and weakfish was determined by the change in length frequency distribution over time.

The allometric condition factor (weight/length^b) was determined for Atlantic menhaden, bay anchovy, bluefish, and ovigerous sand shrimp. The exponent b was the slope of the geometric mean regression equation (Ricker 1975).

ATLANTIC MENHADEN

Robert J. Kurtz

Introduction

The Atlantic menhaden supports a major commercial fishery along the Atlantic coast from northern Florida to the Gulf of Maine (Nicholson 1975). Almost 30 million kg, worth $1.7 million, were landed in New Jersey in 1975 (U. S. Dept. of Commerce 1976).

The Atlantic menhaden is a plankton feeder and may form a major portion of the diet of predatory fishes such as the bluefish and weakfish (Bigelow and Schroeder 1953). It usually matures in 3 years and spawns primarily in offshore waters. Time of spawning varies with location, and spawning may occur during the entire year in certain areas (Nicholson 1972). Larvae and older Atlantic menhaden enter mid-Atlantic estuaries in spring, although the time of arrival varies with location (Hettler 1976). Both adults and young remain until fall when they emigrate to the ocean and spend the winter from Cape Hatteras to the south (Kroger and Guthrie 1973).

Materials and Methods

General materials, methods, and statistical analyses were discussed on pages 70 to 72.

Sex and reproductive condition were determined by examination of the gonads under a dissecting microscope. Gonad weight was determined to the nearest 0.1 g with an Ohaus Autogram 1000 balance. Fish were considered immature when their gonads occupied a small portion of the body cavity and

the GSI (Gonado-somatic Index, gonad weight/body weight) was small. Gonads of mature fish were categorized as at rest, enlarged, ripe, or spent. Each of the first three stages of maturity occupied a larger portion of the body cavity and had a higher GSI value than the previous stage. Females with mature gonads at rest had small but noticeable cells in the ovary. Mature testes at rest showed no convolutions. Mature fish with enlarged gonads had larger (0.3-0.4 mm diameter) eggs in the ovaries, and the testes were somewhat convoluted. In ripe gonads, egg cells in the ovary were greater than 0.5 mm in diameter, and testes were convoluted. Gonads were considered spent when they showed a decrease in size and GSI, were red in color, and were flaccid. They occupied a larger area of the body cavity than gonads at rest. Convolutions in the testes and size of egg cells in the ovaries were reduced.

Age was determined from scales. When possible, scales were removed from the left side of the specimens in the area between the tip of the flexed pectoral fin and the insertion of the dorsal fin (June and Roithmayr 1960). Scales were cleaned and stored in a labeled scale envelope. Scale impressions were made on acetate slides and were read on an EPOI LP-6 Profile Projector at 10 X magnification. Age was determined by counting the annuli of each scale. A Helios caliper was used to measure the distance from the centrum to each annulus and to the edge of the scale.

Results

Few Atlantic menhaden (n = 71) were collected from September through November (Table 56). Thirty-six specimens were taken from the Bay and Forked River but only three specimens were collected from Oyster Creek.

In December, however, more Atlantic menhaden were collected in Oyster Creek (65) than in the Bay (2). Similarly, the number of fish impinged at OCGS during December (2,903) was greater than the number (32) impinged from September through November. During January and February only one specimen was collected; it was taken on 30 January in Oyster Creek. OCGS was shut down from 26 December 1975 to 4 March 1976.

In 1976, the Atlantic menhaden was first collected at OCGS on 8 March, the first day that sampling resumed. It was first collected from the Bay on 12 March. Impingement of the Atlantic menhaden at OCGS increased from March (n = 27) through April (287), May (290), and June (222). Some 1,447 Atlantic menhaden were impinged during July but only 156 were taken in August. A relatively equal number of specimens was taken from the Bay (15), Forked River (11), and Oyster Creek (16) during April. In the immediate vicinity of the OCGS discharge, schools of Atlantic menhaden were frequently sighted during April. During May, many were sighted behind OCGS in the dilution pump discharge. Most fish were collected in the Bay during May (16), June (43), July (41), and August (43).

Most (94%, n = 5,364) of the fish collected were taken from the traveling screens at OCGS (Table 56). Collections from the Bay accounted for 2.6% (148) of the fish, Oyster Creek 2.1% (118), and Forked River 0.7% (39).

A total of 1,230 Atlantic menhaden was examined from September 1975 through August 1976. Specimens ranged in length from 33 to 347 mm. Although age 3+ females were significantly larger (239 mm) than males (231 mm), no significant difference in length by sex was noted for young (age 0+), age 1+, age 2+, and age 4+ specimens. The mean length of successive age classes was as follows: young, age 0+ (111 mm), age 1+ (183 mm), age 2+ (211 mm), age 3+ (236 mm), and age 4+ (266 mm). Few age 5+ and 6+ fish were collected (Table 57).

A scatter diagram of length and weight on an arithmetic scale was generally curvilinear (Fig. 7), and therefore, the geometric mean regression of log length versus log weight was determined for both males and females (Table 58). A t-test between the two regression coefficients indicated no significant difference between the length-weight relationship for males and females. The data were then pooled to generate a single regression equation: log weight =-4.9734 + 3.0566 (log length). The confidence limits on the regression coefficient were ± 0.0166 (Table 59).

The condition of Atlantic menhaden for all months and for each of the four areas was determined (Table 60). Over the entire year, the condition of Atlantic menhaden from the Bay, Forked River, and Oyster Creek was significantly greater than that of specimens from OCGS (Table 61). The condition of fish collected in Forked River and those collected either in the Bay or Oyster Creek was not significantly different. Specimens from the Bay, however, were in better condition than those from Oyster Creek. An insufficient number of specimens was collected from each area to make meaningful comparisons between areas during specific months.

Females (n = 489) significantly outnumbered males (369) for the year but this difference was rarely significant during specific months (Tables 62, 63). Many specimens less than 150 mm were difficult to sex. The smallest specimens sexed were a 53-mm male and a 62-mm female; the largest were a 317-mm male and a 347-mm female.

The gonad condition of 785 specimens was determined (Table 64). Some 80.3% of the Atlantic menhaden were immature. Among mature fish, 43.9% of the gonads (n = 68) were at rest, 43.2% (67) enlarged, 2.6% (4) ripe, and 10.1% (16) spent.

All young and age 1+ fish were immature. Some 95.7% of age 2+, 59% of age 3+, and 3.6% of age 4+ fish were also immature. All age 5+ and 6+ fish were mature (Table 64). Females with enlarged ovaries had eggs 0.1 to 0.4 mm in diameter. Most ripe specimens were males. One ripe female contained eggs larger than 0.5 mm.

Only 786 specimens were aged because the scales, in many cases, had been lost or were unreadable. Young comprised 27.7% (n = 218) of all specimens aged (Table 65). Age 1+ fish comprised 10.1% of the fish examined, age 2+ 29.5%, age 3+ 23.8%, and ages 4+ through 6+ 8.8%. Each age class from young through age 4+ had more females than males (Table 66).

The mean length of young and age 3+ Atlantic menhaden collected in the Bay was larger than those examined from OCGS (Table 67). Age 2+ and 4+ specimens from OCGS, however, were larger than those in the Bay. Although young Atlantic menhaden taken in Oyster Creek were smaller than those from the Bay, age 2+ and 3+ individuals from Oyster Creek had a greater mean length than those from the Bay.

Back calculation of the mean length of both males and females from ages 1 through 6 was made (Tables 68, 69). The back calculated lengths for age 1 (119 mm), 3 (216), and 4 (250) fish were similar between the sexes (Table 70). Age 2 females (181 mm), however, were significantly larger than age 2 males (176 mm). Back calculated mean length of fish in an age class was less than the mean length of all specimens in that age class. This discrepancy occurred because the back calculated length was the length at the time of annulus formation (e.g. age 3) while the mean length included fish that had grown after annulus formation (e.g. age 3+).

<u>Lernaeenicus radiatus</u>, a copepod parasite, was found on 9.7% of the 1,123 specimens examined for abnormalities (Table 71). <u>Olencera praegustator</u>,

an isopod parasite, had an incidence of 0.8%. All O. praegustator were facing anteriorly in the buccal cavity and probably were females (Kroger and Guthrie 1972). Some 39.7% of all Atlantic menhaden had lost scales.

A substantial number of specimens with parasites, diseases, or mechanical damage was found only at the OCGS screens and in the Bay (Table 72). The incidence of parasitism in the Bay (29.5% of all specimens from the Bay) was much greater than at OCGS (7.3%). Some 50.8% of fish from OCGS had mechanical damage whereas only 9.0% of the fish from the Bay were damaged.

Discussion

Many Atlantic menhaden were impinged at OCGS during December, July, April, and May. During December, increased impingement appeared to coincide with emigration of Atlantic menhaden from the Bay. This emigration is directly related to decreasing water temperature (Bigelow and Schroeder 1953, June and Chamberlin 1959). Reintjes (1969) reported that most of the movement from estuaries occurred when the water temperature cooled to 15 C or below.

The increased impingement of Atlantic menhaden in April and May appeared related to its return to the Bay. The Atlantic menhaden migrate north during spring and is not common in estuaries until temperature is above 10 C. (Bigelow and Schroeder 1953). Most fish impinged in July were young.

During emigration of Atlantic menhaden from the Bay in November and December, some fish were attracted to and subsequently remained in the heated water in Oyster Creek (Tatham and Metzger 1976). On 21 November (Bay temp approximately 12 C), no Atlantic menhaden were collected in Oyster Creek. Some were collected in Oyster Creek, however, on 8 and 9 December (Bay temp approximately 6 C). This indicated that most emigration from Barnegat Bay probably occurred at a temperature lower than the 15 C reported by Reintjes

(1969). No large mortality of Atlantic menhaden was observed when OCGS shut down on 19 December (Bay temp approximately 7 C) or on 26 December (Bay temp approximately 3 C). The Atlantic menhaden comprised most of the fish killed when OCGS shut down in January and December 1972 and January 1974 (AEC 1974).

The Atlantic menhaden was also attracted to the heated discharge of OCGS during March and April 1976 (Danila 1976). Most specimens were collected in the warmest portion of the discharge in an approximately 1 m/sec current. Temperature in the Bay was approximately 9 C when the first specimens were observed. Most fish left the immediate area of the discharge in mid-April (discharge temp 27.1 C) but many were observed and collected in the canal near the discharge at a water temperature of 29.7 C in late April.

Although relatively few Atlantic menhaden were collected in Forked River, Oyster Creek, and the Bay from June through August, there was no apparent avoidance of Oyster Creek. Although specimens were taken in Oyster Creek at temperatures as high as 34 C, most were taken below 30 C (D. J. Danila, personal communication). An avoidance temperature of 30.8 and 32.2 C was determined for Atlantic menhaden acclimated to 20.0 and 24.0 C, respectively (Wyllie et al. 1976).

Barnegat Bay served primarily as a nursery area for the Atlantic menhaden. Some 91.1% of the fish examined were age 0+ through 3+, and 80% of the population was immature. Bigelow and Schroeder (1953) stated that Atlantic menhaden became sexually mature after their third winter, and Nicholson (1972) reported that females spawned after reaching three years of age. Atlantic menhaden spawn at sea (Bigelow and Schroeder 1953, Hettler 1976, Nicholson 1972).

The small number of age 1+ fish was also reported by Nicholson (1972). He stated that age 1 Atlantic menhaden are seldom found north of central New Jersey and in some years are not captured north of Delaware Bay.

The incidence of Atlantic menhaden infected with L. radiatus (9.8%) was similar to the incidence of infestation of adult Atlantic menhaden (9.0%) in North Carolina (Guthrie and Kroger 1974). The few incidences of O. praegustator in this study may reflect the fact that Barnegat Bay is near its northernmost range of occurrence. Neither Kroger and Guthrie (1972) nor Westman and Nigrelli (1955) reported it from Atlantic menhaden in New York; the former felt that New York may be beyond its range. Kroger and Guthrie (1972) reported an infestation rate of 4% from Delaware and 8 to 46% in Maryland and Virginia. Infestation decreased south of Virginia. The 0.8% rate of infestation of fish from Barnegat Bay may be less than the actual incidence, however, since O. praegustator is capable of detaching from its host (Kroger and Guthrie 1972).

Most (95.4%) mechanically damaged Atlantic menhaden were taken at OCGS. Some 50.8% of all Atlantic menhaden from OCGS were mechanically damaged as compared to 9.0% from the Bay.

BAY ANCHOVY

Robert J. Kurtz

Introduction

The bay anchovy is an important forage fish that ranges from Maine to Texas (Bigelow and Schroeder 1953) and forms a portion of the diet of important sport and commercial fishes such as striped bass (Schaefer 1970), weakfish (Thomas 1971), and summer flounder (Smith 1969). It occurs in Barnegat Bay from March through December. The life span of the bay anchovy appears to be relatively short, probably not more than 2 or 3 years (Stevenson 1958). Its diet is primarily copepods, megalops, and zoeae (Stevenson 1958).

Materials and Methods

General materials, methods, and statistical analyses were discussed on pages 70 to 72.

Sex was determined by examination of the gonads under a dissecting microsocpe. Gonad weight was determined to the nearest 0.1 g. Stevenson (1958) reported that testes were leaf-like and thin at the edges while ovaries were rounded and bag-like. The gonads were considered immature if they were small and egg cells in the ovaries were small or not distinguishable. Mature gonads were categorized as at rest, enlarged, ripe, or spent. The GSI increased with each stage of maturation and then decreased for spent gonads. Ovaries at rest were coarse internally,

and eggs were small (0.1 mm). Testes at rest had thin edges, a firm texture, and no convolutions. For enlarged gonads, testes were partially convoluted while ovaries contained numerous 0.2 to 0.4-mm egg cells. In ripe gonads, testes were fully convoluted, soft, and disintegrated easily when pressed. Ovaries contained many transparent eggs larger than 0.5 mm. Spent gonads occupied a smaller area of the body cavity and were flaccid. Testes had fewer convolutions, and ovaries had few cells larger than 0.4 mm.

Age and growth were determined by length frequency analysis because scales, otoliths, and vertebrae were unsatisfactory for age determination (Stevenson 1958).

Results

From September through December 1975, most (2.6% of all specimens collected, n = 14,137) bay anchovy were collected in October (Table 73). The number collected declined in November (4,549) and December (756), and no specimens were collected during January and February.

The bay anchovy was first collected in 1976 at OCGS on 11 March and in Barnegat Bay on 23 March. The number collected in March (n = 10,149) represented 1.9% of all specimens. Most specimens were collected in April (53.2%; 286,669) and May (34.8%; 187,848). The number collected decreased greatly in June, (2.8%; 14,926), July (1.4%; 7,808), and August (1.1%; 5,801).

Most bay anchovy were impinged at OCGS during April (55.5%) and May (37.8%) but it was common in June (2.5%) and March (2.1%). The fewest specimens were taken during December (0.04%), November (0.1%), September (0.2%), and July (0.4%).

Most specimens were taken in Oyster Creek, Forked River, and the Bay during April (32.7%), October (18.7%), July (11.2%), and September (10.0%). The fewest were collected in March (0.3%), December (1.0%), August (5.2%), and June (5.2%).

A representative sample (n = 5,143) of the bay anchovy was examined from the four areas. Males ranged in length from 24 to 90 mm and females from 24 to 92 mm. The overall mean length of males and females (58 mm) was not significantly different (Table 74). The length frequency distribution was examined for each month to ascertain age and growth of the population. Data from July and August 1976 were used in connection with data from September through December 1975 to approximate growth.

A single mode was found during each month from March through June. The mean length decreased significantly each month from March through May but was equivalent in May and June (Table 75).

A bimodal distribution of length was found from July through December Specimens from the larger size group in July (mean length = 57 mm) were the same size as those collected during June. This size group was probably composed of smaller bay anchovy present from March through June. From August through December, the difference between the mean length of the two groups was significant (Table 76). One size group in July did not contain enough specimens (n = 9) to statistically test this difference. The mean length of both groups increased each month from July (27 mm, 57 mm) through October (40, 73). A decrease in the mean length of both groups in November was followed by an increase in December.

A scatter diagram of length versus weight on an arithmetic scale revealed some curvilinearity in this relationship among larger fish. The geometric mean regression was generated for both sexes (Table 77). The t-test between the regression coefficients indicated that females were significantly heavier than males of the same length.

The condition of bay anchovy collected in the Bay and Forked River over the year was not significantly different. Specimens from Forked River and the Bay were in significantly better condition, however, than fish from either Oyster Creek or OCGS (Tables 78, 79). The condition of fish from Oyster Creek was not significantly different from those collected at OCGS. No consistent differences were noted in the condition of fish from different areas during individual months (Table 80).

The sex of 5,016 bay anchovy (97.5% of all specimens examined) was determined, and females (57.2%, n = 2,870) significantly outnumbered males (42.8%, 2,146). When 33 of the 48 possible month/area combinations were tested, females outnumbered males in 29 cases, and 15 of the differences were significant (Table 81). From June through December, females significantly outnumbered males in 15 month/area combinations (Table 82). From March through May, however, sex ratios were not significantly different in 10 comparisons. Significantly more females than males were found in all months except March and May (Table 83) and in all areas (Table 84).

Most bay anchovy smaller than 35 mm were immature, while most specimens larger than 40 mm were mature. Those from 35 to 40 mm in length included both immature and mature specimens. From March through July, 99.5% of all specimens were in some state of maturity (at rest, enlarged, ripe, spent).

Immature fish were found primarily from July through December. The gonads of all fish examined from September through December were either immature or at rest.

Specimens from all areas had enlarged gonads in April and enlarged or ripe gonads during May and June (Talbe 85). Those with ripe (26.2%-38.8%) and spent (33.5-55.0%) gonads were predominant in July. During August, most specimens had gonads that were spent (40.3%), immature (18.9%), or at rest (27.8%); few had gonads that were enlarged (0.2%) or ripe (12.8%).

Ripe males were more common than ripe females. Males were ripe from May through August and females from May through July. During May and June, most (66.4%) males were ripe while most (70.7%) females had enlarged gonads (Table 85). However, for specimens collected from OCGS during May, the percentage of ripe males (17.7%) and females (16.8%) was similar. During July and August, many females had enlarged or spent gonads while many males were still ripe.

All 5,143 specimens were examined for abnormalities (Table 86). Lernaeenicus sp., a parasitic copepod, was found on 5.7% of the specimens. It was most common from June through August. Only two specimens with fin rot disease were found. The most common mechanical damage (63.9% of all fish) was missing scales.

The percentage of abnormal fish in each area was examined (Table 87). Substantially more bay anchovy from OCGS (67.4% of all specimens examined from OCGS) and Oyster Creek (74.7%) were mechanically damaged than those from Forked River (52.1%) and the Bay (52.9%). The number of specimens parasitized was too small to allow meaningful comparisons between areas.

Discussion

The appearance of the bay anchovy in Barnegat Bay during March and its departure in December concurred with its reported presence in Delaware Bay (Stevenson 1958) and other studies of Barnegat Bay (Marcellus 1972, McClain 1973). It was the second most abundant fish collected in Barnegat Bay from 1966 to 1970 (Marcellus 1972) and during 1971 and 1972 (McClain 1973). From September 1975 through August 1976, it ranked first in abundance in collections made at OCGS (Table 10) and in Oyster Creek, Forked River, and the Bay (Table 45). Most specimens were collected from April through June.

Young (age 0+) bay anchovy were first collected in July. The length of fish designated as young in this study (21-59 mm) was in agreement with the size limit of age 0+ fish (20-60 mm) described by Marcellus (1972). The two size groups of specimens found from July through December appeared to be young and age 1+ fish. Perlmutter (1939) concluded that two size groups of specimens collected in Long Island probably represented young and age 1+ fish.

The increase in the mean length of bay anchovy collected from July through October was 0.15 mm/day. Marcellus (1972) reported a growth rate of 0.18 mm/day for young from Barnegat Bay during the same months. The decrease in the mean length of both age classes in November may have been attributed to small sample size, the recruitment into the population of small young from a late July to early August spawn, or the emigration of larger fish from the Bay.

Although the length frequency distribution of bay anchovy collected from April through June (35-92 mm) was unimodal, at least two age classes

of fish were probably present. Smaller individuals which entered the Bay in March and April were the young and age 1+ specimens collected from September through November of the previous year. Young and age 1+ fish taken from September through November ranged from 25 to 44 mm and from 65 to 84 mm, respectively. Stevenson (1958) reported that little growth probably occurred during winter. The largest individuals (85-92 mm) were close to the maximum size reported for this species (Hildebrand and Schroeder 1928). These larger specimens were uncommon and may have been age 2+ individuals although Stevenson (1958) reported that older fish tended to remain at sea. The decrease in the mean size of fish from March through May may represent natural mortality of older fish.

Bay anchovy impinged at OCGS were in poorer condition than those collected in the Bay and Forked River. Fish in poorer condition may be less able to withstand the currents in front of the screens and therefore were more likely to be impinged.

Bay anchovy taken from Oyster Creek were also in poorer condition that those from either the Bay or Forked River. Marcy (1976) reported the brown bullhead collected during the winter in the heated discharge canal of the Connecticut Yankee Atomic Station were in significantly poorer condition than those collected outside the discharge. He thought that fish in the heated discharge had higher metabolic rates, were crowded, and had increased competition for food.

Most bay anchovy 30 mm or larger in length were sexed, and most greater than 40 mm were mature. Most spawning in Barnegat Bay appeared to have occurred from May through July. Most fish had enlarged or ripe gonads during May and June. A considerable percentage (23.8-38.8%, depending on area) of specimens were still ripe in July but only 5.7%

to 22.8% of those examined in August had enlarged or ripe gonads. Stevenson (1958) reported spawning in Delaware Bay from May through August. He reported that bay anchovy which spawned during August may have been spawned during the late summer of the previous year. Specimens with immature gonads were young which were spawned in May and were first collected by seine and trawl in July.

Stevenson (1958) found significantly more females than males over the entire year but the sex ratio was approximately equal during the spawning season. In Barnegat Bay, an equal sex ratio was found in March and April and at the beginning of the spawning season (May) but females outnumbered males during June and July.

The number of bay anchovy diseased or parasitized was relatively low. The larger percentage of bay anchovy infected with Lernaeenicus sp. from June through August may have been due to the predominance of older (age 1+ and 2+) specimens which have had a greater chance of infection. From September through December, most fish were young.

The loss of scales was the most common abnormality and may be either a natural phenomenon or an artifact of handling. Bigelow and Schroeder (1953) commented on the deciduous nature of bay anchovy scales, and Stevenson (1958) found that direct ageing of older fish was difficult because few had scales. However, more mechanically damaged (primarily missing scales) bay anchovy were collected at OCGS and Oyster Creek than from Forked River and the Bay. Impingement on the traveling screens and passage through the dilution pumps apparently caused these additional scale losses.

THREESPINE STICKLEBACK

Ferdinand Metzger, Jr.

The threespine stickleback is found along shorelines and in tidal creeks in both brackish and salt water from northern Newfoundland to lower Chesapeake Bay (Bigelow and Schroeder 1953). It is a nest builder and spawns in estuaries during May and June.

General materials, methods, and statistical analyses were discussed on pages 70 to 72 .

A total of 52 threespine stickleback was collected and examined. All were collected during March and April at OCGS, and most (82.7%) were taken at night. The failure to collect specimens in Oyster Creek, Forked River, and Barnegat Bay probably reflected its low abundance in the Bay. Marcellus (1972) collected 219 specimens from 1966 through 1968 in Barnegat Bay but only 25 from 1969 through 1970. McClain (1973) reported only eight threespine stickleback collected by trawl and seine in upper Barnegat Bay from December 1971 through November 1972.

Threespine stickleback ranged in length from 39 to 69 mm (mean = 60 mm). In the Gulf of Maine, the threespine stickleback reached a length of 40 to 50 mm when 1 year old and 50 to 55 mm at age 2 (Bigelow and Schroeder 1953). In the present study, six of the specimens were 39 to 49 mm, 20 were 55 to 60 mm, and 26 were 61 to 69 mm.

In Maine, the threespine stickleback was sexually mature at 2 years (Bigelow and Schroeder 1953). All but six of the fish collected in this study were probably mature.

NORTHERN PIPEFISH

David W. Moore

Introduction

The northern pipefish is found in brackish and ocean water from the Gulf of St. Lawrence to offshore of Texas (Leim and Scott 1966). The shallow water and eelgrass beds in Barnegat Bay provide favorable habitat for northern pipefish. Bigelow and Schroeder (1953) and Hildebrand and Schroeder (1928) gave general information on its habitat, food habits, and reproductive behavior. Mercer (1973) gave more specific information on its length frequency distribution, food habits, and age structure in the York River, Virginia. The northern pipefish has no commercial or sport importance, and few have considered it an important component of estuarine ecosystems.

Materials and Methods

General materials, methods, and statistical analyses were discussed on pages 70 to 72.

Sex was determined by the presence of the marsupium in males. When sex was difficult to determine externally, the gonads were examined under a dissecting microscope. Sex could not be determined for specimens under 100 mm in size. The reproductive condition of males was recorded as immature (marsupium closely attached to the body), mature (pouch easily separated from the body), or gravid (eggs present in the marsupium). The breeding condition of females was not determined.

Histograms of length were plotted for each area by month and sex. When few specimens were collected, several months and areas were grouped. A histogram for fish of undetermined sex was also generated.

Results and Discussion

All northern pipefish collected from Oyster Creek (n = 131, mean length = 161 mm), Forked River (114, 162 mm), and the Bay (241, 156 mm) were examined (Table 88). The northern pipefish was collected only by seine and trawl. Most were taken in November and December and from March through June. The most specimens collected by trawl were taken from October through December and from March through May (Table 89). The most collected by seine were taken during August, September, and October.

Samples taken during a population survey in June showed that the northern pipefish was concentrated in the shallow, heavily vegetated eastern side of Barnegat Bay (Table 37). Briggs and O'Connor (1971) found that northern pipefish preferred naturally vegetated areas.

Seasonal changes in catch by seine and trawl showed that northern pipefish moved from shallow to deeper water as the water temperature decreased. Bigelow and Schroeder (1953) observed northern pipefish in a torpid state and sometimes partially imbedded in the bottom sediments during winter.

Catch-per-unit-effort was determined for the combined seine and trawl catches at Oyster Creek (0.51 specimens/collection), Forked River (0.45), and Barnegat Bay (0.54). The distribution of northern pipefish among areas was similar, and no attraction to or avoidance of Oyster Creek was evident (Table 88).

An estimated 34,830 northern pipefish were impinged at OCGS during the 10 months of sampling (Table 90). In months when many were impinged, at least 50 specimens from day and 50 from night collections were examined. A total of 906 specimens (mean length = 171 mm) was examined. Most were impinged during December and March, and significantly more were impinged at night (69%) than during the day (31%).

Although fish collected from OCGS were generally larger than those taken from the other three areas, the difference was not significant (Table 88). During December and April, months when many specimens were collected in all areas, the length of those collected at OCGS was not significantly different than those from all seine and trawl collections. The trend toward larger specimens at OCGS may be partially attributable to the passage of some small specimens through the larger mesh (9.6 mm) of the traveling screens.

The difference in length between males and females was determined for specimens collected at OCGS. When northern pipefish was common at OCGS, males were significantly smaller than females. The mean length of males taken at OCGS during November, March, and April was 138, 141, and 150 mm, respectively. The mean length of females during the same months was 187, 180, and 183 mm.

The regression equation for males (n = 563) was log weight = -7.5665 + 3.5125 (log length); the confidence limits on the regression coefficient were ± 0.1271. For females (n = 807), the regression equation was log weight = -6.8735 + 3.1980 (log length) with confidence limits of ± 0.1658. Males were significantly heavier than females of the same length.

Significantly more females than males were taken in Oyster Creek, Forked River, and the Bay during all months except from April through

June (Table 91). Some 34% of the specimens from these areas and 45% of the fish examined from OCGS were males. Gravid males comprised 56% of all males collected from Forked River, Oyster Creek, and the Bay but only 36% of all males at OCGS. Many gravid males were taken from the east side of the Bay during the population survey, and substantial spawning probably occurred in that area.

Most gravid males were taken during May and June. In the York River, Virginia, Mercer (1973) found most males during the same months. In Great Bay, New Jersey, most of the recently hatched northern pipefish were collected during May and June (Tatham et al. 1974).

Growth and age structure of the population was difficult to determine from the length frequency distribution because spawning was protracted and growth rapid. Newly hatched young were present from March through August. Young emerged from the brood pouch of the male at a length of 11 to 13 mm, and aquarium raised individuals reached 70 mm in 2 months (Bigelow and Schroeder 1953).

Although Mercer (1973) did not separate specimens by sex, her length frequency histograms suggest that at the end of the first year young ranged from 50 to 125 mm. These fish probably made up a large percentage of the reproductive population in the following year. The length frequency distribution of fish taken at OCGS indicated age 2+ fish during July and August but these fish disappeared by November. Mercer (1973) noted the disappearance of larger, possibly age 2+, northern pipefish during July. Joseph (1957) suggested that the incubation of young may have resulted in increased mortality of males of the Gulf pipefish.

STRIPED BASS

Ferdinand Metzger, Jr.

The striped bass ranges from the Gulf of St. Lawrence to northern Florida and Louisiana (Bigelow and Schroeder 1953). It is an important sport and commercial fish taken off New Jersey. In 1975, 31,672 kg (29% of the striped bass landed in New Jersey) were landed in Ocean County (U. S. Dept. of Commerce 1976). In 1972, an estimated 2,688 striped bass were caught by sport fishermen in upper Barnegat Bay (Halgren 1973).

Only one specimen was collected during this study. It was an immature female which measured 390 mm in length and weighed 778.6 g. It was collected at the mouth of Oyster Creek in April.

Many studies have determined the migratory pattern of the striped bass. Most age 2+ and older fish move north along the coast between Chesapeake Bay and southern New England in the spring and south in the fall (Bigelow and Schroeder 1953). The American Littoral Society and sport fishermen have conducted tagging programs of striped bass along the Atlantic coast since 1967. Analysis of these tag returns by Raney and Weller (1972) and Hoff (1974a) further defined this north-south migration. During fall, some fish migrated only to New Jersey where they overwintered in bays and rivers (Hoff 1974a).

The striped bass spawns in the tidal portions of rivers in either low salinity or freshwater (Bigelow and Schroeder 1953). Hoff (1976) reported limited spawning of the striped bass in April and May in the Mullica River, New Jersey. Twenty-five percent of the females in Connecticut spawned at

the beginning of their fourth year, 75% when 5 years old, and 95% by their sixth year (Merriman 1941). Bason (1971) found that several age 2+ females taken in the Delaware River in the fall had enlarged ovaries and may have matured the following year. Some males matured by their second year, and all matured by the fourth (Merriman 1941, Bason 1971).

Age 2 fish taken in Connecticut attained a length of 280 to 290 mm in the spring, age 3 fish were 400 mm, and age 4 individuals about 480 mm (Merriman 1937). Bason (1971) reported that striped bass in the Delaware River averaged 102 mm at age 1, 218 mm at age 2, 319 mm at age 3, and 430 mm at age 4.

BLUEFISH

Ferdinand Metzger, Jr.

Introduction

The bluefish ranges from Cape Cod to Florida and is occasionally taken in the Gulf of Maine (Bigelow and Schroeder 1953). Bluefish frequent New Jersey waters from May to November (Milstein 1974). It is a highly utilized sport and commerical fish in New Jersey. In 1975, 237,835 kg were landed commercially in Ocean County (U. S. Dept. of Commerce 1976). In 1972, an estimated 19,144 bluefish were caught by sport fishermen in upper Barnegat Bay (Halgren 1973). It was the most abundant fish caught by sport fishermen in Oyster Creek (Table 134). Most specimens examined for life history studies were collected from late October 1975 through August 1976.

Materials and Methods

General materials, methods, and statistical analyses were discussed on pages 70 to 72.

The sex of specimens was determined by examination of the gonads under a dissecting microscope. Specimens smaller than 180 mm were assumed to be young (Bigelow and Schroeder 1953, Richards 1976). The age of specimens greater than 180 mm was determined by examination of the scales. Condition was computed for individuals of the same year class, and analysis by area was made when a sufficient number of specimens was collected in each area.

Results and Discussion

A total of 1,114 bluefish was examined from October 1975 through August 1976. No specimens were taken from January through April. The traveling screens at OCGS accounted for 69.3% (n = 793) of all specimens, Oyster Creek 22.6% (259), the Bay 4.1% (47), and Forked River 3.9% (45). The number and the mean length and weight of bluefish examined during each month are presented in Table 92.

In 1976, specimens were first collected in May. OCGS accounted for 342 (87.2%) specimens. These fish were small (31-62 mm) and had a mean length of 44 mm. Some 46 bluefish, ranging in length from 49 to 405 mm (mean = 312 mm) were captured in Oyster Creek. Four fish were taken from the Bay (3) and Forked River (1), and they ranged in length from 230 to 248 mm. The attraction to the heated water in Oyster Creek and the great volume of water filtered by the traveling screens accounted in part for the larger number of bluefish collected in these areas.

From May through August, a total of 735 bluefish was examined from OCGS, 103 from Oyster Creek, and 79 from the Bay and Forked River (Table 92). Some 78.7% of the fish impinged were taken during May and June. Most of the bluefish impinged from May through August were less than 100 mm in length; the largest was 332 mm.

The mean length of fish collected from Oyster Creek in May was 312 mm, in June 188 mm, in July 166 mm, and in August 219 mm. Mean surface water temperature ranged from 23.7 to 29.4 C (Table 4). The length of bluefish collected in the Bay and Forked River ranged from 38 to 288 mm with a mean length of 86 mm. The largest (465 mm) bluefish collected was taken from Oyster Creek.

In 1975, bluefish were taken in the Bay through October. They began their emigration during October, and none were collected in the Bay in November and December. In the fall, emigration began when water temperatures approached 15 C (Lund and Maltezos 1970). Until OCGS shut down on 19 December 1975 (mean Bay temp = 7.0 C), bluefish remained in the heated discharge. After the shutdown, mortality of young acclimated to 17 C occurred when temperature in the canal decreased from 7 to 3 C, some 8 to 13 h after shutdown (Tatham and Metzger 1976). Wyllie et al. (1976) reported that young bluefish acclimated to 20 C died 14 to 82 h after exposure to 10 C. Although no mortality of bluefish was observed during an OCGS shutdown on 24 November 1975 (mean Bay temp = 8.5 C), stressed individuals were observed (Tatham and Metzger 1976).

Some 782 specimens were aged in October, November, May, and August (Table 93). Individuals from the 0+ through 3+ age classes were found. Young (age 0+) fish were predominant and comprised 77.5% of all fish aged; age 1+ fish represented 20.2%, age 2+ fish 2.1%, and age 3+ fish 0.1%. Thomas (1974) reported that 98% of the bluefish collected in the vicinity of Little Egg Inlet, New Jersey were young.

Young (mean length = 44 mm), age 1+ (292 mm) and age 2+ fish (382 mm) fish first appeared in May, and some individuals from these age classes were collected in Barnegat Bay from May through August (Table 93). One age 3+ bluefish (465 mm) was caught during August in Oyster Creek. Young, however, dominated collections. The extended spawning period of bluefish, variation in growth (Richards 1976), and the relatively few specimens of age 1+ and 2+ fish precluded growth determinations for these fish.

The spawning period of the bluefish on the Atlantic coast extends from spring to August (Bigelow and Schroeder 1953). Thomas (1974) reported that bluefish ranging from 30 to 39 mm were collected off Little Egg Inlet, New Jersey in June, and larval bluefish were taken in September. Ripe bluefish were taken off North Carolina in the spring (Bigelow and Schroeder 1953) and off New York in late June (Deuel et al. 1966).

Length frequency distributions suggested that young from at least two spawns were present in Barnegat Bay in 1976 (Fig. 8, Table 94). Bluefish that ranged in length from 10 to 70 mm (mean = 44 mm) were collected in May. In June, young ranged from 30 to 80 mm with a mean length of 52 mm, and the monthly growth increment was 8 mm. This estimate may be small because of the wide size range of fish during both months. In July and August, two size groups of young were observed. Those from the larger group ranged in length from 70 to 160 mm (mean = 108 mm) in July and from 120 to 190 mm (mean = 150 mm) in August. Their monthly increment in growth was 56 mm in July and 42 mm in August. Young, apparently from a second spawn, ranged in length from 50 to 70 mm (mean = 63 mm) in July and from 30 to 110 mm (mean = 78 mm) in August.

The growth of young was rapid. In November 1975, young had grown to a mean length of 171 mm. The rapid growth of age 1+ and 2+ bluefish has been reported from Long Island Sound (Richards 1976), New Jersey (Lyman 1974), and Woods Hole, Massachusetts (Backus 1962). Richards (1976) reported that bluefish almost doubled their length during the second year. She found considerable variation in growth during any one year, and age 3+ fish had a length range that completely overlapped the

range of age 2+ fish. Generally, the size attained by age 1+ and 2+ bluefish in Barnegat Bay was comparable to the size reported by Richards (1976) from Long Island Sound and Lyman (1974) for New Jersey (Table 95).

The length-weight regression equation for males (n = 279) was log weight = -5.224 + 3.1360 (log length). The confidence limits on the regression coefficient were ± 0.328. For females (n = 202), the regression was log weight = -5.623 + 3.3067 (log length) with confidence limits of ± 0.398. A t-test performed on the regression coefficient of the two equations indicated that females showed a significantly greater increase in weight with length than did males.

All specimens larger than 80 mm in length were sexed, and all were immature. The age at which bluefish mature is not definitely known (Bigelow and Schroeder 1953). The sex of specimens less than 80 mm could not be determined due to undeveloped gonads. Of 481 specimens sexed, significantly more (58.1%, n = 279) were males than females (41.9%, 202). Females ranged in length from 93 to 465 mm (mean = 213 mm) and males from 85 to 405 mm with a mean of 189 mm (Table 96). Neither sex showed a preference for a particular area from May to August.

During July, young (70-190 mm) from Oyster Creek, Forked River, Barnegat Bay, and OCGS were in similar condition (Table 97). In August, fish from Forked River, the Bay, and OCGS were in significantly poorer condition than those from Oyster Creek.

The parasitic isopod, *Lironeca ovalis*, was found in the gill cavity of 47 specimens (4.3% of the bluefish examined). Parasitized fish ranged from 78 to 405 mm. Some 55.3% of the parasitized fish were males, 34.0% were females, and 10.6% were of undetermined sex.

L. ovalis was found in specimens collected from October through December and during July and August. The percent of infestation in Oyster Creek was 8.9% (23 of 259 specimens), Forked River 4.4% (2 of 45), the Bay 21.3% (10 of 47), and OCGS screens 1.5% (12 of 793). The predominant months of infestation were July and August. During these months, the percent of infestation of fish from Oyster Creek was 26.9% (14 of 52), Forked River 6.4% (2 of 31), the Bay 26.3% (10 of 38), and OCGS 7.7% (12 of 156). From October through December 1975, 12 of 13 bluefish infested with *L. ovalis* were taken from Oyster Creek but the infested fish were only 7.7% of the fish examined from Oyster Creek during these months.

Lindsay and Moran (1976) found that 19.5% of 246 specimens collected in the Delaware River were infested with *L. ovalis.* They believed that the incidence of infestation may have been higher because male *L. ovalis* tended to leave the host when it was removed from the water. Of 1,435 bluefish taken in the vicinity of Little Egg Inlet, New Jersey, 14% were infested with *L. ovalis* (Swiecicki 1974). Although other studies reported a greater percentage of infestation, this study found that 29.8% of the infested fish contained an isopod in each gill chamber; Lindsay and Moran (1976) found that only 1% of their specimens contained two *L. ovalis.*

The bluefish examined showed no evidence of disease. The only injuries observed were scale loss and abrasive wounds which were probably incurred during collection. This condition was most common in specimens at OCGS.

WEAKFISH

Robert J. Hillman

Introduction

The weakfish is a predaceous, migratory fish that occurs from Florida to Massachusetts Bay (Bigelow and Schroeder 1953). It is an important sport and commercial fish. In 1975, 215,498 kg were landed in Ocean County, New Jersey (U. S. Department of Commerce 1976). Halgren (1973) estimated that 41,320 weakfish were taken in Barnegat Bay by sport fishermen from December 1971 through November 1972. This study reports on some aspects of its life history in Barnegat Bay.

Materials and Methods

General materials, methods, and statistical analyses were discussed on pages 70 to 72.

All weakfish 180 mm and larger were sexed by visual inspection of the gonads. Specimens less than 180 mm in length collected from August through December were considered young (Thomas 1971) and were not sexed. Scales from the juncture of the spinous and soft dorsal fins were saved for age determination.

Results and Discussion

A total of 1,572 specimens was examined from mid-October through August. Prior to mid-October, only the length of individuals was recorded (Table 98).

Of the 906 specimens examined from September through December, most (n = 457) were collected in November. None were taken from January through mid-April. From mid-April through August, 656 fish were examined. Most (562) were taken in August. Some 83.2% (1,308) of those examined were taken from OCGS. More weakfish were taken from Oyster Creek (5.4/collection) than any other area in the Bay (0.5-1.2/collection).

The heated discharge in Oyster Creek attracted weakfish during the spring and fall. The first specimens collected in 1976 were taken in Oyster Creek in April, and large catches were made in May. Large weakfish were captured in the warmest portion of the discharge during November and mid-December 1976 (K. R. Powers, personal communication). Most weakfish left lower Delaware Bay by October (Thomas 1971), and young (age 0+) along the Atlantic coast migrated to warmer ocean waters off Virginia and North Carolina during winter (Nesbit 1954).

Most of the weakfish that were aged (n = 63) were either young (23.4% of aged specimens, n = 15) or age 3+ fish (21.9%, 14). The age of 19 fish could not be determined because of unreadable scales. From October through December, young that were aged ranged in length from 180 to 232 mm. Age 3+ fish ranged from 290 to 345 mm.

Young comprised most (96.0%, n = 1,514) of the specimens. They accounted for 98.6% (1,290) of the weakfish examined from OCGS and 82.9% (219) of those from the other three areas. Most were collected during August 1976 and from September through November 1975. Few were taken in July and December.

The mean length of young and age 3+ fish from Barnegat Bay was similar to that reported by Thomas (1971) for Delaware Bay. Thomas (1971) reported

that the mean length of young during August 1969 was 64.6 mm, and all were under 180 mm. In Barnegat Bay, the mean length of young (< 180 mm) in August 1976 was 73 mm.

The histogram of length of all young was basically bimodal with size groups at 60 to 70 mm and 130 to 150 mm. During the fall of 1975, the modal length of young taken at OCGS was 60 to 70 mm (n = 20) in September, 70 to 80 mm (54) in October, and 130 to 160 mm (96) in November. During August 1976, the modal length of young taken at OCGS was 60 to 70 mm (80).

A substantial number of young was taken in Oyster Creek, Forked River, and the Bay only during August. Of the 173 young examined then, 77 were from Oyster Creek (44.5% of all young collected in August), 67 from Forked River (38.7%), and 29 from the Bay (16.8%). The mean length of weakfish from Forked River (67 mm) and the Bay (69 mm) was not significantly different than that of weakfish at OCGS (76 mm). The mean length of specimens from Oyster Creek (60 mm), however, was significantly less than that of specimens from OCGS, Forked River, and the Bay.

Weakfish ranged in length from 26 to 672 mm. The regression equation for males (n = 41) was log weight = -5.0108 + 2.9952 (log length), and the confidence limits on the regression coefficient were ± 0.0550. For females (23), the regression equation was log weight = -4.9293 + 2.9627 (log length) with confidence limits of ± 0.3387. The regression coefficient for males was not significantly different than that for females. A pooled regression of 1,266 specimens was log weight = -5.4047 + 3.1599 (log weight) with confidence limits of ± 0.0197.

Thomas (1971) reported a length-weight regression of log weight = -5.2324 + 3.0917 (log length) based on 101 specimens (56-279 mm in length).

Weakfish from Barnegat Bay were significantly heavier than similar sized fish from Delaware Bay.

Most (62.9%, n = 39) of the 63 specimens greater than or equal to 180 mm were captured in Oyster Creek during May and June. The rest were taken at OCGS (29.0%, 18), Forked River (8.1%, 5), and the Bay (1.6%, 1). Most (49.2%, 31) were taken by gill net followed by the traveling screens (29.0%, 18) and trawl (19.4%, 12). Some 42.8% (27) were in the 300 to 400 mm size range (Table 99).

Daiber (1957) and Bigelow and Schroeder (1953) found that most males and females matured at 2 to 3 years of age. However, Daiber (1957) stated that a few larger yearlings (age 1+), particularly males, may contribute to a late summer spawn. Higgins and Pearson (1927) reported than 80% of weakfish 250 mm in length were mature.

Of the 1,572 fish examined, only 44 (2.8%) were larger than 250 mm. Those fish probably were not ripe. In the vicinity of Great Bay, New Jersey, Tatham et al. (1974) collected most weakfish larvae in the ocean and concluded that spawning occurred in the ocean primarily during June. The predominance of young suggests that Barnegat Bay was used primarily as a nursery area.

In paired day-night collections from Oyster Creek, Forked River, and the Bay, 56 (69.1%) weakfish were taken during the day, and 25 (30.9%) were taken at night. More weakfish, however, were impinged at night (70.3%, n = 5,607) than during the day (29.7%, 2,364).

Physical injuries and anomalies were noted in 50 fish (3.2% of the weakfish examined). Eighteen fish (1.2%) had fin rot and 16 fish (1.0%) were infested with the isopod Lironeca ovalis. Two cases of pugheadedness

were found, and one specimen had a slipper limpet, *Crepidula convexa*, attached to its side.

The incidence of *Lironeca ovalis* on weakfish from Barnegat Bay was less than or equal to that reported for weakfish from the Delaware River. Lindsay and Moran (1976) found 2.8% of the weakfish examined from the Delaware River were infested with *L. ovalis*. Thomas (1971) found 20 (0.78%) weakfish infested with at least one *L. ovalis* in 1969.

In Barnegat Bay, Marcellus (1972) took a total of two weakfish from 1966-70, and McClain (1973) took three from December 1971 through November 1972. Marcellus used only a seine whereas McClain used both a seine and a trawl. All of McClain's specimens were taken by trawl. In this study, 150 specimens were taken by trawl in the Bay. Weakfish generally avoid the shallower shoreline.

NORTHERN KINGFISH

Ferdinand Metzger, Jr.

The northern kingfish ranges from Florida to Cape Cod with strays reported as far north as Casco Bay, Maine (Bigelow and Schroeder 1953). It has an extended spawning season that runs through the summer in the waters off New Jersey (Welsh and Breder 1923) and off New York (Schaefer 1965). Many males become sexually mature at age 2+, and most females were mature at age 3+ (Bigelow and Schroeder 1953).

General materials and methods were discussed on pages 70 to 72.

All 10 northern kingfish collected from August through December 1975 and all 6 in May and August 1976 were examined. Specimens ranged in length from 26 to 280 mm.

The northern kingfish has a rapid growth rate, and age and growth were determined from the literature. Welsh and Breder (1923) reported that in New Jersey fish taken in late June were as small as 16 mm but by late September they ranged from 35 to 154 mm. They reported that northern kingfish reached a modal standard length of 120 mm by their first winter (age 0+), 250 mm by their second winter (age 1+), and 350 mm by their third (age 2+). Schaefer (1965) found that young (age 0+) in New York ranged from 25 to 315 mm in October. He found an average length of 260 mm by the second summer (age 1+) and 335 mm by the third summer (age 2+). In Delaware Bay in October, Thomas (1971) collected 6 young that ranged in length from 75 to 321 mm. In Chesapeake Bay, young ranged in length from 50 to 185 mm by October (Hildebrand and Schroeder 1928).

Young and age 1+ fish were collected (Table 100). From August through

December 1975, 10 young ranging in length from 95 to 280 mm were taken. In May, one specimen (267 mm) was collected, and it was probably age 1+. In August, all specimens were young (26 to 110 mm).

In past years, the northern kingfish was common in New Jersey. It ranked 11th among the 20 most abundant species in trawl collections made along the coast of southern New Jersey by the Bingham Oceanographic Institute from 1929 to 1933 (Thomas and Milstein 1974). In recent years, its numbers have decreased. Thomas and Milstein (1974) reported that in the vicinity of Little Egg Inlet, New Jersey during 1972 and 1973, the northern kingfish was not among the 20 most abundant species. Marcellus (1972) collected a total of 416 specimens from 1966 to 1970 in Barnegat Bay. The number of specimens collected declined from 220 in 1966-67 to 59 in 1969-70. McClain (1973) collected only seven northern kingfish in upper Barnegat Bay from December 1971 to December 1972. Halgren (1973) did not report any northern kingfish taken during a creel census in Barnegat Bay during the same period. Although it was relatively common in the sport fishery near Little Egg Inlet in 1972 (Hoff 1973), it was uncommon during 1973 and 1974 (Hoff 1974b, 1975).

SUMMER FLOUNDER

Robert J. Hillman

Introduction

The summer flounder occurs in Barnegat Bay from March through December. It migrates into estuarine and coastal water in the spring and returns to the continental shelf in the fall (Bigelow and Schroeder 1953). Festa (1974) suggested that summer flounder larvae and young (age 0+) enter New Jersey estuaries from October through March. It is an important sport and commercial fish. In 1975, 452,748 kg were landed in Ocean County, New Jersey (U. S. Dept. of Commerce 1976). Halgren (1973) estimated that 31,730 summer flounder were taken by Barnegat Bay sport fishermen from December 1971 to December 1972. A study of its life history in Barnegat Bay was initiated in October 1975.

Materials and Methods

General materials, methods, and statistical analyses were discussed on pages 70 to 72.

For most specimens, sex was determined by visual inspection of the gonads. Maturation was not determined because summer flounder spawn in the ocean (Bigelow and Schroeder 1953). Richards (1970) found that females did not spawn until they were 4 years old (>400 mm in length).

Age was determined from the otolith. The left otolith was used for age determination (Smith 1969) but if it broke during removal, the right otolith was used. Prior to examination, otoliths were placed in a 5%

HCl solution for approximately 1 min. Opaque otoliths were discarded, and specimens were not aged. Fish less than 80 mm in length were considered young (age 0+).

Results and Discussion

A total of 705 summer flounder collected from November through August was analyzed. Few (n = 39) fish were preserved before October, and none were caught from January through mid-March. Most (94.9%, n = 670) specimens were taken at OCGS. Too few specimens were taken in Oyster Creek (3.3%, n = 23), Forked River (0.4%, 3), and the Bay (1.3%, 9) to make comparisons among areas.

Some 651 specimens were aged, and five age classes (ages 0+ to 4+) were found (Table 101). Most fish (74.3%, n = 483) were age 2+ (mean length = 270 mm). Most summer flounder collected in the vicinity of Little Egg Inlet, New Jersey ranged from 270 to 350 mm (Bieder 1976). Festa (1975) found that 85% of the summer flounder taken by sport fishermen in Great Bay, New Jersey were age 2+ fish and that 86.1% were less than 350 mm in length.

The 2+ age class was dominant during all months except December when young predominated (Table 101). Most larger summer flounder left the Bay by December and only smaller individuals (mean length = 117 mm) remained. Some 64% of the fish examined in December were young (mean length = 46 mm).

Of the 651 fish sexed, 286 (49.1%) were males and 297 (50.9%) were females (Table 102). The males to females ratio was not significantly different from 1:1.

Specimens ranged in length from 29 to 478 mm. Mean length and weight, by sex, of specimens impinged at OCGS are presented in Table 103. The mean length of age 1+ through 3+ males examined for the year was less than that of females of the same age class (Table 104). However, the only significant difference was for age 2+ fish.

The mean length of age 1+ to 3+ male and female summer flounder from Barnegat Bay corresponded closely to the back calculated length at time of annulus formation (Table 105) for specimens from Delaware Bay (Smith 1969), Virginia (Eldridge 1962), and Great South Bay, New York (Poole 1961). According to Smith (1969), Poole (1961) mistook the second annulus for the first, and consequently all ages were reported to be one year greater than the actual age. With this correction, Poole's (1961) data are in agreement with those of other workers.

The regression equation for males (n = 317) was log weight = -4.6402 + 2.8314 (log length). The confidence limits on the regression coefficient were ± 0.1273. For females (320), the regression equation was log weight = -4.5421 + 2.7996 (log length) with confidence limits of ± 0.0963. The regression coefficient of the equation for females and for males was not significantly different. A pooled regression of all specimens, including those of undetermined sex (705), was log weight = -4.9698 + 2.9712 (log length), and the confidence limits were ± 0.0283.

Smith (1969) also found no significant difference between the length-weight relationship of male and female summer flounder (n = 269). Individuals from Barnegat Bay weighed significantly less at a given length than fish from Delaware Bay.

Physical anomalies were noted in 165 fish (25% of fish examined). The most common anomaly was missing scales (n = 125) followed by partial or complete ambicoloration (22) and fin damage (21). One case of spinal lordosis was noted. White and Moss (1964) listed only 11 instances of abnormal coloration of summer flounder from North Carolina. Dawson (1962) listed nine records of abnormal coloration. He suggested that genetic or environmental conditions prior to metamorphosis caused partial ambicoloration.

WINTER FLOUNDER

Donald J. Danila

Introduction

The winter flounder is an important sport and commercial species found from Labrador to Georgia (Bigelow and Schroeder 1953). Although it is most abundant in southern New England and New York, it supports a substantial sport and commercial fishery in New Jersey. It is taken by sport fishermen in estuaries from November to April when few other fishes are available. Halgren (1973) estimated the total sport fishery catch in Barnegat Bay from December 1971 through November 1972 to be over 50,000 fish. Commercial landings of the winter flounder in New Jersey from 1971 through 1975 varied from 28,641 kg in 1971 to 72,497 kg in 1973, and ranked 15th to 18th among all fishes landed (U. S. Department of Commerce 1972-75). Ocean County reported more landings than any other New Jersey county.

The winter flounder requires bays and estuaries as spawning and nursery areas; populations are composed of independent stocks associated with individual estuaries (Lobell 1939, Perlmutter 1947, Saila 1961b). Adults are found in mid-Atlantic estuaries only during winter and early spring (Lobell 1939, McCracken 1963, Howe and Coates 1975), and they spend the summer in deeper, offshore waters. Although various stocks mix offshore, interarea movements are slight (Howe and Coates 1975). Salia (1961a) estimated that approximately 90% of the adult winter flounder which were spawned in Green Hill Pond, Rhode Island returned there from Rhode Island Sound. Any impact on a population, therefore, may affect future year classes

in a particular estuary. Since impingement and entrainment losses at OCGS may be significant (AEC 1974), a study of the life history of the winter flounder in Barnegat Bay was begun.

