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PG&E Generating and Marine Research Inc.
1998 Annual Report, Brayton Point Station.

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Case Studies-
Brayton - Shelf

PG&E Generating™

Brayton Point Station
Somerset, Massachusetts

1998 Annual Report

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and
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I. INTRODUCTION

Annual Report

This 1998 Annual Report summarizes results and observations of the ongoing biological and hydrological monitoring programs conducted by Marine Research, Inc. for Brayton Point Station in Mount Hope Bay and surrounding waters. This report also includes temperature, circulating water flow and heat load summaries, monthly barrier net reports, unusual impingement and fish kill summaries and a bibliography of all technical, biological, hydrological, etc. reports submitted to U.S. Environmental Protection Agency and Massachusetts Department of Environmental Protection during 1998.

The purpose of this Annual Report is as stated in section A.9.c of the Station's National Pollutant Discharge Elimination System (NPDES) permit, dated June 16, 1993:

> *"To assist the Technical Advisory Committee (TAC) with their continuing evaluation of the Brayton Point Station impact upon the Mount Hope Bay aquatic community and to facilitate future permit reissuance, the permittee shall provide a summarized statistically analyzed data base of at least 10 prior years. This report will include, for this same period, a summary of all reported days and the number of hours of each day wherein the Maximum Temperature and Delta-T limitations were exceeded, a summary of all reported fish kills, and all unusual fish impingements. This report shall also include a bibliography of all technical reports, biological, hydrological, etc. reports submitted to EPA and the State in fulfillment of the NPDES Permit Program."*
>
> *"Each new year's annual data summary will be incorporated into the historical data base for comparison with future annual data collections."*
>
> *"The annual report conclusions will indicate the trends of the various parameters analyzed and identify any anomalies that appear in the annual historical data comparison. These differences will be explained, if possible. The permittee will make recommendations for any remediation considered necessary or for any programs to better understand the anomaly."*

For this report, the information obtained by the 1998 biological and hydrological monitoring program is compared to the program's historical database, initiated in 1972. In addition, there are three supplements to this report for research completed during 1998. These supplements are the following technical reports:

- Supplement A - *Comparisons of Benthic, Phytoplankton, Zooplankton Populations, Nutrient, Chlorophyll Concentrations and Productivity Values Between 1972-1985 and 1997/1998,* performed and written by Marine Research, Inc. (MRI)

- Supplement B - *1997-1998 Entrainment Survival Study*, performed and written by Lawler, Matusky and Skelley Engineers

- Supplement C- *Mapping Temperature Distributions In Mount Hope Bay, Fall 1998 Deployment*, performed by MRI and Applied Science Associates (ASA) and written by ASA.

Station Description

PG&E Generating operates an electric power generating facility, Brayton Point Station, on an approximately 280 acre site located in Somerset, Massachusetts.[1] The facility provides approximately 1,600 MW of electricity into the New England power grid for sale in the wholesale power market. The facility operates on a continuous basis, 24-hours per day, seven days a week.

The facility is situated on a peninsula, at the confluence of the Taunton and Lee Rivers, in Mount Hope Bay, approximately 1 mile west of Fall River, Massachusetts. Units No. 1 and 2 are rated at 250 MW each and Unit No. 3 is rated at 650 MW. These three units burn mainly coal but can burn some natural gas. Unit No. 4 is rated at 450 MW and burns both No. 6 fuel oil and natural gas. Each unit has two circulating water pumps that draw intake water from either the Taunton or Lee Rivers. Unit No. 1, 2 and 3 circulating water intakes are located on the Taunton River and Unit No. 4 intake is located on the Lee River. The design flow rate for each of the eight circulating water pumps is the following:

Circulating Water Pump	Unit	Design Flow Rate (MGD)	Intake Location
11	1	130.3	Taunton River
12	1	130.3	Taunton River
21	2	130.3	Taunton River
22	2	130.3	Taunton River
31	3	201.6	Taunton River
32	3	201.6	Taunton River
41	4	187.7	Lee River
42	4	187.7	Lee River

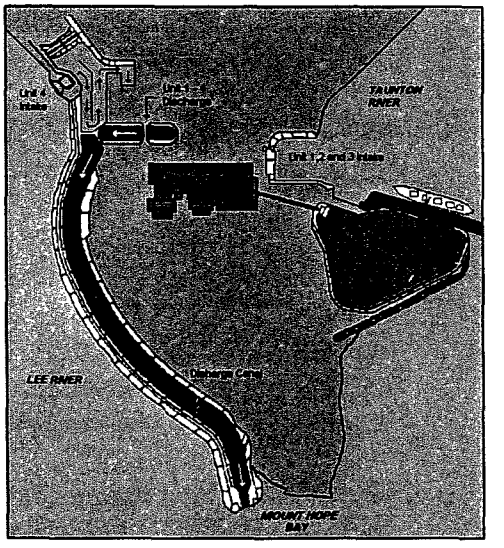

Figure 1: Normal Operation

The maximum total station circulating water flow is 1298.9 MGD with Units 1, 2 and 3 having the potential to draw in 924.5 MGD and Unit No. 4 to draw in 375.4 MGD of bay water.

Biological and Hydrological Monitoring Requirements

The Station's NPDES permit requires hydrological and biological monitoring of Mount Hope Bay and surrounding waters. In addition to the required biological and hydrological monitoring program, additional monitoring programs or enhancements of the required programs have also been initiated by the Station with input from the Brayton Point Technical Advisory Committee.

[1] USGen New England, Inc. is the owner of Brayton Point Station.

The following are the monitoring programs performed in 1998.

- Temperature, salinity, pH and dissolved oxygen profiles at 5 foot intervals at six fixed stations in Mount Hope Bay. These Stations include Stations I (Units 1,2 and 3 intake), D (straight bridge near Units 1, 2 and 3 discharge headwall), A (discharge canal venturi), A'(200 yards south of the venturi), C (mouth of Lees River) and F (south of Spar Island). Sampling frequency is monthly from October through February and every 4 days from March through September when the ichthyoplankton samples are taken.

- Ichthyoplankton sampling with paired 60-cm brideless bongo nets fitted with a 0.505 mm mesh netting at seven fixed stations in Mount Hope Bay. The five stations required by the permit include Stations 1 (south of Braga Bridge), 4 (Lee River), 5 (Cole River), 9 (west of Spar Island), and 10 (East of Spar Island). The additional stations sampled are Station 21 (northeast of Mount Hope Bridge) and 23 (Sakkonet River). The samples are analyzed for species type and abundance. Sampling frequency is once in February and approximately every 4 days from March through mid-May.

- Ichthyoplankton sampling for winter flounder at three locations at the Taunton River intake for Units No. 1, 2 and 3, the Lees River Intake for Unit No. 4 and station M, opposite Montaup Power Station. Only the two intake samples are required by the permit. Like the bay-wide ichthyoplankton sampling program, the sampling frequency is once in February and approximately every 4 days from March through mid-May

- Finfish populations sampling once per month by otter trawl along six fixed transects and four random transects in Mount Hope Bay. The fixed transects are Taunton River, Intake, Lee, Discharge, Cole and Spar Island. In March 1997, the sampling of four random transects was initiated.

- Finfish populations sampling once per month with a fine-mesh Wilcox trawl along ten to twelve random trawls in Mount Hope Bay, one fixed transect in the Warren River, RI and one fixed transect on Ohio Ledge. This sampling is not required in the Station's permit.

- Shallow-water finfish populations sampling by beach seine at four locations in Mount Hope Bay. The locations are Intake, Lee, Discharge, Cole and Spar Island. Sampling frequency is monthly from March through October.

- Young-of-Year winter flounder sampling by beach seine at 19 to 21 locations in upper Mount Hope Bay twice during June and July and once during August.

- Impingement sampling of finfish on the intake screens of Units 1, 2 and 3 daily.

- Benthic sampling of quahogs at six locations in Mount Hope Bay stations A', F and M (north of Braga Bridge) as required in the permit and additional stations Lee River, Assonet River and RB N in the Taunton River. The quahogs are analyzed for cadmium, copper, iron, lead, mercury, nickel, vanadium and zinc, as required in the permit and additional metals: aluminum, arsenic, chromium, cobolt and manganese. The sampling frequency is once in April, July and October.

Piggyback Operation

Periodically since 1993, Unit No. 4 has operated in the piggyback configuration to reduce the volume of circulating water for the station, thus reducing the amount of ichthyoplankton entrained. Piggyback configuration is when the Lee River intake for Unit No. 4 is taken out of service and the circulating water discharge from Unit No. 1, 2 and 3 is routed through the Unit No. 4 circulating water pumps. Thus, Unit No. 4 uses the circulating water discharge from Units No. 1, 2 and 3 for cooling water. Piggyback operation results in a 29% reduction in the maximum station flow rate. Originally established to target the winter flounder spawning season, in 1993 Unit No. 4 operated in the piggyback mode during March. Subsequent years, with the exception of 1995, piggyback operation occurred during most of the spawning season by starting in February and ending in March or April. In 1995, since Unit No. 3 was on a routine overhaul, Unit No. 4 did not operate in the piggyback mode so that ichthyoplankton samples could be collected at the Unit No. 4 intake for entrainment estimates. With Unit No. 3 out of service, the reduction in flow rate was equivalent to piggyback operation

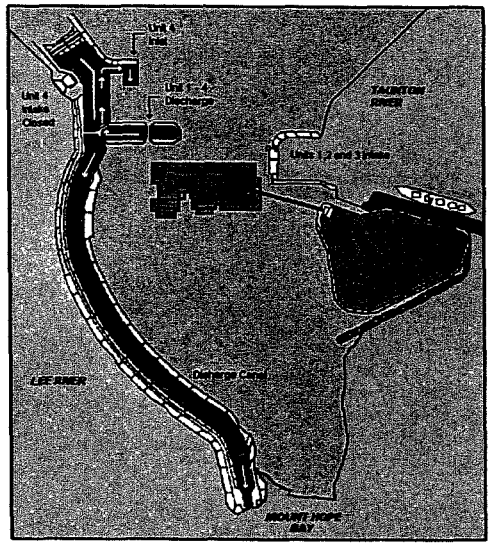

Figure 2: Piggyback Operation

Memorandum of Agreement (MOA)

In early February 1997, Brayton Point Station, the U.S. Environmental Protection Agency, Massachusetts Department of Environmental Protection, Massachusetts Executive Office of Environmental Affairs and Rhode Island Department of Environmental Management entered into a memorandum of agreement (MOA) regarding the operations of the station. Under the terms of the MOA, heat loading into the Bay and circulating water flow is restricted. In addition, the traveling screens for Unit No. 1, 2, and 3 will continuously[2] operate whenever the intake for each unit is in use.

To meet the MOA winter season flow limit, Unit No. 4 has operated in the piggyback mode for eight months out of the year from October through May since February 1997. During the summer months (June through September), Unit No. 4 operates in the once through mode. Refer to Section IV for monthly circulating water flow and heat loading rates.

[2] Prior to entering into the MOA, the traveling screens for Units No. 1, 2 and 3 were rotated every eight hours and continuously during unusual fish impingement events.

II. EXECUTIVE SUMMARY

Hydrographic Data

Two of the most important factors influencing the distribution and health of aquatic organisms are temperature and dissolved oxygen. Excessively high temperature or low oxygen are typically avoided by aquatic organisms. If, however, escape is unavailable, exposure to either can lead to reductions in activity, growth, and fecundity and even to death. The temperature at which particular responses are triggered is highly species and condition specific, but generally temperatures above 28 to 33°C are required. Oxygen levels below 1.25 mg/L for more than a few hours are sufficient to kill most marine organisms, while levels between 2.5 to 3.0 mg/L can result in harmful physiological changes. Dissolved oxygen levels of approximately 5.0 or more are satisfactory for growth (Curely et al. 1974).

Water temperature and dissolved oxygen, along with pH and salinity, were measured at seven locations within Mount Hope Bay during 1998. Measurements were recorded one day per month during January through February and October through December. During the remainder of the year, measurements were recorded four to five days per month.

As judged from measurements taken at Spar Island (Station F), spring time (March through May) water temperatures in the Bay were somewhat higher than average, running 0.8 to 1.4°C higher than the 1986-1997 average. By June and July, a period of relative cooling occurred. During this period, Spar Island water temperatures averaged 0.6 to 0.7°C lower than the 1986-1997 average. During August, temperatures returned to somewhat above normal, running 0.4°C above the 1986-1997 average.

The observed water temperature pattern at Spar Island is consistent with the trends in air temperature recorded at Providence, RI and Boston, MA. These two sites indicate that the winter and spring of 1998 was unusually warm, the warmest on record since the early 1960's. For Providence, January through May air temperatures for 1998 averaged 4.0, 4.1, 2.1, 1.3, and 2.1°C above average. The warm winter and mild summer resulted in a below normal (14%) number of annual heating degree-days and slightly above normal (6%) number of annual cooling degree-days, respectively.

As August is typically the period of highest water temperature within Mount Hope Bay, temperatures during this month can be especially critical to aquatic life. In 1998, average August water column temperatures at Spar Island averaged 23.1°C. August temperatures near the Brayton Point discharge (Station C) averaged 24.1°C while temperatures at the Lee River intake (Station I#4) averaged 25.8°C. Differences in water temperature among locations were generally consistent throughout the 1998 study. Over all months (March through August), discharge-vicinity temperatures averaged 0.9 to 1.7°C higher than Spar Island while the Lee River intake temperatures averaged 1.9 to 2.5°C higher than Spar Island.

Mount Hope Bay has experienced low (<5 mg/L) dissolved oxygen in bottom waters most summers since at least the early 1960's (Curley et al. 1974, Isacc 1997). This hypoxia and anoxia appears to be the result of over-enhanced primary production driven principally by

nitrogen, and to a lesser degree, phosphorus. The primary sources of these nutrients are sewage treatment plant effluents, intermittent sewer overflows, waters from polluted rivers, and polluted water from non-point sources (Olsen et al. 1980).

Observations during 1998 indicate that the condition of low summer dissolved oxygen continues. During June through August, 25% of the observations at Spar Island (Station 10/F) and at the Lee River intake (Station I#4) were less than 5 mg/L. At the Taunton River intake (Station I), 55% of the observations were less than 5 mg/L while near the discharge (Station C) 65% were below 5 mg/L.

Overall, mean monthly dissolved oxygen values recorded during the summer of 1998 were lower than those recorded in 1997 but in only one instance was the monthly mean notably low compared to the overall 1972-1997 times series. Regression analysis of dissolved oxygen time series data suggests that oxygen levels may be improving over time.

Ichthyoplankton Sampling

Over recent years, winter flounder populations have been declining throughout much of Atlantic coast. Within southern New England, the Rhode Island Department of Fish & Wildlife (RIDFW) noted that Narragansett Bay and Rhode Island Sound populations decreased substantially during 1979-90. Abundance indices declined from 169 fish/tow in 1979 to 32 fish/tow in 1982, gradually catches increased through 1988 to 73 fish/tow, but then declined again to 19 fish/tow in 1989-90. Gibson (1996) noted that the decline in Mount Hope Bay appeared to be faster than that noted for Narragansett Bay and Rhode Island Sound. Atlantic States Marine Fishery Commission (ASMFC) (1992) does not point to a single cause for the declining populations, but instead notes a number of contributing factors. One of the primary causes is the loss of habitat, principally through the addition of contaminants and the loss of nearshore shallow habitat. Not only do contaminant additions produce areas of inadequate levels of dissolved oxygen (as described above) but they also can result in such diseases as fin erosion, fin rot, lymphocystis, vibriosis, and hepatic neoplasms. Over fishing is also a major contributing factor. The current management target fishing rate is F_{40}, i.e., a rate which would preserve the spawning stock at 40% of its maximum spawning potential (MSP) after fishing. The 1992 fishing mortality in the southern New England region exceeded that which will preserve only 18-22% of MSP. This degree of overfishing suggests that stock declines are probable.

A program designed to monitor ichthyoplankton recruitment, particularly winter flounder, within Mount Hope Bay has been conducted since 1972. During 1998 sampling took place once in February and once every four to five days from March through mid-May. On each sampling occasion, nine stations were sampled (Stations 1, 4, 9, 10, 21, 23, M and I). Single collections were made at each location with the exception of the Intake Station (I), where collections were made in triplicate. All collections were made with a 60-cm diameter bridleless bongo net. One net of the pair was fitted with 505 μm mesh while the other was fitted with 333 μm mesh. All tows, with the exception of those at Station I, were oblique from bottom to surface. At Station I, tows were oblique but were restricted to the upper half followed by the lower half of the water column.

During February through mid-May of 1998, eggs from seven species and larvae from 22 species were collected. Among eggs, menhaden was the most common species, comprising 59.3% of the total. Tautog and cunner were then next most abundant, making up 27.1% of the total while rockling (7.8%) and windowpane (5.0%), were the third and fouth most abundant, respectively. Three additional species made up the remaining 0.8%. Among larvae, sandlance was the most common species, comprising 78.5% of the total. Winter flounder (14.6%), and grubby (3.7%) were the second and third most abundant, respectively. Nineteen species made up the remaining 3.2% of the total.

Two indices of winter flounder ichthyoplankton abundance were constructed. The first, the geometric mean density, was 7.8 fish/100 m^3. The second index, based on trapezoidal integration of the area under the annual abundance curve, was 865. Both index values were the lowest among the survey 26 years.

No obvious factor was found which could explain the apparently low ichthyoplankton numbers in 1998. The relationship between adult stock size and number of offspring was examined, but no clear-cut relationship was found. Warm water temperatures have been postulated to cause poor year class strength in winter flounder. Despite the warm winter in 1998 and the low larval abundance, no overall correlation between larval abundance in Mount Hope Bay and the January-April Bay temperature index was found. There have been suggestions that larval abundance is higher in years when spring water temperatures warm gradually. The four years of highest larval abundance (1984, 1985, 1992, and 1995) corresponded to four of the five years with the lowest "water temperature difference" between successive sampling dates. The overall correlation, while statistically significant ($p = 0.039$), only explains less than 23% of the variability in the data.

Winter flounder larvae were divided into four life stages: Stage 1, from hatching until the yolk sac is fully absorbed (2.3-3.8 mm); Stage 2, from the end of Stage 1 until a loop or coil forms in the gut (2.6-4.0 mm); Stage 3, from the end of Stage 2 until the left eye migrates past the midline of the head during transformation (3.5-8.0 mm); and Stage 4, from the end of Stage 3 onward (7.3-8.2 mm). Based on samples taken at the Intake Station (I) and the Taunton River Station (M), consistent differences were found between upper and lower halves of the water column. Concentrations in the upper half were 5.0, 9.3, and 6.2/100m^3 for Stages 1, 2 and 3, respectively, while corresponding concentrations in the lower half of the water column were 10.7, 11.7, and 18.2 fish/100m^3, respectively.

Otter Trawl

To monitor trends in post-larval stages of winter flounder population size, trends in other finfish populations, and overall community structure within Mount Hope Bay, otter trawl sampling was conducted. During 1998, two different trawl configurations were used on a monthly basis. The "Standard" trawl program used a 37.5-ft long otter trawl with a 25-ft head rope, 36-ft foot rope, 4.75-in stretch mesh in the body, and 1.5-in stretch mesh in the cod end. During each monthly sampling occasion, January through December ten fixed transects were sampled plus an additional four transects were selected at random from a pool of 83 possible Standard sites. Each trawl was 15 minutes in duration. Although this gear has been used since 1971, the number and location of samples sites has varied over time.

In order to improve the sampling efficiency for age 1 winter flounder, a finer mesh trawl sampling program was initiated in 1993. The "Wilcox" trawl program uses a net with a 30-ft footrope, 2-in stretch mesh in the body, 1.5-in stretch mesh in the cod end and a 0.25-in cod end liner. Ten tows were made each month from January through December with an additional two tows taken during February through May.

Winter flounder was the most abundant species taken in the 1998 Standard trawl catch, accounting for 22% of the total catch. This species was collected in each month with peak numbers occurring in April and May. Winter flounder were collected only along deep transects in July and October and only along shallow transects during January through February. Throughout the rest of the year, catches were generally higher along the deep transects. For all months of 1998, winter flounder mean catches were well below the historical monthly median catch per tow. Peak catches during April and May were 2.0 and 2.7 per tow, respectively. The overall mean catch remained below 1/tow, where it has remained since 1988.

In the Wilcox trawl catches, winter flounder was the second most abundant species, 25%, following bay anchovy. Flounder were taken in all months with the highest catches occurring in May. Catch per tow ranged from 1.2 in January to 29.3 per tow in May. As with the Standard trawl, greatest catches were typically from the deep stations. Overall, winter flounder catches during 1998 averaged 12.7 per tow. This is an increase over 1996 (4.2 per tow), the lowest catch of the six year survey, and 1997 (12.2 per tow). The differences among the years, however, were not statistically significant.

Over the course of the 1998 study, a total of 31 species were collected in the Standard trawl and 39 species in the Wilcox trawl. The top five species in the Standard trawl program were winter flounder (22.3%), windowpane (11.5%), bay anchovy (10.2%), butterfish (9.5%), and alewife (6.8%). The top five species in the Wilcox trawl were similar, bay anchovy (26.0%), winter flounder (25.0%), butterfish (19.6%), scup (5.12%), and alewife (3.7%). Examination of the annual catch per tow time series data from 1972 through 1998 indicated population trends for windowpane, tautog and hogchoker that are similar to that observed for winter flounder. For these benthic species, catches were relatively constant throughout the 1970's. In the early 1980's as fishing rates increased catches began to decline; this decline continued until the late 1980's. During the 1990's catches appear to have stabilized at very low levels.

Analysis of the aggregated resources data from the Standard trawl collections shows relatively constant catches during the period 1972 through the early 1980's. Catches declined more-or-less consistently throughout the 1980's with catches remaining low thereafter. An analysis of species dominance in the Standard trawl catches indicates that there is a growing tendency for relatively more individuals to be concentrated in fewer species.

Results of the sampling with the Wilcox trawl suggest trends in aggregated resource abundance different from those observed with the Standard trawl. The Wilcox trawl has been included as part of the MRI sampling program during the last three years (1996-98) in order to obtain data using a gear with the same size cod end mesh as that used by RIDFW in their sampling of Narragansett Bay and the lower portions of Mount Hope Bay. In his 1996 report Gibson

compared the RIDFW trawl catches for the period 1979 through 1995 to the MRI standard trawl data for the same period and concluded that, while aggregate resource abundance in Narragansett Bay has remained relatively stable, Mount Hope Bay demonstrated no such stability.

The data collected with the Wilcox trawl as part of the MRI program show higher numbers caught per tow than in the Standard trawl because the finer mesh retains more of the smaller, more abundant pelagic species like bay anchovy. In addition, the Wilcox results show a small increasing trend during 1996-98 while the standard trawl catches are declining during the same period. While neither of these trends is statistically significant, they suggest that Gibson's conclusions regarding relative stability of the aggregated resource abundance in Narragansett and Mount Hope Bays may have been biased by the fact that he was comparing trends from gears with different size cod end meshes.

Beach Seine

Near-shore finfish populations in Mount Hope Bay were sampled once per month from March through October at four locations, i.e., Intake, Lee River, Cole River, and Spar Island. Collections were made during the day with two bag seines – one measuring 60 ft × 6 ft with 1/8-inch mesh, the other 300 ft × 8 ft with ½-inch mesh. One haul was made with each net at each station.

During 1998, 19 species were collected with the smaller seine and 18 with the larger seine. Atlantic silversides were the most numerically abundant species, accounting for 82% of all fish taken with both nets. They were taken in all months but were particularly abundant in August when the young-of-year are first recruited to the smaller seine. Striped killifish and mummichog were the next most abundant with greatest numbers being collected in August. Bluefish were most present during June, August and September, with the greatest numbers occurring in September.

Atlantic silversides have been the dominant member of the near-shore community since 1972, when the study began. The March-October large seine data set indicates an upward trend in their numbers over time. Analysis of dominance diversity, however, suggests that that this increase has not been at the expense of other near-shore community species.

Young-of-the-Year Winter Flounder Survey

Since 1992, a beach seine study as been conducted to assess winter flounder year class strength in the near-shore environment. Originally, ten locations were sampled. By 1998, several more stations were added, bringing the total stations to 20-21. Each location is sampled in duplicate or triplicate with a 50 ft × 6 ft net with 1/4-inch mesh.

As with other surveys, the winter flounder catch-per-unit-effort for 1998 was one of the lowest on record. The stratified mean number per haul for the month of June was 1.3 / haul. Only catches during 1993 were lower, 0.4 / haul. Highest average catch in June 1998 was in the Kickamuit River (1.8/haul) followed by the Taunton (1.3/haul), Cole (0.8/haul), and Lee (0.1/haul). Overall, the young-of-year survey catch-per-unit-effort results were highly correlated to the results ichthyoplankton ($r = 0.909$, $P = 0.005$) and trawl ($r = 0.938$, $P = 0.002$) results.

Catches in late June were higher than in early June indicating young-flounder were still moving into the shallows, at least through late June. The daily 1998 growth rate was the highest observed to date, averaging 0.77 mm/day during June. An estimate of the mortality rate for 1998 could not be obtained because, for the first time in the survey, catch rates did not decline until the last sampling date (August).

Entrainment

Ichthyoplankton entrainment collections were conducted concurrently with Mount Hope Bay ichthyoplankton sampling, i.e., once in February and every four to five days thereafter until mid-May. Triplicate samples were obtained by streaming 333-µm mesh, 60-cm diameter plankton nets in the Units 1, 2, and 3 discharge stream. Sampling of the Unit 4 discharge was not conducted in 1998 because, during the larval flounder season, Unit 4 operated in "piggyback" mode.

Concentrations of winter flounder in the Brayton Point discharge closely followed concentrations in Mount Hope Bay, $r^2 = 0.661$, $P \leq 0.0001$. Larvae were present in the discharge stream when sampling first began on February 17, reached a peak geometric mean density of 52 larvae per 100 m^3 on April 8 and 13, and declined to 3 / 100 m^3 by May 18 when sampling ended. The mean March-April 1998 Station flow was 710 MGD. The estimated total number of winter flounder larvae entrained by Units 1, 2, and 3, therefore, was approximately 49 million. The number of entrained winter flounder during 1998 was the lowest yet observed and is consistent with the record low Bay-wide abundance.

Based on life-stage specific survival rates and the number of entrained winter flounder by life stage, the entrainment loss expressed as equivalent age 3 adult flounder is 23,419 (or 14,051 lbs.). Using the general, unstaged survival rates, the estimated loss of equivalent age 3 flounder is 3,024 (1,815 lbs.).

Comparison of discharge concentrations with concentrations of winter flounder in the intake indicated that intake concentrations, especially bottom samples, were significantly different than the discharge. Correcting for this difference, the revised equivalent adult loss estimates are 18,148 for the staged approach and 4,608 for the unstaged approach.

Revolving Screens

Finfish impinged on the revolving screens at Units 1, 2 and 3 were monitored at least three times per week by diverting screenwash water into a collection tank. All fish collected were identified, counted, and measured. In 1998 Unit 1 was out of service for two weeks starting in March, and its circulating pumps and screens were not in service during that time. Unit 2 screenwash system was operational throughout the year. Unit 3 was out of service the last week of March and for three weeks during December.

A total of 46 species were observed in 1998. Numerically, the most abundant species were winter flounder (14.0%), alewife (10.0%), hogchoker (8.0%), Atlantic menhaden (7.2%), silver hake (7.0%), tautog (6.3%), Atlantic silverside (5.1%), Atlantic tomcod (4.6%), butterfish (4.5%), blueback herring (3.8%), threespine stickleback (3.5%), smallmouth flounder (3.4%), and oyster toadfish (3.0%). The annual impingement rate for Units 1,2,3 averaged 0.62 fish per

hour. The estimated number of total number of impinged fish during 1998 was 5,722, the lowest number since the study began in 1972. The average total impingement for the period 1972-1997 is nearly an order of magnitude larger, 53,174. During 1998 a total of 801 winter flounder were impinged compared to the 1972-1997 average of 6,658.

The dominance diversity index based on the 16 most numerically abundant species, despite an improvement in 1998, indicated a significant downward trend. This indicates that the concentration of individuals in fewer species that was observed in the trawl studies is also reflected in the impingement data. This trend, however, is not apparent when all species are used in the analysis.

Heavy Metals

Heavy metal concentrations may be increased in aquatic habitats through a variety of anthropogenic activities. Because the burning of fossil fuels is one of these activities, concentrations of aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, vanadium, and zinc have been monitored since 1979. Station A′, under the Brayton Point Station's discharge plume, was selected to be indicative of the power plant effect while Station F, Spar Island, was meant to be a control station. In 1987 several stations were added within the Taunton River in recognition of its long history of industrial and municipal discharges, particularly wastewater treatment effluent.

In 1998, heavy metal concentrations in quahogs were analyzed from Stations A′, F, and M (Taunton River near Montaup). Samples were taken in April, July and November. Approximately equal sized quahogs were collected from the field, placed on ice and returned to the laboratory for preparation. Prepared specimens were then sent to a state certified analytical laboratory for analysis using atomic absorption spectrophotometry.

Based on the 1979-1998 data set, metal concentrations were similar at Station A′ and Station F for most metals except of iron and mercury, which occurred at greater concentration at Station F. Results using the shorter 1988-19998 data set, with Station M, yields much the same picture. Most metal concentrations were not significantly different among the three stations. The only exceptions were that copper and iron concentrations were highest at Montaup Station M and vanadium was significantly greater at A′. Trend analysis indicated that arsenic was the only element showing a statistically significant increase over time. The results give no indication that Brayton Point Station is a major source for heavy metals.

Temperature, Flow and Heat Load

During 1998, discharge temperature, delta temperature, heat load and discharge 001 and circulating water flow limits as outlined in the NPDES permit and MOA II were not exceeded.

Barrier Net

Since August of 1975, Brayton Point Station has maintained a net located at the terminal end of the discharge canal to serve as a barrier to fish attempting to enter the discharge canal. The net is similar to a commercial trawl net with a stretched mesh size of approximately 2½ inches. The last time the net was replaced was on June 25, 1997.

The barrier net is inspected and maintained on a routine basis by a diving contractor. Any dead fish observed in the net are counted, identified and length measurements estimated. In addition, the quantity of fish sighted upstream and downstream of the net are estimated by their size and species type. These observations are reported to the EPA and MA DEP in a quarterly report.

Unusual Fish impingement and Fish Kills

Although the NPDES permit requires impingement monitoring 3 times per week, since March 1997, finfish impinged on the Units 1, 2 and 3 intake screens were identified, counted and measured almost daily by Marine Research Inc. In 1998, there were no unusual impingement events.

Biocide Applications

Sodium hypochlorite and halogenated hydantoin compounds have been used as biocides to control micro-biofouling in the circulating water cooling system condensers of Unit No. 1, 2 and 3. Since, 1991, no biocide was applied to the Unit No. 4 circulating water system.
From 1996 though early 1998, Unit 1, 2 and 3's condensers were treated with a halogenated hydantoin compound via the targeted biocide system. In July 1998, the biocide was switched to sodium hypochlorite after a test trial in October 1997.

During 1998, biocide residuals were monitored as described in the discharge permit with one exceedance of the condenser outlet TRO limit. Refer to section VII of this report for additional information.

In 1998, station service water systems were treated on five occasions (June, July, August, October, and December) with Betz Clam-Trol CT-1 to control fouling and blockage by blue mussels and barnacles.

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III. ANNUAL REPORT

Marine Research, Inc.

Falmouth, Massachusetts

US Gen New England, Inc.

Brayton Point Station

Annual Report

January - December 1998

June 4, 1999

Revised August 31, 1999

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A2 Fish egg and larval population densities per 100 m³ of water for each species collected in Mount Hope Bay, February-May 1998.

A3 Larval winter flounder population densities per 100 cubic meters of water recorded at Brayton Point Units 1,2,3 Intake Station I in upper and lower halves of the water column, February to mid-May, 1998.

A4 Larval winter flounder population densities per 100 cubic meters of water recorded at Montaup Station M, February to mid-May 1998.

A5 Fish egg and larval population densities per 100 m³ of water for each species entrained at Brayton Point, February-May 1998.

Introduction

This report presents results of the Mount Hope Bay monitoring program related to the operation of Brayton Point Power Station carried out by Marine Research, Inc. during 1998 for U.S. Gen New England, Inc.

Investigations include hydrographic measurements, sampling and analysis of larval winter flounder, sampling of finfish with two otter trawls and two beach seines at fixed and random locations in Mount Hope Bay as well as from the revolving screens at Brayton Point. Reinstated in 1992, entrainment sampling was conducted during the 1998 larval winter flounder season in the Units 1,2,3 discharge stream.

Additional ichthyoplankton sampling was also completed in the Brayton Point intake embayment and near Montaup Power Station on the Taunton River.

A beach seine survey of young-of-the-year flounder was completed during June, July, and August, the seventh year for these collections.

As part of a long-term monitoring program, quahogs were collected on three occasions in spring, summer, and fall and their tissues analyzed for concentrations of thirteen heavy metals.

Hydrographic Data

Introduction

Hydrographic parameters consisting of water temperature, dissolved oxygen, pH, and salinity have been monitored in Mount Hope Bay since 1972. Data collected during 1998 are presented below with a focus on water temperature and dissolved oxygen particularly as they compare with the available time series.

Summary

During 1998, hydrographic measurements - temperature, dissolved oxygen, salinity and pH - were taken according to the sampling schedule established by the Station's NPDES permit dated June 16, 1993: monthly in January, February, October, November, and December, and approximately every four to five days from March through September.

Providence air temperature data averaged on a monthly basis indicated that in general 1998 was a mild year with only June and November departing from the 1961-1990 mean in a negative direction. January, February, and December were particularly mild. A review of surface and bottom water temperatures for the months of March through August was completed for Station C in the upper Bay and for Station 10 or F at mid-Bay over the 1972-1998 time series. Based on linear regression analyses, no significant trends were detected at the 95% probability level over the entire time series or over a subset consisting of 1985-1998. Over the 1985-1998 period no trends were apparent in lower Narragansett Bay at URI's Fox Island station. Providence air temperatures showed a significant upward trend for the month of June, 1985-1997, but the relationship was no longer apparent with the addition of 1998.

An analysis of 1972-1998 dissolved oxygen values from Stations C and F showed significant positive trends in several cases. These occurred for Station C, July, mid-depth, Station 10/F, June, mid-depth and bottom. Slopes ranged from 0.030 to 0.039. Three additional positive slopes were noted at the 90% probability level suggesting that some improvement in water quality has occurred. Bottom dissolved oxygen values below 2 ppm have occurred many years in Mount Hope Bay, generally accounting for less than 12% of all readings taken during June-August at Station C. These hypoxic excursions date back to 1972 and do not appear to have increased in frequency over the time series. During June-August 1998 bottom readings below 5 ppm were noted on 65% of the occasions at Station C, 55% of the occasions at Station I, and 25% of the occasions at Station F and I#4.

Methods

Sampling was conducted at the seven locations shown in Figure H-1 using a Hydrolab Surveyor 3 or Endeco\YSI 600XL. Measurements were made at 5-foot intervals from surface to bottom at Stations F, C, A', I, and I#4. On each occasion readings were also taken in the well-mixed Brayton Point discharge channel at an approximate depth of 2 feet at locations A and D. Each station was sampled monthly in January, February, October-December, and approximately every four to five

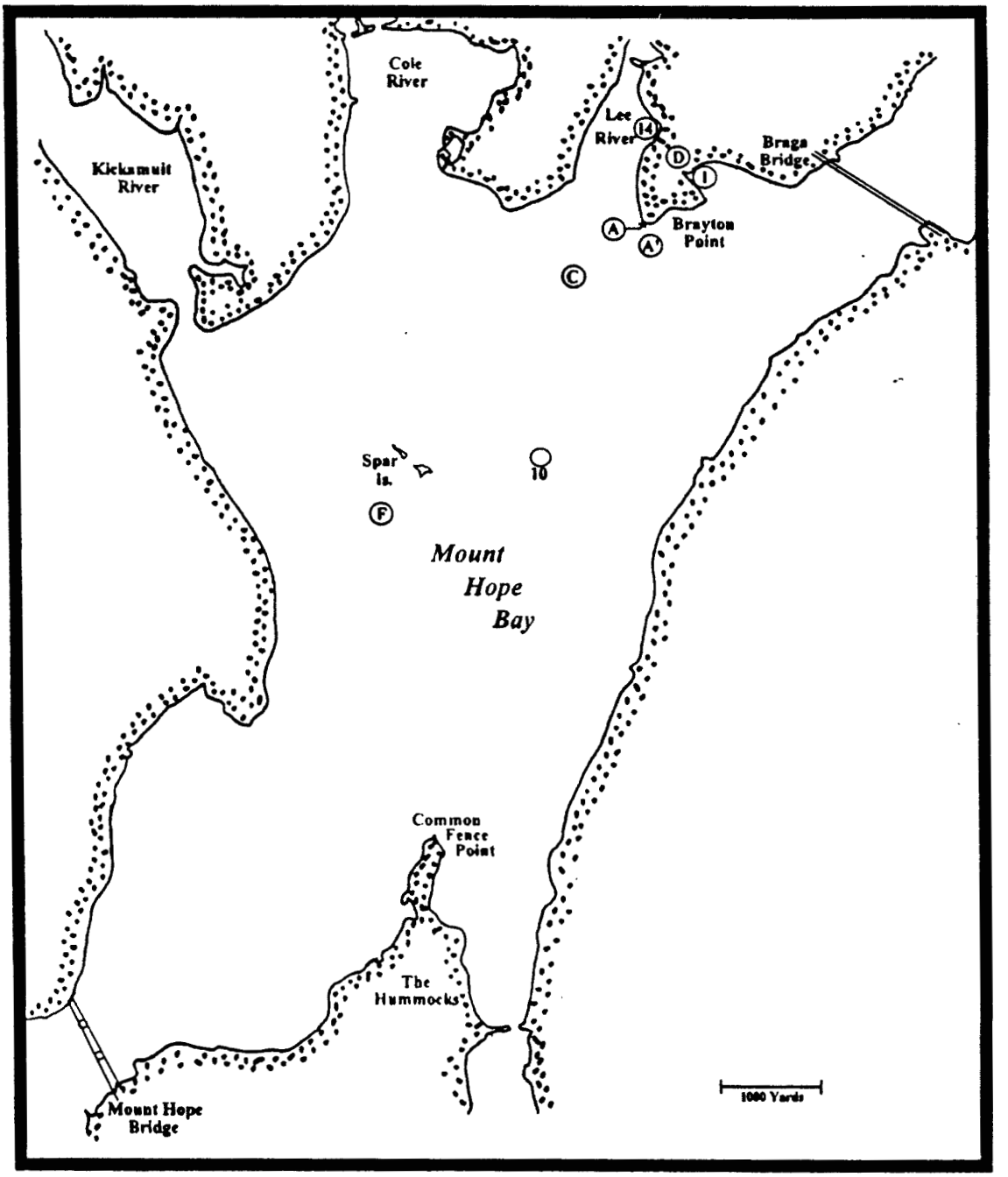

Figure H-1. Location of seven hydrographic stations and ichthyoplankton station 10.

days from March through September wind permitting. Parameters reported for each station were temperature (±0.1°C), dissolved oxygen (±0.1 ppm), pH (±0.1), and salinity (= conductivity, ±0.1 ppm).

Results and Discussion

Providence air temperature data averaged on a monthly basis indicated that 1998 was, in general, a mild year with only June and November departing from the 1961-1990 mean in the negative direction. January, February, and December were particularly mild with departures from normal of +7.2, 7.3, and 5.7 F, respectively. March was also warm with a departure from normal of +3.8 F and readings of 79 to 85 F being recorded on each of the last five days of the month. The summer began with a slightly cool June (departure = -0.9) followed by a slightly warm July (departure = + 0.8) and warm August and September (departures = +2.0 and +2.2, respectively). Similar observations were recorded in Boston for 1998 although January and February did not depart quite so far from normal as Providence (+5.3 and +5.0 F, respectively) and June was even cooler (departure = -3.0). The mild summer was reflected in the annual cooling degree-days total for Providence which was within 6% of normal (1998 = 769, mean = 728), and the warm winter in the annual heating degree-days total was 14% below normal (1998 = 4920, mean = 5718). Refer to Figures H-2 through H-9 and Table H-1.

Hydrographic data recorded in Mount Hope Bay during 1998 are located in Appendix Table A1. Mean monthly water temperatures over the entire water column for Station F, Station C, and Station I#4 over the months of March-August are presented in Table H-2 along with comparable data for the 1986-1997 time series which utilized the current sampling protocol. For 1998, average water column temperatures conformed to the air temperature data with March, April, and May values above average by 1.0 C or more. The widest departure (+1.4 C) was observed at Station F in April. The water column temperature for June was below average (range = -0.2 to -0.8 for the three stations), consistent with below-average air temperatures recorded that month. The Bay temperatures remained slightly below average in July ranging from -0.2 at Station I#4 to -0.8 C at Station C likely lagging behind the cool June. For the month of August, Mount Hope Bay was nearly average at Station F (departure = +0.4 C) and Station C (departure = +0.4 C) and just above average at Station I#4 (departure = +0.6)

Average monthly surface and bottom water temperatures plotted for the months of March through August for the complete time series of the Mount Hope Bay monitoring program appear in Figures H-10 and H-11 for Stations C and 10/F. Station C was selected as an upper Bay location and Station 10/F as a mid-Bay location. Station C was sampled throughout the time series although from 1976 to 1986 readings were only taken once or twice per month during March and April (Table H-3). Station 10, currently included in the ichthyoplankton program, was sampled more frequently during spring of the 1972-1985 period. This station was removed from the hydrological monitoring program after mid-May beginning in July 1993 (Table H-4). To complete the Station 10 time series, Station F hydrographic data were used after mid-May from 1994 through 1998. Station 10 (just west of Spar Island) and Station F (just south of Spar Island) are within 1 nm of each other and are equal in water depth and at about the same latitude within the Bay.

An historical review of surface and bottom readings at Station C using linear regression indicated that surface and bottom temperatures in July increased significantly over the 1985-1995 period. The observed slope of 0.276 for surface water and 0.262 for bottom water translated to an overall increase of 3.0 and 2.9 C, respectively (NEP et al. 1998). A similar statistically significant increase was observed at Station F during July but only for surface waters (slope = 0.205 C, 2.3 C overall). An upward trend was also detected in lower Narragansett Bay water temperatures using the University of Rhode Island Graduate School of Oceanography (URIGSO) Fox Island trawl station data set. Significant, positive slopes were found there for June surface readings and July surface and bottom readings. Increases in both areas of Narragansett Bay were consistent with overall increases in air temperatures as recorded at Green Airport in Providence (NEP et al. 1998).

The relatively cool summer of 1996 reversed the observed upward trends in water temperature in Mount Hope Bay (NEP et al. 1998, Figures H-10, H-11). With the addition of 1997 and 1998 readings, the data sets were re-examined for trends both over the full 1973-1998 time series and the 1985-1998 series subset. Linear trend analysis for the 1973-1998 period produced no significant trends at the 95% probability level. At the 90% level a slight upward trend was detected at Station C, bottom water for the month of August ($p = 0.088$, $R^2 = 11.2\%$). The trend amounted to an annual increase of 0.039 C per year or a total of 1.0 C over the 26-year time series. Focusing on the 1985-1998 temperature subset of the time series, no statistically significant trends were detected at the 95% probability level. At the 90% probability level a single significant trend was found at Station 10/F for July surface waters (Table H-5). The slope in this case was 0.108 ($p = 0.092$) corresponding to an overall increase in temperature of 1.5 C.

Temperature time series were also reexamined for the URIGSO trawl station located at Fox Island and for Providence air temperatures (see also NEP et al. 1998). The Fox Island station is located in 20 feet of water, similar to the Mount Hope Bay stations. Surface and bottom readings were recorded there weekly when each trawl tow was taken (see also Section F, trawl section of this report). Over the 1985-1998 period no trends were apparent in the Fox Island data although, as reported in NEP et al. (1998), an upward trend was detected from 1985-1995 for June surface readings, July surface and July bottom readings (Figure H-12). Providence air temperatures showed a significant upward trend in the month of June for the1985-1997 period (slope = 0.115, $p = 0.026$) translating to an overall increase of 1.5 C, but the addition of the cool June 1998 data set resulted in a slope which was no longer significantly different from zero ($p = 0.228$). Assuming a time lag occurs between changes in air and changes in water temperature, the increase in July surface water temperature noted above at Station 10/F is consistent with increases in ambient air temperature.

Dissolved oxygen concentrations in Mount Hope Bay vary considerably with season, location, and depth. Mixing action from tides and wind can also impact dissolved oxygen concentrations, particularly in shallow areas. Dissolved oxygen levels in shallow portions of the upper Bay particularly in and near the mouths of the tributary rivers are also influenced by abundant growth of macroalgae particularly *Ulva lactuca*, sea lettuce. Generally, dissolved oxygen decreases from surface to bottom as attenuation of light limits photosynthesis. During the warmer months, increase in water temperatures and the reduction in vertical mixing associated with thermal stratification can adversely impact dissolved oxygen levels particularly near the bottom where epibenthic and benthic fauna are

in their season of highest biological activity and oxygen consumption. Salinity and barometric pressure can also affect dissolved oxygen saturation, values increasing with rising pressure and reduced salinity. No pattern is observable for dissolved oxygen over the time series when comparing extremely low dissolved oxygen values to unusually high bottom temperatures. For example, at Station C the lowest bottom dissolved oxygen values in 1996 were 2.1 ppm (July 25) and 1.8 ppm (August 7) when bottom water temperatures were a relatively cool 20.4 C and 21.8 C, respectively. By contrast at this same location on August 27 that same year a bottom dissolved oxygen value of 7.3 ppm was recorded with a bottom temperature of 24.0 C, and on July 8 the bottom dissolved oxygen measured 9.9 ppm with a temperature of 23.5 C. Similar examples are quite commonly encountered at all three shallow hydrographic stations (Appendix Table A1).

Dissolved oxygen in Mount Hope Bay is actively being reviewed and studied at this time as one possible variable contributing to the decline of local fish stocks (ASA 1996). Since fish stocks declined, particularly after 1985, the dissolved oxygen time series was examined to determine if a declining trend in summer oxygen could be detected. Mid-depth and bottom readings taken by Hydrolab at Stations C and F were averaged within each month for May through August and examined by linear regression over the 1972 through 1997 time series. The number of readings taken within each month was the same as for the temperature analyses above (Table H-3). Significant positive trends ($p < 0.051$) were detected in all four cases for June (slopes = 0.032 to 0.047). For July, a significant positive trend was detected at Station C, mid-depth (slope = 0.040, $p = 0.043$) and at the lower 90% probability level at Station F, mid-depth (slope = 0.025, $p = 0.070$). No significant trends were detected with the August data at either the 95 or 90% probability level (NEP et al. 1998). Whether statistically different from zero or not, most trends were positive suggesting that overall daytime oxygen levels may have improved. However non-positive slopes were obtained with the 1972-1997 data for May at mid-depth and bottom. The probability of obtaining 14 positive slopes among 16 by chance alone is only about 0.2% (Sprent 1989).

In all cases, mean monthly dissolved oxygen values recorded during the summer of 1998 were lower then those recorded in 1997 but in only one instance was the monthly mean notably low compared to the overall 1972-1997 time series (Figure H-13). Station C's bottom mean for July (3.4 ppm) was the second lowest of the past ten years (1995 = 3.1 ppm) and the third lowest of the time series (1982 = 2.4 ppm). Re-examination of the time trends data with the addition of 1998 showed that three statistically significant trends were detected, in each case the slopes being positive (Table H-6). These occurred for Station C, July, mid-depth, Station 10/F, June, mid-depth and bottom. Slopes ranged from 0.030 to 0.039. Three additional positive slopes were noted at the 90% probability level; Station C, June, mid-depth and bottom, and Station C, August, bottom. The fact that each of these slopes was positive suggests that oxygen levels may be improving as noted above.

Mean monthly dissolved oxygen readings could readily mask occasional hypoxic events (2 ppm or less) in Mount Hope Bay which would likely have a negative effect on the health and distribution of fishes utilizing the Bay. Realizing that all Hydrolab measurements are taken during daylight hours and that low-oxygen events could occur more frequently during pre-dawn hours, the number of bottom readings falling to or below 5, 4, 3, and 2 ppm were tabulated for each year (Figures H-14 - H-17). Five ppm was selected for the first query because that level is used to help

define water quality standards in both Rhode Island and Massachusetts. Tabulations were completed for June through August at Stations C and F plus Station I and Station I#4 over the 1972-1998 time series. These data indicate that oxygen readings below 5 ppm are common in summer averaging 49%,36%, 68%, and 19% of the readings at Stations C, F, I, and I#4, respectively. The current 1998 season was, in terms of the 5 ppm level, below average at Station F and I#4 (each 25% of the readings) but above average at Stations C (65%) and I (55%). As might be expected low dissolved oxygen readings are less prevalent in the mid-Bay waters around Station F then at the other three locations although values of 4 ppm or below have occurred there every year but three (1987, 1996, and 1997) and occasionally exceed 20% of the June-August readings. At Station C, readings at or below 4 ppm have been common, accounting for 20 to 50% of the summer values in all but six years over the 27-year time series. In 1998, 40% of the readings at this station were at or below 4 ppm. Values at or below 2 ppm also occurred during the time series at Station C but in most cases these readings account for 12% or less of the total daytime readings (5% in 1998). The lowest reading at Station C in 1998 was 1.6 ppm on July 13.

Station I in the Brayton Point Unit 1,2,3 intake averages about 35 feet in depth, nearly twice the depth of the other stations. Because of that, it might be expected to stratify more readily in summer with low oxygen concentrations developing near bottom. While the proportion of readings below a given threshold are not always lower there compared with Station C (see for example 4 ppm, 1972, Figure H-14), the average proportion is clearly higher there for 4 and 5 ppm (0.388 vs 0.279 and 0.682 vs 0.479, respectively). Interestingly, the average proportion is somewhat higher at Station C compared with Station I at 2 and 3 ppm (0.059 vs 0.028 and 0.136 vs 0.122, respectively). At Station I#4 in the Unit 4 Lee River intake, where the time series began in 1984, low readings occur but are uncommon, perhaps because oxygen producing macroalgae are prevalent in the surrounding shallows and because Brayton Point Unit Four contributes to water circulation there. Inconsistent with this general statement, a reading of 0.3 ppm was recorded at Station I#4 on July 13, 1998, the lowest oxygen reading of the season over all stations. Perhaps most importantly these data show that while hypoxic events regularly occur, no increase in the number of daytime, low dissolved oxygen excursions is apparent over the time series

While the information presented above focused on the months of June-August, dissolved oxygen readings less than 5 ppm do occur in September and on rare occasions in October. For example, a bottom dissolved oxygen reading of 2.1 ppm was recorded at Station I on September 12, 1985 and a reading of 3.4 ppm was obtained at Station C on October 30, 1975. Identification of these occurrences is limited by the often reduced sampling interval during those two months, particularly October. Sampling occurred only once in September from 1986-1992 and only once in October from 1977-1997. During the current 1998 season September readings below 5.0 ppm were recorded at Station C and Station I. At Station C a single reading of 4.2 ppm was noted at the bottom on September 3 while at Station I readings below 5.0 occurred through September 21. For the month of September the lowest reading obtained at Station I was 3.4 ppm on the 3rd. All readings taken in the Bay were above 5 ppm by September 25.

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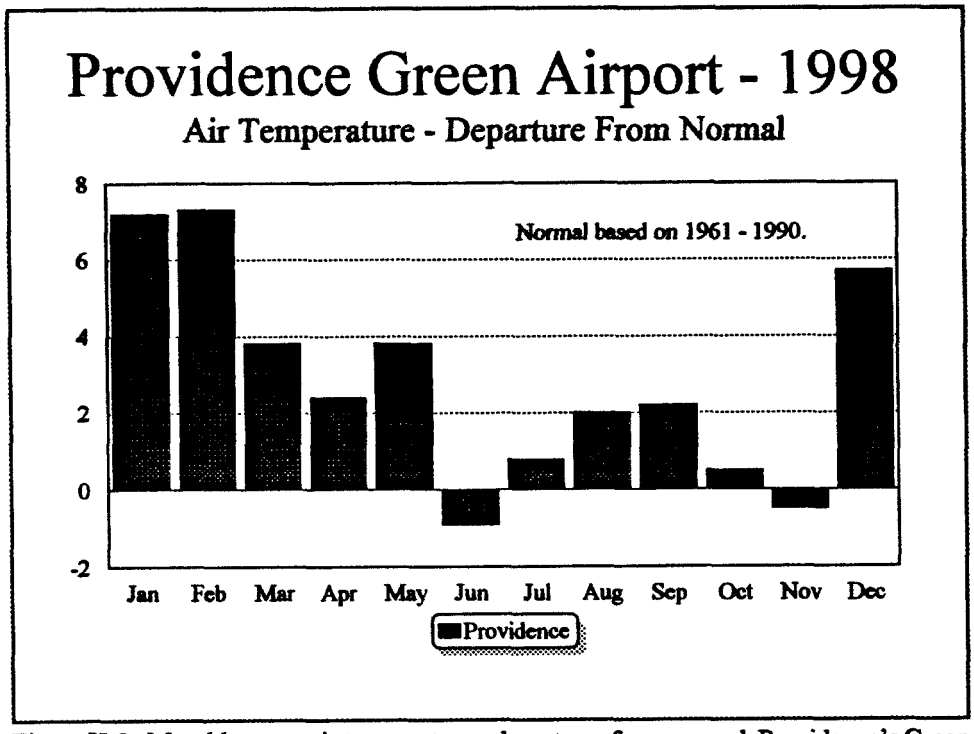


Figure H-2. Monthly mean air temperatures, departures from normal, Providence's Green Airport.

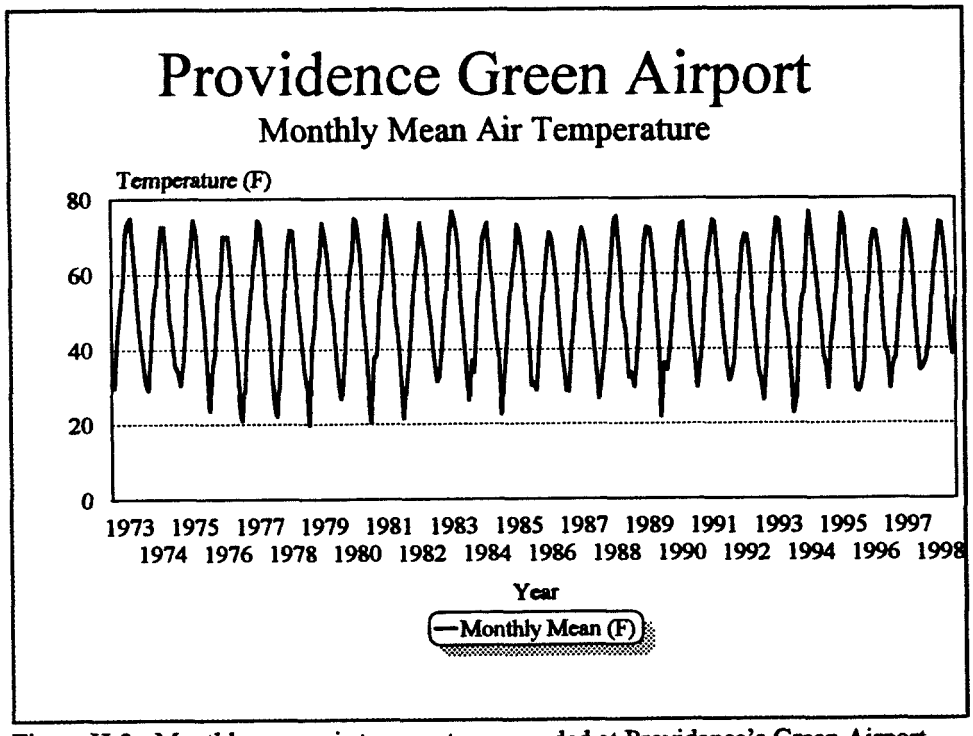


Figure H-3. Monthly mean air temperature recorded at Providence's Green Airport, 1973-1998.

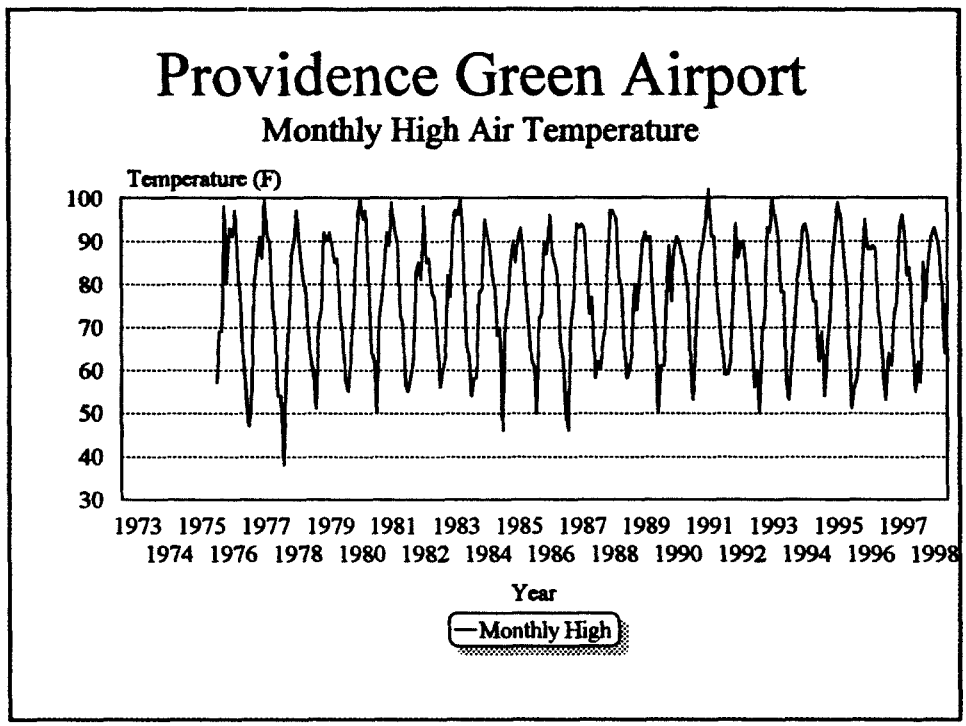


Figure H-4. Monthly high air temperatures recorded at Providence's Green Airport, 1975-1998.

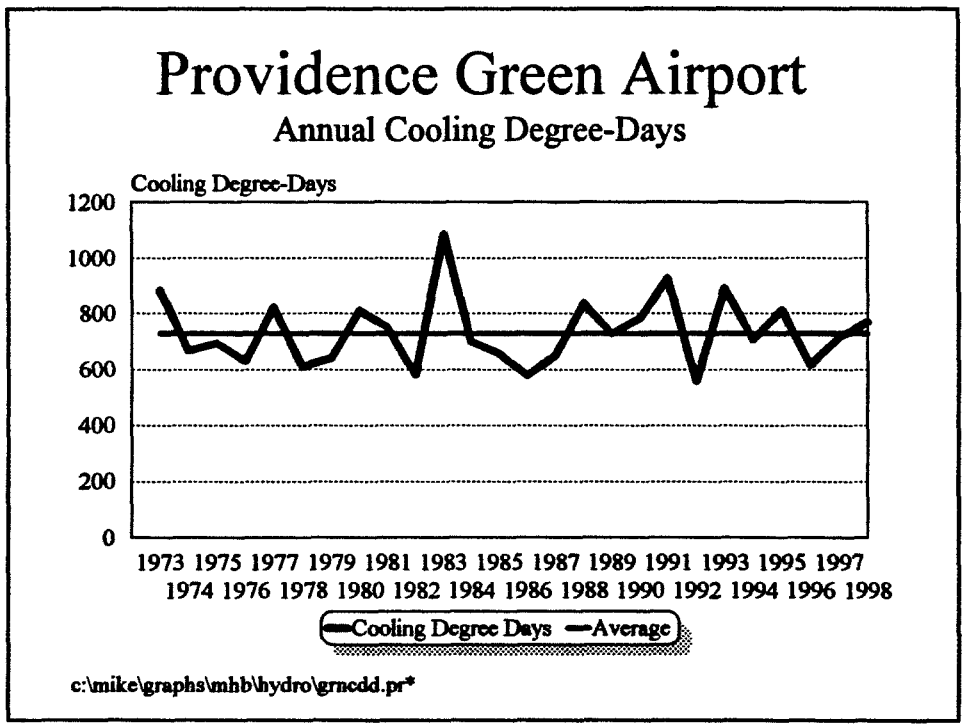


Figure H-5. Annual cooling degree-days recorded at Providence's Green Airport, 1973-1998. The time series average is also shown.

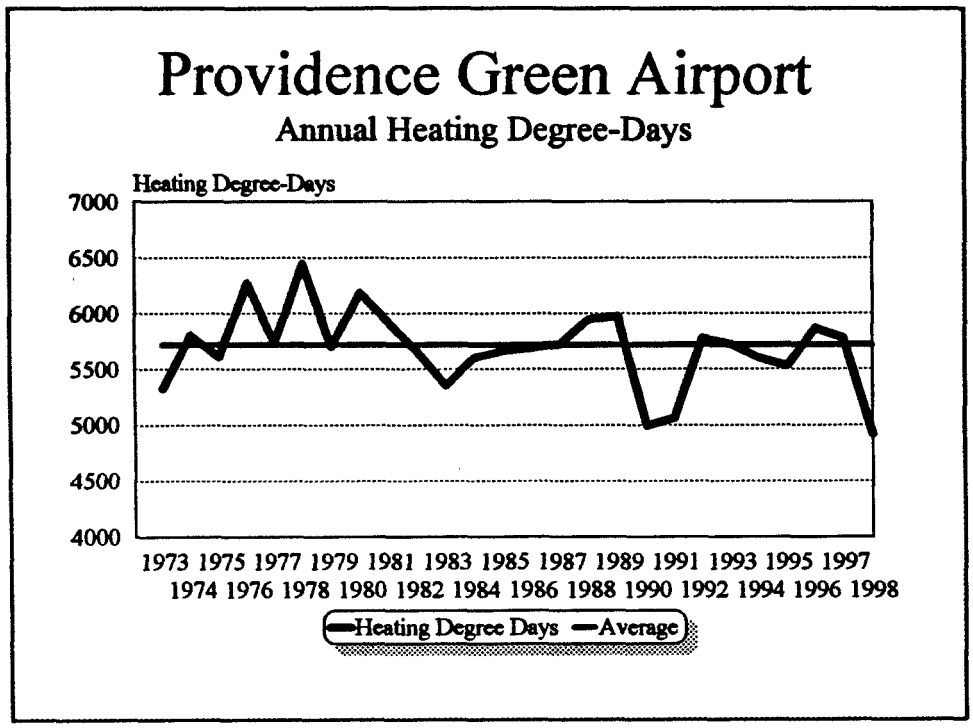


Figure H-6. Annual heating degree-days recorded at Providence's Green Airport, 1973-1998. The time series average is also shown.

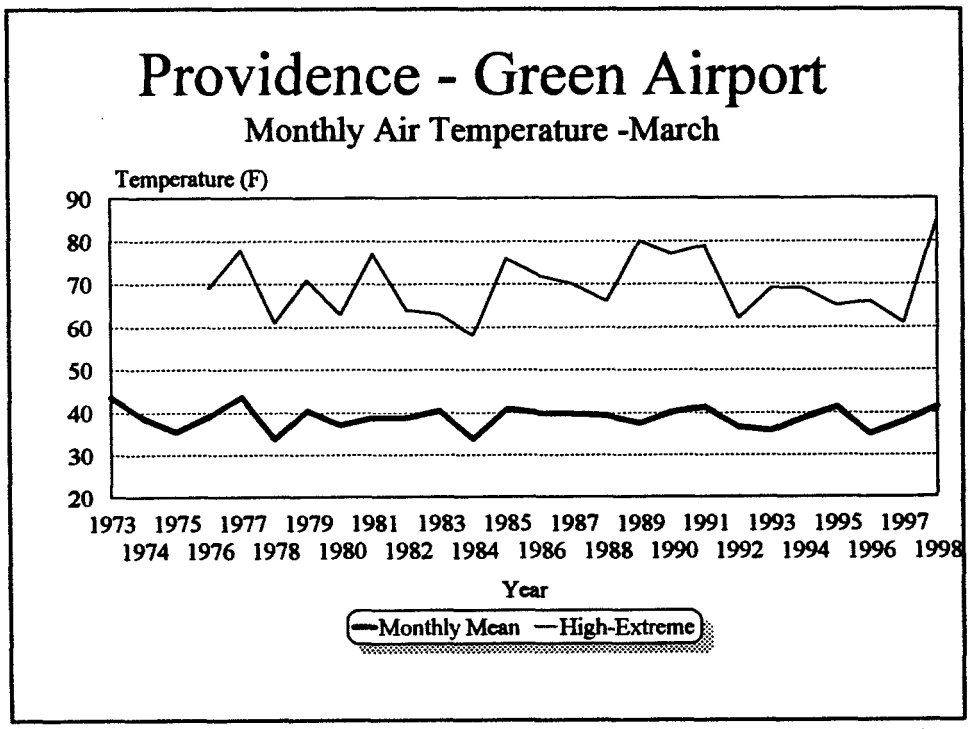
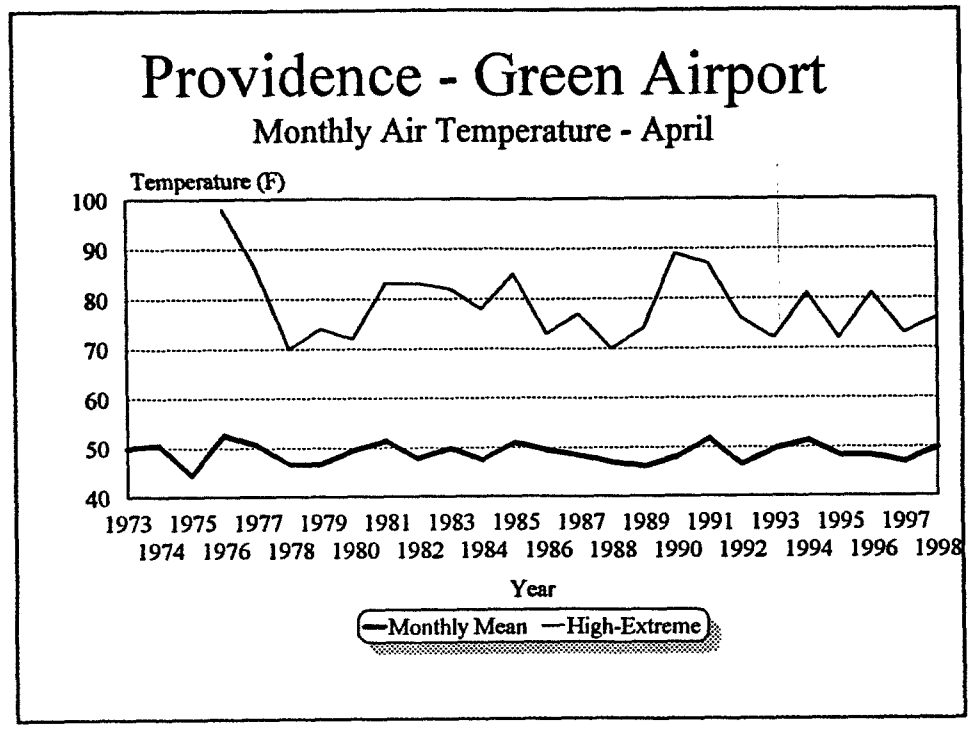
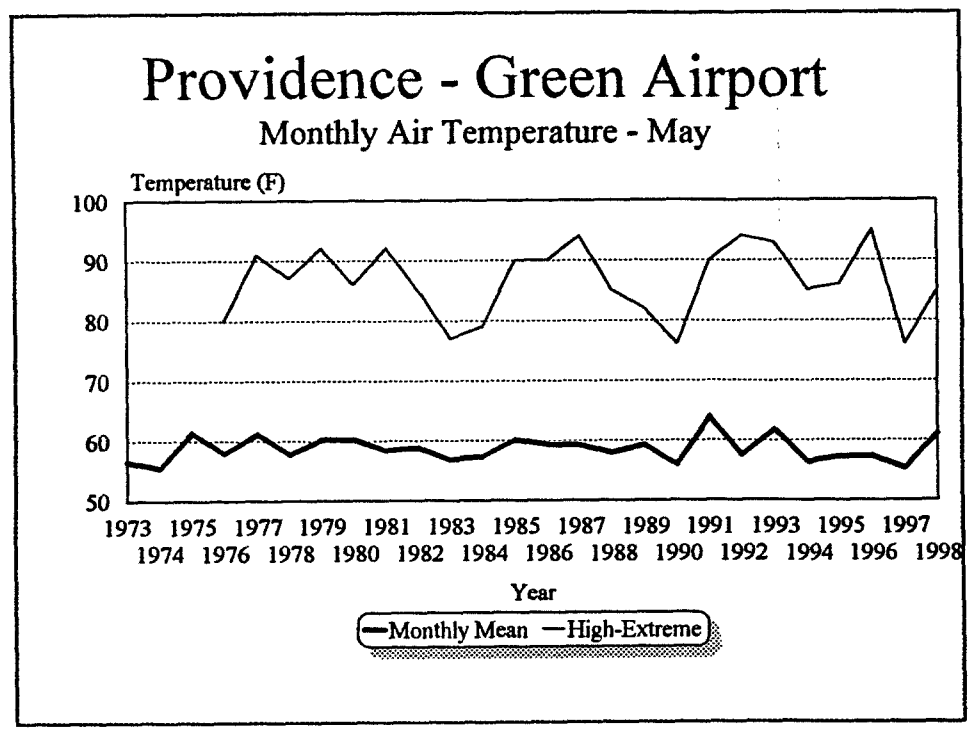


Figure H-7. Monthly mean and maximum air temperatures recorded at Providence's Green Airport, March-August, 1973-1998.





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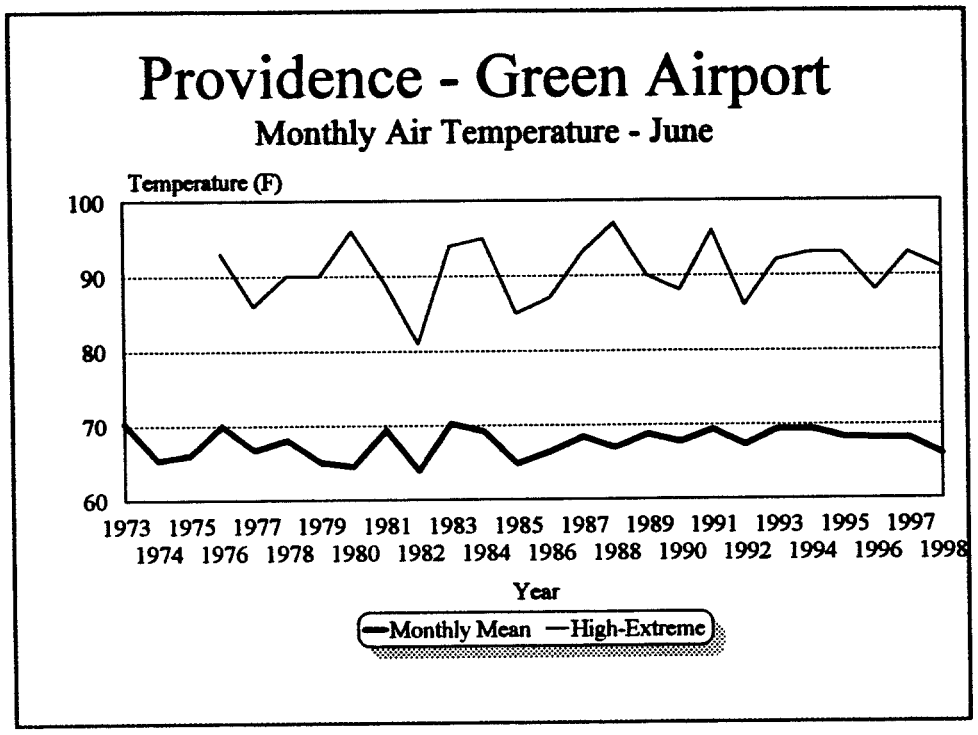

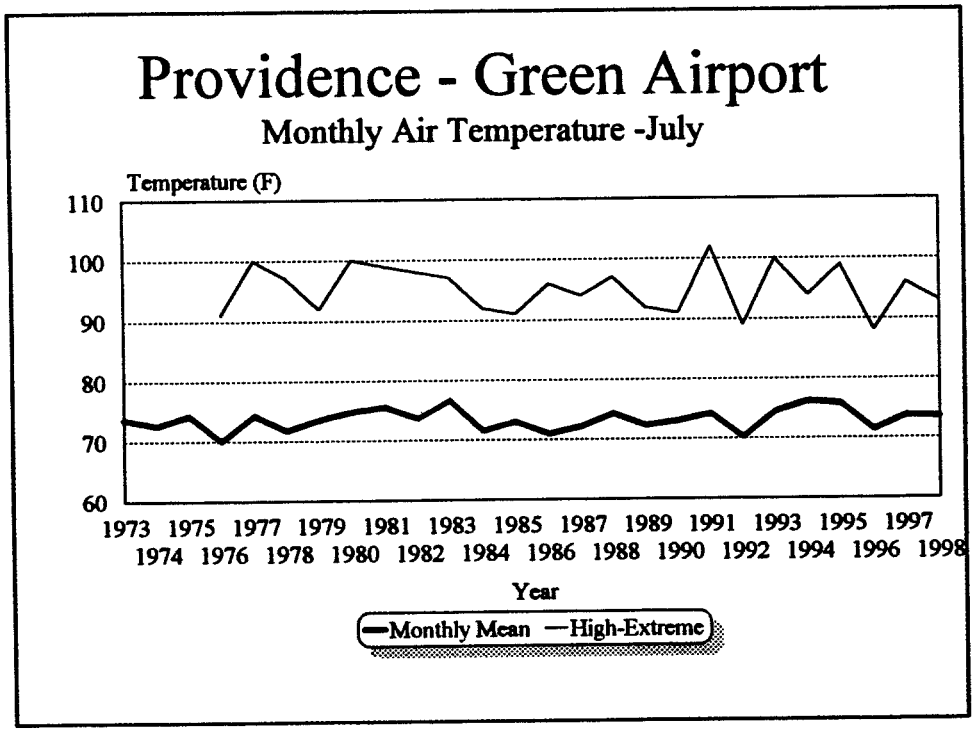

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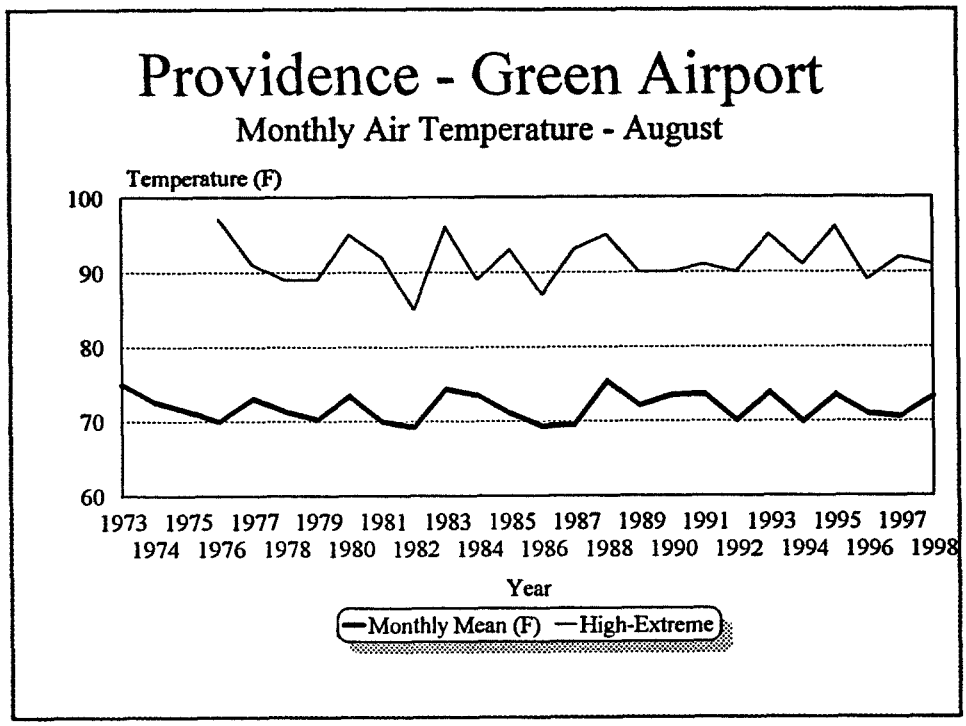

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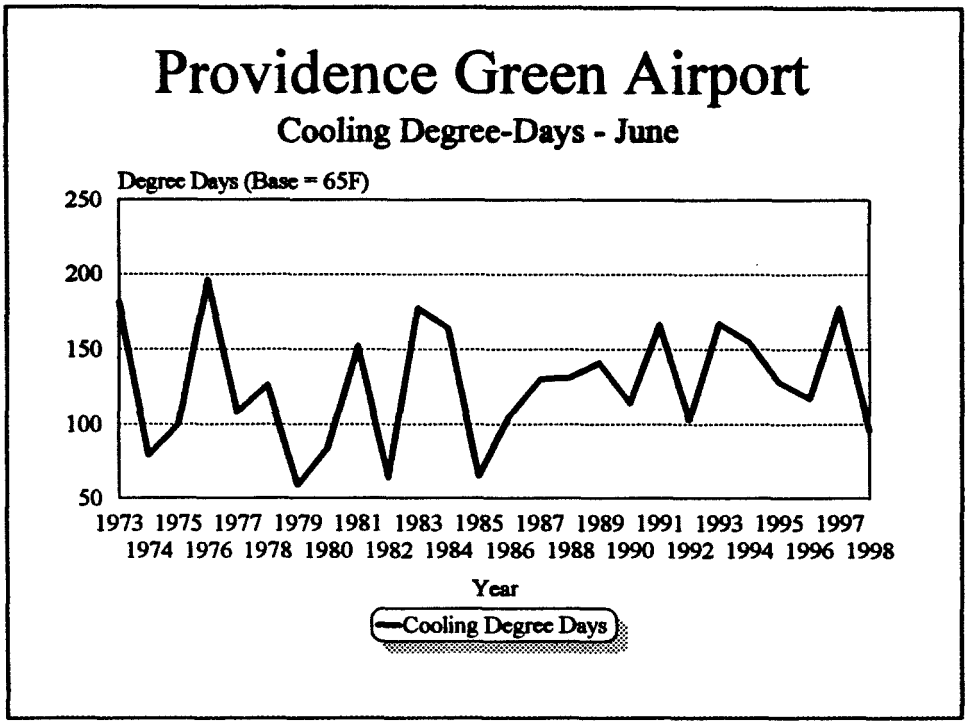


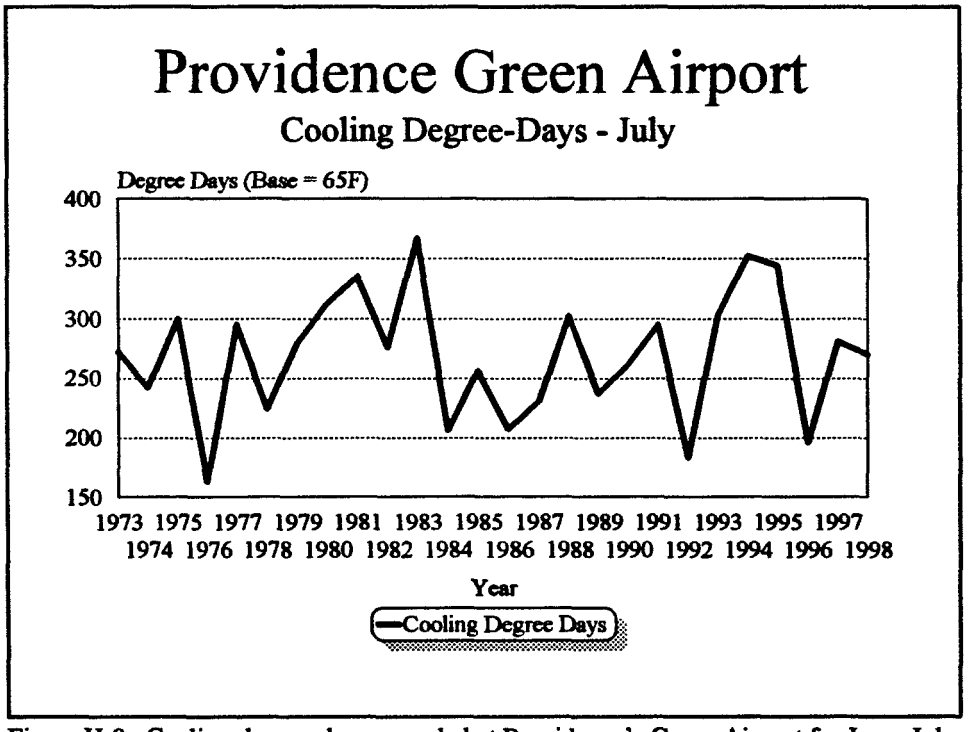
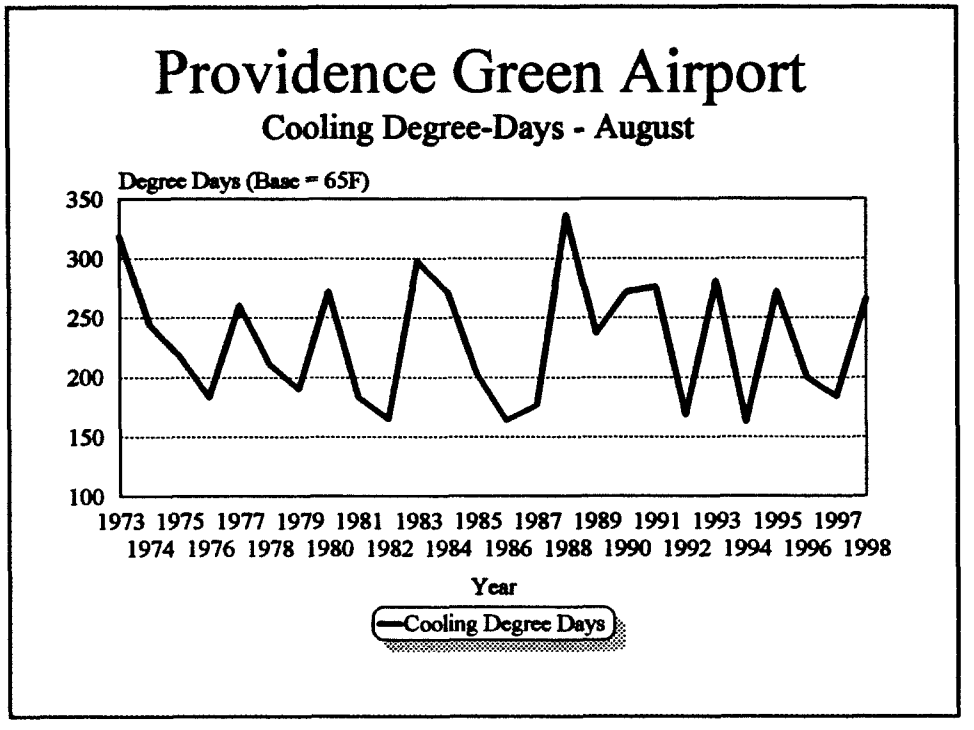
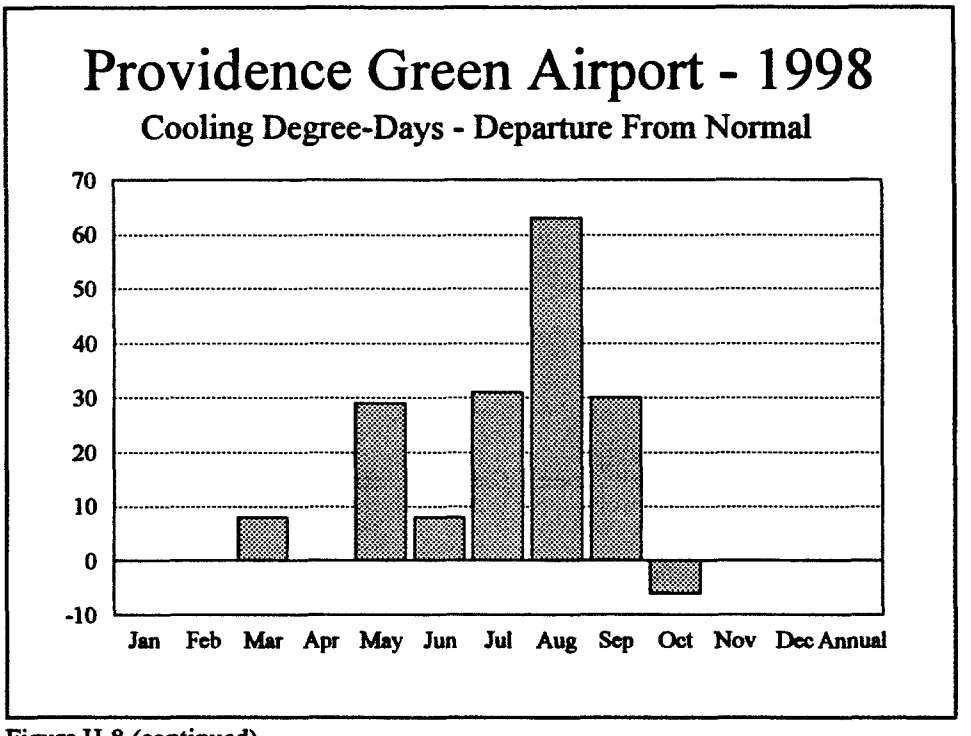


Figure H-8. Cooling degree-days recorded at Providence's Green Airport for June, July, August, 1973-1998 including monthly departures from normal for 1998.





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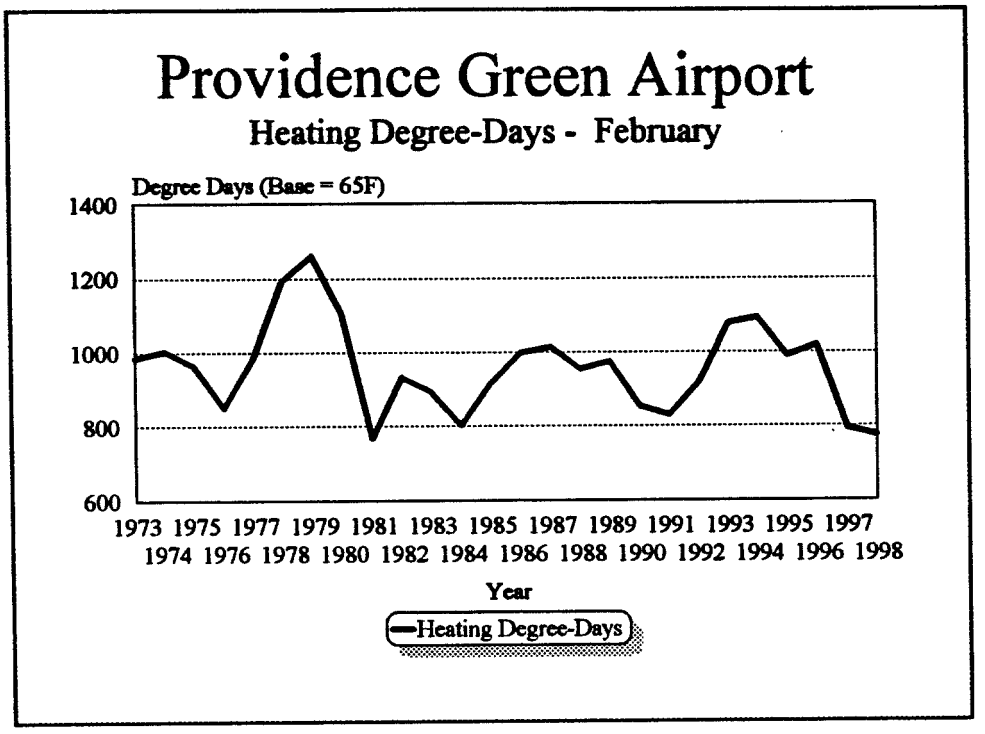


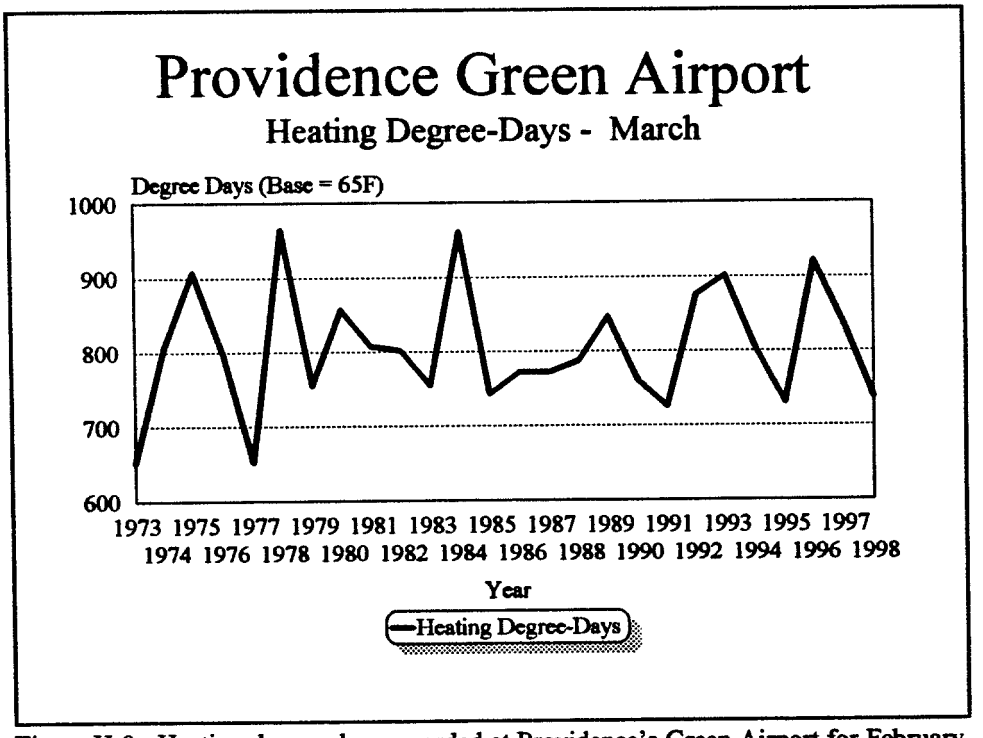
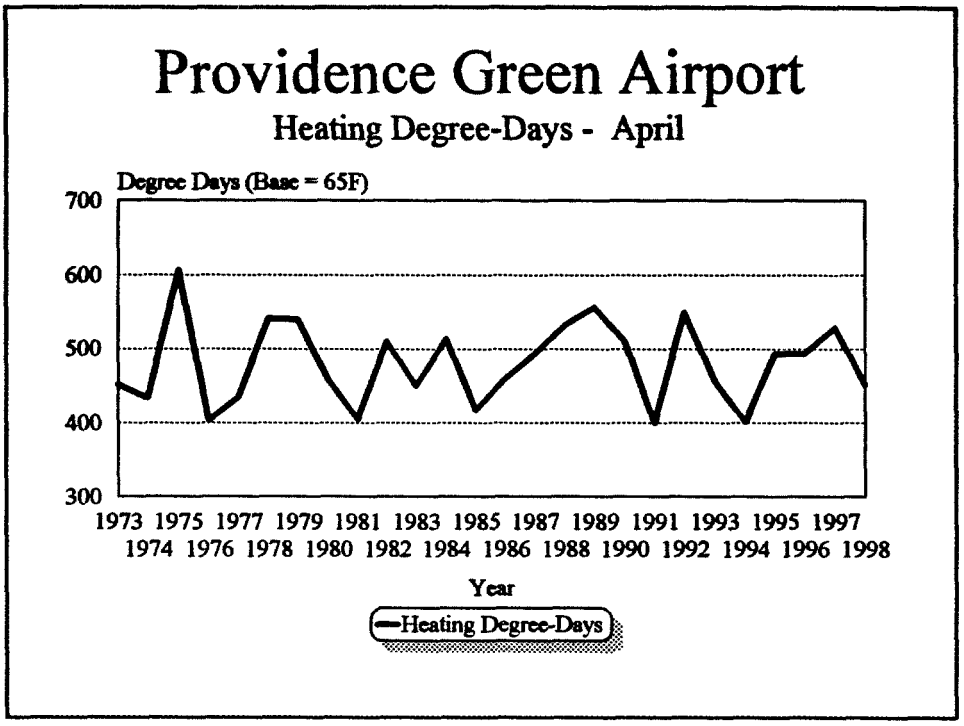
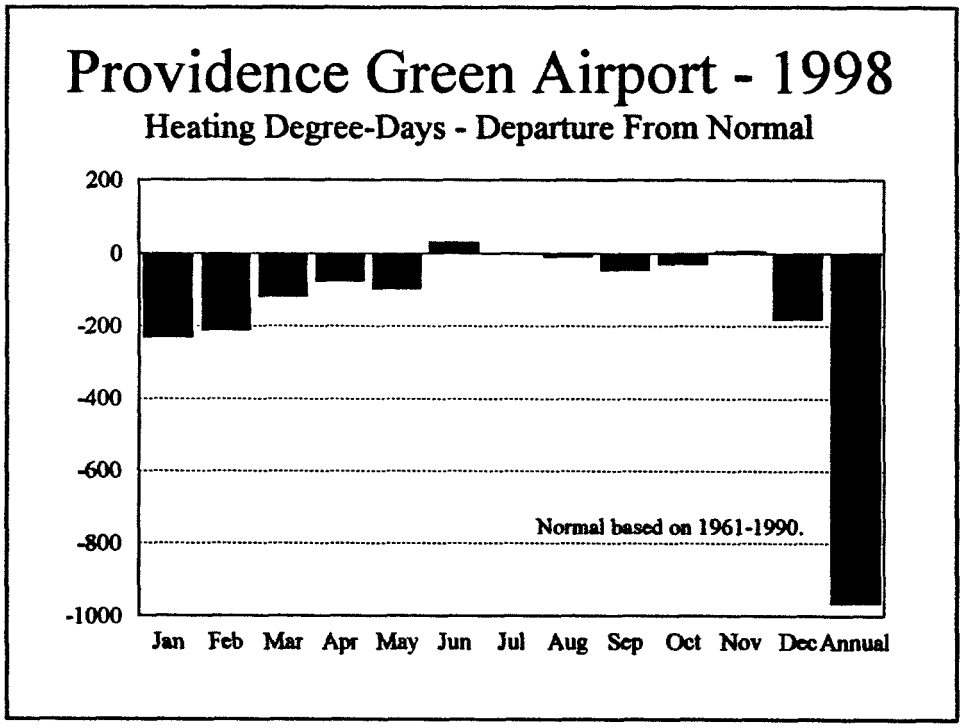


Figure H-9. Heating degree-days recorded at Providence's Green Airport for February, March, and April, 1973-1998, along with departures from normal by month For 1998.





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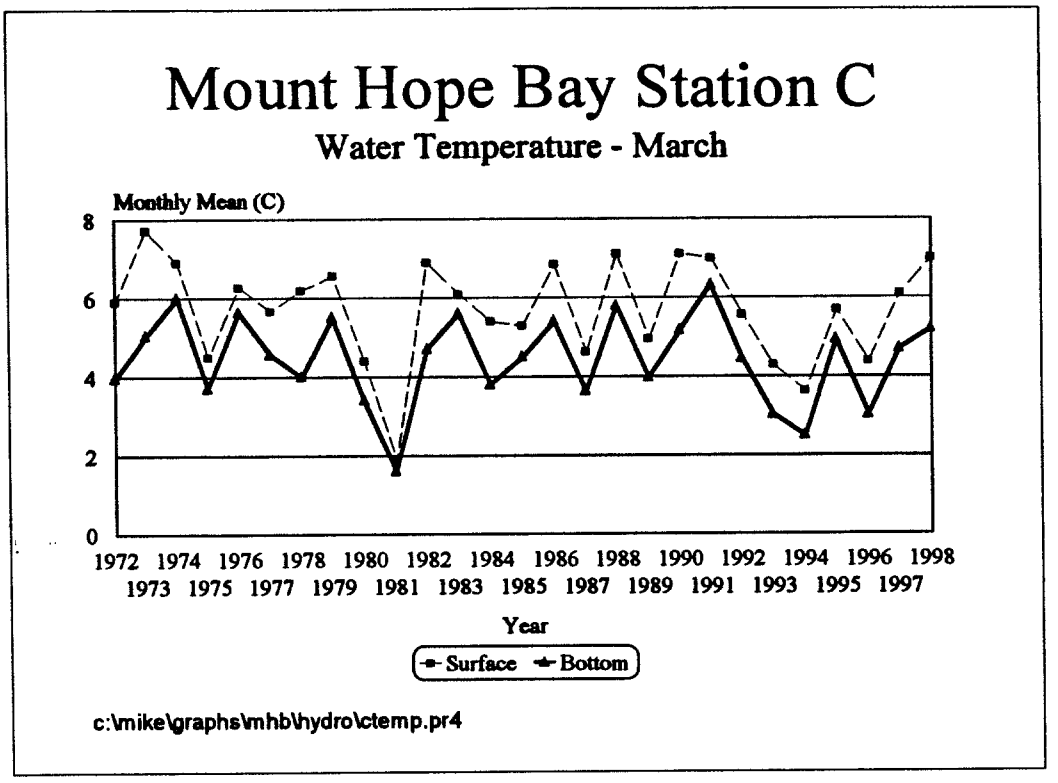


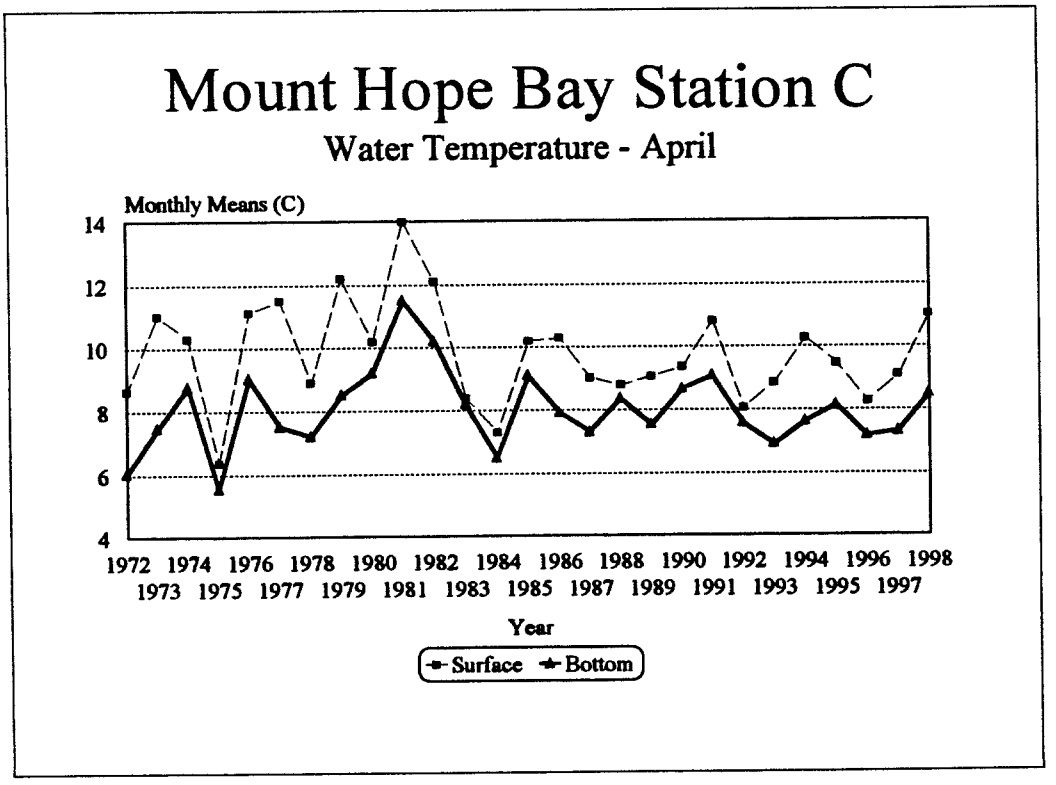
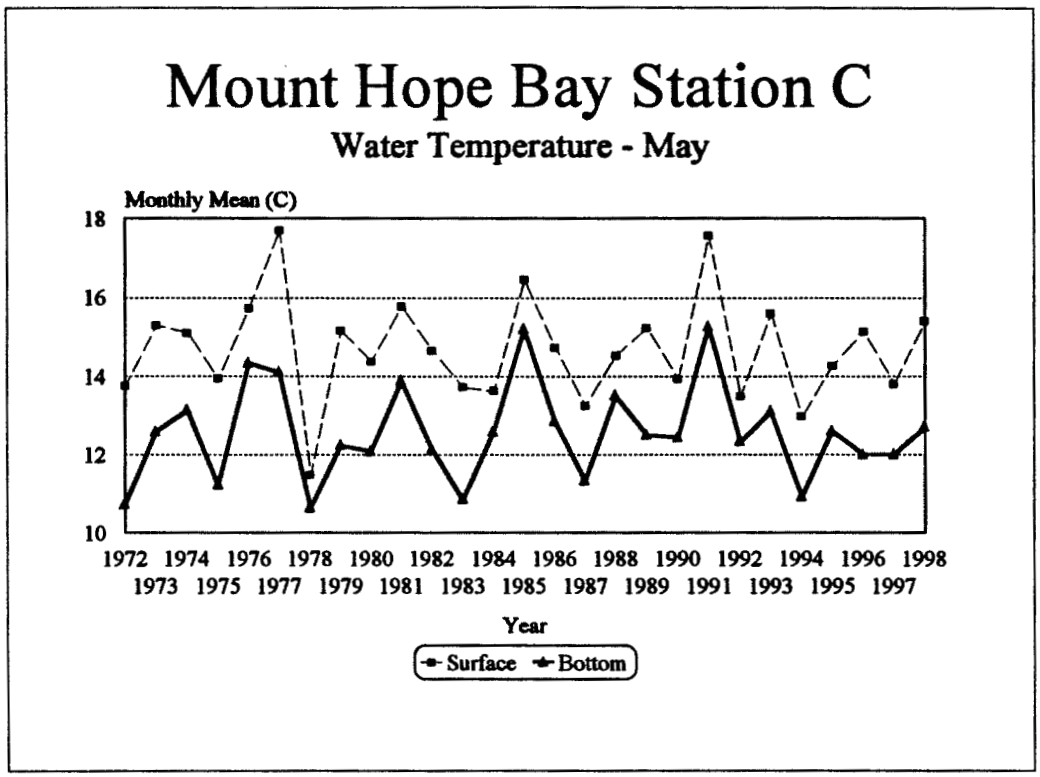
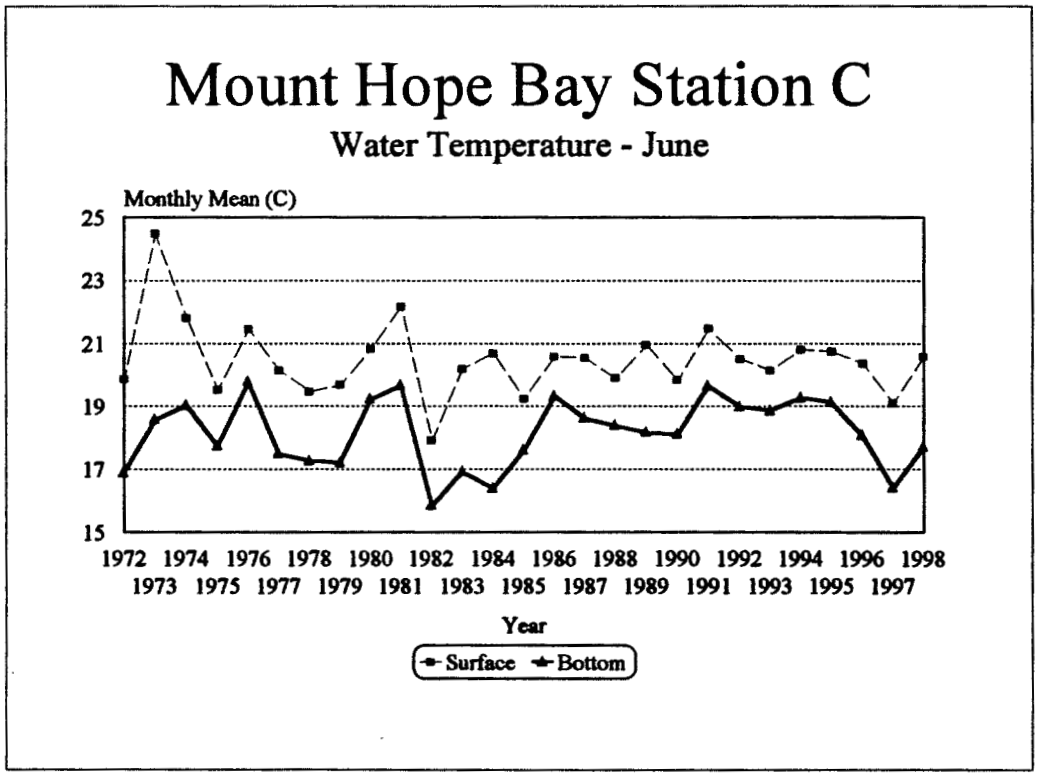


Figure H-10. Mean surface and bottom water temperatures recorded at Mount Hope Bay Station C, March - August, 1972 - 1998.





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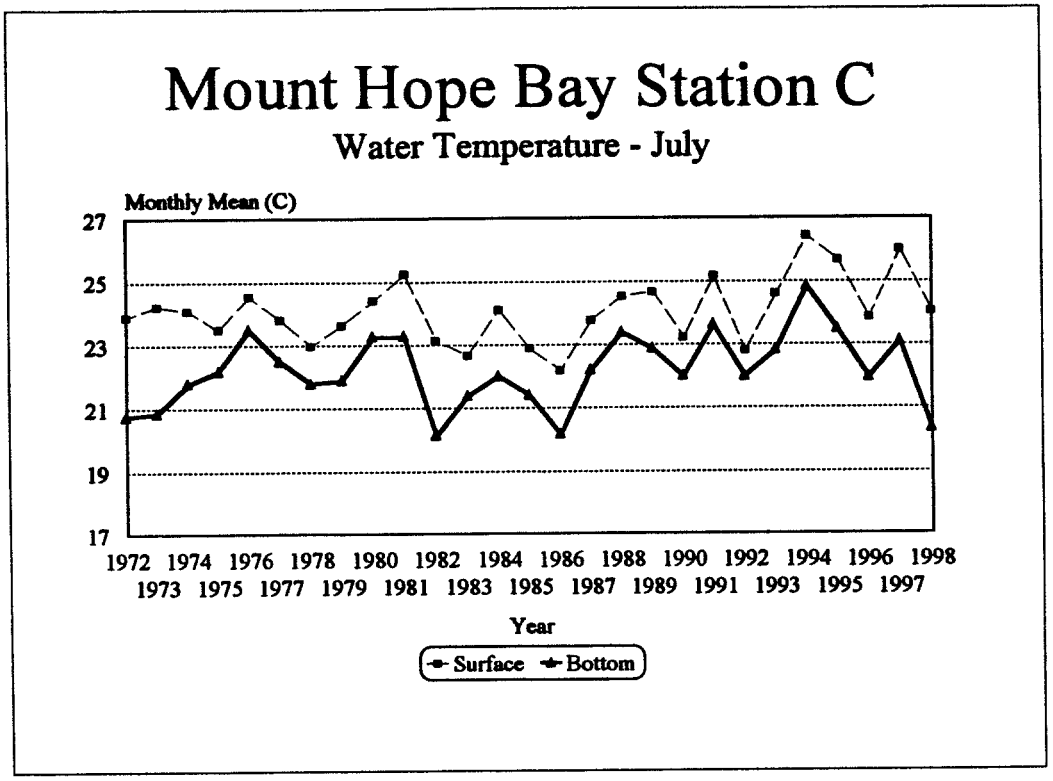

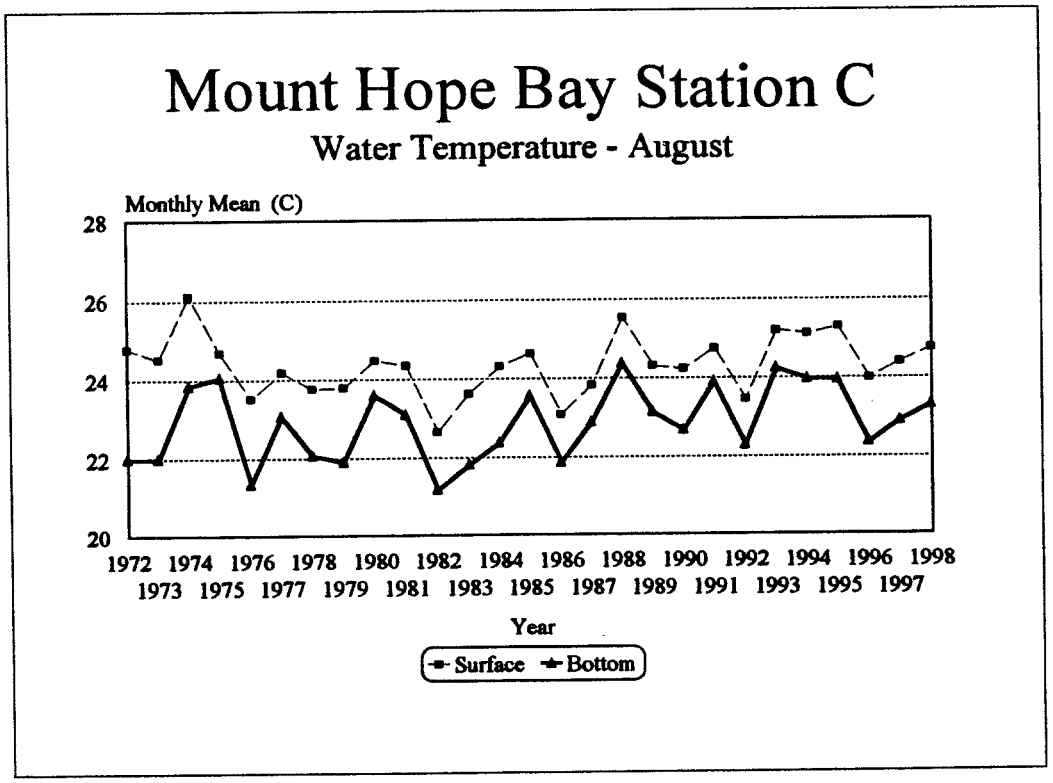

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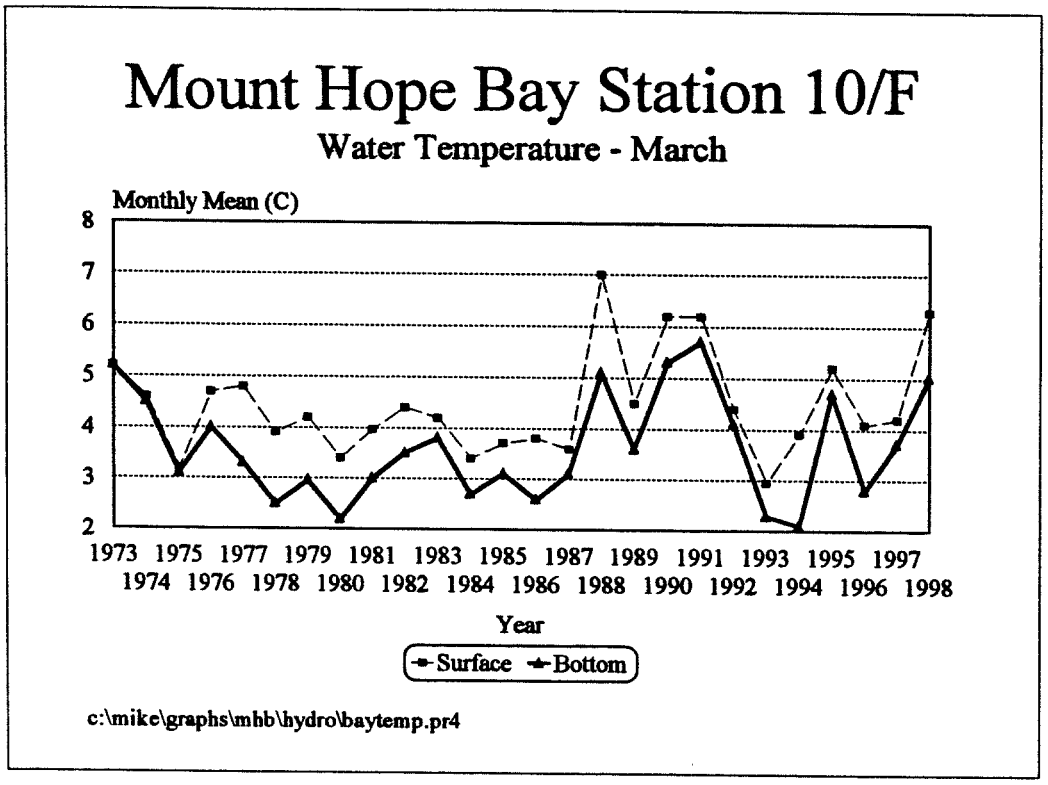


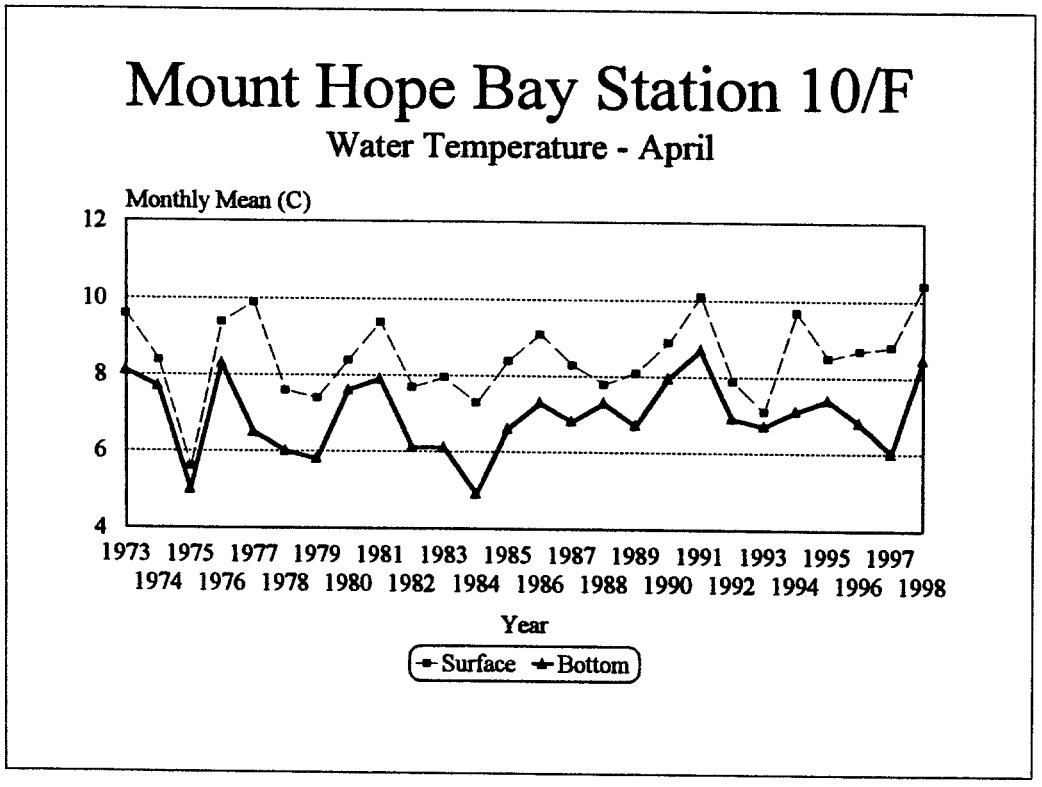
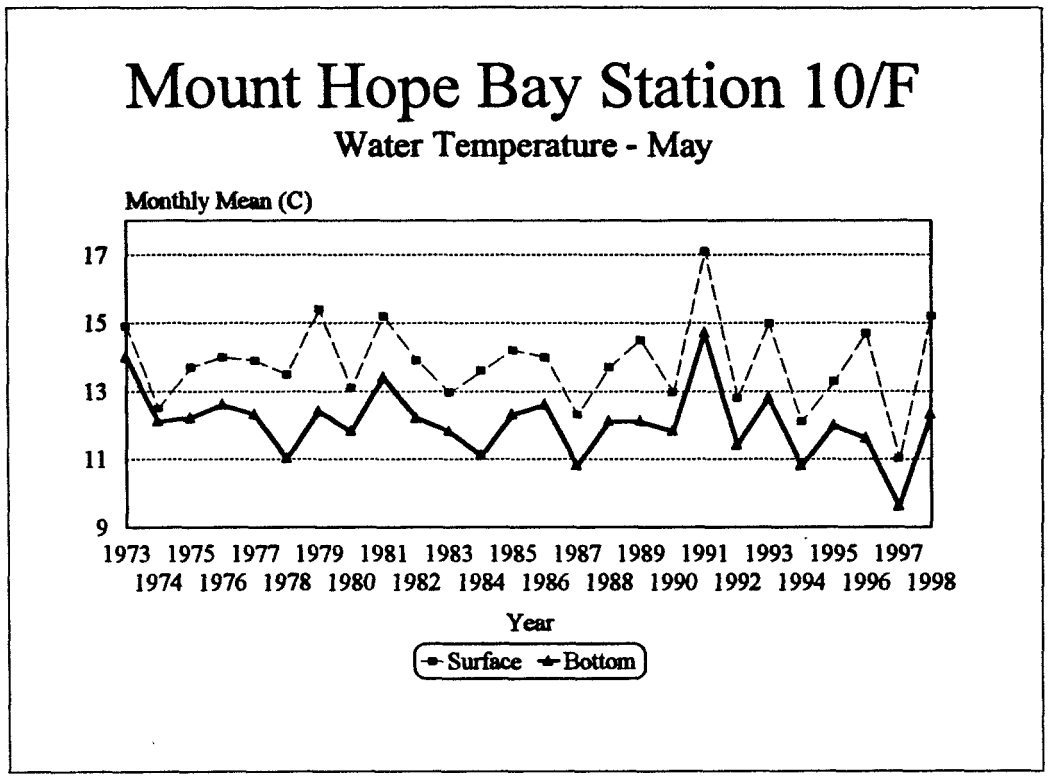
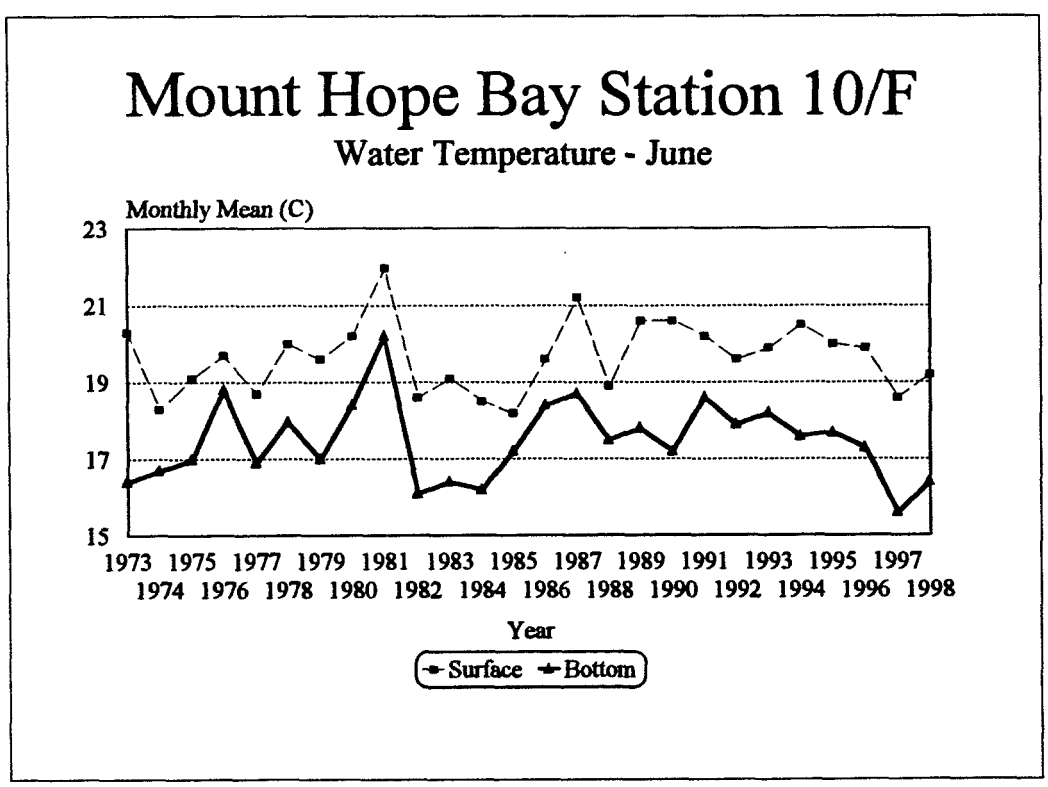


Figure H-11. Mean surface and bottom water temperatures recorded at Mount Hope Bay Station 10/F, March - August, 1972 - 1998.





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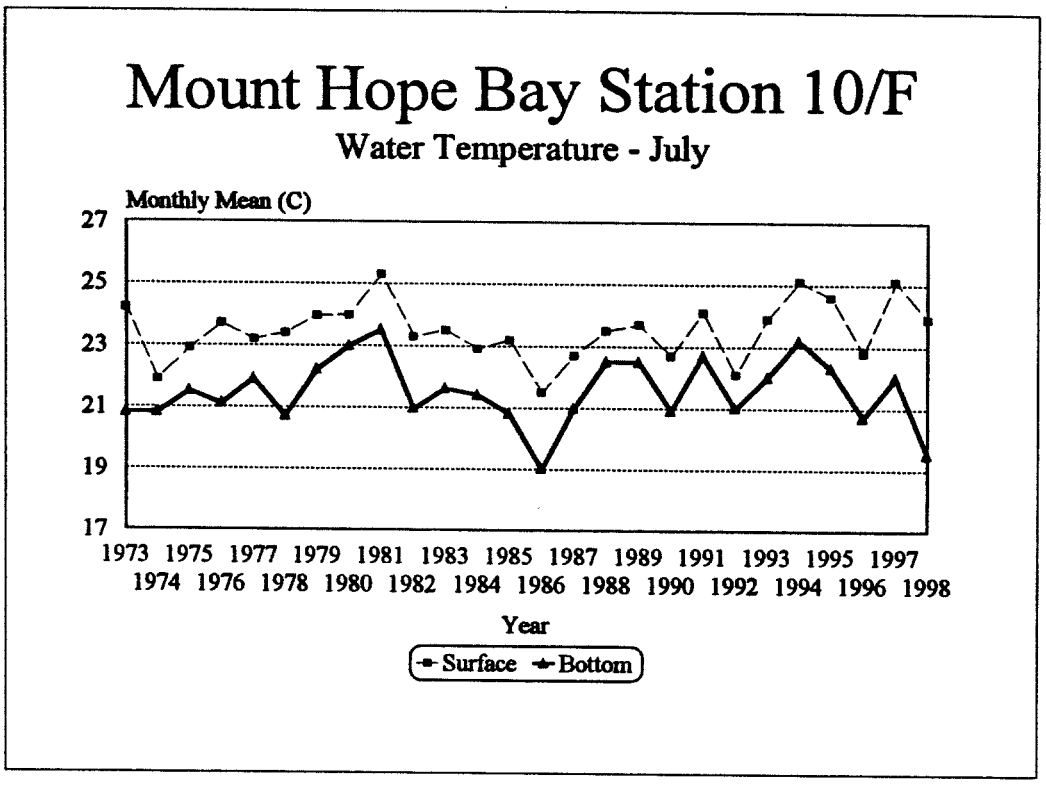

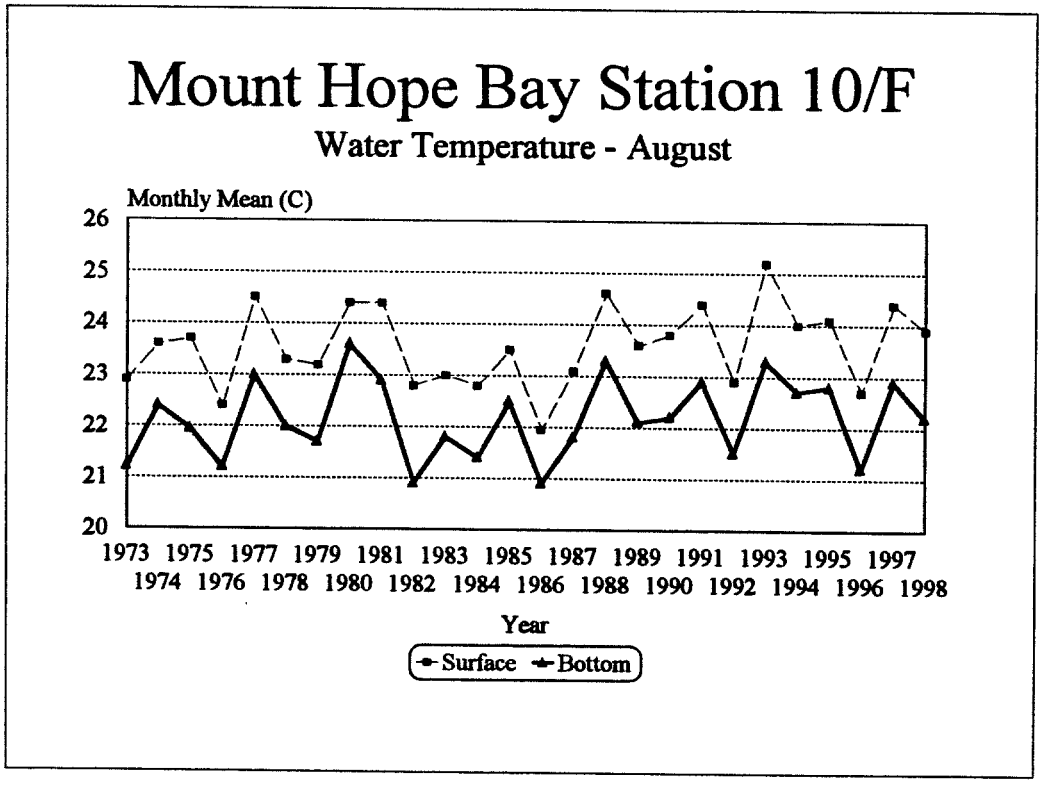

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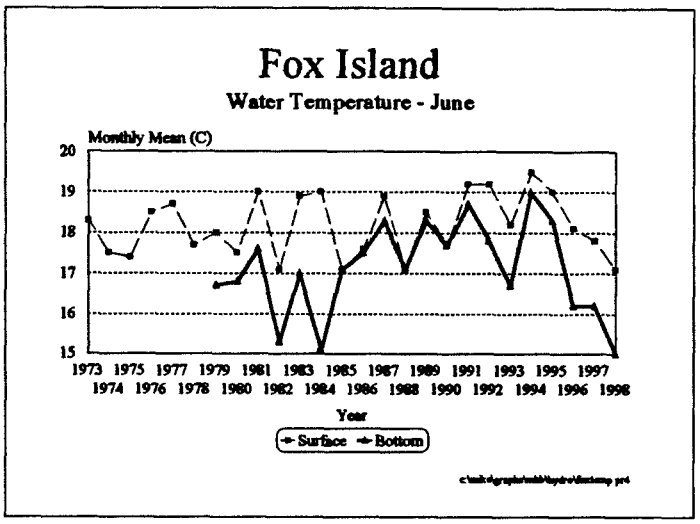
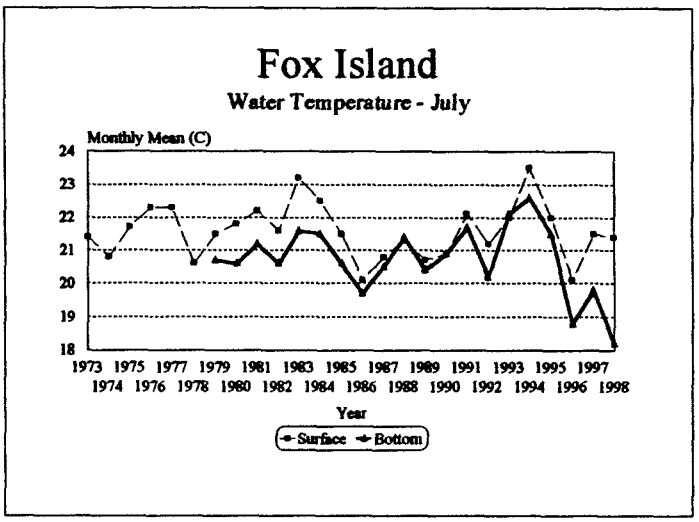




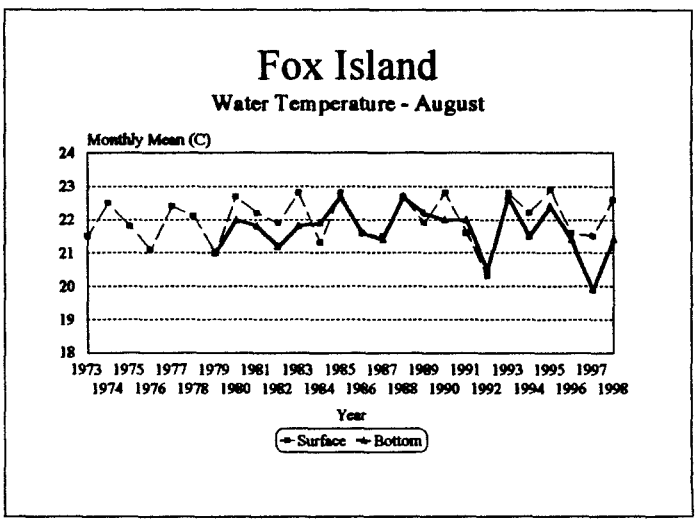
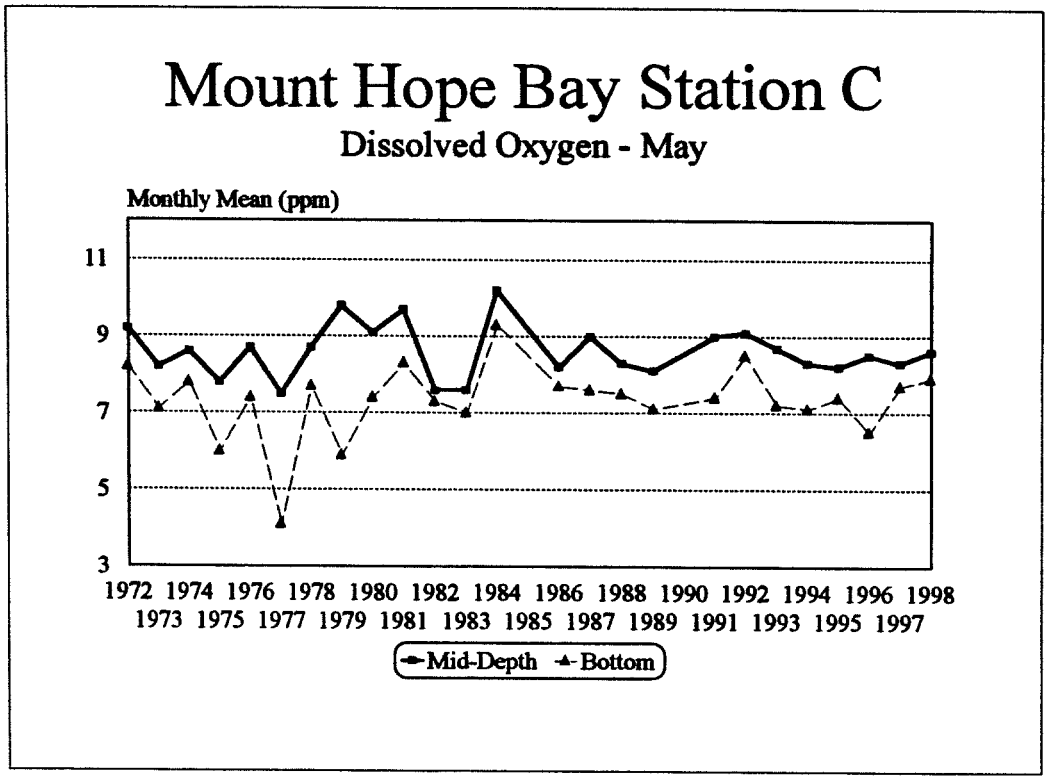


Figure H-12. Mean surface and bottom water tempeatures recorded at URI's Fox Island trawl station, June, July, and August, 1973 - 1998.



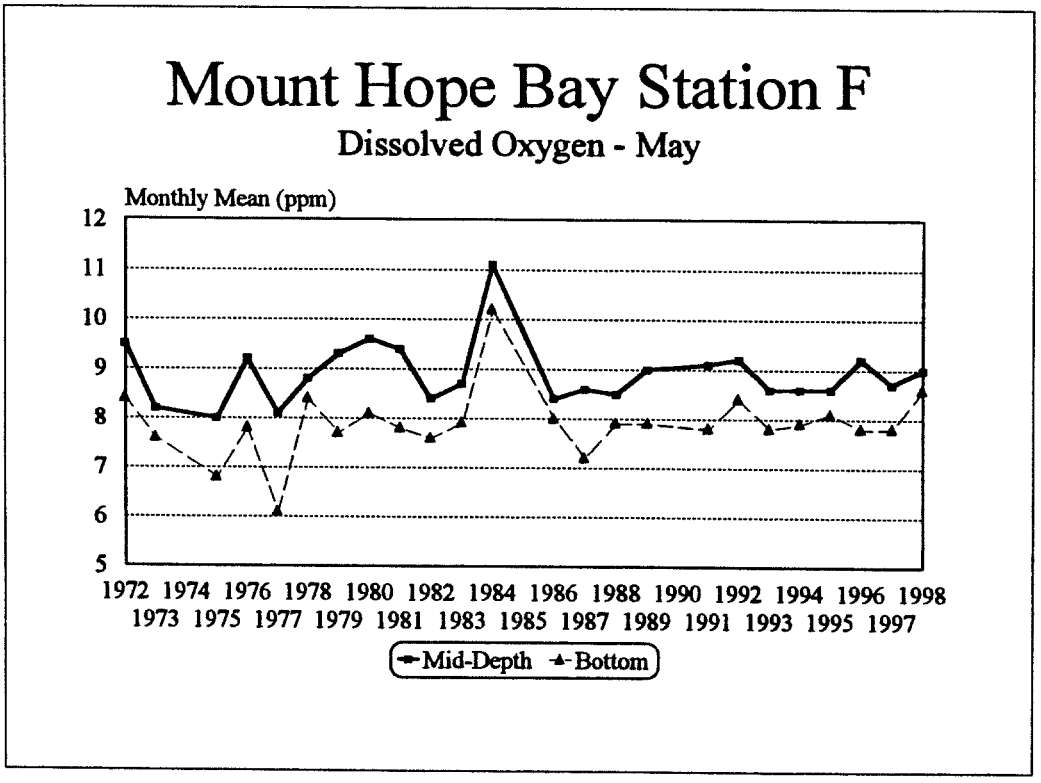
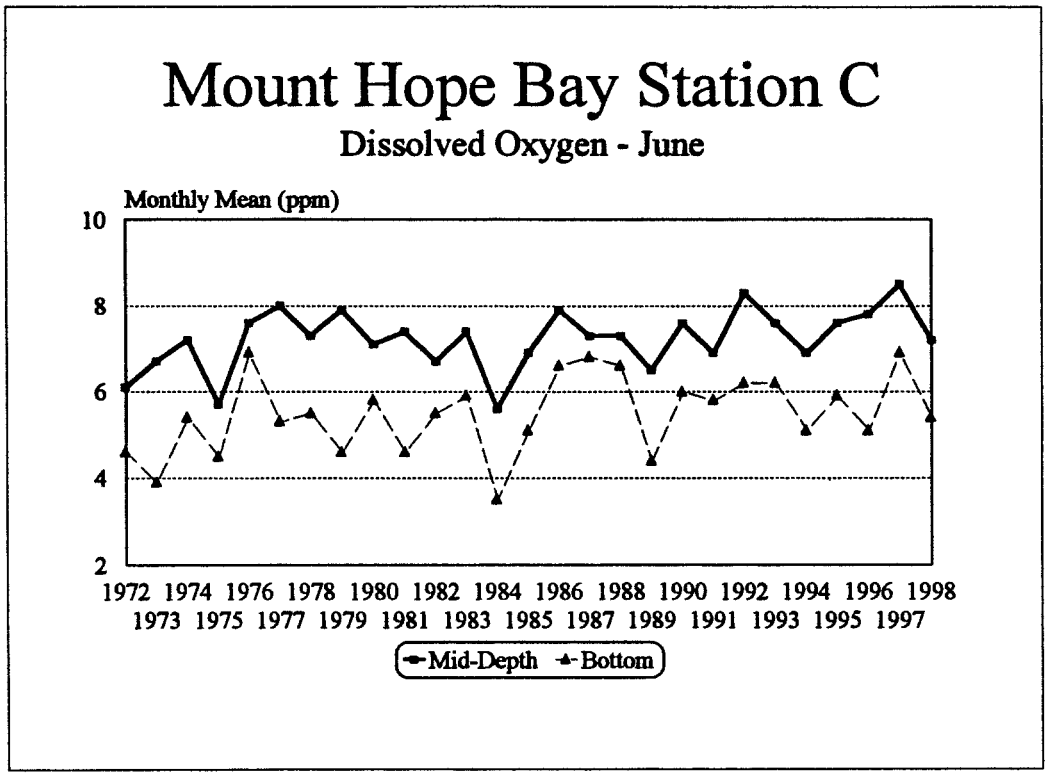


Figure H-13. Mean mid-depth and bottom dissolved oxygen recorded at Mount Hope Bay Station C and F, May - August, 1972-1998.



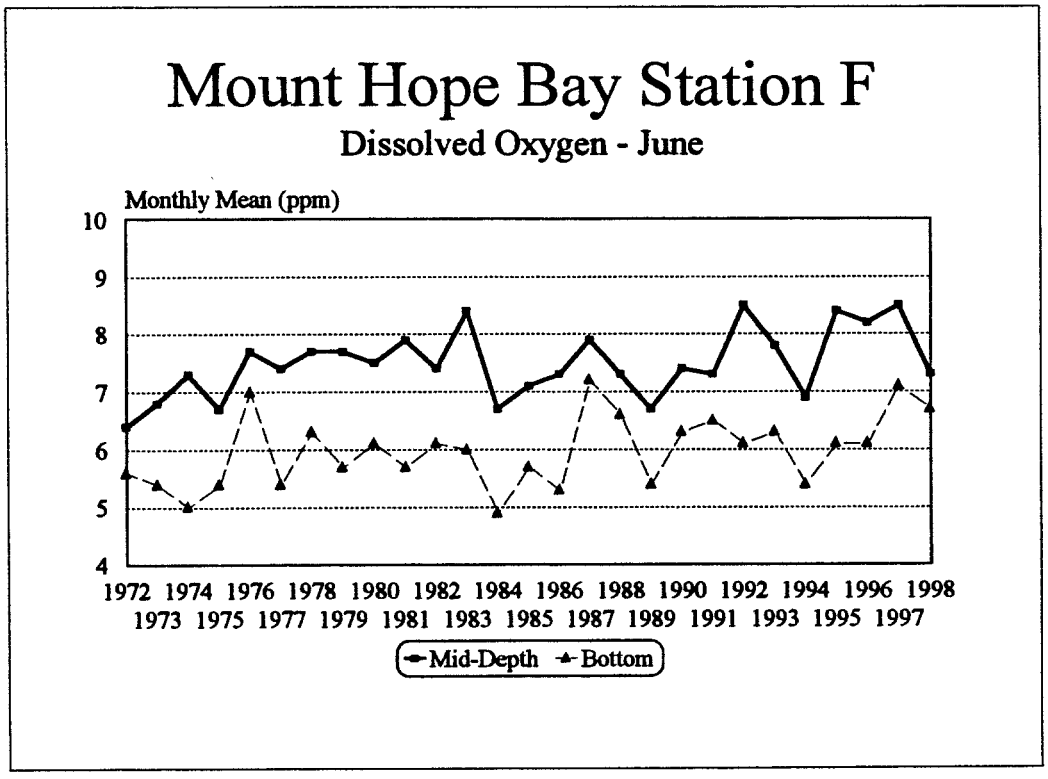
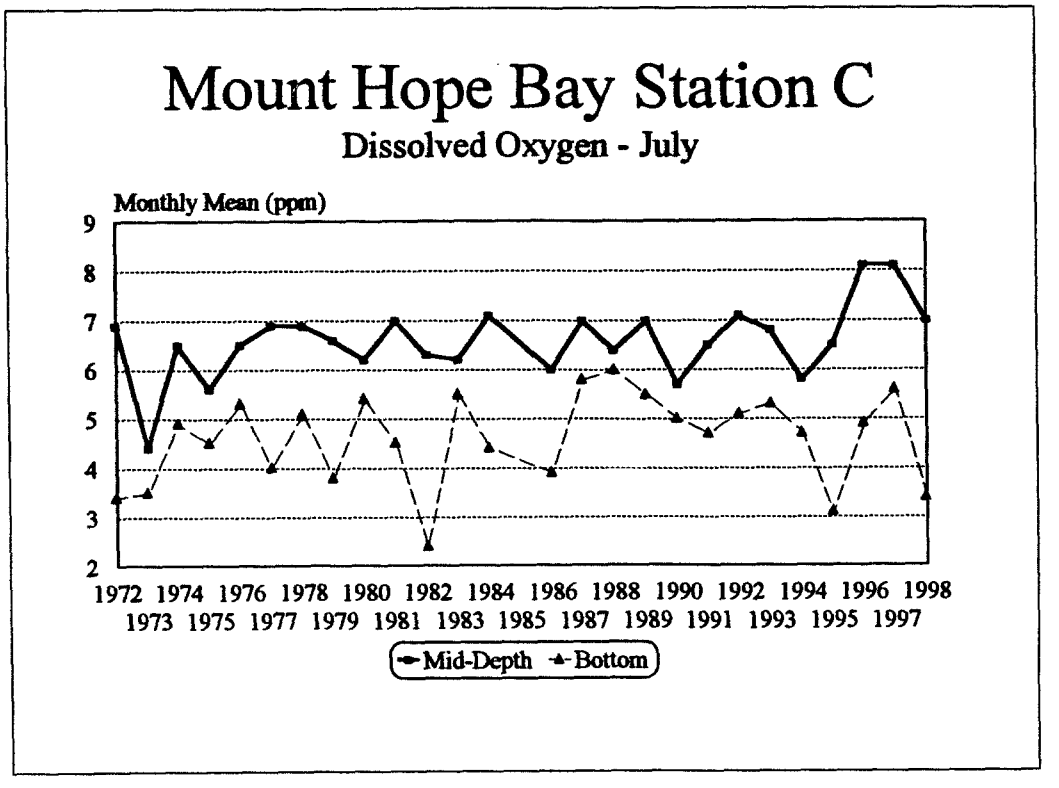


Figure H-13. (continued).



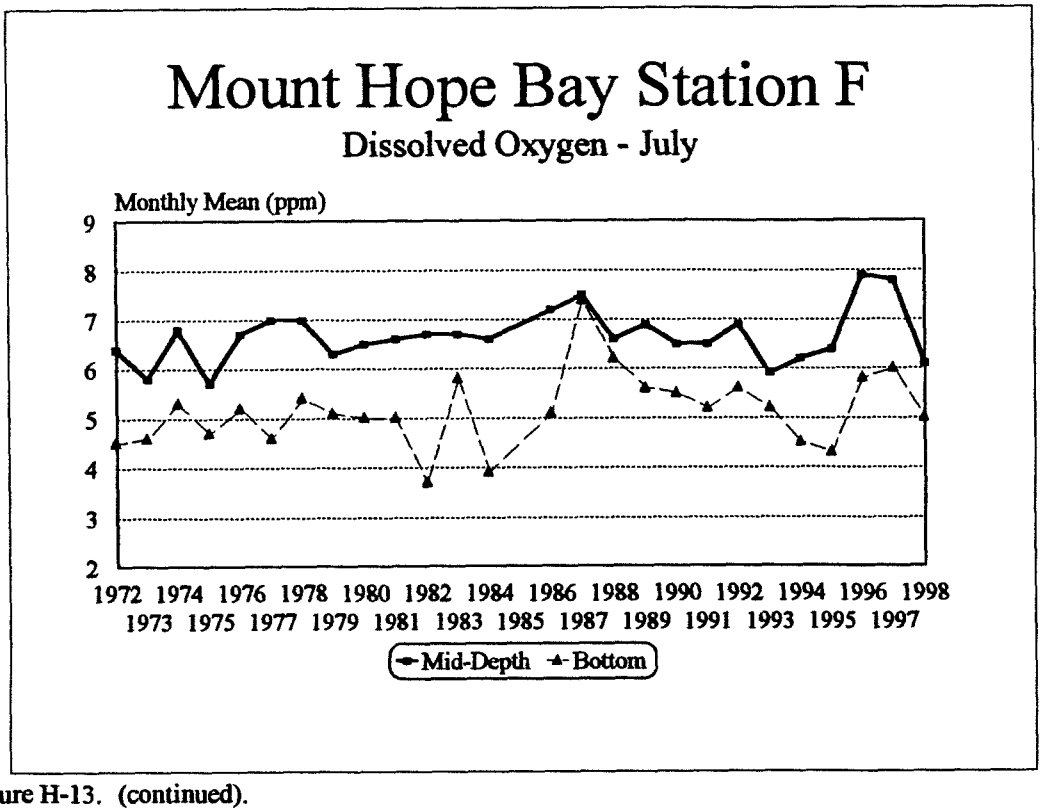
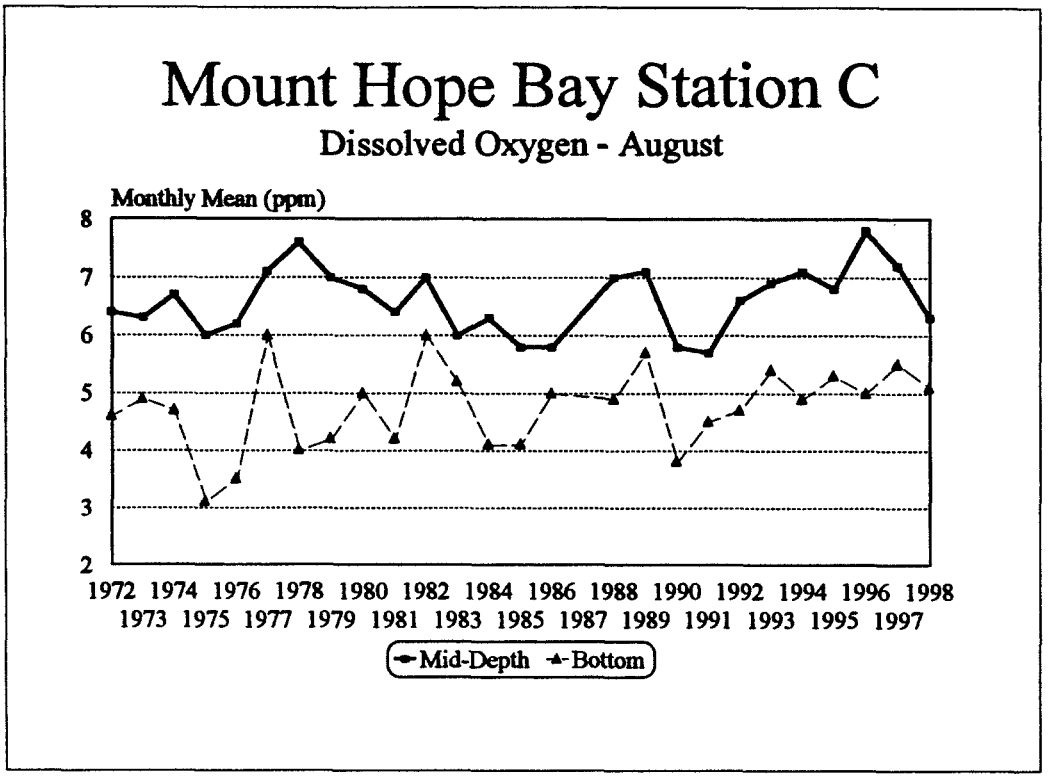
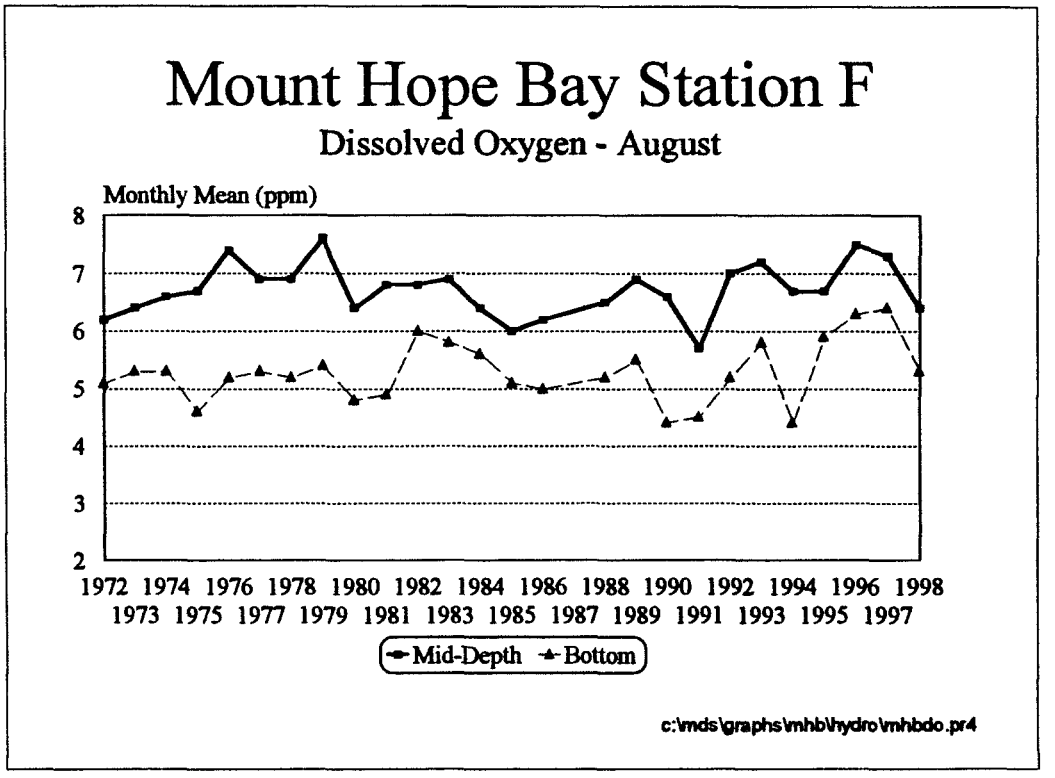


Figure H-13. (continued).





