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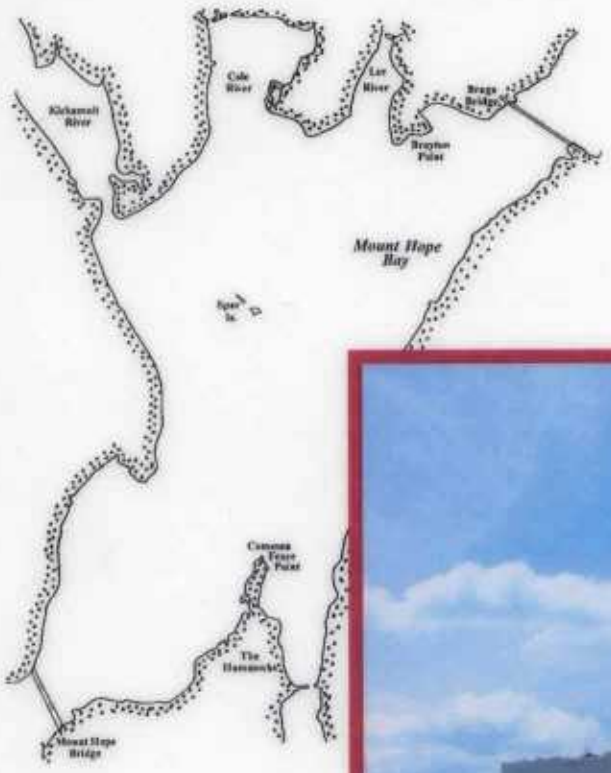
Dominion Brayton Point

Brayton Point Station

2005 Annual Report



Hydrological and Biological Monitoring Program

Brayton Point Station
Somerset, Massachusetts

Dominion

5 Trawl Studies

5.1 INTRODUCTION

Finfish abundance in upper Mount Hope Bay has been sampled continuously at fixed stations since late 1971 using an otter trawl (1.5-in stretched mesh in the cod end). This sampling program is referred to as the standard trawl program. Otter trawl sampling was augmented in 1993 through the addition of tows with a finer-mesh Wilcox trawl (0.25-in mesh liner in the cod end). Wilcox trawl tows have been conducted throughout Mount Hope Bay since 1996 and at two stations in Narragansett Bay since 1997. The standard trawl program was also augmented through the implementation of bay-wide sampling beginning in 1997. The objective of both the standard and Wilcox trawl programs is to document finfish abundance in Mount Hope Bay and at two stations in Narragansett Bay.

5.2 METHODS

Table 5-1 provides an overview of the sampling protocols for the standard and Wilcox trawl programs. Details about the protocols (station locations and schedules, equipment, and tow methods) as well as analytical techniques used in evaluating collections are provided below. Changes made over the years to improve or enhance the sampling programs are also described.

5.2.1 Standard-Trawl Sampling Protocol

5.2.1.1 Stations Sampled

Figure 5-1 shows the locations of fixed stations sampled during the standard trawl program. Five stations were sampled beginning in 1971: Spar Island, Cole and Lee Rivers, Brayton Point Station Intake, and Crossleg. Of these, only the Spar Island sampling station is not located in upper Mount Hope Bay. In 1979, three additional fixed stations were added to the sampling program: Taunton River, Brayton Point Station Discharge, and Mid-Bay. In 1985, Crossleg and Mid-Bay were dropped. The remaining six fixed stations have been sampled continuously since 1986.

Beginning in March 1997, four additional stations were added to the standard trawl program, bringing to 10 the total number sampled annually since that time. Each month, the four additional stations are selected at random from a pool of 38 deep-water stations (>6.2m = 20 ft) and 45 shallow-water stations (≤ 6.2m = 20 ft) established in 1996 for sampling with the Wilcox trawl (Figures 5-2 and 5-3). Three stations are selected each month from the deep-water pool and one from the shallow-water pool. When combined

with the six fixed stations (five shallow and one deep), the added stations result in six shallow-water stations and four deep-water stations being sampled monthly with the standard otter trawl. Additionally, during 1993-1995, six Taunton River-area stations were selected at random from a pool of 23 (Figure 5-4) and sampled during the winter flounder spawning season.

5.2.1.2 Sampling Schedules

All stations in the current standard otter trawl program are sampled once monthly. As shown in Table 5-1, prior to October 1980, fixed stations were sampled twice monthly via single or duplicate tows. Taunton River-area sampling collections were made from February through May in 1993 and from December through May in 1994 and 1995. The four depth-stratified stations selected at random from the pool of Mount Hope Bay deep-water and shallow-water stations (Figures 5-2 and 5-3) were sampled every month beginning March 1997.

5.2.1.3 Gear and Tow Methods

The standard otter trawl measures 11.4 m (37.5 ft) in length and has a 7.6-m (25-ft) head rope, 11-m (36-ft) foot rope, 120.6-mm (4.75-in) stretched mesh in the body, and 38.1-mm (1.5-in) stretched mesh in the cod end. The trawl is towed at a speed of about 1 to 1.5 m/sec, or about 2 to 3 knots.

All transects sampled in the Brayton Point Station otter trawl programs are 1,143 m (3,750 ft) in length, the distance that typically can be traversed by a standard 15-minute tow at the designated tow speed. Occasionally, adjustments in tow duration have been required to cover an established course; most commonly, this has occurred along the fixed-station transect in the Taunton River, where tidally driven currents are strongest. Transects are located using land-based bearings and GPS. At the six stations sampled continuously since 1979, mean water depth is typically 4.6 to 5.5 m (15–18 ft) except at the Brayton Point intake, where depth ranges from 10.7 to 12.2 m (35 to 40 ft); depths at the randomly selected sites are more variable, ranging from approximately 3.6 to 24.4 m (12 to 80 ft). In the rare event that a random station selection calls for a transect to be sampled with both the standard and Wilcox trawls in the same month, every effort is made to tow over adjacent bottom on the second pass and to allow at least 24 hours to elapse between tows.

During sampling, a Hydrolab Surveyor III or YSI 600 is used to document mid-depth and bottom water temperatures and dissolved oxygen.

5.2.1.4 Collection Handling

All fish are identified and counted, and total length (TL) is measured to the nearest millimeter. Winter flounder (*Pseudopleuronectes americanus*) equal to or exceeding 270 mm (10.6 in) TL, the length at which 50% of the stock reaches maturity (NOAA 1995), are weighed to the nearest gram unless choppy seas prevented stabilization of the weight scale.

5.2.2 Wilcox Trawl Sampling Protocol

5.2.2.1 Stations Sampled

In 1993 and 1994, six stations were sampled by the Wilcox trawl. They were randomly selected from a pool comprised of the six fixed stations sampled by the standard trawl program (Figure 5-1, Table 5-1) and the 23 Taunton River-area stations from which six were selected at random for standard trawl sampling (Figure 5-4, Table 5-1). In 1995, 12 stations were included in the Wilcox trawl program, randomly selected from the same pool available in the two preceding years.

In 1996 the Wilcox trawl program was revised to further improve the enumeration of smaller and more fusiform fishes not well retained by the standard trawl. The revised program incorporated random sampling of stations whose depths were consistent with the definitions of deep and shallow stations (>6.2 m = 20 ft and ≤6.2 m = 20 ft) used in the Narragansett Bay trawl program conducted by the Rhode Island Department of Environmental Management (RIDEM) Division of Fish, Wildlife, and Estuarine Resources. Planimeter measurements of Mount Hope Bay using NOAA Chart 13221 indicated that 60% was shallow-water habitat and 40% was deep-water habitat. A total of 83 transects was established for random trawl sampling in the two respective areas: 45 in shallow-water habitat and 38 in deep-water habitat (Figures 5-2 and 5-3). Since 1996, depth-stratified Wilcox trawls have been conducted at 10 randomly selected depth-stratified stations: 4 selected from the 38 deep-water stations and 6 selected from the 23 Taunton River-area transects shown in Figure 5-4.