Materials and Methods

General material, methods, and statistical analyses were discussed on pages 70 to 72.

The sex and reproductive condition of each specimen was determined. Reproductive condition was determined as immature (gonads small in size), enlarged (gonads swollen and enlarged in size), ripe (external pressure caused extrusion of eggs or sperm), spent (gonads flaccid), or mature (gonads at rest). Gonad weight was recorded to the nearest 0.1 g.

The left otolith was used to determine age and rate of growth. The right otolith was not measured due to asymmetry of growth. Measurements (nearest 0.05 mm) from the otolith core to each annulus and to the right margin of the otolith were made with an ocular micrometer at 10 X magnification. The material comprising the outermost zone of the otolith was recorded as opaque or hyaline. March 1 was considered the birth date of winter flounder in Barnegat Bay; if specimens had no annulus formed by that date, one year was added to their age, and the measurement to the otolith margin was used as the last annulus measurement. Length at each year of life was back calculated from the annuli measurements according to the formula of Tesch (1968).

One-way ANOVA was used to test for differences among mean length of winter flounder from the traveling screens at OCGS, Oyster Creek, Forked River, and the OCGS dilution pump discharge from October through April. Data from stations in the Bay and at the three other creek mouths were not analyzed because few specimens

were collected there. Data were partitioned by sex and month of collection. When significant differences occurred, the Student-Newman-Keuls test (Sokal and Rohlf 1969) was used to determine significant differences among the mean lengths.

Results

A total of 966 winter flounder was collected from August 1975 through August 1976 (Table 106). Most (56%) were taken at OCGS. Over 75% of the winter flounder taken from the Bay, Oyster Creek, and Forked River were captured by trawl. From May through August, however, 53% of the fish were taken by seine, and most were young (age 0+). A total of 931 specimens (96% of those collected) was examined.

The number of winter flounder examined by station (Fig. 1) and month is given in Table 107. Some 94 were taken from the Bay, 108 from Forked River, and 72 from Oyster Creek. More collections were taken in Oyster Creek and Forked River because some stations there were also sampled at night. An examination of paired day-night samples from Oyster Creek and Forked River showed that 76% of the winter flounder were collected at night. When catch was adjusted to equalize effort, most (75%) winter flounder were taken at OCGS during the night. In both cases the number of specimens taken at night was significantly greater.

Catches at Bay stations were greatest at the mouth of Double Creek (Sta. 23); many young were taken there during July and August. The largest catches by trawl occurred in Oyster Creek Channel (24) from March through August. Most of these specimens were adults emigrating to the ocean or larger immature fish that probably preferred the cooler water near the Inlet.

In Forked River, most specimens were taken at the mouth (Sta. 4) and fewest at the station (6) nearest OCGS. In Oyster Creek most specimens were taken at its mouth (17) followed by the station nearest OCGS (15).

Many winter flounder were taken in Oyster Creek in December prior to OCGS shutdown. Most were adults that had reentered the Bay. Few were taken at any station during January but many were taken in Forked River and Oyster Creek during February and March. OCGS resumed operation on 4 March. After March, few were taken in Oyster Creek, and most adults left the Bay during April and May. Young were first taken in June when they were large enough (30+ mm) to be collected by seine and trawl. Many young were taken in Forked River from June through August but few were taken in Oyster Creek.

Specimens taken at OCGS illustrated the increase in the number of adults that occurred in November and December. No collections were made during January and February because OCGS was shut down. Many fish were again collected in March, but the number declined after emigration of adults during April and May. The increase in the number of winter flounder impinged during June reflected the recruitment of young. Almost all of those impinged from June through August were young.

Results of the length-weight regression for the winter flounder are given in Table 108. During the breeding season, gonads accounted for as much as 25% of the total weight of a female. Gonad weight of mature fish was subtracted from total body weight before calculation of the regression. Gonads of immature fish weighed less than 0.1 g, and their weight was considered negligible. No significant difference between the slope of the regression equation for males and females was found, and the data were pooled. The relationship determined for winter flounder was log weight=

-5.1608 + 3.0946 (log length).

Specimens preserved in 10% formalin and stored in 40% isopropanol showed a decrease in both length and weight. Pearcy (1962) estimated that the length of young winter flounder decreased 3.7% after a year in neutralized formalin. Danila (unpublished data) found that the length of young stored in 40% isopropanol for approximately 6 months decreased very little (mean decrease=1.4%, range 0-4.4%) but the weight loss was considerable (16.5%, 0-27.3%).

The length of large immature and adult specimens preserved in neutralized 10% formalin also decreased slightly (mean decrease=0.9%, range 0-3.6%). However, weight showed an initial increase (7.9%, -0.5 to 26.1%). After 6 months storage in 40% isopropanol, the average increase in weight was 1.3% (-6.1 to 16.3%).

Some 584 winter flounder were aged (Table 109). All specimens from August 1975 through May 1976 were aged from otoliths; 95% of those taken from June through August 1976 were young and assigned age 0+.

The validity of ageing by otoliths was indicated by a strong correlation (r=0.957) between otolith width and total body length. The mean otolith width at each annulus did not change as the fish grew (coefficient of variation $\leq$ 10.4%). Measurements from the center of the otolith to each annuli are given in Table 110. The number of annuli was generally consistent with the size of the specimen, when separated by sex, and back calculated length compared well with actual lengths of the fish. Annulus width was significantly greater in females than males at ages 1 through 3. This may have been due to faster growth of females. Annuli formation began as early as December in some specimens. Most had formed annuli by April, although a few specimens had not completely formed an annulus by early May.

Most otoliths from winter flounder collected from October through March had hyaline edges (Table 111). Opaque edges were found during April and May prior to emigration. The percentage of hyaline edges in specimens (mostly young) collected from June through August was large. Young normally have a hyaline band surrounding an opaque core during the first summer of growth (Pearcy 1962).

The lengths of winter flounder were back calculated from otolith measurements (Table 112). Mean length of males at age 1 (161 mm) was significantly less than that of females (175 mm). Males were also significantly smaller than females at ages 2 (219, 242 mm), 3 (252, 270 mm), and 4 (255, 288 mm). This was also reported by Berry et al. (1965), Poole (1966), and Lux (1973b). A small sample size for age 4 fish produced a large confidence interval around the calculated mean.

The length frequencies of winter flounder by age (Table 113) had approximately normal distributions and agreed with back calculated length at ages 1 through 3. The more rapid growth of age 1+ and older females was again noted. It appeared that the few older (age 4+ to 6+) specimens were slower growing individuals.

The total length and total body weight of winter flounder by age, sex, and date of capture are given in Table 114. When sample sizes within time periods were large enough to test, age 1+ through 3+ females were significantly larger and heavier than males. Age 3+ males and females taken from January through March, however, were not significantly different in length (males=273 mm, females=285 mm) although females were significantly heavier (males=210.4 g, females=316.4 g). Lux (1969) found that females over 300 mm were generally heavier than males of the same length.

The mean length and weight of young males (66 mm, 3.4 g) and females

(65 mm, 3.3 g) from April through June were similar. However, males were significantly longer and heavier than females (males=81 mm, 6.3 g; females= 75 mm, 4.9 g) during July and August. Most investigators (Berry et al. 1976, Poole 1966, Kennedy and Steele 1971, Lux 1973b) found no difference in growth between young males and females. The significant difference found for young winter flounder during July and August may have been an artifact of sampling or data processing. No significant difference in length between males and females was found when all young winter flounder taken from April through August were combined for analysis.

Length data for both sexes, regardless of age, showed that young were separable from older winter flounder by length frequencies from May through August (Fig. 9). Except for young collected during July and August, females were significantly larger than males. The monthly mean length of males generally varied from 217 to 233 mm but in January and February it was only 200 mm. Because males taken at OCGS tended to be larger than those from the other areas, the OCGS shutdown and subsequent lack of fish from OCGS during these months may partly account for the smaller mean length during January and February. Monthly mean length of females, however, increased with time and ranged from 256 to 270 mm.

Length data of winter flounder by area are given in Table 115, and statistical comparisons of lengths among areas are summarized in Table 116. Although mean length of specimens taken on the OCGS traveling screens was larger than that of specimens from Forked River and from Oyster Creek, only one significant difference was found. From October through December, females taken in Oyster Creek (mean=251 mm) and at OCGS (264 mm) were significantly larger than those taken in Forked River (222 mm).

A 1.09:1 male to female ratio was found for specimens taken from

August 1975 through May 1976 in Oyster Creek, Forked River, and the Bay. For all young examined from June through August 1976, a ratio of 1.24:1 was found. Neither ratio was significantly different from 1:1. However, a significantly larger ratio (7.3:1) of males to females was found for specimens taken at OCGS. Ratios for October and November, December, and March were significantly different than 1:1 but ratios for April and May were not.

A total of 832 winter flounder was examined for gonad condition (Table 117). Most males began to ripen as early as October, and in December nearly all were ripe. Most were spent by the end of March. The ovaries of females began to enlarge in November, and all mature specimens were probably capable of spawning in January. About one third of the females had spawned in January and February, and nearly all had spawned by the end of March. One ripe female was taken in May. Most specimens taken from June through August were young and immature.

Since gonad weight depended upon the size of the specimen as well as the stage of maturity, large ranges in weight were found (Figs. 10, 11). Mean gonad weight for males was largest during November (13.5 g) and December (13.1 g). Although 77% were still ripe in January and February, mean gonad weight had decreased by almost two-thirds (4.6 g). Mean weight of ovaries from enlarged females was greatest during January and February (35.2 g) and declined in March (8.0 g).

Gonad condition by age and time period is given in Table 118. Two periods were included because fish taken from October through February entered the next age class in March. Most (70%) of the males from the 1975 year class were mature during their first winter. Almost all age 1+ and older males were mature. No females of the 1975 year class were mature but

about 60% of the 1974 year class had matured. Only one specimen (1.8%) of the 1973 year class was immature.

A total of 16 fish had damaged fins (mostly caudal), 7 had missing scales or flesh wounds (mostly abrasions from the OCGS traveling screens), 2 had markings which were probably made by condenser tubes, and 1 was missing an eye. The two specimens with condenser tube markings were characterized by numerous, convex, circular impressions approximately 22 mm in diameter. The diameter of a condenser tube is 22.3 mm (M. B. Roche, personal communication). Both specimens were taken in Oyster Creek immediately downstream of the OCGS discharge, and at least one was dead at capture (D. L. Thomas, personal communication). Of the above, 19 fish (4.0% of those examined from OCGS had injuries believed to have been caused by impingement. This was a conservative estimate because only gross injuries were noted. Minor injuries were not noted because they may have been caused or obscured by preservation and handling. An accurate estimate of dead and damaged winter flounder impinged at OCGS was determined during sampling at the traveling screens (Table 12). Some injuries, mostly damaged caudal fins, were probably caused by trawls and seines during capture; these occurred mostly in young (n = 5).

Seven specimens were observed to have light to moderate infections of the microsporidian Glugea stephani (Stunkard and Lux 1965, Sindermann 1970). This parasite is characterized by hypertrophy of host cells and growth of large white sporocysts on the intestine and other internal organs. Five specimens were from the 1974 year class (2.2% of the fish examined from the 1974 year class) and one from the 1975 year class (2.4%). One of the 14 specimens from the 1972 year class was infected. No young (n = 190) were infected. Five males and two females were infected. Two males were mature and the other specimens were immature. One infected male of the 1974 year

class was the only male taken in December that was not ripe; the parasite may have retarded its sexual maturation. Most infected specimens appeared to be less robust than comparable uninfected specimens, and two were the smallest specimens examined for their age and sex during a specific time period.

Two large adults were parasitized by an unknown caligid copepod. The infection was characterized by one to several small protuberances or nodules on the dorsal, anal, or caudal fin; some occurrences may have been missed.

Three developmental anomalies were found in young taken in 1976. One was partially albino, and two had patches of dark pigment on the unpigmented side. Norman (1934) referred to the latter anomaly as "staining".

Discussion

The winter flounder was common in Barnegat Bay from October through April but usually only immature fish were present from late May through September. Fish spawned in the Bay remained there until sexually mature. Adults emigrated from the Bay in April, and most had left by early May.

Temperature, light, and salinity govern the movements and distribution of the winter flounder (McCracken 1963). In laboratory studies, McCracken found lethal salinities were about 8 ppt but a few young have been taken in nearby estuaries at salinities as low as 5 ppt. Larger juveniles and adults were rarely taken at salinities below 16 ppt (Thomas and Milstein 1973). Salinities in the study area were usually above 16 ppt and apparently did not affect the distribution of winter flounder.

McCracken (1963) deduced that winter flounder preferred a temperature of 12 to 15 C and that the upper lethal temperature was 26 C. Other workers reported a lethal temperature as high as 31.4 C (Huntsman and Sparks 1924,

Hoff and Westman 1966, Gift and Westman 1971). Young had the highest lethal temperature. Wyllie et al. (1976) reported that juvenile winter flounder exhibited low thermal responsiveness and little temperature preference in laboratory studies. However, the acclimation of most of these specimens to low (3-6 C) temperatures was believed to have been responsible for the lack of a preferred temperature. Gift and Westman (1971) found an avoidance temperature of about 26.9 C for young and 24.4 C for age 1+ winter flounder during summer months. They suspected that larger winter flounder would avoid an even lower temperature. McCracken (1963) found that regardless of acclimation temperature adults could not extend their upper lethal temperature above 20.2 C. Olla et al. (1969) observed large juvenile and adult winter flounder in Great South Bay, New York at temperatures up to 24 C; however, active movement and feeding ceased above 22 C.

Winter flounder apparently avoided the heated discharge in Oyster Creek after early April when the temperature was greater than 15 C. Very few young were taken in Oyster Creek from May through August; the temperature was usually above their mean avoidance temperature of 26.9 C (Gift and Westman 1971). As water temperature declined from October through February, the warmer temperature in Oyster Creek attracted returning adults. Trawl catches of winter flounder were larger in Oyster Creek during November and December than in Forked River and the Bay. Oyster Creek also supports a locally well-known sport fishery for winter flounder from November through March.

More specimens were taken at night in paired day-night trawl and seine hauls and at OCGS. The activity of winter flounder was reduced at night, and gear avoidance also probably decreased. Olla et al. (1969) observed that winter

flounder were active only during the day. At night fish were quiescent and demonstrated little movement, even when disturbed.

Apparently the shrinkage in size and loss of weight associated with preservation had a minimal effect on the determination of the length-weight relationship. The length-weight relationship of gonadless fish was not significantly different than that given by Lux (1969), Berry (1959), and Kennedy and Steele (1971). Saila (1959) and Kennedy and Steele (1971) also found no significant difference in the length-weight relationship between the sexes.

Berry (1959) and Poole (1966) both found that one hyaline zone and one opaque zone were added to the otolith each year after the first year. The two zones resulted from the differential deposition of organic and calcareous materials during the year. Opaque deposits were usually associated with fast growth periods and hyaline deposits with slow growth or reproductive periods. Berry (1959) found opaque margins on most otoliths from the end of the reproductive season through August and hyaline edges during other months; however, sex, age, and reproductive condition also had to be considered. Winter flounder from Barnegat Bay had a similar pattern of deposition.

Growth curves of winter flounder from Barnegat Bay (Figs. 12, 13) were comparable to those of other populations in the northeastern United States and eastern Canada (Lux 1973b, Howe and Coates 1975, Poole 1966, Kennedy and Steele 1971). During the first two years, growth of winter flounder in Barnegat Bay was slightly greater than in other areas. Growth decreased in comparison with other areas at ages 3 and 4. This decrease may have resulted from the small sample size used in the calculation of these ages or may be an actual decrease in growth. Size specific behavior

patterns or vulnerability to capture may also bias age and growth estimates. Berry et al. (1965) found relatively few large (> 250 mm) individuals in Charlestown Pond, Rhode Island but many small age 3+ to 6+ individuals were taken. They concluded that the local fishery selected fast growing individuals, and consequently a high percentage of slow growing individuals remained in the population.

The growth rate in Barnegat Bay appeared to be slightly greater than Great South Bay and less than Shinnecock Bay, both on Long Island (Poole 1966). Winter flounder from Georges Bank have long been recognized as an exceptionally large sized, racially distinct population (Bigelow and Schroeder 1953, Lux 1973b). Growth from Newfoundland waters was very slow, although winter flounder attained approximately the same length as southern populations at age 10 (Kennedy and Steele 1971). Pearcy (1962) indicated that growth of young in the Mystic River, Connecticut estuary was density dependent. Kurtz (1975) suggested that differences in growth between the Great South Bay and Shinnecock Bay populations might be due to differences in diet. Heredity, population density, and availability of prey may interact to determine rate of growth.

Howe and Coates (1975) and Saila (1961a) reported a similar 1:2.33 ratio of males to females in coastal waters of Massachusetts and Rhode Island, respectively. Briggs (1965) found a similar ratio in the sport fishing catch from four bays on Long Island. In this study the sex ratio was not significantly different from 1:1. Saila (1961a) did not believe that the large proportion of females was due to differential vulnerability to the fyke nets and small experimental otter trawls used to capture his specimens. The ratios reported by Howe and Coates (1975) and Briggs (1965) may have been

biased by the method of capture, a commercial trawl fishery and sport fishery, respectively. Larger winter flounder, mostly females, may be selected more often by these methods.

The high percentage of males impinged at OCGS may have been due to the lower sustained swimming speed of the smaller sized males or sexual differences in activity patterns. The mean size of males (225 mm) impinged at OCGS was significantly smaller than that of females (265 mm). Wyllie et al. (1976) reported that the critical swimming speed of winter flounder acclimated between 3.3 and 6.5 C ranged from 33.5 to 63.7 cm/sec. However, most of their specimens were less than 200 mm in length. At a test velocity of 75 cm/sec, winter flounder 190 to 231 mm in length had a swimming endurance time of about 25 min at 14 C, 10 min at 11 C, and 14 min at 5 C (Beamish 1966). Intake velocities at OCGS were considerably less than 75 cm/sec.

The winter flounder spawns in Barnegat Bay and other bays in southern New Jersey from mid-January through March (Tatham et al. 1974, 1977b). The average incubation time of the demersal eggs is about 15 days (Tatham et al. 1974). In 1976, larvae were common in Barnegat Bay from February through April. Most spawning occurs at a water temperature of 0 to 3.3 C, and the maximum temperature reported for spawning was 4.2 to 5.6 C (Rogers 1976).

Bigelow and Schroeder (1953) and Lux (1973b) reported that winter flounder matured at age 3+. The former reported minimum length at maturity of about 203 mm while the latter's study of winter flounder on Georges Bank indicated length at maturity was around 350 mm. Kennedy and Steele (1971) found that slower growing winter flounder from Newfoundland matured at older ages. Males started to mature at age 4+, and most were mature by age 6+. Females started to mature at age 6+, and most were mature at age 8+. They suggested that maturity was related to size rather than age. Topp (1968)

reported no ripe females that were age 2+ in Cape Cod Bay, Massachusetts. He gave no mean size for those specimens but noted that total gonad weight was less than 2.3 g. Age 3+ and older fish (290+ mm) were mature. It appeared that winter flounder, especially males, from Barnegat Bay matured at a relatively early age. This may account for the disappearance of almost all age 1+ and older winter flounder after May; adults move offshore within a few months after they spawn.

Relative success of year classes appeared to be quite variable. Few specimens of the 1975 year class were taken but young from the 1976 year class were more abundant. Jeffries and Johnson (1974), in a 7-year study of the winter flounder population of Narragansett Bay, Rhode Island, attributed most of the variation in number to climatic trends and not commercial fishing pressure. The relationship between temperature and population size suggests a complex interaction between time of spawning, metamorphosis of larvae, emigration of adults, and success of year classes. A decline in the population of winter flounder in nearby Great Bay, New Jersey and neighboring bays has been noted in recent years by Thomas et al. (1975) and Danila and Howells (in preparation).

Low rates of injury and parasitism were found. Sindermann (1970) noted that microsporidian parasites, such as Glugea stephani, produced the most severe effects of any group of teleost parasites. Stunkard and Lux (1965) found heavy infections in young fish but only light infections in older specimens. They concluded that heavily infected young died as a result of the parasite. The source of the infection was not known, and the year to year variation in infection was often large and unpredictable.

Developmental anomalies were found in only a few young. In some cases, anomalies such as white spotting occurred frequently enough to enable

workers to identify specific year classes (Lux 1973a). Environmental factors during development such as subnormal temperature were thought to be responsible for white spotting (Lux 1973a) and perhaps other pigmentation anomalies. Partial albinism was associated with osteological anomalies and probably resulted from a wound in the larval or post-larval stage (Dawson 1967).

In conclusion, the winter flounder in Barnegat Bay has an estuarine dependent life cycle with patterns of movement similar to other bays in the northeastern United States. Growth appeared to be most similar to that reported from Long Island. Although substantially more males were taken at OCGS, the proportion of males to females in the Bay population was equal. The winter flounder may attain maturity in Barnegat Bay earlier than other northern populations, and success of year classes appeared to be variable.

NORTHERN PUFFER

David W. Moore

Introduction

The northern puffer is a seasonal resident of inshore waters from Newfoundland to Florida (Laroche and Davis 1973). Although of limited commercial importance, it is a desirable sport fish. Halgren (1973) estimated that over 30,000 were caught in Barnegat Bay by sport fishermen during 1972. In recent years, the population of northern puffer in Barnegat Bay and other nearby areas has declined substantially.

Materials and Methods

General materials, methods, and statistical analyses were discussed on pages 70 to 72.

The sex and reproductive condition of small specimens were determined by examination of the gonads under a dissecting microscope. Reproductive condition was described as immature if the gonads were small, closely attached to the dorsal surface of the body cavity, and weighed less than 0.5 g. The gonads of mature fish were categorized as at rest (gonads heavier than 0.5 g but reduced in size; cells visible in ovaries), enlarged (gonads occupied a large portion of the body cavity, cells in ovaries tightly grouped), ripe (gonads occupied a large portion of the

body cavity, eggs less tightly grouped), and spent (gonads flaccid and few large cells in ovaries).

Length frequency distributions were plotted for each of the four areas by month. When few specimens were collected from an area during one month, several areas and months were grouped.

Results and Discussion

A total of 283 northern puffer was examined from September 1975 through August 1976; only 14 were from Oyster Creek, Forked River, and the Bay (Table 119). An estimated 3,251 northern puffer were impinged; 57% were impinged during the third week of May (Table 10). A similar number of fish was impinged during the day and at night.

More males than females were collected during all months except August when most specimens were small, and sex was undetermined (Table 120). Most specimens with enlarged gonads were collected during May and June. Mature males outnumbered mature females by 3:1 during May and 7:1 during June. Laroche and Davis (1973), however, reported that in Chesapeake Bay females were more abundant than males during all months except May and November when the sex ratio was approximately equal. They collected most ripe females from June through the first week of July. Males were ripe over a longer time period and were thought to spawn a greater number of times. Welsh and Breder (1922) took ripe females in the vicinity of Atlantic City, New Jersey from 30 July to 27 August 1922.

Females (mean length = 184 mm) were significantly larger than males (138 mm) at OCGS during May. Both Laroche and Davis (1973) and Welsh and Breder (1922) also reported that females were larger than males. Laroche

and Davis (1973) found that young (age 0+) females grew significantly larger than males. Fish from subsequent age classes showed progressively smaller increments of growth and had an insignificant difference in the rate of growth between sexes.

The length-weight relationship of males and females was not significantly different (Table 121). This relationship was not significantly different from that reported for Chesapeake Bay by Laroche and Davis (1973).

A series of histograms was plotted to determine the age structure of the 283 specimens examined. Because males were smaller than females and nearly a third of the specimens were not sexed, it was necessary to generate a separate histogram for males, females, and fish of undetermined sex. The limited number of specimens made histogram interpretation difficult, and data from Laroche and Davis (1973) were used to facilitate analyses. They used vertebral rings to determine the age and growth of 1,128 northern puffer from Chesapeake Bay and identified four year classes (Table 122).

Most (91%) young were collected during August. Their length ranged from 33 to 98 mm (mean length = 69 mm). Laroche and Davis (1973) reported that young taken in September and October ranged from 88 to 152 mm. The histogram for females from May and June in this study was bimodal, and two year classes were indicated. The mean length of the two size groups was 165 mm (n = 17) and 204 mm (21). The mean length of the two size groups was similar to the mean length of age 1+ and 2+ females from Chesapeake Bay (Table 122). The histogram plotted for males from May and June collections (n = 155) was unimodal, skewed to the left, and had a mean length of 140 mm.

Unlike the results from Chesapeake Bay, no age 3+ or 4+ northern puffer were apparently collected from Barnegat Bay. The absence of older, larger fish may indicate a relatively young population recruited from outside the study area.

The population of northern puffer in Barnegat Bay has undergone a pronounced decline during the last 10 years. In a 4-year study of the fishes of Barnegat Bay, Marcellus (1972) found that northern puffer ranked fourth in abundance during 1966-67; the catch-per-unit-effort by seine was 8.4 n/coll. The number of the northern puffer taken declined each successive year through 1969-70 when it ranked 10th in abundance (0.34 n/coll.). From December 1971 through November 1972, only five specimens were collected in upper Barnegat Bay (McClain 1973), although during the same period it comprised 4.8% of the sport catch (estimated catch = 30,062) in the Bay (Halgren 1973). Although the northern puffer comprised 66% of the boat sport fishing catch in nearby Great Bay, New Jersey during 1969, its population had declined to low levels by 1972 (Hamer 1972, Thomas and Milstein 1973).

SAND SHRIMP

David W. Moore

Introduction

The sand shrimp ranges from Baffin Bay to eastern Florida and is found from inshore waters to 450 m (Whiteley 1948). It is a year-round resident of Barnegat Bay. It is common in the diet of sport and commercial fishes such as the striped bass, tautog, weakfish, summer flounder, and winter flounder (Bigelow and Schroeder 1953). Only specimens from March through August were preserved for life history studies.

Materials and Methods

General materials, methods, and statistical analyses were discussed on pages 70 to 72.

Reproductive condition of the sand shrimp was recorded as ovigerous and non-ovigerous but sex was not determined.

A geometric mean regression was generated for ovigerous and non-ovigerous individuals. A separate regression equation was not generated for males and for non-ovigerous females because the difference between the length-weight relationship of males and non-ovigerous females was not significant (Haefner 1973).

Condition factor was computed only for ovigerous sand shrimp to allow comparisons with data from Haefner (1973). Condition of shrimp from the four areas was compared.

Results and Discussion

The sand shrimp was an abundant macroinvertebrate. A total of 35,541 was taken in seine (ranked third in abundance) and trawl (ranked second in abundance) collections from September through August (Table 123). Significantly more sand shrimp were collected at night than during the day (Table 50). Most (95%) were taken from November through March, and more were taken during December (36%) than during any other month.

The sand shrimp appeared to be attracted to Oyster Creek in December. Before OCGS shut down on 26 December, more than twice as many sand shrimp were taken from Oyster Creek than Forked River (Table 123). From January through March, a similar number of sand shrimp was collected in Oyster Creek and Forked River. The sand shrimp was also apparently attracted to Oyster Creek in April. During August, it avoided the Creek, and substantially more specimens were taken in Forked River and the Bay.

The sand shrimp was the second most abundant organism impinged on the traveling screens, and an estimated 3,201,475 specimens were impinged during the year (Table 123). Forty-one percent of these were taken during December although no collections were taken at OCGS during January and February. Most (92%) were taken at night.

The number and mean length of the 1,115 specimens examined from March through August are given in Table 124. The mean length of sand shrimp from Oyster Creek (32.9 mm, n = 247), Forked River (36.0 mm, n = 338), and Barnegat Bay (29.9 mm, n = 212) was not significantly different. Mean length of specimens impinged at OCGS (42.3 mm, n = 318) was significantly larger than the mean length of those from Oyster Creek and the Bay but not those from Forked River.

A regression equation was calculated for ovigerous and non-ovigerous shrimp. The regression equation of ovigerous females was log weight = -5.4660 + 3.2351 (log length), and the confidence limits were $\pm$ 0.0993. The regression equation for non-ovigerous sand shrimp was log weight = -5.1169 + 2.9618 (log length), and the confidence limits were $\pm$ 0.0469. Ovigerous females were significantly heavier than comparable non-ovigerous specimens.

The length-weight relationship of ovigerous females from Barnegat Bay was not significantly different than that of ovigerous females from Chesapeake Bay (Haefner 1973). The length-weight relationship of non-ovigerous specimens, however, appeared to be different than the relationship Haefner reported for males and non-ovigerous females.

Sand shrimp from Delaware Bay were reported to have a constant, 0.4 mm/week growth rate (Price 1962). Wilcox and Jeffries (1973) found that growth in Rhode Island, however, was correlated to temperature and varied from 0.4 to 1.1 mm/week.

Price (1962) found that both the length of individuals and the age structure of the population from Delaware Bay was dependent on sex. He found that females were larger than males. Females had three age classes but males had only two.

Most (40%) ovigerous sand shrimp were taken in April and the fewest during July and August (Table 125). Price (1962) found that ovigerous sand shrimp were taken from inshore waters during all months but December, and that most spawning in Delaware Bay occurred from March through October. Some 66% of the specimens examined from OCGS and 50% of those from Forked River were ovigerous but relatively few ovigerous sand shrimp were taken from Oyster Creek (18%) and the Bay (6%).

The condition of sand shrimp from OCGS was significantly greater than that of specimens from the other three areas. This difference may be due to the greater percentage of heavier, ovigerous individuals taken at OCGS (Table 126). The difference between the condition of sand shrimp from Forked River, Oyster Creek, and the Bay was not significant.

Differences between the percentage of ovigerous specimens and mean length of sand shrimp examined from OCGS and those from the other three areas may be partially attributable to the different mesh sizes of the sampling gear. The smaller non-ovigerous shrimp caught with the seine and trawl probably passed through the larger mesh of the traveling screens.

BLUE CRAB

Mark R. Newcomb

Introduction

The blue crab is a common macroinvertebrate that is a year-round resident of estuaries in New Jersey. It is a swimming crab that is found primarily from shallow water to 35 m and ranges from Nova Scotia to northern Argentina (Oesterling 1976). Over 1.3 million kg, valued at some $653,000, were landed commercially in New Jersey during 1975 (U. S. Dept. of Commerce 1976); 72,322 kg (5.5%) were landed in Ocean County. The blue crab is also prominent (65.5% of estimated catch) in the Barnegat Bay sport fishery during summer (Halgren 1973). Since impingement losses at OCGS may be significant (AEC 1974), a study of the life history of the blue crab was begun.

Materials and Methods

General materials, methods, and statistical analyses were discussed on pages 70 to 72.

The sex and reproductive condition of the blue crab was determined by the shape of the abdomen. Males have a long, narrow, inverted T-shaped abdomen which persists from the first crab stage (Oesterling 1976). In immature males, the abdomen adheres tightly to the body while in mature males, the abdomen is loosely attached to and easily separated from the body. Immature females have a triangular abdomen that becomes broadly rounded upon maturity. The number of females with eggs and the stage of egg development were noted.

Results

From September 1975 through August 1976, an estimated 4,617,069 blue crab were impinged at OCGS (Table 127). Some 684,894 specimens were actually taken, and 9,964 were examined. Some 1,482 specimens were collected from Oyster Creek, 956 from Forked River, and 1,397 from the Bay.

The blue crab was most abundant from May through August. Some 93% of those impinged at OCGS and 67% of the specimens from the other three areas were collected during these months (Table 127). The mean bottom temperature during this period ranged from 17 to 30 C (Table 4). Few (0.2% of yearly catch) were collected from Forked River, Oyster Creek, and the Bay during January and February. The fewest (1% of the estimated blue crab impinged) were impinged during November and December but no sampling was done during January and February when OCGS was shut down.

The blue crab apparently did not avoid Oyster Creek during the summer (Table 127). The catch in Oyster Creek from June through August was similar to that of other areas. On 21 June 1976, however, the water temperature in the immediate vicinity of the condenser discharge reached 38 C, and 30 to 40 dead blue crab were observed (K. R. Powers, personal communication). Although more specimens were taken in Oyster Creek than in Forked River and the Bay during April and May, the catches in these areas were similar during September and October.

Significantly more blue crab were collected by seine and trawl at night (73%) in Oyster Creek and Forked River than in comparable hauls made during the day (Table 50). Some 82.2% of the specimens impinged at OCGS were taken at night.

Male blue crab ranged in length from 6 to 171 mm and females from 4 to 170 mm. The smallest mature male was 77 mm, and the smallest mature female was 112 mm. The mean length of mature males examined from OCGS (115 mm), Oyster Creek (113), Forked River (115), and the Bay (115) was not significantly different (Table 128). Similarly, the mean length of mature females examined from Oyster Creek (140 mm), Forked River (139), the Bay (140), and OCGS (135) was not significantly different. Although the mean length of mature females examined from OCGS was greater than that of mature males, this difference was not significant.

The mean length of immature males examined from Oyster Creek (33 mm), Forked River (31), and the Bay (29) was smaller than the mean length (44) of immature males from OCGS (Table 128). Immature females collected at OCGS (mean length = 55 mm) were also larger than comparable females collected from Oyster Creek (39 mm), Forked River (36), and the Bay (32). As with mature specimens, females tended to be larger than males but this difference was not significant.

Sex and reproductive condition were determined for 12,813 specimens; most (77%) were collected at OCGS (Table 129). Immature blue crab comprised 91.5% (n = 11,753) of all individuals examined (Table 130). The sex ratio of immature males to females was not significantly different than 1:1 in collections from OCGS (4,520 males:4,531 females), Forked River (365:400), and the Bay (406:425); however, significantly more immature males (585) than females (521) were taken from Oyster Creek.

Seasonal differences in the sex ratio were found. Significantly more immature males than females were found in all areas from November through April. During Spetember 1975 and July and August 1976,

significantly more immature females were impinged at OCGS. The ratios of immature males and females collected from the other three areas during these months were not significantly different. The difference between the number of immature males and females impinged at OCGS during October, May, and June was not significant.

For the year, significantly more mature females than males were impinged at OCGS (Table 131). Sex ratios of mature blue crab in Oyster Creek, Forked River, and the Bay were not compared because of an insufficient number of specimens. When data were combined for all three areas, significantly more mature males than females were collected. Mature individuals were most abundant at OCGS during October (19.8% of all specimens examined) and May (18.4%). During other months, they comprised 0.6 to 10.7% of all blue crab examined from OCGS. Gravid females were collected primarily during June although a few individuals were also taken during May and July.

Discussion

The life history of the blue crab in Barnegat Bay corresponded closely with its life history as reported from other mid-Atlantic estuaries. Most specimens were collected from May through August. Few individuals were collected from November through February because they had burrowed into bottom sediments. In Great Bay and the ocean in the vicinity of Little Egg Inlet, New Jersey, most specimens were collected in summer and early fall (Garlo et al. 1974).

The movements and distribution of mature specimens were similar to those reported from Chesapeake Bay (Cargo 1958, Van Engel 1958), North

Carolina (Judy and Dudley 1970), South Carolina (Fishler and Walburg 1962), and Louisiana (Darnell 1959). After mating, mature females migrated from more brackish to higher salinity water in the ocean or lower estuary. Mature and gravid females taken in the Bay in July were most abundant in higher salinity areas near the Inlet (Table 39). The movement of mature females may account in part for the significantly greater number of mature females impinged at OCGS. Mature males, however, do not migrate but remain in the lower salinity portions of estuaries. Substantially more mature males were collected in the northern, less saline areas of the Bay during July.

After hatching in high salinity water, the blue crab passes through several larval stages before metamorphosis to the first crab stage, and these small crabs then return to less saline estuarine water. The fact that significantly more immature males were impinged at OCGS from November through April and significantly more immature females from July through September apparently reflects seasonal differences in the distribution of immature specimens within the Bay. Sampling in the Bay and creeks was probably too limited in area to detect such movements or seasonal differences. From September through December, the catch among stations including those in Oyster Creek differed little (Table 49).

The population of blue crab in the study area was composed primarily (91%) of immature individuals. The catch of blue crab in the limited area of the Bay regularly sampled appeared to be representative of a larger portion of the Bay. Most (90%) of the blue crab taken in Bay-wide population studies in July were immature. Garlo et al. (1974) found that 87% of the blue crab in Great Bay, New Jersey were immature. They reported that gravid females were most abundant during June and July.

The blue crab is relatively short-lived. Many males are believed to die during their second winter, and females generally live for 2 or, rarely, 3 years (Pearson 1948). One year old immature specimens and 1 and 2 year old mature individuals comprised the two age classes of the blue crab recognized in Chesapeake Bay (Pearson 1948).

Growth was rapid and blue crab spawned during June and July reached 13 to 63 mm by December depending on the time at which they were spawned. Sexual maturity is usually attained after 12 to 18 months, and adults generally live for 1 year thereafter. Females are reported to spawn in their third summer (age 2+). Individuals older than 2 years probably contributed little to the breeding stock (Pearson 1948).

The blue crab apparently did not avoid Oyster Creek east of the Route 9 bridge from June through August. Temperature during these months ranged from 23.2 to 32.7 C. Gift and Westman (1971) reported that the upper avoidance temperature of immature crabs was 37.5 C and the upper avoidance breakdown temperature was 40 C. Mature and large immature individuals (mean carapace width = 109 mm) had an avoidance temperature of 34.3 C and an avoidance breakdown temperature of 39.2 C.

COMMERCIAL FISHERIES

Robert J. Hillman

Introduction

Commercial fisheries data were compiled to compare the commercial fisheries landings from Barnegat Bay and from Ocean County, New Jersey with the number of organisms impinged on the traveling screens at OCGS.

Materials and Methods

Commercial fisheries data for Barnegat Bay were obtained from the National Marine Fisheries Service in Toms River, New Jersey. The data were based on catches in Barnegat Bay from Toms River to the Manahawkin Bridge by 15 crabbers, 5 fyke netters, 3 eel potters, and 10 clam wholesalers who reported their catch. This represented 100% of the commercial fishermen in the Bay (E. LoVerde, personal communication); however, an individual may have been included in more than one category because he fished several types of gear.

Commercial fisheries data for Ocean County, New Jersey were obtained from the monthly New Jersey landings (U. S. Dept. of Commerce 1975, 1976).

Results

A total of 527,005 lbs of fin- and shellfish, valued at $344,464, was reported by commercial fishermen in Barnegat Bay. In terms of poundage and dollar value, October (56,690 lbs, $37,536) and June (54,250 lbs, $39,322) were the most productive months and November (23,500 lbs) and

January ($16,310) the least. Only clams were reported in November.

Landings of the winter flounder (2.4% of total value), white perch (2.9%), and alewife (0.01%) were reported from October through May; all fish were taken by fyke nets (Table 132). The New Jersey Department of Environmental Protection allows fyke netting in bays from 1 October through 13 April; the landings from May were probably a delinquent report from April (E. LoVerde, personal communication). The largest landing by fyke netters (20,850 lbs, $4,613) was in March and the smallest (1,300 lbs, $156) in October. Although more winter flounder (46,450 lbs) were caught than white perch (40,280 lbs), winter flounder accounted for less income ($8,262 and $10,071, respectively). The average price/lb of winter flounder was $0.18, white perch $0.25, and alewife $0.04. Fyke netting accounted for 5.3% of the total income.

The American eel was reported in September, October, and from April through August; all were caught by pot. A total of 29,895 lbs was landed; the largest catch (10,100 lbs, $3,030) occurred in May. The American eel accounted for 2.7% of total income and averaged $0.13/lb.

The blue crab was taken by dredge from December through March and by pot in September and October and from May through August. None were reported in November and April. The total landed was 161,240 lbs. It accounted for $46,686 (13.5% of total value) and averaged $0.29/lb.

Some 247,940 lbs of the northern quahog valued at $270,331 (78.5% of total value) were reported. Quahogs were taken by rakes (54.8% of the total), by hand (32.3%), and by tongs (12.8%).

A total of 3,282,923 lbs of fin- and shellfish, valued at $1,757,205, was landed in Ocean County from September 1975 through August 1976 (Table 133). Commercial landings from Ocean County included those from Barnegat

Bay. Some 38.7% of the commercial catch was the summer flounder. The northern quahog (25% of commercial landings by poundage), weakfish (15.2%), and bluefish (10.5%) accounted for most of the remainder. The smallest dollar values ($53,445-$130,806) were reported from September through December; the largest values were from February ($198,656), March ($203,669), and August ($199,100). The greatest poundage was landed from January through March (291,471-352,400 lbs) and during August (354,625 lbs) and September (290,657 lbs); the least poundage was landed during December (178,953 lbs).

Discussion

Some 16.0% of the poundage and 19.6% of the dollar value of the commercial fisheries landings in Ocean County were from Barnegat Bay. A substantial portion of the landings of the alewife (40.8% of total Ocean County landings), American eel (47.2%), winter flounder (62.7%), white perch (98.2%), blue crab (99.9%), and northern quahog (30.1%) landed in Ocean County was taken from the Bay. Most of the major species reported in the Ocean County landings were not taken in Barnegat Bay.

SPORT FISHERIES

Robert J. Hillman

Introduction

Sport fishery data were collected in Oyster Creek, Forked River, and Barnegat Bay to determine the influence of the heated discharge on the local sport fishery and to compare the sport fishery catch with the number of organisms impinged on the traveling screens at OCGS.

Materials and Methods

Three zones were established in Barnegat Bay for a boat by boat creel census. Zone 1 was the area from Cedar Creek (FL "1") to BWN "E" 13 (lagoon between Forked River and Oyster Creek). It included Forked River from its mouth to FL "19" and the south branch of the River from FL "19" to the Route 9 bridge (Fig. 14). Zone 2 was the area from BWN "E" 13 to Waretown Creek and included Oyster Creek from its mouth to the Route 9 bridge. The eastern boundary of zones 1 and 2 was the Intracoastal Waterway. Zone 3 was the northern approach to Barnegat Inlet (Oyster Creek Channel) from N "40" to Sedge Island.

After January, anglers at the Route 9 bridge and bank immediately east of the bridge at Oyster Creek (zone 4) and the south branch of Forked River (zone 5) were censused. After mid-June, the north bank at the mouth of Oyster Creek (zone 4) and the south bank of Forked River at the Beach Boulevard bridge (zone 5) were also surveyed.

A creel census of boats in zones 1 to 3 and of bank fishermen in zones 4 and 5 was conducted once a week, when weather permitted. The total number of boats in zones 1 to 3 was counted. The number of fishermen per boat, hours fished, fishing rods and crab traps used, and fishes and blue crab taken were recorded for each boat censused. These data were also obtained from fishermen in zones 4 and 5. A catch per individual (c/i) and, where applicable, catch per boat (c/b) were computed for each zone. Surface water temperature and salinity were recorded in each zone.

Results

In the zones in the Bay, 556 anglers fished 1,027 h and caught 2,764 specimens of 12 taxa. Few boat fishermen were observed in Oyster Creek and Forked River. The blue crab dominated the catch (83.3%) followed by the bluefish (6.2%) and summer flounder (4.2%).

In zone 1, 219 individuals fished for 361 h and caught 1,017 (17.5% of the total catch) specimens (Table 134). The c/b and c/i were 12.71 and 4.64, respectively. The blue crab comprised 90.6% of the catch.

Zone 2 was fished by 187 anglers who expended 316 h and had a total catch of 1,114 specimens (19.2% of the total catch). The greatest c/b (16.63) and c/i (5.96) for the zones in the Bay were recorded here. Most (89.5%) of the catch was the blue crab.

The smallest c/b and c/i, 9.89 and 4.22 respectively, were from zone 3. Some 150 anglers fished for 350 h. The blue crab represented 60.3% of the catch, summer flounder 18.2%, bluefish 9.6%, and black sea bass 9.3%. Because this zone was near Barnegat Inlet, most individuals were rod and reel fishermen. This partially explained the smaller percentage of the blue crab in the catch.

The land zones were sampled 27 times from January through 8 September; intensive fishing, however, began in May. Prior to May, the catch in zone 5 consisted of five winter flounder, and nothing was caught in zone 4. OCGS was shut down from 26 December through 4 March. and this apparently affected the sport fishery during January and February, particularly in Oyster Creek. Most fish were caught in these zones from May through August.

The c/i for Oyster Creek (zone 4) and Forked River (zone 5) was 10.26 and 3.96, respectively. About twice as many hours were expended fishing in Oyster Creek but 4.5 times as many specimens were taken there. As in the Bay, the blue crab comprised the greatest part of the catch in zone 4 (81.8%) and 5 (77.9%). The second most abundant species was the bluefish; it comprised 17.0% of the catch in zone 4 and 20.4% in zone 5. The c/i did not apparently decrease when water temperature was maximum (31.5 C).

The most intensive fishing throughout the survey area was from June through August. From September 1975 through May 1976, relatively few (11.2%) specimens were taken. Most (88.8%) specimens were caught from May through 8 September 1976.

Discussion

The most productive areas (largest c/i) were zone 4 (10.26) and zone 2 (5.96). Both zones were associated with the heated discharge from OCGS. Zones 1 (4.64), 3 (4.22), and 5 (3.69) followed in order of decreasing catch. Marcy (1976) and Spigarelli and Thommes (1976) reported increased catch-per-unit-effort in the heated discharge of nuclear power plants. Halgren

(1973) indicated that Oyster Creek had a greater percentage of bank fishermen than any other area of Upper Barnegat Bay surveyed.

Anglers were generally divided into those fishing with rod and reel and those crabbing. Although there were twice as many crabbers as rod and reel fishermen, 82% of the total catch was blue crab.

The land zones were sampled 27 times from January through September, and more specimens (n = 3,028) were taken there, primarily in Oyster Creek, than during the 26 surveys during the entire year in the three zones in the Bay (n = 2,117). Halgren (1973) reported that most (88.9%) of the sport fishes in Barnegat Bay were taken by boat fishermen; only 11.1% were taken by bank fishermen. His survey, however, covered much of Barnegat Bay while this survey covered only a portion of the western Bay in the vicinity of Oyster Creek.

Halgren (1973) found that the blue crab (65.3% of the total catch), winter flounder (7.3%), weakfish (5.9%), bluefish (5.7%), summer flounder (4.5%), and northern puffer (4.3%) dominated the estimated sport fishery catch of Upper Barnegat Bay from December 1971 through November 1972. He estimated that 700,936 fishes and crabs were taken. The present survey found that the blue crab (82.0%), bluefish (12.1%), summer flounder (2.0%), black sea bass (1.3%), and spot (1.3%) dominated the sport fishery catch. The absence of the northern puffer reflected the reduced population along the New Jersey coast in recent years. The reduced catch of the weakfish and winter flounder may be, in part, attributable to the limited area of the Bay that was surveyed.

IMPACT ASSESSMENT

Thomas R. Tatham

Fishes and macroinvertebrates of Barnegat Bay are potentially affected by OCGS in two general ways. They may be damaged or killed by the protective structures which precede the intake to the circulating and dilution water systems and by subsequent introduction into the heated discharge canal. Secondly, some may be affected as a consequence of attraction to, residence in, or avoidance of the heated discharge.

The intake to the circulating water system is preceded by trash racks and rotating traveling screens (9.6-mm mesh). Organisms impinged on the traveling screens are periodically washed into a sluiceway and passed through a flume into the heated discharge canal. Impingement mortality varied depending on the species but the effect of passage through the screen wash flume was negligible.

The intake to the dilution pumps is preceded by trash racks. Organisms passed through the pumps are introduced into water of increased temperature as dilution and heated discharge water mix in the canal.

The effect of impingement, thermal shock experienced when organisms are released into the heated discharge, and subsequent latent mortality on the bay anchovy, Atlantic menhaden, northern pipefish, winter flounder, blue crab, and other important fishes and macroinvertebrates are assessed. The magnitude and importance of these effects on the populations in Barnegat Bay are also discussed.

The number of organisms impinged at the traveling screens at OCGS

was estimated from 941 collections taken from 8 September 1975 through 3 September 1976. No collections were taken from 24 December 1975 through 8 March 1976 because OCGS was shut down. However, collections at OCGS during January and February 1977 indicated that impingement was very low during these months. The effect of dilution pump passage was considered minimal because the immediate mortality of organisms passed through the pump was low. Most of the impact of OCGS was from impingement on the traveling screens.

Mortality from impingement was estimated from immediate condition (live/dead/damaged) and delayed mortality data (Tables 12, 17, 32). The estimated number killed due to impingement was the sum of the estimated number dead immediately after impingement (estimated number impinged X percent immediate mortality) and the estimated number dead after 96 h (estimated number live and damaged X percent delayed mortality of organisms held in the heated discharge). Delayed mortality estimates were assumed to be 100% if adequate data were unavailable.

The significance of the mortality was assessed by comparing the number or biomass of specimens lost to the estimated population of the species in the Bay (see page 40); the commercial fishery catch in the Bay and in Ocean County, New Jersey; the sport fishery catch in the Bay; and the historical records of the fishes and fisheries in Barnegat Bay and adjacent estuaries.

All estimated populations in the Bay were substantial underestimates. The large variability and bias in these estimates was due to the relative inefficiency of the trawl (Loesch et al. 1976), inability to sample the entire water column, relative accessibility of the specimens to capture,

and the apparent inability to capture specimens during migration.

Many factors other than absolute abundance affect commercial fishery statistics. Landings are biased due to a failure to report certain catches or to inaccuracies in these reports. Fishes caught in one area may be landed in another. Restrictions on type of gear and area fished limit the landings of many species. Improvements in gear, gear efficiencies, and techniques may improve catches. Catch-per-unit-effort is a better indication of abundance than landings (Gulland 1966). Changes in effort of commercial fishermen are based on economics, weather, and the availability of the species. Consequently, conclusions about the absolute abundance of a species cannot be completely based on commercial landings.

Sport fishing statistics are similarly biased but careful sampling designs can increase the accuracy of estimates. Although an extensive sport fishing survey was made in Barnegat Bay in 1971 and 1972, Halgren (1973) did not determine confidence limits for his estimates, and only a limited sport fishing survey was conducted during the present study.

The impact of the thermal plume on organisms residing in Barnegat Bay was assessed from fishery and sport fishery data, observations by Ichthyological Associates, Inc. personnel, and the historical record.

Impact on Fin- and Shellfishes

Blue crab

The blue crab accounted for the largest estimated number (4.6 million) and biomass (43,200 kg) of organisms impinged at OCGS. Most (71%) specimens were taken from 2 May through 21 August, and most (91.5%) were immature.

It had an immediate mortality rate of 8%, and 29% were damaged. Most damaged specimens were missing one or more appendage. Specimens with missing appendages are common in nature, and crabs regenerate missing limbs. Although temperature shock studies indicated that 50% of the specimens held at 37 C died at 57 h, impinged blue crab passed into Oyster Creek can leave the immediate area of the discharge for cooler water. The avoidance breakdown temperature of juveniles was 40 C and of adults 39.2 C (Gift and Westman 1971).

The estimated number of both immature and mature blue crab killed by impingement at OCGS was determined from the monthly impingement estimate (Table 127), the monthly percentage of immature and mature crabs (Tables 130, 131), and monthly percent of dead specimens (Table 13). The additional delayed mortality of adults was determined from the percent of days during June (43%), July (26%), and August (35%) that the average condenser discharge temperature exceeded 39.2 C times the estimated number of live and damaged mature crabs passed into the discharge canal during these months. It was assumed that no delayed mortality of immature crabs occurred because the average condenser discharge temperature never exceeded 40 C. The estimated biomass lost was the number of mature and immature crabs lost during each month times the mean weight of mature (115.7 g) and immature (22.3 g) crabs.

A survey conducted from 8 to 20 July estimated the population in the eastern part of the Bay to be 3,860,000 ± 425,000 and in the central and western portions of the Bay to be 195,000 ± 52,000 (Table 38). During July, an estimated 928,116 individuals were impinged, and an estimated 83,530 were killed. The number impinged represented some 23% of the estimated population but only 2% of the estimated population was lost.

Since the estimated population for the central and western areas of the Bay was considered a gross underestimate because of gear avoidance, these percentages were undoubtedly high.

An estimated total of 29,500 mature (3,413.2 kg) and 382,000 immature (8,518.6 kg) blue crab was lost due to impingement and subsequent temperature shock. These 411,500 crabs are some 13 times the number of blue crab the AEC (1974) estimated OCGS would have killed in 1971, but half the number the EPA (1973) estimated would have been lost during 1971. The AEC's estimate of the number of crabs impinged per hour (147) was 9 times less than the number impinged per hour (1,316) during the same period in 1976. The population level in 1971 may have been somewhat lower; the commercial landings in the Bay during 1971 (42,455 kg; E. LoVerde, personal communication) were about 57% of the landings from September 1975 through August 1976.

The mortality of mature blue crab at OCGS was assessed by a comparison of the biomass of mature individuals killed to the sport and commercial fisheries catch from the Bay. The biomass of immature blue crab which would have become mature was estimated from the ratio of immature to mature (9:1) specimens. It was estimated that the 382,000 (8,518.6 kg) immature crabs lost would have become some 42,400 adults (4,911 kg). The total biomass of mature crabs lost was then estimated to be 8,324 kg. The commercial landings from September 1975 through August 1976 were 73,327 kg (Table 132). Halgren's (1973) estimated number of blue crab caught by Barnegat Bay sport fishermen during 1972 (457,444) was multiplied by the estimated weight per blue crab retained (100 g) to give a biomass of 45,744 kg. The biomass of mature blue crab removed by OCGS was 7% of the estimated sport and commercial catch (119,072 kg). Despite this loss no

evidence exists that the population of the blue crab has decreased since OCGS began operation in December 1969. The yearly catch from Barnegat Bay from 1972 through 1975 averaged 75,609 kg (62,000 - 90,800 kg), while the yearly catch from Ocean County, including all of Barnegat Bay, averaged 21,500 kg (1,000 - 79,545 kg) from 1960 through 1969 (E. LoVerde, personal communication).

The blue crab apparently did not avoid Oyster Creek from June through August; it may have been attracted to the warmer water during April and May. From June through August, sport fishermen in Oyster Creek caught more blue crab than sport fishermen in nearby areas of western Barnegat Bay (Table 134).

Bay Anchovy

The bay anchovy was the most abundant fish collected in the Bay and at OCGS, Most (95%) specimens were collected at OCGS from 21 March through 29 May. Both the immediate mortality (77%) and the delayed mortality (85-100%) were high, and it appeared that most specimens impinged at OCGS died. An estimated 1.6 million bay anchovy weighing 4,446 kg were killed at OCGS from September 1975 through August 1976.

Sea gulls, blue crab, and predatory fishes such as the bluefish and weakfish undoubtedly eat some of these dead fishes. Many of these predators were sighted in the immediate vicinity of the screen wash flume discharge at times from May through December.