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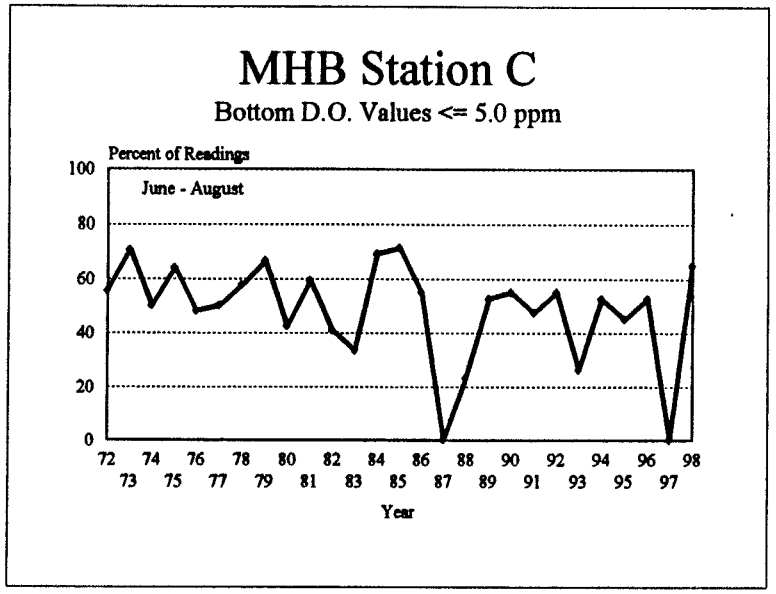
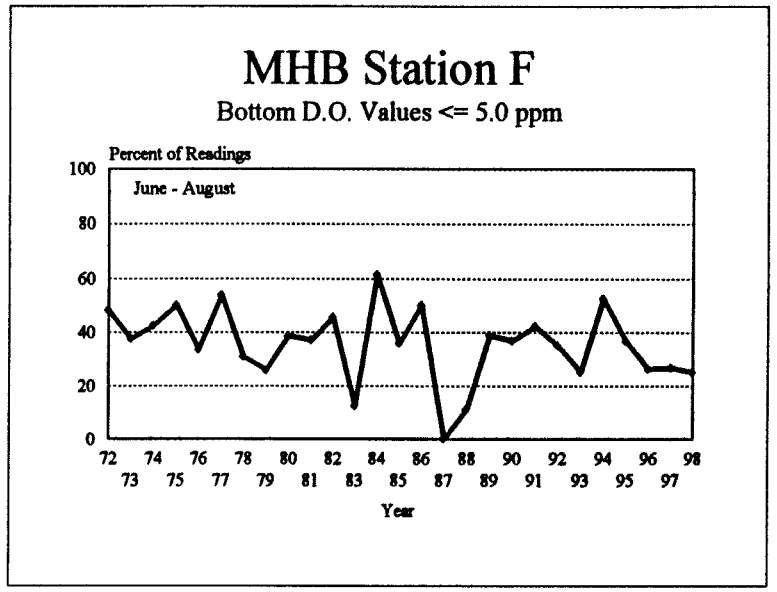
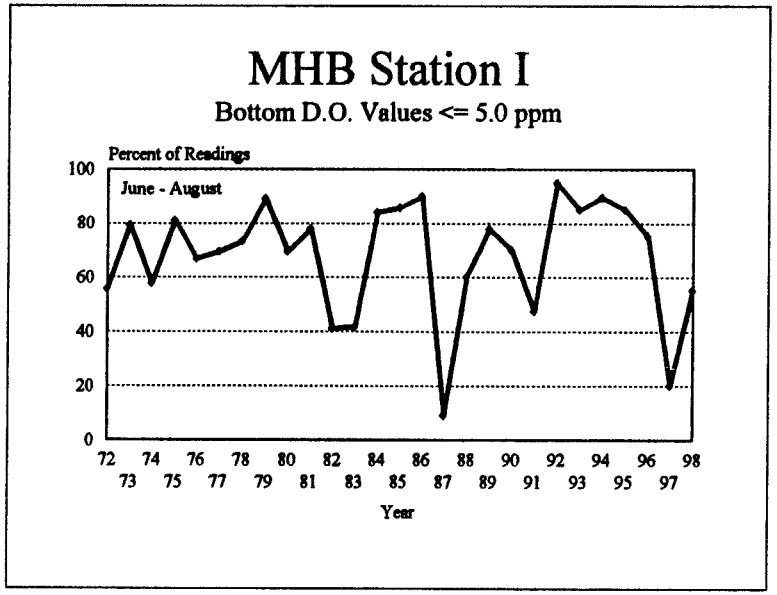






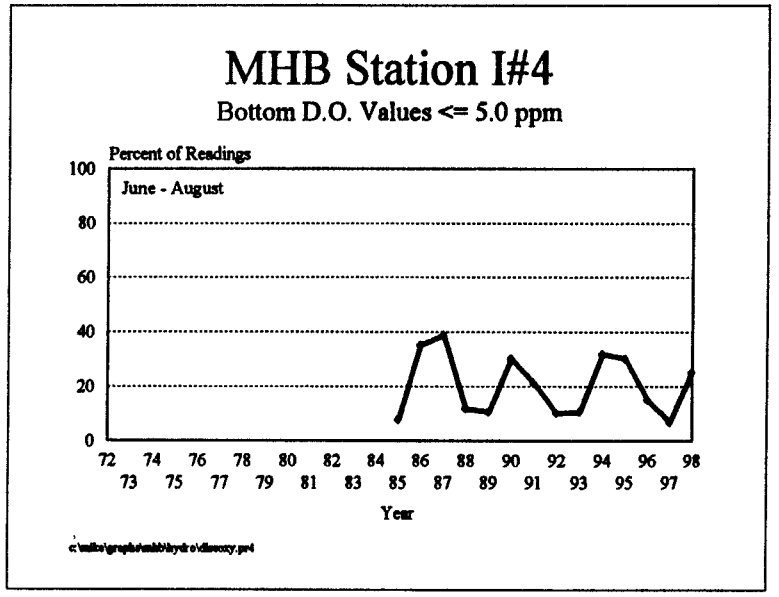
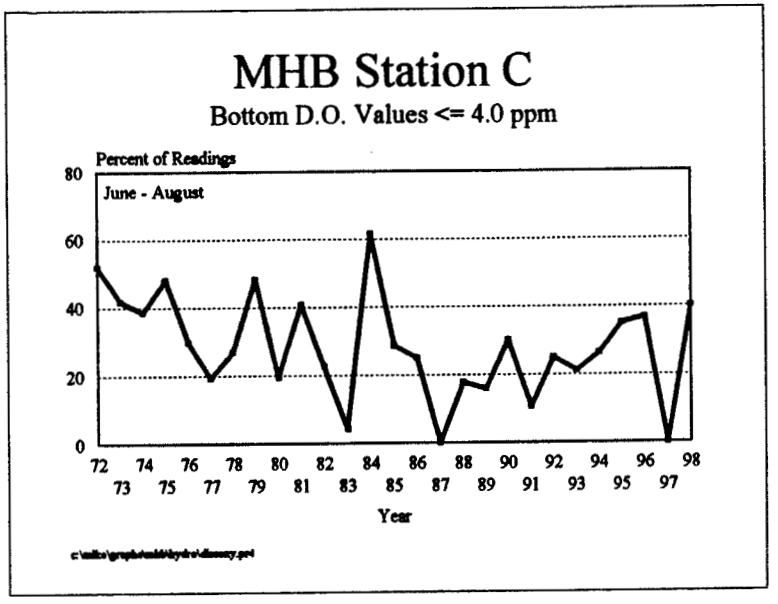
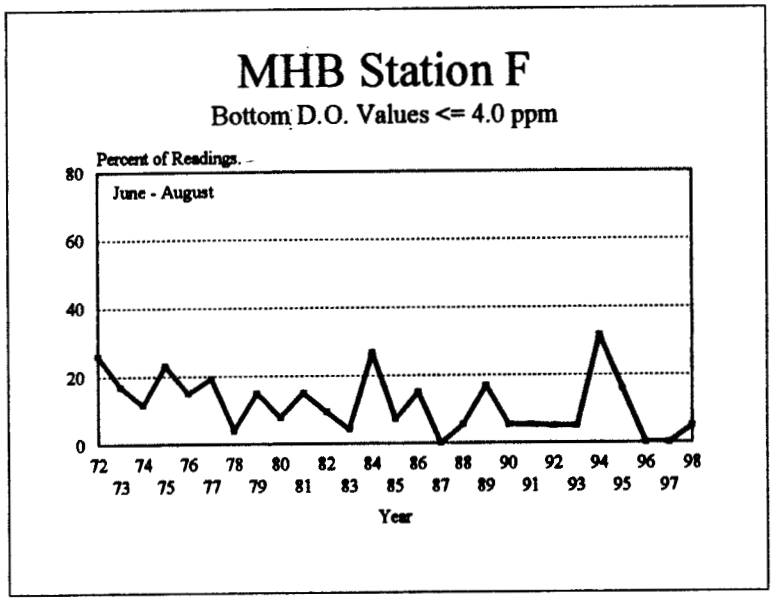
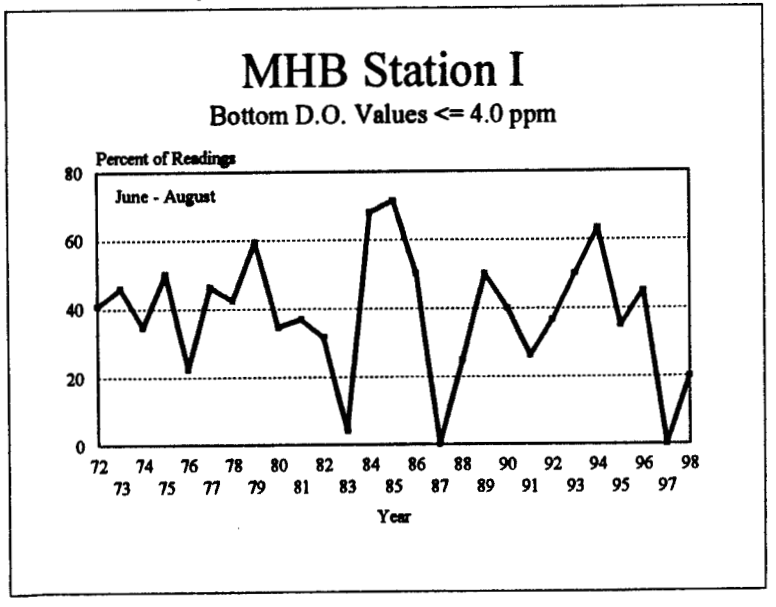


Figure H-14. Percent of dissolved oxygen readings reaching 5 ppm or lower at Stations C, F, I, and I#4, 1972 - 1998.







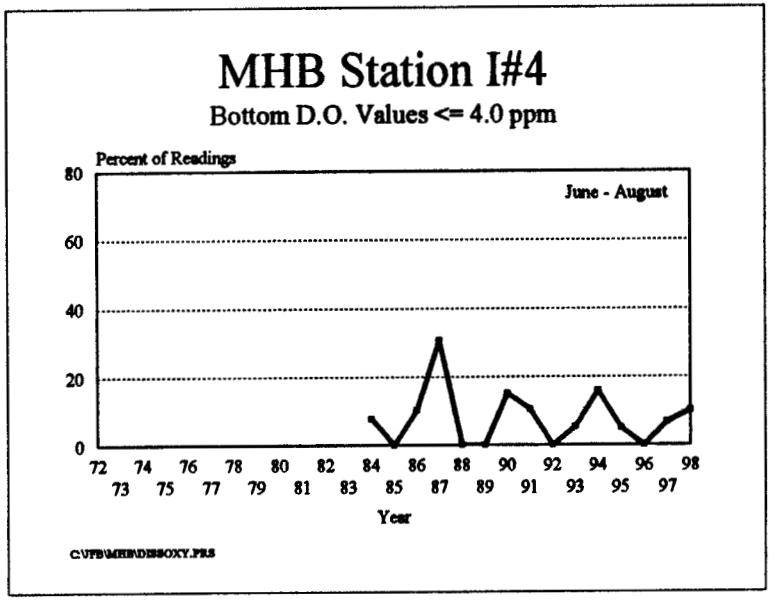
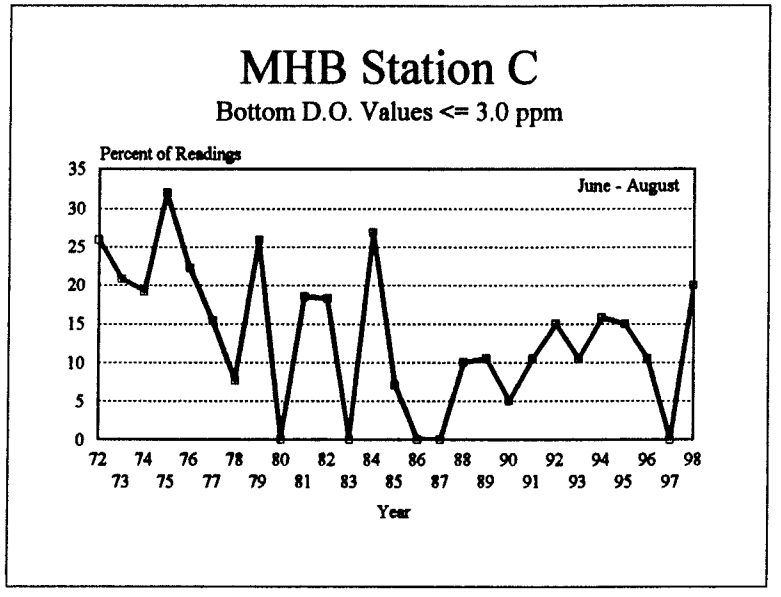
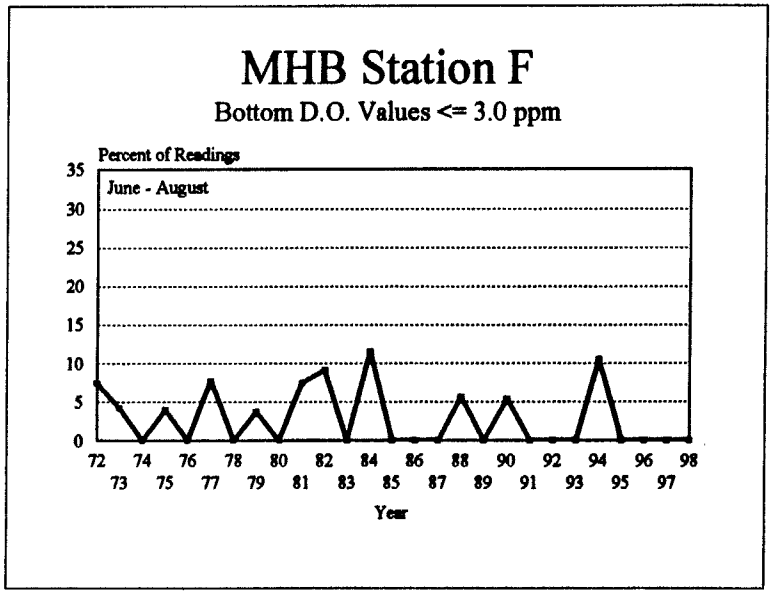
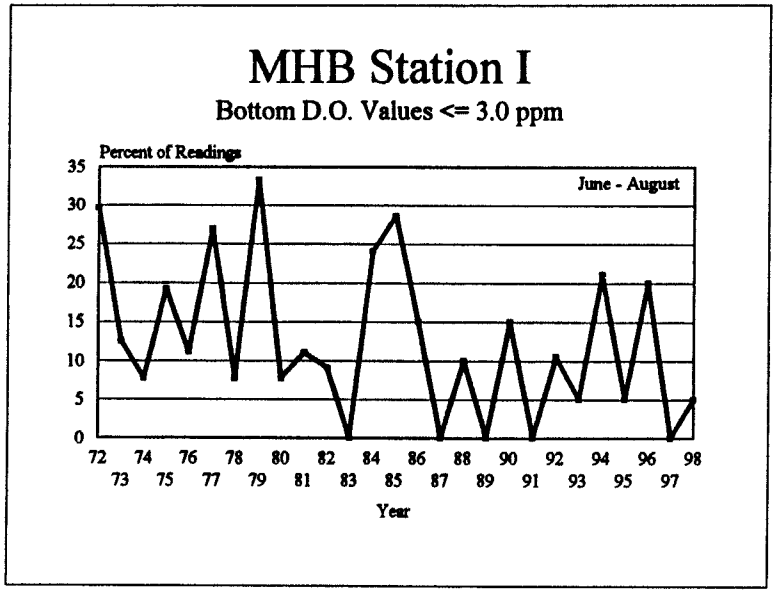


Figure H-15. Percent of dissolved oxygen readings reaching 4 ppm or lower at Stations C, F, I, and I#4, 1972 - 1998.







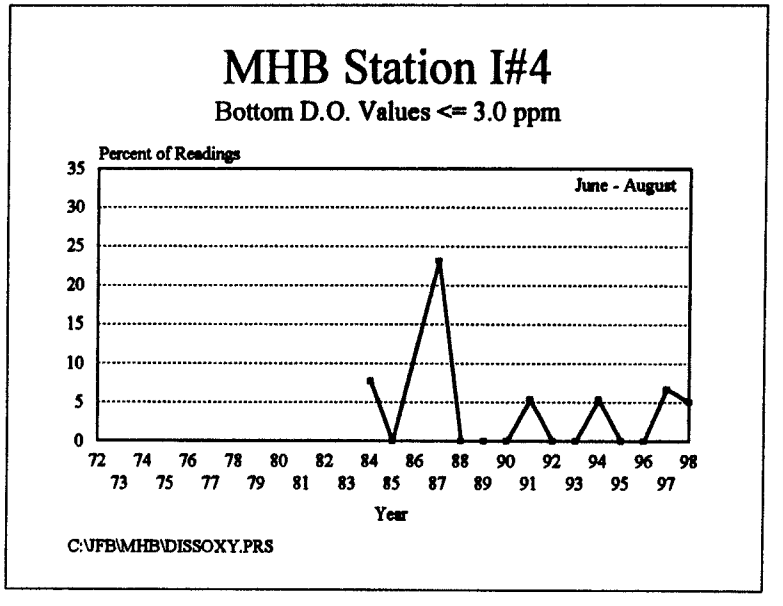
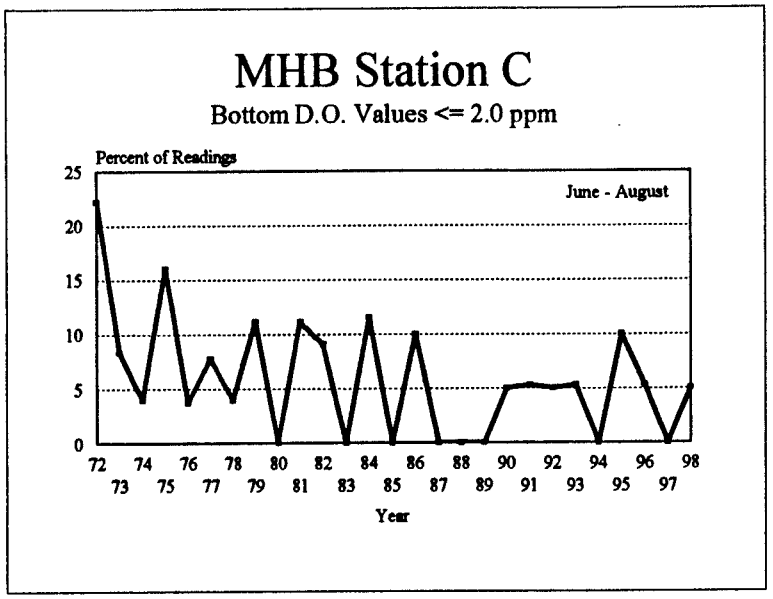
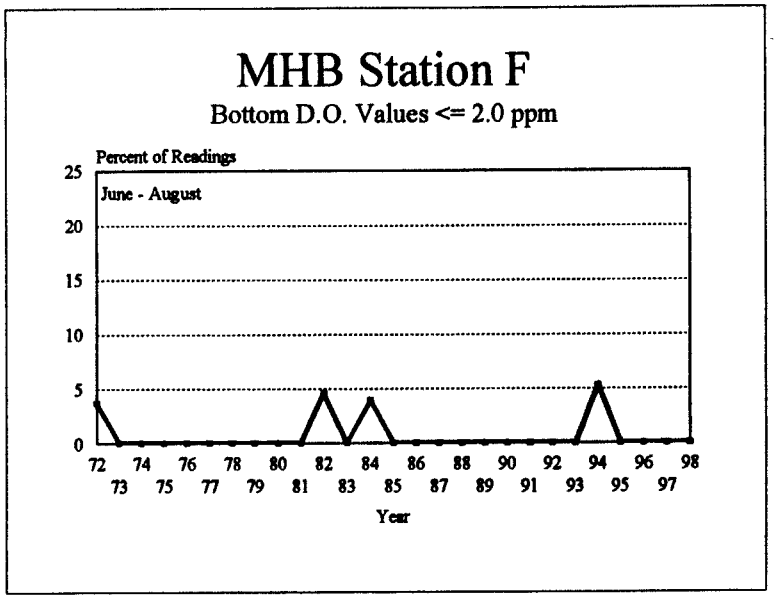
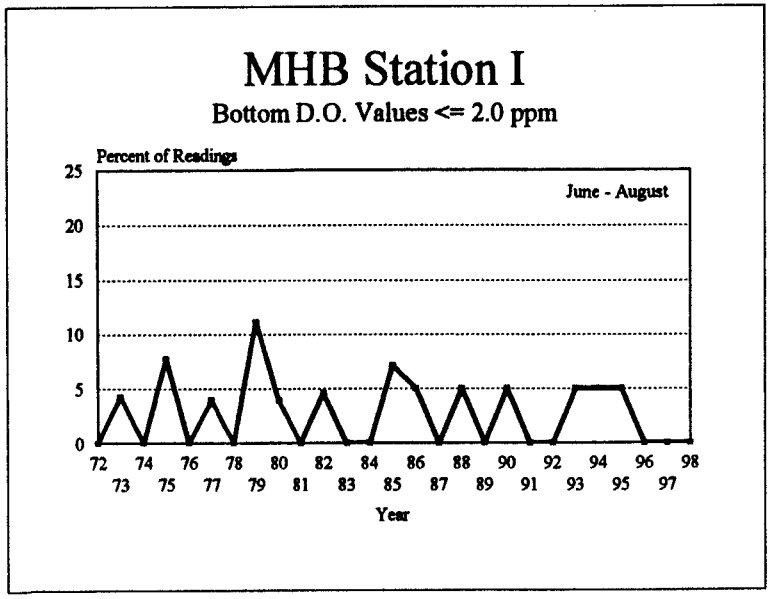


Figure H-16. Percent of dissolved oxygen readings reaching 3 ppm or lower at Stations C, F, I, and I#4, 1972 - 1998.







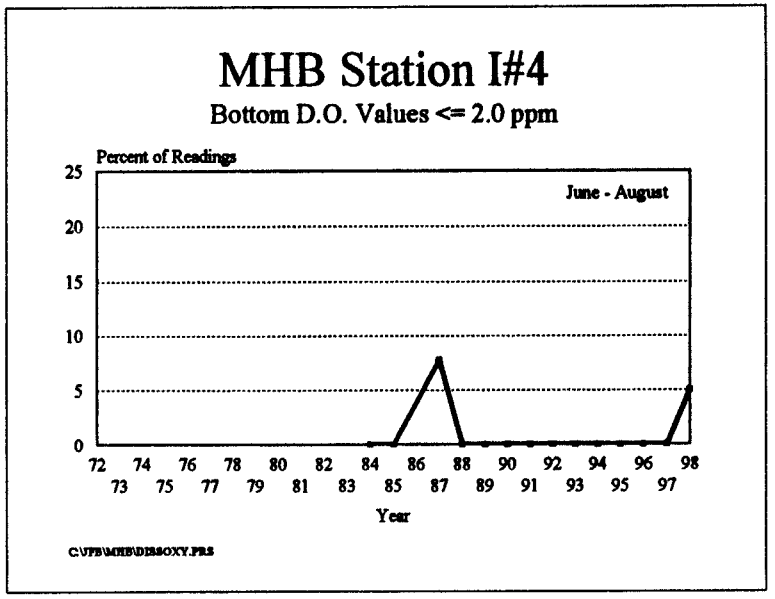


Figure H-17. Percent of dissolved oxygen readings reaching 2 ppm or lower at Stations C, F, I, and I#4, 1972 - 1998.

Table H-1. Average air temperature (°F) for Providence and Boston, January-December 1998 (NOAA monthly summaries).

	Month	1998 Average	Departure from Normal
Providence	January	35.1	7.2
	February	37.0	7.3
	March	41.2	3.8
	April	49.8	2.4
	May	61.1	3.8
	June	66.0	-0.9
	July	73.5	0.8
	August	73.3	2.0
	September	66.3	2.2
	October	54.1	0.5
	November	43.5	-0.5
	December	38.5	5.7
Boston	January	33.9	5.3
	February	35.3	5.0
	March	41.5	2.9
	April	49.4	1.3
	May	60.3	2.1
	June	64.7	-3.0
	July	74.4	0.9
	August	72.5	0.6
	September	66.3	1.5
	October	54.5	-0.3
	November	44.6	-0.7
	December	39.1	5.5

Table H-2. Mean monthly water temperature (°C) for Stations F, C, and I#4 in Mount Hope Bay, March-August, 1986-1998.

Month	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Mean 1986-1997	1998	Minimum	Maximum
								Station F								
March	5.8	3.4	6.2	3.8	6.1	5.9	4.2	2.8	3.5	4.9	3.3	4.6	4.5	5.6	2.8	6.2
April	8.5	7.7	7.5	7.4	8.2	9.3	7.2	7.8	8.1	7.7	7.4	7.8	7.9	9.3	7.2	9.3
May	13.9	11.8	15.6	13.3	12.7	15.8	12.3	14.1	11.4	12.3	13.3	12.3	12.9	13.7	11.4	15.8
June	19.1	19.4	17.8	19.0	19.9	19.5	18.7	19.0	19.0	17.8	19.0	17.0	18.4	17.8	17.8	19.5
July	20.8	22.0	23.2	22.0	22.2	23.4	21.4	22.7	24.3	23.4	21.8	23.5	22.5	21.8	20.8	24.3
August	21.6	22.5	23.6	22.4	22.9	23.5	21.9	24.1	23.4	23.2	22.0	23.0	22.7	23.1	21.6	24.1
								Station C								
March	6.3	4.3	6.4	4.6	6.6	6.8	5.2	4.0	3.7	5.4	3.8	5.6	5.2	6.1	3.7	6.8
April	9.3	8.3	8.7	8.4	9.2	10.1	8.0	8.1	9.2	8.9	7.8	8.4	8.7	9.8	7.8	10.1
May	14.9	12.5	14.1	14.1	13.4	16.6	13.0	14.5	12.1	13.6	13.8	13.2	13.8	14.2	12.1	16.6
June	20.1	19.8	18.6	19.9	19.2	20.5	19.8	19.6	20.3	20.0	19.6	17.9	19.6	19.3	18.6	20.5
July	21.5	23.2	23.1	23.8	19.8	24.6	22.5	23.8	25.3	24.7	23.1	24.7	23.3	22.5	19.8	25.3
August	22.5	24.3	25.1	23.8	23.6	24.4	23.0	25.0	24.6	24.6	23.3	23.7	24.0	24.1	23.0	25.1
								Station I#4								
March	6.8	4.4	7.0	4.9	6.9	7.0	4.8	5.1	6.8	5.6	6.3	6.5	6.0	7.5	4.4	7.5
April	10.0	8.6	8.7	9.1	9.6	11.0	7.9	8.8	11.5	9.6	10.8	9.3	9.6	11.5	7.9	11.5
May	15.3	12.7	15.0	15.1	13.9	17.7	13.6	15.7	13.3	14.2	15.4	14.0	14.7	15.8	12.7	17.7
June	20.6	21.1	20.1	20.9	19.9	21.1	19.4	20.5	21.2	21.0	20.9	19.2	20.5	20.3	19.4	21.2
July	21.2	23.4	23.4	24.3	23.6	25.0	22.9	24.9	25.8	25.5	23.8	26.3	24.2	24.0	21.2	25.8
August	22.5	23.3	25.8	24.2	24.3	25.6	23.4	25.5	24.7	25.1	23.9	24.9	24.4	25.0	22.5	25.8

Table H-3. Number of occasions when Hydrolab readings were taken at Mount Hope Bay Stations C and F, 1972 - 1998.

	March	April	May	June	July	August
1972	2	7	9	9	8	10
1973	6	4	6	7	9	9
1974	2	3	3	8	9	9
1975	4	4	5	8	9	9
1976	4	5	4	9	9	9
1977	3	1	3	9	8	9
1978	1	1	4	9	9	8
1979	1	1	3	9	9	9
1980	1	1	4	9	8	9
1981	1	1	4	9	9	9
1982	1	1	4	9	8	8
1983	1	1	4	9	8	9
1984	1	1	4	9	9	9
1985	1	1	2	8	7	9
1986	2	7	5	7	6	7
1987	7	6	6	7	7	6
1988	5	6	6	7	6	7
1989	7	6	7	7	6	7
1990	6	7	6	7	6	7
1991	7	6	7	6	7	6
1992	7	6	7	6	7	7
1993	7	7	6	7	6	7
1994	7	6	6	6	8	6
1995	7	6	7	7	6	7
1996	7	6	7	6	7	7
1997	6	7	5	6	5	4
1998	6	6	6	7	7	6

Note: 1 or 2 readings typically at monthly intervals.
3 to 5 readings typically taken at weekly intervals.
6 to 7 readings typically taken every 4 to 5 days.
8 to 10 readings typically taken twice per week.

Table H-4. Number of occasions when water temperature readings were taken at ichthyoplankton Station 10 in Mount Hope Bay, 1972 - 1998.

	March	April	May	June	July	August
1972						
1973	3	4	5	4	4	5
1974	4	4	5	4	5	3
1975	4	5	4	4	5	4
1976	5	4	4	5	4	5
1977	5	4	5	3	5	4
1978	4	4	5	4	4	5
1979	5	4	5	4	5	4
1980	7	6	7	6	7	6
1981	7	6	7	7	6	6
1982	7	7	3	7	6	7
1983	6	7	6	7	6	7
1984	6	7	6	7	5	7
1985	6	7	7	6	6	7
1986	5	8	5	7	6	6
1987	7	6	6	7	7	6
1988	5	6	6	7	6	7
1989	6	6	7	7	6	7
1990	6	7	6	7	6	7
1991	7	6	7	6	7	6
1992	7	6	7	6	7	7
1993	6	7	5	7	3	
1994	7	6	4			
1995	7	6	4			
1996	7	6	4			
1997	6	7	3			
1998	6	6	4			

Note: 3 to 5 readings typically taken at weekly intervals.
6 to 8 readings typically taken every 4 to 5 days.

Table H-5. Results of linear trend analyses for 1985-1998 subsets of surface and bottom water temperature time series at Mount Hope Bay Stations C and 10/F.

Subset/ Station	Month	Strata	Slope	R^2	p[1]
C	June	Surface	0.011	0.005	0.810
		Bottom	-0.052	0.063	0.387
	July	Surface	0.100	0.066	0.376
		Bottom	0.060	0.039	0.500
	August	Surface	0.079	0.065	0.381
		Bottom	0.017	0.080	0.762
10/F	June	Surface	0.023	0.015	0.669
		Bottom	-0.069	0.122	0.202
	July	Surface	0.108	0.202	0.092
		Bottom	0.031	0.009	0.739
	August	Surface	0.065	0.116	0.215
		Bottom	0.031	0.032	0.526

[1] p values ≤ 0.05 indicate that the observed slope was significantly different from zero at a probability level of 95%.

Table H-6. Results of trend analyses for mid-depth and bottom dissolved oxygen time series at Mount Hope Bay Stations C and 10/F, 1972-1998.

Station	Month	Strata	slope	R^2	p[1]
C	May	Mid	-0.004	0.002	0.816
		Bottom	0.021	0.030	0.409
	June	Mid	0.033	0.141	0.053
		Bottom	0.041	0.128	0.067
	July	Mid	0.039	0.174	0.034
		Bottom	0.020	0.031	0.393
	August	Mid	0.011	0.014	0.433
		Bottom	0.031	0.118	0.085
10/F	May	Mid	-0.0002	0.000	0.993
		Bottom	0.021	0.055	0.269
	June	Mid	0.030	0.170	0.032
		Bottom	0.034	0.189	0.023
	July	Mid	0.018	0.072	0.186
		Bottom	0.025	0.068	0.200
	August	Mid	0.005	0.008	0.673
		Bottom	0.016	0.055	0.249

[1] p values ≤ 0.05 indicate that the observed slope was significantly different from zero at a probability level of 95%.

Unit 123
Open-cycle
cooling

Unit 4
1972 – 1984 : Clean-cycle
1984-1992 : open-cycle
1993+1998 : piggyback
1995 –
1994 : open cycle

Ichthyoplankton Sampling

Introduction

Fish egg and larval populations in Mount Hope Bay (MHB) have been monitored since June 1972 to determine if any persistent population declines have occurred which might be attributable to the operation of Brayton Point Station. Sampling gear and vessel have remained constant over the years but the number of stations and sampling frequency have changed on several occasions (Table I-1). In September 1979, the number of stations was reduced from 23 to 7 while March-August sampling frequency increased from weekly to every four to five days. In January 1986, the number of stations sampled dropped to five. In 1993, Stations 21 and 23 were returned to the sampling regime since seven stations notably improved the precision of larval flounder estimates and provided ichthyoplankton information on waters in the lower Bay. At that time, the year-round program was scaled back to the months of February-May to concentrate on winter flounder. From 1994 to 1998, ichthyoplankton sampling was also completed in the Unit 1,2,3 intake embayment and in the Taunton River opposite Montaup Power Station.

Numbers of fish eggs and larvae passing through the Unit 1,2,3 cooling water system at Brayton Point Station were determined from June 1972 through December 1985 on the same schedule as the Bay-wide sampling program. Changes in net mesh or replication occurred in 1975, 1977, and 1980 (Table I-1). Entrainment sampling was discontinued after 1985 but was returned to the program in 1992 for the winter flounder larval season as part of a more detailed examination of their stock decline. For the first time since Unit 4 went to open-cycle cooling in July 1984, independent estimates of larval entrainment were determined for Units 1,2,3 and Unit 4 during the 1992 and 1995 larval flounder season. In 1993, Unit 4 operated in piggyback mode during March to reduce Bay water usage (see below), thus no entrainment sampling was completed for that unit until April. In 1994 and 1996 through 1998, that Unit's intake was closed for most or all of the larval flounder period as seasonal piggyback operation continued to be used to reduce larval flounder entrainment.

In 1992, seasonal average densities of larval flounder entrained by Unit 4 amounted to 24% of the seasonal average at MHB Station 4 which is located approximately 500 yards nearer to and centered on the river mouth. In 1993, similar results were obtained with Unit 4 densities amounting to 27% of MHB Station 4 densities. One hypothesis developed to explain these results is that larval flounder follow the main drainage channel on the west side of the river with densities being markedly lower in the cove from which Unit 4 draws cooling water. Sampling was initiated in the Lee River at two locations in 1993 to shed light on relatively small-scale larval flounder abundance there. One station was located in front of the Unit 4 intake and the other along the far shore of the Lee River. With the Unit 4 intake closed in 1994 under piggyback operation and with it open in 1995 during the entire sampling season, these two locations were again sampled along with the addition of a third station upstream to see if the presence or absence of a Unit 4 flow vector altered distribution patterns.

In addition to these studies, mesh extrusion was thoroughly examined in both the Bay sampling program and the entrainment program in 1977, 1978 and 1994, 1995. Since mesh extrusion

coefficients vary from one year to the next, they have been determined for the Mount Hope Bay ichthyoplankton sampling program each year since 1995 when 0.333-mm mesh became the program standard.

Summary

Mount Hope Bay ichthyoplankton populations were sampled once in February, every four to five days weather permitting from March through mid-May, primarily to monitor larval winter flounder populations. Larval flounder were collected from February 17 when sampling began until sampling ceased on May 18. A peak mean density of 56 larvae per 100 m^3 of water was noted on April 3. Two larval flounder abundance indices suggested that 1998 was the lowest year thus far for abundance, ranking 26th over the 1973-1998 period. Annual larval flounder abundance (total or yolk-sac larvae alone) was not found to be correlated with adult abundance in Mount Hope Bay.

Ichthyoplankton tows were completed in the upper and lower halves of the water column in the Brayton Point Units 1,2,3 intake (Station I) on the same schedule as the Bay-wide ichthyoplankton sampling. Results indicated that densities of stage 1, stage 3, and total larval flounder averaged higher in the lower half of the water, and the differences between upper and lower halves of the water column were statistically significant. For stage 2 larvae, densities also averaged higher in the lower half of the water column, but the difference was not statistically significant. The pattern observed in 1998 conforms to that observed in 1995 through1996 whereas in 1994 and 1997 stage 2 larvae were more common in the upper half of the water column

Analysis of variance was used to examine for differences in mean larval flounder density at Montaup Station M, Mount Hope Bay Station 1, and Brayton Point Intake Station I near the mouth of the Taunton River. A statistically significant difference was detected only among stage 1 larvae where seasonal densities were significantly higher at Station I than at Station1while the average density at Station M was intermediate between and similar to each of those two locations. For older stage 2 and stage 3 flounder as well as total larval flounder, densities were statistically similar at the three stations. During previous seasons among-station differences were detected in 1996 and 1997 but not during 1994 and 1995. Among-station differences involved stage 1 larvae in 1996 and 1998, stage 2 larvae in 1997, stage 3 larvae in 1996 and all stages combined in 1996. In general, differences in density among the three locations were relatively small and difficult to discern amid the characteristically high seasonal variability suggesting that the Taunton River mouth area is relatively well mixed.

Concurrent with sampling in the Units 1,2,3 intake embayment, entrainment samples were also taken from the combined discharge stream of those units. In 1998 Unit 4 operated in piggyback mode during the entire larval flounder season to minimize entrainment. Total larval winter flounder entrainment was estimated at 49,047,205. Numbers entrained in 1998 were low, consistent with the low Bay-wide abundance. Total numbers entrained were highly correlated with the Bay-wide larval abundance indices. Equivalent adult analyses for winter flounder were updated to include 1998 and were found to be well below average consistent with low numbers entrained. Using two sets of survival values, 1998 equivalent adults were 3,024 and 23,419 both the lowest of their respective time series.

Larval flounder densities from the Brayton 1,2,3 discharge stream were compared with those collected concurrently in two halves of the water column at Intake Station I. Stage 1 densities averaged highest in the lower intake followed by the upper intake and the discharge. Among stage 2 larvae densities were again highest in the lower intake, followed by the discharge and the upper intake. Older stage 3 individuals were consistently distributed deeper in the water column than younger larvae. In 1998, they were taken at significantly greater densities in the lower intake compared with the upper intake consistent with three of the previous four seasons. Brayton discharge densities were statistically similar to the lower intake densities. These results are generally consistent with results from 1995 through 1997.

The total number of larval flounder which would have been entrained based on intake densities was greater than the number estimated to have been entrained based on discharge densities for each of the four years during which the intake was sampled. Ratios between the two ranged from 1.05 in 1997 to 1.52 in 1998. Since the unstaged EA computations are simple scalar values, the adult estimates vary by the same amount, i.e. the EA estimate for 1998 based on the intake densities (4,608) was 1.52 times higher then the estimate based on the discharge densities (3,024). EA estimates based on staged larvae varied from year to year because of differences in the distribution of stages. Averaged over the four-year period, EA values were 34,294 based on intake densities, 39,917 based on discharge densities. The reason for the greater number of equivalent adults based on discharge densities was the relatively greater number of stage 3 and stage 4 larval flounder in those collections, individuals which have survived the first two larval stages and therefore contribute proportionately more to the equivalent adult totals.

A. Mount Hope Bay

Beginning in 1993, the Mount Hope Bay ichthyoplankton program has focused on the larval winter flounder season extending from February through mid-May of each year.

Methods

Fish egg and larval populations in Mount Hope Bay were sampled once in February and every four to five days from March through mid-May. During the period of more frequent sampling, collections were made on Monday and Friday of one week, Wednesday the next and so on, weather permitting, resulting in six to seven sampling series per month. On each occasion, seven stations were sampled, identified as Stations 1, 4, 5, 9, 10, 21, and 23, (Figure I-1); the stations are not numbered consecutively because they represent seven stations among an original set of 23. On each occasion samples were also taken in the center of the Taunton River opposite Montaup Power Station, identified as Station M, and in the intake embayment of Brayton Point Units 1,2,3, identified as Station I (Figure I-2). Single collections were made at each location with the exception of I where collections were made in triplicate. All collections were completed with paired, 60-cm diameter bridleless "bongo" nets fitted with 0.505 and 0.333-mm mesh netting. All tows, with the exception of those at I, were oblique from bottom to surface. Gear depth was determined using wire angle and length of cable deployed. A VEMCO minilog-TDR attached to the bongo net was used to confirm that the desired depth had been achieved. Since data stored by the minilog-TDR must be

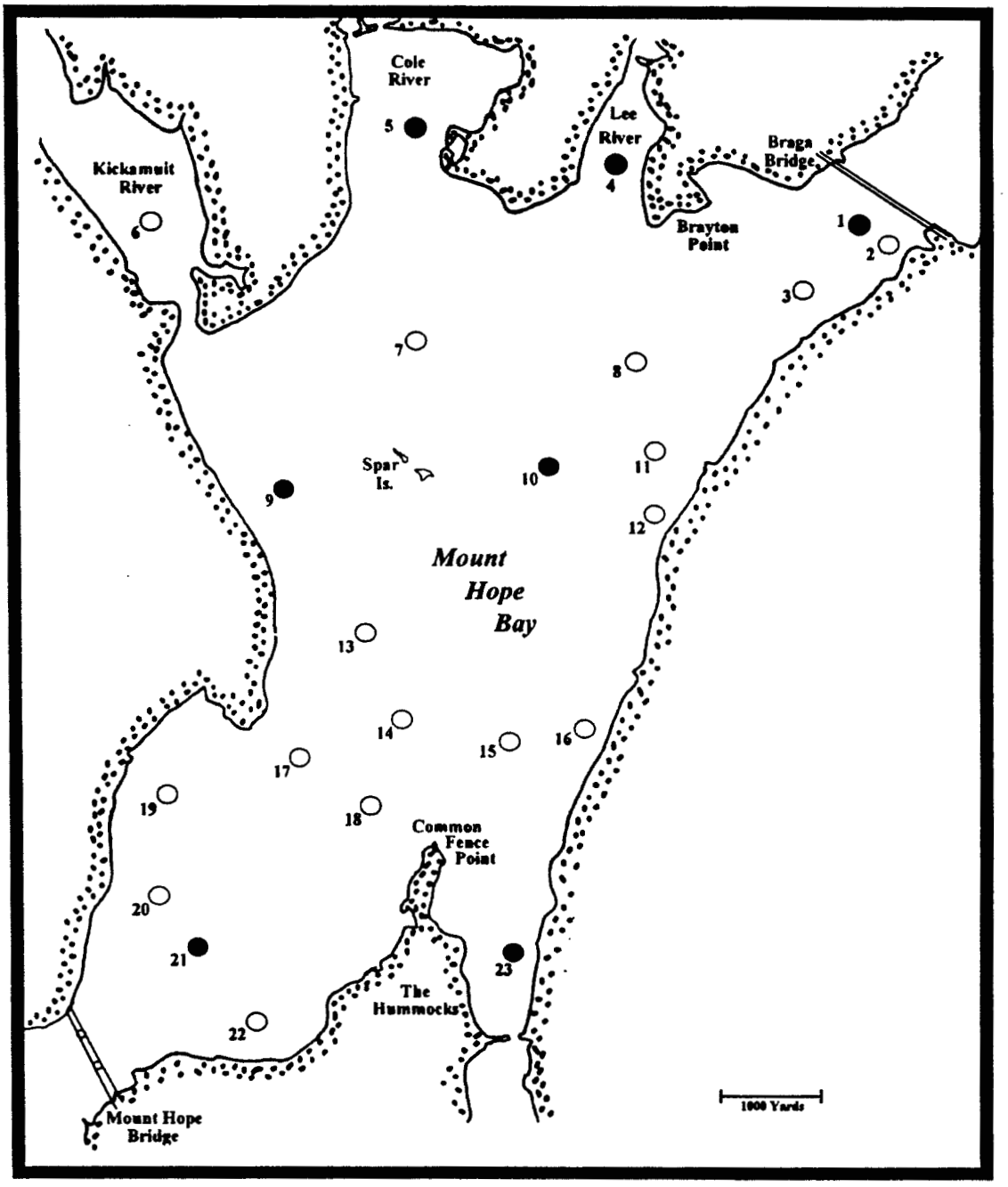


Figure I-1. Seven ichthyoplankton stations (solid circles) sampled in Mount Hope Bay.

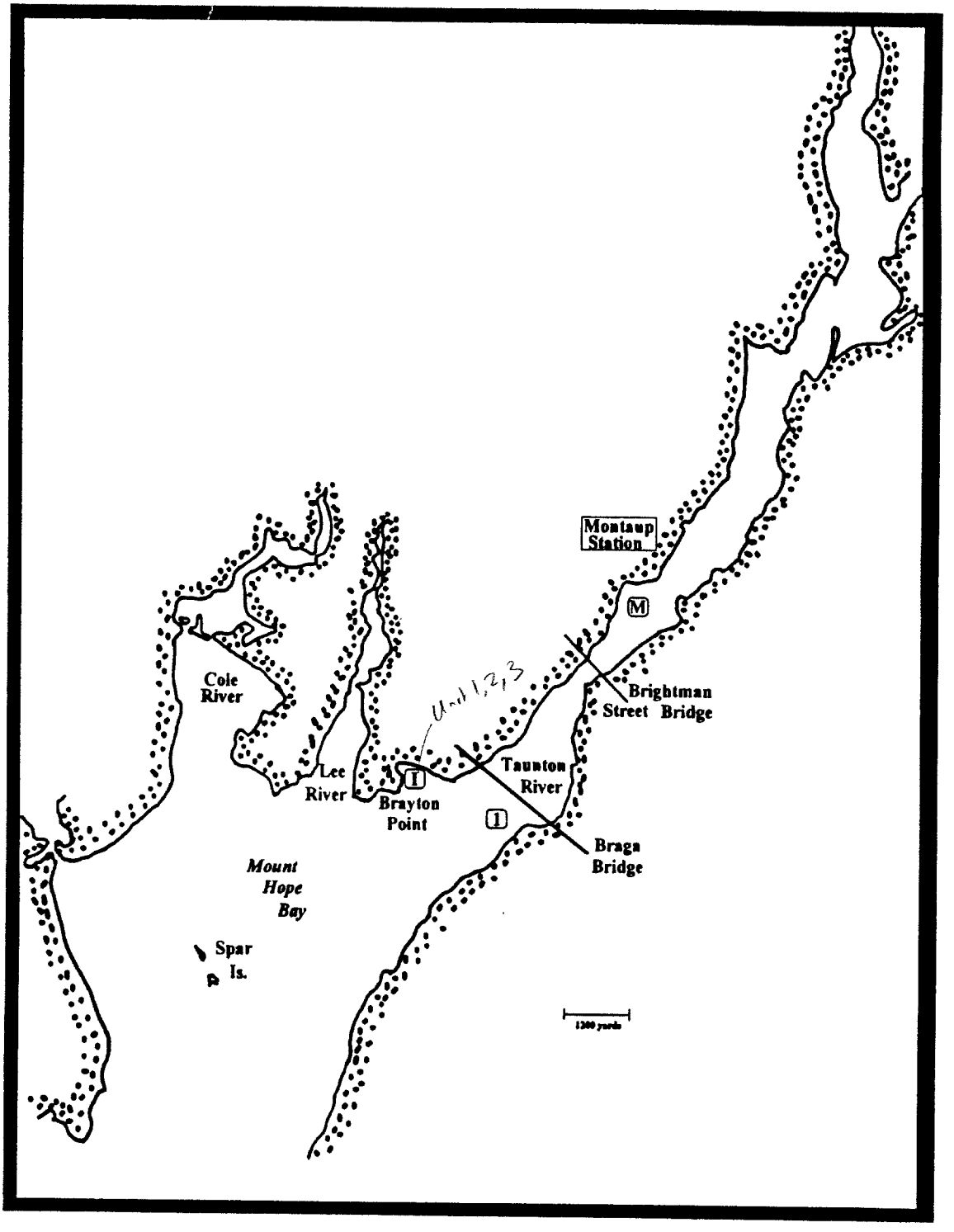


Figure I-2. Location of ichthyoplankton Station M opposite Montaup Power Station and Station I in the Brayton Point Units 1,2,3 Intake embayment. Mount Hope Bay Station 1 is shown for reference.

downloaded to a computer for viewing, it is not a real-time instrument. Data were reviewed following each sampling series and any necessary cable deployment adjustments made on subsequent surveys. At Station I, tows were oblique but restricted to the upper followed by the lower half of the water column, a total of six samples being taken at that station (3 upper, 3 lower). To minimize contamination with surface ichthyoplankton when sampling the lower half of the water column at Station I, the vessel was stopped and winch speed increased during initial wire pay-out and final haul-back so that net descent and ascent through the surface layer involved minimum time and distance. Due to shallow depths at most stations (<20 feet), the net was lowered and hauled back more than once during the course of each tow to make up a minimum tow time of five minutes. With this length of tow, approximately 100 to 150 m^3 of water were sampled. Actual filtration volumes were computed using readings obtained from a net-mounted General Oceanics Model 2030R flowmeter.

Samples were preserved in 10% Formalin-seawater solutions and returned to the laboratory for microscopic analysis. For February-April all 0.333-mm mesh samples were analyzed to insure complete assessment of small larval winter flounder. Beginning in early May when larvae are larger in size, only 0.505 mm mesh samples were analyzed. Since annual abundance indices for flounder larvae in many past years have been based only on samples from 0.505-mm mesh nets (1973-1994), adjustment was necessary to account for extrusion of stage 1 and 2 larvae through the larger mesh, i.e., 1995-1998 0.333-mm mesh counts had to be scaled down. Since earlier studies (NEP and MRI 1995) indicated that older (stage 3) larval flounder are well retained by 0.505 mesh, extrusion analyses were restricted to March and April when young larvae were most common.

Fish eggs and larvae were identified to the lowest distinguishable taxonomic category and counted. In most cases entire samples were examined for fish larvae and the less common types of fish eggs. When a particular species was especially abundant, aliquot subsamples were taken. Such subsamples contained 100 or more specimens of a given species or grouping. Studies have indicated that subsampling error can be maintained at a low level if numbers of specimens in an aliquot increases as the fraction represented by the aliquot grows smaller, e.g., 100 larvae are sufficient in a one-half split, but 200 should be present in a one-quarter split.

Due to their abundance and the economic importance of the species, winter flounder larvae (*Pleuronectes americanus*) were classified into four arbitrary developmental stages. These stages, with their approximate ranges in total length, were defined as follows:

Stage 1 - from hatching until the yolk sac is fully absorbed (2.3-3.8 mm).

Stage 2 - from the end of stage I until a loop or coil forms in the gut (2.6-4.0 mm).

Stage 3 - from the end of stage II until the left eye migrates past the midline of the head during transformation (3.5-8.0 mm).

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

As a check on accuracy and to maintain consistency between sorters, 10% of the samples taken each month were recounted. These samples were selected at random and re-analyzed independently by a second technician in all cases. In every instance the technician carrying out the recount did not know the original sample counts. Analysis of recounts over a long period of time has shown that combined subsampling and technician error average about 12% for eggs and 10% for larvae.

Results and Discussion

Population densities per 100 m^3 of water calculated for each species of fish by station and date among 0.333-mm mesh samples (0.505-mm mesh beginning May 6) are presented in Appendix Table A2. The occurrence of each of the 21 species collected in the spring of 1998 is shown by week in Table I-2. Whether eggs and/or larvae were represented in each case is also shown.

During the late February to mid-May collection period, numerical dominants included Atlantic

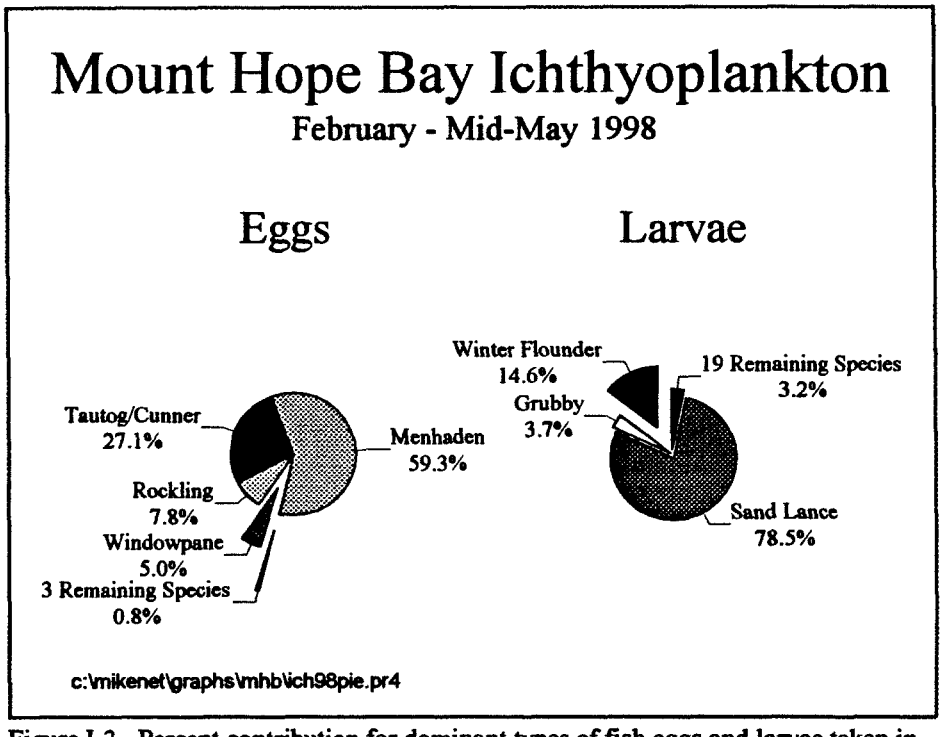


Figure I-3. Percent contribution for dominant types of fish eggs and larvae taken in Mount Hope Bay, February to mid-May, 1998.

menhaden (*Brevoortia tyrannus*), tautog/cunner (the labrids - tautog, *Tautoga onitis* and cunner, *Tautogolabrus adspersus)*, fourbeard rockling (*Enchelyopus cimbrius*), and windowpane (*Scophthalmus aquosus*) among the eggs, along with sand lance (*Ammodytes sp.*), winter flounder, and grubby (*Myoxocephalus aenaeus*) among the larvae (Figure I-3).

The distribution of geometric mean larval flounder densities by week appears in Figure I-4. For reference, high and low geometric mean densities recorded for each week from 1973 through 1997 were also plotted and the area between shaded. Since young larvae were more readily retained by the 0.333-mm mesh utilized beginning in 1995, densities were scaled down by empirically derived mesh conversion factors to align them with past years' results. For 1998, mesh conversion values were 2.66 for stage 1, 2.83 for stage 2 larvae, and 1.37 for early stage 3 larvae (see mesh discussion below). Larval winter flounder were first recorded when sampling began on February 17, reached a peak geometric mean density on April 3 of 56 per 100 m^3 of water (30 per 100 m^3 following mesh adjustment), and continued to be collected in low numbers as late as May 18 when sampling ended. Clearly, densities tracked well below average throughout the larval season, ranking last in the time series.

To facilitate comparison between years, the area under each annual abundance curve was computed using trapezoidal integration (Figure I-5). To provide error estimates, geometric mean densities per 100 m^3 of water were produced for each season along with their 95% confidence limits (Figure I-6, Table I-3). Two-way analysis of variance using log-transformed densities, station and year as main effects, provided the estimated error terms. Prior to calculating station means, early and late season collections were removed to eliminate the large number of zeros recorded during those times. This approach removed less than 0.8% of the total catch from each annual data set. Integrated curve areas and geometric mean densities are listed below in decreasing rank order.

Integrated			Geometric	
Year	Area	Rank	Mean	Year
1992	10826	1	74.9	1992
1978	9599	2	74.9	1984
1985	8845	3	49.4	1985
1984	8453	4	45.1	1995
1995	8245	5	43.7	1982
1982	7630	6	40.4	1978
1975	7366	7	39.9	1989
1979	6272	8	31.4	1976
1989	6211	9	29.5	1975
1973	5678	10	28.4	1997
1983	5205	11	27.5	1973
1980	4247	12	22.1	1987
1976	4180	13	22.1	1974
1987	3897	14	21.0	1980
1974	3628	15	20.3	1983
1986	2791	16	19.9	1979
1981	2508	17	18.5	1990
1997	2500	18	17.5	1991
1993	2485	19	16.8	1981
1990	2351	20	16.6	1993
1977	2202	21	15.6	1986

1991	1970	22	15.0	1994
1994	1895	23	15.0	1988
1988	1741	24	8.8	1977
1996	1210	25	8.3	1996
1998	865	26	7.8	1998

Relatively minor shifts in rank order are apparent between the two abundance indices in most cases. For example, 1984 ranked fourth by curve area, second by geometric mean. Indices for 1979 and 1997 represented the largest differences with seven positions separating the two indices. Values for both years appear in the middle of the scales where relatively small differences separated years. The 1998 season was poor relative to past years, ranking 26th or last using both indices.

Annual larval flounder abundance does not appear to be correlated with adult abundance in Mount Hope Bay. Both curve area and geometric mean larval indices were compared with adult stock size recorded by standard trawl during the months when adults are present in the Bay for the spawning season, February-April, 1973-1998 (kg/tow, see finfish Section A). Correlation coefficients were not significant ($p > 0.10$) in either straight or log scales (Figure I-7, Table I-4). Correlation coefficients were also calculated for stock abundance versus stage 1, yolk-sac larval abundance alone since starvation, predation, and other sources of mortality would have less time to introduce variability into the system. No correlation was detected in this case either ($p > 0.10$; Table I-4). Intuitively, a relationship must exist between spawning stock size and reproductive potential although it can be difficult to detect using larval abundance (because they produce demersal, adhesive eggs winter flounder eggs are not sampled in Mount Hope Bay). The interconnected roles of larval nutrition, predation, and environmental variables result in highly complex systems (see for example Postuma and Zijlstra 1974, Houde 1987, Myers et al. 1995, McGovern and Olney 1996). These complexities are reflected particularly in Mount Hope Bay's 1992 data where larval abundance was the highest yet observed while adult abundance was the lowest. Since winter flounder eggs are demersal and adhesive, their true abundance is not readily measurable with any accuracy in the Mount Hope Bay survey. Any existing relationship between adult and progeny clearly becomes more obscure as mortality operates on the egg and subsequent larval stages. Presumably species like winter flounder which have an incubation period as long as 30 days and a larval period lasting another 50 days or more are subject to predation and other forms of mortality for a long period of time which may contribute to great variability in numbers of offspring.

The shape of larval winter flounder abundance curves has, in some studies, been related to water temperature, cool temperatures during winter and early spring producing broad curves and good year classes (NUSCO 1988, Buckley et al. 1990). Winter flounder stocks in some areas have been shown to decline during periods of relatively warm winters (Jeffries and Johnson 1994, Jeffries and Terceiro 1985). In 1998 the January-April air-water temperature index (5.0 C) was the highest yet observed exceeding the long term mean of 2.4 C by 2.6 C (Figure I-8, Table I-5) consistent with poor larval production. Examination of the late-winter, spring temperature profile (Figure I-9) showed that essentially the entire season was mild reflecting above average February, March, and April air temperatures (4.1, 2.1, and 1.3 C above average, respectively, in Providence according to NOAA weather records).

Many other studies have examined possible relationships between fish stocks and environmental variables (see for example Shepard et al. 1984, Sissenwine 1984, Pihl 1990, Pace et al 1993, Myers et al 1995). In spite of the warm, low larval abundance season in 1998, overall larval collections in Mount Hope Bay do not appear to be correlated with the January-April Bay temperature index (Figure I-10, Table I-6). There is, however, some suggestion that larval abundance reaches greater values during years when spring water temperatures warm gradually without numerous abrupt changes (see also Buckley et al. 1990). The variable "water temperature difference" was calculated by averaging the absolute difference in water temperature (10-ft depth) between successive sampling dates. Since sampling interval shifted from seven to five days beginning in 1980, only 1980-1998 data were considered (see also NEP and MRI 1996). A scatter plot of these data (Figure I-11) shows that the four highest larval abundance seasons (1984, 1985, 1992, 1995) had four of the five lowest mean differences. These four years provided enough leverage to produce a significant correlation coefficient ($r = -0.477$, $p = 0.039$) although little or no pattern is apparent in the remaining years.

In Mount Hope Bay age 1 flounder abundance does appear to be correlated with water temperature, cooler years producing stronger year classes ($r = -0.543$, $p = 0.005$, Figure I-12 , Table I-6). This correlation without a corresponding one between temperature and larval abundance is difficult to interpret in the absence of absolute or relative numbers of eggs produced each season, i.e. years with high survival rates could be masked by low egg production. Results suggest that cool temperatures do not directly or indirectly affect numbers of larvae prior to metamorphosis but that individuals surviving beyond the larval stage are in good condition and more likely to survive beyond that point. Studies completed by Buckley et al. 1990 indicate that cold winters followed by gradual spring warming favor good survival and recruitment. In light of the correlation between temperature and age 1 flounder it is likely that a correlation will be found between temperature and young-of-the-year abundance once a sufficient number of years have been sampled. With seven years currently available (1992-1998) no correlation is apparent between the deviation from the long-term mean in January-April temperatures and mean number of young-of-the-year flounder per haul ($r = 0.149$, $p = 0.749$).

The observed correlation between larval flounder abundance and spring warming pattern (variable = temperature difference, Figure I-11) was also observed among young-of-the-year flounder in spite of the short time series available (1992-1998, $r = -0.833$, $p = 0.020$, Figure I-12). These data support the importance of gradual spring warming in producing better year classes.

Stations 21 and 23 located near the western and eastern outlets of Mount Hope Bay, respectively, were introduced to the sampling program in 1993 after being dropped following the 1985 season. In each year from 1993 through 1998 these two stations increased the bay-wide annual curve area abundance index with two exceptions in the years 1996 and 1997. The addition of those two stations increased the curve area by 11% in 1993, 6% in 1994, 16% in 1995 and 9% in 1998. During those years densities were relatively high down-bay from mid-April to the end of the larval season. Compared with these years, larval distribution differed in 1996 and 1997 with Stations 21 and 23 contributing a smaller percentage of the total catch. During these two seasons, the curve area index actually declined by 3% (1996) and 4% (1997) when Station 21 and 23 densities were added.

The percentage of larval flounder taken at Stations 21 and 23, which originate from upper Mount Hope Bay or enter the Bay from the Sakonnet River and beyond the Mount Hope Bridge, is presently unknown. Earlier work in Narragansett Bay clearly shows winter flounder larvae to be abundant throughout the Bay and in particular the entire Sakonnet River (Bourne and Govoni 1988). Studies completed in 1977 at stations running from the Taunton River through the Sakonnet River nearly to Rhode Island Sound suggested that some spawning may occur below Tiverton (MRI 1979). Spawning in the Sakonnet River was also suggested by sampling completed at four locations in 1993 (NEP and MRI 1994).

Brayton Point Intake Station I and Taunton River Station M

Densities from upper and lower halves of the water column at Brayton Point Intake Station I (Appendix Table A3) were compared with paired sample t-tests using log-transformed densities. For stage 1, stage 3, and total larval flounder, densities, over the season as a whole, averaged statistically higher in the lower half of the water column ($p < 0.001$). For stage 2 larvae, densities averaged higher in the lower half of the water column as well but the difference was not statistically significant ($p = 0.14$; Figure I-13, Table I-7). The pattern observed in 1998 conforms to that observed from 1994 through 1997 with two exceptions. Among stage 2 larvae, densities were greater in the lower-half depth strata in both 1995 and 1996, consistent with 1998. However, in 1997 a reversal occurred as these individuals were significantly more numerous in the upper half of the water column ($p = 0.02$). Greater average densities in the upper water column were also observed among stage 2 individuals in 1994 although in that year the difference could not be shown to be statistically significant because fewer samples were taken (replicate samples were not taken in 1994 and sampling did not begin there until mid-March).

Larval winter flounder are often reported to be more abundant near bottom compared with surface waters. Pearcy (1962) reported that over all size ranges 85% of the larval flounder collected in the Mystic River, Connecticut estuary were in the lower half of the water column. However small larvae (2.5-3.7 mm) were somewhat more common in surface waters relative to older, larger individuals. Sampling by MRI (1979) in upper and lower halves of the water column in the Taunton River ship channel found larval flounder to be generally more abundant in the lower half early in the larval season, more abundant in the upper half during the middle of the season, and in the lower half late in the season. NUSCO (1992) used a specially designed pump sampler to collect yolk-sac larval flounder at four depth strata: surface, mid-depth, 0.3 m above bottom, and at the sediment-water interface. Results indicated that yolk-sac larvae were most abundant at mid-depth and near-bottom, least abundant at the surface and sediment-water interface.

Larval flounder were collected at Station M opposite Montaup Power Station when sampling began there on February 17 and were still present there on May 18 when sampling ended, albeit at a density below 1 per 100 m^3 of water (Appendix Table A4). They reached a peak density of 106 per 100 m^3 of water on April 3. Analysis of variance on log-transformed densities was used to examine for differences in mean larval flounder density at Montaup Station M, Mount Hope Bay Station 1, and Brayton Point Intake Station I since these three stations are near the Taunton River mouth and probably most closely represent the pool of water from which Brayton Point draws its intake water. A statistically significant difference ($p = 0.044$) was detected only among stage 1 larvae

where seasonal densities were significantly higher at Station I than at Station1while the average density at M was intermediate between and similar to each of those two locations. For older stage 2 and stage 3 flounder as well as total larval flounder, densities were statistically similar at the three stations (Table I-8). During previous seasons among-station differences were detected in 1996 and 1997 but not during 1994 and 1995 (Figure I-14). Among-station differences involved stage 1 larvae in 1996 and 1998, stage 2 larvae in 1997, stage 3 larvae in 1996 and all stages combined in 1996.

Annual Stations M, 1, and Intake data sets where no differences were detected were subsequently pooled to improve statistical power to detect any patterns consistent over seasons. Among-station differences were not detected. This was true for stage 1 larvae ($p = 0.145$; 1994, 1995, 1997 pooled), stage 2 larvae ($p = 0.789$; 1994, 1995, 1996, and 1998 pooled), stage 3 larvae ($p = 0.944$; 1994,1995, 1997, and 1998 pooled) and total larval flounder ($p = 0.274$; 1994,1995, 1997, and 1998 pooled; Table I-9). In spite of pooling data sets power to detect among station differences remained low because average density differences between location were relatively small and variability over time was great. For example for total larvae, power to detect differences among stations was only about 17%. In general, the pooled results together with the lack of consistency across years suggests that larval densities are fairly well mixed in and near the lower Taunton River. This is consistent with earlier conclusions based on an array of 12 stations (MRI 1979)

Mount Hope Bay Mesh Comparisons - 0.333 vs 0.505-mm mesh

During March and April 1998, 46 samples taken with 0.505-mm mesh nets were analyzed from the paired bongo tows to quantify larval winter flounder mesh extrusion through the larger mesh (Table I-10). Since all annual abundance indices preceding 1995 were based on 0.505 samples, these data were needed to scale the 1998 0.333-mm mesh based densities downward.

Paired sample t-tests using log-transformed densities were used to examine for differences between nets. Statistically significant differences were detected for both stage 1 and stage 2 larvae (Table I-10). Geometric mean ratios were 2.66 and 2.83, respectively, values which are consistent with past years (Table I-11). Previous values ranged from 1.85 (1997) to 9.21 (1978) for stage 1 individuals and 1.77 (1997) to 3.88 (1977) for stage 2. There was a small but statistically significant difference in catch ratio for stage 3 larvae in 1998 also (1.37, $p = 0.009$). While ratios of 1.20 and 1.21 were recorded for these larger larvae in earlier years (1977, 1978, and 1997), 1998 was the first in which the difference was statistically significant. In calculating the 1998 abundance index, stage 3 densities were divided by1.37 through the third week of April, following which these individuals were assumed to be equally retained by both mesh nets (MRI 1979).

The relatively low mesh ratio values recorded in 1997 could be attributable to high zooplankton densities at that time. While zooplankton displacement volumes were not determined, the samples were noted to contain abundant zooplankton which may have coated the mesh and reduced extrusion. Zooplankton samples taken from the Bay on April 15, 1997 (MRI 1998) indicated that large numbers of copepod nauplii were present in the samples at that time. These data indicate that extrusion is highly variable from year to year and that, even when relatively low as in 1997, can represent an important factor in determining abundance.

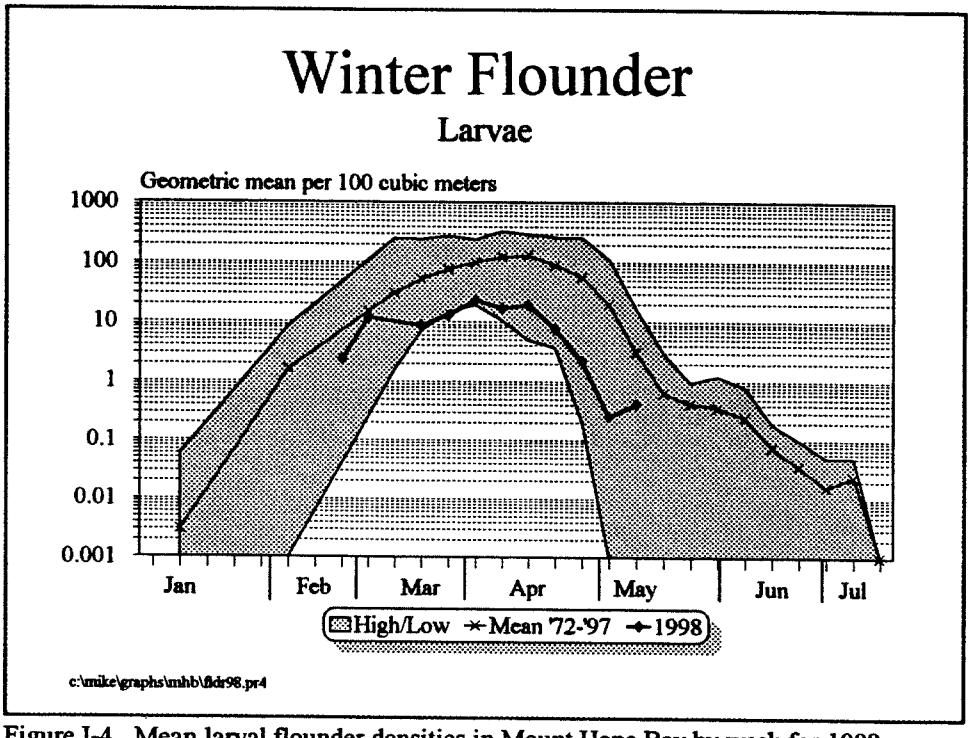


Figure I-4. Mean larval flounder densities in Mount Hope Bay by week for 1998 compared with the high and low for corresponding weeks, 1973-1997.

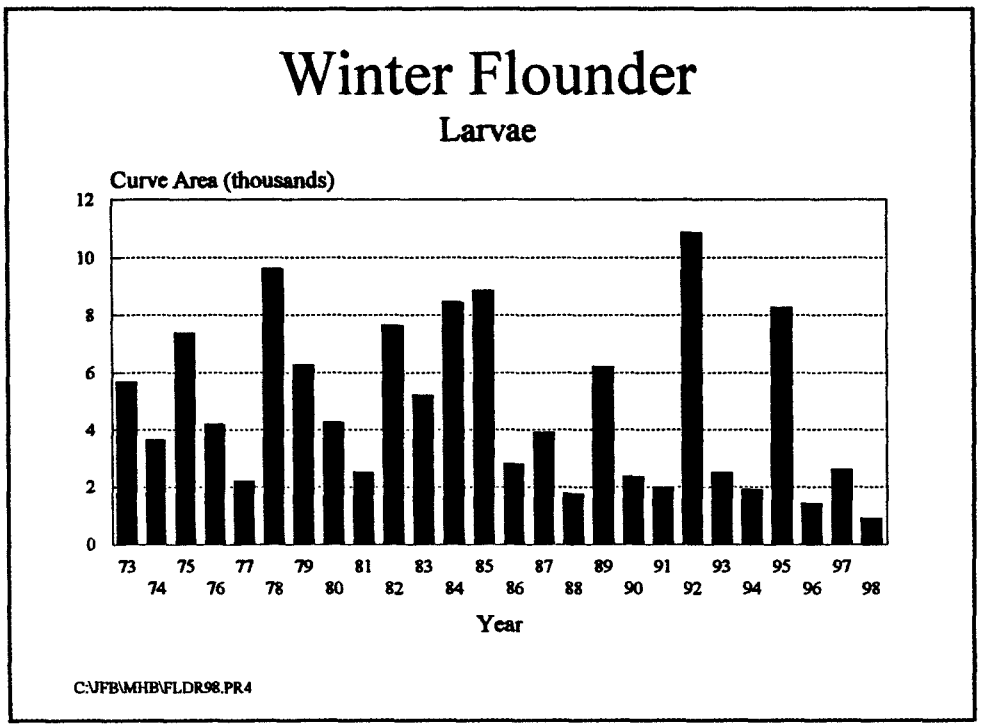


Figure I-5. Larval flounder curve area abundance indices for 1973-1998.

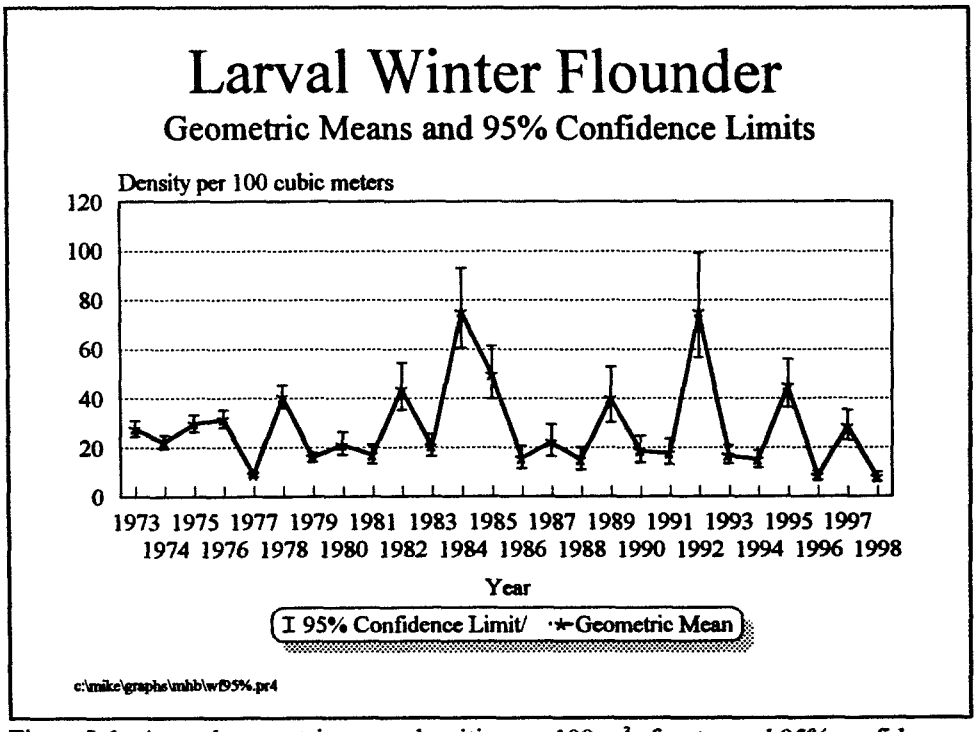


Figure I-6. Annual geometric mean densities per 100 m^3 of water and 95% confidence limits for larval winter flounder, Mount Hope Bay, 1973-1998.

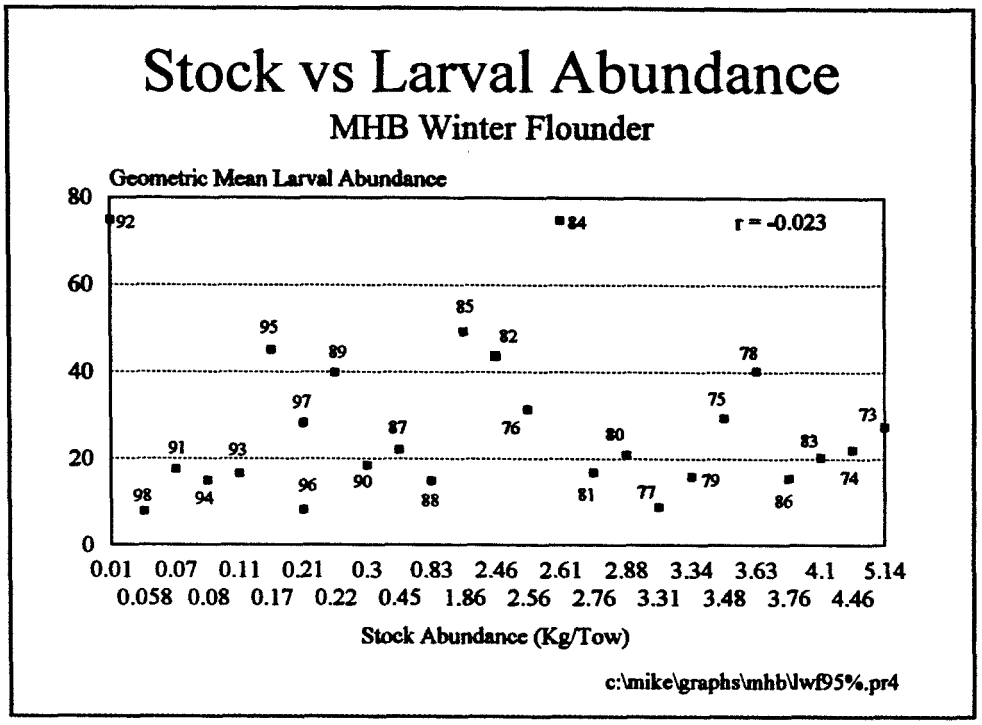


Figure I-7. Seasonal geometric mean larval winter flounder abundance compared with February-April stock abundance in kg per trawl tow, 1973-1998.

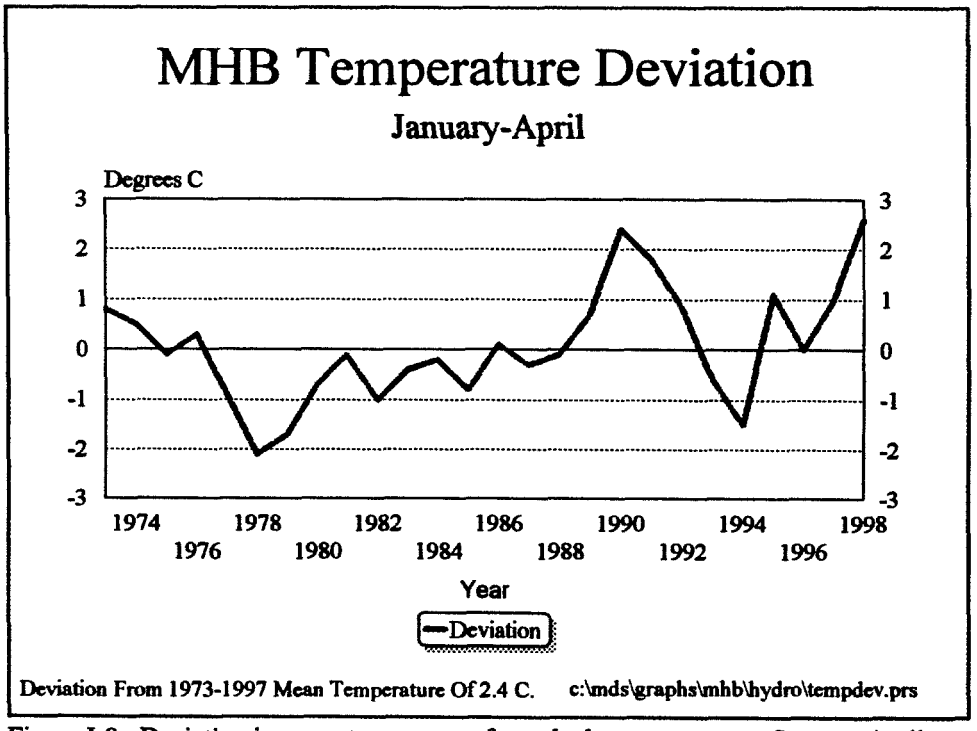


Figure I-8. Deviation in mean temperature from the long-term mean, January-April, 1973-1998. See Table I-4 for details.

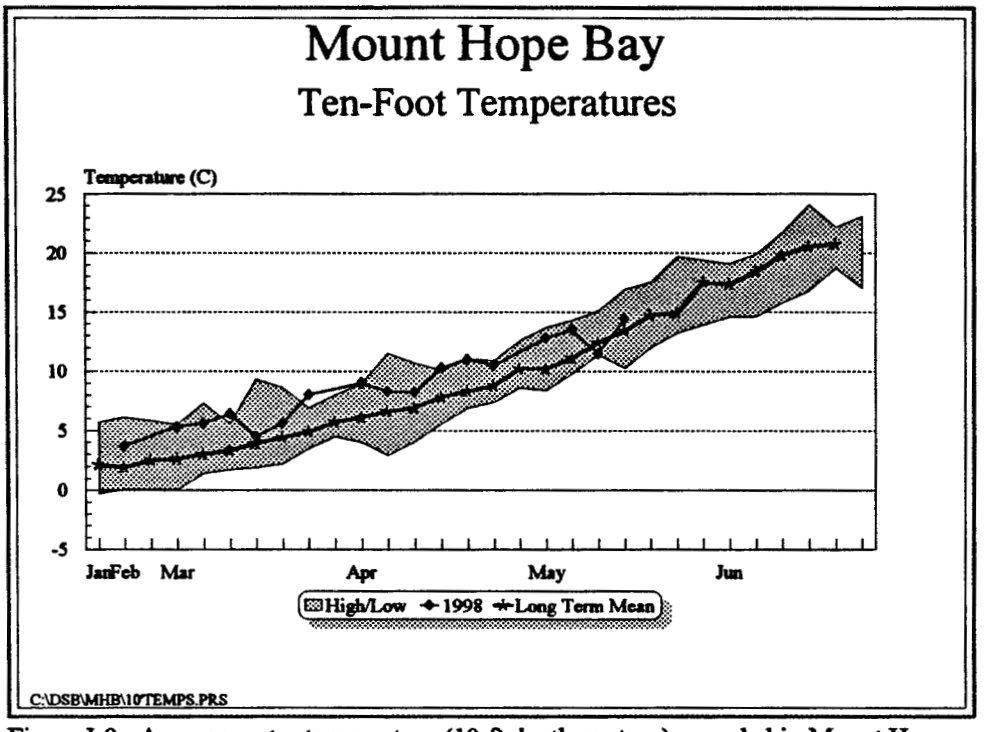


Figure I-9. Average water temperature (10-ft depth contour) recorded in Mount Hope Bay on each ichthyoplankton sampling occasion in 1998 during the larval flounder season. The long-term mean (1980-1997) and range are shown.

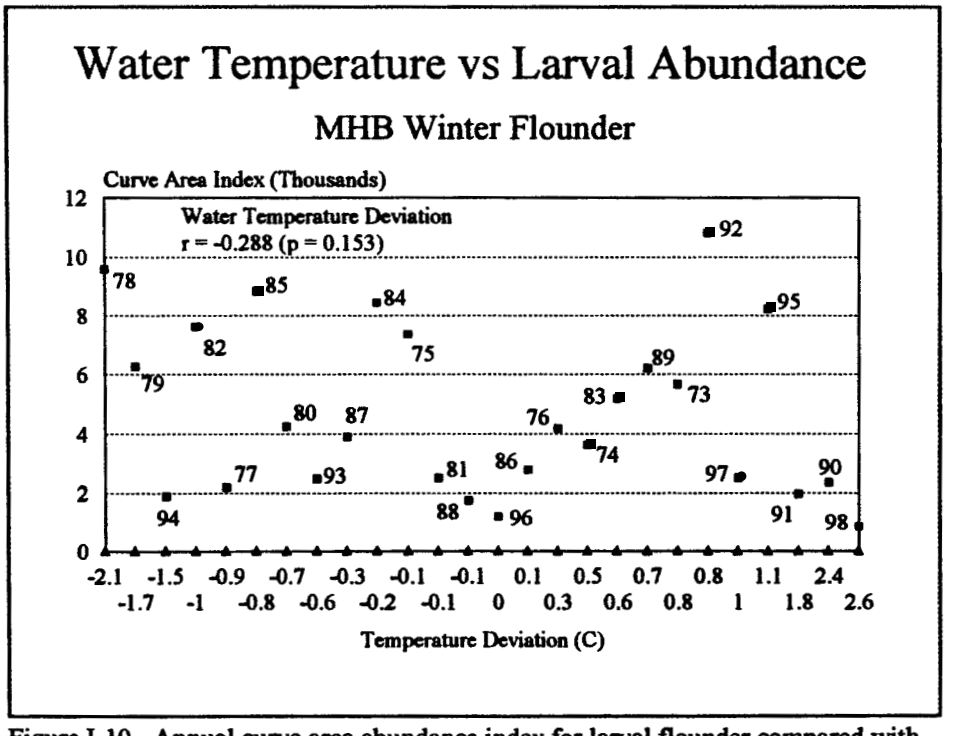


Figure I-10. Annual curve area abundance index for larval flounder compared with deviation in January - April water temperature index from the time series mean.

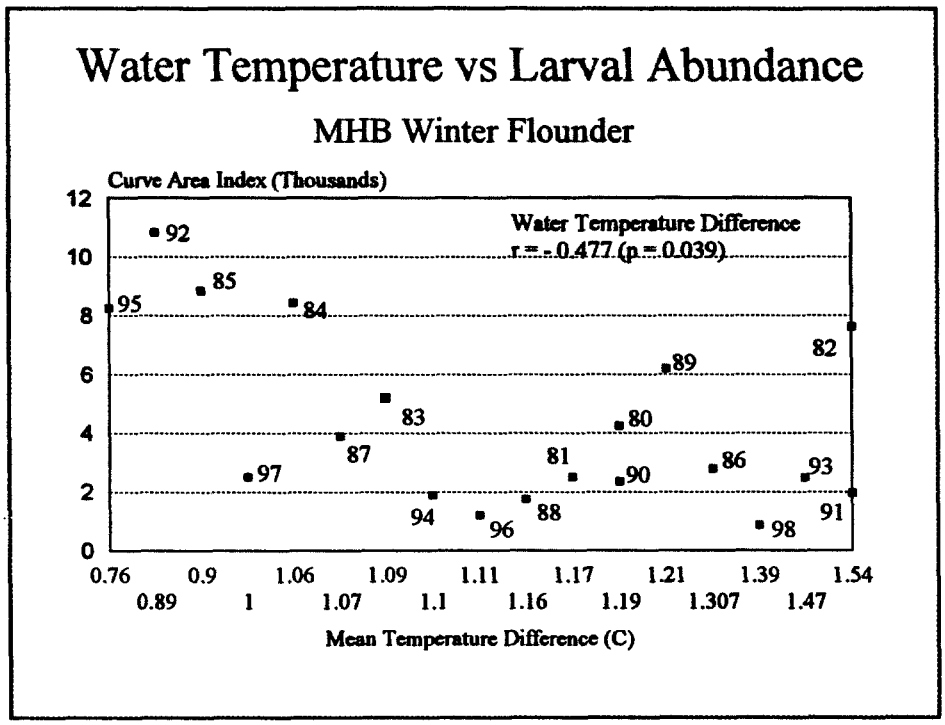


Figure I-11. Annual curve area abundance index for larval flounder compared with the mean absolute difference in successive water temperature readings.

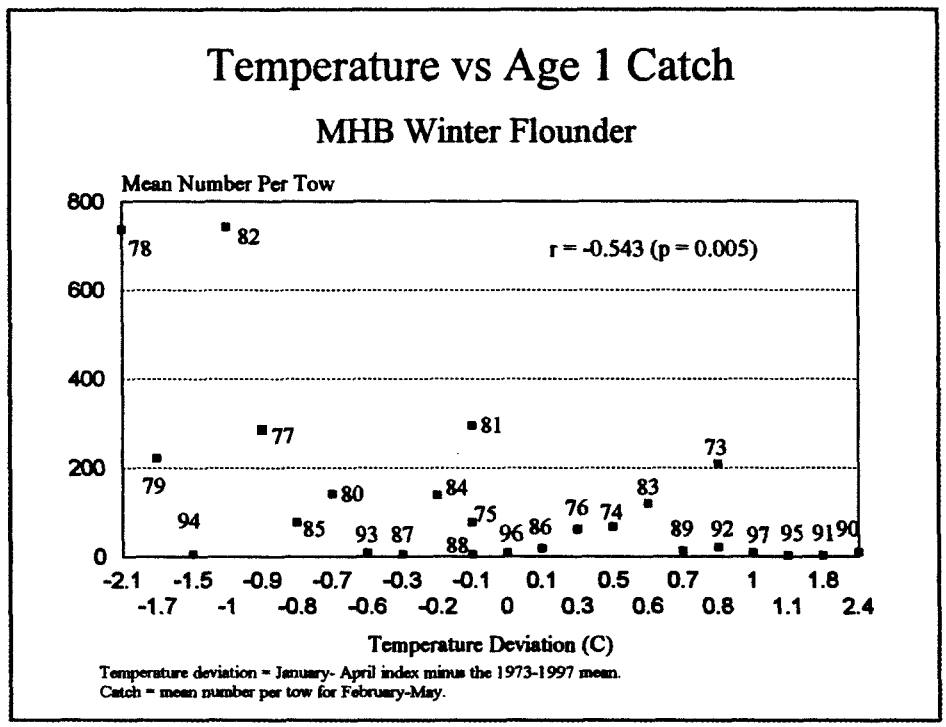
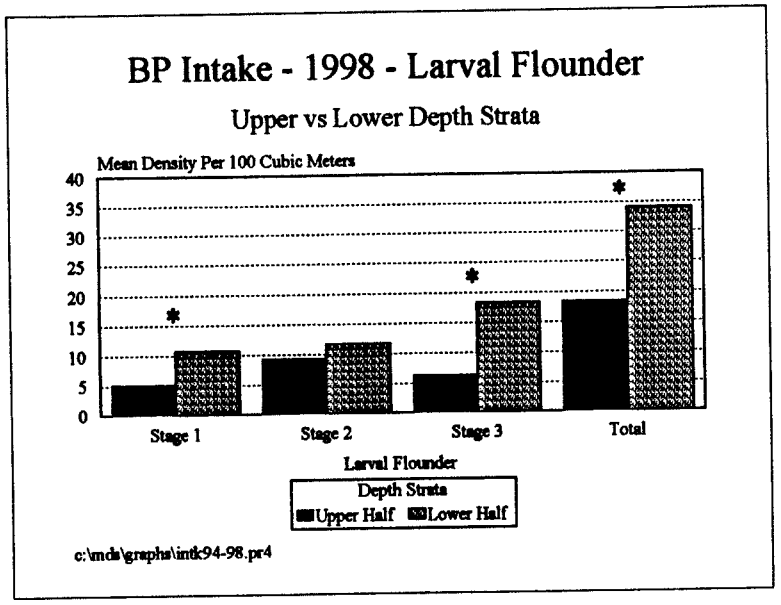
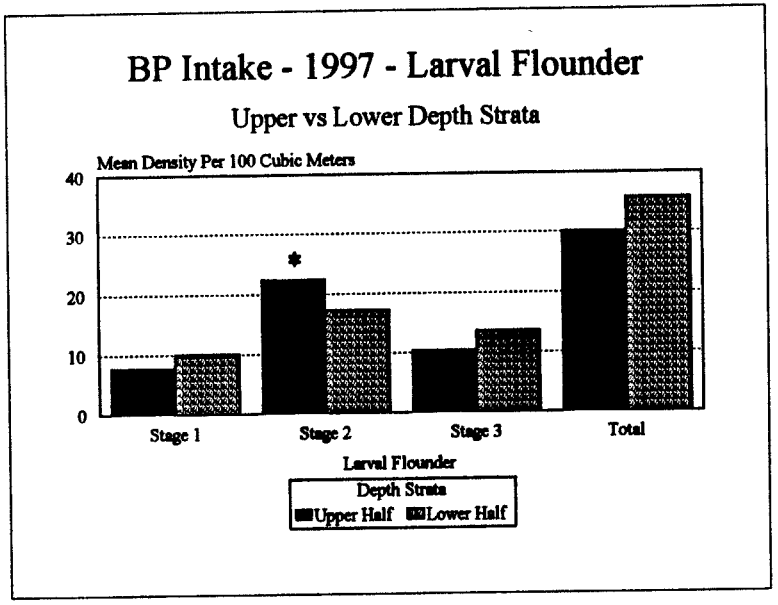
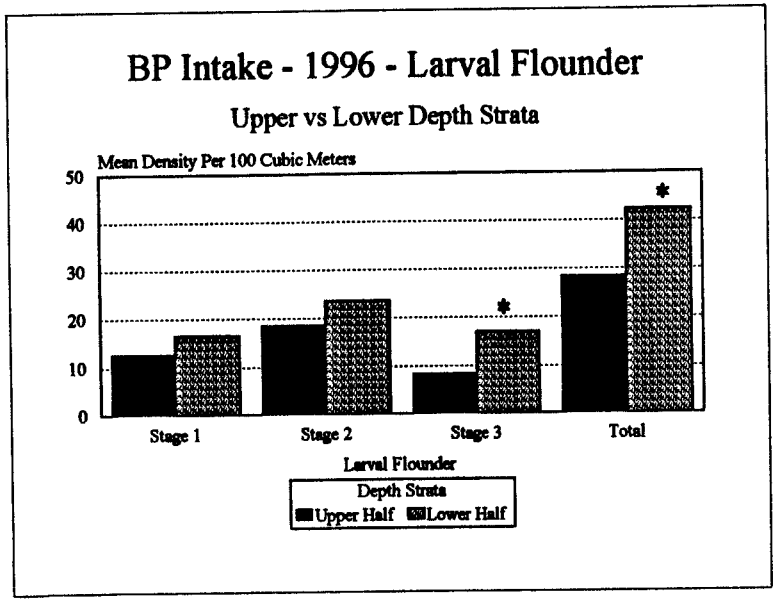


Figure I-12. Mean number of age 1 winter flounder per tow, February - May, compared with deviation in mean water temperature.







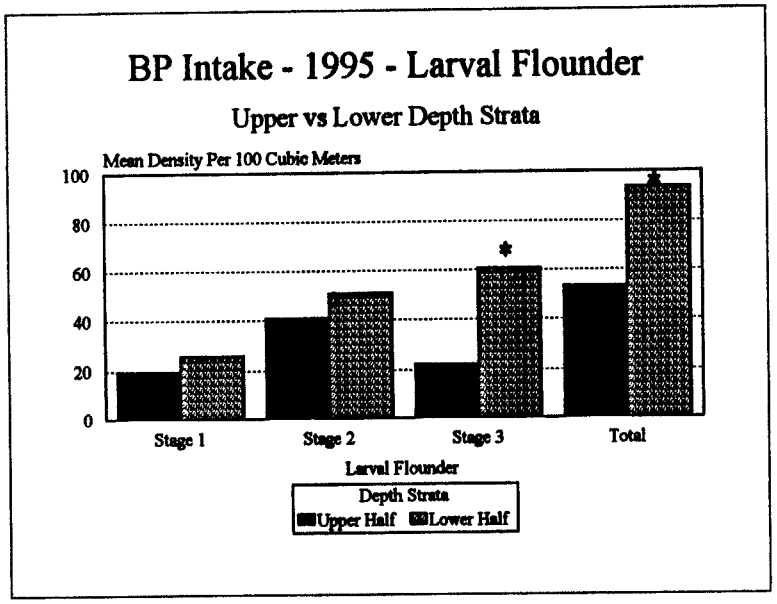
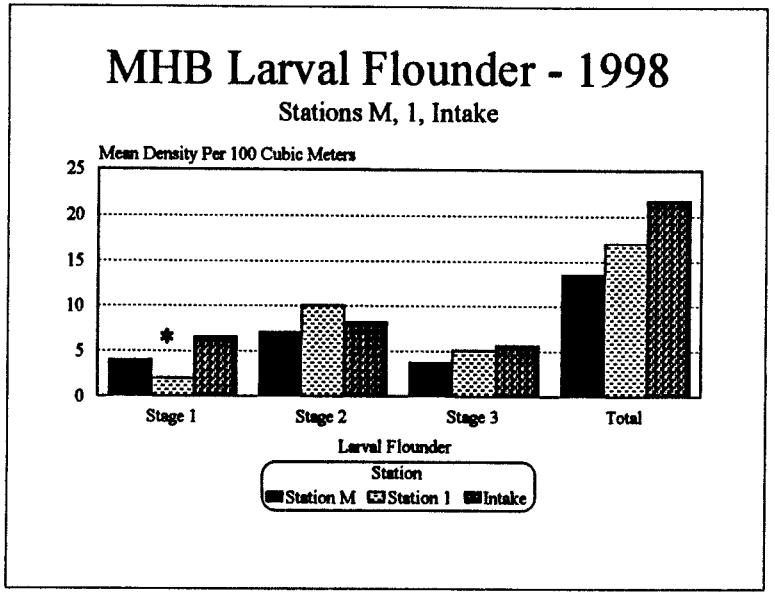
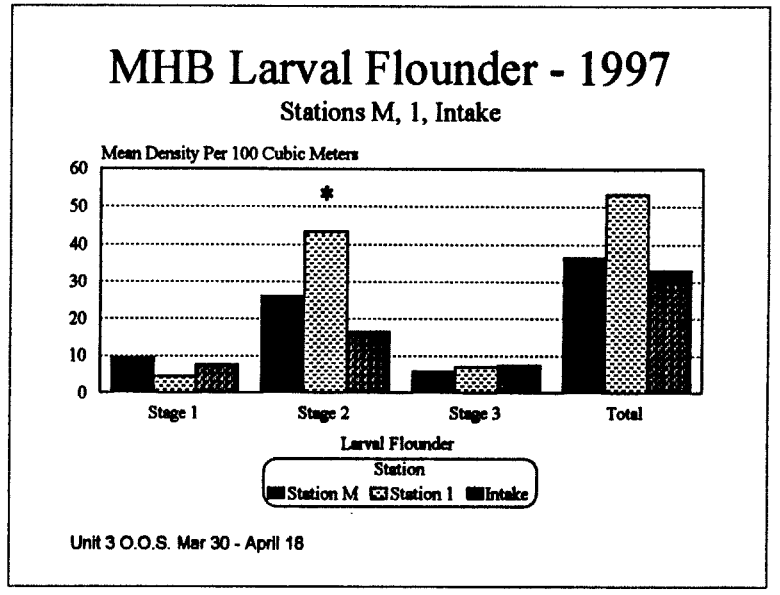
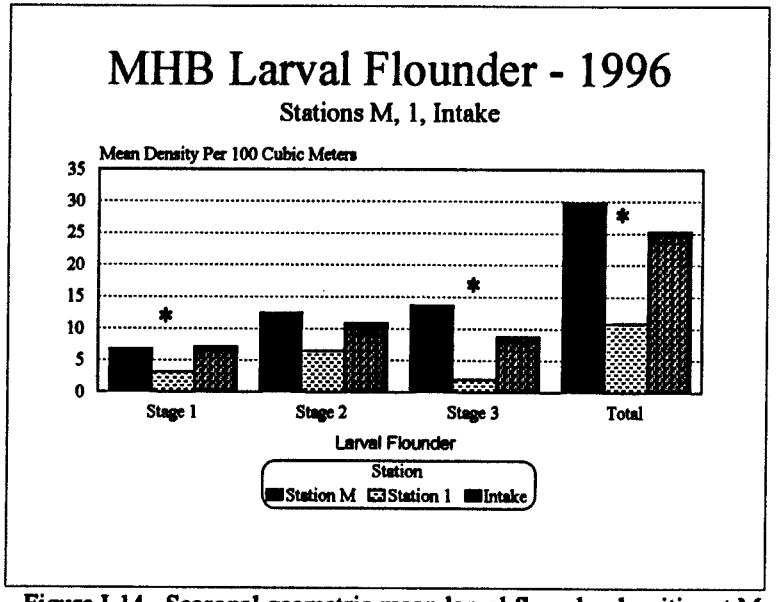


Figure I-13. Seasonal geometric mean larval winter flounder densities per 100 m^3 of water in upper and lower halves of the water column at Brayton Point Units 1,2,3 Intake Station I, 1995 - 1998. An * indicates where statistically significant differences were detected.







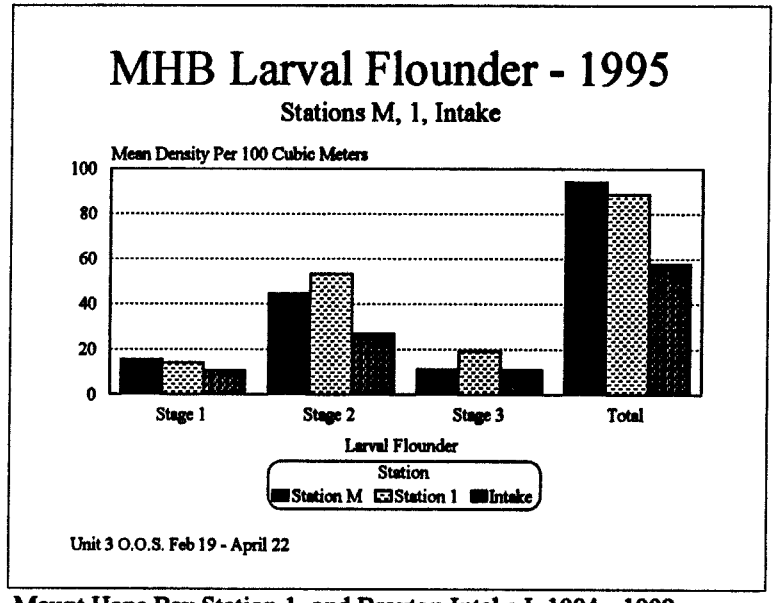
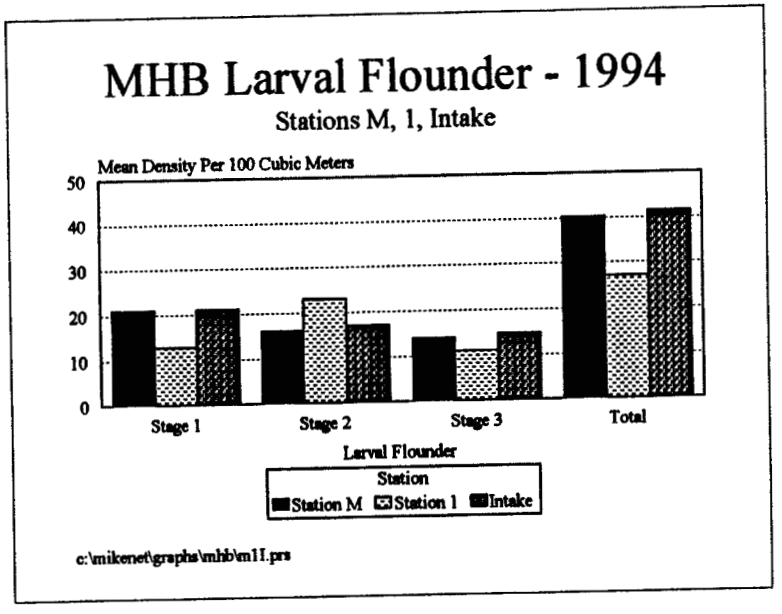


Figure I-14. Seasonal geometric mean larval flounder densities at Montaup Station M, Mount Hope Bay Station 1, and Brayton Intake I, 1994 - 1998. An * indicates where statistically significant differences were detected.



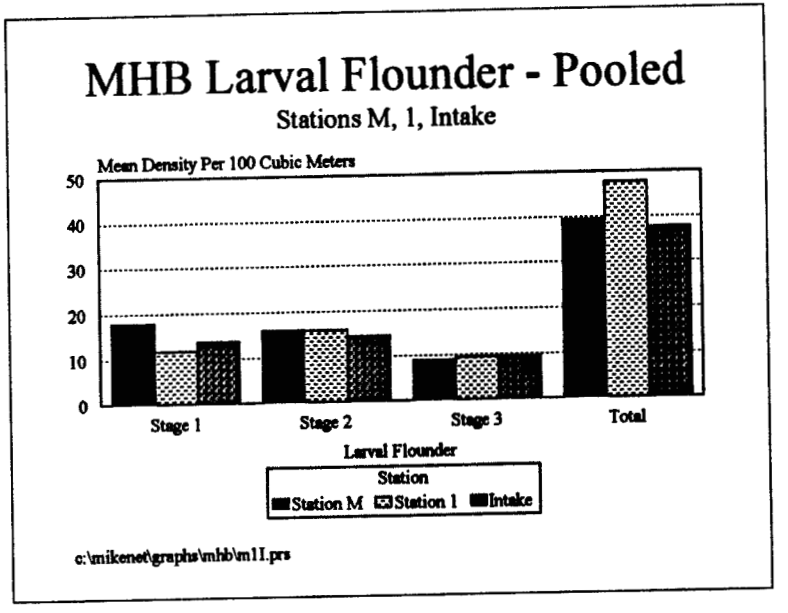


Figure I-14. continued.

Table I-1. Mount Hope Bay and Brayton Point Ichthyoplankton sampling information.

		1973-1	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Mount Hope Bay	January - December	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
	February-Mid-May Only																					■	■	■	■	■	■
	0.505-60 cm Bongo Nets Used	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
	0.333-60 cm Bongo Nets Used - 3					■	■																	■	■	■	■
	Larval Flounder Staged						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	23 Stations Sampled, Single Tows At Each	■	■	■	■	■	■	■																			
	7 Stations Sampled, Single Tows At Each							2	■	■	■	■	■	■								■	■	■	■	■	■
	5 Stations Sampled, Single Tows At Each														■	■	■	■	■	■	■						
	Brayton Intake (I) and Montaup (M) sampled																						■	■	■	■	■
	Weekly, March - August	■	■	■	■	■	■	■																			
	4 - 5-Day Intervals, March - August								■	■	■	■	■	■	■	■	■	■	■	■	■						
	Monthly, September - February	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
	4 - 5 Day Intervals, March - Mid-May																					■	■	■	■	■	■
	Once in February																					■	■	■	■	■	■
Brayton Point Entrainment	Units 1,2,3:																										
	January-December	■	■	■	■	■	■	■	■	■	■	■	■	■													
	February-Mid-May Only																					■	■	■	■	■	■
	0.505-60-cm Nets Used	■	■							■	■	■	■	■								■	■				
	0.333-60-cm Nets Used			■	■	■	■	■	■															■	■	■	■
	Single samples	■	■	■	■	■																					
	Triplicate samples						■	■	■	■	■	■	■	■								■	■	■	■	■	■
	Larval Flounder Staged						■	■	■	■	■	■	■	■								■	■	■	■	■	■
	Unit 4:																										
	February-Mid-May Only																				■	■	■	■	■	■	■
	0.505-60-cm Nets Used																				■	■					
	0.333-60-cm Nets Used																							■		■	
	Larval Flounder Staged																					■		■		■	
	No Sampling - Piggyback Operation																					4	■		■	■	■
	Sampling From April 1 - 16, Otherwise Piggyback																									■	

Shaded cells denote that sampling or operation was conducted.

1. Sampling actually began in June 1972.
2. Change from 23 to 7 stations occurred in October 1979.
3. Paired 0.505-mm mesh samples also taken in sufficient number to determine extrusion coefficient.
4. Unit 4 operated in piggyback mode during March, sampling began in April.

Larval winter flounder staging began, April 1977.

Table I-2. Species of fish represented by eggs (E) and larvae (L) in Mount Hope Bay ichthyoplankton collections taken from February to mid-May 1998 (results shown by week for March-May).

Species		Feb	March				April				May	
		17	2,6	16,20	25	30,3	8	13,17	21	27,1	6	13,18
Atlantic menhaden	*Brevoortia tyrannus*									E	E/L	E/L
Atlantic herring	*Clupea harengus*	L	L	L	L	L		L				
Rainbow smelt	*Osmerus mordax*					L	L	L	L	L	L	L
Fourbeard rockling	*Enchelyopus cimbrius*	E	E	E	E	E	E	E	E/L	E/L	E/L	E/L
Atlantic cod	*Gadus morhua*			L	L	L	L	L				
Atlantic tomcod	*Microgadus tomcod*	L	L		L			L				
Hake	*Urophycis* spp.											L
Threespine stickleback	*Gasterosteus aculeatus*											L
Atlantic silverside	*Menidia menidia*											L
Northern pipefish	*Syngnathus fuscus*						L					
Grubby	*Myoxocephalus aenaeus*	L	L	L	L	L	L	L	L	L		
Longhorn sculpin	*M. octodecemspinosus*	L	L	L								
Shorthorn sculpin	*M. scorpius*		L									
Seasnail	*Liparis atlanticus*							L				L
Wrasses	Labridae		E	E	E	E	E	E	E	E	E	E
Tautog	*Tautoga onitis*										L	
Cunner	*Tautogolabrus adspersus*							L			L	L
Radiated shanny	*Ulvaria subbifurcata*					L				L	L	L
Rock gunnel	*Pholis gunnellus*	L	L	L	L							
Sand lance	*Ammodytes* sp.	L	L	L	L	L	L	L	L	L	L	L
Seaboard goby	*Gobiosoma ginsburgi*					L		L		L	L	L
Atlantic mackerel	*Scomber scombrus*								E			E
Windowpane	*Scophthalmus aquosus*			E	E	E	E	E	E	E	E/L	E/L
American plaice	*Hippoglossoides platessoides*											E
Winter flounder	*Pleuronectes americanus*	L	L	L	L	L	L	L	L	L	L	L

Table I-3. Annual geometric mean densities per 100 m³ of water along with 95% confidence limits for larval winter flounder, Mount Hope Bay, 1973-1998.

Year	Geometric Mean	95% Confidence Limits
1973	27.5	24.5 - 30.9
1974	22.1	19.6 - 24.8
1975	29.5	26.2 - 33.2
1976	31.4	28.0 - 35.3
1977	8.8	7.8 - 10.0
1978	40.4	36.0 - 45.3
1979	15.9	14.1 - 18.0
1980	21.0	16.8 - 26.2
1981	16.8	13.4 - 21.0
1982	43.7	35.2 - 54.2
1983	20.3	16.3 - 25.3
1984	74.9	60.5 - 92.8
1985	49.4	39.8 - 61.3
1986	15.6	11.6 - 20.9
1987	22.1	16.5 - 29.4
1988	15.0	11.1 - 20.0
1989	39.9	30.0 - 52.8
1990	18.5	13.8 - 24.7
1991	17.5	13.1 - 23.4
1992	74.9	56.7 - 99.0
1993	16.6	13.3 - 20.8
1994	15.0	11.9 - 18.7
1995	45.1	36.3 - 55.9
1996	8.3	6.5 - 10.5
1997	28.4	22.8 - 35.3
1998	7.8	6.2 - 9.9

Table I-4. Adult stock size (kg/tow) during February-April and seasonal larval abundance per 100 m^3 of water for Mount Hope Bay winter flounder. Correlation coefficient matrix is shown below.

Year	Stock abundance (kg/tow)[1]	Mean larval abundance Geometric mean	Mean larval abundance (curve index)	Stage 1 (curve index)
1973	5.14	27.5	5678	
1974	4.46	22.1	3628	
1975	3.48	29.5	7366	
1976	2.56	31.4	4180	
1977	3.31	8.8	2202	
1978	3.63	40.4	9599	
1979	3.34	15.9	6272	927
1980	2.88	21.0	4247	1290
1981	2.76	16.8	2508	467
1982	2.46	43.7	7630	2079
1983	4.10	20.3	5205	127
1984	2.61	74.9	8453	1553
1985	1.86	49.4	8845	1270
1986	3.76	15.6	2791	912
1987	0.45	22.1	3897	2149
1988	0.83	15.0	1741	805
1989	0.22	39.9	6211	1616
1990	0.30	18.5	2351	519
1991	0.07	17.5	1970	388
1992	0.01	74.9	10826	1721
1993	0.11	16.6	2485	634
1994	0.08	15.0	1895	453
1995	0.17	45.1	8245	563
1996	0.21	8.3	1395	130
1997	0.21	28.4	2589	250
1998	0.06	7.8	865	81

[1]Based on Mount Hope Bay standard trawl.

Correlation matrix with stock abundance

	r	p
Curve index	0.240	0.239
Log curve index	0.366	0.066
Geometric mean	-0.023	0.910
Stage 1 curve area	0.127	0.593
Log stage 1	0.149	0.530

Table I-5. Mount Hope Bay winter flounder season temperature index (°C), January-April 1972-1998.

Year	Jan[1]	Feb[1]	Mar[2]	Apr[2]	Jan-Apr Mean	Feb-Apr Mean
1972	-0.7	-2.2	-	-		
1973	-0.5	-1.3	5.5	9.1	3.2	4.4
1974	-0.2	-1.7	5.1	8.4	2.9	3.9
1975	1.2	-0.9	3.2	5.7	2.3	2.7
1976	-4.7	1.9	4.8	8.9	2.7	5.2
1977	-6.2	-1.2	4.2	9.1	1.5	4.0
1978	-3.8	-5.5	3.4	7.0	0.3	1.6
1979	-1.1	-6.8	3.5	7.0	0.7	1.2
1980	-1.3	-2.9	2.9	7.9	1.7	2.6
1981	-6.5	3.0	3.6	9.1	2.3	5.2
1982	-5.8	-0.3	4.3	7.3	1.4	3.8
1983	-0.3	0.5	4.3	7.6	3.0	4.1
1984	-3.1	2.8	2.7	6.3	2.2	3.9
1985	-5.3	0.1	3.8	7.7	1.6	3.9
1986	-0.5	-1.7	3.5	8.6	2.5	3.5
1987	-1.7	-1.9	4.0	8.1	2.1	3.4
1988	-2.9	-0.1	3.9	8.2	2.3	4.0
1989	1.0	-1.2	4.2	8.2	3.1	3.7
1990	2.4	1.3	6.1	9.2	4.8	5.5
1991	-1.3	1.7	6.3	10.1	4.2	6.0
1992	-0.3	0.6	4.6	7.7	3.2	4.3
1993	-0.3	-3.2	3.0	7.7	1.8	2.5
1994	-5.2	-3.4	3.5	8.8	0.9	3.0
1995	2.2	-1.4	4.9	8.3	3.5	3.9
1997	-1.5	2.5	4.7	8.0	3.4	5.1
Mean 73-97	-1.8	-0.8	4.1	8.1	2.4	3.8
1998	1.7	2.8	5.8	9.6	5.0 (2.6)[3]	6.1(2.3)

[1]Average air temperature at Green Airport.
[2]Average water temperature, Mount Hope Bay , 10-ft depth.
[3]Deviation from long-term mean of 2.4 C.

Note: Water temperature data are not regularly available during January and February because sampling occurs monthly. Since water temperature and air temperature are highly correlated (r=0.722, see also Jeffries and Johnson 1974), they were combined to produce a temperature index shown in the two right-hand columns.

Table I-6. Correlation matrix between larval winter flounder abundance in Mount Hope Bay and two measures of water temperature.

	Temp. deviation[1]		Temp. difference[2]	
	r	p	r	p
Curve index	-0.288	0.153	-0.477	0.039
Log curve index	-0.338	0.091	-0.440	0.060
Geometric mean	-0.066	0.750	-0.451	0.052

[1]Temperature deviation is obtained by subtracting the annual January-April temperature index from the long-term mean. See Table I-5.

[2]Temperature difference is the absolute mean difference in water temperature readings on subsequent sampling dates.

Table I-7. Seasonal geometric mean densities per 100 m³ of water with 95% confidence limits for larval winter flounder collected in upper and lower halves of the water column, Brayton Point Intake Station I, 1994-1998.

	Upper	Lower	No. Pairs	p[1]	Consistent pairs[2]
1998					
Stage 1	5.0	10.7	39	0.001	26 lower
C.L.	3.2-7.5	7.2-15.9			
Stage 2	9.3	11.7	48	0.15	31 lower
C.L.	6.7-13.1	8.7-15.6			
Stage 3	6.2	18.2	27	<0.0001	25 lower
C.L.	4.1-9.3	12.6-26.1			
Total	18.4	34.0	52	<0.0001	42 lower
C.L.	13.4-25.0	26.7-43.4			
1997					
Stage 1	7.8	10.0	36	0.208	21 lower
C.L.	5.4-11.3	6.5-14.9			
Stage 2	22.3	17.2	39	0.020	25 upper
C.L.	17.6-28.1	13.6-21.7			
Stage 3	10.4	13.5	33	0.125	22 lower
C.L.	7.3-14.7	9.5-19.0			
Total	30.0	35.8	45	0.074	27 lower
C.L.	21.2-42.4	27.6-46.2			
1996					
Stage 1	12.7	16.4	39	0.15	24 lower
C.L.	7.9-20.0	9.4-28.0			
Stage 2	18.5	23.4	40	0.16	23 lower
C.L.	10.4-32.3	13.2-41.0			
Stage 3	8.3	16.8	26	0.001	20 lower
C.L.	4.9-13.8	11.8-23.6			
Total	28.3	42.2	47	0.008	30 lower
C.L.	16.5-48.0	25.3-70.1			

Table I-7 (continued).

	Upper	Lower	No. Pairs	p[1]	Consistent pairs[2]
1995					
Stage 1	19.6	25.8	42	0.116	28 lower
C.L.	12.4-30.3	17.5-37.9			
Stage 2	41.0	50.8	45	0.165	28 lower
C.L.	24.4-68.3	31.7-81.1			
Stage 3	22.0	60.6	27	0.0001	22 lower
C.L.	11.7-40.9	38.7-94.5			
Total	53.3	93.5	51	0.0001	38 lower
C.L.	31.9-88.9	63.1-138.3			
1995-1997					
Stage 1	13.5	17.6	115	0.012	71 lower
C.L.	10.6-17.2	13.6-22.6			
1994					
Stage 1	10.3	16.7	17	0.09	14 lower
C.L.	4.6-21.9	7.5-35.6			
Stage 2	21.2	15.3	20	0.23	11 upper
C.L.	11.5-38.2	7.6-29.7			
Stage 3	13.0	21.6	13	0.12	10 lower
C.L.	6.9-23.6	10.6-42.9			
Total	42.5	52.4	22	0.18	16 lower
C.L.	27.8-64.9	34.6-79.3			

[1]Probability value from two-tail paired t tests. Values ≤ 0.05 are considered statistically significant.

[2]Number of upper-lower pairs whose difference carried the same sign, e.g., 24 of 39 pairs for stage 1 flounder larvae showed greater densities in the lower half of the water column in 1996.

Table-I-8. Summary data from two-way factor (date and station) analysis of variance comparing larval flounder densities (total and staged) at Montaup Station M, MHB 1, and BP 1,2,3 Intake I, 1998.

	Station			
	M	1	I	Station Effect
Total Flounder				
Geometric mean	13.5	17.0	21.6	F=1.13
Lower 95% CL	9.4	119	15.2	p=0.333
Upper 95% CL	19.2	24.1	30.6	d.f.=2/34
Stage 1				
Geometric mean	4.0	2.0	6.5	F=3.55
Lower 95% CL	2.5	1.1	4.2	p=0.043
Upper 95% CL	6.2	3.3	9.9	d.f.=2/26
Stage 2				
Geometric mean	7.1	10.0	8.2	F=0.84
Lower 95% CL	4.8	6.8	5.6	p=0.443
Upper 95% CL	10.4	14.4	11.9	d.f.=2/34
Stage 3				
Geometric mean	3.7	5.1	5.6	F=0.42
Lower 95% CL	1.8	2.6	2.9	p=0.662
Upper 95% CL	6.9	9.2	10.1	d.f.=2/24

[1] p values less than or equal to 0.05 are considered statistically significant.

Note: Geometric mean densities over three upper and lower collections per date were used for Station I.

Table-I-9. Summary data from two factor (date and station) analysis of variance comparing larval flounder densities (total and staged) at Montaup Station M, MHB 1, and BP 1,2,3 Intake I, years pooled.

	Station			
	M	1	I	Station Effect
Total Flounder (1994, 1995, 1997,1998)				
Geometric mean	39.4	47.6	37.5	F = 1.31
Lower 95% CL	31.5	38.2	30.1	p = 0.274
Upper 95% CL	49.1	59.3	46.8	d.f. = 2/118
Stage 1 (1994, 1995, 1997)				
Geometric mean	17.9	11.8	13.8	F = 1.98
Lower 95% CL	11.5	6.4	8.8	p = 0.145
Upper 95% CL	27.8	20.9	21.5	d.f. = 2/72
Stage 2 (1994, 1995, 1996,198))				
Geometric mean	16.1	15.9	14.5	F = 0.24
Lower 95% CL	12.7	12.6	11.4	p = 0.789
Upper 95% CL	20.4	20.1	18.4	d.f. = 2/114
Stage 3 (1994, 1995, 1997,1998)				
Geometric mean	8.9	9.5	9.4	F = 0.06
Lower 95% CL	6.5	7.0	7.0	p = 0.94
Upper 95% CL	12.0	12.7	12.7	d.f. = 2/98

[1] p values less than or equal to 0.05 are considered statistically significant.

Note: Geometric mean densities over three upper and lower collections per date were used for Station I.

Table I-10. Summary data for larval flounder catch ratios from 0.333 and 0.505-mm mesh samples collected in Mount Hope Bay, March-April 1998.

	Stage 1	Stage 2	Stage 1 & 2	Stage 3
Geometric mean	2.66	2.83	2.88	1.37
s.e.	0.54	0.40	0.26	0.22
Range	0.44-15.88	0.84-12.71	1.09-9.44	0.57-4.76
n	41	46	41	21
Paired t-test[1]	$p<0.0001$	$p<0.0001$	$p<0.0001$	$p=0.009$

[1]One-tailed paired sample t-test results:
H_O: mean difference ≤ 0
H_A: mean difference > 0. A ratio of 1 represents a mean difference of 0.

Table I-11. Summary data for larval flounder catch ratios from 0.333 and 0.505-mm mesh samples collected in Mount Hope Bay,March-April 1994-1997, 1978, 1977.

1997	Stage 1	Stage 2	Stage 1 & 2	Stage 3
Geometric mean	1.85	1.77	1.83	1.21
s.e.	0.33	0.28	0.17	0.21
Range	0.42-6.63	0.62-8.16	0.73-4.52	0.28-4.58
n	29	29	29	24
Paired t-test[1]	p<0.001	p<0.001	p<0.001	P=0.09

1996	Stage 1	Stage 2	Stage 1 & 2
Geometric mean	4.54	2.70	2.99
s.e.	1.07	0.39	0.41
Range	0.96-26.4[2]	0.82-12.2[3]	1.2-12.4
n	32	41	41
Paired t-test	p<0.001	p<0.001	p<0.001

1995	Stage 1	Stage 2	Stage 1 & 2
Geometric mean	5.91	1.87	2.25
s.e.	3.02	0.30	0.33
Range	0.75-69.7[4]	0.33-8.58[5]	0.41-8.56
n	31	38	40
Paired t-test	p<0.001	p<0.001	p<0.001

1994	Stage 1	Stage 2	Stage 1 & 2	Stage 3
Geometric mean	1.99	2.61	2.24	0.91
s.e..	0.49	1.16	0.80	0.44
Range	0.07-16.3	0.14-34.0	0.06-34.0	0.18-5.66
n	46	41	53	12
Paired t-test	p<0.001	p<0.001	p<0.001	p>0.05

Table I-11 (continued).

1978	Stage 1	Stage 2	Stage 1 & 2	Stage 3
Geometric mean	9.21	1.81	3.57	1.21
s.e..	1.78	0.32	0.58	0.16
Range	1.0-123.4	0.2-33.7	0.2-48.9	0.2-11.4
Low, high removed	0.9,190.7	0.1,65.6		0.03,30.6
n	123	135	152	87
Paired t-test	p<0.0001	p<0.0001	p<0.0001	p<0.05

1977	Stage 1	Stage 2	Stage 1 & 2	Stage 3
Geometric mean	5.56	3.88	4.01	1.19
s.e.	1.55	0.93	0.89	0.16
Range	0.8-31.8	0.3-65.3	0.3-65.3	0.3-8.5
Low, high removed	0.4,47.1	0.2,82.7		0.2,17.0
n	40	95	95	94
Paired t-test	p<0.0001	p<0.0001	p<0.0001	p<0.05

[1]One-tailed paired sample t-test results:
H_O: mean difference ≤ 0
H_A: mean difference > 0. A ratio of 1 represents a mean difference of 0.

[2]High (28.7) and low (0.49) values removed.

[3]High (12.2) and low (0.82) values removed.

[4]High values of 74.8 and 118.7 omitted as outliers.

[5]High (9.2) and low (0.22) values removed.

B. Brayton Point Entrainment

Methods

Ichthyoplankton entrainment collections at Brayton Point Station were completed in triplicate by streaming 0.333-mm mesh, 60-cm diameter plankton nets in the Units 1,2,3 discharge stream. Sampling of the Unit 4 discharge was not conducted in 1998 because, during the larval flounder season, Unit 4 operated in the "piggyback" mode to reduce entrainment. Piggyback operation involved utilizing Unit 1,2,3 discharge water for cooling rather than Lee River water. Units 1,2,3 sampling was conducted from the bridge spanning the discharge channel upstream of its confluence with the Unit 4 discharge (Figure I-15). Conversion to 0.505-mm mesh was not made in May as it was in the Bay program because extrusion was shown to be greater in entrainment samples than in towed Mount Hope Bay samples (NEP and MRI 1995). Adjustment for extrusion through 0.333-mm mesh was not considered necessary for Unit 1,2,3 samples but adjustment was made to Unit 4 samples collected in previous years based on 0.202-mm mesh samples collected in 1995 (NEP and MRI 1996). Sampling was completed around high water because flowmeter data taken in previous years indicated flow in the discharge streams was comparable to the velocity at which nets were towed in the Bay sampling program. Sampling was conducted on the same days that Mount Hope Bay ichthyoplankton was collected from February through mid-May, i.e., once in February, every four to five days thereafter, weather permitting. Sampling was also coordinated so that the Units 1,2,3 discharge was sampled concurrently with the Intake station (see above).

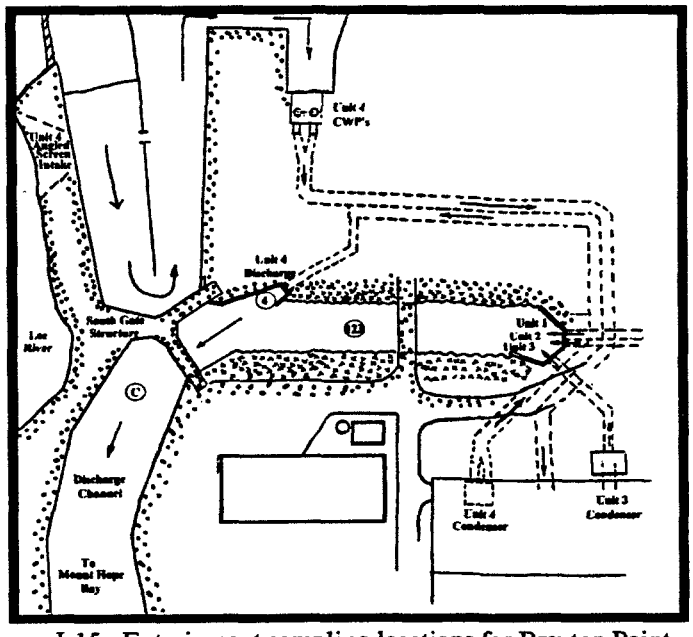


Figure I-15. Entrainment sampling locations for Brayton Point Units 1,2,3 and Unit 4.

All samples were preserved in 10% Formalin solutions, returned to MRI's laboratory, and analyzed as described previously for the Mount Hope Bay samples. Densities per 100 m^3 of water were integrated over time along with circulating water volume data supplied by Brayton Point Station to derive estimates of the total number of larval flounder entrained during the season. In previous years mesh extrusion factors were applied to larval densities where necessary (Table I-12).

Annual larval entrainment estimates were converted to equivalent numbers of age 3 adults, the age at which about half the flounder become sexually mature (NOAA 1993, Witherell and Burnett 1993) using two sets of survival values. The first set was modified from NEP (1978) which used data from Pearcy (1962) and Saila (1976). The NEP(1978) approach consisted of dividing the total number of entrained larvae by 0.09 to estimate the number of eggs which hatched to produce those individuals. The number of eggs was then multiplied in succession by 0.004536, an estimate of survival from a newly hatched egg to day 26; 0.2995, survival from day 27 to metamorphosis; 0.03546, survival of juveniles from 3 to 12 months; 0.3491, survival from 13 to 24 months; and finally 0.33, survival from 24 to 36 months. The second approach followed larval stage-specific survival rates derived from Niantic River data (Crecco and Howell 1990) as modified by Gibson (1993). These are as follows:

S (stage 1) = 2.36E-01
S (stage 2) = 1.08E-01
S (stage 3) = 1.54E-01
S (stage 4) = 6.23E-01
S (age 0) = 7.30E-02
S (age 1) = 2.50E-01
S (age 2) = 4.77E-01

In using the stage-specific rates beginning with the 1978 larval season (larvae were not staged prior to April 1977), it is recognized that NUSCO employs different morphological stage criteria than those used at Brayton Point. However, a comparison of samples from both studies showed stages to be quite comparable until larvae approach metamorphosis, a size not often collected. Although small numbers are entrained each year, flounder eggs were ignored because they are demersal and adhesive and not generally impacted by entrainment. Numbers of age 3 fish were converted to weight based on 0.6 pounds per fish (Gibson 1993).

Results and Discussion

Egg and larval densities standardized to number per 100 m^3 of water by species within each sampling date appear in Appendix Table A5. Larval winter flounder abundance in the Brayton Point discharge streams closely followed abundance in Mount Hope Bay in general as it typically does. Larvae were present in the Unit 1,2,3 discharge stream when sampling first began on February 17, reached a peak geometric mean density of 52 larvae per 100 m^3 of water on April 8 and 13, and declined to 3 per 100 m^3 by May 18 when sampling ended.

Larval flounder densities estimated in the Units 1,2,3 discharge stream were integrated over time with respective monthly average circulating water volume values obtained from Brayton Point Station. The mean March-April 1998 Station flow of 494 thousand gallons per minute (710 million

gallons per day, MGD) was similar to values recorded during the past five years when Unit 4 operated in piggyback mode during much or all of the larval flounder season (Figure I-16). Total number of larval flounder entrained by Units 1,2,3 in 1998 was estimated to be 49,047,205 (Figure I- 17). Total numbers entrained by those three units continued to show good correlation with the Bay-wide larval abundance index (integrated curve area) over the 1973-1998 period ($r = 0.815$, $P < 0.0001$, both on natural log scale, Figure I-18; the years 1986-1991 were excluded since entrainment sampling was not conducted in those years;). Numbers of larval flounder entrained in 1998 were the lowest yet observed consistent with record low Bay-wide abundance and absence of additional entrainment by Unit 4.

Equivalent adult (EA) analyses for winter flounder updated to include the 1998 season appear in Tables I-13 and I-14. The general unstaged survival values produced an estimate for 1998 of 3,024 age 3 fish all attributable to Units 1,2, and 3. Corresponding values for 1992-1997 when entrainment data included Unit 4 ranged from 5,778 fish in 1994 to 62,788 fish in 1992 with a seven-year mean of 17,134 (s.e. = 8,068). A mean value of 29,962 was obtained for Units 1,2,3 for all years dating back to 1973 (s.e. = 5,108). The stage-specific approach produced an estimate of 23,419 age 3 fish for 1998. Equivalent adult values for all four units, with the staged approach, from 1992 through 1998, ranged from 24,348 (1993) to 275,276 (1992) with a mean value of 74,663 (s.e. = 34,794). Dating back to 1978, the first year with complete larval staging, a mean value of 103,820 age 3 fish was obtained (s.e. = 19,413). The large difference between the two sets of survival estimates clearly demonstrate how relatively small changes in survival values applied to large numbers of larvae can result in sizable variations in adult numbers (see Vaughan and Saila 1976, Houde 1987, for example).

Consistent with low bay densities and low numbers of larvae entrained, equivalent adult values were low in 1998 ranking last over the 20 years for which unstaged values could be calculated and last over the 15 years for which the staged approach could be applied.

To provide perspective on the numbers of age 3 fish potentially lost to the local population equivalent adult totals were compared with commercial and recreational flounder landings as well as stock size estimates for Mount Hope Bay. Commercial landings data for statistical area 539, available through 1997, appear in Table I-15. Area 539 includes Narragansett Bay, Rhode Island Sound, and waters south of Block Island. Rhode Island recreational landings were estimated in 1979, 1983, 1989, and 1991 (NOAA 1984, 1985, 1990, 1992) with more current updates through 1997 and revisions dating back to 1981 now available on the Internet from the National Marine Fisheries Service, Fisheries Statistics and Economics Division[1]. For recreational landings only inland collections were considered; ocean collections less than 3 miles from shore and those a greater distance from shore were not included in the total. Based on the data currently available, the unstaged EA values represented an average of 2.4% of the combined commercial and recreational landings ranging from 0.2 to 12.7%. The greater staged larval EA values represented 1.1 to 50.3% with an average of 10.6% (Table I-15).

Rhode Island commercial landings from 0 to 3 miles within shore from 1992 through 1997 averaged 135,667 pounds (s.e. = 10,203). Added to the mean estimated recreational landings for

[1] http://remora.ssp.nmfs.gov/mrfss.

those same years of 35,043 pounds results in an estimate of 170,709 pounds. For that period the unstaged EA values amount to 6.8% and the staged value 29% of those landings.

EA values expressed as a percent of landings were notably large in 1992 and from 1994-1996 compared with past years. In 1992 larval abundance in the Bay represented a record high as did corresponding entrainment. This occurred at a time when landings began to decline in conjunction with dwindling population size region-wide (see finfish section). From 1994 through 1996, landings declined by an order of magnitude or more under stricter regulatory guidance designed to rebuild flounder stocks. As a result of the markedly lower catch rates, EA values have risen. Since stock size and larval abundance do not appear to be correlated (see above), larval production and subsequent entrainment have not declined.

Gibson (1993) estimated winter flounder stock size (age 3+) for Mount Hope Bay using four methods: area swept by trawl, acreage production, mark-recapture, and virtual population assessment. Utilizing data preceding stock decline (pre-1986), these four approaches provided an average estimate of 378,957 fish with wide confidence limits of 40,000 to 718,000. LMS (1993) argued that this estimate was likely well below the actual stock size. Nonetheless, the average loss to entrainment of 32,124 age 3 fish determined by the unstaged approach amounts to 80% of the low confidence limit and 4% of the high limit. The loss of an average of 103,820 fish determined from staged larvae (1978-1998) exceeds the low value and amounts to 14% of the high value.

Units 1,2,3, Entrainment Compared With Intake Densities

Samples of larval flounder collected from the Brayton Point Units 1,2,3 discharge stream were compared with those collected concurrently at Intake Station I (Appendix Table A3) using two factor anova with date and station as main fixed, effects. Larval flounder abundance at the upper intake, lower intake, and Brayton discharge locations were first loge transformed. Comparisons were completed for stage 1, stage 2, and stage 3 individuals as well as all larval flounder combined; 1998 results were further compared with 1995-1997 (Figure I-19, Tables I-16 - I-19).

Stage 1 larvae: In 1998, densities of yolk sac larval flounder were significantly different at all three locations ($p<0.001$). In descending order seasonal geometric means were 11 per 100 m^3 in the lower intake, 5 per 100 m^3 in the upper intake, and 2 per 100 m^3 in the Brayton discharge (Figure I-19, Table I-16). This pattern of highest stage 1 densities at the lower intake station, lowest densities at the Brayton discharge, is consistent with the three preceding years as well although differences were not statistically significant in 1997.

Stage 2 larvae: In 1998 the seasonal geometric mean density at the lower intake (10 per 100 m^3) was significantly greater than the mean density in the Brayton discharge (7 per 100 m^3; $p<0.05$). The mean density at the upper intake location (8 per 100 m^3) was intermediate between those two, multiple comparison procedures being unable to assign that mean to either the high or low group (Table I-17). Statistically significant differences were also detected among the three sampling locations in 1995, 1996, and 1997 although the distribution pattern was not consistent across all years. In all but 1997 densities ranked highest at the lower intake station, lowest at the discharge. In 1997 densities at all three stations proved to be statistically distinct, upper intake ranking highest followed by lower intake and the discharge.

Stage 3 larvae: These older individuals were consistently distributed deeper in the water column then younger larvae. In 1998, they were taken at significantly greater densities in the lower intake (geometric mean = 10 per 100 m^3) compared with the upper intake (geometric mean = 4 per 100 m^3) consistent with three of the previous four seasons. In 1997 the seasonal mean density was greater in the lower intake (13.5 per 100 m^3) compared with the upper as well (10.4 per 100 m^3) but the difference could not be shown to be statistically significant ($p > 0.05$). Brayton discharge densities were statistically similar to the lower intake densities (1997,1996) or if statistically discrete they were more like the lower densities than the upper (1998, 1995; Figure I-19, Table I-18).

Total flounder larvae: Combining all stages, larval flounder densities averaged significantly higher at the lower intake location (29.5 per 100 m^3) while similar at the upper intake (15.8 per 100 m^3) and discharge (14.1 per 100 m^3). These results were consistent across all four larval seasons although in 1997 anova could not distinguish between the lower intake (36.8 per 100 m^3) and the discharge (32.0 per 100 m^3; Figure I-19, Table I-19).

Developing hypotheses concerning the dynamics of larval flounder entrainment by comparing intake and discharge densities is confounded by the configuration of the intake itself. The shipping channel leading to the intake structure is generally 40-feet deep rising to about 25 feet as the intake structure itself is approached. Ichthyoplankton tows were completed in the shipping channel where sufficient space exists to maneuver the sampling vessel. The water column there was divided in half at a depth of about 18 to 20 feet. To the north of the dredged channel is Borden Flats, a large shoal area (5 to 8 feet deep at mean low water, Figure I-20). Recent analyses of temperature profiles in the intake indicate that primarily surface water is entrained, at least relative to the deeper approach channel (Alden Research Laboratory 1996). Assuming flow rates are greatest near-bottom near the intake pumps, it seems likely therefore that larvae residing at a depth of 20 to 25 feet as they approach the intake structure may have the highest probability of being entrained. These larvae would likely have appeared in both the bottom of the surface-half tows and the top of the bottom-half tows making it difficult to unravel entrainment issues with only two-level sampling. It is also important to bear in mind that sampling error is assumed to be minor in both the intake and discharge sampling protocols.

Four sampling seasons, 1995-1998, indicate that older stage 3 larvae occur at greater densities in the lower half of the water column in the Intake area when compared to the upper half (Figure I-16). Similar results appeared in 1994 as well although the absence of replicate samples that year resulted in failure to detect a difference statistically. When comparing Intake and Discharge, stage 3 individuals also occurred at densities which were more similar unlike stage 1 and 2 individuals which were found at greater densities in the intake. These data suggest that larvae concentrated in the lower half of the water column are more susceptible to entrainment.

The lower densities of stage 1 and stage 2 larval flounder in the Unit 1,2,3 discharge compared with the intake remains unanswered. While both early life stages are somewhat more evenly distributed vertically (mean low/up = 1.5 and 1.1, respectively, 1995-1998) then stage 3 larvae (mean low/up = 2.0), both stages remain more abundant in the lower intake where the stage 3 results suggest they should be as susceptible to entrainment. Unless densities of those individuals are maintained over a narrow depth contour from which water has a lower probability of being entrained, results should resemble the stage 3 distribution, i.e., intake and discharge densities should be similar.

Mesh extrusion of small individuals in the discharge appears an unlikely factor based on the 0.202 collections made in 1994 and 1995 (NEP and MRI 1996). Since larvae obtained in entrainment samples are generally in good condition, it appears unlikely that larvae are rendered microscopically unrecognizable by passage through the Station's pumps and condensers. Discrete depth sampling using a pump sampler in the Niantic River showed that yolk-sac larvae were most abundant in the lower half of the water column yet they were significantly less abundant at the sediment-water interface (NUSCO 1992). Additional sampling closer to the intake where depth is 20 to 25 and perhaps at surface, mid-depth, and bottom in the ship channel as well as over Borden Flats will likely be required to resolve the issue.

Due to the differences in larval winter flounder density between the intake and discharge equivalent adult (EA) calculations were repeated using the intake densities recorded from 1995 through 1998. Intake samples collected in 1994 were not included because sampling did not begin there until March 16. Since six samples were taken from the intake on each sampling occasion, the geometric mean of the three upper and three lower samples was calculated for each date. EA values were determined using the staged and unstaged computations as described above (Table I-20).

The total number of larval flounder which would have been entrained based on intake densities was greater than the number estimated to have been entrained based on discharge densities in all four years. Ratios between the two ranged from 1.05 in 1997 to 1.52 in 1998. Since the unstaged EA computations are simple scalar values, the adult estimates vary by the same amount; i.e. the EA estimate for 1998 based on the intake densities (4,608) was 1.52 times higher then the estimate based on the discharge densities (3,024). EA estimates based on staged larvae varied from year to year because of differences in the distribution of stages. In 1995, 1997, and 1998 the EA estimates were larger when based on discharge densities while in 1996 they were larger when based on the intake densities. Averaged over the four year period, EA values were 34,294 based on intake densities and 39,917 based on discharge densities (Table I-20). The reason for the greater number of equivalent adults based on discharge densities was the relatively greater number of stage 3 and stage 4 larval flounder in the discharge collections. These individuals have survived the first two larval stages and a greater percentage of them will therefore survive to become adults.

Other species: In addition to larval winter flounder four other ichthyoplankton groups were sufficiently abundant during late winter and early spring to permit a review of their abundance in the intake and discharge in comparison to larval flounder. These were fourbeard rockling (*Enchelyopus cimbrius*) eggs, tautog/cunner (*the labrids, Tautoga onitis/Tautogolabrus adspersus*) eggs, grubby larvae (*Myoxocephalus aenaeus*), and sand lance (*Ammodytes* spp.) larvae (Figure I-21).

Among the eggs, fourbeard rockling displayed among-station differences during each of the four years studied and labrids did so during three of the four (Figure I-21, Tables I-21 and I-22). Among rockling eggs in 1998 and 1996, seasonal mean densities were statistically similar in lower intake and discharge samples, these two locations exceeding upper intake densities. In 1997 and 1995 all three locations proved to be discrete, the lower intake ranking highest in both cases, followed in descending order by the discharge, and the upper intake. Among labrid eggs, results were somewhat unusual in that seasonal mean densities averaged higher in the discharge samples than at the two intake locations. This was true for all four seasons although in 1996 differences were subtle

and not statistically significant. Consistent within all four years, the upper intake ranked second followed by the lower intake.

Among-station differences were also detected with sculpin and sand lance larvae. Sculpin larvae were generally taken at similar densities in the lower intake and discharge but at significantly lower densities in the upper intake. Collections in 1995 differed from this pattern in that all three stations proved to be distinct. In descending order, lower intake ranked highest followed by the discharge, and then upper intake (Figure I-21, Table I-23). These data suggest that the discharge consists of a mixture of upper and lower intake densities. Results for sand lance larvae differed from the majority of other cases in that they were generally most abundant in the upper intake samples (Figure I-21, Table I-24). This was true in 1996 and 1998 where upper intake densities were significantly greater then the other two locations and in 1995 where the seasonal mean density was greatest in the upper intake but not significantly greater then the discharge sampling location. In 1997 the upper intake and discharge collections were essentially identical (1.8 and 2.1 per 100 m^3, respectively), both exceeding the lower intake.

The distribution of rockling eggs and sculpin larvae suggests, as did the larval flounder data, that ichthyoplankton in the lower half of the water column in the intake have a greater probability of being entrained then those in the upper half. Greater numbers of labrid eggs in the discharge samples compared to both the upper and lower intake during all four seasons suggests that tautog and/or cunner spawn in the discharge channel. Collection of moderate numbers of these eggs in the discharge in March and April each year, 6 to 10 weeks in advance of their normal spawning season (see for example Fritzsche 1978), suggested this was the case in the past (NEP and MRI 1994). Divers tending to the barrier net near the mouth of the discharge canal regularly report observing tautog on both sides of the net (see for example NEP and MRI 1998). Tautog and cunner may also be abundant along the rip rap lining the intake embayment, and later in the season as the Bay warms these individuals would broadcast eggs closer to the intake structure than the intake sampling location.

Data obtained from rockling and labrid eggs as well as sculpin and sand lance larvae failed to explain the lower densities of larval flounder in the discharge canal samples compared with the intake samples. Larval sand lance, found to be more abundant in the upper intake samples compared with the lower intake were about evenly distributed between intake and discharge when upper and lower samples were averaged suggesting the discharge was an even mixture of the two. This was largely the case for sculpin as well although years like 1997 suggest that larvae in the lower half of the intake are more likely to be entrained consistent with the winter flounder results.

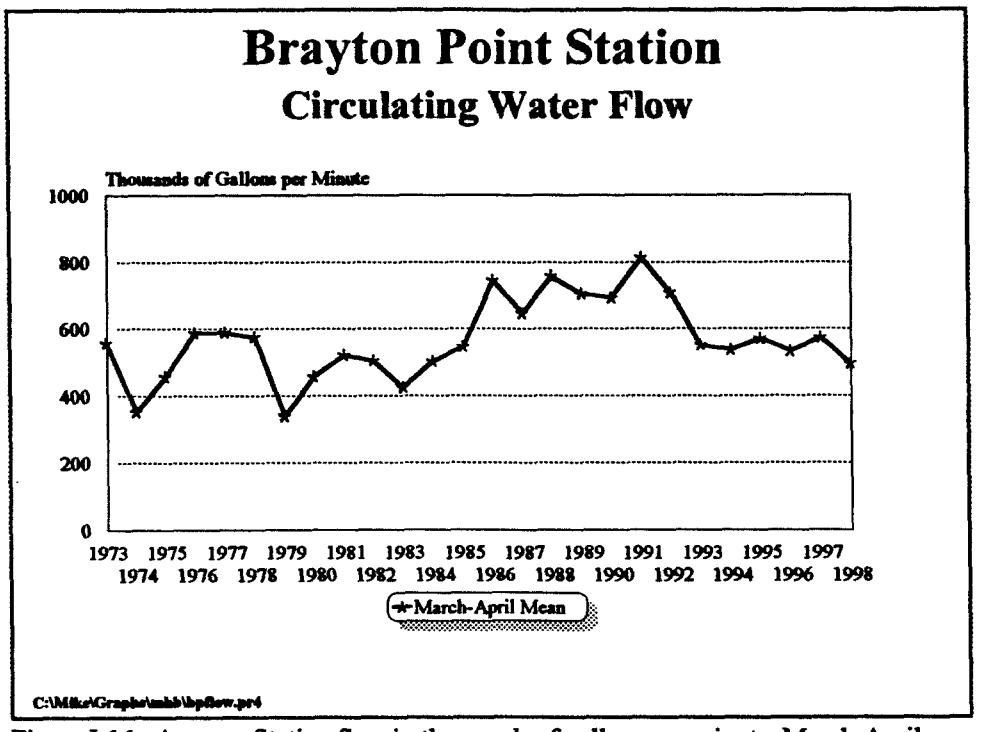


Figure I-16. Average Station flow in thousands of gallons per minute, March-April, 1973-1998.

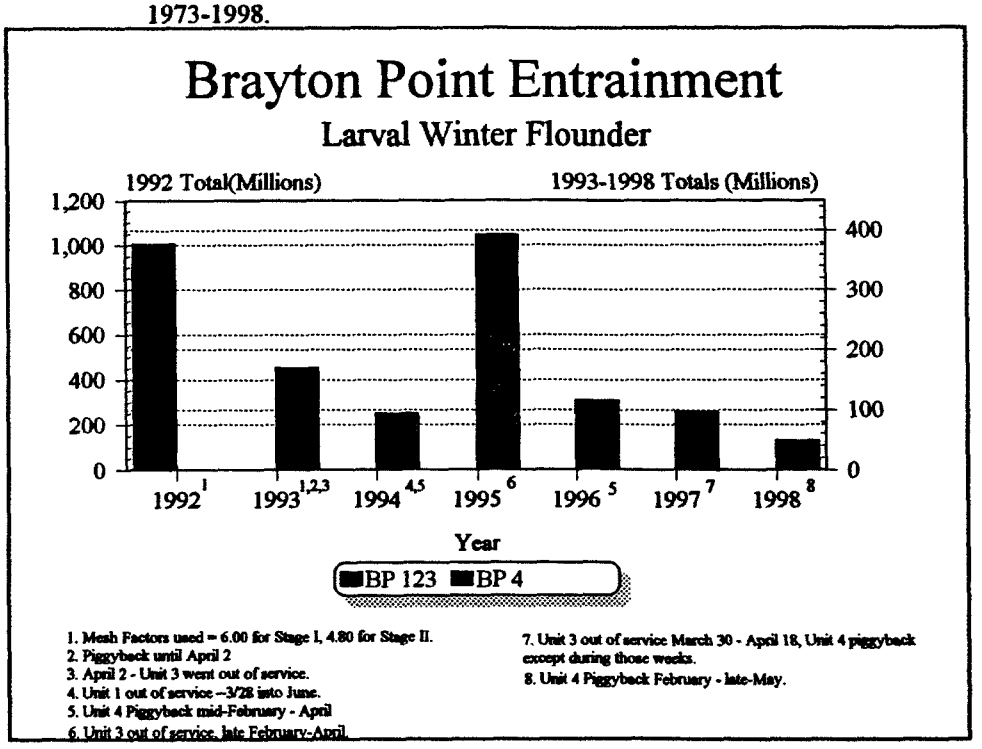


Figure I-17. Total estimated numbers of larval flounder entrained by Brayton Point Units 1,2,3 and 4, 1992-1998.