In 1996, two additional deep-water stations were added to the Wilcox trawl program during the months of February – May to improve knowledge of the abundance and distribution of winter flounder. They were located between the Braga and Brightman Street bridges and were selected randomly from the three stations established in this location in 1993 (Figure 5-4, transects 12–14). With the addition of these two tows, 12 were completed during the winter flounder spawning season.

Beginning July 1997, in addition to the 10 randomly selected depth-stratified stations in Mount Hope Bay and the Taunton River area, Wilcox trawl sampling has been conducted at two sites beyond Mount Hope Bay—a shallow-water station in the Warren River and a deep-water station off Ohio Ledge in Narragansett Bay (Figure 5-5). These two sites are also sampled by the RIDEM Narragansett Bay trawl program (transects 13 and 13-A in the RIDEM program; Lynch 2000).

5.2.2.2 Sampling Schedule

All stations sampled by the Wilcox trawl are surveyed once each month. Prior to 1996, sampling months varied. In 1993, stations were sampled in April and May. The next year, February and March were added to the sampling schedule. In 1995, six stations were sampled from February through March and an additional twelve were sampled in April and May. Since 1996, the 10 randomly selected depth-stratified stations in Mount Hope Bay—four from deep-water transects 1 through 38 and 6 from shallow-water

transects 1–45 (Figure 5-3)—have been sampled every month. An additional two transects between Braga and Brightman Street bridges sampled in 1996 were sampled from February through May. Sampling of the Warren River and Ohio Ledge transects was done for the first time in July of 1997; these have been sampled monthly since then (Table 5-1).

5.2.2.3 Gear, Tow Methods, and Collection Handling

The Wilcox trawl measures 9.1 m (30 ft) along the foot rope and is constructed of 50.8-mm (2-in) stretched mesh in the body and 38.1-mm (1.5-in) stretched mesh in the cod end. The cod end is fitted with a 6.35-mm (0.25-in) mesh liner.

Tow speed and duration, equipment used to measure mid- and bottom water temperatures and dissolved oxygen, and collection handling are the same as described for the standard trawl program (Sections 5.2.1.3 and 5.2.1.4).

5.2.3 Data Analysis

5.2.3.1 Standard Trawl

An abundance index was computed based on the delta distribution (Pennington 1983, 1986, 1996; NUSCO 1988; Smith 1988) for each of the long-term (1972–2005) numerically dominant species collected in the standard trawl: winter flounder, windowpane (*Scophthalmus aquosus*), tautog (*Tautoga onitis*), hogchoker (*Trinectes maculatus*), scup (*Stenotomus chrysops*), butterfish (*Peprilus triacanthus*) and little skate (*Leucoraja erinacea*). To maintain consistency over the time series, the randomly selected bay-wide transects added to the standard trawl program beginning in March 1997 were excluded from these calculations. The delta distribution provides an abundance index with substantially lower variance compared to conventional indices, such as the arithmetic mean, if the data set consists of many zero tows and the non-zero values follow the log-normal distribution. For years where the proportion of zeros was low, the delta mean approached or equaled the arithmetic mean. Non-zero values were checked for normality using procedures outlined by Ryan and Joiner (1976).

Approximately two-thirds of the bay (the lower portion of Mount Hope Bay) is not sampled (Figure 5-1) by the fixed station standard trawl program. This program cannot properly be used to index fish abundance in all of Mount Hope Bay because the sampling stations are located from just south of Spar Island to the north. Sampling conducted in 1997 and later, however, provides a better picture of bay-wide abundance as sampling with the standard trawl was at that time augmented to include randomly selected stations, some of which are located in the lower bay. Therefore, standard trawl data collected since 1997 was used to calculate bay-wide abundance indices for the numerical dominants listed above using standard trawl data collected at the six fixed stations (5 shallow and 1 deep) and the four randomly selected trawl stations (1 shallow and 3 deep), 1997-2005.

For all remaining species captured with the standard trawl, annual indices of abundance were calculated as the arithmetic mean catch at all fixed stations sampled during each year, 1972-2005. In cases where replicates were taken (1972–January 1979), means include only the first tow. From 1979 to 1985, when eight stations were sampled, the three-minute discharge tow, oriented perpendicular to the plume at the time, was excluded since all other tows were 15 minutes in length.

Community stability was evaluated for standard trawl catches through calculation of dominance diversity (Whittaker 1965). Annual dominance diversity values consist of the slope of the linear relationship between annual abundance expressed on a natural logarithmic scale and species rank. Relatively steep slopes indicate that individuals are concentrated among a small number of species. Long-term trend in dominance diversity over the 1972–2005 time series was evaluated using linear regression ($\alpha = 0.05$).

5.2.3.2 Wilcox Trawl

Annual indices of depth-stratified abundance were calculated for Mount Hope Bay for each of the standard trawl numerical dominants listed above from Wilcox trawl catches over 1996–2005, the period for which sampling has been conducted during all months and throughout Mount Hope Bay. Shallow and deep weighting factors were based on the proportion of each depth strata in Mount Hope Bay (approximately 60:40, respectively).

A Narragansett Bay index was also calculated for winter flounder, windowpane, hogchoker, tautog and scup using the Wilcox trawl data collected at the two fixed stations sampled in Narragansett Bay. The Narragansett Bay index is the average annual catch at the two stations, 1997-2005.

5.3 RESULTS AND DISCUSSION

5.3.1 Catch Summary

Twenty-four species were collected in the 109 tows made with the standard trawl in 2005 (Table 5-2). September and October collections contained the most species with 14 collected each month. Generally, species richness was relatively low during February through June (2 to 6 species) and relatively high during July through December (9 to 14 species). These tallies include the randomly selected shallow and deep tows introduced to the program in March 1997. Species richness measured during 2005 sampling with consideration of only the fixed station tows was the same (24 species) and well within the range of 1972 to 2004 values for this index (14 to 39 species; Table 5-3). Since the number of species represented in the catch is proportional to the number of tows completed over the course of the year, a hyperbolic function was fitted to the number of species versus the number of tows completed each year, 1972-2005 (Figure 5-6). The curve describes the relationship with an r^2 value of 0.70 and predicted a value of 30 species for the 109 tows made during 2005, six more than actually collected. The six most abundant species in the 2005 standard trawl catches, which represented 86% of the

total catch, were scup, weakfish (*Cynoscion regalis*), winter flounder, butterfish, striped searobin (*Prionotus evolans*), and windowpane. (Figure 5-7, Table 5-4).

The Wilcox trawl collected 33 species in the 124 tows made during 2005 sampling, approximately in the middle of the range of values measured during 1996 through 2004 (27-41 species) and the same as measured during 2003 and 2004 (Table 5-5 to Table 5-7). Highest species richness was measured during September and December when 15 species were collected. Consistent with collections in the standard trawl, species richness measured in the Wilcox trawl was relatively low during January through May (3 to 8) and relatively high during August through December (13 to 15; Table 5-7). In terms of abundance, the top six species, which accounted for 85% of the total catch with this gear, were scup, winter flounder, Atlantic silverside (*Menidia menidia*), bay anchovy (*Anchoa mitchilli*), alewife (*Alosa pseudoharengus*), and butterfish (Figure 5-8, Table 5-5).

5.3.2 Dominance Diversity

Community stability was indexed through calculation of annual dominance diversity values from the standard trawl catches (Table 5-8). While dominance diversity values are always negative, large negative values (i.e., steep negative slopes) are less desirable in a community because they indicate that total individuals are concentrated among a relatively small number of species. The dominance diversity value calculated for 2005 (-0.211 $r^2 = 0.95$, $p < 0.0001$) was within the range of historical values (-0.149 to -0.309) and reflects an improvement in dominance diversity since 1996. In recent years, abundance has been more evenly distributed among several species. Analysis for trend in the long-term dominance diversity index (i.e., 1972-2005) currently shows a virtual zero slope that is not significantly different from zero (-0.00001, $p = 0.987$; Figure 5-9) signifying stability within the finfish community.