A population survey conducted from 13 to 21 May estimated the bay anchovy population in the Bay to be 1,932,000 ± 755,000 fish (Table 36). Some 618,000 individuals were estimated to have been impinged at OCGS

during the two weeks the survey was conducted. About ten times as many specimens were collected in the Bay during this period than were impinged on the screens. The population survey, however, was conducted during a period of substantial decrease in population size, and the population was undoubtedly underestimated.

Most of the bay anchovy killed were mature but the loss of their reproductive potential in the Bay was difficult to determine. If OCGS affected the bay anchovy population in Barnegat Bay, the impact was not apparent. During June and July 1976, Tatham et al. (1977b) found that the mean monthly density of eggs ($7\text{-}82/m^3$) and larvae ($0.1\text{-}11.9/m^3$) in Barnegat Bay was approximately equal to the densities of eggs ($16.9\text{-}115.2/m^3$) and larvae ($0.1\text{-}6.9/m^3$) from nearby Great Bay and Little Egg Harbor from June and July 1972-75 (Thomas and Milstein 1973; Thomas et al. 1974, 1975; Milstein et al. 1976). During the year, the mean catch (n/coll.) of bay anchovy by seine, excluding three extremely large catches from the heated discharge in April, was 9.0 n/coll. These collections (1,510-7,234 n/coll.) were excluded because these fish were taken from large schools of fish attracted to the heated discharge. This attraction was not present during Marcellus' study because OCGS was not in operation; he had no catch of the bay anchovy greater than 2,000 n/coll. From 1966-69, Marcellus (1972) reported an annual catch of 6.2 to 26.9 n/coll. McClain (1973) reported an annual catch of 20.9 n/coll. from December 1971 through November 1972, and OCGS operated during most of this time.

Winter flounder

An estimated 1,152 juvenile and adult winter flounder (276.1 kg) were impinged at OCGS from November through May. OCGS was shut down

from 24 December 1975 through 4 March 1976. However, sampling during January and February 1977 indicated that relatively few winter flounder were impinged during these months. An estimated 2,612 young (54.3 kg) were impinged from June through August. The overall immediate mortality rate was 22%.

Although no delayed mortality data were available, thermal shock tests indicated that from January through April (ambient temp $\leq$ 7.6 C) juveniles and adults withstood a temperature shock as great as 16 C with little (6.6-7.1%) mortality (Table 18). Some 50% of the young tested during July died in less than 2 min, and complete mortality occurred in 5 min. Assuming a delayed mortality of 7% (Table 17), 316 (75.7 kg) juvenile and adult winter flounder impinged from November through May were killed. Assuming that all young impinged from June through August were killed, a total of 2,928 individuals (130.0 kg) died. This estimate was significantly lower than the 24,000 winter flounder the AEC (1974) estimated that OCGS would have removed in 1971. This difference may be attributed, in part, to their assumption that peak impingement of winter flounder occurred for 6 months. Since the populations in nearby New Jersey estuaries have decreased substantially since the early 1970's, the population of winter flounder in Barnegat Bay in 1971 may also have been larger than the present population.

A population survey conducted during early April estimated the population in the middle portion of the Bay to be 91,000 $\pm$ 8,4000, and this may have been a substantial underestimate (Table 35). An estimated 152 individuals (0.17% of the estimated Bay population) were impinged in the 2 weeks before, the 2 weeks during, and the 2 weeks after the survey.

The estimated biomass impinged was 1.5% of the commercial fisheries landings (2,113.6 kg) during the period, and the estimated biomass killed was 0.6% (Table 132). The impact to the winter flounder population appeared to be less than the major impact predicted by the AEC (1974).

Winter flounder apparently avoided the heated discharge in Oyster Creek after early April when the temperature exceeded 15 C. Few young were taken in Oyster Creek from June through August when the temperature was usually above their mean avoidance temperature of 26.9 C (Gift and Westman 1971). After November, adults were attracted to the warmer water in Oyster Creek; the Creek supports a sport fishery for winter flounder from November through April.

Atlantic menhaden

Most Atlantic menhaden were impinged during December, April, May, and July. An estimated 18,200 fish weighing 1,125 kg were impinged at OCGS from September 1975 through August 1976. Most of those impinged probably died. Although immediate mortality was 31%, delayed mortality was estimated to be 100%.

Most (91.1%) Atlantic menhaden were age 3+ or younger, and 80% of all specimens were immature. Barnegat Bay was primarily a nursery area; most spawning occurred in the ocean.

The Atlantic menhaden was attracted to the heated discharge of OCGS during November and December and during March and April. Some individuals remain in the heated discharge after December, and many were killed when OCGS shut down in January and December 1972 and January 1974 (AEC 1974). From June through August, most specimens were taken at temperatures below 30 C; however, the discharge canal was apparently not avoided.

In evaluating the impingement loss at OCGS, the biomass of Atlantic menhaden impinged was compared to the entire landings in New Jersey rather than the landings for Ocean County. Most fish caught off New Jersey, and some from adjacent states, are landed at Port Monmouth because of the fish processing plant there. The biomass impinged at OCGS was 0.08% of the 1,449,712 kg (U. S. Dept. of Commerce 1976) landed in New Jersey from September 1975 through August 1976.

Northern Pipefish

Although northern pipefish was the sixth most numerous fish impinged at OCGS, there appeared to be little impact to the population. The immediate mortality of northern pipefish impinged at OCGS was 4%. Few specimens were held for delayed mortality studies. Specimens in thermal bioassays conducted from March through May had substantially greater mortality and a higher incidence of gas bubble disease than fish tested during December. It is not known if individuals residing in the heated discharge were affected by gas bubble disease. An estimated 35,000 northern pipefish were impinged at OCGS (Table 90). Most were collected during December and March when fish moved between shallow and deeper water.

A population survey of the northern pipefish was conducted from 23 June through 1 July. The estimated population in the shallow, eastern portion of the Bay was 383,000 ± 179,000 and that in the western and central portion was 45,000 ± 44,000 (Table 37). The abundant beds of eelgrass in the eastern Bay were apparently a favored habitat. For the 6 weeks preceding and during the survey, an estimated 3,100 individuals were impinged at OCGS. This was a small (0.7%) portion of the estimated

population. A larger percentage of gravid males were collected from the Bay (56%) than from OCGS (36%). No apparent attraction or avoidance of the heated discharge in Oyster Creek was noted.

Summer Flounder

The summer flounder was common in collections at OCGS; an estimated 4,500 individuals weighing 900 kg were impinged. An estimated 500 summer flounder died after impingement based on an immediate mortality rate of 11%. No delayed mortality data were available. No attraction to or avoidance of Oyster Creek was found.

The effect on the population in the Bay appeared inconsequential. The biomass impinged represented only 0.15% of the fish landed commercially in Ocean County during the sampling period (Table 133). Most of the fish impinged were age 2+, the dominant age group taken by sport fishermen in Great Bay, New Jersey (Festa 1975). Halgren (1973) estimated that some 32,000 summer flounder (6.6% of the total catch by sport fishermen in boats) were taken in Barnegat Bay from December 1971 through November 1972. The sport fishery data collected from September 1975 through August 1976 indicated that the summer flounder comprised only 2% of the sport fishing catch in the western portion of Barnegat Bay. This survey covered a more limited area of the Bay and was less intense than Halgren's.

Other fin-and shellfishes

Most of the bluefish (77%) and weakfish (99%) impinged at OCGS were young. An estimated 12,300 bluefish (54.3 kg) and 11,000 weakfish (155.5 kg) were impinged. The immediate mortality of both fishes was

about 60%. Both were attracted to the heated discharge during May and November, and both species were observed in the heated discharge after December. At least 200 bluefish died when OCGS shut down on 19 December 1975. The bluefish and weakfish fed on fishes concentrated in the canal and those washed from the traveling screens. Young bluefish were the most common fish taken in Oyster Creek and the western Bay by sport fishermen (Table 134).

The biomass of impinged bluefish and weakfish represented a very small portion of the sport and commercial catch. Halgren (1973) estimated that 41,119 weakfish (6.6% total sport catch) and 36,544 bluefish (5.9%) were taken by Barnegat Bay sport fishermen from December 1971 through November 1972. The biomass impinged represented 0.03% of the poundage of the bluefish and 0.07% of the weakfish landed commercially in Ocean County during the sampling period (Table 133).

An estimated 3,251 northern puffer (200 kg) were impinged at OCGS; most were impinged in May. The immediate mortality was 10%. Although the northern puffer was once an abundant and desirable sport fish in New Jersey, in recent years the population has declined. Marcellus (1972) documented its decline in Barnegat Bay from 1966-69 just prior to the beginning of OCGS operation. Hamer (1972) estimated that it comprised 66% of the boat sport fishing catch in Great Bay, New Jersey in 1969. It comprised only 5% of the sport fishery catch in Great Egg Harbor, New Jersey in 1970-71 (Vennell undated) and Barnegat Bay in 1972 (Halgren 1973). During this study it comprised only 1% of the sport fishery catch.

The sand shrimp was an abundant macroinvertebrate in collections from OCGS and the Bay. The immediate mortality for individuals impinged on the traveling screens was 4%. Although no delayed mortality studies

were conducted, specimens acclimated to 6.2 C and experimentally subjected to an abnormally high temperature shock of 20.1 C had only moderate (40%) mortality. The sand shrimp was apparently attracted to the heated discharge during December.

Very few individuals of the threespine stickleback (an estimated 190 specimens) and northern kingfish (total of 16 fish) were collected at OCGS. No striped bass were collected at OCGS, and only one was collected in the study area. A few individuals were observed in the heated discharge in November 1976. The population of these three species has apparently declined along the New Jersey coast in recent years.

Conclusions

No evidence exists to date that the Oyster Creek Generating Station has had a detrimental effect on populations of fishes, blue crab, and sand shrimp in Barnegat Bay. Some of the fishes killed at the traveling screens are eaten by sea gulls, blue crab, and predatory fishes such as bluefish and weakfish. Although the heated discharge may have been avoided by some species (e.g. winter flounder) during the warmer months of the year, other species were apparently attracted to the discharge (e.g. drums, jacks) or at least did not avoid it (e.g. blue crab, bluefish). A definite attraction to the discharge occurred from November through April.

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Table 1 . Alphabetical listing by common name of all vertebrate species collected by fish and impingement programs from September 1975 through August 1976.

African Pompano - Alectis crinitus
Alewife - Alosa pseudoharengus
American eel - Anguilla rostrata
American shad - Alosa sapidissima
Atlantic croaker - Micropogon undulatus
Atlantic herring - Clupea harengus
Atlantic menhaden - Brevoortia tyrannus
Atlantic moonfish - Vomer setapinnis
Atlantic needlefish - Strongylura marina
Atlantic silverside - Menidia menidia
Banded killifish - Fundulus diaphanus
Bay anchovy - Anchoa mitchilli
Bigeye scad - Selar crumenophahalmus
Black drum - Pogonias cromis
Black sea bass - Centropristis striata
Blackcheek tonguefish - Symphurus plagiusa
Blueback herring - Alosa aestivalis
Bluefish - Pomatomus saltatrix
Bluerunner - Caranx crysos
Bluespotted cornetfish - Fistularia tabacaria
Bluntnose stingray - Dasyatis sayi
Butterfish - Peprilus triacanthus
Chain pickerel - Esox niger
Chain pipefish - Syngnathus louisianae
Clearnose skate - Raja eglanteria
Conger eel - Conger oceanicus
Crevalle jack - Caranx hippos
Cunner - Tautogolabrus adspersus
Diamondback terrapin - Malaclemys terrapin
Feather blenny - Hypsoblennius hentzi
Florida pompano - Trachinotus carolinus
Fourspine stickleback - Apeltes quadracus
Fowler's toad - Bufo fowleri
Gizzard shad - Dorosoma cepedianum
Gray snapper - Lutjanus griseus
Grubby - Myoxocephalus aenaeus
Hogchoker - Trinectes maculatus
Inshore lizardfish - Synodus foetens
Ladyfish - Elops saurus
Lined seahorse - Hippocampus erectus
Lookdown - Selene vomer
Mummichog - Fundulus heteroclitus
Naked goby - Gobiosoma bosci
Northern kingfish - Menticirrhus saxatilis
Northern pipefish - Syngnathus fuscus
Northern puffer - Sphoeroides maculatus
Northern searobin - Prionotus carolinus
Northern sennet - Sphyraena borealis
Northern stargazer - Astroscopus guttatus
Orange filefish - Alutera schoepfi
Oyster toadfish - Opsanus tau
Permit - Trachinotus falcatus
Pirateperch - Aphredoderus sayanus
Planehead filefish - Monacanthus hispidus
Pollock - Pollachius virens
Pumpkinseed - Lepomis gibbosus
Rainwater killifish - Lucania parva
Red hake - Urophycis chuss
Round herring - Etrumeus teres
Round scad - Decapterus punctatus
Sand lance - Ammodytes sp.
Scrawled cowfish - Lactophrys quadricornis
Scup - Stenotomus chrysops
Seaboard goby - Gobiosoma ginsburgi
Sea raven - Hemitripterus americanus
Sheepshead minnow - Cyprinodon variegatus
Short bigeye - Pristigenys alta
Silver anchovy - Engraulis eurystole
Silver hake - Merluccius bilinearis
Silver perch - Bairdiella chrysura
Smallmouth flounder - Etropus microstomus
Smooth dogfish - Mustelus canis
Smooth trunkfish - Lactophrys triqueter
Spot - Leiostomus xanthurus
Spotfin butterflyfish - Chaetodon ocellatus
Spotted goatfish - Pseudupeneus maculatus
Spotted hake - Urophycis regius

Striped anchovy - Anchoa hepsetus
Striped bass - Morone saxatilis
Striped blenny - Chasmodes bosquianus
Striped burrfish - Chilomycterus schoepfi
Striped cusk-eel - Rissola marginata
Striped killifish - Fundulus majalis
Striped mullet - Mugil cephalus
Striped searobin - Prionotus evolans
Summer flounder - Paralichthys dentatus
Tautog - Tautoga onitis
Threespine stickleback - Gasterosteus aculeatus
Tidewater silverside - Menidia beryllina
Weakfish - Cynoscion regalis
White hake - Urophycis tenuis
White mullet - Mugil curema
White perch - Morone americana
Windowpane - Scophthalmus aquosus
Winter flounder - Pseudopleuronectes americanus

Table 2 . Alphabetical listing by scientific name of all vertebrate species collected by fish and impingement programs from September 1975 through August 1976.

Alectis crinitus - African pompano
Alosa aestivalis - Blueback herring
Alosa pseudoharengus - Alewife
Alosa sapidissima - American shad
Alutera schoepfi - Orange filefish
Ammodytes sp. - Sand lance
Anchoa hepsetus - Striped anchovy
Anchoa mitchilli - Bay anchovy
Anguilla rostrata - American eel
Apeltes quadracus - Fourspine stickleback
Aphredoderus sayanus - Pirateperch
Astroscopus guttatus - Northern stargazer
Bairdiella chrysura - Silver perch
Brevoortia tyrannus - Atlantic menhaden
Bufo fowleri - Fowler's toad
Caranx crysos - Blue runner
Caranx hippos - Crevalle jack
Centropristis striata - Black sea bass
Chaetodon ocellatus - Spotfin butterflyfish
Chasmodes bosquianus - Striped blenny
Chilomycterus schoepfi - Striped burrfish
Clupea harengus - Atlantic herring
Conger oceanicus - Conger eel
Cynoscion regalis - Weakfish
Cyprinodon variegatus - Sheepshead minnow
Dasyatis sayi - Bluntnose stingray
Decapterus punctatus - Round scad
Dorosoma cepedianum - Gizzard shad
Elops saurus - Ladyfish
Engraulis eruystole - Silver anchovy
Esox niger - Chain pickerel
Etropus microstomus - Smallmouth flounder
Etrumeus teres - Round herring
Fistularia tabacaria - Bluespotted cornetfish
Fundulus diaphanus - Banded killifish
Fundulus heteroclitus - Mummichog
Fundulus majalis - Striped killifish
Gasterosteus aculeatus - Threespine stickleback
Gobiosoma bosci - Naked goby
Gobiosoma ginsburgi - Seaboard goby
Hemitripterus americanus - Sea raven
Hippocampus erectus - Lined seahorse
Hypsoblennius hentzi - Feather blenny
Lactophys quadricornis - Scrawled cowfish
Lactophys triqueter - Smooth trunkfish
Leiostomus xanthurus - Spot
Lepomis gibbosus - Pumpkinseed
Lucania parva - Rainwater killifish
Lutjanus griseus - Gray snapper
Malaclemys terrapin - Diamondback terrapin
Menidia beryllina - Tidewater silverside
Menidia menidia - Atlantic silverside
Menticirrhus saxatilis - Northern kingfish
Merluccius bilinearis - Silver hake
Micropogon undulatus - Atlantic croaker
Monacanthus hispidus - Planehead filefish
Morone americana - White perch
Morone saxatilis - Striped bass
Mugil cephalus - Striped mullet
Mugil curema - White mullet
Mustelus canis - Smooth dogfish
Myoxocephalus aenaeus - Grubby
Opsanus tau - Oyster toadfish
Paralichthys dentatus - Summer flounder
Peprilus triacanthus - Butterfish
Pogonias cromis - Black drum
Pollachius virens - Pollock
Pomatomus saltatrix - Bluefish
Prionotus carolinus - Northern searobin
Prionotus evolans - Striped searobin
Pristigenys alta - Short bigeye
Pseudopleuronectes americanus - Winter flounder
Pseudupeneus maculatus - Spotted goatfish
Raja eglanteria - Clearnose skate
Rissola marginata - Striped cusk-eel
Scophthalmus aquosus - Windowpane
Selar crumenophthalmus - Bigeye scad
Selene vomer - Lookdown
Sphoeroides maculatus - Northern puffer
Sphyraena borealis - Northern sennet
Stenotomus chrysops - Scup
Strongylura marina - Atlantic needlefish
Symphurus plagiusa - Blackcheek tonguefish
Syngnathus fuscus - Northern pipefish
Syngnathus louisianae - Chain pipefish
Synodus foetens - Inshore lizardfish
Tautog onitis - Tautog
Tautogolabrus adspersus - Cunner
Trachinotus carolinus - Florida pompano
Trachinotus falcatus - Permit
Trinectes maculatus - Hogchoker
Urophycis chuss - Red hake
Urophycis regius - Spotted hake
Urophycis tenuis - White hake
Vomer setapinnis - Atlantic moonfish

Table 3 . Alphabetical listing by scientific names of all macroinvertebrate taxa collected by fish and impingement programs from September 1975 through August 1976.

Actiniaria (order) - sea anemones
Aequorea spp. - a hydromedusa
Anilocra laticauda - an isopod
Callinectes sapidus - blue crab
Callinectes similis - lesser blue crab
Cancer irroratus - rock crab
Crangon septemspinosa - sand shrimp
Cyanea capillata - lion's mane jellyfish
Eurypanopeus depressus - flat mud crab
Glugea staphani - a myxosporidian
Leptosynapta sp. - sea cucumber
Lernaeenicus spp. - parasitic copepods
Libinia dubia - spider crab
Libinia emarginata - spider crab
Limulus polyphemus - horseshoe crab
Lironeca ovalis - a parasitic isopod
Loliginidae (family) - squids
Loligo pealei - Atlantic long-finned squid
Lolliguncula brevis - brief squid
Nemertea (phylum) - ribbon worms
Neopanope texana - a mud crab
Mercenaria mercenaria - hard clam, northern quahog
Olencira praegustator - a parasitic isopod
Ovalipes ocellatus - lady crab
Pagurus longicarpus - long-armed hermit crab
Palaemonetes pugio - grass shrimp
Palaemonetes vulgaris - grass shrimp
Panopeus herbstii - a mud crab
Penaeus aztecus - brown shrimp
Penaeus setiferus - white shrimp
Polychaeta (class) - bristle worms
Portunus gibbesi - a portunid crab
Procambarus blandingi - Blanding's crayfish
Scyphozoa (class) - true jellyfishes
Squilla empusa - mantis shrimp
Stomatopoda (order) - mantis shrimps
Xanthidae (family) - mud crabs

Table 4. Mean surface (S) and bottom (B) water temperature in Forked River, Oyster Creek, the western portion of Barnegat Bay, and Barnegat Inlet from September 1975 through August 1976.

Location (Station No.)		Month											
		Sept. 1975	Oct.	Nov.	Dec.	Jan. 1976	Feb.	March	April	May	June	July	August
Mouth of	S	20.5	16.0	11.8	6.8	1.1	4.9	6.0	12.1	17.5	24.0	24.7	24.3
Cedar Creek (1)	B	20.5	16.2	12.0	7.6	1.0	4.3	5.6	11.7	17.0	22.8	24.5	24.3
Mouth of	S	20.4	15.0	12.3	7.3	0.0	5.1	6.2	12.6	18.2	24.3	24.9	24.8
Stouts Creek (2)	B	20.8	15.7	12.2	7.8	0.3	4.3	6.0	11.8	17.3	22.1	24.2	24.6
Barnegat Bav off	S	20.5	16.5	13.3	8.6	1.0	4.4	7.7	10.4	18.7	23.4	23.6	24.5
Forked River (3)	B	20.5	16.7	13.4	8.8	1.0	4.3	7.8	10.7	18.4	21.2	23.6	24.5
Mouth of	S	19.2	16.7	13.4	6.9	1.2	5.6	8.3	12.3	19.2	24.6	24.1	25.5
Forked River (4)	B	20.4	16.3	13.1	6.8	1.3	5.0	7.9	11.7	18.6	21.0	23.9	24.9
Forked River, just	S	20.8	16.5	12.3	8.4	1.3	4.2	5.6	11.4	18.0	22.7	24.3	25.6
east of Rt. 9 bridge (6)	B	20.8	16.7	12.3	8.3	1.1	4.0	5.6	11.7	18.0	20.3	24.1	25.5
Oyster Creek in	S	23.4	17.6	15.5	9.5	1.5	4.7	8.5	16.2	23.7	28.7	27.4	29.4
vicinity of marinas (15)	B	23.4	17.7	15.6	12.5	1.2	4.6	8.4	16.3	23.7	27.7	27.5	29.5
Mouth of	S	23.0	18.2	16.2	10.2	1.5	5.6	10.4	15.3	23.7	29.3	27.2	29.0
Oyster Creek (17)	B	22.1	17.4	16.0	11.3	1.5	5.2	10.3	14.7	23.4	26.5	26.9	29.1
Barnegat Bay off	S	23.9	16.8	15.4	10.0	1.0	4.8	10.0	12.2	19.8	26.6	25.6	28.0
Oyster Creek (19)	B	23.5	16.7	14.1	9.2	1.1	4.8	8.7	12.3	19.6	23.6	25.3	26.8
Barnegat Bay off	S	21.8	16.1	13.5	7.8	-1.0	4.0	6.8	11.6	18.0	22.9	23.2	25.2
Waretown (21)	B	21.1	16.0	13.0	8.0	1.0	3.8	6.9	11.1	17.5	22.9	23.8	25.5
Mouth of	S	19.7	17.5	12.7	7.7	1.0	5.5	6.4	13.4	19.0	23.9	25.1	25.6
Double Creek (23)	B	20.1	16.3	12.6	7.5	1.1	4.7	5.4	12.1	17.4	22.4	25.1	24.4
Barnegat Inlet (24)	S	19.4	15.8	13.9	8.5	1.5	4.1	6.6	9.6	16.1	24.1	22.1	23.6
	B	19.5	15.4	13.8	9.2	1.0	3.7	6.5	10.8	15.9	23.9	22.1	23.5

Table 5 . Mean monthly water temperature in the OCGS condenser intake and the condenser discharge and the difference between these temperatures (Δ t) from September 1975 through August 1976.

	No. of Observations	Mean temp. Condenser Intake (C)	Mean temp. Condenser Discharge (C)	Δ t
September 1975	30	20.1	28.9	8.8
October	31	16.4	22.8	6.4
November	30	11.8	21.4	9.6
December	31	4.4	13.7	9.3
January 1976[a]	31	0.6	1.2	0.6
February[a]	29	4.1	4.4	0.3
March	31	8.9	13.8	4.9
April	30	14.3	22.5	8.2
May	31	20.0	28.7	8.7
June	30	25.8	35.4	9.6
July	31	26.7	34.4	7.7
August	31	26.6	36.3	9.7

a. OCGS not in operation; only dilution pumps operating.

Table 6. Mean surface (S) and bottom (B) salinities (ppt) in Forked River, Oyster Creek, the western portion of Barnegat Bay, and Barnegat Inlet from September 1975 through August 1976.

Location (Station No.)		Month											
		Sept. 1975	Oct.	Nov.	Dec.	Jan. 1976	Feb.	March	April	May	June	July	August
Mouth of Cedar Creek (1)	S	15.9	16.6	14.5	15.1	12.3	15.4	16.7	17.0	17.1	19.5	23.3	21.4
	B	16.0	17.9	17.3	19.0	17.3	17.8	18.7	18.0	20.0	22.1	25.8	22.6
Mouth of Stouts Creek (2)	S	20.6	20.2	19.1	21.1	19.8	20.7	20.1	21.1	23.2	22.9	27.1	25.1
	B	20.6	21.4	19.2	20.9	20.3	21.0	21.6	21.0	23.4	22.5	27.3	25.7
Barnegat Bay off Forked River (3)	S	23.3	22.0	21.0	22.0	19.0	21.3	22.2	22.2	23.5	24.2	28.2	27.1
	B	24.0	22.0	22.4	22.4	21.3	21.3	22.3	22.2	23.5	23.9	28.1	26.9
Mouth of Forked River (4)	S	22.5	20.6	21.0	21.5	20.1	21.4	21.0	22.3	24.0	24.3	27.7	26.7
	B	22.6	22.0	21.1	22.0	21.9	21.5	21.8	22.5	23.3	24.0	27.6	27.1
Forked River, just east of Rt. 9 bridge (6)	S	20.0	23.0	20.5	21.7	19.9	19.8	21.3	21.8	23.1	23.9	27.2	25.5
	B	21.7	21.2	20.9	21.3	21.2	20.2	22.1	22.0	23.1	23.8	27.2	26.2
Oyster Creek in vicinity of marinas (15)	S	21.1	20.3	20.4	20.1	18.2	19.5	21.5	20.9	22.3	23.4	26.7	26.2
	B	20.6	20.8	20.1	20.8	18.4	19.3	22.3	21.1	22.5	22.9	26.8	26.2
Mouth of Oyster Creek (17)	S	22.0	20.0	20.3	21.8	18.5	20.2	20.2	21.5	23.6	23.3	27.1	26.4
	B	22.0	21.2	20.1	21.7	20.0	21.2	21.0	21.7	23.2	22.6	26.8	25.7
Barnegat Bay off Oyster Creek (19)	S	22.5	22.3	20.8	22.0	18.5	20.6	21.8	21.6	24.0	24.0	27.4	26.0
	B	23.8	22.3	22.0	22.2	18.8	20.9	22.5	22.6	25.1	24.0	27.5	26.5
Barnegat Bay off Waretown (21)	S	24.5	24.3	21.6	22.7	21.0	22.8	24.3	24.3	25.3	25.8	29.0	27.3
	B	25.0	25.1	21.4	23.3	24.0	23.8	24.5	24.5	25.3	24.5	29.0	27.3
Mouth of Double Creek (23)	S	24.0	23.4	22.1	23.5	21.3	23.3	24.6	24.5	24.8	26.8	29.1	27.8
	B	25.0	25.6	21.9	23.1	20.5	23.4	26.4	24.3	25.4	25.8	29.1	28.1
Barnegat Inlet (24)	S	29.5	24.2	27.0	29.3	23.0	22.8	23.3	24.0	25.4	25.6	29.0	26.9
	B	30.0	24.5	27.8	30.0	28.0	24.1	26.0	23.9	25.5	26.3	29.1	27.1

Table 7. Mean surface (S) and bottom (B) pH's in Forked River, Oyster Creek, the western portion of Barnegat Bay, and Barnegat Inlet from October 1975 through August 1976.

Location (Station No.)		Month										
		Oct. 1975	Nov.	Dec.	Jan. 1976	Feb.	March	April	May	June	July	August
Mouth of Cedar Creek (1)	S	7.7	7.8	8.0	8.2	7.7	8.0	8.2	7.7	7.8	7.7	8.0
	B	7.6	7.8	8.0	8.0	7.9	7.8	8.2	7.6	7.5	7.6	7.6
Mouth of Stouts Creek (2)	S	7.9	7.8	8.1	8.3	7.7	7.8	8.3	7.6	7.4	7.6	7.9
	B	7.8	7.8	8.0	8.1	7.7	7.6	8.1	7.5	7.3	7.4	7.3
Barnegat Bay off Forked River (3)	S	8.0	7.7	7.9	7.8	7.9	7.8	7.1	7.7	7.7	7.4	7.9
	B	8.0	7.8	7.7	7.9	7.9	7.6	8.0	7.7	7.7	7.4	7.9
Mouth of Forked River (4)	S	8.0	8.0	8.0	7.9	7.9	7.9	7.5	7.8	7.8	7.7	8.0
	B	7.9	7.9	7.9	7.7	8.0	7.8	8.2	7.6	7.8	7.5	7.5
Forked River just east of Rt. 9 bridge (6)	S	7.8	7.9	7.9	7.8	8.3	7.8	8.3	7.6	8.0	7.3	7.2
	B	7.9	7.9	7.9	7.7	8.1	7.9	8.2	7.6	8.1	7.3	7.3
Oyster Creek near marinas (15)	S	7.8	7.6	8.0	7.5	7.6	7.8	8.1	7.1	7.2	7.5	7.6
	B	7.8	7.6	7.9	7.6	7.7	7.9	8.2	7.0	7.6	7.5	7.5
Mouth of Oyster Creek (17)	S	8.0	7.9	8.1	7.7	7.7	7.7	8.0	7.7	7.5	7.6	7.9
	B	7.8	7.7	7.9	7.3	7.7	7.3	7.6	7.5	7.4	7.3	7.4
Barnegat Bay off Oyster Creek (19)	S	7.8	7.8	7.9	7.3	7.5	7.8	8.0	7.8	7.5	7.2	7.8
	B	7.6	7.8	7.9	7.4	7.3	7.7	8.0	7.8	7.4	7.3	7.7
Barnegat Bay off Waretown (21)	S	7.8	7.9	7.9	8.4	7.5	7.4	8.3	7.8	6.9	7.0	8.5
	B	7.9	7.9	7.9	8.4	7.9	7.5	8.2	7.8	6.9	7.3	8.5
Mouth of Double Creek (23)	S	7.8	8.0	8.2	7.4	7.8	7.8	8.0	7.6	7.5	7.2	7.9
	B	7.9	8.0	8.1	7.1	7.8	7.9	8.0	7.3	7.6	7.4	7.4
Barnegat Inlet (24)	S	8.0	7.8	8.1	8.4	7.9	8.0	8.3	7.6	7.3	7.5	8.6
	B	8.0	8.0	8.2	8.3	7.8	8.1	8.2	7.8	7.1	7.5	8.5

Table 8 . Mean surface (S) and bottom (B) dissolved oxygen values in Forked River, Oyster Creek, the western portion of Barnegat Bay, and Barnegat Inlet from September 1975 through August 1976.

Location (Station No.)		Month											
		Sept. 1975	Oct.	Nov.	Dec.	Jan. 1976	Feb.	March	April	May	June	July	August
Mouth of Cedar Creek (1)	S	8.6	8.6	10.2	10.6	12.9	10.9	10.6	9.1	8.6	8.0	7.9	7.4
	B	9.3	8.6	10.0	10.6	11.8	11.1	10.2	9.3	9.0	7.6	7.5	6.7
Mouth of Stouts Creek (2)	S	8.4	9.1	10.1	10.8	11.0	10.6	10.6	10.0	8.6	7.7	7.8	7.3
	B	8.5	8.8	9.8	10.9	9.7	10.6	10.1	9.7	8.9	7.2	7.2	6.9
Barnegat Bay off Forked River (3)	S	8.8	9.0	10.0	10.3	11.8	11.1	11.1	10.3	8.6	8.8	6.6	7.9
	B	6.8	8.8	9.9	10.0	12.1	11.2	11.1	10.7	8.4	9.2	7.2	7.9
Mouth of Forked River (4)	S	9.3	9.5	9.7	10.1	11.7	11.0	10.9	10.4	8.8	8.4	7.7	7.6
	B	7.6	8.0	9.9	10.3	11.5	11.1	11.0	10.3	8.8	9.2	7.3	7.8
Forked River, just east of Rt. 9 bridge (6)	S	6.8	8.5	9.6	10.4	10.4	11.0	11.4	10.4	8.2	7.3	6.8	7.0
	B	6.5	8.3	9.7	10.2	11.2	11.8	11.2	10.4	8.3	8.3	6.8	6.9
Oyster Creek in vicinity of marinas (15)	S	8.4	8.7	9.6	10.5	11.7	11.1	11.1	10.4	8.6	8.4	7.2	6.7
	B	7.7	8.4	9.7	9.4	11.6	11.2	11.0	10.3	8.4	8.7	7.1	6.5
Mouth of Oyster Creek (17)	S	8.2	8.9	9.5	9.8	12.1	11.1	10.4	9.7	8.5	8.4	7.4	7.5
	B	8.4	8.5	9.7	9.9	11.3	11.2	10.5	9.6	8.3	8.9	6.7	7.3
Barnegat Bay off Oyster Creek (19)	S	7.3	8.7	9.8	10.2	12.1	11.0	10.8	10.5	8.2	8.7	7.0	7.2
	B	7.1	8.5	9.8	10.1	11.9	11.1	11.0	10.0	8.0	9.3	7.0	7.0
Barnegat Bay off Waretown (21)	S	8.9	9.8	9.8	11.2	7.4	9.9	10.5	10.5	8.8	6.7	7.7	7.9
	B	8.4	9.4	9.8	10.9	7.3	10.1	10.4	10.5	8.9	6.6	7.6	7.8
Mouth of Double Creek (23)	S	7.8	9.1	9.9	11.1	11.6	10.2	10.7	8.8	9.2	8.3	8.4	8.1
	B	8.5	9.0	10.0	10.8	9.5	10.1	10.5	9.2	9.5	7.6	7.6	7.8
Barnegat Inlet (24)	S	8.3	10.7	9.6	10.2	10.3	10.2	10.8	10.6	9.3	7.3	7.3	8.4
	B	8.3	10.6	9.5	10.0	10.5	10.6	10.7	10.4	9.3	7.5	7.4	8.1

Table 9 . Mean monthly secchi disc readings (cm) taken in Forked River, Oyster Creek, the western portion of Barnegat Bay, and Barnegat Inlet from September 1975 through August 1976.

Location (Station No.)	Sept. 75	Oct.	Nov.	Dec.	Jan. 76	Feb.	March	April	May	June	July	Aug.
Mouth of Cedar Creek (1)	75	87	102	107	150	115	75	132	108	93	68	70
Mouth of Stouts Creek (2)	79	76	113	110	137	83	77	113	101	86	68	62
Barnegat Bay off Forked River (3)	80	100	105	97	160	85	85	145	105	85	80	68
Mouth of Forked River (4)	77	104	122	97	141	108	94	160	94	82	80	70
Forked River just east of the Rt. 9 bridge (6)	86	76	117	100	132	107	97	123	85	88	69	67
Oyster Creek in vicinity of marina (15)	76	75	105	90	120	112	82	117	92	68	68	63
Mouth of Oyster Creek (17)	86	87	107	110	130	103	78	128	98	66	68	66
Barnegat Bay off Oyster Creek (19)	90	97	120	105	115	77	95	103	105	80	70	63
Barnegat Bay off Waretown (21)	73	105	113	110	140	80	115	173	110	103	85	70
Mouth of Double Creek (23)	90	133	124	127	150	117	92	135	100	83	64	65
Barnegat Inlet (24)	297	105	187	50	170	87	85	185	150	95	113	90

Table 10. Actual and estimated number and weight (kg) of selected species impinged at Oyster Creek Generating Station, Forked River, New Jersey, from 8 September 1975 through 3 September 1976. No samples were taken 24 December through 7 March 1976.

Species	NUMBER Actual	NUMBER Estimated	WEIGHT Actual	WEIGHT Estimated
Alosa aestivalis	7,608	26,409	61.777	236.904
Brevoortia tyrannus	4,527	18,191	313.911	1,125.225
Anchoa mitchilli	384,589	1,643,457	1,066.143	4,446.197
Menidia menidia	16,524	58,138	82.904	295.638
Gasterosteus aculeatus	58	190	.183	.559
Syngnathus fuscus	9,907	34,810	22.474	80.724
Pomatomus saltatrix	1,659	12,283	11.526	54.301
Cynoscion regalis	2,964	11,062	45.827	155.496
Menticirrhus saxatilis	5	16	.641	2.322
Prionotus evolans	4,693	22,434	62.951	325.467
Paralichthys dentatus	978	4,474	180.480	896.131
Pseudopleuronectes americanus	551	3,764	80.827	330.361
Sphoeroides maculatus	434	3,251	32.558	200.051
Total of all fish species	450,840	1,948,852	2,362.303	10,500.047
Palaemonetes vulgaris	69,114	327,247	43.139	218.069
Crangon septemspinosa	749,910	3,201,475	640.082	2,745.487
Callinectes sapidus	705,382	4,617,069	7,555.703	43,191.092
Total of all invertebrate species	1,530,217	8,155,468	8,511.701	47,734.236
Grand Total of all species	1,981,057	10,104,320	10,874.004	58,234.283

Table 11 . Percent fishes and invertebrates impinged during 24 hour samples by period at Oyster Creek Generating Station from 8 September 1975 through 3 September 1976.

	Period 1	Period 2	Period 3	Period 4
Fishes	13.7	17.3	50.5	18.5
Invertebrates	4.1	5.7	69.0	21.2
Fishes and Invertebrates	5.8	7.8	65.7	20.7

TABLE 12. TOTAL OF LIVE, DEAD, AND DAMAGED FISHES AND INVERTEBRATES IMPINGED AT OYSTER CREEK GENERATING STATION, FORKED RIVER, NEW JERSEY DURING 8 SEPTEMBER 1975 THROUGH 3 SEPTEMBER 1976. NO SAMPLES WERE TAKEN 24 DECEMBER THROUGH 7 MARCH 1976.

SPECIES	NUMBER	LIVE	DEAD	DAMAGED	% DEAD
DASYATIS SAYI	1	1	-	-	-
ANGUILLA ROSTRATA	34	5	15	14	44
CONGER OCEANICUS	5	1	-	4	-
ALOSA AESTIVALIS	911	189	397	325	44
ALOSA PSEUDOHARENGUS	128	18	51	59	40
ALOSA SAPIDISSIMA	1	-	-	1	-
BREVOORTIA TYRANNUS	777	54	242	481	31
CLUPEA HARENGUS	41	4	24	13	59
ANCHOA SP.	1	-	1	-	100
ANCHOA HEPSETUS	2	-	2	-	100
ANCHOA MITCHILLI	10394	845	8053	1496	77
SYNODUS FOETENS	8	3	4	1	50
OPSANUS TAU	149	129	10	10	7
MERLUCCIUS BILINEARIS	5	2	-	3	-
UROPHYCIS CHUSS	1	-	-	1	-
UROPHYCIS REGIUS	21	10	6	5	29
UROPHYCIS TENUIS	1	-	1	-	100
RISSOLA MARGINATA	229	119	34	76	15
STRONGYLURA MARINA	2	-	-	2	-
CYPRINODON VARIEGATUS	4	2	-	2	-
FUNDULUS HETEROCLITUS	15	11	1	3	7
FUNDULUS MAJALIS	1	1	-	-	-
MENIDIA BERYLLINA	1	1	-	-	-
MENIDIA MENIDIA	3432	1193	1387	852	40
APELTES QUADRACUS	82	69	5	8	6
GASTEROSTEUS ACULEATUS	14	14	-	-	-
HIPPOCAMPUS ERECTUS	87	79	3	5	3
SYNGNATHUS FUSCUS	1940	1775	85	80	4
MORONE AMERICANA	145	84	10	51	7
CENTROPRISTIS STRIATA	9	3	-	6	-
POMATOMUS SALTATRIX	284	75	172	37	61
ALECTIS CRINITUS	1	-	1	-	100
CARANX CRYSOS	1	-	1	-	100
CARANX HIPPOS	18	-	14	4	78
SELAR CRUMENOPHTHALMUS	1	-	-	1	-
SELENE VOMER	47	6	20	21	43
VOMER SETAPINNIS	1	-	-	1	-
LUTJANUS GRISEUS	3	2	1	-	33
BAIRDIELLA CHRYSURA	106	38	38	30	36
CYNOSCION REGALIS	517	90	303	124	59
LEIOSTOMUS XANTHURUS	1077	279	744	54	69
MICROPOGON UNDULATUS	4	3	-	1	-
POGONIAS CROMIS	1	-	-	1	-
CHAETODON OCELLATUS	1	-	-	1	-
TAUTOGA ONITIS	15	12	-	3	-
MUGIL SP.	1	-	1	-	100
MUGIL CEPHALUS	1	-	-	1	-
MUGIL CUREMA	4	-	2	2	50
ASTROSCOPUS GUTTATUS	18	8	1	9	6
CHASMODES BOSQUIANUS	2	2	-	-	-
HYPSOBLENNIUS HENTZI	2	2	-	-	-
AMMODYTES SP.	5	2	-	3	-

TABLE 12. (CONT.)

SPECIES	NUMBER	LIVE	DEAD	DAMAGED	% DEAD
GOBIOSOMA SP.	2	-	2	-	100
GOBIOSOMA BOSCI	66	12	52	2	79
GOBIOSOMA GINSBURGI	5	3	2	-	40
PEPRILUS TRIACANTHUS	4	-	4	-	100
PRIONOTUS CAROLINUS	14	4	5	5	36
PRIONOTUS EVOLANS	448	241	120	87	27
MYOXOCEPHALUS AENAEUS	1	1	-	-	-
ETROPUS MICROSTOMUS	558	314	99	145	18
PARALICHTHYS DENTATUS	130	74	14	42	11
SCOPHTHALMUS AQUOSUS	45	33	6	6	13
PSEUDOPLEURONECTES AMERICANUS	69	40	15	14	22
TRINECTES MACULATUS	29	25	-	4	-
SYMPHURUS PLAGIUSA	2	2	-	-	-
ALUTERUS SCHOEPFI	5	3	1	1	20
MONACANTHUS HISPIDUS	25	15	4	6	16
LACTOPHRYS TRIQUETER	1	-	-	1	-
SPHOEROIDES MACULATUS	59	53	6	-	10
FISH FRAGMENTS	1	-	1	-	100
AEQUOREA SPP	4	-	-	4	-
CYANEA CAPILLATA	3	2	-	1	-
ORDER ACTINIARIA	1	-	-	1	-
LOLLIGUNCULA BREVIS	83	24	28	31	34
CLASS POLYCHAETA	88	61	6	21	7
FAMILY SYLLIDAE	1	1	-	-	-
SCOLECOLEIDES VIRIDIS	1	1	-	-	-
LIMULUS POLYPHEMUS	39	33	-	6	-
ORDER STOMATOPODA	1	1	-	-	-
SQUILLA EMPUSA	11	9	1	1	9
PENAEUS SETIFERUS	1	1	-	-	-
PENAEUS AZTECUS	58	53	2	3	3
PALAEMONETES VULGARIS	1794	1582	127	85	7
PALAEMONETES PUGIO	12	10	1	1	8
PALAEMONETES SPP	52	26	13	13	25
CRANGON SEPTEMSPINOSA	11792	9222	1542	1028	13
PAGURUS LONGICARPUS	1	-	-	1	-
LIBINIA EMARGINATA	2	2	-	-	-
LIBINIA DUBIA	16	14	-	2	-
CANCER IRRORATUS	17	13	1	3	6
OVALIPES OCELLATUS	133	92	9	32	7
PORTUNUS GIBBESI	11	5	2	4	18
CALLINECTES SAPIDUS	16726	10528	1344	4854	8
CALLINECTES SIMILIS	96	61	5	30	5
FAMILY XANTHIDAE	24	20	3	1	13
NEOPANOPE TEXANA	54	44	-	10	-
EURYPANOPEUS DEPRESSUS	4	3	1	-	25
PHYLUM NEMERTEA	14	12	-	2	-
TOTALS	53054	27771	15045	10238	28

Table 13. Percent dead (by month) of selected fishes and invertebrates impinged at the Oyster Creek Generating Station, Forked River, New Jersey from 8 September, 1975 through 3 September, 1976.

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		8 Sept. 75– 3 Sept. 76	
	%	Number Present	%	Number Present	%	Number Present	%	Number Present	%	Number Present	%	Number Present	%	Number Present	%	Number Present	%	Number Present	%	Number Present	%	Number Present	%	Total Number
Alosa aestivalis	75	4	100	1	0	6	49	490	34	289	43	47	56	48	44	16	-	-	-	-	-	-	44	911
Brevoortia tyrannus	33	3	0	[illegible]	27	11	26	535	17	6	50	30	46	24	25	12	54	121	86	22	100	9	31	777
Anchoa mitchilli	91	70	79	613	51	196	64	80	68	848	73	5988	89	1653	90	634	98	158	99	278	99	108	77	10394
Menidia menidia	-	-	100	2	43	46	30	1228	51	1951	61	170	81	142	56	9	100	1	-	-	-	-	40	3432
Gasterosteus aculeatus	-	-	-	-	-	-	-	-	0	13	0	1	-	-	-	-	-	-	-	-	-	-	0	14
Syngnathus fuscus	33	3	10	10	4	287	4	790	4	519	3	187	3	94	21	38	0	14	0	5	0	1	4	1940
Pomatomus saltatrix	50	6	10	9	0	13	67	3	-	-	-	-	58	66	60	150	79	14	86	21	100	8	61	284
Cynoscion regalis	57	30	51	90	38	179	56	9	-	-	-	-	-	-	0	1	100	10	80	167	74	31	59	517
Prionotus evolans	20	25	14	106	6	116	23	34	-	-	-	-	0	1	0	3	0	1	57	93	99	69	27	448
Paralichthys dentatus	20	10	10	31	2	53	20	10	0	1	0	2	0	7	0	4	33	3	40	5	75	4	11	130
Pseudopleuronectes americanus	-	-	-	-	0	9	0	10	0	17	25	4	0	3	52	21	57	7	-	-	-	-	22	69
Sphoeroides maculatus	0	9	0	7	0	1	-	-	-	-	-	-	11	18	0	3	0	1	13	15	40	5	10	59
Palaemonetes vulgaris	0	1	40	5	8	176	9	581	7	536	2	66	17	30	5	372	8	12	0	3	-	-	7	1794
Crangon septemspinosa	-	-	25	28	18	444	15	8217	10	1170	9	537	5	450	4	1031	22	9	-	-	-	-	13	11972
Callinectes sapidus	12	2133	9	2434	3	1402	4	306	1	449	0	612	6	640	7	2743	9	2806	11	2804	8	345	8	16726

Table 14 . Total impingement estimate by week, with number of specimens impinged per hour, total intake cooling water flow, and total number impinged per million gallons of cooling water flow at Oyster Creek Generating Station, Forked River, New Jersey from 7 September 1975 through 4 September 1976.

Date	Weekly Estimated #	#/Hr	Weekly Gal x 10^6	#/Gal x 10^6
September 7 - 13	7,632	45	3479	2
14 - 20	12,542	75	3479	4
21 - 27	10,666	63	2554	4
September 28 - Oct. 4	6,928•	41	1301	5
October 5 - 11	14,503	86	3139	5
12 - 18	5,299	32	3479	2
19 - 25	31,865	190	3479	9
26 - Nov. 1	8,738	52	3479	3
November 2 - 8	6,510	39	3479	2
9 - 15	21,364	127	3479	6
16 - 22	7,266	43	3479	2
23 - 29	20,362•	121	1105	18
30 - Dec. 6	420,044	2500	2656	158
December 7 - 13	197,018	1173	3479	57
14 - 20	219,380	1306	3263	67
21 - 27	636,350	3788	3215	198
March 7 - 13	97,603	581	3479	28
14 - 20	70,642	420	3479	20
21 - 27	129,327	770	4207	31
28 - April 3	140,334	835	4634	30
April 4 - 10	230,467	1372	4634	50
April 11 - 17	230,441	1372	4634	50
18 - 24	609,754	3629	4634	132
25 - May 1	298,473	1777	4634	64
May 2 - 8	1,132,688	6742	4634	244
9 - 15	326,992	1946	4634	71
16 - 22	101,019	601	4564	22
23 - 29	328,492	1955	4564	72
30 - June 5	1,013,238	6031	4148	244
June 6 - 12	155,032	923	4541	34
13 - 19	1,176,875	7005	4634	254
20 - 26	392,707	2338	4634	85
27 - July 3	205,676	1224	4631	44
July 4 - 10	205,725	1225	4634	44
11 - 17	110,279	656	4634	24
18 - 24	500,511	2979	4634	108
25 - 31	139,602	831	4634	30
August 1 - 7	144,257	859	4634	31
8 - 14	260,076	1548	4634	56
15 - 21	331,804	1975	4634	72
22 - 28	51,641	307	4634	11
29 - Sept. 4	94,198	561	4634	20
Totals	10,104,320	1432	165,572	61

• Portion of estimate from previous week.

Table 15. Results of a stepwise multiple regression analysis for the most common species and for all species combined that were impinged from 8 September, 1975 through 3 September, 1976.

Species	Number of Observations	R^2	REGRESSION EQUATION Water Temperature	Salinity	Oxygen	PH	Time Of Day	Wind Speed	Wind Direction	Screens	Water Flow
Alosa aestivalis	329	0.371	-0.148	-	-0.302	-	0.303	-	-	-	0.007
Brevoortia tyrannus	396	0.314	-	-	-	-0.486	0.173	0.131	-	-	-
Anchoa mitchilli	731	0.610	-0.105	-0.366	-	1.110	0.442	0.172	-	-0.726	0.029
Menidia menidia	410	0.432	-0.203	-	-	-	0.170	0.268	-0.083	-0.395	0.005
Syngnathus fuscus	554	0.371	-0.054	-	0.133	-	0.435	0.244	-0.080	0.362	-
Pomatomus saltatrix	275	0.398	-	-	-	-	0.123	-	-0.087	-1.181	0.007
Cynoscion regalis	272	0.211	-	-0.162	-	0.456	0.208	-	-	-	0.009
Prionotus evolans	286	0.192	-	-0.162	-	0.584	0.283	-	-	-	0.004
Paralichthys dentatus	301	0.030	-	-	-0.079	-	0.144	0.162	-	-	-
Pseudopleuronectes americanus	143	0.280	0.049	-0.062	-	-		-	-	-1.284	-
Palaemonetes vulgaris	461	0.275	-0.070	-	-	-	0.843	-	-	-	0.008
Crangon septemspinosa	544	0.316	-0.163	0.201	-	-0.798	1.023	0.407	-0.130	-	0.009
Callinectes sapidus	753	0.680	0.112	-	-0.108	0.349	1.001	0.248	-	-0.280	0.013
All Species Combined	856	0.599	-0.109	-	-0.167	-	0.820	0.284	-0.060	0.305	0.016

Table 16. Number of fishes and macroinvertebrates collected before and after passage through the screenwash flume from October 1975 through August 1976.

Species	October - December 1975 Before Screenwash Flume	October - December 1975 At Discharge of Screenwash Flume	March - April 1976 Before Screenwash Flume	March - April 1976 At Discharge of Screenwash Flume	May - August 1976 Before Screenwash Flume	May - August 1976 At Discharge of Screenwash Flume	Total Before Screenwash Flume	Total At Discharge of Screenwash Flume
Penaeus aztecus	0	1	-	-	-	-	0	1
Paleomonetes vulgaris	4	2	-	-	-	-	4	2
Crangon septemspinosa	0	2	-	-	3	0	3	2
Ovalipes ocellatus	1	4	-	-	-	-	1	4
Callinectes sapidus	27	108	-	-	20	40	47	144
Callinectes similis	1	0	-	-	-	-	1	0
Neopanope texana	1	1	-	-	-	-	1	1
Lolliguncula brevis	-	-	-	-	4	0	4	0
Anguilla rostrata	0	1	-	-	-	-	0	1
Alosa aestivalis	-	-	16	19	4	0	20	19
Brevoortia tyrannus	10	3	-	-	7	12	17	15
Anchoa mitchilli	9	19	404	302	22	25	435	346
Opsanus tau	1	4	-	-	0	4	1	8
Urophycis sp.	1	0	-	-	-	-	1	0
Rissola marginata	3	0	-	-	3	4	6	4
Fundulus heteroclitus	-	-	-	-	0	32	0	32
Menidia menidia	37	2	27	32	1	14	65	48
Apeltes quadracus	1	0	1	3	-	-	2	3
Hippocampus erectus	2	0	-	-	-	-	2	0
Syngnathus fuscus	15	5	8	5	3	4	26	14
Morone americana	5	0	0	1	-	-	5	1
Centropristis striata	0	1	-	-	-	-	0	1
Pomatomus saltatrix	-	-	-	-	5	3	5	3
Selene vomer	0	1	-	-	-	-	0	1
Bairdiella chrysura	3	1	-	-	-	-	3	1
Cynoscion regalis	1	2	-	-	9	9	10	11
Leiostomus xanthurus	-	-	-	-	9	14	9	14
Micropogon undulatus	1	1	-	-	-	-	1	1
Tautoga onitis	1	0	-	-	-	-	1	0
Tautogolabrus adspersus	-	-	0	1	-	-	0	1
Gobiosoma bosci	2	0	-	-	-	-	2	0
Prionotus evolans	5	7	-	-	6	2	11	9
Etropus microstomus	6	1	-	-	-	-	6	1
Paralichthys dentatus	1	8	0	1	0	1	1	10
Scophthalmus aquosus	-	-	0	1	0	1	0	2
Pseudopleuronectes americanus	2	1	2	5	-	-	4	6
Trinectes maculatus	-	-	-	-	1	0	1	0
Monacanthus hispidus	0	1	-	-	-	-	0	1
Sphoeroides maculatus	-	-	-	-	3	2	3	2
Chilomycterus schoepfi	-	-	-	-	0	2	0	2
Number of Collections	6	8	5	4	14	10	25	22
Number of Taxa	23	22	6	10	15	16	44	48
Number of Specimens Collected	140	172	458	370	100	169	698	711

Table 17. Total numbers and condition (live, dead, damaged) of some fish and macroinvertebrates collected immediately before and after passage through the screenwash flume and subsequently held in ambient and condenser discharge water, from October 1975 through August 1976.