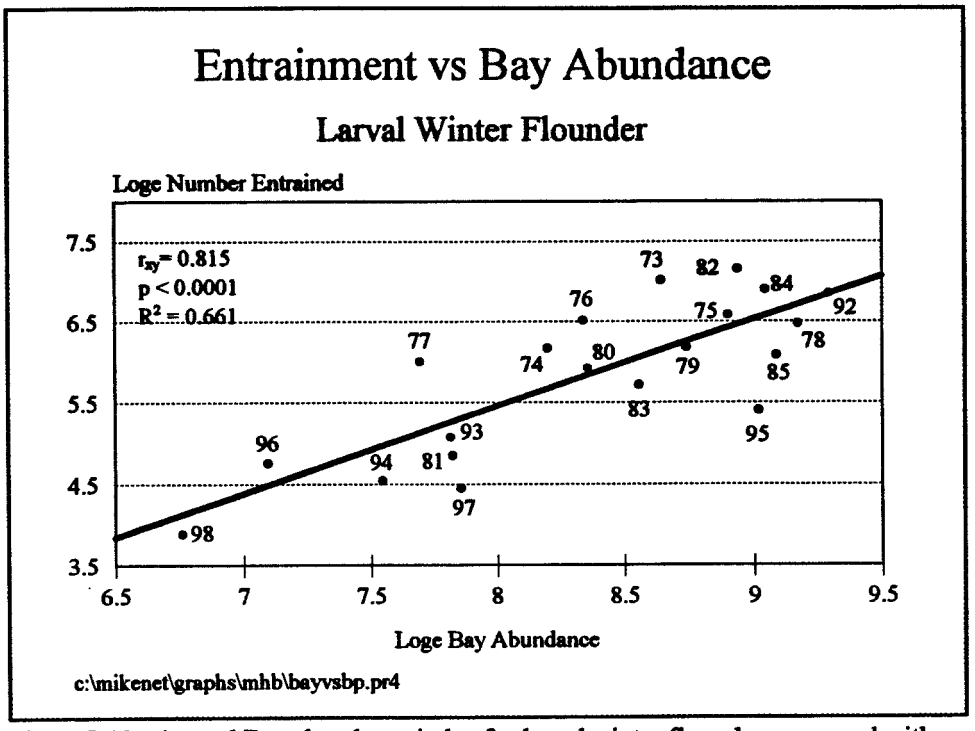
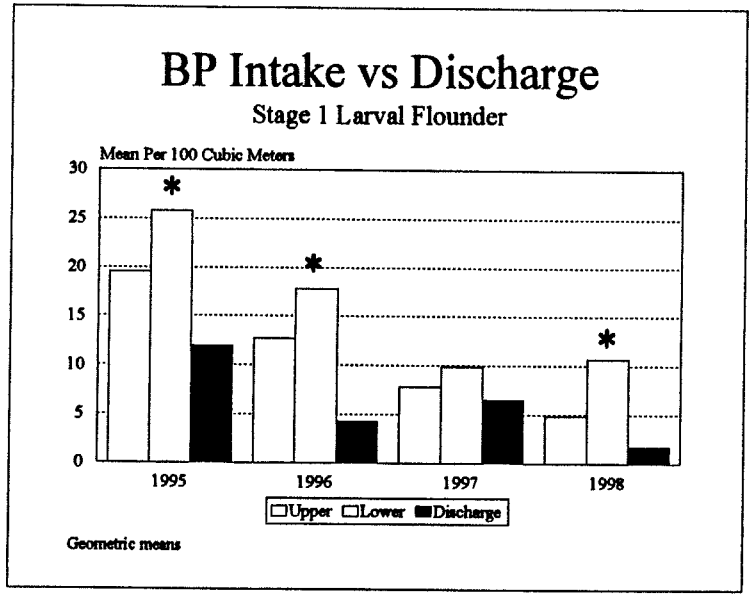
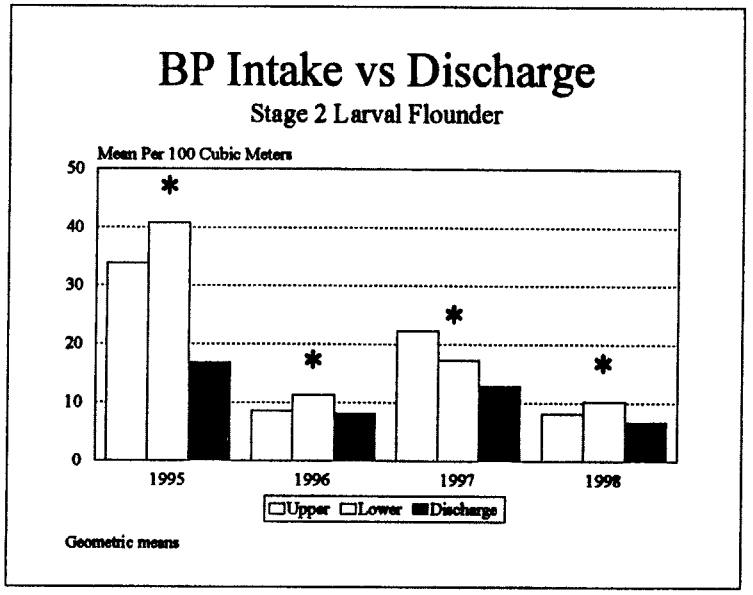
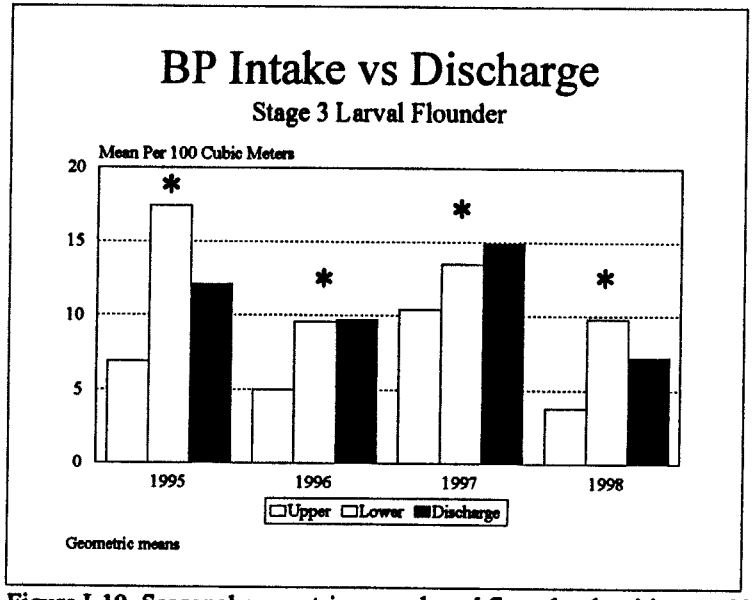


Figure I-18. Annual Bay abundance index for larval winter flounder compared with total numbers entrained at Brayton Point Station, 1973-1985, 1992-1998.







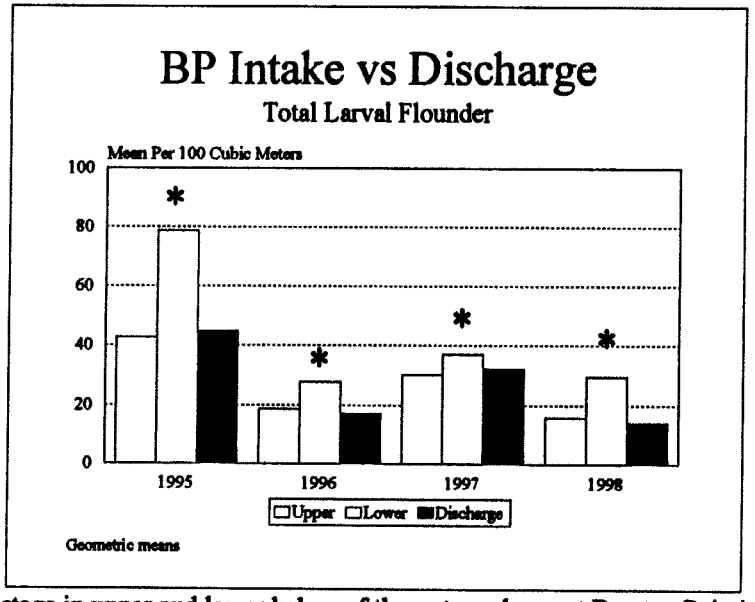


Figure I-19. Seasonal geometric mean larval flounder densities per 100 m^3 of water by stage in upper and lower halves of the water column at Brayton Point's Unit 1,2,3 Intake Station I and Discharge, 1995-1998. An asterisk indicates where statistically significant differences were detected.

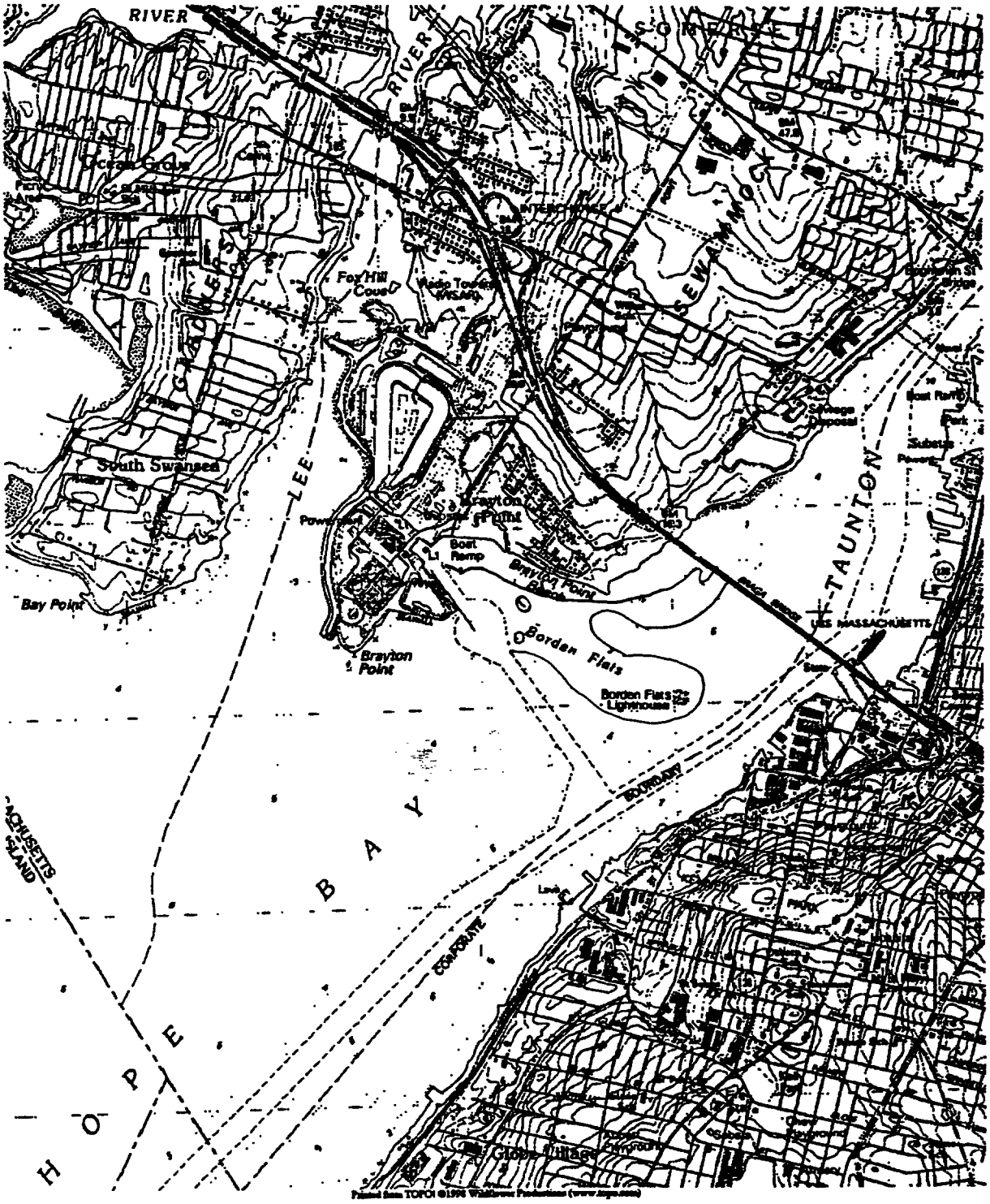
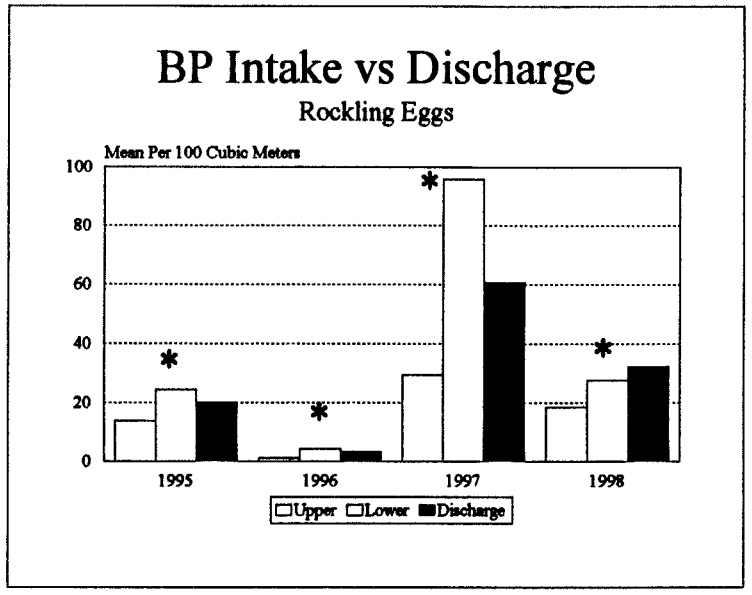
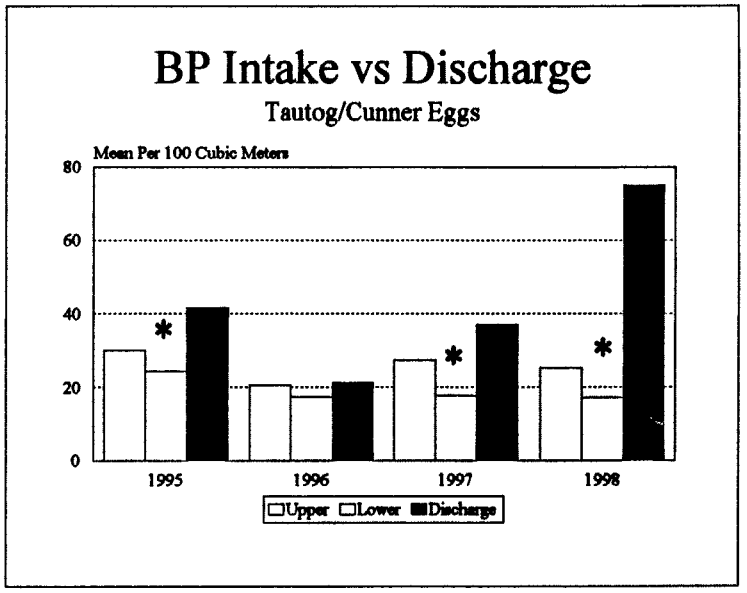
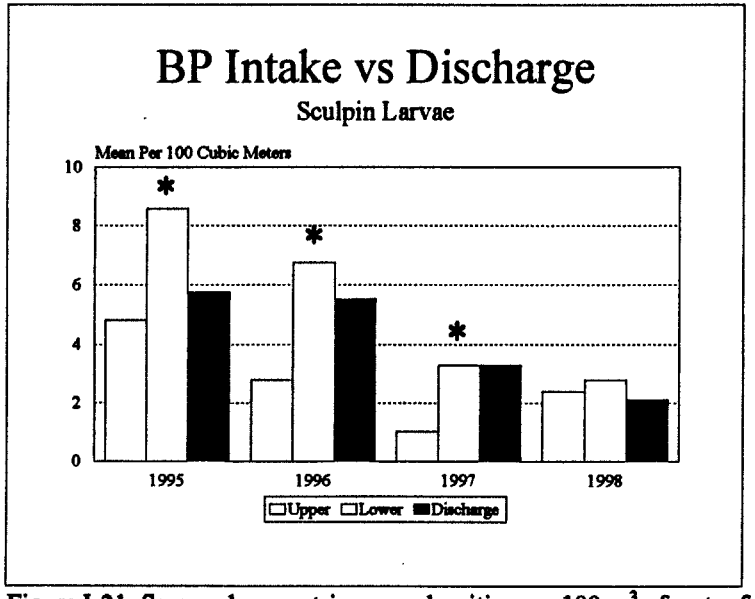


Figure I-20. Area map of upper Mount Hope Bay showing Brayton Point and Borden Flats.







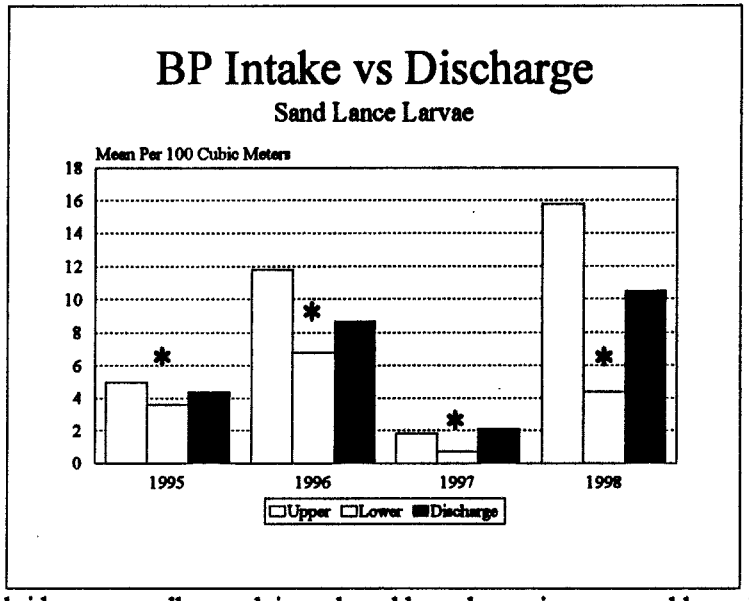


Figure I-21. Seasonal geometric mean densities per 100 m^3 of water for rockling and labrid eggs as well as sculpin and sand lance larvae in upper and lower halves of the water column at Brayton Point's Unit 1,2,3 Intake Station I and Discharge, 1995-1998. An asterisk indicates where statistically significant differences were detected.

Table I-12. Mesh extrusion scalar values used to calculate larval winter flounder entrainment totals. See text for details.

	Mesh used	Extrusion Scalar			
		Stage 1	Stage 2	Stage 3	Stage 4
Unit 1,2,3					
1975-1980	0.333	1.00	1.00	1.00	1.00
1981-1985	0.505	6.00	4.80	1.00	1.00
1992-1993	0.505	6.00	4.80	1.00	1.00
1994-1998	0.333	1.00	1.00	1.00	1.00
Unit 4					
1992-1993	0.505	8.22	6.58	1.00	1.00
1995[1]	0.333	1.37	1.37	1.00	1.00
1997[1]	0.333	1.37	1.37	1.00	1.00

Unit 4 operated in piggyback mode throughout the entire larval flounder season in 1994, 1996, and 1998.

[1]Values shown based on 0.202/0.333 comparisons.

Table I-13. Estimated numbers of winter flounder larvae entrained at Brayton Point and number and weight of equivalent age 3 fish lost to the population, 1973-1985, 1992-1998. Calculations based on general, unstaged survival values.

Year	Brayton Unit	Flounder Larvae Entrained	Age 3 Equiv. Adults (Number)	Age 3 Equiv. Adults (Pounds)
1973	123	1,111,609,436	68,542	41,125
1974	123	480,195,642	29,609	17,765
1975	123	722,733,473	44,564	26,738
1976	123	676,488,805	41,712	25,027
1977	123	404,920,661	24,967	14,980
1978	123	648,530,120	39,988	23,993
1979	123	481,909,000	29,715	17,829
1980	123	374,231,942	23,075	13,845
1981	123	128,048,383	7,895	4,737
1982	123	1,281,247,653	79,002	47,401
1983	123	304,723,796	18,789	11,274
1984	123	992,656,656	61,207	36,724
1985	123	439,964,833	27,128	16,277
	4	427,330,497	26,349	15,810
	Pooled	867,295,330	53,477	32,086
1992	123	943,268,475	58,162	34,897
	4	75,023,678	4,626	2,776
	Pooled	1,018,292,153	62,788	37,673
1993	123	159,922,170	9,861	5,916
	4	12,269,987	757	454
	Pooled	172,192,157	10,617	6,370
1994	123	93,701,467	5,778	3,467
	4	0	0	0
	Pooled	93,701,467	5,778	3,467
1995	123	222,952,470	13,747	8,248
	4	175,542,836	10,824	6,494
	Pooled	398,495,306	24,571	14,743
1996	123	116,430,180	7,179	4,307
	4	0	0	0
	Pooled	116,430,180	7,179	4,307
1997	123	85,708,121	5,285	3,171
	4	11,243,539	693	416
	Pooled	96,951,660	5,978	3,587
1998	123	49,048,205	3,024	1,815
	4	0	0	0
	Pooled	49,048,205	3,024	1,815
Mean	123	485,914,574	29,962	17,977
	4	87,676,317	5,406	3,244
	Pooled	520,985,101	32,124	19,274
S.E.	123	82,839,942	5,108	3,065
	4	53,089,391	3,273	1,964
	Pooled	84,643,189	5,219	3,131

Note: The Unit 4 entrainment value for 1985 is an estimate based on larval densities at Mount Hope Bay Station 4 in the Lee River. Entrainment samples were not collected that year.

Table I-14. Estimated numbers of winter flounder larvae entrained at Brayton Point by stage and number and weight of equivalent age 3 fish lost to the population, 1978-1998. Calculations based on survival values by larval stage. → Staged!

Year	Brayton Unit	Stage 1 Larvae Entrained	Stage 2 Larvae Entrained	Stage 3 Larvae Entrained	Stage 4 Larvae Entrained	Age 3 Equiv. Adults (Number)	Age 3 Equiv. Adults (Pounds)
1978	123	188,941,989	265,980,659	192,884,700	722,772	193,031	115,819
1979	123	187,598,900	178,515,500	115,794,600	0	116,807	70,084
1980	123	161,009,500	119,614,400	93,144,980	463,062	94,523	56,714
1981	123	45,348,462	31,444,032	51,056,930	198,959	47,523	28,514
1982	123	765,306,600	407,170,704	107,914,600	855,749	147,790	88,674
1983	123	52,911,750	518,233,920	97,280,820	808,058	100,624	60,374
1984	123	312,384,900	518,233,920	161,895,600	142,236	189,382	113,629
1985	123	74,236,800	310,754,160	54,865,010	108,863	76,024	45,614
	4	162,694,890	208,765,093	55,870,514	0	68,957	41,374
	Pooled	236,931,690	519,519,253	110,735,524	108,863	144,981	86,989
1992	123	144,440,760	600,268,800	194,595,100	3,963,815	241,243	144,746
	4	4,376,394	35,551,099	34,786,420	309,765	34,033	20,420
	Pooled	148,817,154	635,819,899	229,381,520	4,273,580	275,276	165,166
1993	123	49,311,222	101,131,968	9,063,308	415,672	19,996	11,998
	4	1,218,434	5,743,613	2,973,981	208,822	4,352	2,611
	Pooled	50,529,656	106,875,581	12,037,289	624,494	24,348	14,609
1994	123	29,178,230	34,902,390	29,157,090	463,757	30,636	18,382
	4	0	0	0	0	0	0
	Pooled	29,178,230	34,902,390	29,157,090	463,757	30,636	18,382
1995	123	38,671,450	119,317,200	64,438,800	525,020	68,252	40,951
	4	39,840,310	115,566,600	20,020,490	115,436	28,620	17,172
	Pooled	78,511,760	234,883,800	84,459,290	640,456	96,872	58,123
1996	123	14,841,810	71,100,860	30,487,510	0	32,192	19,315
	4	0	0	0	0	0	0
	Pooled	14,841,810	71,100,860	30,487,510	0	32,192	19,315
1997	123	17,893,390	34,056,170	32,852,370	906,191	35,806	21,484
	4	518,030	6,876,522	3,795,132	53,856	4,093	2,456
	Pooled	18,411,420	40,932,692	36,647,502	960,047	39,899	23,939
			= 49048205				
1998	123	5,858,065	22,928,110	19,324,220	937,810	23,419	14,051
	4	0	0	0	0	0	0
	Pooled	5,858,065	22,928,110	19,324,220	937,810	23,419	14,051
Mean	123	139,195,589	222,243,520	83,650,376	700,798	94,483	56,690
	4	26,081,007	46,562,866	14,680,817	85,985	17,507	10,504
	Pooled	153,105,459	247,077,048	91,480,145	746,656	103,820	62,292
S.E.	123	50,049,852	52,065,067	15,826,209	247,877	18,109	10,865
	4	20,105,095	27,037,624	7,357,535	41,542	8,779	5,268
	Pooled	49,846,305	55,821,112	16,809,626	266,469	19,413	11,648

Note: The Unit 4 entrainment value for 1985 is an estimate based on larval densities at Mount Hope Bay Station 4 in the Lee River. Unit 4 entrainment samples were not collected that year.

1978-1985 are [illegible] 4 [illegible] Table I-21

Table I-15. EA values for unstaged and staged winter flounder larvae compared with commercial and recreational landings data, 1973 - 1998.

Year	Area 539 Commercial Landings (Pounds)	Rhode Island Recreational Landings * (Pounds)	Total Estimated Landings (Pounds)	EA Unstaged (Pounds)	Percent	EA Staged (Pounds)	Percent
1973	1,160,400	306,600	1,467,000	41,125	2.80		
1974	890,500	306,600	1,197,100	17,765	1.48		
1975	822,977	306,600	1,129,577	26,738	2.37		
1976	840,479	306,600	1,147,079	25,027	2.18		
1977	1,094,021	306,600	1,400,621	14,980	1.07		
1978	1,488,454	306,600	1,795,054	23,993	1.34	115,819	6.45
1979	1,818,121	306,600	2,124,721	17,829	0.84	70,084	3.30
1980	2,825,995	313,272	3,139,267	13,845	0.44	56,714	1.81
1981	2,454,937	55,671	2,510,608	4,737	0.19	28,514	1.14
1982	3,003,129	369,278	3,372,407	47,401	1.41	88,674	2.63
1983	2,739,058	315,573	3,054,631	11,274	0.37	60,374	1.98
1984	2,872,232	309,885	3,182,117	36,724	1.15	113,629	3.57
1985	2,572,392	1,073,468	3,645,860	32,086	0.88	86,989	2.39
1986	1,900,455	1,645,229	3,545,684				
1987	1,391,757	432,617	1,824,374				
1988	1,160,465	369,839	1,530,304				
1989	1,004,669	186,063	1,190,732				
1990	719,669	220,072	939,741				
1991	1,444,564	124,331	1,568,895				
1992	790,191	8,933	799,124	37,673	4.71	165,166	20.67
1993	533,589	7,525	541,114	6,370	1.18	14,609	2.70
1994	54,361	33,638	87,999	3,467	3.94	18,382	20.89
1995	89,164	26,345	115,509	14,743	12.76	58,123	50.32
1996	51,591	62,029	113,620	4,307	3.79	19,315	17.00
1997	103,532	71,786	175,318	3,587	2.05	23,939	13.65
1998	Not Available	Not Available	Not Available	1,815		14,051	
Mean (73-97)	1,353,068	320,832	1,663,938	20,193	2.37	65,738	10.61
s.e.	188,482		227,079	2,751	0.56	11,546	3.50

* 1973 - 1978 based on 1979 value. 1980 - 1996 represents inland landings only.

Entrainment sampling was not conducted from 1986 - 1991.

Weight of equivalent adult flounder based on 0.6 pounds per fish.

See p. I.36 for def. of "area 539"

Table I-16. Summary statistics for analysis of variance comparing stage 1 larval flounder densities at Brayton Intake upper and lower with the discharge.

	Intake			F	
	Upper	Lower	Discharge	Station	p
1998					
Geometric mean	4.9	10.7	1.7	71.5	0.0001
95% CL lower	4.0	8.9	1.3		
95% CL upper	6.1	13.0	2.2		
1997					
Geometric mean	7.8	9.9	6.5	3.1	0.053
95% CL lower	6.1	7.8	5.1		
95% CL upper	10.0	12.6	8.4		
1996					
Geometric mean	12.7	17.7	4.3	63.9	0.0001
95% CL lower	10.6	14.9	3.5		
95% CL upper	15.1	21.1	5.3		
1995					
Geometric mean	19.5	25.8	11.9	11.8	0.0001
95% CL lower	15.5	20.7	9.4		
95% CL upper	24.4	32.3	15.0		

Statistically similar locations ($p>0.05$) are joined by a bar.

Table I-17. Summary statistics for analysis of variance comparing stage 2 larval flounder densities at Brayton Intake upper and lower with the discharge.

	Intake			F	
	Upper	Lower	Discharge	Station	p
1998					
Geometric mean	8.1	10.2	6.7	5.6	0.0001
95% CL lower	6.8	8.6	5.6		
95% CL upper	9.6	12.1	8.0		
	*		*		
1997					
Geometric mean	22.3	17.2	12.8	17.6	0.0001
95% CL lower	19.6	15.1	11.2		
95% CL upper	25.4	19.6	14.7		
1996					
Geometric mean	8.6	11.3	8.1	7.0	0.001
95% CL lower	7.4	9.9	7.0		
95% CL upper	9.9	13.0	9.3		
	*		*		
1995					
Geometric mean	33.8	40.8	16.8	30.2	0.001
95% CL lower	28.5	34.5	14.1		
95% CL upper	40.0	48.3	19.9		

Stations joined by a bar were not found to differ statistically. An asterisk indictes that upper intake and discharge were statistically similar.

Table I-18. Summary statistics for analysis of variance comparing stage 3 larval flounder densities at Brayton Intake upper and lower with the discharge.

	Intake			F	
	Upper	Lower	Discharge	Station	p
1998					
Geometric mean	3.8	9.8	8.2	24.6	0.0001
95% CL lower	3.1	8.1	5.9		
95% CL upper	4.7	11.7	8.6		
1997					
Geometric mean	10.4	13.5	14.9	3.8	0.027
95% CL lower	8.6	11.2	12.4		
95% CL upper	12.6	16.3	17.9		
1996					
Geometric mean	5.0	9.6	9.7	26.1	0.0001
95% CL lower	4.2	8.0	8.2		
95% CL upper	6.1	11.4	11.6		
1995					
Geometric mean	5.2	12.3	8.9	24.6	0.0001
95% CL lower	5.6	14.5	10.1		
95% CL upper	8.4	20.9	14.6		

Statistically similar locations ($p>0.05$) are joined by a bar.

Table I-19. Summary statistics for analysis of variance comparing total larval flounder densities at Brayton Intake upper and lower with the discharge.

	Intake			F	
	Upper	Lower	Discharge	Station	p
1998					
Geometric mean	15.8	29.5	14.1	36.7	0.0001
95% CL lower	13.8	25.9	12.4		
95% CL upper	18.0	33.5	16.2		
1997					
Geometric mean	30.0	36.8	32.0	4.0	0.022
95% CL lower	27.1	33.1	28.8		
95% CL upper	33.3	40.8	35.5		
	*		*		
1996					
Geometric mean	18.7	27.6	17.1	18.4	0.0001
95% CL lower	16.6	24.5	15.2		
95% CL upper	21.1	31.0	19.3		
	*		*		
1995					
Geometric mean	42.6	78.6	44.8	24.1	0.0001
95% CL lower	37.0	68.5	39.0		
95% CL upper	48.9	90.2	51.1		
	*		*		

Stations joined by a bar were not found to differ statistically. An asterisk indictes that upper intake and discharge were statistically similar.

Table I-20. Estimated total numbers of larval winter flounder entrained at Brayton Point Station based on both intake and discharge densities. Equivalent adult (EA) estimates using the unstaged and staged approach are shown for both sets of values.

Stage 1 Larval Flounder

	Intake	Discharge
1995	43,196,240	38,671,450
1996	53,575,280	14,841,810
1997	20,396,260	17,893,390
1998	22,436,100	5,858,065
Mean	34,900,970	19,316,179

Stage 2 Larval Flounder

	Intake	Discharge
1995	172,590,900	119,317,200
1996	109,944,100	71,100,860
1997	40,973,240	34,056,170
1998	32,131,240	22,928,110
Mean	88,909,870	61,850,585

Stage 3 Larval Flounder

	Intake	Discharge
1995	50,486,240	64,438,800
1996	28,226,010	30,487,510
1997	22,296,480	32,852,370
1998	16,429,630	19,324,220
Mean	29,359,590	36,775,725

Stage 4 Larval Flounder

	Intake	Discharge
1995	63,497	525,020
1996	114,742	0
1997	373,066	906,191
1998	193,667	937,810
Mean	186,243	592,255

Total Larval Flounder

	Intake	Discharge
1995	278,325,700	222,952,470
1996	196,801,800	116,430,180
1997	89,639,330	85,708,121
1998	74,724,720	49,048,205
Mean	159,872,888	118,534,744

Total EA Values (Staged Approach)

	Intake	Discharge
1995	58,998	68,252
1996	35,254	32,192
1997	24,775	35,806
1998	18,148	23,419
Mean	34,294	39,917

Total EA Values (UnStaged Approach)

	Intake	Discharge
1995	17,162	13,747
1996	12,135	7,179
1997	5,527	5,285
1998	4,608	3,024
Mean	9,858	7,309

Table I-21. Summary statistics for analysis of variance comparing labrid egg densities at Brayton Intake upper and lower with the discharge.

	Intake			F	
	Upper	Lower	Discharge	Station	p
1998					
Geometric mean	25.3	17.2	74.9	52.5	0.0001
95% CL lower					
95% CL upper					
1997					
Geometric mean	27.5	17.7	37.1	13.0	0.0001
95% CL lower					
95% CL upper					
1996					
Geometric mean	20.5	17.4	21.3	2.19	0.119
95% CL lower					
95% CL upper					
1995					
Geometric mean	30.0	24.4	41.6	10.4	0.0001
95% CL lower					
95% CL upper					

Statistically similar locations ($p>0.05$) are joined by a bar.

Table I-22. Summary statistics for analysis of variance comparing larval sculpin densities at Brayton Intake upper and lower with the discharge.

	Intake			F	
	Upper	Lower	Discharge	Station	p
1998					
Geometric mean	2.4	2.8	2.1	1.2	0.313
95% CL lower					
95% CL upper					
1997					
Geometric mean	1.0	3.3	3.3	21.4	0.0001
95% CL lower					
95% CL upper					
1996					
Geometric mean	2.8	6.7	5.5	20.5	0.0001
95% CL lower					
95% CL upper					
1995					
Geometric mean	4.8	8.6	5.8	5.3	0.008
95% CL lower					
95% CL upper					

Statistically similar locations ($p>0.05$) are joined by a bar.

Table I-23. Summary statistics for analysis of variance comparing fourbeard rockling egg densities at Brayton Intake upper and lower with the discharge.

	Intake			F	
	Upper	Lower	Discharge	Station	p
1998					
Geometric mean	18.5	37.6	32.3	45.3	0.0001
95% CL lower					
95% CL upper					
1997					
Geometric mean	29.4	95.7	60.7	114.2	0.0001
95% CL lower					
95% CL upper					
1996					
Geometric mean	1.2	4.2	3.3	34.5	0.0001
95% CL lower					
95% CL upper					
1995					
Geometric mean	13.9	24.4	20.2	23.5	0.0001
95% CL lower					
95% CL upper					

Statistically similar locations ($p>0.05$) are joined by a bar.

Table I-24. Summary statistics for analysis of variance comparing larval sand lance densities at Brayton Intake upper and lower with the discharge.

	Intake			F	
	Upper	Lower	Discharge	Station	p
1998					
Geometric mean	15.8	4.4	10.5	39.9	0.0001
95% CL lower					
95% CL upper					
1997					
Geometric mean	1.8	0.7	2.1	7.7	0.001
95% CL lower					
95% CL upper					
	*		*		
1996					
Geometric mean	11.8	6.8	8.7	6.9	0.002
95% CL lower					
95% CL upper					
1995					
Geometric mean	5.0	3.6	4.4	4.2	0.018
95% CL lower					
95% CL upper					
	*		*		

Stations joined by a bar were not found to differ statistically. An asterisk indictes that upper intake and discharge were statistically similar.

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Finfish Sampling

Introduction

Finfish populations in Mount Hope Bay have been monitored since 1971 to determine whether persistent population declines or shifts in community structure have occurred which might be attributable to operations at Brayton Point Station. Three sampling methods have been used, otter trawl and beach seine for bay-wide fishes and revolving screens for those fishes impinged at the Station. For the trawl program alterations over time included the addition of three stations to an original set of five and changing from duplicate to single tows at each station in October 1979. A decline from twice to once monthly sampling occurred in October 1980, followed by the elimination of two stations in January 1986 (Table F-1). Gear and towing vessel have remained constant through the time series although replacement nets were purchased in 1986, 1987, and 1994. The beach seine sampling program has remained virtually unchanged since May 1972 as has sampling of the revolving screens which began in 1971. A finfish impingement survival study was completed in 1981-1982 (MRI 1982) for Units 1, 2, and 3.

Beginning in 1992 and 1993 respectively, the beach seine and trawl programs were augmented to address concerns about declining winter flounder (*Pleuronectes americanus*) stocks in Mount Hope Bay. During the 1992 winter flounder spawning season, adult collections were the lowest of the 1972-1992 time series while the larval flounder abundance index for that year was the highest. Additional tows were completed from February through May 1993 and from December through May 1993-1995 to determine if the standard six fixed trawl stations were grossly underestimating adult abundance and distribution. Also, the relatively low stock-recruitment relationship calculated for Mount Hope Bay flounder at that time (Gibson 1993a), along with the relatively large mesh of the standard net, suggested that age 1 flounder were being undersampled in the winter and spring. As a result, tows were completed on a monthly schedule with a finer mesh trawl. The current beach seine program has occasionally produced young flounder in small numbers but the four long-term sampling locations were not specifically selected for winter flounder and probably do not sample the best habitat for this species. To better assess the abundance and distribution of young flounder in upper Mount Hope Bay tributaries, additional beach seine sampling was therefore conducted in June 1992 and June-August beginning in 1993.

Summary

In 1998, bottom trawling to sample Mount Hope Bay finfish populations was completed on a monthly basis with two nets. The long-term standard trawl program consisted of single, 15-minute monthly tows along ten fixed and random transects. Thirty-one species were represented in those collections with winter flounder, windowpane, bay anchovy, butterfish, alewife, scup, Atlantic herring, and striped searobin accounting for 77% of the year's total. Collections were clearly greater along deep-water transects compared with shallow ones consistent with observations from past years along the Brayton Point intake channel. Mean catch per tow for winter flounder with the standard net remains below one fish per tow as it has been since 1988. Windowpane abundance, highly correlated with that of flounder, also remains at historically low levels despite a gradual upward trend

observed from 1992 to 1996. Comparison of trends in Mount Hope Bay flounder and windowpane is generally consistent with declines noted in other New England survey time series. Catch per tow in Mount Hope Bay remains low for tautog (none were collected in 1997, 0.1 per tow were taken in 1998) and hogchoker, consistent with available data from other regional surveys. A subtle upward trend is apparent for hogchoker in Mount Hope Bay and Connecticut. Abundance trends were also tracked for scup, butterfish, and skate although these species are rarely abundant in Mount Hope Bay. Aggregate resource abundance in Mount Hope Bay gradually increased from 1994 to 1996, a trend which reversed in 1997 and 1998. Corresponding information for lower Narragansett Bay from the University of Rhode Island showed a downward trend from 1994 through 1996 with 1997 and 1998 remaining low. Information from the Rhode Island Department of Environmental Management showed a downward trend from 1995 through 1998. These data suggested that the upper estuary may not always vary in concert with the lower Bay and nearby coastal waters but at times they do track each other. Dominance diversity trends for Mount Hope Bay showed that 1996 and 1998 represented two of the best values observed over the 1986-1998 period, suggesting that some recovery in the balance of fish populations in Mount Hope Bay has occurred. The entire series (1972-1998) no longer displays a statistically significant downward trend.

A fine-mesh Wilcox trawl was utilized year-round, Bay-wide, for the third year in 1998 using a depth-stratified random design. A total of 39 species were collected with bay anchovy, winter flounder, butterfish, scup, alewife, and Atlantic silversides being the numerical dominants. Collections of winter flounder in 1997 exceeded those in 1996 and 1998 (stratified means = 9.3 vs 6.6 and 8.8 fish per tow, respectively). Windowpane were particularly abundant in the fall of 1996 (3.0 per tow) declining in both 1997 (1.5 per tow) and again in 1998 (0.3 per tow). Total fish increased in each of the three years from 19.5 per tow to 35.2 per tow in 1998. Time series comparisons were completed for flounder for 1993-1998 using data for the Wilcox trawl from February-May when that net was used seasonally in past years. While imprecise due to a small number of tows, catch rates for that period trend downward through 1996 then increase in 1997 and again in 1998. Comparisons of catch per tow between upper and lower Mount Hope Bay indicate that fish utilize deep-water habitat in both areas, averaging higher numbers in the upper Bay over the 1996-1998 period as a whole. Winter flounder average somewhat higher in number in the lower Bay where more deep water habitat exists.

The fine-mesh Wilcox trawl was added to the Mt Hope Bay sampling program because the larger mesh standard trawl was not adequately tracking shifts in abundance of small fish which often increase during times when larger species such as winter flounder and windowpane decline. This was displayed in aggregate resource abundance trends from 1996-1998 which changed little for the standard trawl while increasing for the Wilcox trawl.

Finfish impinged on the revolving screens at Brayton Point Units 1,2,3 were enumerated on a daily basis year-round by diverting the screenwash water to an in-line collection tank. All fish collected were identified, enumerated, and measured. A total of 46 species were sampled from the screens in 1998. Numerical dominants included winter flounder, alewife, hogchoker, Atlantic menhaden, silver hake, tautog, Atlantic silverside, Atlantic tomcod, butterfish, blueback herring,

threespine stickleback, smallmouth flounder, and oyster toadfish. All 16 typical dominants were impinged in below-average numbers.

Beginning in March, near-shore finfish populations in Mount Hope Bay were sampled at four standard locations with 300-ft and 60-ft beach seines. All fish were identified, counted, and measured to the nearest millimeter in total length. Twenty-four species were represented in the catch considering both nets. Atlantic silversides clearly and consistently dominated the near-shore fish community accounting for 82% of the 1998 total. Collections of silversides in the small net, reflecting primarily young-of-the-year, were below average equaling 71% of the 1972-1997 mean. In the large net silverside collections in June, July, and August, representing adults and larger young-of-the-year were also below average, amounting to just 40% of the corresponding mean for 1992-1997.

Continuing a sampling program begun in 1992, young-of-the-year winter flounder were sampled by beach seine on five occasions during the summer of 1998. During each occasion, 18 to 20 locations were sampled with duplicate or triplicate hauls covering the Taunton, Lee, Cole, and Kickamuit River estuaries. Mean number per haul based on June collections indicated that production of young fish ranked sixth over the seven-year period. Clear consistent patterns in catch between stations or even among rivers have not been identified. Mortality rates estimated for Mount Hope Bay tributaries in general were greater than those reported for the Mystic River, CT but comparable to those recorded in the Niantic River, CT. Absolute growth in length as measured during August was greatest in 1996 with individuals reaching a mean total length of 67 mm, 6.3 mm larger then in 1998. Growth in 1998 appeared to be slowest prior to the first sampling series among the seven years studied but compensated for the slow start by rapid growth later in June. During June and July 1998 young flounder grew at a rate of 0.39 mm/day, which was the second most rapid of the time series which ranged from 0.21 to 0.41 mm/day. Water temperature and dissolved oxygen values recorded at time of sampling in most cases did not appear to be limiting to the distribution of young flounder in Mount Hope Bay tributaries. Six annual young-of-the-year surveys completed during late spring-summer provide abundance data for New York, Connecticut, Rhode Island, and other Massachusetts waters. Based on these data, the 1992 year class appears to have been a relatively strong one even as far removed from Mount Hope Bay as New York. In contrast, 1993 appears to have been a poor year class in most cases. The current 1998 season ranked near the middle of the seven-year time series in many of the surveys. In Mount Hope Bay mean larval abundance and mean young-of-the-year catch were found to be strongly correlated. Young-of-the-year abundance was also correlated with numbers of age 1 flounder collected the following spring. However, both relationships were highly dependent on 1992.

A. Otter Trawl

Methods

The long-term, standard trawl program in Mount Hope Bay consisted of single, monthly tows along six fixed transects, each 15 minutes in duration (Figure F-1). Mean water depth was typically 15-18 feet along each transect except at the Brayton Point intake where depth ranged from 35-40 feet. Adjustments in tow duration were occasionally made to cover an established course; this was most common in the Taunton River where tidally driven currents were strongest. Transects were located using land based bearings and differential GPS. The trawl measured 37.5 feet in length with a 25-ft head rope, 36-foot foot rope, 4.75-inch stretch mesh in the body, and 1.5-inch stretch mesh cod end.

From 1993 through 1995 over the course of the winter flounder reproductive season, additional standard trawl tows were completed. These were designed to improve coverage of the Taunton River as well as the deep shipping channel leading to the River considering that only the existing Intake tow was in deep water (>20 feet) and the Taunton River has been shown to contribute the majority of larval flounder to the Bay (MRI 1979). Twenty-three transects, each 1250 yards in length, were established from the confluence of the Assonet River with the Taunton River to the Massachusetts state line (Figure F-2); 1250 yards is the distance established by the standard 15-minute tow. On each monthly sampling occasion, December-May, six transects were selected at random from the pool of 23 and sampled with the standard trawl in addition to the six fixed stations.

Beginning in March 1997, four additional tow were added to the standard trawl program to bring the total completed each month to ten. The four additional stations were selected at random from 83 depth-stratified transects initially established throughout the Bay for the Wilcox trawl (see below). Three stations were selected each month from the deep-water pool and one was selected from the shallow pool. When combined with the existing five shallow and one deep transect, the added tows resulted in six shallow-water stations and four deep-water stations. Sampling methodology remained the same at each location.

Beginning in 1993, in an effort to improve the collection of age 1 flounder, defined as those less than or equal to 150 mm total length (TL; Gibson 1993a), tows were also completed with a fine-mesh Wilcox trawl (Table F-1). This net measured 30 feet along the footrope and was constructed of 2-inch stretch mesh in the body, 1½-inch stretch mesh in the cod end which was fitted with a ¼-inch mesh liner. Six tows were made each month from February through May, increasing to 12 in April and May 1995. The tows were selected at random from a pool of 29 transects consisting of the 23 described above plus the six fixed standard trawl transects. Currently, completion of 10 tows with the standard trawl plus ten to twelve tows with the Wilcox trawl typically required two days' sampling time. When random station selection called for a station to be sampled with both the standard and Wilcox trawl in the same month, every effort was made to tow over adjacent bottom on the second pass and to allow at least 24 hours to elapse between tows.

In 1996 the Wilcox trawl program was revised further to improve enumeration of smaller and more fusiform fishes not well retained by the standard trawl. The revised program utilized a random stratified design to cover all of Mount Hope Bay. Two depth strata were established consistent with the Rhode Island Department of Environmental Management (RIDEM) Division of Fish, Wildlife, and Estuarine Resources, Narragansett Bay trawl program. A total of 45, 1250-yard transects were established in water less than 20 feet deep, and 38 similar transects were established in water deeper than 20 feet (Figure F-3). Based on planimetered surface area using NOAA Chart 13221, 60% of Mount Hope Bay is shallow-water habitat less than 20 feet deep, the remainder exceeding 20 feet, referred to as deep water for purposes of this study. Once per month ten 15-minute trawls were completed in the Bay. Six were selected at random from the shallow pool, four were randomly selected from the deep-station pool. During the months of February through May two additional tows were completed monthly between the Braga and Brightman Street Bridges to improve knowledge of the abundance and distribution of winter flounder. These two tows were selected at random from the three established in those locations in 1993 with all three being in water over 20 feet deep (Figure F-2).

Beginning in July 1997 sampling with the Wilcox trawl was extended outside Mount Hope Bay to include a single tow in the Warren River and one on Ohio Ledge. These two stations are included in RIDEM's monthly sampling program (Lynch 1998, Figure F-4). Sampling these two locations was designed to increase the amount of overlap between the RIDEM Narragansett Bay and Mount Hope Bay sampling programs, realizing that different gear is used.

All fish were identified, counted, and measured (TL = total length) to the nearest millimeter. Flounder equal to or exceeding 270 mm TL, the length at which 50% of the stock reaches maturity (NOAA 1995), were weighed (±1 g) unless choppy seas prevented scale stabilization. These fish were also tagged with RIDEM Petersen disc tags secured through the dorsal musculature. This tagging program was conducted in cooperation with RIDEM with the tags being returned to their office. Mid-depth and bottom water temperatures (°C) along with bottom dissolved oxygen were recorded at each station with a Hydrolab Surveyor III. When sampling the random stations, to save time, Hydrolab profiles were occasionally omitted from one location if two stations were in close proximity to one another.

For the long-term numerical dominants collected by standard trawl, an abundance index was computed based on the delta distribution (Pennington 1983, 1986, 1996; NUSCO 1988, Smith 1988). The delta distribution provides an abundance index with substantially lower variance compared with conventional indices such as the arithmetic mean if the data set consists of many zero tows and the non-zero values follow the lognormal distribution. Delta mean calculations require the iterative computation of one parameter (g) and are therefore best completed with a computer. For winter flounder the proportion of zeros increased markedly after 1985 (see Table F-4). For years where the proportion of zeros was low (see for example 1983-1985, Table F-4), the delta mean approached or equaled the arithmetic mean. Non-zero values were checked for normality using procedures outlined by Ryan and Joiner (1976). To remain consistent with the historical time series the randomly selected bay-wide transects added to the standard trawl program beginning in March 1997 were excluded from these calculations. Since the distribution of annual delta means over the 1972-1997 time series was

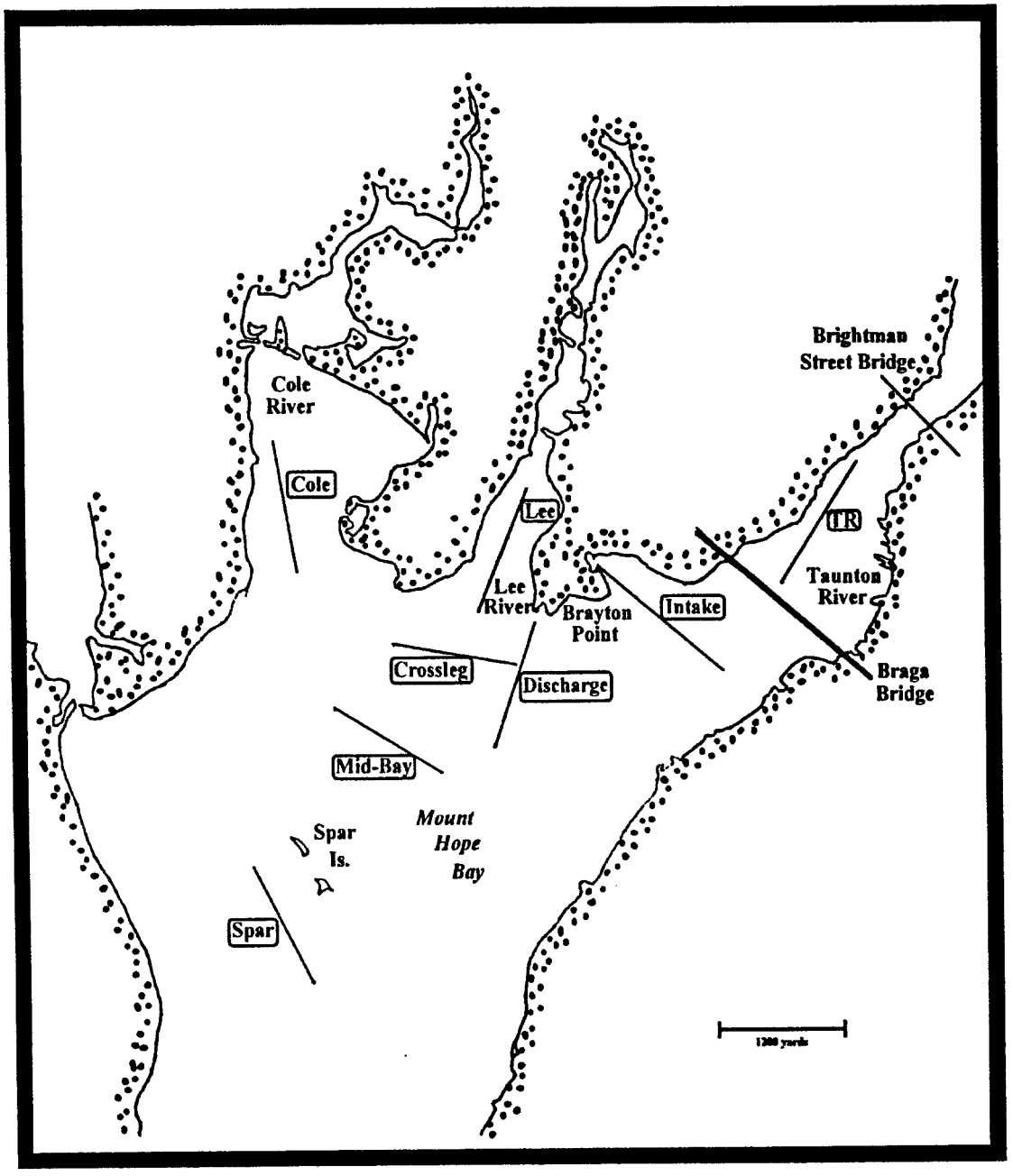


Figure F-1. Location of long-term fixed otter trawl transects.

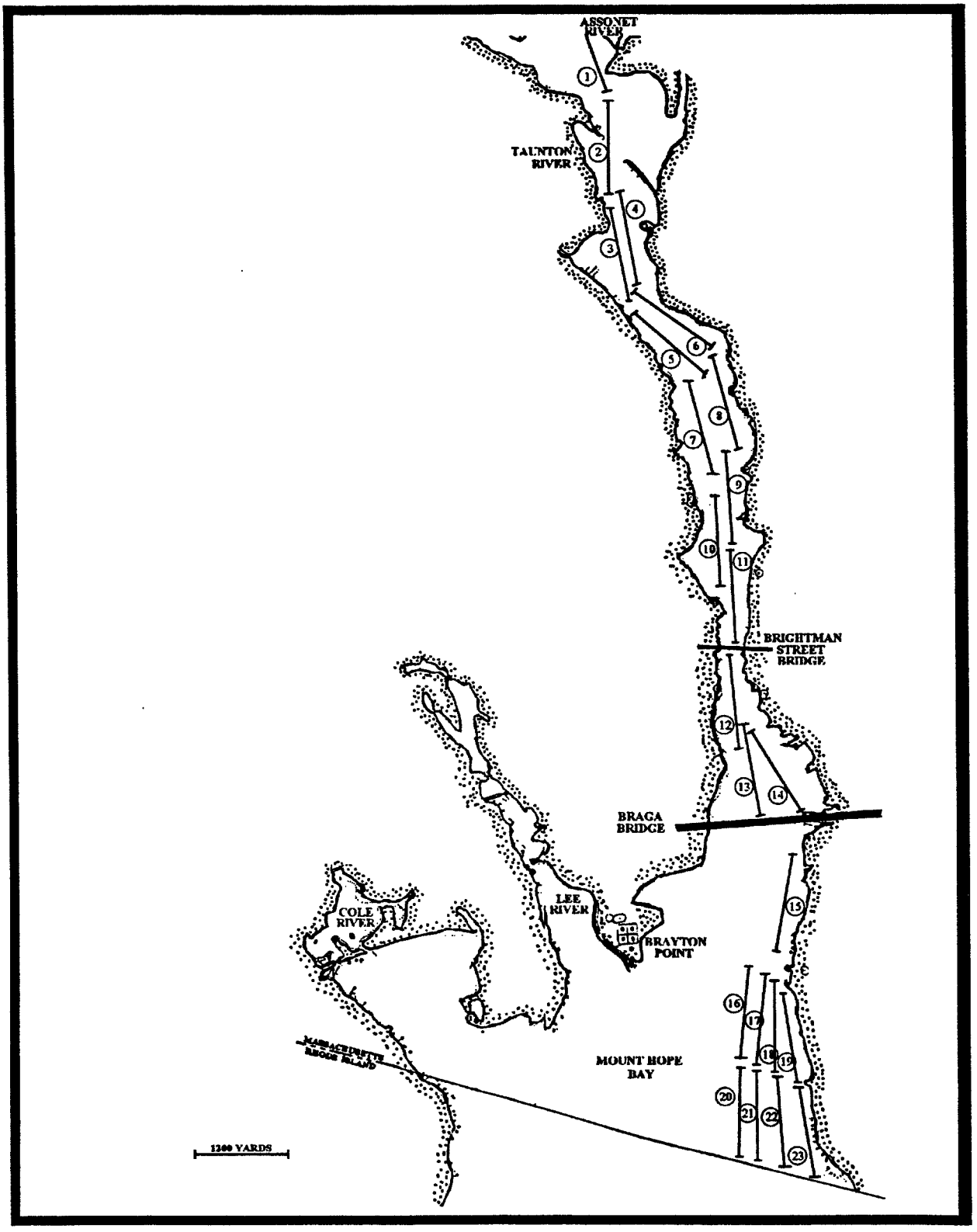


Figure F-2. Pool of 23 trawl transects in upper Mount Hope Bay and the Taunton River from which additional random sampling was completed with both standard and Wilcox trawls.

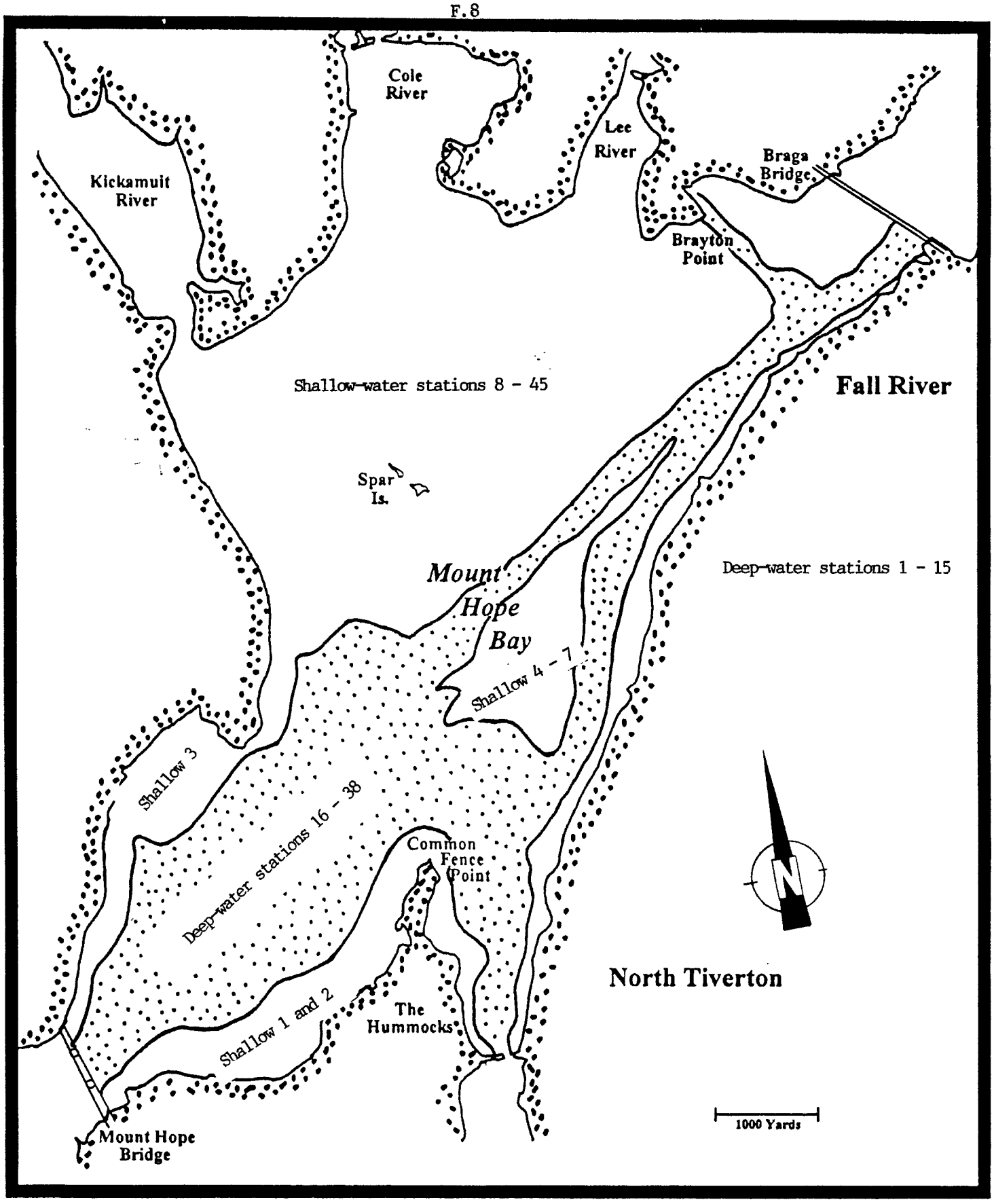


Figure F-3. Approximate locations of shallow (<20 ft) and deep-water (>20 ft) trawl transects in Mount Hope Bay.

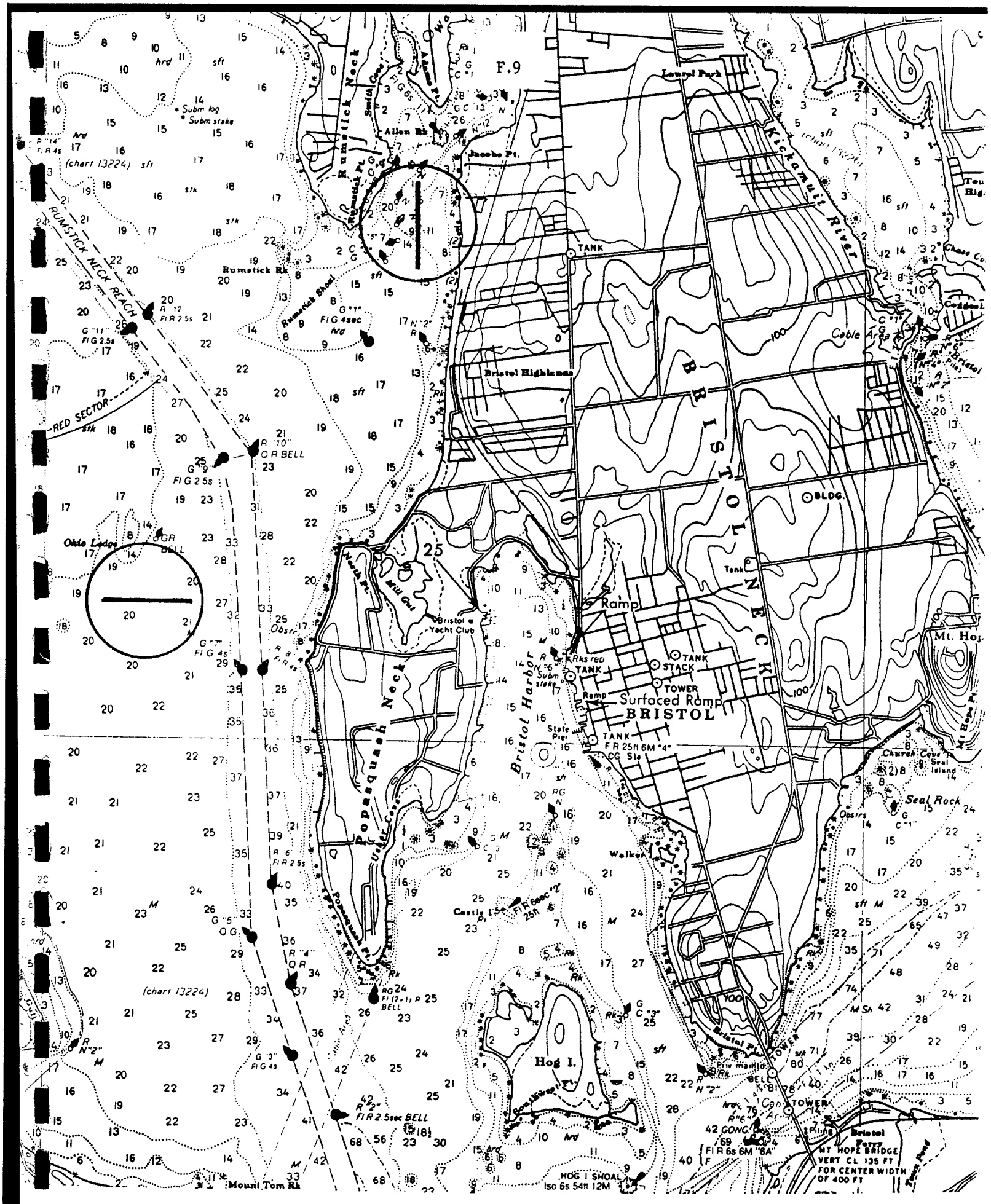


Figure F-4. Approximate location of RIDEM's Ohio Ledge and Warren River trawl transects.

skewed in some cases (see scup, *Stenotomus chrysops*, Table F-12), the median delta mean was used to describe long-term abundance.

Results and Discussion

Standard Trawl

A total of 31 species were collected in the 119 tows completed with the standard trawl in 1998 compared with an average of 25 species per year (s.e. = 1.4) over the 1972-1997 period. Trawls included the randomly selected deep and shallow tows introduced to the program in March 1997. May, August, and September collections produced the most species with 13, 17, and 13 per month, respectively (Tables F-2, 3). Since the number of species represented in the catch is proportional to the number of tows completed over the course of the year, a logistic curve was fit to the number of species versus the number of tows completed each year. The curve, using the form (N = a/1+(x/xo)^b, Figure F-5), described the relationship with an R^2 value of 0.797 and gave a predicted value of 32 species for 1998's total of 119 tows, one more then actually collected. These data suggest that the number of species taken was consistent with the historical pattern accounting for variation in the number of tows.

Eight species of the 31 collected accounted for 77% of the total catch with the standard trawl in 1998 - winter flounder, windowpane (*Scophthalmus aquosus*), bay anchovy (*Anchoa mitchilli*), butterfish (*Peprilus triacanthus*), alewife (*Alosa pseudoharengus*), scup, Atlantic herring (*Clupea harengus*), and striped searobin (*Prionotus evolans*), (Figure F-6). The August collections produced both the highest monthly species counts and the largest overall catch rates with a stratified mean number per tow for total fish of 12 (s.e.= 2.7). Butterfish accounted for the majority of the catch during that month.

Winter flounder, ranked first in the 1998 standard trawl catch, accounting for 22% of the total. They were collected each month of the year with peak collections occurring in April and May when respective stratified means of 2.0 (s.e. = 0.8) and 2.7 fish per tow (s.e. = 0.9) were obtained. Over the course of the year more winter flounder were taken along the deep transects then the shallow ones by a factor of 2.5. Ratios between deep and shallow, where they could be calculated, ranged from 1.2 (April) to 10.6 (August); flounder were collected only along the deep transects in July and October and only along the shallow transects in January and February (Figure F-7). Length-frequency data for winter flounder are presented in Figure F-8 for the January through June and July through December periods. Based on length-at-age data from Howell et al. (1992), ages 1 through at least 6 were represented in the catch. Since it becomes increasingly difficult to age fish based on length as they grow older because of overlapping lengths at age, the single 428 mm individual collected in February was likely older then 6 years. Ages 1 through 3 (1995-1997 year classes) accounted for the majority (79 and 95 %) of individuals in both time frames although it is important to consider that age 1 flounder are under sampled by the standard trawl (NEP and MRI 1996) which will be discussed further below.

Winter flounder mean monthly abundance based on the 1998 standard trawl collections (stratified means over all stations) was compared with the median value of individual monthly means over the 1972 through 1997 period (Figure F-9). All individual monthly means were based on either five (1972-1979), seven (1980-1985), six (1986-1996), or ten stations (1997-1998) . The three-minute Discharge tow was excluded over the 1980-1985 period since it was only one-fifth the length of the other tows. For all months in 1998 flounder mean catch rates were well below the historical monthly median catch per tow. When flounder were more common, they were collected throughout the year but were most abundant during April, May, November and December just before and after their January-to-April spawning season. Low catch rates were typically recorded in February and again from July through September. The February low catch rate presumably resulted from movement of large fish onto spawning grounds perhaps further up into estuaries or near shore beyond the influence of trawling. It is also likely that adults become more aggregated during the spawning season reducing the probability that individuals will be encountered by sampling gear. Movement of large fish downbay to deeper, cooler water in summer and similar movement of young fish to deeper water explains the decrease in catch during summer (see Klein-MacPhee 1978 for synopsis). In 1998 an increase in catch occurred in April and May following the historical pattern but a clear autumn rise preceding the 1999 season was not apparent.

Windowpane ranked second in 1998, accounting for 12% of the year's catch with the standard trawl. They were represented each month of the year as were winter flounder. Although windowpane do not appear to migrate extensively (Moore 1947, Morse and Able 1995) it is likely that they move to deeper water during the warmest and coldest months. They were most abundant from May through July when stratified mean catch per tow reached 1.2 (s.e. = 1.0), 1.1 (s.e. = 0.4), and 1.1 (s.e. = 0.5), respectively. Fish ranged in length from 84 to 297 mm (mean = 224, s.e. = 5.7, n = 63) suggesting, based on work in Rhode Island waters (Moore 1947), that the majority of individuals were two and three-year old fish . Windowpane were more numerous along the deep water transects, the annual average at those locations (1.1 per tow) exceeding the shallow water catch (0.2 per tow) by a factor of 5.5.

Bay anchovy, the numerically dominant ichthyoplankton species in Mount Hope Bay (MRI 1993), contributed 10% of the annual total in the standard trawl. They were found in the catch from May through November at stratified mean densities ranging from 0.5 (s.e. = 0.5) to 1.9 (s.e. = 1.3) per tow, respectively. The fish taken in May were adults ranging in length from 66 to 91 mm, those taken in summer and fall were primarily young-of-the-year ranging in length from 29 to 65 mm total length. Since these fish were well under a size likely to be retained by the standard trawl in proportion to their abundance, the individuals taken were probably entangled in marine vegetation and debris in the net.

Butterfish migrate seasonally both inshore and northward from offshore wintering areas. They are available to bottom trawls because they tend to remain near bottom at least during the day (Murawski et al. 1978). They are a summer- fall resident of Mount Hope Bay and were collected from July through November in 1998 although the majority were found in the August collections (stratified mean = 4.5 per tow, s.e. = 1.0). Overall they ranked fourth in numerical importance contributing 10% to the year's catch. Consistent with many other species, most of the season's

butterfish (79%) were obtained along the deep-water transects (mean shallow = 0.5, mean deep = 2.6, May-November). Over the course of the season, fish ranged in length from 41 to 154 mm (mean = 66 mm, s.e. = 3.1, n = 52). Most fish were apparently young-of-the-year but six age 1 fish were included (Murawski et al. 1978).

Fifth among fishes in the standard trawl was the alewife, an anadromous species which utilizes the tributary rivers and streams of Mount Hope Bay for spawning and nursery habitat. Young and adults typically winter offshore (Neves 1981) but some young fish apparently spend the winter in the deeper waters of Narragansett Bay since they are occasionally impinged on power plant intakes in winter (see for example MRI 1998). They were collected in April, July, October, November, and December. July collections were highest with a stratified mean of 1.5 per tow (s.e. = 0.8). Those taken in April (stratified mean = 0.4, s.e. = 0.4) were individuals completing their first year (88, 88, and 115 mm TL, n=3) with one adult, perhaps three years old included (275 mm TL; Clayton et al. 1978). Young of the year accounted for the majority of fish collected from July through December. They ranged in length from 75 to 121 mm. With one exception (October, n=1) all alewives were collected along deep water transects.

Scup ranked sixth in the 1998 standard trawl catch. They are a seasonal migrant to Mount Hope Bay, spending the winter in deeper continental shelf waters or further south (see for example Bigelow and Schroeder 1953, Clayton et al. 1978). They were taken in May, June, August, and September, the latter catch being highest with a stratified mean of 1.5 per tow (s.e. = 0.1). Over the course of the four-month collection period 56% of the scup taken were found in shallow tows. Length-frequency information indicated that fish averaged 126 mm in length (s.e. = 7.9, range = 69-258). With the exception of two older fish measuring 233 and 258 mm, individuals of this size were probably members of the 1997 year class returning to the upper Bay as one-year-old fish (Morse 1978).

Atlantic herring are widely distributed in New England waters, young fish contributing to the well known sardine fishery. They were found in the standard trawl in March and May collections, most in May with a stratified mean of 2.9 per tow (s.e. = 1.8). Fish ranged in length from 50 to 91 mm averaging 70 mm (s,e, 2.1, n = 29) indicating that they were young fish resulting from the August-October 1997 spawning season (Bigelow and Schroeder 1953, Clayton et al. 1978). They were found in both shallow and deep hauls although 62% were taken along the deep transects.

Searobins (*Prionotus spp.*) are a common bottom fish often taken in trawls, pound-nets, and by hook and line fishermen. They are not often retained for human consumption because they are generally small and difficult to handle because of boney plates on the head and pronounced spines (see for example McBride et al. 1998). Two species occur in Mount Hope Bay, the northern searobin (*P. carolinus*) and the striped searobin (*P. evolans*). Last among the numerical dominants, striped searobin were collected in small numbers from May through September, June's collections providing the most fish with a stratified mean of 1.4 per tow (s.e. = 0.1). While found along both shallow and deep transects, 87% of the total was found in deeper water. Fish averaged 258 mm total length (s.e. = 16.9, range = 88 - 342) suggesting that most were in their third and fourth years (McEachran and Davis 1970).

As the individual species accounts indicated, the deep-water transects clearly produced greater numbers of fish (all species combined) than the shallow transects (Figure F-7). Only in February when a total of three fish were collected, all along shallow transects, did the shallow tows produce more fish then the deep ones. June and July collections represented the extreme with mean number per tow in the deep-water samples exceeding the mean number in the shallow samples by factors of 12 and 48, respectively. The greater productivity of the deep tows is consistent with previous sampling which showed that the deep Intake transect regularly yielded the most fish (NEP et al. 1998). From 1972 through 1983 before fish stocks declined, the mean annual catch at the Intake station accounted for an annual average of 80% of the catch when compared with the mean catch at the three long-term shallow-water stations (Cole, Lee, Spar). The contribution of the Intake tow appeared to decline in response to periodic dredging but returned to as high as 96% of the total in 1994 and 1996. The Intake collections represented 88% of the total in 1997 and 90% of the 1998 total when considering only the original four fixed stations..

Abundance Trends - Standard Trawl

Annual mean catch per tow with 95% confidence limits based on the delta distribution was calculated for winter flounder, windowpane, tautog (*Tautoga onitis*), hogchoker, scup, butterfish, and little skate (*Raja erinacea)*, seven species which have typically dominated the Mount Hope Bay standard trawl catch.

Abundance trends for the numerical dominants in the Mount Hope Bay catch were compared with several other New England trawl surveys. These included data from the Connecticut Department of Environmental Protection trawl survey, the Millstone Nuclear Power Station monitoring program, Rhode Island Division of Fish, Wildlife, and Estuarine Resources survey, University of Rhode Island Graduate School of Oceanography survey, Massachusetts Division of Marine Fisheries survey, and the Pilgrim Nuclear Power Station survey.

The Connecticut DEP trawl survey data was obtained by using a 14-m otter trawl (51-mm cod end mesh), towed for 30 minutes at 3.5 knots, at 40 locations sampled monthly, April-June (spring). Site selection involved a stratified-random design which covers all Long Island Sound waters from the western Connecticut border to New London (Simpson et al. 1995). Monitoring in the Niantic River for the Millstone Nuclear Power Station, also in Connecticut, utilized a 9.1-m otter trawl (6.4-mm bar mesh cod end) towed at three locations during two days per week from ice-out (February, early March) through early April. During the remainder of the year three locations were trawled biweekly (NUSCO 1998).

The RIDEM trawl survey employs a stratified random design in Narrragansett Bay with 16.5-m high-rise trawl (9.5-mm cod end) towed for 20 minutes at 2.5 knots. Surveys were completed in spring and fall of each year (see for example Lynch 1998, Gibson 1993b, Tim Lynch personal communication). Beginning in 1990, using the same gear, a monthly 12-fixed-station (increased to 13 in 1992) monitoring program was added covering the Rhode Island area of Narragansett Bay (Lynch 1993) including two stations in Mount Hope Bay. Data from both trawl series are included in this section.

The longest continuous time series of trawl surveys, dating back to 1967, is maintained by the University of Rhode Island Graduate School of Oceanography (URIGSO). Once a week, year-round, a 10-m bottom trawl (51-mm cod end) is towed for 30 minutes at a station in Narragansett Bay (Fox Island) and one in Rhode Island Sound (Whale Rock; Jeffries and Johnson 1974; Jay Hermson personal communication, February 1998).

The Massachusetts Division of Marine Fisheries (MDMF) resource assessment program employs a 15.5-m trawl (6.4-mm cod end) towed for 20 minutes at 2.5 knots. Surveys were completed in spring and fall covering approximately 85 stations in each season. The northern stock survey covered from the New Hampshire border to Cape Cod and the southern stock survey from Cape Cod through Nantucket and Vineyard Sounds (Howe et al. 1994). Lastly, bottom trawl surveys associated with Pilgrim Nuclear Power Station (PNPS) on the coast of Massachusetts employed a 9.8-m bottom trawl (6.4-mm stretch cod end) towed monthly at four stations from January-March and biweekly during April-December. Tow duration was 15 minutes (Lawton et al. 1992). Due to a change in emphasis the PNPS trawl series became inconsistent with the long-term time series after 1994.

Winter Flounder

Mount Hope Bay winter flounder catch per tow declined sharply following 1983 and dropped below the minimum value of the 1972-1983 time series (10.6 fish per tow in 1976) in 1986 when 5.8 fish per tow were obtained. By 1988, mean catch per tow dropped below 1 fish per tow where it has remained for the past eleven years (Figure F-10, Table F-4).

Time series data provided by the other New England trawl surveys are summarized in Figure F-11 and Table F-5. With the exception of the Connecticut DEP series, each of the flounder surveys are consistent with the Mount Hope Bay survey in that abundance declined sharply during the 1980's and has remained at very low levels through 1998. The Niantic River time series dropped from a high of 51 per tow in 1981 to a low of 1.6 per tow in 1996. The 1997 and 1998 catch were barely higher at 2.4 and 2.1 per tow, respectively. The RIDEM seasonal (spring and fall) survey index declined from 139 flounder per tow in 1979 to 3 per tow in 1998, and the monthly index, which did not begin until 1990, declined from 20 per tow that year to a low of 6 per tow in 1998. The URIGSO series declined from 284 per tow in 1979 to 5 per tow in 1994 then back up to 37 in 1995. Values for 1996 through 1998 ranged from 13 to 18 per tow. The MDMF southern stock index peaked in 1983 at 19 individuals per tow, then declined steadily to 3 per tow in 1991. Since that time catch rates have improved somewhat, rising to 13 per tow in 1994 and 10 per tow in 1996 and 1997. The MDMF northern stock index followed a similar but less pronounced pattern dropping from 29 per tow in 1983 to 10 per tow in 1994. The catch in 1995, 1996, and 1997 improved to 15, 13, and 15 per tow, respectively. The Connecticut DEP time series began in 1984, peaked in 1990 (170 flounder per tow) out of step with the other surveys, and declined sharply through 1995 (48 per tow). Abundance increased in 1996 (93 per tow) ranking sixth with the highest catch since 1991(119 per tow), but then dropped to 57 and 59 per tow in 1997 and 1998. The PNPS survey differed from the Niantic, the three Narragansett Bay surveys, and the Massachusetts MDMF surveys in that catch rates

increased sharply in 1992 (8 per tow) and again in 1993 (12 per tow) from zero in 1991; unfortunately program changes ended that series after 1994 (8 per tow).

The 1992 year class, believed to have been a strong one (NFSC 1996, Gibson 1998), may explain the increase in abundance in the Connecticut DEP series in 1994, the southern MDMF survey that same year, and the PNPS surveys, but it is not apparent in the Niantic nor the three Narragansett Bay surveys. While improvements in catch in the RIDEM and URIGSO surveys was apparent in 1995, the fine mesh cod ends utilized in those surveys would presumably have retained the 1992 year class beginning in 1993. An increase in catch that year was not apparent. In any event the 1992 year class was likely reduced by fishing mortality (Gibson 1998) and each of the survey indices remains at historically low levels.

Windowpane

Annual windowpane abundance in Mount Hope Bay is highly correlated with that of winter flounder ($r = 0.949$, $p < 0.0001$, 1972-1998). Annual abundance declined from a high of 11 per tow in 1979 to 0.07 per tow in 1991 and 1992 (Figure F-12, Table F-6). Abundance gradually increased from 1991, 1992 to 0.91 in 1996 but again declined to 0.73 in 1997 and 0.40 per tow in 1998. The 1996 index of 0.91 per tow was the highest since 1985 when 2.0 per tow was recorded. Based on length-frequency data, age 2 and 3 fish predominated in the catch in 1996 (NEP et al. 1998) suggesting that the 1993 and 1994 year classes were relatively strong and that these fish continued to contribute in declining numbers to the 1997 and 1998 catch. In spite of the subtle upward trend observed over the 1993 through 1997 period, windowpane abundance remains at a relatively low level. For example, the median delta mean observed from 1972-1985 was 4.1 fish per tow, which compares with a median of 0.3 fish per tow over the 1986-1998 period.

Six other New England surveys track windowpane and are of sufficient time series length to permit patterns to emerge for comparison with Mount Hope Bay trends. These include Connecticut DEP, Niantic River, Narragansett Bay - RIDEM and URIGSO, Massachusetts Division of Marine Fisheries, and Plymouth (PNPS, ending with 1994; Figure F-13, Table F-7). The Connecticut DEP, RIDEM Narragansett Bay, and URIGSO Narragansett Bay series, like the Mount Hope Bay time series, display clear downward trends over their length . The long URIGSO series began to decline in 1970 although three relatively strong years did occur from 1978 to 1980. The Niantic River series differed from the Connecticut and Narragansett Bay series in that no long-term downward trend is apparent; rather the reverse appears true. Catch rates increased more or less steadily from 1976 to 1995-96. Collections in 1993 represented the peak over the time series with 6 fish per tow being taken. The MDMF survey showed peak windowpane abundance in 1982 (26 per tow) with a declining trend through 1991 (5 per tow). Collections reversed after that, showing a near-steady increase from 1991 through 1996 (19 per tow) with the exception of 1993 (14 per tow) and 1994 (13 per tow). In 1997 (10 per tow) collections declined to the lowest level since 1991. The post-1991 upward trend observed in the MDMF series is similar to that apparent in the Niantic time series. The PNPS series declined more or less steadily from 1983 to 1991 but rebounded in 1992 and 1993 before dropping sharply again in 1994 when the time series ended. The 1996 catch represented an increase over 1995 in each series except for the Niantic, but that increase did not continue into 1997.

Relatively strong collections in 1996 were common to all but the Niantic series but each series declined from 1996 through 1998, suggesting once again that region-wide signals appear to exist some years for some species.

Tautog

Tautog are closely associated with hard structure such as breakwaters, ledges, pilings, bulkheads, and rocky bottom where they typically remain inactive at night, often lying on their sides (see Bigelow and Schroeder 1953; Olla et al 1974 for example). As a consequence they are not readily available to bottom trawls. When relatively common in Mount Hope Bay, during 1972-1982 for example, annual catch rates averaged less than two fish per haul. Abundance dropped to 0.1 fish per tow in 1986 and has remained at that low level ever since. In 1997, for the first time no tautog were collected at the fixed trawl locations (two individuals were taken that year in two randomly selected, deep tows). Median annual mean catch per tow amounted to 0.9 from 1972 through 1985 dropping to 0.06 over the 1986 through 1998 period (Figure F-14, Table F-8). Tautog are considered to be mildly over-fished (RIDFWER 1994, Gibson 1998), a conclusion consistent with the Mount Hope Bay data.

Abundance trends for tautog are available for four of the areas discussed above for winter flounder and windowpane - Connecticut DEP, Niantic River, and the two Narragansett Bay surveys (both RIDEM and URIGSO; Figure F-15, Table F-9). With one exception all four surveys display clear downward trends over time with 1994 or 1995 representing time series' low points for the Connecticut DEP (0.2 per tow), Niantic River (51 fish collected), and RIDEM (seasonal = 0.1 per tow, monthly = 0.3 per tow) surveys. Average catch in the URIGSO series was also at a low point (0.1 per tow) but a total of seven years, all after 1987, had the same value including 1997. For the first year in the URIGSO Fox Island time series no tautog were collected along that transect in 1998. The Niantic, while trending downward, shows a more subtle decline with several good years (1986-87, 1990-91, 1995-96) interspersed. Interestingly, 1996 turned upward in all four surveys as well as Mount Hope Bay, particularly so in the Niantic where a strong year class of young entered the catch in 1995-96 (NUSCO 1997) but this trend did not carry through into 1997 and 1998.

Hogchoker

The hogchoker is a small, rough-sided, right-eyed flatfish seldom found at more than 6 inches in length. It is most often taken in bays and estuaries and because of its small size has no commercial or recreational value. Never more abundant in the Mount Hope Bay standard trawl than 2.8 per tow on an annual basis (1974), abundance dropped sharply following 1985, reaching record low catch rates for the first time in 1988 and 1989 when zero and one fish (mean = 0.014 per tow) were collected, respectively. Subtle increases in catch relative to that low occurred in 1995 (0.291 per tow), 1996 (0.450 per tow), and 1997 (0.352 per tow); 1998 showed a drop to 0.07 per tow, lowest since 1992. Collections in 1996 represented the highest since 1985 (1.528 per tow; Figure F-14, Table F-10). Median annual mean catch per tow was 1.2 over the 1972-1985 period compared with 0.10 from 1986-1998.

Since hogchoker are of little commercial or recreational value, few surveys track their abundance on a regular basis. Time series are available only for Connecticut and Narragansett Bay (RIDEM; Figure F-16, Table F-11). They are seldom taken in Niantic River collections, were uncommon in lower Narragansett Bay where the URIGSO tows are made, and occur rarely north of Cape Cod where PNPS studies were conducted. Consistent with the Mount Hope Bay trend, catch rates declined in both surveys through the 1980's. Both the Connecticut and Narragansett Bay time series closely paralleled Mount Hope Bay with increases in 1995 and 1996 followed by a downturn in 1997 and 1998. Hogchoker were in fact absent from the two Narragansett Bay series in both 1997 and 1998. The apparent regional decline in this species presents an enigma since overfishing is unlikely to be responsible. While some individuals are probably lost to bottom trawling, their small size suggests most should pass through commercial netting.

Scup, Butterfish, Little Skate

Mean annual abundance for scup in Mount Hope Bay, calculated over the months of May-October when they are present in the Bay, has varied from 0 (1988 and 1990) to 47 per tow (1976) with a median of all annual means of 2.3 per tow. No abrupt declines were apparent following 1985 as with flounder, windowpane, hogchoker, and tautog, although the last relatively productive year was 1981 (10 fish per tow; Figure F-17, Table F-12). Annual estimates of scup abundance were available for comparison from Connecticut (DEP and Niantic River) as well as the two Narragansett Bay surveys. All four time series show scup to have been very abundant in 1991 (Figure F-18, Table F-13). At that time Mount Hope Bay collections were above average but not remarkable, suggesting that scup may not typically move as far up into Narragansett Bay as Mount Hope Bay. This is supported by impingement collections at Brayton Point where scup are uncommon (see following section B). Both Narragansett Bay surveys are consistent with Mount Hope Bay in that 1994 and 1998 abundance was low. Both the RIDEM and URIGSO survey indices showed increasing trends from 1994 through 1997 but these trends did not continue into 1998. No recent upward trend was apparent in Mount Hope Bay. The decline in scup abundance from 1991 through 1994 in both Narragansett Bay surveys is inconsistent with past data indicating that scup appear to increase in number when winter flounder stocks are low (Jeffries and Terceiro 1985; Terceiro 1987; Jeffries 1994). Scup abundance in the Connecticut DEP survey in 1995 (59 per tow) and 1996 (62 per tow) approximated the median annual mean of 62 per tow for that series, but the 1997 value (41 per tow) dropped to its lowest value since 1988 (40 per tow). In that survey, 1998 recorded the second highest value of the time series (103 per tow). In the Niantic River, collections dropped sharply from the 1991 peak of 176 per tow to a time series low in 1996-1997 of 0. 3 per tow but, consistent with the Connecticut DEP series, increased in 1997-98 to 8 per tow near the time series median of 13 per tow.

Butterfish and little skate have never been particularly abundant in Mount Hope Bay trawl collections. Highest observed catch rates were 1.5 per tow for butterfish and 0.9 per tow for little skate, both in 1992. Over the 27-year time series butterfish typically alternated between a near-zero catch year and roughly one individual per tow (Figure F-17, Table F-14). They were taken with some regularity in the Wilcox trawl in 1996, 1997, and 1998, primarily at the deep stations, (mean monthly catch per tow ranged from 0.3 to 1.0 per tow between June and October 1996, 0.1 to 32 per tow

between May and September1997, and 0.6 to 84 per tow between July and September 1998, see below) suggesting that individuals were not generally available to the standard trawl which sampled primarily shallow-water stations until 1997. Most individuals taken in the Bay have been about 100-mm in length (see above), a size which is probably not fully retained by the standard trawl mesh. In 1998 they averaged only 59 mm in the Wilcox trawl (range= 25-160, n = 208) indicating that most were young-of-the-year. Butterfish increased in lower Narragansett Bay in recent years based on both RIDEM and the URIGSO time series although particularly high variability is apparent (Figure F-19, Table F-15). The general increase is coincident with the decline in winter flounder stocks as suggested by Jeffries (1994). A similar pattern has not appeared in Mount Hope Bay however, suggesting they may be under-sampled there by the standard trawl or perhaps that butterfish do not frequent the shallow waters that far up the Bay. Annual estimates of butterfish abundance in Connecticut, both DEP and Niantic, show greater abundance after 1987 than before with wide swings in number from one year to the next, consistent with the lower Narragansett Bay time series. In the Niantic series,, 1997-98 was the second consecutive year with no butterfish being found.

Little skate have generated interest over the past decade because surveys have shown increases in abundance of cartilaginous fishes as numbers of principal demersal species such as winter flounder, yellowtail flounder, cod, and haddock have declined (see for example NOAA 1992 a,b; 1995). In Mount Hope Bay little skate, like butterfish, have always been taken in low numbers, averaging well under one individual per tow except for 1992 when 0.9 per tow was recorded (Figure F-20, Table F-16). In spite of continuing catch rates below one fish per tow, an increasing trend is apparent in the skate time series for 1972-1997 based on a sign test ($p = 0.046$, Sprent 1989). 1998 represented a reversal of that trend, the mean of 0.04 per tow being the lowest since 1981. A weak upward trend is also apparent in the Niantic River (sign test $p = 0.055$) with a stronger one in the URIGSO time series ($p = 0.004$). No trend was apparent in the Connecticut DEP or RIDEM series (Figure F-21, Table F-17).

Other Species

Table F-18 facilitates a general review of the otter trawl catch among years for all other species collected. Annual arithmetic mean catch per tow is shown by species on a calendar year basis for 1972 through 1998. Means include only the first tow in cases where replicates were taken (1972-January 1979). From 1979 to 1985 when eight transects were sampled, the three-minute Discharge tow, oriented perpendicular to the plume at that time, was excluded since all other tows were 15 minutes long. For 1998, the first year in which ten stations were sampled, bay-wide means are shown for the original six, fixed stations and for ten stations.

A lumpfish was collected for the first time in 1998. It was taken along one of the randomly selected deep-water transects in March, which suggests they occur in Mount Hope Bay but remain in the deeper waters of the lower Bay where sampling had not previously been conducted. Larval lumpfish do not appear on the ichthyoplankton species list for Mount Hope Bay (NEP and MRI 1994) but they appear nearly every year on the impinged finfish list (see Revolving Screen section).

The only noteworthy observations in 1998 involved the spotted hake (*Urophycis regia*), weakfish (*Cynoscion regalis*), and summer flounder (*Paralichthys dentatus*). Spotted hake and summer flounder were relatively abundant in the 1998 collections. Spotted hake were taken at a mean density of 0.11 over the six fixed stations compared with a time series mean of 0.01 per tow, and summer flounder were taken at a mean density of 0.13 over the six fixed stations compared with a time series mean of 0.07 per tow. Weakfish, which were relatively abundant in 1996 (annual mean = 1.8 per tow) after being completely absent for six years, were again collected in 1997, albeit in low numbers (mean=0.7 per tow). The increase was short lived however as weakfish were absent from the six fixed stations in 1998 although a single individual was taken along one of the randomly selected locations.

Aggregate Resource Abundance

Aggregate resource abundance in the Mount Hope Bay standard trawl has been compared with that from Narragansett Bay as measured by the RIDEM (seasonal time series) and the URIGSO trawl (Figure F-22, Table F-19, Gibson, 1996). Squid were included with the RIDEM and URIGSO trawl series since they can be an important component of the pelagic community, conserving biomass when fish stocks decline. Squid however, are relatively uncommon in Mount Hope Bay trawl collections and were not included. The Mount Hope Bay series varied without any particular overall trend from 1972 through 1983 (range = 24 to 106 fish per tow), at which point it began to decline, reaching a low of 1.5 fish per tow in 1988. In contrast, the two Narragansett Bay series did not drop as flounder, windowpane and other bottom species declined (see above) but continued to vary without trend. These data suggested that shifts in biomass occurred in lower Narragansett Bay while in Mount Hope Bay either biomass was lost or a shift occurred to species not adequately sampled in the Bay by the standard trawl. These observations were motivation for initiating sampling with the fine-mesh Wilcox trawl throughout the Bay. From 1994 to 1996 the Mount Hope Bay values for the standard trawl gradually increased (2.4 to 5.9 per tow), a trend which then reversed dropping to 4.2 per tow in 1997 and 2.4 per tow in 1998. A decline from 1997 to 1998 was also observed over all stations sampled with the standard trawl beginning in March 1997 (5.5 to 4.6 per tow, respectively). While the standard trawl aggregate catch declined after 1996, the fine-mesh trawl catch in the third year of year- round and bay-wide sampling did the reverse, increasing from 19.5 in 1996 to 22.3 in 1997 and 35.2 fish per tow in 1998. RIDEM values also declined recently from 2332 individuals per tow in 1995 to 1272 in 1996, 1156 in 1997, and 1075 in 1998. The URIGSO data also display a similar downward trend beginning in 1994 (1385 per tow), dropping to 336 per tow in 1996. The 1997 value increased slightly to 360 per tow but 1998 followed with 344 per tow. These data suggest that the upper estuary may not always vary in concert with the lower Bay and nearby coastal waters although in the most recent four or five years all but the Wilcox series have declined.

To examine the distribution of species and species abundance in the standard trawl, one type of dominance diversity index was examined (Whittaker 1965, Gibson 1996). The index simply consists of the slope of the linear relationship between annual abundance expressed on a natural logrithmic scale and species rank. Steep slopes are less desirable in a community since they indicate that individuals are concentrated in a relatively small number of species. Gibson (1996) demonstrated that the time series of annual slopes for the Mount Hope Bay standard trawl declined over the 1972

through 1995 time series. Figure F-23 and Table 20 present dominance diversity values for the standard trawl updated through the 1998 season. Interestingly, the values for 1996 (-0.158) and 1998 (-0.159) not only reversed the trend apparent over the time series but represented the lowest slope (best indices) yet observed. The value for 1997 (-0.248) was about average for the time series (-0.241). The high 1996 and 1998 values can be attributed to the relatively high number of species obtained (27 and 31 versus the average of 25, see above) combined with a catch where numerical dominance was distributed over several species. For example, eight species accounted for 82% of the annual total in 1996, and eight species accounted for 77% of the annual total in 1998, while in 1995 five species represented 85% of the catch. With the relatively low diversity values obtained in 1996 and 1998 the time series no longer displays a statistically significant downward slope at the 95% probability level ($p = 0.074$) and suggests that the fish populations in Mount Hope Bay may be improving in terms of ecological balance in spite of the continued low abundance of the principal bottom fishes such as flounder and windowpane.

Wilcox Trawl - Stratified Random Tows

A total of 39 species were collected with the Wilcox trawl in 1998, the third complete year in which the finer mesh net was used throughout the Bay and throughout the year (Tables F-21 and F-22). Numerical dominants included bay anchovy, winter flounder, butterfish, scup, alewife and Atlantic silverside (*Menidia menidia*). Combined, these six species accounted for 83% of the year's catch (Figure F-6). Differences in net design, particularly mesh size, as well as the greater number of tows completed with the Wilcox trawl (total = 138 vs 119 in 1998) likely contributed to the observed differences in species composition when compared with the standard net. For example, retention of smaller individuals as well as fusiform species in the finer-mesh net is apparent in the presence of individuals of the blackspotted stickleback (*Gasterosteus wheatlandi*), and northern pipefish (*Syngnathus fuscus)*, species which were absent from the standard net catch.

Winter flounder were present in each month's collections with stratified mean number per tow ranging from 1.2 in January to 29.3 in May, with 8.8 per tow for the year (Figure F-24, Table F-23). The peak catch in May was consistent with the historical pattern mentioned above for the standard trawl. With the exception of January and July, flounder were taken in greater numbers at the deep-water stations, collections in September showing the extreme with a deep to shallow ratio of 6.2 to1(Figure F-25). Among the two exceptions, in January and July the shallow tows exceeded the deep by margins of 1.3 and 2.8, respectively. With the exception of the July catch, these results are consistent with the 1996 and 1997 data (NEP et al 1998) and with flounder life history information in general. As the Bay warms in late spring and early summer, winter flounder move from warm, shallow waters to deeper, cooler water (Lobell 1939; Perlmutter 1947; Bigelow and Schroeder 1953; Howe and Coates 1975).. The majority of flounder taken in May (82%) were age 1 fish ranging in length from 82 to 180 mm TL. Pearcy (1962) also reported that as flounder reach age 1 and older they appear to become more photonegative, suggesting that fish might congregate in deeper, darker channel areas as they enter their second year. The reversal in depth distribution among flounder in July was attributable to a single large haul of 80 flounder in a shallow tow and was inconsistent with typical results. Bottom water at hydrographic Station C for the month of July 1998 averaged only 20.3 C, the third coolest observed dating back to 1972 (see hydrographic section).

Perhaps winter flounder remained over shoaler waters later into the summer in response to those cooler temperatures.

Length-frequency data for winter flounder taken by the Wilcox trawl appear in Figure F-8. Since age 0, young-of-the-year flounder have begun to appear in the June catch in past years (fish ranging from 32 to 60 mm TL at that time), and the majority of the year's catch is taken before June, lengths were tabulated for January-May separately from June through December. The predominance of age 1 individuals, those 150 mm and less in total length, is readily apparent in the January-May Wilcox trawl particularly compared to the standard trawl. They accounted for 38% of the catch in the winter-spring standard trawl, 72% in the Wilcox trawl (Figure F-8). These fish also accounted for the majority of flounder later in the season as well.

Collections of winter flounder, windowpane, and all fish were compared over the course of the 1996 through 1998 sampling periods, the three complete years with stratified random stations sampled monthly throughout the Bay by Wilcox trawl (Figure F-26). On an annual basis the 1997 catch for flounder exceeded both 1996 and 1998 (stratified means = 9.3 vs 6.6 and 8.8, respectively; Table F-23). Windowpane were most abundant in the 1996 catch (annual stratified mean = 3.0 per tow) declining in both 1997 (1.5 per tow),and again in 1998 (0.3 per tow). Windowpane were particularly abundant in the fall of 1996 (Figure F-28). Total fish reversed the windowpane pattern increasing each of the three years from19.5 fish per tow in 1996 to 22.3 per tow in 1997, and 35.2 in 1998 (Table F-24). In 1997 and 1998 winter flounder were clearly more abundant in the catch during the early half of the year, particularly in May, when compared with 1996 but the reverse proved true during the second half of the year.

The fine-mesh Wilcox trawl was first used in Mount Hope Bay in 1993 (Table F-1). During that year, and during the subsequent two years, Wilcox tows were completed only during the February-through-May period to focus on small winter flounder. Tows were also restricted to upper Mount Hope Bay, the approach to the Taunton River, and the lower Taunton River itself (Figure F-2). Tows in or near the area covered during 1993-1995 were selected from the 1996 through 1998 data sets to allow six late-winter, early-spring seasons to be compared. Seasonal delta mean catch per tow was calculated for winter flounder and all fish combined (Figure F-27, Table F-25,26). Since the number of tows completed during each season was not large, confidence limits for the most part are wide. Bearing that in mind, winter flounder catch rates declined steadily from 1993 (49.1 per tow) through 1996 (4.2 per tow) with 1997 (12.2 per tow) and 1998 (12.7 per tow) showing a reversal of that trend. The high catch in 1993 reflected the strong 1992 year class which appeared as age 1 fish at that time. The subsequent decline likely reflected natural and fishing mortality within that year class to some degree. Aggregate values reflect the winter flounder pattern to a large extent since they typically contribute a high percentage of the catch during the February-May period (for example 64% in 1996, 63% in 1997). Mean catch per tow declined from 1993 (67.4 per tow) through 1996 (8.4 per tow) then increased in 1997 (23.0 per tow) and 1998 (45.6 per tow).

Since 1996, 1997, and 1998 were the first years that trawling was completed throughout the Bay, collections were compared between the upper and lower Bay with latitude 41.40.00 serving as a convenient dividing line between the two segments. That line extended from Mount Hope Point on the western shoreline to North Tiverton on the eastern side (Figure F-28). Since the lower Bay

by that definition only contains three shallow transects, comparisons were restricted to deep-water stations; data were limited since only four to six deep-water tows are completed each month. Figure F-29 shows mean catch per tow by month for the two Bay segments for all species combined and for winter flounder alone. Comparisons are coarse at best since in some cases data points are based on as little as three tows within the month even with three years combined (i.e., upper Bay in April and October).

With all species pooled together, the upper Bay produced more fish per tow than the lower during 8 of the 12 months, particularly during June through September when anchovy, butterfish, silversides, weakfish, and windowpane were common. For the three-year period as a whole, an average of 48 fish per tow were collected in the upper Bay while 29 per tow were collected in the lower Bay. For winter flounder alone the upper Bay led the lower Bay during 4 of the 12 months with an overall average of 10 fish per tow in the upper Bay compared to 14 per tow in the lower. While conclusions are limited by the number of tows, these data suggest that fish in general utilize deep-water habitat in both the upper and lower Bay. Winter flounder preferring cooler water during summer clearly will find more deep water habitat in the lower bay. During the summer months other fish were comparatively abundant in the upper Bay, primarily utilizing deeper water at that time.

RIDEM personnel, as part of their monthly Narragansett Bay survey, cover two transects in Mount Hope Bay, one just south of Spar Island in water less than 20-ft deep (Station 26) and one just north of the Mount Hope Bridge in water greater than 20-ft deep (Station 25; see for example Lynch 1998). Winter flounder and all fish collections from the year-round 1996 through 1998 Wilcox trawl were compared with the RIDEM trawl to see if collections were similar since while both nets have fine-mesh cod end liners they differ considerably in design (Table F-27). Since the Wilcox transects are randomly selected each month, it proved quite arbitrary to match Wilcox locations with RIDEM Stations 25 and 26. As an alternative, RIDEM Station 25 was compared with the mean catch per tow over the four deep Wilcox locations and RIDEM Station 26 was compared with the mean catch per tow over the six shallow locations. Numbers of winter flounder per tow were standardized to number per hectare of bottom sweep since nets and tow durations differed. Net spread was calculated following Fridman (1981) and Gomez and Jimenez (1994) and is recognized to vary considerably with such things as bottom type, bottom currents, warp length, amount of fish and algae in the net and tow speed (see for example Gunderson (1993). Since nets contributing to regression equations developed by Gomez and Jimenez were all larger then either the Wilcox or RIDEM trawls, wing spread was estimated at 50% of headline length for both nets.

Winter flounder density values from the two surveys in 1996 tracked each other quite well at the deep stations with no suggestion that one survey consistently sampled more flounder then the other (Figure F-30, Table F-28). Along shallow-water transects (Figure F-31) collections were also similar until July when the Wilcox tows consistently produced more flounder than the RIDEM tows. In 1997 and 1998 flounder collections were again similar between nets at the deep stations although in 1998 there were three divergences, May, August, and September. The Wilcox net catch was consistently higher along the shallow tows both years (Figure F-31, Table F-28). Examining aggregate fish catch from 1996 indicated that the deep-water tows produced similar numbers of fish with both nets until June when they diverged, the RIDEM tows consistently yielding more individuals from July through December (Figure F-32). In 1997 the difference in deep water was consistent over

the entire year with the RIDEM deep tow producing more fish then the Wilcox deep tows. 1998 was similar to 1996 with catch being comparable between nets until summer when the RIDEM net surpassed the Wilcox catch. Differences were less consistent at the shallow stations (Figure F-33) although the RIDEM net at times collected as much as 330 times more fish then the Wilcox net (September 1996). In both 1997 and 1998 shallow collections were comparable until August and September or October when the RIDEM net catch exceeded the Wilcox catch. Results suggest that the Wilcox and RIDEM nets collect comparable numbers of flounder with some suggestion that the Wilcox net collects somewhat more at shallow locations assuming that RIDEM Station 26 is comparable to other shallow locations in Mount Hope Bay. Pooling all species suggested the RIDEM gear collects more fish. Some of their larger collections consisted of small pelagic species such as Atlantic herring, butterfish, and anchovy (*Anchoa* spp.). Large collections of these individuals likely reflect that the RIDEM net is a "high rise" net. While the vertical opening of the Wilcox net is estimated to be 3 to 4 feet high, flume studies of the RIDEM net indicate that it rises 8 to 10 feet from footrope to headrope (Tim Lynch, RIDEM, personal communication, September 1997). The high-rise design of the RIDEM net may result in it occasionally lifting off bottom during the course of some tows particularly when filled with large numbers of pelagic species. At these times it would be less likely to capture winter flounder.

Similar results were obtained when comparing the catch from the RIDEM trawl and the Wilcox trawl along the Warren River and Ohio Ledge transects (mean catch per hectare over the two tows, July - December 1997, January - December 1998 Figures F-34 and 35, Table F-29). The Wilcox trawl often collected greater numbers of winter flounder while the RIDEM gear clearly collected more total fish. The large RIDEM collections in August 1997 (mean = 346 per hectare), September 1997 (3,310 per hectare) as well as June, September, and October 1998 (558, 1464, 1097 per hectare, respectively) which compared with mean Wilcox collections of 106, 80, 76, 66, and 34 per hectare, respectively, consisted of large numbers of bay anchovy, butterfish, and silversides. Anchovies (peak = 13 in September 1997), butterfish (peak = 42 in September 1997) and silversides (peak = 16 per hectare in November 1998) were represented in the Wilcox catch but in much lower numbers. These species probably occupy waters near but above bottom where they are taken more often by the RIDEM high rise net but not by the Wilcox net.

RIDEM began their monthly Narragansett Bay survey in 1990 which includes two stations (25, 26) in Mount Hope Bay as mentioned above. Mean number of fish per tow and mean number of winter flounder per tow were calculated for those two stations to see if trends determined in that program match trends with the standard trawl over the same period (Figure F-36, Table F-31). Stratified means for the Wilcox trawl were included although only the most recent three years are available. In general values for total fish parallel each other between sampling programs, 1990 and 1994 were low values in both surveys; 1991 and 1992 were relatively high in both surveys. Some divergence appeared in 1998 in that the RIDEM and Wilcox values increased relative to 1997 while the standard trawl declined. Overall the two programs were well correlated with untransformed data ($r = 0.719$, $p = 0.029$). Data for winter flounder alone also tracked well between surveys. Both surveys trended downward from 1990 to 1992 and again from 1995 to 1998. Abundance estimates were highly correlated ($r = 0.768$, $p = 0.016$; loge transformed data).

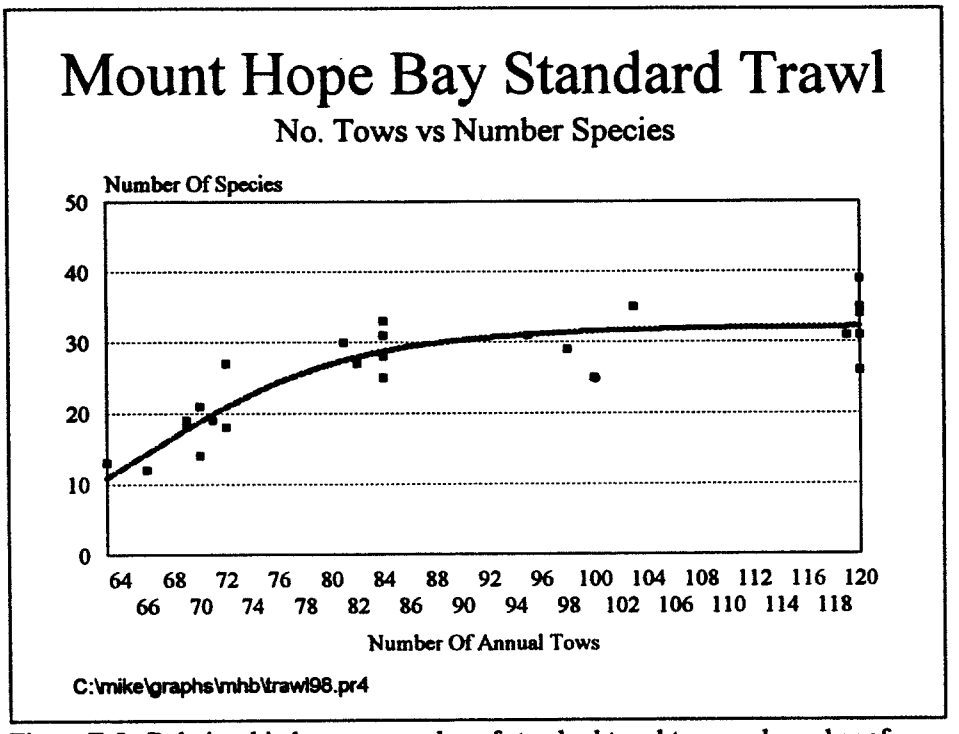
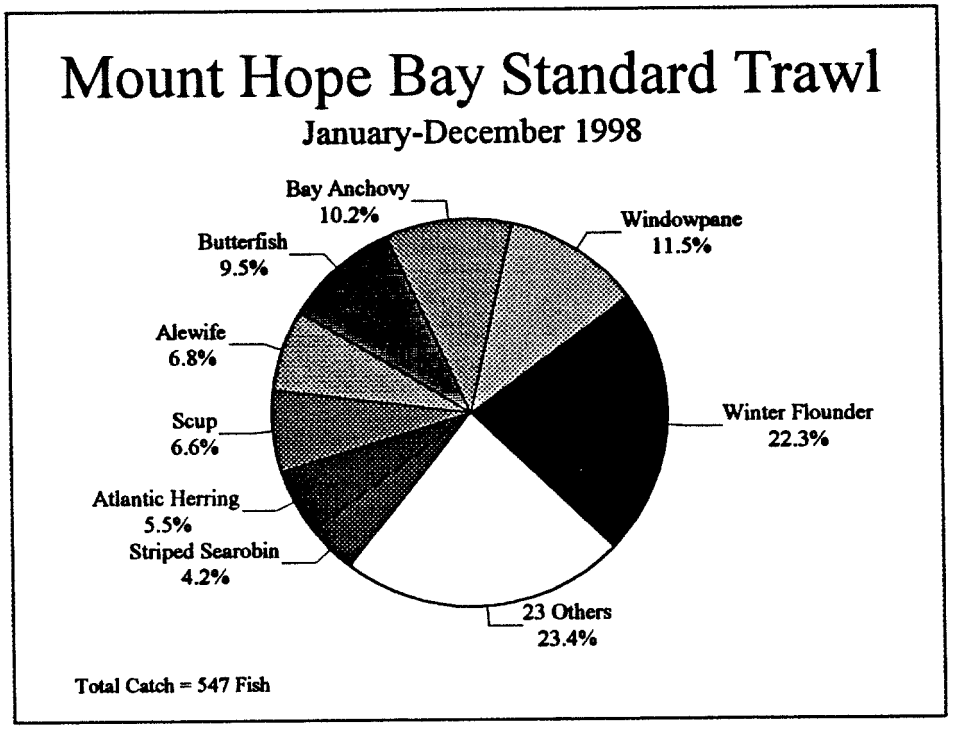


Figure F-5. Relationship between number of standard trawl tows and number of species collected annually in Mount Hope Bay, 1992-1998.



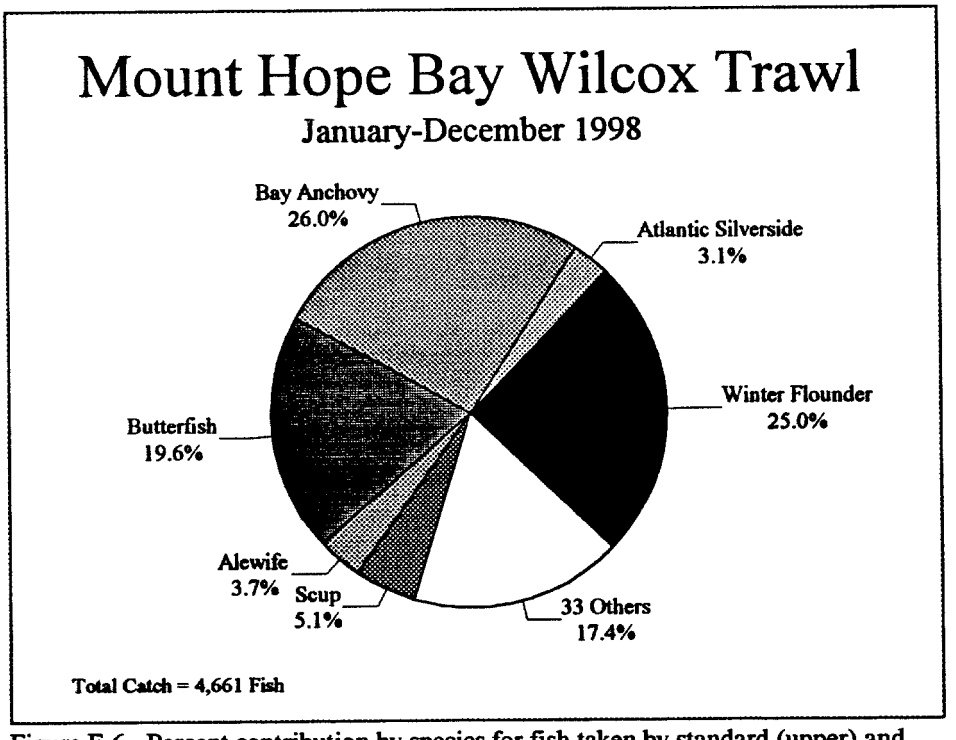
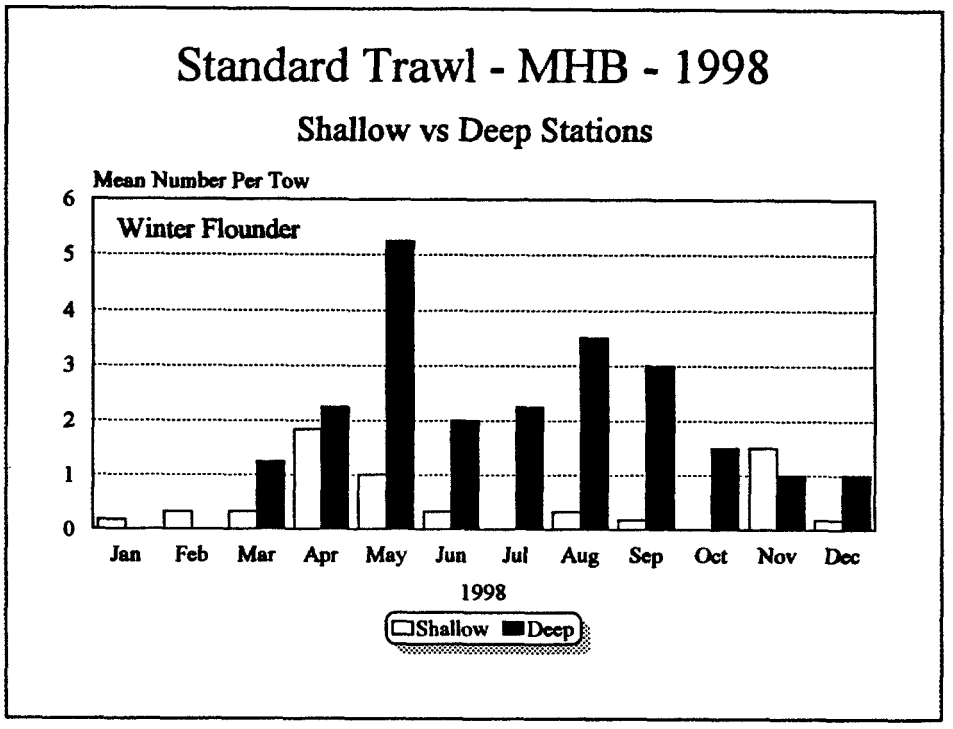


Figure F-6. Percent contribution by species for fish taken by standard (upper) and Fine-mesh Wilcox trawl, January-December 1998.



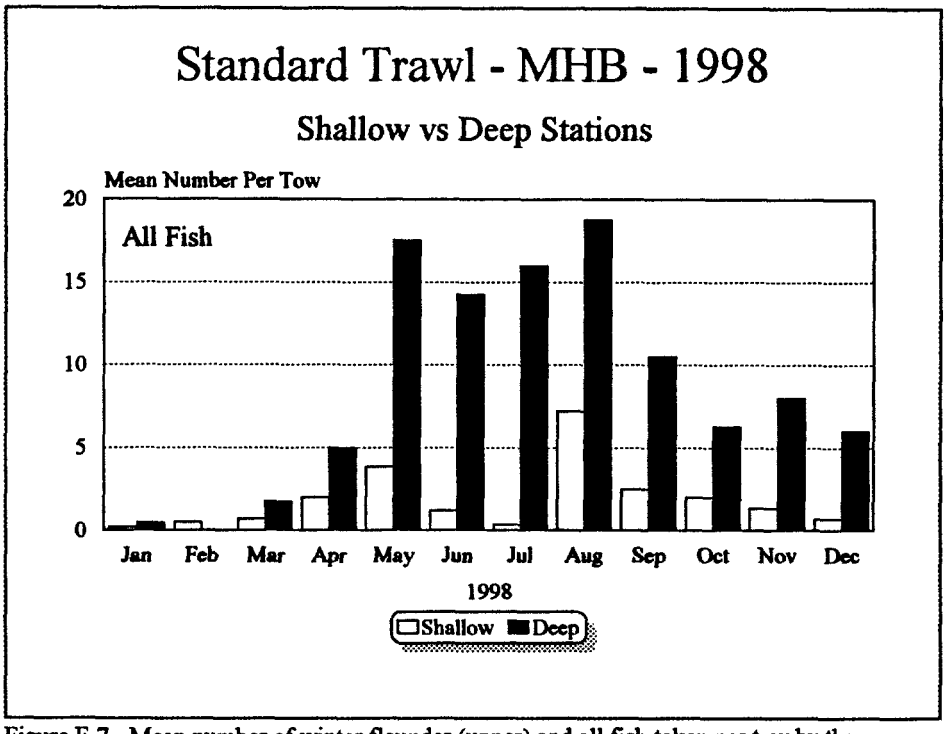
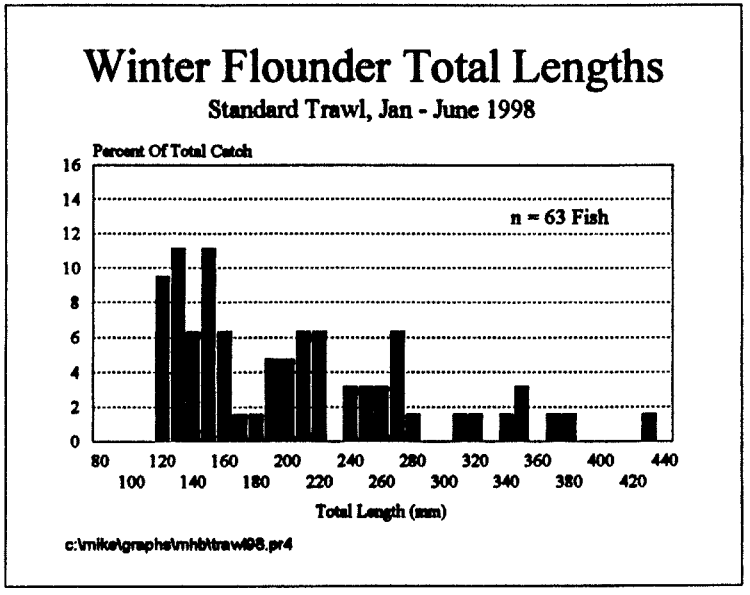
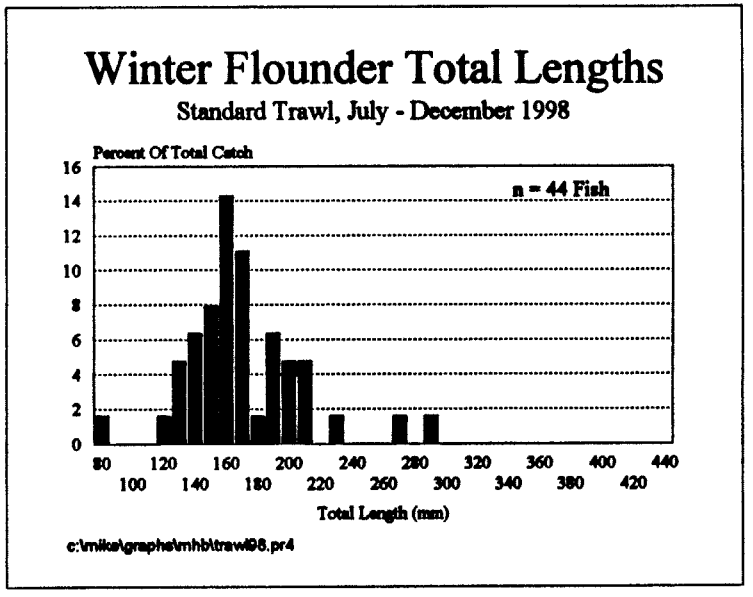
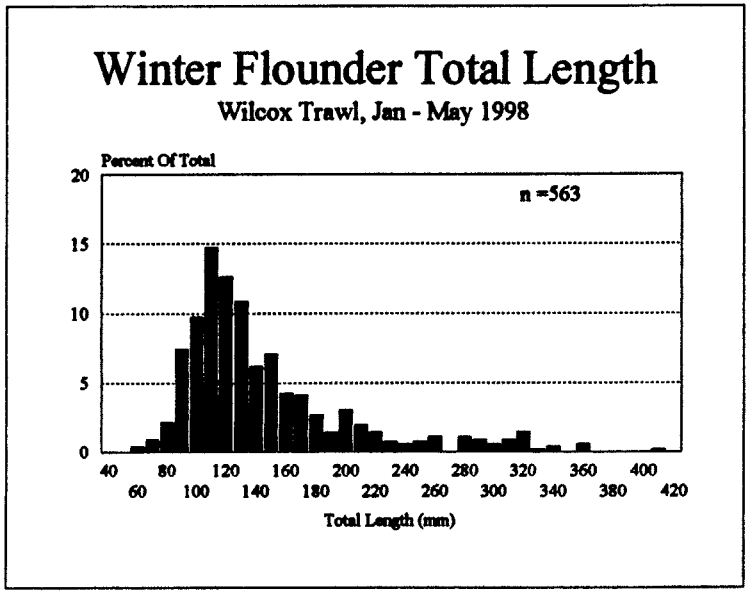


Figure F-7. Mean number of winter flounder (upper) and all fish taken per tow by the standard trawl in Mount Hope Bay by depth strata, 1998.







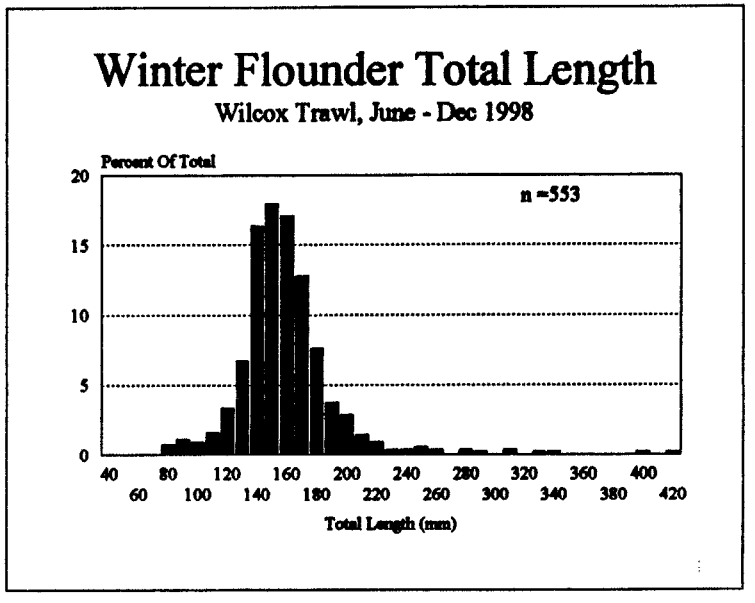


Figure F-8 Winter flounder total length-frequency distribution for standard trawl (top two panes) and Wilcox trawl, 1998.

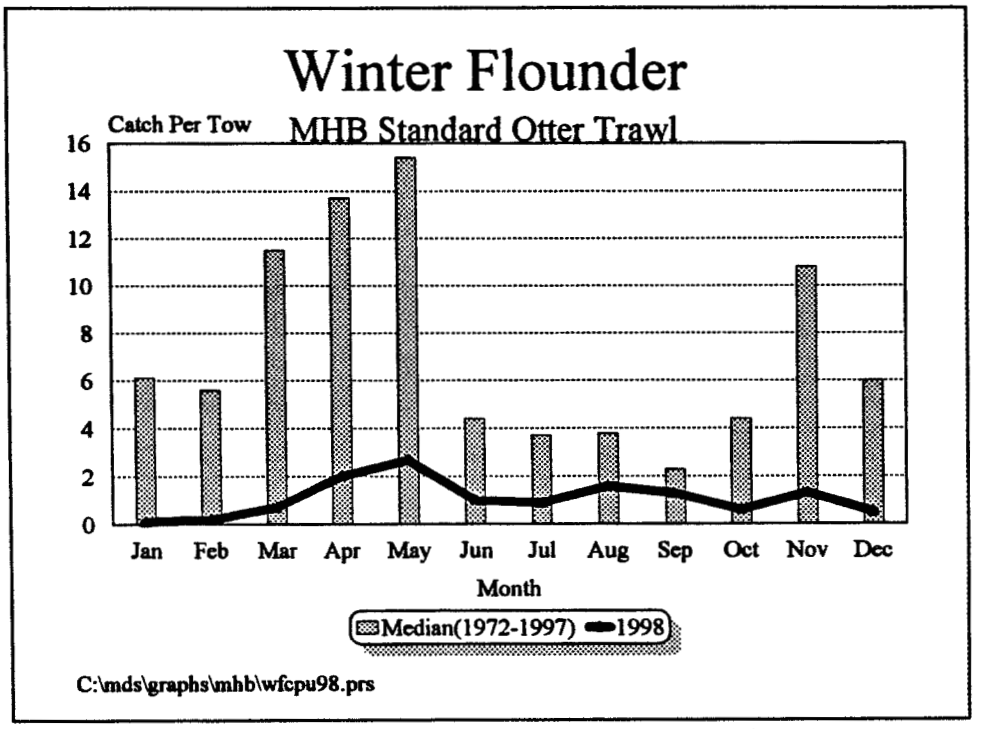
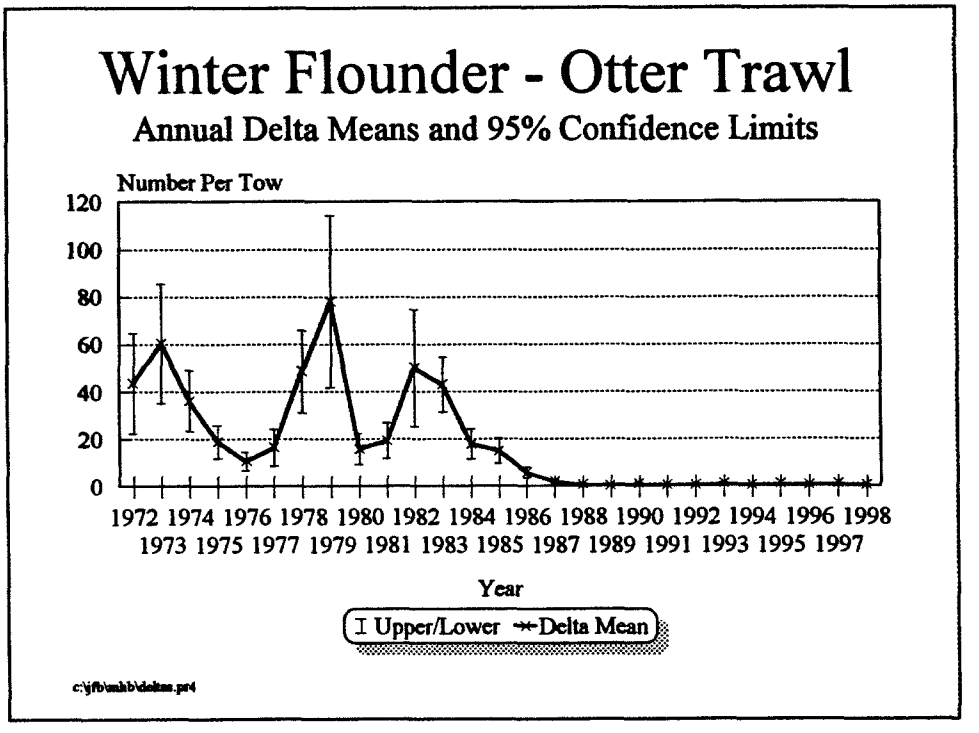


Figure F-9. Mean monthly catch per standard otter trawl tow for winter flounder during 1998. Median monthly catch per tow for 1972-1997 is shown for comparison.



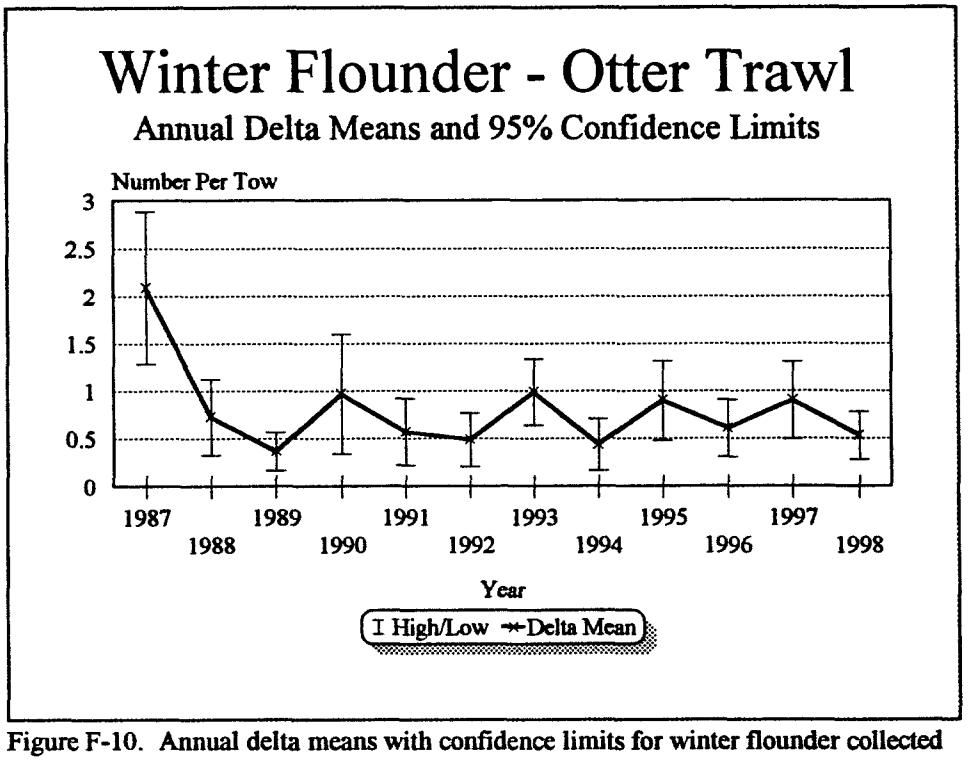


Figure F-10. Annual delta means with confidence limits for winter flounder collected by standard trawl in Mount Hope Bay, 1972-1998 (top) and 1987-1998.

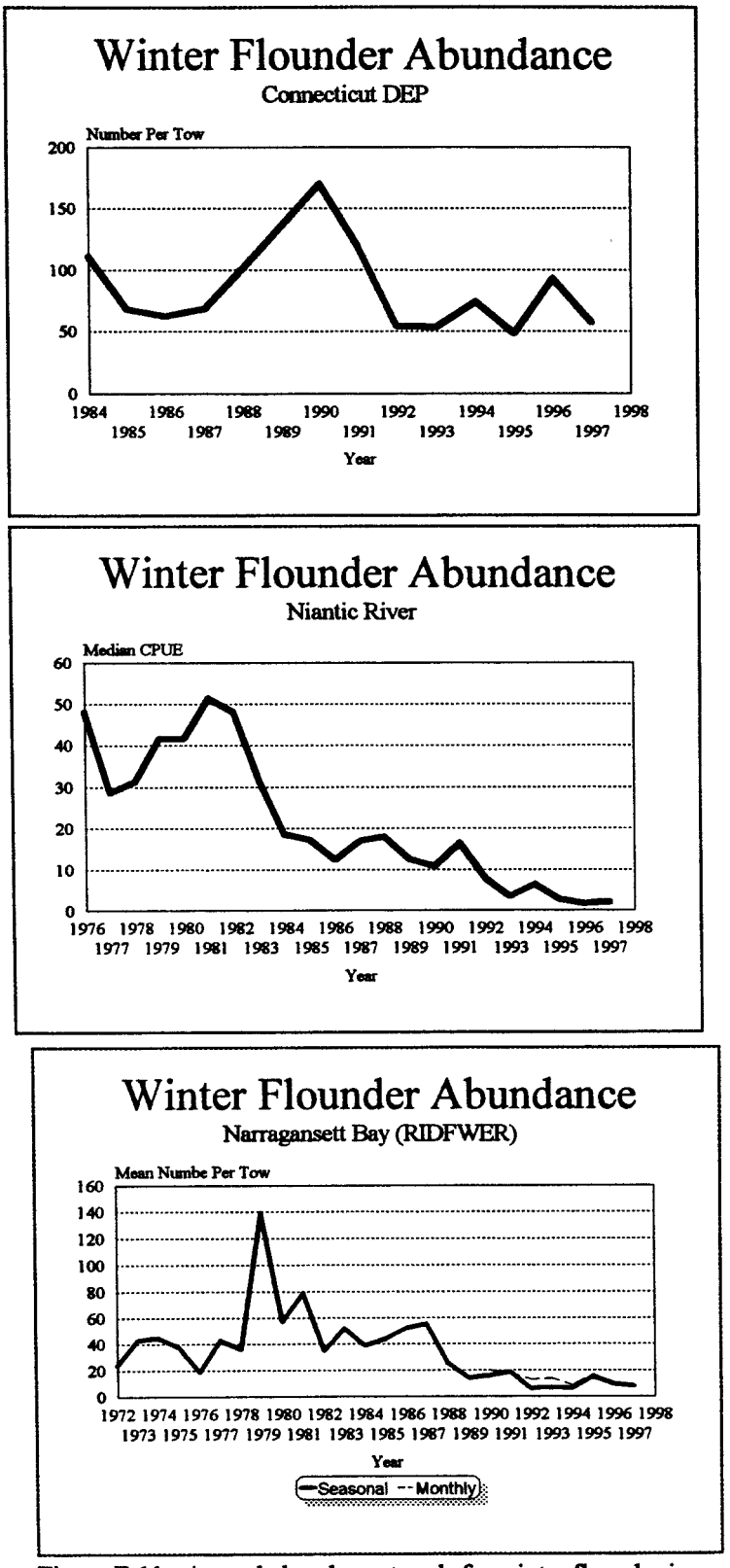
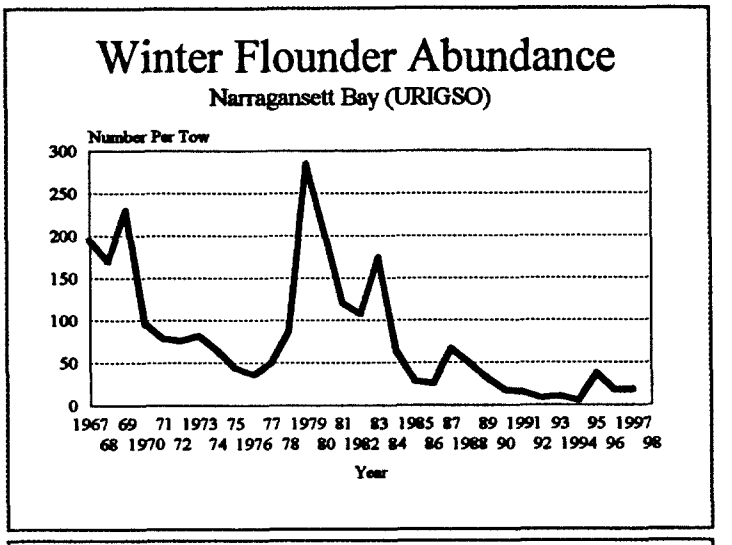
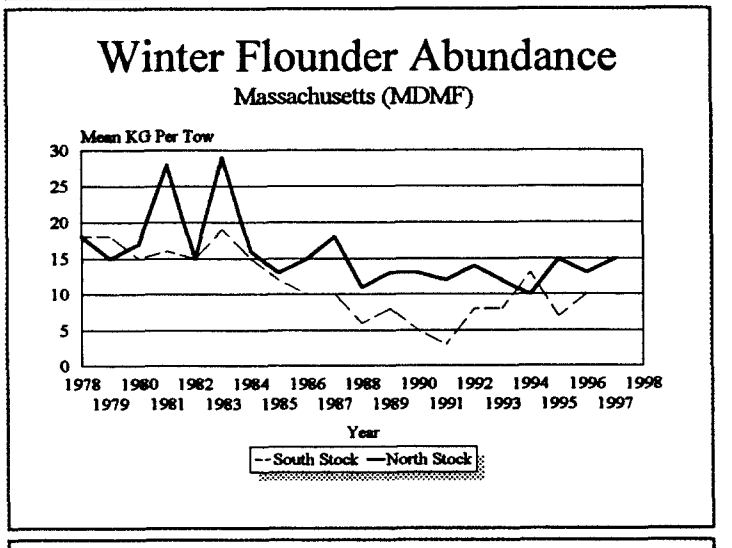


Figure F-11. Annual abundance trends for winter flounder in six New England surveys. See text for details.





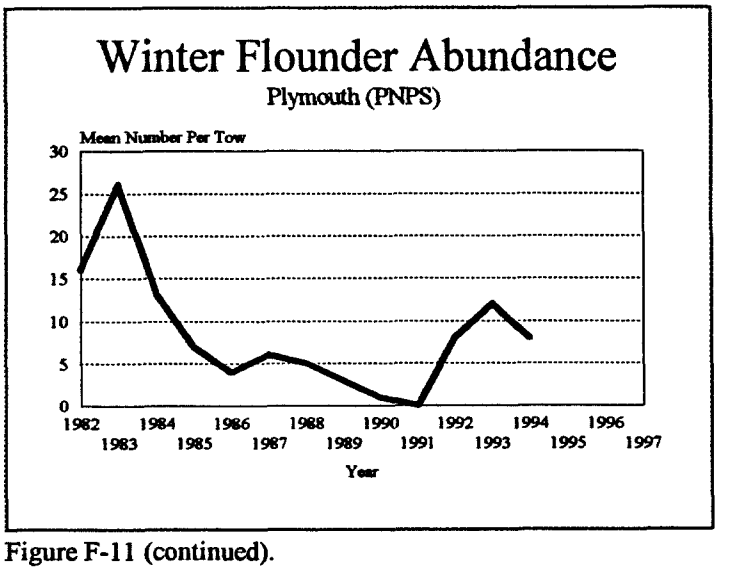
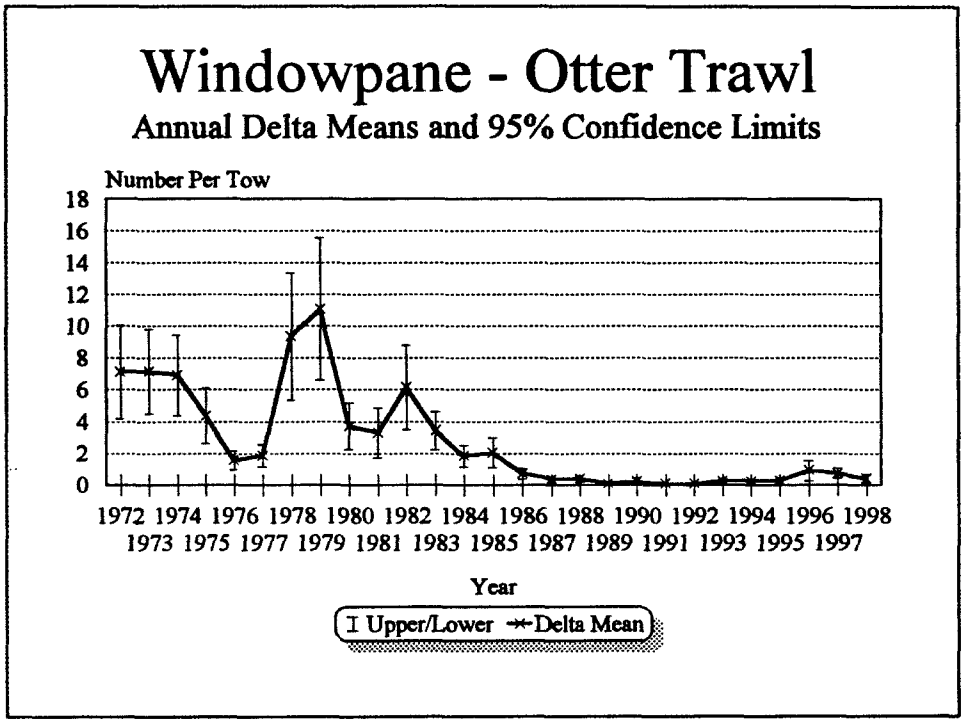


Figure F-11 (continued).



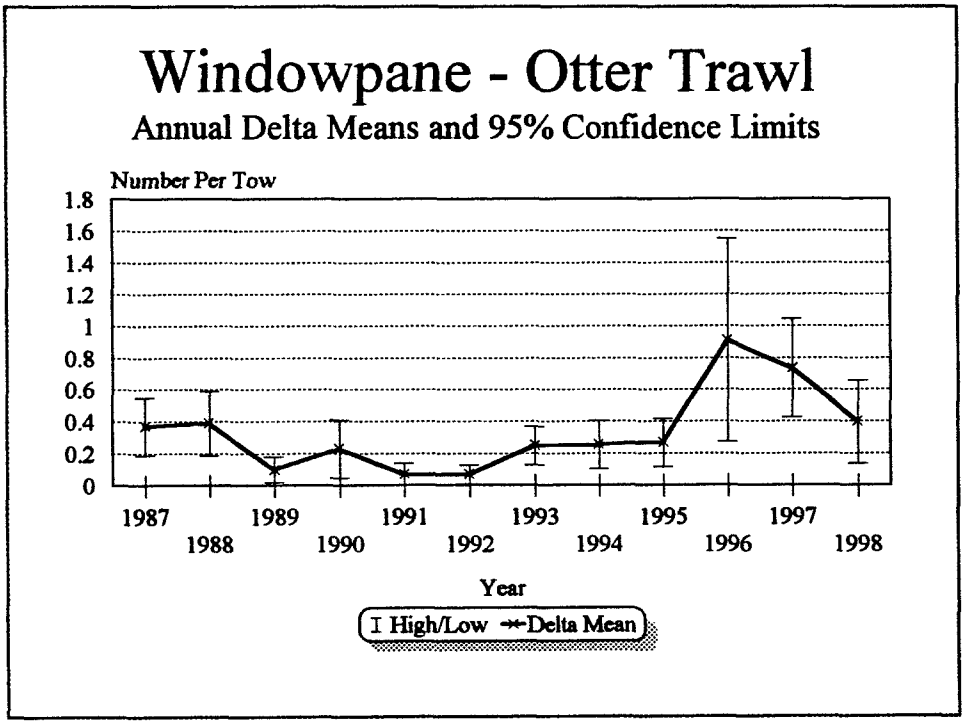


Figure F-12. Annual delta means with confidence limits for windowpane collected by standard trawl in Mount Hope Bay, 1972-1998 (top) and 1987-1998.

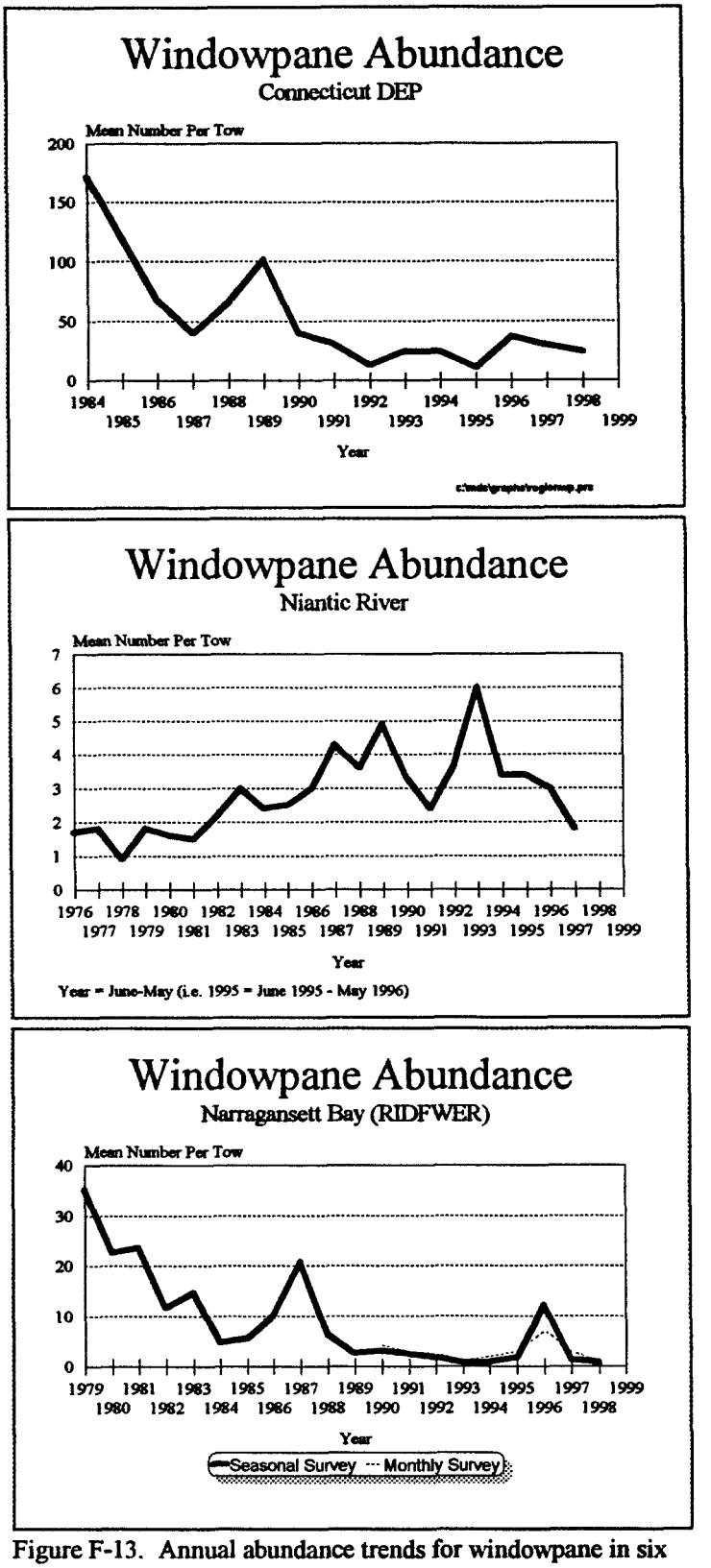
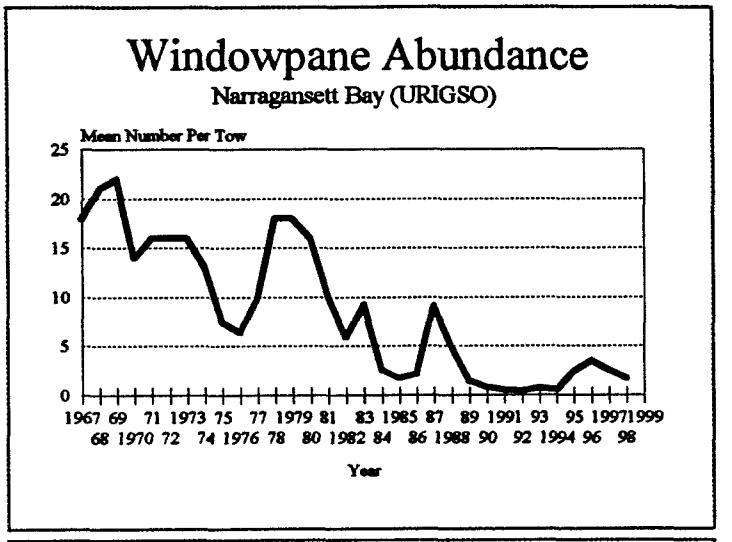
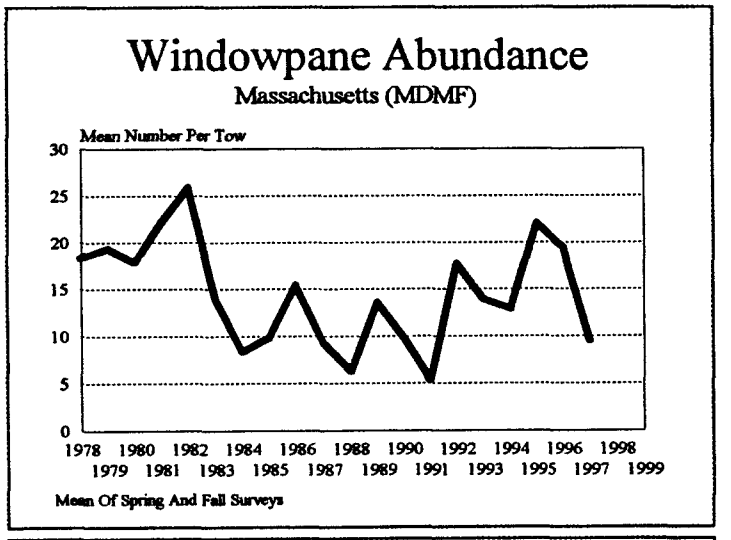


Figure F-13. Annual abundance trends for windowpane in six New England surveys. See text for details.