5.3.3 Abundance Trends

Following are results and discussion relating to the abundance of finfish as indexed in both the standard and Wilcox trawls. Chapter 9 of this report contains statistical comparisons of the standard and Wilcox trawl data for Mount Hope Bay with trawl data for Narragansett Bay.

5.3.3.1 Winter Flounder

Mount Hope Bay winter flounder catches ranged from 11 to 78 fish per tow between 1972 and 1983 in the fixed-station standard trawl collections. The low catch of 11 recorded in 1976 rebounded within three years to the time-series peak of 78 fish per tow in 1979. By 1988, mean catch per tow had dropped below 1 fish per tow, where it has remained for the past seventeen years (Figure 5-10, Table 5-9). The time-series low catch rate was recorded in 2000 (0.1 fish per tow). Since then, catches have increased consistently with the 2005 catch rate being the highest since 2000 at 0.89 fish per tow. Fifty-two individuals were collected in 57 fixed station tows and 100 individuals were collected in 109 trawl tows completed bay-wide. The shorter time series for the standard trawl towed bay-wide (nine years, 1997-2005; Figure 5-11) and the Wilcox trawl towed

bay-wide (ten years, 1996-2005; Figure 5-12), both show declines in abundance during the late 1990s and increases since 2000 and 2001, respectively.

Both bay-wide winter flounder trawl indices generally report a greater number of winter flounder per tow than the fixed station standard trawl index. For example, during the second year in which the three indices are available (i.e., 1998), the Wilcox, bay-wide standard, and fixed station standard trawl programs averaged 9, 1.1, and 0.5 fish per tow, respectively (Table 5-10). This observation is consistent with the fact that more flounder are found in deep waters; and the fixed station standard trawl program only collects samples from one deep-water station. The lower bay contains the majority of Mount Hope Bay's deep water but the fixed station standard trawl does not collect samples from those waters (Figures 5-3 and 5-13). For this, among other reasons, the fixed station standard trawl cannot serve as a representative long-term index for winter flounder in all of Mount Hope Bay.

Average catches of winter flounder in the Wilcox trawl collections in Mount Hope Bay have been consistently greater than those from either standard trawl index. For some years the difference is an order of magnitude (i.e., the Wilcox trawl caught 10 winter flounder for every 1 caught in the standard trawl) or more. To some extent this difference is attributable to the finer mesh of the Wilcox trawl. For example, the average length of winter flounder in Wilcox trawl catches during 2005 was 154 mm, while it was 186 mm in the standard trawl for the same period (Figures 5-14). This finding indicates that the standard trawl is under sampling winter flounder as smaller fish are extruded through the larger mesh of the standard trawl. Given the superior retention of winter flounder in the Wilcox trawl, and that the Wilcox trawl samples throughout Mount Hope Bay, the index generated with this gear provides a better indicator of winter flounder abundance in Mount Hope Bay than either standard trawl index.

Wilcox trawl catches of winter flounder in Mount Hope Bay and Narragansett Bay are generally similar both in terms of average annual catch and trends over time (Table 5-10). Both indices recorded average catch values between 1 and 9 winter flounder per tow during 1997 through 2005, an apparent low in abundance in 2001-2002 and increases in abundance since.

5.3.3.2 Windowpane

Annual windowpane catches in the standard trawl varied widely over the 1972 to 1979 period (Figure 5-15, Table 5-11), with peak abundance occurring in 1979 at 11 fish per tow. Average catch generally declined during 1979 through 1989 and has remained below 1 fish per tow since 1986. Catch rates increased slightly during 1993 through 1996. Based on length-frequency data, age-2 and -3 fish predominated in the catch 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. The subtle upward trend observed over the 1993 through 1996 period reversed as catch declined steadily from 1996 through 2002. Catches have been variable but increased relative to the 2002 low. The shorter time series composed of the bay-wide standard and Wilcox

trawl tows showed a downward trend from 1997 and 1996, respectively, through 2002 and variable but increased catches since. The bay-wide standard trawl catch declined from 1.0 per tow in 1997 to 0.1 in 2001, 2002 and 2004 and increased to 0.3 per tow in 2005 (Figure 5-16, Table 5-12). The Wilcox catch declined steadily from 3.0 per tow in 1996 to 0.03 per tow in 2002 and was 0.2 per tow during 2003 and 2004 and 0.1 in 2005 (Figure 5-17, Table 5-12).

Wilcox trawl catches of windowpane in Mount Hope Bay and Narragansett Bay shared similar trends in abundance over the 1997 through 2005 time period (Table 5-12). Abundance generally declined from 1997 through 2002 and has been variable but higher since in both areas. Average catches of windowpane in Mount Hope Bay, however, were generally higher than those in Narragansett Bay over the time series.

5.3.3.3 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 (Bigelow and Schroeder 1953, Olla et al. 1974). As a result they are not readily available to bottom trawls such as the standard and Wilcox trawl. The majority of these fish are landed by recreational fishermen as opposed to the commercial trawl fisheries (ASMFC 2002, Stirratt 2002). Even when tautog were more abundant in Mount Hope Bay, such as during 1978 and 1982, for example, annual catch rates never exceeded 1.4 fish per tow in the standard trawl (Figure 5-18, Table 5-13). Tautog catch rates have declined since 1986 and remained below 0.2 fish per tow through 2005. No tautog were collected at the fixed trawl locations for the first and only time in 1997 (two individuals were taken that year in two randomly selected deep tows). Catches have been variable since 1997 with the 2005 value of 0.12 fish per tow being the third highest within this time period.

The bay-wide collections in both the standard and Wilcox trawls also suggest that tautog are uncommon throughout Mount Hope Bay or are difficult to catch because of their strong association with structure. Bay-wide catches in the standard trawl were variable over the 1997 to 2005 period ranging from 0.02 to 0.20 with no obvious trend (Figure 5-19, Table 5-14). The bay-wide Wilcox trawl series begun in 1996 also varied without trend through 2005, but catch was notably high in 1999 at 3.1 fish per tow (Table 5-14, Figure 5-20).

Wilcox trawl catches of tautog in Mount Hope Bay and Narragansett Bay were generally similar both in terms of average catch and trends over time during the 1997 through 2005 period (Table 5-14). The year 1999 was an exception, however, when catches of tautog were much higher in Mount Hope Bay than in Narragansett Bay (3.1 vs. 0.1 fish per tow, respectively).

5.3.3.4 Hogchoker

The hogchoker is a small flatfish seldom found larger 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. Annual average catch per tow for hogchoker in the fixed station standard trawl catches was highest during 1974 when catches averaged 2.8 fish per tow. Catches of this species were extremely variable during the 1970s, ranging from this high to as low as 0.25 fish per tow. Variability was much less during the early 1980s until a decline occurred during 1985 to 1988 and record low catch rates where measured during 1988 and 1989 when zero and one fish (mean = 0.014 per tow) were collected, respectively (Figure 5-21, Table 5-15). Small increases in catch relative to that low occurred in 1995 (0.29 per tow), 1996 (0.45 per tow), and 1997 (0.35 per tow) and 2002 (0.15 per tow) and 2003 (0.28 per tow). Annual catch per tow in 2005 (0.25 per tow) represents another of these relatively high values.

The bay-wide series for the standard trawl followed the fixed station pattern closely with little noticeable difference over the 1997-2005 period (Figure 5-22; Table 5-16). Catches in the fine-mesh Wilcox trawl, which varied between 0 in 2001 and 0.2 fish per tow in 1996, have generally not been greater than those in the standard trawl. Catches in the Wilcox trawl during 2005 (0.02 per tow) was among the lowest of the times series (Table 5-16, Figure 5-23).