			1975						1976					
			October - December						March - April					
			Before Flume			After Flume			Before Flume			After Flume		
Species	Test Temperature	Mortalities	Live	Dead	Damg	Live	Dead	Damg	Live	Dead	Damg	Live	Dead	Damg
Crangon septemspinosa		Immediate	-	-	-	-	-	-	-	-	-	-	-	-
	Ambient	Delayed	-	-	-	-	-	-	-	-	-	-	-	-
	Heated Discharge	Delayed	-	-	-	-	-	-	-	-	-	-	-	-
Callinectes sapidus		Immediate	25	0	2	83	0	25	-	-	-	-	-	-
	Ambient	Delayed	24	1	2	81	2	25	-	-	-	-	-	-
	Heated Discharge	Delayed	-	-	-	-	-	-	-	-	-	-	-	-
Brevoortia tyrannus		Immediate	9	0	1	-	-	-	-	-	-	-	-	-
	Ambient	Delayed	2	8	0	-	-	-	-	-	-	-	-	-
	Heated Discharge	Delayed	-	-	-	-	-	-	-	-	-	-	-	-
Anchoa mitchilli		Immediate	5	3	1	7	8	4	3	242	93	8	225	65
	Ambient	Delayed	0	6	0	11	0	0	0	48	0	0	33	0
	Heated Discharge	Delayed	-	-	-	-	-	-	0	48	0	0	40	0
Rissola marginata		Immediate	3	0	0	-	-	-	-	-	-	-	-	-
	Ambient	Delayed	3	0	0	-	-	-	-	-	-	-	-	-
	Heated Discharge	Delayed	-	-	-	-	-	-	-	-	-	-	-	-
Menidia menidia		Immediate	18	19	0	-	-	-	15	8	3	5	3	4
	Ambient	Delayed	1	17	0	-	-	-	13	2	3	5	2	2
	Heated Discharge	Delayed	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus fuscus		Immediate	15	0	0	1	0	0	8	0	0	3	0	0
	Ambient	Delayed	13	2	0	0	1	0	6	1	0	3	0	0
	Heated Discharge	Delayed	-	-	-	-	-	-	0	1	0	-	-	-
Leiostomus xanthurus		Immediate	-	-	-	-	-	-	-	-	-	-	-	-
	Ambient	Delayed	-	-	-	-	-	-	-	-	-	-	-	-
	Heated Discharge	Delayed	-	-	-	-	-	-	-	-	-	-	-	-
Pseudopleuronectes americanus		Immediate	2	0	0	-	-	-	2	0	0	2	0	2
	Ambient	Delayed	1	1	0	-	-	-	2	0	0	2	0	2
	Heated Discharge	Delayed	-	-	-	-	-	-	-	-	-	-	-	-

Table 17. (cont.)

Species	Test Temperature	Mortalities	1976 May - August Before Flume Live	Dead	Damg	After Flume Live	Dead	Damg	1975 - 1976 Total Before Flume Live	Dead	Damg	After Flume Live	Dead	Damg
Crangon septemspinosa		Immediate	3	0	0	-	-	-	3	0	0	-	-	-
	Ambient	Delayed	-	-	-	-	-	-	-	-	-	-	-	-
	Heated Discharge	Delayed	-	-	-	-	-	-	-	-	-	-	-	-
Callinectes sapidus		Immediate	8	0	0	22	0	0	33	0	2	105	0	25
	Ambient	Delayed	4	0	0	8	3	0	28	1	1	89	5	25
	Heated Discharge	Delayed	4	0	0	9	2	0	4	0	0	9	2	0
Brevoortia tyrannus		Immediate	2	0	5	9	3	0	11	0	6	9	3	0
	Ambient	Delayed	0	7	0	0	3	0	2	15	0	0	3	0
	Heated Discharge	Delayed	0	0	0	0	6	0	0	0	0	0	6	0
Anchoa mitchilli		Immediate	1	8	6	0	21	0	9	253	100	15	254	69
	Ambient	Delayed	0	3	0	0	0	0	0	57	0	11	33	0
	Heated Discharge	Delayed	0	4	0	0	0	0	0	52	0	0	40	0
Rissola marginata		Immediate	3	0	0	0	0	2	6	0	0	0	0	2
	Ambient	Delayed	1	0	0	0	0	1	4	0	0	0	0	1
	Heated Discharge	Delayed	0	2	0	0	0	1	0	2	0	0	0	1
Menidia menidia		Immediate	-	-	-	12	0	0	33	27	3	17	3	4
	Ambient	Delayed	-	-	-	5	1	0	14	19	3	10	3	2
	Heated Discharge	Delayed	-	-	-	4	2	0	-	-	-	4	2	0
Syngnathus fuscus		Immediate	2	1	0	2	0	0	25	1	0	6	0	0
	Ambient	Delayed	0	1	0	0	1	0	19	4	0	3	2	0
	Heated Discharge	Delayed	0	1	0	0	1	0	0	2	0	0	1	0
Leiostomus xanthurus		Immediate	9	0	0	9	0	1	9	0	0	9	0	1
	Ambient	Delayed	4	0	0	2	1	0	3	0	0	2	1	0
	Heated Discharge	Delayed	0	5	0	1	6	0	0	5	0	1	6	0
Pseudopleuronectes americanus		Immediate	-	-	-	-	-	-	4	0	0	2	0	2
	Ambient	Delayed	-	-	-	-	-	-	3	1	0	2	0	2
	Heated Discharge	Delayed	-	-	-	-	-	-	-	-	-	-	-	-

Table 18 . Summary of heat shock studies performed from October 1975 through August 1976.

PRIMARY SPECIES

Bio #	Ambient Temp (°C)	Shock Temp (°C)	ΔT (°C)	L_{T50}	% Mortality Control	% Mortality Experimental
			Callinectes sapidus (blue crab)			
76-23	3.8	15.6	11.8	N/A	0.0	0.0
75-01	17.5	23.4	5.9	N/A	7.6	7.1
76-41	18.2	28.0	9.8	N/A	0.0	0.0
76-34	18.3	25.7	7.4	N/A	5.3	5.5
76-64	20.7	34.0	13.3	N/A	20.0	50.0
76-37	21.6	31.1	9.5	N/A	0.0	0.0
76-27	22.9	26.5	3.6	N/A	20.0	33.3
76-54	23.2	32.9	9.7	N/A	13.3	13.3
76-57	24.0	34.0	10.0	N/A	0.0	11.0
76-51	24.3	37.0	12.7	57 hrs	10.0	100.0
			Brevoortia tyrannus (Atlantic menhaden)			
76-03	4.8	24.5	19.7[b]	30 min	0.0	100.0
76-01	6.5	17.7	11.2[b]	N/A	100.0[c]	20.0
76-29	15.8	25.2	9.4	N/A	0.0	0.0
76-40	18.2	28.0	9.8	N/A	0.0	0.0
76-44	19.0	28.2	9.2	53 hrs	0.0	62.5
76-38	21.6	31.1	9.5	20 hrs	0.0	100.0
76-46	22.0	31.2	9.2	49 hrs	10.0	100.0
76-26[a]	22.9	26.5	3.6	N/A	0.0	30.0
76-55	23.1	32.9	9.8	7 hrs	6.3	100.0
76-60	23.4	33.5	10.1	37 min	0.0	100.0
76-58	24.4	34.7	10.3	17 min	2.6	100.0
76-53	24.8	35.0	10.2	13 min	0.0	100.0
76-49	26.0	37.0	11.0	3 min	10.0	100.0
			Anchoa mitchilli (bay anchovy)			
75-12	5.6	15.4	9.8	N/A	0.0	0.0
75-08	7.7	30.4	22.7[b]	8 min	0.0	100.0
75-09	7.7	25.0	17.3[b]	N/A	0.0	26.0
75-10	7.7	21.2	13.4[b]	N/A	0.0	14.0
75-15	7.7	19.8	12.1	N/A	0.0	5.0
75-07	9.8	21.0	11.2	N/A	5.1	1.6
76-21	10.1	18.0	7.9	N/A	65.0	83.0
75-04	15.7	24.7	9.0	N/A	0.0	0.0
76-3	15.8	25.2	9.4	43 hrs	10.5	73.7
75-03	16.2	23.8	7.6	N/A	0.0	0.0
76-35	-	25.7	8.0	-	45.8	100.0
76-39	-	31.1	9.5	-	43.3	100.0
76-45	22.0	31.2	9.2	5.25 hrs	3.9	100.0
76-48	22.5	37.3	14.8	1 min	0.0	100.0
75-06	24.2	29.3	5.1	29.5 hrs	0.0	66.7
76-50	24.5	37.0	12.5	3 min	38.9	100.0

Table 18. (cont.)

Bio #	Ambient Temp (°C)	Shock Temp (°C)	ΔT (°C)	L_{T50}	% Mortality Control	% Mortality Experimental
			Syngnathus fuscus (northern pipefish)			
76-02	1.0	17.7	16.7[b]	N/A	0.0	0.0
75-11	5.6	15.4	9.8	N/A	0.0	5.0
75-14	7.7	19.8	12.1	N/A	0.0	0.0[d]
76-25	7.9	15.6	7.7	87 hrs	0.0	62.5[d]
76-16	9.1	29.1	20.0[b]	5.5 min	0.0	100.0
76-19	10.8	19.6	8.8	N/A	0.0	26.6[d]
76-30	15.8	25.2	9.4	N/A	0.0	44.0[d]
76-36	17.0	25.7	8.7	N/A	20.0	20.0[d]
			Pseudopleuronectes americanus (winter flounder)			
76-10	0.0	16.0	16.0[b]	N/A	0.0	7.1
76-09	2.9	23.0	20.1[b]	2.75 hrs	0.0	93.3
76-11	5.0	23.0	18.0[b]	2.6 hrs	0.0	93.3
76-12	7.0	24.0	17.0[b]	4.75 hrs	0.0	73.3
76-14	7.6	23.6	16.0[b]	N/A	0.0	6.6
76-13	10.1	26.1	16.0[b]	0.9 hrs	0.0	100.0
76-59	19.6	32.9	13.3	1.6 min	0.0	100.0
			SECONDARY SPECIES			
			Crangon septemspinosa (sand shrimp)			
76-05	-0.6	24.0	24.6[b]	5 min	0.0	90.0
76-06	0.1	22.4	22.3[b]	N/A	0.0	45.0
76-07	1.6	23.2	21.6[b]	19 min	6.9	73.3
76-15	6.2	26.2	20.1[b]	N/A	3.1	40.0
			Alosa aestivalis (blueback herring)			
76-24	7.9	15.6	7.7	N/A	0.0	7.1
76-31	15.8	25.2	9.4	N/A	6.6	12.5
76-28	22.9	26.5	3.6	14.5 hrs	40.0	100.0
			Menidia menidia (Atlantic silverside)			
75-13	5.6	15.4	9.8	N/A	5.0	16.0
75-16	7.7	19.8	12.1	N/A	0.0	25.0
76-17	9.1	29.1	20.0[b]	15 min	0.0	95.0
75-05	12.3	22.8	10.5	N/A	0.0	0.0
75-02	15.9	21.5	5.6	N/A	0.0	3.0
76-42	18.2	28.0	9.8	N/A	25.0	18.9
76-63	24.6	34.9	10.3	2.67 hrs	100.0	100.0
			Apeltes quadracus (four spine stickleback)			
76-18	9.1	29.1	20.0[b]	2.25 hrs	0.0	100.0
76-20	9.8	18.5	8.7	N/A	0.0	0.0

Table 18. (cont.)

Bio #	Ambient Temp (°C)	Shock Temp (°C)	ΔT (°C)	L_{T50}	% Mortality Control	% Mortality Experimental
			Morone americana (white perch)			
76-04	1.0	24.5	23.5[b]	50 min	0.0	70.0
76-08	1.6	23.2	21.6[b]	2 hrs	0.0	60.0
			Pomatomus saltatrix			
76-43	19.0	27.9	8.9	86 hrs	33.3[f]	86.9
76-56	24.0	34.0	10.0	49 min	0.0	100.0
76-62	25.3	35.5	10.2	57 min	30.0[f]	100.0
76-47	26.7	37.3	10.6	1 min	0.0	100.0
			Leiostomus xanthurus (spot)			
76-52	25.2	36.0	10.8	52 min	0.0	100.0
76-52	27.7	35.5	7.8	7 hrs	75.0	100.0

a Temperature parameters abnormal (natural causes)
b Simulated discharge.
c Below lower lethal limit.
d Large loss of equilibrium due to gas bubble disease.
e Control mortality due to cannabalism.
f Control mortality due to low O_2 values in control tanks.

Table 19. The effects of sudden temperature increases on the blue crab in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (C)	Control Temperature (C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
6 Oct 75	26.3-70.1	18.5	0	0	0	0	0	23.4	17.5	14	0	0	13	0	0
			24	0	0	0	0	22.9	17.7	13	1	0	13	0	0
			56	0	0	0	0	23.1	18.2	23	1	0	12	1	0
12 Apr 76	18.55-42.70	21.0	0	0.03	0.03	0	0	15.6	3.8	16	-	-	16	-	-
			96	0.03	0.03	0	0	21.0	13.2	16	0	0	16	0	0
19 Apr 76	23.85-46.85	21.5	0	0.06	0.06	0	0	26.5	22.9	14	-	-	15	-	-
			24	0.05	0.05	0	0	27.4	23.6	14	0	0	14	1	0
			28	-	-	-	-	29.8	25.8	14	0	0	13	2	0
			48	0.06	0.06	0	0	28.2	25.4	14	0	0	12	3	0
			80	0.08	0.08	0	0	30.5	21.5	13	1	0	12	3	0
			96	0.05	0.05	0	0	28.3	19.5	9	5	0	12	3	0
10 May 76	21.0-63.3	22.0	0	0	0	0	0	25.9	18.3	18	-	-	19	-	-
			8	0.04	0.04	0	0	27.4	18.0	17	1	0	19	0	0
			72	0.04	0.04	0	0	25.1	16.2	17	1	0	18	1	0
			96	0.03	0.03	0	0	27.3	19.2	17	1	0	18	1	0
17 May 76	22.8-50.1	22.0	0	0	0	0	0	31.1	21.6	10	-	-	10	-	-
			96	0	0	0	0	26.8	17.2	10	0	0	10	0	0
24 May 76	24.6-57.0	23.6	0	0.04	0.04	0	0	28.0	18.2	10	-	-	10	-	-
			96	0	0	0	0	28.0	18.6	10	0	0	10	0	0
28 June 76	34.5-85.1	26.6	0	0.05	0.05	0	0	37.0	24.3	10	-	-	10	-	-
			1	-	-	-	-	36.5	26.3	9	1	0	10	0	0
			24	0.03	0.03	0	0	36.9	26.5	9	1	0	9	1*	0
			48	0	0	0	0	36.9	26.5	7	3	0	9	1	0
			52	-	-	-	-	37.2	26.9	6	4	0	9	1	0
			56	0.05	0.05	0	0	38.0	26.9	6	4	1**	9	1	0
			72	0.03	0.03	0	0	36.5	26.1	2	8	0	9	1	0
			96	0.04	0.04	0	0	36.7	26.2	2	8	0	9	1	0
13 July 76	29.8-82.9	26.0	0	0	0	0	0	32.9	23.2	15	-	-	15	-	-
			24	0.02	0.02	0	0	32.0	22.1	14	1	0	15	0	0
			56	0.03	0.03	0	0	34.0	23.8	14	1	0	14	1	0
			72	0.03	0.03	0	0	34.6	24.6	14	1	0	13	2	0
			96	0.03	0.03	0	0	33.7	25.9	13	2	0	13	2	0

Table 19. (cont.)

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (C)	Control Temperature (C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
19 July 76	66.9-96.0	27.1	0	0.02	0.02	0	0	34.0	24.0	9	-	-	10	-	-
			76	0.03	0.03	0	0	34.4	24.5	8	1	0	10	0	0
			96	0.02	0.02	0	0	33.7	21.7	8	1	0	10	0	0
30 Aug 76	36.8-68.4	24.6	0	0.06	0.06	0	0	34.0	20.7	10	-	-	10	-	-
			1	-	-	-	-	34.2	23.9	9	1	0	10	0	0
			6	-	-	-	-	34.8	24.8	8	2	0	10	-	-
			7	-	-	-	-	34.8	24.8	7	3	0	10	0	0
			24	0.06	0.06	0	0	32.5	21.7	7	3	0	9	1	0
			48	0.03	0.03	0.03	0.03	32.6	24.5	7	3	0	8	2	0
			55	0.04	0.04	0	0	33.9	24.0	6	4	0	8	2	0
			96	0.04	0.04	0	0	31.2	20.8	5	5	0	8	2	0

* mortality due to molting (canabalism)

** dark coloration (stressed)

Table 20. The effects of sudden temperature increases on Atlantic menhaden in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (C)	Control Temperature (°C)	Experimental No. Live	Experimental No. Dead	Experimental No. with Loss of Equilibrium	Control No. Live	Control No. Dead	Control No. with Loss of Equilibrium
5 Jan 76	77.5-126.5	20.0	0	0	0	0	0	17.7	6.5	14	-	-	15	-	-
			1	-	-	-	-	17.4	3.0	14	0	0	15	0	4
			2	-	-	-	-	17.7	1.0	14	0	0	15	0	12
			3	-	-	-	-	17.8	1.0	14	0	0	15	0	14
			5	-	-	-	-	17.6	1.0	14	0	0	15	0	10
			6	-	-	-	-	17.8	1.0	14	0	0	15	0	9
			7	-	-	-	-	17.9	1.0	14	0	0	15	0	7
			8	0	0	0	0	18.0	1.1	14	0	0	15	0	5
			24	0	0	0	0	20.2	0.9	14	0	0	13	2	11
			28	-	-	-	-	20.4	1.3	14	0	0	13	2	12
			32	0	0	0	0	20.8	1.5	14	0	1	13	2	12
			48	0	0	0	0	20.0	1.0	12	2	1	3	12	3
			52	-	-	-	-	20.1	1.2	12	2	0	3	12	0
			56	0	0	0	0	20.1	1.1	12	2	0	3	12	3
			72	0	0	0	0	20.0	1.6	11	3	0	3	12	3
			76	-	-	-	-	19.9	1.1	11	3	0	2	13	2
			96	0	0	0	0	19.5	0.5	11	3	0	0	15	-
12 Jan 76	91.1-114.5	19.0	0	0	0	0	0	24.5	4.8	10	-	-	10	-	-
			1	-	-	-	-	24.8	5.1	1	9	1	10	0	0
			2	-	-	-	-	24.9	5.2	0	10	-	10	0	0
			96	-	-	0	0	-	5.3	0	10	-	10	0	0
19 Apr 76	154-219	21.5	0	0.06	0.06	0	0	26.5	22.9	10	-	-	10	-	-
			8	0.05	0.05	0	0	28.0	25.0	8	2	0	10	0	0
			54	-	-	-	-	28.9	19.9	7	3	0	10	0	0
			96	0.05	0.05	0	0	28.3	19.5	7	3	0	10	0	0
26 Apr 76	152-213	22.5	0	0.05	0.05	0	0	25.2	15.8	11	-	-	9	-	-
			96	0	0	0	0	23.2	14.7	11	0	0	9	0	0

Table 20. (cont.)

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (C)	Temperature (C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
17 May 76	-	22.2	0	0	0	0	0	31.1	21.6	10	-	-	10	-	-
			24	0.03	0.03	0	0	31.2	21.4	4	6	2	10	0	0
			28	-	-	-	-	31.6	21.7	1	9	1	10	0	0
			32	0	0	0	0	31.4	21.6	0	10	-	10	0	0
			96	0	0	0	0	26.8	17.2	-	-	-	10	0	0
24 May 76	159-212	23.6	0	0.04	0.04	0	0	28.0	18.2	8	-	-	8	-	-
			96	0	0	0	0	28.0	18.6	8	0	0	8	0	0
7 June 76	178-272	22.9	0	0.04	0.04	0	0	28.2	19.0	16	-	-	15	-	-
			52	-	-	-	-	31.0	22.5	15	1	0	15	0	0
			72	0.03	0.03	0	0	32.5	22.3	9	7	2	15	0	0
			76	-	-	-	-	33.3	23.5	7	9	2	15	0	0
			80	0.03	0.03	0	0	34.6	24.2	6	10	0	15	0	0
			96	0.03	0.03	0	0	33.7	24.2	6	10	0	15	0	0
14 June 76	162-265	24.2	0	0	0	0	0	31.2	22.0	10	-	-	10	-	-
			24	0	0	0	0	31.8	22.4	9	1	1	10	0	0
			28	-	-	-	-	31.5	22.5	9	1	1	10	0	0
			32	0	0	0	0	32.5	23.5	8	2	2	10	0	0
			48	0	0	0	0	33.2	22.0	6	4	0	10	0	0
			52	-	-	-	-	-	25.0	3	7	2	10	0	0
			56	-	-	-	-	-	26.0	1	9	1	9	1	0
			72	0.02	0.02	0	0	-	23.8	0	10	0	9	0	0
			96	-	-	-	-	-	20.0	-	-	-	9	0	0
28 June 76	57.0-70.7	26.6	0	0.05	0.05	0	0	37.0	26.0	20	-	-	20	-	-
			1	-	-	-	-	36.5	26.3	0	20	-	20	0	0
			96	0.04	0.04	0	0	36.7	26.2	-	-	-	20	0	0
6 July 76	66.6-73.0	26.8	0	0.02	0.02	0	0	35.0	24.8	38	-	-	40	-	-
			1	-	-	-	-	35.4	25.4	0	38	-	40	0	0
			96	0.04	0.04	0	0	36.3	25.4	-	-	-	40	0	0
13 July 76	64.2-99.0	27.0	0	0	0	0	0	32.9	23.1	13	-	-	16	-	-
			4	-	-	-	-	33.2	23.3	9	4	0	16	0	0
			5	-	-	-	-	33.2	23.2	8	5	0	16	0	0
			6	-	-	-	-	33.1	23.2	8	5	1	16	0	0
			8	0	0	0	0	32.4	23.0	6	7	0	16	0	0

Table 20. (cont.)

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
13 July 76			48	0.05	0.05	0	0	32.0	22.5	0	-	-	16	0	0
			96	0.03	0.03	0	0	33.7	25.9	-	-	-	15	1	0
19 July 76	-	27.1	0	0.02	0.02	0	0	34.7	24.4	19	-	-	39	-	-
			1	-	-	-	-	34.6	24.3	0	19	-	39	0	0
			68	0.02	0.02	0	0	35.3	23.9	0	19	-	38	1	0
			96	0.02	0.02	0	0	33.7	21.7	0	19	-	38	1	0
26 July 76	66.8-86.0	27.2	0	0.02	0.02	0	0	33.5	23.4	10	-	-	10	-	-
			1	-	-	-	-	33.6	23.8	0	10	-	10	-	-
			96	0.03	0.03	0	0	25.0	24.9	-	-	-	10	-	-

Table 21. The effects of sudden temperature increases on the bay anchovy in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

Date	Size Range (mm)	Salinity (ppt)	Time From Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
20 Oct 75	35.0-45.5	18.0	0	0	0	0	0	23.8	16.2	29	-	-	30	-	-
			96	0	0	0	0	24.1	16.2	29	0	0	30	0	0
28 Oct 75	31.8-46.2	19.0	0	0	0	0	0	24.7	15.7	28	-	-	30	-	-
			96	0	0	0	0	20.9	12.0	28	0	0	30	0	0
10 Nov 75	21.9-49.4	20.0	0	0	0	0	0	29.3	24.2	55	-	-	60	-	-
			7	-	-	-	-	29.8	24.8	54	1	0	60	0	0
			24	0.03	0.03	0	0	27.3	19.7	29	26	21	60	0	0
			27	-	-	-	-	28.0	16.8	28	27	18	60	00	0
			31	0	0	0	0	28.0	16.8	26	29	12	60	0	0
			48	0.03	0.03	0	0	26.1	15.0	22	33	7	60	0	0
			52	-	-	-	-	26.8	15.5	19	36	4	60	0	0
			56	0	0	0	0	27.0	16.1	19	36	2	60	0	0
18 Nov 75	26.1-42.3	20.0	0	0	0	0	0	21.0	9.8	61	-	-	59	-	-
			4	-	-	-	-	21.7	10.5	61	0	0	59	0	1
			24	0	0	0	0	20.9	9.5	61	0	0	58	1	0
			32	0	0	0	0	21.8	10.1	61	0	0	57	2	0
			48	0.03	0.05	0	0	21.8	10.8	61	0	0	56	3	0
			56	0.06	0.06	0	0	22.3	11.9	60	1	1	56	3	0
			96	0.05	0.07	0	0	20.4	9.4	60	1	0	56	3	0
2 Dec 75	26.4-43.4	21.0	0	0	0	0	0	30.4	7.7	18	-	-	32	-	-
			1	0	0	0	0	30.4	7.7	0	18	-	32	0	0
2 Dec 75	27.0-65.0	21.0	0	0	0	0	0	25.0	7.7	20	-	-	15	-	-
			1	-	-	-	-	25.0	7.8	19	1	0	15	0	0
			2	-	-	-	-	25.2	7.9	19	1	1	15	0	0
			4	-	-	-	-	24.4	7.8	18	2	1	15	0	0
			24	0	0	0	0	30.0	7.4	17	3	1	15	0	0
			31	0	0	0	0	24.1	7.4	17	3	3	15	0	0
			48	0	0	0	0	29.8	6.2	15	5	0	15	0	0
			96	0	0	0	0	26.4	5.8	15	5	1	15	0	0
2 Dec 75	29.5-49.7	21.0	0	0	0	0	0	21.2	7.7	14	-	-	14	-	-
			7	-	-	-	-	21.2	8.0	14	0	2	14	0	0
			24	0	0	0	0	30.0	7.4	14	0	1	14	0	0

Table 21. (cont.)

				Chlorine						EXPERIMENTAL			CONTROL		
			Time From	Experimental		Control		Experimental	Control			No. with			No. with
	Size Range	Salinity	Start					Temperature	Temperature	No.	No.	Loss of	No.	No.	Loss of
Date	(mm)	(ppt)	(hrs)	Free	Total	Free	Total	(°C)	(°C)	Live	Dead	Equilibrium	Live	Dead	Equilibrium
2 Dec 75			28	-	-	-	-	21.6	7.3	13	1	0	14	0	0
			72	0	0	0	0	19.1	4.7	12	2	0	14	0	0
8 Dec 75	27.2-67.8	21.0	0	0	0	0	0	15.4	5.6	21	-	-	21	-	-
			96	0	0	0	0	14.4	6.1	21	0	0	21	0	0
15 Dec 75	27.1-61.8	21.0	0	0	0	0	0	19.8	7.7	20	-	-	20	-	-
			8	0.02	0.02	0	0	20.7	9.8	20	0	1	20	0	0
			24	0	0	0	0	20.0	9.8	19	1	0	20	0	0
5 Apr 76	46.05-74.25	21.0	0	0	0	0	0	18.0	10.1	18	-	-	20	-	-
			2	-	-	-	-	18.2	9.8	18	0	2	20	0	0
			3	-	-	-	-	18.6	9.9	17	1	2	20	0	1
			4	-	-	-	-	19.9	10.2	17	1	4	20	0	1
			5	-	-	-	-	19.9	10.6	16	2	2	20	0	2
			6	-	-	-	-	19.9	11.0	15	3	2	20	0	3
			7	-	-	-	-	20.0	11.2	13	5	2	20	0	3
			8	0.04	0.08	0	0	20.0	11.1	12	6	0	20	0	5
			24	0.04	0.04	0	0	18.9	10.4	11	7	0	12	8	2
			28	-	-	-	-	19.9	11.3	11	7	0	12	8	3
			32	0.03	0.03	0	0	20.3	11.4	11	7	0	11	9	2
			48	0	0	0	0	19.3	10.8	8	10	1	8	12	0
			72	0.02	0.02	0	0	18.7	10.3	4	14	1	8	12	1
			76	-	-	-	-	19.3	10.7	4	14	1	8	12	0
			96	0.03	0.03	0	0	18.0	9.8	3	15	0	7	13	0
26 Apr 76	47.6-72.3	22.5	0	0.05	0.05	0	0	25.2	15.8	19	-	-	19	-	-
			24	0.05	0.05	0	0	22.2	12.8	15	4	0	19	0	0
			48	0.04	0.04	0	0	21.3	12.2	8	11	0	19	0	0
			56	0	0	0	0	22.7	13.0	7	12	0	19	0	0
			72	0.05	0.05	0	0	21.5	13.2	6	13	0	19	0	0
			76	-	-	-	-	21.5	13.2	5	14	0	19	0	0
			96	0	0	0	0	23.2	14.7	5	14	0	17	2	0

Table 21. (cont.)

Date	Size Range (mm)	Salinity (ppt)	Time From Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
10 May 76	38.8-67.0	22.0	0	0	0	0	0	25.7	17.1	35	-	-	24	-	-
			1	-	-	-	-	25.9	16.2	32	3	4	24	0	0
			2	-	-	-	-	26.3	16.5	27	8	4	24	0	1
			3	-	-	-	-	26.5	16.8	22	13	1	24	0	1
			4	-	-	-	-	26.8	17.2	20	15	0	23	1	0
			5	-	-	-	-	27.0	17.6	19	16	0	23	1	1
			7	-	-	-	-	27.2	18.0	19	16	1	23	1	1
			8	0.04	0.04	0	0	27.4	18.0	19	16	1	22	2	0
			24	0.03	0.03	0	0	27.7	18.4	6	29	0	22	2	0
			28	-	-	-	-	28.9	19.6	6	29	2	22	2	0
			32	0.02	0.02	0	0	29.5	20.0	5	30	0	21	3	0
			48	0	0	0	0	27.9	18.8	4	31	0	18	6	0
			52	-	-	-	-	27.5	18.0	4	31	0	18	6	1
			56	0.02	0.02	0	0	27.8	18.9	4	31	0	18	6	2
			72	0.04	0.04	0	0	75.1	16.2	0	35	-	18	6	2
			96	0.03	0.03	0	0	27.3	19.2	-	-	-	13	11	0
17 May 76	41.3-70.4	22.2	0	0	0	0	0	31.1	21.6	30	-	-	30	-	-
			1	-	-	-	-	31.0	21.5	9	21	9	30	0	0
			2	-	-	-	-	31.0	21.5	4	26	0	30	0	0
			4	-	-	-	-	31.2	21.2	3	27	0	26	4	0
			5	-	-	-	-	31.1	21.0	3	27	0	23	7	1
			6	-	-	-	-	31.0	21.1	3	27	0	23	7	0
			24	0.03	0.03	-	-	31.2	21.4	1	29	0	21	9	0
			28	-	-	-	-	31.6	21.7	0	30	-	18	12	0
			32	0	0	0	0	31.4	21.5	-	-	-	17	13	0
			96	0	0	0	0	26.8	17.2	-	-	-	17	13	0
14 June 76	40.5-59.9	24.2	0	0	0	0	0	31.2	22.0	27	-	-	29	-	-
			1	-	-	-	-	31.3	22.0	27	0	3	29	0	0
			2	-	-	-	-	31.5	22.0	26	1	1	29	0	0
			3	-	-	-	-	31.5	22.0	23	4	2	29	0	0
			4	-	-	-	-	31.5	22.0	20	7	4	29	0	0

Table 21. (cont.)

Date	Size Range (mm)	Salinity (ppt)	Time From Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
14 June 76			5	-	-	-	-	31.5	22.1	15	12	5	29	0	0
			6	-	-	-	-	32.4	22.6	11	16	0	29	0	0
			7	-	-	-	-	32.6	22.4	10	17	1	29	0	0
			8	0.02	0.02	0	0	32.7	22.4	6	21	1	29	0	0
			24	0	0	0	0	31.8	22.4	0	27	-	29	0	0
			48	0	0	0	0	34.0	24.4	-	-	-	28	1	0
			96	-	-	-	-	-	24.0	-	-	-	28	1	0
21 June 76	50.3-66.0	24.2	0	0.03	0.03	0	0	37.3	22.5	12	-	-	16	-	-
			<1	-	-	-	-	37.3	25.0	0	12	-	15	0	0
			52	-	-	-	-	38.2	26.9	-	-	-	14	1	0
			96	0.04	0.04	0	0	36.7	25.8	-	-	-	14	1	0
28 June 76	43.7-65.9	26.6	0	0.05	0.05	0	0	37.0	24.5	20	-	-	18	-	-
			<1	-	-	-	-	36.5	26.3	0	20	-	18	0	0
			3	-	-	-	-	36.8	26.5	-	-	-	17	1	0
			24	0.03	0.03	-	-	36.9	26.5	-	-	-	16	2	0
			48	0	0	0	0	36.9	26.5	-	-	-	11	7	0
			96	0.04	0.04	0	0	36.7	26.2	-	-	-	11	7	0

Table 22 . The effects of sudden temperature increases on the northern pipefish in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

Date	Size Range (mm)	Salinity (ppt)	Time From Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
8 Dec 75	115-197	21.0	0	0	0	0	0	15.4	5.6	19	-	-	20	-	-
			48	0.02	0.02	0	0	18.3	8.4	19	0	1	20	0	0
15 Dec 75		21.0	0	0	0	0	0	19.8	7.7	19	-	-	20	-	-
			52	-	-	-	-	19.4	8.3	19	0	4	20	0	0
			72	0	0	0	0	16.8	7.5	19	0	3	20	0	0
			80	0	0	0	0	16.5	7.3	19	0	2	20	0	0
			96	0	0	0	0	14.8	4.7	19	0	1	20	0	0
5 Jan 76	-	21.3	0	0	0	0	0	17.7	6.5	10	-	-	10	-	-
			5	-	-	-	-	17.6	1.0	10	0	0	10	0	1
			6	-	-	-	-	17.8	1.0	10	0	0	10	0	1
			72	0	0	0	0	20.0	1.6	10	0	0	10	0	1
			76	-	-	-	-	19.9	1.1	10	0	0	10	0	1
			96	0	0	0	0	19.5	0.5	10	0	0	10	0	1
22 March 76	117-222	21.0	0	0	0	0	0	29.1	9.1	15	-	-	14	-	-
			1	-	-	-	-	-	8.7	0	15	0	14	0	0
			96	-	-	0	0	-	10.3	0	15	0	14	0	0
29 March 76	112-202	21.7	0	≤.02	≤.02	0	0	19.6	10.8	15	-	-	15	-	-
			24	0.06	0.06	0	0	20.5	11.9	15	0	2	15	0	0
			28	-	-	-	-	21.1	12.2	15	0	3	15	0	0
			32	0.05	0.05	0	0	23.6	14.0	15	0	6	15	0	0
			48	0.06	0.06	0	0	21.7	12.9	15	0	11	15	0	0
			52	-	-	-	-	21.3	11.9	13	2	10	15	0	0
			56	0.05	0.05	0	0	22.9	13.1	13	2	10	15	0	0
			72	0.03	0.03	0	0	23.1	13.7	12	3	10	15	0	0
			76	-	-	-	-	23.7	14.2	12	3	10	15	0	0
			80	0.04	0.04	0	0	22.9	13.5	11	4	9	15	0	0
			96	0.05	0.05	0	0	20.3	11.0	11	4	9	15	0	0
12 Apr 76	133-200	21.0	0	0.03	0.03	0	0	15.6	7.9	8	-	-	10	-	-
			48	0.02	0.02	0	0	17.6	10.4	7	1	1	10	0	0
			72	0.04	0.04	0	0	19.3	11.4	6	2	0	10	0	0

Table 22. (cont.)

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	Experimental No. Live	Experimental No. Dead	Experimental No. with Loss of Equilibrium	Control No. Live	Control No. Dead	Control No. with Loss of Equilibrium
			76	-	-	-	-	20.1	12.3	6	2	2	10	0	0
			80	0.02	0.02	0	0	21.0	16.0	6	2	3	10	0	0
			96	0.03	0.03	0	0	21.0	13.2	3	5	3	10	0	0
26 Apr 76	119-217	22.5	0	0.05	0.05	0	0	25.2	15.8	9	-	-	9	-	-
			72	0.05	0.05	0	0	21.5	13.2	8	1	0	9	0	0
			96	0	0	0	0	23.2	14.7	5	4	3	9	0	0
10 May 76	132-225	22	0	0	0	0	0	25.7	17.0	10	-	-	10	-	-
			48	0	0	0	0	27.9	18.8	10	0	0	10	0	1
			52	-	-	-	-	27.5	18.0	10	0	0	10	0	1
			56	0.02	0.02	0	0	27.8	18.9	10	0	0	9	1	0
			72	0.04	0.04	0	0	25.1	16.2	10	0	4	8	2	0
			76	-	-	-	-	26.4	17.0	10	0	6	8	2	0
			80	0.04	0.04	0	0	28.8	18.2	10	0	0	8	2	0
			96	0.03	0.03	0	0	27.3	19.2	8	2	2	8	2	0

Table 23 . The effects of sudden temperature increases of winter flounder in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

				Chlorine				Experimental	Control	Experimental			Control		
			Time from	Experimental		Control		Temperature	Temperature			No. with			No. with
Date	Size Range (mm)	Salinity (ppt)	Start (hrs)	Free	Total	Free	Total	(^{o}C)	(^{o}C)	No. Live	No. Dead	Loss of Equilibrium	No. Live	No. Dead	Loss of Equilibrium
2 Feb 76	163-231	19.2	0	0	0	0	0	23.0	2.9	15	-	-	15	-	-
			1	-	-	-	-	23.0	2.4	14	1	0	15	0	0
			2	-	-	-		23.0	2.3	11	4	1	15	0	0
			3	-	-	-	-	23.0	2.2	6	9	0	15	0	0
			4	-	-	-	-	23.0	2.0	3	12	0	15	0	0
			24	0	0	0	0	23.0	-0.4	1	14	1	15	0	0
			96	0	0	0	0	23.1	-0.2	1	14	0	15	0	0
9 Feb 76	139-250	20.0	0	0	0	0	0	16.0	0.0	14	-	-	14	-	-
			4	-	-	-	-	16.4	1.0	14	0	1	14	0	0
			6	-	-	-	-	16.0	1.2	14	0	0	14	0	0
			48	0	0	0	0	15.9	2.0	13	1	0	14	0	0
			96	0	0	0	0	16.0	2.8	13	1	0	14	0	0
16 Feb 76	132-237	20.5	0	0	0	0	0	23.0	5.0	15	-	-	15	0	0
			1	-	-	-	-	22.8	5.0	13	2	2	15	0	0
			2	-	-	-	-	23.0	4.9	11	4	2	15	0	0
			3	-	-	-	-	22.9	5.2	5	10	2	15	0	0
			4	-	-	-	-	23.0	5.4	3	12	2	15	0	0
			5	-	-	-	-	23.0	5.6	1	14	0	15	0	0
			96	0	0	0	0	22.9	6.4	1	14	0	15	0	0
23 Feb 76	162-225	20.6	0	0	0	0	0	24.0	7.0	15	-	-	14	-	-
			1	-	-	-	-	23.9	6.5	14	1	0	14	0	0
			3	-	-	-	-	23.7	6.8	12	3	2	14	0	0
			4	-	-	-	-	23.8	6.7	9	6	0	14	0	0
			5	-	-	-	-	23.9	6.7	7	8	0	14	0	0
			6	-	-		-	23.9	7.0	5	10	0	14	0	0
			22	0	0	0	0	23.8	5.4	4	11	0	14	0	0
			96	0	0	0	0	23.9	7.7	4	11	0	14	0	0
1 March 76	113-247	18.0	0	0	0	0	0	26.1	10.1	15	-	-	15	-	-
			1	-	-	-	-	26.0	10.1	8	7	0	15	0	0
			2	-	-	-	-	25.9	9.8	4	11	2	15	0	0
			3	-	-	-	-	26.0	9.9	3	12	2	15	0	0
			4	-	-	-	-	26.0	9.9	2	13	1	15	0	0
			5	-	-	-	-	26.0	9.9	0	15	-	15	0	0
			96	0	0	0	0	-	8.0	0	15	-	15	0	0

Table 23. (cont.)

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	Experimental No. Live	Experimental No. Dead	Experimental No. with Loss of Equilibrium	Control No. Live	Control No. Dead	Control No. with Loss of Equilibrium
8 March 76	100-246	10.6	0	0	0	0	0	23.6	7.6	15	-	-	15	-	-
			3	-	-	-	-	23.5	7.6	15	0	1	15	0	0
			4	-	-	-	-	23.6	7.7	14	1	0	15	0	0
			96	0	0	0	0	23.4	4.0	14	1	0	15	0	0
26 July 76	49.5-76.0	27.2	0	0.02	0.02	0	0	32.9	19.6	20	-	-	20	-	-
			1	-	-	-	-	33.6	23.8	0	20	-	20	-	-
			96	0.03	0.03	0	0	25.0	24.9	-	-	-	20	-	-

Table 24. The effects of sudden temperature increases on sand shrimp in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	Experimental No. Live	Experimental No. Dead	Experimental No. with Loss of Equilibrium	Control No. Live	Control No. Dead	Control No. with Loss of Equilibrium
19 Jan 76	6.7-12.4	20.4	0	0	0	0	0	24.0	-0.6	20	-	-	20	-	-
			1	-	-	-	-	22.5	-0.3	2	18	2	20	0	0
			2	-	-	-	-	22.5	-0.3	2	18	1	20	0	0
			96	0	0	0	0	22.0	-0.8	2	18	0	20	0	0
19 Jan 76	7.3-12.4	20.4	0	0	0	0	0	22.5	0.1	20	-	-	20	-	-
			1	-	-	-	-	22.5	0	12	8	3	20	0	0
			2	-	-	-	-	20.7	-0.1	12	8	1	20	0	0
			8	0	0	0	0	22.1	-0.2	11	9	0	20	0	0
			96	0	0	0	0	22.0	-0.8	11	9	0	20	0	0
26 Jan 76	6.5-12.8	19.7	0	0	0	0	0	23.2	1.6	30	-	-	29	-	-
			1	-	-	-	-	23.0	1.8	12	18	1	29	0	0
			2	-	-	-	-	23.2	1.9	11	19	0	29	0	0
			4	-	-	-	-	23.2	2.0	10	20	0	29	0	0
			5	-	-	-	-	23.2	2.1	10	20	1	29	0	0
			6	-	-	-	-	23.2	2.3	9	21	0	29	0	0
			56	0	0	0	0	23.0	2.7	8	22	0	29	0	0
			72	0	0	0	0	22.9	1.8	8	22	0	28	1	0
			96	0	0	0	0	23.1	1.9	8	22	0	28	1	0
15 March 76	6.9-14.0	21.2	0	0	0	0	0	26.2	6.2	29	-	-	32	-	-
			1	-	-	-	-	26.1	6.4	28	1	2	32	0	0
			2	-	-	-	-	26.1	6.5	24	5	1	32	0	0
			5	-	-	-	-	26.2	7.4	23	6	1	32	0	0
			7	-	-	-	-	26.2	7.5	22	7	1	32	0	0
			8	0	0	0	0	26.2	7.5	21	8	0	32	0	0
			24	0	0	0	0	26.2	6.2	19	10	0	31	1	0
			32	0	0	0	0	26.2	6.3	18	11	0	31	1	0
			48	0	0	0	0	26.2	4.9	17	12	1	31	1	0
			96	0	0	0	0	26.2	6.1	17	12	1	31	1	1

Table 25 . The effects of sudden temperature increases on blueback herring in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

Date	Size Range (mm)	Salinity (ppt)	Start (hrs)	Chlorine Expermiental Free	Chlorine Expermiental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	Experimental No. Live	Experimental No. Dead	Experimental No. with Loss of Equilibrium	Control No. Live	Control No. Dead	Control No. with Loss of Equilibrium
12 Apr 76	76-148	21.0	0	0.03	0.03	0	0	15.6	7.9	14	-	-	13	-	-
			72	0.04	0.04	0	0	19.3	11.4	13	1	0	13	0	0
			96	0.03	0.03	0	0	21.0	13.2	13	1	0	13	0	0
19 Apr 76	60-131	21.5	0	0.06	0.06	0	0	26.5	22.9	21	-	-	20	-	-
			1	-	-	-	-	26.0	22.4	19	2	1	20	0	0
			2	-	-	-	-	26.0	22.9	18	3	2	20	0	0
			3	-	-	-	-	26.1	23.0	18	3	0	20	0	0
			6	-	-	-	-	27.2	24.5	17	4	0	20	0	0
			7	-	-	-	-	27.8	24.5	16	5	1	20	0	0
			8	0.05	0.05	0	0	28.0	25.0	16	5	0	20	0	0
			24	0.05	0.05	0	0	27.4	23.6	1	20	1	18	2	0
			28	-	-	-	-	29.8	25.8	0	21	0	18	2	0
			32	0.08	0.08	0	0	29.2	26.4	0	21	0	17	3	0
			48	0.06	0.06	0	0	28.2	25.4	0	21	0	16	4	0
			52	-	-	-	-	28.9	19.9	0	21	0	15	5	0
			96	0.05	0.05	0	0	28.3	19.5	0	21	0	14	6	0
26 Apr 76	61.7-128.8	22.5	0	0.05	0.05	0	0	25.2	15.8	16	-	-	15	-	-
			4	-	-	-	-	25.4	15.9	15	1	0	15	0	0
			48	0.04	0.04	0	0	21.3	12.2	14	2	0	15	0	0
			96	0	0	0	0	23.2	14.7	14	2	0	14	1	0

Table 26 . The effects of sudden temperature increases on Atlantic silverside in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

				Chlorine						EXPERIMENTAL			CONTROL		
				Experimental		Control									
Date	Size Range (mm)	Salinity (ppt)	Time From Start (hrs)	Free	Total	Free	Total	Experimental Temperature (°C)	Control Temperature (°C)	No. Live	No. Dead	No. with Loss of Equilibrium	No. Live	No. Dead	No. with Loss of Equilibrium
13 Oct 75	52.8-89.7	20.5	0	0	0	0	0	21.5	15.9	30	-	-	30	-	-
			8	0	0	0	0	23.8	18.0	30	0	2	30	0	0
			24	0	0	0	0	23.2	17.4	29	1	2	30	0	0
			27	-	-	-	-	24.4	17.8	29	1	2	30	0	0
			31	0	0	0	0	25.0	18.9	29	1	1	30	0	0
			52	-	-	-	-	24.0	18.7	29	1	1	30	0	0
			96	0	0	0	0	22.8	17.0	29	0	1	30	0	0
3 Nov 75	29.5-96.5	20.5	0	0	0	0	0	22.8	12.3	65	-	-	62	-	-
			96	0	0	0	0	25.3	14.8	65	0	0	62	0	0
8 Dec 75	33.2-91.8	21.0	0	0	0	0	0	15.4	5.6	19	-	-	21	-	-
			52	-	-	-	-	19.1	8.5	18	1	0	21	0	0
			56	0.02	0.04	0	0	19.9	8.1	17	2	0	21	0	0
			72	0	0	0	0	15.8	7.2	16	3	1	21	0	0
			96	0	0	0	0	14.4	6.1	16	3	0	20	1	0
15 Dec 75	33.0-112.1	21.0	0	0	0	0	0	19.8	7.7	20	-	-	18	-	-
			4	-	-	-	-	20.1	8.9	19	1	0	18	0	0
			6	-	-	-	-	20.5	9.3	18	2	0	18	0	0
			48	.02	.06	0	0	18.1	8.1	17	3	1	18	0	0
			52	-	-	-	-	19.4	8.3	16	4	0	18	0	0
			56	.02	.02	0	0	19.1	9.1	16	4	0	18	0	1
			72	0	0	0	0	16.8	7.5	15	5	0	18	0	1
22 March 76	31.6-65.7	21.0	0	0	0	0	0	29.1	9.1	20	-	-	20	-	-
			1	-	-	-	-	29.3	8.7	5	15	0	20	0	0
			2	-	-	-	-	29.3	8.8	3	17	0	20	0	0
			3	-	-	-	-	29.0	9.0	3	17	3	20	0	0
			4	-	-	-	-	28.8	9.1	3	17	0	20	0	0
			7	-	-	-	-	29.0	9.4	3	17	1	20	0	0
			24	0	0	0	0	28.9	7.4	1	19	0	20	0	0
			96	0	0	0	0	28.9	10.3	1	19	0	20	0	0

Table 26 . (cont.)

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
24 May 76	49.8-102.2	23.6	0	0.04	0.04	0	0	28.0	18.2	37	-	-	40	-	-
			72	0	0	0	0	26.2	16.7	35	2	0	35	5	0
			76	-	-	-	-	26.7	17.0	33	4	0	34	6	0
			80	0	0	0	0	28.5	17.5	32	5	0	33	7	0
			96	0	0	0	0	28.0	18.6	30	7	0	30	10	0
23 Aug 76	46.0-83.9	23.4	0	0.03	0.03	0	0	34.9	24.6	36	-	-	30	-	-
			1	-	-	-	-	35.5	25.6	36	0	3	30	0	0
			2	-	-	-	-	36.0	26.1	30	6	19	30	0	0
			3	-	-	-	-	36.6	26.7	11	25	11	30	0	0
			4	-	-	-	-	37.3	27.1	0	36	-	30	0	0
			24	0.06	0.06	0	0	35.8	25.6	-	-	-	23	7	0
			27	-	-	-	-	36.5	27.0	-	-	-	18	12	0
			31	0.02	0.02	0	0	37.2	27.1	-	-	-	10	20	0
			55	0	0	0	0	37.2	27.3	-	-	-	9	21	0
			96	0.08	0.08	0	0	25.2	37.0	-	-	-	2	28	0

Table 27. The effects of sudden temperature increases on fourspine stickleback in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	Experimental No. Live	Experimental No. Dead	Experimental No. with Loss of Equilibrium	Control No. Live	Control No. Dead	Control No. with Loss of Equilibrium
22 March 76	26.4-44.6	21.0	0	0	0	0	0	29.1	9.1	20	-	-	20	-	-
			1	-	-	-	-	29.3	8.7	19	1	4	20	0	0
			2	-	-	-	-	29.3	8.8	12	8	2	20	0	0
			3	-	-	-	-	29.0	9.0	4	16	4	20	0	0
			4	-	-	-	-	28.8	9.1	2	18	1	20	0	0
			5	-	-	-	-	28.9	9.3	0	20	-	20	0	0
			96	0	0	0	0	-	10.3	0	20	-	20	0	0
5 Apr 76	27.6-47.3	21.0	0	0.07	0.07	0	0	18.5	9.8	14	-	-	14	-	-
			96	0.02	0.02	0	0	18.7	10.3	14	0	0	14	0	0

Table 28. The effects of sudden temperature increases on white perch in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

Date	Size Range (mm)	Salinity (ppt)	Time from Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	Experimental No. Live	Experimental No. Dead	Experimental No. with Loss of Equilibrium	Control No. Live	Control No. Dead	Control No. with Loss of Equilibrium
12 Jan 76	-	19.5	0	0	0	0	0	24.5	1.0	10	-	-	10	-	-
			1	-	-	-	-	24.8	1.0	4	6	4	10	0	0
			2	-	-	-	-	24.8	0.8	3	7	0	10	0	0
			96	0	0	0	0	24.6	1.8	3	7	0	10	0	0
26 Jan 76	56.5-116.5	19.5	0	0	0	0	0	23.2	1.6	10	0	0	10	0	0
			1	-	-	-	-	23.0	1.8	6	4	1	10	0	0
			2	-	-	-	-	23.2	1.9	5	5	0	10	0	0
			3	-	-	-	-	23.2	2.0	5	5	1	10	0	0
			6	-	-	-	-	23.2	2.3	4	6	0	10	0	0
			96	0	0	0	0	23.1	1.9	4	6	0	10	0	0

Table 29. The effects of sudden temperature increases on bluefish in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

Date	Size Range (mm)	Salinity (ppt)	Time From Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
7 June 76	35.2-55.4	22.9	0	0.04	0.04	0	0	27.9	19.0	23	-	-	27	-	-
			24	0.03	0.03	0	0	30.2	20.3	21	2	3	27	0	0
			28	-	-	-	-	31.0	21.1	21	2	2	27	0	0
			32	0.06	0.06	0	0	31.8	21.8	20	3	4	27	0	0
			48	0.05	0.05	0	0	31.4	21.7	16	7	8	27	0	0
			52	-	-	-	-	32.3	22.5	15	8	4	24	3	1
			56	0.02	0.02	0	0	33.1	23.7	13	10	2	24	3	1
			72	0.03	0.03	0	0	32.1	22.3	8	15	0	22	5	0
			80	0.03	0.03	0	0	34.2	24.2	8	15	1	22	5	0
			96	0.03	0.03	0	0	33.7	23.7	3	20	0	18	9	0
21 June 76	42.9-57.7	24.0	0	0.03	0.03	0	0	37.3	22.5	10	-	-	10	-	-
			1	-	-	-	-	37.3	25.0	0	10*	-	10	0	0
			24	0.03	0.03	0	0	36.8	26.4	-	-	-	5	5**	0
			48	0	0	0	0	38.0	26.7	-	-	-	5	5	0
19 July 76	100.7-181.3	27.1	0	0.02	0.02	0	0	34.0	24.0	14	-	-	15	-	-
			1	-	-	-	-	34.6	24.3	0	14	-	15	0	0
			96	0.02	0.02	0	0	33.7	21.7	0	14	-	15	0	0
16 Aug. 76	106.0-185.4	21.8	0	0.03	0.03	0	0	25.3	35.5	10	-	-	10	-	-
			1	-	-	-	-	25.3	34.7	3	7	2	10	0	0
			2	-	-	-	-	25.7	34.6	1	9	0	10	0	0
			3	-	-	-	-	26.0	34.6	0	10	-	10	0	0
			24	0.03	0.03	0	0	23.5	34.6	-	-	-	7	3	0
			96	0	0	0	0	21.7	32.3	-	-	-	7	3	0

* all dead in 1 min.

** Mortality due to canabalism.

Table 30 . The effects of sudden temperature increases on spot in the vicinity of Oyster Creek Generating Station, Forked River, New Jersey. Only the time at which events occurred is listed.