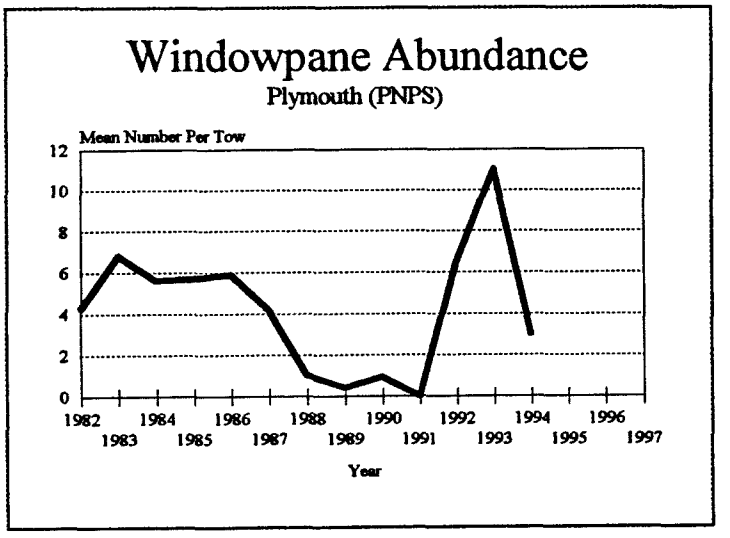
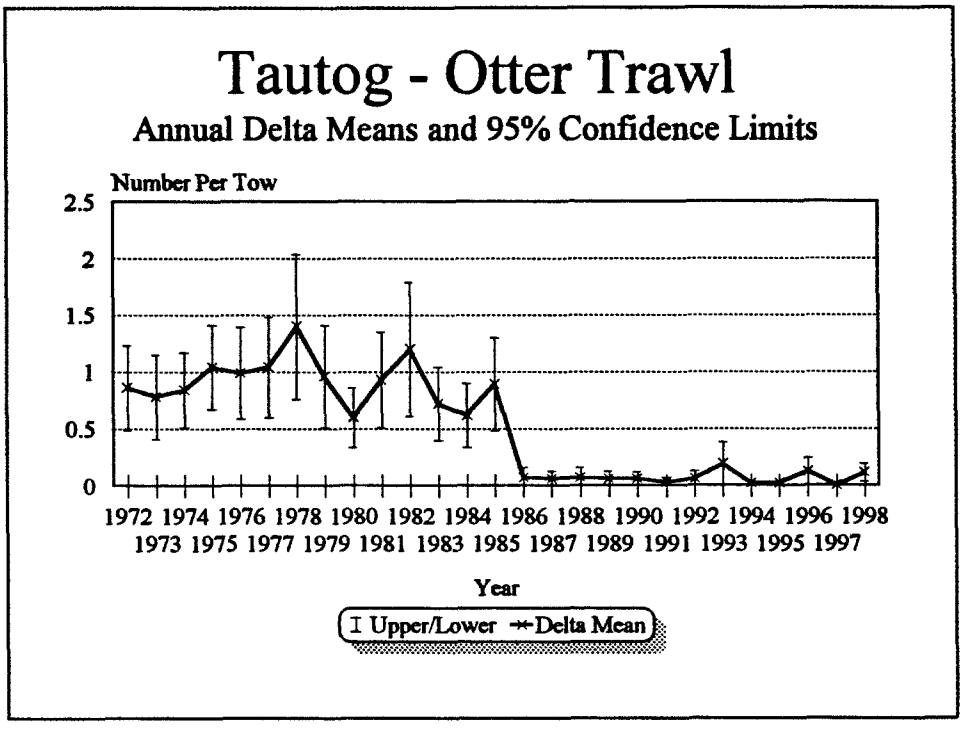


Figure F-13 (continued).



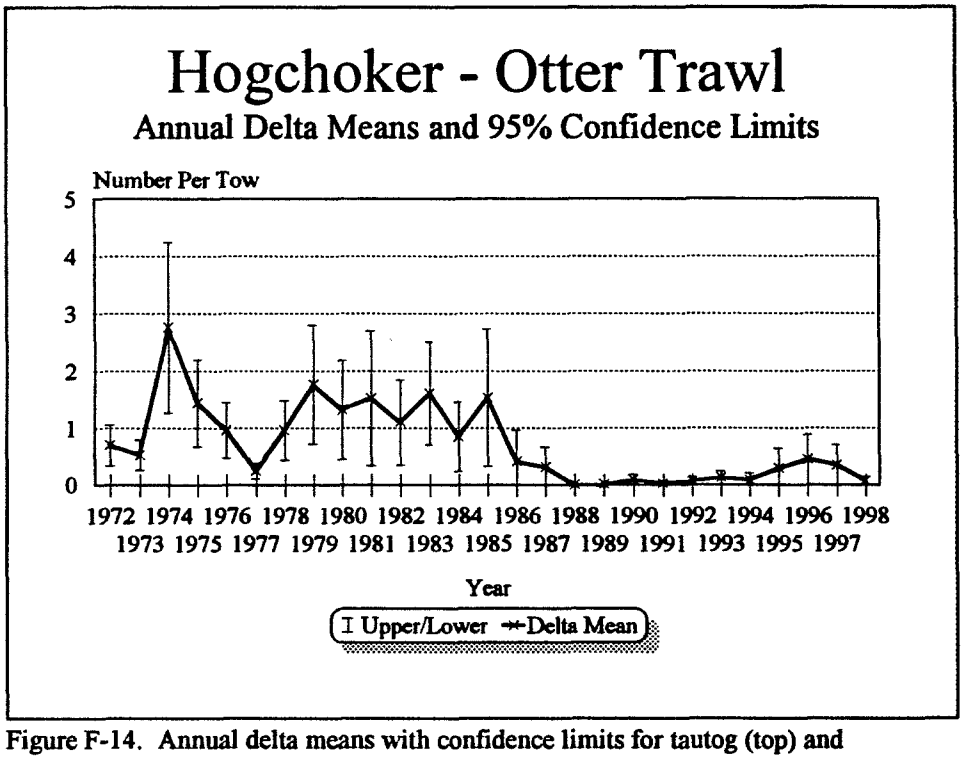
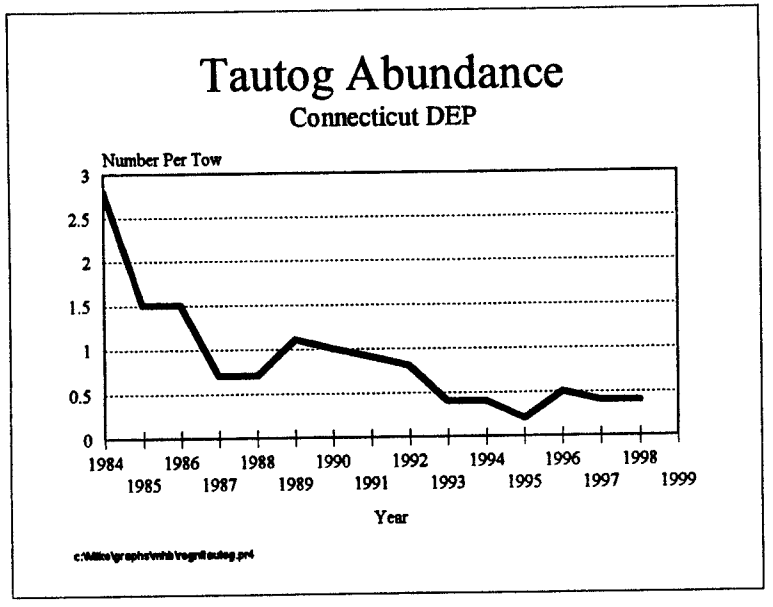
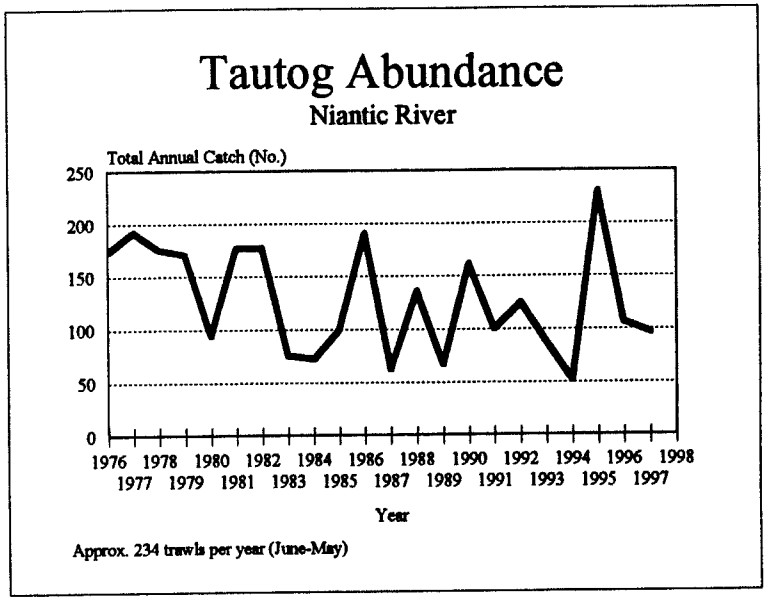
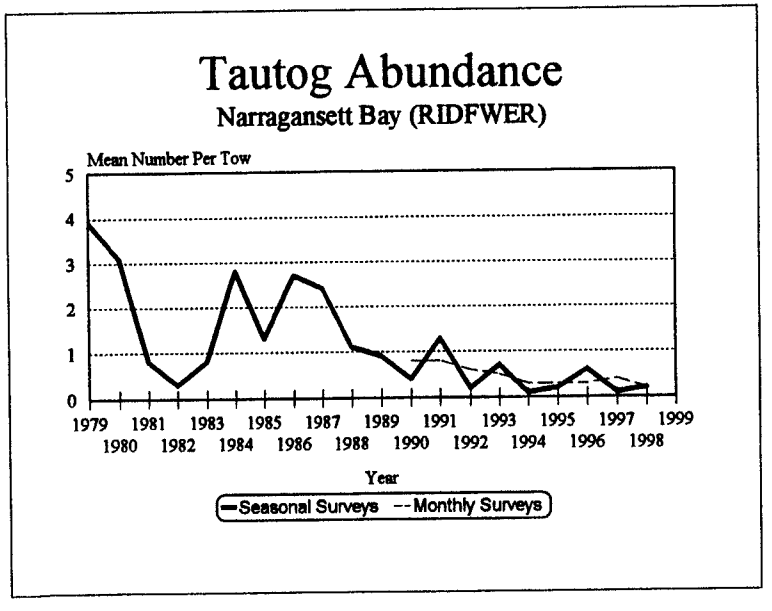


Figure F-14. Annual delta means with confidence limits for tautog (top) and hogchoker collected by standard trawl in Mount Hope Bay, 1972-1998.







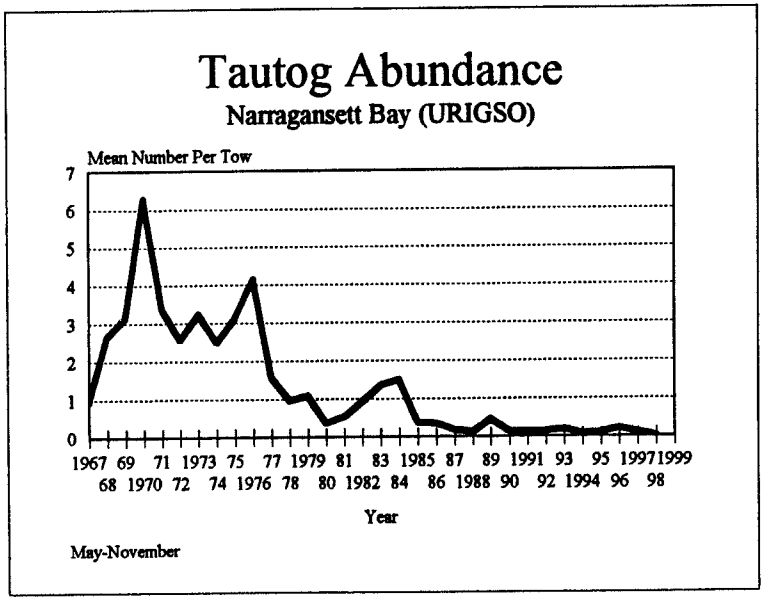
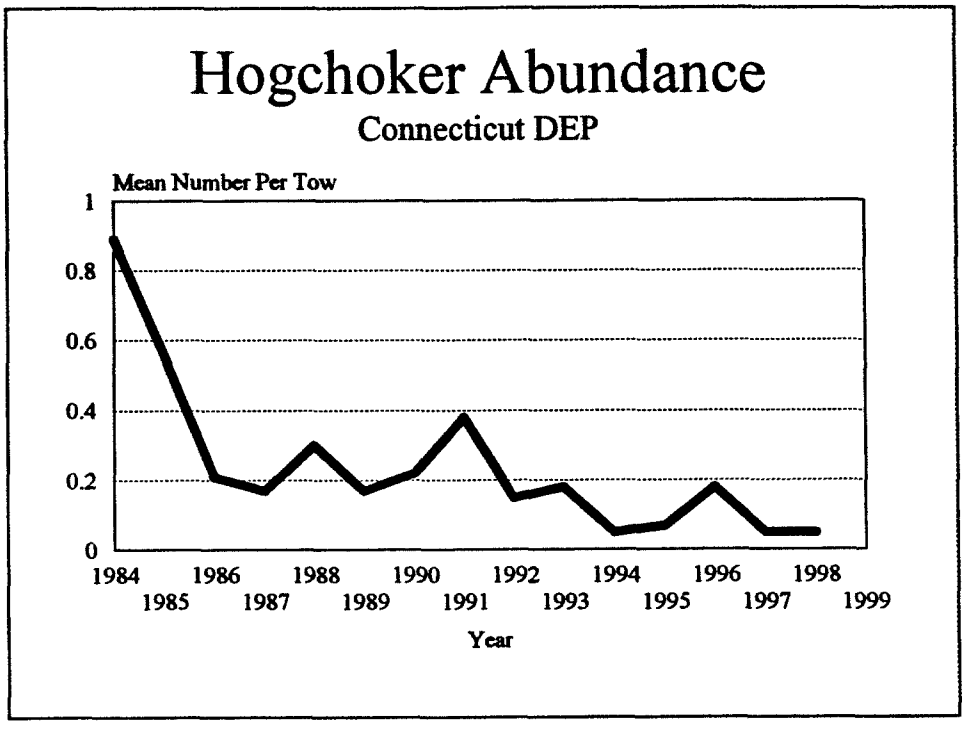


Figure F-15. Annual abundance trends for tautog in four New England surveys. See text for details.



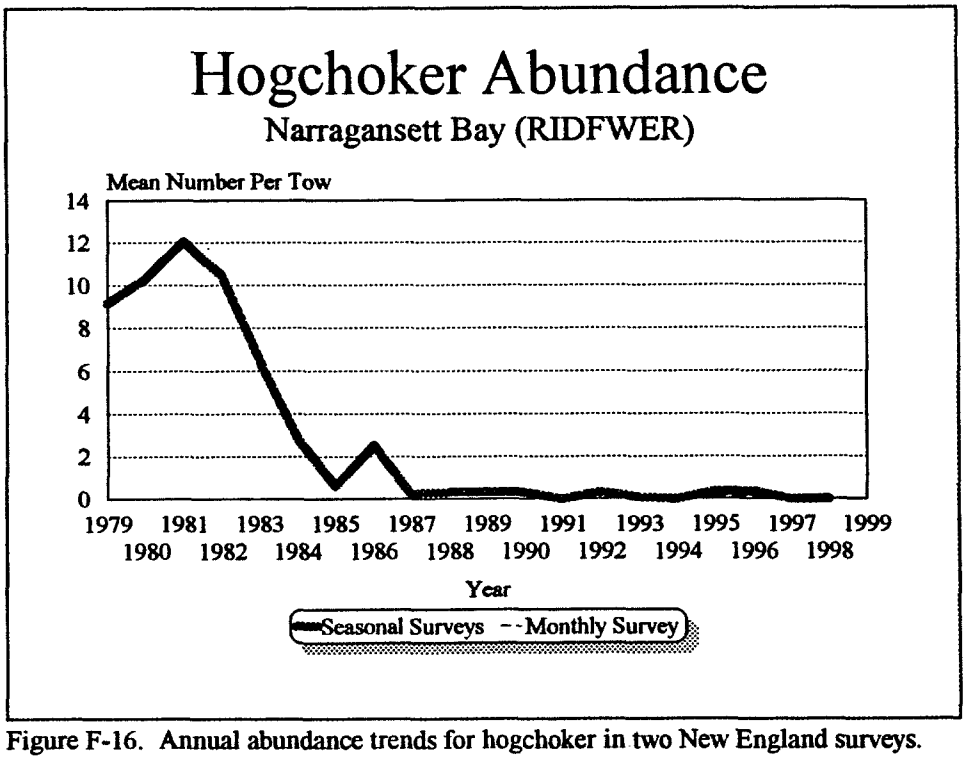
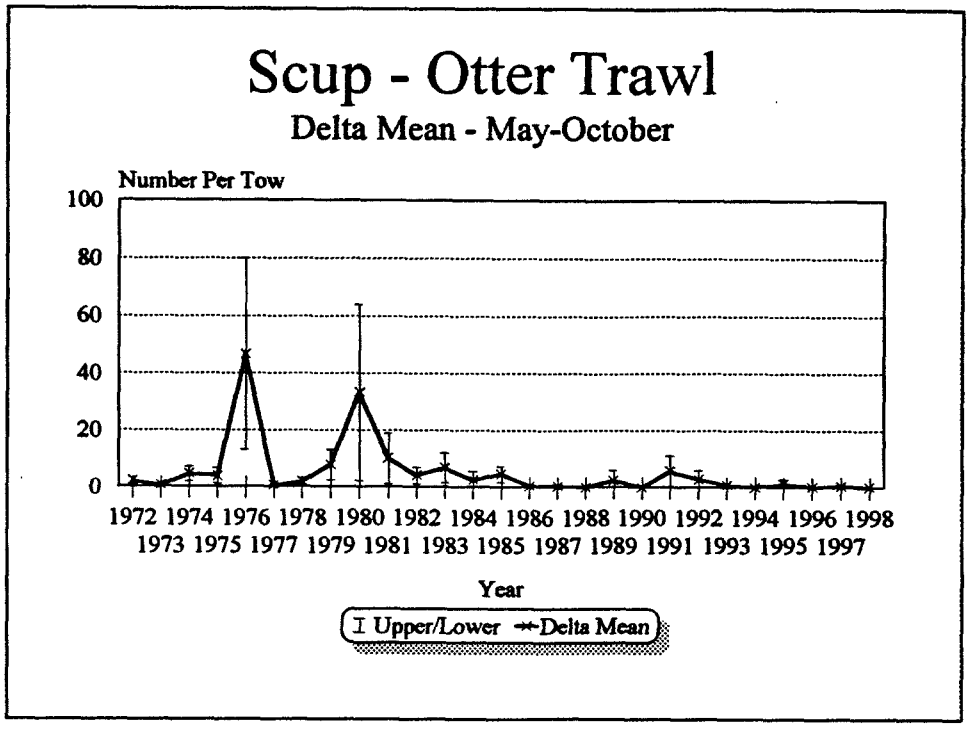


Figure F-16. Annual abundance trends for hogchoker in two New England surveys. See text for details.



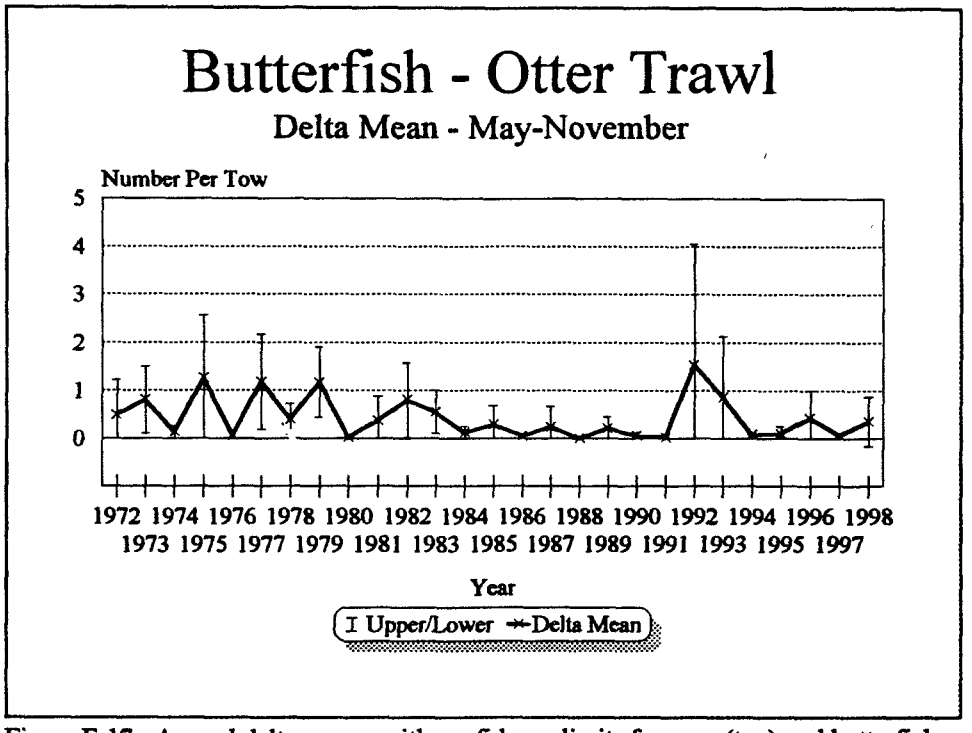
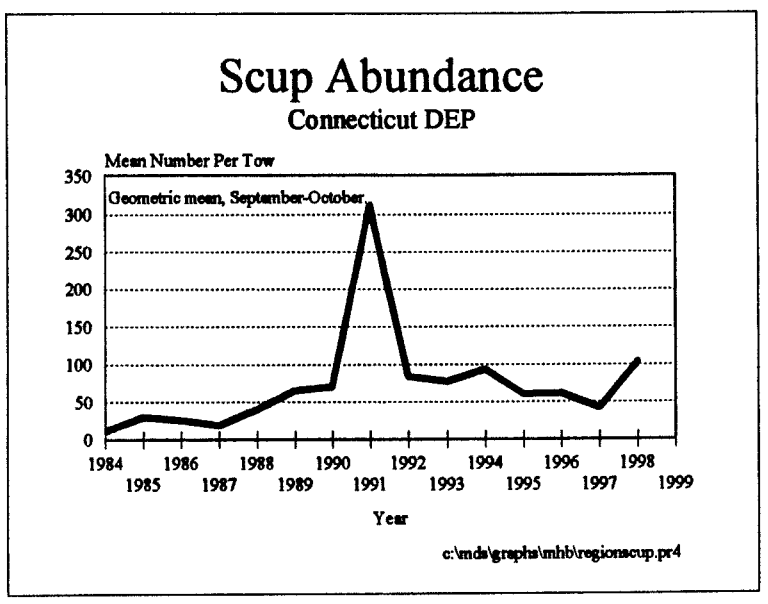
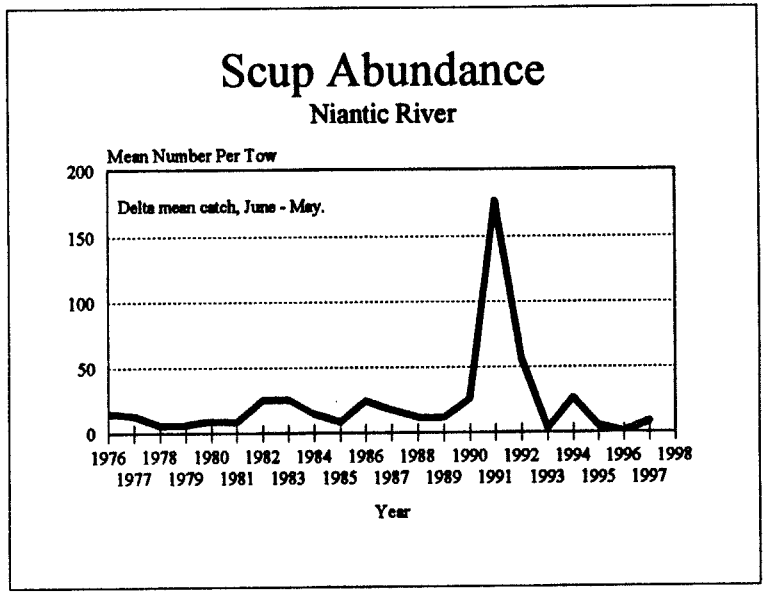
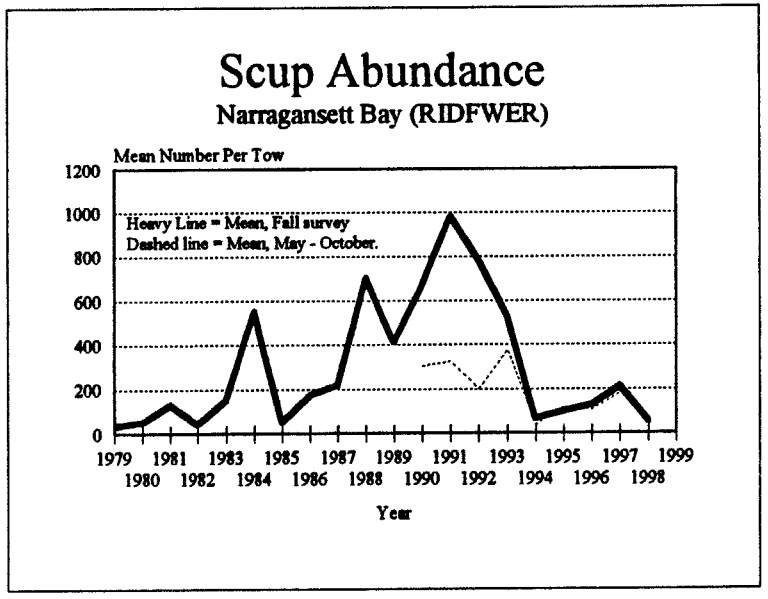


Figure F-17. Annual delta means with confidence limits for scup (top) and butterfish collected by standard trawl in Mount Hope Bay, 1972-1998.







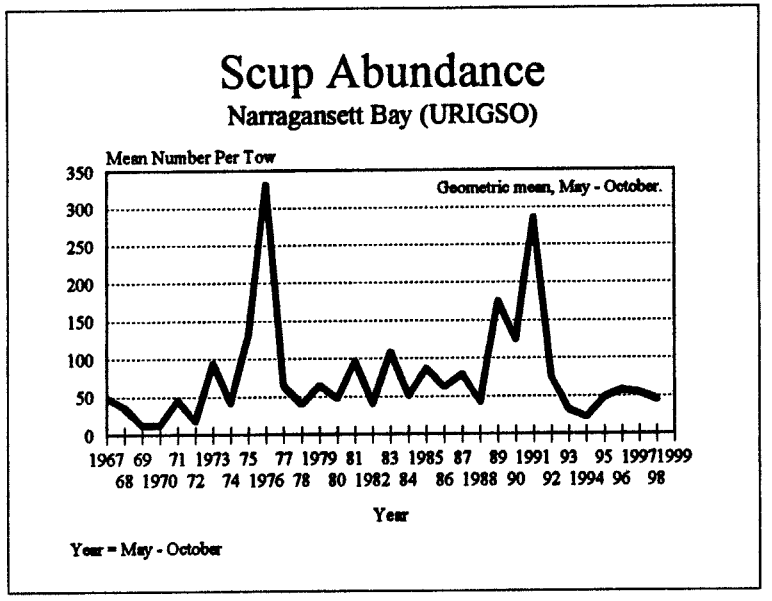
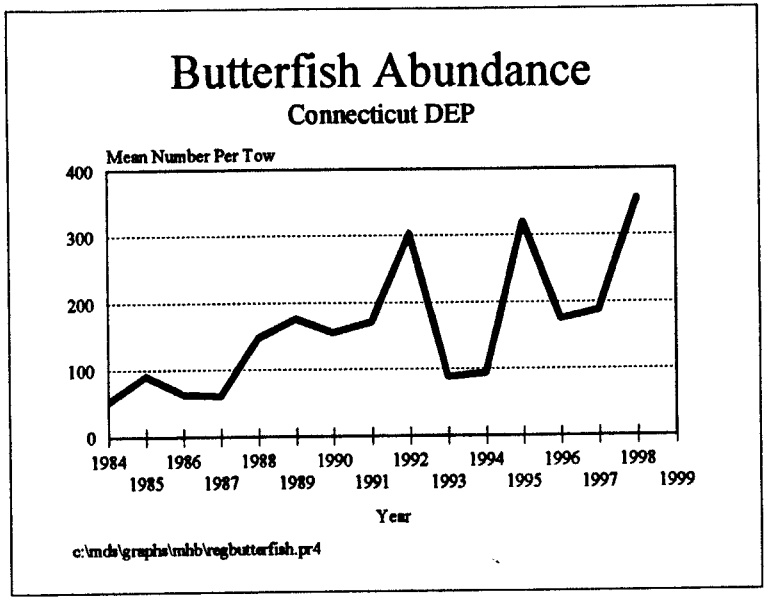
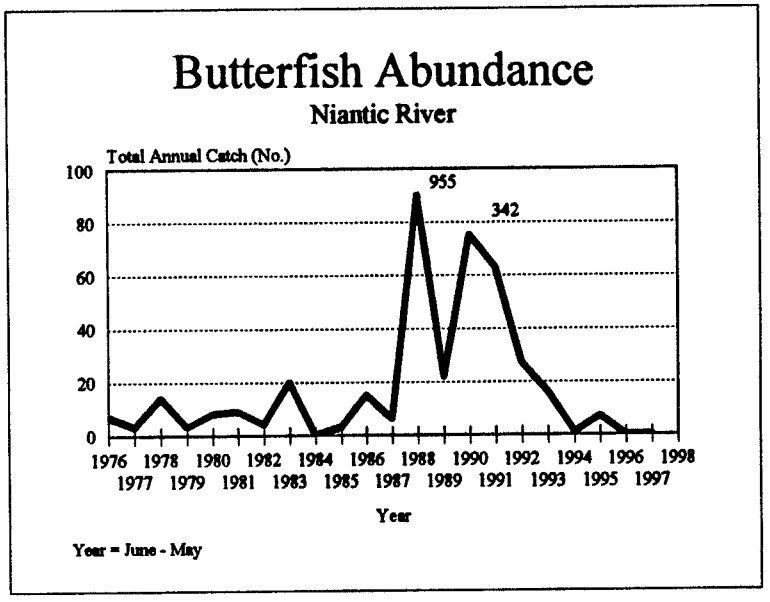
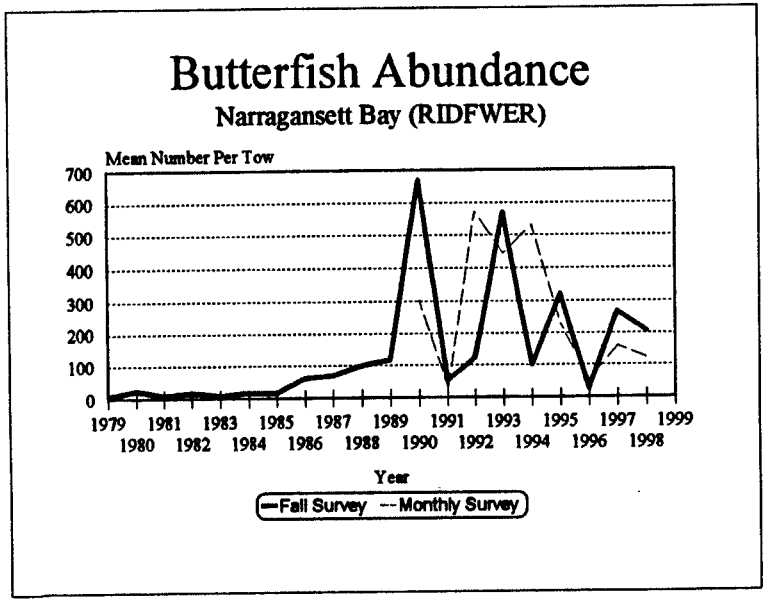


Figure F-18. Annual abundance trends for scup in four New England surveys. See text for details.







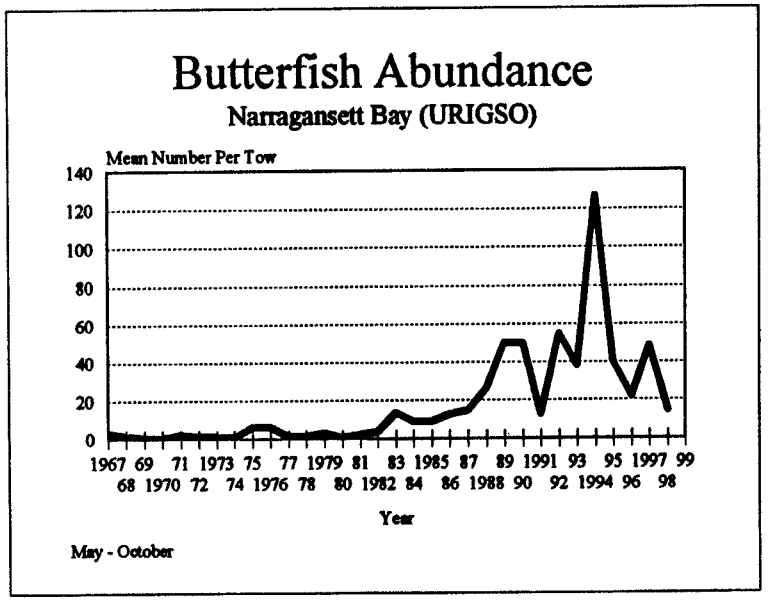


Figure F-19. Annual abundance trends for butterfish in four New England surveys. See text for details.

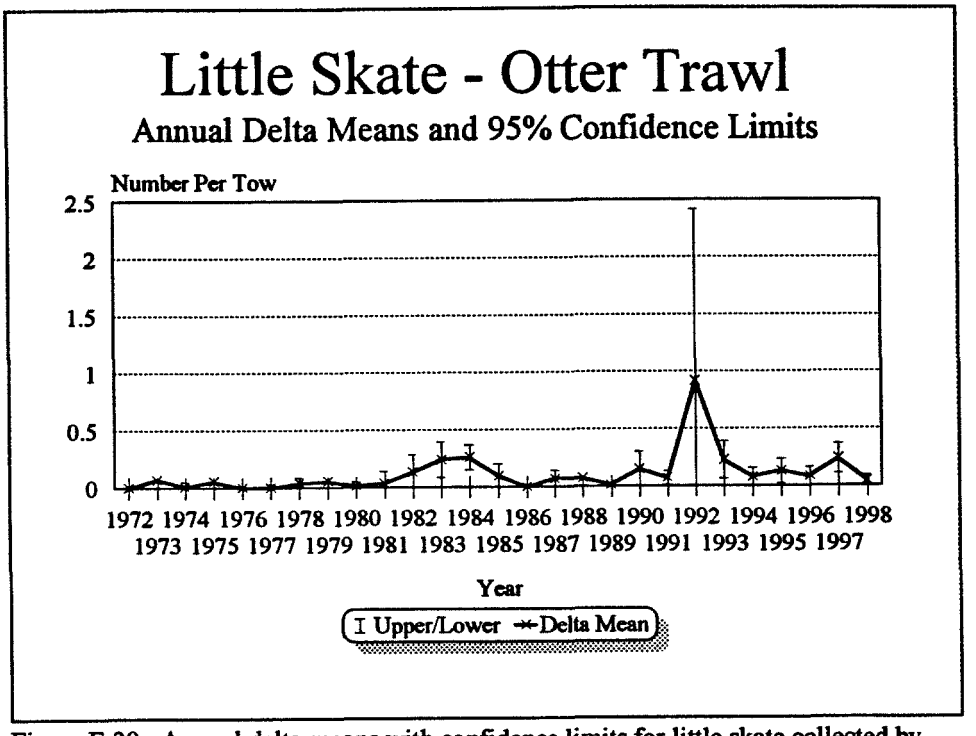
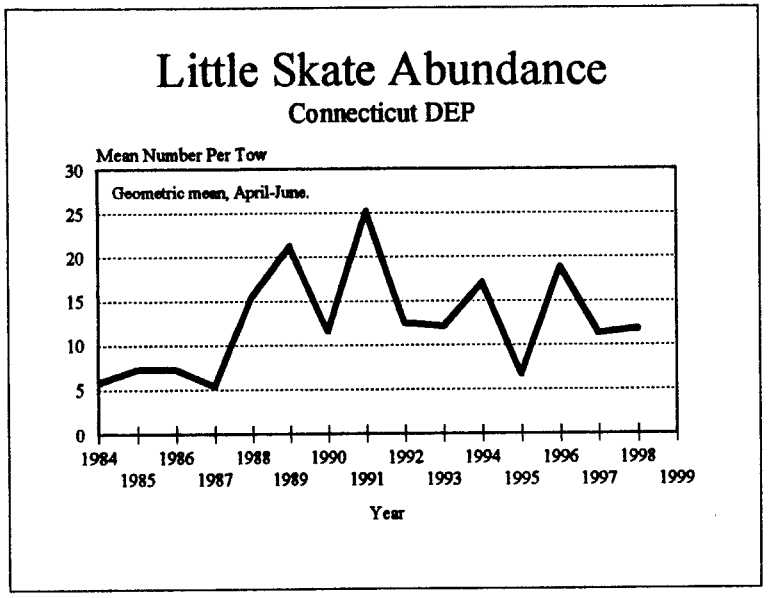
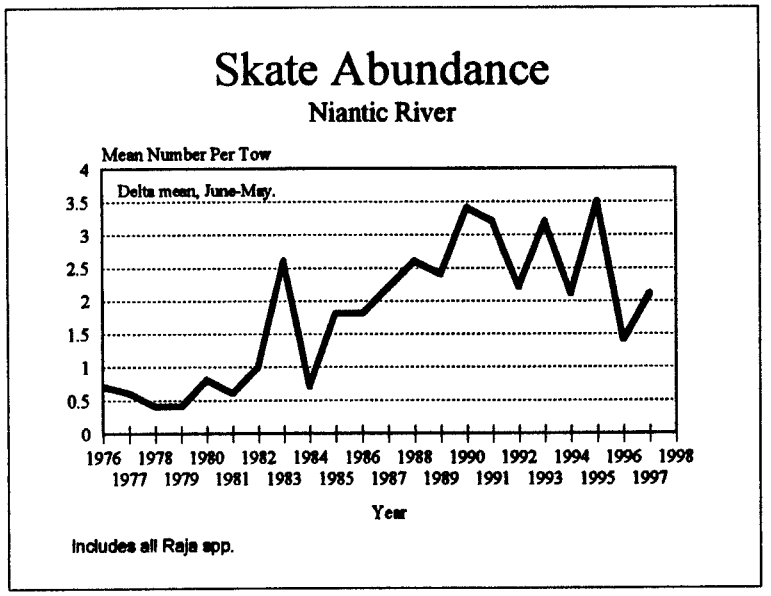
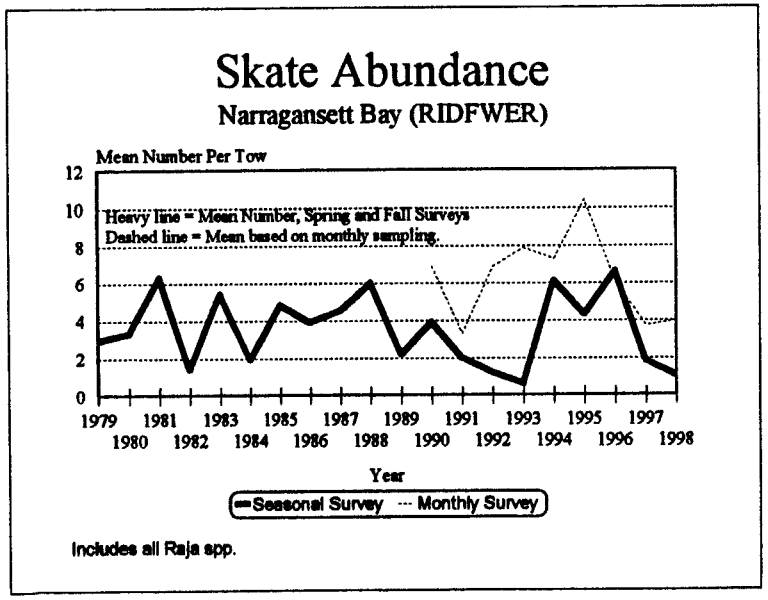


Figure F-20. Annual delta means with confidence limits for little skate collected by standard trawl in Mount Hope Bay, 1972-1998.







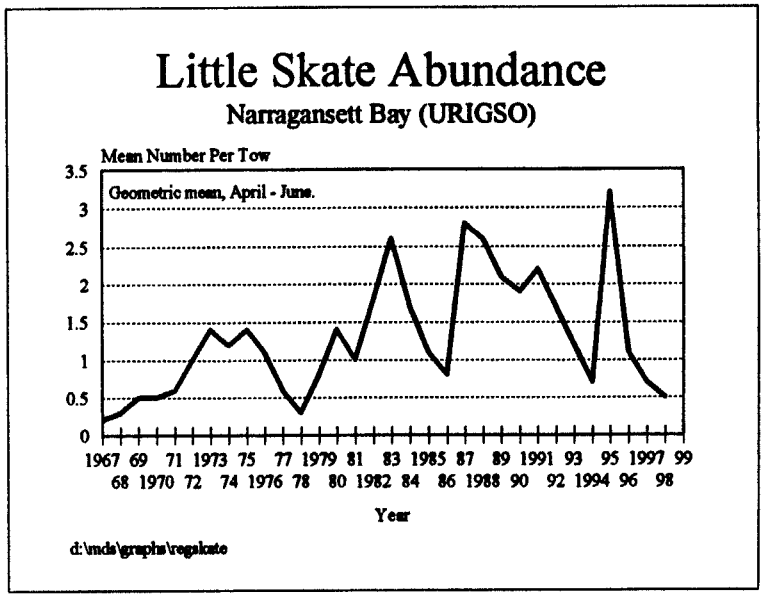


Figure F-21. Annual abundance trends for little skate in four New England surveys. See text for details.

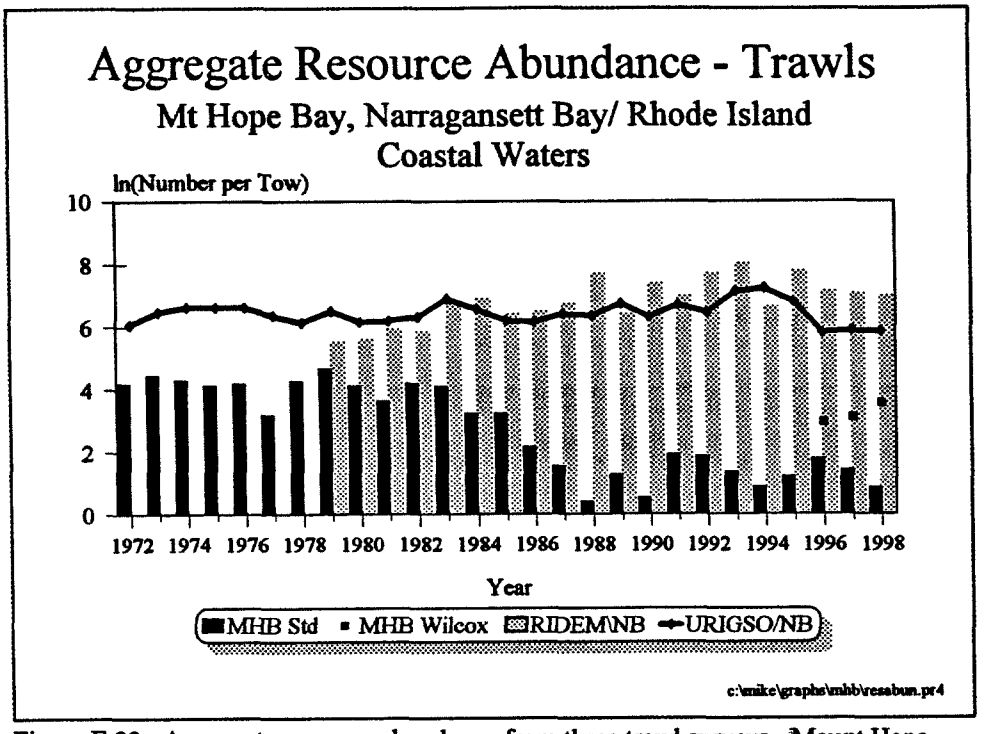


Figure F-22. Aggregate resource abundance from three trawl surveys - Mount Hope Bay standard trawl, RIDEM Narragansett Bay trawl, and URIGSO trawl, 1972-1998. Adapted from Gibson (1996).

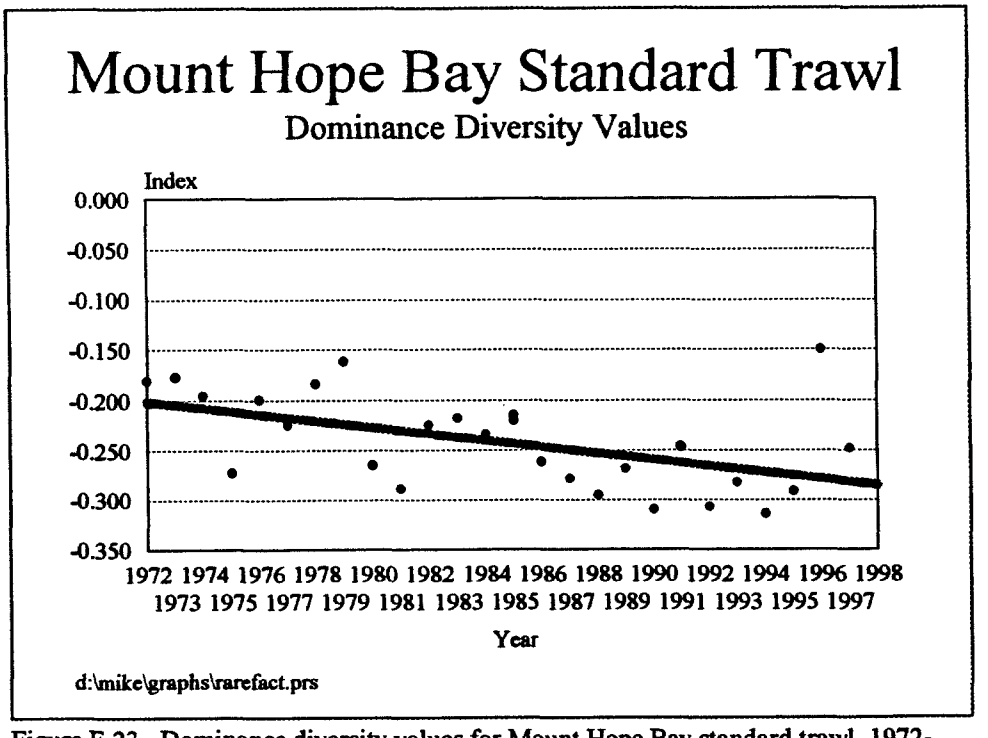


Figure F-23. Dominance diversity values for Mount Hope Bay standard trawl, 1972-1998.

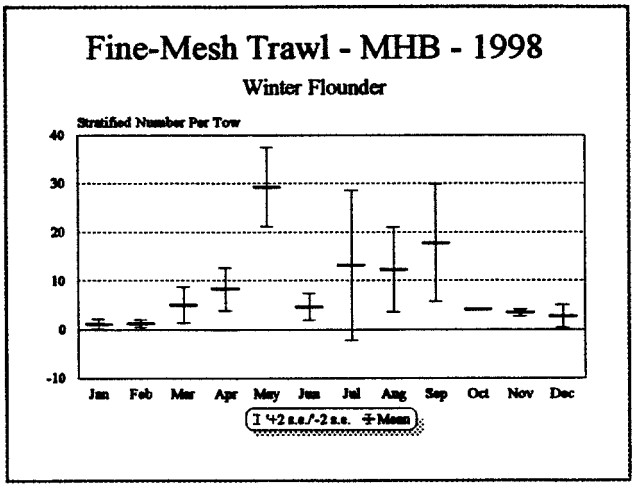
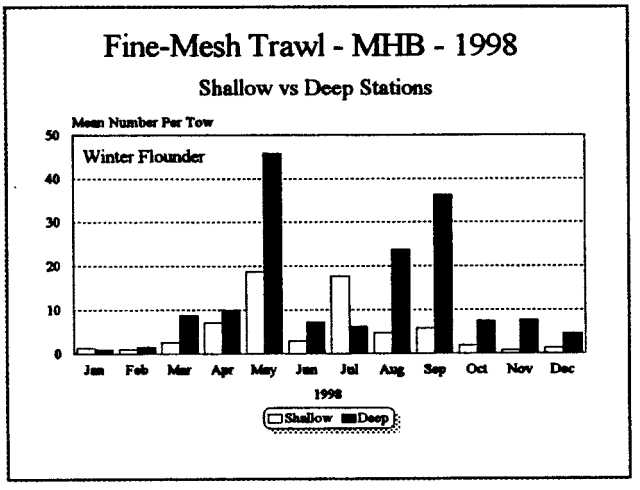


Fig. F-24. Stratified monthly means for winter flounder collected with the fine-mesh Wilcox trawl, 1998.



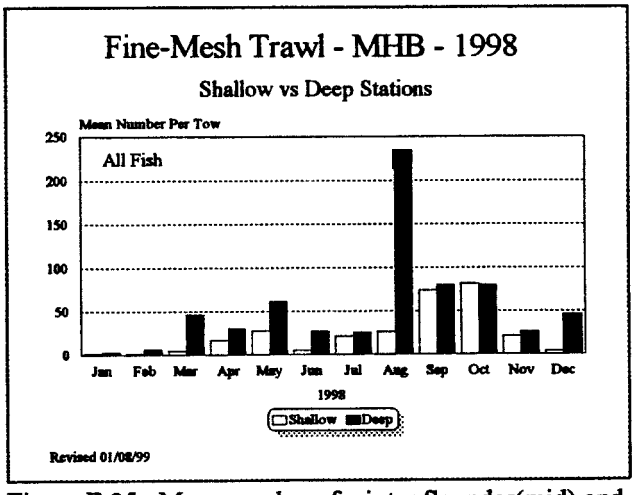


Figure F-25. Mean number of winter flounder(mid) and all fish per tow by depth strata collected with the fine-mesh trawl in Mount Hope Bay, 1998.

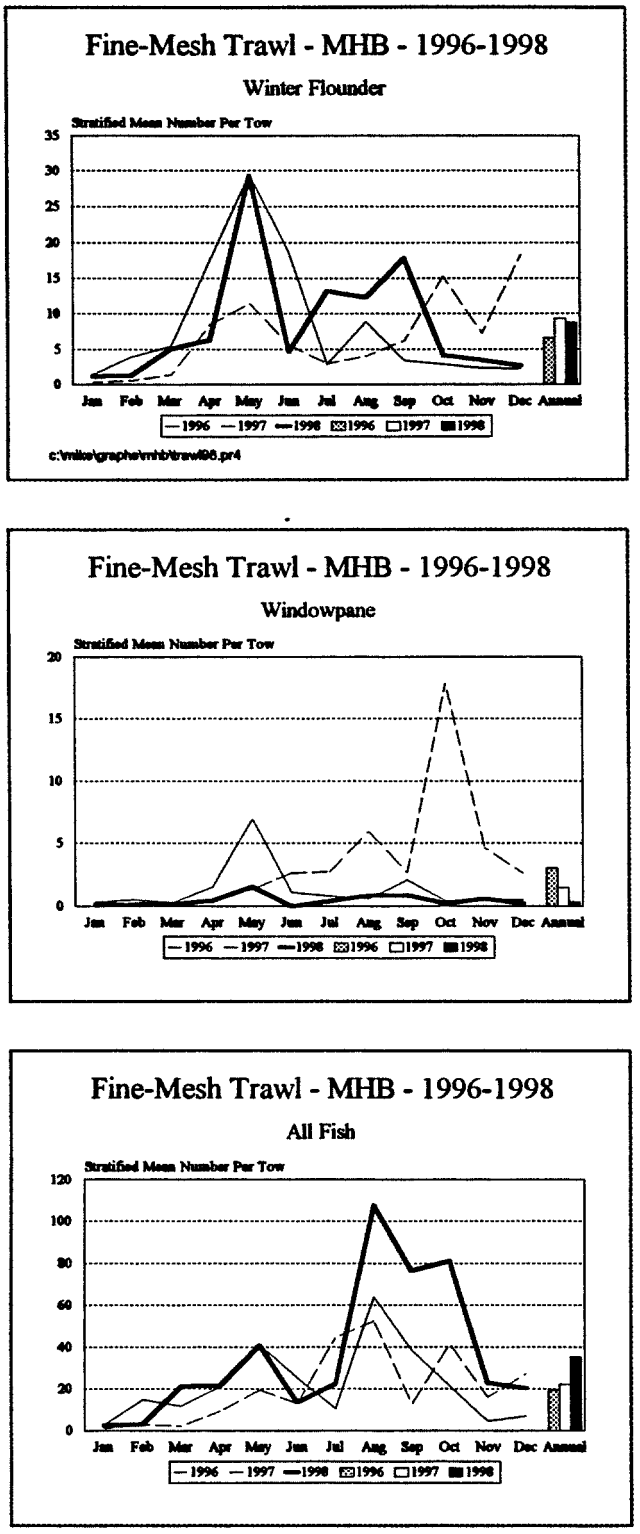
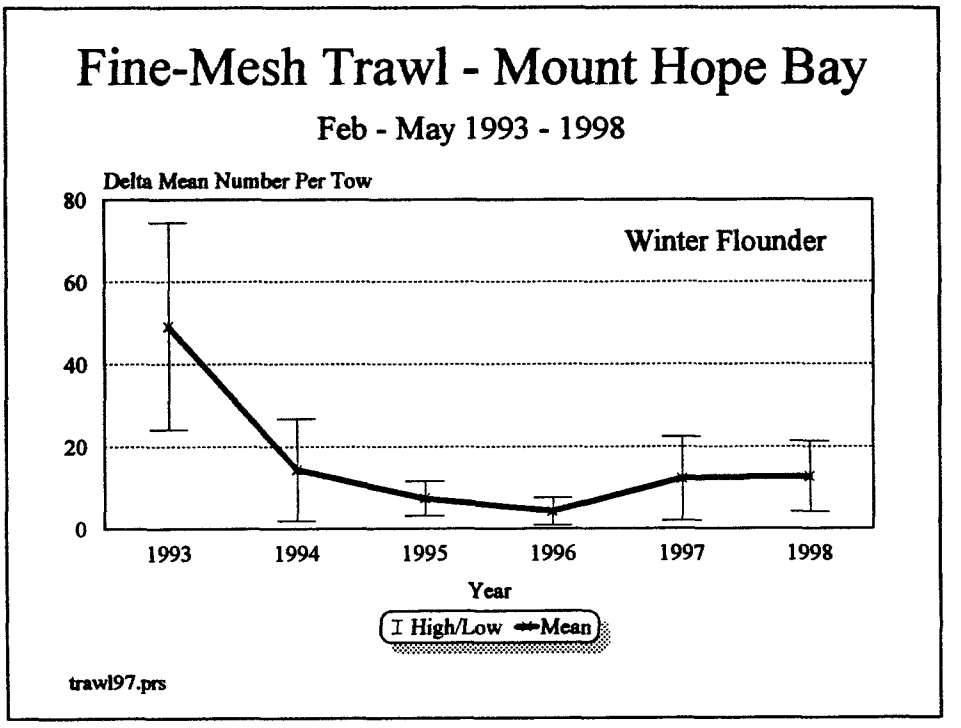


Figure F-26. Stratified mean numbers of winter flounder, windowpane, and all fish, fine-mesh trawl, 1996-1998.



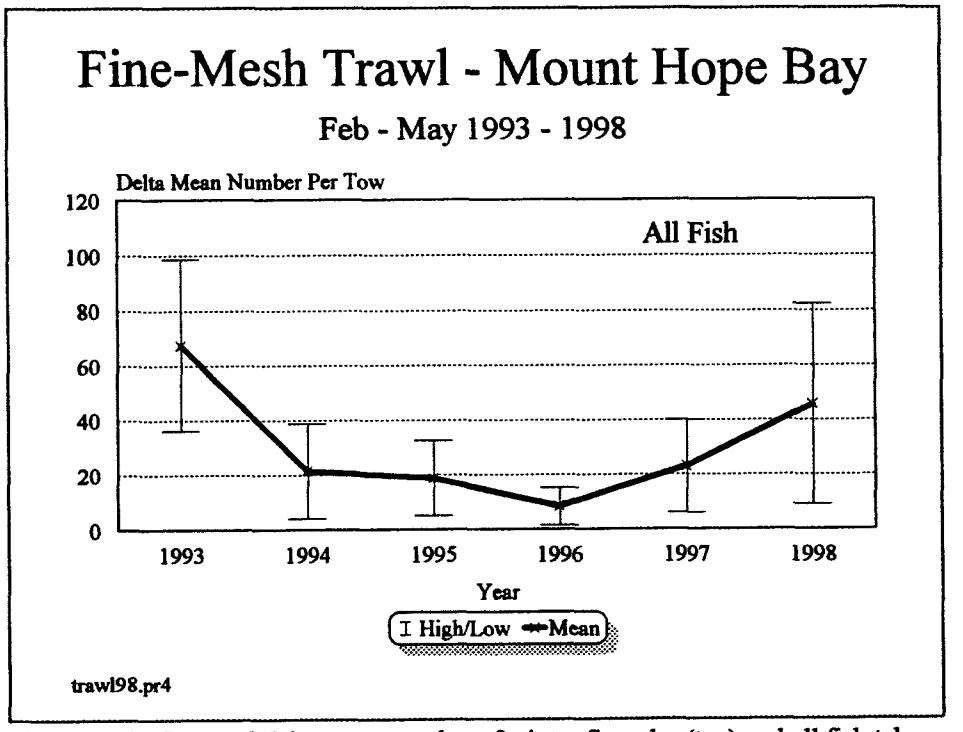


Figure F-27. Seasonal delta mean number of winter flounder (top) and all fish taken by fine-mesh trawl in upper Mount Hope Bay, February-May 1993-1998.

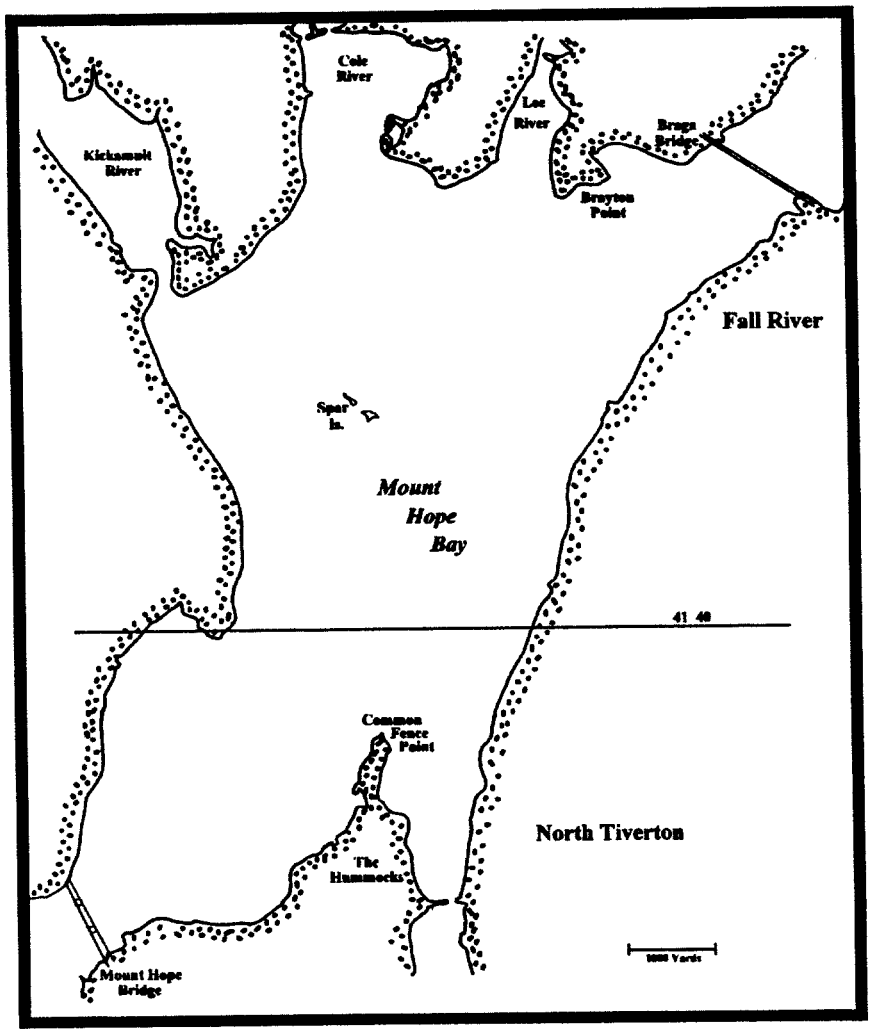
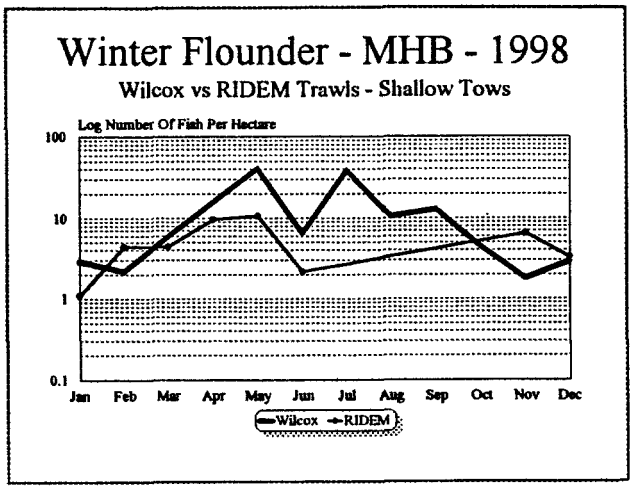
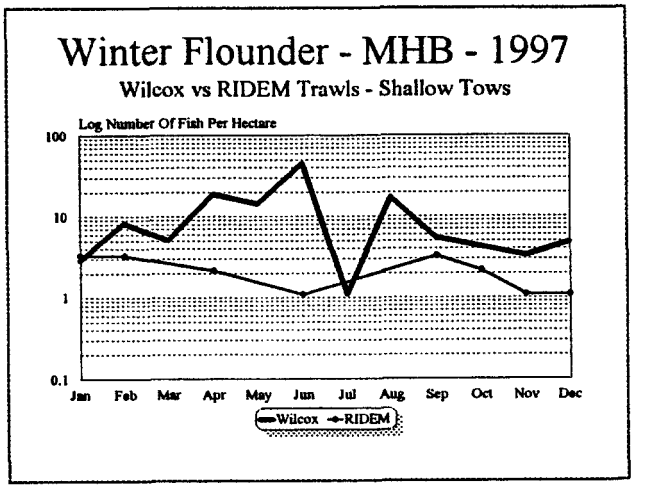


Figure F-28. Location of latitude 41°40' line used to divide Mount Hope Bay into upper and lower halves.





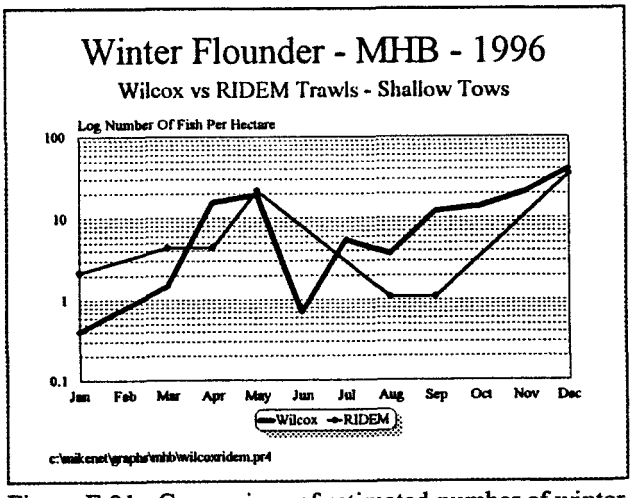
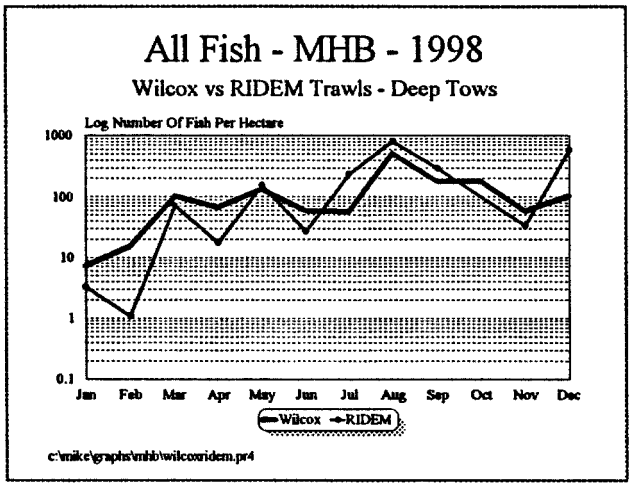
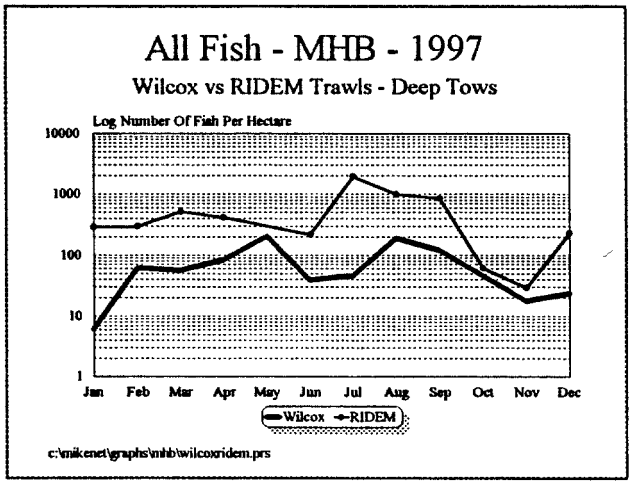


Figure F-31. Comparison of estimated number of winter flounder per hectare along shallow-water transects based on fine-mesh Wilcox and RIDEM trawls sampled in Mount Hope Bay, 1996-1998.





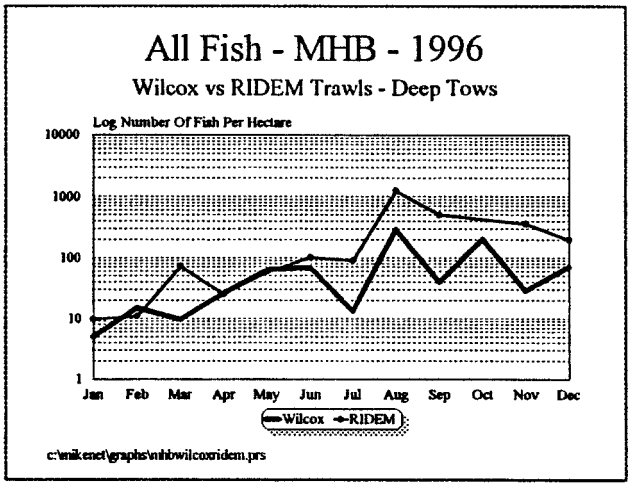
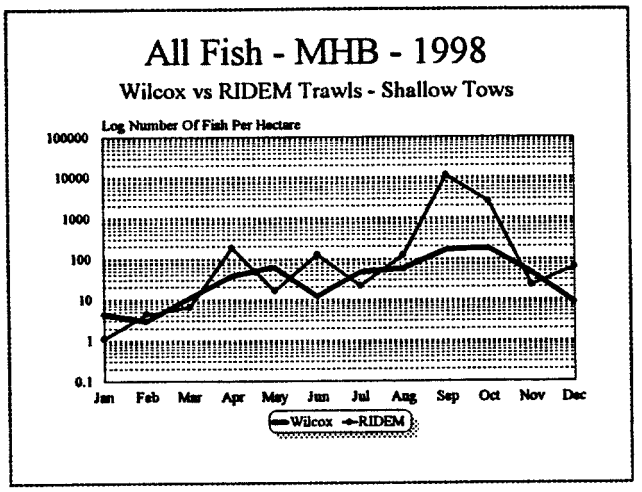
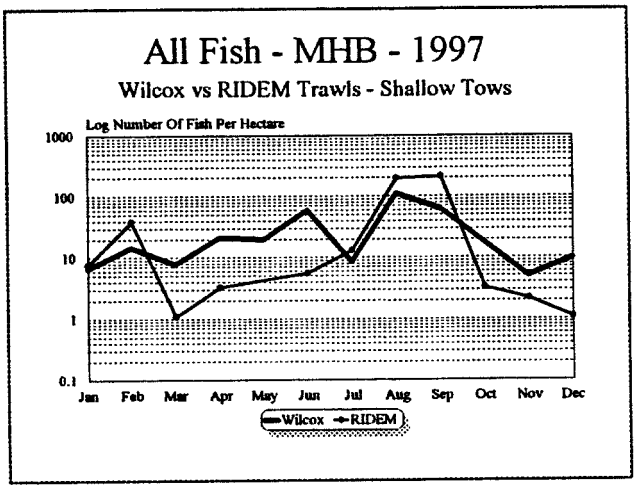


Figure F-32. Comparison of estimated number of winter flounder per hectare along deep-water transects based on fine-mesh Wilcox and RIDEM trawls sampled in Mount Hope Bay, 1996-1998.





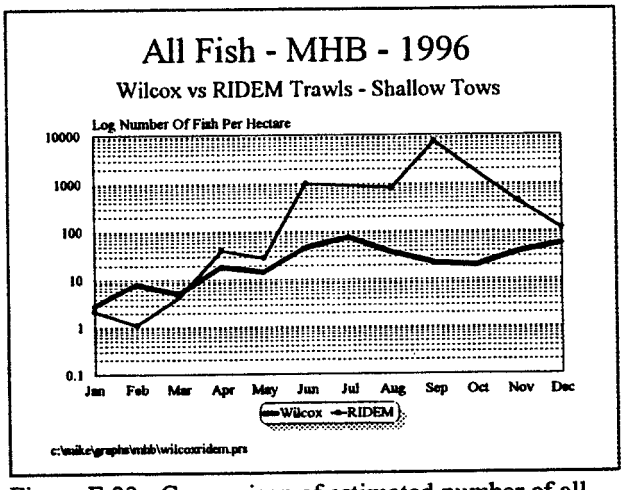
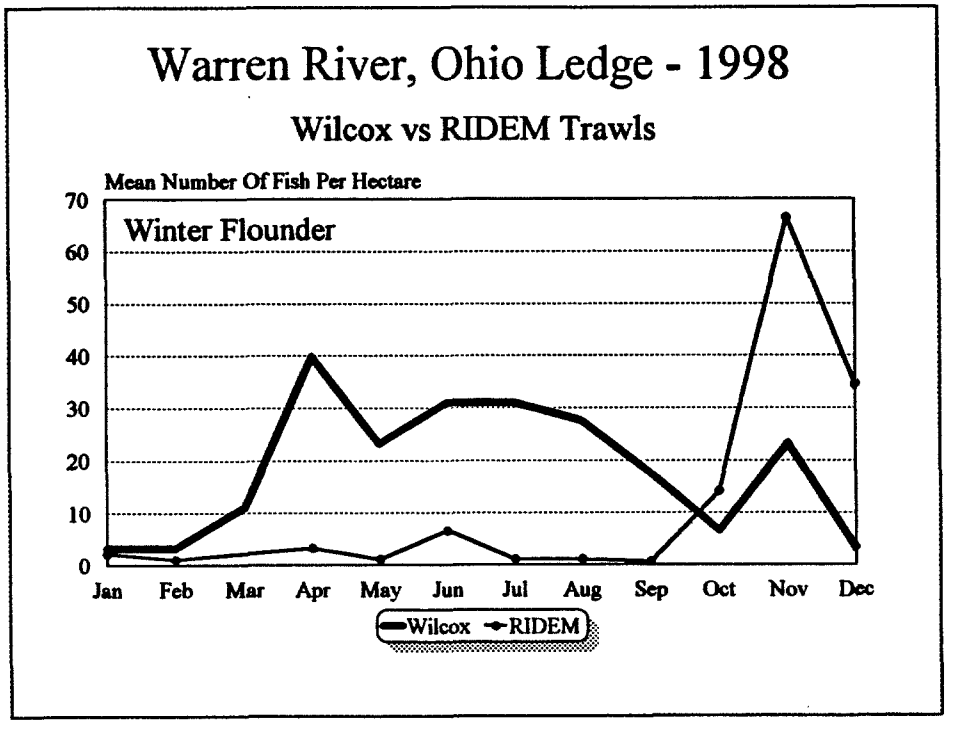


Figure F-33. Comparison of estimated number of all fish per hectare along shallow-water transects based on fine-mesh Wilcox and RIDEM trawls sampled in Mount Hope Bay, 1996-1998.



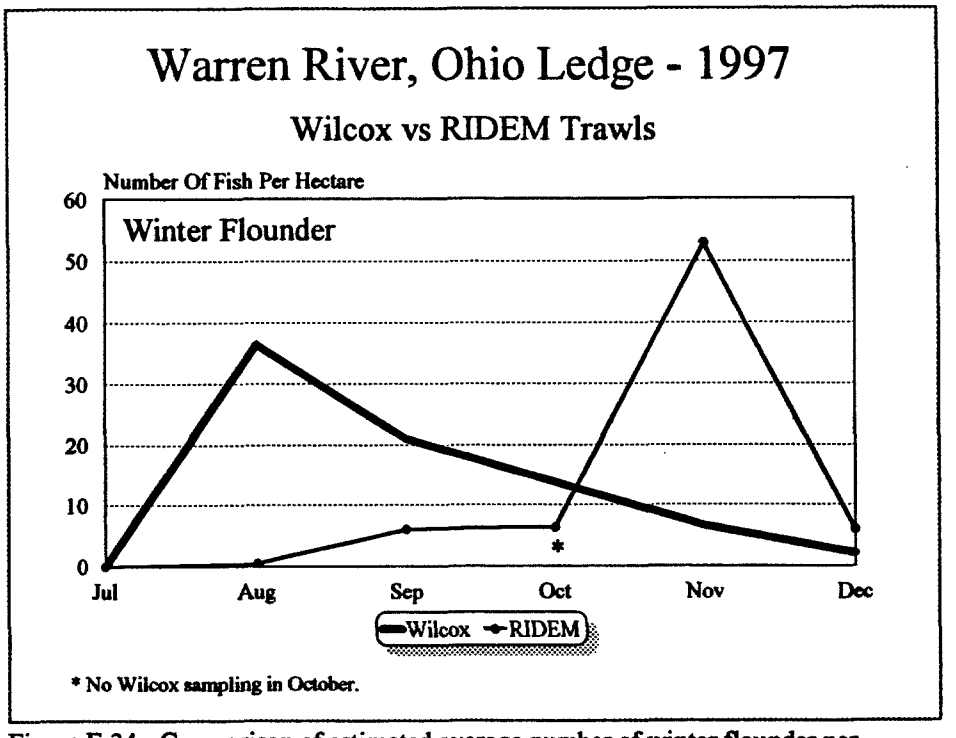
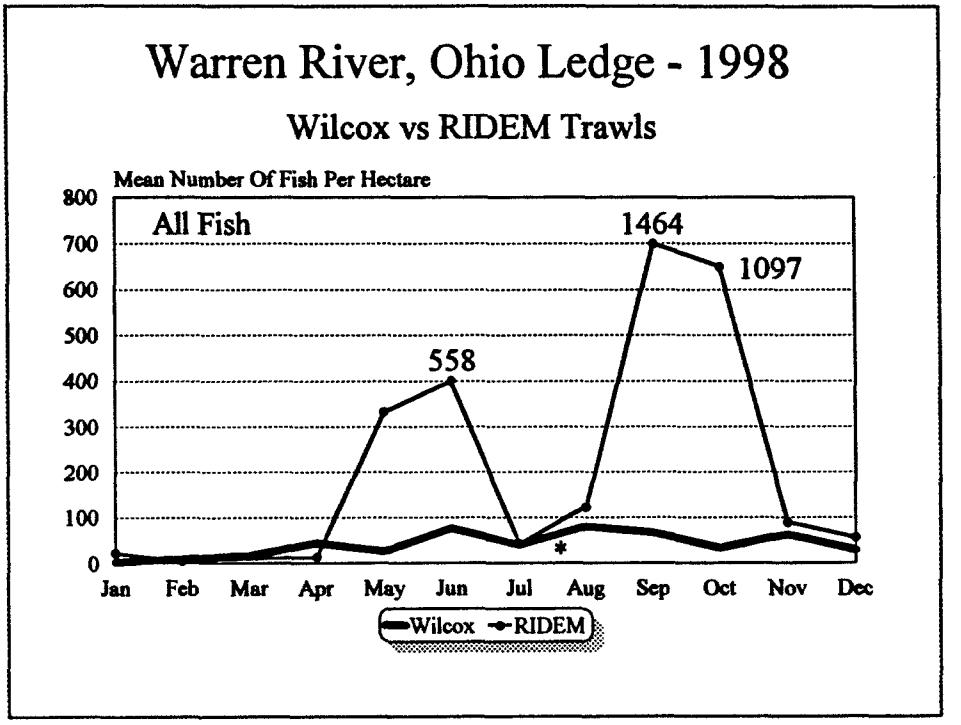


Figure F-34. Comparison of estimated average number of winter flounder per hectare along Warren River and Ohio Ledge transects in Narragansett Bay based on fine-mesh Wilcox and RIDEM trawls, 1997 and 1998.



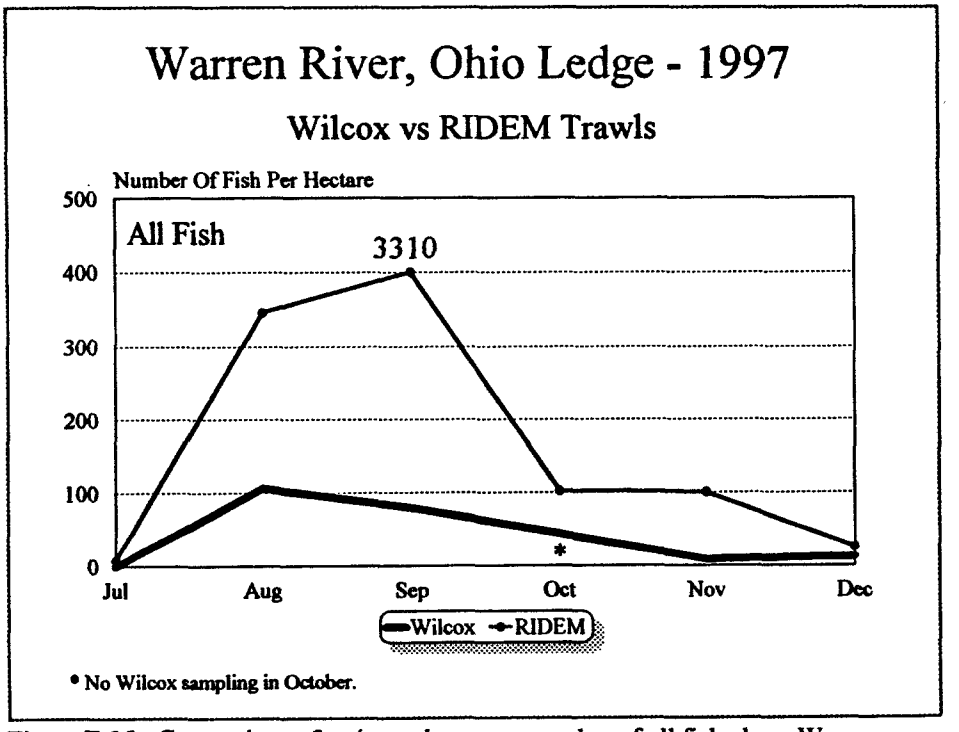
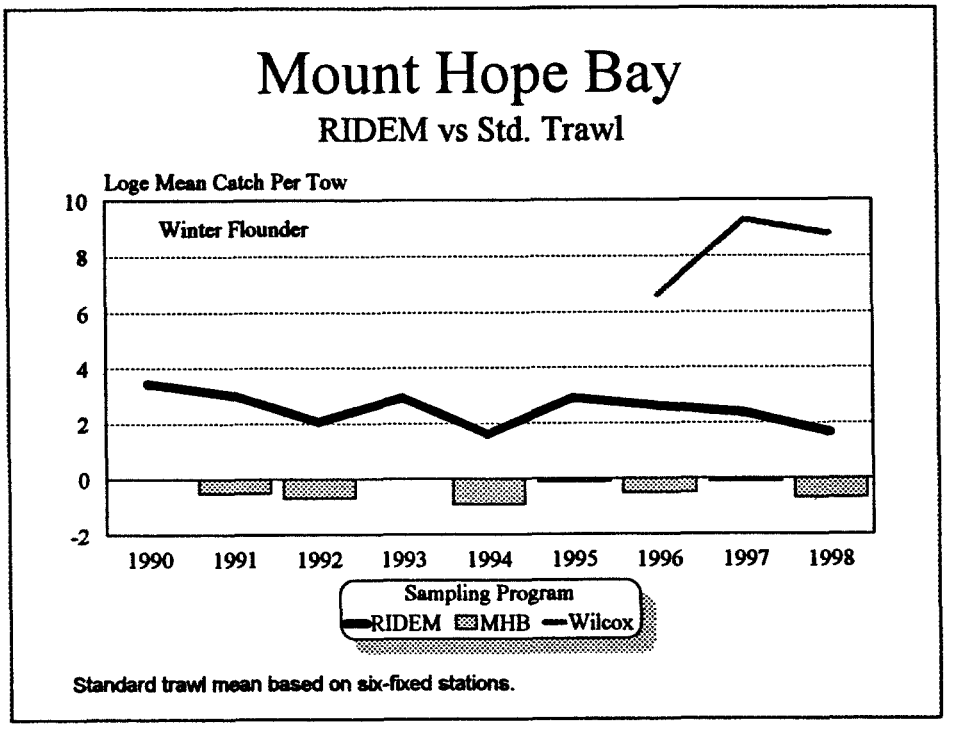


Figure F-35. Comparison of estimated average number of all fish along Warren River and Ohio Ledge transects in Narragansett Bay based on fine-mesh Wilcox and RIDEM trawls, 1997 and 1998.



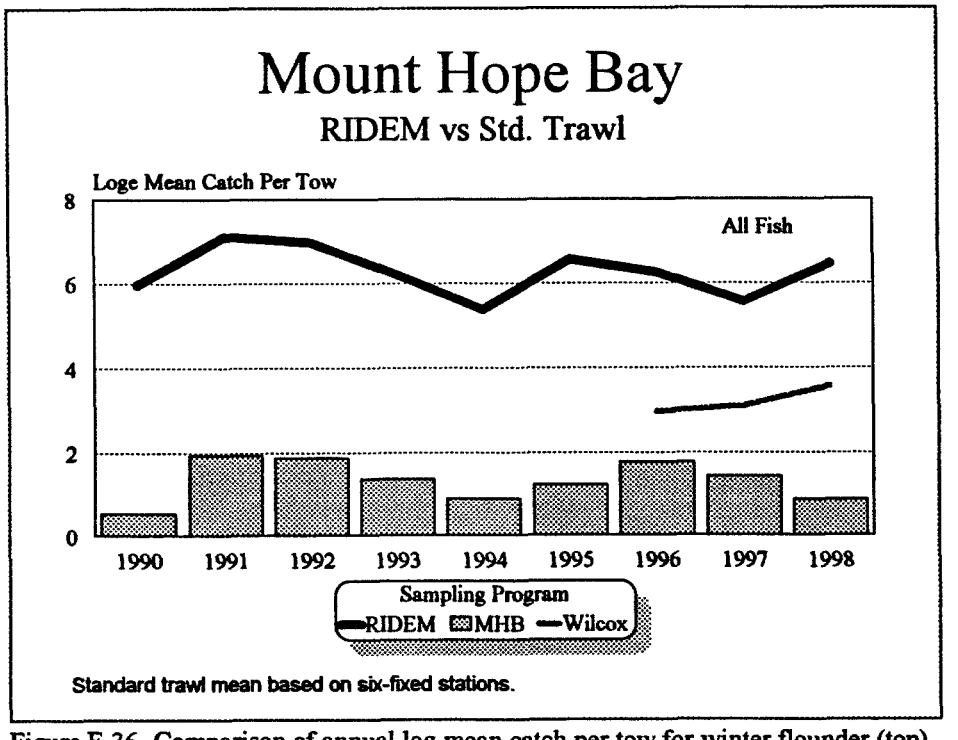
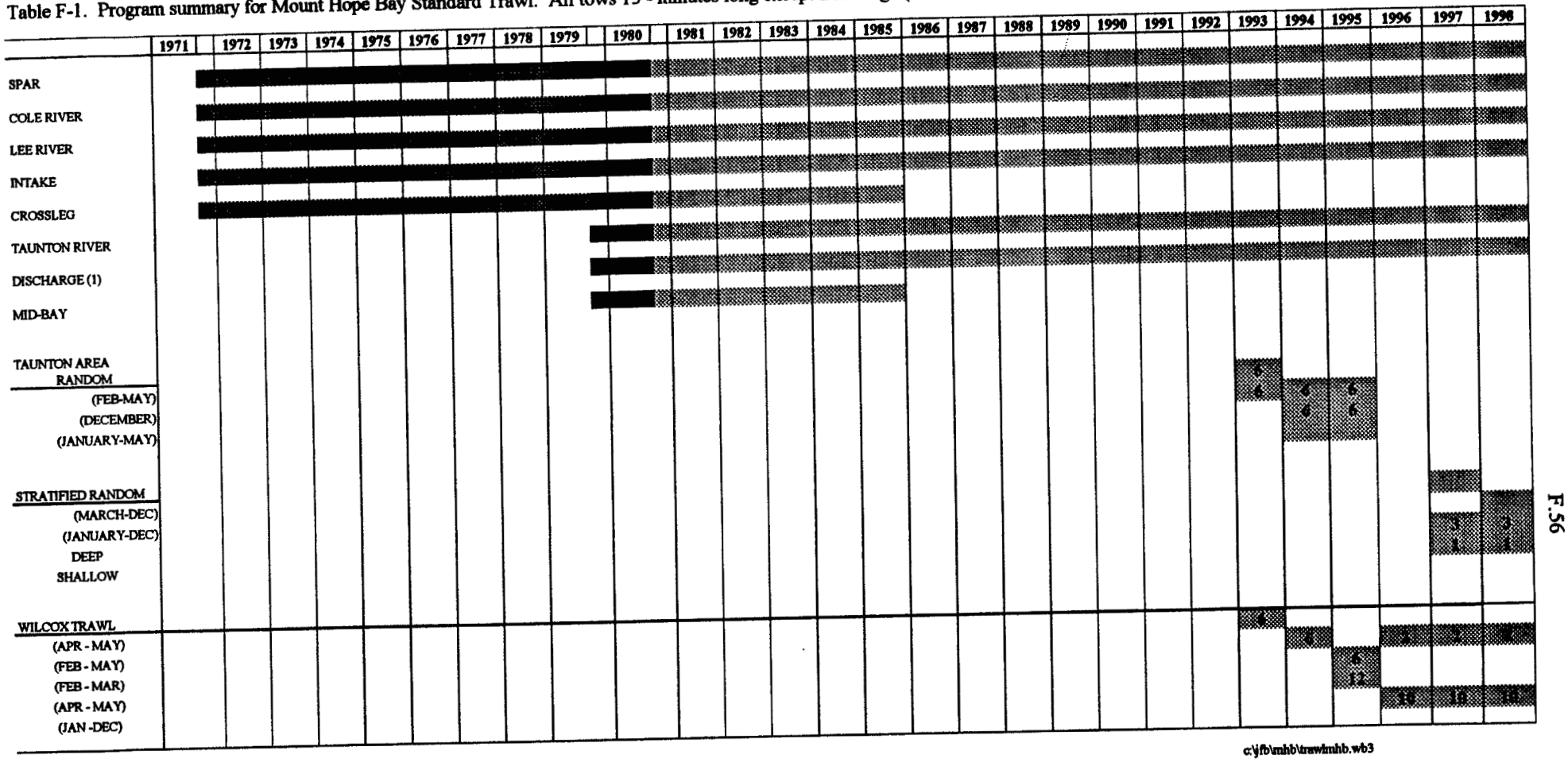


Figure F-36. Comparison of annual log mean catch per tow for winter flounder (top) and all fish between the standard trawl, the Wilcox trawl, and RIDEM's trawl towed in Mount Hope Bay, 1990-1998.

Table F-1. Program summary for Mount Hope Bay Standard Trawl. All tows 15 - minutes long except Discharge (see footnote)



Duplicate tows, twice per month

Single tows, twice per month

Single monthly tows

(1) Discharge tow, perpendicular to plume and only 3-minutes long October 1979 - December 1985. Reoriented in line with plume and lengthened to 15 - minute tow beginning January 1986.

(2) 1993 - 1995 Wilcox trawls were focused on the upper Bay and the Taunton River. Tows in 1996 included the entire Bay.
Numbers in cell indicate number of stations sampled.

Table F-2. Species of finfish and months of occurrence in standard otter trawl collections from Mount Hope Bay, 1998.

Species		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Raja erinacea	Little skate	x			x	x	x		x		x		x
Alosa aestivalis	Blueback herring				x								
A. pseudoharengus	Alewife				x			x			x	x	x
Brevoortia tyrannus	Atlantic menhaden								x				x
Clupea harengus	Atlantic herring					x							
Anchoa mitchilli	Bay anchovy					x		x	x	x	x		
Osmerus mordax	Rainbow smelt							x					
Merluccius bilinearis	Silver hake											x	
Urophycis chuss	Red hake				x								
U. regia	Spotted hake					x	x	x		x	x		
Opsanus tau	Oyster toadfish					x			x				x
Menidia menidia	Atlantic silverside											x	x
P. evolans	Striped searobin					x	x	x	x	x			
Cyclopterus lumpus	Lumpfish			x									
Morone americana	White perch											x	
Pomatomus saltatrix	Bluefish								x	x			
Selene setapinnis	Atlantic moonfish								x	x	x		
Stenotomus chrysops	Scup					x	x		x	x			
Cynoscion regalis	Weakfish								x				
Menticirrhus saxatilis	Northern kingfish								x				
Tautoga onitis	Tautog				x	x	x			x	x	x	x
Tautogolabrus adspersus	Cunner											x	
Gobiosoma ginsburgi	Seaboard goby			x									x
Peprilus triacanthus	Butterfish							x	x	x		x	
Etropus microstomus	Smallmouth flounder							x	x	x			
Paralichthys dentatus	Summer flounder					x	x	x	x	x			
P. oblongus	Fourspot flounder					x	x	x	x	x		x	
Scophthalmus aquosus	Windowpane	x	x	x	x	x	x	x	x	x	x	x	x
Pleuronectes americanus	Winter flounder	x	x	x	x	x	x	x	x	x	x	x	x
Trinectes maculatus	Hogchoker					x	x	x	x				
Sphoeroides maculatus	Northern puffer						x						
Number of species		3	2	4	7	13	11	12	17	13	8	11	9

Note: Both fixed and random tows included.

Table F-3. Numbers of finfish, by species, collected by standard otter trawl along six fixed and four randomly selected transects in Mount Hope Bay, January-December 1998.

January 15, 1998

		Standard Trawl						Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton R.	Dischge	36	2	8	12
Mid.Temp.(°C):		4.3	3.7	4.1	4.0	4.4	8.0	4.8	4.2	3.9	3.9
Bot. Temp.(°C):		4.5	4.1	4.4	4.6	4.3	5.3	4.4	4.8	4.2	4.2
Bot. D.O.(ppm):		9.2	9.6	9.8	9.6	9.4	9.4	9.7	9.4	9.7	9.7
Raja erinacea	Little skate								1		
Scophthalmus aquosus	Windowpane	1									
Pleuronectes americanus	Winter flounder				1						

February 9, 1998

		Standard Trawl						Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton R.	Dischge	36	2	8	12
Mid.Temp.(°C):		3.5	3.3	3.5	3.7	3.8	4.1	3.6	2.9	3.2	3.2
Bot. Temp.(°C):		3.4	3.3	3.7	3.7	3.4	3.7	3.5	3.2	3.2	3.2
Bot. D.O.(ppm):		9.1	9.4	9.5	9.8	9.6	9.3	9.2	9.5	9.3	9.6
Scophthalmus aquosus	Windowpane					1					
Pleuronectes americanus	Winter flounder		1		1						

March 24, 1998

		Standard Trawl						Shallow	Deep		
Station:		Intake	Spar[1]	Cole	Lee	Taunton R.	Discharge	7	8	18	22
Mid.Temp.(°C):		4.7	5.7	5.2	5.9	5.3	6.7	4.9	4.5	4.5	4.4
Bot. Temp.(°C):		4.8	4.8	5.3	5.8	4.9	5.5	4.7	4.5	4.5	4.4
Bot. D.O.(ppm):		9.9	10.4	10.7	10.9	10.3	10.4	10.5	10.0	10.1	10.1
Cyclopterus lumpus	Lumpfish								1		
Gobiosoma ginsburgi	Seaboard goby						1				
Scophthalmus aquosus	Windowpane							1	1		
Pleuronectes americanus	Winter flounder						2		3	2	

[1]Sample bumped - too heavy to bring aboard.

Table F-3 (continued).

April 23, 1998

Station:		Standard Trawl Intake	Spar	Cole	Lee	Taunton R.	Dischge	Shallow 3	Deep 6	15	18
Mid.Temp.(°C):		8.9	12.0	13.6	10.3	10.5	13.0	12.1	10.5	9.6	9.7
Bot. Temp.(°C):		8.8	9.5	10.4	10.3	9.9	10.4	12.0	10.0	8.6	8.5
Bot. D.O.(ppm):		9.0	8.5	6.9	9.0	8.1	9.4	9.3	9.1	9.7	9.8
Raja erinacea	Little skate	1									
Alosa aestivalis	Blueback herring								4		
A. pseudoharengus	Alewife								4		
Urophycis chuss	Red hake	1									
Tautoga onitis	Tautog		1								1
Scophthalmus aquosus	Windowpane		1	1				1			1
Pleuronectes americanus	Winter flounder	1	1	2	1		3	4			8

May 26, 1998

Station:		Standard Trawl Intake	Spar	Cole	Lee	Taunton	Dischge	Shallow 4	Deep 7	18	23
Mid.Temp.(°C):		15.8	15.0	17.5	16.4	14.7	19.9	14.7	14.7	13.7	13.5
Bot.Temp.(°C):		14.2	14.3	16.3	17.5	15.6	17.0	14.5	14.3	13.6	13.5
Bot.D.O.(ppm):		7.4	8.3	7.2	7.9	7.7	7.4	8.6	8.3	8.5	8.9
Raja erinacea	Little skate							1	1		
Clupea harengus	Atlantic herring					3		8		1	17
Anchoa mitchilli	Bay anchovy										5
Urophycis regia	Spotted hake	1									
Opanus tau	Oyster toadfish	1									
Prionotus evolans	Striped searobin		1								1
Stenotomus chrysops	Scup									1	1
Tautoga onitis	Tautog	1				1				2	
Paralichthys dentatus	Summer flounder	2									
P. oblongus	Fourspot flounder	1							1	2	
Scophthalmus aquosus	Windowpane	10	1					1			
Pleuronectes americanus	Winter flounder	7						6	9	4	1
Trinectes maculatus	Hogchoker	1				1					

Table F-3 (continued).

		June 16, 1998									
		Standard Trawl						Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Dischge	29	4	8	12
Mid.Temp.(°C):		15.9	19.0	19.0	20.9	18.3	19.9	18.6	15.7	17.0	16.8
Bot.Temp.(°C):		15.1	18.5	17.3	18.4	16.6	16.2	16.5	14.6	15.9	15.7
Bot.D.O.(ppm):		5.6	6.7	4.6	5.1	6.3	6.0	5.7	6.9	7.0	6.4
Raja erinacea	Little skate										1
Urophycis regia	Spotted hake	7								1	
Prionotus evolans	Striped searobin	3							3	4	4
Stenotomus chrysops	Scup									3	4
Tautoga onitis	Tautog					1					1
Paralichthys dentatus	Summer flounder	1	1								
P. oblongus	Fourspot flounder								6		1
Scophthalmus aquosus	Windowpane	5				1		1		2	2
Pleuronectes americanus	Winter flounder					2			2	4	2
Trinectes maculatus	Hogchoker					1					
Sphoeroides maculatus	Northern puffer										1

Table F-3 (continued).

		July 28, 1998									
		Standard Trawl						Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Dischge	28	2	7	15
Mid.Temp.(°C):		24.3	22.3	24.3	23.7	24.6	25.3	23.3	23.5	21.9	21.2
Bot.Temp.(°C):		20.0	22.1	23.6	23.8	24.2	23.5	23.3	19.8	19.4	19.8
Bot.D.O.(ppm):		4.3	7.0	4.9	7.0	6.8	7.6	4.9	7.0	4.6	5.3
Alosa pseudoharengus	Alewife	2							9	4	
Anchoa mitchilli	Bay anchovy								3		
Osmerus mordax	Rainbow smelt								4		
Urophycis regia	Spotted hake										3
Prionotus evolans	Striped searobin										3
Peprilus triacanthus	Butterfish								4		
Etropus microstomus	Smallmouth flounder										2
Paralichthys dentatus	Summer flounder				1	1			2	1	1
P. oblongus	Fourspot flounder										2
Scophthalmus aquosus	Windowpane	1								4	6
Pleuronectes americanus	Winter flounder	2							2		5
Trinectes maculatus	Hogchoker									1	3

Table F-3 (continued).

		August 24, 1998									
		Standard Trawl						Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Dischge	6	2	15	21
Mid.Temp.(°C):		24.8	22.5	24.5	25.4	23.9	25.9	22.9	23.2	22.2	22.6
Bot.Temp.(°C):		22.0	22.4	24.1	26.5	24.0	24.6	22.3	22.0	21.8	22.4
Bot.D.O.(ppm):		4.5	5.2	5.8	5.9	6.1	6.1	6.1	5.7	6.4	6.6
Raja erinacea	Little skate	1							2		
Brevoortia tyrannus	Atlantic menhaden					1					
Anchoa mitchilli	Bay anchovy					2		12			
Opanus tau	Oyster toadfish	1									
Prionotus evolans	Striped searobin	1					1		1		
Pomatomus saltatrix	Bluefish		1					1			1
Selene setapinnis	Atlantic moonfish								1		
Stenotomus chrysops	Scup				1		2	7	1		1
Cynoscion regalis	Weakfish								1		
Menticirrhus saxatilis	Northern kingfish				2						
Peprilus triacanthus	Butterfish	5				8	1	2	12	11	6
Etropus microstomus	Smallmouth flounder									1	
Paralichthys dentatus	Summer flounder	3							4		
P. oblongus	Fourspot flounder								1		
Scophthalmus aquosus	Windowpane	1							3		
Pleuronectes americanus	Winter flounder	4				2			2	8	
Trinectes maculatus	Hogchoker	2							1		

Table F-3 (continued).

		September 25, 1998									
		Standard Trawl						Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Dischge	27	10	18	23
Mid.Temp.(°C):		20.6	19.9	20.1	20.5	20.7	21.9	20.3	19.9	19.5	19.6
Bot.Temp.(°C):		20.1	20.0	20.0	20.2	20.5	20.9	20.4	19.8	19.5	19.4
Bot.D.O.(ppm):		9.0	7.5	8.6	8.0	6.8	8.3	7.5	6.9	7.6	7.5
Anchoa mitchilli	Bay anchovy								13		
Urophycis regia	Spotted hake									1	
Prionotus evolans	Striped searobin							1			
Pomatomus saltatrix	Bluefish		1						1		
Selene setapinnis	Atlantic moonfish	2									
Stenotomus chrysops	Scup		2					8	5		
Tautoga onitis	Tautog		1								
Peprilus triacanthus	Butterfish									1	
Etropus microstomus	Smallmouth flounder									2	
Paralichthys dentatus	Summer flounder							1		1	
P. oblongus	Fourspot flounder									1	
Scophthalmus aquosus	Windowpane								1	2	
Pleuronectes americanus	Winter flounder							1	6	6	

Table F-3 (continued).

October 27, 1998

Station:		Standard Trawl Intake	Spar	Cole	Lee	Taunton	Dischge	Shallow 19	Deep 4	14	27
Mid.Temp.(°C):		14.4	14.2	14.6	14.4	14.5	15.3	14.2	14.0	14.1	14.0
Bot.Temp.(°C):		14.3	14.3	14.8	14.7	14.4	14.4	14.3	14.2	13.9	13.9
Bot.D.O.(ppm):		7.4	9.1	9.6	10.0	9.5	8.7	9.1	9.3	4.9	7.6
Raja erinacea	Little skate										1
Alosa pseudoharengus	Alewife		1								
Anchoa mitchilli	Bay anchovy		10							9	
Urophycis regia	Spotted hake									1	
Selene setapinnis	Atlantic moonfish	2									
Tautoga onitis	Tautog			1					1		
Scophthalmus aquosus	Windowpane	3									2
Pleuronectes americanus	Winter flounder	1								2	3

November 16, 1998

Station:		Standard Trawl Intake	Spar	Cole	Lee	Taunton	Dischge	Shallow 8	Deep 4	7	9
Mid.Temp.(°C):		11.5	10.2	9.9	10.6	10.3	12.1	10.0	10.4	10.0	9.9
Bot.Temp.(°C):		10.8	10.2	10.3	10.5	10.4	11.3	10.2	10.0	10.0	10.0
Bot.D.O.(ppm):		9.9	10.5	10.7	11.0	11.2	8.4	10.5	10.3	10.4	10.5
Alosa pseudoharengus	Alewife								8	2	
Anchoa mitchilli	Bay anchovy									1	
Merluccius bilinearis	Silver hake								1		
Menidia menidia	Atlantic silverside							1			
Morone americana	White perch	1							1		
Tautoga onitis	Tautog			1							
Tautoga onitis	Cunner						1				
Peprilus triacanthus	Butterfish								1	1	
Paralichthys oblongus	Fourspot flounder								1		
Scophthalmus aquosus	Windowpane	3						1	2	1	
Pleuronectes americanus	Winter flounder	5	2		1		1		2	2	

Table F-3 (continued).

		December 17 , 1998									
		Standard Trawl						Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Dischge	4	2	11	17
Mid.Temp.(°C):		7.8	7.1	6.6	7.0	7.5	10.8	7.5	7.5	7.6	7.2
Bot.Temp.(°C):		7.5	7.5	7.8	7.5	7.9	8.0	7.5	7.6	8.1	7.5
Bot.D.O.(ppm):		13.0	19.0	22.5	20.8	16.0	18.1	23.6	14.6	21.4	24.2
Raja erinacea	Little skate									3	
Alosa pseudoharengus	Alewife									7	
Brevoortia tyrannus	Atlantic menhaden										3
Opanus tau	Oyster toadfish	1									
Menidia menidia	Atlantic silverside	1									
Tautoga onitis	Tautog				1						1
Gobiosoma ginsburgi	Seaboard goby	4									
Scophthalmus aquosus	Windowpane		1			1					
Pleuronectes americanus	Winter flounder	1				1			2	1	

Table F-4. Annual abundance and variation parameters for winter flounder collected under the Mount Hope Bay standard trawl program based on the delta distribution 1972-1998.

Year	No. of tows	Delta mean	Variance	Standard deviation	Proportion of zeros	Coefficient of variation of mean	95% Confidence limits
1972	95	43.65	112.17	10.59	0.16	0.243	±21.18
1973	103	60.37	157.34	12.54	0.08	0.208	±25.08
1974	120	36.24	40.73	6.38	0.08	0.176	±12.76
1975	120	18.89	12.38	3.52	0.17	0.186	±7.04
1976	120	10.60	3.53	1.88	0.15	0.177	±3.76
1977	100	16.46	15.41	3.93	0.21	0.239	±7.86
1978	120	48.56	75.34	8.68	0.04	0.179	±17.36
1979	120	78.02	328.00	18.11	0.08	0.232	±36.22
1980	84	15.75	10.89	3.30	0.18	0.210	±6.60
1981	84	19.35	14.38	3.79	0.17	0.196	±7.58
1982	84	49.97	152.64	12.35	0.16	0.247	±24.70
1983	84	43.01	33.88	5.82	0.00	0.135	±11.64
1984	82	17.93	10.19	3.19	0.02	0.178	±6.38
1985	81	14.97	7.17	2.68	0.06	0.179	±5.36
1986	70	5.816	1.31	1.14	0.31	0.196	±2.28
1987	72	2.089	0.16	0.40	0.49	0.191	±0.80
1988	70	0.730	0.04	0.21	0.71	0.288	±0.42
1989	72	0.366	0.01	0.10	0.79	0.273	±0.20
1990	66	0.966	0.10	0.32	0.77	0.331	±0.64
1991	71	0.569	0.03	0.16	0.76	0.281	±0.32
1992	69	0.486	0.02	0.13	0.77	0.267	±0.26
1993	69	0.992	0.03	0.16	0.48	0.161	±0.32
1994	63	0.441	0.02	0.13	0.79	0.304	±0.27
1995	69	0.905	0.04	0.21	0.64	0.230	±0.42
1996	72	0.612	0.02	0.15	0.72	0.247	±0.30
1997	63	0.904	0.04	0.21	0.71	0.228	±0.41
1998	71	0.534	0.02	0.13	0.72	0.237	±0.25

Note: In 1997 and 1998 when the standard trawl was towed bay-wide, the mean shown is based on the six fixed stations to be consistent with past years.

Table F-5. Abundance indices for several New England winter flounder surveys.

	Connecticut DEP[1]	Millstone Niantic River[2]	RIDFWER Narr. Bay [3]	[4]	URIGSO Narr. Bay[5]	MDMF Southern Stock[6]	MDMF Northern Stock[6]	PNPS Plymouth[7]	MHB[8]
1967					195				
1968					169				
1969					230				
1970					96				
1971					78				
1972			24		75				44
1973			43		81				60
1974			45		65				36
1975			38		44				19
1976		48	19		36				11
1977		29	43		50				16
1978		31	36		88	18	18		49
1979		42	139		284	18	15		78
1980		42	57		202	15	17		16
1981		51	79		120	16	28		19
1982		48	35		107	15	15	16	50
1983		31	52		174	19	29	26	43
1984	111	18	39		63	15	16	13	18
1985	68	17	44		28	12	13	7	15
1986	62	12	52		24	10	15	4	6
1987	68	17	55		66	10	18	6	2
1988	101	18	26		50	6	11	5	0.7
1989	135	13	14		30	8	13	3	0.4
1990	170	11	16	20	17	5	13	1	1
1991	119	16	19	18	15	3	12	0	0.6
1992	54	8	6	13	8	8	14	8	0.5
1993	53	3	7	14	10	8	12	12	1
1994	74	6	6	9	5	13	10	8	0.4
1995	48	3	15	17	37	7	15	-	0.9
1996	93	2	10	11	17	10	13	-	0.6
1997	57	2	8	10	18	10	15	-	0.9
1998	59	2	3	6	13			-	0.5

[1]Geometric mean number per trawl tow, April-June.
[2]Annual delta mean number per tow, fish > 150 mm.
[3]Mean number per tow, spring and fall surveys.
[4]Arithmetic mean number per tow based on monthly survey.
[5]Annual geometric mean number per tow, Fox Island tow.
[6]Stratified mean catch (kg) per tow, spring survey.
[7]Mean catch per tow, Warren Cove.
[8]Annual delta mean number per tow.

Note: In 1997 and 1998 when the standard trawl was towed bay-wide, the mean shown is based on the six fixed stations to be consistent with past years. Due to differences in gear and methodology, trends should be viewed within columns only.

Table F-6. Annual abundance and variation parameters for windowpane collected under the Mount Hope Bay standard trawl program based on the delta distribution 1972-1998.

Year	No. of tows	Delta mean	Variance	Standard deviation	Proportion of zeros	Coefficient of variation of mean	95% Confidence limits
1972	95	7.12	2.126	1.46	0.44	0.205	±2.92
1973	103	7.14	1.767	1.33	0.29	0.186	±2.66
1974	120	6.92	1.605	1.27	0.24	0.183	±2.54
1975	120	4.37	0.747	0.86	0.38	0.198	±1.72
1976	120	1.55	0.087	0.29	0.54	0.190	±0.58
1977	100	1.85	0.128	0.36	0.47	0.193	±0.72
1978	120	9.36	4.027	2.01	0.29	0.214	±4.02
1979	120	11.09	5.012	2.24	0.24	0.202	±4.48
1980	84	3.721	0.534	0.73	0.38	0.196	±1.46
1981	84	3.292	0.615	0.78	0.51	0.238	±1.56
1982	84	6.146	1.782	1.33	0.38	0.217	±2.66
1983	84	3.428	0.359	0.60	0.37	0.175	±1.20
1984	82	1.834	0.117	0.34	0.51	0.187	±0.68
1985	81	2.038	0.216	0.47	0.52	0.228	±0.94
1986	70	0.732	0.028	0.17	0.71	0.230	±0.34
1987	72	0.374	0.008	0.09	0.76	0.237	±0.18
1988	70	0.387	0.010	0.10	0.76	0.256	±0.20
1989	72	0.098	0.002	0.04	0.92	0.408	±0.08
1990	66	0.233	0.009	0.09	0.88	0.397	±0.18
1991	71	0.070	0.001	0.04	0.94	0.511	±0.08
1992	69	0.072	0.001	0.03	0.93	0.436	±0.06
1993	69	0.246	0.004	0.06	0.78	0.241	±0.12
1994	63	0.254	0.006	0.08	0.83	0.296	±0.15
1995	69	0.268	0.006	0.08	0.80	0.283	±0.15
1996	72	0.913	0.102	0.32	0.76	0.350	±0.64
1997	63	0.734	0.024	0.15	0.64	0.210	±0.31
1998	71	0.399	0.016	0.13	0.80	0.320	±0.26

Note: In 1997 and 1998 when the standard trawl was towed bay-wide, the mean shown is based on the six fixed stations to be consistent with past years.

Table F-7. Abundance indices for several New England surveys - windowpane.

	Connecticut DEP[1]	Millstone Niantic River[2]	RIDFWER[3]	Narr. Bay[4]	URIGSO Narr. Bay[5]	MDMF[3]	PNPS Plymouth[6]	MHB[7]
1967					18			
1968					21			
1969					22			
1970					14			
1971					16			
1972					17			7.1
1973					16			7.1
1974					13			6.9
1975					7.5			4.4
1976		1.7			6.4			1.6
1977		1.8			10			1.9
1978		0.9			18	18.4		9.4
1979		1.8	35		24	19.3		11.1
1980		1.6	23		16	17.9		3.7
1981		1.5	24		10	22.3		3.3
1982		2.2	12		5.9	25.9	4.3	6.1
1983		3.0	15		9.2	14.0	6.8	3.4
1984	172	2.4	4.7		2.5	8.4	5.6	1.8
1985	119	2.5	5.6		1.7	9.8	5.7	2.0
1986	68	3.0	10		2.1	15.4	5.9	0.7
1987	40	4.3	21		9.1	9.3	4.2	0.4
1988	66	3.6	6.4		4.9	6.3	1.0	0.4
1989	102	4.9	2.6		1.4	13.6	0.4	0.1
1990	40	3.3	3.1	4.2	0.8	9.7	0.9	0.2
1991	31	2.4	2.4	3.0	0.5	5.3	0	0.1
1992	13	3.7	1.8	2.6	0.4	17.7	6.5	0.1
1993	25	6.0	0.8	1.3	0.7	13.8	11.0	0.2
1994	24	3.4	0.9	2.0	0.5	12.9	3.0	0.3
1995	11	3.4	1.8	2.9	2.4	22.0	-	0.3
1996	37	3.0	12	7.1	3.5	19.4	-	0.9
1997	30	1.8	1.4	3.0	2.5	9.5	-	0.7
1998	24		0.8	1.0	1.7		-	0.4

[1]Geometric mean number per trawl tow, April-June.
[2]Delta mean catch, June-May.
[3]Mean number per tow, spring and fall surveys.
[4]Arithmetic mean number per tow based on monthly sampling program.
[5]Geometric mean number per tow.
[6]Mean catch per tow, Warren Cove.
[7]Annual delta mean number per tow.

NOTE: Due to differences in gear and methodology, trends should be viewed within columns only.

Table F-8. Annual abundance and variation parameters for tautog collected under the Mount Hope Bay standard trawl program based on the delta distribution 1972-1998.

Year	No. of tows	Delta mean	Variance	Standard deviation	Proportion of zeros	Coefficient of variation of mean	95% Confidence limits
1972	95	0.856	0.03	0.18	0.67	0.21	±0.36
1973	103	0.776	0.03	0.17	0.66	0.22	±0.34
1974	120	0.835	0.03	0.16	0.66	0.19	±0.32
1975	120	1.037	0.03	0.19	0.60	0.18	±0.38
1976	120	0.991	0.04	0.20	0.67	0.20	±0.40
1977	100	1.038	0.05	0.22	0.67	0.21	±0.44
1978	120	1.396	0.10	0.32	0.63	0.23	±0.64
1979	120	0.958	0.05	0.22	0.73	0.23	±0.44
1980	84	0.596	0.02	0.13	0.70	0.22	±0.26
1981	84	0.929	0.04	0.21	0.65	0.23	±0.42
1982	84	1.196	0.09	0.29	0.71	0.24	±0.58
1983	84	0.720	0.03	0.16	0.77	0.22	±0.32
1984	82	0.620	0.02	0.14	0.71	0.23	±0.28
1985	81	0.885	0.04	0.20	0.68	0.23	±0.40
1986	70	0.070	0.00	0.04	0.96	0.57	±0.08
1987	72	0.055	0.00	0.03	0.96	0.55	±0.06
1988	70	0.070	0.00	0.04	0.96	0.57	±0.08
1989	72	0.055	0.00	0.03	0.96	0.55	±0.06
1990	66	0.061	0.00	0.03	0.94	0.49	±0.06
1991	71	0.028	0.02	0.02	0.97	0.71	±0.04
1992	69	0.058	0.00	0.03	0.96	0.52	±0.06
1993	69	0.194	0.01	0.09	0.91	0.46	±0.18
1994	63	0.016	[1]	[1]	0.98	[1]	[1]
1995	69	0.015	[1]	[1]	0.99	[1]	[1]
1996	72	0.125	0.004	0.06	0.93	0.48	±0.12
1997	63	0	0	0	1.00	0	0
1998	71	0.113	0.001	0.04	0.89	0.34	±0.08

[1]Only one fish taken.

Note: In 1997 and 1998 when the standard trawl was towed bay-wide, the mean shown is based on the six fixed stations to be consistent with past years.

Table F-9. Abundance indices for several New England surveys - tautog.

	Connecticut DEP[1]	Millstone Niantic River[2]	RIDFWER Narr. Bay [3]	[4]	URIGSO Narr. Bay[5]	MHB[6]
1967					1.0	
1968					2.7	
1969					3.2	
1970					6.3	
1971					3.3	
1972					2.5	0.9
1973					3.2	0.8
1974					2.5	0.8
1975					3.1	1.0
1976		173			4.1	1.0
1977		192			1.5	1.0
1978		175			1.0	1.4
1979		170	3.9		1.1	1.0
1980		94	3.1		0.4	0.6
1981		176	0.8		0.5	0.9
1982		177	0.3		0.9	1.2
1983		75	0.8		1.4	0.7
1984	2.8	72	2.8		1.5	0.6
1985	1.5	100	1.3		0.4	0.9
1986	1.5	190	2.7		0.3	0.1
1987	0.7	62	2.4		0.2	0.1
1988	0.7	135	1.1		0.1	0.1
1989	1.1	66	0.9		0.4	0.1
1990	1.0	161	0.4	0.8	0.1	0.1
1991	0.9	100	1.3	0.8	0.1	0.03
1992	0.8	124	0.2	0.6	0.1	0.1
1993	0.4	87	0.7	0.5	0.2	0.2
1994	0.4	51	0.1	0.3	0.1	0.02
1995	0.2	230	0.2	0.3	0.1	0.02
1996	0.5	106	0.6	0.3	0.2	0.1
1997	0.4	96	0.1	0.4	0.1	0
1998	0.4		0.2	0.2	0	0.1

[1]Geometric mean number per trawl tow, April-June.
[2]Total number taken at three stations in approximately 234 trawls, June-May.
[3]Mean number per tow, spring and fall surveys.
[4]Arithmetic mean number per tow based on monthly survey.
[5]Geometric mean number per tow, May-November.
[6]Annual delta mean number per tow.

NOTE: Due to differences in gear and methodology, trends should be viewed within columns only.

Table F-10. Annual abundance and variation parameters for hogchoker collected under the Mount Hope Bay standard trawl program based on the delta distribution 1972-1998.

Year	No. of tows	Delta mean	Variance	Standard deviation	Proportion of zeros	Coefficient of variation of mean	95% Confidence limits
1972	95	0.704	0.68	0.18	0.75	0.26	±0.36
1973	103	0.528	0.86	0.13	0.73	0.25	±0.26
1974	120	2.757	1.70	0.75	0.63	0.27	±1.50
1975	120	1.437	1.36	0.38	0.68	0.26	±0.76
1976	120	0.961	0.95	0.24	0.73	0.25	±0.48
1977	100	0.247	0.45	0.07	0.84	0.28	±0.14
1978	120	0.957	1.22	0.26	0.73	0.27	±0.52
1979	120	1.761	1.54	0.52	0.71	0.30	±1.04
1980	84	1.317	1.05	0.43	0.77	0.33	±0.86
1981	84	1.524	1.51	0.59	0.79	0.39	±1.18
1982	84	1.098	1.10	0.38	0.79	0.35	±0.76
1983	84	1.611	1.24	0.45	0.64	0.28	±0.90
1984	82	0.847	1.11	0.31	0.81	0.37	±0.62
1985	81	1.528	1.50	0.60	0.79	0.39	±1.20
1986	70	0.407	2.11	0.28	0.93	0.69	±0.56
1987	72	0.313	0.43	0.18	0.94	0.58	±0.36
1988	70	0					
1989	72	0.014	[1]				
1990	66	0.089	0.30	0.05	0.94	0.56	±0.10
1991	71	0.028	0.00	0.02	0.97	0.71	±0.04
1992	69	0.058	0.00	0.04	0.97	0.69	±0.08
1993	69	0.118	0.21	0.06	0.94	0.51	±0.12
1994	63	0.086	0.004	0.06	0.97	0.70	±0.12
1995	69	0.291	0.03	0.17	0.93	0.60	±0.35
1996	72	0.450	0.05	0.22	0.90	0.49	±0.44
1997	63	0.352	0.03	0.18	0.91	0.51	±0.36
1998	71	0.070	0.001	0.04	0.94	0.51	±0.07

[1]One individual collected.

Note: In 1997 and 1998 when the standard trawl was towed bay-wide, the mean shown is based on the six fixed stations to be consistent with past years.

Table F-11. Abundance indices for several New England surveys - hogchoker.

	Connecticut DEP[1]	RIDFWER Narr. Bay[2]	Narragansett Bay[3]	MHB[4]
1979		9.17		1.8
1980		10.29		1.3
1981		12.02		1.5
1982		10.48		1.1
1983		6.45		1.6
1984	0.90	2.83		0.8
1985	0.56	0.62		1.5
1986	0.21	2.50		0.4
1987	0.17	0.27		0.3
1988	0.30	0.31		0
1989	0.17	0.35		0.01
1990	0.22	0.32	0.1	0.1
1991	0.38	0	0.1	0.03
1992	0.15	0.32	0.1	0.1
1993	0.18	0.08	0	0.1
1994	0.05	0	0	0.1
1995	0.07	0.35	0.1	0.3
1996	0.18	0.37	0.1	0.5
1997	0.05	0	0	0.4
1998	0.05	0	0	0.1

[1]Geometric mean catch per tow, September-October.
[2]Mean number per tow, fall survey.
[3]Mean number per tow, monthly survey.
[4]Annual delta mean number per tow.

NOTE: Due to differences in gear and methodology, trends should be viewed within columns only.

Table F-12. Annual abundance and variation parameters for scup collected under the Mount Hope Bay standard trawl program based on the delta distribution, May-October 1972-1998.

Year	No. of tows	Delta mean	Variance	Standard deviation	Proportion of zeros	Coefficient of variation of mean	95% Confidence limits
1972	60	2.124	0.42	0.65	0.63	0.31	±1.30
1973	60	0.639	0.06	0.25	0.78	0.39	±0.50
1974	60	4.620	1.73	1.31	0.43	0.28	±2.62
1975	60	3.825	1.73	1.31	0.55	0.34	±2.62
1976	60	46.560	279.25	16.71	0.27	0.36	±33.42
1977	60	0.596	0.04	0.20	0.78	0.34	±0.40
1978	60	1.931	0.38	0.61	0.55	0.32	±1.22
1979	60	7.833	7.15	2.67	0.53	0.34	±5.34
1980	42	33.144	237.66	15.42	0.36	0.47	±30.84
1981	42	10.110	19.87	4.46	0.57	0.44	±8.92
1982	41	4.106	2.11	1.45	0.61	0.35	±2.90
1983	42	6.846	6.64	2.58	0.57	0.38	±5.16
1984	42	2.565	2.30	1.52	0.79	0.59	±3.04
1985	42	4.662	1.87	1.37	0.36	0.29	±2.74
1986	34	0.480	0.07	0.26	0.85	0.54	±0.52
1987	36	0.523	0.10	0.31	0.86	0.59	±0.62
1988	35	0					
1989	36	2.491	3.08	1.75	0.86	0.70	±3.50
1990	36	0					
1991	35	5.693	7.68	2.77	0.63	0.49	±5.54
1992	35	2.912	2.47	1.57	0.71	0.54	±3.14
1993	34	0.762	0.19	0.44	0.85	0.58	±0.88
1994	35	0.057	0.002	0.04	0.94	0.70	±0.003
1995	33	1.308	0.62	0.79	0.79	0.60	±1.57
1996	36	0.190	0.008	0.09	0.86	0.47	±0.18
1997	27	1.415	1.11	1.06	0.85	0.75	±2.11
1998	36	0.139	0.01	0.08	0.92	0.59	±0.16

Note: In 1997 and 1998 when the standard trawl was towed bay-wide, the mean shown is based on the six fixed stations to be consistent with past years.

Table F-13. Abundance indices for several New England surveys - scup.

	Connecticut DEP[1]	Millstone Niantic River[2]	RIDFWER Narr. Bay [3]	[4]	URIGSO Narr. Bay[5]	MHB[6]
1967					48.6	
1968					36.0	
1969					11.8	
1970					12.0	
1971					45.4	
1972					17.6	2.1
1973					94.3	0.6
1974					40.9	4.6
1975					129.9	3.8
1976		14.8			330.9	46.6
1977		13.0			63.8	0.6
1978		5.6			39.1	1.9
1979		6.2	31.7		64.1	7.8
1980		9.2	50.0		46.9	33.1
1981		7.9	129.3		95.9	10.1
1982		25.1	40.2		39.9	4.1
1983		25.9	152.2		108.3	6.8
1984	10.0	14.3	550.8		50.9	2.6
1985	29.8	8.3	48.9		86.1	4.7
1986	25.7	24.1	173.8		61.5	0.5
1987	18.5	17.4	218.0		79.1	0.5
1988	39.7	11.4	700.1		42.1	0
1989	65.1	11.0	409.8		175.7	2.5
1990	69.5	25.8	668.2	305.5	124.3	0
1991	311.6	176.0	980.3	325.7	286.0	5.7
1992	83.7	56.3	780.4	198.9	74.5	2.9
1993	76.9	2.7	525.5	378.3	31.4	0.8
1994	92.5	26.4	63.9	39	21.1	0.1
1995	59.1	5.1	98.1	118	48.0	1.3
1996	61.5	0.3	125.4	107	57.5	0.2
1997	41.3	8.1	211.7	181	54.1	1.4
1998	103.3		51.8	38	44.6	0.1

[1]Geometric mean number per trawl tow, September-October.
[2]Delta mean catch, June-May, three stations.
[3]Arithmetic mean number per tow, fall survey.
[4]Mean number per tow, May-October.
[5]Geometric mean number per tow, May-October.
[6]Delta mean number per tow, May-October.

NOTE: Due to differences in gear and methodology, trends should be viewed within columns only.

Table F-14. Annual abundance and variation parameters for butterfish collected under the Mount Hope Bay standard trawl program based on the delta distribution, May-November 1972-1998.

Year	No. of tows	Delta mean	Variance	Standard deviation	Proportion of zeros	Coefficient of variation of mean	95% Confidence limits
1972	65	0.488	0.135	0.367	0.94	0.753	±0.734
1973	70	0.805	0.123	0.350	0.86	0.435	±0.700
1974	70	0.136	0.005	0.068	0.90	0.496	±0.135
1975	70	1.260	0.425	0.652	0.83	0.517	±1.303
1976	70	0.064	0.001	0.035	0.94	0.547	±0.070
1977	70	1.183	0.247	0.497	0.83	0.420	±0.994
1978	70	0.398	0.025	0.157	0.83	0.395	±0.315
1979	70	1.172	0.133	0.365	0.70	0.311	±0.730
1980	50	0.020	[1]	[1]	0.98	[1]	[1]
1981	48	0.369	0.064	0.254	0.94	0.688	±0.508
1982	48	0.804	0.155	0.394	0.83	0.490	±0.788
1983	49	0.552	0.050	0.224	0.80	0.406	±0.448
1984	49	0.123	0.004	0.063	0.92	0.512	±0.126
1985	49	0.283	0.040	0.199	0.92	0.703	±0.398
1986	40	0.050	[1]	[1]	[1]	[1]	[1]
1987	42	0.238	0.046	0.215	0.95	0.903	±0.430
1988	42	0					
1989	42	0.209	0.015	0.121	0.91	0.578	±0.242
1990	36	0.056	0.002	0.039	0.94	0.691	±0.077
1991	41	0.024	[1]	[1]	0.98	[1]	[1]
1992	41	1.541	1.585	1.259	0.93	0.817	±2.518
1993	40	0.865	0.405	0.636	0.90	0.735	±1.272
1994	38	0.079	[1]	[1]	0.97	[1]	[1]
1995	39	0.100	0.006	0.078	0.95	0.785	±0.157
1996	42	0.422	0.084	0.290	0.93	0.686	±0.579
1997	33	0.121	0.003	0.058	0.88	0.476	±0.115
1998	42	0.35	0.065	0.255	0.93	0.725	±0.509

[1]Individuals present in only one tow.

Note: In 1997 and 1998 when the standard trawl was towed bay-wide, the mean shown is based on the six fixed stations to be consistent with past years.

Table F-15. Abundance indices for several New England surveys - butterfish.

	Connecticut DEP[1]	Millstone Niantic River[2]	RIDFWER Narr. Bay [3]	[4]	URIGSO Narr. Bay[5]	MHB[6]
1967					2.8	
1968					1.7	
1969					0.6	
1970					0.3	
1971					2.3	
1972					1.4	0.5
1973					1.3	0.8
1974					0.9	0.1
1975					6.1	1.3
1976		7			5.9	0.1
1977		3			1.4	1.2
1978		14			1.4	0.4
1979		3	5		3.0	1.2
1980		8	24		0.5	0.02
1981		9	8		2.1	0.4
1982		4	18		3.7	0.8
1983		20	9		13.6	0.6
1984	52	0	19		8.9	0.1
1985	90	3	17		8.7	0.3
1986	63	15	60		12.5	0.1
1987	60	6	68		14.7	0.2
1988	147	955	98		26.3	0
1989	175	22	117		50.0	0.2
1990	155	342	669	304	49.7	0.1
1991	171	63	53	31	12.5	0.02
1992	302	27	123	571	54.8	1.5
1993	88	16	569	444	37.3	0.9
1994	93	1	99	531	126.7	0.1
1995	320	7	320	228	39.6	0.1
1996	174	0	24	54	21.7	0.4
1997	187	0	266	158	48.3	0.1
1998	355		205	122	14.2	0.4

[1]Geometric mean number per trawl tow, September-October.
[2]Total number taken in approximately 234 trawls, June-May.
[3]Mean number per tow, fall survey.
[4]Mean number per tow, May-November of monthly survey.
[5]Geometric mean number per tow, May-October.
[6]Delta mean number per tow, May-November.

NOTE: Due to differences in gear and methodology, trends should be viewed within columns only.

Table F-16. Annual abundance and variation parameters for little skate collected under the Mount Hope Bay standard trawl program based on the delta distribution 1972-1998.

Year	No. of tows	Delta mean	Variance	Standard deviation	Proportion of zeros	Coefficient of variation of mean	95% Confidence limits
1972	95	0					
1973	103	0.068	0.0008	0.028	0.94	0.410	±0.056
1974	120	0.008	[1]	[1]	0.99	[1]	[1]
1975	120	0.054	0.0005	0.023	0.95	0.433	±0.047
1976	120	0					
1977	100	0					
1978	120	0.038	0.0003	0.017	0.96	0.453	±0.034
1979	120	0.054	0.0006	0.025	0.96	0.457	±0.049
1980	84	0.012	[1]	[1]	0.99	[1]	[1]
1981	84	0.036	0.0004	0.020	0.96	0.567	±0.041
1982	84	0.132	0.003	0.053	0.92	0.398	±0.105
1983	84	0.241	0.006	0.077	0.86	0.319	±0.154
1984	82	0.260	0.006	0.078	0.84	0.300	±0.156
1985	81	0.096	0.003	0.054	0.95	0.567	±0.109
1986	70	0.094	0.001	0.037	0.91	0.390	±0.073
1987	72	0.069	0.001	0.035	0.94	0.512	±0.071
1988	70	0.071	0.001	0.031	0.93	0.437	±0.062
1989	72	0.014	[1]	[1]	0.99	[1]	[1]
1990	66	0.150	0.006	0.077	0.92	0.511	±0.153
1991	71	0.070	0.001	0.031	0.93	0.437	±0.061
1992	69	0.916	0.563	0.750	0.96	0.819	±1.500
1993	69	0.228	0.007	0.081	0.85	0.354	±0.161
1994	63	0.079	0.002	0.040	0.94	0.510	±0.081
1995	69	0.129	0.003	0.054	0.91	0.418	±0.108
1996	72	0.083	0.002	0.043	0.94	0.519	±0.09
1997	63	0.237	0.004	0.065	0.81	0.276	±0.131
1998	71	0.042	0.001	0.024	0.96	0.57	±0.048

[1]One fish taken.

Note: In 1997 and 1998 when the standard trawl was towed bay-wide, the mean shown is based on the six fixed stations to be consistent with past years.

Table F-17. Abundance indices for several New England surveys - little skate.

	Connecticut DEP[1]	Millstone Niantic River[2]	RIDFWER Narr. Bay [3]	[4]	URIGSO Narr. Bay[5]	MHB[6]
1967					0.2	
1968					0.3	
1969					0.5	
1970					0.5	
1971					0.6	
1972					1.0	0
1973					1.4	0.1
1974					1.2	0.01
1975					1.4	0.1
1976		0.7			1.1	0
1977		0.6			0.6	0
1978		0.4			0.3	0.04
1979		0.4	2.9		0.8	0.05
1980		0.8	3.3		1.4	0.01
1981		0.6	6.3		1.0	0.04
1982		1.0	1.4		1.8	0.1
1983		2.6	5.4		2.6	0.2
1984	5.7	0.7	1.9		1.7	0.3
1985	7.2	1.8	4.8		1.1	0.1
1986	7.2	1.8	3.9		0.8	0.1
1987	5.3	2.2	4.5		2.8	0.1
1988	15.5	2.6	6.0		2.6	0.1
1989	21.2	2.4	2.2		2.1	0.01
1990	11.5	3.4	3.9	6.9	1.9	0.2
1991	25.2	3.2	2.0	3.3	2.2	0.1
1992	12.4	2.2	1.2	6.9	1.7	0.9
1993	12.0	3.2	0.6	7.9	1.2	0.2
1994	17.0	2.1	6.1	7.3	0.7	0.1
1995	6.6	3.5	4.3	10.4	3.2	0.1
1996	18.8	1.4	6.6	6.1	1.1	0.1
1997	11.2	2.1	1.8	3.7	0.7	0.2
1998	11.7		1.0	4.0	0.5	0.04

[1]Geometric mean number per trawl tow, April-June.
[2]Delta mean catch, June-May. Data for *Raja* spp.
[3]Mean number per tow, spring and fall surveys, *Raja* spp.
[4]Mean number per tow based on monthly sampling, *Raja* spp.
[5]Geometric mean number per tow.
[6]Annual delta mean number per tow.

NOTE: Due to differences in gear and methodology, trends should be viewed within columns only.

Table F-18. Mean annual otter trawl catch per tow at the standard fixed stations in Mount Hope Bay by species, 1972-1998.[1]

Species		1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Mustelus canis	Smooth dogfish	0.04	0.02	0.02	0	0.05	0	0.03	0	0	0	0	0	0	0
Anguilla rostrata	American eel	0.07	0.03	0.05	0	0.03	0.02	0.03	0.08	0	0.01	0	0.01	0.02	0.04
Conger oceanicus	Conger eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alosa aestivalis	Blueback herring	0	0.02	0.03	0	0	0	0.05	0	0.01	0	0.01	0	0	0.01
A. pseudoharengus	Alewife	0.13	0.29	0.38	0.10	0.02	0.02	0.13	0.05	0.05	0	0.06	0.11	0.06	0.01
A. sapidissima	American shad	0	0	0	0	0	0	0	0.05	0	0	0.01	0.01	0.01	0
Brevoortia tyrannus	Atlantic menhaden	0.38	0.17	0.13	0.15	0	0	0.03	0.06	0	0.01	0.01	0.04	0	0.05
Clupea harengus	Atlantic herring	0.17	0.27	0.03	0.02	0.07	0.08	0.08	0.03	0	0	0	0	0	0.02
Anchoa mitchilli	Bay anchovy	0.07	0.85	2.70	26.37	0.98	1.18	0.10	0.35	1.75	0.02	0.02	0.06	0	0.01
Osmerus mordax	Rainbow smelt	0.54	1.12	0.92	0.17	0.10	0	0.08	0.38	0.17	0.04	0.08	0.44	0.01	0.01
Synodus foetens	Inshore lizardfish	0	0	0.15	0	0	0.02	0	0	0	0.02	0	0	0	0
Opsanus tau	Oyster toadfish	0.52	0.41	1.72	0.37	0.15	0.04	0.25	0.18	0.12	0.17	0.43	0.38	0.34	0.23
Enchelyopus cimbrius	Fourbeard rockling	0	0	0	0	0	0	0.02	0.03	0	0	0	0	0	0
Merluccius bilinearis	Silver hake	0.29	0.41	0.17	0.10	0.05	0.10	0.15	0.05	0	0.02	0.87	0.18	0.11	0.01
Microgadus tomcod	Atlantic tomcod	0.27	0.17	0.08	0.02	0	0.10	0.97	0.50	0.15	0.10	0.11	0.04	0.08	0.02
Pollachius virens	Pollock	0	0	0	0	0	0	0	0.02	0	0.01	0.02	0	0	0
Urophycis chuss	Red hake	0.11	0.03	0.03	0	0.07	0.04	0.17	0.05	0.20	0	0.04	0.18	0.01	0.14
U. regia	Spotted hake	0.03	0.07	0	0.03	0	0	0	0.02	0.06	0	0	0.02	0	0.02
U. tenuis	White hake	0.38	0.58	0.18	0.52	0.07	0	0.10	0.05	0.06	0	0	0.01	0	0
Fundulus majalis	Striped killifish	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0
Menidia menidia	Atlantic silverside	0	0	0.08	0	0	0.06	0.25	0.03	0.01	0.15	0	0.02	0.06	0.02
Apeltes quadracus	Fourspine stickleback	0	0.02	0	0	0	0	0.02	0	0	0	0	0	0	0
Gasterosteus aculeatus	Threespine stickleback	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Syngnathus fuscus	Northern pipefish	0.08	0.34	1.15	0	0.02	0.04	0.53	0.05	0.50	0.42	0.23	0.01	0.17	0.04
Prionotus carolinus	Northern searobin	0.25	0.08	0.05	0.02	0.03	0	0.02	0	0	0	0	0.01	0	0.01
P. evolans	Striped searobin	0.21	0.41	0.30	0.08	0.05	0.02	0.02	0.02	0.01	0	0.02	0.01	0.02	0
Myoxocephalus aenaeus	Grubby	0.04	0	0.02	0	0.02	0	0.07	0.15	0.06	0	0.05	0.08	0.01	0
M. octodecemspinosus	Longhorn sculpin	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0
Cyclopterus lumpus	Lumpfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table F-18 (continued).

Species		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Mean 72-97	1998
Mustelus canis	Smooth dogfish	0.01	0	0	0	0	0	0	0	0	0	0.03	0	0.01	0
Anguilla rostrata	American eel	0.01	0	0.01	0	0	0	0.01	0	0	0	0	0	0.02	0
Conger oceanicus	Conger eel	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0
Alosa aestivalis	Blueback herring	0	0	0	0	0.02	0	0	0.01	0	0.01	0	0.09	0.01	0.03
A. pseudoharengus	Alewife	0	0	0.03	0.03	0.02	0	0.01	0.21	0	0.01	0.2	0.02	0.07	0.31
A. sapidissima	American shad	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0
Brevoortia tyrannus	Atlantic menhaden	0	0	0	0	0	0.03	0	0	0	0	0.07	0	0.04	0.03
Clupea harengus	Atlantic herring	0	0.44	0	0.10	0	0.08	0	0	0	0	0	0.02	0.05	0.24
Anchoa mitchilli	Bay anchovy	0	0	0	0.01	0	0.14	0.19	0.02	0	0.1	0.14	0.56	1.37	0.54
Osmerus mordax	Rainbow smelt	0	0	0.01	0	0	0.01	0	0.03	0	0	0.08	0.11	0.17	0.03
Synodus foetens	Inshore lizardfish	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0
Opsanus tau	Oyster toadfish	0.22	0.07	0.03	0	0.02	0	0	0.02	0	0.07	0.07	0.02	0.22	0.06
Enchelyopus cimbrius	Fourbeard rockling	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Merluccius bilinearis	Silver hake	0	0	0	0.01	0	0	0.02	0	0	0	0.02	0	0.10	0.01
Microgadus tomcod	Atlantic tomcod	0.01	0	0	0.03	0	0.01	0	0.01	1.22	0	0.09	0	0.15	0
Pollachius virens	Pollock	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Urophycis chuss	Red hake	0.06	0	0	0	0	0	0	0	0.02	0.04	0.03	0	0.05	0.01
U. regia	Spotted hake	0	0.01	0	0	0	0	0.01	0	0	0	0.08	0	0.01	0.12
U. tenuis	White hake	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0
Fundulus majalis	Striped killifish	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Menidia menidia	Atlantic silverside	0.09	0.07	0	0	0	0	0	0.12	0	0.01	0.07	0	0.04	0.02
Apeltes quadracus	Fourspine stickleback	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasterosteus aculeatus	Threespine stickleback	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0
Syngnathus fuscus	Northern pipefish	0	0	0	0	0.02	0	0	0	0.02	0	0	0	0.02	0
P. evolans	Striped searobin	0	0	0	0	0	0.03	0.01	0	0	0.1	0.02	0	0.05	0.19
Myoxocephalus aenaeus	Grubby	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0
M. octodecemspinosus	Longhorn sculpin	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0
Cyclopterus lumpus	Lumpfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01

Table F-18 (continued).

Species		1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Morone americana	White perch	0.30	0.17	0.27	0.10	0.60	0.06	0.08	0.06	0.08	0.02	0.12	0.02	0.05	0
M. saxatilis	Striped bass	0.04	0.12	0.02	0	0.08	0	0	0	0.01	0	0.02	0	0	0
Centropristis striata	Black sea bass	0	0	0	0	0.02	0	0	0.02	0	0	0	0	0	0
Pomoxis nigromaculatus	Black crappie	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomatomus saltatrix	Bluefish	0	0.02	0.47	0.25	0.10	0.06	0.20	0.21	0.02	0.04	0.08	0.12	0.05	0.09
Caranx chrysos	Blue runner	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0
C. hippos	Crevalle jack	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0
Selene setapinnis	Atlantic moonfish	0	0.03	0	0	0.02	0.02	0	0	0	0	0	0	0	0.05
S. vomer	Lookdown	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0
Trachurus lathami	Rough scad	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0
Cynoscion regalis	Weakfish	5.07	7.22	11.47	2.30	0.57	0.42	3.87	0.53	3.42	0.61	0.19	1.65	0	0.07
Leiostomus xanthurus	Spot	0	0.02	0	0	0.02	0	0	0	0	0	0	0.01	0	0
Menticirrhus saxatilis	Northern kingfish	0.23	0.27	0.60	0.02	0.02	0	0.10	0.03	0.04	0.01	0.01	0.02	0.02	0.01
Tautogolabrus adspersus	Cunner	0.88	1.34	0.45	0.85	0.92	0.14	0.62	1.94	0.56	0.35	0.52	0.29	0.16	0.09
Pholis gunnellus	Rock gunnel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiosoma ginsburgi	Seaboard goby	0.05	0.10	0.17	0.03	0.02	0.04	0.05	0.17	0.02	0.15	0.04	0.12	0.01	0.01
Scomber scombrus	Atlantic mackerel	0	0	0	0	0	0	0.02	0.02	0	0	0.01	0	0	0
Etropus microstomus	Smallmouth flounder	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0
Paralichthys dentatus	Summer flounder	0.04	0.02	0.12	0.07	0.20	0.04	0	0	0.05	0.04	0.13	0.01	0.11	0.17
P. oblongus	Fourspot flounder	0	0	0.02	0	0	0	0	0	0	0	0.02	0	0	0.01
Sphoeroides maculatus	Northern puffer	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0
Number of species		31	35	35	26	31	25	34	39	28	25	31	33	27	30

Table F-18 (continued).

Species		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Mean 72-97	1998
Morone americana	White perch	0	0	0	0	0.05	0	0.03	0	0	0	0	0	0.08	0.02
M. saxatilis	Striped bass	0	0	0	0	0	0	0	0	0	0	0.02	0.01	0	0
Centropristis striata	Black sea bass	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0
Pomoxis nigromaculatus	Black crappie	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomatomus saltatrix	Bluefish	0.15	0.07	0	0.07	0	0.01	0	0	0	0.01	0	0	0.08	0.04
Caranx chrysos	Blue runner	0	0.01	0	0	0	0.01	0	0	0	0	0	0	0	0
C. hippos	Crevalle jack	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0
Selene setapinnis	Atlantic moonfish	0	0	0.01	0	0	0.01	0	0	0.03	0	0	0.02	0.01	0.04
S. vomer	Lookdown	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trachurus lathami	Rough scad	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cynoscion regalis	Weakfish	5.07	0.01	0	0.01	0	0	0	0	0	0	1.81	0.65	1.53	0.01
Leiostomus xanthurus	Spot	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0
Menticirrhus saxatilis	Northern kingfish	0	0	0	0	0	0	0.01	0.02	0.05	0.01	0.03	0.02	0.06	0.02
Tautogolabrus adspersus	Cunner	0	0.06	0.03	0.08	0	0.04	0.01	0.04	0	0	0	0.08	0.36	0.01
Pholis gunnellus	Rock gunnel	0	0	0	0	0	0	0	0	0	0	0	0.03	0	0
Gobiosoma ginsburgi	Seaboard goby	0.03	0	0.04	0.01	0	0.01	0	0	0	0	0	0.03	0.04	0.04
Scomber scombrus	Atlantic mackerel	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0
Etropus microstomus	Smallmouth flounder	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0.04
Paralichthys dentatus	Summer flounder	0.30	0.17	0.03	0	0.03	0	0.06	0.03	0.03	0.03	0.11	0.09	0.07	0.16
P. oblongus	Fourspot flounder	0	0	0	0	0	0	0.02	0	0	0	0.02	0	0	0.13
Sphoeroides maculatus	Northern puffer	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Number of species		21	18	14	18	12	19	19	18	13	18	27	19	25	31

[1]Species not listed: *Raja erinacea, Stenotomus chrysops, Tautoga onitis, Peprilus triacanthus, Scophthalmus aquosus, Pleuronectes americanus*, *Trinectes maculatus*

Table F-19. Aggregate annual mean number of fish per tow for Mount Hope Bay standard trawl, Mount Hope Bay fine-mesh Wilcox trawl, RIDEM Narragansett Bay, and URIGSO trawls, 1972-1998.

	Mount Hope Bay[1]			
	Standard	Wilcox	RIDEM[2]	URIGSO[3]
1972	65.2			425.5
1973	84.9			634.9
1974	73.3			748.1
1975	62.4			749.0
1976	65.0			747.3
1977	23.9			572.0
1978	70.7			463.8
1979	106.1		253.5	661.4
1980	61.9		271.7	470.1
1981	37.8		381.6	490.0
1982	66.6		341.9	557.6
1983	60.3		859.5	991.0
1984	25.5		977.6	717.2
1985	25.6		618.6	498.4
1986	8.7		670.2	475.6
1987	4.7		824.8	607.0
1988	1.5		2252.5	578.6
1989	3.6		620.8	852.0
1990	1.7		1567.9	557.8
1991	6.9		1061.6	809.3
1992	6.5		2243.9	635.6
1993	3.9		3005.7	1255.8
1994	2.4		736.7	1385.4
1995	3.4		2331.9	904.0
1996	5.9	19.5	1272.2	335.0
1997	4.2	22.3	1156.0	359.7
1998	2.4	35.2	1075.0	344.0

[1]Standard trawl = fixed stations only. Wilcox trawl = Stratified means.
[2]Spring and fall surveys; includes squid.
[3]Whale Rock and Fox Island; includes squid.

Table F-20. Dominance diversity slopes for Mount Hope Bay standard Bay trawl collections, 1972-1998.

1972	-0.180	1985	-0.214
1973	-0.176	1986	-0.261
1974	-0.195	1987	-0.278
1975	-0.272	1988	-0.295
1976	-0.199	1989	-0.268
1977	-0.224	1990	-0.309
1978	-0.183	1991	-0.245
1979	-0.161	1992	-0.307
1980	-0.264	1993	-0.282
1981	-0.288	1994	-0.314
1982	-0.224	1995	-0.291
1983	-0.217	1996	-0.149
1984	-0.233	1997	-0.248[1]
		1998	-0.159

[1]Fixed stations only.

Table F-21. Numbers of finfish, by species, collected with a small mesh Wilcox trawl along randomly selected transects in upper Mount Hope Bay, January-December 1998.

January 22, 1998

		Shallow						Deep			
Station:		5	7	10	18	19	39	7	25	27	37
Mid.Temp.(°C):		3.3	3.3	2.8	3.4	3.4	4.7	3.8	3.4	2.7	3.7
Bot.Temp.(°C):		3.7	3.7	3.9	3.9	3.9	4.0	4.0	3.7	3.8	3.8
Bot.D.O.(ppm):		9.5	9.5	9.1	9.0	9.0	8.7	8.9	9.1	9.1	9.0
Raja erinacea	Little skate				1			2			1
Alosa pseudoharengus	Alewife										1
Osmerus mordax	Rainbow smelt									1	
Menidia menidia	Atlantic silverside									1	
Myoxocephalus aenaeus	Grubby	1			1						2
Tautogolabrus adspersus	Cunner										1
Scophthalmus aquosus	Windowpane						1				
Pleuronectes americanus	Winter flounder	5			1		2	2			2

February 10, 1998

		Shallow								Deep			
Station:		2	9	14	17	18	20	TR1	TR2	16	18	19	24
Mid.Temp.(°C):		3.1	4.0	4.0	4.9	4.9	3.5	3.5	3.5	3.1	3.2	3.1	3.2
Bot.Temp.(°C):		3.1	3.4	3.4	3.6	3.6	3.5	3.3	3.3	3.2	3.2	3.2	3.2
Bot.D.O.(ppm):		9.5	9.5	9.5	9.6	9.6	10.0	9.6	9.6	9.5	9.4	9.5	9.4
Raja erinacea	Little skate	1									2		1
Osmerus mordax	Rainbow smelt								6	1			
Urophycis chuss	Red hake											1	
Menidia menidia	Atlantic silverside	1							7			1	
Myoxocephalus aenaeus	Grubby										7		3
Scophthalmus aquosus	Windowpane								1	1			
Pleuronectes americanus	Winter flounder		2		1	3		1	2	1	4	1	1

Table F-21 (continued).

		March 13, 1998											
		Shallow								Deep			
Station:		4	13	23	26	33	40	TR1	TR2	1	28	33	37
Mid.Temp.(°C):		3.6	4.7	4.7	6.3	5.3	5.2	5.8	5.8	5.3	4.2	3.5	4.8
Bot.Temp.(°C):		3.9	4.6	4.6	5.2	5.2	5.2	5.7	5.7	5.2	4.8	4.7	4.8
Bot.D.O.(ppm):		10.5	10.4	10.1	9.9	9.9	10.1	9.5	9.5	9.6	10.1	10.4	10.1
Raja erinacea	Little skate						1	3	2		1		2
Alosa aestivalis	Blueback herring							1					
A. pseudoharengus	Alewife							22	18	13			1
A. sapidissima	American shad							1					
Microgadus tomcod	Atlantic tomcod							2	1	1			
Merluccius bilinearis	Silver hake							1					
Osmerus mordax	Rainbow smelt		1				1	11	20	16		1	1
Urophycis chuss	Red hake										1		
U. regia	Spotted hake		1			1	1	1	8	4			3
Menidia menidia	Atlantic silverside	1					2	19	17	13	3	21	5
Gasterosteus aculeatus	Threespine stickleback												1
Syngnathus fuscus	Northern pipefish												1
Myoxocephalus aenaeus	Grubby										2		1
Tautoga onitis	Tautog								1				
Tautogolabrus adspersus	Cunner		1			1			2	3	1		
Gobiosoma ginsburgi	Seaboard goby					1							
Scophthalmus aquosus	Windowpane						1				1		
Pleuronectes americanus	Winter flounder	2	2	3		1	8	11	29	7	1	1	4

Table F-21 (continued).