Between 1997 and 2005, hogchoker were only collected in 1998 in Narragansett Bay with the Wilcox trawl. In contrast, hogchoker were captured in every year except 2001 in Mount Hope Bay during this same time period suggesting hogchoker density in Mount Hope Bay is greater than in Narragansett Bay (Table 5-16).

5.3.3.5 Scup

Mean annual abundance for scup in Mount Hope Bay, calculated from the fixed station standard trawl survey over the months of May-October when they are normally present in the Bay, has varied from 0 (1988 and 1990) to 47 per tow (1976) (Table 5-17, Figure 5-24). Catches have generally been low and variable with occasional years of high catch. For example, 1976, 1980 and 2002 had catches of 47, 33, 15 fish per tow, respectively, while catches in other years were generally below five. Scup catches averaged a relatively high 6.6 fish per tow in 2005. Bay-wide standard trawl sampling displayed the same pattern in abundance as the fixed station sampling over the 1997 through 2005 period, with catches in 2005 (5.7) being relatively high (Figure 5-25, Table 5-18). The Wilcox trawl also showed similar trends, but higher catches overall and with a peak in 2000 instead of 2002. Wilcox trawl average catch in Mount Hope Bay during 2005 was a relatively high 23.7 fish per tow (Figure 5-26, Table 5-18).

Wilcox trawl catches of scup in Mount Hope Bay and Narragansett Bay generally shared similar trends in abundance over the 1997 through 2005 time period, but certain years including 2005 exhibited dramatic differences between the two areas (Table 5-18). Abundance increased from 1997 through 2000 in Mount Hope Bay and 1997 through 2001 in Narragansett Bay and then declined through 2004 in both areas. Catches in 2005 in Mount Hope Bay and Narragansett Bay were very different with 23.7 fish per tow in Mount Hope Bay but only 4 fish per tow in Narragansett Bay. Catches of scup were generally higher than many of the other species collected in the Wilcox trawl (e.g.

maximum average catch was 51 in Mount Hope Bay during 2000 and 63 in Narragansett Bay during 2001).

5.3.3.6 Butterfish

Butterfish have never been abundant in the Mount Hope Bay fixed station standard trawl collections. This is likely due to the tendency of butterfish to be near the surface when inshore and thus not susceptible to bottom sampling gear (Bigelow and Schroeder 1953, Collette and Klein-MacPhee 2002). Butterfish are also reported to prefer sandy bottoms that are limited in many portions of Mount Hope Bay. The highest observed annual catch rate in Mount Hope Bay was 1.5 fish per tow in 2003. Only four other years in the 32-year time series had annual catches exceeding 1 per tow (i.e., 1992 at 1.541, 1979 at 1.2, 1977 at 1.2, and 1975 at 1.3; Figure 5-27, Table 5-19). Overall, butterfish abundance, as indexed by the fixed station standard trawl program, has been variable and without discernable trend over the 1972-2005 period.

Over the bay-wide standard trawl series, which began in 1997, stratified mean values for butterfish ranged from 0.2 in 2004 to 1.9 in 2002 (Figure 5-28, Table 5-20). Butterfish were collected at higher catch rates in the Wilcox trawl where the fine mesh retains young-of-the-year. For example, catches during 1998 and 1999 averaged 12.1 and 13.2 fish per tow, respectively, an order of magnitude higher than catches in the typical standard trawl catch (Figure 5-29, Table 5-20). Butterfish were generally more abundant in Mount Hope Bay Wilcox trawl catches than those in Narragansett Bay. The major exception was 2003 when average catch in Narragansett Bay (20.4 fish per tow) was much greater than in Mount Hope Bay (1.2 fish per tow).

5.3.3.7 Little Skate

Like butterfish, little skate have always been taken in very low numbers in the standard trawl collections, averaging well under one individual per tow except for 1992 when 0.9 per tow was recorded, the highest of the time series (Figure 5-30, Table 5-21). Catches have been zero after 2002 in fixed station standard trawl tows. The shorter bay-wide stratified mean series begun in 1997 declined from 0.3 per tow in 1997 to 0.01 in 2001 and 2004 and increased to 0.11 in 2005 (Figure 5-31, Table 5-22). The Wilcox series followed the same pattern, dropping from 0.50 per tow in 1996 to 0 in 2004 and rose to 0.03 in 2005 (Figure 5-32, Table 5-22). Wilcox trawl catches in Narragansett Bay were lower than those in Mount Hope Bay in all years except 2004 and 2005. There was no discernable trend in little skate abundance in Narragansett Bay over the 1997 through 2005 sampling period.

5.3.3.8 Other Species

Table 5-23 provides average fixed station otter trawl catches for all other species collected. Annual arithmetic mean catch per tow is shown by species on a calendar year basis for 1972 through 2005. Results for seven species - weakfish, bay anchovy, cunner (*Tautogolabrus adspersus*), oyster toadfish (*Ospanus tau*), rainbow smelt (*Osmerus mordax*), Atlantic tomcod (*Microgadus tomcod*) and summer flounder (*Paralichthys*

dentatus) - are contained in Figures 5-33 through 5-36. Summer flounder are notable because of their importance in commercial and recreational fisheries.

With the exception of weakfish and summer flounder, catch rates for each of the seven species were below their respective time series means. Notable for each species is an increase in catch rates for one or two years between 1994 and 1998. Summer flounder present a contrast to the other species in that they experienced a clear upward trend from 1990 through 2002. The 2002 annual mean for summer flounder, 0.56 per tow, exceeded all previous years and was more than six times the long-term annual mean. By 2005 the catch dropped to 0.019 fish per tow, still above the time-series mean. The previous increase in catch of summer flounder is consistent with Northeast Fisheries Science Center stock assessment data, which indicated a substantial increase in stock biomass throughout the Northeast beginning in 1989 (NFSC 2002). Rhode Island Division of Fish and Wildlife data for Narragansett Bay further indicate that the 2000 year class was among the strongest of the 1979-2001 time series. Other species that have experienced notable increases in abundance over recent years include alewife and Atlantic silverside.

5.4 CONCLUSIONS

Twenty-four species were collected in the 109 tows made with the standard trawl in 2005, approximately in the middle of the range of values measured during 1972 through 2004 (14-39). Seasonal differences in species richness during 2005 was typical of most years; species richness was relatively low during February through June (2 to 6 species) and relatively high during July through December (9 to 14 species). The six most abundant species in the 2005 standard trawl catches, representing 86% of the total catch, were scup, weakfish (*Cynoscion regalis*), winter flounder, butterfish (*Peprilus triacanthus*), striped searobin (*Prionotus evolans*), and windowpane.

The Wilcox trawl collected 33 species in the 124 tows made during 2005 sampling, approximately in the middle of the range of values measured during 1996 through 2004 (27-43 species) and the same as measured during 2003 and 2004. Consistent with collections in the standard trawl and previous years of Wilcox trawl sampling, species richness measured in 2005 Wilcox trawl collections was relatively low during January through May (3 to 8) and relatively high during August through December (13 to 15). In terms of abundance, the top six species, which accounted for 85% of the total catch with this gear, were scup, winter flounder, Atlantic silverside (*Menidia menidia*), bay anchovy (*Anchoa mitchilli*), alewife (*Alosa pseudoharengus*), and butterfish.

Abundance of several benthic species, including winter flounder, windowpane, tautog and hogchoker, has decreased in the standard trawl program since the early 1970s and in the Wilcox trawl program since the mid-1990s. Importantly, however, catch rates of these species increased during recent years. Despite increasing and decreasing trends in abundance for individual species, the fish community sampled with the standard trawl has remained stable in terms of species richness and the distribution of abundance among

species, as evidenced by the lack of significant trend in the dominance diversity index calculated from data collected with this trawl.