Date	Size Range (mm)	Salinity (ppt)	Time From Start (hrs)	Chlorine Experimental Free	Chlorine Experimental Total	Chlorine Control Free	Chlorine Control Total	Experimental Temperature (°C)	Control Temperature (°C)	EXPERIMENTAL No. Live	EXPERIMENTAL No. Dead	EXPERIMENTAL No. with Loss of Equilibrium	CONTROL No. Live	CONTROL No. Dead	CONTROL No. with Loss of Equilibrium
6 July 76	57.2-76.8	26.8	0	0.03	0.03	0	0	36.0	25.2	20	-	-	20	-	-
			1	-	-	-	-	35.9	26.1	9	11	1	20	0	0
			2	-	-	-	-	36.2	26.1	0	20	-	20	0	0
			96	0.04	0.04	0	0	36.3	25.4	-	-	-	20	0	0
16 Aug 76	61.5-125.0	21.8	0	0.03	0.03	0	0	35.5	27.7	20	-	-	20	-	-
			1	-	-	-	-	34.7	25.3	19	1	5	20	0	0
			2	-	-	-	-	34.6	25.7	11	9	4	20	0	0
			3	-	-	-	-	34.6	26.0	4	16	4	20	0	0
			4	-	-	-	-	35.4	26.7	0	16	-	20	0	0
			48	0.06	0.06	0	0	34.3	22.8	-	-	-	9	11	0
			51	-	-	-	-	35.1	25.8	-	-	-	8	12	0
			55	0.04	0.04	0	0	35.2	26.2	-	-	-	7	13	0
			72	0.03	0.03	0	0	32.8	22.1	-	-	-	6	14	0
			79	0	0	0	0	33.5	23.3	-	-	-	5	15	0
			96	0	0	0	0	32.3	21.7	-	-	-	5	15	0

TABLE 31. TOTAL NUMBER OF FISHES AND MACROINVERTEBRATES COLLECTED AT THE DISCHARGE OF THE DILUTION PUMPS WITH THE DILUTION PUMP SAMPLER FROM SEPTEMBER 1975 THROUGH AUGUST 1976.

SPECIES	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	TOTAL
LOLLIGUNCULA BREVIS	-	-	-	-	-	-	-	-	-	-	-	2	2
LIMULUS POLYPHEMUS	-	-	-	-	-	-	-	-	4	1	1	-	6
PENAEUS AZTECUS	1	-	-	-	-	-	-	-	-	-	-	-	1
PALAEMONETES VULGARIS	-	-	-	-	7	47	ABUNDANT		-	-	-	-	54+
CRANGON SEPTEMSPINOSA	-	-	-	31	31	503	ABUNDANT		16	2	-	-	583+
OVALIPES OCELLATUS	-	1	-	-	-	-	-	-	-	-	-	-	1
CALLINECTES SAPIDUS	2	135	48	-	-	-	46	5	253	346	638	496	1969
CALLINECTES SIMILIS	1	-	2	-	-	-	-	-	-	-	-	-	3
DASYATIS SAYI	-	-	-	-	-	-	-	-	-	-	-	1	1
ANGUILLA ROSTRATA	-	1	-	3	-	-	1	-	6	7	6	1	25
ALOSA AESTIVALIS	-	-	-	12	1	1	1	9	2	-	-	1	27
BREVOORITA TYRANNUS	-	1	1	1	-	-	7	-	11	8	22	12	63
CLUPEA HARENGUS	-	-	-	-	-	-	1	-	1	1	-	-	3
ANCHOA MITCHILLI	-	4	3	-	-	-	24	58	460	31	2	-	582
OPSANUS TAU	-	3	-	-	-	-	-	-	-	-	1	-	4
RISSOLA MARGINATA	-	-	-	2	-	-	-	2	-	6	61	17	88
FUNDULUS HETEROCLITUS	-	-	-	-	-	1	-	-	-	-	-	-	1
MENIDIA MENIDIA	-	-	1	4	1	1	6	6	1	1	-	-	21
APELTES QUADRACUS	-	-	-	-	1	2	1	-	-	-	-	-	4
SYNGNATHUS FUSCUS	1	-	2	4	1	-	-	-	1	-	-	-	9
MORONE AMERICANA	-	-	1	5	-	-	-	1	1	-	2	-	10
POMATOMUS SALTATRIX	-	3	1	1	-	-	-	-	1	4	6	5	21
BAIRDIELLA CHRYSURA	-	10	-	1	-	-	-	-	-	-	-	-	11
CYNOSCION REGALIS	-	1	-	1	-	-	-	-	-	-	-	2	4
LEIOSTOMUS XANTHURUS	-	-	-	-	-	-	-	-	-	53	193	64	310
MENTICIRRHUS SAXATILIS	-	-	-	-	-	-	-	-	-	2	-	-	2
TAUTOGA ONITIS	-	1	-	2	-	-	-	-	1	-	-	-	4
PEPRILUS TRIACANTHUS	-	-	-	-	-	-	-	-	-	-	2	-	2
PRIONOTUS EVOLANS	2	1	1	1	-	-	-	-	-	-	-	-	5
ETROPUS MICROSTOMUS	-	-	-	12	-	-	-	-	-	-	-	-	12
PARALICHTHYS DENTATUS	-	1	-	-	-	-	-	-	1	1	2	1	6
SCOPHTHALMUS AQUOSUS	-	-	-	-	-	-	-	1	-	-	-	-	1
PSEUDOPLEURONECTES AMERICANUS	-	-	-	3	13	35	9	1	5	-	1	-	67
TRINECTES MACULATUS	-	-	-	-	-	-	-	-	-	-	1	-	1
MONOCANTHUS HISPIDUS	-	1	-	-	-	-	-	-	-	-	-	-	1
SPHOEROIDES MACULATUS	-	-	-	-	-	-	-	-	7	-	-	1	7
TOTAL SPECIMENS	7	169	60	83	55	590	96	83	771	462	938	603	3911+
TOTAL FISH	3	27	10	52	17	40	50	78	498	113	299	105	1293
TOTAL TAXA	5	13	9	15	7	7	11	10	16	13	13	12	36

Table 32. Total number and condition (live, dead, damaged) of some fishes and macroinvertebrates collected after passage through the dilution pumps, and subsequently held in ambient and condenser discharge water for 48-96 hours from October 1975 through August 1976.

			1975 October - December			1976 January - April		
Species	Test Temperature	Mortalities	Live	Dead	Damg	Live	Dead	Damg
Crangon septemspinosa		Immediate	25	6	0	440	5	11
	Ambient	Delayed	0	0	0	80	4	1
	Heated Discharge	Delayed	-	-	-	-	-	-
Callinectes sapidus		Immediate	141	5	37	51	0	0
	Ambient	Delayed	103	0	26	41	0	0
	Heated Discharge	Delayed	-	-	-	-	-	-
Anguilla rostrata		Immediate	14	0	1	2	0	0
	Ambient	Delayed	1	0	0	1	0	0
	Heated Discharge	Delayed	-	-	-	-	-	-
Brevoortia tyrannus		Immediate	1	0	1	6	0	0
	Ambient	Delayed	0	0	1	0	6	0
	Heated Discharge	Delayed	-	-	-	-	-	-
Anchoa mitchilli		Immediate	3	3	1	18	20	16
	Ambient	Delayed	1	0	0	0	34	0
	Heated Discharge	Delayed	-	-	-	-	-	-
Rissola marginata		Immediate	0	0	0	2	0	2
	Ambient	Delayed	0	0	0	1	0	1
	Heated Discharge	Delayed	-	-	-	-	-	-
Menidia menidia		Immediate	0	0	0	11	1	1
	Ambient	Delayed	0	0	0	7	5	0
	Heated Discharge	Delayed	-	-	-	-	-	-
Syngnathus fuscus		Immediate	6	0	1	1	0	0
	Ambient	Delayed	0	0	0	1	0	0
	Heated Discharge	Delayed	-	-	-	-	-	-
Leiostomus xanthurus		Immediate	0	0	0	0	0	0
	Ambient	Delayed	0	0	0	0	0	0
	Heated Discharge	Delayed	-	-	-	-	-	-
Pseudopleuronectes americanus		Immediate	0	0	0	34	0	1
	Ambient	Delayed	0	0	0	34	1	0
	Heated Discharge	Delayed	-	-	-	-	-	-

Table 32. (cont.)

Species	Test Temperature	Mortalities	1976 May - August Live	Dead	Damg	Total Live	Dead	Damg
Crangon septemspinosa		Immediate	5	1	0	470	12	11
	Ambient	Delayed	0	0	0	80	4	1
	Heated Discharge	Delayed	0	0	0	0	0	0
Callinectes sapidus		Immediate	1075	64	358	1267	69	395
	Ambient	Delayed	39	4	0	183	4	26
	Heated Discharge	Delayed	2	0	1	2	0	1
Anguilla rostrata		Immediate	5	0	2	21	0	3
	Ambient	Delayed	3	0	0	5	0	0
	Heated Discharge	Delayed	0	4	0	0	4	0
Brevoortia tyrannus		Immediate	23	8	13	30	8	14
	Ambient	Delayed	7	10	1	7	16	2
	Heated Discharge	Delayed	0	18	0	0	18	0
Anchoa mitchilli		Immediate	46	33	5	67	56	22
	Ambient	Delayed	7	28	0	8	62	0
	Heated Discharge	Delayed	0	16	0	0	16	0
Rissola marginata		Immediate	31	3	14	33	3	16
	Ambient	Delayed	16	2	4	17	2	5
	Heated Discharge	Delayed	2	21	0	2	21	0
Menidia menidia		Immediate	0	1	0	11	2	1
	Ambient	Delayed	0	0	0	7	5	0
	Heated Discharge	Delayed	0	0	0	0	0	0
Syngnathus fuscus		Immediate	0	1	0	7	1	1
	Ambient	Delayed	0	0	0	1	0	0
	Heated Discharge	Delayed	0	0	0	0	0	0
Leiostomus xanthurus		Immediate	154	118	38	154	118	38
	Ambient	Delayed	60	12	0	60	12	0
	Heated Discharge	Delayed	38	42	0	38	42	0
Pseudopleuronectes		Immediate	4	0	0	38	0	1
americanus	Ambient	Delayed	4	0	0	38	1	0
	Heated Discharge	Delayed	0	0	0	0	0	0

Table 33. Numbers of abundant fishes and macroinvertebrates per 10^6 gallons sampled in the dilution pump discharge and at the traveling screens during comparable periods of time from October 1975 through August 1976.

Species		October 1975 No. Coll	October 1975 No/ 10^6 gal	November No. Coll	November No/ 10^6 gal	March 1976 No. Coll	March 1976 No/ 10^6 gal	April No. Coll	April No/ 10^6 gal	May No. Coll	May No/ 10^6 gal	June No. Coll	June No/ 10^6 gal	July No. Coll	July No/ 10^6 gal	August No. Coll	August No/ 10^6 gal
Callinectes sapidus	Dilution Pump	13.5	15.2	48	18.8	46	5.6	-	-	253	49.1	346	67.2	638	93.1	496	72.4
	Traveling Screens	560	7.0	284	5.7	412	10.4	-	-	6972	199.5	9077	185.9	4843	181.7	4470	102.6
	DP:TS		1:0.46		1:0.31		1:19	-	-		1:4.1		1:2.8		1:1.95		1:1.4
Alosa aestivalis	Dilution Pump	-	-	-	-	-	-	9	2.6	-	-	-	-	-	-	-	-
	Traveling Screens	-	-	-	-	-	-	83	7.0	-	-	-	-	-	-	-	-
	DP:TS	-	-	-	-	-	-		1:2.7	-	-	-	-	-	-	-	-
Brevoortia tyrannus	Dilution Pump	-	-	-	-	-	-	-	-	-	-	-	-	22	3.1	-	-
	Traveling Screens	-	-	-	-	-	-	-	-	-	-	-	-	90	3.4	-	-
	DP:TS	-	-	-	-	-	-	-	-	-	-	-	-		1:1.1	-	-
Anchoa mitchilli	Dilution Pump	-	-	-	-	-	-	58	16.8	460	89.2	91	6.0	-	-	-	-
	Traveling Screens	-	-	-	-	-	-	1176	98.4	4364	124.9	90	5.4	-	-	-	-
	DP:TS	-	-	-	-	-	-		1:5.9		1:1.4		1:1.7	-	-	-	-
Rissola marginata	Dilution Pump	-	-	-	-	-	-	-	-	-	-	6	1.7	61	8.6	17	2.4
	Traveling Screens	-	-	-	-	-	-	-	-	-	-	29	1.8	29	1.0	12	2.8
	DP:TS	-	-	-	-	-	-	-	-	-	-		1:1.1		1:0.72		1:0.12
Leiostomus xanthurus	Dilution Pump	-	-	-	-	-	-	-	-	-	-	53	3.2	-	-	64	9.3
	Traveling Screens	-	-	-	-	-	-	-	-	-	-	613	37.0	-	-	64	1.5
	DP:TS	-	-	-	-	-	-	-	-	-	-		1:11.6	-	-		1:0.16

Table 34. Summary of population surveys conducted during 1976.

Survey	Dates Sampled	Gear Used	Total Area Surveyed($X10^6 m^2$)	Number of Samples Taken
Winter flounder	6, 7, 8, 15, 16 April	4.9-m trawl	68.97	160
Bay anchovy	13, 14, 21 May	4.9-m trawl	34.69	90
Northern pipefish	23, 24, 28, 29 June,	4.9-m trawl	61.90	39
	1 July	2.7-m trawl	36.31	81
Blue crab	8, 9, 15, 16, 19,	4.9-m trawl	60.38	60
	20 July	2.7-m trawl	24.70	80

Table 35. Results of the winter flounder population survey conducted during the period 6-8 April 1976 in Barnegat Bay.

A. Results of $\ln(X+1+K/2)$ transformation

	Raw Data	Transformed
$\bar{x}$	2.12	0.91
S	2.81	0.77
CV	132.5%	84.4%
Skewness	1.98	0.37
Kurtosis	7.07	2.38

Contagion coefficient - 0.84   GOF χ^2 = 16.84, 16 df sig at P=.05

B. Stratification of population and sampling results

Stratum	North	South	Inlets	Creeks	Total
Area ($10^6 m^2$)	29.99	28.62	2.48	7.88	68.97
Number of sampling units in area (N_h)	29117	27786	2408	7650	N=66961
Number of samples taken (n_h)	47	47	9	17	n= 120
Transformed sample mean within stratum ($\bar{y}_h$)	1.23	0.56	0.78	0.53	
Transformed stratum variance (S_h^2)	0.53	0.42	0.86	0.27	
Transformed stratum standard deviation (S_n)	0.73	0.64	0.93	0.52	
Estimated stratum totals ($N_h\bar{y}_n$)	35814	15560	1878	4055	57307

Population mean per unit $\bar{y}_{st} = \frac{\Sigma N_h \bar{y}_n}{N} = \frac{57307}{66961}$ = 0.86 (transformed) = 1.36 (derived)

Estimate of variance of $\bar{y}_{st}$ $S^2(\bar{y}_{st})$ = 0.0038

$S(\bar{y}_{st})$ = 0.062 (transformed) = 0.064 (derived)

C. Population Estimate

Total population ($\bar{y}(st) \cdot N$)	91,000
95% confidence limits ($\bar{y}_{st} \pm t \cdot s_{(\bar{y}_{st})} \cdot N$)	± 8,400

Table 36 . Results of the bay anchovy population survey conducted during the period 13-21 May 1976 in Barnegat Bay.

Stratum	North	West	South	Total
Area ($10^6 m^2$)	16.09	4.27	14.33	34.69
Number of sampling units in area (N_h)	15621	4146	13913	N = 33680
Number of samples taken (N_h)	24	26	40	n = 90
Sample mean within stratum ($\bar{y}_h$)	18.54	49.77	102.53	
Stratum variance ($S^2{}_h$)	1410.52	6800.34	26878.72	
Stratum standard deviation (S_h)	37.56	82.46	163.95	
Estimated stratum totals ($N_h \bar{y}_h$; X10^5)	2.90	2.06	14.27	19.23

Population mean per unit $\bar{y}_{st} = \frac{\sum N_h \bar{y}_h}{N} = \frac{19.23 \text{ X}10^5}{33680} = 57.10$

Estimate of variance of $\bar{y}_{st}$ $S^2(\bar{y}_{st}) = 130.82$

$S(\bar{y}_{st}) = 11.44$

Total population ($\bar{y}_{st} \cdot N$) 1,923,000

95% confidence limits ($\bar{y}_{st} \pm t \cdot S_{(\bar{y}_{st})} \cdot N$) $\pm$755,000

Table 37 . Results of the northern pipefish survey conducted during the period 23 June through 1 July 1976 in Barnegat Bay.

A. East side of Bay (2.7-m trawl samples)

Stratum	East	Inlet/Sand	Total
Area ($10^6 m^2$)	22.12	14.19	36.31
Number of sampling units in area (N_h)	105083	67411	N=172494
Number of samples taken (n_h)	67	14	n= 81
Sample mean within stratum ($\bar{y}_h$)	1.64	3.14	
Stratum variance (S^2_n)	3.03	8.58	
Stratum standard deviation (S_h)	1.74	2.93	
Estimated stratum totals ($N_h \bar{y}_h$; $X10^5$)	1.72	2.11	3.83

Population mean per unit $\bar{y}_{st} = \frac{\sum N_h \bar{y}_h}{N} = \frac{3.83 \ X10^5}{172494} = 2.22$

Estimate of variance of $\bar{y}_{st}$ $S^2_{(\bar{y}_{st})} = 0.28$

$S_{(\bar{y}_{st})} = 0.53$

Total population ($\bar{y}_{st} \cdot N$) 383,000

95% confidence limits ($\bar{y}_{st} \pm t \cdot S(\bar{y}_{st}) \cdot N$) $\pm$179,000

B. West Side of Bay (4.9-m trawl samples)

Stratum	Center	West	Total
Area ($10^6 m^2$)	56.10	5.80	61.90
Number of sampling units in area (N_h)	54466	5631	N= 60097
Number of samples taken (n_h)	34	5	n= 39
Sample mean within stratum ($\bar{y}_h$)	0.79	0.40	
Stratum variance (S^2_h)	5.62	0.30	
Stratum standard deviation (S_h)	2.36	0.55	
Estimated stratum totals ($N_h \bar{y}_h$; $X10^4$)	4.30	0.23	4.53

Population mean per unit $\bar{y}_{st} = \frac{\sum N_h \bar{y}_h}{N} = \frac{4.53 \ X10^4}{60097} = 0.75$

Estimate of variance of $\bar{y}_{st}$ $S^2 (\bar{y}_{st}) = 0.14$

$S (\bar{y}_{st}) = 0.37$

Total population ($\bar{y}_{st} \cdot N$) 45,000

95% confidence limits ($\bar{y}_{st} \pm t \cdot S(\bar{y}_{st}) \cdot N$) $\pm$ 44,000

Table 38. Results of the blue crab population survey conducted during the period 8-20 July 1976 in Barnegat Bay.

A. East side of Bay (2.7-m trawl samples)

Stratum	North	North Central	South Central	Inlet	South	Total
Area ($10^6 m^2$)	10.57	3.65	6.43	2.29	1.76	24.70
Number of sampling units in area (N_h)	50214	17340	30546	10879	8361	N= 117340
Number of samples taken (n_h)	32	14	20	9	5	n= 80
Sample mean within stratum ($\bar{y}_h$)	22.3	29.9	18.4	39.1	14.6	
Stratum variance (S^2_h)	148.7	730.8	114.7	1040.6	68.8	
Stratum standard deviation (S_h)	12.2	27.0	10.7	32.3	8.3	
Estimated stratum totals ($N_h\bar{y}_h$; $X10^5$)	11.20	5.18	5.62	4.25	12.2	38.45

Population mean per unit $\bar{y}_{st} = \frac{\sum N_h \bar{y}_h}{N} = \frac{30.45 \times 10^5}{117340} = 32.9$

Estimate of variance of $\bar{y}_{st}$ $S^2_{(\bar{y}_{st})} = 3.42$

$S(\bar{y}_{st}) = 1.85$

Total population ($\bar{y}_{st} \cdot N$) 3,860,000

95% confidence limits ($\bar{y}_{st} \pm t \cdot S_{(\bar{y}_{st})} \cdot N$) $\pm$ 425,000

B. West side of Bay (4.9-m trawl samples)

Stratum	North	North Central	South Central	South	Total
Area ($10^6 m^2$)	11.35	8.47	17.71	22.85	60.38
Number of sampling units in area (N_h)	11025	8227	17203	22195	N= 58650
Number of samples taken (n_h)	8	12	20	20	n = 60
Sample mean within stratum ($\bar{y}_h$)	2.63	7.83	3.35	2.00	
Stratum variance (S^2_h)	6.25	28.73	23.43	4.62	
Stratum standard deviation (S_h)	2.50	5.36	4.84	2.15	
Estimated stratum totals ($N_h\bar{y}_h$; $X10^4$)	2.90	6.44	5.76	4.44	19.54

Population mean per unit $\bar{y}_{st} = \frac{\sum N_h \bar{y}_h}{N} = 3.33$

Estimate of variance of $\bar{y}_{st}$ $S^2(\bar{y}_{st}) = 0.21$

$S(\bar{y}_{st}) = 0.45$

Total population ($\bar{y}_{st} \cdot N$) 195,000

95% confidence limits ($\bar{y}_{st} \pm t \cdot S_{(\bar{y}_{st})} \cdot N$) $\pm$ 52,000

Table 39. Summary of the life history stages of the blue crab taken during the population survey 8 through 20 July 1976.

A. 2.7-m Trawl Strata	Number of hauls	Immature	Immature Paper Shell	Immature Molting	Mature Male	Mature Female	Mature Male Paper Shell	Mature Female Paper Shell	Mature Male Molting	Mature Female Molting	Egg Bearing Female (orange)	Egg Bearing Female (black)
North	32	582	42	14	62	2	10	0	0	0	0	0
North Central	14	405	4	1	6	0	2	0	1	0	0	0
South Central	20	310	18	4	20	6	2	1	0	1	5	1
Inlet	9	281	3	5	9	12	0	0	0	0	28	14
South	5	69	1	1	5	3	0	0	0	0	3	0
Subtotal	90	1647	68	25	102	23	14	1	1	1	36	15
B. 4.9-m trawl Strata												
North	8	21	0	0	0	0	0	0	0	0	0	0
North Central	12	89	5	0	0	0	0	0	0	0	0	0
South Central	20	50	5	1	5	1	0	0	0	0	4	1
South	20	28	0	0	0	3	0	0	0	0	1	1
Subtotal	60	188	10	1	5	4	0	0	0	0	5	2
Totals		1835	78	26	107	27	14	1	1	1	41	17

Ratios

Immature	0.90	Immature Paper Shell	0.04	Mature Paper Shell	0.07	Females Egg Bearing	0.67	orange eggs	0.71
Mature	0.10	Immature Molting	0.01	Mature Molting	0.01			black eggs	0.29
		Immature Hardshell	0.95	Mature Hardshell	0.92				

Table 40. Summary of statistics from replicate trawl studies made in Forked River and Oyster Creek during 1975 and 1976.

	Range	Mean	Standard Deviation	Standard Error of Mean	CV
Forked River, 11 August 1975					
Total fish species	1-3	2.14	0.90	0.34	42%
Total fish catch	1-10	5.43	2.82	1.07	52%
Anchoa mitchilli	1-6	3.29	2.14	0.81	65%
Oyster Creek, 11 August 1975					
Total fish species	3-7	4.25	1.58	0.56	37%
Total fish catch	3-34	13.75	10.61	3.75	77%
Anchoa mitchilli	0-18	6.50	6.72	2.38	103%
Callinectes sapidus	0-10	2.25	3.37	1.19	150%
Forked River, 27 May 1976					
Total fish species	1-3	2.13	0.83	0.30	39%
Total fish catch	6-125	47.13	43.44	15.36	92%
Anchoa mitchilli	4-125	45.88	43.93	15.53	96%
Crangon septemspinosa	6-25	14.38	5.63	1.99	39%
Callinectes sapidus	1-14	5.50	4.72	1.67	86%
Oyster Creek, 27 May 1976					
Total fish species	0-4	1.43	1.27	0.48	89%
Total fish catch	0-19	7.00	7.98	3.02	114%
Anchoa mitchilli	0-19	6.14	7.65	2.89	125%
Crangon septemspinosa	0-29	8.14	9.89	3.74	121%
Callinectes sapidus	3-9	5.00	2.31	0.87	46%
Forked River, 28 June 1976					
Total fish species	1-3	2.25	0.89	0.31	40%
Total fish catch	171-667	431.13	202.29	71.52	47%
Anchoa mitchilli	155-667	426.38	205.80	72.76	48%
Leiostomus xanthurus	0-15	3.63	5.01	1.77	138%
Callinectes sapidus	1-5	2.75	1.67	0.59	61%
Oyster Creek, 28 June 1976					
Total fish species	1-3	1.88	0.83	0.30	44%
Total fish catch	1-13	8.25	4.30	1.52	52%
Anchoa mitchilli	0-11	3.88	4.36	1.54	112%
Leiostomus xanthurus	0-9	4.00	3.38	1.20	85%
Callinectes sapidus	1-8	3.75	2.55	0.90	68%

Table 40. (cont.)

	Range	Mean	Standard Deviation	Standard Error of Mean	CV
Forked River, 2 July 1976					
Total fish species	2-5	3.25	1.28	0.45	39%
Total fish catch	199-473	314.88	102.55	36.26	33%
Anchoa mitchilli	145-437	269.63	101.45	35.87	38%
Leiostomus xanthurus	20-108	43.88	27.76	9.82	63%
Leiostomus xanthurus*	20-52	34.71	10.77	4.07	31%
Callinectes sapidus	0-9	2.50	2.83	1.00	113%
Oyster Creek, 2 July 1976					
Total fish species	2-4	2.63	0.74	0.26	28%
Total fish catch	52-174	84.25	41.39	14.63	49%
Anchoa mitchilli	29-125	57.88	32.16	11.37	56%
Anchoa mitchilli*	29-86	48.29	18.67	7.06	39%
Leiostomus xanthurus	15-49	25.88	11.67	4.12	45%
Forked River, 5 August 1976					
Total fish species	1-4	2.75	1.16	0.41	42%
Total fish catch	12-43	31.00	11.71	4.14	38%
Anchoa mitchilli	10-43	28.88	11.84	4.19	41%
Leiostomus xanthurus	0-2	1.13	0.83	0.30	73%
Callinectes sapidus	0-3	0.75	1.04	0.37	139%
Oyster Creek, 5 August 1976					
Total fish species	1-4	2.00	1.07	0.38	54%
Total fish catch	1-12	6.00	3.96	1.40	66%
Anchoa mitchilli	0-12	4.38	4.37	1.55	100%
Leiostomus xanthurus	0-3	0.88	1.36	0.48	155%
Callinectes sapidus	0-3	1.38	1.19	0.42	86%

* with one large collection omitted.

Table 41. Frequency distributions of categories of organisms from ten replicate trawl series taken in the mouth of Oyster Creek and Forked River on 11 August 1975 and 27 May through 5 August 1976.

Category	Subsample Size	Number of times the subsample mean fell within 25% of the sample mean in 100 trials										Mean
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	
All combined[a]	2	5	7	7	7	7	5	8	3	2	-	41.3
Fish species		-	1	-	1	-	2	2	2	2	-	62.4
Fish specimens		1	-	2	-	4	1	1	1	-	-	44.5
Anchoa mitchilli		1	1	3	-	1	2	2	-	-	-	37.7
Leiostomus xanthurus		1	1	-	2	1	-	1	-	-	-	34.0
Callinectes sapidus		1	2	2	3	-	-	1	-	-	-	29.3
All combined	3	1	3	3	4	7	12	3	11	4	3	56.5
Fish species		-	-	1	-	-	-	-	5	3	1	74.8
Fish specimens		-	-	-	-	3	2	1	2	-	2	66.1
Anchoa mitchilli		-	-	-	1	2	4	-	2	1	-	56.8
Leiostomus xanthurus		1	-	-	1	-	2	1	1	-	-	48.5
Callinectes sapidus		-	2	1	-	2	3	1	-	-	-	41.0
All combined	4	-	3	1	1	5	9	5	6	6	15	69.7
Fish species		-	-	-	-	-	1	-	1	-	8	89.4
Fish specimens		-	-	-	-	-	2	2	1	2	3	77.6
Anchoa mitchilli		-	-	-	-	3	2	1	1	1	2	65.9
Leiostomus xanthurus		-	-	-	1	-	1	2	1	-	1	65.5
Callinectes sapidus		-	3	-	-	2	-	-	2	2	-	52.1
All combined	5	-	-	2	3	1	9	5	4	5	22	76.7
Fish species		-	-	-	-	-	-	1	-	-	9	94.8
Fish specimens		-	-	-	-	-	1	1	1	2	5	86.1
Anchoa mitchilli		-	-	-	-	1	8	1	-	1	4	75.2
Leiostomus xanthurus		-	-	1	1	-	-	-	1	1	2	68.0
Callinectes sapidus		-	-	1	2	-	1	1	2	1	1	63.4
All combined	6	-	-	-	-	3	3	2	5	8	30	87.5
Fish species		-	-	-	-	-	-	-	1	-	9	100.0
Fish specimens		-	-	-	-	-	-	-	1	1	8	95.0
Anchoa mitchilli		-	-	-	-	-	-	2	1	2	5	87.5
Leiostomus xanthurus		-	-	-	-	1	1	-	-	2	2	78.8
Callinectes sapidus		-	-	-	-	1	1	-	1	2	4	70.8
All combined	7	-	-	-	-	-	-	1	1	6	35	96.2
Fish species		-	-	-	-	-	-	-	-	-	8	100.0
Fish specimens		-	-	-	-	-	-	-	-	-	8	100.0
Anchoa mitchilli		-	-	-	-	-	-	-	-	-	8	97.9
Leiostomus xanthurus		-	-	-	-	-	-	1	-	1	4	92.7
Callinectes sapidus		-	-	-	-	-	-	-	-	3	5	94.4

a. In addition to below also includes northern pipefish, crevalle jack, lookdown, weakfish, and sand shrimp.

Table 42. Description of trawl stations regularly sampled during Oyster Creek Generating Station Ecological Studies.

Station 01: Cedar Creek Mouth

Area Sampled:	Navigation channel in mouth of Cedar Creek, west of Intracoastal Waterway can bouy C "63"; tow is made in mid-channel between flashing light FL "1" and the third black channel marker inside Cedar Creek.
Depth Sampled:	1.5 to 2.1 m
Current:	Very slight, dependent on tide.
Clarity:	Clear to tannic brown.
Aquatic Vegetation:	Zostera marina attached and detrital, common to abundant. Detrital form most abundant after prolonged easterly winds; Agardhiella common.

Station 02: Stouts Creek Mouth

Area Sampled:	Navigation channel in mouth of Stouts Creek, due west of Intracoastal Waterway mid-channel marker BW N "C1"; tow is made in mid-channel between the fourth black channel marker inside Stouts Creek and ending approximately at a distance offshore equal to that of flashing light FL "1".
Depth Sampled:	1.2 to 3.1 m
Current:	Slight, dependent on tide.
Clarity:	Clear to tannic brown.
Aquatic Vegetation:	Zostera marina attached and detrital, common to abundant. Detrital form most abundant after prolonged easterly winds; Agardhiella occasional.

Station 03: Barnegat Bay off Mouth of Forked River

Area Sampled:	Barnegat Bay immediately east of mouth of Forked River, approximately at a distance offshore equal to that of flashing light FL "2"; tow is made between bouys "1" and "2" of the north and south channel approaches to Forked River.
Depth Sampled:	1.5 to 2.1 m
Current:	Slight, dependent on tide.
Clarity:	Clear to turbid.
Aquatic Vegetation:	Detritus (Zostera marina) occasional to common; attached Zostera and Codium fragile occasional; Agardhiella common.

Table 42 . (cont.)

	Station 04: Forked River Mouth
Area Sampled:	Mouth of Forked River, west of Intracoastal Waterway mid-channel marker BW N "D1"; tow is made in north approach channel between bouys 5 and 6 outside of mouth and bouys 9 and 10 inside of mouth.
Depth Sampled:	1.5 to 2.1 m
Current:	Slight to moderate, predominantly westerly due to influence of OCGS.
Clarity:	Normally clear.
Aquatic Vegetation:	Detritus (*Zostera marina*) none to abundant; *Codium fragile* none to occasional.
	Station 06: Forked River, east of Route 9 Bridge
Area Sampled:	South branch of Forked River, west of Beach Blvd. bridge and east of Route 9 bridge; tow is made east to west beginning at last house on north bank and ending near Route 9 bridge.
Depth Sampled:	2. 1 to 2.4 m
Current:	Moderate, westerly due to influence of OCGS.
Clarity:	Clear
Aquatic Vegetation:	None attached; detritus and woody debris occasional to common.
	Station 15: Oyster Creek, east of Route 9 Bridge
Area Sampled:	Oyster Creek, approximately 0.5 miles west of Route 9 bridge; tow is made in the channel west to east beginning approximately 180 m west of the bulkheaded pond on the north bank.
Depth Sampled:	1.2 to 2.4 m
Current:	Moderate, easterly due to influence of OCGS.
Clarity:	Clear
Aquatic Vegetation:	None attached; detritus and woody debris none to occasional.

Table 42 . (cont.)

Station 17: Oyster Creek Mouth

Area Sampled:	Mouth of Oyster Creek, due west of Intracoastal Waterway mid-channel marker BW N "E1"; tow is made west to east beginning at second black channel stake located just west of bulkhead on north bank and ending in vicinity of first channel marker can and nun.
Depth Sampled:	1.8 to 3.7 m
Current:	Slight to moderate, predominantly easterly due to influence of OCGS.
Clarity:	Clear
Aquatic vegetation:	Detritus (Zostera marina) occasional to common; Zostera and Codium fragile none to occasional; shellhash occasional.

Station 19: Barnegat Bay off Mouth of Oyster Creek

Area Sampled:	Barnegat Bay immediately east of mouth of Oyster Creek, approximately at a distance offshore equal to that of flashing light FL "3"; tow is made in the plume, usually in the area between the beached barge to the north and the Oyster Creek navigational channel to the south.
Depth Sampled:	1.1 to 2.1 m
Current:	Slight, dependent on tide
Clarity:	Clear to turbid
Aquatic Vegetation:	Algae (Ulva and Codium fragile) and detritus, occasional to common; Zostera marina occasional.

Station 21: Barnegat Bay off Waretown Creek

Area Sampled:	Barnegat Bay west - northwest of Intracoastal Waterway mid-channel marker BW N "F", off Waretown Creek; tow is made beginning at a point in the middle of a visual transect between marker BW N "F" and a large cedar-siding brown house on shore, south of the Holiday Beach Club.
Depth Sampled:	2.4 to 3.7 m
Current:	Slight, dependent on tide.
Clarity:	Usually clear.
Aquatic Vegetation:	Ulva, Codium fragile, Zostera marina, and detritus all common to abundant.

Table 42. (cont.)

	Station 23: Double Creek Mouth
Area Sampled:	Mouth of Double Creek, southwest of Intracoastal Waterway flashing light FL R "68"; tow is made in mid-channel between the fourth black channel stake inside Double Creek and the flashing light FL R "2".
Depth Sampled:	2.1 to 3.7 m
Current:	Slight, dependent on tide.
Clarity:	Usually clear.
Aquatic Vegetation:	*Zostera marina* and detritus, occasional to abundant; *Ulva* and *Codium fragile* occasional to common.
	Station 24: North Approach Channel to Barnegat Inlet (Oyster Creek Channel)
Area Sampled:	Oyster Creek Channel approach to Barnegat Inlet, immediately west of Sedge Islands; tow is made between channel marker numbers "30" and "32".
Depth Sampled:	2.1 to 5.5 m
Current:	Moderate to strong, dependent on tide.
Clarity:	Usually very clear.
Aquatic Vegetation:	None in sampling area; detritus occasional.

Table 43. Description of seine stations regularly sampled during Oyster Creek Generating Station Ecological Studies.

	Station 01: Cedar Creek Mouth
Area Sampled:	Off the easternmost peninsula of the north bank of Cedar Creek Mouth, area sampled is approximately 60m of a narrow (5m) sandy beach on the south side of the peninsular tip.
Beach and Bottom Composition:	Hard-packed sand and gravel; slope very gentle.
Depth Sampled:	0 to 1m; during extremely high tides entire beach is submerged to vegetation zone.
Current:	Slight, dependent on tide.
Clarity:	Normally clear, turbid with surf.
Aquatic Vegetation:	None attached in immediate sampling area; small amounts of floating Zostera marina and detritus sometimes encountered.
Shore Vegetation:	Phragmites communis, 95%; Panicum virgatum, 4%. Several other forms all less than 1% each.
	Station # 02: Stouts Creek Mouth
Area Sampled:	Off the easternmost point of the south bank of Stouts Creek Mouth, area sampled is approximately 60m of a narrow (5m) sandy beach in a small cove on the northside of the point.
Beach and Bottom Composition:	Firm sand and gravel at water's edge, becoming soft sand with patches of mud; slope gentle.
Depth Sampled:	0 to 1.1 m; during extremely high tides entire beach is submerged to vegetation zone.
Current:	Slight, dependent on tide.
Clarity:	Normally clear, turbid with surf.
Aquatic Vegetation:	Occasional patches of detritus and Zostera marina in sampling area; occasional floating Zostera and Ulva.
Shore Vegetation:	Phragmites communis, 75%; Spartina patens, 15%; several other forms all less than 1% each.

Table 43 . (cont.)

Station 04: Forked River Mouth

Area Sampled:	At the easternmost point of the South bank of Forked River Mouth; area sampled is approximately 60 m of a narrow (5 m) sandy beach in the cove on the north side of the point.
Beach and Bottom Composition:	Soft sand throughout sampling area with frequent patches of mud; slope gentle.
Depth Sampled:	0 to 1.1 m.
Current:	Slight to moderate, predominantly westerly due to influence of OCGS.
Clarity:	Normally clear.
Aquatic Vegetation:	Occasional patches of *Zostera marina* and benthic detritus in sampling area; floating *Zostera*, *Ulva* and detritus, occasional to common.
Shore Vegetation:	*Phragmites communis*, 90%. Several other forms less than 1% each.

Station 17: Oyster Creek Mouth

Area Sampled:	North bank of Oyster Creek Mouth, opposite Sands Point. Area sampled is approximately 60 m of a narrow (5 m) sandy beach immediately east of the bulkhead at the mouth of Oyster Creek.
Beach and Bottom Composition:	Hard sand and coarse gravel from shore to a depth of about 0.6 m, becoming soft sand and mud to edge of sampling area; slope steep.
Depth Sampled:	0 to 1.2 m
Current:	Slight to moderate, predominantly easterly due to influence of OCGS.
Clarity:	Normally clear, turbid with surf.
Aquatic Vegetation:	None attached in immediate sampling area; occasional floating *Zostera marina* and detritus.
Shore Vegetation:	*Ammophila breviligulata*, 80%; *Phragmites communis*, 10%; several other forms less than 1% each.

Table 43. (cont.)

	Station 20: Barnegat Bay at Sands Point Harbor
Area Sampled:	West bank of Barnegat Bay, approximately 0.75 miles south of Oyster Creek and 0.3 miles north of Waretown Creek, northwest of Intracoastal Waterway mid-channel marker BW N "F"; area sampled is approximately 60 m of a narrow (1-2 m) sandy beach located immediately south of the Holiday Beach Club on Shore Drive, across from 342 R, Shore Drive.
Beach and Bottom Composition:	Hard packed sand at water's edge; coarse gravel to a depth of about 0.3 m, becoming hard, fine sand to edge of sampling area. Slope gentle.
Depth Sampled:	0 to 1.2 m
Current:	Slight, dependent on tide.
Clarity:	Normally clear, turbid with surf.
Aquatic Vegetation:	None attached in sampling area; floating Zostera marina, Codium fragile and detritus, occasional to common; immediately beyond sampling area is a zone of attached Zostera.
Shore Vegetation:	Phragmites communis, 99%. Several other forms less than 1% each.
	Station 22: Barnegat Bay at Barnegat Beach
Area Sampled:	West bank of Barnegat Bay, approximately 0.5 miles south of Barnegat Beach, northwest of Intracoastal Waterway flashing light FL R "68"; area sampled is approximately 60 m of a wide (15 m) sandy beach at the end of Beach View Avenue.
Beach and Bottom Composition:	Firm at water's edge; coarse gravel to depth of about 0.3 m, becoming hard sand to edge of sampling area. Slope moderate.
Depth Sampled:	0 to 1.1 m
Current:	Slight, dependent on tide.
Clarity:	Clear to turbid.
Aquatic Vegetation:	None attached in sampling area; floating Zostera marina common to abundant, Codium fragile and detritus occasional to common; beach often completely covered with a layer of dead Zostera up to 30 cm thick.
Shore Vegetation:	Phragmites communis, 90%. Several other forms less than 1% each.

Table 43. (cont.)

	Station 23: Double Creek Mouth
Area Sampled:	North bank of mouth of Double Creek, area sampled is approximately 60 m of a narrow (5 m) sandy beach, located between two groin bulkheads immediately northwest of Double Creek flashing light FL R "2".
Beach and Bottom Composition:	Firm sand throughout, with some gravel to edge of sampling area; slope gentle.
Depth Sampled:	0 to 1.1 m
Current:	None to slight.
Clarity:	Clear to turbid.
Aquatic Vegetation:	None attached in sampling area; floating Zostera marina occasional to abundant, Codium fragile and detritus oaccasional to common; beach often completely covered with a layer of dead Zostera up to 30 cm thick.
Shore vegetation:	Phragmites communis, 90%; Ammophila breviligulata, 5%. Several other forms less than 1% each.

Table 44. Description of gill net stations regularly sampled during Oyster Creek Generating Station Ecological Studies.

<u>Station # 01: Cedar Creek Mouth</u>

Area Sampled:	Off the eastern most peninsula of the north bank of the mouth of Cedar Creek due west of Intracoastal Waterway buoy C "63".
Depth:	1.5 to 2.4 m
Direction of Set:	Perpendicular to shoreline, northwest to southeast from peninsula toward flashing light "64".
Current:	Very slight, dependent on tide; sampling influenced more by wind direction and velocity than tidal current.
Clarity:	Clear to tannic brown.
Aquatic Vegetation:	None to occasional, mostly *Zostera marina*.

<u>Station # 02: Stouts Creek Mouth</u>

Area Sampled:	Off the eastern most point of the south bank of the mouth of Souts Creek due west of Intracoastal Waterway mid-channel marker BW N "C1".
Depth:	1.5 to 2.4 m
Direction of Set:	West to east from beach toward stake marking entrance to Stouts Creek channel.
Current:	Very slight, dependent on tide; sampling operation influenced more by wind direction and velocity than tidal current.
Clarity:	Clear to tannic brown.
Aquatic Vegetation:	None to occasional, mostly *Zostera marina*.

<u>Station # 04: Forked River Mouth</u>

Area Sampled:	Off the south bank of the mouth of Forked River in a small cove located on the north side of the eastern most point, west southwest of Intracoastal Waterway mid-channel marker BW N "D1".
Depth:	1.5 to 1.8 m
Direction of Set:	Perpendicular to shoreline, north toward Forked River channel, between channel markers "B9" and "B11".
Current:	Slight to moderate, predominantly westerly due to influence of OCGS.
Clarity:	Clear to turbid.
Aquatic Vegetation:	None to occasional, mostly *Zostera marina*.

Table 44. (cont.)

	Station # 06: Forked River, east of Route 9 Bridge
Area Sampled:	South branch of Forked River, west of Beach Blvd. bridge and east of Route 9 bridge; just west of last house on north bank of River.
Depth:	1.5 to 2.1 m near banks, 2.7 m in mid-channel
Direction of Set:	Northeast to southwest, from River bank toward OCGS.
Current:	Moderate, westerly due to influence of OCGS.
Clarity:	Clear to turbid.
Aquatic Vegetation:	Occasional, Zostera marina and detritus.
	Station # 15: Oyster Creek, east of Route 9 Bridge
Area Sampled:	Oyster Creek, east of Route 9 bridge, approximately 1 mile upstream of the Creek mouth.
Depth:	1.8 to 2.0 m near banks, 3.5 m in mid-channel.
Direction of Set:	Northeast to southwest, bank to bank, approximately 180 m west of bulkheaded pond on north bank.
Current:	Moderate, easterly due to influence of OCGS.
Clarity:	Clear to turbid.
Aquatic Vegetation:	None to occasional, mostly Zostera marina.
	Station # 17: Oyster Creek Mouth
Area Sampled:	Off the north bank of the mouth of Oyster Creek, immediately east of bulkhead and due west of Intracoastal Waterway mid-channel marker BW N "E1".
Depth:	1.5 to 1.8 m
Direction of Set:	Perpendicular to shoreline, northwest to southeast, between red channel markers at Oyster Creek mouth.
Current:	Slight to moderate, predominantly easterly due to influence of OCGS.
Clarity:	Clear to turbid.
Aquatic Vegetation:	None to occasional, mostly Zostera marina.

Table 44 . (cont.)

	Station # 23: Double Creek Mouth
Area Sampled:	Off the easternmost point of the north bank of the mouth of Double Creek southwest of Intracoastal Waterway fishing light FL R "68", and due west of Double Creek flashing light FL R "2".
Depth:	1.5 to 2.1 m
Direction of Set:	West to east, from end of bulkhead directly toward Barnegat Light, parallel to channel.
Current:	Slight, dependent on tide; sampling operation influenced more by wind direction and velocity than tidal current.
Clarity:	Clear to turbid
Aquatic Vegetation:	None to occasional, mostly *Zostera marina*.

TABLE 45. TOTAL NUMBER OF SPECIMENS TAKEN BY TRAWL, SEINE, AND GILL NET FROM SEPTEMBER 1975 THROUGH AUGUST 1976 IN BARNEGAT BAY AND WESTERN TRIBUTARIES.

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTALS
MUSTELUS CANIS	-	-	-	-	-	-	-	-	-	-	-	2	2
DASYATIS SAYI	-	-	-	-	-	-	-	-	-	-	5	-	5
ANGUILLA ROSTRATA	19	3	1	1	-	8	11	15	29	27	11	11	136
CONGER OCEANICUS	-	1	-	1	-	-	-	-	-	-	-	-	2
ALOSA AESTIVALIS	2	1	4	32	-	1	16	29	-	-	-	-	85
ALOSA PSEUDOHARENGUS	-	1	2	8	-	1	30	15	1	-	-	-	58
ALOSA SAPIDISSIMA	-	-	-	3	-	-	15	2	-	-	-	-	20
BREVOORTIA TYRANNUS	3	24	12	67	1	-	13	42	16	44	41	43	306
CLUPEA HARENGUS	-	-	-	-	-	-	12	466	38	1	-	-	517
ETRUMEUS TERES	-	-	1	-	-	-	-	-	-	-	-	-	1
ANCHOA HEPSETUS	57	11	-	-	-	-	-	-	-	-	-	-	68
ANCHOA MITCHILLI	5358	10090	3868	539	-	-	245	17642	4661	3118	6327	3112	54560
SYNODUS FOETENS	-	-	2	-	-	-	-	-	-	-	2	1	5
OPSANUS TAU	25	25	15	1	3	1	-	3	7	28	49	51	208
UROPHYCIS REGIUS	-	-	-	-	-	-	4	18	7	-	-	-	29
RISSOLA MARGINATA	-	-	-	2	-	-	-	2	31	22	9	12	78
STRONGYLURA MARINA	3	-	-	-	-	-	-	-	8	6	40	6	63
CYPRINODON VARIEGATUS	-	2	5	-	1	2	11	6	-	1	-	-	28
FUNDULUS DIAPHANUS	-	-	-	-	-	-	-	1	2	1	-	-	4
FUNDULUS HETEROCLITUS	12	25	52	19	11	27	75	90	16	22	35	44	428
FUNDULUS MAJALIS	-	2	-	-	-	4	3	2	-	2	1	7	21
LUCANIA PARVA	6	4	-	1	-	-	-	1	1	1	-	1	15
MENIDIA BERYLLINA	-	-	-	11	30	94	242	136	22	17	14	4	570
MENIDIA MENIDIA	1765	1139	3051	2181	100	121	2438	3689	350	535	1933	739	18041
APELTES QUADRACUS	90	76	11	384	192	1021	2667	196	57	59	22	31	4806
FISTULARIA TABACARIA	1	-	-	-	-	-	-	-	-	-	-	2	3
HIPPOCAMPUS ERECTUS	2	-	-	2	-	-	-	1	-	1	-	-	6
SYNGNATHUS FUSCUS	30	51	56	51	2	5	49	58	76	38	33	52	501
MORONE AMERICANA	2	1	5	5	-	2	2	1	-	2	2	-	22
MORONE SAXATILIS	-	-	-	-	-	-	-	1	-	-	-	-	1
CENTROPRISTIS STRIATA	3	5	-	-	-	-	-	-	1	6	1	12	28
LEPOMIS GIBBOSUS*	-	4	-	-	-	-	-	-	-	-	-	-	4
POMATOMUS SALTATRIX	25	15	9	12	-	-	-	-	52	11	24	52	200
CARANX HIPPOS	-	7	1	-	-	-	-	-	-	-	139	25	172
SELENE VOMER	14	42	13	2	-	-	-	-	-	-	3	5	79
TRACHINOTUS CAROLINUS	-	-	-	-	-	-	-	-	-	-	3	1	4
TRACHINOTUS FALCATUS	1	-	6	-	-	-	-	-	-	-	6	14	27
LUTJANUS GRISEUS	-	2	-	-	-	-	-	-	-	-	-	-	2
STENOTOMUS CHRYSOPS	-	-	-	-	-	-	-	-	-	3	-	1	4
BAIRDIELLA CHRYSURA	19	9	2	-	-	-	-	-	-	3	1	3	37
CYNOSCION REGALIS	17	10	2	1	-	-	-	1	16	21	17	113	198
LEIOSTOMUS XANTHURUS	1	-	1	-	-	-	-	-	24	719	1350	537	2632
MENTICIRRHUS SAXATILIS	3	3	-	-	-	-	-	-	1	-	-	5	12
MICROPOGON UNDULATUS	6	-	-	-	-	-	-	-	-	-	-	-	6
TAUTOGA ONITIS	8	11	13	6	-	6	1	8	7	1	5	10	76
TAUTOGOLABRUS ADSPERSUS	-	1	1	-	-	-	1	-	1	2	-	-	6
MUGIL CEPHALUS	3	-	2	1	-	-	-	1	-	1	3	2	13
MUGIL CUREMA	6	2	-	-	-	-	-	2	1	-	4	5	20
SPHYRAENA BOREALIS	-	-	-	-	-	-	-	-	-	-	-	1	1
ASTROSCOPUS GUTTATUS	-	-	-	-	-	-	-	-	-	-	1	2	3
CHASMODES BOSQUIANUS	4	2	2	1	1	1	-	-	-	-	3	3	17
HYPSOBLENNIUS HENTZI	1	-	1	-	-	-	-	-	-	-	-	3	5
AMMODYTES SP.	-	-	214	193	-	-	30	32	-	-	-	-	469
GOBIOSOMA SP.	-	-	-	-	-	-	1	-	-	-	-	-	1
GOBIOSOMA BOSCI	37	30	18	37	7	14	6	3	5	4	8	17	189
GOBIOSOMA GINSBURGI	-	-	-	3	1	-	-	-	-	-	-	4	8
PEPRILUS TRIACANTHUS	-	-	-	-	-	-	-	-	1	-	1	1	3
PRIONOTUS CAROLINUS	-	-	-	-	-	-	-	-	-	-	-	7	7
PRIONOTUS EVOLANS	4	2	6	-	-	-	-	-	-	-	2	16	30
ETROPUS MICROSTOMUS	2	4	1	7	1	-	-	-	-	-	-	-	15
PARALICHTHYS DENTATUS	1	4	1	1	-	-	-	8	3	5	2	8	33
SCOPHTHALMUS AQUOSUS	-	-	1	1	-	-	1	5	1	-	-	1	10
PSEUDOPLEURONECTES AMERICANUS	1	16	13	40	4	18	47	27	13	24	21	49	273
TRINECTES MACULATUS	8	1	1	2	-	-	13	2	3	3	13	7	53
MONACANTHUS HISPIDUS	-	1	-	-	-	-	-	-	-	-	-	-	1
SPHOEROIDES MACULATUS	-	-	-	-	-	-	-	-	1	2	2	9	14
MALACLEMYS TERRAPIN	-	-	-	-	-	-	-	-	-	-	1	-	1
CRANGON SEPTEMSPINOSA	71	560	1671	12419	757	3173	6586	4210	1102	150	38	554	31291
CALLINECTES SAPIDUS	261	185	67	158	24	68	275	305	634	551	691	858	4097
TOTAL SPECIMENS	7871	12372	9151	16192	1135	4567	12794	27020	7191	5431	10863	6443	121030
TOTAL TAXA	37	38	36	33	15	18	26	34	33	34	39	46	69
TOTAL COLLECTIONS	101	93	93	93	66	93	93	93	93	93	93	93	1097

* Lepomus gibbosus misidentified as Lepomus macrochirus in Tatham 1977a.

TABLE 46. TOTAL NUMBER OF SPECIMENS TAKEN BY TRAWL FROM SEPTEMBER 1975 THROUGH AUGUST 1976 IN BARNEGAT BAY AND WESTERN TRIBUTARIES.