		April 14, 1998											
		Shallow								Deep			
Station:		21	29	31	34	39	45	TR1	TR3	15	16	21	25
Mid.Temp.(°C):		9.2	9.4	9.8	9.3	9.2	9.8	8.8	8.0	8.0	7.7	8.3	7.3
Bot.Temp.(°C):		8.0	8.9	8.2	7.9	7.9	9.4	7.7	7.9	7.3	7.4	7.5	7.2
Bot.D.O.(ppm):		9.5	8.9	9.2	9.4	9.2	9.5	9.4	9.4	10.0	9.4	9.6	9.3
Alosa aestivalis	Blueback herring								42				
A. pseudoharengus	Alewife			3		39			57				
A. sapidissima	American shad							1					
Clupea harengus	Atlantic herring											2	
Gadus morhua	Atlantic cod				3						1		
Urophycis regia	Spotted hake	1	3			1			1			1	
Urophycis spp.	Hake									2		1	2
Syngnathus fuscus	Northern pipefish				1								
Myoxocephalus aenaeus	Grubby					1				1			1
Tautoga onitis	Tautog	1								1			
Tautogolabrus adspersus	Cunner									1			2
Macrozoarces americanus	Ocean pout												1
Etropus microstomus	Smallmouth flounder										1	2	1
Scophthalmus aquosus	Windowpane	1	2			1					1		
Pleuronectes americanus	Winter flounder	4	15	1	4	18	1	5	4	18	5	20	8

Table F-21 (continued).

		May 19, 1998											
		Shallow								Deep			
Station:		3	10	16	23	28	36	TR1	TR2	1	18	25	33
Mid.Temp.(°C):		14.4	13.8	16.2	16.2	14.0	15.3	13.4	13.0	12.6	12.7	12.2	15.3
Bot.Temp.(°C):		12.7	12.3	13.7	12.7	12.6	13.0	12.0	11.8	11.8	11.8	11.7	12.1
Bot.D.O.(ppm):		8.8	8.2	9.1	7.7	8.7	9.0	7.9	8.5	8.5	8.6	8.8	8.6
Raja erinacea	Little skate	1	3						2	2	3	1	2
Clupea harengus	Atlantic herring						34	3	1	1			3
Anchoa mitchilli	Bay anchovy										1		
Merluccius bilinearis	Silver hake										1		
Microgadus tomcod	Atlantic tomcod	1		1			2		4		1	5	4
Urophycis chuss	Red hake		1					1	3	5	4	6	1
U. regia	Spotted hake	1											
Opanus tau	Oyster toadfish									1			
Prionotus evolans	Striped searobin	1											
Stenotomus chrysops	Scup											1	
Tautoga onitis	Tautog								3	1			1
Tautogolabrus adspersus	Cunner					1			1	1		6	1
Paralichthys dentatus	Summer flounder		2							1			
P. oblongus	Fourspot flounder						1			1	2	1	
Scophthalmus aquosus	Windowpane	3			1			1	5	5	1	5	1
Pleuronectes americanus	Winter flounder	32	25	13	10	18	14	9	40	49	70	66	40
Trinectes maculatus	Hogchoker							1					

Table F-21 (continued).

		June 10, 1998									
		Shallow						Deep			
Station:		13	16	21	31	33	41	2	11	19	29
Mid.Temp.(°C):		16.3	16.3	18.0	18.7	17.6	18.8	13.4	13.1	15.2	12.8
Bot.Temp.(°C):		14.2	15.8	15.8	16.1	16.6	15.5	12.4	12.0	14.1	12.0
Bot.D.O.(ppm):		6.8	5.8	6.3	5.6	6.4	6.9	6.5	7.0	7.3	7.4
Raja erinacea	Little skate									1	4
Clupea harengus	Atlantic herring							49			
Gadus morhua	Atlantic cod							1			
Urophycis chuss	Red hake										1
U. regia	Spotted hake	1									
Prionotus carolinus	Northern searobin										2
P. evolans	Striped searobin	1	1	1							
Stenotomus chrysops	Scup	1	4	1	1	2		1	1		3
Tautoga onitis	Tautog							1	2		
Tautogolabrus adspersus	Cunner								10		
Phollis gunnellus	Rock gunnel								2		
Paralichthys dentatus	Summer flounder	1									
Pleuronectes americanus	Winter flounder	6		4	4	4		5	1	7	16

Table F-21 (continued).

		July 15, 1998									
		Shallow						Deep			
Station:		2	4	7	14	19	38	4	12	25	33
Mid.Temp.(°C):		20.5	20.3	20.9	23.0	23.5	23.2	19.8	18.8	17.2	19.5
Bot.Temp.(°C):		19.8	19.2	18.6	18.8	19.1	19.2	17.1	18.8	17.2	18.2
Bot.D.O.(ppm):		6.9	6.9	6.3	6.0	6.2	6.1	6.0	6.7	7.3	6.6
Raja erinacea	Little skate									2	
Alosa pseudoharengus	Alewife			1				3	13	2	
Anchoa mitchilli	Bay anchovy							1	1		3
Urophycis regia	Spotted hake			1				6	2		
Stenotomus chrysops	Scup		2	4			1		22		7
Tautogolabrus adspersus	Cunner									1	
Peprilus triacanthus	Butterfish		1		1		2		1	1	
Etropus microstomus	Smallmouth flounder			2			1				
Paralichthys dentatus	Summer flounder	1		2		1			2		
P. oblongus	Fourspot flounder							3		1	
Scophthalmus aquosus	Windowpane							2	2		
Pleuronectes americanus	Winter flounder		8	80	2	6	10	10	10	4	1
Trinectes maculatus	Hogchoker							2			

Table F-21 (continued).

		August 20 , 1998									
		Shallow						Deep			
Station:		3	7	10	14	19	22	7	15	29	31
Mid.Temp.(°C):		22.2	22.9	24.1	23.3	23.6	23.6	22.3	22.5	21.5	21.3
Bot.Temp.(°C):		21.1	21.4	23.4	22.4	22.0	22.8	21.1	21.0	21.0	20.9
Bot.D.O.(ppm):		5.8	5.5	5.5	5.8	5.1	5.5	5.5	6.1	6.2	6.2
Raja erinacea	Little skate							1			
Alosa pseudoharengus	Alewife							1			
Brevoortia tyrannus	Atlantic menhaden			1							
Anchoa mitchilli	Bay anchovy	3	1	14		4	3	9	1		
Osmerus mordax	Rainbow smelt							6			
Urophycis chuss	Red hake							5			
U. regia	Spotted hake										3
Menidia menidia	Atlantic silverside										
Prionotus evolans	Striped searobin								1		
Pomatomus saltatrix	Bluefish			1							
Stenotomus chrysops	Scup	8	10					3	2		
Cynoscion regalis	Weakfish	3		3	1	1		12			2
Menticirrhus saxatilis	Northern kingfish	2									
Tautoga onitis	Tautog								2		
Peprilus triacanthus	Butterfish	15	2	17	6	16	12	374	243		159
Etropus microstomus	Smallmouth flounder								1		
Paralichthys dentatus	Summer flounder	2	1	1				1	2		1
Scophthalmus aquosus	Windowpane							6	1		2
Pleuronectes americanus	Winter flounder	4	15			10		9	47	4	35
Trinectes maculatus	Hogchoker							3			

Table F-21 (continued).

		September 18, 1998									
		Shallow						Deep			
Station:		6	8	16	19	32	33	7	14	15	21
Mid.Temp.(°C):		20.5	21.8	22.0	22.2	22.5	22.5	20.1	20.6	20.7	20.7
Bot.Temp.(°C):		19.6	20.8	21.9	20.6	21.3	21.3	19.5	19.3	19.3	20.1
Bot.D.O.(ppm):		7.1	6.9	7.7	7.8	6.1	6.1	6.7	7.3	7.4	7.6
Alosa pseudoharengus	Alewife							2			
Brevoortia tyrannus	Atlantic menhaden						1	3			1
Anchoa mitchilli	Bay anchovy		1			30	223	29	1		2
Urophycis chuss	Red hake							2		1	
U. regia	Spotted hake								1	1	
Syngnathus fuscus	Northern pipefish					1					
Prionotus evolans	Striped searobin			1				1	2	3	
Selene setapinnis	Atlantic moonfish				1			21	8		
Stenotomus chrysops	Scup	72		21		10	18			6	8
Cynoscion regalis	Weakfish		1		1			1	1		
Menticirrhus saxatilis	Northern kingfish				3				5		
Peprilus triacanthus	Butterfish	4		7	9			8	29	4	1
Etropus microstomus	Smallmouth flounder		2						6	7	2
Paralichthys dentatus	Summer flounder								3	1	
P. oblongus	Fourspot flounder		1						6	2	
Scophthalmus aquosus	Windowpane		1						6	2	
Pleuronectes americanus	Winter flounder	10	12		11		2	10	58	66	11
Trinectes maculatus	Hogchoker				1				2		

Table F-21 (continued).

		October 28, 1998									
		Shallow						Deep			
Station:		7	12	13	21	24	41	18	20	21	30
Mid.Temp.(°C):		14.0	14.2	14.2	14.4	14.4	14.3	13.9	14.0	14.0	13.9
Bot.Temp.(°C):		14.1	14.4	14.4	14.6	14.6	14.2	13.7	14.0	14.0	13.9
Bot.D.O.(ppm):		8.9	10.4	10.4	9.3	9.3	8.5	9.2	7.8	7.8	7.8
Alosa pseudoharengus	Alewife		1		4						
Anchoa mitchilli	Bay anchovy	31	60	201	110	30	34	114	40	84	
Merluccius bilinearis	Silver hake										1
Urophycis regia	Spotted hake				1		1		3		1
Opsanus tau	Oyster toadfish										1
Centropristis striata	Black sea bass									1	
Stenotomus chrysops	Scup			1			1		12	6	11
Cynoscion regalis	Weakfish		3								
Tautoga onitis	Tautog								5	3	5
Gobiosoma ginsburgi	Seaboard goby						1				
Etropus microstomus	Smallmouth flounder						1				1
Paralichthys dentatus	Summer flounder										1
Scophthalmus aquosus	Windowpane							1			1
Pleuronectes americanus	Winter flounder		1		2	3	6	1	9	12	8

Table F-21 (continued).

		November 18, 1998									
		Shallow						Deep			
Station:		10	15	16	30	37	39	7	12	20	25
Mid.Temp.(°C):		9.9	10.2	10.2	10.3	10.5	10.5	10.0	9.9	10.0	9.9
Bot.Temp.(°C):		10.0	10.1	10.1	10.3	10.0	10.0	10.2	10.0	9.9	10.2
Bot.D.O.(ppm):		11.4	11.6	11.6	10.4	11.1	11.1	11.0	10.5	11.2	10.4
Raja erinacea	Little skate	1								1	2
Alosa pseudoharengus	Alewife	2						6			6
Brevoortia tyrannus	Atlantic menhaden	1						2			
Anchoa mitchilli	Bay anchovy	2	1	3	8	4	94	3	2		
Merluccius bilinearis	Silver hake					1		2		3	3
Urophycis chuss	Red hake										18
Menidia menidia	Atlantic silverside	2									
Prionotus evolans	Striped searobin							1			
Morone americana	White perch							1			
Tautoga onitis	Tautog								1		
Peprilus triacanthus	Butterfish							3			
Etropus microstomus	Smallmouth flounder		1					1	2		9
Paralichthys oblongus	Fourspot flounder							2			2
Scophthalmus aquosus	Windowpane	1						3	1		1
Pleuronectes americanus	Winter flounder	2		1		1	1	7	6	9	9

Table F-21 (continued).

		December 28, 1998									
		Shallow						Deep			
	Station:	5	6	17	19	27	30	7	8	18	19
Mid.Temp.(°C):		5.1	5.1	5.3	5.0	5.2	5.1	5.0	5.2	5.1	5.0
Bot.Temp.(°C):		5.3	5.3	5.0	5.1	5.6	5.3	5.7	5.3	5.4	5.2
Bot.D.O.(ppm):		22.9	22.9	22.2	21.2	21.5	19.4	19.7	21.9	21.3	24.1
Raja erinacea	Little skate	1									
Alosa pseudoharengus	Alewife				1			60			
Brevoortia tyrannus	Atlantic menhaden							41	1		
Clupea harengus	Atlantic herring							1			
Anchoa mitchilli	Bay anchovy					1					
Osmerus mordax	Rainbow smelt							1			
Merluccius bilinearis	Silver hake					1		3	6	1	1
Menidia menidia	Atlantic silverside					7	3	23	4	10	6
Myoxocephalus aenaeus	Grubby										1
Morone americana	White perch							1			
Gobiosoma ginsburgi	Seaboard goby							1			1
Etropus microstomus	Smallmouth flounder								1		1
Paralichthys oblongus	Fourspot flounder							1			
Scophthalmus aquosus	Windowpane		1						1		
Pleuronectes americanus	Winter flounder	3	3	1		1		2	13		4

Table F-22. Species of finfish and months of occurrence in Wilcox trawl collections from Mount Hope Bay, 1998.

Species		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Raja erinacea	Little skate	x	x	x		x	x	x	x			x	x
Alosa aestivalis	Blueback herring	x		x	x								
A. pseudoharengus	Alewife			x	x			x	x	x	x	x	x
A. sapidissima	American shad			x	x								
Brevoortia tyrannus	Atlantic menhaden								x	x		x	x
Clupea harengus	Atlantic herring				x	x	x						x
Anchoa mitchilli	Bay anchovy					x		x	x	x	x	x	x
Osmerus mordax	Rainbow smelt	x	x	x					x				x
Gadus morhua	Atlantic cod				x		x						
Merluccius bilinearis	Silver hake			x		x					x	x	x
Microgadus tomcod	Atlantic tomcod			x		x							
Urophycis chuss	Red hake		x	x		x	x		x	x		x	
U. regia	Spotted hake			x	x	x	x	x	x	x	x		
Urophycis spp.	Hakes				x								
Opsanus tau	Oyster toadfish					x					x		
Menidia menidia	Atlantic silversides	x	x	x					x			x	x
Gasterosteus aculeatus	Threespine stickleback			x									
Syngnathus fuscus	Northern pipefish			x	x					x			
Prionotus carolinus	Northern searobin						x						
P. evolans	Striped searobin					x	x		x	x		x	
Myoxocephalus aenaeus	Grubby	x	x		x	x							x
Morone americana	White perch											x	x
Centropristis striata	Black sea bass										x		
Pomatomus saltatrix	Bluefish								x				
Selene setapinnis	Atlantic moonfish									x			

Table F-22 (continued).

Species		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stenotomus chrysops	Scup					x	x	x	x	x	x		
Cynoscion regalis	Weakfish								x	x	x		
Menticirrhus saxatilis	Northern kingfish									x			
Tautoga onitis	Tautog			x	x	x	x		x		x	x	
Tautogolabrus adspersus	Cunner	x		x	x	x	x	x	x				
Macrozoarces americanus	Ocean pout				x								
Pholis gunnellus	Rock gunnel						x						
Gobiosoma ginsburgi	Seaboard goby			x							x		x
Peprilus triacanthus	Butterfish							x	x	x		x	
Etropus microstomus	Smallmouth flounder				x			x	x	x	x	x	x
Paralichthys dentatus	Summer flounder					x	x	x	x	x			
P. oblongus	Fourspot flounder					x		x		x	x	x	x
Scophthalmus aquosus	Windowpane	x	x	x	x	x		x	x	x	x	x	x
Pleuronectes americanus	Winter flounder	x	x	x	x	x	x	x	x	x	x		x
Trinectes maculatus	Hogchoker					x		x	x	x		x	
Number of species		8	7	17	15	18	13	13	20	18	14	15	15

Table F-23. Stratified mean number of winter flounder per Wilcox tow collected in Mount Hope Bay, 1996-1998.

	1998		1997		1996	
	Mean	s.e.	Mean	s.e.	Mean	s.e.
January	1.2	0.54	1.4	0.39	0.3	0.16
February	1.3	0.37	3.9	0.98	0.5	0.32
March	5.1	1.83	5.4	1.96	1.3	0.68
April	8.3	2.16	17.4	3.43	8.4	3.50
May	29.3	4.09	29.4	8.85	11.4	3.85
June	4.7	1.38	18.7	4.28	5.6	2.03
January-June	8.7	10.35	13.2	2.50	4.6	1.08
July	13.2	7.68	2.8	0.82	2.9	0.92
August	12.3	4.34	8.9	3.20	4.0	1.72
September	17.8	6.04	3.4	1.60	6.2	2.33
October	4.2	1.07	No Sampling		15.3	4.93
November	3.5	0.35	2.3	0.70	7.3	1.15
December	2.7	1.18	2.2	0.61	18.4	5.22
Jan-December	8.8	1.20	9.3	1.58	6.6	0.92

Table F-24. Stratified mean number of fish per Wilcox tow (all species) collected in Mount Hope Bay, 1996-1998.

	1998		1997		1996	
	Mean	s.e.	Mean	s.e.	Mean	s.e.
January	2.5	0.84	2.9	0.80	1.2	0.51
February	3.5	1.03	14.9	3.37	2.7	1.18
March	21.2	5.70	12.0	4.32	2.3	1.14
April	22.0	8.08	20.9	4.16	9.4	3.76
May	40.8	6.54	41.2	12.74	19.5	4.41
June	13.7	4.29	25.2	6.11	13.0	6.56
January-June	18.0	2.70	20.6	3.46	7.9	1.56
July	22.8	9.32	10.6	3.08	44.4	14.34
August	107.6	35.35	63.9	15.73	52.4	29.54
September	76.6	23.10	38.4	10.61	12.9	4.88
October	81.3	18.27	No sampling		41.5	17.56
November	23.2	9.69	4.6	1.40	16.1	2.73
December	20.5	11.58	7.0	1.42	27.3	7.70
Jan-December	35.2	4.95	22.3	2.90	19.5	3.16

Table F-25. Delta mean catch-per-tow parameters for winter flounder, Mount Hope Bay Wilcox trawl collections, February-May 1993-1998.

Year	Number of tows	Delta mean	Variance	Standard deviation	Proportion of zero tows	Coefficient of variation of mean	95% confidence limits
1993	19	49.1	141.6	11.9	0	0.242	±25.0
1994	24	14.4	38.3	6.2	0.125	0.430	±12.4
1995	36	7.4	4.5	2.1	0.306	0.285	±4.2
1996	20	4.2	2.8	1.7	0.450	0.404	±3.4
1997	18	12.2	26.6	5.2	0.222	0.424	±10.3
1998	18	12.7	18.6	4.3	0	0.339	±8.6

Table F-26. Delta mean catch-per-tow parameters for all fish, Mount Hope Bay trawl collections, February-May 1993-1998.

Year	Number of tows	Delta mean	Variance	Standard deviation	Proportion of zero tows	Coefficient of variation of mean	95% confidence limits
1993	19	67.4	241.3	15.5	0	0.230	±31.1
1994	24	21.5	76.0	8.7	0.042	0.406	±17.4
1995	36	18.8	46.6	6.8	0.139	0.363	±13.7
1996	20	8.4	11.4	3.4	0.400	0.401	±6.8
1997	18	23.0	72.1	8.5	0.222	0.369	±17.0
1998	18	45.6	335.9	18.3	0	0.402	±36.7

Table F-27. Comparison of Mount Hope Bay standard and Wilcox trawls with RIDEM trawl, gear, and methodology.

	Mount Hope Bay		
	Standard	Wilcox	RIDEM
Head rope (ft)	25	26	39
Foot rope (ft)	36	30	54
Body mesh (inches stretch)	4.8	2.0	2.0- 4.5
Cod end mesh (inches stretch)	1.5	1.5	1.0
Liner (inches)	no	0.25	0.40
Doors (ft)		1.7 x 3	2 x 4
Tow speed (ft/sec)	4.2	4.2	4.2
Tow duration (minutes)	15	15	20

Table F-28. Mean number of winter flounder and all fish per hectare estimated from shallow and deep fine-mesh, Wilcox trawl transects compared with RIDEM stations 25 in deep water and 26 in shallow water, 1996 -1998.

Winter Flounder

	RIDEM				Fine-mesh Wilcox			
	No. Per Tow		No. Per Hectare		No. Per Tow		No. Per Hectare	
1998	Deep 25	Shallow 26	Deep 25	Shallow 26	MeanDeep	MeanShallow	MeanDeep	MeanShallow
Jan	0	1	0.0	1.1	1.0	1.3	2.2	2.9
Feb	0	4	0.0	4.4	1.7	1.0	3.7	2.2
Mar	11	4	12.0	4.4	8.8	2.7	19.5	5.9
Apr	3	9	3.3	9.8	10.0	7.2	22.1	15.8
May	7	10			45.7	18.7	100.9	41.2
June	12	2	13.1	2.2	7.3	3.0	16.0	6.6
July	8	0	8.7	0.0	6.3	17.7	13.8	39.0
August	10	0	10.9		23.8	4.8	52.5	10.7
Sept	17	0	18.5	0.0	36.3	5.8	80.1	12.9
October	0	0	0.0	0.0	7.5	2.0	16.6	4.4
Nov	15	6	16.4	6.5	7.8	0.8	17.1	1.8
December	2	3	2.2	3.3	4.8	1.3	10.5	2.9

All Fish

	RIDEM				Fine-mesh Wilcox			
	No. Per Tow		No. Per Hectare		No. Per Tow		No. Per Hectare	
1998	Deep 25	Shallow 26	Deep 25	Shallow 26	MeanDeep	MeanShal	MeanDeep	MeanShal
Jan	3	1	3.3	1.1	3.3	2.0	7.2	4.4
Feb	1	4	1.1	4.4	6.8	1.3	15.1	2.9
Mar	67	6	73.0	6.5	46.5	4.8	102.7	10.7
Apr	16	174	17.4	189.7	30.3	16.7	67.0	36.8
May	144	15			61.3	27.5	135.5	60.7
June	25	116	27.3	126.4	26.8	5.3	59.1	11.8
July	214	20	233.3	21.8	25.5	21.0	56.3	46.4
August	742	111	808.8	121.0	234.0	26.0	516.9	57.4
Sept	270	10172	294.3	11087.5	80.8	74.0	178.4	163.5
October	0	2339	0.0	2549.5	80.3	82.0	177.3	181.1
November	31	21	33.8	22.9	26.5	21.0	58.5	46.4
December	536	57	584.2	62.1	46.3	3.8	102.2	8.5

Table F-28. continued.

Winter Flounder

	RIDEM				Wilcox			
1996	No. Per Tow		No. Per Hectare		No. Per Tow		No. Per Hectare	
	Deep 25	Shallow 26	Deep 25	Shallow 26	MeanDeep	MeanShal	MeanDeep	MeanShal
Jan	1	2	1.1	2.2	0.5	0.2	1.1	0.4
Feb	2	0	2.2	0.0	1.3	0.0	2.9	0.0
Mar	9	4	9.8	4.4	2.3	0.7	5.1	1.5
Apr	15	4	16.4	4.4	10.7	7.0	23.6	15.5
May	42	20	45.8	21.8	15.7	8.7	34.6	19.2
June	23	0	25.1	0.0	13.8	0.3	30.4	0.7
Jul	11	0	12.0	0.0	3.5	2.5	7.7	5.5
Aug	40	1	43.6	1.1	7.5	1.7	16.6	3.7
Sep	28	1	30.5	1.1	4.8	5.5	10.5	12.1
Oct					29.3	6.3	64.6	14.0
Nov	28	0	30.5	0.0	4.3	9.3	9.4	20.6
Dec	32	32	34.9	34.9	18.5	18.3	40.9	40.5

All Fish

	RIDEM				Wilcox			
	No. Per Tow		No. Per Hectare		No. Per Tow		No. Per Hectare	
1996	Deep 25	Shallow 26	Deep 25	Shallow 26	MeanDeep	MeanShal	MeanDeep	MeanShal
Jan	9	2	9.8	2.2	2.3	1.3	5.0	2.9
Feb	10	1	10.9	1.1	6.8	3.7	15.1	8.2
Mar	66	4	71.9	4.4	4.3	2.3	9.6	5.1
Apr	23	38	25.1	41.4	11.8	8.5	26.1	18.8
May	54	26	58.9	28.3	28.7	6.5	63.3	14.4
June	93	921	101.4	1003.9	31.5	20.8	69.6	45.9
July	82	0	89.4	0.0	60.0	34.0	132.5	75.1
Aug	1143	745	1245.9	812.1	133.0	17.0	293.8	37.6
Sep	464	6723	505.8	7328.1	18.0	10.0	39.8	22.1
October			0.0	0.0	91.0	9.0	201.0	19.9
November	334	388	364.1	422.9	13.0	17.0	28.7	37.6
December	180	107	196.2	116.6	32.0	25.0	70.7	55.2

Table F-28. continued.

Winter Flounder

	RIDEM				Fine-mesh Wilcox			
	No. Per Tow		No. Per Hectare		No. Per Tow		No. Per Hectare	
1997	Deep 25	Shallow 26	Deep 25	Shallow 26	MeanDeep	MeanShallow	MeanDeep	MeanShallow
Jan	10	3	10.9	3.3	1.5	1.3	3.3	2.9
Feb	4	3	4.4	3.3	4.3	3.7	9.5	8.2
Mar	1	0	1.1	0.0	10.2	2.3	22.5	5.1
Apr	27	2	29.4	2.2	31.2	8.5	68.9	18.8
May					64.8	6.5	143.1	14.4
June	62	1	67.6	1.1	12.4	20.8	27.4	45.9
July	70	0	76.3	0.0	6.3	0.5	13.8	1.1
August	8		8.7		10.5	7.8	23.2	17.3
Sept	26	3	28.3	3.3	4.8	2.5	10.5	5.5
October	3	2	3.3	2.2				
Nov	1	1	1.1	1.1	3.5	1.5	7.7	3.3
December	3	1	3.3	1.1	2.3	2.2	5.0	4.8

All Fish

	RIDEM				Fine-mesh Wilcox			
	No. Per Tow		No. Per Hectare		No. Per Tow		No. Per Hectare	
1997	Deep 25	Shallow 26	Deep 25	Shallow 26	MeanDeep	MeanShal	MeanDeep	MeanShal
Jan	264	7	287.8	7.6	2.8	3.0	6.1	6.6
Feb	273	36	297.6	39.2	27.8	6.5	61.5	14.4
Mar	473	1	515.6	1.1	25.2	3.5	55.6	7.7
Apr	381	3	415.3	3.3	38.2	9.7	84.4	21.4
May					91.0	9.0	201.0	19.9
June	202	5	220.2	5.5	17.8	27.2	39.3	60.0
July	1807	12	1969.6	13.1	21.0	3.8	46.4	8.5
August	923	181	1006.1	197.3	85.5	50.0	188.9	110.5
Sept	782	193	852.4	210.4	54.5	28.0	120.4	61.9
October	56	3	61.0	3.3				
November	27	2	29.4	2.2	8.0	2.3	17.7	5.1
December	210	1	228.9	1.1	10.8	4.5	23.7	9.9

Table F-29. Numbers of fish, by species, collected in two fixed trawls in the Warren River and on Ohio Ledge, 1998.

January 20, 1998

Station:		13	13A
Mid. Temp. (°C):		3.3	3.0
Bot. Temp. (°C):		4.0	3.5
Bot. D.O. (ppm):		9.6	9.7
Pleuronectes americanus	Winter flounder		3

February 27, 1998

Station:		13	13A
Mid. Temp. (°C):		4.1	4.0
Bot. Temp. (°C):		4.0	3.9
Bot. D.O. (ppm):		10.4	10.3
Tautoga onitis	Tautog	2	
Tautogolabrus adspersus	Cunner	1	
Gobiosoma ginsburgi	Seaboard goby	3	
Pleuronectes americanus	Winter flounder	3	

March 18, 1998

Station:		13	13A
Mid. Temp. (°C):		4.4	3.9
Bot. Temp. (°C):		4.5	4.3
Bot. D.O. (ppm):		10.4	10.0
Alosa pseudoharengus	Alewife	1	
Myoxocephalus aenaeus	Grubby	1	
Tautogolabrus adspersus	Cunner	2	
Etropus microstomus	Smallmouth flounder		1
Pleuronectes americanus	Winter flounder	1	9

April 28, 1998

Station:		13	13A
Mid. Temp. (°C):		10.3	10.0
Bot. Temp. (°C):		9.7	9.5
Bot. D.O. (ppm):		9.1	9.3
Scophthalmus aquosus	Windowpane		4
Pleuronectes americanus	Winter flounder	1	35

Table F-29 (continued).

May 29, 1998

Station:		13	13A
Mid. Temp. (°C):		17.3	16.1
Bot. Temp. (°C):		15.6	14.4
Bot. D.O. (ppm):		8.4	8.3
Urophycis chuss	Red hake		1
Prionotus evolans	Striped searobin		1
Tautogolabrus adspersus	Cunner	1	
Pleuronectes americanus	Winter flounder		21

June 29, 1998

Station:		13	13A
Mid. Temp. (°C):		19.3	18.9
Bot. Temp. (°C):		19.3	17.4
Bot. D.O. (ppm):		7.1	5.0
Alosa pseudoharengus	Alewife		10
Microgadus tomcod	Atlantic tomcod	1	
Urophycis chuss	Red hake		1
Stenotomus chrysops	Scup		16
Tautoga onitis	Tautog	2	
Macrooarces americanus	Ocean pout		1
Peprilus triacanthus	Butterfish		10
Pleuronectes americanus	Winter flounder	1	27

Table F-29 (continued)

July 24, 1998

Station:		13	13A
Mid. Temp. (°C):		21.8	21.5
Bot. Temp. (°C):		20.5	18.8
Bot. D.O. (ppm):		6.2	4.7
Anchoa mitchilli	Bay anchovy	1	
Urophycis regia	Spotted hake		1
Myoxocephalus aenaeus	Grubby	1	
Pholis gunnellus	Rock gunnel	1	
Peprilus triacanthus	Butterfish	1	2
Paralichthys dentatus	Summer flounder	1	
Scophthalmus aquosus	Windowpane		1
Pleuronectes americanus	Winter flounder	15	13

August 31, 1998

Station:		13	13A
Mid. Temp. (°C):		22.8	27.7
Bot. Temp. (°C):		21.4	29.4
Bot. D.O. (ppm):		4.7	4.2
Brevoortia tyrannus	Atlantic menhaden		2
Anchoa mitchilli	Bay anchovy		4
Menidia menidia	Atlantic silversides	2	
Syngnathus fuscus	Northern pipefish	29	
Cynoscion regalis	Weakfish	9	
Pholis gunnellus	Rock gunnel	1	
Paralichthys dentatus	Summer flounder	1	
Pleuronectes americanus	Winter flounder	24	1

Table F-29 (continued).

September 28, 1998

Station:		13	13A
Mid. Temp. (°C):		20.4	20.0
Bot. Temp. (°C):		20.1	20.0
Bot. D.O. (ppm):		7.8	7.2
Anchoa mitchilli	Bay anchovy	6	7
Prionotus evolans	Striped searobin	1	1
Syngnathus fuscus	Northern pipefish	1	
Stenotomus chrysops	Scup	1	12
Cynoscion regalis	Weakfish		9
Menticirrhus saxatilis	Northern kingfish	1	
Paralichthys dentatus	Summer flounder		1
P. oblongus	Fourspot flounder		1
Scophthalmus aquosus	Windowpane		3
Pleuronectes americanus	Winter flounder		16

November 5, 1998 (for October)

Station:		13	13A
Mid. Temp. (°C):		10.5	10.9
Bot. Temp. (°C):		10.5	11.7
Bot. D.O. (ppm):		10.6	9.9
Raja erinacea	Little skate		1
Brevoortia tyrannus	Atlantic menhaden	1	
Anchoa mitchilli	Bay anchovy		10
Myoxocephalus aenaeus	Grubby	1	
Syngnathus fuscus	Northern pipefish	10	
Tautogolabrus adspersus	Cunner	2	
Pleuronectes americanus	Winter flounder	2	4

Table F-29 (continued).

November 25 1998

Station:		13	13A
Mid. Temp. (°C):		8.7	8.6
Bot. Temp. (°C):		9.2	8.8
Bot. D.O. (ppm):		11.3	11.2
Brevoortia tyrannus	Atlantic menhaden	2	
Merluccius bilinearis	Silver hake		6
Menidia menidia	Atlantic silverside	16	
Syngnathus fuscus	Northern pipefish	3	
Myoxocephalus aenaeus	Grubby	1	1
Tautoga onitis	Tautog	1	
Tautogolabrus adspersus	Cunner	1	
Gobiosoma ginsburgi	Seaboard goby	2	1
Scophthalmus aquosus	Windowpane		1
Pleuronectes americanus	Winter flounder	4	17

December 15, 1998

Station:		13	13A
Mid. Temp. (°C):		6.5	6.5
Bot. Temp. (°C):		6.6	8.2
Bot. D.O. (ppm):			
Brevoortia tyrannus	Atlantic menhaden	3	10
Merluccius bilinearis	Silver hake		1
Myoxocephalus aenaeus	Grubby	1	
Tautogolabrus adspersus	Cunner	6	
Gobiosoma ginsburgi	Seaboard goby	3	
Pleuronectes americanus	Winter flounder		3

Table F-30. Number of winter flounder and all fish per hectare collected along the Warren River and Ohio Ledge transects in Narragansett Bay by RIDEM and with the fine-mesh Wilcox trawl, 1998.

Warren River (13)				
Winter Flounder	RIDEM		Fine-mesh Wilcox	
	Catch	No. Per Hectare	Catch	No. Per Hectare
Jan	2	2.2	0	0.0
Feb	2	2.2	3	6.6
Mar			1	2.2
Apr	0	0.0	1	2.2
May	1	1.1	0	0.0
Jun	8	8.7	1	2.2
July	2	2.2	15	33.1
Aug	0	0.0	24	53.0
Sep	0	0.0	0	0.0
Oct	20	21.8	2	4.4
Nov	110	119.9	4	8.8
Dec	58	63.2	0	0.0

Warren River (13)				
All Fish	RIDEM[1]		Fine-mesh Wilcox	
	Catch	No. Per Hectare	Catch	No. Per Hectare
Jan	4	4.4	0	0.0
Feb	8	8.7	9	19.9
Mar			4	8.8
Apr	12	13.1	1	2.2
May	8	8.7	1	2.2
Jun	22	24.0	4	8.8
July	6	6.5	20	44.2
Aug	6	6.5	66	145.8
Sep	845	921.1	10	22.1
Oct	86	93.7	16	35.3
Nov	146	159.1	30	66.3
Dec	88	95.9	13	28.7

Ohio River (13A)				
Winter Flounder	RIDEM		Fine-mesh Wilcox	
	Catch	No. Per Hectare	Catch	No. Per Hectare
Jan	2	2.2	3	6.6
Feb	0	0.0	0	0.0
Mar			9	19.9
Apr	6	6.5	35	77.3
May	1	1.1	21	46.4
Jun	4	4.4	27	59.6
July	0	0.0	13	28.7
Aug	2	2.2	1	2.2
Sep	1	1.1	16	35.3
Oct	6	6.5	4	8.8
Nov	12	13.1	17	37.6
Dec	5	5.5	3	6.6

Ohio River (13A)				
All Fish	RIDEM[1]		Fine-mesh Wilcox	
	Catch	No. Per Hectare	Catch	No. Per Hectare
Jan	38	41.4	3	6.6
Feb	2	2.2	0	0.0
Mar			11	24.3
Apr	15	16.4	39	86.2
May	602	656.2	23	50.8
Jun	1001	1091.1	65	143.6
July	74	80.7	17	37.6
Aug	219	238.7	7	15.5
Sep	1841	2006.7	50	110.5
Oct	1927	2100.4	15	33.1
Nov	19	20.7	26	57.4
Dec	14	15.3	14	30.9

[1] Squid excluded.

Table F-31. Mean number of fish and winter flounder per tow in Mount Hope Bay taken with the standard trawl and RIDEM trawl, 1990-1998. Stratified mean determined with the Wilcox trawl is shown for 1996-1998.

	All fish			Winter flounder		
	Standard trawl[1]	RIDEM[2]	Wilcox[3]	Standard trawl	RIDEM	Wilcox
1990	2	393		1	31	
1991	7	1217		0.6	20	
1992	7	1067		0.5	8	
1993	4	500		1	19	
1994	2	217		0.4	5	
1995	3	703		1	18	
1996	6	519	19	0.6	13	7
1997	4	258	22	1	11	9
1998	2	629	35	0.5	5	9

[1]Delta mean, six fixed stations.

[2]Arithmetic mean at Stations 25 (north of Mount Hope Bridge) and 26 (south of Spar Island).

[3]Stratified mean, bay-wide survey.

B. Revolving Screens

Methods

Finfish impinged on the Units 1,2,3 revolving screens at Brayton Point were initially monitored three times per week by diverting screenwash water to an in-line collection tank located downstream of the screens while the screens were operational. Weekly totals were summed to derive an annual total. All fish collected in the tank were identified, counted, and measured to the nearest millimeter (total length). Since 1997, Brayton Point Station Units 1,2,3 screens have run continuously to reduce the probability that fish will be injured by impingement, and they are monitored daily. To have collection periods of sufficient length, an MRI biologist contacts Station personnel and requests that the in-line collection tank be opened at a specified time prior to his arrival at the Station. Following this approach, typical collection intervals range from 4 to 8 hours depending on the amount of debris and algae being impinged at the time (the collection tank overflows when sidewall mesh panels foul). Counts made at each week's wash collections are extrapolated to estimate a weekly total. These are summed to derive an annual total. Also reported is the weekly number of fish taken in the weekly samples divided by the sum of the number of hours represented by screenwash samples. For example, if screens are sampled seven times during given week with 6 hours being represented by each wash and a total of 50 fish taken, then an impingement rate of 1.2 fish per hour will be obtained (50 fish/42 hours).

If an impingement rate of 25 or more fish per hour is obtained at Brayton Point, Station procedures require that Station personnel and various regulatory agencies be notified. MRI personnel are required to take additional samples until the impingement rate drops below 7 fish per hour as specified in the Station's NPDES permit.

Fixed screens of 1.5-inch square on Units 1 and 2 and 1-inch square wire mesh on Unit 3 were in place May through October to reduce impingement of horseshoe crabs (*Limulus polyphemus*) which are not consistently removed from the revolving screens by the wash system. In 1998 Unit 1 was out of service for two weeks starting March 3, and its circulating pumps and screens were not in use during that time. Unit 2 screenwash system was operational throughout the year. Unit 3 was out of service the last week of March and for three weeks in December, and its circulating water pumps and screens were not used during those times.

Results and Discussion

A total of 46 species was represented in the 1998 collections. Numerical dominants included winter flounder (*Pleuronectes americanus*), alewife (*Alosa pseudoharengus*), hogchoker (*Trinectes maculatus*), Atlantic menhaden (*Brevoortia tyrannus*), silver hake (*Merluccius bilinearis*), tautog (*Tautoga onitis*), Atlantic silverside (*Menidia menidia*), Atlantic tomcod (*Microgadus tomcod*), butterfish (*Peprilus triacanthus*), blueback herring (*Alosa aestivalis*), threespine stickleback (*Gasterosteus aculeatus*), smallmouth flounder (*Etropus microstomus*), and oyster toadfish (*Opsanus tau*). These thirteen species accounted for 80% of the 1998 total (Figure F-37). Station impingement rates, tallied on a weekly basis, ranged from a low of 0 during the week of November 2 to a maximum of 7.16 fish/hour during the week of December 29, 1997 (the first week of 1998) when Atlantic menhaden, alewives, and blueback herring were abundant. Collections taken in January contained

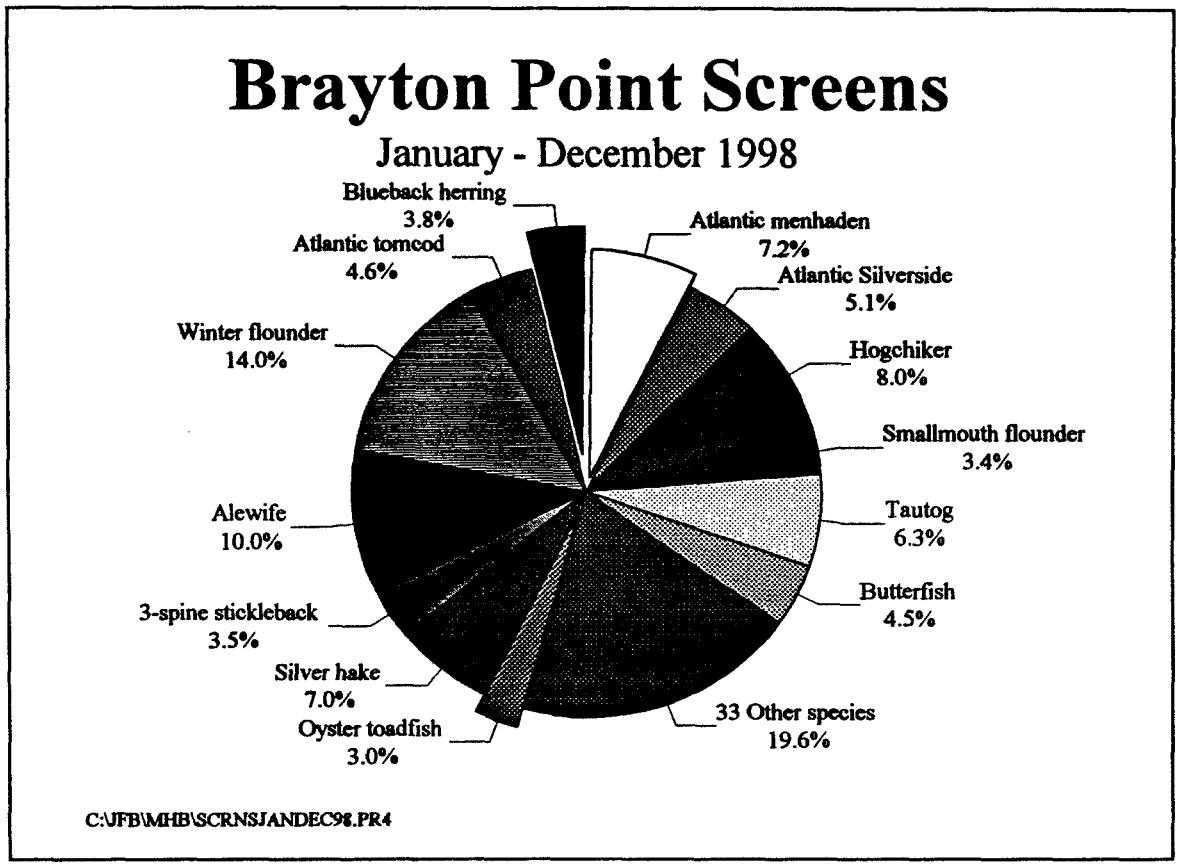


Figure F-37. Percent contribution by species for fish impinged on the Brayton Point Unit 1,2,3 screens, January-December, 1998.

the most species with a count of 29 (Table F-32); the lowest monthly species count was six in September. Tautog were impinged most often, being present during 28 weeks out of 52 in 1998 (Table F-33).

The annual impingement rate for Units 1,2,3 averaged 0.62 fish per hour. Corresponding rates for 1974 through 1997 are presented in Figure F-8 and Table F-34. Over that 24-year period impingement rates for all three Taunton River intakes averaged 5.3 fish per hour, ranging from 1.0 (1996) to 12.4 (1977). From 1984 to 1996 when impingement rates for Units 1,2 were assessed separately from Unit 3, rates were 4 to 11.5 times greater for Unit 3 screens compared to Units 1,2. The 1998 value for Units 1,2, 3 were lowest over the 1974-1998 time series.

A master species list for the Brayton Point Units 1,2,3 screens appears in Table F-35 for annual periods 1972-1998. The current year's total of 46 species was slightly higher than the 1972-1997 mean of 44 species.

Annual extrapolated totals for the sixteen most abundant species impinged by Units 1,2,3 over the past 27 years are listed in Table F-36. In 1998 these species represented 74% of the annual extrapolated total, below the average percent contribution (90%) for that group over the 1972-1997 period. All sixteen species as well as the "all others" category were impinged in below average

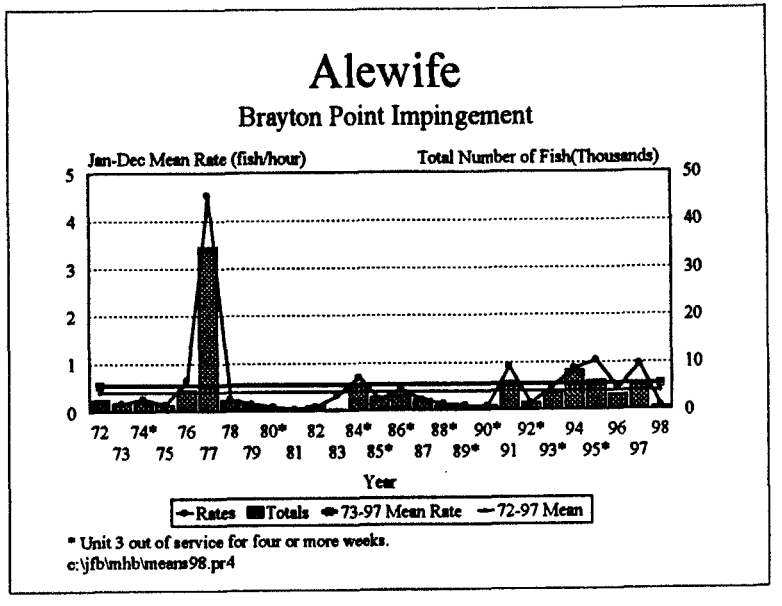
numbers. Tautog and butterfish totals amounted to 46 and 43% of their 27-year means of 776 and 607 respectively. The remaining 14 species were impinged in numbers lower than 20% of their long-term means. The 1998 values for winter flounder, Atlantic silversides, threespine stickleback and striped killifish all ranked last in the 27 years the screens have been sampled (Figure F-38).

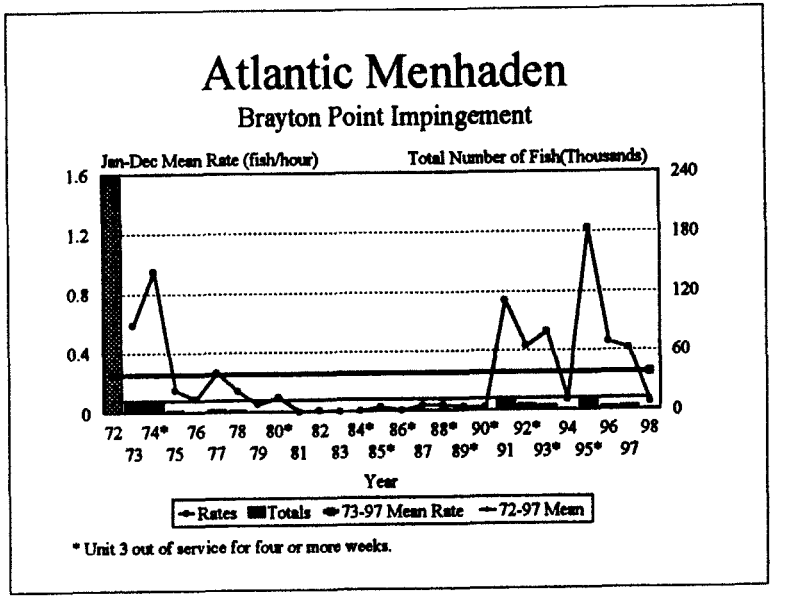
The extrapolated totals in Table F-33 present a comprehensive summary of annual impingement by Brayton Point Units 1,2,3. However, those totals are subject to changes in Station operation such as unit outage periods and variations in wash schedules which could bias abundance patterns. Trends in screen and trawl data for winter flounder were compared to determine if they follow similar patterns. Screenwash data were examined using Unit 3 impingement rates, i.e., numbers of winter flounder collected from the screens per hour of wash time (Table F-37). Values were calculated by month for January through May 1973-1998. Mean number collected per trawl tow over that period represented the trawl catch. The months of January through May were selected because peak winter flounder abundance on the revolving screens typically occurs during February and March and the trawl catch usually reaches one of two seasonal peaks in May (see Figure F-39). Since Unit 3 outage periods were relatively common in April and May (9 out of 27 years) including the low flounder years of 1988-1991, February and March provided the most complete data set. Mean catch per otter trawl tow (January-May) was plotted by year along with mean number of flounder impinged per hour in February, March, and the average over both months. A review of the plots indicated that March screen data matched best with the trawl data (Figure F-39). Values were significantly correlated in untransformed scale ($r = 0.606$, $p < 0.01$) improving when trawl data were log-transformed ($r = 0.660$, $p < 0.01$). The plot using the average impingement within February and March was included here for comparison and to provide data for 1974, 1979, 1983, and 1995 when Unit 3 was out of service in March. Tracking the trends, both the trawl and screens showed a decrease in catch from 1973 to 1976. An increase in catch was apparent between 1977 and 1979 although the 1979 screen catch was low (February-March plot) while the trawl catch was high. A decline followed through 1981 (trawl) and 1983 (screens). The dramatic decline in numbers of flounder displayed by the trawl catch from 1983 through 1992 is also apparent in the revolving screen data although a delay of several years occurred, i.e., the screen catch did not decline noticeably until 1988.

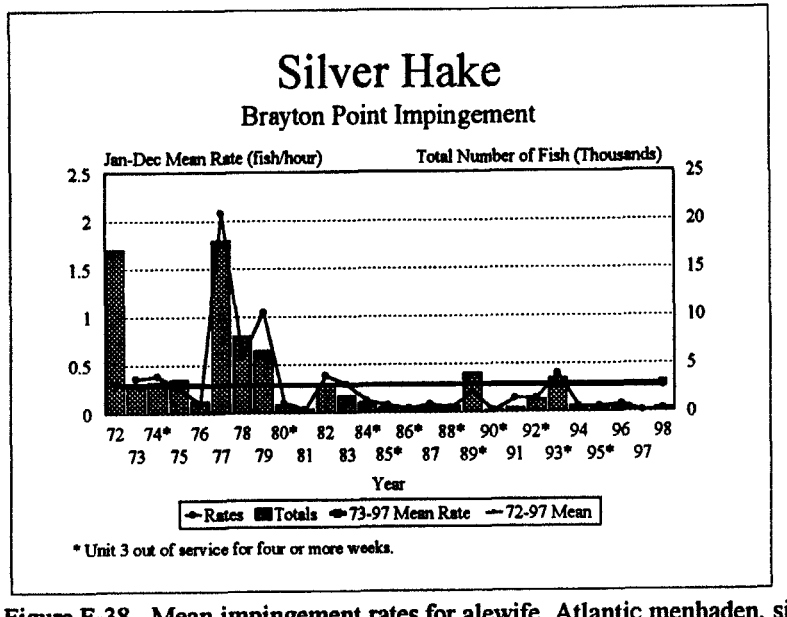
The 1998 mean impingement rate for flounder of 0.18 for the January-May period was lower than all previous years. The April 1998 screen catch (0.03 fish per hour) equaled the 1992 rate and was only greater than the 1991 rate of zero while May 1998 represented the second time (1997 being the first) in the 17 years that Unit 3 data were available for May that no winter flounder were impinged.

Gibson (1996) calculated a dominance diversity index for the Brayton Point Unit 1,2,3 intake screen fish impingement data using only the 16 numerical dominants tabulated in Brayton Point annual reports (Table F-36 in this report). The index was calculated by fitting a least squares linear regression line to loge annual impingement totals for each species versus that species rank within the year. The regression coefficient or slope represented a diversity index (Whittaker 1965) and was calculated for each year from 1972 through 1994. In any community steep slopes (larger negative numbers) are less desirable than shallow ones because they indicate that numbers of individuals are

concentrated within few species. However, Gibson pointed out that annual indices were increasing over time (slopes were becoming steeper), indicating that total numbers of fish among those impinged appeared to be concentrated among fewer species. Over time rarefaction appeared to be occurring. Diversity indices for the 16 dominants and all species impinged (annual average = 44 species) were updated through 1998 (Figure F-40). For the 16 numerical dominants a significant increase in negative slopes over time remains in spite of improved slopes in 1996, 1997 and 1998 resulting in an overall decreasing trend (slope = -0.004, p = 0.003, Figure F-40). The 1998 diversity value is the highest since 1982. However, for all species impinged no trend is apparent, the slope over time being nearly horizontal (slope = 4.2E-4, p = 0.474) indicating no relationship between diversity indices and year. While shifts in abundance of the numerical dominants have occurred over time, increases in the less common species have had a stabilizing effect. No evidence of unhealthy rarefaction was apparent over the full complement of species.







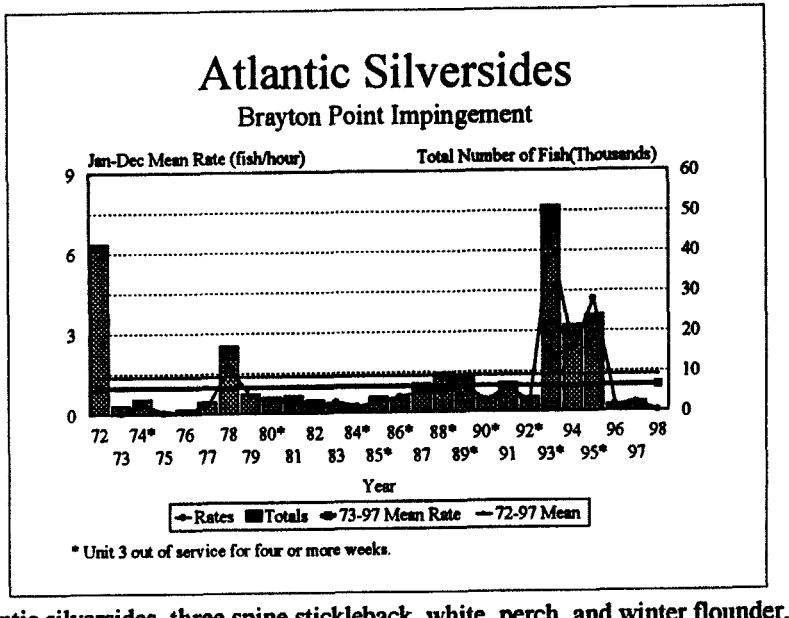
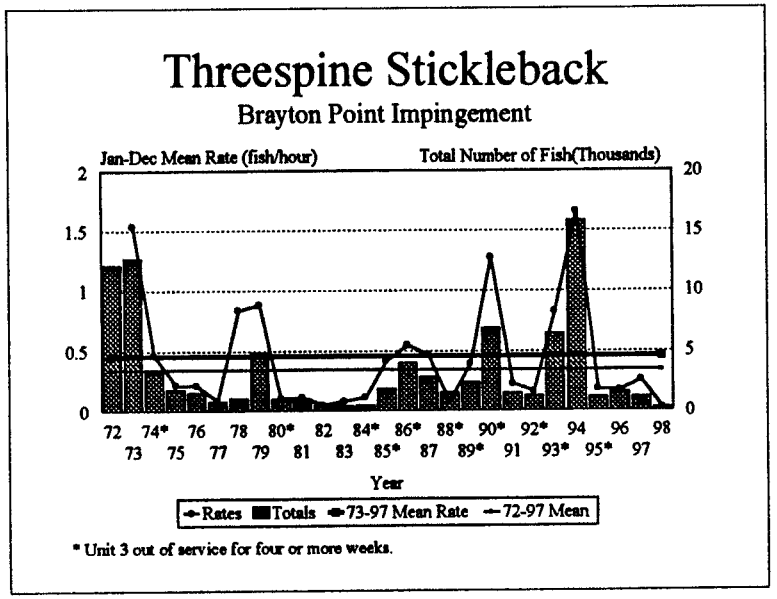
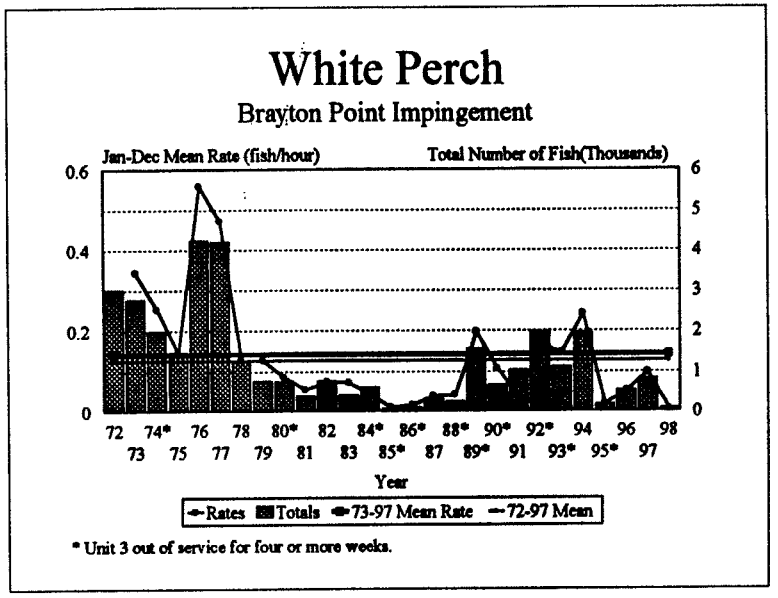


Figure F-38. Mean impingement rates for alewife, Atlantic menhaden, silver hake, Atlantic silversides, three spine stickleback, white perch, and winter flounder, January-December 1972-1998.





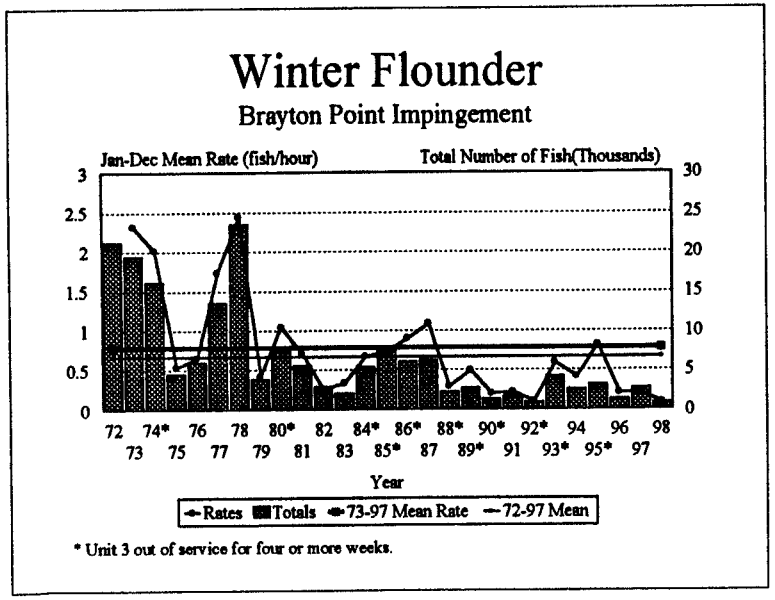
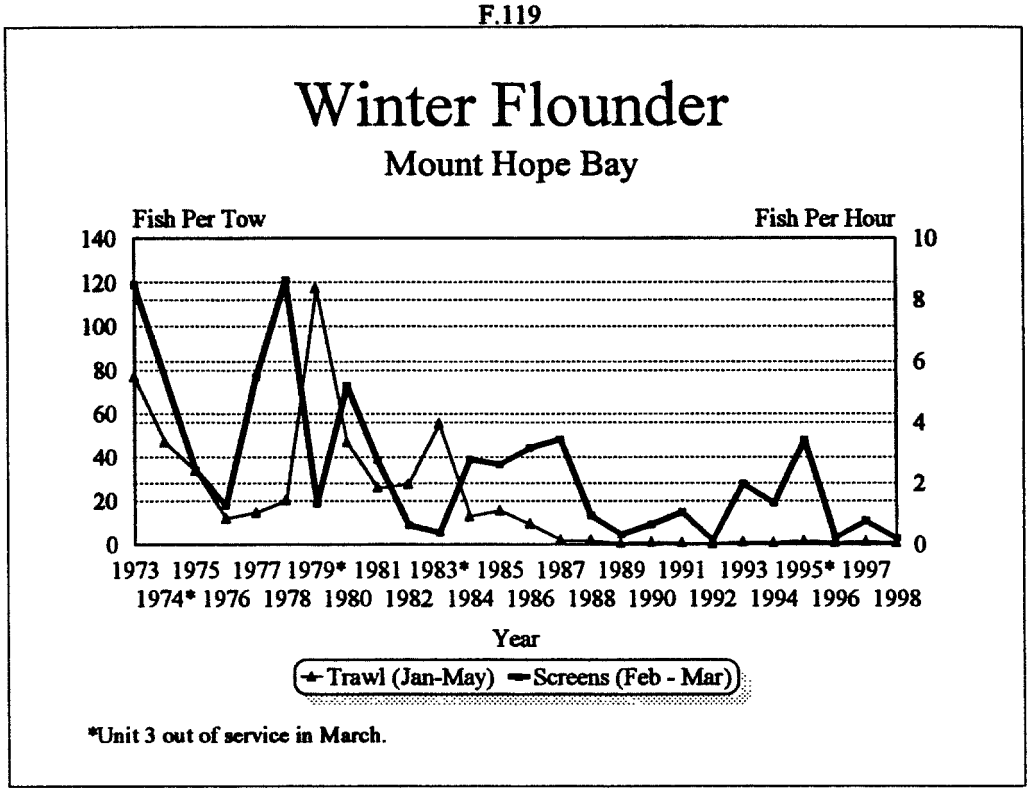


Figure F-38. (continued).



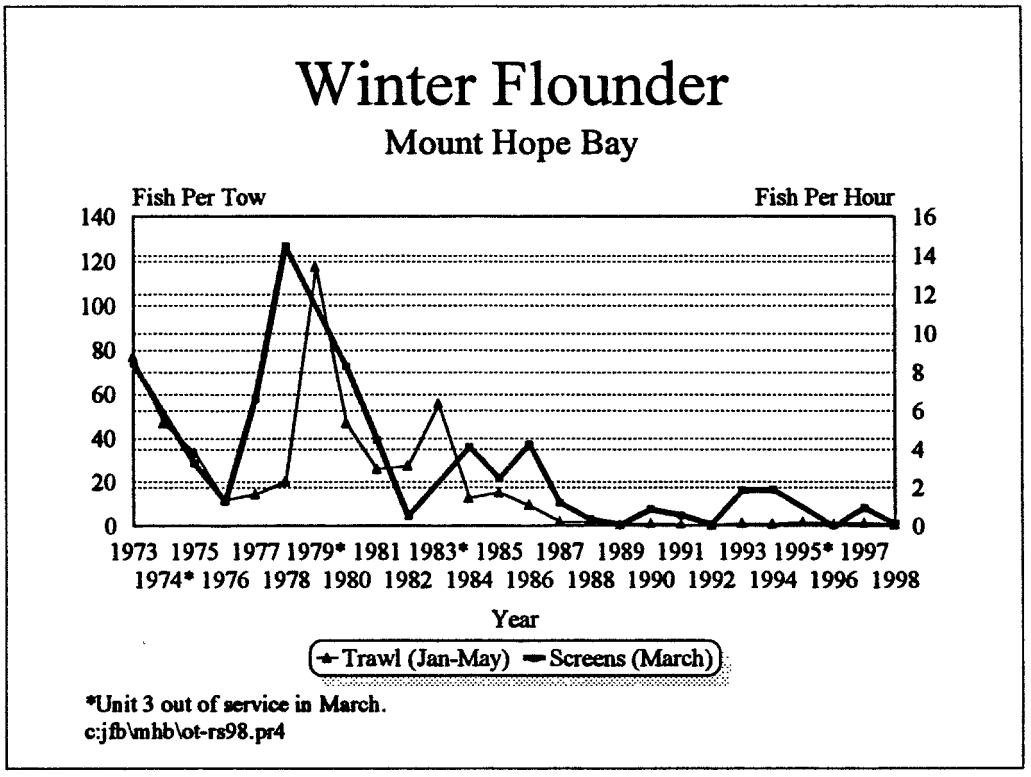
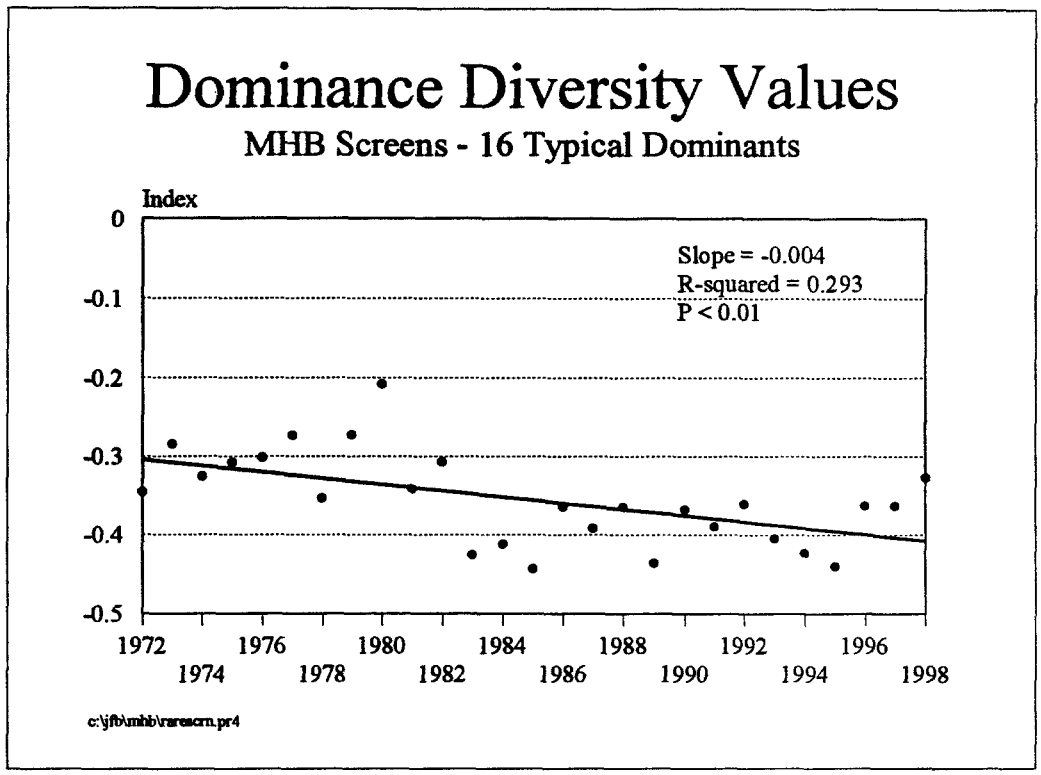


Figure F-39. Mean number of winter flounder impinged per hour at Brayton Point during February-March and during March compared with mean number per otter trawl tow for January-May in Mount Hope Bay, 1973-1998.



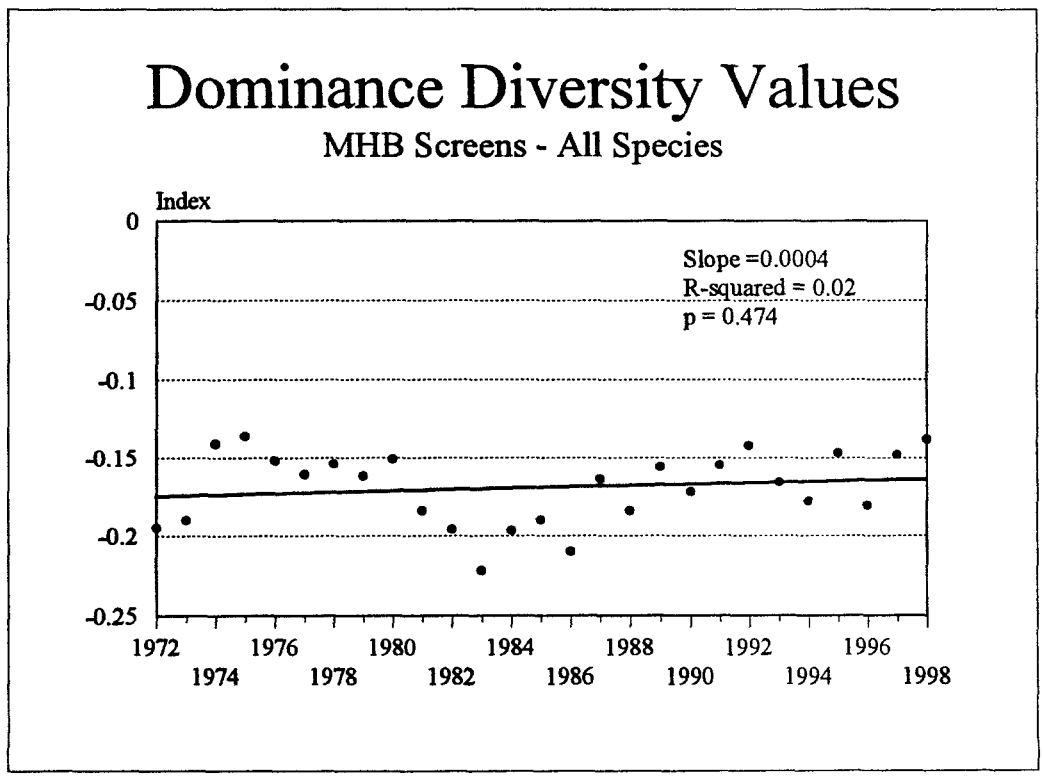


Figure F-40. Dominance diversity values for 16 typical dominants and all species collected from Brayton Point Units 1,2,3 intake screens, 1972-1998.

Table F-32. Species of fish taken on the Brayton Point revolving screens by month, January-December 1998.

Species		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Squalus acanthias	Spiney dogfish												X
Raja erinacea	Little skate	X	X	X	X	X	X	X				X	X
Anguilla rostrata	American eel	X	X	X	X			X				X	
Conger oceanicus	Conger eel	X											X
Alosa aestivalis	Blueback herring	X	X	X	X	X		X			X	X	X
A. pseudoharengus	Alewife	X	X	X	X	X		X	X	X		X	X
A. sapidissima	American shad			X									
Brevoortia tyrannus	Atlantic menhaden	X							X	X	X	X	X
Clupea harengus	Atlantic herring	X			X	X	X						
Anchoa mitchilli	Bay anchovy	X				X	X	X			X		
Osmerus mordax	Rainbow smelt	X	X	X	X								
Salvelinus fontinalis	Brook trout												X
Merluccius bilinearis	Silver hake	X	X	X								X	X
Microgadus tomcod	Atlantic tomcod	X	X		X	X	X						X
Urophycis chuss	Red hake	X	X	X									
U. regis	Spotted hake	X	X	X	X	X							X
Ophidion marginatum	Striped cusk-eel											X	
Opsanus tau	Oyster toadfish				X	X	X	X			X	X	
Fundulus heteroclitus	Mummichog	X											X
F. majalis	Striped killifish												
Menidia menidia	Atlantic silverside	X	X	X				X	X	X			X
Gasterosteus aculeatus	Threespine stickleback	X	X	X	X								X
Hippocampus erectus	Lined seahorse					X							
Syngnathus fuscus	Northern pipefish	X		X	X	X		X	X		X	X	X
Prionotus carolinus	Northern searobin												

Table F-32. (continued).

Species		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Prionotus evolans	Striped searobin	X										X	
Myoxocephalus aenaeus	Grubby	X	X	X	X			X					X
M. octodecemspinosus	Longhorned sculpin												X
Morone americana	White perch	X				X					X		X
M. saxatilis	Striped bass	X	X										X
Centropriatis striata	Black seabass	X											
Lepomis macrochrius	Bluegill		X	X	X	X	X						
Pomatomus saltatrix	Bluefish						X						
Trachinotus falcatus	Permit								X				
Stenotomus chrysops	Scup												
Cynoscion regalis	Weakfish										X		
Tautoga onitis	Tautog	X	X	X	X	X			X	X	X	X	X
Tautogolabrus adspersus	Cunner	X		X	X	X		X	X			X	X
Peprilus triacanthus	Butterfish							X	X				X
Etropus microstomus	Smallmouth flounder	X	X		X		X						X
Paralichthys dentatus	Summer flounder				X								
Paralichthys oblongus	Fourspot flounder	X											X
Scophthalmus aquosus	Windowpane	X	X		X		X	X				X	X
Pleuronectes americanus	Winter flounder	X	X	X	X		X	X		X	X	X	X
Trinectes maculatus	Hogchoker	X				X	X	X	X			X	X
Aluterus schoepfi	Orange filefish									X			
Number of species		29	18	17	19	15	11	14	9	6	9	15	26

Table F-33. Species and estimated weekly numbers of finfish taken on the revolving screens, January-December 1998.

Week beginning:	January					February				March					April				May				June			
Species	29	5	12	19	26	2	9	16	23	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22
Squalus acanthias Spiny dogfish																										
Raja erinacea Little skate		8							3	9		4		4				3	3		13				4	5
Anguilla rostrata American eel	11		7		5		3		4	5	5			4												
Conger oceanicus Conger eel	4			5	5																					
Alosa aestivalis Blueback herring	120	8	4	11	4				13				14		4				3							
A. pseudoharengus Alewife	152	11	10		4	8	4		44		8	37	87	110	16	8		11	14		9					
A. sapidissima American shad													5													
Brevoortia tyrannus Atlantic menhaden	195	8	16		5																					
Clupea harengus Atlantic herring	15		4	4										4							5					3
Anchoa mitchilli Bay anchovy	4																				9					9
Osmerus mordax Rainbow smelt	20	3			9		4	4	4	5		5	4	4	4											
Salvelinus fontinalis Brook trout																										
Merluccius bilinearis Silver hake	7				4			4		5																
Microgadus tomcod Atlantic tomcod	42	12	17	8	19	4		4							4			4	7	6	21	18			42	
Urophycis chuss Red hake	10								3			3														
U. regis Spotted hake	7								3			7	25	45	4				3							
Ophidion marginatum Striped cusk-eel																										
Opsanus tau Oyster toadfish																	5	4			8	5	9	15	22	11
Fundulus heteroclitus Mummichog				4																						

Table F-33. (continued).

Week beginning:	January					February				March				April					May				June			
Species	29	5	12	19	26	2	9	16	23	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22
F. majalis Striped killifish																										
Menidia menidia Atlantic silverside	167	11			4	19	3		16			12	4													
Gasterosteus aculeatus Threespine stickleback	47	19	3		34	28		15	16			8	9	12		6										
Hippocampus erectus Lined seahorse																					7					
Syngnathus fuscus Northern pipefish	29	4		5							4		5	7	5				3	4	9	4				
Prionotus carolinus Northern searobin																										
Prionotus evolans Striped searobin	4																									
Myoxocephalus aenaeus Grubby	7	4	7	8	10	43	7	15	23	5			8	4												
M. octodecemspinosus Longhorned sculpin																										
Morone americana White perch	4																					5				
M. saxatilis Striped bass		4					3																			
Centropristis striata Black seabass	4		4																							
Lepomis macrochrius Bluegill									4			12					5		4		12				5	
Pomatomus saltatrix Bluefish																										3
Trachinotus falcatus Permit																										
Stenotomus chrysops Scup																										
Cynoscion regalis Weakfish																										
Tautoga oritis Tautog	26	4	7	4	5			4	4	5		3	4		19	40	41	26		6	8	11				
Tautogolabrus adspersu Cunner	8	4											4	4	5		9	21			11	6				

Table F-33. (continued).

Week beginning:	January					February				March					April				May				June			
Species	29	5	12	19	26	2	9	16	23	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22
Peprilus triacanthus Butterfish																										
Etropus microstomus Smallmouth flounder	55	4	9		5	16									4										5	
Paralichthys dentatus Summer flounder																8		3								
Paralichthys oblongus Fourspot flounder	4																									
Scophthalmus aquosus Windowpane	9	4		4	4			4						4											5	
Pleuronectes americanu Winter flounder	245	25	51	43	53	52	32	62	13	55	5	18	8	10	7		4								5	
Trinectes maculatus Hogchoker	15																				7	14	14	9	118	112
Aluterus schoepfi Orange filefish																										
Total	1211	133	139	96	170	170	56	112	150	89	22	109	177	212	72	62	64	72	37	16	119	63	23	24	206	143
Unit 1,2,3 fish/hour	7.16	0.74	0.80	0.49	0.86	1.06	0.33	0.69	0.89	0.67	0.13	0.54	1.12	1.19	0.48	0.40	0.39	0.31	0.27	0.10	0.65	0.42	0.16	0.14	1.10	0.88
Number of species	26	16	12	10	15	7	7	8	13	7	4	10	12	12	10	4	5	7	7	3	12	7	2	2	8	6
Fixed screens	out	out	out	out	out	out	out	out	out	out	out	out	out	out	out	out	out	out	in	in	in	in	in	in	in	in

Table F-33. (continued).

Week beginning:	July					August					September				October					November					December			
Species	29	6	13	20	27	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	7	14	21	28
Squalus acanthias Spiny dogfish																										4	
Raja erinacea Little skate	16																					7				17	
Anguilla rostrata American eel																						13					
Conger oceanicus Conger eel																										4	
Alosa aestivalis Blueback herring				4										6								21				4	
A. pseudoharengus Alewife			5						5	4											4	6	9		6		3
A. sapidissima American shad																											
Brevoortia tyrannus Atlantic menhaden							11	4	9	7	15			6						4		14	4		6	18	91
Clupea harengus Atlantic herring																											
Anchoa mitchilli Bay anchovy		4	5											6	3												
Osmerus mordax Rainbow smelt																											
Salvelinus fontinalis Brook trout																										4	
Merluccius bilinearis Silver hake																						53	230	6	18	23	48
Microgadus tomcod Atlantic tomcod																								9		22	24
Urophycis chuss Red hake																											
U. regis Spotted hake																										7	9
Ophidion marginatum Striped cusk-eel																				4							
Opsanus tau Oyster toadfish	6	8	5											12	7	9	6	4		16	13	8					
Fundulus heteroclitus Mummichog																											3

Table F-33. (continued).

Week beginning:	July					August					September				October				November				December			
Species	29	6	13	20	27	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	7	14	21	28
F. majalis Striped killifish																											
Menidia menidia Atlantic silverside					4				4			6												26	7		9
Gasterosteus aculeatus Threespine stickleback																											3
Hippocampus erectus Lined seahorse																											
Syngnathus fuscus Northern pipefish		4			4			4	4								7				3	8	9				
Prionotus carolinus Northern searobin																											
Prionotus evolans Striped searobin																						13					
Myoxocephalus aenaeus Grubby					4																					10	5
M. octodecemspinosus Longhorned sculpin																											4
Morone americana White perch																		4						6	13	14	25
M. saxatilis Striped bass																										4	11
Centropristis striata Black seabass																											
Lepomis macrochirus Bluegill																											
Pomatomus saltatrix Bluefish																											
Trachinotus falcatus Permit									5																		
Stenotomus chrysops Scup																											
Cynoscion regalis Weakfish														6													
Tautoga onitis Tautog									5	4			4	6	3	11	4			11					7	34	54
Tautogolabrus adspersu Cunner				9		3																7				7	5

Table F-33. (continued).

Week beginning:	July					August					September					October				November				December			
Species	29	6	13	20	27	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	7	14	21	28
Peprilus triacanthus Butterfish				9		3	48	9	32															9	75	57	17
Etropus microstomus Smallmouth flounder																									6	37	51
Paralichthys dentatus Summer flounder																											
Paralichthys oblongus Fourspot flounder																											3
Scophthalmus aquosus Windowpane		4																		4		14				7	3
Pleuronectes americanu Winter flounder	3											3		4						5		6	10	17	6	34	25
Trinectes maculatus Hogchoker	66	15	29	8	8	3	27													4			4			4	
Aluterus schoepfi Orange filefish												3															
Total	91	35	48	30	20	9	86	17	64	15	15	12	4	46	13	20	17	8	0	48	20	170	266	73	144	311	393
Unit 1,2,3 fish/hour	0.65	0.22	0.28	0.18	0.11	0.06	0.45	0.12	0.30	0.10	0.11	0.07	0.02	0.18	0.08	0.07	0.08	0.05	0.00	0.26	0.13	0.97	1.09	0.33	0.75	1.88	2.52
Number of species	4	5	5	4	4	3	3	3	7	3	1	3	1	7	3	2	3	2	0	7	3	12	6	6	9	19	19
Fixed screens	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	out	out	out	out	out	out	out	out	out

Table F-34. Mean annual impingement rates (fish/hour) during operational periods for Brayton Point Units 1,2 and 3, 1974-1998.

Year	Units 1,2	Unit 3		Combined[1]	
1998[2]				0.62	
1997[2]				3.47	
1996	0.2	1.8		2.0	
1995[3]	0.7	10.9	(O.O.S.[4] late Feb-late Apr)	11.6	
1994	0.1	8.4		8.5	
1993	0.1	11.5	(O.O.S. April, May)	11.6	
1992	0.2	2.0	(O.O.S. June)	2.2	
1991	0.2	4.9	(O.O.S. May)	5.1	
1990	0.04	3.1	(O.O.S. Apr - late May)	3.14	
1989	0.1	3.8	(O.O.S. mid-Apr - Mid-May)	3.9	
1988	0.3	2.3	(O.O.S. Apr - mid-May)	2.6	
1987	0.1	4.4		4.5	
1986	0.3	5.5	(O.O.S. Jan, Oct-Dec)	5.8	
1985	1.0	4.2	(O.O.S. May, Sept-Dec)	5.2	
1984	0.2	4.0	(O.O.S. Jan)	4.2	
1983				6.3	(Jan-Sept; Unit 3 O.O.S. Oct-Dec)
1982				4.5	
1981				3.0	(Jan-Aug; Unit 3 O.O.S. Sept - mid-Dec)
1980				3.9	(Jan-Mar, June-Dec; Unit 3 O.O.S. Apr-May)
1979				3.2	(Jan, Feb, June-Dec; Unit 3 O.O.S. Mar - mid-June)
1978				8.8	
1977				12.4	
1976				4.0	(Jan-Sept; Unit 3 O.O.S. Oct-Dec)
1975				2.4	(Jan-Sept, Dec; Unit 3 O.O.S. Oct-Nov)
1974				5.2	(Jan-Feb, Jun-Dec; Unit 3 O.O.S. Mar-May)

[1]Data not separated by unit. For 1984-1996 Units 1,2 and Unit 3 values can be added to obtain combined value.

[2]Screens run continuously starting in February 1997.

[3]No sampling early May-late August due to construction of new collection facility.

[4]O.O.S. - Out of service.

Table F-35. Species of fish represented in collections from the Brayton Point revolving screens by year, 1972-1998.

Species		1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Petromyzon marinus	Sea lamprey	x		x	x	x		x																				
Squalus acanthias	Spiny dogfish	x					x														x						x	x
Raja erinacea	Little skate	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
R. ocellata	Winter skate				x																							
Anguilla rostrata	American eel	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Conger oceanicus	Conger eel				x	x	x	x	x			x					x	x	x				x	x			x	x
Alosa aestivalis	Blueback herring	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
A. pseudoharengus	Alewife	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
A. sapidissima	American shad											x	x					x	x								x	x
Brevoortia tyrannus	Atlantic menhaden	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Clupea harengus	Atlantic herring	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Etrumeus teres	Round herring	x		x			x												x									
Dorosoma cepedianum	Gizzard shad																								x			
Anchoa mitchilli	Bay anchovy	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Engraulis eurystole	Silver anchovy								x																			
Notemigonus crysoleucas	Golden shiner					x																						
Esox niger	Chain pickerel																			x								
Osmerus mordax	Rainbow smelt	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Salmo trutta	Brown trout					x																						x
Synodus foetens	Inshore lizardfish	x		x			x	x	x		x	x							x	x					x		x	
Enchelyopus cimbrius	Fourbeard rockling	x	x														x	x	x									
Gadus morhua	Atlantic cod										x																	
Merluccius bilinearis	Silver hake	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Microgadus tomcod	Atlantic tomcod	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pollachius virens	Pollock	x			x			x	x			x	x				x										x	
Urophycis chuss	Red hake	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
U. regia	Spotted hake		x	x	x	x	x			x	x		x		x		x				x	x	x	x	x		x	x
U. tenuis	White hake	x	x	x	x	x	x	x	x	x				x	x													
Ophidion marginatum	Striped cusk-eel				x	x								x		x	x	x			x	x	x	x	x			x
Opsanus tau	Oyster toadfish	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Lophius americanus	Goosefish																							x				
Cyprinodon variegatus	Sheepshead minnow	x		x	x					x									x				x	x				
Fundulus heteroclitus	Mummichog	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
F. majalis	Striped killifish	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Menidia menidia	Atlantic silverside	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Apeltes quadracus	Fourspine stickleback		x					x			x			x	x					x		x						
Gasterosteus aculeatus	Threespine stickleback	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Table F-35. (continued).

Species		1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
G. wheatlandi	Blackspotted stickleback																x	x	x	x	x	x	x	x				
Pungitius pungitius	Ninespine stickleback													x														
Hippocampus erectus	Lined seahorse				x	x															x	x					x	x
Syngnathus fuscus	Northern pipefish	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Dactylopterus volitans	Flying gurnard							x															x		x			
Prionotus carolinus	Northern searobin	x	x	x	x	x	x	x	x	x	x	x	x				x		x		x						x	x
P. evolans	Striped searobin	x	x	x	x	x	x	x	x	x	x	x		x		x	x			x	x	x	x	x	x	x	x	x
Myoxocephalus aenaeus	Grubby	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
M. octodecemspinosus	Longhorn sculpin	x																							x			x
M. scorpius	Shorthorn sculpin	x																										
Cyclopterus lumpus	Lumpfish	x		x	x	x	x	x	x	x	x			x	x	x		x	x	x	x	x	x	x	x	x	x	
Liparis atlanticus	Seasnail		x																									
Morone americana	White perch	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
M. saxatilis	Striped bass	x	x						x							x	x			x	x		x	x	x	x	x	x
Centropristis striata	Black sea bass	x	x	x	x	x	x	x	x	x				x	x		x		x		x				x		x	x
Lepomis macrochirus	Bluegill	x	x	x	x	x	x	x	x	x		x	x	x			x	x	x			x	x	x	x	x	x	x
Micropterus salmoides	Largemouth bass						x	x		x																		
Perca flavescens	Yellow perch							x				x																
Pomoxis nigromaculatus	Black crappie	x			x																							
Pomatomus saltatrix	Bluefish	x		x	x	x	x	x	x	x	x	x		x	x	x	x		x		x	x		x			x	x
Alectis ciliaris	African pompano									x								x		x				x				
Caranx chrysos	Blue runner					x	x	x	x			x					x		x				x					
Caranx hippos	Crevalle jack	x	x	x		x	x	x	x	x		x		x	x		x	x	x		x	x	x	x			x	
Rachycentron canadum	Cobia																		x									
Decapterus macarellus	Mackerel scad		x																									
Selar crumenophthalmus	Bigeye scad			x		x					x																	
Selene setapinnis	Atlantic moonfish		x	x	x	x	x	x				x							x	x	x	x		x	x	x	x	
S. vomer	Lookdown							x	x			x							x	x							x	
Trachinotus falcatur	Permit																											x
Lutjanus grisens	Gray snapper																							x				
Archosargus probatocephalu	Sheepshead	x																										
Stenotomus chrysops	Scup	x		x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x		x	x
Bairdiella chrysoura	Silver perch	x																										
Cynoscion regalis	Weakfish	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x				x	x	x
Leiostomus xanthurus	Spot		x	x																								
Menticirrhus saxatilis	Northern kingfish	x	x	x	x			x	x			x		x								x	x			x	x	
Pogonias cromis	Black drum	x						x																				

Table F-35. (continued).

Species		1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Chaetodipterus faber	Atlantic spadefish						x																					
Chaetodon capistratus	Foureye butterflyfish			x				x																				
C. ocellatus	Spotfin butterflyfish	x		x								x															x	
Mugil spp.	Mullet																								x			
M. cephalus	Striped mullet	x		x	x	x	x	x	x	x		x		x	x							x			x	x		
M. curema	White mullet											x																
Sphyraena borealis	Northern sennet		x																									
Tautoga onitis	Tautog	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tautogolabrus adspersus	Cunner	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Macrozoarces americanus	Ocean pout																										x	
Astroscopus guttatus	Northern stargazer	x																										
Ammodytes sp.	Sand lance					x				x			x		x			x	x									
Gobiosoma ginsburgi	Seaboard goby				x		x	x	x		x								x						x			
Euthynnus alletteratus	Little tunny																						x					
Scomber scombrus	Atlantic mackerel							x																				
Peprilus triacanthus	Butterfish	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Etropus microstomus	Smallmouth flounder			x	x	x	x	x		x		x			x	x	x		x	x	x	x	x	x	x	x	x	x
Paralichthys dentatus	Summer flounder				x							x		x	x		x					x						x
P. oblongus	Fourspot flounder	x		x		x	x		x	x		x				x	x		x			x	x	x			x	x
Scophthalmus aquosus	Windowpane	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pleuronectes americanus	Winter flounder	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Trinectes maculatus	Hogchoker	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Aluterus schoepfi	Orange filefish		x		x		x			x													x	x				x
Monocanthus hispidus	Planehead filefish			x			x	x	x																			
Sphoeroides maculatus	Northern puffer	x	x	x	x	x	x	x	x	x	x	x	x		x	x			x	x	x	x	x	x	x	x	x	
Number of species		55	44	50	51	50	51	55	48	45	38	47	29	39	39	35	44	37	49	39	42	43	44	44	43	34	50	46

Table F-36. Estimated annual impingement of dominant finfish on the Brayton Point Station intake screens, 1972-1998.

Species		1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Brevoortia tyrannus	Atlantic menhaden	237134	11634	11696	1581	843	2418	1571	437	820	34	121	0	79	671
Pleuronectes americanus	Winter flounder	21152	19321	16112	4436	5937	13538	23452	3843	7420	5492	2808	2042	5373	7612
Menidia menidia	Atlantic silverside	42309	2096	3780	643	1267	3091	16864	4955	4046	4457	3354	2529	1769	3896
Trinectes maculatus	Hogchoker	7137	2125	2014	1536	4866	21330	9980	2805	4173	1533	15274	2160	7728	5026
Alosa pseudoharengus	Alewife	2399	1709	2034	1327	4474	34480	2413	1371	752	245	1106	319	5268	2766
Merluccius bilinearis	Silver hake	16976	2645	3223	3471	1218	17927	7930	6458	830	368	2943	1708	1021	483
Gasterosteus aculeatus	Threespine stickleback	12118	12650	3261	1793	1512	773	1043	4828	964	994	422	364	417	1840
Anchoa mitchilli	Bay anchovy	707	223	808	14931	1382	2143	643	4969	758	137	2871	2855	433	702
Morone americana	White perch	3009	2758	1978	1477	4238	4200	1240	764	739	393	755	413	601	44
Alosa aestivalis	Blueback herring	2839	1151	270	486	745	901	493	440	264	55	3582	643	5977	102
Tautoga onitis	Tautog	1469	276	202	341	385	2547	2351	318	643	733	2894	221	584	462
Scophthalmus aquosus	Windowpane	2408	1238	286	220	327	1904	2396	1063	1448	1888	684	70	18	217
Osmerus mordax	Rainbow smelt	1498	2129	2304	121	293	556	3305	571	227	387	251	161	203	1
Peprilus triacanthus	Butterfish	285	269	248	96	14	325	20	82	696	36	134	6	0	581
Cynoscion regalis	Weakfish	802	965	148	289	171	1776	440	253	132	35	1467	21	0	109
Fundulus majalis	Striped killifish	1553	224	84	69	403	1785	200	342	542	442	62	0	242	47
TOTAL ABOVE SPECIES		353795	61413	48448	32817	28075	109694	74341	33499	24454	17229	38728	13512	29713	24559
PERCENT		98%	98%	89%	95%	86%	93%	91%	91%	85%	92%	81%	82%	91%	81%
ALL OTHER SPECIES		5599	1233	5889	1831	4445	8491	7212	3481	4341	1527	9118	2951	3088	5857
GRAND TOTAL		359394	62646	54337	34648	32520	118185	81553	36980	28795	18756	47846	16463	32801	30416

Table F-36. (continued).

Species		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Mean 1972-1997	1998
Brevoortia tyrannus	Atlantic menhaden	106	763	294	290	210	10187	5476	4183	639	9357	3203	3890	11832.2	413
Pleuronectes americanus	Winter flounder	6047	6195	2198	2650	1293	1587	859	4181	2508	3107	1294	2645	6657.8	801
Menidia menidia	Atlantic silverside	3577	7151	9792	8547	3437	7166	3586	51181	21599	23932	1628	2391	9194.0	292
Trinectes maculatus	Hogchoker	4158	2383	916	3622	291	160	56	231	712	124	356	188	3880.2	457
Alosa pseudoharengus	Alewife	3191	2244	880	662	848	5928	1445	3444	8160	6038	3119	4930	3905.8	575
Merluccius bilinearis	Silver hake	443	728	647	4019	142	350	1307	3476	570	308	670	101	3075.5	398
Gasterosteus aculeatus	Threespine stickleback	3986	2813	1526	2406	6852	1431	1250	6389	15790	1146	1587	1149	3434.8	200
Anchoa mitchilli	Bay anchovy	628	881	14	516	292	465	29	991	89	73	33	28	1446.2	40
Morone americana	White perch	80	314	244	1556	668	1030	1953	1110	1940	165	535	826	1270.4	71
Alosa aestivalis	Blueback herring	529	669	2002	842	79	2976	507	139	2408	1295	143	370	1150.3	216
Tautoga onitis	Tautog	676	1782	1226	566	58	104	106	367	691	118	79	982	776.2	360
Scophthalmus aquosus	Windowpane	314	145	34	12	4	8	42	185	138	84	162	182	595.3	66
Osmerus mordax	Rainbow smelt	44	472	280	443	220	360	265	2106	2808	77	358	746	776.4	66
Peprilus triacanthus	Butterfish	4914	57	116	15	219	459	615	58	22	36	191	6286	606.9	259
Cynoscion regalis	Weakfish	179	103	21	4	35	125	49	0	0	0	27	98	278.8	6
Fundulus majalis	Striped killifish	36	2	349	216	52	78	50	140	201	141	8	31	280.7	0
TOTAL ABOVE SPECIES		28908	26702	20334	26366	14700	32414	17595	78181	58275	46001	13393	24843	49153.4	4220
PERCENT		90%	85%	89%	88%	92%	89%	93%	94%	92%	93%	92%	86%	90%	74%
ALL OTHER SPECIES		3166	4835	2470	3501	1257	4106	1387	5005	5314	3207	1112	4106	4020.3	1502
GRAND TOTAL		32074	31537	22804	29867	15957	36520	18982	83186	63589	49208	14505	28949	53173.8	5722

Table F-37. Mean number of winter flounder impinged per hour at Brayton Point Unit 3 by month January-May and mean number per otter trawl tow January-May in Mount Hope Bay, 1973-1998.

	Revolving Screens						Otter Trawl
Year	Jan	Feb	Mar	Apr	May	Mean	Jan-May
1973	[1]	8.50	8.50	2.60	0.20	5.00	76.8
1974	8.02	[1]	[1]	[1]	[1]	[1]	46.8
1975	0.77	1.59	3.26	0.66	0.08	1.27	33.5
1976	0.89	1.29	1.27	0.61	0.03	0.82	11.7
1977	0.52	4.34	6.62	2.15	1.49	3.02	14.4
1978	2.13	2.80	14.48	7.75	1.10	5.65	20.0
1979	0.89	1.33	[1]	[1]	[1]	[1]	117.2
1980	0.69	2.08	8.34	0.53	0.03	2.33	46.8
1981	0.50	0.99	4.49	0.22	0.15	1.27	25.7
1982	0.08	0.73	0.53	0.49	0.14	0.39	27.2
1983	1.97	0.39	[1]	0.40	0.06	0.71	55.5
1984	[1]	1.43	4.12	1.40	0.23	1.80	12.6
1985	0.29	2.74	2.48	[1]	[1]	1.84	15.3
1986	[1]	2.04	4.27	0.64	0.11	1.77	9.3
1987	1.29	5.67	1.22	1.02	0.04	1.85	2.0
1988	0.90	1.52	0.38	[1]	[1]	0.93	1.9
1989	0.83	0.56	0.10	[1]	[1]	0.50	0.5
1990	0.82	0.45	0.87	[1]	[1]	0.71	1.1
1991	0.38	1.55	0.55	0.07	[1]	0.64	0.7
1992	0.10	0.18[2]	0.11[2]	0.03[2]	0.01	0.09	0.2
1993	1.20[2]	2.09[2]	1.85[2]	[1]	[1]	1.71	1.2
1994	1.40[2]	0.81[2]	1.91[2]	0.33[2]	0.08	0.91	0.8
1995	1.47[2]	3.43[2]	[1]	[1]	[3]	2.45	1.2
1996	1.20[2]	0.44[2]	0.02[2]	0.00[2]	0.03	0.34	0.9
1997	0.49[2]	0.59[2]	0.96[2]	0.13[2]	0.00[2]	0.43	1.4
1998	0.47[2]	0.25[2]	0.15	0.03[2]	0.00	0.18	0.7

[1]Unit 3 out of service.
[2]Fixed screens removed.
[3]Sluiceway sampler under construction.
Note: Unit 3 impingement rate calculated for 1973-1983 and 1997, 1998.

C. Beach Seine

Methods

Near-shore finfish populations in Mount Hope Bay were sampled once per month from March through October at the four locations shown in Figure F-41. July's sampling was delayed until early August due to strong winds. Collections were made during the day with two bag seines - one measuring 60 feet (18.3 m) x 6 feet (1.8 m) with 1/8-inch (3-mm) mesh, the other 300 feet (91.4 m) x 8 feet (2.4 m) with 1/2-inch (12.5-mm) mesh. One haul was made with each net at each station at adjacent, non-overlapping areas of the beach. The large net was set by boat in a semicircle as uniformly as wind and tide would allow. The small net was set by walking offshore to a depth of about four feet and then parallel to shore over a measured distance of 50 feet. All fish were identified, counted, and the total length measured to the nearest millimeter for up to 50 individuals per species per haul. Collections and surface water temperatures recorded at each station are summarized in Table F-38.

Results and Discussion

During the March-October 1998 sampling season, 19 species were collected with the 60-ft seine, 18 with the 300-ft net, and 24 were obtained overall. The greatest number of species taken in one month was 13 obtained in August; the least was 3 in April. Atlantic silversides (*Menidia menidia*) clearly dominated numerically within the shore-zone fish community accounting for 82%

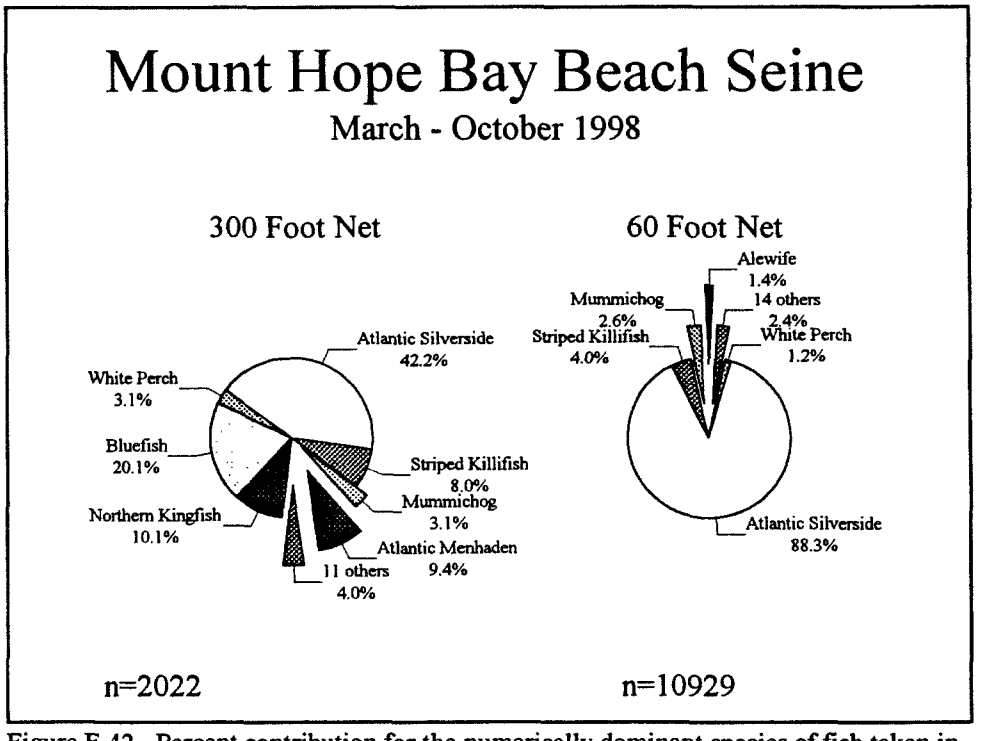


Figure F-42. Percent contribution for the numerically dominant species of fish taken in 300 and 60-ft beach seines in Mount Hope Bay, March - October 1998.

of all fish taken with both nets (Figure F-42). Atlantic silversides were collected in all sampling months, being particularly abundant in August when young-of-the-year reached about 30 mm total length, a size sufficiently large to permit retention by the 1/8-inch mesh of the 60-ft seine. Striped killifish (*Fundulus majalis*) were collected the entire sampling season, while mummichogs (*Fundulus heteroclitus*) were absent in April and September only; both species were most abundant in August. Bluefish (*Pomatomus saltatrix)* were present in June, August, and September, being most abundant in September.

A review of the catch by net indicated that Atlantic silversides were dominant in the 300-ft seine, accounting for 42% of the annual total. Bluefish, northern kingfish, Atlantic menhaden and striped killifish contributed an additional 20, 10, 9 and 8% to the 300-ft total, respectively. The 60-ft seine catch was also dominated by silversides (88%) with striped killifish, and mummichogs contributing 4.0 and 2.6%, respectively (Figure F-42).

Comparison of catches of each dominant species at the four stations showed that adult silversides were most abundant in the 300-ft seine at the Cole River in April. In August when young-of-the-year silversides dominated the catch in the 60-ft net, the Lee River ranked above the other stations (Figure F-43). Striped killifish and mummichogs were most numerous in August at the Intake. In September, bluefish were most common in the 300-ft seine at Spar Island and the Lee River.

Tables F-39 and F-40 summarize beach seine collections from 1972 through 1998. To make these data sets as comparable as possible, only daytime hauls were included from past years (1973-1980) when companion collections were made at night. For the 60-ft seine, data collected from May through October were used since relatively few fish were taken during March and April. For the 300-ft seine, data from June through August were summarized since the large net was consistently used in earlier years during those months. Table F-41 also shows the 300-ft catch per haul over the March-October period from 1981-1998 since it was used monthly at each station during those years.

These summaries indicate that Atlantic silversides have clearly and consistently been a dominant member of the nearshore fish community in Mount Hope Bay from 1972 through 1998. The 60-ft seine catch per haul ranged from 57 in 1979 to 1409 in 1993, reflecting primarily young-of-the-year (Table F-39, Figure F-44). The 1998 mean of 396 fish per haul with the 60-ft net amounted to 71% of the 1972-1997 mean of 557 fish per haul. A significant upward trend remains apparent for silversides over the 1972-1998 time series (sign test $p<0.02$, Figure F-44). The mean number of silversides collected in the large seine June-August (16 fish per haul) representing both one-year-old spawning stock and larger young-of-the-year, was 40% of the June-August 1972-1997 mean of 40 fish per haul (Table F-40, Figure F-44). The March-October 1998 mean of 27 fish equaled the 1981-1997 mean (Table F-41). No trend is apparent for silversides in the large seine for the June-August period (sign test at $p = 0.05$), while the March-October data set shows an upward trend (sign test at $p < 0.001$). Since these collections reflect members of two year classes (adult and young-of-the-year), greater variability is not surprising.

Striped killifish were caught in below-average numbers in the 60-ft net. The 1998 catch rate of 13 killifish per haul amounted to 48% of the 1972-1997 mean of 28 per haul. Catches in the 300-ft net were above average; the 1998 rate of 8 was 1.2 times the June-August mean of 7 and March-October value equaled its 1981-1997 mean of 5 fish per haul.

The mummichog mean catch of 10 per haul in the 60-ft seine was 35% of the 1972-1997 mean of 30 per haul. Catches in the 300-ft seine were above average with the June-August rate (5 per haul) being 1.3 times the 1972-1997 mean of 4 fish per haul and the March-October mean (2 per haul) being 1.7 times the 1981-1997 mean (1.1 per haul; Tables F-39 to F-41, Figure F-44).

Bluefish were sampled in below-average numbers in the 1997 300-ft seine June-August sampling period with a mean of 3 per haul which was 13% of the 27 year mean of 24 per haul. The 1998 March-October mean of 13 fish per haul was slightly higher than the 16 year mean of 11(Tables F-40 and F-41, Figure F-44).

Dominance diversity indices as described under trawl and screen studies (Whitaker 1965, Gibson 1996) were calculated for both the 300-ft and 60-ft beach seines. Gibson (1996) reported that weak rarefaction occurred in the Mount Hope Bay 60-ft seine through 1994 when only the top seven numerically dominant species were included. These seven were silversides, bluefish, river herring, striped killifish, mummichog, and winter flounder. For both seines from 1972-1998, diversity indices showed little evidence of a downward trend over time (Figure F-45). In fact the inclusion of 1998 values as in 1997 further decreased the overall slope from -0.002 to -0.001 for the large net and from -0.004 to -0.002 for the small net. However, including all species suggests that the near-shore fish community has not shown a shift toward dominance by fewer species.

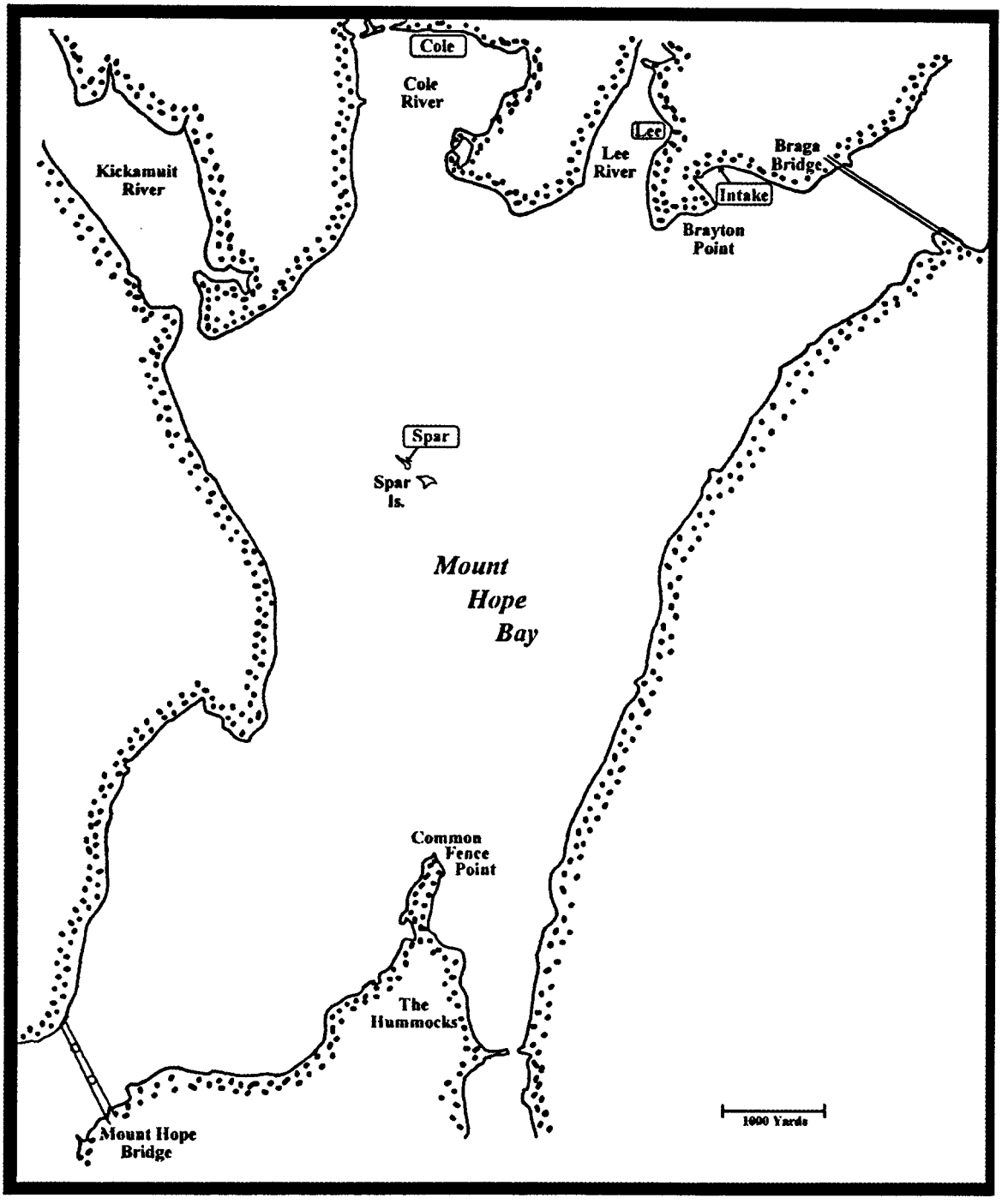
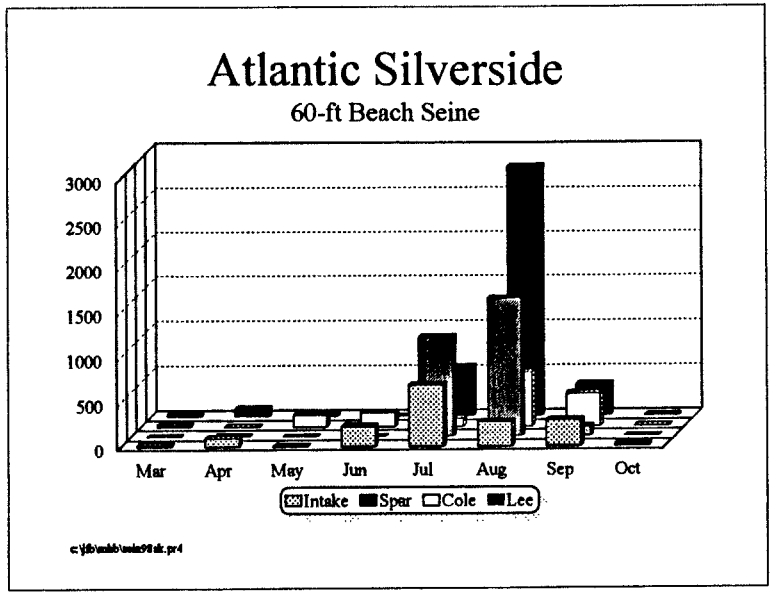
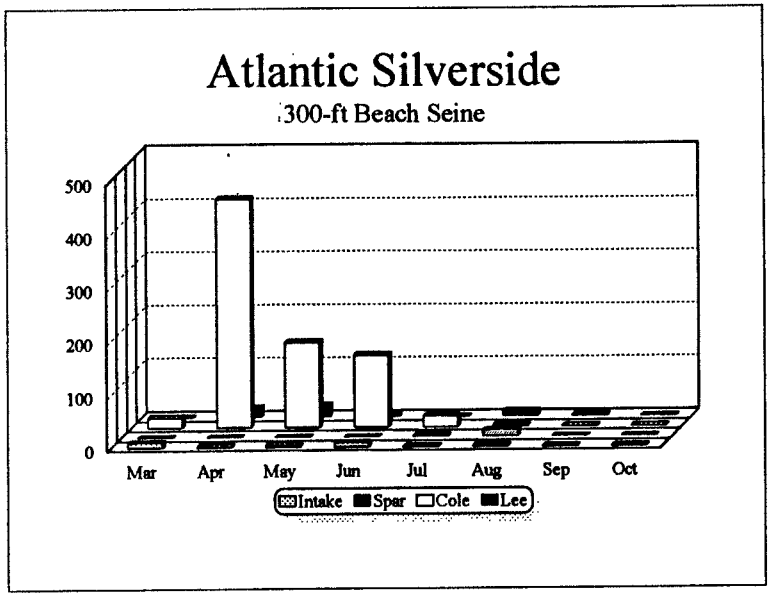
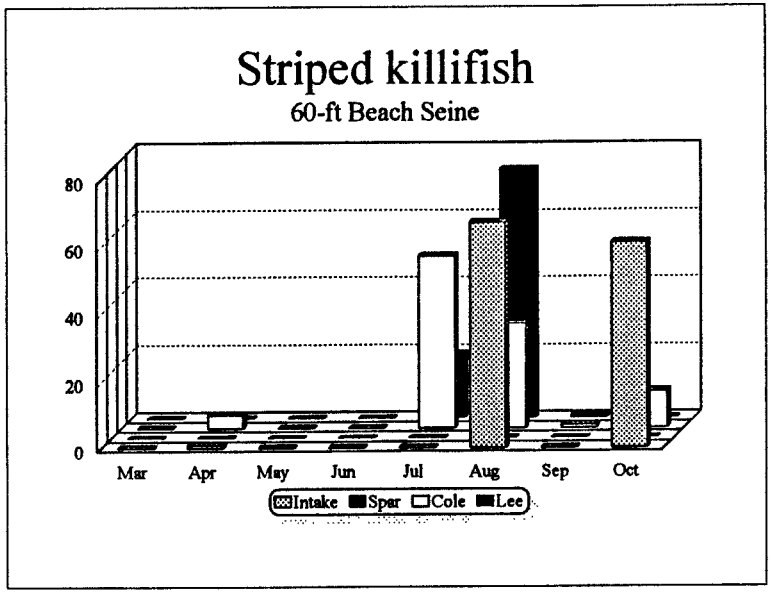


Figure F-41. Location of beach seine sites.







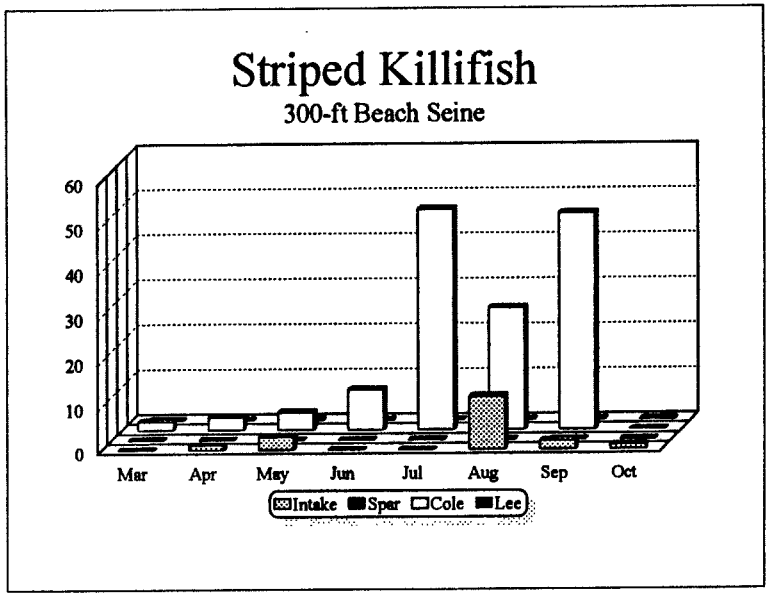
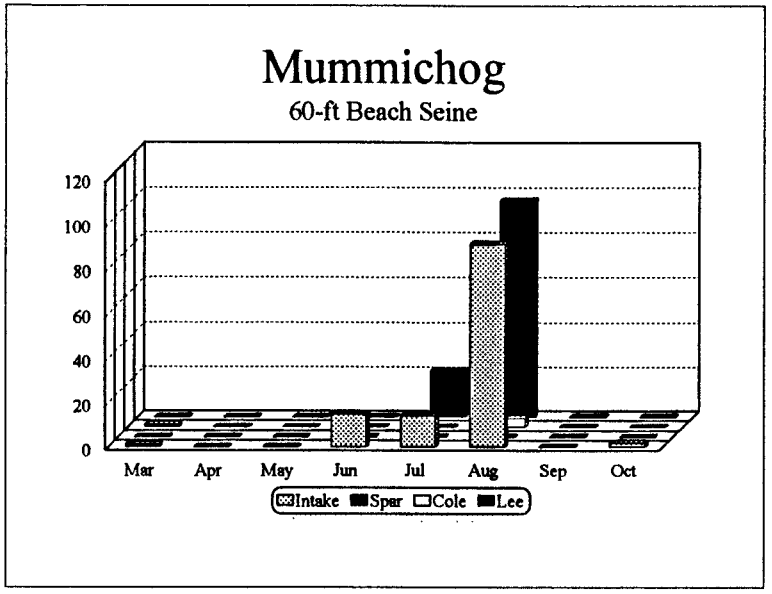


Figure F-43. Numbers of Atlantic silverside, striped killifish, mummichog, and bluefish collected by beach seine by month by station in Mount Hope Bay, 1998.



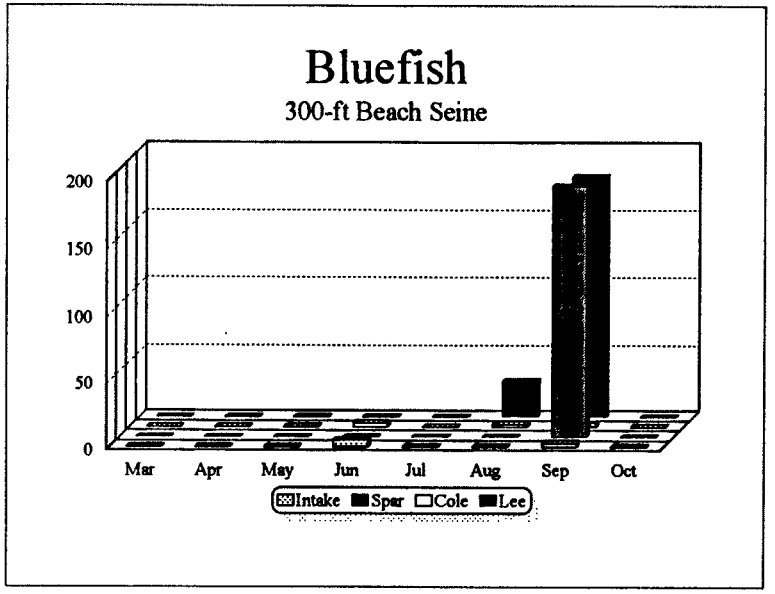
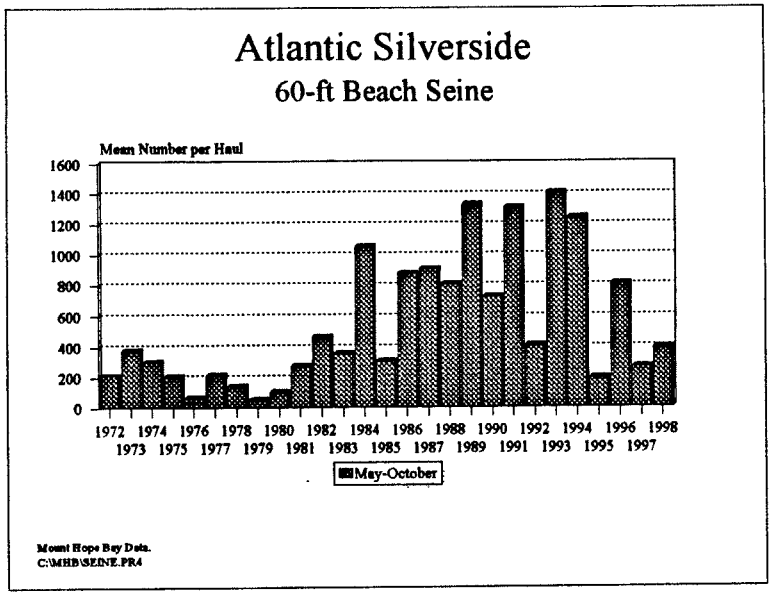
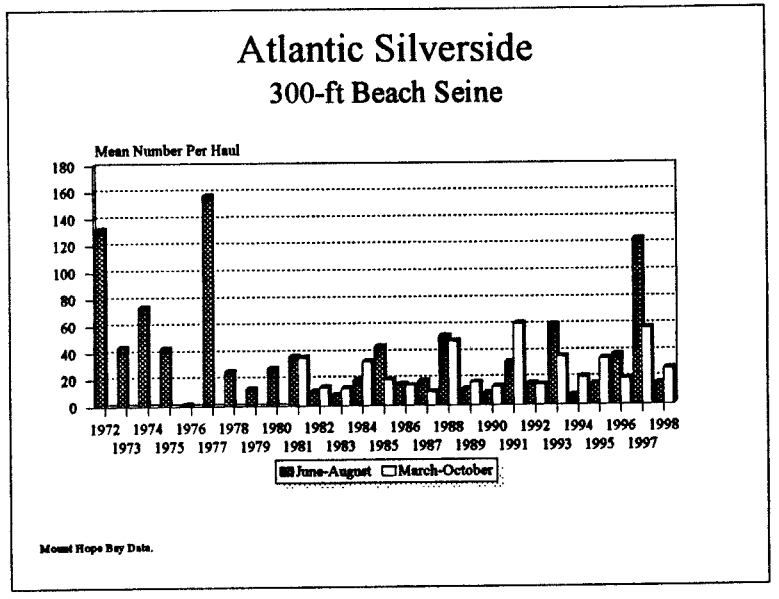
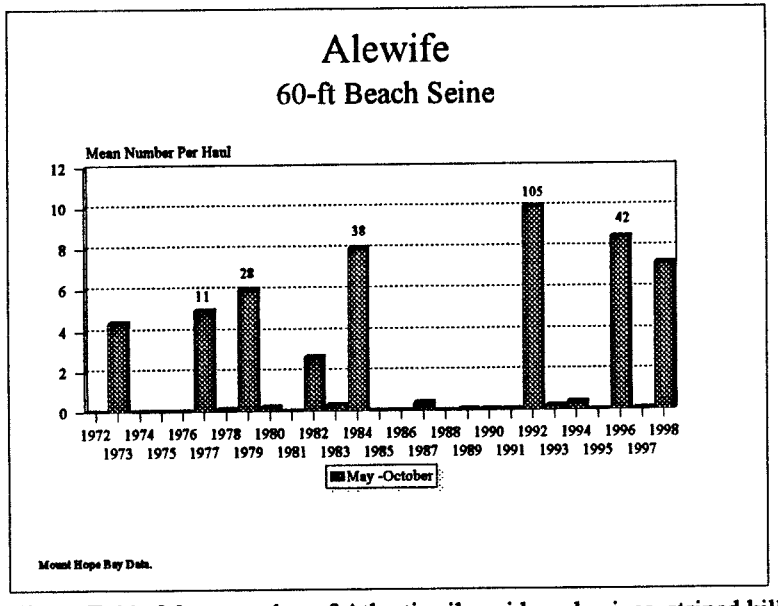


Figure F-43. (continued).







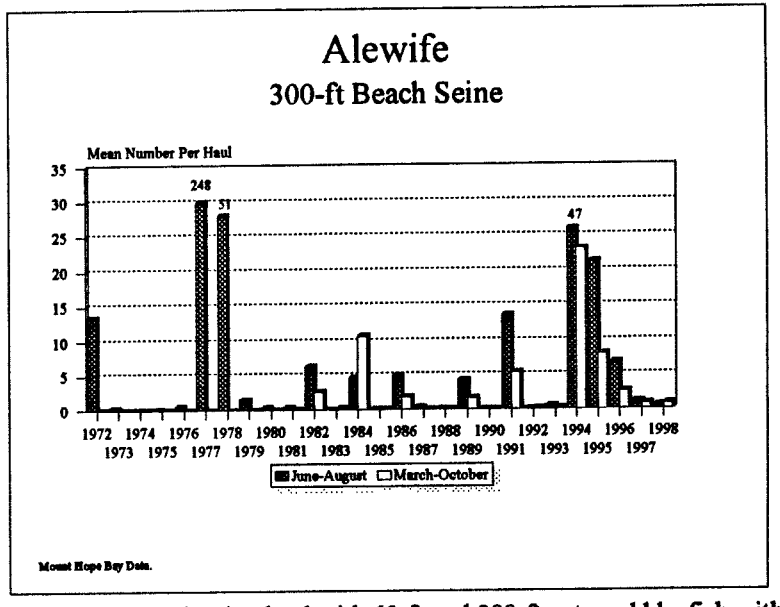
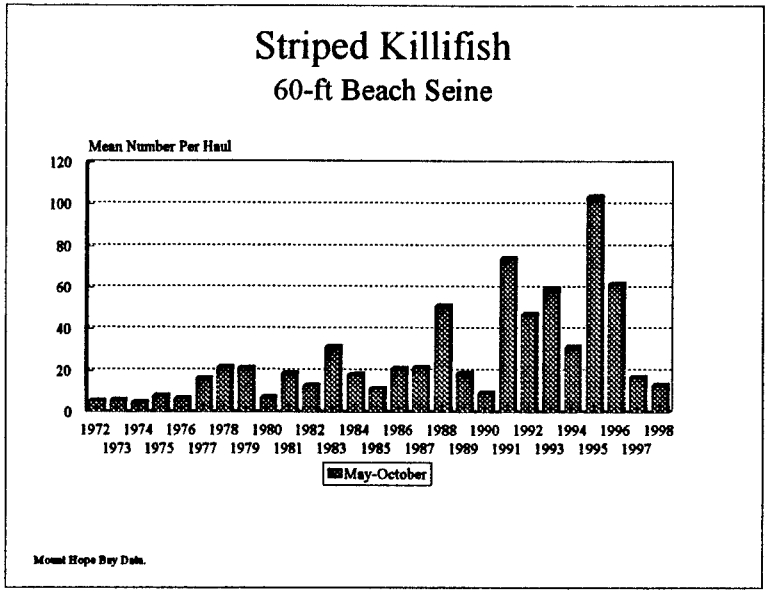
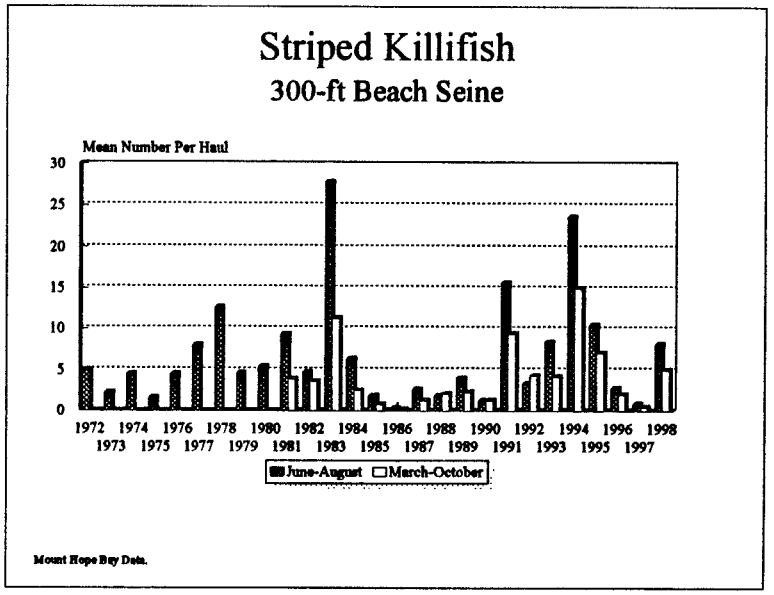
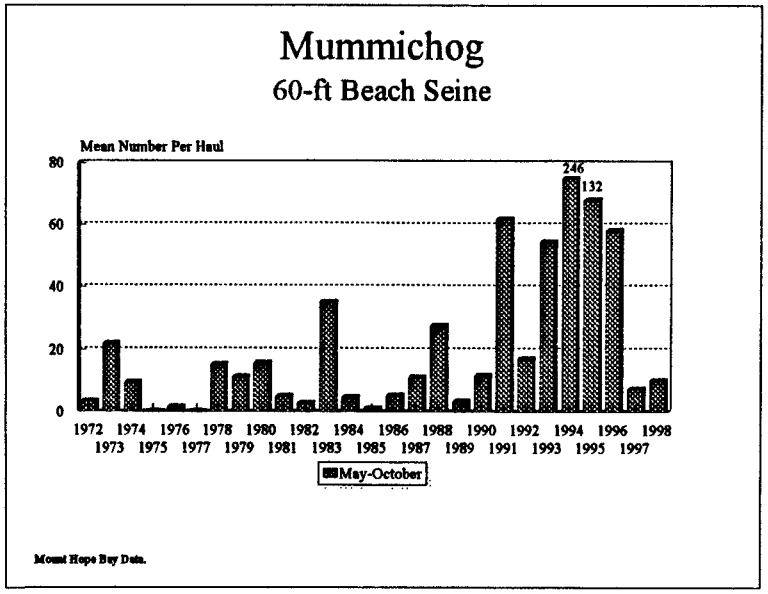


Figure F-44. Mean number of Atlantic silversides, alewives, striped killifish, and mummichogs per beach seine haul with 60-ft and 300-ft nets and bluefish with 300-ft net, 1972-1998.







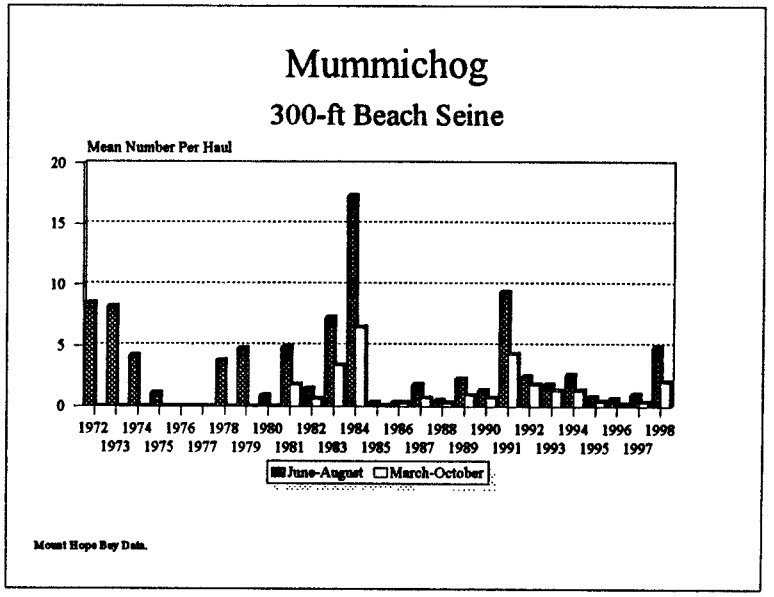


Figure F-44. (continued).

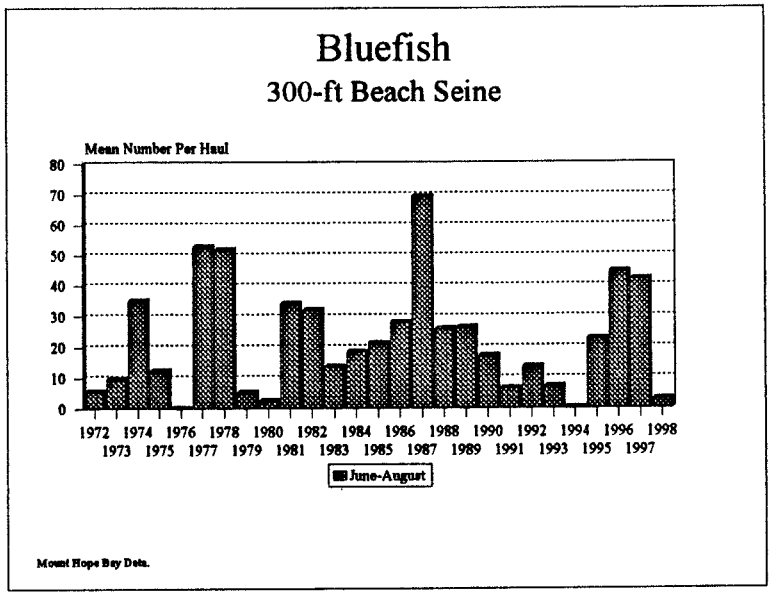
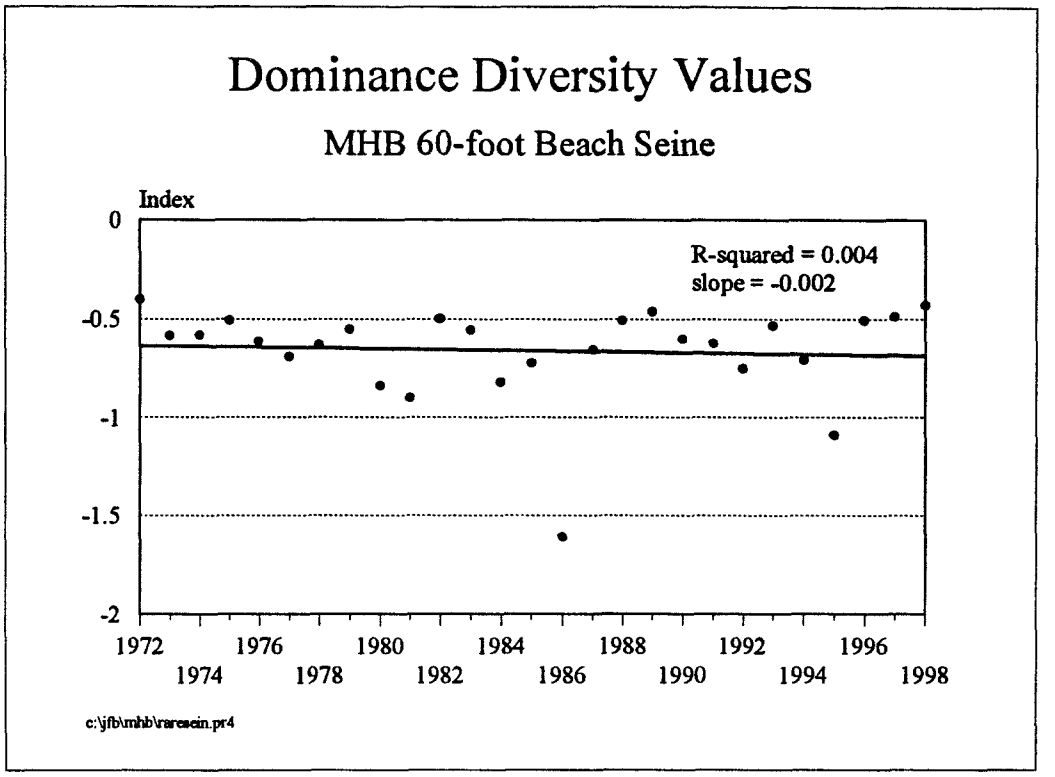


Figure F-44. (continued).



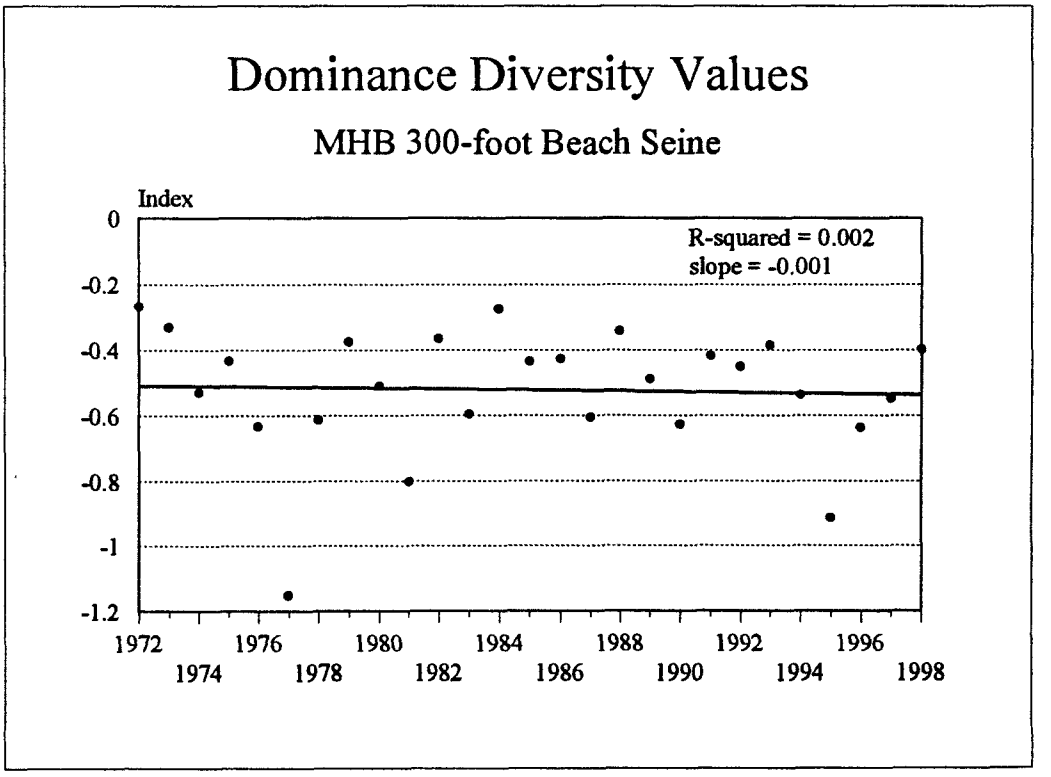


Figure F-45. Dominance diversity values for Mount Hope Bay beach seine 60-ft and 300-ft nets, 1972-1997.

Table F-38. Species and numbers of finfish collected by 300-ft and 60-ft (300/60) beach seines on a monthly basis at four stations in Mount Hope Bay, March-October 1998.

	March 30, 1998				
Station:	Intake	Spar	Cole	Lee	Total
Temp. °C:	9.1	10.1	14.0	12.0	
Microgadus tomcod Atlantic tomcod		0/1			0/1
Fundulus heteroclitus Mummichog	0/1		0/1		0/2
F. majalis Striped killifish			2/0		2/0
Menidia menidia Atlantic silverside	9/16		18/19	0/25	27/60
Pleuronectes americanus Winter flounder	1/1				1/1

	April 29, 1998				
Station:	Intake	Spar	Cole	Lee	Total
Temp. °C:	13.5	11.5	13.0	12.0	
Microgadus tomcod Atlantic tomcod				0/1	0/1
F. majalis Striped killifish	1/1		3/4		4/5
Menidia menidia Atlantic silverside	1/93	0/2	429/0	18/92	448/187

Table F-38 (continued).

	May 27, 1998				
Station:	Intake	Spar[1]	Cole	Lee	Total
Temp. °C:	23.5	19.0	22.5	22.5	
Alosa aestivalis Blueback herring			15/3		15/3
Microgadus tomcod Atlantic tomcod	0/1				0/1
Fundulus heteroclitus Mummichog	4/0				4/0
F. majalis Striped killifish	3/0		4/0		7/0
Menidia menidia Atlantic silverside	4/5		158/128	21/20	183/153
Tautoga onitis Tautog	1/0				1/0
Tautogolabrus adspersus Cunner				1/0	1/0
Gobiosoma ginsburgi Seaboard goby			0/1		0/1

[1]Very high tide - no fish taken.

Table F-38 (continued).

	June 26, 1998				
Station:	Intake	Spar	Cole	Lee	Total
Temp. °C:	24.8	22.3	23.3	24.0	
Alosa pseudoharengus Alewife	1/43		1/110	0/13	2/166
Fundulus heteroclitus Mummichog	5/15				5/15
F. majalis Striped killifish			9/0		9/0
Menidia menidia Atlantic silverside	8/227		134/155	3/0	145/382
Gasterosteus aculeatus Threespine stickleback			0/96	0/1	0/97
Syngnathus fuscus Northern pipefish			1/1		1/1
Morone saxatilis Striped bass		1/0			1/0
Lepomis macrochirus Bluegill	0/1				0/1
Pomatomus saltatrix Bluefish	5/0		3/0		8/0
Scophthalmus aquosus Windowpane			1/5		1/5
Pleuronectes americanus Winter flounder	0/1		3/8		3/9
Trinectes maculatus Hogchoker			1/0		1/0

Table F-38 (continued).

	August 5, 1998 (for July)				
Station:	Intake	Spar	Cole	Lee	Total
Temp. °C:	24.6	25.5	25.4	26.4	
Alosa pseudoharengus Alewife	0/6				0/6
Brevoortia tyrannus Atlantic menhaden				190/0	190/0
Fundulus heteroclitus Mummichog	8/14		33/0	3/21	44/35
F. majalis Striped killifish			49/51	0/19	49/70
Menidia menidia Atlantic silverside	0/684	2/1106	20/89	0/545	22/2424
Gasterosteus aculeatus Threespine stickleback				0/1	0/1
Syngnathus fuscus Northern pipefish			2/0	0/3	2/3
Morone americana White perch	1/0				1/0
Caranx spp. Jack	2/0		0/1		2/1
Morone menticirrhus Northern kingfish	72/42		113/27	14/0	199/69
Tautoga onitis Tautog	11/4	1/1			12/5
Pleuronectes americanus Winter flounder			2/0		2/0

Table F-38 (continued).

	August 21, 1998				
Station:	Intake	Spar	Cole	Lee	Total
Temp. °C:	25.5	24.0	24.5	27.0	
Alosa aestivalis Blueback herring	0/2				0/2
Alosa pseudoharengus Alewife				4/0	4/0
Microgadus tomcod Atlantic tomcod	0/1				0/1
Opsanus tau Oyster toadfish	0/1				0/1
Cyprinodon variegatus Sheepshead minnow				0/1	0/1
Fundulus heteroclitus Mummichog	10/91		0/4	0/97	10/192
F. majalis Striped killifish	12/67		27/31	0/74	39/172
Menidia menidia Atlantic silverside	2/273	12/1536	3/597	9/2803	26/5209
Morone americana White perch	61/146				61/146
Pomatomus saltatrix Bluefish			2/1	27/0	29/1
Menticirrhus saxatilis Northern kingfish	1/2			5/0	6/2
Tautoga onitis Tautog	6/8	2/0			8/8
Pleuronectes americanus Winter flounder			3/0		3/0

Table F-38 (continued).

	September 24, 1998				
Station:	Intake	Spar	Cole	Lee	Total
Temp. °C:	23.8	19.5	23.5	21.0	
Alosa aestivalis Blueback herring		1/0			1/0
F. majalis Striped killifish	2/0		48/1	0/1	50/2
Menidia menidia Atlantic silverside	0/294	0/105	0/363	2/352	2/1114
Pomatomus saltatrix Bluefish	3/2	187/65	1/0	179/8	370/75
Caranx hippos Crevalle jack				19/0	19/0
Tautoga onitis Tautog	0/2				0/2

	October 27, 1998				
Station:	Intake	Spar	Cole	Lee	Total
Temp. °C:	16.3	13.3	13.5	13.5	
Alosa pseudoharengus Alewife	1/0				1/0
Cyprinodon variegatus Sheepshead minnow	0/1				0/1
Fundulus heteroclitus Mummichog	0/2				0/2
F. majalis Striped killifish	1/61		0/11		1/72
Menidia menidia Atlantic silverside	0/18		0/1	0/2	0/21

Table F-39. Species and number of finfish per haul collected by 60-ft seine at four stations in Mount Hope Bay, May-October, 1972-1998.

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Albula vulpes																						P					
Bonefish																											
Anguilla rostrata	0.1		0.1	0.1	0.2	0.1	0.2	0.1			P									P							
American eel																											
Alosa aestivalis											6.0					P		0.4				2.4					0.2
Blueback herring																											
A. pseudoharengus		4.4				11.1	0.1	27.8	0.2		2.7	0.3	38.4			0.4		P	P	P	105.2	0.2	0.4			0.1	7.2
Alewife																											
Brevoortia tyrannus	0.1	0.2		0.1		0.1			31.9		P			P				0.1		0.1	P				P		
Atlantic menhaden																											
Clupea harengus				0.1										1.3													
Atlantic herring																											
Anchoa mitchilli		0.2	1.7					4.2				P	1.5														
Bay anchovy																											
Anchoa spp.	19.7																										
Anchovy																											
Unidentified clupeiforms			15.0																								P
Opsanus tao																											
Oyster toadfish																											
Microgadus tomcod	0.4	0.5		0.1	0.1	0.1	1.9		1.6	P	0.2	0.1		0.5	0.2	3.7	0.1	P	P		1.2	0.8	1.0	P	0.3	1.0	0.1
Atlantic tomcod																											
Urophycis regia					0.1																						
Spotted hake																											
Strongylura marina				0.2		0.2				P															0.1		
Atlantic needlefish																											
Cyprinodon variegatus	0.3								0.1								0.2	P	P	0.3		8.2		3.0		0.2	0.1
Sheepshead minnow																											
Fundulus heteroclitus	3.5	21.9	9.4	0.2	1.5	0.1	15.3	11.4	15.8	5.0	2.9	35.2	4.8	1.2	5.3	11.2	27.6	3.5	11.8	61.7	17.3	54.5	246.0	131.5	58.3	7.5	10.2
Mummichog																											
F. majalis	5.6	5.8	4.8	8.1	6.8	16.4	21.8	21.6	7.3	18.9	13.0	31.3	18.4	11.6	21.0	21.9	51.5	19.1	9.5	74.5	47.4	59.8	31.4	104.0	62.2	17.2	13.2
Striped killifish																											
Fundulus spp.	2.3		0.8	2.8																							
Killifishes																	4.3	P				P		0.3	0.1		
Lucania parva																											
Rainwater killifish											P	0.4				0.5	P					0.1			0.1		
Menidia beryllina																											
Inland silverside																											
M. menidia	215.4	379.1	303.3	211.4	69.3	216.7	143.7	57.1	107.2	276.0	468.9	361.8	1051.9	314.8	880.0	908.5	809.4	1330.8	729.5	1308.8	412.1	1408.8	1245.5	194.7	811.6	266.6	396.0
Atlantic silverside																											
Apeltes quadracus						0.1	0.2		0.1		P	0.2	0.2		0.1	P		P	0.1				P	P	0.1	0.1	
Fourspine stickleback																											
Gasterosteus aculeatus								0.6		P				0.3			0.1	1.8	P		0.1	0.3			0.1	0.1	4.1
Threespine stickleback																											
G. wheatlandi																		P									
Blackspotted stickleback																											
Pungitius pungitius																	P	P	P		P						
Ninespine stickleback																											
Syngnathus fuscus	0.4	0.1	0.6	0.3	0.4		0.3	0.3			0.2	0.3	0.4	0.1	P	0.2	0.1	P		0.1	P	0.8	0.2	0.4	0.2	0.1	0.2
Northern pipefish																											
Prionotus carolinus																										0.1	
Northern searobin																											
Myxocephalus aenaeus																									P		
Grubby																											
Morone americana	2.1	0.1		0.1	0.9		0.1																				6.1
White perch																											
Lepomis macrochirus								0.1																			P
Bluegill																											
Pomatomus saltatrix	0.1	0.2	0.4	0.7	0.1	0.1	0.1	0.4	0.1	0.7	0.7	0.1	0.3	0.3	0.1	0.5	0.4	0.3	1.1	0.2	P		0.2		1.6	0.2	3.2
Bluefish																											
Caranx hippos	0.1	0.2									P		0.1				0.8	P					1.4				

Table F-39. (continued).

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Crevalle jack																											
Caranx spp.																										0.1	P
Jacks																											
Selar crumenophthalmus			0.1																								
Bigeye scad																											
Selene vomer													P														
Lookdown																											
Trachinotus falcatus	P					0.1											0.3										
Permit																											
Stenotomus chrysops								0.1											P	P							
Scup																											
Cynoscion regalis	P		0.4																							0.3	
Weakfish																											
Leiostomus xanthurus																	0.1										
Spot																											
Menticirrhus saxatilis	0.9	0.2	0.1	1.1			0.1		0.2	P	P	P				P				P	0.4	P	0.2		0.9	0.1	3.0
Northern kingfish																											
Mugil cephalus		0.7											0.2														
Striped mullet																											
M. curema												P					0.5	P	2.9						P		
White mullet																											
Tautoga onitis	0.9		0.1	0.8	0.3	1.0	0.7	0.4			0.2	0.3	P	P		0.1	P				0.5	1.0	0.1			0.3	0.9
Tautog																											
Tautogolabrus adspersus	P										P						P		P	0.6	P	0.9	0.1	P	0.2		
Cunner																											
Ammodytes sp.								0.1								P											
Sand lance																											
Gobiosoma ginsburgi												P								P		0.3	P				P
Seaboard goby																											
Scophthalmus aquosus																											0.2
Windowpane																											
Pleuronectes americanus	P		0.4		0.1		0.1	0.1	0.1			P		0.3		P			0.2	0.1	4.3	0.4	P	0.3	P		0.4
Winter flounder																											
Sphoeroides maculatus								0.1												P							
Northern puffer																											
Number of species	19	13	14	14	11	12	13	15	11	8	16	15	12	11	7	14	17	17	14	15	14	17	14	10	17	15	20

P = Species present but < 0.05 fish per haul.

Table F-40. Species and number of finfish per haul collected by 300-ft seine at four stations in Mount Hope Bay, June-August, 1972-1998.

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Anguilla rostrata American eel	2.0	0.2	0.3	0.4	0.3			0.2	0.1	0.1	0.2		2.0														
Alosa aestivalis Blueback herring	0.4										0.2		2.0		0.4	0.3	0.1	4.3	0.1	13.6	0.1						
A. pseudoharengus Alewife	0.9	0.2		0.1	0.5	247.5	50.6	1.5	0.3	0.3	6.3		4.6	0.1	4.9	0.3	0.2	4.3	0.1	13.6	0.1	0.5	46.5	21.3	6.9	1.1	0.5
Alosa spp. Herring	12.5	0.1			20.8	0.6	1.7																				
Brevoortia tyrannus Atlantic menhaden	0.1	0.1			20.8	0.6	1.7							2.6	0.1		0.3	0.1		462.4	0.1						15.8
Clupea harengus Atlantic herring		0.1					0.8																				
Anchoa mitchilli Bay anchovy		1.5	4.2		1.0					3.8		0.3	1.3	1.3							0.2						
Unidentified clupeiforms	0.5		0.3																								
Osmerus mordax Rainbow smelt	0.1									0.1																	
Synodus foetens Inshore lizardfish	P		0.1	0.1				0.1																			
Opsanus tau Oyster toadfish	0.1			0.1				0.1							0.1				0.1		0.2						
Microgadus tomcod Atlantic tomcod	0.3		1.0					0.3	0.8	0.3	1.8	0.3	2.0	0.5	0.1		0.8		0.1		0.2	1.5	0.1				
Hyporhamphus unifasciatus Halfbeak																											
Cyprinodon variegatus Sheepshead minnow	P																										
Fundulus heteroclitus Mummichog	8.5	8.2	4.2	1.1			3.8	4.8	0.9	4.9	1.5	7.3	17.3	0.3	0.3	1.8	0.5	2.3	1.3	9.4	2.5	1.8	2.6	0.8	0.6	1.0	4.9
F. majalis Striped killifish	5.0	2.2	4.5	1.6	4.5	8.0	12.6	4.6	5.4	9.3	4.7	27.8	6.3	1.8	0.3	2.6	1.8	4.0	1.3	15.6	3.3	8.4	23.6	10.5	2.8	0.9	8.1
Fundulus spp. Killifishes	2.4																										
Menidia beryllina Inland silverside																	0.1										
M. menidia Atlantic silverside	131.8	43.9	73.6	43.1	0.8	156.8	25.6	13.3	27.9	37.2	11.4	7.9	19.3	43.8	15.9	17.9	52.4	12.2	9.1	31.9	15.4	59.6	7.3	15.3	37.7	123.3	16.1
Apeltes quadracus Fourspine stickleback	P																										
Gasterosteus aculatus Threespine stickleback																						0.7					
Pungitius pungitius Ninespine stickleback																	0.1			0.2							
Syngnathus fuscus Northern pipefish	0.3	0.1	P	0.3			0.5		0.3		0.2	0.1	0.5		0.2	0.1	0.3	0.3		0.2		0.9	0.1			0.1	0.3
Prionotus evolans Striped searobin																				0.3	0.1						
Morone americana White perch	1.4	0.2	0.2		3.3						0.1		0.3														5.2
M. saxatilis Striped bass				0.1															0.1	0.3		0.4		0.2	0.9	0.3	0.1

Table F-40. (continued).