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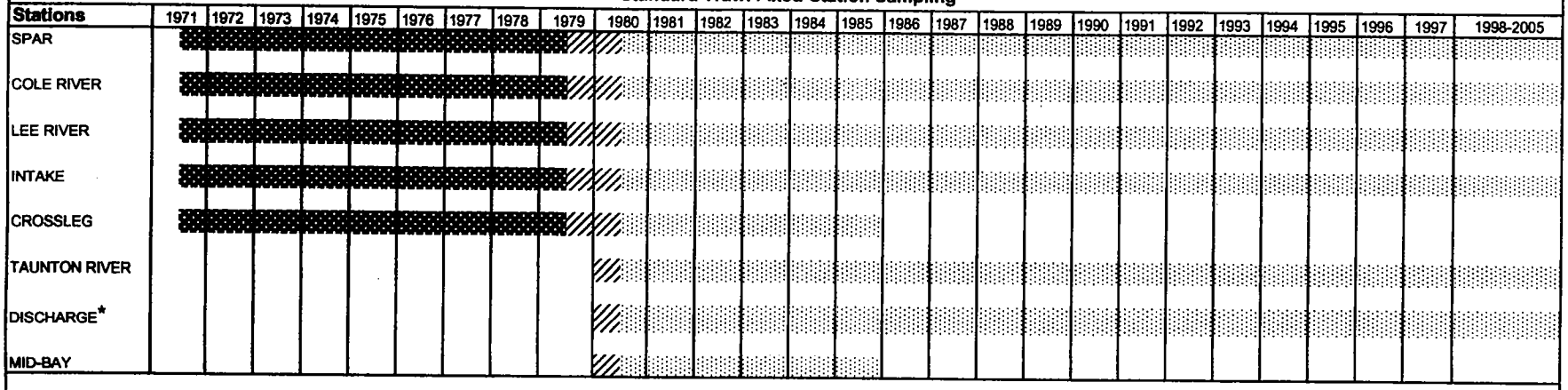
5.6 TABLES

Table 5-1. Otter Trawl Sampling Protocol - Standard and Wilcox Trawls, 1971-2005

Standard Trawl Fixed-Station Sampling



Standard Trawl Sampling Augmentations (Random Sampling)

Stations	Sampling Schedule	Station Depth	1993	1994	1995	1996	1997	1998-2005
Taunton Area Station Pool (23 stations; see Figures 5-2 and 5-3)	February - May	Variable	6					
	December	Variable	6	6	6			
	January - May	Variable		6	6			
Depth-Stratified Station Pool (38 deep stations, 45 shallow stations; see Figures 5-4 and 5-5)	March - December	Deep					3	
		Shallow					1	
	January - December	Deep						3
		Shallow						1

Wilcox Trawl Sampling (Random Sampling)

Stations	Sampling Schedule	Station Depth	1993	1994	1995	1996	1997	1998-2005
Station Pool: 6 standard-trawl fixed stations and 23 Taunton-area stations sampled in standard trawl program (see Figure 5-3)	February - March	Variable			6			
	April - May	Variable	6		12			
	February - May	Variable		6		2**		
Depth-Stratified Pool of Stations: 38 deep-water stations and 45 shallow-water stations (see Figure 5-3)	January - December	Deep				4	4	4
		Shallow				6	6	6
Narragansett Bay Stations: Ohio Ledge (deep water) and Warren River (shallow water)	January - December	Deep					1	1
		Shallow					1	1

Duplicate tows twice per month Single tows twice per month Single monthly tows

* 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.

** In 1996 only, two of three stations between Braga and Brightman Street bridges (Taunton area deep-water stations 12-14) were sampled in addition to the 10 Mount Hope Bay depth-stratified, randomly selected stations sampled every year since 1996.

Notes:

(1) Numbers in cells indicate number of stations sampled.

(2) Depth Stratification: Deep = greater than 6.2m (20 ft); Shallow = less than or equal to 6.2m (20 ft).

Table 5-2. Species of finfish and months of occurrence in Mount Hope Bay standard trawl collections, 2005

Species		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Leucoraja erinacea	Little skate					x	x			x	x	x
Conger oceanicus	Conger eel										x	
Alosa pseudoharengus	Alewife						x			x	x	x
Anchoa mitchilli	Bay anchovy							x		x		
Osmerus mordax	Rainbow smelt											x
Microgadus tomcod	Atlantic tomcod				x							
Opsanus tau	Oyster toadfish							x				
Menidia menidia	Atlantic silversides							x				x
Syngnathus fuscus	Northern pipefish								x	x	x	
Prionotus evolans	Striped searobin						x	x	x	x		
Myoxocephalus aenaeus	Grubby											x
Centropristis striata	Black sea bass								x	x		
Selene setapinnis	Atlantic moonfish								x			
Stenotomus chrysops	Scup					x		x	x	x		
Cynoscion regalis	Weakfish							x	x	x		
Tautoga onitis	Tautog			x		x	x	x	x	x	x	x
Tautogolabrus adspersus	Cunner	x		x	x	x			x		x	x
Scomber scombrus	Atlantic mackerel						x					
Peprilus triacanthus	Butterfish						x	x	x	x	x	
Etropus microstomus	Smallmouth flounder				x				x		x	
Paralichthys dentatus	Summer flounder					x	x	x	x	x		
Scophthalmus aquosus	Windowpane	x	x	x	x		x	x	x	x	x	x
Pseudopleuronectes americanus	Winter flounder		x	x	x	x	x	x	x	x	x	x
Trinectes maculatus	Hogchoker			x					x	x	x	
Number of species		2	2	5	5	6	9	11	14	14	11	9

Table 5-3. Species caught in Mount Hope Bay standard trawl collections (fixed stations only), 1972-2005 (page 1 of 2)

Species		1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Leucoraja erinacea	Little skate		x	x	x			x	x	x	x	x	x	x	x	x	x
Mustelus canis	Smooth dogfish	x	x	x		x		x								x	
Anguilla rostrata	American eel	x	x	x		x	x	x	x		x		x	x	x	x	
Conger oceanicus	Conger eel																x
Alosa aestivalis	Blueback herring		x	x				x		x		x			x		
A. pseudoharengus	Alewife	x	x	x	x	x	x	x	x	x		x	x	x	x		
A. sapidissima	American shad								x			x	x	x			
Brevoortia tryannus	Atlantic menhaden	x	x	x	x			x	x		x	x	x		x		
Clupea harengus	Atlantic herring	x	x	x	x	x	x	x	x						x		x
Anchoa mitchilli	Bay anchovy	x	x	x	x	x	x	x	x	x	x	x	x		x		
Osmerus mordax	Rainbow smelt	x	x	x	x	x		x	x	x	x	x	x	x	x		
Synodus foetens	Inshore lizardfish			x			x				x						
Enchoelyopus cimbrius	Fourbeard rockling							x	x								
Merluccius bilinearis	Silver hake	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	
Pollachius virens	Pollock								x		x	x					
Urophycis chuss	Red hake	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
U. tenuis	White hake	x	x	x	x	x		x	x	x			x				
Osparus tau	Oyster toadfish	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fundulus majalis	Striped killifish								x								
Menidia menidia	Atlantic silverside			x			x	x	x	x	x		x	x	x	x	x
Apeltes quadracus	Fourspine stickleback		x					x								x	
Gasterosteus aculeatus	Threespine stickleback																
Syngnathus fuscus	Northern pipefish		x	x	x		x	x	x	x	x	x	x	x	x		
Prionotus carolinus	Northern searobin	x	x	x	x	x		x					x		x		
P. evolans	Striped searobin	x	x	x	x	x	x	x	x	x		x	x	x			
Myoxocephalus aenaeus	Grubby	x		x		x		x	x	x		x	x	x			
M. octodecemspinosus	Longhorn sculpin								x								
Cyclopterus lumpus	Lumpfish																
Morone americana	White perch	x	x	x	x	x	x	x	x	x	x	x	x	x			
M. saxatilis	Striped bass	x	x	x		x				x		x					
Centropristis striata	Black sea bass					x			x								
Pomoxis nigromaculatus	Black crappie	x															
Pomoatomus saltatrix	Bluefish		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Caranx chrysos	Blue runner								x								x
C. hippos	Crevalle jack													x			
Selene setapinnis	Atlantic moonfish		x			x	x								x		
S. vomer	Lookdown								x								
Stenotomus chrysops	Scup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Trachurus lathami	Rough scad								x								
Cynoscion regalis	Weakfish	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
Leiostomus xanthurus	Spot		x		x								x			x	
Menticirrhus saxatilis	Northern kingfish	x	x	x	x	x		x	x	x	x	x	x	x	x		
Tautoga onitus	Tautog	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
Pholis gunnellus	Rock gunnel																
Gobiosoma ginsburgi	Seaboard goby	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Scomber scombrus	Atlantic mackeral							x	x			x					
Peprilus triacanthus	Butterfish	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Etropus microstomus	Smallmouth flounder													x			
Parlichthys dentatus	Summer flounder	x	x	x	x	x	x			x	x	x	x	x	x	x	x
P. oblongus	Fourspot flounder			x								x			x		
Scopthalmus aquosus	Windowpane flounder	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pseudopleuronectes americanus	Winter flounder	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	
Sphoeroides maculatus	Northern puffer												x			x	
	Species Total	30	35	35	28	29	25	34	39	29	25	31	33	27	30	20	16