SPECIES	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTALS
DASYATIS SAYI	-	-	-	-	-	-	-	-	-	-	5	-	5
ANGUILLA ROSTRATA	13	3	1	1	-	8	11	5	27	24	9	6	108
CONGER OCEANICUS	-	1	-	1	-	-	-	-	-	-	-	-	2
ALOSA AESTIVALIS	-	1	-	32	-	-	16	28	-	-	-	-	77
ALOSA PSEUDOHARENGUS	-	1	-	8	-	-	7	3	-	-	-	-	19
ALOSA SAPIDISSIMA	-	-	-	3	-	-	15	2	-	-	-	-	20
BREVOORTIA TYRANNUS	-	-	1	7	1	-	1	-	1	2	3	8	24
CLUPEA HARENGUS	-	-	-	-	-	-	6	454	33	1	-	-	494
ETRUMEUS TERES	-	-	1	-	-	-	-	-	-	-	-	-	1
ANCHOA MITCHILLI	4377	9771	3557	539	-	-	129	4776	4461	2518	5847	2516	38491
SYNODUS FOETENS	-	-	2	-	-	-	-	-	-	-	1	-	3
OPSANUS TAU	24	22	15	1	3	1	-	3	6	16	33	24	148
UROPHYCIS REGIUS	-	-	-	-	-	-	4	17	7	-	-	-	28
RISSOLA MARGINATA	-	-	-	2	-	-	-	1	6	1	1	9	20
STRONGYLURA MARINA	1	-	-	-	-	-	-	-	-	-	-	-	1
CYPRINODON VARIEGATUS	-	-	-	-	-	1	-	-	-	-	-	-	1
FUNDULUS HETEROCLITUS	-	1	1	1	1	1	2	1	-	-	-	-	8
LUCANIA PARVA	-	2	-	-	-	-	-	-	-	-	-	-	2
MENIDIA BERYLLINA	-	-	-	-	-	3	-	-	-	-	-	-	3
MENIDIA MENIDIA	2	13	1355	773	8	9	177	41	18	-	6	31	2433
APELTES QUADRACUS	8	4	4	318	170	991	2592	179	36	59	8	4	4373
FISTULARIA TABACARIA	1	-	-	-	-	-	-	-	-	-	-	1	2
HIPPOCAMPUS ERECTUS	2	-	-	1	-	-	-	1	-	1	-	-	5
SYNGNATHUS FUSCUS	8	29	45	47	1	5	37	50	47	27	10	19	325
MORONE AMERICANA	-	-	1	5	-	1	2	-	-	1	-	-	10
CENTROPRISTIS STRIATA	3	5	-	-	-	-	-	-	1	6	1	10	26
POMATOMUS SALTATRIX	4	6	3	12	-	-	-	-	1	2	10	11	49
CARANX HIPPOS	-	1	1	-	-	-	-	-	-	-	52	8	62
SELENE VOMER	14	41	13	2	-	-	-	-	-	-	1	3	74
STENOTOMUS CHRYSOPS	-	-	-	-	-	-	-	-	-	3	-	1	4
BAIRDIELLA CHRYSURA	17	9	-	-	-	-	-	-	-	3	-	2	31
CYNOSCION REGALIS	17	10	2	1	-	-	-	1	3	2	14	100	150
LEIOSTOMUS XANTHURUS	-	-	1	-	-	-	-	-	1	556	1130	452	2140
MENTICIRRHUS SAXATILIS	1	1	-	-	-	-	-	-	-	-	-	1	3
MICROPOGON UNDULATUS	5	-	-	-	-	-	-	-	-	-	-	-	5
TAUTOGA ONITIS	8	10	13	5	-	6	1	8	7	1	5	6	70
TAUTOGOLABRUS ADSPERSUS	-	1	1	-	-	-	1	-	1	2	-	-	6
SPHYRAENA BOREALIS	-	-	-	-	-	-	-	-	-	-	-	1	1
CHASMODES BOSQUIANUS	3	2	2	1	1	1	-	-	-	-	-	1	11
HYPSOBLENNIUS HENTZI	1	-	1	-	-	-	-	-	-	-	-	1	3
AMMODYTES SP.	-	-	214	192	-	-	28	30	-	-	-	-	464
GOBIOSOMA SP.	-	-	-	-	-	-	1	-	-	-	-	-	1
GOBIOSOMA BOSCI	8	28	17	36	7	14	6	2	3	1	1	4	127
GOBIOSOMA GINSBURGI	-	-	-	3	1	-	-	-	-	-	-	-	4
PEPRILUS TRIACANTHUS	-	-	-	-	-	-	-	-	1	-	1	1	3
PRIONOTUS CAROLINUS	-	-	-	-	-	-	-	-	-	-	-	7	7
PRIONOTUS EVOLANS	4	2	6	-	-	-	-	-	-	-	2	11	25
ETROPUS MICROSTOMUS	1	3	-	7	1	-	-	-	-	-	-	-	12
PARALICHTHYS DENTATUS	1	4	1	1	-	-	-	8	3	5	2	8	33
SCOPHTHALMUS AQUOSUS	-	-	1	1	-	-	1	5	1	-	-	1	10
PSEUDOPLEURONECTES AMERICANUS	1	15	13	40	4	18	46	27	5	14	5	26	214
TRINECTES MACULATUS	5	1	1	2	-	-	13	2	3	3	11	7	48
MONACANTHUS HISPIDUS	-	1	-	-	-	-	-	-	-	-	-	-	1
SPHOEROIDES MACULATUS	-	-	-	-	-	-	-	-	1	1	2	4	8
CRANGON SEPTEMSPINOSA	2	409	804	9859	399	2062	4234	3579	1044	141	20	31	22584
CALLINECTES SAPIDUS	60	98	69	123	24	68	237	247	500	306	358	268	2358
TOTAL SPECIMENS	4591	10495	6146	12024	621	3189	7567	9470	6217	3696	7538	3583	75137
TOTAL TAXA	27	30	29	30	13	15	23	24	25	25	26	33	56
TOTAL COLLECTIONS	52	52	52	52	33	52	52	52	52	52	52	52	605

TABLE 47. TOTAL NUMBER OF SPECIMENS TAKEN BY SEINE FROM SEPTEMBER 1975 THROUGH AUGUST 1976 IN BARNEGAT BAY AND WESTERN TRIBUTARIES.

SPECIES	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTALS
ANGUILLA ROSTRATA	6	-	-	-	-	-	-	10	2	3	2	5	28
BREVOORTIA TYRANNUS	-	-	-	-	-	-	-	-	-	4	2	-	6
CLUPEA HARENGUS	-	-	-	-	-	-	-	12	5	-	-	-	17
ANCHOA HEPSETUS	57	11	-	-	-	-	-	-	-	-	-	-	68
ANCHOA MITCHILLI	981	319	311	-	-	-	116	12866	200	600	480	596	16469
SYNODUS FOETENS	-	-	-	-	-	-	-	-	-	-	1	1	2
OPSANUS TAU	1	3	-	-	-	-	-	-	1	12	16	27	60
UROPHYCIS REGIUS	-	-	-	-	-	-	-	1	-	-	-	-	1
RISSOLA MARGINATA	-	-	-	-	-	-	-	1	25	21	8	3	58
STRONGYLURA MARINA	2	-	-	-	-	-	-	-	8	6	40	6	62
CYPRINODON VARIEGATUS	-	2	5	-	1	1	11	6	-	1	-	-	27
FUNDULUS DIAPHANUS	-	-	-	-	-	-	-	1	2	1	-	-	4
FUNDULUS HETEROCLITUS	12	24	51	18	10	26	73	89	16	22	35	44	420
FUNDULUS MAJALIS	-	2	-	-	-	4	3	2	-	2	1	7	21
LUCANIA PARVA	6	2	-	1	-	-	-	1	1	1	-	1	13
MENIDIA BERYLLINA	-	-	-	11	30	91	242	136	22	17	14	4	567
MENIDIA MENIDIA	1763	1126	1696	1408	92	112	2261	3648	332	535	1927	708	15608
APELTES QUADRACUS	82	72	7	66	22	30	75	17	21	-	14	27	433
FISTULARIA TABACARIA	-	-	-	-	-	-	-	-	-	-	-	1	1
HIPPOCAMPUS ERECTUS	-	-	-	1	-	-	-	-	-	-	-	-	1
SYNGNATHUS FUSCUS	22	22	11	4	1	-	12	8	29	11	23	33	176
MORONE AMERICANA	1	1	4	-	-	-	-	-	-	1	-	-	7
CENTROPRISTIS STRIATA	-	-	-	-	-	-	-	-	-	-	-	2	2
LEPOMIS GIBBOSUS	-	4	-	-	-	-	-	-	-	-	-	-	4
POMATOMUS SALTATRIX	-	3	5	-	-	-	-	-	-	5	7	4	24
CARANX HIPPOS	-	6	-	-	-	-	-	-	-	-	87	16	109
SELENE VOMER	-	1	-	-	-	-	-	-	-	-	2	2	5
TRACHINOTUS CAROLINUS	-	-	-	-	-	-	-	-	-	-	3	1	4
TRACHINOTUS FALCATUS	1	-	6	-	-	-	-	-	-	-	6	14	27
LUTJANUS GRISEUS	-	2	-	-	-	-	-	-	-	-	-	-	2
BAIRDIELLA CHRYSURA	-	-	2	-	-	-	-	-	-	-	1	1	4
CYNOSCION REGALIS	-	-	-	-	-	-	-	-	-	-	2	13	15
LEIOSTOMUS XANTHURUS	-	-	-	-	-	-	-	-	23	163	197	52	435
MENTICIRRHUS SAXATILIS	-	2	-	-	-	-	-	-	-	-	-	4	6
TAUTOGA ONITIS	-	-	-	-	-	-	-	-	-	-	-	4	4
MUGIL CEPHALUS	3	-	2	1	-	-	-	1	-	1	3	2	13
MUGIL CUREMA	6	2	-	-	-	-	-	2	1	-	4	5	20
ASTROSCOPUS GUTTATUS	-	-	-	-	-	-	-	-	-	-	1	2	3
CHASMODES BOSQUIANUS	1	-	-	-	-	-	-	-	-	-	3	2	6
HYPSOBLENNIUS HENTZI	-	-	-	-	-	-	-	-	-	-	-	2	2
AMMODYTES SP.	-	-	-	1	-	-	2	2	-	-	-	-	5
GOBIOSOMA BOSCI	29	2	1	1	-	-	-	1	5	3	7	13	62
GOBIOSOMA GINSBURGI	-	-	-	-	-	-	-	-	-	-	-	4	4
PRIONOTUS EVOLANS	-	-	-	-	-	-	-	-	-	-	-	5	5
ETROPUS MICROSTOMUS	1	1	1	-	-	-	-	-	-	-	-	-	3
PSEUDOPLEURONECTES AMERICANUS	-	-	-	-	-	-	1	-	8	10	16	23	58
TRINECTES MACULATUS	3	-	-	-	-	-	-	-	-	-	2	-	5
SPHOEROIDES MACULATUS	-	-	-	-	-	-	-	-	-	-	-	5	5
CRANGON SEPTEMSPINOSA	69	151	867	2560	358	1111	2352	631	58	9	18	523	8707
CALLINECTES SAPIDUS	172	83	18	35	-	-	38	56	126	213	281	540	1562
TOTAL SPECIMENS	3218	1841	2987	4107	514	1375	5186	17491	885	1641	3203	2702	45150
TOTAL TAXA	20	22	15	12	7	7	12	20	19	22	30	37	50
[illegible]	[illegible]	34	34	34	26	34	34	34	34	34	34	34	404

TABLE 48. TOTAL NUMBER OF SPECIMENS TAKEN BY GILL NET FROM SEPTEMBER 1975 THROUGH AUGUST 1976 IN BARNEGAT BAY AND WESTERN TRIBUTARIES.

SPECIES	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTALS
MUSTELUS CANIS	-	-	-	-	-	-	-	-	-	-	-	2	2
ALOSA AESTIVALIS	2	-	4	-	-	1	-	1	-	-	-	-	8
ALOSA PSEUDOHARENGUS	-	-	2	-	-	1	23	12	1	-	-	-	39
BREVOORTIA TYRANNUS	3	24	11	60	-	-	12	42	15	38	36	35	276
CLUPEA HARENGUS	-	-	-	-	-	-	6	-	-	-	-	-	6
MORONE AMERICANA	1	-	-	-	-	1	-	1	-	-	2	-	5
MORONE SAXATILIS	-	-	-	-	-	-	-	1	-	-	-	-	1
POMATOMUS SALTATRIX	21	6	1	-	-	-	-	-	51	4	7	37	127
CARANX HIPPOS	-	-	-	-	-	-	-	-	-	-	-	1	1
BAIRDIELLA CHRYSURA	2	-	-	-	-	-	-	-	-	-	-	-	2
CYNOSCION REGALIS	-	-	-	-	-	-	-	-	13	19	1	-	33
LEIOSTOMUS XANTHURUS	1	-	-	-	-	-	-	-	-	-	23	33	57
MENTICIRRHUS SAXATILIS	2	-	-	-	-	-	-	-	1	-	-	-	3
MICROPOGON UNDULATUS	1	-	-	-	-	-	-	-	-	-	-	-	1
TAUTOGA ONITIS	-	1	-	1	-	-	-	-	-	-	-	-	2
PSEUDOPLEURONECTES AMERICANUS	-	1	-	-	-	-	-	-	-	-	-	-	1
SPHOEROIDES MACULATUS	-	-	-	-	-	-	-	-	-	1	-	-	1
MALACLEMYS TERRAPIN	-	-	-	-	-	-	-	-	-	-	1	-	1
CALLINECTES SAPIDUS	29	4	-	-	-	-	-	2	8	32	52	50	177
TOTAL SPECIMENS	62	36	18	61	0	3	41	59	89	94	122	158	743
TOTAL TAXA	9	5	4	2	0	3	3	6	6	5	7	6	19
TOTAL COLLECTIONS	11	7	7	7	7	7	7	7	7	7	7	7	88

Table 49. Summary of results of two-way analysis of variance applied to trawl, seine, and gill net collections from September 1975 through August 1976.

Species	Time Period	Gear	Replicate[a]	Station	Date	Station X Date Interaction
Anchoa mitchilli	September-December	trawl	NS	**	**	**
Menidia menidia	November-December	trawl	* (1>2)	**	**	**
Apeltes quadracus	February-March	trawl	NS	**	NS	NS
Leiostomus xanthurus	June-August	trawl	NS	**	**	**
Callinectes sapidus	September-December	trawl	NS	**	NS	NS
Anchoa mitchilli	September-November	seine	NS	*	**	**
Anchoa mitchilli	April-August	seine	* (1>2)	**	**	**
Menidia menidia	September-December	seine	NS	*	**	NS
Leiostomus xanthurus	June-August	seine	NS	**	**	NS
Callinectes sapidus	September-December	seine	* (1>2)	NS	NS	NS
Callinectes sapidus	May-August	seine	NS	*	**	NS
Brevoortia tyrannus	March-August	gill net		**	*	
Pomatomus saltatrix	May-August	gill net		NS	NS	

The following ANOVA had significant X^2 in Barlett's test:

Anchoa mitchilli	April-August	trawl
Callinectes sapidus	April-August	trawl
Menidia menidia	March-August	seine

a NS = not significant
* = achieved significance at $P \leq 0.05$
** = achieved significance at $P \leq 0.01$
Largest mean replicate indicated where significant. Significant differences among stations and dates given on following table.

Table 50. Summary of results of three-way analysis of variance applied to day-night trawl and seine collections from September 1975 through August 1976.

Species	Time Period	Gear	Replicate[a]	Station	Date	Time	StaXDate	StaXTime	DateXTime	StaXDateXTime
Anchoa mitchilli	March-August	trawl	NS	**	**	**(D > N)	**	**	**	NS
Crangon septemspinosa	October-December	trawl	NS	NS	**	**(N > D)	NS	**	NS	NS
Crangon septemspinosa	February-May	trawl	NS	**	**	**(N > D)	**	**	**	**
Callinectes sapidus	March-August	trawl	NS	**	**	**(N > D)	*	**	**	**
Anchoa mitchilli	April-August	seine	**(1>2)	**	**	**(N > D)	**	*	*	*
Menidia menidia	January-August	seine	**(1>2)	**	**	NS	*	NS	NS	*
Leiostomus xanthurus	May-August	seine	NS	NS	*	**(N > D)	NS	NS	NS	NS
Crangon septemspinosa	January-August	seine	NS	NS	**	**(N > D)	NS	NS	**	NS

The following ANOVA had significant X^2 in Bartlett's test:

Callinectes sapidus	October-December	trawl
Callinectes sapidus	March-August	seine

a NS=not significant
*=achieved significance at $P \leq 0.05$
**=achieved significance at $P \leq 0.01$
Largest mean replicate and largest mean catch by day or night indicated where significant.
Significant differences among stations and dates given on following table.

Table 51. Results of the Student-Newman-Kuals multiple range test applied to main effect means from two-way analysis of variance. Means underlined are not significantly different.

Anchoa mitchilli September - December trawl	station	23	1	2	4	19	3	21	24	17	15	6
	mean[a]	1.483	1.467	1.369	1.264	1.176	1.113	0.756	0.742	0.282	0.226	0.105
	date[b]	October 2	October 1	November 1	September 1	September 2	December 2	December 1	November 2			
	mean	1.532	1.371	1.293	1.093	1.002	0.336	0.328	0.306			
Menidia menidia November - December trawl	station	2	3	21	23	1	4	15	19	6	17	24
	mean	1.253	1.095	0.999	0.756	0.676	0.594	0.480	0.337	0.165	0.113	0.075
	date	December 2	November 2	November 1	December 1							
	mean	0.952	0.778	0.545	0.104							
Apeltes quadracus February - March trawl	station	23	3	4	19	21	6	2	1	15	17	24
	mean	1.435	1.230	1.103	1.015	0.915	0.893	0.756	0.518	0.351	0.185	0.038
Leiostomus xanthurus June - August trawl	station	19	15	23	17	24	2	1	3	21	4	6
	mean	0.852	0.801	0.754	0.719	0.673	0.428	0.362	0.333	0.263	0.242	0.228
	date	July 1	June 2	August 1	July 2	August 2	June 1					
	mean	0.881	0.791	0.587	0.411	0.351	0.063					
Callinectes sapidus September - December trawl	station	23	1	2	4	15	6 & 17	19	21 & 24	3		
	mean	0.472	0.354	0.341	0.296	0.235	0.210	0.207	0.086	0.030		
Anchoa mitchilli September - November seine	station	17	1	4	20	22	23	2				
	mean	0.645	0.547	0.489	0.478	0.378	0.350	0.240				
	date	September 2	October 2	September 1	November 1	October 1 & November 2						
	mean	1.090	0.925	0.365	0.300	0.000						

Table 51. (cont.)

Species											
Anchoa mitchilli April - August seine	station	17	22	4	20	23	1	2			
	mean	0.820	0.769	0.476	0.459	0.361	0.284	0.164			
	date	August 1	July 1	July 2	April 1	June 1	June 2	August 1	May 2	April 2	May 1
	mean	1.190	0.871	0.557	0.537	0.456	0.416	0.287	0.176	0.172	0.099
Menidia menidia September - December seine	station	20	22	23	2	17	1	4			
	mean	1.491	1.149	1.026	0.964	0.929	0.867	0.794			
	date	September 1	November 1	October 1	November 2	December 2	October 2	September 2	December 1		
	mean	1.603	1.369	1.349	0.989	0.881	0.867	0.743	0.449		
Leiostomus xanthurus June - August seine	station	23	22	20	4	17	2	1			
	mean	0.818	0.595	0.487	0.468	0.311	0.050	0.040			
	date	June 2	July 2	July 1	June 1	August 1	August 2				
	mean	0.663	0.583	0.371	0.322	0.272	0.207				
Callinectes sapidus May - August seine	station	4	23	22	20	17	2	1			
	mean	0.959	0.908	0.826	0.720	0.719	0.615	0.584			
	date	August 2	July 2	August 1	June 2	May 2	June 1	July 1	May 1		
	mean	1.288	1.111	0.986	0.712	0.594	0.535	0.519	0.347		
Brevoortia tyrannus March - August gill net	station	1	23	17	4	2	15	6			
	mean	0.951	0.727	0.682	0.538	0.452	0.241	0.000			
	date	April 1	August	July	June	May	March				
	mean	0.750	0.642	0.587	0.586	0.283	0.229				

a means from log (X + 1) transformed data
b 1 and 2 refer to first and second sampling dates during months

Table 52. Results of the Student-Newman-Kuels multiple range test applied to main effect means from three-way analysis of variance. Means underlined are not significantly different.

Anchoa mitchilli March - August trawl	station	4	17	19	3				
	mean[a]	1.048	1.031	0.839	0.758				
	date	July	April	May	August	June	March		
	mean	1.422	1.114	1.074	0.980	0.690	0.233		
Crangon septemspinosa October - December trawl	date	December	November	October					
	mean	2.092	0.767	0.754					
Crangon septemspinosa February - May trawl	station	19	4	3	17				
	mean	1.754	1.673	1.599	1.306				
	date	March	February	April	May				
	mean	2.097	1.532	1.407	1.295				
Callinectes sapidus March - August trawl	station	19	17	4	3				
	mean	1.052	0.906	0.740	0.593				
	date	May	July	June	August & March	April			
	mean	1.059	0.904	0.895	0.844	0.389			
Anchoa mitchilli April - August seine	station	17	20	4					
	mean	1.313	0.694	0.636					
	date	April	June	July	May	August			
	mean	1.210	1.198	0.945	0.774	0.610			
Menidia menidia January - August seine	station	17	20	4					
	mean	1.222	0.964	0.832					
	date	March	July	April	August	May	June	February	January
	mean	1.707	1.391	1.309	1.012	0.730	0.706	0.602	0.591
Leiostomus xanthurus May - August seine	date	July	June	August	May				
	mean	0.695	0.542	0.428	0.232				
Crangon septemspinosa January - August seine	date	March	February	April	August	January	May	June	
	mean	1.812	1.486	1.086	0.681	0.671	0.469	0.138	

a means from log (X + 1) transformed data

Table 53. Results of multiple regression analysis applied to catches of species taken by trawl, seine, and gill net from September 1975 through August 1976.

Species	Gear	Number of Observations	r^2 [a]	regression equation[b]
Anchoa mitchilli	trawl	307	0.060	
Menidia menidia	trawl	95	0.354	catch = 0.328 (OCGS heat rejection) - 0.003 (OCGS water flow)
Apeltes quadracus	trawl	164	0.116	
Syngnathus fuscus	trawl	148	-	
Leiostomus xanthurus	trawl	80	0.052	
Pseudopleuronectes americanus	trawl	85	-	
Cangon septemspinosa	trawl	290	0.188	
Callinectes sapidus	trawl	302	0.104	
Anchoa mitchilli	seine	101	0.063	
Fundulus heteroclitus	seine	71	0.184	
Menidia beryllina	seine	70	-	
Menidia menidia	seine	250	0.057	
Apeltes quadracus	seine	71	-	
Syngnathus fuscus	seine	64	0.097	
Cangon septemspinosa	seine	153	0.047	
Callinectes sapidus	seine	146	0.363	catch = 0.107 (water temperature) + 0.292 (tide direction) - 0.066 (salinity)
Brevoortia tyrannus	gill net	39	-	
Pomatomus saltatrix	gill net	25	-	
Callinectes sapidus	gill net	32	0.454	catch = 0.122 (water temperature)

a r^2 determined before tolerance value was too small or F-value insufficient for further computation. A dash indicates no independent variable met above criteria for r^2 computation.

b Given for 3 species in which $r^2 > 0.35$

Table 54. Comparison of ranks and percent of total seine catch of important species between the present study and Marcellus (1972).

Present Rank	Present % of total	Species	Marcellus (1972) Rank	Marcellus (1972) % of total
1	47.2	Anchoa mitchilli	2	19.4
2	44.8	Menidia menidia *	1	50.5
3	1.6	Menidia beryllina *	4	7.2
4	1.2	Leiostomus xanthurus	>15	<0.1
5	1.2	Apeltes quadracus	3	9.8
6	1.2	Fundulus heteroclitus	7	1.3
7	0.5	Syngnathus fuscus	8	1.1
8	0.3	Caranx hippos	>15	<0.1
9	0.2	Anchoa hepsetus	>15	<0.1
10.5	0.2	Strongylura marina	13	0.3
10.5	0.2	Gobiosoma bosci	>15	<0.1
36.5	<0.1	Bairdiella chrysura	5	3.3
31.5	<0.1	Sphoeroides maculatus	6	3.2
13.5	<0.1	Pseudopleuronectes americanus	9	0.8
-	None	Clupea harengus	10	0.7

* Marcellus (1972) noted that he misidentified M. beryllina as M. menidia during the first six months of study, resulting in an underestimate of the former and overestimate of the latter.

Table 55. Fishes taken in Barnegat Bay and western tributaries grouped by temporal and spatial occurrence.

Residents

Anguilla rostrata *
Opsanus tau
Rissola marginata ?
Cyprinodon variegatus
Fundulus heteroclitus
Fundulus majalis
Lucania parva
Menidia beryllina
Menidia menidia
Apeltes quadracus
Hippocampus erectus ?
Syngnathus fuscus
Morone americana
Tautoga onitis
Tautogolabrus adspersus ?
Chasmodes bosquianus ?
Hypsoblennius hentzi ?
Gobiosoma bosci
Pseudopleuronectes americanus
Trinectes maculatus

Cool water migrants

Alosa aestivalis
Alosa pseudoharengus
Alosa sapidissima
Clupea harengus
Urophycis regius
Micropogon undulatus

Warm water migrants

Dasyatis sayi
Brevoortia tyrannus
Anchoa mitchilli
Synodus foetens
Strongylura marina
Fistularia tabacaria
Centropristis striata
Pomatomus saltatrix
Caranx hippos
Selene vomer
Trachinotus carolinus
Trachinotus falcatus
Lutjanus griseus
Bairdiella chrysura
Cynoscion regalis
Leiostomus xanthurus
Menticirrhus saxatilis
Mugil cephalus
Mugil curema
Sphyraena borealis
Prionotus evolans
Paralichthys dentatus
Monacanthus hispidus
Sphoeroides maculatus

Local Marine Strays

Mustelus canis
Conger oceanicus
Etrumeus teres
Anchoa hepsetus
Morone saxatilis
Stenotomus chrysops
Astroscopus guttatus ?
Ammodytes sp.
Gobiosoma ginsburgi ?
Peprilus triacanthus
Prionotus carolinus
Etropus microstomus ?
Scophthalmus aquosus

Freshwater strays

Fundulus diaphanus
Lepomis gibbosus

* catadromus
? indicates some uncertainty

Table 56. Actual number and percent of Atlantic menhaden collected from OCGS Screens, Barnegat Bay, Forked River, Oyster Creek from September, 1975 through August, 1976.

	Number September	October	November	December	January	February	March	April	May	June	July	August
OCGS Screens	5	3	24	2903	-	-	27	287	290	222	1447	156
Barnegat Bay	-	18	9	-	-	-	3	15	15	27	31	30
Forked River	3	5	1	2	-	-	-	11	1	3	7	6
Oyster Creek	-	1	2	65	1	-	10	16	-	13	3	7
Total	8	27	36	2970	1	-	40	329	306	265	1488	199

	Percent September	October	November	December	January	February	March	April	May	June	July	August
OCGS Screens	62.5	11.1	66.7	97.7	-	-	67.5	87.2	94.8	83.8	97.2	78.4
Barnegat Bay	-	66.7	25.0	-	-	-	7.5	4.6	4.9	10.2	2.1	15.1
Forked River	37.5	18.5	2.8	0.1	-	-	-	3.3	0.3	1.1	0.5	3.0
Oyster Creek	-	3.7	5.5	2.2	100.0	-	25.0	4.8	-	4.9	0.2	3.5
Total	100.0	100.0	100.0	100.0	100.0	-	100.0	99.9	100.0	100.0	100.0	100.0

Table 57. Summary of results of t-tests (P = 0.05) on mean lengths between males and females and between successive year classes of Atlantic menhaden examined from September 1975 through August 1976.

	All Males vs Females			4^+ Males vs Females	
N	369	489	N	22	34
$\overline{X}$	207.7	215.2	$\overline{X}$	266.09	265.44
S	46.1	45.4	S	21.21	15.21
S^2	2123.4	2057.5	S^2	449.86	231.34
t	= 2.60 @ 856 df S.*		t	= 0.13 @ 64 df NS	
	Young Males vs Females			Young vs 1^+	
N	35	40	N	218	79
$\overline{X}$	117.77	134.33	$\overline{X}$	110.47	183.38
S	32.66	39.89	S	29.07	30.27
S^2	1066.7	1591.2	S^2	845.06	916.27
t	= 1.95 @ 74 df NS **		t	= 18.85 @ 295 df S	
	1^+ Males vs Females			1^+ vs 2^+	
N	25	43	N	79	232
$\overline{X}$	185.44	188.91	$\overline{X}$	183.38	211.02
S	31.86	24.90	S	30.29	19.12
S^2	1015.05	620.01	S^2	916.27	365.57
t	= 0.50 @ 66 df NS		t	= 9.44 @ 309 df S	
	2^+ Males vs Females			2^+ vs 3^+	
N	93	125	N	232	187
$\overline{X}$	209.5	212.4	$\overline{X}$	211.02	235.98
S	18.32	19.40	S	19.12	24.45
S^2	335.62	376.36	S^2	365.0	597.8
t	= 1.14 @ 216 df NS		t	= 11.72 @ 417 df S	
	3^+ Males vs Females			3^+ vs 4^+	
N	71	115	N	187	56
$\overline{X}$	231.4	239.0	$\overline{X}$	235.98	265.70
S	24.88	23.88	S	24.45	17.63
S^2	619.01	570.25	S^2	597.80	310.82
t	= 2.06 @ 184 df S		t	= 8.45 @ 241 df S	

* S - significant @ P = 0.05.
** NS - not significant @ P = 0.05

Table 58. GM functional regression analysis of log length vs log weight for males and females of Atlantic menhaden examined from September 1975 to August 1976.

MALES:	Slope	3.0302
	Confidence Interval B	0.176
	Intercept	-4.9186
	No. of Pairs	369
FEMALE:	Slope	3.0702
	Confidence Interval of B	0.228
	Intercept	-5.0002
	No. of Pairs	488

Test of Significance between regression: t = 0.815@853 df
Not Significant @ P = 0.05

Table 59. Pooled GM functional regression analysis of log length vs log weight of Atlantic menhaden examined from September 1975 to August 1976.

Pooled:	Slope	3.0566
	Confidence Interval B	0.0166
	Intercept	-4.9734
	No. of Pairs	1229

Table 60. Condition factor of Atlantic menhaden examined from the traveling screens at Barnegat Bay, Forked River, Oyster Creek and OCGS from September 1975 through August 1976.

Location	Freq	Min	Max	Mean	S. dev.
Bay	119	7.9	19.7	13.96	2.00
Forked River	29	9.6	18.6	13.35	2.24
Oyster Creek	115	8.9	19.3	13.19	2.16
OCGS	870	1.1	53.9	11.21	2.50

Table 61. Summary of the results of t-test on the mean condition factor between Barnegat Bay (BB), Forked River (F.R.), Oyster Creek (O.C.), Oyster Creek Generating Station (OCGS), all months combined for the Atlantic menhaden examined from September 1975 through August 1976.

Location	t-test	degrees of freedom	Results
BB vs FR	t=1.438	146	BB ≅ FR
BB vs OC	=2.827	232	BB > OC
BB vs OCGS	=11.505	987	BB > OCGS
FR vs OC	=0.354	142	FR ≅ OC
FR vs OCGS	=4.583	897	FR > OCGS
OC vs OCGS	=8.103	983	OC > OCGS

Table 62 . Numbers of male and female Atlantic menhaden examined from the traveling screens at OCGS, Barnegat Bay, Forked River, and Oyster Creek from September 1975 through August 1976.

	OCGS		BAY		FORKED RIVER		OYSTER CREEK		
	Males	Females	Males	Females	Males	Females	Males	Females	Total
September 1975	-	-	-	-	1	1	-	-	2
October	-	1	6	11	-	-	-	1	19
November	-	3	1	3	1	-	-	-	8
December	114	162	-	-	-	1	27	28	332
January 1976	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-
March	7	20	1	-	3	4	17	30	82
April	37	43	7	7	5	2	7	6	114
May	56	57	1	11	1	-	-	-	126
June	10	19	12	8	2	1	-	8	60
July	15	14	10	13	-	4	-	1	57
August	17	24	2	3	2	2	4	2	56
Total	257	342	40	56	15	15	55	76	856

Table 63. Results of chi-square test (p = 0.05) between the numbers of male and female Atlantic menhaden examined from the traveling screen at OCGS, Barnegat Bay, Forked River, and Oyster Creek from September 1975 through August 1976.

	OCGS SCREENS	BARNEGAT BAY	FORKED RIVER	OYSTER CREEK
September, 1975	-	-	*	-
October	*	*	-	*
November	*	*	*	-
December	S (F>M)	-	*	NS
January, 1976	-	-	-	-
February	-	-	-	-
March	-	*	*	NS
April	NS	*	*	*
May	NS	*	*	-
June	NS	*	*	*
July	NS	NS	*	*
August	NS	*	*	*

NS = Not significant
S = Significant
F>M = Numbers of females exceed males significantly (P = 0.05)
* = Insufficient data
- = No data

Table 64. Gonad condition of Atlantic menhaden examined from the traveling screens at OCGS, Barnegat Bay, Forked River, and Oyster Creek from September 1975 through August 1976.

		Number of specimens				
Age	Immature	Mature	Enlarged	Ripe	Spent	Total
0	218	0	0	0	0	218
1	79	0	0	0	0	79
2	220	3	7	0	0	230
3	111	31	42	1	3	188
4	2	27	16	2	9	56
5	0	6	0	1	2	9
6	0	1	2	0	2	5
	630	68	67	4	16	785

		Percent of specimens for each gonad condition				
Age	Immature	Mature	Enlarged	Ripe	Spent	Total
0	27.77	-	-	-	-	27.77
1	10.06	-	-	-	-	10.06
2	28.03	0.38	0.89	-	-	29.30
3	14.14	3.95	5.35	0.13	0.38	23.95
4	0.25	3.44	2.04	0.25	1.15	7.13
5	-	0.76	-	0.13	0.25	1.14
6	-	0.13	0.25	-	0.25	0.63
	80.25	8.66	8.53	0.51	2.03	99.98

		Percent of specimens for each age class				
Age	Immature	Mature	Enlarged	Ripe	Spent	Total
0	100	-	-	-	-	100
1	100	-	-	-	-	100
2	95.7	1.3	3.0	-	-	100
3	59.0	16.5	22.3	0.5	1.6	99.9
4	3.6	48.2	28.6	3.6	16.1	100.1
5	-	66.7	-	11.1	22.2	100
6	-	20.0	40.0	-	40.0	100

Table 65 . Number and percent of Atlantic menhaden in each age class for specimens examined from September 1975 through August 1976.

Age	No. Specimens	%
0	218	27.7
1	79	10.1
2	232	29.5
3	187	23.8
4	56	7.1
5	9	1.1
6	5	0.6
	786	99.9

Table 66 . Number, percent and chi-square of Atlantic menhaden in each age class, by sex for specimens examined from September 1975 through August 1976.

Age	Number		%			
	Male	Female	Male	Female	X^2 *	S/NS **
0	35	40	46.7	53.3	0.33	NS
1	25	43	36.8	63.2	4.76	S
2	93	125	42.7	57.3	4.69	S
3	71	115	38.3	61.8	10.40	S
4	22	34	39.3	60.7	2.56	NS
5	3	6	-	-	-	
6	1	4	-	-	-	
	250	367				

* chi-square X^2 value testing number of males versus females to determine if sex ratio varies significantly from 50:50

** S/NS = Significant or Not Significant at P = .05

Table 67 . Number and means length ($\overline{x}$) of age 0+ - 6+ Atlantic menhaden examined from the traveling screens at OCGS, Barnegat Bay, Oyster Creek and Forked River from September 1975 through August 1976.

Age		OCGS	Bay	Oyster Creek	Forked River
0	* N	88	30	55	**
	$\overline{X}$ (mm)	100.8	121.3	110.9	**
1	N	55	**	**	**
	$\overline{X}$	190.3	**	**	**
2	N	184	22	13	**
	$\overline{X}$	211.5	198.2	213.9	**
3	N	123	20	19	**
	$\overline{X}$	227.9	242.2	246.7	**
4	N	26	15	**	**
	$\overline{X}$	268.4	262.7	**	**
5	N	**	**	**	**
	$\overline{X}$	**	**	**	**
6	N	**	**	**	**
	$\overline{X}$	**	**	**	**

* = 10 or more spm/catagory
** = less than 10 specimens.

Table 68. Back calculation of the mean length of all ages 1-6 female Atlantic menhaden examined from September 1975 through August 1976.

Age	Freq.	Minimum	Maximum	Mean	Standard Deviation	Standard Error	95% CI Low	95% CI High
1	325	53.53	220.99	120.37	29.97	1.66	117.12	123.63
2	281	107.11	260.87	181.10	23.47	1.40	178.36	183.85
3	160	155.05	298.99	217.54	22.89	1.81	213.99	221.09
4	44	216.06	319.49	251.08	22.40	3.38	244.32	257.83
5	9	246.91	329.75	286.39	29.99	10.00	263.33	309.44
6	4	283.07	334.87	318.60	24.09	12.04	280.28	356.92

Table 69. Back calculation of the mean length of all ages 1-6 male Atlantic menhaden examined from September 1975 through August 1976.

Age	Freq.	Minimum	Maximum	Mean	Standard Deviation	Standard Error	95% CI Low	95% CI High
1	215	65.12	197.66	116.03	26.74	1.82	112.45	119.60
2	191	125.59	250.70	176.13	22.64	1.64	172.92	179.34
3	98	160.73	278.90	212.06	24.07	2.43	207.25	216.87
4	26	203.58	288.30	248.32	22.50	4.41	239.24	257.41
5	4	225.42	272.96	255.66	20.81	10.40	222.55	288.76
6	1	258.17	258.17	258.17	-	-	-	-

Table 70. Results of t-tests between mean length of Atlantic menhaden based on back calculated body length of specimens examined from September 1975 through August 1976.

MALE VS FEMALE by Age

Age 1	t = 1.72 @ 538 df	ns
Age 2	t = 2.29 @ 470 df	S
Age 3	t = 1.83 @ 256 df	ns
Age 4	t = 0.50 @ 68 df	ns

Comparison of successive age classes by sex:

MALES:

1 vs 2	t = 24.29 @ 404 df	S
2 vs 3	t = 12.49 @ 287 df	S
3 vs 4	t = 6.91 @ 122 df	S

FEMALES:

1 vs 2	t = 27.47 @ 604 df	S
2 vs 3	t = 15.81 @ 439 df	S
3 vs 4	t = 8.64 @ 202 df	S

S/ns = Significant or not significant at P = 0.05.

Table 71. The number and percentage of diseased, parasitized, mechanically damaged, and other abnormal Atlantic menhaden examined from September 1975 through August 1976.

Category: Specific Abnormality	N	% of Each Category	% of All Specimens Examined
Disease parasite only:			
Lernaeenicus spp. (only)	64	87.7	5.7
Olencera praegustator (only)	6	8.2	0.5
Fin rot	1	1.4	0.1
Lernaeenicus and Olencera	2	2.7	0.2
	73	100.0	6.5
Mechanical damage only:			
Probably dead at capture	7	1.6	0.6
Scaled	290	66.3	25.8
Scaled with flesh missing	106	24.3	9.4
Fin damage	7	1.6	0.6
Eye damage	10	2.3	0.9
Scaled with fin damage	17	3.9	1.5
	437	100.0	38.8
Multiple trauma:			
Probably dead at capture w/Lernaeenicus	3	7.0	0.3
Scaled w/Lernaeenicus	28	65.1	2.5
Scaled and flesh missing w/Lernaeenicus	2	4.7	0.2
Fin damage w/Lernaeenicus	5	11.6	0.4
Eye damage w/Lernaeenicus	1	2.3	0.1
Scaled and fin damage w/Lernaeenicus	2	4.7	0.2
Scaled w/Olencera	1	2.3	0.1
Fin abnormality w/Lernaeenicus	1	2.3	0.1
	43	100.0	3.9
Genetic: Anomoles			
Pugheadedness	1	-	0.1
Fin abnormality (only)	1	-	0.1
			0.2
Normal	568	-	50.6
≤	1123	-	100.0

Table 72 . Number and percent of all normal, parasitized/diseased, and mechanically damaged Atlantic menhaden examined from the traveling screens at OCGS, Barnegat Bay, Forked River, and Oyster Creek from September 1975 through August 1976.

	Number Normal	All Disease/ and Parasites	All Mechanical Damage
OCGS	376	66	457
Bay	75	36	11
Forked River	20	5	4
Oyster Creek	97	9	7
Total	568	116	479

Percentages between areas

	% Observed Normal	% All Diseased/ and Parasites	% All Mechanical Damage	% Expected in Each Area Based on the Specimens Examined
OCGS	66.2	56.9	95.4	76.7
Bay	13.2	31.0	2.3	10.6
Forked River	3.5	4.3	0.8	2.6
Oyster Creek	17.1	7.6	1.4	10.1
Total	100.0	99.8	99.9	100.0

Percentages within areas

	% Observed Normal	% All Diseased/ Parasites	% All Mechanical Damage	Total
OCGS	41.8	7.3	50.8	99.9
Bay	61.5	29.5	9.0	100.0
Forked River	69.0	17.2	13.8	100.0
Oyster Creek	85.8	8.0	6.2	100.0
Total				

Table 73 Actual number and percentage of bay anchovy collected from OCGS screens, Barnegat Bay, Forked River, Oyster Creek from September, 1975 through August, 1976.

Number	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
OCGS Screens	815	4,047	642	217	-	-	10,008	269,027	183,299	12,133	1,770	3,018
Barnegat Bay	4867	5,405	2,768	408	-	-	9	658	2,501	1,665	1,519	1,529
Forked River	355	3,590	635	12	-	-	18	105	1,529	472	629	545
Oyster Creek	177	1,095	504	119	-	-	114	16,879	519	656	3,890	709
Total	6,214	14,137	4,549	756	-	-	10,149	286,669	187,848	14,926	7,808	5,801

Percent	Sept.	Oct.	Nov.	Dec.	Jan	Feb.	Mar.	Apr.	May	June	July	August
OCGS Screens	13.1	28.6	14.1	28.7	-	-	98.6	93.8	97.6	81.3	22.6	52.0
Barnegat Bay	78.3	38.2	60.8	54.0	-	-	0.1	0.2	1.3	11.1	19.5	26.4
Forked River	5.7	25.4	14.0	1.6	-	-	0.2	0.1	0.8	3.2	8.1	9.4
Oyster Creek	2.9	7.8	11.1	15.7	-	-	1.1	5.9	0.3	4.4	49.8	12.2
Total	100.0	100.0	100.0	100.0	-	-	100.0	100.0	100.0	100.0	100.0	100.0

Table 74. Results of t-test of mean lengths for male vs female bay anchovy examined from collections taken from September 1975 through August 1976.

	Male	Female
N	2146	2870
X	58.17	57.98
S	12.3	13.1
S^2	151.29	171.61

t = 0.522 @ 5014 df (not significant)

Table 75 . Summary of results of t-test (P = 0.05) on mean lengths (of all fish from all areas each month) between months for the bay anchovy examined from September 1975 through August 1976.

	September	October	November	December
N	360	639	79	79
X	40.90	52.77	46.73	49.24
S	13.24	16.99	19.05	18.83
S^2	175.3	288.7	362.5	354.6
t		t = 11.87@997 S	t = 2.94@716 S	t = 0.83@156 NS

	January	February	March	April
N	-	-	844	544
X			68.61	63.69
S			8.24	9.88
S^2			67.9	97.6
		Dec.	12.0	15.5
t			t = 17.15@921 S	t = 5.02@1386 S

		May	June	July	August
N		701	665	684	550
X		57.42	57.05	56.96	53.64
S		9.08	7.25	6.72	14.69
S^2	Apr	82.45	52.56	45.16	215.80
		11.62@1243 S	0.37@1364 NS	0.24@1347 NS	5.26@1234 S

S/NS Significant or Not Significant at P=.05

Table 76. Summary of results of t-test (P = 0.05) on mean lengths within months showing bimodal frequency distributions for the bay anchovy examined from September 1975 through August 1976.

	Sept. - Sept.		Oct. - Oct.		Nov. - Nov.		Dec. - Dec.		Aug. - Aug.	
N	300	60	393	196	50	29	52	27	181	369
X	35.5	67.7	40.4	72.5	32.7	71.0	36.0	74.7	34.4	63.1
S	5.7	4.6	7.3	5.2	3.0	5.6	3.2	4.3	5.1	6.1
S^2	32.49	21.16	53.29	27.04	9.0	31.36	10.24	18.49	26.01	37.21
t =	41.17@358df S		54.9 @ 587 S		39.59 @ 77 S		45.24 @ 77 S		54.6 @ 548 S	

S= Significance at P=.05

Table 77. GM functional regression analysis of log length vs log weight for males and females for the bay anchovy examined from September 1975 through August 1976.

MALES:	Slope	3.0366
	Confidence Interval of B	0.0789
	Intercept	-5.2001
	No. of Pairs	2146
FEMALES:	Slope	3.0810
	Confidence Interval of B	0.0469
	Intercept	-5.2756
	No. of Pairs	2870

t-test of significance between regression: t = 3.043@ 5012 df
Significant @ P = .05

Table 78. Condition factor by location for the bay anchovy examined from September 1975 through August 1976.

Location	Freq.	Min	Max	Mean	S. dev
Bay	1084	2.5	18.5	5.94	1.12
Forked River	903	2.7	15.0	5.90	1.07
Oyster Creek	1220	0.9	11.3	5.70	1.00
OCGS Screens	1887	2.2	11.3	5.65	0.89

Table 79. Summary of the results of t-tests on the mean condition factor between Barnegat Bay (BB), Forked River (FR), Oyster Creek (OC), Oyster Creek Generating Station (OCGS) for the bay anchovy examined from September 1975 through August 1976.

Locations	t-test	degrees of freedom	Results
BB vs FR	t=+0.814	1985	BB $\approxeq$ FR
BB vs OC	t=+5.440	2302	BB $>$ OC
BB vs OCGS	t=+7.773	2969	BB $>$ OCGS
FR vs OC	t=+4.423	2121	FR $>$ OC
FR vs OCGS	t=+6.494	2788	FR $>$ OCGS
OC vs OCGS	t=+1.456	3105	OC $\approxeq$ OCGS

Table 80. Summary of the results of t-tests on the mean condition factor between Barnegat Bay (BB), Forked River (FR), Oyster Creek Generating Station (OCGS) by month for the bay anchovy examined from September 1975 through August 1976.

	Locations	t-test	Degrees of freedom	Results
September	BB vs FR	t=+0,075	301	BB≅FR
	BB vs OCGS	=-5,168	227	BB<OCGS
	FR vs OCGS	=-4,636	186	FR<OCGS
October	BB vs FR	t=-0.935	323	BB≅FR
	BB vs OC	=-0,278	263	BB≅OC
	BB vs OCGS	=-2,627	346	BB<OCGS
	FR vs OC	=+0,555	258	FR≅OC
	FR vs OCGS	=-1,842	341	FR≅OCGS
	OC vs OCGS	=-2,364	281	OC<OCGS
November	BB vs OCGS	t=+0,819	77	BB≅OCGS
December	OC vs OCGS	t=-3,973	66	OC<OCGS
March	OC vs OCGS	t=+3,035	787	OC>OCGS
April	BB vs FR	t=-4,312	162	BB<FR
	BB vs OC	=-7,365	297	BB<OC
	BB vs OCGS	=-9,873	218	BB<OCGS
	FR vs OC	=-1,583	331	FR≅OC
	FR vs OCGS	=-4,754	243	FR<OCGS
	OC vs OCGS	=-0,447	378	OC≅OCGS
May	BB vs FR	t=+1,437	274	BB≅FR
	BB vs OC	=+6,885	335	BB>OC
	BB vs OCGS	=+8,064	366	BB>OCGS
	FR vs OC	=+5,225	331	FR>OC
	FR vs OCGS	=+6,214	361	FR>OCGS
	OC vs OCGS	=+0,465	423	OC≅OCGS

	Locations	t-test	degree of freedom	Results
June	BB vs FR	t=+0,062	302	BB≅FR
	BB vs OC	=-0,470	394	BB≅OC
	BB vs OCGS	=-1,777	339	BB≅OCGS
	FR vs OC	=-0,899	252	FR≅OC
	FR vs OCGS	=-2.108	197	FR>OCGS
	OC vs OCGS	=-1,211	289	OC≅OCGS
July	BB vs FR	t=+3,411	318	BB>FR
	BB vs OC	=+2,758	396	BB>OC
	BB vs OCGS	=+6,676	251	BB>OCGS
	FR vs OC	=-0,158	428	FR≅OC
	FR vs OCGS	=+3,895	283	FR>OCGS
	OC vs OCGS	=+3,455	361	OC>OCGS
August	BB vs FR	t=-1,527	245	BB≅FR
	BB vs OC	=-2,277	221	BB<OC
	BB vs OCGS	=+0,757	316	BB≅OCGS
	FR vs OC	=-0,865	230	FR≅OC
	FR vs OCGS	=+2,569	324	FR>OCGS
	OC vs OCGS	=+3,907	300	OC>OCGS

Table 81. Numbers of male and female bay anchovy examined from Oyster Creek, Forked River, OCGS screens and Barnegat Bay from September 1975 through August 1976.

	Oyster Creek		Forked River		OCGS		Barnegat Bay	
	Males	Females	Males	Females	Males	Females	Males	Females
September, 1975	-	-	36	81	11	46	52	90
October	42	56	65	63	99	134	63	100
November	-	-	-	-	12	17	15	32
December	14	18	3	7	10	25	-	-
January, 1976	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-
March	87	87	-	-	318	344	4	2
April	108	128	48	52	62	84	30	34
May	104	93	64	72	105	121	64	76
June	46	127	15	66	87	101	86	137
July	114	136	75	101	36	73	57	87
August	51	41	36	69	88	103	41	64
Σ	566	686	342	511	828	1048	412	622

Table 82 . Results of chi-square test (at P=.05) between the numbers of male and female bay anchovy examined from Oyster Creek, Forked River, OCGS Screens, and Barnegat Bay from September 1975 through August 1976.

	Oyster Creek	Forked River	OCGS Screens	Barnegat Bay
September, 1975	-	S (F>M)	S (F> M)	S (F>M)
October	NS	NS	S (F> M)	S (F >M)
November	-	-	NS	S (F >M)
December	NS	**	S (F> M)	-
January, 1976	-	-	-	-
February	-	-	-	-
March	NS	-	NS	**
April	NS	NS	NS	NS
May	NS	NS	NS	NS
June	S (F> M)	S (F>M)	NS	S (F>M)
July	NS	S (F>M)	S (F> M)	S (F> M)
August	NS	S (F>M)	NS	S (F> M)

NS=Not Significant
S=Signficiant
F> M=Numbers of females exceed males signficiantly (P=.05)
- = No Specimens

* Test was performed only when the number of males and females in each area/month totaled at least 20 specimens and included 10 specimens of each sex

** Insufficiant data

Table 83. Results of chi-square test (P = .05) of male vs female bay anchovy compared by month for collections taken from September 1975 through August 1976.

Month	Males	Females	X^2	S/NS*
September	101	216	41.7	S
October	269	353	11.3	S
November	27	49	6.4	S
December	27	50	7.6	S
January	-	-	-	-
February	-	-	-	-
March	409	433	0.7	NS
April	247	297	4.6	S
May	338	363	0.9	NS
June	234	431	58.4	S
July	282	397	19.5	S
August	217	277	5.9	S

* S/NS - S is significant difference from 50:50 ratio. NS is not significant difference from 50:50 ratio.

Table 84. Results of chi-square test (P=.05) of male vs female bay anchovy compared by area for collections taken from September 1975 through August 1976.

	Oyster Creek		Forked River		OCGS Screens		Bay	
	Male	Female	Male	Female	Male	Female	Male	Female
Σ	566	686	342	511	828	1048	412	622
X^2	11.50		33.48		25.80		42.65	
S/NS	S		S		S		S	

S/NS Significant or Not Significant at P=.05

Table 85 Number of bay anchovies of each gonad condition by month, area, and sex examined from September 1975 through August 1976.

		OYSTER CREEK					FORKED RIVER					OCGS SCREEN					BARNEGAT BAY				
		I	M	E	R	S	I	M	E	R	S	I	M	E	R	S	I	M	E	R	S
September	Male	-	-	-	-	-	20	16	-	-	-	-	11	-	-	-	27	25	-	-	-
	Female	-	-	-	-	-	50	31	-	-	-	-	46	-	-	-	19	41	-	-	-
October	Male	5	37	-	-	-	27	38	-	-	-	2	97	-	-	-	21	42	-	-	-
	Female	9	47	-	-	-	27	36	-	-	-	-	134	-	-	-	36	64	-	-	-
November	Male	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	11	4	-	-	-
	Female	-	-	-	-	-	-	-	-	-	-	-	17	-	-	-	30	2	-	-	-
December	Male	6	8	-	-	-	2	1	-	-	-	6	9	-	-	-	-	-	-	-	-
	Female	8	10	-	-	-	5	2	-	-	-	1	19	-	-	-	-	-	-	-	-
March	Male	-	85	2	-	-	-	-	-	-	-	-	317	1	-	-	-	4	-	-	-
	Female	-	86	1	-	-	-	-	-	-	-	-	342	2	-	-	-	2	-	-	-
April	Male	1	81	25	1	-	-	41	7	-	-	-	40	22	-	-	-	30	-	-	-
	Female	-	102	26	-	-	-	51	1	-	-	-	70	14	-	-	-	32	2	-	-
May	Male	2	24	14	64	-	-	7	11	46	-	-	32	40	33	-	-	5	20	39	-
	Female	3	43	38	9	-	-	16	47	9	-	-	81	38	2	-	-	7	56	13	-
June	Male	1	-	4	41	-	-	1	-	14	-	1	4	16	65	1	-	-	9	77	-
	Female	-	-	110	17	-	4	1	60	1	-	-	5	77	12	7	-	-	135	2	-
July	Male	1	-	10	95	8	-	4	8	59	4	-	-	2	23	11	-	1	1	55	-
	Female	4	6	45	2	79	-	4	37	-	60	-	10	11	3	49	-	1	36	-	50
August	Male	7	6	-	20	18	13	3	-	6	14	4	21	-	30	33	9	13	-	7	12
	Female	6	9	1	-	25	22	19	-	-	28	9	39	-	-	55	23	27	-	-	14

* I = Immature gonads
M = Mature gonads (at rest)
E = Enlarged gonads
R = Ripe gonads
S = Spent gonads

Table 86 . The number and percentage of diseased / parasitized, mechanically damaged and otherwise abnormal bay anchovy examined from September 1975 through August 1976.

Category: Specific Abnormality	N	Each Category	% of All Specimens Examined
Disease/Parasite:			
Lernaeenicus spp.	37	97.4	0.72
Fin rot	1	0.6	0.02
	38	100.0	0.74
Mechanical Damage:			
Probably dead at time of capture	28	0.9	0.54
Scale	2805	88.2	54.54
Scaled with flesh missing	166	5.2	3.23
Fin damaged	28	0.9	0.54
Eye damage	100	3.1	1.94
Scaled w/fin damage	53	1.7	1.03
	3180	100.0	61.82
Multiple trauma:			
Probably dead at capture/Lernaeenicus	5	1.9	0.10
Scaled w/Lernaeenicus	226	87.6	4.39
Scaled and flesh missing w/Lernaeenicus	15	5.8	0.29
Fin damage w/Lernaeenicus	1	0.4	0.02
Eye damage w/Lernaeenicus	6	2.3	0.12
Scaled and fin damage w/Lernaeenicus	4	1.5	0.08
Scaled w/fin rot	1	0.4	0.02
	258	99.9	5.02
No Abnormalities	1667	100.0	32.41
	5143	-	99.99

Table 87. Abnormalities of bay anchovy by number and percent for aggregate of all normal, parasitized/diseased, and mechanically damaged fish examined from each area for September, 1975 through August, 1976.