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Lepomis macrochirus Bluegill														0.2													
Pomatomus saltatrix Bluefish	5.5	9.5	34.9	12.3		52.8	51.9	5.3	2.5	34.2	32.0	13.7	18.5	21.3	28.1	69.4	25.8	26.3	17.1	6.6	13.6	7.2	0.2	22.7	44.7	42.3	3.1
Caranx crysos Blue runner																	0.1										
C. hippos Crevalle jack	1.3	0.8											0.3			8.4	0.2			0.1			1.8				
Caranx spp. Jacks																										0.1	0.2
Trachinotus falcatus Permit																	0.5	0.1									
Lutjanus griseus Gray snapper																							0.1				
Stenotomus chrysops Scup					26.3			5.8	0.9		2.1			0.6						38.1		0.1					
Cynoscion regalis Weakfish	2.1	0.3																									
Menticirrhus saxatilis Northern kingfish	9.8	1.5	0.1	0.2							0.2									1.0	0.8	0.1	0.1		3.3	0.4	17.1
Mugil cephalus Striped mullet	P	0.4																		0.4		2.3					
M. curema White mullet																		2.6									
Mugil spp. Mullets																											
Tautoga onitis Tautog	1.0	0.3	0.6	1.3		2.0	0.8	4.0	1.8	0.1	0.7	1.5	2.3	1.2	1.6	2.7	1.5	0.3		0.2	0.3	0.3	0.2	0.2	0.3	0.1	1.7
Tautogolabrus adspersus Cunner	P							0.1				0.2							0.5	0.2		0.1	0.1		0.3		
Scomber scombrus Atlantic mackerel								1.0					1.3														
Peprilus triacanthus Butterfish																										0.1	
Scophthalmus aquosus Windowpane	P			0.1				0.3	0.1		0.4	0.1	0.4		0.1			0.1							0.1		0.1
Pleuronectes americanus Winter flounder	2.2	0.5	0.4	0.3			0.1	0.1			0.3	1.7	1.9	1.8	1.3	0.6	0.8	1.8	1.1	3.4	38.5	1.8	0.6	0.1	0.1	0.6	0.7
Trinectes maculatus Hogchoker	P							0.4			0.2	0.3		0.3	0.2	0.2											0.1
Sphoeroides maculatus Northern puffer	0.1																0.1			0.8	0.3	0.1					
Number of species	29	18	14	14	9	7	11	16	11	10	16	12	16	13	14	11	17	13	11	19	15	16	13	7	11	12	15

P = Species present but <0.05 fish per haul.

Table F-41. Species and number of finfish per haul collected by 300-ft beach seine at four stations in Mount Hope Bay, March-October, 1981-1998.

	1981	1982	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Anguilla rostrata American eel	0.1		P		P												
Alosa aestivalis Blueback herring		0.1			0.9	0.1	P			0.1			0.5	0.1	P	0.1	0.5
A. pseudoharengus Alewife	0.1	2.6	0.2	P	1.8	0.1	0.1	1.6	P	5.4	0.1	0.2	23.1	8.1	2.6	0.8	0.2
Brevoortia tyrannus Atlantic menhaden				0.1	0.1		0.2	P		203.7	0.1		0.5			P	5.9
Clupea harengus Atlantic herring				0.3	0.2		0.7	0.1									
Anchoa mitchilli Bay anchovy	1.4	0.1	0.1	0.5													
Osmerus mordax Rainbow smelt	P			P			0.1					P				P	
Microgadus tomcod Atlantic tomcod	0.3	0.7	0.1	0.3	5.1	P	0.4	5.3	P	P	3.4	0.8	8.2		P	0.1	
Pollachius virens Pollock		0.1					P										
Urophycis regia Spotted hake			0.1														
Hyporhamphus unifasciatus Halfbeak					P												
Opsanus tau Oyster toadfish	0.1				P												
Strongylura marina Atlantic needlefish	0.2								0.2				P				
Cyprinodon variegatus Sheepshead minnow								0.1				0.1					
Fundulus heteroclitus Mummichog	1.8	0.6	3.4	0.1	0.3	0.7	0.3	0.9	0.7	4.3	1.8	1.3	1.3	0.4	0.2	0.4	2.0
F. majalis Striped killifish	3.9	3.6	11.3	0.8	0.2	1.3	2.1	2.3	1.3	9.4	4.3	4.2	15.0	7	2	0.5	5.0
Menidia beryllina Inland silverside				P	P		P										
M. menidia Atlantic silverside	36.1	14.2	12.7	18.5	15.2	9.7	48.0	16.7	14.4	60.2	14.3	35.8	20.7	34.4	19.2	60.5	26.7
Apeltes quadracus Fourspine stickleback				P													
Gasterosteus aculatus Threespine stickleback												0.3			P	P	
Pungitius pungitius Ninespine stickleback							P										
Syngnathus fuscus Northern pipefish		0.1	P		0.2	0.1	0.2	0.3	0.0	0.1	0.0	0.4	0.2		P	P	0.1
Morone americana White perch		P					P	P									1.9

Table F-41. (contined).

	1981	1982	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
M. saxatilis Striped bass						0.2		P	P	0.1		0.2		0.1	0.3	0.1	P
Lepomis macrochirus Bluegill						P											
Pomatomus saltatrix Bluefish	13.6	15.4	5.9	10.4	12.8	27.4	10.4	10.0	6.4	13.5	6.1	2.8	6.2	8.8	16.8	10.6	12.7
Caranx hippos Crevalle jack		0.1					3.4	0.1		1.8			2.2				0.6
C. latus Horse-eye jack							P										
Caranx spp. Jacks																0.5	0.1
Trachinotus falcatus Permit							0.4	P									
Lutjanus gresius Gray snapper													P				
Stenotomus chrysops Scup		0.8		0.2						14.8	0.0	P					
Menticirrhus saxatilis Northern kingfish		0.9	P							0.4	0.4	P	P		1.2	0.1	6.4
Mugil cephalus Striped mullet			0.3		P							0.9					
M. curema White mullet			0.2				1.5										
Mugil spp. Mullet										0.2						0.3	
Tautoga onitis Tautog	0.1	0.3	0.8	1.0	0.6	1.5	0.8	0.3	P	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.7
Tautogolabrus adspersus Cunner			0.1						0.2	0.1			P		0.1		P
Scomber scombrus Atlantic mackerel			0.5														
Peprilus triacanthus Butterfish			P													P	
Scophthalmus aquosus Windowpane	P	0.2	0.1	0.2	P	P	0.1	P							P		P
Pleuronectes americanus Winter flounder	P	0.2	3.8	1.7	0.5	0.3	0.9	0.8	0.4	1.3	17.1	1.3	0.5	P	0.1	0.2	0.3
Trinectes maculatus Hogchoker		0.1	0.2		0.1	0.1						P					P
Sphoeroides maculatus Northern puffer	P						P			0.4	0.1						
Number of species	16	19	21	17	20	15	24	18	13	19	14	18	17	9	16	19	19

P = Species present but < 0.05 fish per haul.

D. Young-of-the-Year Winter Flounder Survey

Since 1972, four locations have been sampled by beach seine to monitor near-shore finfish species diversity and abundance (see Section C). Small numbers of young winter flounder were occasionally taken at those four locations, but they probably do not represent ideal flounder nursery area. For example, averaged over March-October 1981-1997, less than 1 fish per haul was obtained with the 300-ft net (excluding 1992 when an unusually high number, n = 459, was taken at the Cole River site). With only the four-station beach seine program, winter flounder post-larval year-class strength cannot be assessed until the trawl begins to retain them as they approach age one. To begin to determine annual production soon after metamorphosis, additional beach seine sampling was initiated at ten locations in June 1992. In 1993 the sampling regime was broadened to include the months of July and August, also four stations were added bringing the total to fourteen. The sampling plan changed slightly in 1994 by adding one station in the Kickamuit River for a total of fifteen stations (Table F-42). In an effort to increase precision, beginning with 1995 and continuing through 1998, stations were added by reducing replication at locations with low variability. The number of additional stations ranged from four to six depending on variability between replicates and tide related constraints.

Methods

In 1992, following Poole (1966) and Saucerman (1990), saltwater coves with organic substrates and sufficient seinable bottom (minimum 175 linear feet) with good depth contour were selected for young-of-the year winter flounder sampling (Figure F-46, Table F-42). Four sites were located in the lower Taunton River, two each were located in the lower Lee and Cole Rivers, one was located in the Kickamuit River, and one in the Brayton Point intake embayment. In 1993 in addition to these 10 fixed sites, four additional locations were sampled, selected at random from the remaining 27 seinable sites. Two sites were selected from the Taunton River, one from the Lee, and one from the Kickamuit. No additional seine sites could be found in the upper Cole River because of the steepness of the banks in that area. In 1994 a randomly selected station was added to the Kickamuit River drawing upon the effort originally intended for the upper Cole. This brought the total number of stations to 15 and improved precision in the river with the second longest shoreline. Maintaining a three-day sampling effort, beginning with 1995, attempts were made to further increase the total number of stations sampled by dropping from three to two replicates per location in cases where inter-replicate variability was relatively low. Typically only two replicates were collected if numbers of flounder in the first and second hauls varied by 20% or less. Occasionally only two replicates were completed due to shoreline space limitations. Using this approach, between 20 and 21 stations were sampled over the five surveys completed in 1998. Station 13, initially a random station, was sampled on each occasion in 1997 and 1998 because good hauls could be made there independent of tidal stage. In 1992 sampling was completed twice in June, increasing in 1993 to twice in June, twice in July, and once in August. Five surveys have been completed each summer since then.

Each location was sampled in duplicate or triplicate with a 50-ft x 6-ft, ¼-inch mesh bag seine. The bottom line consisted of conventional leads spaced one foot apart with an additional 50-ft length of lead core line secured to it. Hauls were standardized by walking straight offshore until the net was

extended, then walking parallel to shore over a measured distance of 50 feet. Based on actual measurements, due to bowing of the net, distance from shore approximated 46 feet (14 m) so that each haul covered an estimated 2300 ft^2 (214 m^2). Occasionally, depending on tidal stage, the net could not be fully stretched offshore due to water depth; this typically became more of a problem in summer as *Spartina* coverage increased, reducing seinable area. Four shortened hauls occurred in June and five occurred in July for an overall percentage of 8.7%. In these cases the catch was scaled upward to a standard 2300 ft^2 (214 m^2) set based on the actual bottom covered. Great care was taken to haul so the lead line remained on bottom. Flounder from replicates one and two were held in containers (aerated if necessary) until two or three collections at a station were completed. All flounder were measured to the nearest mm in total length before release. Water temperature (C), salinity (‰), and dissolved oxygen (mg/l) were recorded near shore and near bottom at each station.

Results and Discussion

The two young-of-the-year winter flounder surveys completed in June produced stratified means of 0.6 (s.e. = 0.2) and 1.9 (s.e. = 0.7) fish per haul (Figures F-47, F-48, Tables F-43,F-44a). Stratified mean number per haul for the month of June was 1.3 flounder per haul (s.e. = 0.4) placing 1998 sixth ahead of only 1993 (0.4 per haul). Consistent with each year except for 1996, numbers of flounder increased from the first to the second sample survey suggesting that young continued to move into shoal areas during the month of June. Considering all five surveys completed during the summer, a stratified mean of 1.9 flounder per haul was obtained, ranking fourth behind 1995 (4.8 per haul), 1996 (4.1 per haul), and 1997 (3.5 per haul); 1992 was excluded because sampling occurred only in June (Figure F-48, Table F-44b).

Clear, consistent patterns in catch among stations or among rivers have not been easily identifiable when comparing collections over the 1992 through 1998 period. Station C (Breeds Cove in the Taunton River) has been most consistent, producing relatively high catch rates each year except 1994. Station E in the Brayton Point intake embayment produced relatively high catch rates in 1992, 1993, 1996 and 1998 but did not do so in 1994, 1995, or 1997. Station I in the Cole River supplied good collections in 1992 but did not prove productive again until 1997. In June 1998, collections averaged highest in the Kickamuit River (1.8 per haul) followed by the Taunton (1.3 per haul), Cole (0.8 per haul), and Lee (0.1 per haul) pooling collections over both sampling series. Over all years the Cole River has accounted for an average of 37% of the catch followed by the Kickamuit (24%), Taunton(22%), and Lee (17%; Figure F-49). Over the seven years surveyed, the Lee River has shown the greatest variability in contribution of young flounder varying from 0 to 44% of the June stratified mean. In 1998 the Lee contributed only 3% of the young collected in June.

At times macroalgal growth in the Lee River, consisting primarily of *Ulva lactuca*, has been so extensive that seining through it was nearly impossible. In 1998, likely due to above-average June rainfall and resulting runoff, growth was particularly abundant to the point that the normal complement of four stations could not be sampled. While it can be difficult to spot small flounder mixed with several hundred pounds of *Ulva* and therefore sampling error may be high, it is uncommon to collect young-of-the-year in areas with abundant algal growth, suggesting that it is not good habitat for them. Dense growth of *Ulva rigida* has been shown to dramatically alter benthic community structure in an

Italian lagoon (Tagliapietra et al. 1998). Although that study did not address fish populations, it is logical to expect that they would be affected as well. Proportions of the flounder catch among Mount Hope Bay rivers appear more evenly distributed when the entire June-August catch is pooled (Figure F-49). The Lee River contribution appeared to improve later in the summer due to collections at sites low in macroalgae.

A two-way analysis of variance (ANOVA) using log-transformed station means with date and station as main, fixed effects (random stations excluded) detected a significant among-station effect for 1998 ($p = 0.002$, loge-transformed data). Station 13 in the Taunton River, Station E in the Brayton Point intake, and J in the Kickamuit River ranked first through third over the season as a whole. Poorest numbers were obtained at Taunton River Stations A and D (Figure F-46). With the exception of the high rank of Station E in 1998, these results are identical to 1997's results; in 1997 Station E ranked roughly in the middle of the range. An additional ANOVA was run using mean densities by river with the randomly selected locations included, river and year as fixed, main effects. Data for 1992 were included in an initial run by focusing only on June collections. A subsequent ANOVA excluded 1992 but utilized all six dates from 1993 through 1998. The first test with 1992 included detected a statistically significant difference among tributary river ($p = 0.035$; loge catch data), the Cole River averaging more young flounder then the other three systems which were statistically similar. The second test, using data from the entire summer season, failed to detect a difference among rivers using either straight ($p = 0.449$) or loge transformed data ($p = 0.562$). The relatively high proportion of the catch in June from the Cole River (mean = 37%), particularly in 1992, 1993, 1996, and 1997 is shown in Figure F-49.

Since young winter flounder are reported to move relatively little during summer (Deegan and Saucerman 1991), catch per seine haul can be used to provide an estimate of natural mortality. However, since it is not possible to separate actual mortality from what may amount to subtle movements to and from deeper water as temperatures change, the tide rises and falls along the shoreline, or decreases in availability to the seine occur as individuals bury in the sediment, mortality estimates are considered approximate at best. During each young-of-the-year flounder season except for 1996, stratified mean catch per tow increased from the first to second June sampling series, suggesting that young flounder continue to disperse into shoal areas during that period. The 1996 season differed from the other six seasons in that catch declined from the early (2.6 per haul) to late June (2.4 per haul) series but then increased sharply into the early July sampling (9.3 per haul). In 1994 and 1995 a consistent drop in catch occurred from the second June series through the two July series. In 1993 and 1997 a decline occurred between the two July periods. August collections continued to show a decline in catch in 1995, 1996, and 1997, with young increasing in number per haul in 1993 and 1994. Results for 1998 were unique in that catch per haul increased from one sampling period to the next right through the two July periods; the only decline occurred from the second July sampling to the August sampling. Focusing on the July decline in catch, which was common to all years except for 1998, over that two-week period stratified mean number per haul provided a survival rate of 0.556 in 1997, 0.428 in 1996, 0.676 in 1995, 0.750 in 1994, and 0.682 in 1993. Linearly projecting those rates over a 30-day period would suggest survival rates of 0.309 in 1997, 0.183 in 1996, 0.457 in 1995, 0.563 in 1994, and 0.465 in 1993 (Figure F-50, Table F-45). Instantaneous natural mortality rates (Z_{mon}) corresponding to these survival rates are 1.174 for 1997,

1.698 for 1996, 0.782 for 1995, 0.575 for 1994, and 0.766 for 1993. The 1997 value appeared to reverse the increase in mortality rates observed from 1994 through 1996.

In 1995, 1996, and 1997 catch rates declined consistently from the first July series through the single August series, a period of approximately 30 days. Linear regression using log transformed mean densities provided respective, 30-day survival rates of 0.144, 0.384, and 0.398 (Z_{mon} = 1.937, 0.956, and 0.923, respectively). The apparent low survival rate in 1995 over this interval was attributed, at least in part, to high summer water temperatures which likely led to movement of young flounder into deeper water or to burying themselves in the substrate where they became less susceptible to the seine (Figure F-51, NEP and MRI 1996).

Mortality rates estimated for Mount Hope Bay tributaries are greater than those reported for the Mystic River, Connecticut (Z_{mon} = 0.371, survival = 0.690, Pearcy 1962). Comparable monthly mortality rates reported for two locations in the Niantic River determined from 1984 to 1997 vary widely from Z_{mon} = 0.213 to 1.398 (survival = 0.808 to 0.247; NUSCO 1998); only the 1996 Mount Hope Bay value exceeded this range. Z_{mon} values reported for the closely related juvenile plaice (*Pleuronectes platessa*) in British coastal bays range from 0.563 to 0.693 (Lockwood 1980; Poxton et al. 1982; Poxton and Nasir 1985) similar to the 1994 value for Mount Hope Bay and well within the Niantic River range.

Young-of-the-year growth patterns for each year in which young flounder have been sampled are shown in Figure F-52 and Table F-46. Mean total length during the second week of June when sampling commenced each year ranged from 38.6 mm in 1998 to 47.8 mm in 1996. Absolute growth in length as measured during the August sampling series was greatest in 1996 (mean total length = 67.0 mm, s.e. = 0.9) 6.3 mm larger then in 1998, the second highest year. Only the 1996, 1997, and 1998 seasons of the six thus far showed apparent continued growth into the August sampling. In each year from 1993 through 1995 mean length dropped by 2 to 4 mm between the July and August sampling dates, suggesting that larger individuals moved to deeper water late in summer leaving smaller fish behind. This observation suggested that mortality rates utilizing the August catch data would likely overestimate the true mortality rate. Overall growth appeared less in 1995 (August mean = 51.5 mm, s.e. = 1.4) although the greatest observed drop in length occurred into August of that year along with a pronounced drop in catch; 1995 was also the warmest summer of the six sampled (Figure F-51; see also hydrographic section) supporting the suggestion that larger fish move offshore first, particularly under the influence of high water temperatures.

Daily instantaneous growth rates, the preferred expression for short term exponential growth (Schreck and Moyle 1990), for the month of June was most rapid in 1998 (G = 0.0176), slowest in 1995 (G = 0.0066). Between these two years values ranged from G = 0.0095 in 1994 to G = 0.0157 in 1993. Linearized growth rates over the June sampling dates (15 days) in descending order equaled 0.77 mm/day in 1998, 0.72 mm/day in 1993, 0.65 mm/day in 1996, 0.63 mm/day in 1994, 0.53 mm/day in 1992, 0.47 mm/day in 1997, and only 0.31 mm/day in 1995 (Figures F-52,53). Consistent with Sogard (1991), Sogard and Able (1992), and NUSCO (1998), growth appeared to be most rapid early in summer, declining later in July and August although, as mentioned above, this pattern is likely confounded by late season movement to deeper water. Growth in 1998 appeared to be the slowest

prior to the first sampling series among the seven years studied but compensated for it by rapid growth later in June.

In spite of recording the warmest larval flounder season in 1998 (January-April, see ichthyoplankton section), water temperatures averaged only 18.7 C at the young-of-the-year sampling locations during the first June survey in 1998. This compares with means ranging from 18.8 in 1997 to 21.7C in 1995 (Figure F-54). Since the spring of 1997 was similarly cool yet growth appeared consistent with other seasons, perhaps post-metamorphic growth in 1998 was somewhat reduced by the combination of a warm larval season and low, late spring water temperatures, all other variables being equal.

Since growth was approximately linear over the four June and July sampling dates (45 to 49-days) during 1993 through 1998 (Figure F-52), rates of growth based on linear regression equations were 0.41 mm/day in 1996 ($R^2 = 0.938$), 0.39 mm/day in 1998 ($R^2 = 0.864$), 0.36 mm/day in 1994 ($R^2 = 0.950$), 0.33 mm/day in 1993 ($R^2 = 0.882$), 0.21 mm/day in 1995 ($R^2 = 0.984$) and 0.19 mm/day in 1997 ($R^2 = 0.828$) (Figure F-53). Expressed on a weekly basis the mean of these values (0.32 mm/day) was 2.2 mm per week, consistent with that observed by Pearcy (1962) and Mulkana (1966) in Connecticut and Rhode Island waters.

Mean lengths attained in Mount Hope Bay tributaries over the past six seasons were similar to mean lengths recorded in the Niantic River during late July through September 1983 through 1996 (38 - 66 mm TL; NUSCO 1998) and in Rhode Island coastal ponds in 1996 (Gray 1996). Similar lengths were also obtained in five Long Island Sound river systems (48-67 mm TL, July-August 1991-1993; Howell and Molnar 1995). Consistent with Mount Hope Bay results, Howell and Molnar (1995) noted greater absolute growth in 1993 compared with 1992, offering as one potential explanation that 1993 was 0.6 to 2.0 C warmer than 1992, which could have accelerated growth rates.

Water temperature and dissolved oxygen values in most cases did not appear to be limiting to the distribution of young flounder in Mount Hope Bay tributaries with the exception of late July-early August 1995. Olla et al.(1969) reported that young flounder were active to 22.2 C, but they were buried in the sand at 23 C where temperatures are lower. Casterlin and Reynolds (1982), studying winter flounder acclimatd at 15-17 C in shuttleboxes, found that yearling flounder voluntarily occupied 8-27 C water. In summarizing their work and that of others Casterlin and Reynolds stated that avoidance is initiated at or below 27 C and, if escape or the ability to bury themselves in soft sediment is not possible, heat death occurs at 29 C. Miller et al. (1988) reported an LC50 of 1.0 mg/l dissolved oxygen for 2 cm flounder; they did not provide avoidance values. Water temperatures exceeded 23 C at some locations in Mount Hope Bay studies as early as June 21 in each year but 1992 and in fact reached 23.5 C in the Cole River on June 12 in 1996. The Cole River exceeded 25 C by late June in 1995 and 1997, and young flounder were clearly present at those locations. By mid-July each year (excluding 1996 which was a cool summer), sampling site temperatures were typically warmer than 24 C, and by late July 1994 and 1995 all exceeded 26 C. In 1997 all but some Taunton River sites equaled or exceeded 26 C. Although winter flounder were collected in water as warm as 28.2 C in 1994 and 1997 and 32.2 C in 1995, others could have been missed if they were buried in the sand.

It is also likely that cooler water was present further offshore within the seine area but removed from the hydrographic measurement location.

Generally dissolved oxygen readings in shallow water at time of sampling in the Mount Hope surveys were above 5 mg/l and often above 100% saturation. Many stations held an abundance of sea lettuce (*Ulva lactuca*) which probably contributed to relatively high oxygen readings during the day. At times these reached as high as 178% saturation (Kickamuit River in June, Table F-43). Readings below 5 mg/l were not recorded in 1997 nor 1998, occurred in only one instance in 1996 (Kickamuit River, 4.0 mg/l, 57.6 % saturation) and on an overall small number of occasions in 1993, 1994 and 1995 (MRI 1994, NEP and MRI 1995, 1996, 1998, NEP et al. 1998). These data, particularly the pronounced drop in catch from late July to mid-August 1995, suggest that water temperatures rather than daytime dissolved oxygen likely lead to young flounder vacating certain shoal areas thereby limiting their summer habitat for periods of time. Dissolved oxygen, however, at least during daylight hours, does not appear to be limiting. If young flounder are forced to seek waters with higher dissolved oxygen during darkness before photosynthesis replaces that lost to respiration (presumably in the hours just before dawn), individuals clearly return, probably with the next flood tide (Tyler 1971). As reported by Bejda et al (1992), wide fluctuations in dissolved oxygen, if they occur, apparently result in reduced growth rates during the summer.

Six annual young-of-the-year flounder surveys completed during late spring- summer provide abundance data for New York, Connecticut, Rhode Island, and other Massachusetts waters. The New York State Department of Environmental Conservation completed small mesh trawl surveys in Peconic Bay weekly at 16 randomly selected locations from May through October beginning with 1985. They utilized a 4.9-m, semi-balloon shrimp trawl with 1.3 cm cod end liner. The Connecticut Department of Environmental Protection has conducted standardized seine sampling (8m bag seine) for young winter flounder since 1988 at eight intertidal sites sampled each September with six hauls being completed at each site (Howell and Molnar 1995). Environmental studies around Millstone Nuclear Power Station in Waterford, Connecticut include annual assessments of young-of-year (age 0) flounder in the Niantic River and Niantic Bay (NUSCO 1998). Collections were made weekly with 1-meter beam trawls at two river locations and two bay locations. The Rhode Island Department of Environmental Management (RIDEM) multi-species survey employs a 200-ft seine, single hauls, monthly at sixteen stations (Powell 1986). They also complete a coastal ponds survey begun in 1993 using a 130-ft seine monthly from May through October. Lastly the Massachusetts survey completed by the Massachusetts Division of Marine Fisheries (MDMF) specifically to assess flounder uses a 21-ft net, triplicate shore hauls at 49 stations sampled between mid-June and mid-July. The 49 stations cover Bass River, Cotuit Bay, Great Pond, Lewis Bay, Stage Harbor, and Waquoit Bay, all on the south shore of Cape Cod. Results from the six surveys including Mount Hope Bay for 1992-1998 are summarized in Table F-47 and Figure F-55.

The 1992 year class was a strong one based on the Mount Hope Bay, MDMF, RIDEM (all but June, 4-station series), and New York surveys, that year ranking highest among the seven years of the time series in each case. In contrast to 1992, 1993 production was poor based on Mount Hope Bay, MDMF, and both Connecticut surveys. Numbers of young taken in 1994 were even lower than 1993 in the RIDEM surveys while 1994 produced the highest numbers of the time series in the Niantic

River. The current 1998 season ranked near the middle of the seven-year time series in many of the surveys. The RIDEM coastal pond survey presented the highest rank where 1998 placed second behind 1997. The MDMF survey index in 1998 ended a four-year upward trend. In general these data suggest that some regional signals appear in early year class strength as evidenced by the 1992 year class which was relatively strong in Massachusetts, Connecticut, and New York waters. Overall only two statistically significant Spearman's rank correlations occurred among this group of surveys over the 1992-1998 period. The Mount Hope Bay June catch was correlated with the RIDEM June catch ($\rho = 0.786$, $p = 0.036$) and also with the MDMF abundance index ($\rho = 0.721$, $p = 0.068$). The latter was significant only at the 90% probability level. Data suggest that some region-wide signals exist which account for years like 1992 when strong year classes occur over a wide area, but they appear as isolated cases or at most run for two or three years before becoming obscure.

Analysis of larval abundance indices and subsequent age 1 abundance during the following February-April demonstrated a weak correlation from 1973 through 1998 ($r = 0.500$, $p = 0.011$, both in $\log_e$ scale, see trawl section). A stronger relationship is likely to emerge between larval abundance and young-of-the-year abundance since they are more closely related in time and the interval over which natural mortality functions shorter. Although only seven years are currently available, these data were examined using the annual geometric mean larval flounder abundance and the stratified mean abundance of young flounder per haul for June. Seine data for both June dates were included because in most cases early June data have indicated that young continue to move into near shore areas over the course of the month (see earlier). Mean larval abundance and mean young-of-the-year catch were found to be well correlated ($r = 0.909$, $p = 0.005$, Figure F-56) as were young-of-the-year abundance and age 1 abundance the following spring (February-April, mean number per tow, fine-mesh trawl; $r = 0.938$, $p = 0.002$, Figure F-57). Clearly however 1992 was key to the strength of both relationships; excluding 1992 resulted in a decline of both correlation coefficients (larvae vs young-of-the-year $r = 0.872$, $p = 0.024$; young-of-the-year vs age 1, $r = -0.305$, $p = 0.556$) the latter becoming non significant.

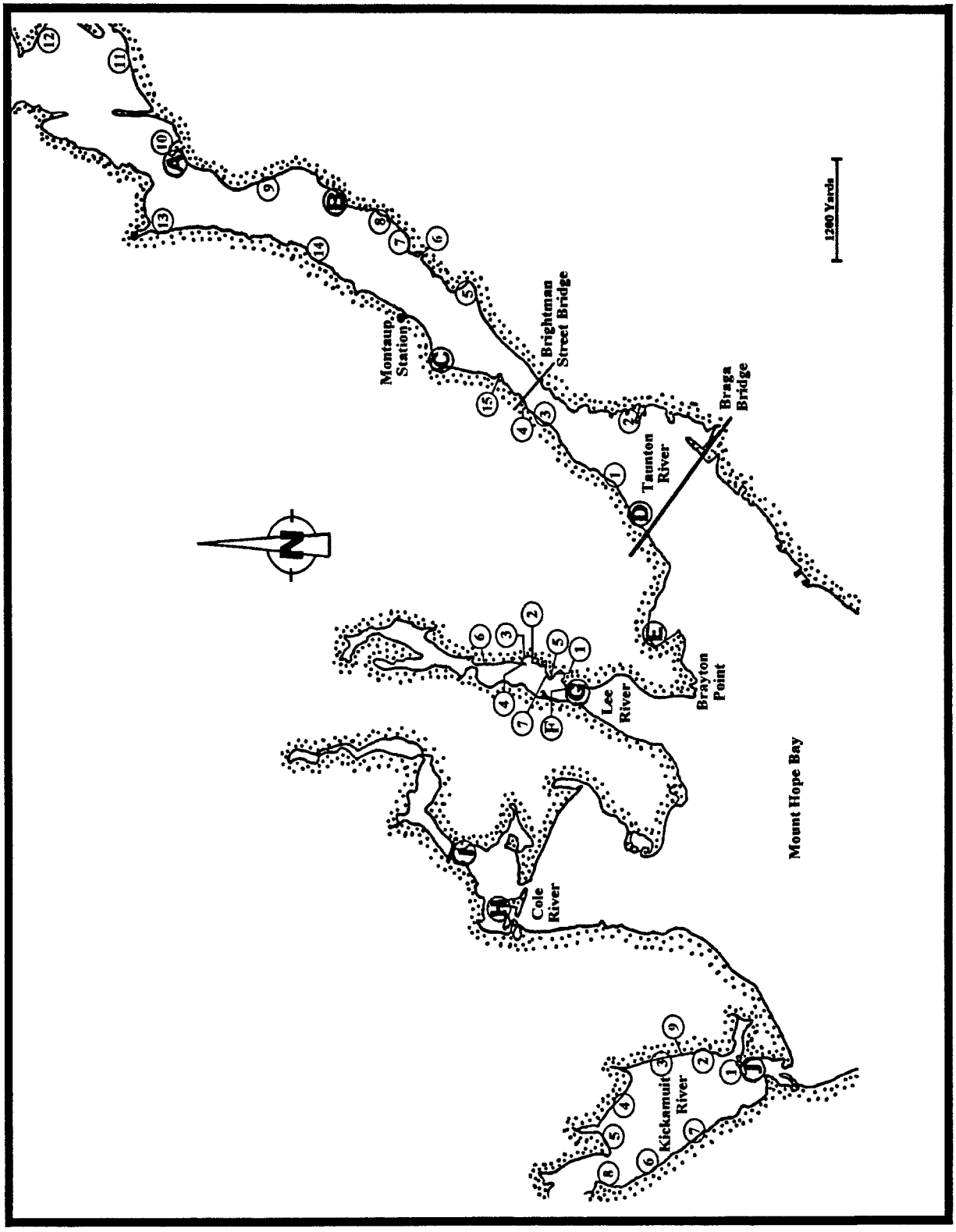


Figure F-46. Location of young-of-the-year beach seine stations in Mount Hope Bay tributaries.

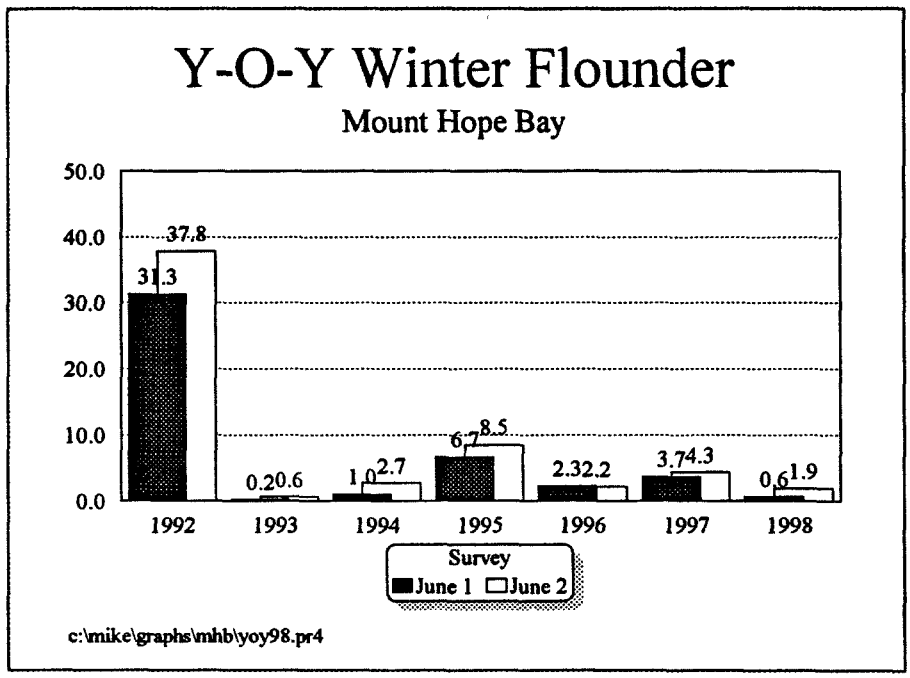
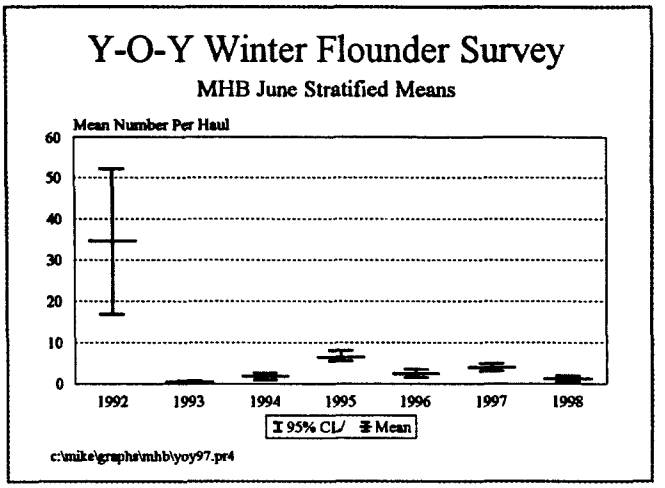
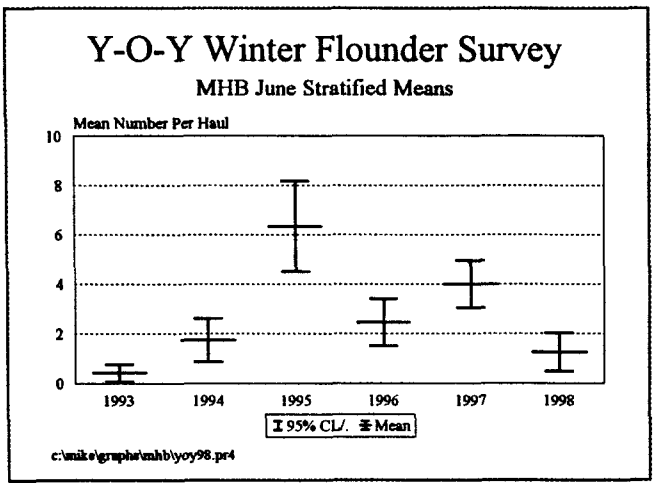


Figure F-47. Mean number of young-of-the-year winter flounder taken per seine haul during two June sampling series, 1992-1998.





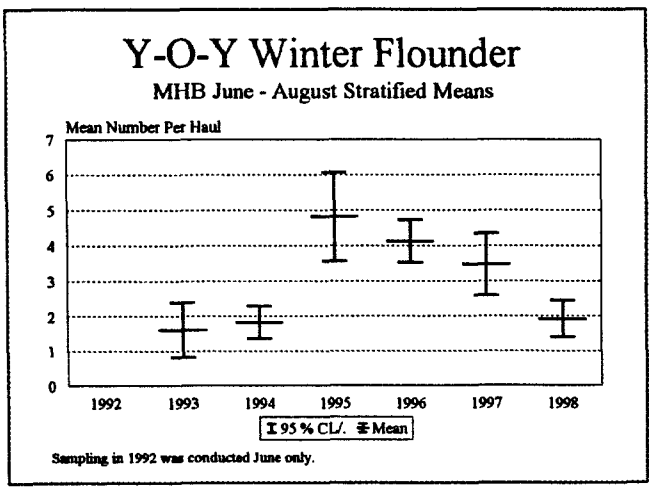
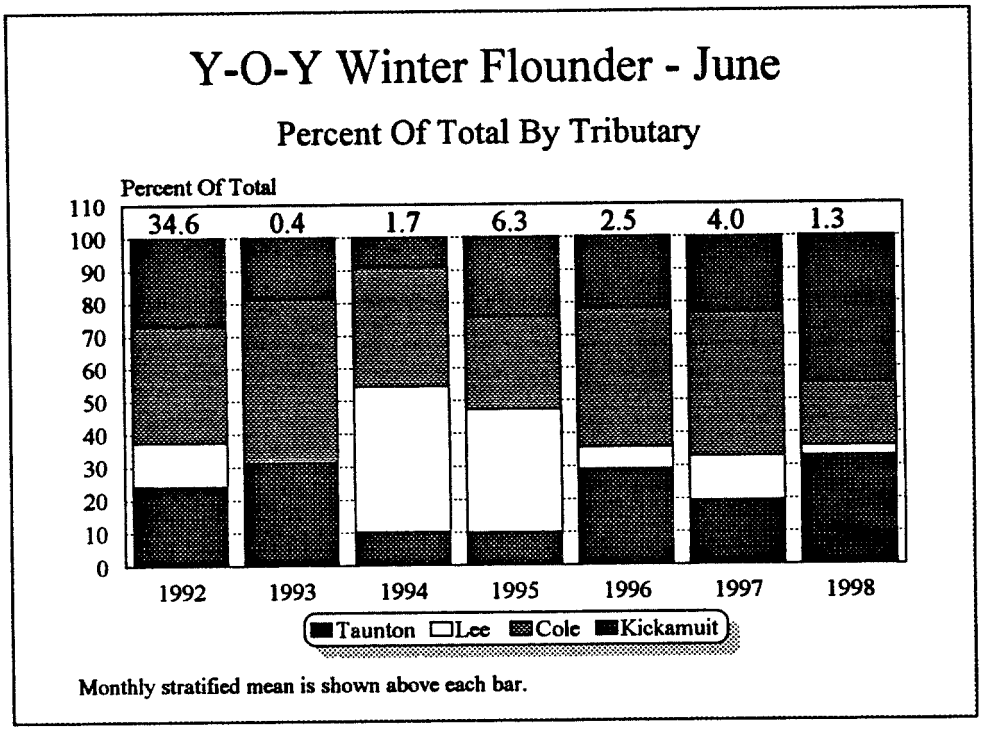


Figure F-48. Stratified mean number of young-of-the-year winter flounder per seine haul during June 1992-1998 (top), June 1993-1998 (mid), and June-August 1992-1998.



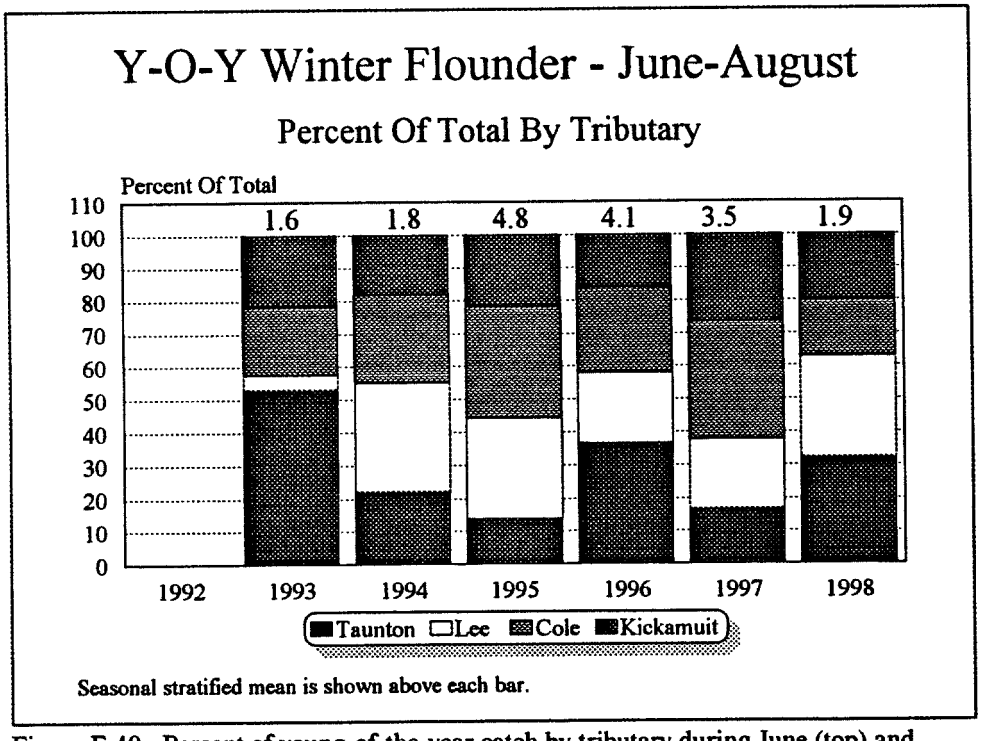


Figure F-49. Percent of young-of-the-year catch by tributary during June (top) and June-August, 1992-1998.

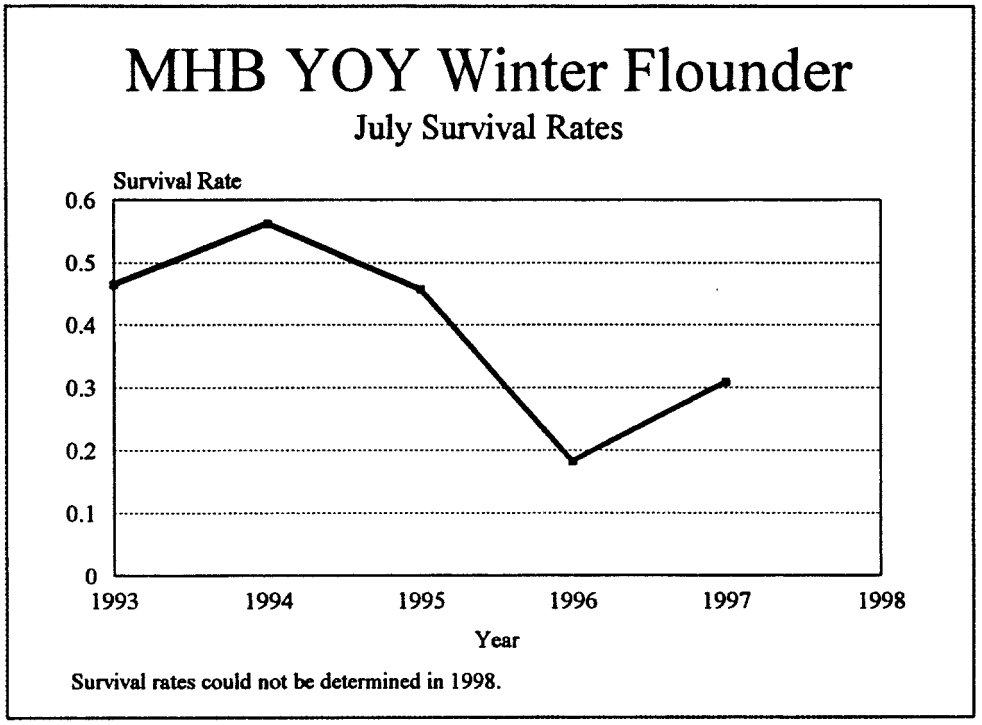


Figure F-50. Survival rates calculated over 30 days in July, young-of-the-year winter flounder, 1993-1998.

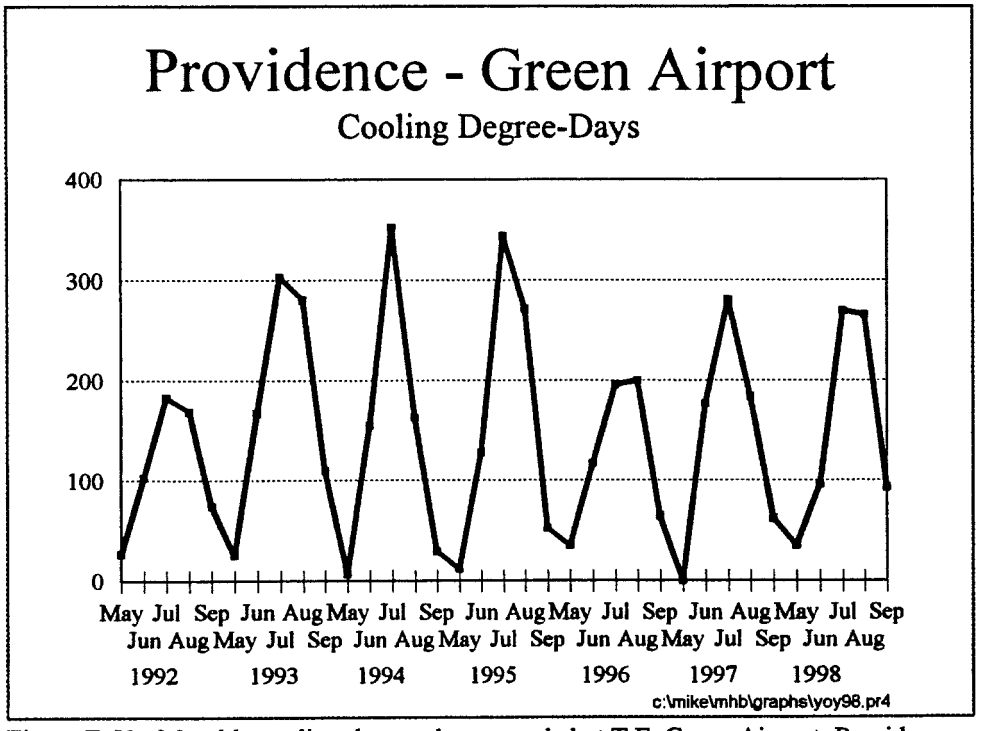
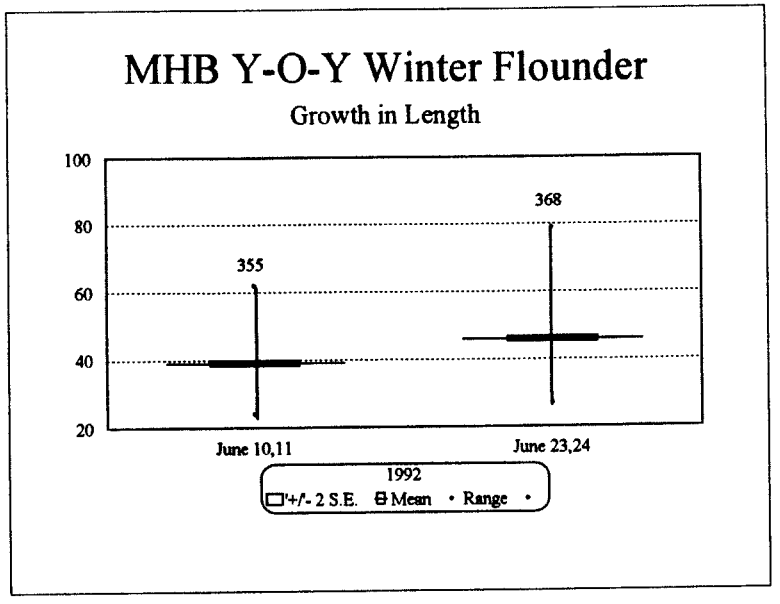
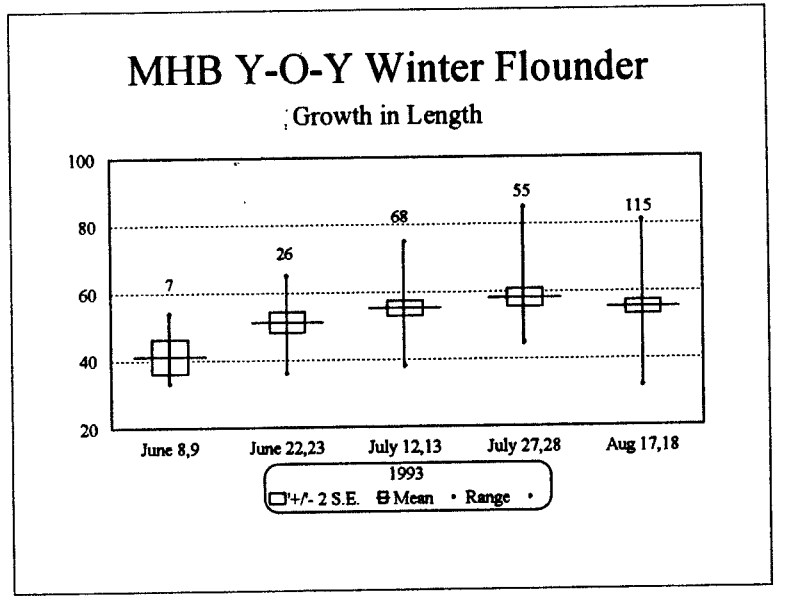
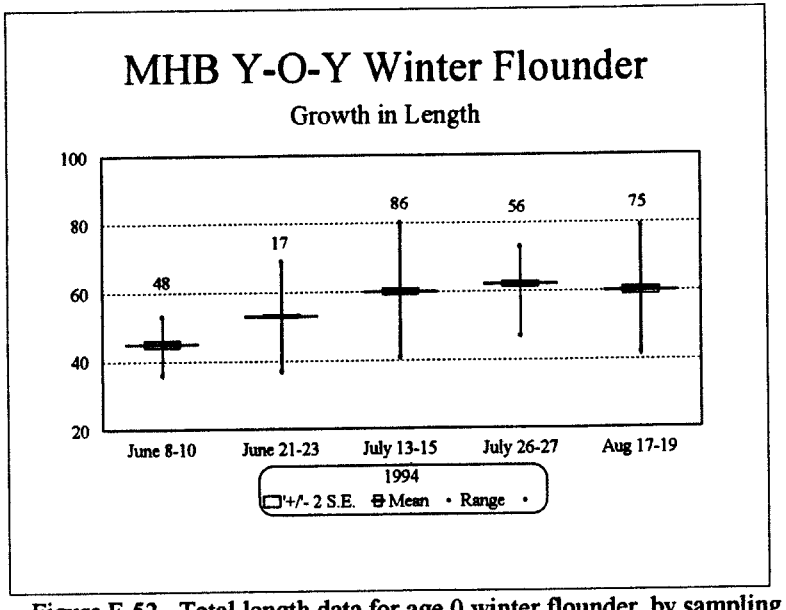


Figure F-51. Monthly cooling degree-days recorded at T.F. Green Airport, Providence, Rhode Island, May-September 1992-1998. Data from NOAA National Weather Service.







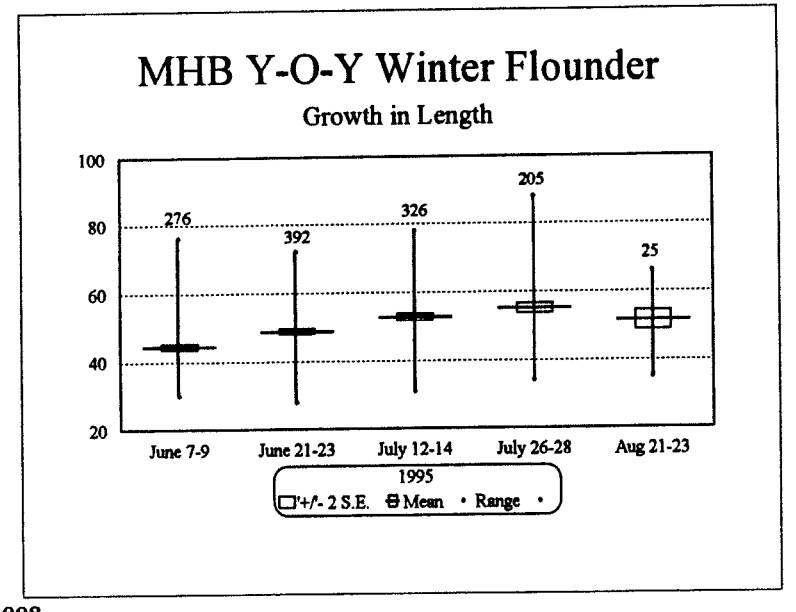
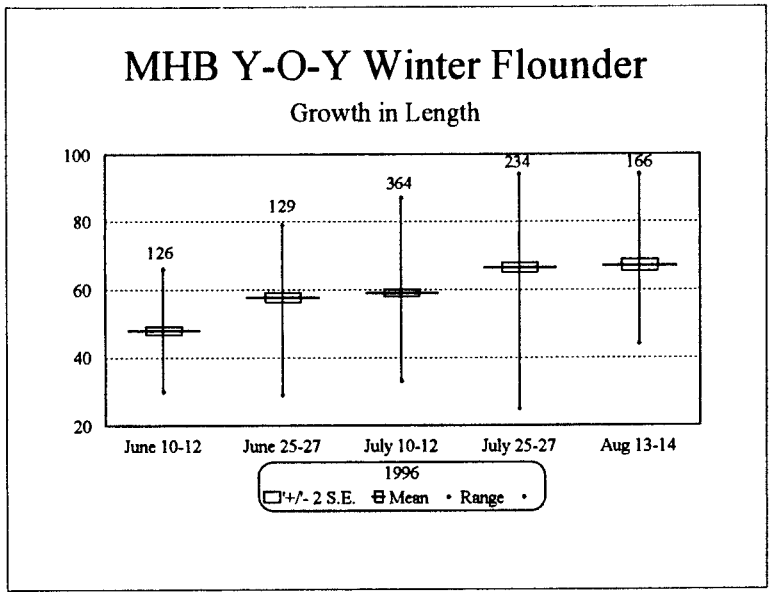
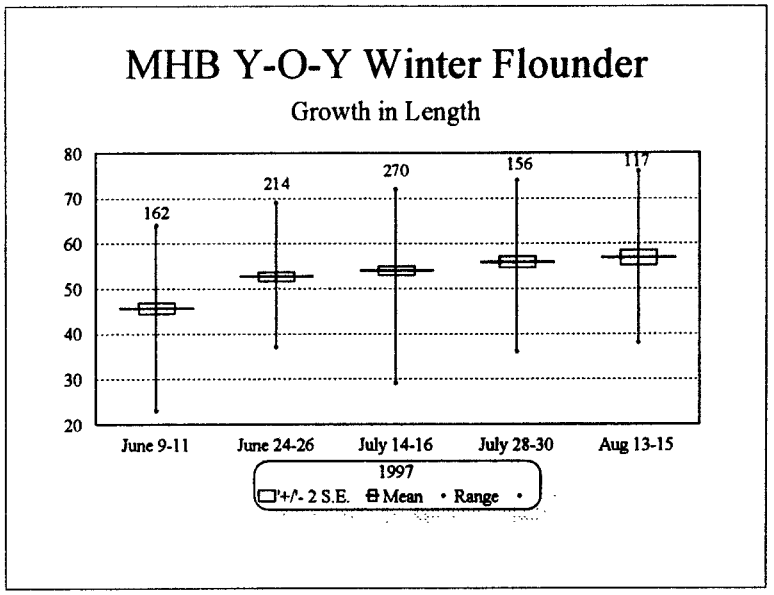


Figure F-52. Total length data for age 0 winter flounder by sampling series, 1992-1998.





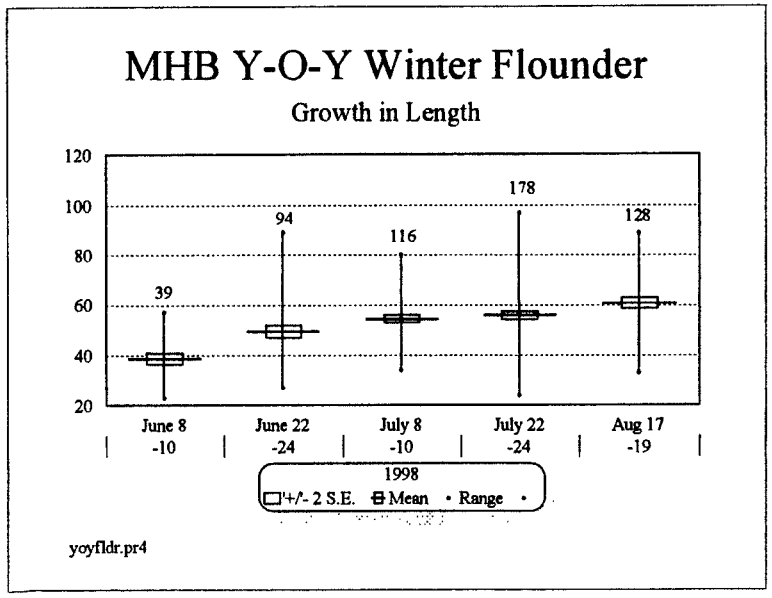


Figure F-52. continued.

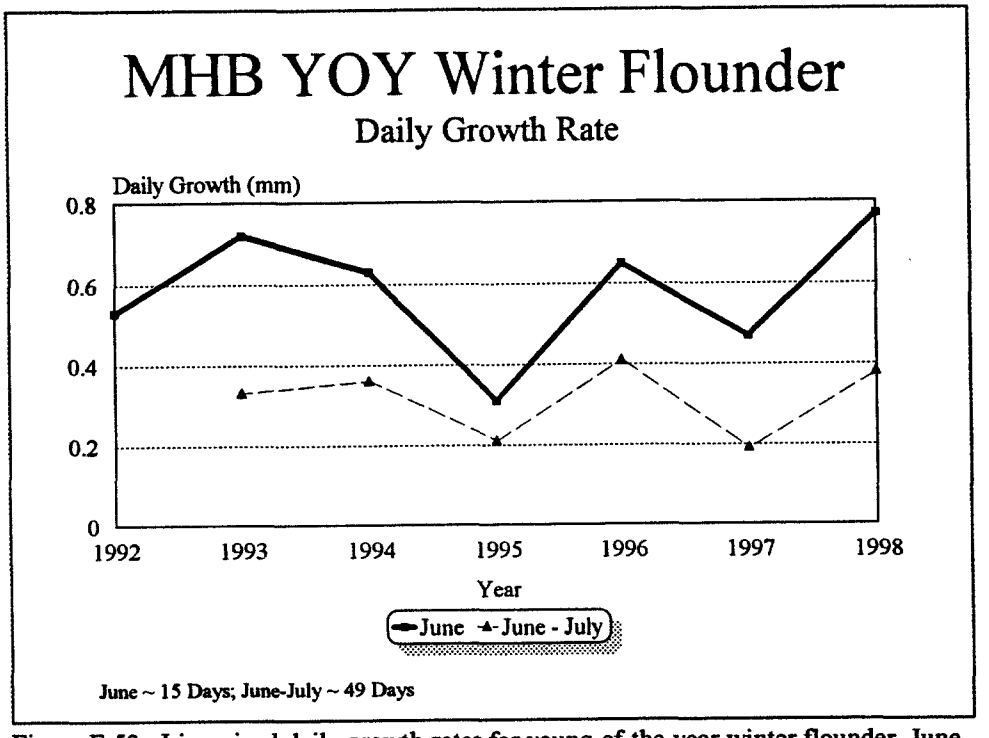


Figure F-53. Linearized daily growth rates for young-of-the-year winter flounder, June 1992-1998, June-July 1993-1998.

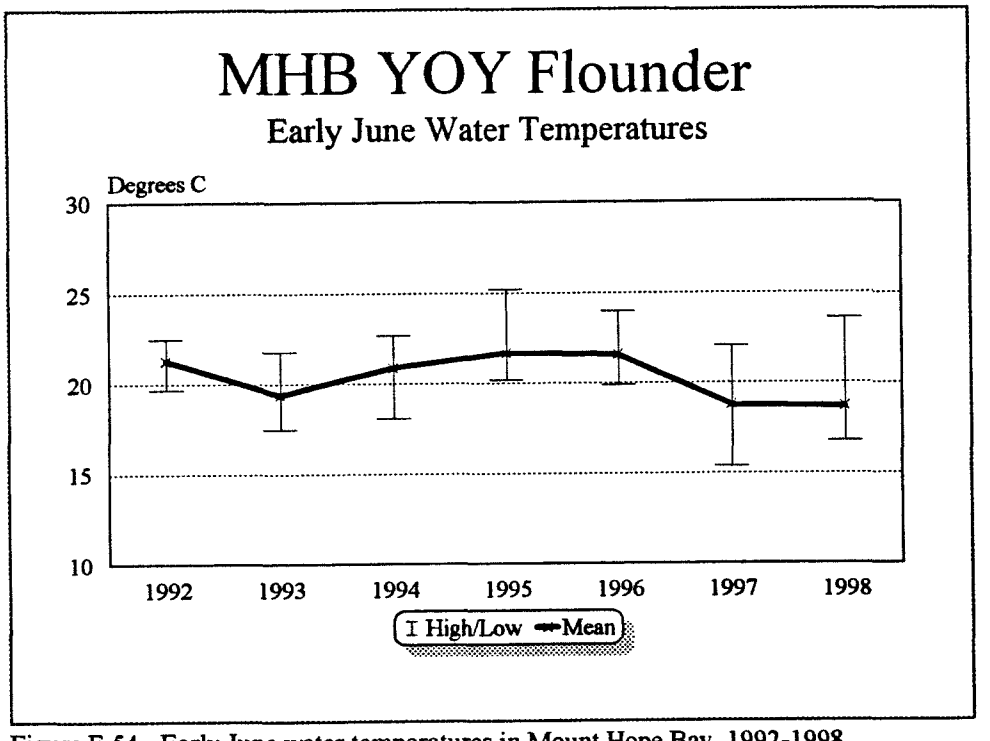
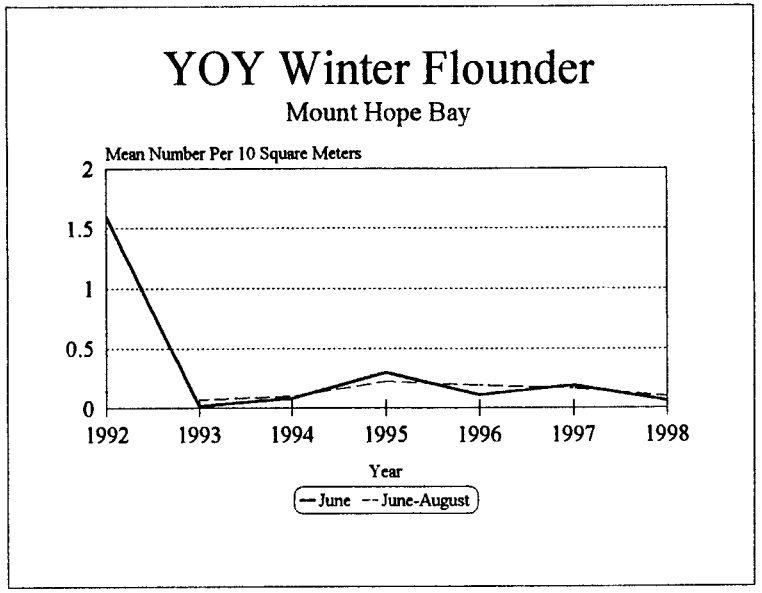
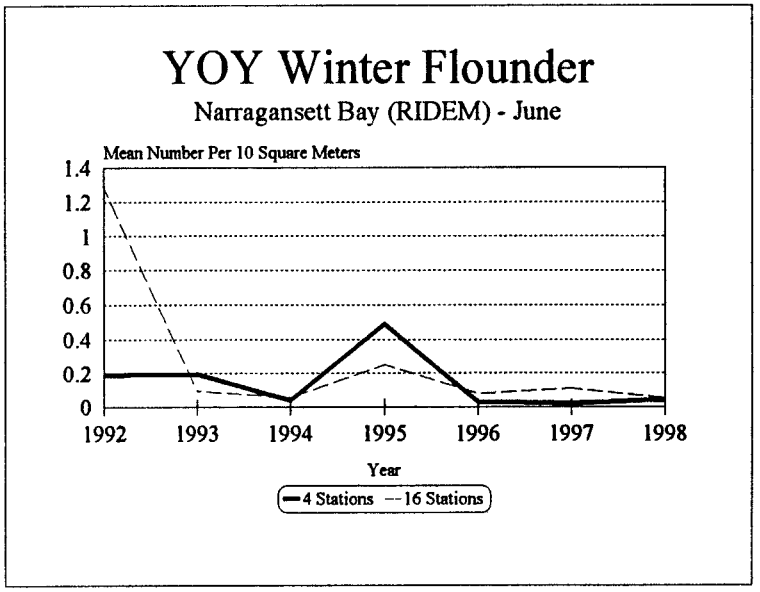
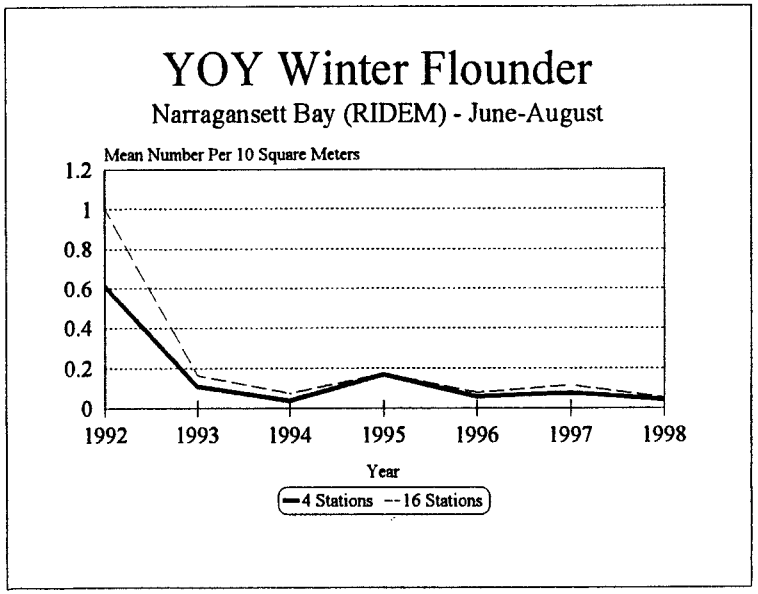


Figure F-54. Early June water temperatures in Mount Hope Bay, 1992-1998.







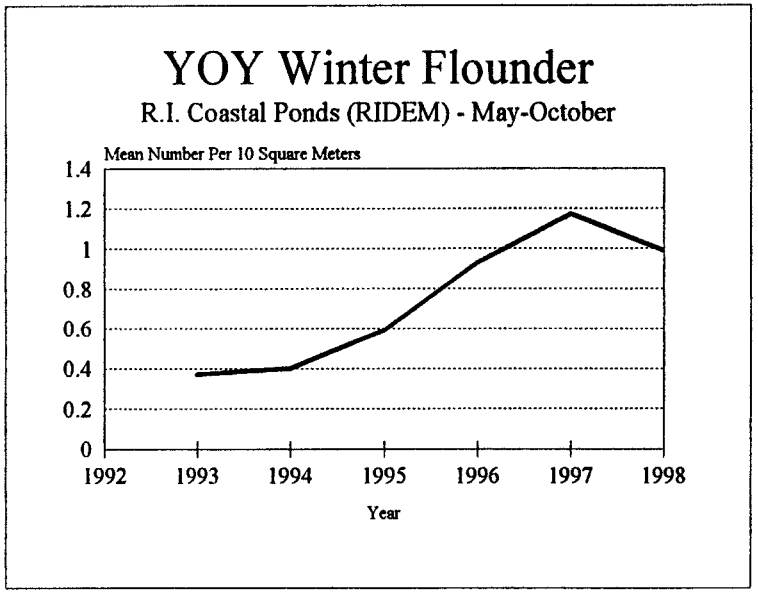
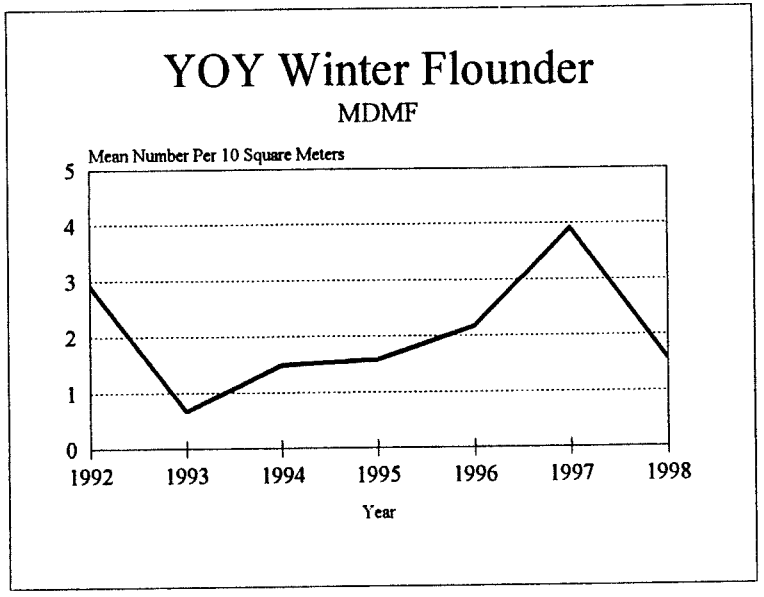
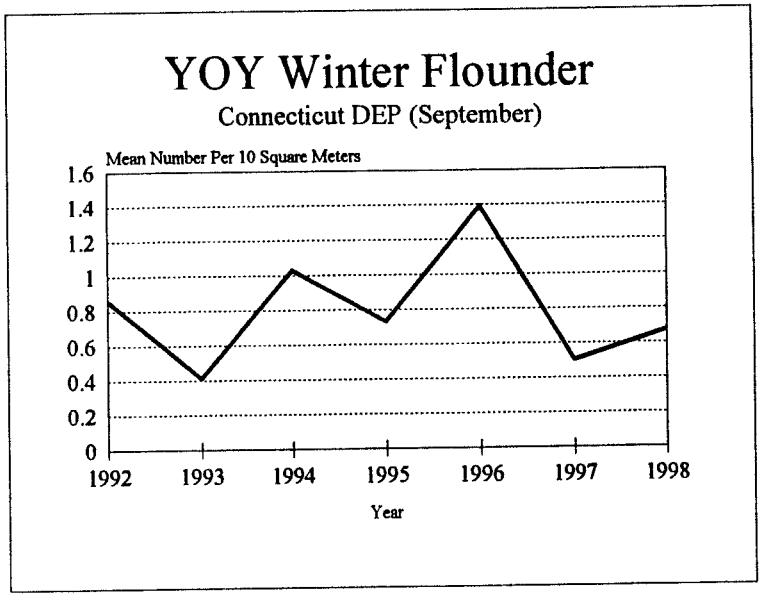
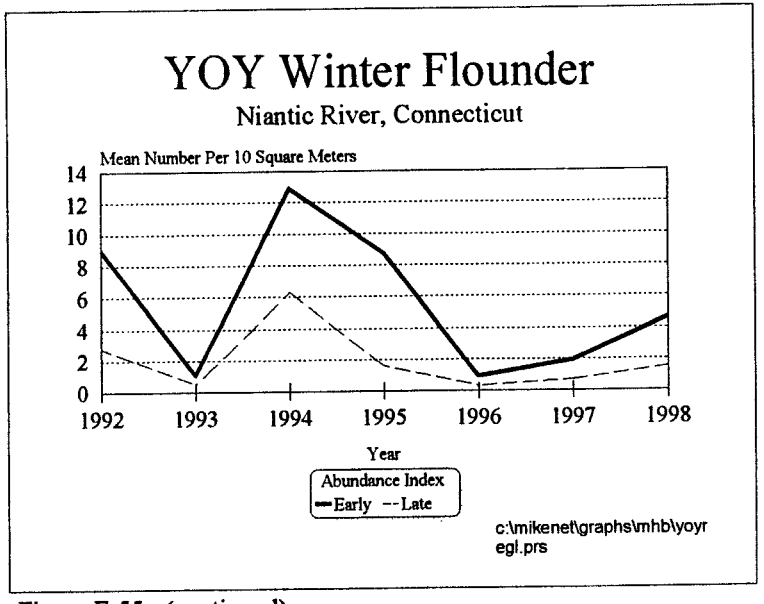


Figure F-55. Mean number of young-of-the-year winter flounder collected in Mount Hope Bay, Narragansett Bay, Massachusetts, Connecticut, and New York survey, 1992 - 1998.







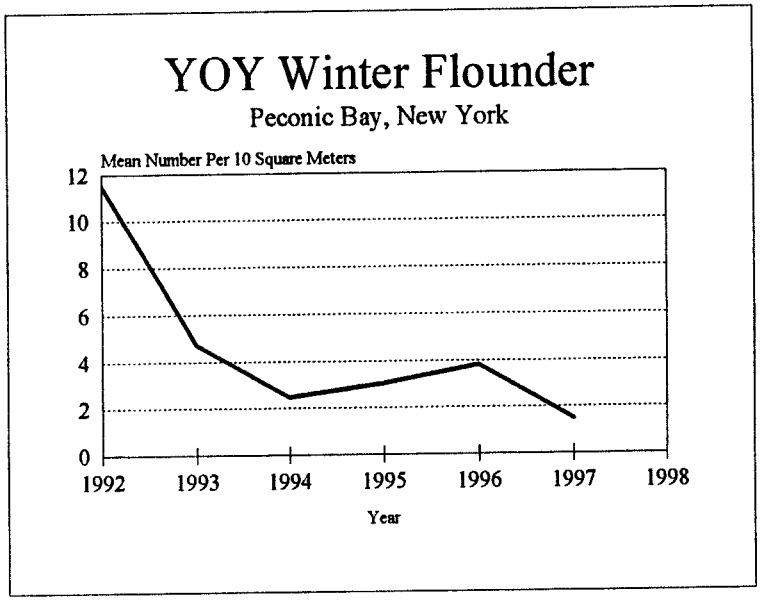


Figure F-55. (continued).

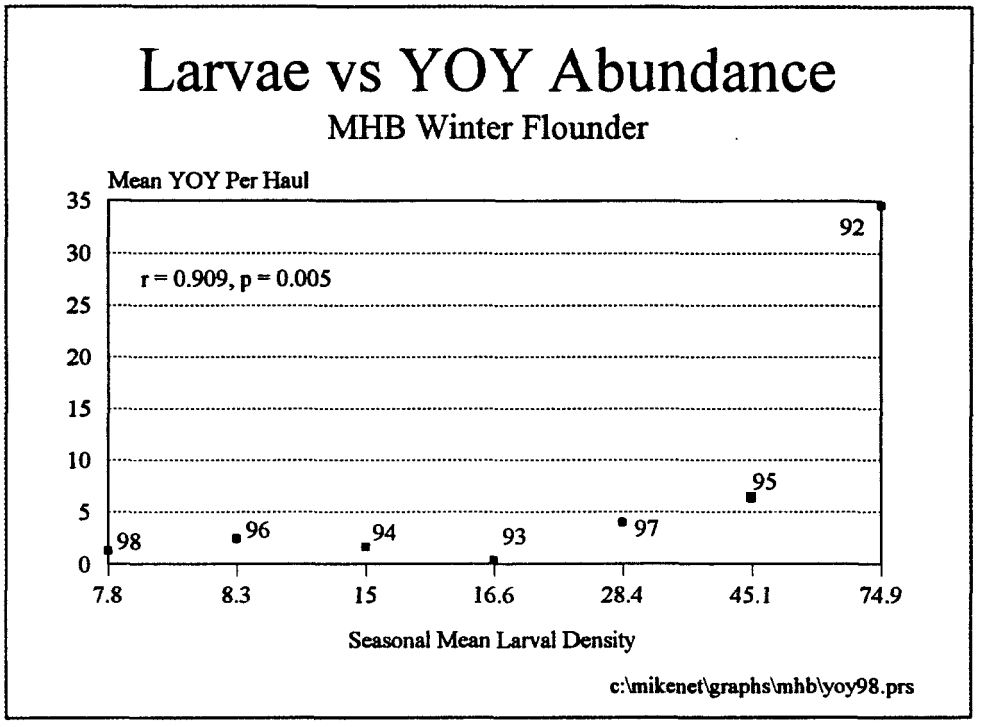


Figure F-56. Comparison between seasonal geometric mean larval flounder abundance and young-of-the-year abundance per seine haul in June.

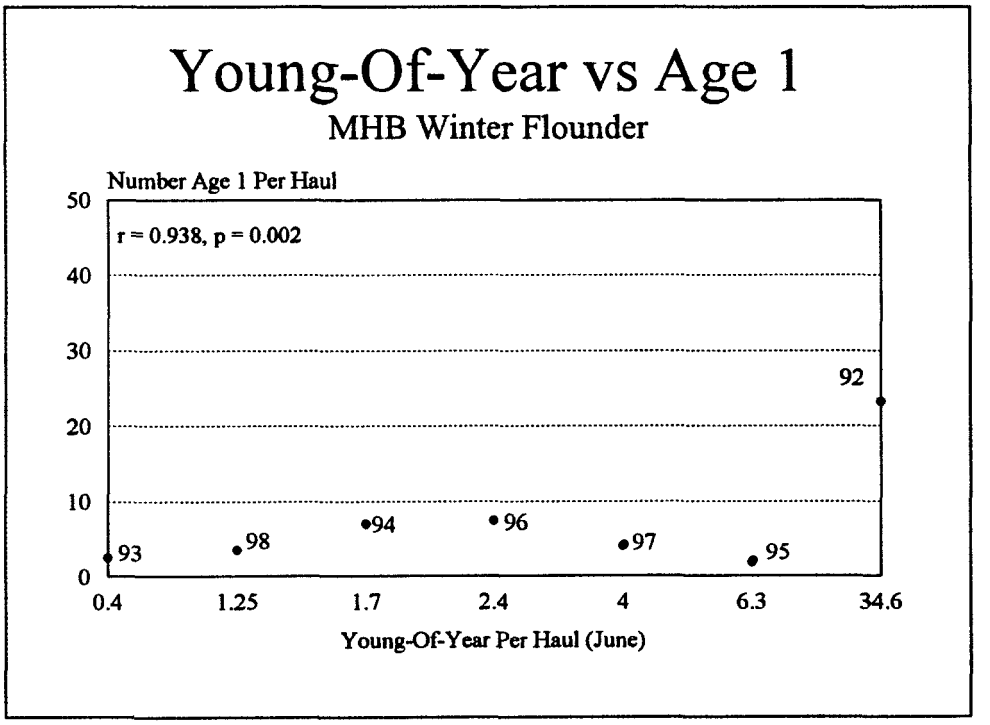


Figure F-57. Comparison between mean number of young-of-the-year winter flounder per seine haul in June and mean number of age 1 flounder taken by trawl during the following February - April period.

Table F-42 . Program summary for Mount Hope Bay young-of-the-year winter flounder seine survey.

	1992	1993	1994	1995	1996	1997	1998
10 Fixed Stations	■	■	■	■	■	■	■
4 Random Stations		■					
5 Random Stations			■				
8 - 11 Random Stations				■	■	■	■
Two Surveys In June	■						
Two Surveys in June and July One In August		■	■	■	■	■	■

Two or three replicate hauls completed at each location each survey.

Table F-43. Number of young-of-the-year winter flounder collected per standard (2300 ft²= 214 m²) seine haul at fixed and random locations in upper Mount Hope Bay tributaries, June-August 1998.

					June 8,9,10, 1998				
	Replicate				River Mean	Temp	Salinity	D.O.	Percent
Station	I	II	III	Mean	(s.e.)[1]	°C	‰	(mg/l)	Saturation
Taunton River									
A	0	0	1	0.3		16.8	18.1	7.7	93.0
B	0	0		0		17.3	19.6	8.3	101.6
C	0	3	3	2.0		18.1	21.3	8.6	108.4
D	0	0		0		17.1	23.8	8.1	103.3
E	0	3	0	1.0		17.8	25.3	8.1	104.8
2	2	0	0	0.7		19.2		8.4	104.8
3	0	0		0		18.3		9.8	120.2
5	1	6	0	2.3		19.5		10.1	125.6
6	1	3	0	1.3		17.1	19.2	7.7	93.8
7	0	0		0		23.6		7.6	101.2
9	0	4	2	2.0		17.0	18.8	7.5	90.8
13	1	0	0	0.3		17.3	20.4	7.4	89.8
15	5	0	1	2.0		19.1		9.1	111.4
					0.9 (0.3)				
Lee River									
G	0	0		0		19.4	26.8	7.7	103.4
6	0	0		0		21.8	25.8	12.9	179.4
					0				
Cole River									
H	0	0		0		19.5	25.4	8.2	109.7
I	0	0		0		19.6	23.8	9.3	123.1
					0				
Kickamuit River									
J	1	1	1	1.0		18.8	26.0	9.5	125.6
1	0	0		0		19.5	26.9	9.9	132.0
5	0	0		0		17.7	26.5	9.6	118.2
9	0	0		0		18.1	26.2	11.0	143.5
					0.3 (0.3)				

[1]Standard error based on number of stations.

Table F-43 (continued).

Station	Replicate I	Replicate II	Replicate III	Mean	River Mean (s.e.)[1]	Temp °C	Salinity ‰	D.O. (mg/l)	Percent Saturation
					June 22,23,24, 1998				
Taunton River									
A	0	2	1	1.0		20.5	7.6	6.3	76.9
B	0	1	1	0.7		20.1	11.7	6.5	81.0
C	0	0		0		20.5	13.1	6.3	78.8
D	0	0		0		21.0	15.8	6.2	80.4
E	4	3	1	2.7		21.1	14.5	6.7	86.6
1	0	0		0		20.7	16.6	6.8	88.0
5	6	1	0	2.3		20.4	10.7	6.3	77.5
6	1	0	2	1.0		20.8	11.8	7.2	90.7
7	0	1	2	1.0		20.9	10.3	6.9	86.3
9	4	11	13	9.3		20.5	8.7	6.3	77.4
13	5	2	3	3.3		20.4	4.8	7.5	89.9
14	0	0		0		20.9	8.0	6.3	78.5
15	0	0		0		20.4	23.0	6.5	83.0
					1.6 (0.7)				
Lee River									
G	0	1	0	0.3		21.7	16.4	6.4	83.6
					0.3 (0.3)				
Cole River									
H	0	0		0		22.0	13.6	6.1	78.9
I	0	4	5	3.0		21.9	8.0	5.9	74.1
					1.5 (1.5)				
Kickamuit River									
J	6	8	17	10.3		22.0	16.0	8.7	115.4
2	3	4	0	2.3		21.9	15.6	6.8	89.8
7	1	0	0	0.3		21.7	16.1	5.4	72.2
9	0	0		0		22.0	14.7	8.8	115.0
					3.2 (2.4)				

Table F-43 (continued).

Station	Replicate I	Replicate II	Replicate III	Mean	River Mean (s.e.)[1]	Temp °C	Salinity ‰	D.O. (mg/l)	Percent Saturation
					July 8,9,10, 1998				
Taunton River									
A	0	0		0		22.7	7.3	5.9	70.9
B	1	1	2	1.3		22.4	9.6	6.0	73.2
C	0	0		0		22.6	10.2	7.1	85.6
D	0	0		0		23.2	18.8	9.0	117.6
E	4	13	9	8.7		23.5	19.0	9.4	124.2
5	7	23	5	11.7		22.6	11.0	6.3	77.0
7	1	0	0	0.3		22.6	9.0	6.2	75.4
10	0	0		0		22.8	6.7	6.1	70.8
12	0	0		0		23.3	5.4	6.3	76.4
13	4	21	3	9.3		22.9	3.9	6.3	75.0
14	1	0	0	0.3		22.4	7.6	6.8	80.7
					2.9 (1.4)				
Lee River									
F	0	0		0		25.2	15.4	10.6	
G	0	1	2	1.0		24.6	15.4	10.8	
5	0	3	2	1.7		24.9	15.5	9.7	
7	8	9	2	6.3		25.9	18.2	9.8	133.4
					2.3 (1.4)				
Cole River									
H	0	2	1	1.0		25.1	15.6	10.2	
I	0	0	1	0.3		26.2	15.7	10.7	
					0.7 (0.4)				
Kickamuit River									
J	4	1	9	4.7		24.0	15.6	9.9	
2	1	1		1.0		23.5	15.6	9.3	
5	0	0		0		22.8	15.6	6.1	
9	0	1	0	0.3		23.6	15.6	9.3	
					1.5 (1.1)				

Table F-43 (continued).

Station	Replicate I	Replicate II	Replicate III	Mean	River Mean (s.e.)[1]	Temp °C	Salinity ‰	D.O. (mg/l)	Percent Saturation
					July 22,23,24, 1998				
Taunton River									
A	0	1	0	0.3		25.4	17.5	6.9	92.9
B	3	5	0	2.7		27.3	17.3	7.9	109.2
C	1	7	4	4.0		25.5	23.7	7.5	104.8
D	0	1	1	0.7		24.6	24.7	7.1	98.4
E	12	0	0	4.0		24.8	25.8	8.2	114.0
5	9	3	7	6.3		24.6	23.3	7.1	98.0
6	10	7	1	6.0		24.6	21.4	7.3	98.4
7	1	1		1.0		24.6	20.5	7.0	93.9
9	3	6	6	5.0		26.5	17.6	7.2	99.8
11	0	2	5	2.2		26.7	15.5	7.0	94.7
13	8	5	13	8.7		26.2	17.0	7.0	95.4
					3.7 (0.8)				
Lee River									
G	1	2	5	2.7		27.0	23.1	7.8	111.6
5	0	5	1	2.0		27.9	23.1	10.4	150.6
7	6	4	5	5.0		27.5	25.1	9.3	136.3
					3.2 (0.9)				
Cole River									
H	1	3	4	2.7		27.4	23.0	9.5	136.8
I	2	0	3	1.7		27.4	22.7	10.5	151.4
					2.2 (0.5)				
Kickamuit River									
J	4	12	1	5.7		25.4	23.9	9.8	137.1
2	0	0		0		25.3	23.9	10.8	149.7
8	0	0		0		25.2	23.6	8.0	110.8
9	0	0		0		25.5	24.1	9.6	134.2
					1.4 (1.4)				

Table F-43 (continued).

Station	Replicate I	Replicate II	Replicate III	Mean	River Mean (s.e.)[1]	Temp °C	Salinity ‰	D.O. (mg/l)	Percent Saturation
					August 17, 18,19, 1998				
Taunton River									
A	0	0		0		24.4	21.9	6.3	85.4
B	1	0	3	1.3		24.4	22.7	7.1	94.1
C	0	14	0	4.7		25.0	24.9	5.9	80.0
D	1	1		0.7		23.7	26.3	6.6	90.8
E	3	0	3	2.0		24.4	25.0	7.2	98.3
3	7	6		6.5		23.8	23.7	7.1	95.2
5	0	1	3	1.3		24.5	23.3	6.7	92.2
7	1	1	3	1.7		24.5	22.4	7.7	105.2
9	6	1	2	3.0		24.5	22.0	6.7	90.6
10	0	0	0	0		24.5	21.8	6.6	86.8
13	0	2	4	2.0		24.5	22.0	6.7	90.5
16	1	6	2	3.0		24.4	23.3	6.5	90.0
					2.0 (0.4)				
Lee River									
G	1	0	2	1.0		26.7	26.0	7.0	101.6
1	0	0		0		26.0	26.0	5.9	82.9
5	7	7		7.0		24.3	24.7	5.8	79.9
					2.7 (2.2)				
Cole River									
H	3	1	2	2.0		25.7	25.5	5.6	79.1
I	0	3	0	1.0		26.0	24.0	6.2	89.8
					1.5 (0.5)				
Kickamuit River									
J	0	1	0	0.3		25.4	25.9	7.8	109.5
1	0	0		0		25.1	26.1	8.7	122.4
7	0	1	4	1.7		24.5	25.8	5.9	81.4
9	0	0		0		24.9	25.9	7.8	109.0
					O.5 (0.4)				

Table F-44a . Stratified mean number of young-of-the-year winter flounder per haul during two June sampling series, Mount Hope Bay tributaries, 1992-1998.

Year	Number of samples	Mean	S.E.	95% confidence limits
1992	20	34.56	7.929	±17.666
1993	24	0.42	0.164	±0.348
1994	30	1.74	0.421	±0.881
1995	36	6.34	0.882	±1.830
1996	41	2.46	0.467	±0.955
1997	37	3.99	0.944	±1.948
1998	41	1.25	0.367	±0.742

Table F-44b. Stratified mean number of young-of-the-year winter flounder per haul during five June-August sampling series, Mount Hope Bay tributaries, 1992-1998.

Year	Number of samples	Mean	S.E.	95% confidence limits
1992[1]	-	-	-	-
1993	70	1.60	0.390	±0.788
1994	75	1.83	0.233	±0.469
1995	94	4.82	0.626	±1.251
1996	99	4.13	0.303	±0.606
1997	95	3.48	0.437	±0.874
1998	103	1.92	0.264	±0.517

[1]Sampled in June only.

Table F-45. July mortality rates, young-of-the-year winter flounder, Mount Hope Bay, 1992-1998.

	Survival Rate	Mortality Rate	Z_{mon}
1992	-		
1993	0.465	0.535	0.766
1994	0.563	0.437	0.575
1995	0.457	0.543	0.782
1996	0.183	0.817	1.698
1997	0.309	0.691	1.174
1998[1]	-	-	-

[1]Catch rate did not decline until August; see text.

Table F-46. Total length data (mm) for young-of-the-year (age 0) winter flounder collected by beach seine 1992-1998.

Date	Mean	s	s.e..	Range	n	Daily Instantaneous Growth (g_i)[1]
1992						
10,11 June	39.0	7.1	0.4	24 - 62	355	
23,24 June	45.9	8.3	0.4	27 - 79	368	0.0125
1993						
8,9 June	41.1	7.0	2.6	33 - 54	7	
22,23 June	51.2	7.5	1.5	36 - 65	26	0.0157[2]
12,13 July	55.2	8.7	1.1	38 - 75	68	
27,28 July	58.1	9.5	1.3	45 - 85	55	
17,18 August	55.2	10.9	1.0	32 - 81	115	0.0042[3]
1994						
8-10 June	44.8	7.7	1.1	36 - 53	48	
21-23 June	53.0	5.8	0.4	37 - 69	176	0.0129[2]
13-15 July	60.2	7.9	0.9	41 - 80	86	
26-27 July	62.3	6.0	0.8	47 - 73	56	
17-19 August	60.4	8.5	1.0	42 - 79	75	0.0043[3]
1995						
7-9 June	44.4	6.4	0.4	30 - 76	276	
21-23 June	48.7	7.5	0.4	28 - 72	392	0.0066[2]
12-14 July	52.7	8.2	0.5	31 - 78	326	
26-28 July	55.1	9.7	0.7	34 - 88	205	
21-23 August	51.5	7.1	1.4	35 - 66	25	0.0020[3]
1996						
10-12 June	47.8	6.6	0.6	30 - 66	126	
25-27 June	57.6	8.3	0.7	29 - 79	129	0.0124[2]
10-12 July	58.9	10.7	0.6	33 - 87	364	
25-27 July	66.4	11.3	0.7	25 - 94	234	
13-14 August	67.0	11.0	0.9	44 - 94	166	0.0050[3]
1997						
9-11 June	45.6	7.6	0.6	23-64	162	
24-26 June	52.6	6.9	0.5	37-69	214	0.0095[2]
14-16 July	53.9	7.7	0.5	29-72	270	
28-30 July	55.8	7.8	0.6	36-74	156	
13-15 August	56.8	8.2	0.8	38-76	117	0.0034[3]

Table F-46 (continued).

Date	Mean	s	s.e..	Range	n	Daily Instantaneous Growth (g_l)[1]
1998						
8-10 June	38.6	6.9	1.1	23-57	39	
22-24 June	49.4	11.2	1.2	27-89	94	0.0176
8-10 July	54.4	8.9	0.8	34-80	116	
22-24 July	55.8	11.0	0.8	24-97	178	
17-19 August	60.7	11.0	1.0	33-89	128	0.0065

[1] $g_l = \frac{\ln(l_t/l_o)}{t}$

[2] For June only.

[3] June to August.

Table F-47. Numbers of young-of-the-year winter flounder per 10 m² (except New York) collected in Mount Hope Bay, Massachusetts, Rhode Island, Connecticut and New York surveys, 1992-1998.

	1998		1997		1996		1995		1994		1993		1992	
Survey	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e	Mean	s.e..
Massachusetts														
Mount Hope Bay[1]														
(June)	0.059	0.017	0.185	0.044	0.113	0.022	0.297	0.040	0.083	0.019	0.019	0.007	1.600	0.400
(June-Aug)	0.099	0.012	0.163	0.020	0.193	0.014	0.225	0.029	0.101	0.013	0.074	0.018	-	-
MDMF[1]	1.57	0.27	0.390	0.050	2.170	0.040	1.570	0.072	1.480	0.190	0.660	0.092	2.920	0.466
Rhode Island														
RIDEM[2]														
(June) 4 stations	0.043	0.043	0.022	0.022	0.032	0.021	0.490	0.284	0.038	0.030	0.194	0.159	0.188	0.010
16 stations	0.054	0.024	0.109	0.046	0.083	0.038	0.249	0.095	0.059	0.024	0.097	0.020	1.283	0.586
(June-Aug) 4 stns.	0.039	0.018	0.075	0.046	0.054	0.019	0.167	0.110	0.036	0.009	0.106	0.058	0.610	0.297
16 stns.	0.051	0.012	0.115	0.026	0.077	0.019	0.172	0.057	0.074	0.022	0.163	0.039	1.000	0.246
Coastal ponds	0.99	0.18	1.17	0.21	0.83	0.18	0.59	0.14	0.37	0.14	0.27	0.12	-	-
Connecticut														
DEP seine (Sept)[3]	0.67 (0.43-1.01)		1.03 (0.65 - 1.52)		0.41 (0.28 - 0.58)		0.86 (0.54 - 1.34)		0.4 (0.36-2.50)		1.39 (1.01 - 1.88)		0.73 (0.51 - 1.09)	
Niantic River														
(early)[4]	4.63(3.25-6.00)		1.92 (1.67-2.50)		0.88 (0.50 - 1.50)		8.75 (5.25 - 14.00)		12.88 (12.55 - 17.25)		1.06 (0.70 - 1.50)		9.00 (5.75 - 12.25)	
(late)	1.50 (0.67-2.000		0.70 (0.20-1.000		0.30 (0.20 - 0.60)		1.58 (1.20 - 2.67)		6.29 (3.83 - 7.50)		0.50 (0.30 - 0.70)		2.81 (2.38 - 3.33)	
New York														
Peconic Bay[5] (May-Oct)			1.48 (1.23-1.77)		3.80 (3.14-4.56)		3.02 (2.55-3.54)		2.44 (1.98–2.96)		4.73 (3.96-5.61)		11.49 (9.14-14.3)	

[1]Stratified means.
[2]Four stations include Kickamuit River, Spar Island, Hog Island, Spectacle Cove - those in or near Mount Hope Bay. Sixteen stations run throughout Narragansett Bay.
[3]Mean seine catch = all sites, September. 95% confidence limits in parentheses.
[4]Median values for lower river; early = May-July, late = August-September. 95% confidence limits in parentheses.
[5]Geometric mean number per trawl tow = all sites, May-October. 95% confidence limits in parentheses.

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Heavy Metals

Introduction

Heavy metals occur naturally in the earth's environment and in some cases (e.g., copper, zinc, selenium, molybdenum) are essential micronutrients for plants and animals. Many heavy metals however are produced or concentrated through anthropogenic activities and end up in waterways at potentially harmful concentrations. This can occur, for example, by direct discharges from manufacturing operations, wastewater treatment facilities, incineration of waste materials, and as a result of mining operations (Campbell 1994; Gibbs and Miskiewicz 1995, Radach and Heyer 1997, and others). At low levels heavy metals can be harmful to fish by altering prey availability via shifts in community structure (see for example Clements and Rees 1997). As they grow, marine organisms, particularly filter-feeding shellfish, can concentrate sublethal levels of these metals which may be passed along a food chain to humans via direct ingestion (Jennings and Rainbow 1979, Atchison et al. 1987, Zia and Alikhan 1989, Leah et al. 1992, Nott and Nicolaidou 1993, Reinfelder and Fisher 1994). Since heavy metals are produced at power stations burning fossil fuels, sampling them has regularly been part of the studies at Brayton Point.

Heavy metal concentrations in quahogs (*Mercenaria mercenaria*) have been analyzed at a minimum of two locations in Mount Hope Bay since 1979 (Table M-1). Station A' under the Brayton Point discharge plume was selected to mirror near-field bioaccumulation of metals potentially released by the power station and Spar Island; Station F, was selected as a control (Figure M-1). Collections were made annually in October near the end of each growing season. A comparison of concentrations at A' and F was the primary initial focus, but changes over time, if any, were also of interest as the data base enlarged. Metals analyzed initially included aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, vanadium, and zinc. The list was shortened to eight metals in 1993, then expanded again in 1997 (Table M-1).

Under direction of the Brayton Point Technical Advisory Committee and NPDES permit, both sampling locations A' and F were located south of the power station. In October 1987, to investigate other potential heavy metal sources, two new stations located in the Taunton River north of the generating station were sampled, Winslow Point and Montaup. These were sampled in addition to A' and F since the Taunton River has a long history of industrial and municipal discharges (see for example MDWPC 1979, Ackerman 1981). Of the nine elements measured in quahogs from the four locations in 1987, it was apparent that all were present throughout the ecosystem, not just downstream of Brayton Point; no evidence of their origin was found.[1] For five elements: aluminum, chromium, copper, iron, and nickel, the concentration at one of the up-bay stations was greater in magnitude compared to any down-bay location. Conversely, concentrations of four elements were greater at a down-bay station than an up-bay location - cadmium, manganese, vanadium, and zinc.

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[1]Four elements - arsenic, cobalt, lead, and selenium - were not measured because of what is called "matrix interference" during analysis (MRI 1988a).

In June 1988, to assess heavy metals in quahogs at other stations north of the generating station, sampling occurred at three new locations - Lee River, Assonet River, and RB N in the Taunton River - as well as at Montaup and Station F (Figure M-1); Station A' was not sampled on that date. The Lee River sample was added to measure the concentration of metals in quahogs found just west of Brayton Point. The Assonet River location was chosen to show the concentrations of elements emanating from the Assonet River and Assonet Bay area (not shown in Figure M-1), while sampling at the RB N station measured those concentrations further north in the Taunton River. That summer sampling occurred once only, indicating in most cases that metal concentrations were greater in June than October (MRI 1988b).

From 1988-1992, October sampling was completed at six locations (F, A', Lee, Montaup, Assonet, and RB N). In 1993 the program was refined, reducing the number of stations to three, A', F, M, the number of metals to eight, but increasing sampling to three times annually, April, July and October. (Changes were instituted in July with the new NPDES permit so sampling did not occur in April 1993.) The six metals dropped from the program at that time were aluminum, arsenic, chromium, cobalt, manganese, and selenium; although not detected in Brayton's thermal effluent, mercury was added for the first time because of its significant human health concerns. With the exception of selenium, the metals deleted in 1993 were sampled again beginning in 1997 as part of program enhancements associated with the repermitting of Brayton Point Station.

Summary

In 1998 heavy metal concentrations in quahogs were analyzed at three locations in Mount Hope Bay (Station A' under the Brayton Point discharge plume and F near Spar Island) and its main tributary, the Taunton River (Montaup, Station M). Samples were taken in April, July, and November and analyzed for cadmium, copper, iron, lead, mercury, nickel, vanadium, and zinc. For the second time since 1992 samples were also analyzed for aluminum, arsenic, chromium, cobalt, and manganese, referred to here as the secondary metals. Paired comparisons of the longest time series, the autumn data from 1979-1998, indicated that metal concentrations were similar at Station A' and Station F in each case but iron, which occurred at greater concentrations at Station F. Mercury, with a six-year time series, also showed a significantly greater mean concentration at Station F, but only if the detection limit was used where censored data were available. Trend analyses indicated that arsenic was the only element showing a statistically significant linear relationship with time; concentrations appeared to increase by 0.18 ppm per year from 1979-1992 and 1997-1998. Although only six years' data were available for mercury (1993-1998), concentrations of that element also appeared to increase over time with a slope ranging from 0.006 to 0.015 depending on the substitution method used to handle values below the test method's detection limit. No trends in concentration were detected at Taunton River Station M at the conventional 95% probability level. Comparisons of heavy metal concentrations at the three sampling stations over the 1988-1998 time series (excluding mercury and the secondary metals) indicated that copper, iron, and vanadium values showed statistically significant among-station differences. Copper and iron concentrations were highest at Montaup Station M. Vanadium mean concentrations were significantly greater at Station A' compared with those at M or F, inconsistent with the complete time series results. Metal concentrations compared over the three seasonal sampling events from 1994-1998 suggested that no

seasonal effect has occurred at the 95% probability level. At the 90% probability level nickel appeared higher in summer compared with spring and fall.

Methods

Quahogs were collected by rake on April 22, July 21, and November 5, 1998 from Stations A', F, and M (Figure M-1) and placed on ice in the field, then immediately in a freezer upon return for storage until they could be analyzed by a state certified analytical laboratory. In the field every effort was made to collect quahogs of similar size at each station since metal concentration may vary with size (Boyden 1974 and 1977, Wang and Fisher 1997, Table M-2). Approximately five quahogs from each location were shucked, pooled and blended by mixer, and an aliquot was wet-weighed in a beaker. Dry weight was obtained by heating a 100-ml aliquot in an oven at 105 C to a constant weight. Digestion on the wet-weighed sample followed immediately using first a solution of sulfuric acid, then nitric acid, followed by hydrogen peroxide. Atomic absorption spectrophotometry was utilized to analyze for the following elements in duplicate: aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, vanadium, and zinc.

Whenever an element was not detected in a sample set, the concentration of that element was considered to be less than the analytical detection limit of the method employed. Detection limits for some metals have changed over the years (see NEP and MRI 1998).

To determine if element concentrations appeared to be changing over time, simple linear regression analyses were performed on each element using element concentration as the dependent variable and year (entered as time t with 1979 = 1) as the independent variable. Paired t-tests were performed on each metal to determine if a significant difference ($p = 0.05$) in concentration was apparent between Stations A' and F. In cases where no difference was detected, data from the two stations were averaged for the regression analyses. Suggestions offered by Helsel (1990) were used to include less-than values (censored data) in the regression analyses. These included substituting zero, one-half the detection limit, and the detection limit itself. Regression coefficients were examined to determine if any were significantly different from zero; probabilities of Type I error of $p = 0.05$ or less were considered statistically significant.

Results and Discussion

The longest time series of heavy metal data consisted of the autumn samples from Stations A' near Brayton Point and Station F near Spar Island taken from 1979 through 1998 and analyzed for cadmium, copper, iron, lead, nickel, vanadium, and zinc (Table M-3). Metal concentrations were compared between these two sites using paired t-tests. Paired comparisons were also completed for the five metals sampled in 1997 and 1998 for the first time since 1992 (aluminum, arsenic, chromium, cobalt, and manganese; referred to here as secondary metals) and for the 1993-1998 series of mercury samples(Table M-4, M-5). With the exception of iron, paired t-tests indicated there were no significant differences in wet-weight metal concentration between Stations A' and F for the long time series metals ($p=0.05$, Table M-5). In the case of iron, concentrations averaged significantly higher at Station F (time series mean at F = 20.1 ppm, mean at A' = 15.7 ppm, $p = 0.027$). Mercury, with

only a six-year time series, also showed a mean concentration significantly greater at Station F (time series mean at F = 0.07 ppm, mean at A' = 0.04 ppm, p = 0.046). The mercury time series contained two censored values (1993, F and 1994, A'), a statistically significant difference being obtained only when the detection limit was used for those two values. No difference was detected when one-half the detection limit was substituted nor when zero was substituted for the censored values.

For each metal, except iron and mercury, mean differences between Station A' and F were small. This was particularly true for lead and aluminum where the means were nearly identical (Table M-5). The power to detect differences of such low magnitude is directly related to the sample size and standard deviation of the differences and was quite low with the 10 to 20 pairs of samples available (only six in the case of mercury; Cohen 1988, Hintze 1996)[2]. As an example, using zinc, a mean difference between the two stations of 1.11 ppm was noted over the 20-year period (standard deviation of the difference = 4.79). Statistical power amounted to 18% (probability of Type II error = 82%[3] with a Type I error of 5%). To increase power from that realized in the current analysis to a more acceptable 80% would require approximately 147 pairs of samples. In other words a great many samples would be required to detect statistically such a small difference between stations. Power among the remaining metals ranged from 5% and 6% for aluminum and cobalt, respectively, which occurred at similar mean levels at both stations to 27% for copper. Sample sizes required to realize power of 80% for these metals ranged from over 1000 to 83, respectively.

Trends in metal concentration using October values averaged at A' and F, except for iron and mercury which were treated separately by station, were not detected for any of the continuously sampled metals at the conventional 95% level of statistical significance nor at the lower 90% level (Figure M-2, Table M-6). For cadmium, lead, and vanadium this was true regardless of substitution method used for the censored data (Table M-6). Among the secondary metals no trends were detected at the 95 or 90% level except for arsenic. For arsenic a significant positive slope was apparent (p = 0.012; Table M-7). For that metal levels were consistent from 1980 through 1986 but increased after that year resulting in an overall concentration increase of 0.183 ppm per year over the 14 years available with a 95% confidence interval around the slope of 0.049 to 0.317. The upward trend was also statistically significant when Station A' and Station F were examined separately (0.183 ppm per year in each case, Table M-7).

Mercury concentrations were also examined for trends although only six years' data were available (Table M-3, Figure M-2). Analyses were completed separately for Station F and A' since paired t-tests indicated that concentrations averaged significantly higher at F. A significant upward trend was detected with data collected at A' regardless of substitution method used for the censored

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[2]No correction was made to the power calculations for the observed correlation between metal concentrations at Station A' and F as suggested by Cohen (1988). By choosing not to apply that correction the referenced power is likely understated and therefore conservative.

[3]Type II error occurs when the null hypothesis (= no difference between means) is accepted as true when it is, in fact, false. Power describes the probability of not making such an error. Type I error occurs when the null hypothesis is incorrectly rejected and was set at 5% for this review.

value in 1994 although when substituting zero for that value the slope (0.009 ppm per year) was significantly different from zero only at the 90% level (p = 0.061, Table M-6). Substituting one-half the limit for the 1994 value produced a slope of 0.008 ppm per year (p = 0.0.014) and substituting the limit itself a slope of 0.006 ppm per year (p = 0.010). At Station F, data suggested an upward trend with all three substitution methods although only at the 90% probability level. Since the censored value occurred at the beginning of the time series (1993) substituting a zero for that value produced the steepest slope (0.015 ppm per year, p = 0.084; Table M-6). Substituting one-half the detection limit and the detection limit itself resulted in estimated slopes of 0.013 (p = 0.084) and 0.012 (p = 0.087), respectively.

Although just six annual data points make identifying patterns uncertain, the accumulation of mercury in Mount Hope Bay quahogs at A' as measured in the fall in most cases appear comparable to values observed in other Massachusetts shellfish while those at Station F appear relatively high. Mean wet weight mercury concentrations reported for soft-shelled clam ranged from 0.01 to 0.053 ppm for Boston and Salem Harbor and other Massachusetts coastal waters (Capuzzo et al. 1986; Wallace et al 1988; Schwartz et al. 1993). Reported mean values in ocean quahogs and blue mussel were 0.018 and 0.021 ppm under the same studies. In 1997 and 1998, the two most recent years, over all three sampling stations and three dates of the Mount Hope Bay study (Figure M-3) mercury values ranged from 0.03 at Station F in June 1997 to 0.24 ppm at M in October 1997. Readings exceeding 0.05 ppm, near the high value reported for Boston Harbor soft-shelled clams, were obtained in June and October at A', July and October at Station F, and on all three dates at M in 1997 and in all cases in 1998. O'Connor and Beliaeff (1995) listed 0.24 ppm dry weight as the point where mercury concentrations can be considered high. This was based on the mean plus one standard deviation for seven species of shellfish monitored throughout the United States. All mercury values in 1998 exceeded this level, ranging from 0.31 to 0.91 ppm dry weight. Although Mount Hope Bay values appear relatively high, the FDA maintains an action limit of 1 ppm wet weight for mercury in fish, four times greater than the high value recorded in Mount Hope Bay shellfish samples.

Among the 11 metals for which no trends were detected all slopes were negative (Table M-6, M-7). The probability of obtaining 13 negative slopes in 16 tests[2] by chance alone is only 0.9% (see any binomial probability table such as Zar 1996) and at least suggests that the concentration of these elements in quahog tissue is heading in the preferred direction.

Statistical power associated with the above trend analyses was examined following Neter et al (1996). Two variables were considered, the power or Type II error rate associated with the ability to detect a positive or negative rate of change over the 1979 through 1998 time series and the rate of change or slope which could be detected with the current sampling plan with power set at 80% and 90% (Type II error of 20% and 10%, respectively). For example, using the nickel analysis of the 1979 - 1998 October concentrations, test results showed a least squares regression coefficient (slope) of -0.253 ppm per year. From the test we concluded that the observed slope was not statistical

[2]The 16 tests included in this statement consist of two tests for lead (A' and F), two for mercury (A' and F), two for arsenic (A' and F), plus the 10 remaining metals.

different from zero and therefore there appears to be no linear relationship between nickel concentration and year. The Type I error rate for the analysis was set at 5% (i.e. there was a low, 5% chance that we would fail to conclude that the slope was zero when it was in fact zero or that we would conclude there was a relationship between nickel concentration and time when there was not). In this analysis a Type II error rate of 55% occurred. In other words there was a 55% chance that we failed to detect a slope which was in fact different from zero. Power, the probability of reaching the correct conclusion, was therefore only about 45% and the probability that we could incorrectly conclude that no relationship exists relatively high. With the current data set, Type I error set to 5% and Type II error set to 20% or 10% (power = 80 or 90%) we would be able to detect an annual change in nickel concentration of about ± 0.40 or ± 0.45 ppm, respectively, with the data in hand. (Table M-8) summarizes these power analyses for each metal including the shorter secondary metal time series.

Heavy metal concentrations (wet-weight) from quahogs collected in October at Montaup Station M from 1988, when sampling began there, through 1998 appear in Figure M-4 and Table M-9. Included are the secondary metals sampled from 1988 through 1992 and again in 1997 and 1998. Linear regression analysis suggested that no significant trends occurred over the eleven-year period at the 95 % statistical probability level for any of the long time series metals. This was also true for the five secondary metals for which seven years were available and for mercury with a six-year time series. A single trend (positive) was detected at the 90% probability level for vanadium when the detection limit was substituted for the three censored values (1992,1997,1998). Since two of the three censored values occurred at one end of the time series, substituting the highest possible value in those cases may have biased the results. Mercury and arsenic which, through 1997, each showed an increasing trend over their short time series at the 90% probability level, declined in 1998 so that those apparent trends no longer appear significantly different from zero (Figure M-4, Table M-10).

Metal concentrations were compared among the three currently sampled stations - near-field Station A', Spar Island Station F, and Montaup Station M - using a one-way analysis of variance and the eleven annual October values (1988-1998; the short mercury and secondary metal data sets were excluded). One-half the detection limit was substituted for the censored values. Based on Bartlett's and Levene's tests for homogeneity of variances, copper and iron values were log (base e) transformed to equalize the variances; variances tested homogenous for the other elements at the 95% probability level . No among-station differences were detected for cadmium ($p = 0.894$), lead ($p = 0.211$), nickel ($p = 0.892$), and zinc ($p = 0.733$). Significant differences were detected however for copper ($p = 0.040$), iron ($p = 0.0001$) and vanadium ($p = 0.001$, Table M-11). Copper concentrations were statistically higher at Montaup Station M (mean = 2.8 ppm) then at Spar Island Station F (mean = 1.9 ppm). Multiple comparison procedures were unable to decern whether Station A' off Brayton Point (mean = 2.2 ppm) belong with M or F. Iron concentrations were significantly greater upstream at Station M (mean concentration = 30.8 ppm) while similar over this shorter time series at Station A' (mean = 12.6 ppm) and F (mean = 16.9 ppm); iron concentrations at Station F averaged higher than at Station A' over the 1979-1998 time series, see above.). Vanadium mean concentrations were significantly greater at Station A' (mean concentration = 0.45 ppm) then at M or F (means = 0.27 and 0.30 ppm, respectively). Interestingly, no difference was detected between Station A' and

Station F for vanadium when the entire 1979 through 1998 time series was examined using paired t-tests (n = 13 pairs, see above).

For the four metals where no difference was detected among stations using the autumn data, statistical power was relatively low primarily because differences between stations were low. For example, for zinc, power was 10% (probability of Type II error = 90% with Type I error = 5%; Cohen 1988, Hintze 1996). In this case approximately 170 samples would have been required at each station to bring power up to 80% and 223 samples would have been necessary to achieve power of 90%. For the remaining metals power for the current analysis amounted to 7% for cadmium and nickel, 32% for lead. Mean concentrations among station for cadmium and nickel were nearly identical over the eleven-year time series, hence a vast number of samples (474 and 465, respectively) would be necessary to separate them with power of 80%. For lead somewhat greater differences were observed but 34 samples would still have been required to reach power of 80%. In these cases the data strongly suggest that metal concentrations do not differ among station.

Since heavy metal concentration is known to vary with sampling season in some shellfish (see for example Riget et al. 1996), wet-weight values were compared over the three seasonal sampling events using a one-way analysis of variance, stations as replicates, including 1994 through 1998 to provide 15 data points per season (Table M-12, M-13). No seasonal effect was detectable for any of the eight metals at the 95% level ($p = 0.05$). At the 90% level ($p = 0.10$) a difference was detected for nickel, July's mean value (1.4 ppm) exceeding April (1.1 ppm) and October (1.1 ppm). Zinc showed the largest seasonal variation among the remaining metals ($p = 0.141$) with a mean concentration of 22.9 ppm in summer (July 21) compared with a mean concentration of 19.8 ppm in both spring (April 22) and autumn (November 5). With only 15 data points in each season, differences appear subtle and would likely require a large number of readings to discern any real differences. This is reflected in low power values as described under the among-station analysis. For zinc, which displayed the widest range among seasons, power was only 40% with the 15 data points within each season. Approximately 37 samples would be required to achieve power of 80% with a Type I error rate of 5% and 48 would be required for 90% power.

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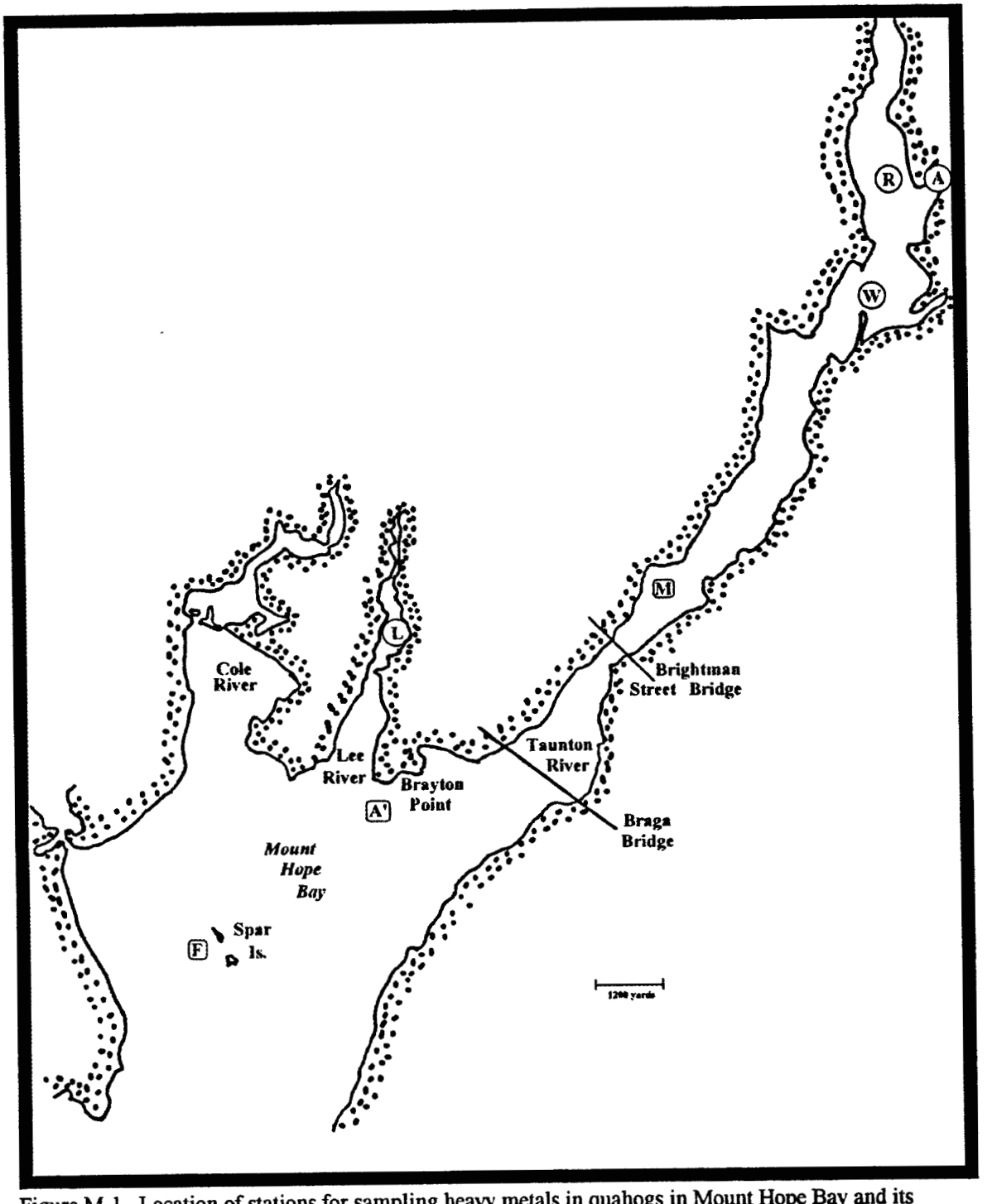
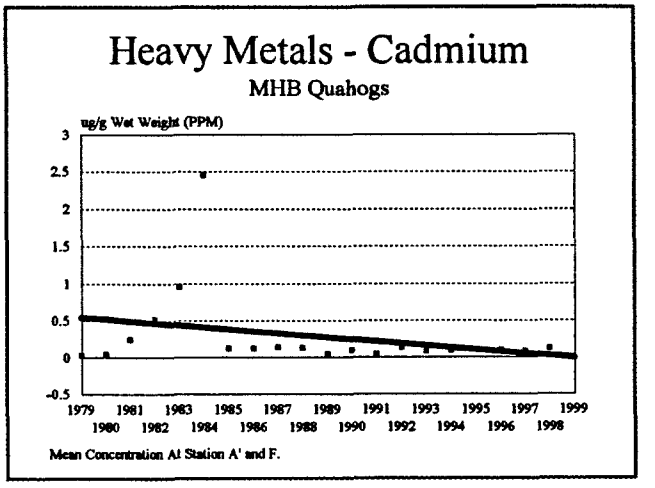
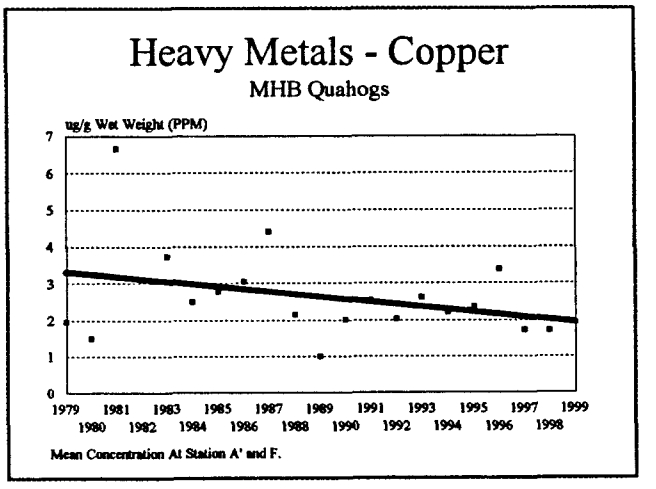


Figure M-1. Location of stations for sampling heavy metals in quahogs in Mount Hope Bay and its tributaries. Stations F, A', and M currently sampled.





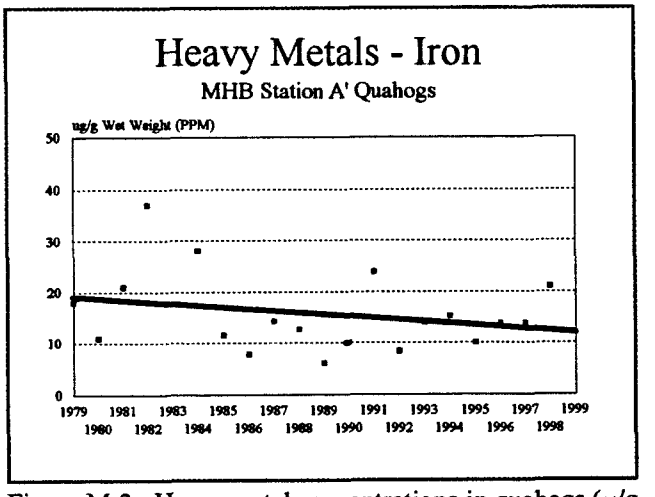
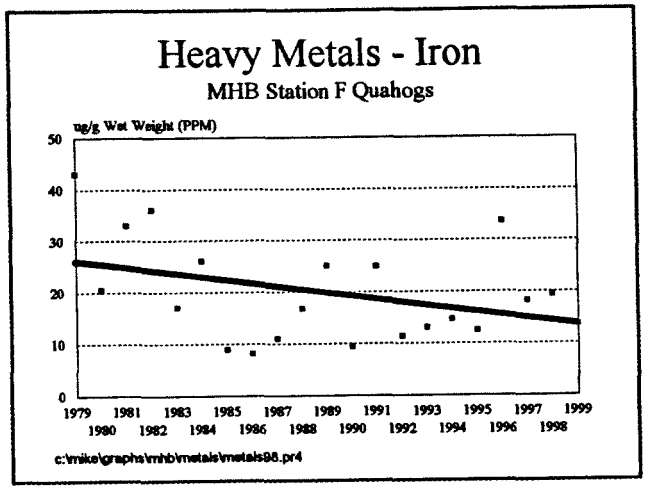
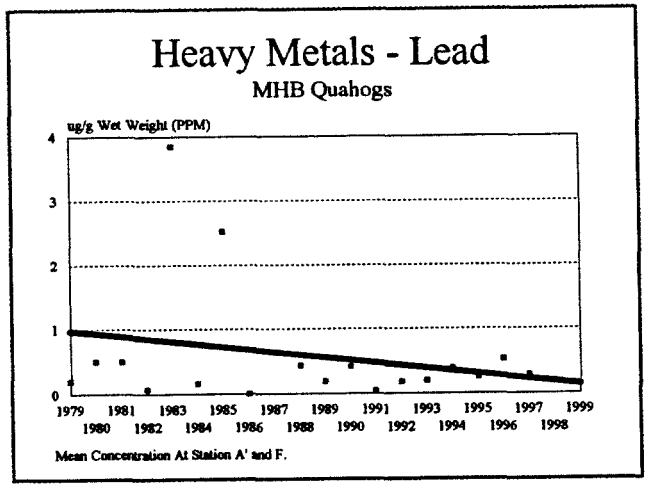
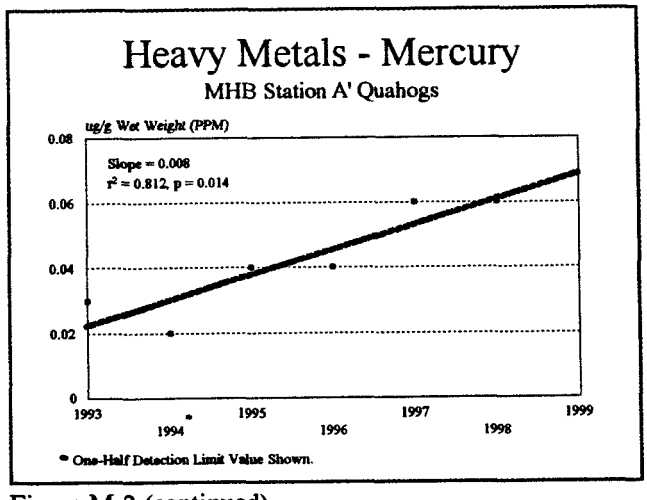


Figure M-2. Heavy metal concentrations in quahogs (μ/g wet weight), Mount Hope Bay, autumn, 1979-1998, with least square trend lines.







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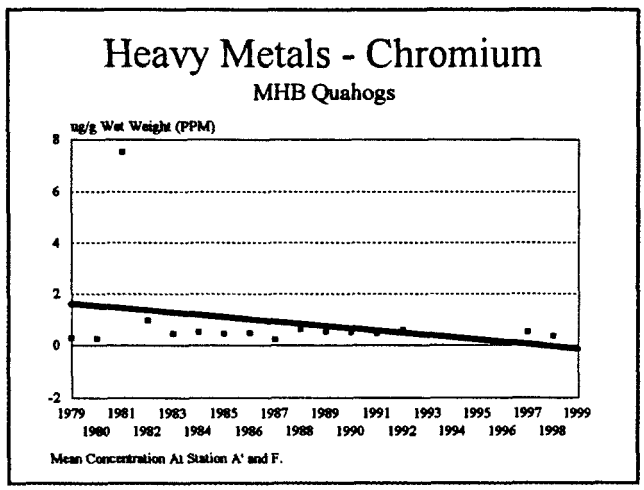

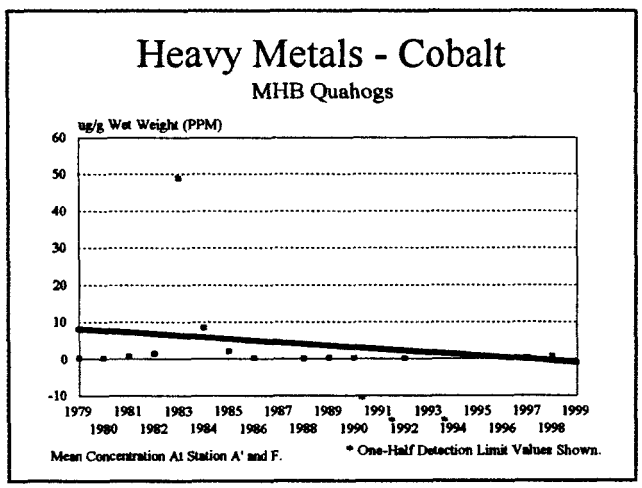

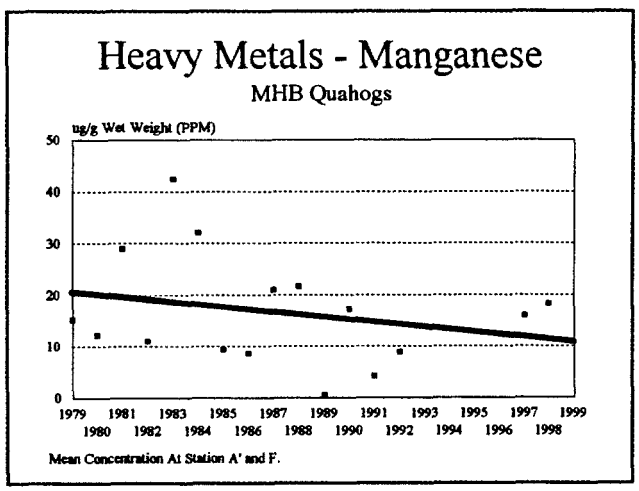

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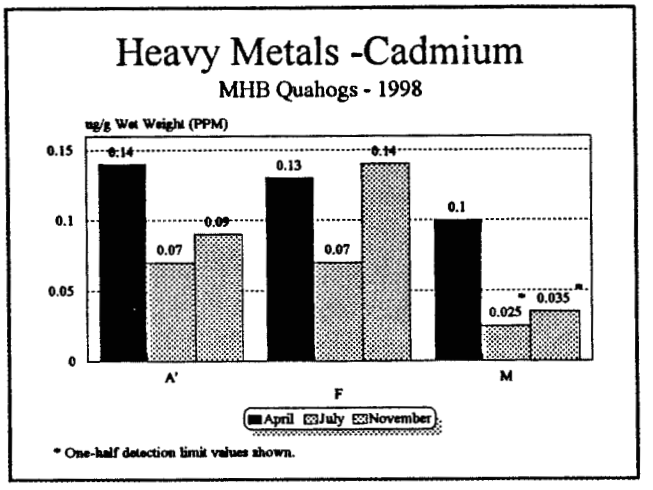
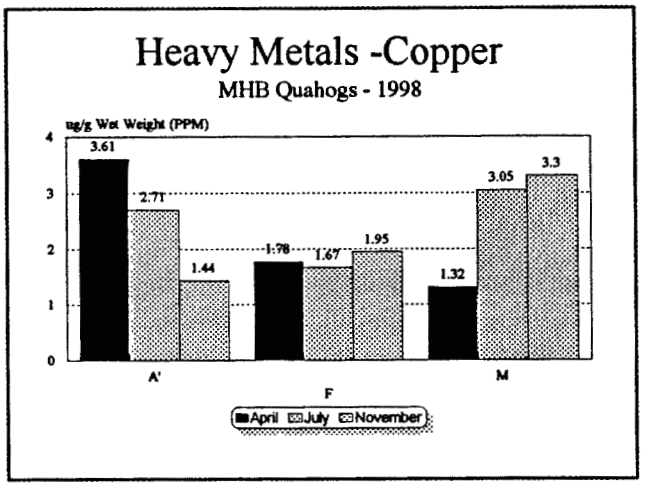




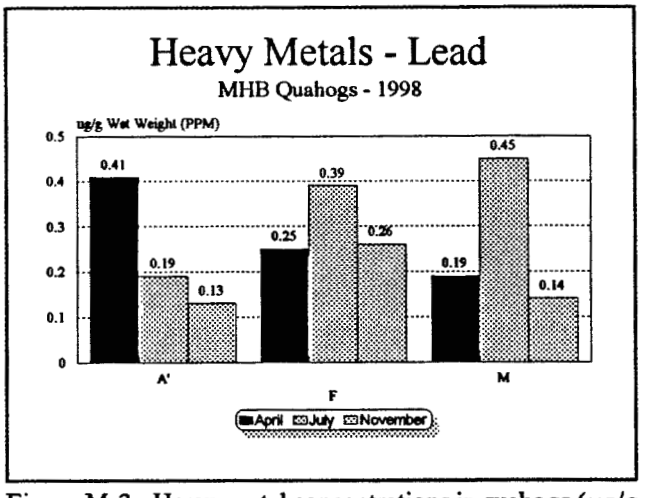
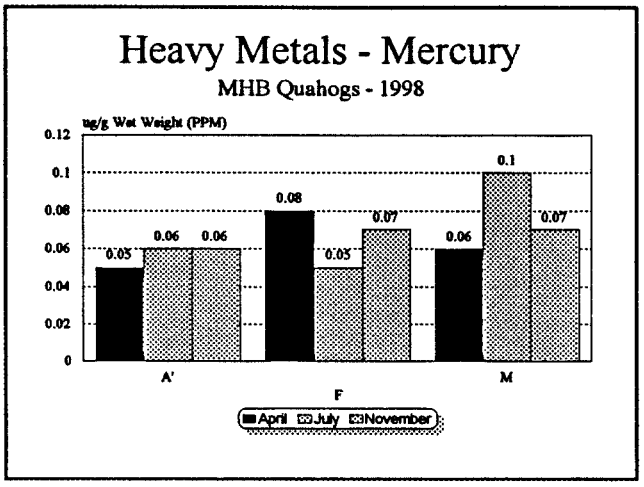
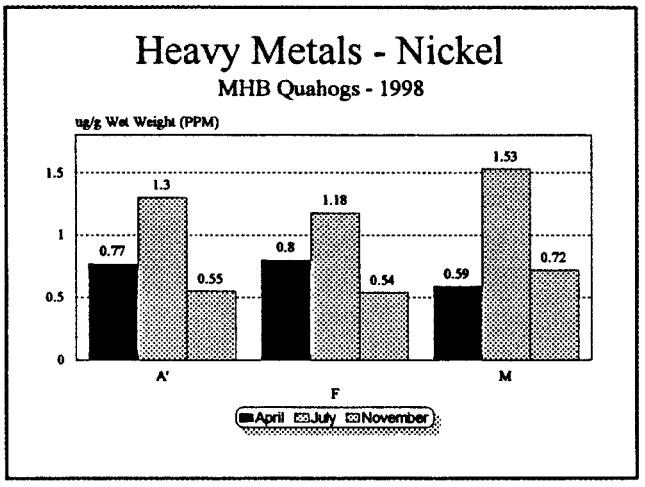
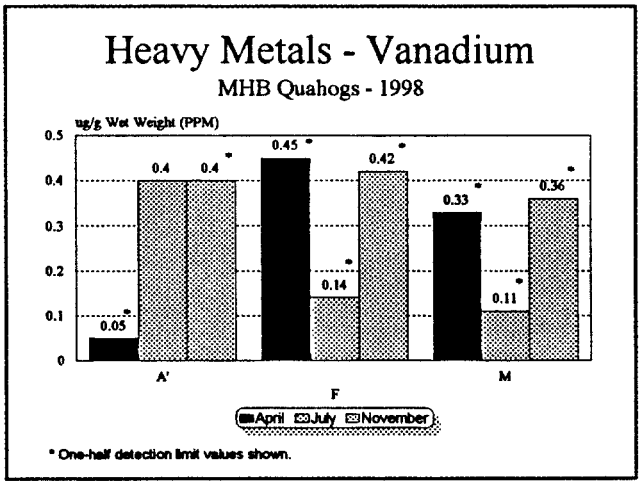


Figure M-3. Heavy metal concentrations in quahogs (μg/g wet weight), Mount Hope Bay, April, July, November 1998, by station.







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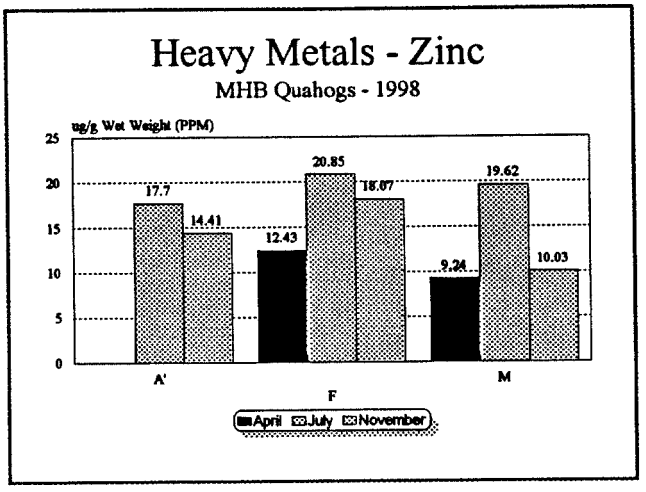

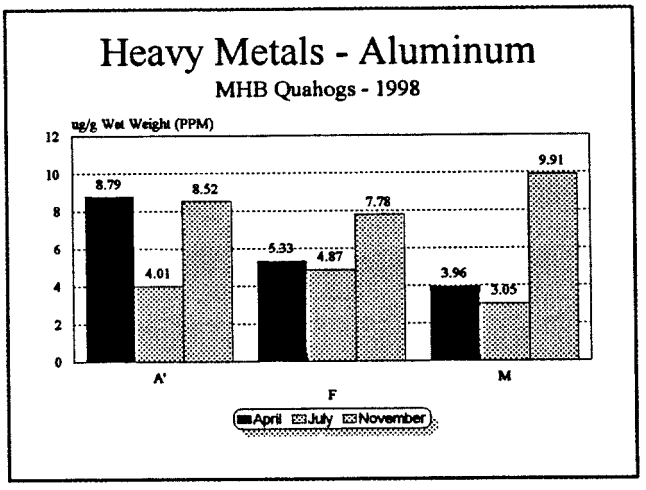

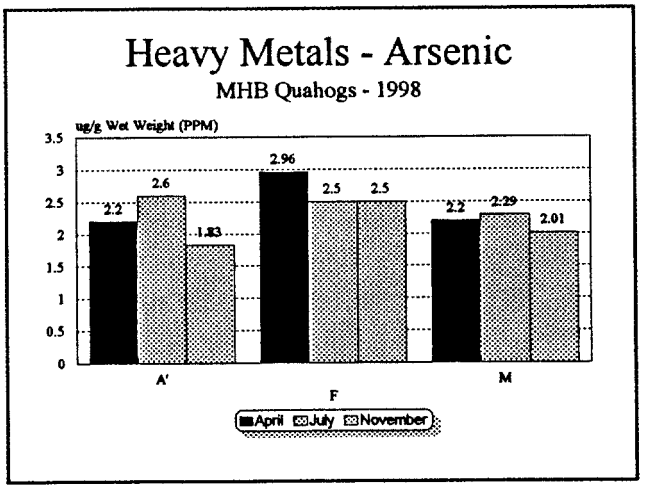

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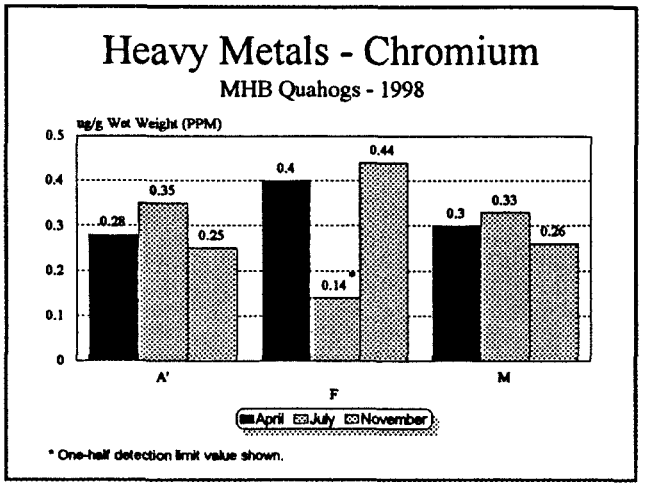

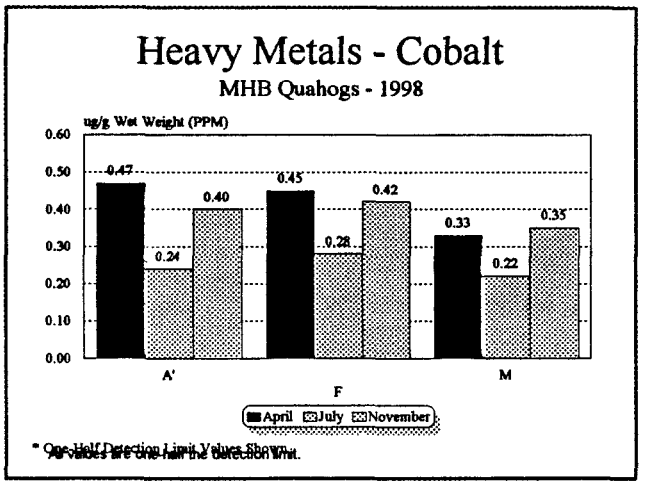

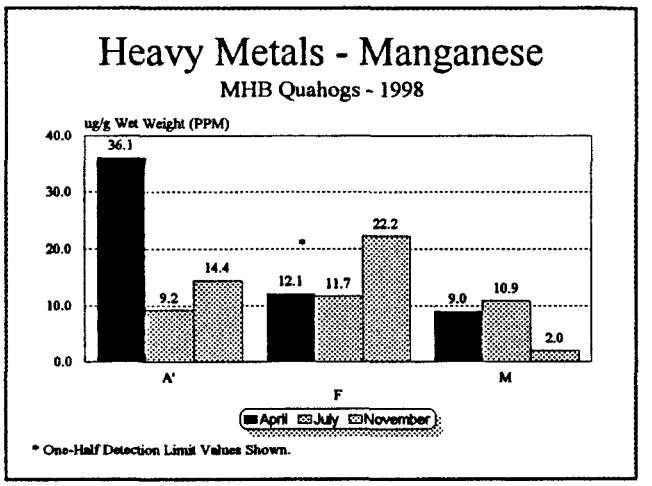

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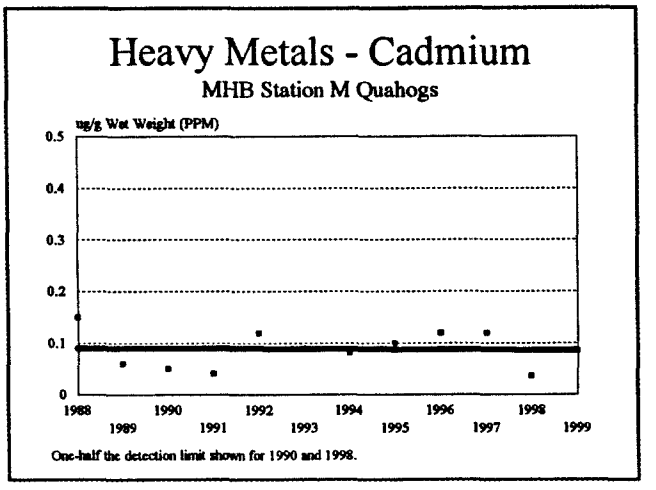
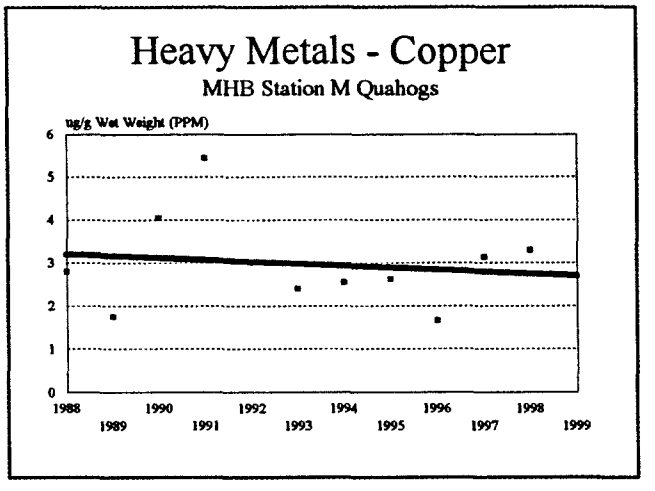




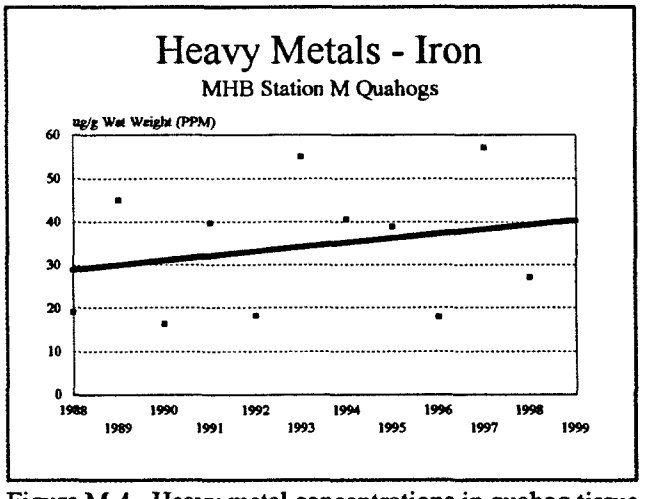
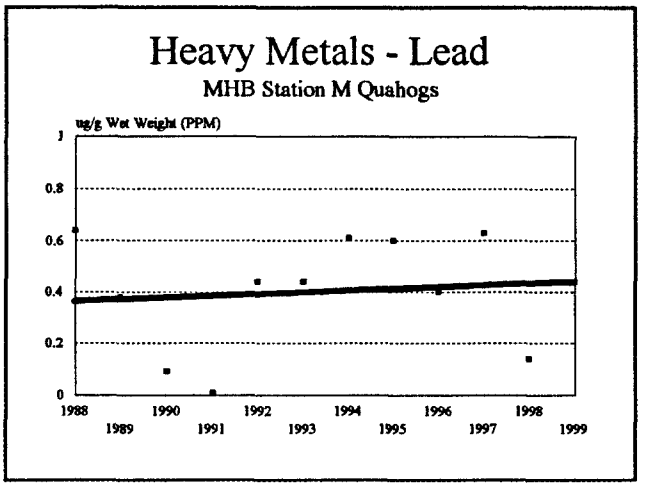
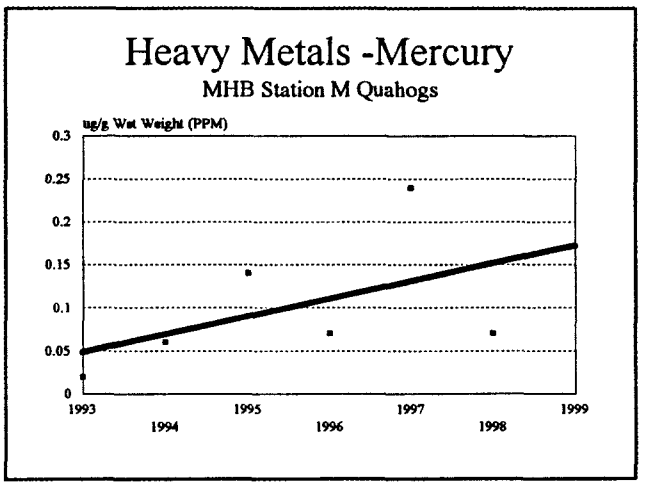
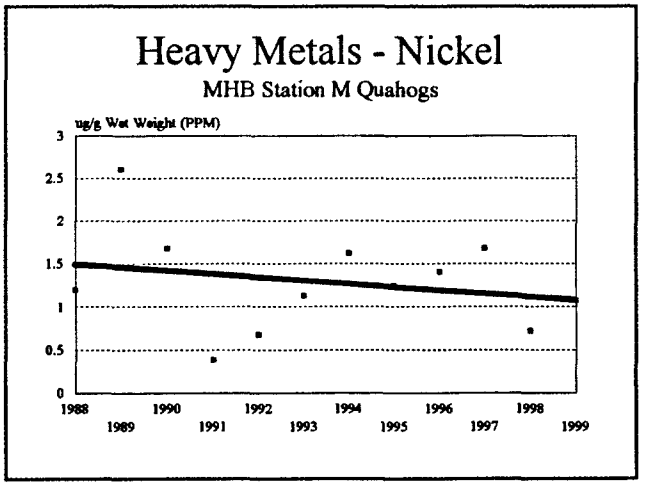


Figure M-4. Heavy metal concentrations in quahog tissue (μg/g wet weight), Mount Hope Bay Station M, 1988-1998, with fitted trend lines.