Table 5-3. Species caught in Mount Hope Bay standard trawl collections (fixed stations only), 1972-2005 (page 2 of 2)

Species		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Leucoraja erinacea	Little skate	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Mustelus canis	Smooth dogfish									x									
Anguilla rostrata	American eel	x				x								x					
Conger oceanicus	Conger eel														x				x
Alosa aestivalis	Blueback herring			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
A. sapidissima	American shad									x			x					x	
Brevoortia tyrannus	Atlantic menhaden				x					x		x		x	x	x	x		
Clupea harengus	Atlantic herring		x		x						x	x	x	x		x		x	
Anchoa mitchilli	Bay anchovy		x		x	x	x		x	x	x	x	x	x		x			x
Osmerus mordax	Rainbow smelt	x			x		x			x	x	x							x
Synodus foetens	Inshore lizardfish												x		x	x			
Enchoelyopus cimbrius	Fourbeard rockling																		
Merluccius bilinearis	Silver hake		x			x				x		x	x			x	x	x	
Microgadus tomcod	Atlantic tomcod		x		x		x	x		x					x				x
Pollachius virens	Pollock																		
Urophycis chuss	Red hake							x	x	x		x	x				x		
U. regia	Spotted hake					x				x		x	x	x	x	x	x		
U. tenuis	White hake																		
Ospanus tau	Oyster toadfish	x		x			x		x	x	x	x	x	x	x		x	x	x
Fundulus majalis	Striped killifish																		
Menidia menidia	Atlantic silverside						x		x	x		x	x	x		x	x	x	x
Apeltes quadracus	Fourspine stickleback																		
Gasterosteus aculeatus	Threespine stickleback	x																	
Syngnathus fuscus	Northern pipefish			x				x					x					x	x
Prionotus carolinus	Northern searobin			x				x							x		x		
P. evolans	Striped searobin				x	X			x	x		x	x	x	x	x	x	x	x
Myoxocephalus aenaeus	Grubby																x		x
M. octodecemspinosus	Longhorn sculpin								x										
Cyclopterus lumpus	Lumpfish											x							
Morone americana	White perch			x		x						x							
M. saxatilis	Striped bass									x	x		x			x			
Centropristis striata	Black sea bass		x											x		x	x	x	x
Pomoxis nigromaculatus	Black crappie																		
Pomoatomus saltatrix	Bluefish		x		x				x			x	x	x	x	x		x	
Caranx chrysos	Blue runner				x								x						
C. hippos	Crevalle jack		x										x						
Selene setapinnis	Atlantic moonfish	x			x			x			x	x	x	x	x	x		x	x
S. vomer	Lookdown																x		x
Stenotomus chrysops	Scup		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Trachurus lathami	Rough scad																		
Cynoscion regalis	Weakfish		x							x	x	x	x	x	x	x	x	x	x
Leiostomus xanthurus	Spot												x						
Menticirrhus saxatilis	Northern kingfish					x	x	x	x	x	x	x	x				x		
Tautoga onitus	Tautog	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
Pholis gunnellus	Rock gunnel										x			x	x				
Gobiosoma ginsburgi	Seaboard goby	x	x		x						x	x				x			
Scomber scombrus	Atlantic mackeral						x												x
Peprilus triacanthus	Butterfish		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
Parlichthys dentatus	Summer flounder	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
P. oblongus	Fourspot flounder					x				x		x		x		x			
Scopthalmus aquosus	Windowpane flounder	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pseudopleuronectes americanus	Winter flounder	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
Sphoeroides maculatus	Northern puffer											x							
	Species Total	14	18	14	18	19	18	14	18	25	20	31	29	25	23	27	24	21	24

Table 5-4. Numbers of finfish (by species) collected in Mount Hope Bay standard trawl tows, 2005 (page 1 of 3)

2 February 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Discharge	45	1	9	12
Mid.Temp. (C)		1.3	1.4	1.8	2.1	1.9	3.4	3.1	1.6	0.9	0.8
Bot. Temp. (C)		1.5	1.4	2.3	2.5	1.9	1.4	1.6	0.9	1.3	1.4
Bottom DO (ppm)		11.5	9.9	11.9	11.2	11.8	11.5	10.8	12.9	9.3	11.4
Menidia menida	Atlantic silversides	1									
Scophthalmus aquosus	Windowpane									2	
Pseudopleuronectes americanus	Winter flounder					1		2			

28 February 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake [1]	Spar	Cole	Lee [1]	Taunton [1]	Discharge [1]	25	21	24	26
Mid.Temp. (C)			2.3	3.0				2.7	2.1	2.0	2.0
Bot. Temp. (C)			2.2	5.1				2.5	2.1	2.1	2.1
Bottom DO (ppm)			10.5	11.1				11.1	9.9	10.5	10.0
Tautogolabrus adspersus	Cunner								1		
Scophthalmus aquosus	Windowpane			1							

[1] Not sampled due to cooling system problem.

14 March 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Discharge	25	12	15	18
Mid.Temp. (C)		2.6	2.0	2.5	2.1	1.9	2.6	2.1	2.0	1.7	1.7
Bot. Temp. (C)		1.9	1.7	2.5	2.3	1.0	2.0	1.3	1.7	1.7	1.7
Bottom DO (ppm)		17.9	13.1	14.1		17.4	19.5	13.0	12.4	12.7	12.5
Scophthalus aquosus	Windowpane					1					
Pseudopleuronectes americanus	Winter flounder			1	1					1	
Trinectes maculatus	Hogchoker									1	

25 April 2005										
		Fixed Stations						Randomly Selected Stations		
								Shallow	Deep	
Station:		Intake	Spar	Cole	Lee	Taunton	Discharge	26	15	
Mid.Temp. (C)		11.2	11.0	12.7	12.4	11.7		12.2	9.6	
Bot. Temp. (C)		10.6	10.1	12.4	12.8	11.3		11.3	9.2	
Bottom DO (ppm)		8.7	13.4	12.0	11.2	13.0		17.9	17.5	
Tautoga onitis	Tautog			1						
Tautogolabrus adspersus	Cunner	1								
Scophthalus aquosus	Windowpane							1	1	
Pseudopleuronectes americanus	Winter flounder	2		2						
Trinectes maculatus	Hogchoker	1		3						

Only seven stations sampled - heavy weather, wind SSE 20-25.