	Number Normal	All Disease and Parasite	All Mechanical Damage	Total
OCGS	503	145	1360	2008
Bay	494	27	586	1107
Oyster Creek	268	70	997	1335
Forked River	402	54	495	951
	1667	296	3438	

Percentages observed between areas

	% Observed Normal	% All Disease and Parasites	% All Mechanical Damage	% expected in each catagory eased of the Specimens Examined
OCGS	30.2	49.0	39.6	36.5
Bay	29.6	9.1	17.0	21.1
Oyster Creek	16.1	23.7	29.0	24.7
Forked River	24.1	18.2	14.4	17.7
	100.0	100.0	100.0	100.0

Percentages observed within areas

	% Observed Normal	% All Disease and Parasites	% All Mechanical Damage	Total
OCGS	25.0	7.2	67.7	99.9
Bay	44.6	2.4	52.9	99.9
Oyster Creek	20.1	5.2	74.7	100.0
Forked River	42.3	5.6	52.1	100.0

Table 88. Number and mean length of northern pipefish examined from Oyster Creek, Forked River, Barnegat Bay and adjacent creeks, and the screens at OCGS from September 1975 through August 1976.

	Oyster Creek		Forked River		Bay and adjacent creeks		OCGS Screens	
	No.	Length (mm)	No.	Length (mm)	No.	Length (mm)	No.	Length (mm)
September	6	150.17	8	159.63	16	156.19	3	145.33
October	4	174.25	6	155.50	32	162.28	18	186.89
November	9	164.44	20	156.65	24	163.33	120	165.34
December	23	161.70	15	149.67	12	161.75	109	169.45
January	1	131.00	-	-	1	180.00	-	-
February	2	153.00	2	107.00	2	177.00	-	-
March	15	162.80	18	163.11	18	160.50	243	166.02
April	22	163.27	13	160.38	22	164.91	116	174.43
May	22	169.00	12	172.08	35	169.11	96	178.93
June	8	166.00	16	182.69	15	181.73	117	176.21
July	5	145.40	-	-	24	126.42	70	171.10
August	11	152.73	3	175.00	33	131.52	12	182.75
Total	131	161.64	114	162.39	241	156.30	906	171.00
No. of Collections	260		255		394			

Table 89 . Number of northern pipefish taken by seine and trawl from Oyster Creek, Forked River, and Barnegat Bay and adjacent creeks from September 1975 through August 1976.

	Seine	Trawl
September	22	8
October	22	29
November	11	45
December	4	47
January	1	1
February	0	6
March	4	49
April	8	50
May	28	41
June	11	28
July	16	9
August	23	25

Table 90 . Estimated number of northern pipefish impinged on the traveling screens at OCGS from 7 September 1975 to 4 September 1976.

	Day	Night	Total
September 7 - October 4*			37
October 5 - November 1*			117
November 2 - November 29*			3508
November 30 - December 27*			12040
December 28 - March 6	Refueling-repair shutdown		
March 7 - April 3	2183	6783	8966
April 4 - May 1	777	2775	3552
May 2 - May 29	1076	2474	3550
May 30 - July 3	812	1793	2605
July 4 - July 31	111	243	354
August 1 - September 4	44	57	101
Total	5003	14125	34830

*Data not separated into day-night periods

Table 91. Sex and breeding condition of northern pipefish examined from September 1975 through August 1976.

	Oyster Creek, Forked River, and the mouth of other creeks and Barnegat Bay						OCGS Screens					
	Male				Female	Sex Undetermined	Male				Female	Sex Undetermined
	A	B	C	Total			A	B	C	Total		
September	-	3	-	3	27	-	-	-	-	-	2	-
October	1	-	-	1	41	-	1	-	-	1	18	-
November	11	5	-	16	36	-	32	5	-	37	68	1
December	13	3	-	16	33	1	25	4	-	29	80	-
January	-	-	-	-	2	-	-	-	-	-	-	-
February	2	-	-	2	3	1	-	-	-	-	-	-
March	8	5	-	13	38	2	22	71	1	94	142	-
April	2	10	21	33	24	-	1	17	15	23	84	-
May	-	-	35	35	34	-	-	8	55	63	42	-
June	-	2	24	26	13	-	-	11	78	89	32	-
July	-	1	3	4	15	5	-	24	27	51	20	5
August	-	1	4	5	34	8	-	2	5	7	6	-
Total	37	30	87	154	300	17	81	142	181	404	494	6

A - immature
B - mature
C - gravid

Table 92. Mean, minimum, and maximum length and weight of bluefish collected in Oyster Creek, Forked River, Barnegat Bay and adjacent creeks, and at the traveling screens of OCGS from October 1975 through August 1976.

October 1975

Location	Number	Length (mm) Min.	Length (mm) Max.	Length (mm) Mean	Length (mm) SDEV	Weight (g) Min.	Weight (g) Max.	Weight (g) Mean	Weight (g) SDEV
Barnegat Bay and adjacent creeks	0	-	-	-	-	-	-	-	-
Forked River	0	-	-	-	-	-	-	-	-
Oyster Creek	3	210.0	234.0	224.67	12.86	111.8	179.3	155.37	37.79
Screens at OCGS	6	53.0	193.0	173.17	57.78	1.5	91.1	31.67	33.97

November 1975

Location	Number	Length (mm) Min.	Length (mm) Max.	Length (mm) Mean	Length (mm) SDEV	Weight (g) Min.	Weight (g) Max.	Weight (g) Mean	Weight (g) SDEV
Barnegat Bay and adjacent creeks	0	-	-	-	-	-	-	-	-
Forked River	0	-	-	-	-	-	-	-	-
Oyster Creek	96	162.0	292.0	202.31	31.83	39.8	331.8	112.80	69.66
Screens at OCGS	46	149.0	208.0	170.15	12.26	34.5	109.0	53.76	13.79

December 1975

Location	Number	Length (mm) Min.	Length (mm) Max.	Length (mm) Mean	Length (mm) SDEV	Weight (g) Min.	Weight (g) Max.	Weight (g) Mean	Weight (g) SDEV
Barnegat Bay and adjacent creeks	0	-	-	-	-	-	-	-	-
Forked River*	13	176.0	261.0	205.54	25.87	60.2	247.0	126.17	54.55
Oyster Creek	57	164.0	256.0	210.89	21.08	49.9	272.0	134.56	48.55
Screens at OCGS	6	180.0	252.0	206.00	27.86	58.0	209.2	102.93	55.54

*These were dead fish collected by dip net.

Table 92. (cont.)

Location	Number	May 1976 Length (mm) Min.	Max.	Mean	SDEV	Weight (g) Min.	Max.	Mean	SDEV
Barnegat Bay and adjacent creeks	3	246.0	248.0	247.00	1.00	190.3	208.6	197.23	1.50
Forked River	1	230.0	230.0	230.00	0.00	153.5	153.5	153.50	0.00
Oyster Creek	46	49.0	405.0	312.28	63.27	0.8	1094.2	432.47	240.86
Screens at OCGS	342	31.0	62.0	43.94	5.92	0.2	19.0	0.62	1.03

Location	Number	June 1976 Length (mm) Min.	Max.	Mean	SDEV	Weight (g) Min.	Max.	Mean	SDEV
Barnegat Bay and adjacent creeks	6	62.0	243.0	96.17	72.00	1.9	165.5	29.73	66.51
Forked River	0	-	-	-	-	-	-	-	-
Oyster Creek	5	67.0	275.0	188.20	110.70	2.6	274.2	143.26	130.35
Screens at OCGS	237	35.0	88.0	51.75	7.84	0.4	6.3	1.17	0.71

Location	Number	July 1976 Length (mm) Min.	Max.	Mean	SDEV	Weight (g) Min.	Max.	Mean	SDEV
Barnegat Bay and adjacent creeks	11	58.0	288.0	123.55	65.19	1.7	198.3	33.25	57.02
Forked River	9	93.0	177.0	130.78	25.38	8.4	62.6	26.34	16.36
Oyster Creek	25	92.0	406.0	166.04	89.84	7.0	907.0	140.31	274.18
Screens at OCGS	60	46.0	156.0	94.00	23.24	0.8	48.8	9.65	9.24

Location	Number	August 1976 Length (mm) Min.	Max.	Mean	SDEV	Weight (g) Min.	Max.	Mean	SDEV
Barnegat Bay and adjacent creeks	27	72.0	212.0	152.37	30.93	3.0	129.6	42.06	24.81
Forked River	22	38.0	213.0	154.50	35.78	0.6	112.3	48.13	28.52
Oyster Creek	27	133.0	465.0	218.74	113.13	23.5	1527.0	293.79	445.51
Screens at OCGS	96	46.0	332.0	95.35	43.59	1.0	558.2	19.98	67.49

Table 93. Number and mean length of 0+, 1+, 2+, and 3+ bluefish collected in the vicinity of OCGS in November and December 1975 and May and August 1976.

November 1975

Age	Number	Mean Length (mm)	SDEV	CVAR
0+	86	170.7	8.8	5.2
1+	56	224.4	23.2	10.4

December 1975

Age	Number	Mean Length (mm)	SDEV	CVAR
0+	19	179.8	7.0	3.9
1+	57	219.5	15.4	7.0

May 1976

Age	Number	Mean Length (mm)	SDEV	CVAR
0+	343	44.0	5.9	13.4
1+	38	291.8	39.2	13.4
2+	11	381.5	12.5	3.3

August 1976

Age	Number	Mean Length (mm)	SDEV	CVAR
0+	158	114.4	39.6	34.6
1+	7	238.0	48.2	20.2
2+	6	394.2	7.7	2.0
3+	1	465.0	0.0	0.0

Table 94. Number and mean length of young bluefish collected in the vicinity of OCGS from May through August 1976.

May 1976

Number	Mean Length (mm)	SDEV	CVAR
341	43.9	5.7	13.1

June 1976

Number	Mean Length (mm)	SDEV	CVAR
242	51.9	7.6	14.6

July 1976

Number*	Mean Length (mm)	SDEV	CVAR
8	63.1	5.8	9.2
87	107.7	23.9	22.2

August 1976

Number*	Mean Length (mm)	SDEV	CVAR
78	77.8	14.0	18.0
80	150.1	18.5	12.3

*During July and August two distinct size groups of young bluefish were present in the system, this is probably a result of two different spawns.

TABLE 95. NUMBERS, AGES, ACTUAL AND BACK-CALCULATED FORK LENGTHS IN MILLIMETERS OF BLUEFISH FROM LONG ISLAND SOUND FROM JULY THROUGH MID-NOVEMBER 1975, AND COMPARISONS WITH BLUEFISH FROM NEW JERSEY (DATES UNKNOWN), WOODS HOLE, MASSACHUSETTS IN OCTOBER 1961, AND NEW JERSEY IN THE VICINITY OF THE OYSTER CREEK NUCLEAR GENERATING STATION FROM OCTOBER 1975 TO AUGUST 1976.*

LONG ISLAND SOUND						NEW JERSEY (LYMAN 1974)	WOODS HOLE (BACKUS 1962)			NEW JERSEY (OCGS STUDY 1975-76)	
		FORK LENGTH									
AGE WHEN CAUGHT	NUMBER OF FISH	ACTUAL MEAN	ACTUAL RANGE	BACK-CALCULATED MEAN	BACK-CALCULATED RANGE	FORKED LENGTH (MEAN)	NUMBER OF FISH	FORK LENGTH MEAN	FORK LENGTH RANGE	NUMBER OF FISH	MEAN LENGTH
0+	0									606	84.6
1+	0			230	150-310	200	21	380	260-430	158	230.3
2+	4	510	490-520	400	300-490	350	9	440	380-510	17	385.9
3+	21	510	440-590	490	370-610	460	1	610	610	1	465.0
4+	12	580	530-630	580	460-660	550					
5+	11	660	600-690	640	550-710	620					
6+	14	710	640-760	690	590-740	690					
7+	2	740	730-750	710	710	730					

*VALUES TAKEN FROM RICHARDS (1975).

Table 96. Number and mean length of male and female bluefish collected in the vicinity of OCGS in 1975 and 1976.

Male

Number	Mean Length (mm)	SDEV	CVAR
279	188.7	60.19	31.9

Female

Number	Mean Length (mm)	SDEV	CVAR
202	213.1	68:2	32.0

Table 97. Condition of young (70-190 mm) bluefish collected in the vicinity of OCGS during July and August 1976.

July 1976

Location	Number	Min.	Max.	Mean	SDEV.
Forked River	9	1.4	2.5	1.85	0.32
Oyster Creek	21	1.6	2.4	1.86	0.20
Bay and adjacent creeks	7	1.6	2.0	1.75	0.12
OCGS Screens	53	1.3	2.5	1.80	0.28

August 1976

Location	Number	Min.	Max.	Mean	SDEV.
Forked River	18	1.6	2.1	1.79	0.15
Oyster Creek	20	1.7	2.4	2.00	0.21
Bay and adjacent creeks	26	1.4	1.9	1.68	0.12
OCGS Screens	70	1.4	2.6	1.84	0.25

Table 98. Number and mean length of all weakfish taken in the vicinity of OCGS from September 1975 through August 1976.

Month	Freq. (All)	Mean length (All)	Freq. (<180)	Mean length (<180)
September	113	87.52	112	86.40
October	330	97.19	329	96.90
November	457	141.43	442	139.80
December	18	109.22	18	109.22
April through June	43	340.65	1	175.00
July	49	78.35	45	53.20
August	562	74.11	560	72.95

Table 99. Frequency and percent of weakfish 180 mm and larger taken in the vicinity of OGGS from September 1975 through August 1976.

Length (mm)	Frequency	Percent
180 - 200	12	19.0
200 - 300	15	23.8
300 - 400	27	42.8
400 - 500	6	9.5
500 - 600	2	3.2
600 - 700	1	1.6

Table 100. The lengths, weights, means, and standard deviation of young and 1+ northern kingfish collected from Barnegat Bay from August 1975 to August 1976.

		Length				Weight			
Age	No.	Min.	Max.	Mean	SDEV.	Min.	Max.	Mean	SDEV.
0+	15	26.0	280.0	160.93	86.82	0.1	217.6	70.99	68.90
1+	1	267.0	267.0	267.00	0.00	158.6	158.6	158.60	0.00

Table 101. Age, number, and percentage of age 0+ through 4+ summer flounder taken in Barnegat Bay from September 1975 through August 1976

	Age	Sept-Oct	November	December	Mar-May	June-July	August
Frequency	0+	1	6	53	0	5	1
	1+	3	29	3	11	3	15
	2+	30	241	27	76	37	72
	3+				4	16	17
	4+				1		
Percent	0+	2.94	2.17	63.86	0.00	8.20	0.95
	1+	8.82	10.50	3.61	11.96	4.92	14.29
	2+	88.24	87.32	32.53	82.61	60.66	68.57
	3+				4.35	26.23	16.19
	4+				1.09		

Table 102. Frequency and percent of age classes of male, female, and sex undetermined summer flounder taken in Barnegat Bay from September 1975 through August 1976.

	Age Class					
Frequency	0+	1+	2+	3+	4+	Total
Undetermined	62	5	1	-	-	68
Male	2	47	229	8	-	286
Female	2	12	253	29	1	297
Total	66	64	483	37	1	

Percent	0+	1+	2+	3+	4+	Total
Undetermined	9.5	0.8	0.2	-	-	10.5
Male	0.3	7.2	35.2	1.2	-	43.9
Female	0.3	1.8	38.9	4.5	0.2	45.7
Total	10.1	9.8	74.3	5.7	0.2	

Table 103. Statistical breakdown of male and female summer flounder by month and sex taken on the traveling screens of OCGS from September 1975 through August 1976.

		Length				Weight			
Male	Freq	Min	Max	Mean	S. Dev	Min	Max	Mean	S. Dev
September	1	244	244	244.0	-	122	122	122.0	
October	15	222	281	245.3	19.2	93	207	135.6	37.3
November	126	131	302	236.0	28.8	12	258	124.2	43.6
December	18	24	286	236.5	56.4	79	222	143.7	37.2
March	6	163	240	204.2	29.5	35	132	76.0	40.4
April	13	173	287	246.4	32.3	43	223	132.7	49.5
May	25	227	348	275.2	29.9	110	407	193.4	70.8
June	17	114	357	289.1	51.4	12	430	243.0	90.9
July	12	84	352	263.8	82.2	29	341	203.5	107.1
August	57	170	360	289.9	52.7	47	479	245.8	111.4
Female									
September	3	230	278	248.3	25.9	105	184	131.2	45.3
October	14	201	369	261.6	37.1	78	485	175.4	94.3
November	152	143	309	263.9	24.9	12	316	177.5	51.7
December	10	211	319	267.0	30.0	81	298	190.6	59.7
March	5	213	286	247.2	34.3	82	215	137.8	57.7
April	13	237	314	279.5	20.1	116	275	194.5	48.5
May	28	248	395	303.0	29.1	129	550	261.7	87.6
June	13	255	344	312.5	27.9	147	374	279.4	73.6
July	18	155	415	317.7	60.1	35	707	337.9	154.0
August	46	94	398	311.8	70.4	47	674	316.9	165.2

Table 104. Length and weight of male and female summer flounder age 1+ through 3+ taken from September 1975 through August 1976.

Sex: Male		LENGTH				WEIGHT			
Age	Freq	Min	Max	Mean	S.Dev	Min	Max	Mean	S.Dev.
1+	47	114.0	261.0	196.1	32.0	11.9	162.8	72.1	33.1
2+	229	158.0	356.0	263.6	35.5	11.9	442.0	176.4	78.4
3+	8	316.0	378.0	344.5	22.1	295.1	547.1	385.1	91.5

Sex: Female		LENGTH				WEIGHT			
Age	Freq	Min	Max	Mean	S. Dev.	Min	Max	Mean	S. Dev.
1+	12	143.0	239.0	200.6	27.1	23.7	105.1	73.1	23.4
2+	253	201.0	369.0	275.5	31.8	69.6	484.9	202.4	75.2
3+	29	319.0	444.0	364.3	27.6	278.9	924.8	460.1	138.9

Table 105. A comparison of the length of summer flounder from Delaware Bay (Smith, 1969), Great South Bay (Poole, 1961), Virginia (Eldridge, 1962), and Barnegat Bay.

	Calculated Length (mm) at Time of Annulus Formation								
	I	II	III	IV	V	VI	VII	VIII	IX
				MALE					
Smith (1969) Delaware Bay		256	345	403	449				
Poole (1961)[1] Great South Bay	251	326	387	427					
Eldridge (1962)[2] Virginia	170	240	319	357	381	399	414	426	
Barnegat Bay [3]	196	264	345						
				FEMALE					
Smith (1969) Delaware Bay		279	387	460	512	568	616	657	
Poole (1961)[1] Great South Bay	271	377	465	531	644				
Eldridge (1962)[2] Virginia	170	240	377	424	471	518	566	613	657
Barnegat Bay [3]	201	275	364						

1. According to Smith (1969), Poole (1961) mistook the second annulus for the first and consequently all ages were reported to be one year greater than the actual age.

2. The lengths given for Eldridge at the end of year one and year two are estimates of the average observed length frequency at these times as reported in his thesis.

3. Mean length for year class rather than back calculated length.

Table 106. Number of winter flounder collected by various sampling programs and examined during life history studies from August 1975 through August 1976.

	Fish Sampling				OCGS		Special Surveys[a]		Miscellaneous[b]
	Trawl	Seine	Gill Net	No. Examined	Traveling Screens	No. Examined	Various Gear	No. Examined	No. Examined
August	-	-	-	-	-	-	-	-	2
September	1	0	0	0	0	-	-	-	0
October	15	0	1	14	1	1	-	-	1
November	13	0	0	13	57	57	5	5	0
December	40	0	0	40	156	146	52	45	15
January	4	0	0	4	-	-	-	-	27
February	18	0	0	18	-	-	22	22	0
March	46	1	0	47	83	83	-	-	7
April	27	0	0	27	28	28	-	-	0
May	5	8	0	12	30	24	-	-	0
June	14	10	0	24	154	149	-	-	18
July	5	16	0	20	26	23	-	-	0
August	26	23	0	49	9	9	-	-	1
Total collected	212	60	1	-	543	-	79	-	-
Total examined				268		520		72	71
% examined				98		96		91	-

a includes OCGS shutdown surveys made in Oyster Creek.

b includes specimens from preliminary trawl surveys, OCGS dilution pump sampler and 316A studies. The total catch was not determined.

Table 107. Number of specimens of winter flounder examined by location of collection in Barnegat Bay from August 1975 through August 1976 in life history studies.

General Location	BAY							FORKED RIVER				OYSTER CREEK				OCGS Traveling Screens[b]	OCGS Dilution Pump Sampler[c]	
Station Number	1	2	20	21	22	23	24	3	4	6	Misc.[a]	15	17	19	Misc.[a]			Total
August	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2
September	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
October	-	3	-	1	-	-	-	4	1	1	-	-	4	2	-	1	-	17
November	-	2	-	-	-	1	-	4	1	-	-	-	2	3	5	57	-	75
December	3	-	-	1	-	-	-	5	6	2	-	11	8	3	46	146	15	246
January	-	-	-	1	-	1	-	-	1	-	-	-	1	-	-	-	27	31
February	-	1	-	-	-	-	-	2	7	-	-	-	5	2	24	-	-	41
March	2	-	1	-	-	3	3	5	13	3	4	10	8	1	1	83	-	137
April	-	-	-	1	-	4	1	5	6	3	-	3	3	1	-	28	-	55
May	-	-	-	-	-	-	3	1	8	-	-	-	-	-	-	24	-	36
June	1	2	-	-	2	1	1	10	7	-	18	-	-	-	-	149	-	191
July	1	1	-	1	2	7	-	-	7	-	-	-	1	-	-	23	-	43
August	10	8	1	1	3	13	5	1	2	-	1	-	-	4	-	9	-	58
Total	17	17	2	6	7	30	15	37	59	9	23	24	32	16	76	520	42	932

a Miscellaneous includes those specimens taken at stations sampled during OCGS shutdown surveys and during 316A studies not reported herein. One specimen was taken at a miscellaneous Bay station in October and not totaled here.

b OCGS not operating during January and February.

c No samples examined after January.

Table 108. The length-weight[a] relationship of winter flounder taken in Barnegat Bay from September 1975 through August 1976.

A. Males (323 specimens)
log (wt) = 3.0442 log (length) - 5.0589
correlation coefficient = 0.997

B.. Females (275 specimens)
log (wt) = 3.1330 log (length) - 5.2365
correlation coefficient = 0.998

C. All Fish (598 specimens)
log (wt) = 3.0946 log (length) - 5.1608
correlation coefficient = 0.998

[a] Total weight minus gonad weight used in calculations.

Table 109. Number of winter flounder taken in Barnegat Bay from August 1975 through August 1976 examined and aged during life history study.

Month	Total Examined	Total Aged [a]
August	2	2
September	0	0
October	18	17
November	75	35
December	246	151
January	31	13
February	41	33
March	137	70
April	55	43
May	36	29
June	191	96
July	43	37
August	58	58
Total	933	584

[a] All specimens from August 1975 through May 1976 aged by examining otoliths. 181 of 191 specimens from June through August 1976 were young of year and assigned age on basis of length frequencies.

Table 110. Measurements to otolith annuli (in mm) by sex of winter flounder taken in Barnegat Bay from August 1975 through August 1976.

	Sex	Mean	Standard Deviation	CV
Annulus 1	male	0.88	0.08	9.0%
	female	0.90	0.09	10.4%
	female > male (t_{373} = 2.27, P $\leq$ 0.05)			
Annulus 2	male	1.17	0.11	9.4%
	female	1.24	0.12	9.7%
	female > male (t_{197} = 4.25, P $\leq$ 0.01)			
Annulus 3	male	1.30	0.12	9.4%
	female	1.37	0.12	8.6%
	female > male (t_{52} = 2.13, P $\leq$ 0.05)			

Table 111. Otolith edge type of winter flounder taken in Barnegat Bay from October 1975 through August 1976.

Date	MALES Number Examined	MALES % Opaque	MALES % Hyaline	FEMALES Number Examined	FEMALES % Opaque	FEMALES % Hyaline
Oct.-Nov.	30	7	93	16	6	94
December	84	10	90	66	17	83
Jan.-Feb.	14	43	57	32	9	91
March	39	41	59	31	45	55
April	23	78	22	20	90	10
May	13	77	23	11	64	36
June	16	12	88	13	8	92
July	9	0	100	9	0	100
August	6	0	100	7	0	100

Table 112. Lengths of winter flounder taken in Barnegat Bay as calculated from otolith measurements.

Age	Number of Specimens Examined	Min	Max	Mean	Standard Deviation	Standard Error	95% Confidence Interval
MALES							
1	200	101	208	161	19.4	1.4	159-164
2	90	166	283	219	23.3	2.5	215-224
3	24	205	315	252	27.4	5.6	240-263
4	5	231	275	255	18.9	8.5	231-278
FEMALES							
1	175	118	229	175	20.8	1.6	172-178
2	109	183	315	242	27.3	2.6	237-248
3	30	216	343	270	25.8	4.7	261-280
4	4	261	328	288	28.6	14.3	242-333

Table 113. Age and length frequency distribution of winter flounder by sex taken in Barnegat Bay from September 1975 through August 1976.

Length(mm)	MALES Age 0	1	2	3	4	5	6	FEMALES 0	1	2	3	4
30-40	-	-	-	-	-	-	-	1	-	-	-	-
40-59	6	-	-	-	-	-	-	6	-	-	-	-
50-59	17	-	-	-	-	-	-	14	-	-	-	-
60-69	18	-	-	-	-	-	-	24	-	-	-	-
70-79	22	-	-	-	-	-	-	20	-	-	-	-
80-89	27	-	-	-	-	-	-	15	-	-	-	-
90-99	7	-	-	-	-	-	-	7	-	-	-	-
100-109	5	-	-	-	-	-	-	1	-	-	-	-
110-119	-	3	-	-	-	-	-	1	-	-	-	-
120-129	2	2	-	-	-	-	-	1	-	-	-	-
130-139	-	3	-	-	-	-	-	-	-	-	-	-
140-149	5	1	-	-	-	-	-	2	-	-	-	-
150-159	2	4	-	-	-	-	-	-	1	-	-	-
160-169	1	1	-	-	-	-	-	1	-	-	-	-
170-179	2	3	-	-	-	-	-	-	3	-	-	-
180-189	1	13	4	-	-	-	-	-	2	-	-	-
190-199	-	7	3	-	-	-	-	-	3	-	-	-
200-209	-	17	4	-	-	-	-	-	3	1	-	-
210-219	-	13	10	1	-	-	-	-	6	2	-	-
220-229	-	17	11	1	-	-	-	-	7	3	-	-
230-239	-	15	9	3	-	-	-	-	6	8	1	-
240-249	-	8	6	2	-	-	-	-	8	8	-	-
250-259	-	3	6	2	-	-	-	-	8	10	3	-
260-269	-	1	7	4	-	-	-	-	6	9	3	1
270-279	-	-	3	1	1	1	1	-	8	6	4	-
280-289	-	-	1	1	1	-	-	-	4	12	6	1
290-299	-	-	-	2	1	-	-	-	1	9	2	-
300-309	-	-	1	1	-	-	-	-	-	3	3	-
310-319	-	-	1	1	-	-	-	-	-	3	2	1
320-329	-	-	-	-	-	-	-	-	-	3	-	-
330-339	-	-	-	-	-	-	-	-	-	-	-	1
340-349	-	-	-	-	-	-	-	-	-	1	2	-
Total	115	111	66	19	3	1	1	93	66	78	26	4

Number of males 316
Number of females 267
Total number 583

Table 114. Lengths and weights by age of winter flounder taken in Barnegat Bay from October 1975 through August 1976.

Date	Age	MALES (length in mm) Number	Min	Max	Mean	SD	FEMALES (length in mm) Number	Min	Max	Mean	SD
Oct-Dec	0	7	127	171	150.7	14.7	2	143	147	145.0	-
	1	88	152	264	216.0	21.5	46	179	285	241.2	28.3
	2	22	189	310	251.0	31.3	26	209	341	274.0	33.3
	3	2	263	290	276.5	-	6	284	316	297.3	13.3
	4	2	282	295	288.5	-	2	312	338	325.0	-
Jan-Mar	0	7	103	180	144.1	26.2	2	122	161	141.5	-
	1	14	114	222	154.8	37.3	16	174	299	244.7	30.1
	2	22	182	265	226.4	22.4	30	213	325	259.5	30.6
	3	8	215	315	272.9	33.3	13	253	342	284.8	25.4
	4	1	-	-	275.0	-	2	261	281	271.0	-
	5	1	-	-	271.0	-	-	-	-	-	-
Apr-June	0	53	41	91	65.6	13.0	45	36	92	65.2	13.5
	1	7	137	233	175.0	34.4	2	150	175	162.5	-
	2	22	181	270	222.0	21.2	22	227	297	271.3	21.4
	3	9	221	270	246.8	17.1	7	235	343	276.3	34.4
	4	-	-	-	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	-	-	-	-
	6	1	-	-	275.0	-	-	-	-	-	-
July-Aug	0	48	54	105	81.0	11.8	44	51	110	75.0	13.7
	1	1	-	-	184.0	-	1	-	-	193.0	-
	2	-	-	-	-	-	1	-	-	281.0	-

Date	Age	MALES (weight in g) Number	Min	Max	Mean	SD	FEMALES (weight in g) Number	Min	Max	Mean	SD
Oct-Dec	0	7	24.8	57.5	40.1	12.6	2	35.3	39.3	37.3	-
	1	88	39.0	249.5	127.4	41.2	46	68.6	380.0	202.2	82.5
	2	22	76.2	359.7	200.7	72.3	26	127.8	566.7	302.0	110.7
	3	2	199.6	312.5	256.1	-	6	293.3	457.6	379.4	62.2
	4	2	234.5	325.8	280.2	-	2	361.6	448.4	405.0	-
Jan-Mar	0	7	13.9	68.8	34.5	20.4	2	17.5	45.6	31.6	-
	1	14	15.2	127.7	44.6	33.9	16	74.5	286.4	182.8	62.9
	2	22	60.7	241.3	132.7	46.1	30	148.2	469.6	236.1	85.7
	3	8	102.6	304.6	210.4	68.5	13	230.1	498.5	316.4	83.8
	4	1	-	-	211.4	-	2	238.7	285.7	262.2	-
	5	1	-	-	226.7	-	-	-	-	-	-
Apr-June	0	53	0.6	8.8	3.4	2.2	45	0.4	8.9	3.3	2.3
	1	7	23.5	126.8	66.6	35.7	2	31.7	56.7	44.2	-
	2	22	67.8	264.3	132.6	47.5	22	140.5	405.0	275.0	71.4
	3	9	137.0	237.6	182.7	35.0	7	139.4	558.9	276.2	134.9
	4	-	-	-	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	-	-	-	-
	6	1	-	-	192.2	-	-	-	-	-	-
July-Aug	0	48	1.3	15.3	6.3	3.1	44	1.1	14.8	4.9	2.9
	1	1	-	-	74.1	-	1	-	-	85.3	-
	2	-	-	-	-	-	1	-	-	298.6	-

Table 115 *Lengths of winter flounder taken in Barnegat Bay from October 1975 through August 1976 by location of collection.*

Months	Location[a]	Number Examined	Length (mm) of Males Min	Max	Mean	Standard Deviation	Number Examined	Length (mm) of Females Min	Max	Mean	Standard Deviation
October-November	Bay	4	208	229	219.8	10.0	3	179	254	21 .7	38.8
	Forked River	7	152	230	198.4	31.7	4	199	217	20 .8	7.8
	Oyster Creek	11	181	251	205.5	20.2	5	180	273	220.0	36.0
	OCGS traveling screens	51	187	267	220.0	18.6	7	220	341	253.3	40.9
	OCGS dilution pump sampler	0	-	-	-	-	0	-	-	-	-
December	Bay	2	189	235	212.0	32.5	2	254	275	264.5	14.9
	Forked River	8	142	295	231.4	42.9	4	207	261	238.0	22.5
	Oyster Creek	37	163	258	219.2	23.3	32	147	317	255.3	36.9
	OCGS traveling screens	95	127	310	228.8	29.3	51	143	338	265.4	30.6
	OCGS dilution pump sampler	8	152	274	214.5	38.6	7	240	316	268.7	26.6
January-February	Bay	0	-	-	-	-	3	247	297	270.7	25.1
	Forked River	4	142	265	198.8	53.3	6	122	279	205.7	66.3
	Oyster Creek	8	103	240	182.1	52.0	24	218	321	267.8	24.7
	OCGS traveling screens	0	-	-	-	-	0	-	-	-	-
	OCGS dilution pump sampler	19	139	262	208.4	32.3	8	230	317	263.9	33.3
March	Bay	2	118	203	160.5	60.1	7	174	342	254.7	48.8
	Forked River	13	125	282	213.8	55.3	12	213	303	253.2	27.3
	Oyster Creek	13	114	298	214.5	46.8	7	223	307	265.4	26.2
	OCGS traveling screens	67	118	315	219.8	43.3	16	189	325	263.0	32.3
April	Bay	2	242	267	254.5	17.9	4	175	343	259.3	72.2
	Forked River	9	170	235	208.2	24.1	5	264	288	270.0	10.1
	Oyster Creek	3	137	235	196.3	[illegible]2.2	4	150	295	250.3	68.3
	OCGS traveling screens	19	137	270	220.2	29.9	9	227	295	266.9	22.8
May	Bay	1	-	-	203.0	-	2	231	235	233.0	2.8
	Forked River	5	43	58	51.0	6.0	4	36	57	47.0	8.7
	Oyster Creek	0	-	-	-	-	0	-	-	-	-
	OCGS traveling screens	15	172	275	238.3	30.2	9	251	290	273.0	12.5
June	Bay	3	64	220	121.0	86.1	4	61	76	68.5	6.2
	Forked River	6	64	68	66.7	1.5	12	55	86	68.8	8.5
	Oyster Creek	0	-	-	-	-	0	-	-	-	-
	OCGS traveling screens	45	41	233	81.2	47.6	28	46	297	89.3	70.5
July	Bay	7	76	91	84.4	5.9	5	69	83	75.6	6.9
	Forked River	4	56	77	63.3	10.5	3	68	70	69.0	1.0
	Oyster Creek	0	-	-	-	-	1	-	-	63.0	-
	OCGS traveling screens	6	54	88	74.2	14.1	11	51	87	61.7	11.0
August	Bay	25	65	184	88.6	22.9	16	71	281	105.8	54.6
	Forked River	2	77	81	79.0	2.8	2	64	72	68.0	5.7
	Oyster Creek	1	-	-	79.0	-	3	70	85	75.7	8.1
	OCGS traveling screens	4	77	86	82.8	4.0	5	68	90	78.6	8.2

[a] Bay includes stations 1, 2, 20, 21, 22, 23, 24. Forked River and Oyster Creek includes all stations within and at mouths. No specimens were examined from the dilution pump sampler after February.

Table 116. Summary of results of one-way analysis of variance applied to length data of winter flounder taken in Barnegat Bay from October 1975 through April 1976. Means underlined are not significantly different.

MALES

Date	Location (mean)		
October-December	Oyster Creek (216.0) - Forked River (216.0) - OCGS screens (225.7)	F = 2.85	N.S.
December-January	Dilution Pump (210.2) - Oyster Creek (219.7) - Forked River (235.1)	F = 2.46	N.S.
March-April	Oyster Creek (211.1) - Forked River (211.5) - OCGS screens (235.1)	F = 0.56	N.S.

FEMALES

Date	Location (mean)		
October-December	Forked River (221.9) - Oyster Creek (250.5) - OCGS screens (263.9)	F = 6.15	$P \leq 0.01$
December-January	Forked River (238.0) - Oyster Creek (255.3) - Dilution Pump (266.1)	F = 1.20	N.S.
March-April	Forked River (258.1) - Oyster Creek (259.9) - OCGS screens (264.4)	F = 0.22	N.S.

Table 117. Gonad condition by month of winter flounder taken in Barnegat Bay from October 1975 through August 1976.

Date	MALES (% of Total) Number Examined	Immature	Mature	Enlarged	Spent	FEMALES (% of Total) Number Examined	Immature	Mature	Enlarged	Ripe	Spent
Oct.-Nov.	73	-	11	89	-	20	55	-	45	-	-
Dec.	150	1	-	99	-	96	13	-	87	-	-
Jan.-Feb.	31	6	-	77	16	41	7	-	54	7	32
March	95	4	83	9	3	42	19	69	12	-	-
April	33	6	87	6	-	22	9	91	-	-	-
May	21	24	76	-	-	15	27	66	7	-	-
June	54	91	9	-	-	44	93	7	-	-	-
July-Aug.	49	100	-	-	-	46	98	2	-	-	-

Table 118. Gonad condition by age of winter flounder taken in Barnegat Bay from October 1975 through August 1976.

Age	Year Class	Date	MALES (% of Total) Number Examined	Immature	Mature	Enlarged	Spent	FEMALES (% of Total) Number Examined	Immature	Mature	Enlarged	Ripe	Spent
0	1975	Oct.-Feb.	15	13	-	73	13	4	100	-	-	-	-
1	1974		90	1	9	89	1	61	33	-	52	3	11
2	1973		26	-	-	96	4	38	2	-	82	-	16
3	1972		2	-	-	100	-	9	-	-	100	-	-
4	1971		2	-	-	100	-	8	-	-	100	-	-
0	1976	Mar.-Aug.	101	100	-	-	-	89	100	-	-	-	-
1	1975		19	32	68	10	-	4	100	-	-	-	-
2	1974		40	-	90	10	-	41	12	78	10	-	-
3	1973		17	-	82	18	-	17	-	88	12	-	-
4	1972		1	-	-	100	-	2	-	100	-	-	-
5	1971		1	-	100	-	-	-	-	-	-	-	-
6	1970		1	-	100	-	-	-	-	-	-	-	-

Table 119. Number and mean length of northern puffer examined from Oyster Creek, Forked River, Barnegat Bay and adjacent creeks, and the traveling screens from August 1975 through August 1976.

Month	Oyster Creek No.	Oyster Creek Length (mm)	Forked River No.	Forked River Length (mm)	Barnegat Bay and adjacent creeks No.	Barnegat Bay and adjacent creeks Length (mm)	OCGS screens No.	OCGS screens Length (mm)	Total No.	Total Length (mm)
August to November 1975	0	0	0	0	1	87.0	8	37.00	9	42.60
April 1976	0	0	0	0	0	0	13	174.69	13	174.70
May 1976	0	0	2	151.50	0	0	122	150.65	124	150.70
June 1976	0	0	1	220.00	0	0	31	152.00	32	154.10
July 1976	2	196.00	0	0	1	140.0	9	147.44	12	154.60
August 1976	5	102.80	1	169.00	1	67.0	86	81.80	95	88.30
Total	7	129.43	4	173.00	3	98.0	269	129.55	283	129.80

Table 120. Sex and breeding condition of northern puffer collected from Barnegat Bay and the OCGS traveling screens from September 1975 through August 1976.

Date	Male				Female					Sex
	Immature	Mature	Enlarged	Ripe	Immature	Mature	Enlarged	Ripe	Spent	Undetermined
Sept. 1975	-	2	-	-	-	-	-	-	-	-
Oct.	1	1	-	-	-	1	-	-	-	1
Nov.	-	2	-	-	-	-	-	-	-	-
Dec.	-	-	-	-	-	-	-	-	-	-
Jan. 1976	-	-	-	-	-	-	-	-	-	-
Feb.	-	-	-	-	-	-	-	-	-	-
Mar.	-	-	-	-	-	-	-	-	-	-
Apr.	-	-	9	-	-	-	4	-	-	-
May	-	-	84	8	-	-	32	1	-	3
June	-	-	27	-	-	-	4	-	-	1
July	-	5	2	-	-	1	-	-	2	2
Aug.	6	5	-	-	3	2	-	-	1	76
Total	7	15	122	8	3	4	40	1	3	83

Table 121. Length-weight regression equations (Ricker 1975) of northern puffer examined from Barnegat Bay from September 1975 through August 1976 and Chesapeake Bay from 1969 through 1970 (Laroche and Davis 1973).

	Barnegat Bay	Chesapeake Bay
Males	(n=155)	(n=180)
Slope	3.0600	2.9930
Confidence Limits of Slope	± .1896	
Intercept	-4.7818	-4.6430
R^2	0.9710	0.9948
Females	(N=53)	(n=168)
Slope	3.07500	2.9010
Confidence Limits of Slope	± .19201	
Intercept	-4.76600	-4.4140
R^2	.98500	.9820

Table 122. Number and mean length of northern puffer from Barnegat Bay from May and June 1976 and from Chesapeake Bay from November 1969 through November 1970 (Laroche and Davis 1973).

	Barnegat Bay		Chesapeake Bay	
Age	Male	Female	Male	Female
1+	-	156 mm (17)	133 mm (190)	151 mm (315)
2+	-	204 mm (21)	183 mm (88)	208 mm (99)
3+	-	-	208 mm (22)	237 mm (32)
4+	-	-	227 mm (7)	259 mm (9)

Table 123. The estimated number of sand shrimp taken at OCGS and the number collected by seine and trawl from Oyster Creek, Forked River, and Barnegat Bay and adjacent creeks from September 1975 through August 1976.

	OCGS	Oyster Creek	Forked River	Barnegat Bay and adjacent creeks	Total by seine and trawl
September	-	6	22	49	77
October	311	287	75	189	551
November	11,359	320	575	774	1,669
December	1,340,644	7,505	2,882	1,784	12,171
January	-	170	255	647	1,072
February	-	1,452	1,036	1,338	3,826
March	175,676	2,660	2,421	2,681	7,762
April	255,106	2,126	1,159	1,364	4,649
May	798,831	334	589	112	1,035
June	617,873	51	90	8	149
July	1,655	24	2	12	38
August	20	13	219	310	542
Total	3,201,475	14,948	9,325	9,268	33,541

Table 124. Number and mean length of examined sand shrimp taken from OCGS, Forked River, Oyster Creek, and Barnegat Bay and adjacent creeks from March through August 1976.

	OCGS		Forked River		Oyster Creek		Barnegat Bay	
	No.	Mean length (mm)	No.	Mean length (mm)	No.	Mean length (mm)	No.	Mean length (mm)
March	69	43.23	50	29.25	60	29.87	9	33.93
April	115	43.06	105	38.48	99	33.19	61	29.48
May	39	40.93	94	37.22	32	35.41	36	37.15
June	91	41.54	62	30.85	41	36.35	3	38.13
July - August	4	41.75	27	26.00	15	29.14	103	27.06
Total	318	42.38	338	36.02	247	32.95	212	29.91

Table 125. Number of non-ovigerous and ovigerous sand shrimp examined from OCGS, Forked River, Oyster Creek, and Barnegat Bay and adjacent creeks from March through August 1976.

	OCGS		Forked River		Oyster Creek		Barnegat Bay	
	A	B	A	B	A	B	A	B
March	44	25	48	2	55	5	9	–
April	32	83	64	41	85	14	29	2
May	13	26	57	37	24	8	30	6
June	35	56	29	33	29	11	1	2
July - August	2	2	27	–	15	–	103	–
Total	126	192	225	113	208	38	172	10

A - non-ovigerous
B - ovigerous

Table 126. Number, mean, and standard deviation of the condition factor of sand shrimp examined from the OCGS traveling screens, Forked River, Oyster Creek, and Barnegat Bay and adjacent creek mouths from March through August 1976.

	Number	Mean Condition Factor	Standard Deviation
OCGS Screens	321	7.51	1.37
Forked River	338	7.18	1.23
Oyster Creek	247	6.98	1.16
Barnegat Bay	215	7.06	1.14

Table 127. The actual and estimated number of blue crab impinged on the traveling screens at OCGS and the number of blue crab collected from Forked River, Oyster Creek, and other creek mouths and Barnegat Bay stations from September 1975 through August 1976.

	OCGS		Forked River	Oyster Creek	Barnegat Bay	Total (actual)
	Actual	Estimated				
September	8,064	25,975	8	77	94	8,243
October	13,337	47,526	40	43	95	13,515
November	5,869	22,460	40	28	19	5,956
December	2,510	6,020	98	41	18	2,667
January[a]	-	-	3	5	16	24
February[a]	-	-	18	19	31	68
March	19,406	97,908	146	115	14	19,681
April	52,808	115,409	32	196	75	53,111
May	90,148	471,278	133	344	145	90,770
June	136,504	2,071,428	147	176	196	137,023
July	193,171	928,116	149	239	246	193,805
August	163,077	830,947	142	199	448	163,866
Total	684,894	4,617,069	956	1482	1397	688,729

a. No collections taken because OCGS was not in operation.

Table 128. Number and mean length of blue crab examined from OCGS, Forked River, Oyster Creek, and Barnegat Bay from September 1975 through August 1976.

	Mature				Immature			
	Male		Female		Male		Female	
	No.	Length	No.	Length	No.	Length	No.	Length
OCGS	339	114.88	574	134.74	4520	43.89	4531	54.47
Forked River	26	115.08	7	139.38	365	30.68	400	35.94
Oyster Creek	44	113.39	47	139.53	585	32.84	521	38.80
Barnegat Bay	17	115.35	6	139.83	406	29.34	425	32.30
Total	426		634		5876		5877	

Table 129. Number and sex of blue crab examined from OCGS, Forked River, Oyster Creek, and Barnegat Bay from September 1975 through August 1976.

	OCGS		Forked River		Oyster Creek		Barnegat Bay	
Month	Male	Female	Male	Female	Male	Female	Male	Female
September	960	1247	6	3	12	5	45	36
October	809	965	16	30	17	25	45	35
November	542	430	21	19	15	12	9	10
December	213	143	52	47	49	28	8	5
January	0	0	2	1	3	1	0	1
February	0	0	11	1	9	8	14	2
March	305	210	40	34	59	37	7	0
April	367	337	12	19	93	93	37	31
May	283	277	57	64	125	113	61	78
June	507	514	41	43	76	95	44	53
July	419	472	66	78	98	78	64	87
August	452	510	67	68	73	75	89	83
Total	4859	5105	391	407	629	568	423	431

Table 130. Number and sex of immature blue crab examined from OCGS, Forked River, Oyster Creek, and Barnegat Bay from September 1975 through August 1976.

	OCGS		Forked River		Oyster Creek		Barnegat Bay	
Month	Male	Female	Male	Female	Male	Female	Male	Female
September	854	1146	2	3	8	5	42	36
October	712	711	14	29	16	23	42	33
November	536	397	20	19	14	12	9	10
December	212	142	52	47	49	28	7	5
January	0	0	2	1	3	1	0	1
February	0	0	11	1	9	8	14	2
March	301	206	40	34	59	37	7	0
April	356	299	12	17	80	71	37	29
May	238	219	53	62	116	106	57	77
June	460	452	36	41	72	83	42	52
July	411	467	60	78	88	74	62	87
August	440	492	63	68	71	73	87	83
Total	4520	4531	365	400	585	521	406	425

Table 131. Number and sex of mature blue crab examined from OCGS, Forked River, Oyster Creek, and Barnegat Bay from September 1975 through August 1976.

Month	OCGS		Forked River		Oyster Creek		Barnegat Bay	
	Male	Female	Male	Female	Male	Female	Male	Female
September	106	101	4	0	4	0	3	0
October	97	254	2	1	1	2	3	2
November	6	33	1	0	1	0	0	0
December	1	1	0	0	0	0	1	0
January	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0
March	4	4	0	0	0	0	0	0
April	11	38	0	2	13	22	0	2
May	45	58	4	2	9	7	4	1
June	47	62	5	2	4	12	2	1
July	8	5	6	0	10	4	2	0
August	14	18	4	0	2	2	2	0
Total	339	574	26	7	44	47	17	6

Table 132. Commercial fisheries landings reported from the waters between Toms River and the Manahawkin Bridge from September 1975 through August 1976.

Species	September 1975 lbs.	Value ($)	Gear*	October 1975 lbs.	Value ($)	Gear	November 1975 lbs.	Value ($)	Gear	December 1975 lbs.	Value ($)	Gear
Blue crab	14640	3294	330	24000	6000	330	-	-	-	31200	9360	805
American eel	1285	386	340	1100	330	340	-	-	-	-	-	-
Northern quahog**	3020	3174	845	3030	3105	845	3530	3702	845	3400	3569	845
Northern quahog**	12090	12696	855	19690	20183	855	18800	19742	855	13600	14277	855
Northern quahog**	15120	15871	955	7570	7762	955	1170	1234	955	-	-	-
Winter flounder	-	-	-	1300	156	310	-	-	-	5200	780	310
White perch	-	-	-	-	-	-	-	-	-	3000	750	310
Total	46155	35421		56690	37536		23500	24678		56400	28736	

Species	January 1976 lbs.	Value ($)	Gear	February 1976 lbs.	Value ($)	Gear	March 1976 lbs.	Value ($)	Gear	April 1976 lbs.	Value ($)	Gear
Blue crab	8800	2220	805	15280	3820	805	8000	2000	805	-	-	-
American eel	-	-	-	-	-	-	-	-	-	4800	1680	340
Northern quahog**	2140	2354	845	2040	2296	845	3380	3806	845	2790	3143	845
Northern quahog**	8560	9416	855	11570	13013	855	13540	15226	855	11180	12574	855
Northern quahog**	-	-	-	-	-	-	-	-	-	4660	5239	955
Winter flounder	6300	945	310	8900	1602	310	12000	2400	310	6300	945	310
White perch	5500	1375	310	10310	2578	310	8850	2213	310	7120	1780	310
Total	31300	16310		48100	23309		45770	25645		36850	25361	

Table 132. (cont.)

Species	May 1976 lbs.	Value ($)	Gear	June 1976 lbs.	Value ($)	Gear	July 1976 lbs.	Value ($)	Gear	August 1976 lbs.	Value ($)	Gear
Blue crab	8600	2580	330	19600	7350	330	14520	5082	330	16600	4980	330
American eel	10100	3030	340	8500	2550	340	2200	660	340	1910	573	340
Northern quahog**	2950	3318	845	2620	2942	845	1160	1309	845	1800	2024	845
Northern quahog**	9830	11060	855	6540	7356	855	5820	6543	855	5400	6070	855
Northern quahog**	6880	7742	955	16990	19124	955	16280	18320	955	10790	12141	955
Winter flounder	6450	1290	310	-	-	-	-	-	-	-	-	-
White perch	5500	1375	310	-	-	-	-	-	-	-	-	-
Alewife	1200	48	310	-	-	-	-	-	-	-	-	-
Total	51510	30443		54250	39322		39980	31914		36500	25788	

* Gear = 310 - fyke net
330 - crab pots
340 - eel pots
805 - clam dredge
845 - clam tongs
855 - clam rake
955 - clam by hand

** Meats

Table 133. Commercial fisheries landings reported from Ocean County, New Jersey from September 1975 through August 1976.

Species	September 1975 Lbs	September 1975 Value ($)	October 1976 Lbs	October 1976 Value ($)	November 1975 Lbs	November 1975 Value ($)	December 1975 Lbs	December 1975 Value ($)	January 1976 Lbs	January 1976 Value ($)	February 1976 Lbs	February 1976 Value ($)
Alewife	-	-	-	-	-	-	1,738	397	-	-	-	-
Bluefish	100,038	15,300	102,007	10,384	49,166	4,849	-	-	14	5	-	-
American eel[1]	4,195	1,259	2,500	750	-	-	-	-	-	-	-	-
Winter flounder[2]	-	-	1,945	273	-	-	5,536	852	6,425	973	8,900	1,602
Summer flounder[3]	18,090	9,333	21,062	9,435	29,713	12,713	80,761	31,395	304,796	125,107	272,450	139,601
Weakfish[4]	153,694	24,259	120,639	15,062	112,883	11,438	8,858	8,314	75	25	100	25
White perch	-	-	750	188	-	-	3,000	750	5,500	1,375	10,310	2,578
Crabs, blue, hard	14,640	3,294	24,000	6,000	-	-	31,200	9,360	8,880	2,220	15,280	3,820
Northern quahog (meat)[5]	-	-	86,550	88,714	67,150	70,508	48,560	50,988	26,750	29,425	45,360	51,030
Total	290,657	$ 53,445	359,453	$130,806	258,912	$ 99,508	178,953	$ 96,036	352,440	$159,130	352,400	$198,656

Species	March 1976 Lbs	March 1976 Value ($)	April 1976 Lbs	April 1976 Value ($)	May 1976 Lbs	May 1976 Value ($)	June 1976 Lbs	June 1976 Value ($)	July 1976 Lbs	July 1976 Value ($)	August 1976 Lbs	August 1976 Value ($)	Total (Lbs)
Alewife	-	-	-	-	1,200	48	-	-	-	-	-	-	2,938
Bluefish	-	-	-	-	4,452	604	17,260	2,777	31,861	6,266	89,384	13,330	345,016
American eel	-	-	15,430	5,401	19,300	5,790	12,200	3,660	4,920	1,476	4,760	1,428	63,305
Winter flounder	12,000	2,400	8,893	1,409	15,014	2,232	11,017	1,864	1,706	420	545	106	71,981
Summer flounder	206,028	133,245	86,846	38,794	89,528	35,644	47,785	26,848	50,899	34,899	64,337	39,139	1,272,295
Atlantic menhaden	-	-	708	35	-	-	-	-	-	-	470	26	1,178
Weakfish	203	68	13,162	4,075	11,591	2,087	-	-	19,276	4,814	58,619	15,192	499,100
White perch	8,850	2,213	7,120	1,780	5,500	1,375	-	-	-	-	-	-	41,030
Crabs, blue, hard	8,000	2,000	-	-	8,600	2,580	19,600	7,350	14,520	5,082	16,600	4,980	161,320
Northern quahog (meat)[5]	56,390	63,439	74,510	83,824	78,650	88,481	104,610	117,686	116,320	130,860	119,910	134,899	824,760
Total	291,471	$203,365	206,669	$134,318	321,835	$138,839	212,472	$160,185	239,302	$183,817	354,625	$199,100	

Grand Total (Lbs) 3,297,163

1. Reported as Eels, common
2. Reported as Flounders, blackback
3. Reported as Flounders, fluke
4. Reported as Sea trout, grey
5. Reported as clams, hard

Table 134 . Sport fisheries catch in western Barnegat Bay, Forked River, and Oyster Creek from September 1975 through 8 September 1976.