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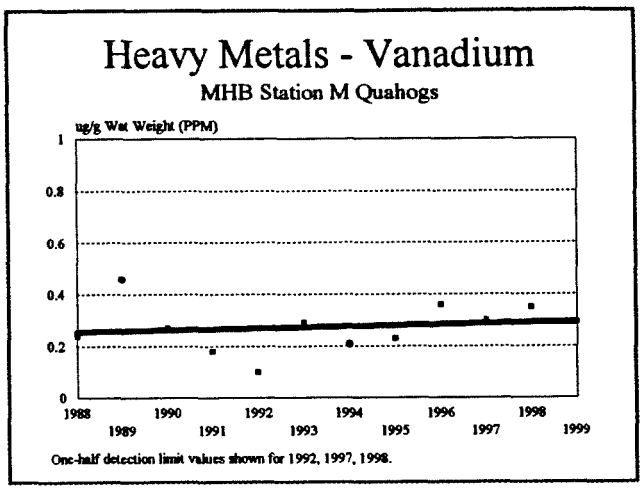

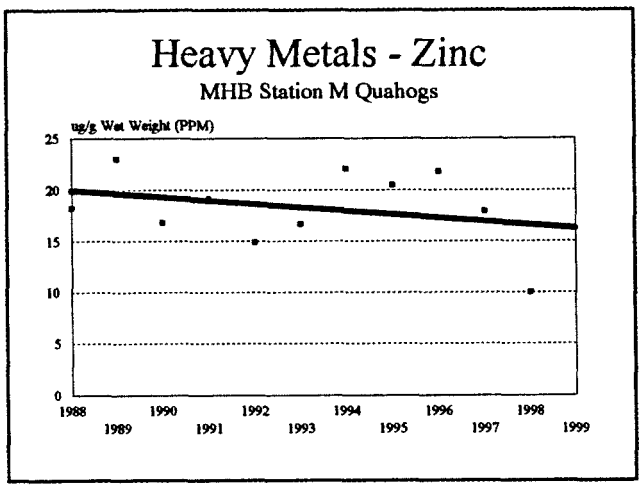

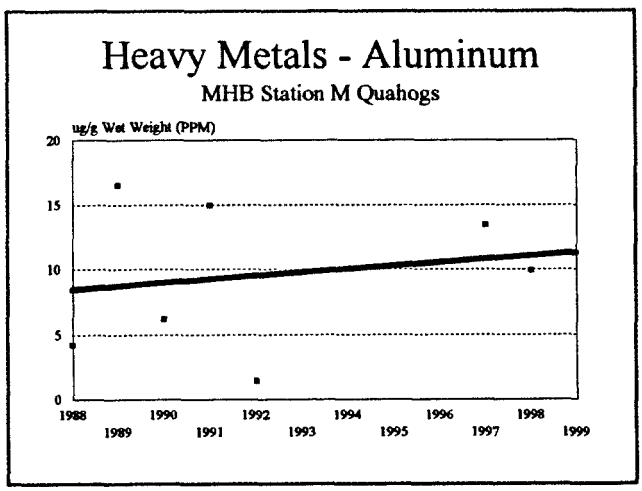

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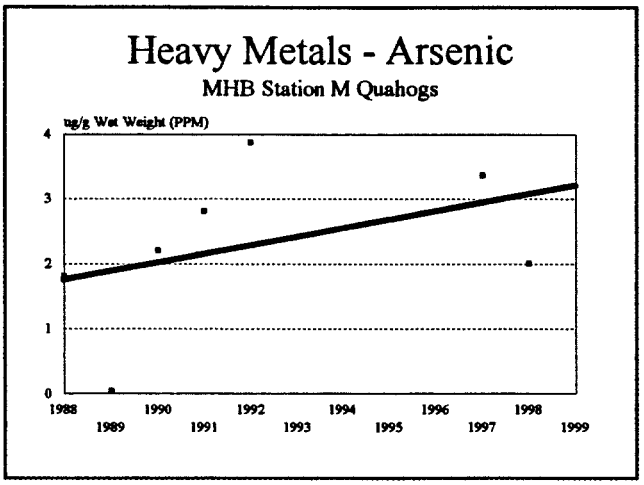

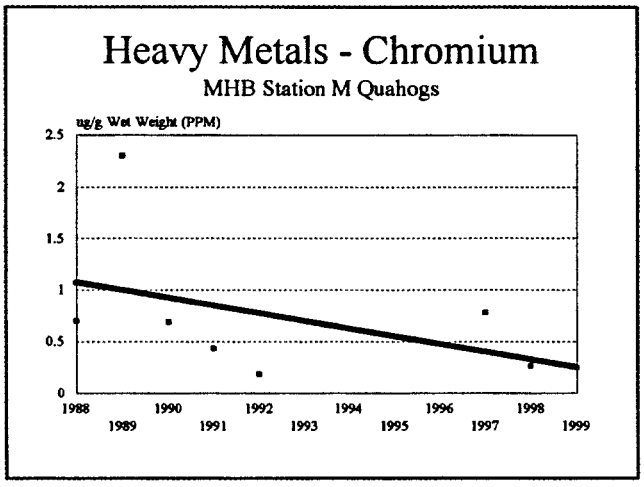

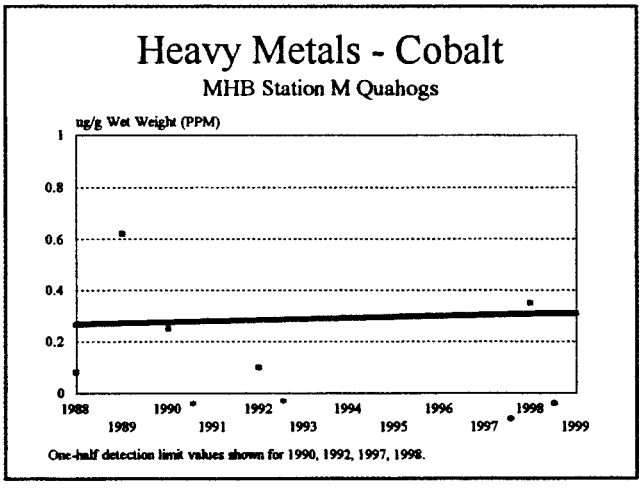

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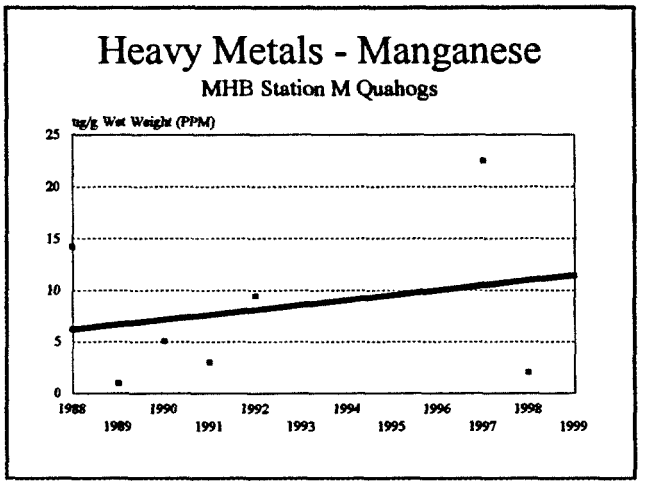

Figure M-4 (continued).

Table M-1. Sampling schedule for heavy metals in quahog tissue, Mount Hope Bay, 1979-1998.

Station	Sampling Month	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
A'	April																				
	July																				
	October																				
F	April																				
	June																				
	July																				
	October																				
M	April																				
	June																				
	July																				
	October																				
Montaup	October																				
Winslow Pt.	October																				
Lee River	June																				
	October																				
Assonet River	June																				
	October																				
RBN	June																				
	October																				

Samples analyzed for Aluminum, Arsenic, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Nickel, Selenium, Vanadium, Zinc.

Samples analyzed for Cadmium, Copper, Iron, Lead, Mercury, Nickel, Vanadium, Zinc.

Samples analyzed for Aluminum, Arsenic, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Nickel, Vanadium, Zinc.

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Table M-2. Shell length data (mm) for quahogs taken in Mount Hope Bay (F, A') and the lower Taunton River (M) for heavy metal analyses, 1998.

		F	A'	M
April				
	Mean	45.5	45.1	44.7
	s.e.	0.3	0.4	0.5
	n	10	10	10
	Range	44-47	44-47	43-47
July				
	Mean	45.2	44.8	44.6
	s.e.	0.4	0.4	0.3
	n	10	10	10
	Range	44-47	43-47	43-46
November				
	Mean	46.0	45.3	44.3
	s.e.	0.3	0.3	0.3
	n	10	10	10
	Range	45-47	44-47	43-46

Table M-3. Average concentrations of eight heavy metal elements ($\mu g/g$) in quahog wet-tissue samples collected from Stations A' (plume) and F (Spar Island) in Mount Hope Bay, 1979-1998. Samples were collected in August of 1981, September of 1980, and October/November all other years.

	1979		1980		1981		1982		1983		1984		1985		1986		1987		1988	
	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F
Cadmium	<0.06	<0.06	<0.10	<0.10	<0.45	<0.50	0.51	0.53	0.96	0.94	1.90	3.00	<0.09	0.12	0.10	0.15	0.11	0.17	0.12	0.14
Copper	1.73	2.19	1.32	1.67	6.30	6.60	3.00	3.20	4.04	3.41	2.20	2.80	2.61	2.92	3.30	2.80	4.42	<1.80	2.30	2.00
Iron	18.00	43.00	10.90	20.50	21.00	33.00	37.00	36.00	17.75	17.12	28.00	26.00	11.50	8.94	7.74	8.18	14.10	11.00	12.60	16.80
Lead	<0.40	<0.40	<1.00	<1.00	<1.00	<1.00	0.08	0.07	3.88	3.80	0.22	0.11	2.47	2.57	<0.01	<0.01	[1]	[1]	0.50	0.38
Nickel	1.28	2.12	2.74	2.02	4.00	4.20	2.90	3.70	6.12	6.40	12.00	21.00	4.73	4.20	1.41	1.44	1.16	1.24	1.70	1.20
Vanadium	0.44	0.34	0.29	0.23	1.30	2.50	<1.00	<1.00	<5.00	<5.00	<10.00	<10.00	<2.40	<2.40	0.48	0.26	0.39	0.22	0.40	0.13
Zinc	22.00	23.70	19.10	17.30	40.00	36.00	15.00	7.30	35.32	24.60	34.00	34.00	21.70	22.80	17.30	21.20	22.40	17.80	20.40	23.70

	1989		1990		1991		1992		1993		1994		1995		1996		1997		1998	
	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F
Cadmium	0.05	<0.06	0.10	<0.10	0.04	0.05	0.14	0.12	0.08	0.08	0.09	0.09	0.10	0.09	0.10	0.11	0.12	0.06	0.09	0.14
Copper	0.68	1.32	1.87	2.16	2.44	2.65	2.14	1.93	3.45	1.79	2.77	1.62	2.63	2.07	4.66	2.10	2.13	1.30	1.44	1.95
Iron	6.10	25.00	9.93	9.37	23.84	24.94	8.28	11.36	13.80	13.10	15.09	14.70	10.00	12.43	13.70	33.60	13.63	18.20	20.96	19.46
Lead	0.06	0.33	0.39	0.44	0.07	0.01	0.24	0.12	0.22	0.18	0.35	0.44	0.20	0.30	0.49	0.55	0.21	0.36	0.13	0.26
Mercury									0.03	<0.02	<0.04	0.06	0.04	0.07	0.04	0.08	0.06	0.11	0.06	0.07
Nickel	1.52	1.69	2.56	2.06	0.98	1.00	0.90	0.63	1.23	1.16	0.95	1.32	1.16	0.98	0.79	1.43	0.95	1.29	0.55	0.54
Vanadium	<0.46	<0.62	0.40	0.30	0.33	0.24	0.48	0.35	0.50	0.31	0.51	0.43	0.55	0.27	0.44	0.18	0.71	<0.70	<0.79	<0.83
Zinc	9.70	19.70	24.00	22.40	21.75	18.50	13.17	13.83	20.40	14.60	24.64	22.05	20.00	23.68	26.03	21.00	19.88	16.80	14.41	18.07

[1]Not measured because of interference.
Note that mercury sampling began in 1993.

Table M-4. Average concentrations of five secondary heavy metal elements ($\mu g/g$) in quahog wet-tissue samples collected from Stations A' (plume) and F (Spar Island) in Mount Hope Bay, 1979-1992, 1997, 1998. Samples were collected in August of 1981, September of 1980, and October/November all other years.

	1979		1980		1981		1982		1983		1984		1985		1986		1987		1988	
	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F	A'	F
Aluminum	[1]	[1]	2.60	6.60	3.60	4.60	16.00	17.00	39.70	31.80	8.60	12.00	4.14	3.57	5.42	4.64	<0.95	2.16	6.89	5.60
Arsenic	[1]	[1]	1.10	1.20	0.31	0.36	0.07	0.57	0.09	0.41	0.75	0.32	0.38	0.31	0.03	0.02	[2]	[2]	3.54	0.92
Chromium	0.26	0.30	0.24	0.26	5.40	9.60	0.80	1.10	0.33	0.55	<1.00	<1.00	0.55	0.35	0.57	0.34	0.24	0.18	1.00	0.20
Cobalt	0.19	0.38	0.25	0.26	0.90	0.51	1.10	1.70	51.50	46.09	6.80	10.00	2.15	1.99	0.28	0.34	[2]	[2]	0.12	0.14
Manganese	12.70	17.80	7.60	16.80	24.00	34.00	16.00	6.00	61.10	23.70	28.00	36.00	7.80	10.70	6.44	10.70	25.00	17.00	21.60	21.60

			1989		1990		1991		1992	1997		1998	
	A'	F	A'	F	A'	F	A'	F		A'	F	A'	F
Aluminum	7.50	11.00	4.60	5.40	10.40	6.80	4.31	3.34		4.40	5.88	8.52	7.78
Arsenic	0.04	0.04	1.96	0.62	3.73	2.09	5.73	5.19		2.84	3.78	1.83	2.50
Chromium	0.61	0.39	0.40	0.59	0.52	0.38	0.69	0.46		0.37	0.63	0.25	0.44
Cobalt	<0.46	<0.62	<0.50	<0.50	[2]	[2]	<0.20	<0.25		<0.71	0.70	<0.79	<0.83
Manganese	0.44	0.48	27.20	7.14	4.65	3.59	6.70	10.79		19.88	12.18	14.41	22.24

[1]Not sampled. Note: samples were not analyzed for these metals during 1993-1996.

[2]Not measured due to interference.

Table M-5. Summary data for paired sample t-tests comparing mean heavy metal concentrations in quahogs from Mount Hope Bay Stations A' and F, 1979-1998 (see text for details).

Metal	Mean A'	Mean F	Difference Mean	Difference s	Number of pairs[1]	Number of Consecutive pairs[2]	Paired t-test[3]
Cadmium	0.32	0.41	-0.09	0.29	14	8 @ F	0.290
Copper	2.71	2.45	0.26	0.84	19	10 @ A'	0.196
Iron	15.70	20.14	-4.44	8.27	20	11 @ F	0.027
Lead	0.63	0.66	-0.03	0.12	15	8 @ F	0.376
Mercury	0.04	0.07	-0.03	0.02	6		0.034
Nickel	2.48	2.98	-0.50	2.05	20	12 @ F	0.289
Vanadium	0.50	0.44	0.06	0.39	13	12 @ F	0.599
Zinc	22.06	20.95	1.11	4.79	20	11 @ A'	0.314
Aluminum	8.51	8.54	-0.04	3.00	15	8 @ F	0.964
Arsenic	1.60	1.31	0.29	0.97	14	7 @ A'	0.285
Chromium	0.82	1.05	-0.24	1.13	15	8 @ F	0.433
Cobalt	6.40	6.21	0.19	2.10	10	6 @ F	0.782
Manganese	17.72	15.67	2.05	12.48	16	9 @ F	0.521

[1]Censored data pairs omitted except for mercury where the detection limit was substituted. See text for details.
[2]Number of A' vs F pairs whose difference carried the same sign, e.g., in 11 of 19 pairs of iron values the Station F value was higher than the A' value.
[3]Probability value from two-tailed paired t-tests. Values ≤0.05 were considered statistically significant.

Table M-6. Summary data for linear trend analyses, heavy metal concentrations in Mount Hope Bay quahogs, Stations A' and F, autumn1979-1998.

	Total n	Censored Values	Substitution method	slope	r^2 (%)	p[1]
Cadmium	20	3	0	-0.023	6.2	0.292
			½ limit	-0.027	8.6	0.210
			Limit	-0.031	11.2	0.149
Copper	20	0	-	-0.069	10.9	0.154
Iron A'	20	0	-	-0.358	7.9	0.230
Iron F	20	0	-	-0.372	13.3	0.114
Lead	19	4	0	-0.027	2.8	0.497
			½ limit	-0.042	7.1	0.271
			Limit	-0.057	12.9	0.130
Mercury A'	6	1	0	0.009	62.6	0.061
			½ limit	0.008	81.2	0.014
			Limit	0.006	84.0	0.010
Mercury F	6	1	0	0.015	56.7	0.084
			½ limit	0.013	56.7	0.084
			Limit	0.012	56.1	0.087
Nickel	20	0	-	-0.252	17.7	0.065
Vanadium	20	6	0	-0.010	2.0	0.550
			½ limit	-0.067	11.9	0.136
			Limit	-0.125	10.1	0.173
Zinc	20	0	-	-0.359	10.7	0.160

[1]probability that the observed slope is not statistically different from zero. Slopes in shaded rows are statistically different from zero at $p<0.05$.

Table M-7. Summary data for linear trend analyses, heavy metal concentrations (secondary list) in Mount Hope Bay quahogs, Stations A' and F, autumn 1979-1992, 1997, 1998.

	Total n	Censored Values	Substitution method	slope	r^2 (%)	p[1]
Aluminum	15	0	-	-0.388	6.3	0.366
Arsenic A' and F	14	0	-	0.183	42.0	0.012
Arsenic A'	14	0	-	0.183	34.0	0.029
Arsenic F	14	0	-	0.183	44.0	0.010
Chromium	16	1	0	-0.084	7.1	0.318
			½ limit	-0.087	7.7	0.297
			Limit	-0.090	8.3	0.278
Cobalt	14	3	0	-0.460	4.5	0.466
			½ limit	-0.444	4.2	0.481
			Limit	-0.436	4.1	0.489
Manganese	16	0	-	-0.485	6.4	0.343

[1]probability that the observed slope is not statistically different from zero. Slopes in shaded rows are statistically different from zero at $p<0.05$.

Table M-8. Power associated with heavy metal trend analyses, Mount Hope Bay, Stations A' and F, autumn 1979-1998. See text for details.

Metal	n	Observed slope	Power (%)	Detectable slope with Power of 80%	90%
Cadmium[1]	20	-0.027	25	±0.07	±0.08
Copper	20	-0.069	32	±0.14	±0.17
Iron - A'	20	-0.358	23	±0.85	±1.05
Iron - F	20	-0.618	36	±1.10	±1.32
Lead[1]	19	-0.042	19	±0.11	±0.14
Nickel	20	-0.253	45	±0.40	±0.45
Vanadium[1]	20	-0.067	33	±0.13	±0.15
Zinc	20	-0.359	32	±0.73	±0.87
Aluminum	15	-0.388	<20	±1.25	±1.50
Chromium	14	-0.087	18	±0.24	±0.29
Cobalt	14	-0.490	<20	±1.90	±2.20
Manganese	16	-0.485	15	±1.50	±1.80

[1]One-half the detection limit substituted for censored data.

Table M-9. Average heavy metal concentrations ($\mu g/g$) in wet tissues of quahog samples collected from Station M in October/November 1988-1998.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Cadmium	0.15	0.06	<0.10[1]	0.04	0.12	0.09	0.08	0.10	0.12	0.12	<0.07
Copper	2.80	1.76	4.04	5.44	3.01	2.40	2.55	2.62	1.66	3.14	3.30
Iron	19.00	45.00	16.20	39.70	18.10	55.00	40.60	38.80	17.92	57.12	27.14
Lead	0.64	0.38	0.09	0.01	0.44	0.44	0.61	0.60	0.40	0.63	0.14
Mercury						0.02	0.06	0.14	0.07	0.24	0.07
Nickel	1.20	2.60	1.68	0.38	0.67	1.13	1.62	1.25	1.41	1.68	0.72
Vanadium	0.24	0.46	0.27	0.18	<0.20[1]	0.29	0.21	0.23	0.36	<0.60[1]	<0.71
Zinc	18.20	23.00	16.80	19.20	14.90	16.70	22.00	20.50	21.76	17.92	10.03
Aluminum	4.18	16.50	6.20	14.98	1.40					13.44	9.91
Arsenic	1.82	0.04	2.21	2.82	3.87					3.36	2.01
Chromium	0.70	2.30	0.69	0.43	0.18					0.78	0.26
Cobalt	0.08	0.62	<0.50[1]	[2]	<0.20[1]					<0.60[1]	<0.71
Manganese	14.20	0.97	5.04	2.97	9.48					22.40	2.01

[1]One-half the detection limit was substituted for these values in statistical tests.
[2]Not sampled due to interference. Note also that mercury sampling began in 1993 and the last five elements were not analyzed from 1993-1996 samples.

Table M-10. Summary data for linear trend analyses, heavy metal concentrations at Montaup Station M, autumn 1988-1998.

	Total n	Censored Values	Substitution method	slope	r^2 (%)	p[1]
Cadmium	11	2	0	-0.0006	0.2	0.902
			½ limit	-0.0004	0.1	0.917
			Limit	-0.0002	0	0.956
Copper	11	0	-	-0.047	2.2	0.663
Iron	11	0	-	1.046	5.2	0.498
Lead	11	0	-	0.007	1.1	0.761
Mercury	6	0	-	0.021	23.9	0.325
Nickel	11	0	-	-0.038	4.3	0.540
Vanadium	11	3	0	0.022	24.0	0.325
			½ limit	0.004	1.6	0.708
			Limit	0.030	31.7	0.072
Zinc	11	0	-	-0.333	8.8	0.376
Aluminum	7	0	-	0.224	0.7	0.858
Arsenic	7	0	-	0.317	30.2	0.201
Chromium	7	0	-	-0.174	27.5	0.227
Cobalt	6	4	0	-0.053	25.3	0.309
			½ limit	0.001	0	0.978
			Limit	0.055	26.7	0.293
Manganese	7	0	-	0.383	1.1	0.821

[1]probability that the observed slope is not statistically different from zero.
Note: the last five elements were not analyzed from samples collected 1993-1996.

Table M-11. Results of one-way analyses of variance for heavy metal concentrations in quahogs (wet weight) comparing three autumn sampling locations, 1988-1998.

		Mean concentration (ppm)			Anova	
Metal	n	A'	F	M	F	p
Cadmium	11	0.09	0.09	0.09	0.11	0.894
Copper[1]	11	2.19	1.86	2.82	3.58	0.040
Iron[1]	11	12.57	16.88	30.85	13.01	0.000
Lead	11	0.26	0.31	0.40	1.64	0.211
Nickel	11	1.21	1.21	1.30	0.11	0.892
Vanadium	11	0.45	0.30	0.27	9.03	0.001
Zinc	11	19.49	19.49	18.27	0.31	0.733

[1] Anova based on log e transformed values to equalize variances. Values shown are the geometric mean.

Shaded values are significantly different than the other two stations'.

Table M-12. Summary data for one-way analyses of variance for heavy metal concentrations in quahogs (wet weight) comparing three sampling seasons, 1994-1998.

		ppm mean concentration (s)			Anova	
Metal	n	Spring	Summer	Autumn	F	p
Cadmium	15	0.10 (0.022)	0.10 (0.023)	0.10 (0.021)	0.60	0.552
Copper	15	2.29 (0.683)	2.46 (0.642)	2.38 (0.863)	0.23	0.798
Iron	15	27.89 (16.523)	28.78 (22.699)	23.33 (13.111)	0.40	0.672
Lead	15	0.43 (0.148)	0.40 (0.435)	0.38 (0.167)	0.15	0.865
Mercury	15	0.07 (0.024)	0.08 (0.038)	0.08 (0.050)	0.73	0.487
Nickel	15	1.08 (0.367)	1.35 (0.359)	1.10 0.360)	2.66	0.082
Vanadium	15	0.36 (0.100)	0.37 (0.179)	0.38 (0.142)	0.08	0.923
Zinc	12	19.83 (4.552)	22.90 (5.660)	19.80 (4.087)	2.05	0.14

Table M-13. Average heavy metal concentrations (over two replicates; $\mu g/g$) in wet-weight tissues of quahog samples collected from Stations A', F, and M in April, July, and November 1998.

	A'			F			M		
	April	July	Nov	April	July	Nov	April	July	Nov
Cadmium	0.14	0.07	0.09	0.13	0.07	0.14	0.10	0.05	0.07
Copper	3.61	2.71	1.44	1.78	1.67	1.95	1.32	3.05	3.30
Iron	28.26	9.68	20.96	17.76	18.07	19.46	13.20	26.16	27.14
Lead	0.41	0.19	0.13	0.25	0.39	0.26	0.19	0.45	0.14
Mercury	0.05	0.06	0.06	0.08	0.05	0.07	0.06	0.10	0.07
Nickel	0.77	1.30	0.55	0.80	1.18	0.54	0.59	1.53	0.72
Vanadium	0.94	0.40	0.79	0.89	0.28	0.83	0.66	0.22	0.71
Zinc	18.84	17.70	14.41	12.43	20.85	18.07	9.24	19.62	10.03
Aluminum	8.79	4.01	8.52	5.33	4.87	7.78	3.96	3.05	9.91
Arsenic	2.20	2.60	1.83	2.96	2.50	2.50	2.20	2.29	2.01
Chromium	0.28	0.35	0.25	0.40	0.28	0.44	0.30	0.33	0.26
Cobalt	0.94	0.47	0.79	0.89	0.56	0.83	0.66	0.44	0.71
Manganese	36.11	9.20	14.41	12.14	11.68	22.24	9.02	10.90	2.01

APPENDIX

Table A1. Hydrographic data, January-December 1998.

Appendix Table A1. Hydrographic data, January-December 1998.

Station F								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
1-15	0959	NE	Surf	3.8	11.3	102.3	7.7	27.2
		15	5	3.7	11.1	102.1	7.7	27.4
			10	3.7	11.1	102.6	7.7	28.6
			15	4.1	10.7	102.2	7.8	31.0
			20	4.1	10.7	101.4	7.8	31.1
2-17	0958	E	Surf	2.8	11.3	101.8	7.8	27.6
		10-15	5	2.8	11.3	101.6	7.8	27.6
			10	3.2	11.1	101.4	7.8	29.0
			15	3.3	10.5	98.1	7.7	31.2
			20	3.4	10.4	97.5	7.7	31.6
3-2	0949	NW	Surf	5.7	10.3	96.5	7.7	23.1
		5	5	5.4	10.2	95.7	7.7	24.6
			10	4.4	9.9	94.8	7.8	31.0
			15	4.4	9.9	94.7	7.8	30.4
			20	4.4	9.8	94.4	7.8	31.8
3-6	1029	NE	Surf	6.1	10.1	94.4	7.7	20.7
		15-20	5	6.1	10.0	94.5	7.8	23.5
			10	5.6	9.7	93.0	7.8	26.4
			15	4.9	9.6	92.2	7.8	29.8
			18	4.9	9.5	91.4	7.8	30.2
3-16	0930	N	Surf	4.0	11.3	97.4	7.5	17.3
		10-15	5	4.0	11.1	96.5	7.5	18.0
			10	4.1	10.7	96.5	7.7	23.7
			15	4.2	9.9	93.5	7.7	29.7
			20	4.2	9.8	92.9	7.7	30.3
3-20	1149	NE	Surf	5.0	8.9	89.6	7.6	23.6
		15-20	5	4.8	8.7	88.7	7.6	23.6
			10	4.8	8.6	87.8	7.6	24.0
			15	4.6	7.9	86.9	7.7	33.1
			20	4.6	7.7	83.9	7.7	33.2
3-25	1229	SW	Surf	7.3	11.1	105.8	8.7	21.6
		5-10	5	6.3	11.1	105.5	8.7	24.7
			10	6.7	10.5	103.6	8.7	28.7
			15	4.8	10.8	102.8	8.7	30.9
			16	4.7	10.7	101.6	8.7	31.1
3-30	1206	SW	Surf	10.1	11.0	113.6	8.7	23.8
		10-15	5	10.0	11.0	113.1	8.7	23.8
			10	8.7	11.0	111.1	8.7	26.2
			15	7.1	10.9	109.2	8.7	30.3
			19	7.1	10.7	107.6	8.7	30.3

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station F (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
4-3	0946	N	Surf	9.8	9.8	101.1	7.5	24.7
		5-10	5	9.9	9.8	101.1	7.5	24.6
			10	9.3	9.8	100.8	7.5	25.9
			15	8.2	9.7	98.6	7.5	29.4
			19	7.5	9.2	94.0	7.4	31.2
4-8	1143	SE	Surf	10.8	9.9	103.9	7.5	23.5
		10-15	5	9.8	10.1	104.9	7.5	26.0
			10	9.2	10.1	104.6	7.6	27.7
			15	7.1	9.3	94.7	7.5	32.2
			18	7.1	9.2	93.0	7.5	32.2
4-13	0931	NE	Surf	8.7	9.9	100.2	7.5	25.8
		10	5	8.6	9.7	99.3	7.5	27.5
			10	7.5	9.5	97.5	7.5	32.0
			15	7.3	9.4	95.5	7.5	32.3
			20	7.3	9.3	94.6	7.5	32.4
			22	7.3	9.2	93.9	7.5	32.2
4-17	1040	SSW	Surf	9.9	9.2	96.5	7.7	27.6
		10-15	5	9.9	9.3	96.9	7.7	27.6
			10	9.5	9.3	96.2	7.7	28.1
			15	8.6	9.3	95.0	7.6	29.4
			20	8.5	9.1	93.1	7.6	29.7
			21	8.5	9.1	92.7	7.6	29.7
4-21	1212	SW	Surf	12.9	9.8	105.5	7.6	21.5
		10-15	5	12.3	9.8	104.1	7.6	22.3
			10	11.0	9.2	97.9	7.6	26.9
			15	9.6	8.9	93.1	7.6	28.7
			18	9.4	8.8	91.7	7.6	29.0
4-27	0932	NW	Surf	10.3	9.3	97.4	7.7	26.4
		15-20	5	10.3	9.3	96.9	7.7	26.4
			10	9.7	9.2	96.8	7.7	28.9
			15	9.6	9.2	96.4	7.7	29.2
			20	9.6	9.2	96.2	7.7	29.3
			23	9.6	9.1	95.9	7.7	29.4
5-1	1002	SW	Surf	13.4	9.4	104.6	7.5	24.1
		10-15	5	13.3	9.1	102.1	7.5	24.6
			10	13.3	9.0	100.3	7.5	24.5
			15	11.3	8.9	96.6	7.5	27.3
			19	10.6	9.0	96.6	7.6	28.6
5-6	1233	SE	Surf	16.5	9.3	107.7	7.7	20.1
		10-15	5	16.5	9.3	108.4	7.7	20.1
			10	13.0	8.6	97.2	7.5	27.2
			15	11.7	8.6	95.6	7.5	28.8
			18	11.5	8.6	94.7	7.5	29.1

Appendix Table A1. Hydrographic data , January-December 1998 (continued).

Station F (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
5-13	0931	ENE	Surf	11.2	9.3	99.8	7.6	25.9
		15-20	5	11.2	9.2	99.3	7.6	26.0
			10	11.2	9.2	99.3	7.6	26.1
			15	11.2	9.1	99.0	7.6	27.1
			20	11.0	8.9	98.1	7.6	30.5
			22	11.0	8.9	97.9	7.6	39.6
5-18	1245	SW	Surf	17.9	9.0	109.9	7.7	22.8
		5-10	5	15.3	9.7	112.4	7.8	24.2
			10	13.9	9.5	108.1	7.7	25.6
			15	12.3	8.7	97.9	7.6	28.9
			20	12.3	8.5	95.3	7.6	28.9
			21	12.3	8.4	94.3	7.6	29.0
5-22	0943	N	Surf	16.0	9.1	107.9	7.8	24.5
		15-20	5	16.0	9.2	108.9	7.8	24.6
			10	15.9	9.2	108.4	7.8	24.6
			15	15.2	8.6	100.3	7.7	25.9
			18	13.9	8.1	93.7	7.7	28.1
5-26	1003	SW	Surf	16.8	8.8	106.5	7.8	25.9
		5-10	5	15.9	8.7	103.9	7.8	26.4
			10	15.2	8.6	101.7	7.8	27.2
			15	14.7	8.5	99.3	7.8	27.9
			20	14.4	8.4	98.6	7.8	28.3
			21	14.3	8.3	97.2	7.8	28.5
6-1	1016	SW	Surf	19.4	7.9	100.4	7.9	25.1
		10-15	5	19.0	7.9	99.6	7.8	25.7
			10	18.4	7.9	98.7	7.8	26.7
			15	18.0	7.6	95.0	7.8	26.9
			18	18.0	7.5	93.4	7.8	26.9
6-5	0957	W	Surf	17.1	7.8	101.3	8.0	27.7
		20-30	5	17.1	7.8	101.0	8.0	27.7
			10	17.1	7.8	100.7	8.0	27.7
			15	17.1	7.8	100.6	8.0	27.7
			18	17.1	7.8	100.7	8.0	27.7
6-10	1033	SW	Surf	17.7	8.5	107.0	7.9	27.8
		10-15	5	17.7	8.4	105.9	7.0	27.9
			10	16.3	7.9	97.6	7.8	28.6
			15	15.0	8.0	96.5	7.8	30.4
			20	14.2	6.8	81.5	7.6	30.9
6-16	1000	S	Surf	19.0	8.9	97.4	7.4	15.4
		15	5	19.0	7.9	95.3	7.4	16.2
			10	18.7	7.4	92.5	7.5	20.9
			15	18.2	7.2	90.5	7.6	26.1
			20	16.4	6.8	84.2	7.6	29.5
			21	16.2	6.7	82.8	7.6	29.4

Appendix Table A1. Hydrographic data , January-December 1998 (continued).

Station F (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
6-19	1256	S	Surf	21.5	7.2	88.4	7.1	11.4
		10	5	19.4	6.3	76.8	7.1	17.6
			10	18.9	6.0	75.9	7.4	24.1
			15	17.0	5.9	73.7	7.5	28.3
			19	15.9	5.4	66.6	7.4	29.9
6-24	1032	S	Surf	20.2	7.0	87.5	7.3	19.1
		15	5	19.6	6.5	81.7	7.3	20.6
			10	18.8	6.5	82.0	7.5	23.7
			15	17.9	6.5	80.9	7.6	26.0
			20	17.3	6.1	75.7	7.5	27.1
			21	16.9	6.0	74.0	7.5	28.0
6-29		NOT SAMPLED - HEAVY SEAS						
7-3	1305	S	Surf	26.2	9.6	128.5	7.8	14.2
		5-10	5	23.0	8.9	116.0	8.0	19.3
			10	20.9	6.6	84.8	7.4	23.1
			15	18.8	5.5	69.3	7.3	27.3
			19	18.2	4.3	53.2	7.2	28.4
7-8	0928	Light,	Surf	23.2	8.8	114.3	7.9	17.9
		variable	5	23.0	8.7	113.6	8.0	19.4
			10	21.8	6.7	87.0	7.7	87.0
			15	18.9	5.2	65.1	7.4	27.7
			20	16.7	4.7	58.1	7.3	30.4
7-13	0900	SW	Surf	21.3	7.7	101.4	7.7	23.5
		10-15	5	20.9	7.1	92.1	7.7	24.0
			10	20.2	6.4	82.5	7.6	25.3
			15	18.2	5.0	63.1	7.5	28.5
7-17	0826	SW	Surf	24.2	8.3	112.7	7.8	23.4
		2	5	24.1	8.1	110.7	7.8	23.7
			10	22.2	6.3	83.7	7.6	25.4
			15	20.0	5.5	70.9	7.4	28.0
			16	19.9	5.4	69.3	7.4	28.4
7-22	1014	SW	Surf	24.4	9.1	126.5	8.0	25.4
		15	5	24.0	9.1	124.9	8.0	25.5
			10	23.1	7.0	94.7	7.8	26.4
			15	21.0	6.2	81.5	7.6	28.6
			20	20.3	5.8	76.3	7.5	29.3

Appendix Table A1. Hydrographic data, January-December 1998.

Station F (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
7-27	0859	SW	Surf	23.6	8.0	108.0	8.1	24.6
		5-10	5	23.3	7.6	102.8	8.0	25.2
			10	22.7	7.2	96.9	8.0	26.0
			15	21.7	6.7	88.4	7.9	26.9
			18	21.1	4.5	56.8	7.7	27.2
7-31	1012	NE	Surf	24.6	7.9	111.5	7.8	27.1
		15	5	24.6	7.8	110.5	7.8	27.2
			10	23.8	5.6	77.9	7.4	28.4
			15	22.2	5.4	74.1	7.3	29.9
			19	22.1	5.0	68.7	7.3	30.1
8-5	1200	SW	Surf	25.3	7.0	100.3	7.8	26.5
		5-10	5	24.9	6.7	95.4	7.8	27.9
			10	24.9	6.4	91.1	7.7	28.0
			15	21.4	4.2	56.6	7.3	30.8
			17	21.0	3.9	53.1	7.3	30.9
8-10	0857	SSW	Surf	23.2	6.3	86.8	8.0	27.5
		~10	5	23.0	6.2	84.7	8.0	27.8
			10	22.6	5.8	78.5	8.0	28.0
			15	22.4	5.4	73.4	7.9	28.0
			19	22.4	5.2	70.7	7.9	28.1
8-14	1003	SW	Surf	23.5	6.9	96.8	7.6	29.8
		2	5	23.5	6.7	94.7	7.6	29.8
			10	23.0	6.3	87.9	7.5	30.5
			15	22.9	6.1	87.4	7.5	30.5
			19	22.7	5.3	74.0	7.4	30.7
8-19	0947	NW	Surf	[1]				
		20	5					
			10	23.2	6.2	85.0	7.9	27.0
			15	23.2	6.3	86.7	8.0	27.3
			19	21.9	6.1	82.3	7.9	28.8
8-24	1024	SW	Surf	23.1	6.9	94.7	8.0	27.8
		10-15	5	23.0	6.8	92.4	8.0	27.8
			10	22.6	6.2	83.7	8.0	28.0
			15	22.4	5.8	78.4	7.9	28.1
			20	22.4	5.4	73.5	7.9	28.1
			21	22.4	5.2	71.1	7.9	28.1
8-31	0836	SW	Surf	24.2	7.9	109.4	8.0	26.5
		10-15	5	24.3	7.9	110.3	8.0	26.5
			10	24.2	7.2	100.3	7.9	26.8
			15	23.6	6.7	91.6	7.8	27.2
			16	22.6	5.8	79.3	7.7	27.9

[1] No readings - operator error.

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station F (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
9-3	1257	SSE	Surf	25.5	7.8	111.8	8.0	28.8
		~5	5	24.6	8.1	114.4	8.0	28.8
			10	23.9	7.6	106.3	7.9	29.0
			15	22.4	6.8	92.9	7.7	30.3
			18	21.9	5.4	73.9	7.6	30.6
9-8	1417	NW	Surf	24.0	6.9	96.5	7.7	29.4
		~12	5	23.9	6.4	89.2	7.8	29.3
			10	22.7	6.4	87.7	7.8	29.6
			15	21.8	6.0	81.6	7.8	30.4
			18	21.8	5.9	80.5	7.8	30.4
9-11	1623	WNW	Surf	22.8	8.4	115.9	8.0	29.0
		~9	5	22.0	8.1	109.2	8.0	29.4
			10	21.4	7.2	97.4	7.9	29.9
			15	20.7	6.5	87.0	7.9	30.5
9-17	1115	NNE	Surf	22.9	8.0	110.1	7.9	29.2
		~8	5	22.3	7.7	105.6	7.9	29.4
			10	22.1	7.6	102.9	7.9	29.4
			15	20.6	7.1	94.0	7.9	30.7
			18	20.4	6.5	86.7	7.9	30.8
9-21	0855	SW	Surf	20.7	8.7	116.5	8.1	30.6
		~5	5	20.7	9.0	119.5	8.1	30.6
			10	20.6	8.8	117.4	8.0	30.6
			15	20.4	7.7	101.8	8.0	30.8
			20	20.3	7.6	100.6	7.9	30.8
			21	20.3	7.4	98.4	7.9	30.9
9-25	0947	S	Surf	19.9	9.1	119.5	8.1	30.1
		5-15	5	19.9	9.1	119.2	8.1	30.1
			10	19.9	9.0	117.7	8.1	30.2
			15	19.9	8.8	115.3	8.0	30.4
			18	20.0	7.5	98.8	8.0	30.5
9-30	0803	Calm	Surf	20.1	7.6	101.0	7.6	30.1
			5	20.1	7.6	101.2	7.6	30.1
			10	20.1	7.6	10.4	7.6	30.5
			15	20.3	6.3	84.2	7.5	31.2
10-27	1026	E	Surf	13.9	10.6	120.8	8.1	26.5
		0-5	5	14.0	10.1	116.3	8.0	27.3
			10	14.2	9.8	114.4	8.1	29.0
			15	14.3	9.6	112.2	8.0	29.7
			19	14.3	9.1	107.2	8.0	30.1

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station F (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
11-16	1130	SW	Surf	10.0	11.5	122.8	8.1	29.5
		15-20	5	10.2	11.0	118.5	8.1	29.3
			10	10.2	10.9	117.2	8.1	29.3
			15	10.2	10.8	116.7	8.1	29.9
			17	10.2	10.5	112.7	8.1	29.9
12-17	1037	SW	Surf	7.5	22.5	226.1	8.2	28.2
		~10	5	7.3	20.2	203.0	8.2	29.1
			10	7.1	19.7	197.4	8.2	29.3
			15	7.3	19.3	195.4	8.2	30.1
			20	7.5	19.0	193.4	8.2	30.3

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station C								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
1-15	1204	NE	Surf	4.7	11.0	102.5	7.7	26.1
		15	5	4.7	10.9	102.8	7.7	27.1
			10	5.8	10.5	102.7	7.7	29.3
			15	4.9	10.3	99.1	7.8	29.4
			17	4.5	10.5	99.5	7.8	29.8
2-17	1054	E	Surf	4.0	11.3	103.2	7.8	26.0
		10-15	5	4.0	11.3	103.3	7.8	25.8
			10	5.5	10.8	103.8	7.8	28.1
			15	4.3	10.5	98.9	7.8	29.7
			19	4.3	10.4	97.9	7.8	29.6
3-2	1342	SW	Surf	7.1	9.0	94.7	7.7	20.7
		5-10	5	6.7	9.9	95.7	7.7	24.2
			10	5.6	9.7	93.8	7.8	27.9
			15	4.9	9.7	92.4	7.8	28.8
			16	4.9	9.6	91.4	7.8	28.9
3-6	1125	NE	Surf	6.9	9.8	96.2	7.8	26.0
		15-20	5	6.9	9.6	95.0	7.8	27.4
			10	5.3	9.7	93.3	7.8	28.2
			15	5.1	9.4	90.3	7.8	29.4
			17	5.1	9.3	89.0	7.8	28.9
3-16	1304	N	Surf	5.2	10.8	97.4	7.7	19.3
		10-15	5	5.2	10.7	96.8	7.6	19.9
			10	4.4	10.3	94.9	7.7	25.6
			15	4.1	10.2	93.6	7.7	26.5
			16	4.1	10.1	92.8	7.7	26.5
3-20	1244	NE	Surf	5.3	8.4	86.0	7.6	23.6
		15-20	5	5.3	8.3	85.0	7.6	23.7
			10	5.3	8.4	85.0	7.6	24.0
			15	5.3	7.7	82.1	7.6	29.5
			18	4.7	7.7	82.1	7.6	30.7
3-25	1332	SW	Surf	7.5	11.2	107.9	8.7	23.1
		5-10	5	6.9	11.1	107.5	8.7	26.2
			10	6.4	10.9	106.2	8.7	28.7
			15	5.2	10.9	104.6	8.7	30.6
3-30	1051	SW	Surf	10.0	10.5	106.8	8.7	22.0
		15-20	5	9.9	10.5	106.9	8.7	22.2
			10	8.9	10.5	106.6	8.7	25.8
			15	7.3	10.4	104.6	8.7	29.4
			19	7.3	10.4	103.7	8.7	29.3

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station C (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
4-3	1037	N	Surf	10.0	10.1	104.9	7.4	24.8
		5-10	5	9.9	9.9	102.6	7.4	25.4
			10	9.4	9.6	100.0	7.4	28.0
			15	8.3	9.6	98.7	7.4	29.7
			18	7.4	9.4	96.9	7.4	29.7
4-8	1049	E	Surf	10.3	10.0	102.1	7.4	21.4
		10-15	5	10.1	9.8	102.2	7.5	25.5
			10	7.9	9.6	98.5	7.5	30.4
			15	7.2	9.3	94.3	7.5	31.6
			16	7.2	9.2	93.5	7.5	31.7
4-13	1022	NE	Surf	9.7	9.5	99.2	7.5	27.9
		10-15	5	9.7	9.4	98.0	7.5	27.8
			10	7.6	9.4	97.7	7.6	29.1
			15	7.9	9.2	94.4	7.5	31.4
			20	7.7	9.0	92.3	7.5	31.4
			22	7.7	9.0	91.7	7.5	31.5
4-17	1129	SW	Surf	11.1	9.6	101.4	7.7	25.2
		15-20	5	11.1	9.6	100.8	7.7	25.1
			10	11.0	9.4	99.6	7.7	25.3
			15	10.6	9.4	99.3	7.7	26.7
			19	8.6	8.9	91.6	7.6	29.2
4-21	1304	SW	Surf	13.0	9.4	99.6	7.5	19.5
		10-15	5	12.5	9.3	98.1	7.5	20.4
			10	11.6	9.1	98.1	7.6	26.1
			15	10.4	8.7	92.3	7.6	27.5
			17	9.9	8.6	89.7	7.5	28.1
4-27	1313	N	Surf	12.0	8.7	93.8	7.6	25.2
		10-15	5	11.9	8.6	92.9	7.6	25.2
			10	11.5	8.5	91.8	7.6	27.4
			15	10.3	8.6	91.3	7.6	28.3
			16	10.2	8.9	93.6	7.6	28.4
5-1	1057	SW	Surf	13.7	9.0	100.3	7.5	22.4
		10-15	5	13.6	9.0	99.6	7.5	22.6
			10	12.8	8.7	95.9	7.5	24.6
			15	11.4	8.3	90.1	7.5	26.8
			19	11.4	8.3	89.6	7.5	26.8
5-6	1326	SE	Surf	15.7	8.8	98.8	7.5	17.8
		10-15	5	15.8	8.7	99.1	7.5	18.3
			10	13.7	8.2	93.7	7.5	27.2
			15	11.8	7.8	84.8	7.4	28.0
			17	11.8	7.5	82.8	7.4	28.0

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station C (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
5-13	1023	ENE	Surf	11.7	9.0	97.8	7.6	25.4
		15-2	5	11.7	9.0	97.4	7.6	25.4
			10	11.7	9.0	97.3	7.6	25.5
			15	11.7	8.9	96.6	7.6	25.3
			20	11.2	8.8	95.8	7.6	27.6
5-18	1331	N	Surf	17.3	9.4	111.8	7.7	21.5
		10-15	5	17.3	9.2	109.0	7.7	21.5
			10	15.9	9.5	110.6	7.7	22.5
			15	12.9	7.9	89.6	7.6	27.8
			20	12.3	7.5	83.7	7.5	28.0
5-22	0952	N	Surf	16.4	8.4	99.7	7.7	24.5
		15-20	5	16.4	8.4	100.1	7.7	24.9
			10	14.8	8.2	95.8	7.6	26.4
			15	14.0	7.3	83.8	7.5	27.5
5-26	1151	SW	Surf	17.8	8.2	100.6	7.7	24.6
		10-15	5	17.4	8.2	99.5	7.8	24.7
			10	16.8	8.0	96.1	7.7	25.2
			15	15.6	7.4	88.4	7.7	26.6
			17	15.5	7.8	86.3	7.7	26.7
6-1	1023	SW	Surf	21.3	7.5	98.3	7.8	24.5
		10-15	5	20.6	7.7	97.7	7.8	24.9
			10	19.5	7.7	97.4	7.8	25.0
			15	19.2	7.7	97.2	7.8	25.5
			17	19.1	7.3	92.3	7.8	25.8
6-5	1005	W	Surf	19.7	7.4	100.0	8.0	26.0
		20-30	5	19.7	7.4	99.8	8.0	26.0
			10	19.4	7.4	98.8	8.0	26.1
			15	18.6	7.5	98.6	8.0	26.2
			18	18.1	7.5	97.5	8.1	26.5
6-10	1239	SW	Surf	19.6	8.5	110.9	7.9	27.7
		10-15	5	19.5	8.5	111.0	7.9	27.7
			10	17.6	8.0	101.6	7.7	28.4
			15	16.7	7.5	93.7	7.7	29.0
			17	16.6	6.4	79.7	7.7	29.1
6-16	1146	S	Surf	19.0	8.5	100.6	7.2	13.4
		15-20	5	18.9	8.0	95.2	7.2	13.6
			10	18.7	7.6	90.0	7.2	14.0
			15	18.4	6.6	83.8	7.5	26.1
			18	16.4	6.5	80.2	7.5	29.2

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station C (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/o
6-19	1305	S	Surf	23.7	8.8	111.0	7.5	9.3
		10	5	21.6	7.7	97.1	7.3	14.5
			10	19.5	6.2	78.7	7.3	22.1
			15	17.2	5.7	71.0	7.4	28.0
			18	17.0	3.2	39.7	7.2	28.5
6-24	1043	S	Surf	20.4	7.3	91.7	7.4	18.3
		15	5	20.6	6.8	85.9	7.3	85.9
			10	21.0	6.2	78.6	7.3	19.3
			15	18.5	4.9	61.8	7.3	24.7
			19	17.4	2.8	35.9	7.1	26.7
6-29	0736	S	Surf	20.6	7.2	92.6	7.5	22.5
		20	5	20.6	7.2	92.5	7.6	22.5
			10	20.6	7.1	91.9	7.6	22.5
			15	20.6	7.0	90.4	7.6	22.4
			18	19.3	3.8	49.1	7.2	25.3
7-3	1313	S	Surf	24.7	8.2	105.4	7.4	11.9
		5-10	5	22.8	7.1	92.3	7.4	18.5
			10	21.2	5.4	69.8	7.2	23.6
			15	18.9	3.4	43.3	7.0	26.6
			18	18.9	3.3	41.2	7.0	26.2
7-8	0937	Light,	Surf	23.3	7.7	98.8	7.7	17.1
		variable	5	23.3	9.1	117.9	8.1	18.4
			10	22.1	7.3	95.2	7.9	22.1
			15	20.3	3.1	40.0	7.1	25.4
			19	18.3	2.7	34.1	7.0	28.5
7-13	0918	SW	Surf	22.0	7.7	101.7	7.7	23.0
			5	21.9	7.6	100.5	7.7	23.0
			10	21.4	7.0	91.2	7.7	23.2
			15	20.7	4.9	64.0	7.4	24.7
			19	18.7	1.6	20.3	7.1	27.6
7-17	0835	SW	Surf	24.6	7.7	105.8	7.8	23.7
		2	5	24.2	8.1	111.0	7.9	23.8
			10	23.9	6.7	91.4	7.8	24.6
			15	20.1	4.2	53.8	7.4	25.9
7-22	1024	SW	Surf	24.5	8.9	124.0	8.0	25.1
		15	5	24.4	8.9	123.5	8.0	25.1
			10	24.3	8.7	120.3	8.0	25.2
			15	21.5	5.3	69.9	7.4	27.7
			18	21.3	5.0	66.3	7.4	27.9

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station C (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
7-27	0909	SW	Surf	24.1	8.6	117.8	8.2	24.5
		5-10	5	24.0	8.5	116.5	8.2	24.6
			10	23.6	6.3	86.1	7.9	25.3
			15	22.0	2.6	33.5	7.6	26.4
			18	21.8	2.4	31.2	7.5	26.5
7-31	1023	NE	Surf	25.0	7.2	101.6	7.7	27.1
		15	5	25.0	7.2	101.9	7.7	27.3
			10	24.8	7.4	104.9	7.7	27.5
			15	23.6	4.9	67.8	7.3	28.7
			18	23.2	4.3	59.4	7.2	29.1
8-5	1150	SW	Surf	26.1	7.6	110.8	7.9	27.2
		5-10	5	25.6	7.0	100.4	7.8	27.7
			10	24.8	5.4	77.5	7.5	28.5
			15	22.1	3.5	47.5	7.2	30.2
8-10	0910	WSW	Surf	24.3	6.6	92.3	8.0	26.9
		~12	5	24.3	6.5	89.9	8.0	26.9
			10	24.2	6.2	86.3	8.0	26.9
			15	24.2	6.0	83.2	7.9	26.9
			20	24.2	5.7	78.6	7.9	26.9
8-14	0948	SW	Surf	24.0	6.5	91.5	7.5	29.5
		2	5	24.0	6.4	91.1	7.5	29.6
			10	24.0	6.3	87.9	7.5	30.5
			15	23.9	6.3	83.3	7.5	29.9
			19	23.8	5.9	82.7	7.5	30.0
8-19	0958	NW	Surf	23.3	7.2	98.1	7.9	27.1
		20	5	23.8	6.0	83.0	7.9	26.8
			10	24.0	5.8	80.5	7.9	27.0
			15	23.4	5.2	71.1	7.8	27.6
			17	23.1	4.5	62.2	7.8	27.7
8-24	1207	SW	Surf	26.4	6.7	96.9	8.0	26.6
		10-15	5	24.6	5.2	86.8	8.0	26.3
			10	24.1	6.8	94.4	8.0	26.5
			15	23.9	6.6	91.4	8.0	26.9
			19	23.7	6.7	92.3	8.0	27.0
8-31	0846	SW	Surf	24.4	8.1	112.3	8.0	26.4
		10-15	5	24.6	5.1	112.4	8.0	26.3
			10	24.6	7.0	97.8	7.9	26.9
			15	23.3	5.5	74.2	7.7	27.7
			16	22.9	4.3	59.3	7.7	27.9
9-3	1127	Light,	Surf	25.1	7.3	103.4	7.9	28.7
		Variable	5	25.0	7.2	102.8	8.0	28.7
			10	24.8	7.3	103.8	8.0	28.7
			15	23.6	6.1	84.6	7.7	29.4
			16	23.1	4.2	57.6	7.5	29.8

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station C (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
9-8	1424	NW	Surf	23.6	6.6	91.4	7.8	29.4
		~12	5	23.8	5.9	82.6	7.8	29.3
			10	23.7	5.8	81.3	7.8	29.2
			15	22.6	5.5	76.1	7.8	29.9
			16	22.6	5.3	73.2	7.8	29.9
9-11	1633	WNW	Surf	23.8	7.4	103.7	7.9	29.4
		~9	5	22.6	6.8	93.5	7.8	29.5
			10	21.9	6.4	87.1	7.8	29.5
			15	21.4	6.2	82.8	7.8	29.5
9-17	1202	WSW	Surf	23.3	8.4	116.4	7.9	29.1
		~8	5	22.9	8.2	113.2	7.9	29.1
			10	22.7	8.0	109.7	7.9	29.6
			15	21.1	7.2	96.6	7.8	30.4
			16	21.0	6.6	88.0	7.8	30.4
9-21	0904	SSW	Surf	22.2	8.2	112.4	8.1	29.8
		~10	5	22.2	83	113.6	8.1	29.7
			10	22.2	8.3	113.0	8.1	29.7
			15	21.9	8.0	108.5	8.0	29.8
			20	22.7	6.8	94.1	8.1	29.9
9-25	1205	S	Surf	20.7	9.0	119.9	8.1	29.7
		5-15	5	20.7	9.1	121.0	8.1	29.6
			10	20.7	9.1	121.2	8.1	29.6
			15	20.7	9.1	120.4	8.1	29.6
			20	20.7	8.9	118.5	8.1	29.5
9-30	0813	Calm	Surf	21.3	7.2	96.8	7.6	29.8
			5	21.3	7.2	97.4	7.6	30.1
			10	21.1	7.2	97.3	7.6	30.7
			15	21.1	6.3	85.5	7.5	30.1
			16	21.0	6.2	84.6	7.5	30.8
10-27	1327	E	Surf	14.4	10.4	120.6	8.0	27.8
		0-5	5	14.2	10.0	115.8	8.0	27.8
			10	14.7	9.8	115.1	8.0	28.4
			15	14.8	9.3	110.1	8.0	29.5
			19	14.5	8.9	105.4	8.0	30.3
11-16	1316	SW	Surf	12.5	10.9	122.1	8.1	28.8
		15-20	5	12.7	10.7	121.2	8.1	28.6
			10	11.5	10.6	117.1	8.1	29.1
			15	11.1	10.1	110.5	8.0	29.3
12-17	1141	SW	Surf	8.0	22.0	222.4	8.2	27.9
		~10	5	9.0	21.0	218.4	8.2	28.4
			10	8.4	21.1	216.5	8.2	28.4
			15	7.8	20.2	205.3	8.2	29.4
			16	7.5	19.9	201.6	8.2	29.6

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station A'								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
1-15	1218	NE	Surf	9.3	10.3	108.1	7.7	27.9
		5-10	5	9.0	10.3	107.7	7.8	28.0
			10	8.0	10.4	106.3	7.8	28.2
			15	5.5	10.4	101.2	7.8	29.5
			17	5.3	10.4	100.8	7.8	29.5
2-17	1144	E	Surf	5.7	11.2	107.4	7.8	25.2
		10-15	5	7.2	10.9	108.7	7.8	27.1
			10	7.1	10.6	106.1	7.8	27.8
			15	5.9	10.5	102.6	7.8	28.9
			20	4.2	10.3	97.3	7.8	29.7
3-2	1315	W	Surf	7.3	10.5	102.3	7.7	22.5
		5	5	8.7	10.2	104.1	7.7	24.5
			10	10.4	9.7	103.4	7.7	25.7
			15	8.8	9.8	101.5	7.8	26.5
			20	8.1	10.0	101.3	7.8	26.7
			21	8.3	9.7	99.4	7.8	26.7
3-6	1154	NE	Surf	7.8	9.4	95.2	7.8	27.0
		15-20	5	9.3	9.3	97.0	7.8	27.1
			10	6.9	9.3	92.5	7.8	28.3
			15	6.6	9.2	91.3	7.8	28.1
			20	5.3	9.3	89.4	7.8	29.1
3-16	1235	N	Surf	8.3	10.1	100.6	7.6	23.0
		10-15	5	7.6	10.2	99.2	7.7	22.6
			10	9.2	10.0	102.1	7.7	23.6
			15	8.5	9.9	100.1	7.7	24.4
			17	8.4	9.9	99.2	7.7	24.3
3-20	1313	NE	Surf	7.6	8.3	88.3	7.5	26.1
		15-20	5	6.6	7.7	83.4	7.6	26.7
			10	8.5	7.9	87.4	7.5	26.4
			15	7.5	7.6	86.1	7.6	28.1
			18	5.3	7.6	80.2	7.6	30.7
3-25	1412	SW	Surf	9.2	10.6	109.0	8.7	26.2
		15-20	5	9.1	10.7	108.6	8.7	25.9
			10	9.1	10.4	106.7	8.7	27.4
			15	7.6	10.6	106.0	8.7	28.7
			20	5.4	10.7	103.3	8.7	30.5
			23	5.4	10.7	102.8	8.7	30.6
3-30	1046	SW	Surf	11.8	10.1	108.1	8.7	24.1
		10-15	5	11.6	10.0	106.5	8.7	24.3
			10	11.4	9.9	105.6	8.7	24.8
			15	8.5	10.4	106.0	8.7	28.4
			19	7.2	10.5	104.5	8.7	29.3

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station A' (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
4-3	1108	W	Surf	10.4	9.5	99.5	7.5	25.1
		5-10	5	10.3	9.5	99.0	7.4	25.4
			10	8.5	9.4	96.5	7.4	29.3
			15	8.4	9.1	93.9	7.4	29.7
			19	8.3	9.0	92.6	7.4	29.9
4-8	1021	E	Surf	11.2	9.6	102.9	7.4	25.9
		5	5	11.4	9.5	102.2	7.5	26.0
			10	9.8	9.4	100.0	7.5	29.5
			15	7.3	9.7	97.9	7.5	31.3
4-13	1054	NE	Surf	10.4	9.3	99.3	7.5	29.1
			5	10.5	9.1	97.8	7.5	29.2
			10	10.1	9.0	96.5	7.5	30.2
			15	9.1	9.1	95.7	7.5	30.4
			20	7.8	9.1	93.4	7.5	30.9
4-17	1200	SW	Surf	14.5	8.4	95.1	7.6	24.3
		15-20	5	14.3	8.4	94.9	7.6	24.6
			10	11.5	8.9	95.0	7.7	24.9
			15	10.7	9.0	94.5	7.6	26.0
			20	8.9	8.8	91.1	7.6	29.1
4-21	1331	SW	Surf	13.1	9.3	99.1	7.5	18.7
		10-15	5	13.7	8.9	97.4	7.5	21.2
			10	11.6	8.9	96.1	7.6	26.0
			15	10.1	8.7	91.6	7.5	27.9
			18	9.9	8.6	89.6	7.6	28.1
4-27	1244	N	Surf	13.9	8.4	95.0	7.5	26.6
		10-15	5	14.0	8.4	94.8	7.6	26.6
			10	13.7	8.4	94.3	7.6	26.7
			15	12.5	8.5	93.3	7.6	27.1
			18	11.7	8.6	93.7	7.6	27.4
5-1	1129	SW	Surf	13.8	8.9	99.7	7.5	22.3
		10-15	5	13.8	8.9	99.0	7.5	22.3
			10	13.5	8.7	96.5	7.5	23.0
			15	11.5	8.3	90.5	7.5	26.7
			20	11.5	8.1	87.8	7.5	26.6
			23	11.4	8.1	88.5	7.5	26.8
5-6	1354	SE	Surf	15.7	8.7	98.0	7.5	18.0
		10-15	5	15.8	8.5	97.1	7.5	19.9
			10	13.6	8.1	92.8	7.5	27.2
			15	11.9	8.0	88.8	7.5	28.2
			17	11.9	7.8	86.5	7.5	28.1

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station A' (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
5-13	1053	NE	Surf	12.6	8.8	96.2	7.6	24.4
		20-25	5	12.5	8.8	96.7	7.5	24.4
			10	14.3	8.5	97.8	7.5	25.6
			15	12.8	8.5	95.0	7.6	27.5
			20	11.3	8.6	94.4	7.6	28.2
5-18	1358	W	Surf	17.7	9.2	109.9	7.7	21.4
		15-20	5	17.5	9.0	108.5	7.7	23.3
			10	15.4	9.3	107.7	7.7	24.0
			15	13.7	8.6	98.2	7.6	26.7
			20	12.4	8.3	93.2	7.5	28.1
			22	12.3	7.7	86.5	7.5	28.2
5-22	1001	N	Surf	19.1	7.6	95.8	7.7	24.9
		15-20	5	18.0	7.7	95.0	7.7	24.6
			10	16.9	7.3	94.4	7.6	25.7
			15	14.4	6.9	80.0	7.5	27.0
5-26	1157	SW	Surf	20.3	7.3	98.8	7.7	25.1
		10-15	5	20.2	7.2	93.0	7.7	25.1
			10	19.9	7.2	92.2	7.7	25.3
			15	18.6	7.2	90.9	7.7	25.8
			17	17.0	7.4	90.6	7.7	26.3
6-1	1033	SW	Surf	22.6	7.1	94.9	7.8	24.3
		10-15	5	22.0	7.3	96.5	7.8	24.5
			10	20.9	7.5	97.3	7.8	24.9
			15	19.5	7.6	96.9	7.8	25.3
			18	19.5	7.5	95.5	7.8	25.8
6-5	1013	W	Surf	20.4	7.4	101.5	8.0	26.0
		20-30	5	20.6	7.4	101.4	8.0	25.9
			10	19.7	7.6	102.2	8.0	26.0
			15	19.7	7.6	102.5	8.0	26.1
			17	19.5	7.7	102.8	8.0	26.2
6-10	1233	SW	Surf	21.3	7.9	107.2	7.9	27.5
		10-15	5	20.9	8.1	108.4	7.9	27.5
			10	20.1	8.2	107.6	7.9	27.6
			15	18.4	7.9	100.9	7.9	28.0
			17	18.1	7.6	96.9	7.9	28.1
6-16	1223	S	Surf	19.2	7.7	91.2	7.3	13.3
		15	5	18.9	7.4	88.5	7.2	15.4
			10	19.9	6.9	86.6	7.4	19.1
			15	17.7	6.5	81.5	7.5	27.4
			19	16.2	6.0	73.7	7.5	29.4

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station A' (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
6-19	1317	S	Surf	23.5	7.3	93.6	6.9	11.1
		10	5	24.5	7.3	96.5	7.2	14.8
			10	22.7	6.8	90.4	7.3	20.5
			15	18.3	5.6	70.1	7.3	25.8
			18	18.0	5.0	63.1	7.3	26.2
6-24		S	Surf	22.7	5.8	77.1	7.2	19.5
		15	5	23.0	5.9	79.3	7.2	20.1
			10	23.1	5.8	76.9	7.3	19.9
			15	22.5	5.2	69.2	7.2	21.8
			20	21.5	4.5	58.7	7.2	22.5
6-29	0755	S	Surf	20.1	7.4	94.0	7.6	22.3
		20	5	20.1	7.3	93.5	7.6	22.2
			10	20.1	7.3	92.8	7.6	22.4
			15	20.1	7.2	91.8	7.6	22.2
			18	20.1	7.2	92.2	7.6	22.2
7-3	1324	S	Surf	25.0	7.4	95.6	7.1	11.1
		5-10	5	25.1	6.5	86.6	7.2	16.9
			10	22.3	5.6	72.9	7.2	23.1
			15	19.4	4.9	61.8	7.2	26.1
			20	18.8	4.4	55.3	7.2	27.1
			23	18.8	4.2	52.8	7.1	27.2
7-8	0949	SE	Surf	24.1	8.7	114.8	8.0	18.2
		5	5	24.5	6.5	87.9	7.6	20.6
			10	24.8	5.4	74.6	7.3	22.6
			15	22.2	4.7	61.9	7.2	25.1
			19	19.5	3.4	43.4	7.1	27.4
7-13	0935	SW	Surf	22.3	7.8	103.6	7.7	22.6
		10-15	5	22.1	7.3	97.5	7.7	22.6
			10	21.8	6.7	87.8	7.6	23.0
			15	20.1	4.9	63.1	7.4	25.6
			20	19.0	2.8	35.3	7.2	26.5
			24	19.0	2.6	33.6	7.2	27.4
7-17	0840	SW	Surf	24.9	7.5	104.2	7.9	23.5
		2	5	25.2	7.1	98.2	7.8	23.8
			10	25.0	7.3	100.6	7.8	23.7
			15	22.2	4.5	65.1	7.4	25.9
7-22	1035	SW	Surf	27.0	7.0	101.2	7.8	25.6
		15	5	26.6	6.9	99.5	7.8	25.8
			10	26.5	6.7	96.0	7.7	25.9
			15	22.9	5.8	78.6	7.5	27.2
			17	21.9	4.6	61.4	7.4	27.5

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station A' (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
7-27	0926	SW	Surf	24.2	8.5	117.6	8.2	24.7
		5-10	5	24.2	8.6	117.5	8.2	24.6
			10	24.0	7.8	106.9	8.1	24.7
			15	23.9	7.6	102.9	8.1	24.8
			19	22.4	3.2	42.5	7.6	26.3
7-31	1038	NE	Surf	26.7	6.4	94.4	7.6	27.3
		15	5	26.1	6.7	97.2	7.7	27.3
			10	25.3	6.8	97.2	7.7	27.4
			15	23.7	5.0	69.8	7.3	27.9
			18	23.3	4.1	57.0	7.2	28.9
8-5	1146	SW	Surf	26.5	6.2	89.6	7.7	26.6
		5-10	5	26.5	6.3	92.4	7.7	27.9
			10	26.3	6.1	89.2	7.7	28.0
			15	24.0	4.6	65.1	7.4	29.2
8-10	0927	WSW	Surf	25.7	6.4	90.7	8.0	26.8
		~12	5	25.6	6.2	88.6	8.0	26.8
			10	25.6	6.2	88.6	8.0	26.7
			15	25.2	6.3	88.9	8.0	26.7
			20	24.7	6.3	87.9	8.0	26.7
8-14	0937	SW	Surf	24.2	6.3	89.3	7.5	29.6
		2	5	24.1	6.3	90.0	7.5	29.7
			10	24.1	6.4	90.7	7.5	29.7
			15	24.0	6.3	89.5	7.5	29.6
8-19	1017	NW	Surf	25.4	5.3	75.4	7.8	27.1
		20	5	25.5	52	74.7	7.8	27.2
			10	24.9	5.5	78.1	7.8	27.1
			15	25.3	5.3	75.1	7.8	27.2
			17	25.4	5.2	74.6	7.8	27.1
8-24	1218	SW	Surf	27.2	6.3	91.3	8.0	26.6
		10-15	5	26.9	6.3	91.4	8.0	26.6
			10	25.9	6.0	86.3	8.0	26.8
			15	25.6	6.2	87.4	8.0	26.5
			19	24.6	6.1	85.3	8.0	26.5
8-31	0858	SW	Surf	27.1	6.3	92.6	7.9	26.9
		10-15	5	26.7	6.3	91.5	7.9	26.8
			10	26.2	6.1	88.1	7.9	27.0
			15	24.2	4.7	64.9	7.8	27.7
			16	22.9	4.0	54.8	7.7	28.0
9-3	1148	SSE	Surf	25.3	7.4	105.5	8.0	28.6
		~5	5	25.3	7.2	102.6	7.9	28.7
			10	25.3	7.3	104.1	8.0	28.6
			15	24.2	6.9	97.1	7.8	28.9
			16	23.3	5.0	70.1	7.5	29.7

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station A' (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
9-8	1436	NW	Surf	24.4	5.7	80.5	7.8	29.4
		~12	5	24.5	5.1	72.4	7.8	29.3
			10	24.3	5.1	71.5	7.8	29.4
			15	24.3	5.1	71.5	7.8	29.3
			16	24.4	5.0	71.3	7.8	29.3
9-11	1643	WNW	Surf	25.2	7.5	107.7	7.9	29.4
		~10	5	24.5	7.6	108.2	7.9	29.3
			10	24.3	7.6	107.6	7.9	29.4
			15	23.5	7.6	106.4	7.9	29.3
9-17	1218	WSW	Surf	23.3	7.1	98.5	7.9	29.7
		~8	5	23.9	6.8	95.0	7.9	29.5
			10	23.5	6.7	93.5	7.9	29.5
			15	22.7	6.5	89.9	7.8	29.8
			16	22.3	6.2	84.3	7.8	29.9
9-21	0916	SSW	Surf	24.3	6.4	90.1	8.1	29.8
		~10	5	24.2	6.6	92.8	8.1	30.0
			10	24.2	6.6	92.7	8.1	29.8
			15	23.7	6.6	92.4	8.1	29.7
			20	22.5	6.7	91.2	8.1	29.7
9-25	1212	S	Surf	23.3	8.0	111.2	8.0	29.4
		5-15	5	22.9	8.0	110.7	8.0	29.3
			10	21.9	8.3	112.0	8.1	29.5
			15	20.9	8.4	111.6	8.1	29.5
			19	20.9	8.3	110.9	8.1	29.5
9-30	0828	Calm	Surf	22.3	7.3	100.2	7.6	29.9
			5	22.9	7.2	100.5	7.6	29.8
			10	21.9	7.3	100.4	7.6	29.9
			15	21.1	7.4	99.9	7.6	30.0
			17	21.2	7.3	98.6	7.6	30.1
10-27	1301	E	Surf	19.8	8.8	114.1	8.	28.9
		0-5	5	17.4	9.5	117.3	8.0	28.5
			10	15.3	9.6	114.1	8.0	29.1
			15	14.5	9.1	107.7	8.0	30.2
			19	14.4	8.7	102.8	8.0	30.3
11-16	1323	SW	Surf	12.4	8.7	97.9	8.1	28.8
		15-20	5	12.2	8.6	96.2	8.1	28.8
			10	12.1	8.5	94.8	8.1	28.8
			15	11.3	8.4	91.8	8.1	28.8
12-17	1222	SW	Surf	11.7	18.4	203.6	8.1	28.8
		~10	5	11.3	18.2	198.6	8.1	28.5
			10	10.3	18.0	192.1	8.1	27.7
			15	8.0	18.1	184.6	8.2	29.3

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
1-15	1346	NE	Surf	4.5	10.7	100.3	7.7	27.5
		10-15	5	4.6	10.4	99.4	7.8	29.6
			10	4.5	10.4	99.1	7.8	29.4
			15	4.3	10.4	98.8	7.8	29.8
			20	4.3	10.4	98.7	7.8	30.6
			25	4.3	10.4	98.7	7.8	30.4
			30	4.4	10.3	98.4	7.8	30.1
			35	4.5	10.3	97.8	7.8	30.0
2-17	1205	E	Surf	3.6	11.2	100.2	7.8	23.8
		10-15	5	4.8	11.0	102.3	7.8	25.1
			10	4.4	10.4	98.1	7.8	29.2
			15	4.0	10.3	96.6	7.8	30.0
			20	3.8	10.2	95.8	7.8	30.7
			25	3.8	10.1	95.6	7.8	30.9
			30	3.8	10.0	94.8	7.8	31.4
			35	3.8	9.9	93.2	7.8	31.1
			39	3.9	9.6	91.4	7.8	31.8
3-2	1056	NW	Surf	6.1	10.1	91.7	7.5	16.5
		5	5	5.8	10.0	92.5	7.6	20.1
			10	5.4	9..7	92.7	7.8	26.6
			15	5.0	9.6	91.7	7.8	29.0
			20	4.9	9.6	91.7	7.8	28.9
			25	4.6	9.7	92.5	7.8	29.7
			30	4.5	9.7	92.5	7.8	29.7
			35	4.5	9.7	92.1	7.8	30.1
			40	4.5	9.7	92.3	7.8	29.9
3-6	1318	W	Surf	8.0	10.1	99.5	8.2	23.0
		10-15	5	6.4	9.8	96.2	8.2	27.5
			10	5.3	9.4	91.0	8.1	29.0
			15	5.0	9.4	90.4	8.2	29.6
			20	4.8	9.4	90.5	8.3	30.1
			25	4.7	9.4	90.8	8.4	30.9
			30	4.6	9.3	89.7	8.2	31.5
			35	4.6	9.3	89.9	8.1	31.5
			39	4.6	9.4	90.8	8.2	31.9
3-16	1006	N	Surf	4.2	11.2	95.8	7.4	14.7
		10-15	5	4.5	10.9	96.3	7.4	18.9
			10	5.2	10.1	94.2	7.6	24.9
			15	4.3	10.0	92.8	7.7	26.7
			20	4.2	10.0	92.6	7.7	26.7
			25	4.5	9.7	91.3	7.7	27.9
			30	4.3	9.6	90.6	7.7	30.1
			35	4.3	9.6	91.3	7.7	30.0
			39	4.3	9.6	91.0	7.7	30.2

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
3-20	1324	NE	Surf	5.1	8.6	90.0	7.6	23.3
		15-20	5	5.1	8.4	87.0	7.6	23.3
			10	5.2	8.3	86.0	7.6	24.3
			15	4.6	7.7	83.0	7.6	31.4
			20	4.6	7.6	83.0	7.6	32.6
			25	4.6	7.9	85.0	7.7	32.6
			30	4.6	7.9	85.0	7.7	32.8
			35	4.6	7.8	85.0	7.7	32.8
			40	4.6	7.6	82.0	7.7	32.7
3-25	1539	SW	Surf	7.5	11.3	108.4	8.7	21.5
		15-20	5	7.5	11.2	107.2	8.7	21.4
			10	5.7	10.9	105.5	8.7	29.6
			15	4.9	10.8	103.3	8.7	31.2
			20	4.8	10.6	101.9	8.7	31.8
			25	4.7	10.4	99.6	8.7	32.0
			30	4.7	10.3	98.4	8.7	32.1
			35	4.8	10.1	96.8	8.7	31.9
			39	4.8	9.8	94.3	8.7	32.5
3-30	0817	SW	Surf	9.1	10.5	103.8	8.6	20.2
		10-15	5	7.7	10.3	102.4	8.6	27.2
			10	7.2	10.3	102.2	8.7	28.3
			15	6.9	10.3	102.3	8.7	29.3
			20	6.7	10.3	102.1	8.7	29.5
			25	6.7	10.3	101.8	8.7	29.5
			30	6.5	10.2	100.6	8.7	29.2
			35	6.6	10.2	100.3	8.7	29.6
			40	6.6	10.2	100.3	8.7	29.5
4-3	1231	W	Surf	10.6	9.3	98.1	7.4	25.4
		10-15	5	10.2	9.5	99.3	7.4	26.3
			10	8.7	9.2	95.3	7.4	29.2
			15	8.3	9.1	93.8	7.4	29.8
			20	7.8	9.1	93.5	7.4	31.1
			25	7.3	9.1	93.2	7.4	32.3
			30	7.3	9.1	93.0	7.5	32.4
			35	7.1	9.2	93.0	7.5	32.1
			40	7.0	9.1	92.7	7.5	32.5
4-8	0859	E	Surf	9.1	10.3	102.3	7.4	20.9
		10-15	5	8.8	9.8	100.3	7.5	26.8
			10	8.3	9.8	100.1	7.5	28.7
			15	7.5	9.7	98.4	7.5	30.7
			20	7.2	9.5	96.2	7.5	31.4
			25	6.7	9.4	95.1	7.5	32.7
			30	6.7	9.4	94.3	7.5	32.8
			35	6.6	9.3	93.4	7.5	33.1
			38	6.6	9.1	91.9	7.5	32.9

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
4-13	1104	NE	Surf	9.2	9.5	97.2	7.5	25.5
		20-25	5	8.8	9.4	95.7	7.5	26.5
			10	8.3	9.2	95.1	7.5	30.6
			15	8.0	9.1	93.7	7.5	31.2
			20	7.7	9.1	92.9	7.5	31.2
			25	7.5	9.0	92.1	7.5	32.1
			30	7.3	9.0	91.7	7.5	32.3
			35	7.2	8.8	90.1	7.5	32.5
			40	7.1	8.7	88.4	7.5	32.2
4-17	1318	SE	Surf	11.4	8.9	93.8	7.6	22.9
		20-25	5	11.4	8.9	93.8	7.6	23.3
			10	11.4	8.8	93.7	7.6	24.7
			15	11.1	8.9	93.7	7.6	25.4
			20	9.8	8.9	92.9	7.6	27.5
			25	8.5	9.0	92.5	7.7	29.6
			30	8.3	9.0	92.3	7.7	29.8
			35	8.0	8.9	90.6	7.6	30.2
			39	7.9	8.6	87.1	7.6	30.3
4-21	1454	W	Surf	13.7	9.3	98.7	7.5	16.7
		15-20	5	13.6	9.1	96.2	7.4	17.1
			10	11.0	9.1	95.5	7.6	25.0
			15	10.6	9.0	94.6	7.6	25.9
			20	9.9	8.9	93.3	7.6	28.0
			25	9.4	8.8	92.2	7.6	29.2
			30	9.1	8.7	90.3	7.6	29.6
			35	8.8	8.7	90.0	7.6	29.9
			39	8.7	8.7	89.8	7.6	30.1
4-27	1008	NW	Surf	10.9	9.1	94.8	7.6	23.9
		15-20	5	11.1	8.8	92.5	7.6	25.3
			10	10.5	8.6	91.1	7.6	27.5
			15	10.5	8.6	90.7	7.6	27.6
			20	10.5	8.6	90.8	7.6	27.6
			25	10.3	8.7	91.8	7.6	27.9
			30	10.1	8.7	92.2	7.6	28.3
			35	10.1	8.8	92.5	7.7	28.2
			40	9.8	8.5	89.1	7.6	28.5
5-1	1248	SW	Surf	13.8	9.4	103.6	7.5	20.7
		10-15	5	13.4	9.2	101.3	7.5	21.3
			10	11.9	8.9	96.7	7.5	26.1
			15	11.1	8.8	95.2	7.5	27.7
			20	10.7	8.9	95.7	7.6	28.2
			25	10.6	8.9	95.5	7.6	28.5
			30	10.5	8.8	95.2	7.6	28.4
			35	10.5	8.8	94.5	7.6	28.5
			40	10.4	8.7	93.6	7.6	28.5
			41	10.4	8.6	92.9	7.6	28.6

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
5-6	1519	SE	Surf	15.8	8.9	99.8	7.5	17.4
		10-15	5	15.5	8.7	97.8	7.5	18.4
			10	12.8	8.3	92.7	7.5	27.2
			15	12.2	8.2	91.2	7.5	28.1
			20	11.9	8.2	90.5	7.5	28.5
			25	11.2	8.2	90.1	7.6	29.3
			30	10.8	8.2	90.0	7.6	29.8
			35	10.3	8.3	89.8	7.6	30.5
			39	10.2	8.2	88.6	7.6	30.8
5-13	0817	ENE	Surf	11.8	8.8	94.9	7.6	23.3
		1520	5	11.8	8.8	94.1	7.5	23.7
			10	11.6	8.5	92.9	7.6	26.6
			15	11.5	8.4	92.0	7.6	28.1
			20	11.4	8.3	91.6	7.6	28.7
			25	11.3	8.3	91.6	7.6	28.9
			30	11.2	8.3	91.5	7.6	29.2
			35	11.2	8.3	91.3	7.6	29.5
			39	11.1	8.3	91.2	7.6	29.7
5-18	1425	SW	Surf	16.1	9.1	104.9	7.5	19.9
		5-10	5	15.3	9.1	104.3	7.6	21.5
			10	15.1	8.9	101.9	7.6	22.3
			15	12.6	8.2	93.2	7.5	27.9
			20	12.3	8.1	90.0	7.6	28.4
			25	12.0	8.2	91.5	7.6	28.9
			30	11.7	8.1	90.4	7.6	29.4
			35	11.6	8.1	89.4	7.6	29.3
			40	11.5	7.8	86.7	7.6	29.5
			44	11.6	7.6	84.7	7.6	29.4
5-22	0931	N	Surf	16.	8.2	97.2	7.6	24.6
		15-20	5	15.8	7.9	92.9	7.5	25.0
			10	14.6	7.4	86.7	7.5	26.6
			15	13.7	7.4	84.7	7.5	27.7
			20	13.4	7.4	84.5	7.5	28.1
			25	13.0	7.5	85.1	7.5	28.4
			30	12.6	7.4	83.8	7.5	28.8
			35	12.4	7.4	83.4	7.5	29.1
			37	12.4	7.2	80.9	7.5	29.0
5-26	1230	SW	Surf	18.2	8.2	101.0	7.7	24.4
		10	5	17.8	8.1	98.9	7.7	24.8
			10	16.8	7.7	93.2	7.7	25.4
			15	16.5	7.5	90.4	7.7	25.3
			20	15.0	7.7	90.4	7.7	27.3
			25	14.6	7.7	89.8	7.8	27.7
			30	14.3	7.6	88.8	7.7	28.1
			35	14.2	7.4	86.4	7.7	27.7

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
6-1	1039	SW	Surf	19.9	7.5	96.0	7.8	24.0
		10-15	5	19.8	7.5	95.6	7.8	24.2
			10	19.7	7.4	94.6	7.8	24.4
			15	19.5	7.4	93.4	7.8	24.6
			20	18.2	6.8	85.4	7.7	26.2
			25	16.7	6.8	83.0	7.6	27.5
			30	16.4	6.7	81.5	7.6	27.7
			35	16.3	6.7	80.8	7.6	27.7
6-5	1018	W	Surf	18.3	7.8	101.7	8.0	24.3
		20-30	5	18.5	7.7	99.7	8.0	24.7
			10	19.4	7.3	96.8	7.9	25.6
			15	18.1	6.3	82.3	7.7	27.3
			20	17.6	5.9	77.8	7.6	28.5
			25	16.9	5.7	74.3	7.6	29.1
			30	15.7	5.7	72.4	7.6	30.1
			35	14.8	5.2	65.7	7.5	30.9
6-10	1338	SW	Surf	19.1	8.1	105.6	7.8	27.8
		10-15	5	18.8	8.2	105.4	7.8	27.7
			10	18.7	8.1	104.2	7.8	27.8
			15	15.0	6.9	83.5	7.6	30.5
			20	14.2	6.5	78.4	7.6	31.4
			25	13.7	6.5	77.8	7.6	31.9
			30	13.6	6.4	76.2	7.5	32.3
			35	12.9	6.2	73.4	7.5	32.9
			36	12.8	6.0	70.9	7.5	33.0
6-16	1256	S	Surf	19.3	8.5	99.6	7.2	11.0
		10	5	19.2	7.8	93.1	7.3	12.7
			10	18.6	6.9	84.5	7.4	20.9
			15	17.7	6.4	81.0	7.5	27.6
			20	16.1	6.5	80.5	7.5	29.5
			25	15.7	6.7	81.9	7.6	30.3
			30	15.5	6.6	80.9	7.6	30.4
			35	15.2	6.3	76.3	7.5	30.5
			40	15.1	5.6	684	7.5	30.6
			43	15.1	5.6	67.5	7.5	30.5
6-19	1323	S	Surf	25.2	9.7	127.5	7.8	10.6
		10	5	22.4	7.8	98.8	7.4	13.4
			10	18.7	5.9	74.2	7.3	22.7
			15	17.4	5.4	67.2	7.4	27.4
			20	16.9	5.3	65.9	7.4	28.4
			25	15.9	5.8	70.9	7.5	30.0
			30	15.3	5.6	68.7	7.5	30.7
			33	15.2	5.6	68.0	7.5	30.8

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
6-24	1016	S	Surf	20.7	6.7	83.5	7.2	17.3
		15	5	20.7	6.6	83.3	7.3	18.2
			10	20.8	6.4	81.2	7.3	18.7
			15	20.3	5.5	69.9	7.2	20.9
			20	18.0	4.9	61.5	7.3	25.6
			25	17.4	5.1	63.1	7.3	26.7
			30	17.0	5.2	63.9	7.4	27.6
			35	16.8	5.2	63.8	7.4	27.9
			37	16.6	5.1	63.1	7.4	28.1
6-29	8015	S	Surf	19.9	6.7	85.6	7.4	21.8
		20	5	20.0	6.7	85.5	7.4	21.8
			10	20.1	6.7	85.1	7.4	21.9
			15	20.3	6.4	82.2	7.5	23.0
			20	18.4	5.7	72.3	7.5	27.2
			25	17.0	6.2	77.5	7.6	30.0
			30	16.8	6.3	79.8	7.6	30.4
			35	16.7	6.3	78.6	7.6	30.6
			36	16.7	6.2	77.9	7.6	30.6
7-3	1331	S	Surf	26.9	7.9	105.3	7.3	10.1
		5-10	5	22.6	7.0	89.2	7.3	17.9
			10	19.3	5.4	68.1	7.2	26.1
			15	18.8	4.9	61.0	7.2	26.5
			20	18.6	4.8	60.5	7.3	27.2
			25	17.3	5.0	62.1	7.3	30.2
			30	16.5	5.4	66.6	7.4	31.4
			35	16.3	5.5	67.7	7.4	32.0
			39	16.2	5.5	68.0	7.4	31.8
7-8	0914	Light	Surf	22.4	8.1	100.3	7.4	13.9
		variable	5	22.2	7.1	89.0	7.4	16.3
			10	20.7	5.7	72.6	7.3	22.0
			15	19.2	5.0	62.9	7.2	26.2
			20	18.7	4.6	57.5	7.2	27.3
			25	17.5	4.7	58.7	7.3	29.0
			30	16.8	4.8	59.7	7.3	30.2
			35	16.6	4.9	59.9	7.3	30.2
			40	16.4	4.8	59.3	7.3	30.7
7-13	0945	SW	Surf	22.3	7.4	97.9	7.6	23.0
		10-15	5	21.5	5.8	76.3	7.5	24.1
			10	20.3	4.7	60.5	7.4	25.3
			15	19.5	4.0	50.6	7.3	26.3
			20	18.4	3.9	48.9	7.3	27.7
			25	17.8	4.0	49.7	7.3	28.6
			30	17.7	4.0	49.9	7.3	28.9
			35	16.3	3.8	46.8	7.3	30.3
			39	16.0	3.6	44.5	7.3	31.0

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
7-17	0853	SW	Surf	24.4	7.3	99.8	7.7	22.6
		2	5	24.2	6.8	92.8	7.6	22.9
			10	23.5	5.7	76.9	7.6	24.4
			15	19.9	5.5	71.3	7.5	28.0
			20	19.0	5.1	65.0	7.4	28.7
			25	18.2	4.6	57.6	7.4	28.9
			30	17.5	4.1	50.4	7.3	29.4
			35	17.6	4.3	54.1	7.3	29.6
7-22	1041	SW	Surf	25.8	8.3	117.9	7.9	25.5
		15	5	25.2	7.8	109.8	7.9	25.4
			10	24.7	7.2	100.2	7.8	25.4
			15	24.8	7.0	97.3	7.8	25.7
			20	20.3	5.5	72.6	7.5	29.1
			25	20.1	5.4	70.6	7.5	29.2
			30	19.9	5.2	67.7	7.4	29.2
			35	19.1	4.9	62.6	7.4	29.6
			38	18.6	4.5	57.2	7.4	30.0
7-27	0935	SW	Surf	24.0	7.4	101.5	8.1	24.8
		5-10	5	24.0	6.7	92.5	8.0	25.0
			10	23.8	5.1	70.1	7.8	25.7
			15	21.9	5.0	66.0	7.8	26.6
			20	20.5	4.2	55.7	7.7	27.3
			25	20.2	4.3	55.1	7.7	27.6
			30	19.8	4.2	54.4	7.7	27.9
			35	19.5	4.2	54.4	7.7	28.1
			38	19.4	4.3	54.7	7.7	28.5
7-31	1045	NE	Surf	24.5	6.8	95.0	7.7	26.1
		15	5	24.9	6.7	95.1	7.7	26.5
			10	23.5	4.7	65.3	7.3	28.7
			15	22.9	4.7	64.8	7.3	29.3
			20	21.8	5.0	68.0	7.4	30.3
			25	21.0	4.9	65.8	7.3	30.9
			30	20.4	5.1	68.1	7.4	31.3
			35	20.4	5.1	68.0	7.4	31.3
			36	20.3	5.1	68.1	7.4	31.3
8-5	1256	SW	Surf	25.2	6.5	92.3	7.6	27.1
		5-10	5	24.5	6.1	86.5	7.6	27.8
			10	23.6	5.2	73.1	7.5	28.8
			15	21.5	4.3	59.1	7.3	30.7
			20	20.6	4.2	55.9	7.3	31.3
			25	19.9	3.9	51.3	7.3	31.6
			30	19.3	3.7	48.6	7.3	31.9
			35	18.9	3.4	43.8	7.2	32.3
			37	18.9	3.2	41.2	7.2	32.3

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
8-10	0935	WSW	Surf	25.3	5.9	84.1	7.9	26.7
		~12	5	25.3	5.7	81.3	7.9	26.7
			10	24.8	5.6	78.3	7.9	26.7
			15	24.1	5.2	72.0	7.9	26.9
			20	23.5	5.1	70.4	7.8	27.2
			25	22.3	4.3	58.4	7.8	27.8
			30	21.8	3.3	44.2	7.7	28.0
			35	21.6	3.2	42.0	7.7	28.0
			40	21.5	2.9	39.1	7.7	28.1
8-14	0859	SW	Surf	23.8	6.4	90.6	7.4	29.5
		2	5	23.7	6.3	88.9	7.4	29.3
			10	23.7	6.1	85.3	7.4	29.9
			15	23.7	6.0	84.6	7.4	29.6
			20	22.6	5.3	72.9	7.4	30.7
			25	22.1	5.0	69.0	7.3	31.6
			30	21.9	4.6	62.9	7.3	31.1
			35	21.9	4.6	63.2	7.3	31.2
			37	21.9	4.6	62.5	7.3	31.5
8-19	1026	NW	Surf	23.4	6.2	84.2	7.8	26.8
		20	5	23.5	5.6	76.3	7.8	27.0
			10	23.5	5.3	73.2	7.8	27.6
			15	23.4	4.9	67.2	7.8	27.8
			20	22.8	4.9	66.3	7.8	28.3
			25	22.6	4.8	65.6	7.8	28.4
			30	22.4	4.8	65.0	7.8	28.6
			35	22.3	4.7	63.6	7.8	28.6
			38	22.3	4.6	61.8	7.8	28.6
8-24	1319	SW	Surf	26.0	7.3	104.9	8.1	26.5
		10-15	5	25.9	7.6	109.0	8.0	26.5
			10	25.9	7.6	108.2	8.0	26.4
			15	25.6	7.3	103.3	8.0	26.4
			20	24.8	6.4	90.2	7.9	26.6
			25	22.5	5.0	67.7	7.8	27.9
			30	22.3	4.6	62.7	7.8	28.0
			35	22.1	4.5	60.3	7.8	28.2
			38	22.0	4.3	58.0	7.7	28.2
8-31	0906	SW	Surf	24.4	7.7	106.4	8.0	26.2
		10-15	5	24.4	7.7	106.5	8.0	26.3
			10	24.4	6.9	96.5	7.9	26.6
			15	22.2	4.7	63.4	7.7	28.2
			20	21.2	4.5	60.3	7.8	28.9
			25	20.6	4.7	61.1	7.8	29.3
			30	19.9	14.6	60.3	7.8	29.6
			35	19.6	4.3	56.1	7.7	29.7
			37	19.6	4.0	51.9	7.7	29.7

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
9-3	1035	Calm	Surf	23.9	7.6	106.0	7.7	27.6
			5	23.8	6.1	85.8	7.7	29.1
			10	22.9	4.7	64.9	7.6	29.9
			15	21.7	4.2	57.5	7.6	30.6
			20	21.3	4.1	55.4	7.6	30.8
			25	21.0	4.0	53.3	7.6	31.0
			30	20.5	3.9	51.6	7.6	31.2
			35	20.1	3.6	47.5	7.5	31.4
			36	20.0	3.4	44.9	7.5	31.5
9-8	1442	NW	Surf	23.8	5.6	77.9	7.8	29.1
		~12	5	23.4	5.1	70.7	7.8	29.4
			10	23.2	4.9	68.2	7.8	29.5
			15	22.7	4.8	66.3	7.8	29.8
			20	22.5	4.8	65.7	7.8	29.9
			25	22.4	4.7	64.7	7.8	30.0
			30	22.3	4.8	65.9	7.8	30.1
			35	22.2	4.8	65.8	7.8	30.1
9-11	1504	WNW	Surf	22.7	7.7	104.8	7.8	29.1
		~10	5	22.4	7.4	100.8	7.8	29.2
			10	22.3	7.2	98.5	7.8	29.3
			15	22.0	6.3	85.8	7.8	29.5
			20	21.4	6.5	87.4	7.8	30.1
			25	21.4	6.5	86.8	7.8	30.1
			30	21.2	6.3	84.6	7.8	30.3
			35	21.2	6.2	82.6	7.8	30.3
			38	21.1	6.1	81.3	7.8	30.4
9-17	1233	WSW	Surf	22.5	6.2	84.7	7.8	29.1
		~8	5	22.0	5.7	77.9	7.8	29.6
			10	21.7	5.4	72.6	7.8	29.9
			15	20.9	5.1	68.7	7.8	30.5
			20	20.4	5.1	67.1	7.8	30.8
			25	20.3	4.9	65.1	7.8	30.8
			30	20.3	4.7	62.1	7.8	30.9
			35	20.2	4.4	57.9	7.7	30.9
			36	20.2	4.2	55.9	7.7	30.9
9-21	0922	SSW	Surf	23.0	5.8	79.5	8.0	29.7
		~10	5	23.0	5.9	81.5	8.0	29.6
			10	22.8	5.9	81.0	8.0	29.6
			15	21.5	5.7	76.8	7.9	30.1
			20	20.8	4.9	65.6	7.9	30.4
			25	20.6	4.7	62.3	7.8	30.6
			30	20.6	4.6	61.1	7.8	30.6
			35	20.5	4.5	60.1	7.8	30.6
			40	20.4	4.4	58.4	7.8	30.7
			41	20.4	4.3	56.8	7.8	30.7

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
9-25	1245	S	Surf	20.9	9.0	119.1	8.1	28.9
		5-15	5	21.0	9.0	119.7	8.1	28.9
			10	21.1	9.0	119.6	8.1	29.0
			15	20.8	8.3	110.5	8.0	29.0
			20	20.6	7.7	102.7	7.9	30.3
			25	20.3	6.9	91.6	7.9	30.7
			30	20.3	6.7	88.7	7.9	30.7
			35	20.2	6.4	85.3	7.9	30.9
			39	20.1	6.1	81.1	7.9	31.0
9-30	0834	Calm	Surf	20.7	7.1	94.4	7.6	29.5
			5	20.7	7.1	94.7	7.6	29.6
			10	20.7	7.1	94.2	7.6	29.6
			15	20.9	7.0	93.8	7.6	29.9
			20	21.0	7.0	94.0	7.6	30.0
			25	20.5	5.8	78.1	7.4	31.4
			30	19.9	5.2	69.1	7.3	31.8
			35	19.9	5.0	66.5	7.3	31.8
			36	19.9	5.0	66.1	7.3	31.8
10-27	1230	E	Surf	14.5	10.5	121.4	8.0	27.6
		0-5	5	14.2	9.8	113.2	8.0	28.4
			10	14.5	9.2	108.7	8.0	30.0
			15	14.4	8.9	104.4	8.0	30.2
			20	14.4	8.8	103.5	8.0	30.6
			25	14.3	8.6	101.9	8.0	31.1
			30	14.3	8.5	100.4	8.0	31.3
			35	14.3	8.2	97.7	8.0	31.4
			40	14.3	7.4	87.6	8.0	30.4
11-16	1357	SW	Surf	11.0	11.3	121.9	8.1	27.5
		15-20	5	11.1	11.2	120.9	8.1	27.5
			10	11.3	11.0	120.0	8.1	27.8
			15	11.5	10.8	118.2	8.1	28.3
			20	11.6	10.5	115.7	8.0	28.7
			25	11.2	10.4	113.8	8.0	29.4
			30	10.9	10.0	109.6	8.0	29.8
			34	10.8	9.9	107.8	8.0	29.9
12-17	1318	SW	Surf	7.6	15.4	154.4	8.2	28.0
		~10	5	7.4	14.5	145.1	8.2	28.1
			10	7.6	14.1	142.2	8.2	28.4
			15	7.7	13.6	138.1	8.2	29.8
			20	7.8	13.4	136.6	8.2	29.9
			25	7.7	13.3	135.2	8.2	29.9
			30	7.6	13.2	134.3	8.2	29.9
			35	7.5	13.1	133.1	8.2	29.9
			36	7.5	13.0	132.4	8.2	29.9

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I4								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
1-15	1129	NE	Surf	3.8	11.6	106.6	7.8	26.9
		10	5	4.6	11.2	105.9	7.7	28.0
			10	5.4	10.7	102.3	7.7	27.6
			15	5.0	10.6	100.7	7.7	28.2
			17	4.9	10.5	100.2	7.7	28.9
2-17	1131	E	Surf	7.3	11.1	110.2	7.8	26.9
		10-15	5	7.9	10.6	107.1	7.8	27.4
			10	5.8	11.0	106.4	7.8	27.8
			15	5.1	11.0	104.4	7.8	27.7
			19	4.7	11.2	105.6	7.8	28.1
3-2	1323	SW	Surf	7.5	10.0	97.5	7.7	21.8
		5-10	5	6.9	10.0	97.1	7.7	23.6
			10	6.7	9.5	94.3	7.7	28.3
			15	5.7	9.5	92.0	7.7	28.0
			17	5.7	9.4	91.2	7.8	28.5
3-6	1135	NE	Surf	7.5	9.5	94.2	7.8	24.8
		15-20	5	8.0	9.3	93.3	7.8	25.7
			10	8.5	9.2	94.3	7.8	27.0
			15	7.5	9.3	93.8	7.8	27.8
			17	7.5	9.4	95.0	7.8	27.6
3-16	1244	N	Surf	5.7	10.4	96.7	7.7	21.4
		10-15	5	5.4	10.3	95.1	7.7	22.0
			10	8.6	9.3	94.1	7.6	23.7
			15	6.3	9.3	88.9	7.6	24.1
			17	5.6	9.5	89.3	7.7	24.1
3-20	1255	NE	Surf	5.7	8.5	88.0	7.6	25.4
		15-20	5	6.1	8.4	87.1	7.6	26.0
			10	6.8	7.7	83.4	7.6	27.1
			15	5.7	7.9	85.1	7.6	28.7
			17	5.2	7.8	85.1	7.6	29.1
3-25	1341	SW	Surf	8.6	11.4	113.5	8.7	24.3
		5-10	5	8.7	11.3	113.1	8.7	24.6
			10	10.5	10.3	109.4	8.7	27.6
			15	9.0	10.5	108.7	8.7	27.8
3-30	1101	SW	Surf	10.8	10.5	108.7	8.7	21.7
		15-20	5	10.5	10.5	108.0	8.7	22.0
			10	9.2	10.3	106.0	8.6	26.2
			15	8.6	10.1	102.4	8.6	26.9
			19	8.3	10.1	101.6	8.6	27.2

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I4 (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
4-3	1048	W	Surf	10.4	9.2	95.7	7.4	23.6
		10-15	5	10.4	9.2	95.2	7.4	23.8
			10	12.5	8.0	89.2	7.3	27.7
			15	11.8	8.1	89.2	7.3	27.7
			18	11.3	8.1	88.1	7.3	27.3
4-8	1030	W	Surf	10.0	9.7	100.6	7.5	24.8
		10-15	5	10.1	9.8	102.0	7.5	25.8
			10	9.9	9.2	97.8	7.4	29.3
			15	9.2	9.0	94.5	7.5	29.5
4-13	1034	NE	Surf	9.8	9.1	95.6	7.6	28.4
		10-15	5	9.6	9.1	95.9	7.5	29.0
			10	9.6	8.7	92.5	7.5	29.8
			15	9.1	8.7	91.3	7.5	30.2
			19	8.9	8.6	89.8	7.5	30.1
4-17	1141	SW	Surf	11.8	8.8	92.7	7.6	23.1
		15-20	5	11.8	8.7	92.4	7.6	22.8
			10	12.4	7.8	91.4	7.5	24.9
			15	13.4	7.8	87.6	7.5	27.0
			18	12.7	7.7	85.8	7.5	27.4
4-21	1315	SW	Surf	12.9	9.4	99.5	7.5	18.6
		15-20	5	12.9	9.3	98.6	7.5	18.7
			10	15.0	8.1	93.3	7.5	25.7
			15	14.4	7.9	90.5	7.5	26.0
			17	14.4	7.9	89.9	7.5	25.9
4-27	1253	N	Surf	12.5	8.6	93.6	7.6	24.9
		10-15	5	12.5	8.5	92.8	7.6	24.9
			10	12.2	8.0	87.6	7.6	26.2
			15	11.3	8.2	87.4	7.5	26.5
			18	11.3	8.0	86.2	7.5	26.6
5-1	1107	SW	Surf	13.7	8.8	98.0	7.5	21.8
		10-15	5	13.9	8.7	97.2	7.5	22.0
			10	15.9	7.8	91.9	7.4	23.7
			15	15.1	8.0	91.8	7.5	23.7
			18	14.5	7.9	90.5	7.4	23.6
5-6	1337	SE	Surf	16.6	8.7	102.3	7.8	18.8
		10-15	5	16.5	8.7	102.0	7.8	18.9
			10	16.1	6.7	81.6	7.4	25.9
			15	15.3	6.6	79.0	7.4	26.1
5-13	1035	NE	Surf	12.2	8.8	96.7	7.6	25.6
		20-25	5	12.2	8.7	95.1	7.6	25.8
			10	13.8	8.0	91.3	7.5	26.3
			15	12.7	8.1	89.9	7.5	26.3
			19	12.5	8.0	89.4	7.5	26.4

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I4 (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
5-18	1341	N	Surf	17.9	9.2	110.3	7.7	21.2
		5-10	5	17.9	9.2	111.2	7.7	21.2
			10	17.8	6.9	85.5	7.4	25.5
			15	17.1	6.9	83.9	7.4	25.7
			20	16.7	6.6	79.5	7.4	26.3
5-22	0957	N	Surf	15.8	9.2	108.1	7.9	24.5
		15-20	5	15.9	9.3	110.3	7.8	24.6
			10	16.9	7.3	88.0	7.6	25.7
			14	16.2	7.3	86.8	7.6	25.9
5-26	1115	SW	Surf	18.1	7.9	98.0	7.7	24.7
		5-10	5	18.1	7.9	97.8	7.7	24.8
			10	18.0	7.8	96.6	7.7	24.7
			15	17.3	8.0	97.2	7.8	24.9
			19	16.9	7.5	90.1	7.7	25.0
6-1	1028	SW	Surf	20.5	7.1	92.5	7.9	23.6
		10-15	5	20.5	7.2	92.5	7.9	23.9
			10	20.5	7.2	92.6	7.9	23.5
			15	20.3	7.2	92.4	7.9	23.5
			17	20.1	7.0	89.2	7.8	23.7
6-5	1009	W	Surf	22.0	7.1	99.8	7.9	25.0
		20-30	5	21.4	7.0	96.3	7.9	25.3
			10	18.7	7.2	95.3	8.0	25.6
			15	19.1	6.8	90.8	7.9	25.9
			17	19.1	6.6	87.1	7.9	26.0
6-10	1225	SW	Surf	19.8	7.5	98.2	7.7	27.2
		10-15	5	19.6	7.5	98.2	7.7	27.3
			10	18.9	7.7	99.2	7.8	27.4
			15	18.2	7.6	96.4	7.8	27.5
			16	18.2	7.5	95.4	7.8	27.3
6-16	1156	S	Surf	19.2	7.9	93.1	7.2	12.5
		15	5	19.2	7.8	92.3	7.2	12.7
			10	20.9	5.7	73.4	7.3	22.2
			15	18.8	5.1	64.3	7.3	24.7
			20	18.4	5.1	64.9	7.3	25.6
6-19	1312	S	Surf	25.5	9.5	125.3	7.9	10.3
		10	5	22.6	8.1	102.0	7.4	11.7
			10	21.7	6.8	85.1	7.2	13.8
			15	21.2	6.4	80.8	7.2	15.8

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I4 (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
6-24	1053	S	Surf	21.1	7.1	89.6	7.4	17.7
		15	5	21.0	6.9	87.4	7.3	17.6
			10	21.0	6.9	86.9	7.3	17.5
			15	20.7	6.6	83.2	7.3	18.3
6-29	0747	S	Surf	20.0	6.3	79.9	7.4	22.2
		20	5	20.1	6.2	78.6	7.4	22.1
			10	20.0	6.2	79.0	7.4	22.2
			15	20.0	6.2	79.0	7.4	22.2
			16	20.0	6.2	78.7	7.4	22.1
7-3	1319	S	Surf	27.3	8.8	118.1	7.7	10.7
		5-10	5	23.5	7.8	100.5	7.5	17.1
			10	23.1	5.9	77.2	7.2	20.7
			15	23.2	4.9	65.3	7.1	21.4
			20	21.2	2.2	28.3	6.8	22.4
7-8	0943	SE	Surf	23.9	9.5	124.7	8.1	17.0
		5	5	24.0	7.2	94.5	7.7	18.3
			10	21.7	5.4	69.9	7.3	22.8
			15	21.8	4.8	62.8	7.2	23.5
			20	21.7	4.5	59.0	7.2	23.9
7-13	0925	SW	Surf	22.6	6.7	89.4	7.6	22.2
		10-15	5	22.3	5.9	77.8	7.5	22.5
			10	22.3	5.9	78.4	7.5	22.8
			15	22.1	6.0	79.5	7.5	22.5
			20	22.1	2.0	27.3	7.2	24.2
			21	20.9	0.3	3.8	7.0	24.9
7-17	0845	SW	Surf	25.1	6.5	90.2	7.7	22.7
		2	5	25.0	6.5	90.4	7.7	22.9
			10	24.9	6.8	92.4	7.8	21.3
			15	24.8	7.0	95.8	7.8	23.3
			19	24.7	7.1	98.0	7.8	23.3
7-22	1030	SW	Surf	25.6	7.9	111.7	8.0	24.5
		15	5	25.4	8.0	112.0	8.0	24.5
			10	25.4	8..0	111.6	8.0	24.5
			15	25.3	7.9	111.0	8.0	24.6
			17	25.2	7.5	105.5	7.9	24.9
7-27	0918	SW	Surf	24.6	6.8	93.2	8.0	24.7
		5-10	5	24.6	6.8	93.4	8.0	24.7
			10	24.4	7.0	97.4	8.1	24.7
			15	24.4	7.2	99.6	8.1	24.9
			20	24.4	7.1	98.0	8.1	24.7

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I#4 (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
7-31	1031	NE	Surf	25.0	6.6	93.3	7.7	27.1
		15	5	25.0	6.5	91.7	7.6	27.1
			10	25.0	6.3	89.7	7.6	27.1
			15	25.0	5.7	81.	7.5	27.3
			18	25.0	5.8	82.4	7.5	27.4
8-5	1141	SW	Surf	26.2	6.3	90.9	7.7	27.1
		5-10	5	26.0	6.0	87.5	7.7	27.5
			10	25.9	6.0	87.1	7.7	27.3
			15	25.8	5.9	85.5	7.7	27.7
8-10	0918	WSW	Surf	25.6	5.7	80.4	7.9	26.5
		~10	5	25.6	5.2	74.2	7.9	26.4
			10	25.4	5.8	82.6	8.0	26.6
			15	25.5	6.1	86.0	8.0	26.6
			20	25.5	6.2	87.3	8.0	26.6
8-14	0926	SW	Surf	23.7	5.6	78.3	7.3	29.5
		2	5	23.8	5.6	79.1	7.4	29.5
			6	23.8	5.6	79.2	7.4	29.5
8-19	1009	NW	Surf	23.7	4.6	63.7	7..7	26.6
		20	5	23.4	5.6	77.0	7.7	26.8
			10	23.8	4.8	66.2	7.7	26.8
			15	23.8	4.7	64.3	7.7	26.8
			17	23.8	4.6	63.8	7.7	26.8
8-24	1137	SW	Surf	25.4	7.2	102.5	8.0	26.3
		10-15	5	25.3	7.3	103.2	8.0	26.4
			10	25.2	7.2	101.7	8.0	26.5
			15	25.2	7.1	99.9	8.0	26.5
			20	25.1	6.8	96.0	8.0	26.5
			21	25.0	6.5	91.8	7.9	26.5
8-31	0853	SW	Surf	26.2	5.4	77..9	7.6	26.5
		10-15	5	25.7	5.4	78.1	7.7	26.5
			10	25.8	5.2	74.2	7.6	26.5
			15	26.0	4.7	67.2	7.5	26.8
9-3	1138	Calm	Surf	24.8	6.5	91.3	7.7	28..3
			5	24.7	6.3	89.7	7.8	28.3
			10	24.7	6.5	91.6	7.8	28.4
			15	24.8	6.7	94.6	7.9	28.4
			19	24.8	6.8	95.7	7.9	28.4
9-8	1430	NW	Surf	23.8	5.6	78.4	7.7	28.8
		~12	5	23.8	5.5	77.3	7.7	28.8
			10	23.8	5.6	78.4	7.8	28.9
			15	23.7	5.6	77.8	7.8	29.0

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station I#4 (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
9-11	1638	WNW	Surf	23.6	7.3	101.8	7.8	29.3
		~10	5	22.7	8.4	115.5	8.0	29.4
			10	22.3	8.8	119.4	8.0	29.4
			15	21.5	7.6	101.4	7.8	29.3
9-17	1211	WSW	Surf	23.0	8.4	115.3	8.0	29.1
		~8	5	22.7	8.2	111.9	7.9	29.0
			10	22.6	7.9	107.8	7.9	29.0
			15	22.5	7.8	106.1	7.9	29.2
9-21	0911	SSW	Surf	22.7	6.8	94.1	8.1	29.9
		~10	5	22.9	7.2	98.8	8.1	29.7
			10	22.9	7.2	99.1	8.1	29.7
			15	22.9	7.2	98.9	8.1	29.7
			20	22.9	7.1	98.6	8.1	29.7
9-25	1139	S	Surf	20.6	9.0	118.7	8.1	29.2
		5-15	5	20.5	8.9	117.3	8.1	29.2
			10	20.5	8.9	117.2	8.1	29.1
			15	20.4	8.8	115.1	8.0	29.1
			20	20.2	8.0	105.1	8.0	29.1
9-30	0820	Calm	Surf	20.6	7.0	93.9	7.6	29.9
			5	20.6	7.1	94.3	7.6	29.9
			10	20.6	7.0	94.1	7.6	30.0
			15	20.6	6.9	92.8	7.6	30.0
			17	20.6	6.9	92.6	7.6	30.0
10-27	1338	E	Surf	14.6	11.0	128.7	8.1	28.1
		0-5	5	14.5	10.7	125.2	8.1	28.1
			10	15.2	10.1	119.5	8.0	28.7
			15	14.7	9.5	111.8	8.0	28.6
			17	14.7	9.2	108.2	8.0	28.7
11-16	1245	SW	Surf	13.6	10.9	124.5	8.1	28.5
		15-20	5	13.1	10.8	122.1	8.1	28.4
			10	12.6	10.8	121.7	8.1	28.5
			15	11.5	10.9	119.7	8.1	28.3
			16	11.4	10.6	116.6	8.1	28.4
12-17	1151	SW	Surf	9.1	22.8	237.1	8.2	28.5
		~10	5	8.6	21.7	223.5	8.1	28.5
			10	8.1	21.5	218.7	8.2	28.4
			15	7.7	20.0	201.3	8.2	28.4

Appendix Table A1. Hydrographic data, January-December 1998 (continued)..

Station A								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
1-15	1720	NE 10-15	~2	17.4	10.2	120.3	7.6	27.7
2-17	1412	E 15-20	~2	13.4	8.2	96.6	8.1	28.8
3-2	1217	NW 5	~2	14.9	8.4	100.5	8.1	27.6
3-6	1548	NE 15-20	~2	14.1	7.2	85.3	8.1	28.3
3-16	1017	NW 10-15	~2	19.3	9.1	115.2	7.7	23.1
3-20	1407	NE 15-20	~2	14.1	9.2	105.7	8.0	27.5
3-25	1700	SW 5-10	~2	19.1	7.8	97.7	7.3	26.2
3-30	0836	SW 10-15	~2	20.6	8.1	105.8	8.5	26.0
4-3	1246	W 10-15	~2	19.6	8.0	102.7	7.3	27.3
4-8	0705	E 10-15	~2	16.0	8.6	104.0	7.4	28.9
4-13	1114	NE 20-25	~2	16.5	8.3	102.0	7.4	30.0
4-17	1328	SE 20-25	~2	19.7	7.9	99.2	7.5	24.9
4-21	1508	S 15-20	~2	20.3	8.0	103.1	7.5	25.6
4-27	1020	NW 10-15	~2	19.7	7.9	100.5	7.5	27.1
5-1	1303	SW 15-20	~2	22.3	7.8	105.1	7.4	25.5
5-6	1537	E 10	~2	23.3	7.4	100.2	7.4	24.6

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station A (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
5-13	1116	NE 20-25	~2	21.0	7.8	103.8	7.5	26.8
5-18	1435	W 15-20	~2	27.6	7.0	102.4	7.4	24.5
5-22	1019	N 15-20	~2	28.7	6.3	94.5	7.4	25.5
5-26	1501	SW 10	~2	28.2	6.7	99.8	7.5	24.7
6-1	1059	SW 10-15	~2	29.2	6.2	92.8	7.6	23.7
6-5	1039	W 20-30	~2	24.5	6.6	97.4	7.8	25.5
6-10	1559	SW 10-15	~2	27.6	7.3	110.9	7.7	27.2
6-16	0715	S 8	~2	26.3	6.2	90.1	7.3	25.8
6-19	1336	S 10	~2	27.7	6.2	91.4	7.3	21.8
6-24	0954	S 15	~2	28.4	5.5	81.3	7.2	20.4
6-29	0815	S 20	~2	26.5	6.3	91.2	7.3	22.2
7-3	1356	S 5-10	~2	29.7	5.3	78.7	7.2	22.5
7-8	0833	Light, variable	~2	29.4	4.8	71.9	7.0	22.6
7-13	1000	SW 10-15	~2	29.6	4.8	73.4	7.3	24.6
7-17	0911	SW 2	~2	31.1	6.0	93.1	7.5	23.3
7-22	0931	SSW 15	~2	33.4	6.3	102.0	7.6	24.7
7-27	0958	SW 5-10	~2	31.1	5.3	82.0	7.8	25.6

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station A (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
7-31	1103	NE 15	~2	32.6	5.4	87.8	7.4	27.4
8-5	1340	SW 5-10	~2	33.8	5.1	84.6	7.4	27.9
8-10	0953	WSW ~12	~2	32.8	5.0	80.7	7.8	26.8
8-14	1048	SW 2	~2	30.9	5.7	90.8	7.4	28.9
8-19	1308	NW 20	~2	29.8	6.5	88.2	6.7	27.1
8-24	1627	SW 10-15	~2	33.7	6.4	103.5	7.9	26.6
8-31	0930	SW 10-15	~2	32.5	5.7	91.5	7.8	27.1
9-3	1615	S ~12	~2	31.3	6.3	99.0	7.8	29.0
9-8	1504	NNW ~12	~2	30.5	5.6	87.0	7.7	29.4
9-11	1404	NNW ~10	~2	31.4	6.5	103.5	7.8	29.6
9-17	1321	WSW ~8	~2	29.9	6.8	106.2	7.8	29.9
9-21	0944	SSW ~10	~2	31.4	7.3	115.7	7.8	30.0
9-25	0353	S 5-15	~2	30.4	8.1	126.5	8.0	29.4
9-30	0857	SW ~10	~2	30.3	6.4	102.0	7.5	29.1
10-27	1731	E 0-5	~2	26.1	7.9	115.6	7.9	29.5
11-16	1640	SW 15-20	~2	23.1	9.6	131.6	8.0	28.6
12-17	1603	SW ~10	~2	21.5	23.8	318.6	8.0	28.6

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

			Station D					
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
1-15	1725	NE 10-15	~2	13.4	10.2	117.4	7.8	27.6
2-17	1408	E 15-20	~2	13.3	8.8	102.4	8.1	28.8
3-2	1222	NW 5	~2	15.1	10.8	97.7	7.9	26.6
3-6	1536	NE 15-20	~2	14.3	10.9	97.8	8.0	27.8
3-16	1022	N 10-15	~2	15.2	9.6	111.5	7.6	24.0
3-20	1402	N 15	~2	14.0	10.1	116.3	8.0	28.3
3-25	1700	NE/SW 5-10	~2	14.9	8.7	101.0	7.3	25.4
3-30	0841	SW 10-15	~2	15.4	9.2	108.3	8.6	27.5
4-3	1251	W 10-15	~2	17.1	8.4	103.1	7.4	28.3
4-8	0709	E 10-15	~2	16.5	8.65	102.6	7.4	27.8
4-13	1118	NE 20-25	~2	16.7	8.1	99.5	7.4	29.9
4-17	1331	SE 20-25	~2	19.6	7.9	99.3	7.5	24.4
4-21	1512	S 15-20	~2	20.1	7.8	100.5	7.5	25.8
4-27	1024	NW 10-15	~2	19.6	7.8	99.8	7.5	27.1
5-1	1308	SW 15-20	~2	22.4	7.5	101.8	7.4	25.6
5-6	1543	E 10	~2	23.6	7.2	99.2	7.4	25.2

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station D (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
5-13	1119	NE 20-25	~2	21.4	7.9	104.4	7.5	25.6
5-18	1439	W 15-20	~2	23.3	7.5	102.6	7.5	24.5
5-22	1025	N 15-20	~2	24.8	6.7	94.6	7.5	25.4
5-26	1506	SW 10	~2	28.0	6.7	100.1	7.6	24.6
6-1	1104	SW 1-15	~2	30.4	6.7	102.9	7.7	23.8
6-5	1048	W 20-30	~2	25.6	6.7	99.6	7.9	25.1
6-10	1604	SW 10-15	~2	29.1	7.5	116.8	7.8	27.0
6-16	0720	S 8	~2	26.9	6.1	89.6	7.4	25.0
6-19	1340	S 10	~2	29.6	6.2	93.2	7.3	20.2
6-24	0958	S 15	~2	29.4	5.4	81.4	7.2	20.1
6-29	0829	S 20	~2	27.7	6.6	97.0	7.4	22.2
7-3	1352	S 5-10	~2	30.1	5.5	82.9	7.2	22.2
7-8	0838	Light, variable	~2	29.7	5.0	75.4	7.1	22.8
7-13	1008	SW 10-15	~2	29.4	4.9	34.4	7.4	25.1
7-17	0918	SW 2	~2	31.6	5.7	89.7	7.5	24.4
7-22	0935	SSW 15	~2	33.9	6.4	104.0	7.6	25.0
7-27	1003	SW 5-10	~2	32.2	5.2	82.5	7.8	25.9

Appendix Table A1. Hydrographic data, January-December 1998 (continued).

Station D (continued)								
Date	Time	Wind	Depth (ft)	Temp (°C)	DO (ppm)	Percent Saturation	pH	Salinity (o/oo)
7-31	1108	NE 15	~2	32.5	5.4	86.7	7.4	27.5
8-5	1346	SW 5-10	~2	33.0	5.2	84.8	7.4	28.1
8-10	0957	WSW ~12	~2	33.9	5.0	82.0	7.8	26.8
8-14	1056	SW 2	~2	27.2	6.1	91.5	7.5	29.7
8-19	1315	NW 20	~2	30.9	5.5	85.9	7.8	27.7
8-24	1631	SW 10-15	~2	35.1	6.6	109.8	8.0	26.6
8-31	0935	SW 10-15	~2	33.0	6.1	98.2	7.8	27.2
9-3	1620	S ~12	~2	28.3	5.7	85.5	7.7	29.5
9-8	1511	NNW ~12	~2	31.7	6.2	99.0	7.7	29.5
9-11	1400	NNW ~10	~2	311	6.5	103.0	7.7	29.6
9-17	1326	WSW ~8	~2	31.0	6.5	102.4	7.8	30.1
9-21	0949	SSW ~10	~2	31.3	6.5	103.8	7.9	29.9
9-25	0348	S 5-15	~2	30.0	8.0	124.7	8.0	29.3
9-30	0903	SW ~10	~2	30.6	6.7	106.3	7.5	28.9
10-27	1726	E 0-5	~2	22.3	8.9	121.7	7.9	29.4
11-16	1645	SW 15-20	~2	20.3	10.1	132.3	8.1	28.5
12-17	1606	SW ~10	~2	15.2	30.4	360.8	8.1	28.6

Table A2. Fish egg and larval population densities per 100 m^3 of water for each species collected in Mount Hope Bay, February-May 1998.

File C:\MIKE\access\mhb467.mdb Table: Table2-17

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS 1	4	5	9	10	21	23	MEANS ARITHM.	GEOM.
ENCHELYOPUS CIMBRIUS	6.29	1.61	1.74	5.10	3.78	7.24	6.29	4.58	3.
TOTAL EGGS	6.29	1.61	1.74	5.10	3.78	7.24	6.29	4.58	3.9

File C:\MIKE\access\mhb467.mdb Table: Table2-17

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS 1	4	5	9	10	21	23	MEANS ARITHM.	GEOM.
CLUPEA HARENGUS	1.57	0.00	0.00	0.00	0.00	1.61	1.57	0.68	0.50
MICROGADUS TOMCOD	0.00	3.23	1.74	0.00	0.00	0.00	0.00	0.71	0.42
MYOXOCEPHALUS AENAEUS	31.46	48.43	10.42	3.40	33.99	20.92	31.46	25.73	19.83
MYOXOCEPHALUS OCTODECEMSPINOSUS	3.15	3.23	0.00	0.00	7.55	2.41	3.15	2.78	1.99
PHOLIS GUNNELLUS	29.89	20.99	1.74	8.49	25.50	19.31	29.89	19.40	14.52
AMMODYTES SP.	108.53	50.04	15.63	2.55	36.83	105.41	108.53	61.07	36.78
P. AMERICANUS STAGE 1	4.72	3.23	1.74	0.85	1.89	0.80	4.72	2.56	2.07
P. AMERICANUS STAGE 2	14.16	1.61	0.00	0.85	1.89	2.41	14.16	5.01	2.78
P. AMERICANUS TOTAL	18.88	4.84	1.74	1.70	3.78	3.22	18.88	7.57	4.84
TOTAL LARVAE	193.47	130.76	31.25	16.14	107.65	152.88	193.47	117.95	87.92

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DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM
ENCHELYOPUS CIMBRIUS	15.98	0.00	6.93	3.96	25.29	28.79	3.10	12.01	7
LABRIDAE	0.00	0.00	2.31	0.99	0.00	0.00	0.00	0.47	0.3
TOTAL EGGS	15.98	0.00	9.24	4.95	25.29	28.79	3.10	12.48	7

File C:\MIKE\access\mhb467.mdb Table: Table2

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
CLUPEA HARENGUS	0.00	0.00	1.54	0.00	0.00	1.03	1.03	0.51	0.40
MYOXOCEPHALUS AENAEUS	28.77	1.65	15.40	26.75	25.29	22.62	25.83	20.90	16.17
MYOXOCEPHALUS SCORPIUS	0.00	0.00	0.00	0.00	1.95	0.00	0.00	0.28	0.17
PHOLIS GUNNELLUS	0.00	1.65	0.77	1.98	9.73	6.17	7.23	3.93	2.66
AMMODYTES SP.	778.33	339.24	293.29	168.44	311.21	366.01	172.55	347.01	306.89
P. AMERICANUS STAGE 1	20.78	11.58	6.16	16.84	0.00	2.06	18.60	10.86	7.00
P. AMERICANUS STAGE 2	20.78	41.37	18.47	10.90	3.89	4.11	29.96	18.50	13.53
P. AMERICANUS TOTAL	41.55	52.95	24.63	27.74	3.89	6.17	48.56	29.36	20.92
TOTAL LARVAE	848.65	395.50	335.63	224.92	352.05	401.99	255.21	401.99	368.07

File C:\MIKE\access\mhb467.mdb Table: Table6

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM
ENCHELYOPUS CIMBRIUS	120.30	139.06	50.18	6.47	83.35	88.29	0.00	69.66	32.
LABRIDAE	18.64	9.00	6.75	0.00	4.53	0.86	0.00	5.68	2.9
TOTAL EGGS	138.93	148.05	56.93	6.47	87.88	89.15	0.00	75.35	34

File C:\MIKE\access\mhb467.mdb Table: Table6

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
CLUPEA HARENGUS	0.85	2.45	2.89	0.00	0.00	1.71	0.00	1.13	0.83
MICROGADUS TOMCOD	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.14	0.10
MYOXOCEPHALUS AENAEUS	4.24	3.27	6.75	27.74	13.59	66.00	8.31	18.56	10.99
MYOXOCEPHALUS OCTODECEMSPINOSUS	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.12	0.09
PHOLIS GUNNELLUS	1.69	0.00	3.86	0.00	0.91	10.29	2.49	2.75	1.68
AMMODYTES SP.	326.16	103.88	167.90	365.30	283.59	471.44	98.91	259.60	223.06
P. AMERICANUS STAGE 1	0.00	8.18	13.51	12.95	3.62	0.86	4.16	6.18	4.04
P. AMERICANUS STAGE 2	36.43	41.72	41.49	0.00	23.56	15.43	13.30	24.56	15.89
P. AMERICANUS TOTAL	36.43	49.90	55.00	12.95	27.18	16.29	17.45	30.74	26.83
TOTAL LARVAE	369.36	159.51	237.37	405.99	325.26	565.73	128.00	313.03	279.64

File c:\mike\access\mhb467.mdb Table: Table16

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
ENCHELYOPUS CIMBRIUS	2.72	1.55	1.79	1.64	75.04	12.61	14.40	15.68	5.
LABRIDAE	0.91	7.77	7.15	0.00	0.86	0.84	0.00	2.50	1.4
TOTAL EGGS	3.62	9.33	8.94	1.64	75.90	13.45	14.40	18.18	9.

File c:\mike\access\mhb467.mdb Table: Table16

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
CLUPEA HARENGUS	0.00	0.00	0.00	0.00	0.00	0.84	0.90	0.25	0.20
MYOXOCEPHALUS AENAEUS	1.81	0.00	0.00	4.10	9.49	22.69	11.70	7.11	3.62
MYOXOCEPHALUS OCTODECEMSPINOSUS	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.12	0.09
PHOLIS GUNNELLUS	0.00	0.00	0.00	0.00	0.86	0.84	0.00	0.24	0.19
AMMODYTES SP.	142.10	6.22	149.27	308.41	252.72	336.15	1040.47	319.33	166.82
P. AMERICANUS STAGE 1	0.00	0.00	0.00	0.00	0.00	0.00	10.80	1.54	0.42
P. AMERICANUS STAGE 2	12.67	10.10	16.09	13.12	28.46	5.04	21.60	15.30	13.55
P. AMERICANUS STAGE 3	0.00	0.00	0.00	0.00	1.73	0.00	0.00	0.25	0.15
P. AMERICANUS TOTAL	12.67	10.10	16.09	13.12	30.19	5.04	32.40	17.09	14.48
TOTAL LARVAE	156.58	16.32	165.35	325.64	293.26	366.40	1085.48	344.15	206.57

File C:\MIKE\access\mhb467.mdb Table: Table20

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	GEOM
ENCHELYOPUS CIMBRIUS	218.63	144.02	49.00	3.33	272.57	28.02	2.70	102.61	37
LABRIDAE	1.98	41.38	26.58	0.00	6.38	1.70	4.50	11.79	5.
SCOPHTHALMUS AQUOSUS	0.00	2.48	0.83	0.00	0.00	0.00	0.00	0.47	0
TOTAL EGGS	220.61	187.88	76.41	3.33	278.95	29.71	7.20	114.87	48.

File C:\MIKE\access\mhb467.mdb Table: Table20

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS 1	4	5	9	10	21	23	MEANS ARITHM.	GEOM.
GADUS MORHUA	0.00	1.66	0.00	0.00	0.00	0.00	0.00	0.24	0.15
MYOXOCEPHALUS AENAEUS	6.92	9.10	4.98	8.33	46.23	8.49	11.70	13.68	10.27
MYOXOCEPHALUS OCTODECEMSPINOSUS	0.00	0.00	0.00	0.00	1.59	0.00	0.00	0.23	0.15
AMMODYTES SP.	96.95	170.50	910.26	110.74	651.94	63.67	74.71	296.97	175.69
P. AMERICANUS STAGE 1	2.97	4.14	2.49	5.00	4.78	0.85	39.60	8.55	4.24
P. AMERICANUS STAGE 2	58.37	71.18	30.73	9.16	38.26	5.09	21.60	33.48	24.24
P. AMERICANUS STAGE 3	0.99	1.66	1.66	0.00	3.19	0.00	0.00	1.07	0.79
P. AMERICANUS TOTAL	62.32	76.97	34.88	14.16	46.23	5.94	61.20	43.10	32.68
TOTAL LARVAE	166.20	258.23	950.13	133.23	745.99	78.11	147.61	354.21	240.64

File C:\MIKE\access\mhb467.mdb Table: Table25

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
ENCHELYOPUS CIMBRIUS	17.58	1.99	13.66	11.67	35.04	81.76	64.82	32.36	19.[illegible]
LABRIDAE	20.51	9.96	20.49	7.78	7.58	2.58	8.53	11.06	9.[illegible]
SCOPHTHALMUS AQUOSUS	7.81	0.00	0.00	0.00	0.00	3.44	5.12	2.34	1.[illegible]
TOTAL EGGS	45.91	11.95	34.15	19.45	42.62	87.78	78.46	45.76	37.6

File C:\MIKE\access\mhb467.mdb Table: Table25

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS 1	4	5	9	10	21	23	MEANS ARITHM.	GEOM.
CLUPEA HARENGUS	0.00	1.00	1.71	1.95	0.00	1.72	0.00	0.91	0.71
GADUS MORHUA	0.00	0.00	0.00	0.00	0.00	0.86	0.00	0.12	0.09
MICROGADUS TOMCOD	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.14	0.10
MYOXOCEPHALUS AENAEUS	12.70	5.98	8.54	5.84	18.00	3.44	7.68	8.88	7.83
PHOLIS GUNNELLUS	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.12	0.09
AMMODYTES SP.	959.25	1864.39	525.87	60.31	342.86	48.20	0.00	542.98	137.52
P. AMERICANUS STAGE 1	6.84	0.00	0.00	19.45	2.84	5.16	8.53	6.12	3.48
P. AMERICANUS STAGE 2	133.83	2.99	78.54	50.58	72.93	21.52	17.91	54.04	33.22
P. AMERICANUS STAGE 3	5.86	0.00	3.41	1.95	3.79	3.44	0.85	2.76	2.21
P. AMERICANUS TOTAL	146.53	2.99	81.95	71.98	79.56	30.12	27.29	62.92	40.17
TOTAL LARVAE	1118.48	1874.35	618.06	140.06	441.36	84.34	35.82	616.07	304.37

File C:\MIKE\access\mhb467.mdb Table: Table30

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS 1	4	5	9	10	21	23	MEANS ARITHM.	GEOM.
ENCHELYOPUS CIMBRIUS	32.31	1.06	0.00	20.81	55.16	41.23	39.77	27.19	13.
LABRIDAE	11.08	7.40	12.83	3.29	2.63	0.00	1.05	5.47	3.6
SCOPHTHALMUS AQUOSUS	0.92	0.00	1.17	1.10	0.88	0.00	3.14	1.03	0.
PLEURONECTES AMERICANUS	0.00	0.00	0.00	0.00	0.00	3.75	0.00	0.54	0.2
TOTAL EGGS	44.31	8.46	13.99	25.19	58.67	44.98	43.95	34.22	28.

File C:\MIKE\access\mhb467.mdb Table: Table30

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
CLUPEA HARENGUS	0.00	0.00	0.00	0.00	0.00	0.94	4.19	0.73	0.39
GADUS MORHUA	0.92	0.00	0.00	0.00	0.00	0.94	0.00	0.27	0.21
MYOXOCEPHALUS AENAEUS	4.62	3.17	1.17	8.76	3.50	14.06	10.46	6.53	4.99
ULVARIA SUBBIFURCATA	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.15	0.11
AMMODYTES SP.	1539.83	507.64	254.21	16.43	189.13	6.56	217.67	390.21	136.46
P. AMERICANUS STAGE 1	1.85	5.29	3.50	7.67	1.75	0.94	1.05	3.15	2.39
P. AMERICANUS STAGE 2	28.62	16.92	25.65	18.62	28.90	33.73	37.67	27.16	26.21
P. AMERICANUS STAGE 3	7.39	3.17	8.16	6.57	3.50	2.81	4.19	5.11	4.71
P. AMERICANUS TOTAL	37.85	25.38	37.32	32.85	34.15	37.48	42.91	35.42	35.03
TOTAL LARVAE	1583.22	537.25	292.69	58.04	226.78	59.97	275.23	433.31	245.72

File C:\MIKE\access\mhb468.mdb Table: Table3

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM
ENCHELYOPUS CIMBRIUS	90.81	23.69	13.19	37.55	89.60	39.67	9.52	43.43	32
LABRIDAE	6.49	12.83	7.03	23.47	9.33	0.83	3.17	9.02	6.1
SCOPHTHALMUS AQUOSUS	0.00	0.99	18.46	0.00	0.00	0.00	0.00	2.78	0
TOTAL EGGS	97.30	37.51	38.68	61.01	98.94	40.49	12.69	55.23	46.

File C:\MIKE\access\mhb468.mdb Table: Table3

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS 1	4	5	9	10	21	23	MEANS ARITHM.	GEOM.
OSMERUS MORDAX	0.00	5.92	2.64	0.00	0.00	0.00	0.00	1.22	0.59
GADUS MORHUA	0.00	0.00	1.76	0.00	0.00	0.83	0.00	0.37	0.26
MYOXOCEPHALUS AENAEUS	2.78	3.95	0.00	0.94	6.53	7.44	12.69	4.90	3.39
AMMODYTES SP.	34.29	8.88	15.82	7.51	13.07	466.06	542.61	155.46	38.24
GOBIOSOMA GINSBURGI	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.14	0.10
P. AMERICANUS STAGE 1	8.34	7.90	5.27	5.63	3.73	0.00	14.28	6.45	4.90
P. AMERICANUS STAGE 2	101.93	35.53	33.41	23.47	31.73	20.66	25.39	38.87	33.49
P. AMERICANUS STAGE 3	15.75	11.84	21.10	13.14	14.00	19.83	7.14	14.69	13.95
P. AMERICANUS TOTAL	126.02	55.28	59.78	42.24	49.47	40.49	46.80	60.01	55.63
TOTAL LARVAE	163.09	75.02	80.00	50.69	69.07	514.82	602.11	222.11	140.15

File C:\MIKE\access\mhb468.mdb Table: Table8

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
ENCHELYOPUS CIMBRIUS	141.60	23.14	32.96	20.93	61.71	78.76	60.99	60.01	48.[illegible]
LABRIDAE	12.47	8.05	3.66	9.30	18.09	8.56	0.00	8.59	6.27
SCOPHTHALMUS AQUOSUS	0.00	7.04	0.00	0.00	0.00	36.81	4.36	6.89	1.[illegible]
TOTAL EGGS	154.07	38.23	36.62	30.24	79.79	124.13	65.34	75.49	63.6[illegible]

File C:\MIKE\access\mhb468.mdb Table: Table8

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
OSMERUS MORDAX	0.00	0.00	8.24	0.00	0.00	0.00	0.00	1.18	0.37
GADUS MORHUA	0.89	0.00	0.00	0.00	0.00	0.00	1.09	0.28	0.22
SYNGNATHUS FUSCUS	0.00	0.00	0.00	0.00	0.00	0.86	0.00	0.12	0.09
MYOXOCEPHALUS AENAEUS	1.78	0.00	0.92	0.00	0.00	2.57	3.27	1.22	0.87
AMMODYTES SP.	6.23	3.02	0.92	6.98	6.38	16.26	1.09	5.84	3.89
P. AMERICANUS STAGE 1	8.02	3.02	1.83	3.49	3.19	0.86	6.53	3.85	3.10
P. AMERICANUS STAGE 2	40.08	5.03	24.72	23.26	45.75	14.55	30.49	26.27	21.82
P. AMERICANUS STAGE 3	8.91	3.02	10.07	15.12	23.41	14.55	19.60	13.52	11.54
P. AMERICANUS TOTAL	57.00	11.07	36.62	41.87	72.35	29.96	56.63	43.64	38.20
UNIDENTIFIED FRAGMENTS	0.00	0.00	0.00	0.00	1.06	0.00	0.00	0.15	0.11
P. AMERICANUS TOTAL	57.00	11.07	36.62	41.87	72.35	29.96	56.63	87.28	38.20
TOTAL LARVAE	65.90	14.09	46.69	48.85	79.79	49.65	62.08	52.43	47.18

File C:\MIKE\access\mhb468.mdb Table: Table13

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS 1	4	5	9	10	21	23	MEANS ARITHM.	GEOM.
ENCHELYOPUS CIMBRIUS	13.92	3.29	5.25	7.63	106.56	38.19	67.72	34.65	17.
LABRIDAE	0.00	4.93	1.05	0.00	9.27	7.03	9.54	4.55	2.7
SCOPHTHALMUS AQUOSUS	0.00	0.00	3.15	1.91	0.00	0.00	0.00	0.72	0.
TOTAL EGGS	13.92	8.22	9.46	9.54	115.83	45.22	77.25	39.92	23.6

File C:\MIKE\access\mhb468.mdb Table: Table13

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS 1	4	5	9	10	21	23	MEANS ARITHM.	GEOM.
CLUPEA HARENGUS	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.14	0.10
OSMERUS MORDAX	0.00	4.93	4.20	0.00	0.00	0.00	0.00	1.30	0.63
GADUS MORHUA	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.10
MYOXOCEPHALUS AENAEUS	3.98	0.00	3.15	1.91	0.00	3.01	8.58	2.95	2.02
LIPARIS ATLANTICUS	0.00	0.00	0.00	0.00	0.93	0.00	0.95	0.27	0.21
AMMODYTES SP.	5.96	23.01	11.56	23.85	7.41	13.06	38.15	17.57	14.58
P. AMERICANUS STAGE 1	3.98	0.00	4.20	6.68	8.34	3.01	1.91	4.02	3.16
P. AMERICANUS STAGE 2	54.68	26.30	46.24	3.82	25.95	6.03	5.72	24.10	15.62
P. AMERICANUS STAGE 3	53.68	32.87	28.37	5.72	14.83	5.02	14.31	22.12	16.30
P. AMERICANUS TOTAL	112.33	59.17	78.82	16.22	49.11	14.07	21.94	50.24	38.65
TOTAL LARVAE	123.27	87.11	97.73	41.98	57.45	31.15	69.62	72.62	66.06

File C:\MIKE\access\mhb468.mdb Table: Table17

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
ENCHELYOPUS CIMBRIUS	5.50	2.76	23.58	87.20	66.72	175.39	76.13	62.47	31
LABRIDAE	11.79	10.12	3.22	17.44	10.40	3.93	0.94	8.26	5.9
SCOPHTHALMUS AQUOSUS	1.57	0.00	4.29	0.87	0.87	21.24	5.64	4.92	2
TOTAL EGGS	18.87	12.88	31.09	105.51	77.98	200.56	82.71	75.66	52.0

File C:\MIKE\access\mhb468.mdb Table: Table17

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
OSMERUS MORDAX	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.12	0.09
MICROGADUS TOMCOD	0.00	0.00	0.00	0.00	0.00	0.79	0.00	0.11	0.09
MYOXOCEPHALUS AENAEUS	1.57	0.92	0.00	0.87	0.87	0.79	2.82	1.12	0.98
TAUTOGOLABRUS ADSPERSUS	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.15	0.11
AMMODYTES SP.	8.65	5.52	0.00	0.00	13.86	0.00	21.62	7.09	3.15
GOBIOSOMA GINSBURGI	0.00	0.92	1.07	0.00	0.00	0.00	0.00	0.28	0.22
P. AMERICANUS STAGE 1	0.00	0.00	2.14	0.00	0.00	2.36	0.94	0.78	0.54
P. AMERICANUS STAGE 2	14.15	1.84	9.65	40.99	25.99	44.05	24.44	23.01	16.16
P. AMERICANUS STAGE 3	13.36	0.00	5.36	44.47	12.13	17.30	13.16	15.11	9.51
P. AMERICANUS TOTAL	27.51	1.84	17.15	85.46	38.13	63.71	38.54	38.90	25.47
TOTAL LARVAE	37.73	9.20	19.30	87.20	52.86	65.28	62.98	47.79	38.57

File C:\MIKE\access\mhb468.mdb Table: Table21

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM
ENCHELYOPUS CIMBRIUS	33.93	2.00	5.93	123.88	11.40	85.68	43.50	43.76	21.
LABRIDAE	11.92	3.00	6.92	14.22	33.24	10.45	4.94	12.10	9.3
SCOMBER SCOMBRUS	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.29	0.
SCOPHTHALMUS AQUOSUS	8.25	0.00	3.95	45.69	5.70	12.54	7.91	12.01	6.7
TOTAL EGGS	54.11	6.99	16.81	183.79	50.34	108.67	56.35	68.15	44

File C:\MIKE\access\mhb468.mdb Table: Table21

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
OSMERUS MORDAX	4.59	11.99	9.89	0.00	0.95	0.00	0.00	3.92	1.85
ENCHELYOPUS CIMBRIUS	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.14	0.10
MYOXOCEPHALUS AENAEUS	0.92	0.00	0.00	0.00	0.95	2.09	0.99	0.71	0.56
AMMODYTES SP.	11.92	0.00	1.98	0.00	4.75	9.40	10.88	5.56	3.30
P. AMERICANUS STAGE 1	0.00	0.00	0.00	1.02	0.95	1.04	4.94	1.14	0.74
P. AMERICANUS STAGE 2	9.17	1.00	2.97	20.31	7.60	10.45	20.76	10.32	7.10
P. AMERICANUS STAGE 3	23.85	1.00	3.95	25.39	2.85	11.49	6.92	10.78	6.59
P. AMERICANUS STAGE 4	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.14	0.10
P. AMERICANUS TOTAL	33.02	2.00	6.92	46.71	11.40	22.99	33.61	22.38	15.20
TOTAL LARVAE	50.44	13.99	19.77	46.71	18.05	34.48	45.48	32.70	29.28

File C:\MIKE\access\mhb468.mdb Table: Table27

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM
ENCHELYOPUS CIMBRIUS	42.05	13.64	1.04	3.94	21.95	49.64	41.17	24.78	14
LABRIDAE	64.83	399.33	76.91	227.72	59.46	25.26	54.89	129.77	86.8
SCOPHTHALMUS AQUOSUS	61.32	66.23	48.85	11.83	1.83	13.06	68.61	38.82	23.
UNIDENTIFIED	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.14	0.
TOTAL EGGS	168.20	480.17	126.80	243.49	83.24	87.96	164.67	193.51	162.

File C:\MIKE\access\mhb468.mdb Table: Table27

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
OSMERUS MORDAX	0.00	0.00	5.20	0.99	0.00	0.00	0.00	0.88	0.43
ENCHELYOPUS CIMBRIUS	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.15	0.11
MYOXOCEPHALUS AENAEUS	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.09
ULVARIA SUBBIFURCATA	0.88	0.97	0.00	0.99	0.00	0.87	0.98	0.67	0.60
AMMODYTES SP.	6.13	4.87	2.08	1.97	4.57	21.77	23.52	9.27	6.02
GOBIOSOMA GINSBURGI	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.14	0.10
P. AMERICANUS STAGE 2	2.63	0.00	3.12	0.99	0.00	5.23	2.94	2.13	1.56
P. AMERICANUS STAGE 3	5.26	0.00	6.24	6.90	0.00	2.61	14.70	5.10	3.12
P. AMERICANUS TOTAL	7.88	0.00	9.35	7.89	0.00	7.84	17.64	7.23	4.40
TOTAL LARVAE	15.77	6.82	17.67	11.83	4.57	30.48	42.15	18.47	14.46

File C:\MIKE\ACCESS\mhb469.mdb Table: Table1

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
BREVOORTIA TYRANNUS	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.12	0.[illegible]
ENCHELYOPUS-UROPHYCIS-PEPRILUS	8.20	0.00	0.00	2.88	8.40	78.45	39.35	19.61	6.2
ENCHELYOPUS CIMBRIUS	0.91	0.00	1.00	0.00	0.00	0.00	0.00	0.27	0.[illegible]
LABRIDAE	275.00	414.24	292.82	178.80	183.82	39.23	153.14	219.58	181.8
PARALICHTHYS-SCOPHTHALMUS	68.30	6.65	36.98	70.17	78.78	53.31	101.81	59.43	46.[illegible]
TOTAL EGGS	352.40	421.73	330.80	251.86	271.00	170.99	294.30	299.01	289.1

File C:\MIKE\ACCESS\mhb469.mdb Table: Table1

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
OSMERUS MORDAX	0.00	0.00	1.00	0.00	2.10	0.00	0.00	0.44	0.30
ENCHELYOPUS CIMBRIUS	0.00	0.00	0.00	0.96	0.00	2.01	0.00	0.42	0.29
MYOXOCEPHALUS AENAEUS	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.14	0.10
ULVARIA SUBBIFURCATA	0.00	0.83	1.00	0.00	1.05	2.01	0.86	0.82	0.71
AMMODYTES SP.	6.37	1.66	4.00	0.00	2.10	1.01	2.57	2.53	2.00
GOBIOSOMA GINSBURGI	0.00	0.00	0.00	0.96	2.10	2.01	0.00	0.72	0.51
P. AMERICANUS STAGE 1	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.14	0.10
P. AMERICANUS STAGE 2	0.00	0.00	1.00	3.85	0.00	1.01	0.00	0.84	0.53
P. AMERICANUS STAGE 3	0.00	0.00	0.00	1.92	2.10	0.00	0.86	0.70	0.50
P. AMERICANUS TOTAL	0.00	0.00	1.00	5.77	2.10	2.01	0.86	1.68	1.18
TOTAL LARVAE	6.37	2.50	7.00	7.69	9.45	10.06	4.28	6.76	6.19

File C:\MIKE\ACCESS\mhb469.mdb Table: Table6

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
BREVOORTIA TYRANNUS	56.34	17.24	2103.06	498.36	1710.58	8.61	4.65	628.41	94.9
ENCHELYOPUS-UROPHYCIS-PEPRILUS	29.39	0.00	0.00	70.39	67.71	45.40	11.62	32.07	12.6
ENCHELYOPUS CIMBRIUS	1.63	0.00	0.00	2.11	0.00	3.91	0.77	1.20	0.
LABRIDAE	725.04	50.89	447.80	123.18	552.37	325.59	513.00	391.13	293.5
PARALICHTHYS-SCOPHTHALMUS	114.31	3.28	235.10	75.32	201.35	87.66	106.17	117.60	74.
TOTAL EGGS	926.71	71.41	2785.96	769.37	2532.01	471.17	636.22	1170.41	727.3

File C:\MIKE\ACCESS\mhb469.mdb Table: Table6

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS 1	4	5	9	10	21	23	MEANS ARITHM.	GEOM.
BREVOORTIA TYRANNUS	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.11	0.09
OSMERUS MORDAX	3.27	4.92	0.00	0.00	0.00	0.00	0.00	1.17	0.59
ENCHELYOPUS CIMBRIUS	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.10	0.08
TAUTOGA ONITIS	0.00	0.00	0.00	0.00	0.00	3.13	2.32	0.78	0.45
TAUTOGOLABRUS ADSPERSUS	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.11	0.09
T. ADSPERSUS STAGE 1	3.27	1.64	0.00	0.70	0.89	0.00	0.00	0.93	0.67
T. ADSPERSUS STAGE 2	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.10	0.08
ULVARIA SUBBIFURCATA	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.12	0.09
AMMODYTES SP.	0.00	0.00	3.20	0.00	0.00	1.57	0.00	0.68	0.40
GOBIOSOMA GINSBURGI	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.11	0.09
SCOPHTHALMUS AQUOSUS	0.00	0.82	0.00	0.00	0.00	0.00	1.55	0.34	0.25
P. AMERICANUS STAGE 3	1.63	0.00	0.00	0.00	0.00	0.00	0.77	0.34	0.25
P. AMERICANUS TOTAL	1.63	0.00	0.00	0.00	0.00	0.00	0.77	0.34	0.25
TOTAL LARVAE	8.16	8.21	3.20	2.11	0.89	7.04	4.65	4.90	3.88

File C:\MIKE\ACCESS\mhb469.mdb Table: Table13

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
BREVOORTIA TYRANNUS	0.00	1.42	1.48	0.00	0.73	0.00	0.00	0.52	0.
ENCHELYOPUS-UROPHYCIS-PEPRILUS	13.19	0.71	8.86	2.02	22.77	31.50	47.84	18.13	9.2
ENCHELYOPUS CIMBRIUS	1.55	0.71	0.00	0.00	0.00	0.00	0.66	0.42	0.
LABRIDAE	185.42	309.42	261.36	359.69	279.16	129.76	927.64	350.35	292.
SCOMBER SCOMBRUS	0.00	0.00	0.00	0.00	0.00	2.25	1.33	0.51	0.
PARALICHTHYS-SCOPHTHALMUS	96.20	68.84	56.11	43.70	78.61	41.25	134.23	74.13	68.
SCOPHTHALMUS AQUOSUS	0.00	1.42	1.48	1.34	0.00	0.00	0.00	0.61	0.4
TOTAL EGGS	296.36	382.51	329.29	406.75	381.28	204.76	1111.71	444.67	387

File C:\MIKE\ACCESS\mhb469.mdb Table: Table13

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM.
BREVOORTIA TYRANNUS	0.78	0.71	1.48	0.00	0.73	0.00	0.00	0.53	0.44
OSMERUS MORDAX	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.10	0.08
ENCHELYOPUS CIMBRIUS	0.00	0.00	0.00	0.00	1.47	0.00	0.66	0.30	0.22
UROPHYCIS SPP.	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.21	0.14
MENIDIA SPP.	0.00	0.00	0.74	0.00	0.73	0.00	0.00	0.21	0.17
LIPARIS ATLANTICUS	1.55	0.71	0.00	0.00	0.00	0.00	0.00	0.32	0.23
ULVARIA SUBBIFURCATA	0.78	0.00	0.00	0.00	0.00	0.75	0.00	0.22	0.18
AMMODYTES SP.	0.00	0.71	0.00	0.67	0.73	0.00	0.66	0.40	0.35
GOBIOSOMA GINSBURGI	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.11	0.08
SCOPHTHALMUS AQUOSUS	1.55	1.42	2.21	0.67	0.00	0.75	0.66	1.04	0.92
P. AMERICANUS STAGE 3	3.88	0.00	0.74	0.00	0.00	0.00	0.66	0.75	0.46
P. AMERICANUS STAGE 4	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.09	0.08
P. AMERICANUS TOTAL	3.88	0.00	0.74	0.00	0.00	0.00	1.33	0.85	0.53
TOTAL LARVAE	8.53	4.26	5.91	1.34	3.67	3.00	3.32	4.29	3.76

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DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

STATIONS

SPECIES	1	4	5	9	10	21	23	MEANS ARITHM.	MEANS GEOM
BREVOORTIA TYRANNUS	234.81	2446.09	2864.89	22580.79	0.00	43.72	48.90	4031.31	260
ENCHELYOPUS-UROPHYCIS-PEPRILUS	0.74	0.00	1.76	0.00	12.14	55.76	18.34	12.68	3.9
ENCHELYOPUS CIMBRIUS	0.74	0.00	0.88	0.00	0.00	0.63	1.75	0.57	0.
LABRIDAE	553.80	1950.33	904.52	1467.34	267.02	696.97	883.61	960.51	813.4
SCOMBER SCOMBRUS	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.10	0.
PARALICHTHYS-SCOPHTHALMUS	39.87	6.13	35.20	27.17	67.83	157.13	129.22	66.08	44
SCOPHTHALMUS AQUOSUS	6.65	2.72	2.64	0.00	10.71	0.00	5.24	3.99	2.
HIPPOGLOSSOIDES PLATESSOIDES	0.00	0.00	0.00	0.00	0.00	0.00	3.49	0.50	0
TOTAL EGGS	836.61	4405.27	3809.88	24075.31	358.41	954.21	1090.55	5075.75	1995

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DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS 1	4	5	9	10	21	23	MEANS ARITHM.	GEOM.
BREVOORTIA TYRANNUS	4.43	1.36	0.00	0.00	10.71	0.00	0.00	2.36	1.05
ENCHELYOPUS CIMBRIUS	0.00	0.68	1.76	0.00	0.00	1.27	0.00	0.53	0.40
UROPHYCIS SPP.	0.00	0.68	0.88	0.85	0.00	0.63	0.00	0.43	0.38
MENIDIA SPP.	0.00	0.68	0.88	0.00	0.00	0.63	0.00	0.31	0.26
GASTEROSTEUS ACULEATUS	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.12	0.09
LIPARIS ATLANTICUS	0.00	0.00	0.00	0.00	0.00	0.63	2.62	0.46	0.29
T. ADSPERSUS STAGE 1	1.48	0.68	0.00	0.85	0.71	1.27	0.00	0.71	0.62
ULVARIA SUBBIFURCATA	0.00	0.00	0.00	0.00	0.71	0.00	0.87	0.23	0.18
AMMODYTES SP.	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.10	0.08
SCOPHTHALMUS AQUOSUS	0.74	6.13	1.76	1.70	3.57	0.00	0.00	1.99	1.37
P. AMERICANUS STAGE 3	0.00	0.00	0.00	0.00	0.71	0.63	2.62	0.57	0.39
P. AMERICANUS STAGE 4	0.00	0.00	0.00	0.00	0.00	0.00	1.75	0.25	0.16
P. AMERICANUS TOTAL	0.00	0.00	0.00	0.00	0.71	0.63	4.37	0.82	0.47
UNIDENTIFIED FRAGMENTS	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.12	0.09
TOTAL LARVAE	6.65	10.21	5.28	4.25	17.14	5.07	8.73	8.19	7.35

Table A3. Larval winter flounder population densities per 100 cubic meters of water recorded at Brayton Point Units 1,2,3 Intake Station I in upper and lower halves of the water column, February to mid-May, 1998.