10 May 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Discharge	10	20	25	29
Mid.Temp. (C)		9.6	10.3	10.6	10.4	10.4	12.6	10.3	9.5	9.9	9.5
Bot. Temp. (C)		9.4	9.7	10.7	10.3	9.9	9.8	9.5	9.3	9.3	9.4
Bottom DO (ppm)		8.8	9.4	10.5	8.2	9.6	9.0	9.3	9.2	9.5	9.8
Microgadus tomcod	Atlantic tomcod								1		
Tautogolabrus adspersus	Cunner								1		
Etropus microstomus	Smallmouth flounder								1		
Scophthalmus aquosus	Windowpane					1					
Pseudopleuronectes americanus	Winter flounder	1		8		4		2	7		6

17 June 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Discharge	9	21	25	26
Mid.Temp. (C)		14.4	18.4	17.5	19.3	17.1	20.0	19.0	15.5	15.0	14.2
Bot. Temp. (C)		13.1	14.3	17.0	17.2	15.0	19.4	19.7	13.1	12.3	12.7
Bottom DO (ppm)		9.4	8.8	3.9	4.1	7.8	7.8	8.1	9.4	10.1	9.7
Leucoraja erinacea	Little skate								1	1	1
Stenotomus chrysops	Scup									1	
Tautoga onitis	Tautog							1			1
Tautogolabrus adspersus	Cunner						1				
Parallichthys dentatus	Summer flounder			1	2	2					1
Pseudopleuronectes americanus	Winter flounder	1				1		4	7		1

Table 5-4. Numbers of finfish (by species) collected in Mount Hope Bay standard trawl tows, 2005 (page 2 of 3)

12 July 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Discharge	40	16	22	32
Mid.Temp. (C)		[19]	21.4	22.2	22.9	20.3	23.9	21.9	20.0	19.9	21.0
Bot. Temp. (C)		18.0	18.9	23.6	20.8	19.4	17.8	19.4	17.8	18.3	17.4
Bottom DO (ppm)		5.1	8.0	7.8	5.5	6.8	6	6.5	7.5	8.1	7.8
Leucoraja erinacea	Little skate								1	1	
Alosa pseudoharengus	Alewife									12	
Prionotus evolans	Striped searobin								1		
Tautoga onitis	Tautog	1									
Scomber scombrus	Atlantic mackerel									1	
Peprilus triacanthus	Butterfish	1							1	26	
Paralichthys dentatus	Summer flounder	1			1						
Scophthalmus aquosus	Windowpane	1								1	
Pseudopleuronectes americanus	Winter flounder	1									

10 August 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake[1]	Spar	Cole[2]	Lee[2]	Taunton	Discharge	25	9	12	17
Mid.Temp. (C)			25.0	26.5	26.8	25.8	26.6	25.4	23.7	23.6	24.1
Bot. Temp. (C)			23.2	26.0	26.5	25.7	26.2	24.6	23.5	23.3	23.5
Bottom DO (ppm)			5.4	5.1	7.1	6.2	5.7	6.1	5.8	5.5	5.5
Anchoa mitchilli	Bay anchovy						1				2
Opsanus tau	Oyster toadfish		1								
Menidia menidia	Atlantic silverside						1				
Prionotus evolans	Striped searobin										1
Stenotomus chrysops	Scup		1				3	5		6	2
Cynoscion regalis	Weakfish						7	11	3	4	62
Taotoga onitis	Tautog		1								
Peprilus triacanthus	Butterfish							2		1	11
Paralichthys dentatus	Summer flounder					1	1	1		1	1
Scophthalmus aquosus	Windowpane										
Pseudopleuronectes americanus	Winter flounder					2			1		

14 September 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake	Spar	Cole[1]	Lee	Taunton	Discharge	13	14	24	26
Mid.Temp. (C)		21.3	23.3	24.2	24.3	23.3	24.3	23.1	21.1	22.3	22.5
Bot. Temp. (C)		20.5	21.8	24.1	24.2	22.4	24.2	21.9	19.2	20.9	21.1
Bottom DO (ppm)		4.7	6.8	7.5	8.3	6.2	8.7	7.6	6.2	6.9	6.5
Syngnathus fuscus	Northern pipefish	1									
Prionotus evolans	Striped searobin	15				4	5	2		10	3
Centropristis striata	Black sea bass	1							1		
Selene setapinnis	Atlantic moonfish						1				3
Stenotomus chrysops	Scup	20	65		43	18	20	11	6	28	75
Cynoscion regalis	Weakfish	20				2	6				
Tautoga onitis	Tautog	1								1	
Tautogolabrus adspersus	Cunner								1		
Peprilus triacanthus	Butterfish		1								
Etropus microstomus	Smallmouth flounder									2	
Paralichthys dentatus	Summer flounder	1	1			1	1				
Scophthalmus aquosus	Windowpane	2							1	7	2
Pseudopleuronectes americanus	Winter flounder	4				3	1			4	3
Trinectes maculatus	Hogchoker	3								1	

[1] Whelk pot trawl popped the cod end.

24 October 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Discharge	5	5	24	29
Mid.Temp. (C)		16.0	14.4	14.1	15.2	16.2	18.5	14.4	15.3	15.3	16.6
Bot. Temp. (C)		16.2	16.0	16.2	16.7	15.4	17.2	16.1	16.2	16.3	16.1
Bottom DO (ppm)		9.6	10.1	7.7	9.5	9.5	8.4	10.2	10.3	10.5	10.8
Leucoraja erinacea	Little skate										1
Alosa pseudoharengus	Alewife								1		
Anchoa mitchilli	Bay anchovy			1			1				
Syngnathus fuscus	Northern pipefish			1							
Prionotus evolans	Striped searobin			1							1
Centropristis striata	Black sea bass										
Stenotomus chrysops	Scup	1					1	2	9	1	
Cynoscion regalis	Weakfish	5									
Tautoga onitis	Tautog			1							
Peprilus triacanthus	Butterfish	1							4		
Paralichthys dentatus	Summer flounder				1			1			1
Scophthalmus aquosus	Windowpane				1						
Pseudopleuronectes americanus	Winter flounder	4	1			1					1
Trinectes maculatus	Hogchoker	5		1							

Table 5-4. Numbers of finfish (by species) collected in Mount Hope Bay standard trawl tows, 2005 (page 3 of 3)

18 November 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Discharge	25	27	31	33
Mid.Temp. (C)		12.3	11.9	11.7	12.0	12.3	15.4	12.6	12.2	11.6	11.9
Bot. Temp. (C)		12.7	12.7	12.8	12.1	12.8	14.2	12.7	12.8	12.6	12.3
Bottom DO (ppm)		9.3	9.8	10.6	10.2	9.8	9.0	10.2	10.0	10.2	11.2
Leucoraja erinacea	Little skate										4
Conger oceanicus	Conger eel							1			
Alosa pseudoharengus	Alewife					1		1			
Syngnathus fuscus	Northern pipefish				1						
Tautoga onitis	Tautog				1						
Tautogolabrus adspersus	Cunner				1						
Peprilus triacanthus	Butterfish								2		
Etropus microstomus	Smallmouth flounder								2		
Scophthalmus aquosus	Windowpane					5			1		
Pseudopleuronectes americanus	Winter flounder		1	2	2	3	3	1	4		1
Trinectes maculatus	Hogchoker				1						

15 December 2005											
		Fixed Stations						Randomly Selected Stations			
								Shallow	Deep		
Station:		Intake	Spar	Cole	Lee	Taunton	Discharge	39	8	14	31
Mid.Temp. (C)		7.4	4.8	3.8	5.3	6.1	9.4	6.2	6.1	6.1	7.3
Bot. Temp. (C)		7.9	7.4	5.1	5.1	6.7	10.1	6.8	7.1	7.9	7.8
Bottom DO (ppm)		8.7	9.8	10.2	11.0	9.7	9.3	10.3	9.7	9.3	9.3
Leucoraja erinacea	Little skate										2
Alosa pseudoharengus	Alewife					1					
Osmerus mordax	Rainbow smelt									1	
Menidia menidia	Atlantic silversides	3		2			2				
Myoxocephalus aenaeus	Grubby										6
Tautoga onitis	Tautog						1				
Tautogolabrus adspersus	Cunner			1							
Scophthalmus aquosus	Windowpane					2			2		
Pseudopleuronectes americanus	Winter flounder			1	1					1	2

*No January sampling due to ice in bay and severe weather conditions.