Zone	1	2	3	4	5	
Temp. Range(C), sur	7.0-25.2	7.0-29.5	6.2-25.4	4.5-31.5	4.5-27.0	Totals
Sal. Range(ppt), sur	16.0-28.0	19.5-29.0	21.0-31.0	12.0-27.5	14.0-28.0	
Boats Fishing	110	80	112	-	-	302
Boats Sampled	80	67	64	-	-	211
Hours Fished	361.0	316.0	350.0	589.75	294.0	1910.75
Rods Used	77	87	149	112	63	488
Traps Used	307	239	51	256	141	994
Catch	1017	1114	633	2494	539	5797
Individual Fishing	219	187	150	243	146	945
Catch/Boat	12.71	16.63	9.89	-	-	-
Catch/Individual	4.64	5.96	4.22	10.26	3.69	-
Species Taken						
American eel	2	1	1	-	-	4
Inshore Lizardfish	-	-	1	-	-	1
Oyster toadfish	-	-	-	1	-	1
Black sea bass	-	18	59	-	-	77
Bluefish	61	48	61	425	109	704
Crevalle jack	-	-	-	1	-	1
Scup	-	3	1	-	-	4
Weakfish	5	4	-	-	-	9
Spot	23	15	-	26	9	73
Northern kingfish	-	3	1	-	-	4
Summer flounder	-	-	115	2	-	117
Winter flounder	-	24	11	-	5	40
Northern puffer	4	1	1	-	-	6
Blue crab	922	997	382	2039	416	4756
Total	1017	1114	633	2494	539	5797
Taxa	6	10	10	6	4	14

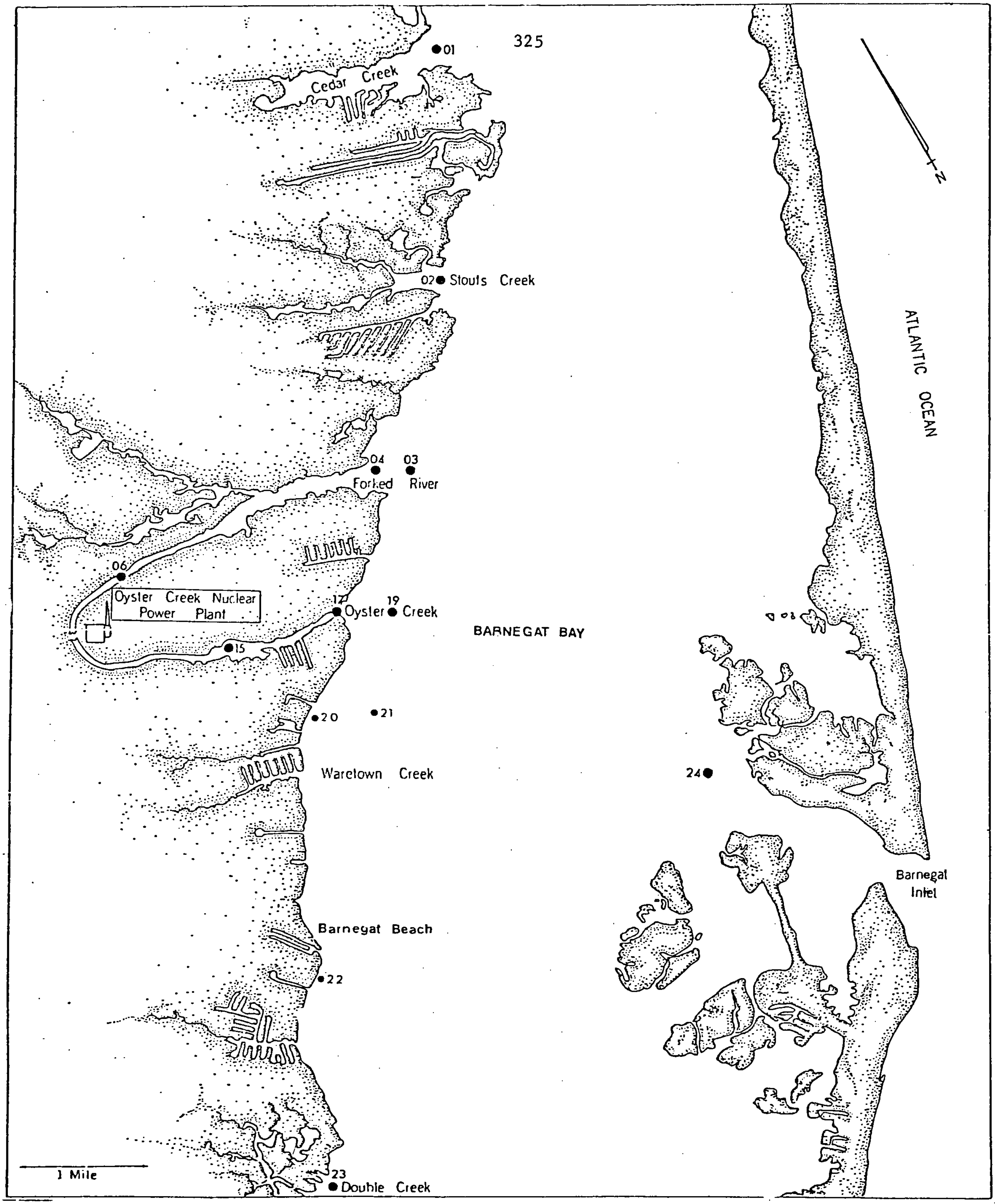

Figure 1. Sampling locations for biological collections taken for the OCGS ecological study.

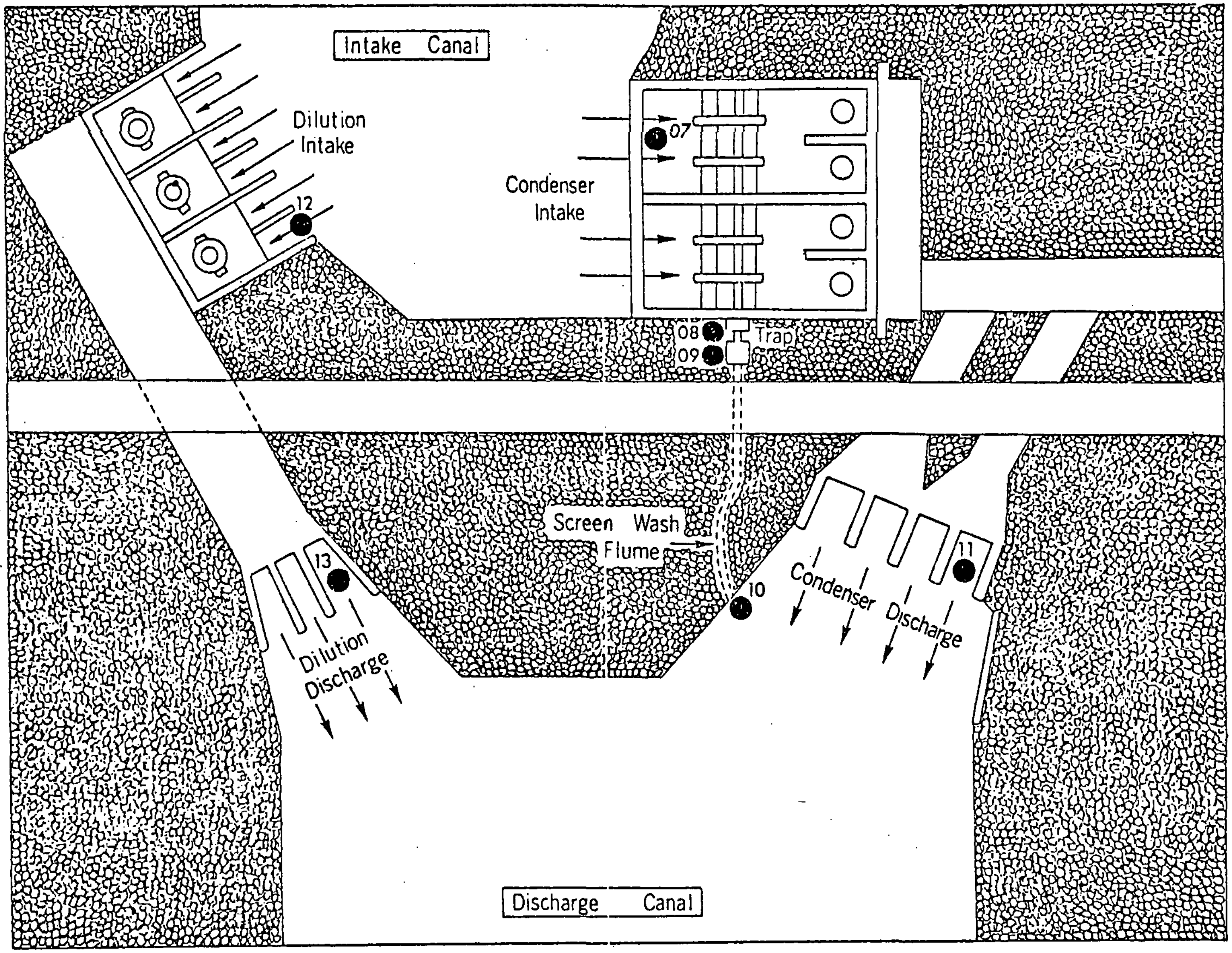

Figure 2 . Sampling locations (●) for biological collections at the Oyster Creek Generating Station.

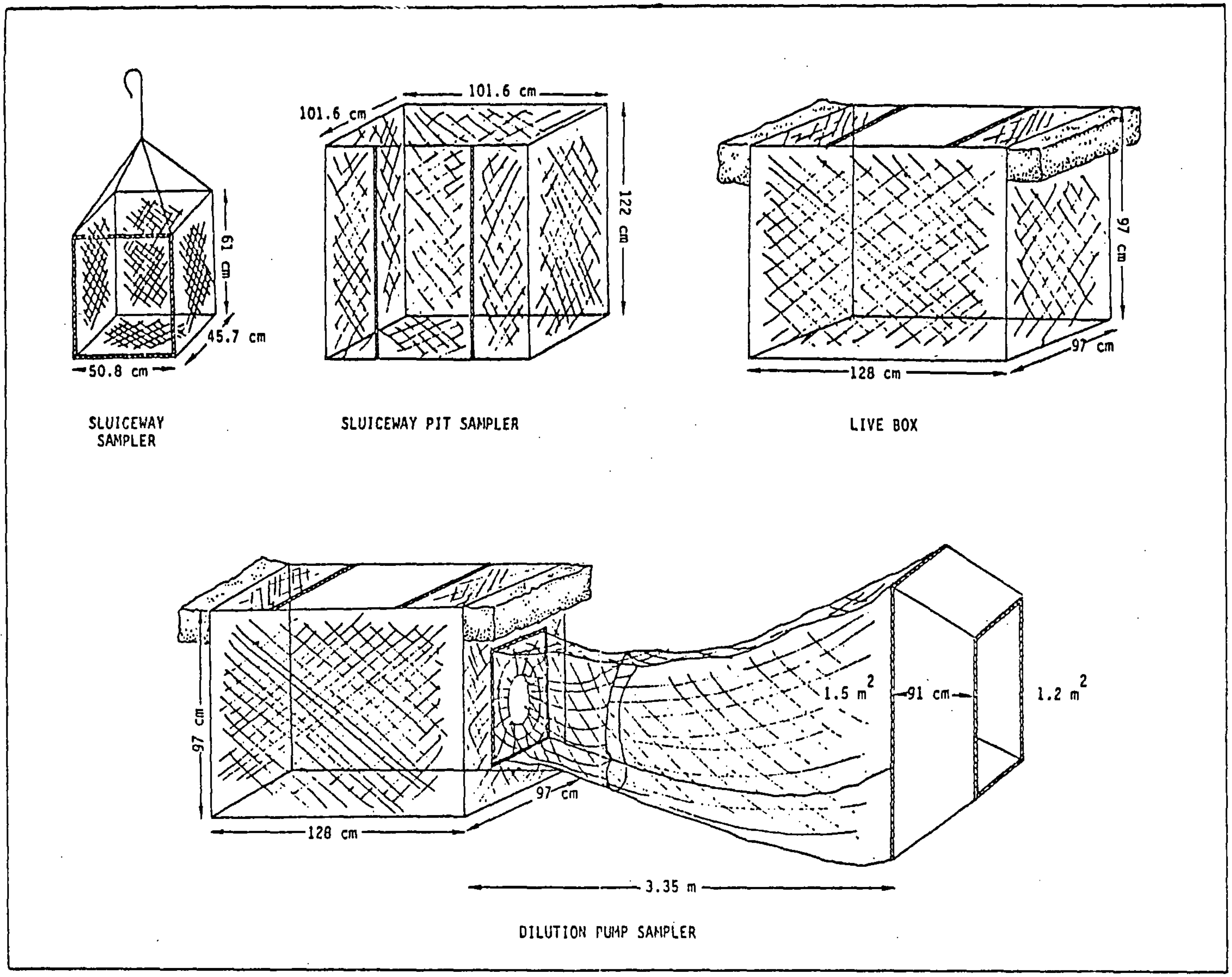

Figure 3. Sampling gear used in the impingement, dilution pump, and delayed mortality studies for the Oyster Creek Generating Station Ecological Studies.

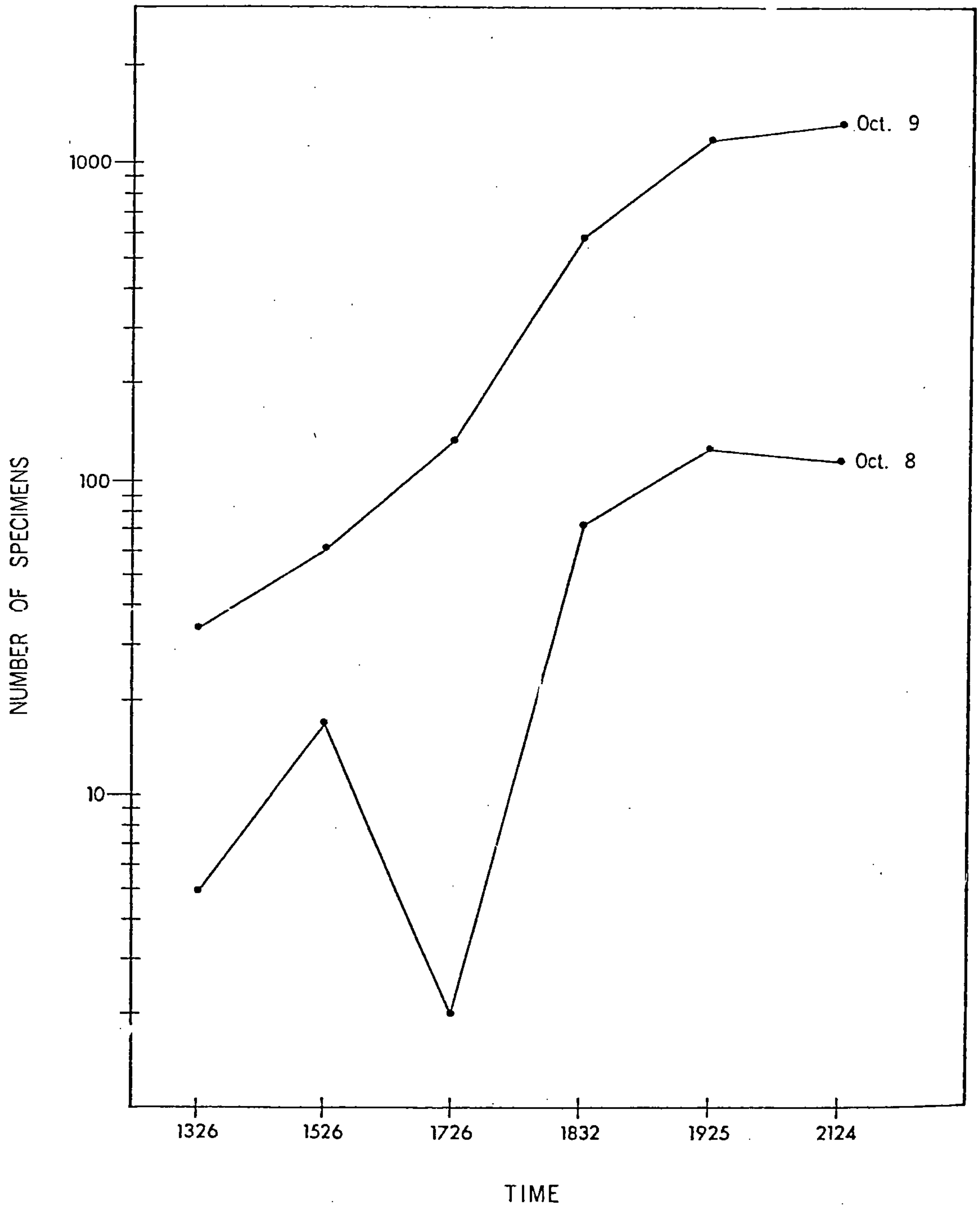

Figure 4. Number of specimens impinged on October 8 during SW winds and on October 9 during NE winds at the Oyster Creek Generating Station.

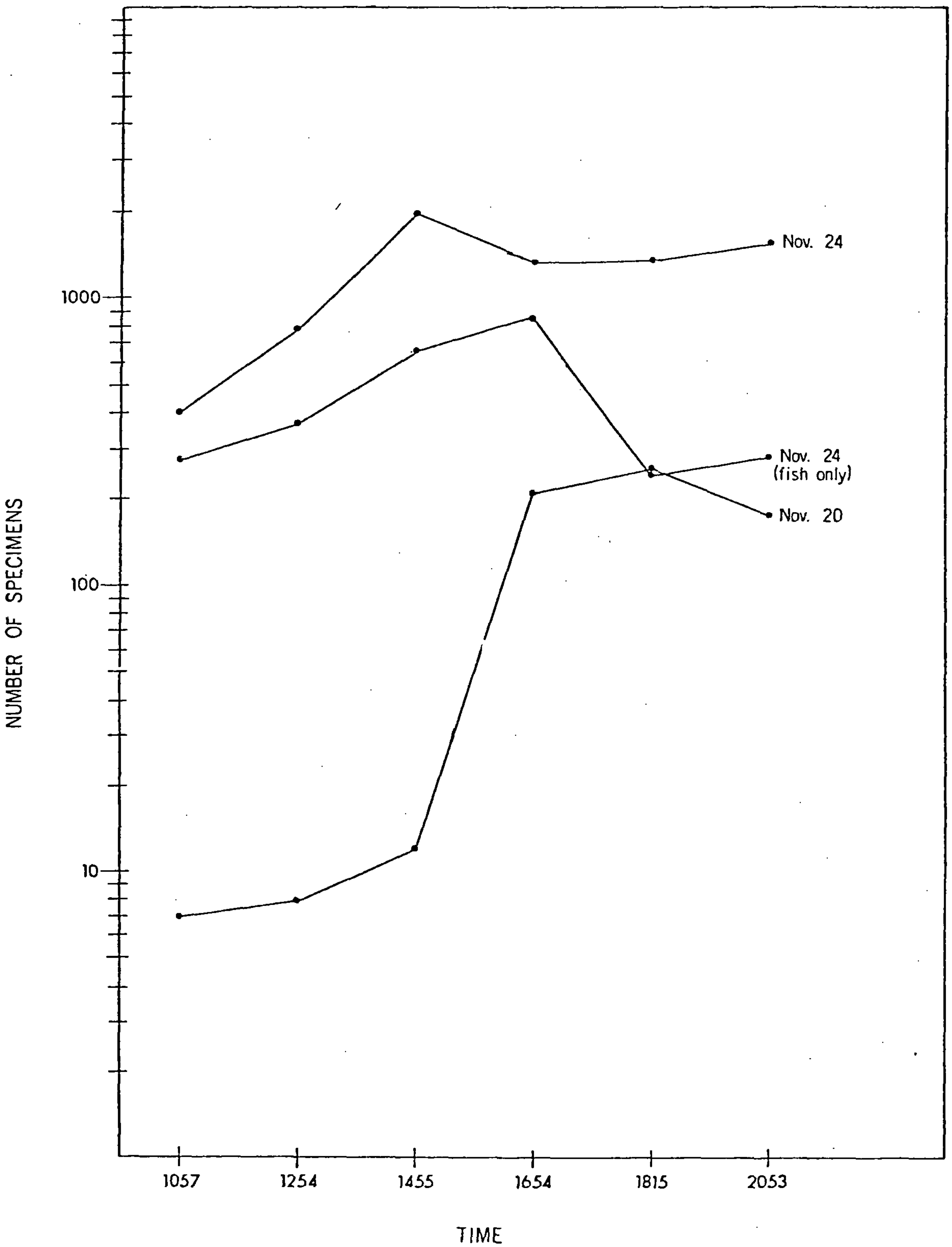

Figure 5. Number of specimens impinged on November 20 during N winds and on November 24 during NE winds.

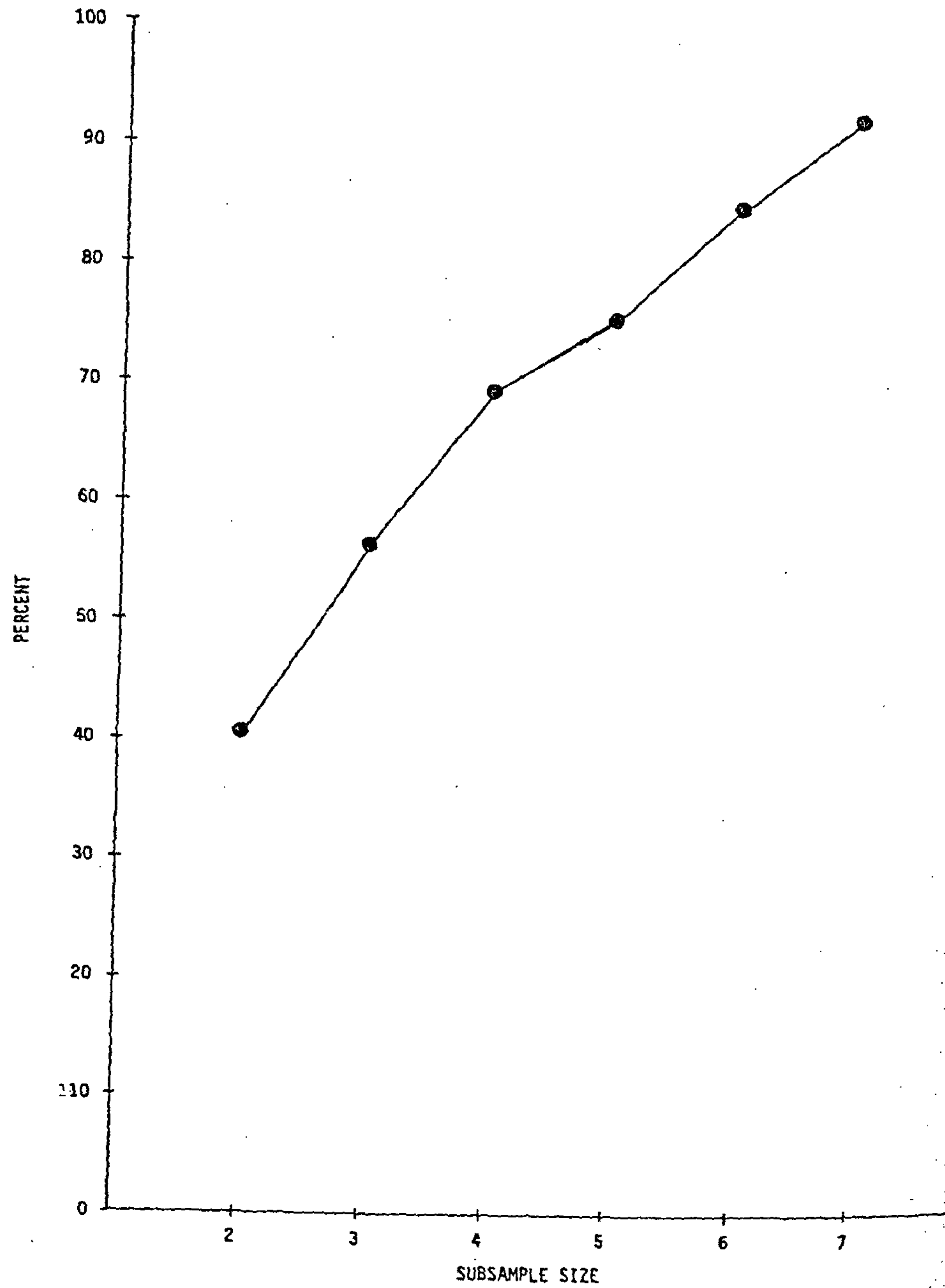

Fig. 6. Percentages subsample means for all parameters combined fell within 25% of sample mean by subsample size.

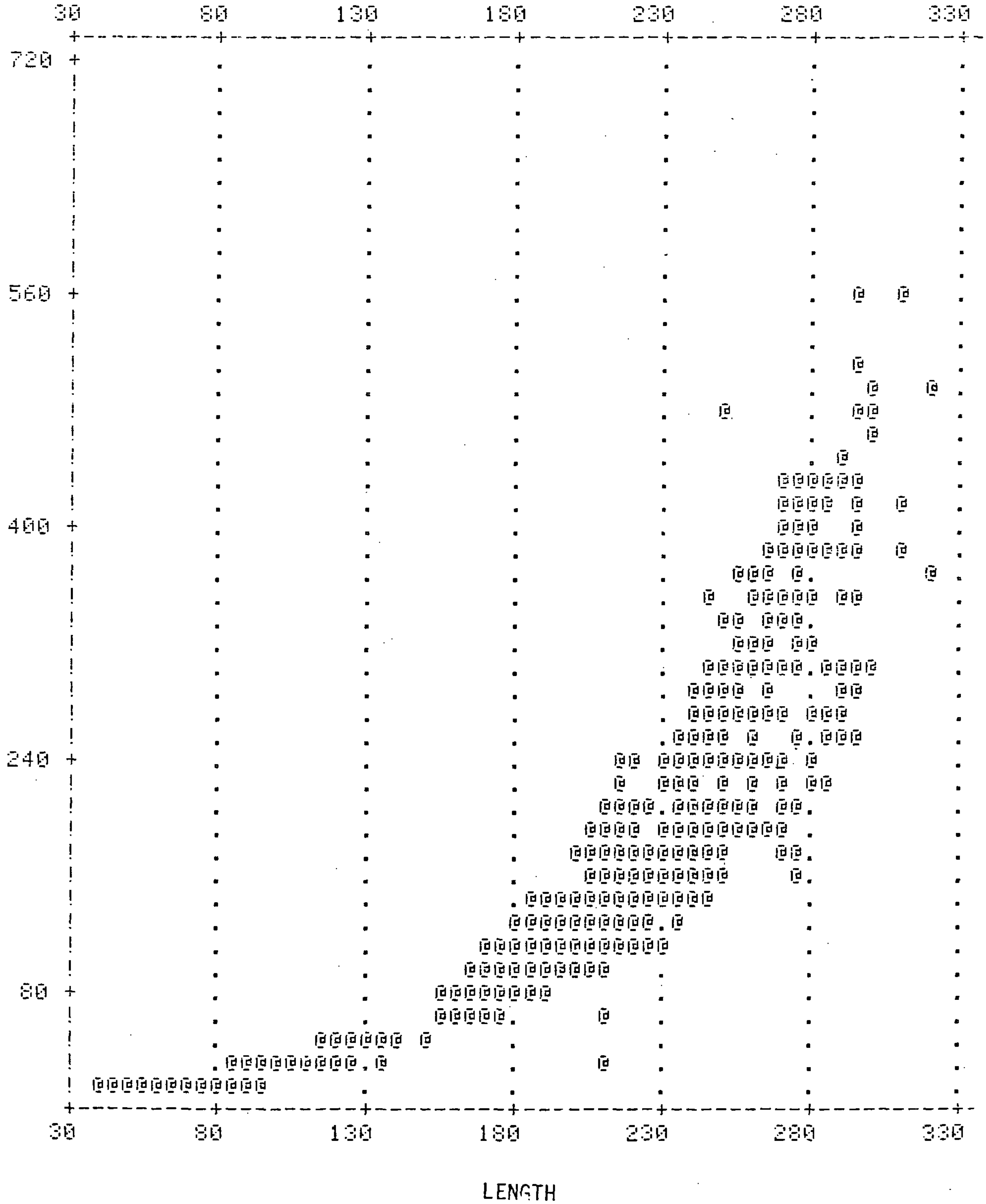

Fig. 7 . Scatter diagram of length vs weight for Atlantic menhaden examined from collections taken from September, 1975 through August, 1976.

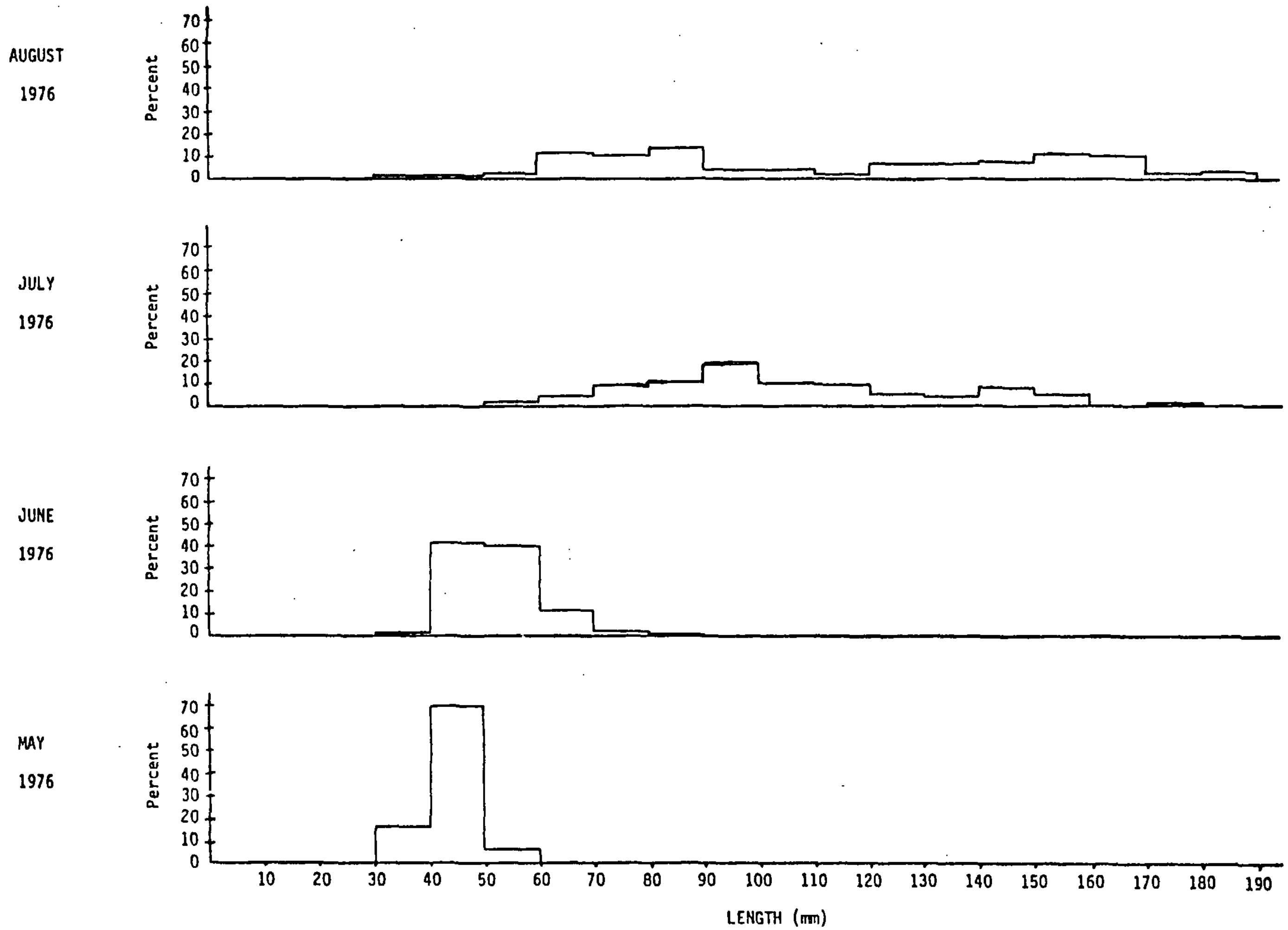

Fig. 8 . Length frequency histogram for young (0+) bluefish collected from May through August in the vicinity of OCGS in 1976.

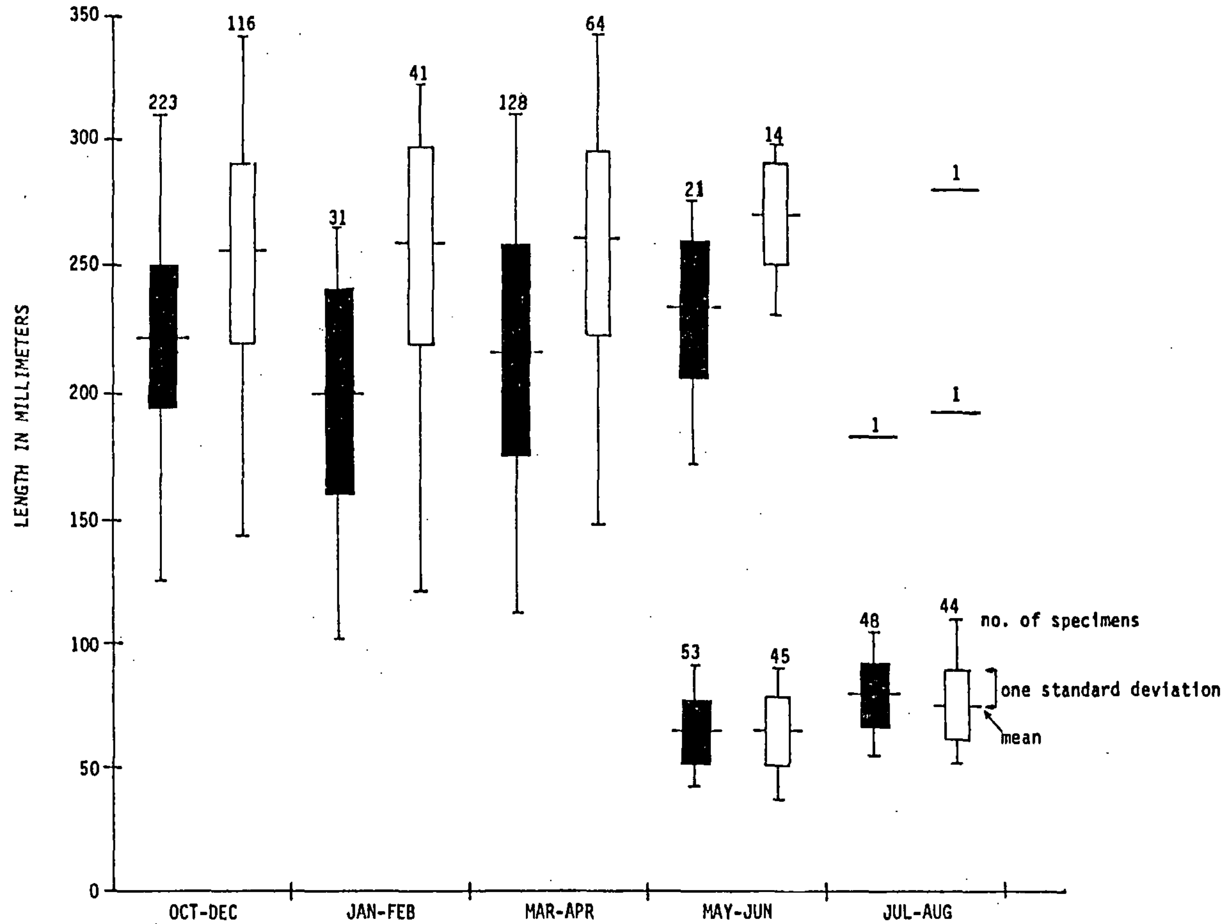

Fig. 9 . Lengths of male (■) and female (□) winter flounder taken in Barnegat Bay, N. J. from October 1975 through August 1976. The range, mean, and one standard deviation from the mean are illustrated.

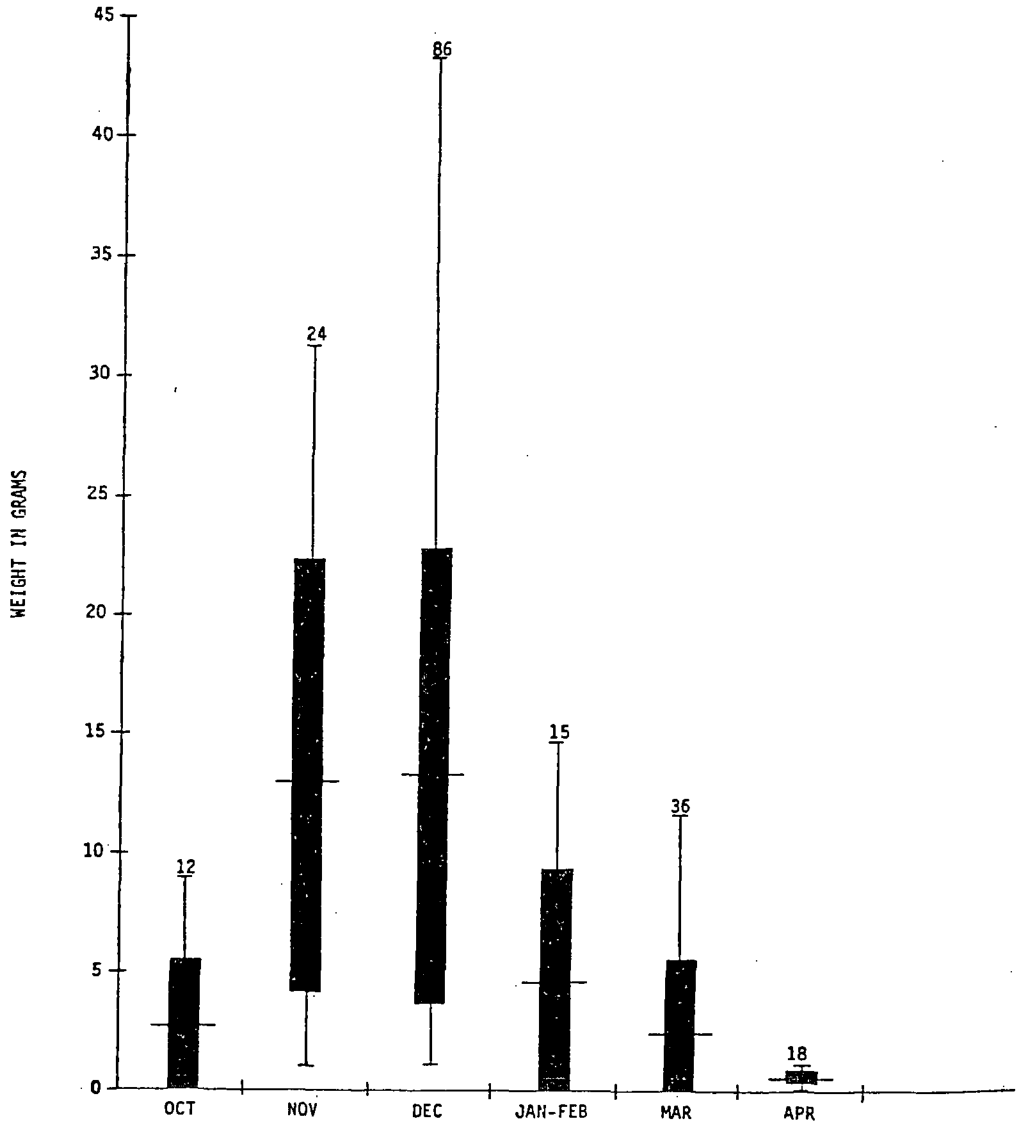

Fig. 10 . Total gonad weights of male winter flounder taken in Barnegat Bay from October 1975 through April 1976. The range, mean, and one standard deviation from the mean are illustrated.

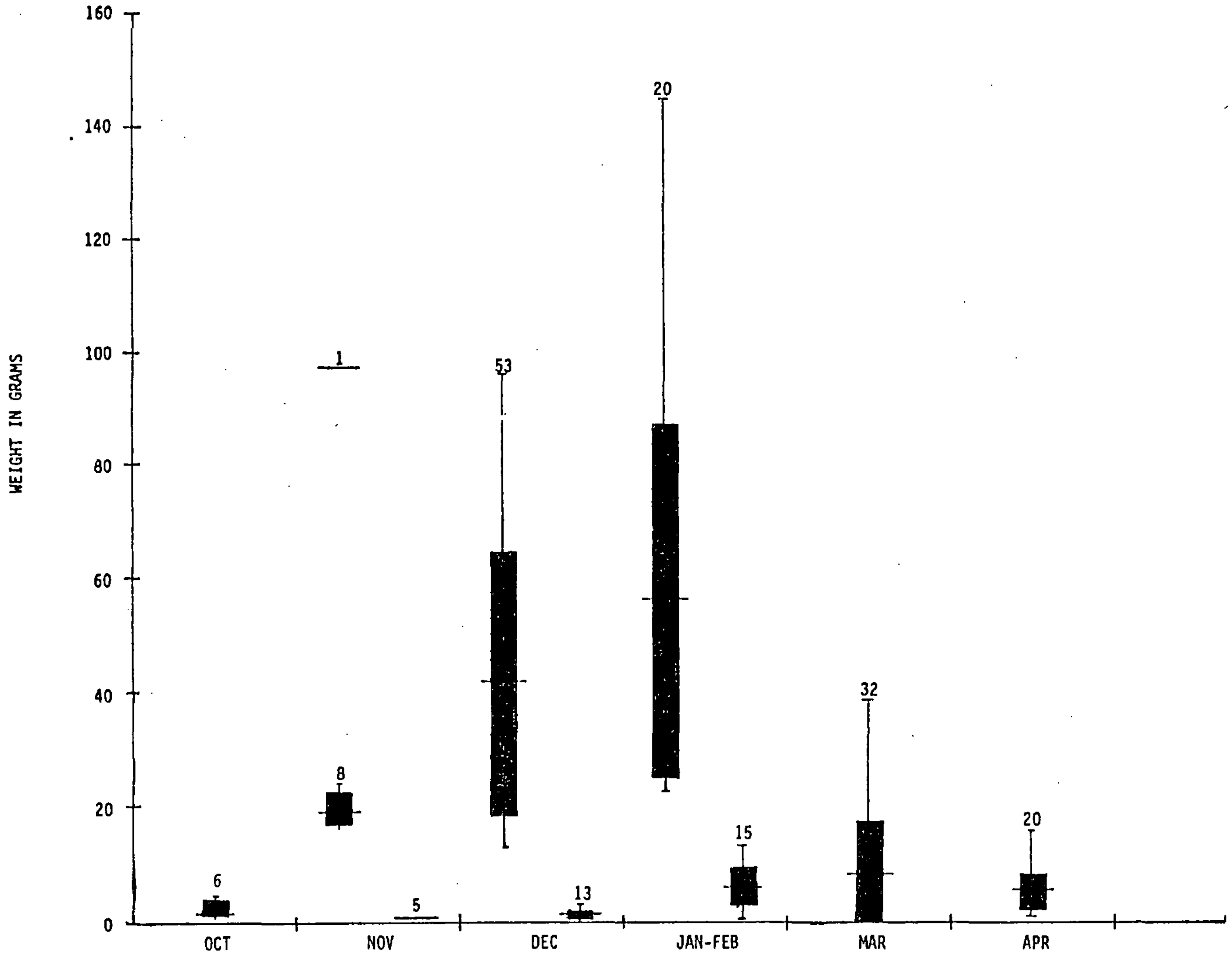

Fig. 11. Total gonad weights of female winter flounder taken in Barnegat Bay from October 1975 through April 1976. The range, mean, and one standard deviation from the mean are illustrated.

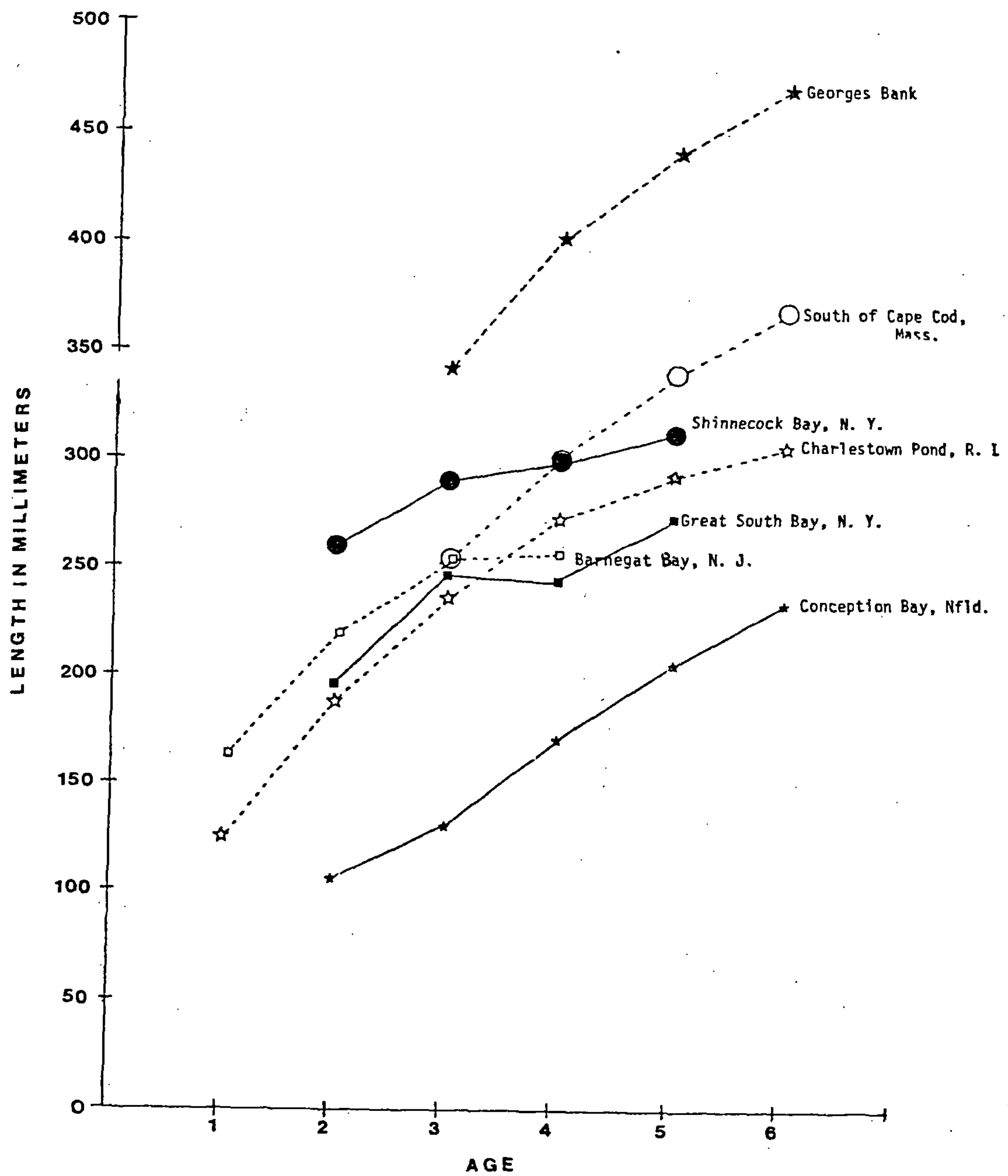

Fig. 12 . Growth rates of male winter flounder taken in the northeastern United States and eastern Canada.

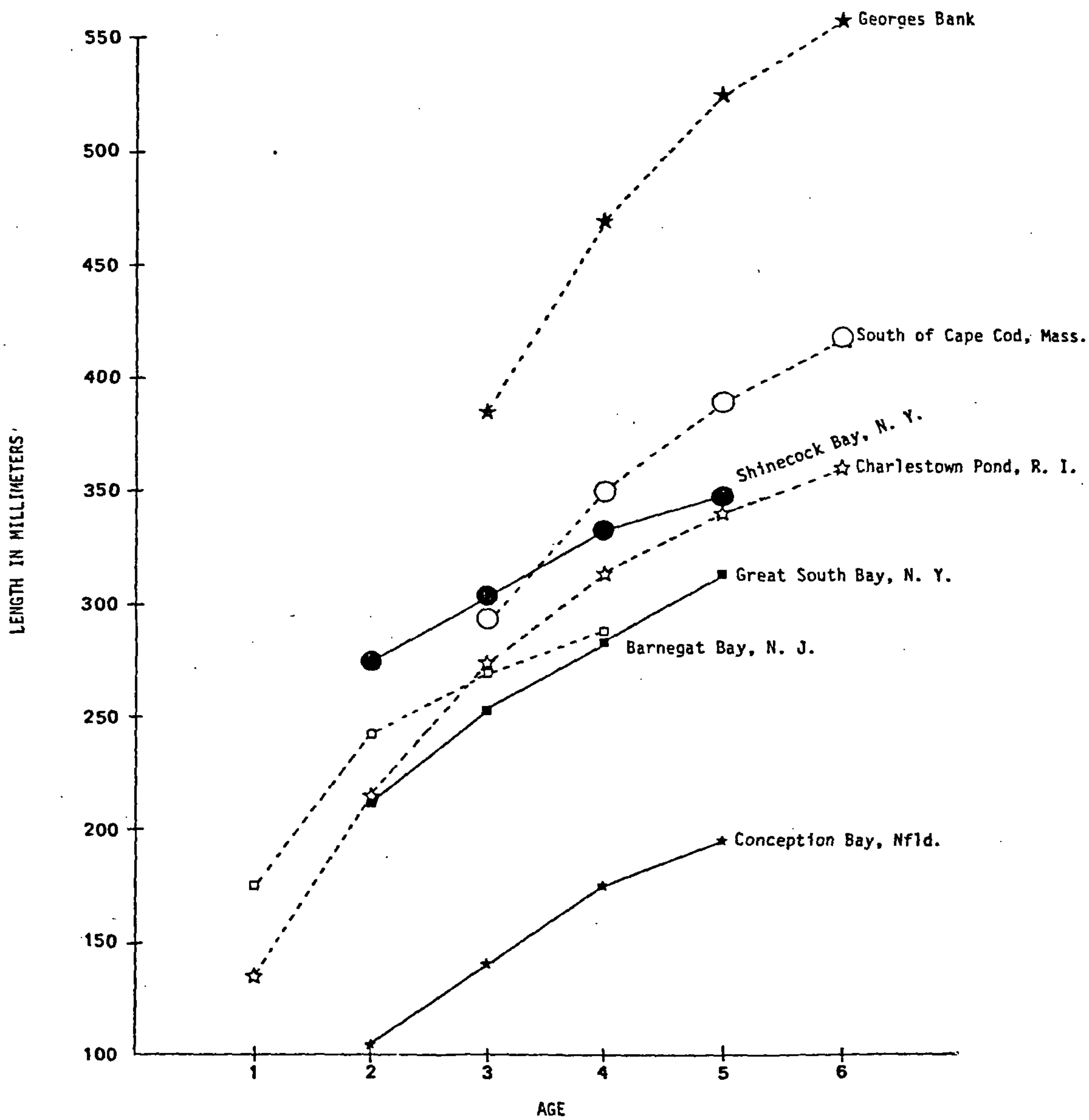

Fig. 13. Growth rates of female winter flounder taken in the northeastern United States and eastern Canada.

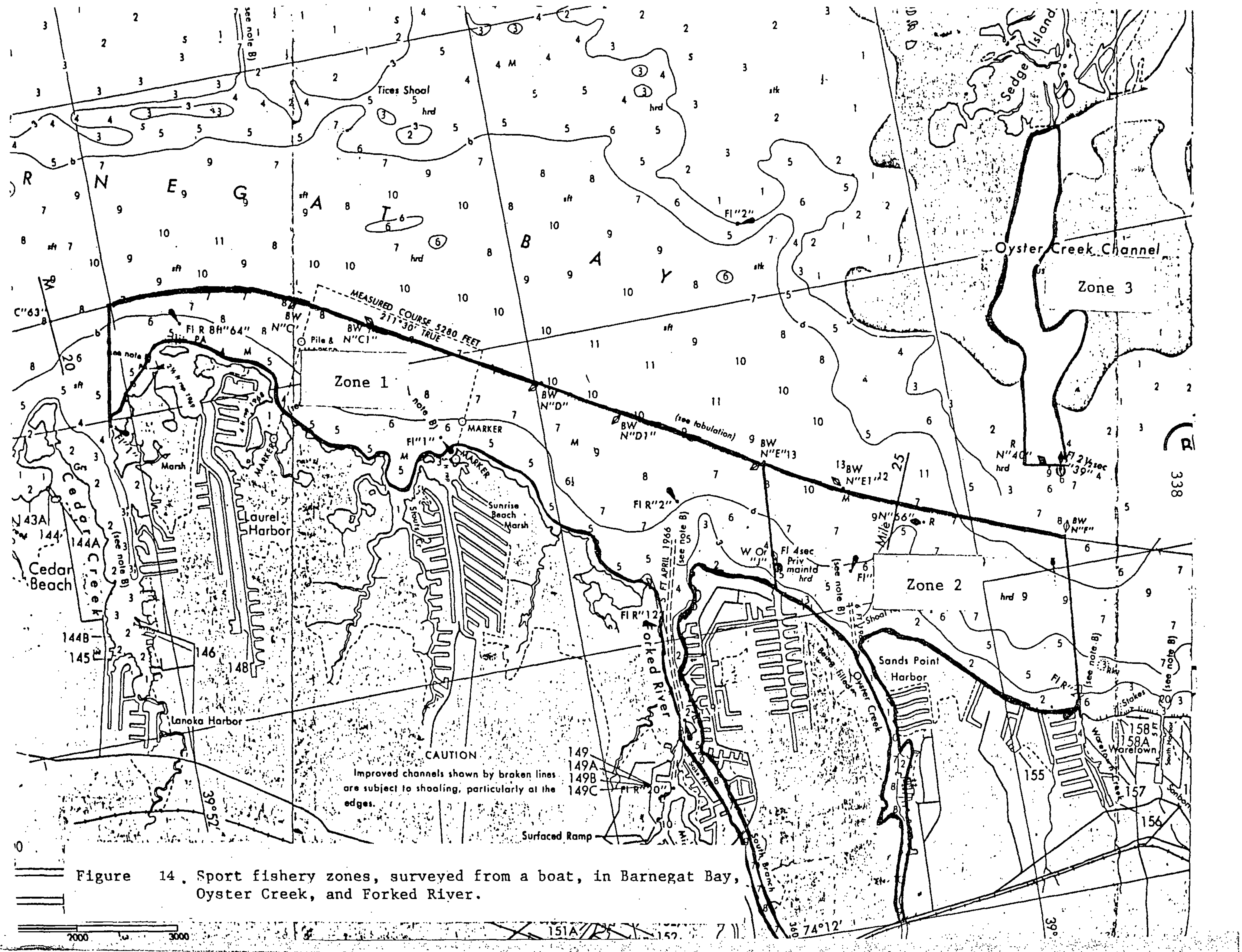

Figure 14. Sport fishery zones, surveyed from a boat, in Barnegat Bay, Oyster Creek, and Forked River.