Appendix Table A3. Larval winter flounder population densities per 100 cubic meters of water recorded at Brayton Point Units 1,2,3 Intake Station I in upper and lower halves of the water column, February - mid-May, 1998.

Date 1998	Strata and Replicate	Stage 1 Density	Stage 2 Density	Stage 3 Density	Stage 4 Density	Total Density
Feb 17	Upper 1	5.95	4.25	0.00	0.00	10.20
	Upper 2	5.33	7.11	0.00	0.00	12.45
	Upper 3	10.39	8.91	0.00	0.00	19.29
	Lower 1	27.96	2.27	0.00	0.00	30.22
	Lower 2	20.70	3.70	0.00	0.00	24.39
	Lower 3	24.80	5.67	0.00	0.00	30.47
March 2	Upper 1	12.91	8.88	0.00	0.00	21.79
	Upper 2	28.17	11.56	0.00	0.00	39.72
	Upper 3	8.88	13.32	0.00	0.00	22.20
	Lower 1	34.19	10.01	0.00	0.00	44.20
	Lower 2	31.08	3.70	0.00	0.00	34.78
	Lower 3	30.95	11.74	0.00	0.00	42.70
March 6	Upper 1	41.76	25.99	0.00	0.00	67.75
	Upper 2	35.63	18.27	0.00	0.00	53.91
	Upper 3	42.12	19.71	0.00	0.00	61.83
	Lower 1	31.34	18.65	0.00	0.00	49.99
	Lower 2	37.09	18.54	0.00	0.00	55.63
	Lower 3	34.62	10.72	0.00	0.00	45.33
March 11	Upper 1	9.26	16.83	0.84	0.00	26.93
	Upper 2	0.86	4.32	0.00	0.00	5.19
	Upper 3	9.96	26.05	0.00	0.00	36.01
	Lower 1	15.20	25.08	0.00	0.00	40.28
	Lower 2	13.87	56.95	0.73	0.00	71.55
	Lower 3	25.07	19.91	0.00	0.00	44.99
March 16	Upper 1	4.99	14.96	0.00	0.00	19.94
	Upper 2	0.00	11.80	0.00	0.00	11.80
	Upper 3	3.08	10.78	0.00	0.00	13.86
	Lower 1	0.79	3.17	0.00	0.00	3.97
	Lower 2	2.28	12.16	0.00	0.00	14.44
	Lower 3	0.00	3.16	0.00	0.00	3.16
March 20	Upper 1	15.57	80.43	1.73	0.00	97.72
	Upper 2	18.53	77.32	0.00	0.00	95.85
	Upper 3	35.44	55.43	0.00	0.00	90.87
	Lower 1	34.01	34.80	0.79	0.00	69.60
	Lower 2	9.86	31.86	1.52	0.00	43.23
	Lower 3	26.30	22.03	0.71	0.00	49.04
March 25	Upper 1	4.71	24.71	1.18	0.00	30.59
	Upper 2	7.44	27.92	1.86	0.00	37.22
	Upper 3	8.34	44.81	0.00	0.00	53.14
	Lower 1	16.33	35.23	0.00	0.00	51.55
	Lower 2	21.43	29.81	0.00	0.00	51.24
	Lower 3	7.24	14.48	0.00	0.00	21.71

Appendix Table A3. continued.

Date 1998	Strata and Replicate	Stage 1 Density	Stage 2 Density	Stage 3 Density	Stage 4 Density	Total Density
March 30	Upper 1	10.02	22.04	4.01	0.00	36.06
	Upper 2	10.63	30.70	0.00	0.00	41.32
	Upper 3	0.00	14.74	1.05	0.00	15.79
	Lower 1	18.52	31.75	1.76	0.00	52.03
	Lower 2	13.53	50.75	3.38	0.00	67.66
	Lower 3	19.46	8.19	1.02	0.00	28.68
April 3	Upper 1	0.96	1.84	0.46	0.00	3.26
	Upper 2	2.68	7.62	2.68	0.00	12.98
	Upper 3	1.06	14.86	6.37	0.00	22.29
	Lower 1	67.14	24.50	3.63	0.00	95.27
	Lower 2	45.47	39.22	15.16	0.00	99.85
	Lower 3	40.09	30.90	8.35	0.00	79.35
April 8	Upper 1	1.15	33.46	17.31	0.00	51.92
	Upper 2	0.00	6.17	3.80	0.00	9.97
	Upper 3	3.15	22.07	12.61	0.00	37.83
	Lower 1	0.85	41.57	20.36	0.00	62.77
	Lower 2	3.04	16.73	8.62	0.00	28.39
	Lower 3	6.03	31.02	17.23	0.00	54.28
April 13	Upper 1	2.69	33.18	19.73	0.00	55.60
	Upper 2	3.18	24.38	15.90	0.00	43.46
	Upper 3	9.84	18.78	8.94	0.00	37.56
	Lower 1	7.33	38.30	39.11	0.00	84.74
	Lower 2	3.72	25.11	27.90	0.00	56.72
	Lower 3	8.12	23.45	31.57	0.00	63.14
April 17	Upper 1	2.89	6.75	9.65	0.00	19.30
	Upper 2	3.02	1.51	2.27	0.00	6.80
	Upper 3	0.79	2.38	3.97	0.00	7.14
	Lower 1	1.79	14.35	30.50	0.00	46.64
	Lower 2	1.49	5.98	24.66	0.00	32.13
	Lower 3	1.58	2.37	20.57	0.00	24.53
April 21	Upper 1	2.01	0.00	19.09	0.00	21.10
	Upper 2	2.67	6.22	19.55	0.00	28.43
	Upper 3	0.79	4.77	10.33	0.79	16.68
	Lower 1	0.94	5.61	27.12	0.00	33.67
	Lower 2	5.43	3.88	25.60	0.00	34.91
	Lower 3	4.20	0.00	29.43	0.00	33.63
April 27	Upper 1	0.00	9.82	24.56	0.00	34.38
	Upper 2	0.00	5.62	8.84	0.00	14.46
	Upper 3	0.00	5.11	27.26	0.00	32.37
	Lower 1	2.47	6.59	42.83	0.00	51.89
	Lower 2	0.76	7.59	34.90	0.00	43.25
	Lower 3	0.84	7.54	34.35	0.00	42.72

Appendix Table A3. continued.

Date 1998	Strata and Replicate	Stage 1 Density	Stage 2 Density	Stage 3 Density	Stage 4 Density	Total Density
May 1	Upper 1	0.00	0.82	3.29	0.00	4.12
	Upper 2	0.00	0.97	5.84	0.00	6.81
	Upper 3	0.00	0.88	3.51	0.00	4.39
	Lower 1	0.00	1.47	11.05	0.00	12.52
	Lower 2	0.00	3.62	17.22	0.00	20.84
	Lower 3	0.00	4.87	25.98	0.81	31.66
May 6	Upper 1	0.00	0.00	0.00	0.00	0.00
	Upper 2	0.00	0.00	0.00	0.00	0.00
	Upper 3	0.00	0.76	0.00	0.00	0.76
	Lower 1	0.00	0.00	1.40	0.00	1.40
	Lower 2	0.00	0.00	2.15	0.00	2.15
	Lower 3	0.00	2.16	2.16	1.44	5.76
May 13	Upper 1	0.00	4.71	5.49	0.00	10.20
	Upper 2	0.00	1.49	11.14	0.00	12.63
	Upper 3	0.00	1.53	11.49	0.77	13.79
	Lower 1	0.00	8.65	59.82	2.16	70.63
	Lower 2	0.00	7.71	60.94	1.40	70.05
	Lower 3	0.00	8.54	38.17	1.71	48.42
May 18	Upper 1	0.00	0.00	0.77	0.00	0.77
	Upper 2	0.00	0.00	0.00	0.00	0.00
	Upper 3	0.00	0.00	0.81	0.00	0.81
	Lower 1	0.00	0.75	4.49	0.75	5.99
	Lower 2	0.00	0.00	0.00	0.00	0.00
	Lower 3	0.00	0.78	1.57	0.00	2.35

Table A4. Larval winter flounder population densities per 100 cubic meters of water recorded at Montaup Station M, February to mid-May 1998.

Appendix Table A4. Larval winter flounder population densities per 100 cubic meters of water recorded at Montaup Station M, February - mid-May 1998.

	Larval Winter Flounder				
Date 1998	Stage 1 Density	Stage 2 Density	Stage 3 Density	Stage 4 Density	Total Density
February 17	6.50	2.44	0.00	0.00	8.94
March 2	0.00	0.83	0.00	0.00	0.83
6	16.64	15.71	0.00	0.00	32.35
13	6.23	14.54	0.00	0.00	20.77
16	0.77	14.63	0.00	0.00	15.40
20	11.31	25.70	1.03	0.00	38.03
25	10.97	19.95	0.00	0.00	30.93
30	0.91	31.06	3.65	0.00	35.63
April 3	18.53	73.31	13.70	0.00	105.53
8	3.59	28.70	5.38	0.00	37.67
13	7.01	29.80	28.04	0.00	64.85
17	8.69	17.38	28.67	0.00	54.74
21	0.87	6.07	3.47	0.00	10.41
27	0.00	0.00	9.76	0.00	9.76
May 1	0.00	0.96	1.93	0.00	2.89
6	0.00	0.77	0.00	0.00	0.77
13	0.00	0.67	2.01	0.00	2.68
18	0.00	0.00	0.68	0.00	0.68

Table A5. Fish egg and larval population densities per 100 m^3 of water for each species entrained at Brayton Point, February-May 1998.

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DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
CLUPEA HARENGUS I (Atl. herring)	2.46	
CLUPEA HARENGUS II	10.62	
CLUPEA HARENGUS III	8.01	
ARITHMETIC MEAN CLUPEA HARENGUS	7.03	
GEOMETRIC MEAN CLUPEA HARENGUS	6.12	
MICROGADUS TOMCOD I (Atl. tomcod)	0.61	
MICROGADUS TOMCOD II	0.00	
MICROGADUS TOMCOD III	0.00	
ARITHMETIC MEAN MICROGADUS TOMCOD	0.20	
GEOMETRIC MEAN MICROGADUS TOMCOD	0.17	
MYOXOCEPHALUS SPP. I (Sculpin SP.)	0.00	
MYOXOCEPHALUS SPP. II	0.62	
MYOXOCEPHALUS SPP. III	0.00	
ARITHMETIC MEAN MYOXOCEPHALUS SPP.	0.21	
GEOMETRIC MEAN MYOXOCEPHALUS SPP.	0.18	
MYOXOCEPHALUS AENAEUS I (Grubby)	30.73	
MYOXOCEPHALUS AENAEUS II	26.25	
MYOXOCEPHALUS AENAEUS III	26.33	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	27.77	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	27.60	
MYOXOCEPHALUS OCTODECEMSPINOSUS I (Longhorn Sculpin)	0.00	
MYOXOCEPHALUS OCTODECEMSPINOSUS II	0.62	
MYOXOCEPHALUS OCTODECEMSPINOSUS III	1.72	
ARITHMETIC MEAN MYOXOCEPHALUS OCTODECEMSPINOSUS	0.78	
GEOMETRIC MEAN MYOXOCEPHALUS OCTODECEMSPINOSUS	0.64	
PHOLIS GUNNELLUS I (Rock Gunnel)	1.23	
PHOLIS GUNNELLUS II	3.75	
PHOLIS GUNNELLUS III	2.29	
ARITHMETIC MEAN PHOLIS GUNNELLUS	2.42	
GEOMETRIC MEAN PHOLIS GUNNELLUS	2.26	
AMMODYTES SP. I (Sand lance)	20.28	
AMMODYTES SP. II	20.62	
AMMODYTES SP. III	0.00	
ARITHMETIC MEAN AMMODYTES SP.	13.64	
GEOMETRIC MEAN AMMODYTES SP.	6.70	
P. AMERICANUS STAGE 1 I (Winter flounder)	0.00	
P. AMERICANUS STAGE 1 II	1.87	
P. AMERICANUS STAGE 1 III	0.00	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	0.62	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	0.42	

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DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
P. AMERICANUS STAGE 2 I	1.23	
P. AMERICANUS STAGE 2 II	1.25	
P. AMERICANUS STAGE 2 III	1.72	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	1.40	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	1.39	
TOTAL LARVAE I	56.55	
TOTAL LARVAE II	65.61	
TOTAL LARVAE III	40.07	
ARITHMETIC MEAN TOTAL LARVAE	54.08	
GEOMETRIC MEAN TOTAL LARVAE	52.78	
P.AMERICANUS TOTAL I	1.23	
P.AMERICANUS TOTAL II	3.12	
P.AMERICANUS TOTAL III	1.72	
ARITHMETIC MEAN TOTAL P.AMERICANUS	2.02	
GEOMETRIC MEAN TOTAL P.AMERICANUS	1.92	

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DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I (Fourbeard Rockling)	0.61	
ENCHELYOPUS CIMBRIUS II	2.50	
ENCHELYOPUS CIMBRIUS III	0.57	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	1.23	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	1.07	
HIPPOGLOSSOIDES PLATESSOIDES I (American Plaice)	0.00	
HIPPOGLOSSOIDES PLATESSOIDES II	1.87	
HIPPOGLOSSOIDES PLATESSOIDES III	0.00	
ARITHMETIC MEAN HIPPOGLOSSOIDES PLATESSOIDES	0.62	
GEOMETRIC MEAN HIPPOGLOSSOIDES PLATESSOIDES	0.42	
PLEURONECTES AMERICANUS I (Winter Flounder)	0.61	
PLEURONECTES AMERICANUS II	1.87	
PLEURONECTES AMERICANUS III	1.14	
ARITHMETIC MEAN PLEURONECTES AMERICANUS	1.21	
GEOMETRIC MEAN PLEURONECTES AMERICANUS	1.15	
TOTAL EGGS I	1.23	
TOTAL EGGS II	6.25	
TOTAL EGGS III	1.72	
ARITHMETIC MEAN TOTAL EGGS	3.07	
GEOMETRIC MEAN TOTAL EGGS	2.52	

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DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
CLUPEA HARENGUS I	0.00	
CLUPEA HARENGUS II	2.32	
CLUPEA HARENGUS III	1.33	
ARITHMETIC MEAN CLUPEA HARENGUS	1.22	
GEOMETRIC MEAN CLUPEA HARENGUS	0.98	
MYOXOCEPHALUS AENAEUS I	4.34	
MYOXOCEPHALUS AENAEUS II	6.95	
MYOXOCEPHALUS AENAEUS III	11.33	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	7.54	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	7.04	
PHOLIS GUNNELLUS I	0.87	
PHOLIS GUNNELLUS II	1.54	
PHOLIS GUNNELLUS III	1.33	
ARITHMETIC MEAN PHOLIS GUNNELLUS	1.25	
GEOMETRIC MEAN PHOLIS GUNNELLUS	1.23	
AMMODYTES SP. I	33.88	
AMMODYTES SP. II	24.70	
AMMODYTES SP. III	23.32	
ARITHMETIC MEAN AMMODYTES SP.	27.30	
GEOMETRIC MEAN AMMODYTES SP.	26.84	
P. AMERICANUS STAGE 1 I	6.95	
P. AMERICANUS STAGE 1 II	6.95	
P. AMERICANUS STAGE 1 III	8.00	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	7.30	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	7.27	
P. AMERICANUS STAGE 2 I	4.34	
P. AMERICANUS STAGE 2 II	6.18	
P. AMERICANUS STAGE 2 III	5.33	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	5.28	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	5.23	
TOTAL LARVAE I	50.38	
TOTAL LARVAE II	48.63	
TOTAL LARVAE III	50.65	
ARITHMETIC MEAN TOTAL LARVAE	49.89	
GEOMETRIC MEAN TOTAL LARVAE	49.68	
P.AMERICANUS TOTAL I	11.29	
P.AMERICANUS TOTAL II	13.12	
P.AMERICANUS TOTAL III	13.33	
ARITHMETIC MEAN TOTAL P.AMERICANUS	12.58	
GEOMETRIC MEAN TOTAL P.AMERICANUS	12.51	

File C:\MIKE\access\bp80.mdb Table: Table2

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	20.85	
ENCHELYOPUS CIMBRIUS II	17.75	
ENCHELYOPUS CIMBRIUS III	17.33	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	18.64	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	18.52	
LABRIDAE I ray finned sp.	0.00	
LABRIDAE II	3.86	
LABRIDAE III	66.64	
ARITHMETIC MEAN LABRIDAE	23.50	
GEOMETRIC MEAN LABRIDAE	5.89	
PLEURONECTES AMERICANUS I	0.00	
PLEURONECTES AMERICANUS II	0.00	
PLEURONECTES AMERICANUS III	0.67	
ARITHMETIC MEAN PLEURONECTES AMERICANUS	0.22	
GEOMETRIC MEAN PLEURONECTES AMERICANUS	0.19	
TOTAL EGGS I	20.85	
TOTAL EGGS II	21.61	
TOTAL EGGS III	84.63	
ARITHMETIC MEAN TOTAL EGGS	42.36	
GEOMETRIC MEAN TOTAL EGGS	33.72	

File C:\MIKE\access\bp80.mdb Table: Table6

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	UNIT 4
CLUPEA HARENGUS I	1.56	
CLUPEA HARENGUS II	1.27	
CLUPEA HARENGUS III	0.69	
ARITHMETIC MEAN CLUPEA HARENGUS	1.18	
GEOMETRIC MEAN CLUPEA HARENGUS	1.14	
MICROGADUS TOMCOD I	0.00	
MICROGADUS TOMCOD II	0.64	
MICROGADUS TOMCOD III	0.69	
ARITHMETIC MEAN MICROGADUS TOMCOD	0.44	
GEOMETRIC MEAN MICROGADUS TOMCOD	0.40	
MYOXOCEPHALUS AENAEUS I	5.21	
MYOXOCEPHALUS AENAEUS II	8.91	
MYOXOCEPHALUS AENAEUS III	1.38	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	5.17	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	4.26	
PHOLIS GUNNELLUS I	1.04	
PHOLIS GUNNELLUS II	0.00	
PHOLIS GUNNELLUS III	0.69	
ARITHMETIC MEAN PHOLIS GUNNELLUS	0.58	
GEOMETRIC MEAN PHOLIS GUNNELLUS	0.51	
AMMODYTES SP. I	16.68	
AMMODYTES SP. II	26.10	
AMMODYTES SP. III	16.55	
ARITHMETIC MEAN AMMODYTES SP.	19.78	
GEOMETRIC MEAN AMMODYTES SP.	19.27	
P. AMERICANUS STAGE 1 I	1.04	
P. AMERICANUS STAGE 1 II	1.91	
P. AMERICANUS STAGE 1 III	2.76	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	1.90	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	1.81	
P. AMERICANUS STAGE 2 I	15.64	
P. AMERICANUS STAGE 2 II	8.91	
P. AMERICANUS STAGE 2 III	9.65	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	11.40	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	11.04	
TOTAL LARVAE I	41.18	
TOTAL LARVAE II	47.74	
TOTAL LARVAE III	32.40	
ARITHMETIC MEAN TOTAL LARVAE	40.44	
GEOMETRIC MEAN TOTAL LARVAE	39.80	

File C:\MIKE\access\bp80.mdb Table: Table6

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	59.94	
ENCHELYOPUS CIMBRIUS II	54.11	
ENCHELYOPUS CIMBRIUS III	59.98	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	58.01	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	57.70	
MYOXOCEPHALUS AENAEUS I	0.00	
MYOXOCEPHALUS AENAEUS II	4.46	
MYOXOCEPHALUS AENAEUS III	0.00	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	1.49	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	0.76	
LABRIDAE I	4.17	
LABRIDAE II	2.55	
LABRIDAE III	6.20	
ARITHMETIC MEAN LABRIDAE	4.31	
GEOMETRIC MEAN LABRIDAE	4.08	
TOTAL EGGS I	64.11	
TOTAL EGGS II	61.11	
TOTAL EGGS III	66.18	
ARITHMETIC MEAN TOTAL EGGS	63.80	
GEOMETRIC MEAN TOTAL EGGS	63.50	

File C:\MIKE\access\bp80.mdb Table: Table6

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

========== LARVAE ==========

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
P.AMERICANUS TOTAL I	16.68	
P.AMERICANUS TOTAL II	10.82	
P.AMERICANUS TOTAL III	12.41	
ARITHMETIC MEAN TOTAL P.AMERICANUS	13.30	
GEOMETRIC MEAN TOTAL P.AMERICANUS	13.06	

File C:\MIKE\access\bp80.mdb Table: Table11

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
CLUPEA HARENGUS I	3.92	
CLUPEA HARENGUS II	1.50	
CLUPEA HARENGUS III	4.60	
ARITHMETIC MEAN CLUPEA HARENGUS	3.34	
GEOMETRIC MEAN CLUPEA HARENGUS	3.10	
MICROGADUS TOMCOD I	0.78	
MICROGADUS TOMCOD II	0.00	
MICROGADUS TOMCOD III	0.00	
ARITHMETIC MEAN MICROGADUS TOMCOD	0.26	
GEOMETRIC MEAN MICROGADUS TOMCOD	0.21	
MYOXOCEPHALUS AENAEUS I	1.57	
MYOXOCEPHALUS AENAEUS II	0.75	
MYOXOCEPHALUS AENAEUS III	0.77	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	1.03	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	0.99	
PHOLIS GUNNELLUS I	0.78	
PHOLIS GUNNELLUS II	0.00	
PHOLIS GUNNELLUS III	0.00	
ARITHMETIC MEAN PHOLIS GUNNELLUS	0.26	
GEOMETRIC MEAN PHOLIS GUNNELLUS	0.21	
AMMODYTES SP. I	67.51	
AMMODYTES SP. II	28.59	
AMMODYTES SP. III	21.46	
ARITHMETIC MEAN AMMODYTES SP.	39.18	
GEOMETRIC MEAN AMMODYTES SP.	34.58	
P. AMERICANUS STAGE 1 I	0.00	
P. AMERICANUS STAGE 1 II	0.00	
P. AMERICANUS STAGE 1 III	0.77	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	0.26	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	0.21	
P. AMERICANUS STAGE 2 I	3.14	
P. AMERICANUS STAGE 2 II	9.03	
P. AMERICANUS STAGE 2 III	6.90	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	6.36	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	5.88	
TOTAL LARVAE I	77.71	
TOTAL LARVAE II	39.87	
TOTAL LARVAE III	34.49	
ARITHMETIC MEAN TOTAL LARVAE	50.69	
GEOMETRIC MEAN TOTAL LARVAE	47.32	

File C:\MIKE\access\bp80.mdb Table: Table11

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	40.03	
ENCHELYOPUS CIMBRIUS II	21.82	
ENCHELYOPUS CIMBRIUS III	41.38	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	34.41	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	32.99	
LABRIDAE I	9.42	
LABRIDAE II	6.02	
LABRIDAE III	3.07	
ARITHMETIC MEAN LABRIDAE	6.17	
GEOMETRIC MEAN LABRIDAE	5.66	
TOTAL EGGS I	49.45	
TOTAL EGGS II	27.84	
TOTAL EGGS III	44.45	
ARITHMETIC MEAN TOTAL EGGS	40.58	
GEOMETRIC MEAN TOTAL EGGS	39.29	

File C:\MIKE\access\bp80.mdb Table: Table11

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
P.AMERICANUS TOTAL I	3.14	
P.AMERICANUS TOTAL II	9.03	
P.AMERICANUS TOTAL III	7.66	
ARITHMETIC MEAN TOTAL P.AMERICANUS	6.61	
GEOMETRIC MEAN TOTAL P.AMERICANUS	6.10	

File C:\MIKE\access\bp80.mdb Table: Table16

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
CLUPEA HARENGUS I	0.00	
CLUPEA HARENGUS II	0.00	
CLUPEA HARENGUS III	4.08	
ARITHMETIC MEAN CLUPEA HARENGUS	1.36	
GEOMETRIC MEAN CLUPEA HARENGUS	0.72	
MYOXOCEPHALUS AENAEUS I	0.00	
MYOXOCEPHALUS AENAEUS II	1.09	
MYOXOCEPHALUS AENAEUS III	0.00	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	0.36	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	0.28	
AMMODYTES SP. I	22.10	
AMMODYTES SP. II	25.18	
AMMODYTES SP. III	16.33	
ARITHMETIC MEAN AMMODYTES SP.	21.20	
GEOMETRIC MEAN AMMODYTES SP.	20.82	
P. AMERICANUS STAGE 1 I	0.00	
P. AMERICANUS STAGE 1 II	0.00	
P. AMERICANUS STAGE 1 III	1.36	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	0.45	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	0.33	
P. AMERICANUS STAGE 2 I	5.53	
P. AMERICANUS STAGE 2 II	2.74	
P. AMERICANUS STAGE 2 III	0.68	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	2.98	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	2.44	
TOTAL LARVAE I	27.63	
TOTAL LARVAE II	29.01	
TOTAL LARVAE III	22.46	
ARITHMETIC MEAN TOTAL LARVAE	26.37	
GEOMETRIC MEAN TOTAL LARVAE	26.12	
P.AMERICANUS TOTAL I	5.53	
P.AMERICANUS TOTAL II	2.74	
P.AMERICANUS TOTAL III	2.04	
ARITHMETIC MEAN TOTAL P.AMERICANUS	3.43	
GEOMETRIC MEAN TOTAL P.AMERICANUS	3.20	

File C:\MIKE\access\bp80.mdb Table: Table16

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	15.96	
ENCHELYOPUS CIMBRIUS II	18.06	
ENCHELYOPUS CIMBRIUS III	12.93	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	15.65	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	15.47	
LABRIDAE I	2.46	
LABRIDAE II	13.68	
LABRIDAE III	117.73	
ARITHMETIC MEAN LABRIDAE	44.62	
GEOMETRIC MEAN LABRIDAE	17.14	
TOTAL EGGS I	18.42	
TOTAL EGGS II	31.75	
TOTAL EGGS III	130.66	
ARITHMETIC MEAN TOTAL EGGS	60.28	
GEOMETRIC MEAN TOTAL EGGS	42.58	

File C:\MIKE\access\bp80.mdb Table: Table20

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
CLUPEA HARENGUS I	0.00	
CLUPEA HARENGUS II	0.00	
CLUPEA HARENGUS III	0.63	
ARITHMETIC MEAN CLUPEA HARENGUS	0.21	
GEOMETRIC MEAN CLUPEA HARENGUS	0.18	
GADUS MORHUA I all. 100	0.64	
GADUS MORHUA II	0.00	
GADUS MORHUA III	0.00	
ARITHMETIC MEAN GADUS MORHUA	0.21	
GEOMETRIC MEAN GADUS MORHUA	0.18	
MICROGADUS TOMCOD I	0.00	
MICROGADUS TOMCOD II	0.00	
MICROGADUS TOMCOD III	0.63	
ARITHMETIC MEAN MICROGADUS TOMCOD	0.21	
GEOMETRIC MEAN MICROGADUS TOMCOD	0.18	
MYOXOCEPHALUS AENAEUS I	5.11	
MYOXOCEPHALUS AENAEUS II	12.91	
MYOXOCEPHALUS AENAEUS III	5.02	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	7.68	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	6.98	
PHOLIS GUNNELLUS I	0.00	
PHOLIS GUNNELLUS II	1.29	
PHOLIS GUNNELLUS III	0.00	
ARITHMETIC MEAN PHOLIS GUNNELLUS	0.43	
GEOMETRIC MEAN PHOLIS GUNNELLUS	0.32	
AMMODYTES SP. I	44.73	
AMMODYTES SP. II	61.34	
AMMODYTES SP. III	49.59	
ARITHMETIC MEAN AMMODYTES SP.	51.89	
GEOMETRIC MEAN AMMODYTES SP.	51.23	
P. AMERICANUS STAGE 1 I	10.86	
P. AMERICANUS STAGE 1 II	9.04	
P. AMERICANUS STAGE 1 III	5.65	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	8.52	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	8.23	
P. AMERICANUS STAGE 2 I	26.84	
P. AMERICANUS STAGE 2 II	23.25	
P. AMERICANUS STAGE 2 III	15.69	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	21.92	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	21.35	

File C:\MIKE\access\bp80.mdb Table: Table20

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	UNIT 4
ENCHELYOPUS CIMBRIUS I	72.20	
ENCHELYOPUS CIMBRIUS II	74.91	
ENCHELYOPUS CIMBRIUS III	58.37	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	68.49	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	67.80	
LABRIDAE I	10.86	
LABRIDAE II	191.78	
LABRIDAE III	20.09	
ARITHMETIC MEAN LABRIDAE	74.24	
GEOMETRIC MEAN LABRIDAE	35.27	
PARALICHTHYS-SCOPHTHALMUS I	0.00	
PARALICHTHYS-SCOPHTHALMUS II	0.00	
PARALICHTHYS-SCOPHTHALMUS III	0.63	
ARITHMETIC MEAN PARALICHTHYS-SCOPHTHALMUS	0.21	
GEOMETRIC MEAN PARALICHTHYS-SCOPHTHALMUS	0.18	
PLEURONECTES AMERICANUS I	0.64	
PLEURONECTES AMERICANUS II	1.29	
PLEURONECTES AMERICANUS III	1.88	
ARITHMETIC MEAN PLEURONECTES AMERICANUS	1.27	
GEOMETRIC MEAN PLEURONECTES AMERICANUS	1.21	
TOTAL EGGS I	83.70	
TOTAL EGGS II	267.98	
TOTAL EGGS III	80.97	
ARITHMETIC MEAN TOTAL EGGS	144.22	
GEOMETRIC MEAN TOTAL EGGS	121.55	

Runder / windspare

File C:\MIKE\access\bp80.mdb Table: Table20

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

========== LARVAE ==========

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
TOTAL LARVAE I	88.17	
TOTAL LARVAE II	107.84	
TOTAL LARVAE III	77.20	
ARITHMETIC MEAN TOTAL LARVAE	91.07	
GEOMETRIC MEAN TOTAL LARVAE	89.81	
P.AMERICANUS TOTAL I	37.70	
P.AMERICANUS TOTAL II	32.29	
P.AMERICANUS TOTAL III	21.34	
ARITHMETIC MEAN TOTAL P.AMERICANUS	30.44	
GEOMETRIC MEAN TOTAL P.AMERICANUS	29.54	

File C:\MIKE\access\bp80.mdb Table: Table25

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
CLUPEA HARENGUS I	0.00	
CLUPEA HARENGUS II	0.00	
CLUPEA HARENGUS III	0.66	
ARITHMETIC MEAN CLUPEA HARENGUS	0.22	
GEOMETRIC MEAN CLUPEA HARENGUS	0.18	
MYOXOCEPHALUS AENAEUS I	11.78	
MYOXOCEPHALUS AENAEUS II	11.28	
MYOXOCEPHALUS AENAEUS III	9.28	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	10.78	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	10.70	
AMMODYTES SP. I	62.03	
AMMODYTES SP. II	68.98	
AMMODYTES SP. III	41.74	
ARITHMETIC MEAN AMMODYTES SP.	57.58	
GEOMETRIC MEAN AMMODYTES SP.	56.11	
P. AMERICANUS STAGE 1 I	2.48	
P. AMERICANUS STAGE 1 II	6.63	
P. AMERICANUS STAGE 1 III	0.66	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	3.26	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	2.53	
P. AMERICANUS STAGE 2 I	8.06	
P. AMERICANUS STAGE 2 II	18.57	
P. AMERICANUS STAGE 2 III	29.15	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	18.60	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	16.44	
P. AMERICANUS STAGE 3 I	0.00	
P. AMERICANUS STAGE 3 II	1.99	
P. AMERICANUS STAGE 3 III	3.31	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	1.77	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	1.34	
TOTAL LARVAE I	84.36	
TOTAL LARVAE II	107.45	
TOTAL LARVAE III	84.80	
ARITHMETIC MEAN TOTAL LARVAE	92.20	
GEOMETRIC MEAN TOTAL LARVAE	91.19	
P.AMERICANUS TOTAL I	10.54	
P.AMERICANUS TOTAL II	27.19	
P.AMERICANUS TOTAL III	33.13	
ARITHMETIC MEAN TOTAL P.AMERICANUS	23.62	
GEOMETRIC MEAN TOTAL P.AMERICANUS	21.24	

File C:\MIKE\access\bp80.mdb Table: Table25

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	17.37	
ENCHELYOPUS CIMBRIUS II	17.24	
ENCHELYOPUS CIMBRIUS III	23.85	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	19.49	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	19.21	
LABRIDAE I	3.10	
LABRIDAE II	4.64	
LABRIDAE III	11.26	
ARITHMETIC MEAN LABRIDAE	6.34	
GEOMETRIC MEAN LABRIDAE	5.56	
PLEURONECTES AMERICANUS I	0.62	
PLEURONECTES AMERICANUS II	0.00	
PLEURONECTES AMERICANUS III	0.00	
ARITHMETIC MEAN PLEURONECTES AMERICANUS	0.21	
GEOMETRIC MEAN PLEURONECTES AMERICANUS	0.17	
TOTAL EGGS I	21.09	
TOTAL EGGS II	21.89	
TOTAL EGGS III	35.11	
ARITHMETIC MEAN TOTAL EGGS	26.03	
GEOMETRIC MEAN TOTAL EGGS	25.25	

File C:\MIKE\access\bp80.mdb Table: Table30

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
MYOXOCEPHALUS AENAEUS I	0.00	
MYOXOCEPHALUS AENAEUS II	1.89	
MYOXOCEPHALUS AENAEUS III	1.95	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	1.28	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	1.04	
AMMODYTES SP. I	104.21	
AMMODYTES SP. II	155.95	
AMMODYTES SP. III	76.11	
ARITHMETIC MEAN AMMODYTES SP.	112.09	
GEOMETRIC MEAN AMMODYTES SP.	106.88	
P. AMERICANUS STAGE 1 I	2.58	
P. AMERICANUS STAGE 1 II	0.95	
P. AMERICANUS STAGE 1 III	1.95	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	1.83	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	1.74	
P. AMERICANUS STAGE 2 I	22.39	
P. AMERICANUS STAGE 2 II	5.67	
P. AMERICANUS STAGE 2 III	4.88	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	10.98	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	8.69	
P. AMERICANUS STAGE 3 I	0.86	
P. AMERICANUS STAGE 3 II	1.89	
P. AMERICANUS STAGE 3 III	0.00	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	0.92	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	0.75	
TOTAL LARVAE I	130.04	
TOTAL LARVAE II	166.34	
TOTAL LARVAE III	84.90	
ARITHMETIC MEAN TOTAL LARVAE	127.09	
GEOMETRIC MEAN TOTAL LARVAE	121.91	
P.AMERICANUS TOTAL I	25.84	
P.AMERICANUS TOTAL II	8.51	
P.AMERICANUS TOTAL III	6.83	
ARITHMETIC MEAN TOTAL P.AMERICANUS	13.72	
GEOMETRIC MEAN TOTAL P.AMERICANUS	11.56	

File C:\MIKE\access\bp80.mdb Table: Table30

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	40.48	
ENCHELYOPUS CIMBRIUS II	48.20	
ENCHELYOPUS CIMBRIUS III	73.19	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	53.95	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	52.09	
LABRIDAE I	10.33	
LABRIDAE II	8.51	
LABRIDAE III	10.73	
ARITHMETIC MEAN LABRIDAE	9.86	
GEOMETRIC MEAN LABRIDAE	9.79	
SCOPHTHALMUS AQUOSUS I windowpane	12.06	
SCOPHTHALMUS AQUOSUS II	0.00	
SCOPHTHALMUS AQUOSUS III	0.00	
ARITHMETIC MEAN SCOPHTHALMUS AQUOSUS	4.02	
GEOMETRIC MEAN SCOPHTHALMUS AQUOSUS	1.35	
PLEURONECTES AMERICANUS I	0.00	
PLEURONECTES AMERICANUS II	1.89	
PLEURONECTES AMERICANUS III	0.98	
ARITHMETIC MEAN PLEURONECTES AMERICANUS	0.96	
GEOMETRIC MEAN PLEURONECTES AMERICANUS	0.79	
TOTAL EGGS I	62.87	
TOTAL EGGS II	58.60	
TOTAL EGGS III	84.90	
ARITHMETIC MEAN TOTAL EGGS	68.79	
GEOMETRIC MEAN TOTAL EGGS	67.60	

File C:\MIKE\access\bp81.mdb Table: Table3

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	151.63	
ENCHELYOPUS CIMBRIUS II	224.69	
ENCHELYOPUS CIMBRIUS III	149.64	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	175.32	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	171.23	
LABRIDAE I	6234.78	
LABRIDAE II	1916.78	
LABRIDAE III	1442.68	
ARITHMETIC MEAN LABRIDAE	3198.08	
GEOMETRIC MEAN LABRIDAE	2563.34	
SCOPHTHALMUS AQUOSUS I	0.00	
SCOPHTHALMUS AQUOSUS II	0.00	
SCOPHTHALMUS AQUOSUS III	3.84	
ARITHMETIC MEAN SCOPHTHALMUS AQUOSUS	1.28	
GEOMETRIC MEAN SCOPHTHALMUS AQUOSUS	0.69	
TOTAL EGGS I	6386.41	
TOTAL EGGS II	2141.47	
TOTAL EGGS III	1596.16	
ARITHMETIC MEAN TOTAL EGGS	3374.68	
GEOMETRIC MEAN TOTAL EGGS	2772.85	

File C:\MIKE\access\bp81.mdb Table: Table3

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
GADUS MORHUA I	1.06	
GADUS MORHUA II	0.99	
GADUS MORHUA III	0.96	
ARITHMETIC MEAN GADUS MORHUA	1.00	
GEOMETRIC MEAN GADUS MORHUA	1.00	
MYOXOCEPHALUS AENAEUS I	0.00	
MYOXOCEPHALUS AENAEUS II	0.00	
MYOXOCEPHALUS AENAEUS III	1.92	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	0.64	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	0.43	
AMMODYTES SP. I	7.42	
AMMODYTES SP. II	1.99	
AMMODYTES SP. III	7.67	
ARITHMETIC MEAN AMMODYTES SP.	5.69	
GEOMETRIC MEAN AMMODYTES SP.	5.01	
P. AMERICANUS STAGE 1 I	9.54	
P. AMERICANUS STAGE 1 II	6.96	
P. AMERICANUS STAGE 1 III	12.47	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	9.66	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	9.39	
P. AMERICANUS STAGE 2 I	18.03	
P. AMERICANUS STAGE 2 II	27.84	
P. AMERICANUS STAGE 2 III	18.23	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	21.36	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	20.86	
P. AMERICANUS STAGE 3 I	4.24	
P. AMERICANUS STAGE 3 II	6.96	
P. AMERICANUS STAGE 3 III	2.88	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	4.69	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	4.44	
TOTAL LARVAE I	40.29	
TOTAL LARVAE II	44.74	
TOTAL LARVAE III	44.12	
ARITHMETIC MEAN TOTAL LARVAE	43.05	
GEOMETRIC MEAN TOTAL LARVAE	42.84	
P.AMERICANUS TOTAL I	31.81	
P.AMERICANUS TOTAL II	41.76	
P.AMERICANUS TOTAL III	33.57	
ARITHMETIC MEAN TOTAL P.AMERICANUS	35.71	
GEOMETRIC MEAN TOTAL P.AMERICANUS	35.34	

File C:\MIKE\access\bp81.mdb Table: Table8

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
OSMERUS MORDAX I (rainbow smelt)	0.00	
OSMERUS MORDAX II	2.79	
OSMERUS MORDAX III	0.00	
ARITHMETIC MEAN OSMERUS MORDAX	0.93	
GEOMETRIC MEAN OSMERUS MORDAX	0.56	
MYOXOCEPHALUS AENAEUS I	0.00	
MYOXOCEPHALUS AENAEUS II	0.93	
MYOXOCEPHALUS AENAEUS III	0.00	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	0.31	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	0.24	
AMMODYTES SP. I	1.91	
AMMODYTES SP. II	0.93	
AMMODYTES SP. III	0.82	
ARITHMETIC MEAN AMMODYTES SP.	1.22	
GEOMETRIC MEAN AMMODYTES SP.	1.17	
P. AMERICANUS STAGE 1 I	3.83	
P. AMERICANUS STAGE 1 II	0.93	
P. AMERICANUS STAGE 1 III	0.00	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	1.59	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	1.10	
P. AMERICANUS STAGE 2 I	34.46	
P. AMERICANUS STAGE 2 II	28.84	
P. AMERICANUS STAGE 2 III	33.51	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	32.27	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	32.06	
P. AMERICANUS STAGE 3 I	28.71	
P. AMERICANUS STAGE 3 II	14.89	
P. AMERICANUS STAGE 3 III	14.71	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	19.44	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	18.44	
TOTAL LARVAE I	68.91	
TOTAL LARVAE II	49.31	
TOTAL LARVAE III	49.04	
ARITHMETIC MEAN TOTAL LARVAE	55.75	
GEOMETRIC MEAN TOTAL LARVAE	54.82	
P.AMERICANUS TOTAL I	67.00	
P.AMERICANUS TOTAL II	44.66	
P.AMERICANUS TOTAL III	48.22	
ARITHMETIC MEAN TOTAL P.AMERICANUS	53.29	
GEOMETRIC MEAN TOTAL P.AMERICANUS	52.25	

File C:\MIKE\access\bp81.mdb Table: Table8

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	126.34	
ENCHELYOPUS CIMBRIUS II	129.32	
ENCHELYOPUS CIMBRIUS III	140.59	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	132.08	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	131.29	
LABRIDAE I	14.36	
LABRIDAE II	13.96	
LABRIDAE III	6.54	
ARITHMETIC MEAN LABRIDAE	11.62	
GEOMETRIC MEAN LABRIDAE	10.98	
TOTAL EGGS I	140.70	
TOTAL EGGS II	143.28	
TOTAL EGGS III	147.12	
ARITHMETIC MEAN TOTAL EGGS	143.70	
GEOMETRIC MEAN TOTAL EGGS	142.96	

File C:\MIKE\access\bp81.mdb Table: Table13

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
OSMERUS MORDAX I	2.08	
OSMERUS MORDAX II	0.93	
OSMERUS MORDAX III	2.46	
ARITHMETIC MEAN OSMERUS MORDAX	1.82	
GEOMETRIC MEAN OSMERUS MORDAX	1.74	
AMMODYTES SP. I	4.16	
AMMODYTES SP. II	0.93	
AMMODYTES SP. III	6.55	
ARITHMETIC MEAN AMMODYTES SP.	3.88	
GEOMETRIC MEAN AMMODYTES SP.	3.22	
P. AMERICANUS STAGE 1 I	3.12	
P. AMERICANUS STAGE 1 II	4.66	
P. AMERICANUS STAGE 1 III	2.46	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	3.41	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	3.31	
P. AMERICANUS STAGE 2 I	10.40	
P. AMERICANUS STAGE 2 II	25.17	
P. AMERICANUS STAGE 2 III	23.74	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	19.77	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	18.41	
P. AMERICANUS STAGE 3 I	30.15	
P. AMERICANUS STAGE 3 II	30.77	
P. AMERICANUS STAGE 3 III	26.19	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	29.03	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	28.86	
TOTAL LARVAE I	49.90	
TOTAL LARVAE II	62.46	
TOTAL LARVAE III	61.39	
ARITHMETIC MEAN TOTAL LARVAE	57.92	
GEOMETRIC MEAN TOTAL LARVAE	57.39	
P.AMERICANUS TOTAL I	43.66	
P.AMERICANUS TOTAL II	60.60	
P.AMERICANUS TOTAL III	52.38	
ARITHMETIC MEAN TOTAL P.AMERICANUS	52.21	
GEOMETRIC MEAN TOTAL P.AMERICANUS	51.55	

File C:\MIKE\access\bp81.mdb Table: Table13

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	19.75	
ENCHELYOPUS CIMBRIUS II	22.38	
ENCHELYOPUS CIMBRIUS III	21.28	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	21.14	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	21.04	
LABRIDAE I	4.16	
LABRIDAE II	372.92	
LABRIDAE III	4.91	
ARITHMETIC MEAN LABRIDAE	127.33	
GEOMETRIC MEAN LABRIDAE	21.44	
SCOPHTHALMUS AQUOSUS I	1.04	
SCOPHTHALMUS AQUOSUS II	0.93	
SCOPHTHALMUS AQUOSUS III	0.00	
ARITHMETIC MEAN SCOPHTHALMUS AQUOSUS	0.66	
GEOMETRIC MEAN SCOPHTHALMUS AQUOSUS	0.58	
TOTAL EGGS I	24.95	
TOTAL EGGS II	396.23	
TOTAL EGGS III	26.19	
ARITHMETIC MEAN TOTAL EGGS	149.12	
GEOMETRIC MEAN TOTAL EGGS	64.17	

File C:\MIKE\access\bp81.mdb Table: Table17

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	18.94	
ENCHELYOPUS CIMBRIUS II	12.89	
ENCHELYOPUS CIMBRIUS III	22.01	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	17.95	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	17.49	
LABRIDAE I	706.95	
LABRIDAE II	2864.18	
LABRIDAE III	1199.82	
ARITHMETIC MEAN LABRIDAE	1590.32	
GEOMETRIC MEAN LABRIDAE	1334.82	
SCOPHTHALMUS AQUOSUS I	2.10	
SCOPHTHALMUS AQUOSUS II	1.98	
SCOPHTHALMUS AQUOSUS III	3.67	
ARITHMETIC MEAN SCOPHTHALMUS AQUOSUS	2.59	
GEOMETRIC MEAN SCOPHTHALMUS AQUOSUS	2.51	
TOTAL EGGS I	727.99	
TOTAL EGGS II	2879.06	
TOTAL EGGS III	1225.50	
ARITHMETIC MEAN TOTAL EGGS	1610.85	
GEOMETRIC MEAN TOTAL EGGS	1359.80	

File C:\MIKE\access\bp81.mdb Table: Table17

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
CLUPEA HARENGUS I	2.10	
CLUPEA HARENGUS II	0.00	
CLUPEA HARENGUS III	0.00	
ARITHMETIC MEAN CLUPEA HARENGUS	0.70	
GEOMETRIC MEAN CLUPEA HARENGUS	0.46	
OSMERUS MORDAX I	0.00	
OSMERUS MORDAX II	2.98	
OSMERUS MORDAX III	0.00	
ARITHMETIC MEAN OSMERUS MORDAX	0.99	
GEOMETRIC MEAN OSMERUS MORDAX	0.58	
MYOXOCEPHALUS AENAEUS I	0.00	
MYOXOCEPHALUS AENAEUS II	0.00	
MYOXOCEPHALUS AENAEUS III	0.92	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	0.31	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	0.24	
AMMODYTES SP. I	0.00	
AMMODYTES SP. II	2.98	
AMMODYTES SP. III	2.75	
ARITHMETIC MEAN AMMODYTES SP.	1.91	
GEOMETRIC MEAN AMMODYTES SP.	1.46	
GOBIOSOMA GINSBURGI I	0.00	
GOBIOSOMA GINSBURGI II	0.99	
GOBIOSOMA GINSBURGI III	0.92	
ARITHMETIC MEAN GOBIOSOMA GINSBURGI	0.64	
GEOMETRIC MEAN GOBIOSOMA GINSBURGI	0.56	
P. AMERICANUS STAGE 2 I	8.42	
P. AMERICANUS STAGE 2 II	7.93	
P. AMERICANUS STAGE 2 III	8.26	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	8.20	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	8.18	
P. AMERICANUS STAGE 3 I	10.52	
P. AMERICANUS STAGE 3 II	7.93	
P. AMERICANUS STAGE 3 III	9.17	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	9.21	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	9.13	
TOTAL LARVAE I	21.04	
TOTAL LARVAE II	22.81	
TOTAL LARVAE III	22.01	
ARITHMETIC MEAN TOTAL LARVAE	21.96	
GEOMETRIC MEAN TOTAL LARVAE	21.87	

File C:\MIKE\access\bp81.mdb Table: Table17

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
P.AMERICANUS TOTAL I	18.94	
P.AMERICANUS TOTAL II	15.87	
P.AMERICANUS TOTAL III	17.43	
ARITHMETIC MEAN TOTAL P.AMERICANUS	17.41	
GEOMETRIC MEAN TOTAL P.AMERICANUS	17.31	

File C:\MIKE\access\bp81.mdb Table: Table21

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	140.99	
ENCHELYOPUS CIMBRIUS II	149.82	
ENCHELYOPUS CIMBRIUS III	139.61	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	143.47	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	142.69	
LABRIDAE I	538.78	
LABRIDAE II	271.10	
LABRIDAE III	456.00	
ARITHMETIC MEAN LABRIDAE	421.96	
GEOMETRIC MEAN LABRIDAE	402.97	
SCOPHTHALMUS AQUOSUS I	9.23	
SCOPHTHALMUS AQUOSUS II	9.81	
SCOPHTHALMUS AQUOSUS III	4.13	
ARITHMETIC MEAN SCOPHTHALMUS AQUOSUS	7.72	
GEOMETRIC MEAN SCOPHTHALMUS AQUOSUS	7.26	
PLEURONECTES AMERICANUS I	0.00	
PLEURONECTES AMERICANUS II	2.68	
PLEURONECTES AMERICANUS III	0.00	
ARITHMETIC MEAN PLEURONECTES AMERICANUS	0.89	
GEOMETRIC MEAN PLEURONECTES AMERICANUS	0.54	
TOTAL EGGS I	689.00	
TOTAL EGGS II	433.41	
TOTAL EGGS III	599.74	
ARITHMETIC MEAN TOTAL EGGS	574.05	
GEOMETRIC MEAN TOTAL EGGS	560.13	

File C:\MIKE\access\bp81.mdb Table: Table21

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
OSMERUS MORDAX I	2.52	
OSMERUS MORDAX II	0.89	
OSMERUS MORDAX III	2.48	
ARITHMETIC MEAN OSMERUS MORDAX	1.96	
GEOMETRIC MEAN OSMERUS MORDAX	1.85	
MYOXOCEPHALUS AENAEUS I	0.00	
MYOXOCEPHALUS AENAEUS II	0.89	
MYOXOCEPHALUS AENAEUS III	0.83	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	0.57	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	0.51	
AMMODYTES SP. I	1.68	
AMMODYTES SP. II	0.89	
AMMODYTES SP. III	1.65	
ARITHMETIC MEAN AMMODYTES SP.	1.41	
GEOMETRIC MEAN AMMODYTES SP.	1.38	
GOBIOSOMA GINSBURGI I	0.00	
GOBIOSOMA GINSBURGI II	0.89	
GOBIOSOMA GINSBURGI III	0.00	
ARITHMETIC MEAN GOBIOSOMA GINSBURGI	0.30	
GEOMETRIC MEAN GOBIOSOMA GINSBURGI	0.24	
P. AMERICANUS STAGE 2 I	3.36	
P. AMERICANUS STAGE 2 II	1.78	
P. AMERICANUS STAGE 2 III	2.48	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	2.54	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	2.48	
P. AMERICANUS STAGE 3 I	9.23	
P. AMERICANUS STAGE 3 II	18.73	
P. AMERICANUS STAGE 3 III	14.04	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	14.00	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	13.44	
P. AMERICANUS STAGE 4 I	0.00	
P. AMERICANUS STAGE 4 II	0.00	
P. AMERICANUS STAGE 4 III	0.83	
ARITHMETIC MEAN P. AMERICANUS STAGE 4	0.28	
GEOMETRIC MEAN P. AMERICANUS STAGE 4	0.22	
TOTAL LARVAE I	16.78	
TOTAL LARVAE II	24.08	
TOTAL LARVAE III	22.30	
ARITHMETIC MEAN TOTAL LARVAE	21.06	
GEOMETRIC MEAN TOTAL LARVAE	20.76	

File C:\MIKE\access\bp81.mdb Table: Table21

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

========== LARVAE ==========

SPECIES	STATIONS UNITS 1,2,3	UNIT 4
P.AMERICANUS TOTAL I	12.59	
P.AMERICANUS TOTAL II	20.51	
P.AMERICANUS TOTAL III	17.35	
ARITHMETIC MEAN TOTAL P.AMERICANUS	16.82	
GEOMETRIC MEAN TOTAL P.AMERICANUS	16.45	

File C:\MIKE\access\bp81.mdb Table: Table27

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	26.73	
ENCHELYOPUS CIMBRIUS II	24.12	
ENCHELYOPUS CIMBRIUS III	18.55	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	23.13	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	22.80	
LABRIDAE I	50.88	
LABRIDAE II	43.06	
LABRIDAE III	32.05	
ARITHMETIC MEAN LABRIDAE	41.99	
GEOMETRIC MEAN LABRIDAE	41.11	
SCOPHTHALMUS AQUOSUS I	39.67	
SCOPHTHALMUS AQUOSUS II	45.65	
SCOPHTHALMUS AQUOSUS III	26.99	
ARITHMETIC MEAN SCOPHTHALMUS AQUOSUS	37.43	
GEOMETRIC MEAN SCOPHTHALMUS AQUOSUS	36.45	
TOTAL EGGS I	117.27	
TOTAL EGGS II	112.83	
TOTAL EGGS III	77.58	
ARITHMETIC MEAN TOTAL EGGS	102.56	
GEOMETRIC MEAN TOTAL EGGS	100.43	

File C:\MIKE\access\bp81.mdb Table: Table27

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ALOSA SPP. I	0.00	
ALOSA SPP. II	0.00	
ALOSA SPP. III	0.84	
ARITHMETIC MEAN ALOSA SPP.	0.28	
GEOMETRIC MEAN ALOSA SPP.	0.23	
CLUPEA HARENGUS I	0.00	
CLUPEA HARENGUS II	4.31	
CLUPEA HARENGUS III	0.00	
ARITHMETIC MEAN CLUPEA HARENGUS	1.44	
GEOMETRIC MEAN CLUPEA HARENGUS	0.74	
OSMERUS MORDAX I	2.59	
OSMERUS MORDAX II	0.00	
OSMERUS MORDAX III	2.53	
ARITHMETIC MEAN OSMERUS MORDAX	1.71	
GEOMETRIC MEAN OSMERUS MORDAX	1.33	
MYOXOCEPHALUS AENAEUS I	0.86	
MYOXOCEPHALUS AENAEUS II	0.00	
MYOXOCEPHALUS AENAEUS III	0.84	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	0.57	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	0.51	
AMMODYTES SP. I	16.38	
AMMODYTES SP. II	13.78	
AMMODYTES SP. III	25.30	
ARITHMETIC MEAN AMMODYTES SP.	18.49	
GEOMETRIC MEAN AMMODYTES SP.	17.85	
GOBIOSOMA GINSBURGI I	1.72	
GOBIOSOMA GINSBURGI II	0.00	
GOBIOSOMA GINSBURGI III	0.00	
ARITHMETIC MEAN GOBIOSOMA GINSBURGI	0.57	
GEOMETRIC MEAN GOBIOSOMA GINSBURGI	0.40	
P. AMERICANUS STAGE 2 I	2.59	
P. AMERICANUS STAGE 2 II	10.34	
P. AMERICANUS STAGE 2 III	0.84	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	4.59	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	3.21	
P. AMERICANUS STAGE 3 I	20.70	
P. AMERICANUS STAGE 3 II	15.50	
P. AMERICANUS STAGE 3 III	15.18	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	17.13	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	16.91	

File C:\MIKE\access\bp81.mdb Table: Table27

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ALOSA SPP. I	0.00	
ALOSA SPP. II	0.00	
ALOSA SPP. III	0.84	
ARITHMETIC MEAN ALOSA SPP.	0.28	
GEOMETRIC MEAN ALOSA SPP.	0.23	
CLUPEA HARENGUS I	0.00	
CLUPEA HARENGUS II	4.31	
CLUPEA HARENGUS III	0.00	
ARITHMETIC MEAN CLUPEA HARENGUS	1.44	
GEOMETRIC MEAN CLUPEA HARENGUS	0.74	
OSMERUS MORDAX I	2.59	
OSMERUS MORDAX II	0.00	
OSMERUS MORDAX III	2.53	
ARITHMETIC MEAN OSMERUS MORDAX	1.71	
GEOMETRIC MEAN OSMERUS MORDAX	1.33	
MYOXOCEPHALUS AENAEUS I	0.86	
MYOXOCEPHALUS AENAEUS II	0.00	
MYOXOCEPHALUS AENAEUS III	0.84	
ARITHMETIC MEAN MYOXOCEPHALUS AENAEUS	0.57	
GEOMETRIC MEAN MYOXOCEPHALUS AENAEUS	0.51	
AMMODYTES SP. I	16.38	
AMMODYTES SP. II	13.78	
AMMODYTES SP. III	25.30	
ARITHMETIC MEAN AMMODYTES SP.	18.49	
GEOMETRIC MEAN AMMODYTES SP.	17.85	
GOBIOSOMA GINSBURGI I	1.72	
GOBIOSOMA GINSBURGI II	0.00	
GOBIOSOMA GINSBURGI III	0.00	
ARITHMETIC MEAN GOBIOSOMA GINSBURGI	0.57	
GEOMETRIC MEAN GOBIOSOMA GINSBURGI	0.40	
P. AMERICANUS STAGE 2 I	2.59	
P. AMERICANUS STAGE 2 II	10.34	
P. AMERICANUS STAGE 2 III	0.84	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	4.59	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	3.21	
P. AMERICANUS STAGE 3 I	~~0.00~~ 20.70	
P. AMERICANUS STAGE 3 II	15.50	
P. AMERICANUS STAGE 3 III	15.18	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	~~10.29~~ 17.13	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	5.43	

File C:\MIKE\access\bp81.mdb Table: Table27

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
TOTAL LARVAE I	44.84	
TOTAL LARVAE II	43.92	
TOTAL LARVAE III	45.54	
ARITHMETIC MEAN TOTAL LARVAE	44.77	
GEOMETRIC MEAN TOTAL LARVAE	44.59	
P.AMERICANUS TOTAL I	23.28	
P.AMERICANUS TOTAL II	25.84	
P.AMERICANUS TOTAL III	16.02	
ARITHMETIC MEAN TOTAL P.AMERICANUS	21.71	
GEOMETRIC MEAN TOTAL P.AMERICANUS	21.23	

File C:\MIKE\access\bp82.mdb Table: Table1

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ALOSA SPP. I	0.00	
ALOSA SPP. II	0.00	
ALOSA SPP. III	0.89	
ARITHMETIC MEAN ALOSA SPP.	0.30	
GEOMETRIC MEAN ALOSA SPP.	0.24	
OSMERUS MORDAX I	0.87	
OSMERUS MORDAX II	0.00	
OSMERUS MORDAX III	0.89	
ARITHMETIC MEAN OSMERUS MORDAX	0.59	
GEOMETRIC MEAN OSMERUS MORDAX	0.52	
AMMODYTES SP. I	0.00	
AMMODYTES SP. II	0.00	
AMMODYTES SP. III	0.89	
ARITHMETIC MEAN AMMODYTES SP.	0.30	
GEOMETRIC MEAN AMMODYTES SP.	0.24	
GOBIOSOMA GINSBURGI I	0.00	
GOBIOSOMA GINSBURGI II	0.00	
GOBIOSOMA GINSBURGI III	1.77	
ARITHMETIC MEAN GOBIOSOMA GINSBURGI	0.59	
GEOMETRIC MEAN GOBIOSOMA GINSBURGI	0.40	
P. AMERICANUS STAGE 2 I	0.00	
P. AMERICANUS STAGE 2 II	0.92	
P. AMERICANUS STAGE 2 III	0.00	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	0.31	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	0.24	
P. AMERICANUS STAGE 3 I	14.00	
P. AMERICANUS STAGE 3 II	14.74	
P. AMERICANUS STAGE 3 III	11.53	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	13.42	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	13.32	
P. AMERICANUS STAGE 4 I	0.00	
P. AMERICANUS STAGE 4 II	0.00	
P. AMERICANUS STAGE 4 III	1.77	
ARITHMETIC MEAN P. AMERICANUS STAGE 4	0.59	
GEOMETRIC MEAN P. AMERICANUS STAGE 4	0.40	
TOTAL LARVAE I	14.87	
TOTAL LARVAE II	15.66	
TOTAL LARVAE III	17.73	
ARITHMETIC MEAN TOTAL LARVAE	16.09	
GEOMETRIC MEAN TOTAL LARVAE	16.00	

File C:\MIKE\access\bp82.mdb Table: Table1

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ENCHELYOPUS CIMBRIUS I	40.24	
ENCHELYOPUS CIMBRIUS II	47.92	
ENCHELYOPUS CIMBRIUS III	22.17	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	36.77	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	34.89	
LABRIDAE I	589.60	
LABRIDAE II	593.42	
LABRIDAE III	776.77	
ARITHMETIC MEAN LABRIDAE	653.26	
GEOMETRIC MEAN LABRIDAE	643.57	
PARALICHTHYS-SCOPHTHALMUS I	86.60	
PARALICHTHYS-SCOPHTHALMUS II	66.34	
PARALICHTHYS-SCOPHTHALMUS III	50.54	
ARITHMETIC MEAN PARALICHTHYS-SCOPHTHALMUS	67.83	
GEOMETRIC MEAN PARALICHTHYS-SCOPHTHALMUS	65.96	
TOTAL EGGS I	716.45	
TOTAL EGGS II	707.68	
TOTAL EGGS III	849.49	
ARITHMETIC MEAN TOTAL EGGS	757.87	
GEOMETRIC MEAN TOTAL EGGS	750.20	

File C:\MIKE\access\bp82.mdb Table: Table1

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
P.AMERICANUS TOTAL I	14.00	
P.AMERICANUS TOTAL II	15.66	
P.AMERICANUS TOTAL III	13.30	
ARITHMETIC MEAN TOTAL P.AMERICANUS	14.32	
GEOMETRIC MEAN TOTAL P.AMERICANUS	14.25	

File C:\MIKE\access\bp82.mdb Table: Table6

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ALOSA SPP. I	2.07	
ALOSA SPP. II	1.86	
ALOSA SPP. III	1.81	
ARITHMETIC MEAN ALOSA SPP.	1.91	
GEOMETRIC MEAN ALOSA SPP.	1.91	
OSMERUS MORDAX I	1.04	
OSMERUS MORDAX II	0.93	
OSMERUS MORDAX III	0.00	
ARITHMETIC MEAN OSMERUS MORDAX	0.66	
GEOMETRIC MEAN OSMERUS MORDAX	0.58	
ENCHELYOPUS CIMBRIUS I	0.00	
ENCHELYOPUS CIMBRIUS II	0.00	
ENCHELYOPUS CIMBRIUS III	0.91	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	0.30	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	0.24	
TAUTOGA ONITIS I tautog	0.00	
TAUTOGA ONITIS II	0.00	
TAUTOGA ONITIS III	0.91	
ARITHMETIC MEAN TAUTOGA ONITIS	0.30	
GEOMETRIC MEAN TAUTOGA ONITIS	0.24	
ULVARIA SUBBIFURCATA I radiated shanny	0.00	
ULVARIA SUBBIFURCATA II	0.93	
ULVARIA SUBBIFURCATA III	0.00	
ARITHMETIC MEAN ULVARIA SUBBIFURCATA	0.31	
GEOMETRIC MEAN ULVARIA SUBBIFURCATA	0.24	
GOBIOSOMA GINSBURGI I	0.00	
GOBIOSOMA GINSBURGI II	0.93	
GOBIOSOMA GINSBURGI III	0.00	
ARITHMETIC MEAN GOBIOSOMA GINSBURGI	0.31	
GEOMETRIC MEAN GOBIOSOMA GINSBURGI	0.24	
P. AMERICANUS STAGE 2 I	1.04	
P. AMERICANUS STAGE 2 II	0.00	
P. AMERICANUS STAGE 2 III	0.00	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	0.35	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	0.27	
P. AMERICANUS STAGE 3 I	2.07	
P. AMERICANUS STAGE 3 II	0.93	
P. AMERICANUS STAGE 3 III	0.91	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	1.30	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	1.24	

File C:\MIKE\access\bp82.mdb Table: Table6

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
BREVOORTIA TYRANNUS I	0.00	
BREVOORTIA TYRANNUS II	4.65	
BREVOORTIA TYRANNUS III	3.62	
ARITHMETIC MEAN BREVOORTIA TYRANNUS	2.76	
GEOMETRIC MEAN BREVOORTIA TYRANNUS	1.96	
pollock hake bottom		
ENCHELYOPUS-UROPHYCIS-PEPRILUS I	0.00	
ENCHELYOPUS-UROPHYCIS-PEPRILUS II	60.41	
ENCHELYOPUS-UROPHYCIS-PEPRILUS III	22.64	
ARITHMETIC MEAN ENCHELYOPUS-UROPHYCIS-PEPRILUS	27.68	
GEOMETRIC MEAN ENCHELYOPUS-UROPHYCIS-PEPRILUS	10.30	
ENCHELYOPUS CIMBRIUS I	87.04	
ENCHELYOPUS CIMBRIUS II	25.09	
ENCHELYOPUS CIMBRIUS III	8.15	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	40.10	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	26.51	
PRIONOTUS SPP. I	0.00	
PRIONOTUS SPP. II	0.93	
PRIONOTUS SPP. III	0.00	
ARITHMETIC MEAN PRIONOTUS SPP.	0.31	
GEOMETRIC MEAN PRIONOTUS SPP.	0.24	
LABRIDAE I	1728.42	
LABRIDAE II	4672.87	
LABRIDAE III	7780.25	
ARITHMETIC MEAN LABRIDAE	4727.18	
GEOMETRIC MEAN LABRIDAE	3943.06	
PARALICHTHYS-SCOPHTHALMUS I	225.90	
PARALICHTHYS-SCOPHTHALMUS II	289.96	
PARALICHTHYS-SCOPHTHALMUS III	253.55	
ARITHMETIC MEAN PARALICHTHYS-SCOPHTHALMUS	256.47	
GEOMETRIC MEAN PARALICHTHYS-SCOPHTHALMUS	253.72	
TOTAL EGGS I	2041.36	
TOTAL EGGS II	5053.91	
TOTAL EGGS III	8068.21	
ARITHMETIC MEAN TOTAL EGGS	5054.50	
GEOMETRIC MEAN TOTAL EGGS	4329.98	

File C:\MIKE\access\bp82.mdb Table: Table6

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

========== LARVAE ==========

SPECIES	STATIONS UNITS 1,2,3	UNIT 4
TOTAL LARVAE I	6.22	
TOTAL LARVAE II	5.58	
TOTAL LARVAE III	4.53	
ARITHMETIC MEAN TOTAL LARVAE	5.44	
GEOMETRIC MEAN TOTAL LARVAE	5.39	
P.AMERICANUS TOTAL I	3.11	
P.AMERICANUS TOTAL II	0.93	
P.AMERICANUS TOTAL III	0.91	
ARITHMETIC MEAN TOTAL P.AMERICANUS	1.65	
GEOMETRIC MEAN TOTAL P.AMERICANUS	1.47	

File C:\MIKE\access\bp82.mdb Table: Table13

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
BREVOORTIA TYRANNUS I	2.30	
BREVOORTIA TYRANNUS II	3.11	
BREVOORTIA TYRANNUS III	0.80	
ARITHMETIC MEAN BREVOORTIA TYRANNUS	2.07	
GEOMETRIC MEAN BREVOORTIA TYRANNUS	1.90	
ENCHELYOPUS-UROPHYCIS-PEPRILUS I	13.01	
ENCHELYOPUS-UROPHYCIS-PEPRILUS II	9.34	
ENCHELYOPUS-UROPHYCIS-PEPRILUS III	16.09	
ARITHMETIC MEAN ENCHELYOPUS-UROPHYCIS-PEPRILUS	12.81	
GEOMETRIC MEAN ENCHELYOPUS-UROPHYCIS-PEPRILUS	12.49	
ENCHELYOPUS CIMBRIUS I	0.00	
ENCHELYOPUS CIMBRIUS II	0.00	
ENCHELYOPUS CIMBRIUS III	0.80	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	0.27	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	0.22	
LABRIDAE I	187.50	
LABRIDAE II	167.11	
LABRIDAE III	215.58	
ARITHMETIC MEAN LABRIDAE	190.06	
GEOMETRIC MEAN LABRIDAE	188.04	
SCOMBER SCOMBRUS I (Atlantic mackerel)	2.30	
SCOMBER SCOMBRUS II	0.00	
SCOMBER SCOMBRUS III	0.80	
ARITHMETIC MEAN SCOMBER SCOMBRUS	1.03	
GEOMETRIC MEAN SCOMBER SCOMBRUS	0.81	
ETROPUS MICROSTOMUS I (smallmouth flounder)	0.77	
ETROPUS MICROSTOMUS II	0.00	
ETROPUS MICROSTOMUS III	0.00	
ARITHMETIC MEAN ETROPUS MICROSTOMUS	0.26	
GEOMETRIC MEAN ETROPUS MICROSTOMUS	0.21	
PARALICHTHYS-SCOPHTHALMUS I	84.18	
PARALICHTHYS-SCOPHTHALMUS II	90.30	
PARALICHTHYS-SCOPHTHALMUS III	83.66	
ARITHMETIC MEAN PARALICHTHYS-SCOPHTHALMUS	86.05	
GEOMETRIC MEAN PARALICHTHYS-SCOPHTHALMUS	85.61	
TOTAL EGGS I	290.05	
TOTAL EGGS II	269.87	
TOTAL EGGS III	317.74	
ARITHMETIC MEAN TOTAL EGGS	292.55	
GEOMETRIC MEAN TOTAL EGGS	290.24	

File C:\MIKE\access\bp82.mdb Table: Table13

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
ALOSA SPP. I	8.42	
ALOSA SPP. II	3.11	
ALOSA SPP. III	1.61	
ARITHMETIC MEAN ALOSA SPP.	4.38	
GEOMETRIC MEAN ALOSA SPP.	3.65	
OSMERUS MORDAX I	0.77	
OSMERUS MORDAX II	8.30	
OSMERUS MORDAX III	4.83	
ARITHMETIC MEAN OSMERUS MORDAX	4.63	
GEOMETRIC MEAN OSMERUS MORDAX	3.57	
GADUS MORHUA I	0.00	
GADUS MORHUA II	0.00	
GADUS MORHUA III	0.80	
ARITHMETIC MEAN GADUS MORHUA	0.27	
GEOMETRIC MEAN GADUS MORHUA	0.22	
MENIDIA SPP. I	0.77	
MENIDIA SPP. II	0.00	
MENIDIA SPP. III	0.00	
ARITHMETIC MEAN MENIDIA SPP.	0.26	
GEOMETRIC MEAN MENIDIA SPP.	0.21	
LIPARIS ATLANTICUS I	5.36	
LIPARIS ATLANTICUS II	11.42	
LIPARIS ATLANTICUS III	7.24	
ARITHMETIC MEAN LIPARIS ATLANTICUS	8.00	
GEOMETRIC MEAN LIPARIS ATLANTICUS	7.65	
MORONE AMERICANA I	0.00	
MORONE AMERICANA II	1.04	
MORONE AMERICANA III	0.00	
ARITHMETIC MEAN MORONE AMERICANA	0.35	
GEOMETRIC MEAN MORONE AMERICANA	0.27	
AMMODYTES SP. I	0.77	
AMMODYTES SP. II	2.08	
AMMODYTES SP. III	0.00	
ARITHMETIC MEAN AMMODYTES SP.	0.95	
GEOMETRIC MEAN AMMODYTES SP.	0.76	
GOBIOSOMA GINSBURGI I	1.53	
GOBIOSOMA GINSBURGI II	2.08	
GOBIOSOMA GINSBURGI III	0.00	
ARITHMETIC MEAN GOBIOSOMA GINSBURGI	1.20	
GEOMETRIC MEAN GOBIOSOMA GINSBURGI	0.98	

File C:\MIKE\access\bp82.mdb Table: Table13

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
SCOPHTHALMUS AQUOSUS I	0.00	
SCOPHTHALMUS AQUOSUS II	1.04	
SCOPHTHALMUS AQUOSUS III	0.00	
ARITHMETIC MEAN SCOPHTHALMUS AQUOSUS	0.35	
GEOMETRIC MEAN SCOPHTHALMUS AQUOSUS	0.27	
P. AMERICANUS STAGE 1 I	0.77	
P. AMERICANUS STAGE 1 II	0.00	
P. AMERICANUS STAGE 1 III	0.00	
ARITHMETIC MEAN P. AMERICANUS STAGE 1	0.26	
GEOMETRIC MEAN P. AMERICANUS STAGE 1	0.21	
P. AMERICANUS STAGE 2 I	5.36	
P. AMERICANUS STAGE 2 II	9.34	
P. AMERICANUS STAGE 2 III	4.83	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	6.51	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	6.25	
P. AMERICANUS STAGE 3 I	29.08	
P. AMERICANUS STAGE 3 II	39.44	
P. AMERICANUS STAGE 3 III	39.42	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	35.98	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	35.50	
P. AMERICANUS STAGE 4 I	4.59	
P. AMERICANUS STAGE 4 II	6.23	
P. AMERICANUS STAGE 4 III	4.83	
ARITHMETIC MEAN P. AMERICANUS STAGE 4	5.22	
GEOMETRIC MEAN P. AMERICANUS STAGE 4	5.16	
TRINECTES MACULATUS I	0.00	
TRINECTES MACULATUS II	1.04	
TRINECTES MACULATUS III	0.00	
ARITHMETIC MEAN TRINECTES MACULATUS	0.35	
GEOMETRIC MEAN TRINECTES MACULATUS	0.27	
UNIDENTIFIED FRAGMENTS I	0.00	
UNIDENTIFIED FRAGMENTS II	0.00	
UNIDENTIFIED FRAGMENTS III	0.80	
ARITHMETIC MEAN UNIDENTIFIED FRAGMENTS	0.27	
GEOMETRIC MEAN UNIDENTIFIED FRAGMENTS	0.22	
TOTAL LARVAE I	57.40	
TOTAL LARVAE II	85.11	
TOTAL LARVAE III	64.35	
ARITHMETIC MEAN TOTAL LARVAE	68.95	
GEOMETRIC MEAN TOTAL LARVAE	67.72	

File C:\MIKE\access\bp82.mdb Table: Table13

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
P.AMERICANUS TOTAL I	39.80	
P.AMERICANUS TOTAL II	55.01	
P.AMERICANUS TOTAL III	49.07	
ARITHMETIC MEAN TOTAL P.AMERICANUS	47.96	
GEOMETRIC MEAN TOTAL P.AMERICANUS	47.36	

File C:\MIKE\access\bp82.mdb Table: Table18

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

EGGS

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
BREVOORTIA TYRANNUS I	536.19	
BREVOORTIA TYRANNUS II	733.28	
BREVOORTIA TYRANNUS III	727.88	
ARITHMETIC MEAN BREVOORTIA TYRANNUS	665.78	
GEOMETRIC MEAN BREVOORTIA TYRANNUS	654.73	
ENCHELYOPUS-UROPHYCIS-PEPRILUS I	24.67	
ENCHELYOPUS-UROPHYCIS-PEPRILUS II	16.51	
ENCHELYOPUS-UROPHYCIS-PEPRILUS III	17.93	
ARITHMETIC MEAN ENCHELYOPUS-UROPHYCIS-PEPRILUS	19.70	
GEOMETRIC MEAN ENCHELYOPUS-UROPHYCIS-PEPRILUS	19.35	
ENCHELYOPUS CIMBRIUS I	0.00	
ENCHELYOPUS CIMBRIUS II	9.56	
ENCHELYOPUS CIMBRIUS III	6.27	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	5.28	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	3.24	
UROPHYCIS SPP. I	0.82	
UROPHYCIS SPP. II	0.00	
UROPHYCIS SPP. III	0.00	
ARITHMETIC MEAN UROPHYCIS SPP.	0.27	
GEOMETRIC MEAN UROPHYCIS SPP.	0.22	
LABRIDAE I	1598.71	
LABRIDAE II	1987.84	
LABRIDAE III	3363.28	
ARITHMETIC MEAN LABRIDAE	2316.61	
GEOMETRIC MEAN LABRIDAE	2185.93	
PARALICHTHYS-SCOPHTHALMUS I	167.77	
PARALICHTHYS-SCOPHTHALMUS II	132.06	
PARALICHTHYS-SCOPHTHALMUS III	188.24	
ARITHMETIC MEAN PARALICHTHYS-SCOPHTHALMUS	162.69	
GEOMETRIC MEAN PARALICHTHYS-SCOPHTHALMUS	160.15	
PLEURONECTES AMERICANUS I	0.00	
PLEURONECTES AMERICANUS II	0.87	
PLEURONECTES AMERICANUS III	0.00	
ARITHMETIC MEAN PLEURONECTES AMERICANUS	0.29	
GEOMETRIC MEAN PLEURONECTES AMERICANUS	0.23	
TOTAL EGGS I	2328.16	
TOTAL EGGS II	2880.11	
TOTAL EGGS III	4303.61	
ARITHMETIC MEAN TOTAL EGGS	3170.63	
GEOMETRIC MEAN TOTAL EGGS	3042.76	

File C:\MIKE\access\bp82.mdb Table: Table18

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

========== LARVAE ==========

SPECIES	STATIONS UNITS 1,2,3	UNIT 4
BREVOORTIA TYRANNUS I	4.11	
BREVOORTIA TYRANNUS II	0.00	
BREVOORTIA TYRANNUS III	0.00	
ARITHMETIC MEAN BREVOORTIA TYRANNUS	1.37	
GEOMETRIC MEAN BREVOORTIA TYRANNUS	0.72	
ANCHOA SPP. I	0.00	
ANCHOA SPP. II	3.48	
ANCHOA SPP. III	3.59	
ARITHMETIC MEAN ANCHOA SPP.	2.35	
GEOMETRIC MEAN ANCHOA SPP.	1.74	
OSMERUS MORDAX I	0.82	
OSMERUS MORDAX II	0.87	
OSMERUS MORDAX III	0.90	
ARITHMETIC MEAN OSMERUS MORDAX	0.86	
GEOMETRIC MEAN OSMERUS MORDAX	0.86	
ENCHELYOPUS CIMBRIUS I	0.00	
ENCHELYOPUS CIMBRIUS II	0.87	
ENCHELYOPUS CIMBRIUS III	0.00	
ARITHMETIC MEAN ENCHELYOPUS CIMBRIUS	0.29	
GEOMETRIC MEAN ENCHELYOPUS CIMBRIUS	0.23	
MENIDIA SPP. I	1.64	
MENIDIA SPP. II	0.00	
MENIDIA SPP. III	0.00	
ARITHMETIC MEAN MENIDIA SPP.	0.55	
GEOMETRIC MEAN MENIDIA SPP.	0.38	
TAUTOGA ONITIS I	0.00	
TAUTOGA ONITIS II	0.00	
TAUTOGA ONITIS III	0.90	
ARITHMETIC MEAN TAUTOGA ONITIS	0.30	
GEOMETRIC MEAN TAUTOGA ONITIS	0.24	
T. ADSPERSUS STAGE 1 I	0.00	
T. ADSPERSUS STAGE 1 II	0.87	
T. ADSPERSUS STAGE 1 III	0.00	
ARITHMETIC MEAN T. ADSPERSUS STAGE 1	0.29	
GEOMETRIC MEAN T. ADSPERSUS STAGE 1	0.23	
GOBIOSOMA GINSBURGI I	0.82	
GOBIOSOMA GINSBURGI II	0.87	
GOBIOSOMA GINSBURGI III	0.00	
ARITHMETIC MEAN GOBIOSOMA GINSBURGI	0.56	
GEOMETRIC MEAN GOBIOSOMA GINSBURGI	0.50	

File C:\MIKE\access\bp82.mdb Table: Table18

DENSITIES IN NUMBER OF PLANKTON PER 100 CUBIC METERS OF WATER

LARVAE

SPECIES	STATIONS UNITS 1,2,3	STATIONS UNIT 4
SCOPHTHALMUS AQUOSUS I	0.00	
SCOPHTHALMUS AQUOSUS II	0.87	
SCOPHTHALMUS AQUOSUS III	0.00	
ARITHMETIC MEAN SCOPHTHALMUS AQUOSUS	0.29	
GEOMETRIC MEAN SCOPHTHALMUS AQUOSUS	0.23	
P. AMERICANUS STAGE 2 I	0.00	
P. AMERICANUS STAGE 2 II	0.87	
P. AMERICANUS STAGE 2 III	0.00	
ARITHMETIC MEAN P. AMERICANUS STAGE 2	0.29	
GEOMETRIC MEAN P. AMERICANUS STAGE 2	0.23	
P. AMERICANUS STAGE 3 I	0.82	
P. AMERICANUS STAGE 3 II	4.34	
P. AMERICANUS STAGE 3 III	3.59	
ARITHMETIC MEAN P. AMERICANUS STAGE 3	2.92	
GEOMETRIC MEAN P. AMERICANUS STAGE 3	2.54	
P. AMERICANUS STAGE 4 I	0.82	
P. AMERICANUS STAGE 4 II	0.00	
P. AMERICANUS STAGE 4 III	0.90	
ARITHMETIC MEAN P. AMERICANUS STAGE 4	0.57	
GEOMETRIC MEAN P. AMERICANUS STAGE 4	0.51	
TOTAL LARVAE I	9.05	
TOTAL LARVAE II	13.03	
TOTAL LARVAE III	9.86	
ARITHMETIC MEAN TOTAL LARVAE	10.65	
GEOMETRIC MEAN TOTAL LARVAE	10.50	
P.AMERICANUS TOTAL I	1.64	
P.AMERICANUS TOTAL II	5.21	
P.AMERICANUS TOTAL III	4.48	
ARITHMETIC MEAN TOTAL P.AMERICANUS	3.78	
GEOMETRIC MEAN TOTAL P.AMERICANUS	3.48	

IV. TEMPERATURE, FLOW AND HEAT LOAD SUMMARY

Brayton Point Station's National Pollutant Discharge Elimination System (NPDES) permit includes limits on the maximum hourly average discharge temperature and delta temperature and daily maximum flow through the discharge canal (permitted discharge point 001). In addition to these limits, in early 1997, Brayton Point Station, the U.S. Environmental Protection Agency, Massachusetts Department of Environmental Protection, Massachusetts Executive Office of Environmental Affairs and Rhode Island Department of Environmental Management entered into a memorandum of agreement (MOA)[1] which includes limits to the circulating water flow, total heat load into the Bay and the delta temperature during piggyback operations.

Discharge temperature, delta temperature, heat load and discharge 001 and circulating water flow limits as outlined in the NPDES permit and MOA II were not exceeded in 1998. Table IV-1 lists the dates, time and duration of occurrence and the maximum temperatures recorded for those periods when the discharge temperature and delta temperature limit were exceeded during the years 1981 through 1990.

The maximum hourly average discharge temperature limit in the Station's NPDES permit is 95° F. Table IV-2 lists monthly average discharge temperatures for the years 1977 through 1998.

The maximum hourly average delta T is 22° F during once through operation and 30° F during piggyback operations. In 1998, Unit No. 4 operated in the piggyback mode from January 1 through May 27 and from October 1 through December 31, 1998. Tables IV-3 and IV-4 list the monthly maximum and monthly average delta T, respectively, for the years 1977 through 1998.

As outlined in MOA II, the monthly average circulating water flow limit during October through May and June through September is 0.925 and 1.13 BGD, respectively, and the seasonal average circulating water flow limit during June through September is 1.08 BGD. The monthly total circulating cooling water flow volume estimates for the years 1977 through 1998 are presented in Table IV-5 and graphed in Figure IV-1. The monthly average circulating cooling water flow volume estimates for the years 1977 through 1998 are presented in Table IV-6.

As outlined in MOA II, the monthly total heat load limit during October through May and June through September is 4.1 and 3.4 TBTU, respectively, and the seasonal total heat load to the Bay limit during October through May and June through September is 29 and 13 TBTU, respectively. An estimate of total monthly, seasonal and annual heat rejected to the receiving waters of Mount Hope Bay is provided in Table IV-7 and graphed in Figure IV-2.

In addition, Table IV-8 identifies important Brayton Point Station operational and engineering events that affected cooling water discharge flows and heat rejection to the bay.

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[1] MOA I was in effect from February 6 through April 2, 1997 and MOA II was in effect April 3, 1997 and will remain in effect until re-issuance of a new NPDES permit.

TABLE IV-1

TEMPERATURE EXCEEDANCE SUMMARY
(DEG F)

DATE	START TIME	EVENTS	INLET TEMPERATURES MAX	MIN	AVG	DISCHARGE TEMPERATURES MAX	MIN	AVG
8/83	NA	1	NA	NA	NA	96	96	96
07/18/88	2100	1	80	80	80	96	96	96
08/03/88	1500	7	83	81	82	99	96	97
08/04/88	1200	12	84	82	83	99	96	97
08/05/88	1800	6	84	83	83	96	96	96
08/06/88	1800	3	84	83	84	96	96	96
08/06/88	2200	6	83	81	82	97	96	96
08/07/88	2400	1	82	82	82	96	96	96
08/09/88	2200	1	82	82	82	96	96	96
08/10/88	1800	2	83	83	83	96	96	96
08/11/88	1200	5	85	83	84	97	96	96
08/12/88	1500	6	84	83	84	98	96	97
08/13/88	1600	1	86	86	86	96	96	96
08/14/88	0400	1	84	84	84	96	96	96
08/14/88	1400	29	86	84	84	101	96	97
08/16/88	0300	4	85	84	84	96	96	96
07/20/90	2300	1	81	81	81	96	96	96

DATE	EVENTS	DISCHARGE TEMP
1/84	3	29
01/20/86	1	23

Note: NA: Not available

TABLE IV-2

MONTHLY AVERAGE DISCHARGE TEMPERATURE
(Deg F)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Average
1977	52.0	48.1	56.1	60.8	73.2	78.7	82.5	82.3	82.0	71.8	67.1	56.3	67.6
1978	52.5	51.3	52.1	60.3	66.7	85.0	84.0	85.7	80.9	74.1	66.5	55.0	67.8
1979	54.0	50.9	52.2	57.6	67.3	81.0	85.6	83.7	85.3	76.6	69.8	56.5	68.4
1980	52.1	49.5	53.1	56.9	66.3	78.4	84.8	83.4	84.2	72.0	58.6	51.1	65.9
1981	42.7	50.2	52.5	62.4	73.7	86.3	86.6	84.5	82.3	70.7	62.9	51.2	67.2
1982	45.7	48.7	55.0	63.8	69.2	78.0	81.6	83.9	82.3	74.3	68.7	61.6	67.7
1983	57.5	53.9	60.0	61.0	67.3	81.2	90.0	91.0	84.6	78.3	68.5	62.5	71.3
1984	56.1	54.1	60.2	64.2	76.0	82.4	85.9	85.7	82.1	74.3	65.8	56.6	70.3
1985	49.4	49.2	54.8	61.2	70.3	78.3	88.0	91.2	80.8	78.5	63.8	55.2	68.4
1986	47.7	50.6	54.9	62.0	71.3	81.7	85.8	87.2	81.3	73.2	62.8	56.7	67.9
1987	51.3	52.8	56.1	60.6	68.7	81.4	90.6	88.1	85.6	75.4	65.7	58.4	69.6
1988	50.9	55.1	59.7	64.0	72.2	81.3	92.4	91.8	86.3	75.2	70.0	61.7	71.7
1989	57.4	55.1	61.2	65.6	69.2	83.1	87.9	85.9	83.4	78.5	71.8	57.3	71.4
1990	55.7	58.6	61.5	67.2	73.6	78.1	86.7	87.4	85.1	77.5	65.2	60.1	71.4
1991	55.2	55.6	58.8	66.9	71.6	81.1	89.0	90.9	82.3	74.3	68.2	59.2	71.1
1992	54.2	53.5	56.2	60.6	64.8	78.5	81.6	85.9	82.9	74.5	61.6	56.2	67.5
1993	53.3	51.6	55.6	57.7	67.8	78.3	87.8	89.0	86.0	74.0	64.0	56.0	68.4
1994	47.2	49.9	55.9	66.0	68.0	81.0	90.3	87.2	81.6	72.7	65.4	57.0	68.5
1995	52.6	48.3	53.9	60.3	69.4	83.2	91.3	89.6	82.8	77.6	64.8	53.2	68.9
1996	48.5	48.5	52.6	60.0	69.0	81.6	86.7	88.1	82.5	74.1	65.8	57.3	67.9
1997	52.3	57.1	60.2	62.9	72.2	80.4	90.1	89.2	85.5	76.9	65.7	58.2	70.9
1998	56.1	55.6	60.7	65.8	76.3	79.9	87.7	89.5	86.0	76.5	69.7	63.8	72.3
Maximum	57.5	58.6	61.5	67.2	76.3	86.3	92.4	91.8	86.3	78.5	71.8	63.8	72.3
Average	52.0	52.2	56.5	62.2	70.2	80.9	87.1	87.3	83.4	75.0	66.0	57.3	69.2
Minimum	42.7	48.1	52.1	56.9	64.8	78.0	81.6	82.3	80.8	70.7	58.6	51.1	65.9

Note: Piggyback operations; Delta temperature limit - 30 degree F

TABLE IV-3

HOURLY MAXIMUM TEMPERATURE RISE
(deg F)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977	20.0	19.0	20.0	18.0	19.0	19.0	17.0	15.0	17.0	17.0	16.0	21.0	21.0
1978	20.0	20.0	20.0	20.0	20.0	20.0	19.2	15.0	15.0	15.0	14.0	20.0	20.0
1979	17.3	17.3	17.1	20.0	25.0	16.0	18.0	22.0	22.0	24.0	26.0	19.0	26.0
1980	19.0	27.0	21.0	19.0	23.0	20.0	18.0	19.0	18.0	17.0	17.0	20.0	27.0
1981	20.0	21.0	20.0	23.0	22.0	21.0	18.0	18.0	19.0	20.0	20.0	21.0	23.0
1982	20.0	20.0	20.0	27.0	27.0	26.0	14.0	18.0	22.0	19.0	20.0	23.0	27.0
1983	24.0	25.0	25.0	28.0	18.0	27.0	22.0	26.0	14.0	25.0	26.0	28.0	28.0
1984	29.0	19.0	25.0	28.0	27.0	25.0	15.0	21.0	18.0	19.0	21.0	19.0	29.0
1985	21.0	19.0	18.0	16.0	21.0	17.0	20.0	22.0	21.0	16.8	16.6	15.4	22.0
1986	14.8	17.3	17.0	14.9	18.2	17.9	16.8	16.0	16.9	16.9	22.6	22.0	22.6
1987	16.7	21.7	20.5	20.2	18.1	17.9	22.0	15.7	15.3	16.7	17.2	16.3	22.0
1988	16.5	19.1	21.6	21.4	21.3	21.9	20.9	20.3	19.9	20.3	19.6	19.5	21.9
1989	19.6	21.9	21.0	21.8	17.5	21.3	21.6	18.0	20.4	21.3	21.4	20.3	21.9
1990	19.9	20.2	20.1	19.5	19.9	16.6	18.5	17.2	18.8	17.9	19.7	20.0	20.2
1991	21.3	19.2	20.2	21.7	18.1	14.9	15.2	20.0	14.0	13.0	21.8	21.9	21.9
1992	16.6	16.5	16.8	19.0	14.5	19.6	17.5	17.6	16.4	16.5	15.8	15.8	19.6
1993	17.1	19.6	26.0	19.1	18.9	18.7	20.1	16.1	17.0	15.6	16.0	18.0	26.0
1994	17.6	25.6	27.0	28.0	18.0	17.0	16.4	13.4	18.3	16.9	18.2	16.4	28.0
1995	15.8	16.4	16.2	16.4	19.6	17.8	18.1	17.0	17.2	16.4	16.2	16.2	19.6
1996	16.1	16.9	27.2	20.6	17.0	18.8	16.8	18.4	17.6	18.9	19.6	18.5	27.2
1997	19.2	22.9	25.7	23.7	22.6	17.5	16.5	19.0	16.5	21.6	17.0	22.7	25.7
1998	28.7	26.9	29.8	30.0	28.3	18.3	18.0	18.5	18.7	28.9	24.9	30.0	30.0
Maximum	29.0	27.0	29.8	30.0	28.3	27.0	22.0	26.0	22.0	28.9	26.0	30.0	30.0
Average	19.6	20.5	21.6	21.6	20.6	19.5	18.2	18.3	17.9	18.8	19.4	20.2	24.1
Minimum	14.8	16.4	16.2	14.9	14.5	14.9	14.0	13.4	14.0	13.0	14.0	15.4	19.6

Note: Piggyback operations; Delta temperature limit - 30 degree F

9/14/99

TABLE IV-4

MONTHLY AVERAGE TEMPERATURE RISE
(Deg F)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average
1977	15.7	15.9	15.9	12.6	12.8	12.0	7.3	6.4	12.0	11.2	12.7	13.7	12.3
1978	16.2	15.8	13.4	14.4	12.9	15.8	8.3	9.0	8.1	9.6	11.1	10.0	12.0
1979	11.2	13.8	11.6	11.4	13.2	11.0	12.3	9.9	16.1	18.3	18.4	14.5	13.5
1980	16.1	17.8	17.2	12.6	13.3	13.1	10.9	9.4	13.8	13.4	13.2	15.6	13.9
1981	14.6	15.9	15.1	14.9	16.1	14.8	9.9	8.9	12.4	12.7	12.1	10.8	13.2
1982	11.3	12.5	13.3	17.3	11.9	15.1	8.3	11.3	15.2	14.5	15.1	16.1	13.5
1983	17.7	16.8	19.4	15.5	12.4	15.3	17.0	15.5	11.2	15.1	16.4	18.7	15.9
1984	19.7	10.8	16.1	15.5	14.9	14.6	9.1	11.1	13.0	15.0	15.1	14.9	14.2
1985	16.1	14.2	13.3	11.7	9.3	10.5	13.0	15.2	14.6	11.4	10.9	11.4	12.6
1986	9.4	11.6	11.1	9.0	8.7	10.3	11.3	10.9	12.5	11.8	14.2	15.1	11.3
1987	10.3	14.7	14.2	12.5	11.8	13.3	13.6	12.4	12.7	12.5	13.3	12.2	12.8
1988	13.3	15.0	16.3	16.5	15.4	13.9	14.6	13.5	15.6	15.1	17.1	17.4	15.3
1989	17.6	16.0	16.4	15.4	10.2	14.8	12.5	9.3	13.7	15.6	17.4	17.4	14.7
1990	16.5	17.0	16.1	16.8	14.9	10.7	11.6	11.0	13.6	12.0	15.2	15.0	14.2
1991	16.0	14.3	13.1	14.1	9.1	10.0	11.9	13.3	9.9	9.3	13.6	11.8	12.2
1992	12.6	13.3	13.5	12.7	7.6	9.4	10.1	11.1	11.2	12.6	9.3	11.6	11.3
1993	11.7	12.7	15.2	10.4	10.0	10.2	13.0	11.0	12.0	12.0	12.0	12.0	11.9
1994	13.0	14.7	16.9	16.0	12.0	10.0	10.6	10.5	12.3	11.4	11.2	11.4	12.5
1995	10.9	11.4	11.0	11.2	11.7	13.4	12.9	12.2	11.5	12.4	12.1	12.0	11.9
1996	11.4	12.3	13.0	12.7	10.9	12.1	11.7	12.4	12.7	13.0	13.9	12.2	12.4
1997	13.1	15.6	16.7	15.0	15.0	13.3	12.9	13.6	14.2	14.9	15.4	16.1	14.7
1998	16.4	15.6	17.4	16.0	17.5	12.4	13.1	12.9	13.6	15.1	18.5	18.3	15.6
Maximum	19.7	17.8	19.4	17.3	17.5	15.8	17.0	15.5	16.1	18.3	18.5	18.7	15.9
Average	14.1	14.4	14.8	13.8	12.3	12.5	11.6	11.4	12.8	13.1	14.0	14.0	13.3
Minimum	9.4	10.8	11.0	9.0	7.6	9.4	7.3	6.4	8.1	9.3	9.3	10.0	11.3

Note: Piggyback operations; Delta temperature limit - 30 degree F

TABLE IV-5

TOTAL MONTHLY 001 FLOW
(Million Gallons)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Total
1977	22,177	24,324	26,920	25,590	13,333	15,930	18,237	20,913	22,710	26,338	26,394	26,561	269,427
1978	26,263	17,408	24,654	26,634	25,777	25,545	20,073	27,435	23,718	20,714	25,920	24,642	288,783
1979	18,879	18,340	14,415	15,330	15,872	14,520	19,778	24,149	24,270	23,715	21,180	21,607	232,055
1980	25,265	24,592	25,885	14,610	22,382	24,300	24,707	20,367	19,710	18,135	18,445	19,530	257,928
1981	18,693	16,016	22,568	23,130	18,848	18,090	27,793	19,375	16,437	15,835	16,700	20,538	234,023
1982	21,898	23,596	25,234	19,002	21,855	21,060	26,725	27,094	21,120	26,369	26,031	26,852	286,836
1983	26,440	22,266	15,723	21,435	27,447	25,971	24,114	21,139	19,665	16,272	15,261	15,140	250,873
1984	19,267	22,287	21,954	21,909	21,638	23,790	27,156	27,187	25,290	26,598	21,300	33,108	291,483
1985	26,868	23,884	26,868	26,154	23,380	30,270	34,686	37,805	23,073	26,901	23,478	26,992	330,359
1986	30,799	36,294	38,952	26,262	33,908	35,379	33,892	31,149	22,083	25,212	22,899	26,232	363,061
1987	32,482	26,085	25,888	30,699	29,664	29,184	38,356	38,685	37,146	35,883	32,520	30,098	386,690
1988	37,863	34,982	39,571	27,918	31,180	32,028	32,916	39,392	27,870	25,761	27,150	28,483	385,114
1989	28,396	24,903	31,561	30,090	31,062	37,911	35,557	33,368	35,082	36,636	38,403	39,572	402,541
1990	37,901	32,200	35,027	25,836	26,651	37,476	38,549	36,763	30,588	37,464	29,535	37,687	405,677
1991	37,857	34,140	33,682	37,587	29,729	34,854	38,986	36,878	25,980	26,979	33,618	33,778	404,068
1992	38,440	36,331	33,272	28,785	32,516	27,126	34,140	34,034	36,855	34,106	27,600	32,603	395,808
1993	31,880	34,008	27,745	24,645	19,322	32,049	38,387	36,896	35,547	37,591	36,378	38,914	393,362
1994	38,105	32,530	28,970	20,262	29,193	28,602	33,998	35,696	32,292	30,693	35,556	31,722	377,619
1995	34,674	28,756	24,896	26,403	35,421	38,490	39,568	39,258	33,987	29,844	29,379	34,252	394,929
1996	34,401	29,771	21,102	26,853	26,964	28,863	34,178	37,594	35,736	35,929	30,156	34,026	394,929
1997	35,179	27,068	24,258	27,234	28,418	29,826	32,237	28,901	27,636	28,660	28,308	29,342	347,067
1998	28,005	23,030	23,214	20,164	22,634	26,182	30,378	31,503	29,665	23,832	24,993	17,581	301,182
Maximum	38,440	36,331	39,571	37,587	35,421	38,490	39,568	39,392	37,146	37,591	38,403	39,572	405,677
Average	29,624	26,946	26,925	24,842	25,782	28,066	31,110	31,163	27,566	27,703	26,873	28,603	336,082
Minimum	18,693	16,016	14,415	14,610	13,333	14,520	18,237	19,375	16,437	15,835	15,261	15,140	232,055

Note: Piggyback operations; Delta temperature limit - 30 degree F

Note: Flow data from October 1993 to present contains an estimate for Unit 3&4 service water.

9/14/99

Figure IV-1
ANNUAL TOTAL DISCHARGE 001 FLOW

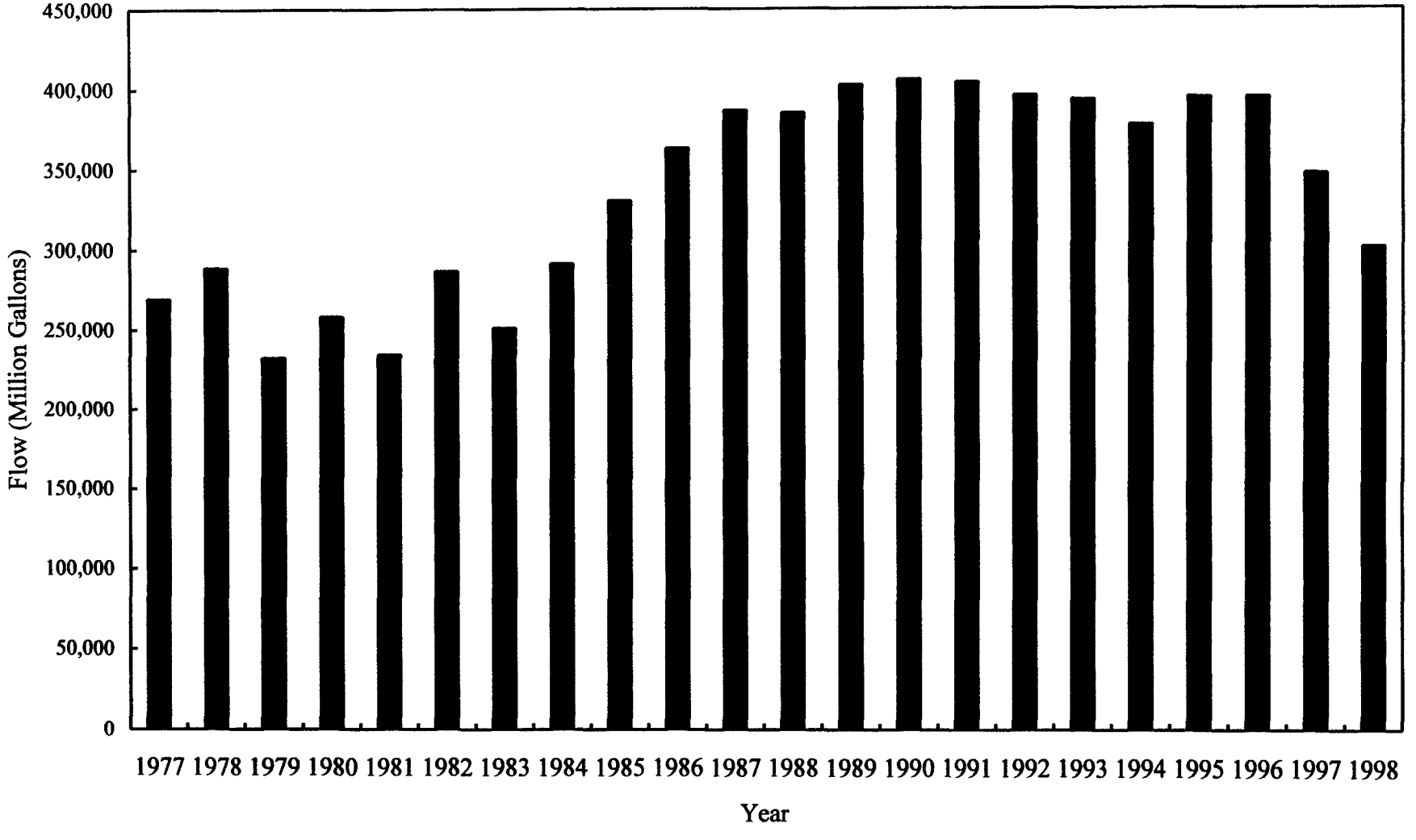

TABLE IV-6

MONTHLY AVERAGE CIRCULATING WATER FLOW
(Billion Gallons per Day)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUMMER SEASON
1977	0.715	0.869	0.868	0.853	0.430	0.531	0.588	0.675	0.757	0.850	0.880	0.857	0.638
1978	0.847	0.622	0.795	0.888	0.832	0.852	0.648	0.885	0.791	0.668	0.864	0.795	0.793
1979	0.609	0.655	0.465	0.511	0.512	0.484	0.638	0.779	0.809	0.765	0.706	0.697	0.678
1980	0.815	0.848	0.835	0.487	0.722	0.810	0.797	0.657	0.657	0.585	0.615	0.630	0.730
1981	0.603	0.572	0.728	0.771	0.608	0.603	0.897	0.625	0.548	0.511	0.557	0.663	0.670
1982	0.706	0.843	0.814	0.633	0.705	0.702	0.862	0.874	0.704	0.851	0.868	0.866	0.787
1983	0.853	0.795	0.507	0.715	0.885	0.866	0.778	0.682	0.656	0.525	0.509	0.488	0.745
1984	0.622	0.769	0.708	0.730	0.698	0.793	0.876	0.877	0.843	0.858	0.710	1.068	0.848
1985	0.867	0.853	0.867	0.872	0.754	1.009	1.119	1.220	0.769	0.868	0.783	0.871	1.031
1986	0.994	1.296	1.257	0.875	1.094	1.179	1.093	1.005	0.736	0.813	0.763	0.846	1.004
1987	1.048	0.932	0.835	1.023	0.957	0.973	1.237	1.248	1.238	1.158	1.084	0.971	1.175
1988	1.221	1.206	1.276	0.931	1.006	1.068	1.062	1.271	0.929	0.831	0.905	0.919	1.084
1989	0.916	0.889	1.018	1.003	1.002	1.264	1.147	1.076	1.169	1.182	1.280	1.277	1.163
1990	1.223	1.150	1.130	0.861	0.860	1.249	1.244	1.186	1.020	1.209	0.985	1.216	1.175
1991	1.221	1.219	1.087	1.253	0.959	1.162	1.258	1.190	0.866	0.870	1.121	1.090	1.120
1992	1.240	1.253	1.073	0.960	1.049	0.904	1.101	1.098	1.229	1.100	0.920	1.052	1.083
1993	1.028	1.215	0.895	0.822	0.623	1.068	1.238	1.190	1.185	1.191	1.191	1.233	1.171
1994	1.207	1.139	0.912	0.653	0.920	0.931	1.075	1.130	1.054	0.968	1.163	1.001	1.048
1995	1.096	1.005	0.781	0.858	1.121	1.261	1.254	1.244	1.111	0.941	0.957	1.083	1.218
1996	1.087	1.004	0.658	0.873	0.847	0.940	1.102	1.190	1.169	1.136	1.001	1.075	1.101
1997	1.112	0.944	0.760	0.885	0.895	0.972	1.018	0.910	0.899	0.903	0.921	0.924	0.950
1998	0.903	0.823	0.749	0.672	0.730	0.873	0.980	1.016	0.989	0.769	0.833	0.597	0.965
Maximum	1.240	1.296	1.276	1.253	1.121	1.264	1.258	1.271	1.238	1.209	1.280	1.277	1.218
Average	0.952	0.950	0.864	0.824	0.828	0.931	1.001	1.001	0.915	0.889	0.892	0.919	0.963
Minimum	0.603	0.572	0.465	0.487	0.430	0.484	0.588	0.625	0.548	0.511	0.509	0.488	0.638

Note: Piggyback operations; Delta temperature limit - 30 degree F

Note: Summer Season is June through September

9/24/99

TABLE IV-7

MONTHLY TOTAL HEAT LOAD
(Trillion BTU)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUMMER SEASON	ENERGY
1977	2.9	3.2	3.6	2.7	1.4	1.6	1.1	1.1	2.3	2.5	2.8	3.0	6.1	28.2
1978	3.6	2.3	2.8	3.2	2.8	3.4	1.4	2.1	1.6	1.7	2.4	2.1	8.4	29.1
1979	1.8	2.1	1.4	1.5	1.8	1.3	2.0	2.0	3.3	3.6	3.3	2.6	8.6	26.6
1980	3.4	3.7	3.7	1.5	2.5	2.7	2.3	1.6	2.3	2.0	2.0	2.5	8.8	30.2
1981	2.3	2.1	2.8	2.9	2.5	2.2	2.3	1.4	1.7	1.7	1.7	1.9	7.7	25.6
1982	2.1	2.5	2.8	2.7	2.2	2.7	1.9	2.6	2.7	3.2	3.3	3.6	9.8	32.1
1983	3.9	3.1	2.5	2.8	2.8	3.3	3.4	2.7	1.8	2.1	2.1	2.4	11.3	33.0
1984	3.2	2.0	3.0	2.8	2.7	2.9	2.1	2.5	2.7	3.3	2.7	4.1	10.2	34.0
1985	3.6	2.8	3.0	2.6	1.8	2.7	3.8	4.8	2.8	2.6	2.1	2.6	14.0	35.1
1986	2.4	3.5	3.6	2.0	2.5	3.0	3.2	2.8	2.3	2.5	2.7	3.3	11.4	33.9
1987	2.8	3.2	3.1	3.2	2.9	3.2	4.4	4.0	3.9	3.7	3.6	3.1	15.6	41.2
1988	4.2	4.4	5.4	3.8	4.0	3.7	4.0	4.4	3.6	3.3	3.9	4.1	15.8	48.9
1989	4.2	3.3	4.3	3.9	2.6	4.7	3.7	2.6	4.0	4.8	5.6	5.8	15.0	49.5
1990	5.2	4.6	4.7	3.6	3.3	3.4	3.7	3.4	3.5	3.8	3.8	4.7	13.9	47.6
1991	5.1	4.1	3.7	4.4	2.3	2.9	3.9	4.1	2.1	2.1	3.8	3.3	13.0	41.8
1992	4.0	4.0	3.8	3.1	2.1	2.1	2.9	3.2	3.4	3.6	2.1	3.2	11.6	37.5
1993	3.1	3.6	3.5	2.1	1.6	2.7	4.2	3.4	3.6	3.7	3.6	3.8	13.9	39.0
1994	4.1	3.9	4.0	2.6	2.9	2.3	3.0	3.1	3.2	2.9	3.3	3.0	11.6	38.1
1995	3.1	2.7	2.2	2.4	3.4	4.2	4.2	3.9	3.2	3.0	2.9	3.4	15.6	38.7
1996	3.2	3.0	2.2	2.8	2.4	2.9	3.3	3.8	3.7	3.8	3.5	3.4	13.7	38.0
1997	3.8	3.4	3.2	3.3	3.5	3.2	3.4	3.2	3.2	3.5	3.5	3.8	13.0	41.1
1998	3.8	3.0	3.3	2.7	3.3	2.7	3.4	3.4	3.4	2.9	3.9	2.6	12.9	38.4
Maximum	5.2	4.6	5.4	4.4	4.0	4.7	4.4	4.8	4.0	4.8	5.6	5.8	15.8	49.5
Average	3.4	3.2	3.3	2.8	2.6	2.9	3.1	3.0	2.9	3.0	3.1	3.3	11.9	36.7
Minimum	1.8	2.0	1.4	1.5	1.4	1.3	1.1	1.1	1.6	1.7	1.7	1.9	6.1	25.6

Figure IV-2
ANNUAL ESTIMATED HEAT LOAD

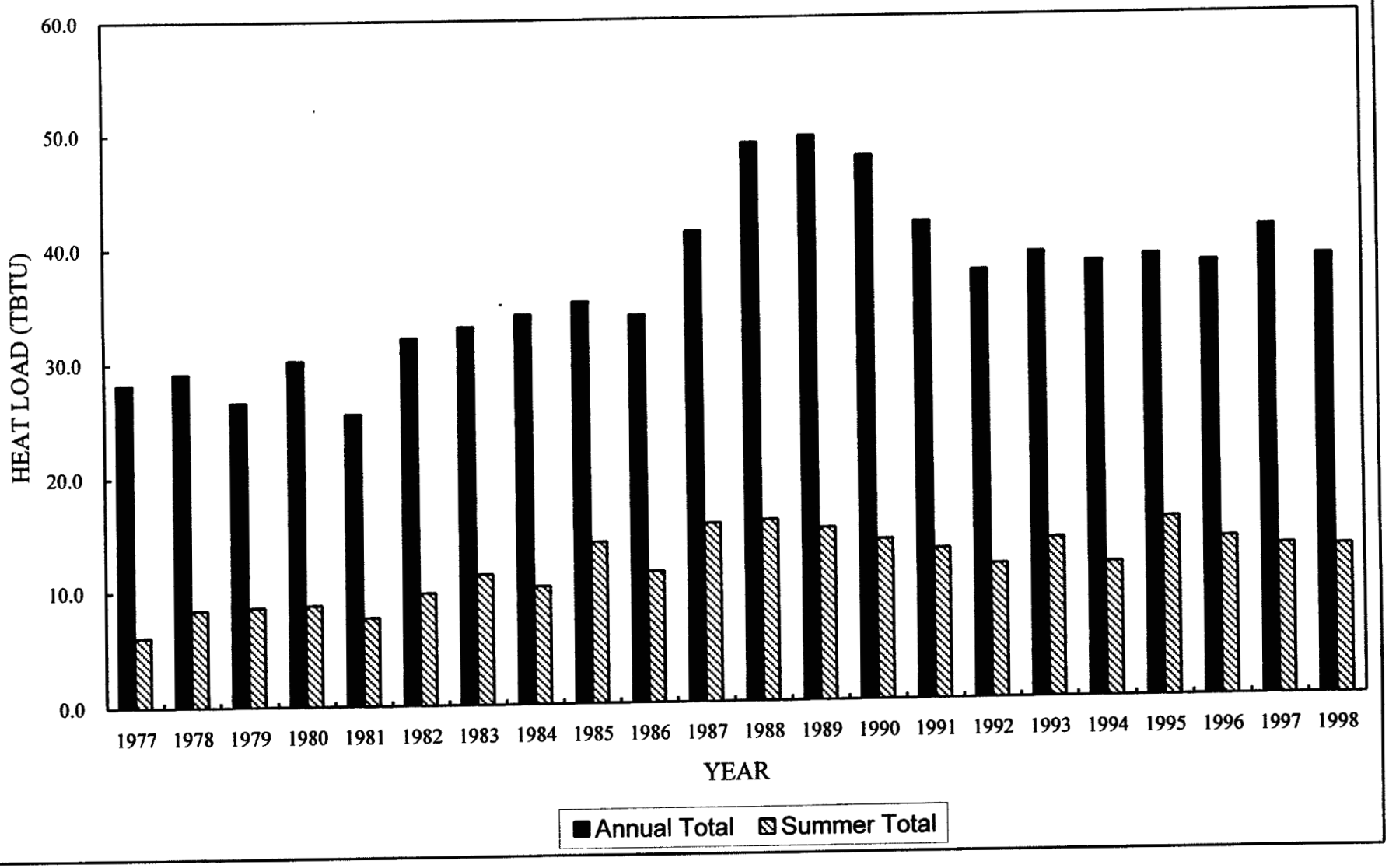

Table IV-8
CHRONOLOGY
BRAYTON POINT STATION OPERATIONS
1962 - 1998

A chronology of Station milestones is presented to assist with discussions regarding changes to circulating cooling water discharges and thermal output:

Year	Milestone
1962	Unit 1 start commercial operation
1963	Unit 2 start commercial operation
1969	Unit 3 start commercial operation
1973	First NPDES discharge permit - 90 F discharge temperature limit
1974	Unit 4 start commercial operation - closed cycle cooling
1975	Discharge channel relocated to present location & fish barrier nets installed
1979	95 F discharge temperature limit approved
1981	Unit 4 begins piggyback operation (5/81)
1983	Unit 3 unscheduled outage (8/26/83 - 2/28/84)
1984	Unit 4 end piggyback, start once-through cooling with new angled screen intake on Lee River (7/84)
1985	Unit 3 unscheduled outage (8/25/85 - 2/15/86)
1986	Unit 3 unscheduled outage (8/27/86 - 1/27/87)
1993	Unit 4 piggyback demonstration (March only)
1994	Unit 4 piggyback operation (2/17 - 4/29)
1995	Unit 3 scheduled outage (2/18 - 4/30) – piggyback equivalent
1996	Unit 4 piggyback operation (2/28 - 4/30)
1997	Unit 4 piggyback operation (2/6 - 3/29 and 4/17 - 5/30)

Table IV-8 (continued)

Year	Milestone
1998	Unit 4 piggyback operation (1/1 - 5/27 and 10/01 - 12/31) Unit 3 unscheduled outage (12/12 – 12/31)

V. FISH BARRIER NET

Since August of 1975, Brayton Point Station has maintained a net located at the terminal end of the discharge canal to serve as a barrier to fish attempting to enter the discharge canal. The net is similar to a commercial trawl net with a stretched mesh size of approximately 2½ inches. The last time the net was replaced was on June 25, 1997. Prior to that, the net was replaced on June 9, 1995.

The cod end of the barrier net was opened during the summer months from July 8 through September 9, 1998 to allow the fish to leave the canal, if avoidance temperatures were reached.

The barrier net is inspected and maintained on a routine basis (usually 2-3 times per week) by a diving contractor. Any dead fish observed in the net are counted, identified and length measurements estimated. In addition, the quantity of fish sighted upstream and downstream of the net are estimated by their size and species type. These observations are reported to the EPA and MA DEP in a quarterly report. Copies of these reports are in Attachment V-1.

During 1998, there were no unusual fish mortalities associated with the discharge canal or barrier net.

Attachment V-1

1998 QUARTERLY FISH REPORTS

New England Power
A NEES company

April 9, 1998

Planning and Administration (SPA)
Environmental Protection Agency
P.O Box 8127
Boston, Massachusetts 02114

Sir or Madam:

RE: NEW ENGLAND POWER COMPANY, BRAYTON POINT STATION, SOMERSET MASSACHUSETTS - NPDES QUARTERLY FISH REPORT, PERMIT NUMBER MA0003654

Pursuant to section A.2.j.(2) of New England Power Company Brayton Point Station's NPDES permit, enclosed is the 1998 First Quarter Fish Report for our Brayton Point Station.

If you have any questions, please contact Meredith M. Simas at telephone number 508-646-5338.

Very Truly Yours,

Barry A. Ketschke
Plant Manager

Enclosure (1)

Brayton Point Station
P.O. Box 440
Somerset, MA 02726-0040
Telephone: 508-646-5000
Fax: 508-646-5344

April 1, 1998

Meridith Simas
New England Power Company
Brayton Point Road
Somerset MA 02726

RE: Net report summery for 1st Quarter 1998
FISH:
Outside: Striped bass were reported during January, typically in small schools of 20-30 and sizes ranging from 10-15 inches. Striped bass were again observed in small schools on the later days of March.
Inside: No fish were observed during this period.
Fisherman: There was little or no sportfishing activity on site during the working hours of this period. Small striped bass was reported during the beginning of January.

DEAD FISH:
Total fish kill for the period

Striped bass	2	Typically 10-15 inches
Monk fish	1	6 inches.

NET CONDITION:
The net was in good condition. No defects were reported. The cod-end was closed during the period. Principle marine growth consisted of Tublaria.

FINANCIAL:
Total invoiced hours for maintenance during the Quarter were 148.5 hours.

If there are any questions or if I can be of further assistance please call.

Sincerely,

Stephen T. Antoniou

INNER TECH Commercial Diving P.O. Box 9123, Warwick, RI 02886 (401) 621-3283

MEMBER ADC ASSOCIATION OF DIVING CONTRACTORS

New England Power
A NEES company

July 13, 1998

Planning and Administration (SPA)
Environmental Protection Agency
P.O Box 8127
Boston, Massachusetts 02114

Sir or Madam:

RE: NEW ENGLAND POWER COMPANY, BRAYTON POINT STATION, SOMERSET MASSACHUSETTS - NPDES QUARTERLY FISH REPORT, PERMIT NUMBER MA0003654

Pursuant to section A.2.j.(2) of New England Power Company Brayton Point Station's NPDES permit, enclosed is the 1998 First Quarter Fish Report for our Brayton Point Station.

If you have any questions, please contact Meredith M. Simas at telephone number 508-646-5338.

Very Truly Yours,

Barry A. Ketschke
Plant Manager

Brayton Point Station
P.O. Box 440
Somerset, MA 02726-0040
Telephone: 508-646-5000
Fax: 508-646-5344

Quarterly Fish Report
April, May and June 1998

New England Power Company's Brayton Point Station counts, identifies and estimates the size of any dead fish collected in the net located in the discharge canal which are observed during weekly inspections and maintenance activities of the net. Also, the quantity of fish sighted upstream and downstream of the net are estimated by their size and species type. Inner Tech Divers performed the inspection and maintenance of the discharge canal net this quarter.

The number, species type and estimated size of dead fish collected in the discharge canal net are summarized below in Table 1 for second quarter 1998.

Dead Fish Collected in Net
Table 1

DATE	TYPE	QUANTITY	ESTIMATED SIZE
04/01	striped bass	1	15 inches
04/06	striped bass	1	12 inches
04/14	striped bass	1	18 inches
04/24	striped bass	1	18 inches
05/22	striped bass	2	6 to 12 inches
05/26	striped bass	1	12 inches
05/29	striped bass	1	18 inches
06/01	striped bass	1	12 inches
06/24	striped bass	1	23 inches
TOTAL PER QUARTER		10	6 to 23 inches

The estimated quantity, species type and size of fish sighted upstream of the discharge canal net are summarized below in Table 2 for second quarter 1998.

Fish Sighted Upstream of the Net
Table 2

DATE	TYPE	QUANTITY	ESTIMATED SIZE
04/06	tautog	1	15 inches
06/09	striped bass	2	12 inches

The estimated quantity, species type and size of fish sighted downstream of the discharge canal net are summarized below in Table 3 for second quarter 1998.

Fish Sighted Downstream of the Net
Table 3

DATE	TYPE	QUANTITY	ESTIMATED SIZE
04/06	tautog	2 - 3	12 - 15 inches
04/10	tautog striped bass	2 - 3 4	12 - 15 inches 12 inches
04/14	tautog striped bass	1 5	18 inches 6 - 12 inches
04/20	striped bass	100+	18 inches
04/24	striped bass	100+	12 - 18 inches
04/27	shad	10	small
05/01	shad striped bass	small school small school	6 inches 12 inches
05/04	shad scup striped bass	small school large school large school	small 6 - 8 inches 8 - 12 inches
05/08	striped bass	large school	12 inches
05/26	striped bass	large school	6 - 12 inches
06/01	bluefish	small school	no size noted
06/09	scup	small school	no size noted
06/16	striped bass	small school	no size noted
06/21	striped bass	small school	less than 12 inches

U.S. Generating Company
Brayton Point Station

P.O. Box 440
Somerset, MA 02726-0440

508.646.5000
Fax: 508.646.5415
www.usgen.com

October 15, 1998

Planning and Administration (SPA)
Environmental Protection Agency
P.O Box 8127
Boston, Massachusetts 02114

Sir or Madam:

RE: USGEN NEW ENGLAND, INC., BRAYTON POINT STATION, SOMERSET MASSACHUSETTS - NPDES QUARTERLY FISH REPORT, PERMIT NUMBER MA0003654

Pursuant to section A.2.j.(2) of USGen New England, Inc., Brayton Point Station's NPDES permit, enclosed is the 1998 Third Quarter Fish Report for our Brayton Point Station.

If you have any questions, please contact me at telephone number 508-646-5338.

Very Truly Yours,

Meredith M. Simas

Meredith M. Simas
Environmental Engineer

Quarterly Fish Report
July, August and September 1998

USGen New England, Inc.'s Brayton Point Station counts, identifies and estimates the size of any dead fish collected in the net located in the discharge canal which are observed during weekly inspections and maintenance activities of the net. Also, the quantity of fish sighted upstream and downstream of the net are estimated by their size and species type. Inner Tech Divers performed the inspection and maintenance of the discharge canal net this quarter.

The number, species type and estimated size of dead fish collected in the discharge canal net are summarized below in Table 1 for third quarter 1998.

Dead Fish Collected in Net
Table 1

DATE	TYPE	QUANTITY	ESTIMATED SIZE
07/17	tautog	15	6 - 22 inches
07/18	tautog striped bass	4 1	6 - 8 inches 12 inches
07/24	tautog	1	6 inches
09/08	monkfish	1	8 inches
09/11	monkfish	1	8 inches
09/17	striped bass	1	8 inches
09/22	striped bass	1	24 inches
09/25	striped bass	1	24 inches
09/29	striped bass monkfish	2 2	10 and 18 inches 8 inches
TOTAL PER QUARTER		30	6 to 24 inches

The estimated quantity, species type and size of fish sighted upstream of the discharge canal net are summarized below in Table 2 for third quarter 1998.

Fish Sighted Upstream of the Net
Table 2

DATE	TYPE	QUANTITY	ESTIMATED SIZE
No fish were sighted upstream of the discharge canal net during third quarter 1998.			

The estimated quantity, species type and size of fish sighted downstream of the discharge canal net are summarized below in Table 3 for third quarter 1998.

Fish Sighted Downstream of the Net
Table 3

DATE	TYPE	QUANTITY	ESTIMATED SIZE
08/14	shad	4	10 inches
08/17	shad	3	10 inches
08/19	scup	small school	8 inches
08/25	scup	small school	no size remarked
08/31	scup	small school	no size remarked
09/03	scup	100	6-8 inches
09/11	scup	5	6 inches
09/17	mullett	200 to 300	10 to 12 inches
09/22	mullett	100 to 200	10 to 12 inches
09/29	mullett	100 to 200	10 to 12 inches

U.S. Generating Company
Brayton Point Station

P.O. Box 440
Somerset, MA 02726-0440

508.646.5000
Fax: 508.646.5415
www.usgen.com

January 15, 1999

Planning and Administration (SPA)
Environmental Protection Agency
P.O Box 8127
Boston, Massachusetts 02114

Dear Sir or Madam:

RE: USGEN NEW ENGLAND, INC., BRAYTON POINT STATION, SOMERSET MASSACHUSETTS - NPDES QUARTERLY FISH REPORT, PERMIT NUMBER MA0003654

Pursuant to section A.2.j.(2) of USGen New England, Inc., Brayton Point Station's NPDES permit, enclosed is the 1998 Fourth Quarter Fish Report for our Brayton Point Station.

If you have any questions, please contact me at telephone number 508-646-5338.

Very Truly Yours,

Meredith M. Simas

Meredith M. Simas
Environmental Engineer

Quarterly Fish Report
October, November and December 1998

USGen New England, Inc.'s Brayton Point Station counts, identifies and estimates the size of any dead fish collected in the net located in the discharge canal which are observed during weekly inspections and maintenance activities of the net. Also, the quantity of fish sighted upstream and downstream of the net are estimated by their size and species type. Inner Tech Divers performed the inspection and maintenance of the discharge canal net this quarter.

The number, species type and estimated size of dead fish collected in the discharge canal net are summarized below in Table 1 for forth quarter 1998.

Dead Fish Collected in Net
Table 1

DATE	TYPE	QUANTITY	ESTIMATED SIZE
10/03/98	striped bass	1	12 inches
10/07/98	tautog	1	8 inches
10/14/98	striped bass	2	10 and 12 inches
10/30/98	striped bass (?)	1	14 inches
11/16/98	tautog	1	12 inches
TOTAL PER QUARTER		6	8 to 14 inches

The estimated quantity, species type and size of fish sighted upstream of the discharge canal net are summarized below in Table 2 for fourth quarter 1998.

Fish Sighted Upstream of the Net
Table 2

DATE	TYPE	QUANTITY	ESTIMATED SIZE
No fish were sighted upstream of the discharge canal net during forth quarter 1998.			

The estimated quantity, species type and size of fish sighted downstream of the discharge canal net are summarized below in Table 3 for fourth quarter 1998.

Fish Sighted Downstream of the Net
Table 3

DATE	TYPE	QUANTITY	ESTIMATED SIZE
10/03/98	mullet	>100	12 inches
10/07/98	striped bass bluefish	>5 >5	10 inches 8 inches
10/14/98	mullet	large school	12 inches
10/23/98	striped bass	>200	12 inches
10/27/98	mullet	>100	10 to 18 inches
10/30/98	striped bass	>30	8 inches
11/03/98	striped bass	100 to 150	12 to 24 inches
11/05/98	striped bass	100	12 to 18 inches
11/10/98	bluefish striped bass	30 30	12 inches 12 inches
11/16/98	striped bass	100 - 150	12 to 18 inches
11/23/98	striped bass tautog	30 to 40 5	12 inches 20 inches
11/28/98	striped bass bluefish tautog kingfish	-- -- 1 1	12 inches 12 to 18 inches 20 inches 6 inches
12/01/98	striped bass bluefish	1 30	12 inches 12 inches
12/09/98	striped bass tautog	4 1	8 to 12 inches 14 inches
12/11/98	striped bass bluefish tautog	2 50+ 3	12 to 14 inches 18 inches 8 to 12 inches
12/15/98	bluefish tautog	50+ 12	12 to 18 inches 8 t0 12 inches

DATE	TYPE	QUANTITY	ESTIMATED SIZE
12/19/98	striped bass bluefish	8 2	18 inches 24 inches
12/23/98	striped bass bluefish tautog	4 50+ 2	18 inches 12 to 18 inches 24 inches
12/28/98	striped bass tautog	100+ 4	24 to 30 inches 24 inches
12/30/98	otter striped bass bluefish tautog	1 100+ 100+ 2	large 12 - 24 inches 24+ inches 24 inches

VI. UNUSUAL IMPINGEMENT AND FISH KILL SUMMARY

Unusual Impingement

Although the NPDES permit requires impingement monitoring 3 times per week, since March 1997, finfish impinged on the Units 1, 2 and 3 intake screens were identified, counted and measured almost daily by Marine Research Inc. Each monitoring period represents one of the three daily 8-hour work periods.

In October 1995, the term "unusual impingement" was clarified by the TAC and the Fisheries Subcommittee to be an impingement rate of 25 or more fish per hour (an event that is likely to occur less than 5% of the observation periods, based on historic records). In 1998, there were no unusual impingement events.

Table VI-1 provides a 15-year summary of unusual impingement events observed at the Station. Refer to Tab III, Finfish Sampling, Section B of MRI's report, attached, for additional impingement information.

Additionally, starting February 6, 1997, the traveling intake screens for Unit No. 1, 2 and 3 were operated in the continuous mode as required in MOA II.

Fish Kills

In accordance with the NPDES discharge permit, the discharge canal, fish barrier net, and the nearby beach areas adjacent to the terminal end of the discharge canal are inspected routinely for dead fish or fish exhibiting loss of equilibrium. Historically, a reportable fish kill was defined as 500 or more dead fish observed in the vicinity of the discharge canal. Following a fish kill reported in August 1991, the NPDES discharge permit was revised redefining a fish kill as the cumulative number of dead fish observed within any 24-hour period that exceeds: a) 100 fish of either of the following species: striped bass or bluefish or winter flounder; or b) 200 of any other single species of fish not named above.

No fish kills were observed at the Brayton Point Station in 1998. A summary of fish kills reported prior to date are summarized in Table VI-2.

Table VI-1
UNUSUAL IMPINGEMENT EVENTS
1983 - 1998

YEAR	WEEK	RATE (fish/hour)	DOMINANT SPECIES
1998	No unusual impingement events determined		
1997	2/28	43	alewife
	3/10	47	alewife
1996	No unusual impingement events determined		
1995	1/2	147	silverside, alewife
	1/9	75	silverside
	1/16	93	silverside, menhaden
	1/30	98	silverside, menhaden
	2/6	38 and 47	menhaden, silverside
	2/13	66	silverside, blueback, flounder
1994	1/3	56	silverside, flounder
	1/10	25	silverside
	2/28	69 and 80	threespine, silverside
	3/7	35	tomcod, threespine, flounder
	3/21	70	silverside, threespine
	3/28	39	threespine
	12/19	69	silverside
	12/26	71 and 97	alewife, blueback, silverside
1993	1/4	96	menhaden, silverside
	1/11	34	menhaden, silverside
	1/18	39	menhaden, silverside
	1/25	25	silverside
	2/15	40	silverside

YEAR	WEEK	RATE (fish/hour)	DOMINANT SPECIES
1993	2/22	72	silverside, threespine
	3/8	27	silverside, threespine
	3/15	9327	silverside
	3/22	286, 98, 38	silverside
	12/20	137	silverside, silver hake
	12/27	36	silverside
1992	12/30	34	menhaden
1991	2/4	43 and 39	alewife, silverside, blueback
	2/18	54	silverside
	2/25	30	blueback, silverside, menhaden
	3/25	26	alewife, blueback
	12/23	28	menhaden, alewife
1990	2/19	47	threespine, silverside
	3/5	26	silverside, threespine
1989	1/9	28	silverside
	11/27	82	silver hake
1988	2/15	32	silverside
	12/12	25	silverside, blueback, alewife
	12/19	57	silverside
1987	1/26	32	silverside, flounder
	2/16	36	silverside
	2/23	83	silverside, flounder, threespine
	3/30	30	flounder, blueback

YEAR	WEEK	RATE (fish/hour)	DOMINANT SPECIES
1986	2/10	41	flounder, threespine
	3/10	40	flounder, silverside, threespine
	3/24	34	flounder, silverside
1986	5/26	30	bay anchovy, hogchoker, tomcod
	7/14	48	butterfish
	8/4	33	flounder
1985	1/7	32	silver hake
	6/17	112	bluefish
1984	4/2	64 and 37	alewife, blueback, flounder
	6/11	26	hogchoker
1983	1/16	39	flounder, anchovy

Table IV-2
REPORTED FISH KILLS
1971 - 1998

DATE	DESCRIPTION
08/14/91	972 striped bass; Observed in discharge canal; Contributing factors included elevated chlorine levels, low dissolved oxygen and high ambient temperatures; Resulted in $500,000 settlement with Commonwealth of Massachusetts and agreement to install targeted chlorination on Unit No. 3.
05/27/90	387 striped bass; Observed in fish barrier net; Coincident with low level chlorine spill and rapid decrease in discharge canal temperature.
06/27/83	167 striped bass; Observed in the Unit No. 4 cooling loop and the Unit No. 1,2 and 3 discharge canal barrier net; Unit No. 4 was operating in the "piggyback" mode; Cause not identified.
08/18/82	50 American eel; Most observed in discharge leg of Unit No. 4 cooling loop.
08/23/78	150 to 200 adult and juvenile tautog and a few perch; Observed in the fish barrier net; Associated with Unit start-up.
11/13/76	2,000 menhaden; Observed in discharge canal; Associated with start-up of service water system; odor of hydrogen sulfide detected, likely cause of low dissolved oxygen.
07/14/75	20,000 menhaden; Observed in discharge canal; Coincident with very heavy freshwater runoff during that period.
11/29/71	114,000 menhaden; Young of the year trapped on the intake traveling screens.
08/05/71	"Thousands" of menhaden; Observed in upper Lee River; Likely due to low dissolved oxygen caused by chemical spill not associated with Brayton Point Station (according to Massachusetts Division of Marine Fisheries).
07/10/71	300 to 400 menhaden; Observed in the Taunton River; Fish physically damaged and probably resulted from broken trawl fishing nets (per J. Scanlon of Save The Bay).
04/21/71	250 menhaden; Observed in discharge canal and Lee River.

VII. BIOCIDE PROGRAM SUMMARY

Circulating Water

Units 1, 2 and 3 uses a targeted biocide system to treat the condenser cooling water influent to control microbiological growth that would otherwise cause inefficient heat transfer and flow reduction. Unit No. 4 is not equipped with a targeted biocide system and has not received biocide treatment since 1991. Targeted biocide treatment is the process of injecting a saturated concentration of a biocide through fixed nozzles in front of the condenser tube sheet for a short duration of time. Sections of a condenser's tube sheet are treated sequentially.

In accordance with the Station's NPDES discharge permit, each condenser half of Units 1, 2, and 3 is treated for a period of not more than two hours per day, at an instantaneous maximum total residual oxidant (TRO) concentration of 0.2 ppm, as measured prior to mixing with another Unit's condenser discharge. Four consecutive samples are collected daily and analyzed for TRO when each condenser is being treated. In addition, the Station's combined circulating water discharge, permitted discharge 001, is sampled and analyzed for TRO once per week during the chlorination cycle and, whenever possible, the sample is collected during Unit No. 3 treatment. The TRO instantaneous maximum limit for discharge 001 is 0.065 ppm.

Both sodium hypochlorite and halogenated hydantoin products are approved for use by the Station's NPDES permit. From 1987, when the targeted biocide system was first installed on Unit No. 2, until September 1991, sodium hypochlorite was used in the targeted biocide system. From October 1991 through April 1995, biocide treatment of all condensers was suspended. Then, from May 1995 through March 1998, with the exception of a four week trial on Unit No. 1 with sodium hypochloride, halogenated hydantoin products were used in the targeted biocide system. In July 1998, the targeted biocide system used sodium hypochlorite as the biocide.

Halogenated hydantoin products in the targeted biocide treatment program were used at the Station with limited success. To our knowledge, Brayton Point Station is the only station in the industry to use halogenated hydantoin in a targeted biocide system. During the three years that the halogenated hydantoin products were used in the targeted biocide system, the effectiveness of the hydantoin has been considerably lower than that of sodium hypochlorite. One potential cause of the ineffectiveness of halogenated hydantoin could be because the contact time within the condenser is less than the solubility time of the hydantoin. As a result of the lower effectiveness of halogenated hydantoin, sodium hypochlorite was again used as the biocide in the targeted biocide system starting in July 1998.

During 1998, biocide residuals were monitored as described in the discharge permit with one exceedance of the condenser outlet TRO limit. On July 17, the instantaneous maximum TRO limit was exceeded by 0.1 ppm while treating Unit No. 2 condenser. The cause of the exceedance was determined to be from air and gas bubbles trapped at piping high points in the new chemical feed system. The bubbles located between the chemical injection point at the condenser inlet and the chemical pump outside the plant (200 – 300 feet away) would expand

and contract as the target nozzles were switched, varying the chemical feed rate. This occurred even if the chemical feed rate was constant.

Because of the exceedance, the chemical feed system was shut down and modified to include a metering pump with a chemical day tank adjacent to each Unit's dilution pump, eliminating the long piping runs on the chemical injection piping. Table VII-1 describes biocide feed rates and monitored biocide residuals for 1998.

Table VII-2 describes the historical use of biocide applications to the circulating water cooling systems from 1981 through 1998. Usage is expressed as equivalent pounds of chlorine to facilitate comparison between the hydantoin product and sodium hypochlorite.

Service Water

The Station's service water system is composed of three small-volume cooling water systems which includes piping and pumps. Unit 1 and 2 share a common system whereas Unit 3 and 4 each has their own systems. The service water system is subject to blockage by biological fouling caused by mussels, barnacles, and hydroids that attach and grow on surfaces within the service water system and eventually reduced the effective pipe diameters of service water heat exchanger tubes.

Since June 1991, the service water systems are periodically treated with an approved molluskacide, Betz Clam-Trol CT-1, in accordance with a treatment schedule approved by the EPA and the State. CT-1 is metered into the service water system to produce a 15 ppm residual for a treatment duration period (12 to 18 hours) determined by the inlet cooling water temperature. To have the desired effect, treatments occur about six to eight weeks apart resulting in a treatment frequency of three to six times per year. Units 1 & 2 are treated simultaneously and Units 3 and 4 are treated individually.

Table VII-3 summarizes the application of CT-1 by service water system for application years 1991 through 1998.

Table VII-1
1998 BIOCIDE SUMMARY

MONTH		UNIT 1		UNIT 2		UNIT 3		001 TRO (ppm)
		TRO (ppm)	Feedrate (lbs/hr)	TRO (ppm)	Feedrate (lbs/hr)	TRO (ppm)	Feedrate (lbs/hr)	
JANUARY	Average	0.05	1.9	0.05	1.6	0.05	3.7	ND[1]
	Maximum	0.05	2.0	0.09	1.6	0.05	4.1	ND
	Minimum	0.05	1.7	0.05	1.6	0.05	3.4	ND
	Days[2]	7		5		3		
FEBRUARY	Average	0.05	1.9	0.05	2.2	0.05	5.4	ND
	Maximum	0.05	9.0	0.08	7.2	0.05	22.5	ND
	Minimum	0.05	1.1	0.05	0.9	0.05	2.2	ND
	Days	6		5		6		
MARCH	Average	0.05	1.4	0.05	4.3	0.05	6.6	ND
	Maximum	0.05	2.8	0.07	9.0	0.08	22.5	ND
	Minimum	0.05	0.8	0.05	0.7	0.05	1.7	ND
	Days	7		10		7		
APRIL	No Treatment							

1. Not detected
2. Number of days that at least one treatment cycle took place

MONTH		UNIT 1		UNIT 2		UNIT 3		001 TRO (ppm)
		TRO (ppm)	Feedrate (lbs/hr)	TRO (ppm)	Feedrate (lbs/hr)	TRO (ppm)	Feedrate (lbs/hr)	
MAY	No Treatment							
JUNE	No Treatment							
JULY	Average	0.05	14.5	0.05	14.6	0.05	19.2	ND
	Maximum[3]	0.2	15.4	0.3	16.2	0.10	19.4	ND
	Minimum	0.05	13.0	0.05	13.8	0.05	18.6	ND
	Days	6		5		4		
AUGUST	No Treatment							
SEPTEMBER	No Treatment							
OCTOBER	No Treatment							
NOVEMBER	No Treatment							
DECEMBER	No treatment							
ANNUAL SUMMARY	Average	0.05	5.0	0.05	5.6	0.05	8.2	ND
	Maximum	0.2	15.39	0.3	16.2	0.1	19.4	ND
	Minimum	0.05	0.8	0.05	0.7	0.05	1.7	ND
	Days	26		25		20		

3. One exceedance occurred on July 17, 1998 on Unit No. 2. As a result, the targeted systems on Units 1,2 and 3 were re-engineered.

Table VI-2
CIRCULATING WATER TREATMENT
BIOCIDE USAGE SUMMARY

YEAR	UNIT 1 (lbs)[4]	UNIT 2 (lbs)	UNIT 3 (lbs)	UNIT 4 (lbs)	TOTAL (lbs)	BIOCIDE
1981	no data	no data	no data	no data	89,600	hypochlorite
1982	no data	no data	no data	no data	108,500	hypochlorite
1983	no data	no data	no data	no data	159,400	hypochlorite
1984	no data	no data	no data	no data	116,000	hypochlorite
1985	no data	no data	no data	no data	116,000	hypochlorite
1986	no data	no data	no data	no data	79,000	hypochlorite
1987	no data	no data	no data	no data	89,000	hypochlorite
1988	32,100	19,200	32,100	32,100	115,500	hypochlorite
1989	10,900	6,600	10,900	10,900	39,000	hypochlorite
1990	12,000	12,000	34,000	27,000	85,000	hypochlorite
1991	7,400	4,600	19,300	38,100	69,400	hypochlorite
1992	0	0	0	0	0	no treatment
1993	0	0	0	0	0	no treatment
1994	0	0	0	0	0	no treatment
1995	1,700	750	4,000	0	6,400	hydantoin
1996	2,000	2,000	3,400	0	7,400	hydantoin
1997	1,200	500	1,500	0	3,200	hydantoin/hypo
1998	520	570	670	0	1760	hydantoin/hypo

4. Expressed as equivalent pounds of chlorine

Table VI-3
SERVICE WATER SYSTEM TREATMENT
CT-1 USAGE SUMMARY

YEAR	UNIT 1 AND 2 (gal)	UNIT 3 (gal)	UNIT 4 (gal)	TOTAL (gal)
1991	660	0	0	660
1992	1,100	1,500		2,600
1993	860	1,900		2,800
1994	800	1,200	800	2,800
1995	500	880	760	2,140
1996	540	820	640	2,000
1997	680	1,040	770	2,480
1998	693	756	684	2,133

VIII. BIBLIOGRAPHY OF REGULATORY SUBMITTALS

The following is a list of documents or reports submitted or distributed during 1998, in fulfillment of the Brayton Point Station National Pollutant Discharge Elimination System (NPDES) discharge permit program:

1. Monthly Discharge Monitoring Reports; these twelve (12) monthly reports summarize all sampling and analysis results for each of the Station's permitted discharge points.

2. Quarterly Fish Reports; these four (4) quarterly reports summarize the amount of dead fish caught in the fish barrier net and an estimate of the fish sighted upstream and downstream of the net.

3. Monthly Memorandum of Agreement II (MOA II) Reports; these twelve (12) monthly reports summarize heat load, circulating water flow, temperature rise and intake traveling screen rotation as outlined in the MOA II dated April 4, 1997.

4. Letter to U.S. Environmental Protection Agency and Massachusetts Department of Environmental Protection submitting the NPDES permit renewal application, January 15, 1998.

5. Letter to Rhode Island Department of Environmental Protection and Technical Advisory Committee, submitting a courtesy copy of the NPDES permit renewal application, January 27, 1998

6. Letter to U.S. Environmental Protection Agency, Massachusetts Department of Environmental Protection and Technical Advisory Committee submitting the "Semi-Annual Biological and Hydrological Report - 1997", January 30, 1998.

7. Letter to U.S. Environmental Protection Agency, submitting copy of the NPDES permit with MOAII changes as requested by Environmental Protection Agency's Senior Permit Engineer, February 9, 1998.

8. Letter to U.S. Environmental Protection Agency submitting the notification reauthorizing the signatory responsibility of the DMRs, February 11, 1998.

9. Letter from the Technical Advisory Committee to U.S. Environmental Protection, requesting Environmental Protection Agency's assistance in obtaining information for permit renewal, February 13, 1998.

10. Letter to U.S. Environmental Protection Agency, Massachusetts Department of Environmental Protection and Technical Advisory Committee submitting the "Annual Biological and Hydrological Report - 1996", March 12, 1998.

11. Letter from U.S. Environmental Protection Agency requesting information pursuant to §308(a) of the Clean Water Act as a result of the Technical Advisory Committee's letter dated February 13, 1998, April 6, 1998.

12. Letter to U.S. Environmental Protection Agency submitting the notification of a chemical clean on Unit No. 4, April 24, 1998.

13. Letter to Massachusetts Department of Environmental Protection providing an update on permit transfer to the new owner upon sale, April 24, 1998.

14. Letter to U.S. Environmental Protection Agency regarding the notification of the date change on the chemical clean on Unit No. 4, May 5, 1998.

15. Letter to U.S. Environmental Protection Agency requesting verification that the existing permits, including the NPDES permit, MOAII and permit application renewal dated January 15, 1998, will be transferred to the new owner, May 7, 1998.

16. Letter to U.S. Environmental Protection Agency, Massachusetts Department of Environmental Protection and Technical Advisory Committee submitting an amendment (pages H.33 and H.34) to the "1996 Annual Biological and Hydrological Report", May 11, 1998.

17. Letter to Massachusetts Department of Environmental Protection requesting verification that the existing permits, including the NPDES permit, MOAII and permit application renewal dated January 15, 1998, will be transferred to the new owner, May 20, 1998.

18. Letter to U.S. Environmental Protection Agency responding to their April 6, 1998 request for information pursuant to §308(a) of the Clean Water Act, May 26, 1998.

19. Letter to U.S. Environmental Protection Agency and Massachusetts Department of Environmental Protection reporting one total residual oxidant (TRO) exceedence, July 21, 1998.

20. Letter from U.S. Environmental Protection Agency notifying that the existing permits, including the NPDES permit, MOAII and permit application renewal dated January 15, 1998, will be transferred to the new owner, July 29, 1998.

21. Letter to U.S. Environmental Protection Agency, Massachusetts Department of Environmental Protection and Technical Advisory Committee submitting the "1997 Annual Biological and Hydrological Report", August 26, 1998.

22. Letter to U.S. Environmental Protection Agency, Massachusetts Department of Environmental Protection and Technical Advisory Committee submitting the "1998 Semi-Annual Biological and Hydrological Report", August 31, 1998.

23. Letter to U.S. Environmental Protection Agency notifying that the sale of Brayton Point Station from New England Power to USGen New England was complete, September 1, 1998.

24. Letter to Massachusetts Department of Environmental Protection notifying that the sale of Brayton Point Station from New England Power to USGen New England was complete, September 1, 1998.

25. Letter from U.S. Environmental Protection Agency transferring the existing NPDES permit to the new owner, September 3, 1998.

26. Letter to U.S. Environmental Protection Agency submitting the notification reauthorizing the signatory responsibility of the DMRs, September 15, 1998.

27. Letter to U.S. Environmental Protection Agency and Massachusetts Department of Environmental Protection follow-up of July 21, 1998 letter on TRO exceedence, September 21, 1998.