Table 5-5. Numbers of finfish (by species) collected in Mount Hope Bay Wilcox trawl tows, 2005 (page 1 of 3)

20 January 2005													
		Shallow						Deep				Narragansett Bay[1]	
Station:		17	19	21	27	30	38	18	26	27	29	1	2
Mid.Temp. (C):		3.3	2.1	3.9	3.6	3.2	2.2	3.4	3.7	3.7	2.2		
Bot.Temp. (C):		3.9	3.7	3.9	4	4.2	3.8	4.4	4.5	4.5	3.9		
Bot.D.O. (ppm):		7.4	5.1	7.8	7.5	6.6	6	4.8	3.3	3.3	3.7		
Alosa pseudoharengus	Alewife							1		1			
Menidia menidia	Atlantic silverside	1		16				1	3	10			
Myoxocephalus aenaeus	Grubby							1		1	1		
Pseudopleuronectes americanus	Winter flounder				1	2	3						

[1] no sampling

15 February 2005													
		Shallow						Deep				Narragansett Bay	
Station:		15	27	33	38	40	42	14	20	24	26	1[2]	2
Mid.Temp. (C):		3.1	3.4	3.3	3.7	4.2	3.5	2.7	2.6	2.6	2.7	3.7	3.6
Bot.Temp. (C):		3	2.9	3	2.8	3	3.1	2.5	2.5	2.6	2.5	3.7	2.8
Bot.D.O. (ppm):		8.6	8.4	8.5	8.3	8.7	8.4	8	7.1	8.1	8	8.7	8.8
Merluccius bilinearis	Silver hake							1					
Syngnathus fuscus	Northrn pipefish					1				2			
Myoxocephalus aenaeus	Grubby				1						2		
Tautoga onitis	Tautog										1		
Pholis gunnellus	Rock gunnel										1		
Scophthalmus aquosus	Windowpane		1										
Pseudopleuronectes americanus	Winter flounder	1				1		1	1	1			

[2] Lost net

18 March 2005													
		Shallow						Deep				Narragansett Bay	
Station:		9	12	14	20	30	34	23	29	31	33	1	2
Mid.Temp. (C):		3.7	4.2	2.6	4.5	4.6	4.7	3.4	3.8	2.3	3	3.3	2.3
Bot.Temp. (C):		2.4	2.4	2.3	2.4	3.3	3.2	2	2.1	1.9	2.2	2.3	2
Bot.D.O. (ppm):		17.3	14.2	14.3	14	14.5	16	15	17	14.5	14.9	15.2	15.4
Menidia menidia	Atlantic silverside												1
Myoxocephalus aenaeus	Grubby							1	1	4			
Pseudopleuronectes americanus	Winter flounder							1	1	1	1		3

11 April 2005													
		Shallow						Deep				Narragansett Bay	
Station:		10	20	25	28	35	45	2	26	30	33	1	2
Mid.Temp. (C)[1]:													
Bot.Temp. (C)[1]:													
Bot.D.O. (ppm)[1]:													
Leucoraja erinacea	Little skate							1	1				
Osmerus mordax	Rainbow smelt							2					
Urophycis regia	Spotted hake								1				
Menidia menidia	Atlantic silverside							1					
Myoxocephalus aenaeus	Grubby							1	4				
Tautoga onitis	Tautog								2				
Tautogolabrus adspersus	Cunner							1	1				
Pseudopleuronectes americanus	Winter flounder	2	2	6	1		2	6	9	2		3	

[1] data not available

18 May 2005													
		Shallow						Deep				Narragansett Bay	
Station:		9	15	26	33	40	45	2	6	10	28	1	2
Mid.Temp. (C):		13.7	13.3	13.3	14.1	14	13.5	11	14.3	12.4	12.6	11.2	11.2
Bot.Temp. (C):		10.1	10.6	10.6	10.8	10.4	10.9	9	9.7	10	9.7	10.2	10.2
Bot.D.O. (ppm):		14.4	14.4	14.4	14.3	15.8	13.8	13.8	17.62	16.2	16.3	13.9	13.9
Alosa pseudoharengus	Alewife							1					
Gadus morhua	Atlantic cod	1			1		1		5		17		
Microgadus tomcod	Atlantic tomcod	1	1	1		2	10		3				
Stenotomus chrysops	Scup							1					
Tautoga onitis	Tautog						1			1			
Tautogolabrus adspersus	Cunner							1					
Scophthalmus aquosus	Windowpane			1								1	
Pseudopleuronectes americanus	Winter flounder	3	1	14	6	2	7	2	8	5	1	7	2

Table 5-5. Numbers of finfish (by species) collected in Mount Hope Bay Wilcox trawl tows, 2005 (page 2 of 3)

20 June 2005												
		Shallow				Deep				Narragansett Bay	
Station:		7	36	42		10	20	22	37	1	2
Mid.Temp. (C):		17.3	18.9	16.6		17.6	15.9	15.9	15.5		
Bot.Temp. (C):		15.2	17.5	15.9		15.6	14.8	14.5	14.5		
Bot.D.O. (ppm):		7.5	8.1	7		8.1	6.8	7.7	7.1		
Leucoraja erinacea	Little skate						1				
Clupea harengus	Atlantic herring	1							1		
Gadus morhua	Atlantic cod	1					1				
Urophycis regia	Spotted hake	1									
Syngnathus fuscus	Northern pipefish		1								
Myoxocephalus aenaeus	Grubby		4								
Stenotomus chrysops	Scup	4						1	2		
Menticirrhus saxatilis	Northern kingfish								9		
Tautoga onitis	Tautog	1					1				
Tautogolabrus adspersus	Cunner		1								
Pholis gunnellus	Rock gunnel		1								
Gobiosoma ginsburgi	Seaboard goby		1								
Scophthalmus aquosus	Windowpane	2						2	1		
Pseudopleuronectes americanus	Winter flounder	26	9	3		13	12	12	31		

Note: Winch broke - only seven stations sampled.

13 July 2005												
		Shallow						Deep				Taunton River[1]	
Station:		17	21	26	30	34	40	13	26	29	34	1	2
Mid.Temp. (C):		22.2	22	22.5	23	21.7	22.2	19.1	20.2	21	20.4		
Bot.Temp. (C):		20	19.2	19.8	20.1	19.8	20	17.5	18.2	17.7	17.1		
Bot.D.O. (ppm):		5.7	5.1	6.9	5	5.6	5.4	9.3	9.4	7.4	8.1		
Ophidium marginatum	Striped cusk-eel							1					
Moxocephalus aenaeus	Grubby						1				1		
Stenotomus chrysops	Scup			8	1				1	15			
Tautoga onitis	Tautog									3			
Gobiosoma ginsburgi	Seaboard goby		1										
Peprilus triacanthus	Butterfish	1	4	2		6	18	20	4	1	3		
Etropus microstomas	Smallmouth flounder				1								
Pseudopleuronectes americanus	Winter flounder	1						5	13	10	1		

[1] no sampling

24 August 2005													
		Shallow						Deep				Narragansett Bay[1]	
Station:		5	9	18	25	38	41	14	26	30	34	1	2
Mid.Temp. (C):		24.6	23.6	24.1	23.4	23.3	24.3	23	22.5	23.1	22.5		
Bot.Temp. (C):		22.9	22.6	22.9	23.3	23.2	23.3	22.4	22.3	22.8	22.4		
Bot.D.O. (ppm):		6.2	6	6.8	5.6	6.5	5.3	6.6	6.4	6.6	6.8		
Alosa pseudoharengs	Alewife		1	1	1								
Brevoortia tyrannus	Atlantic menhaden					1							
Anchoa mitchilli	Bay anchovy	85	20	4	1	6				1	1		
Menidia menidia	Atlantic silverside					1	4	4	2	4	1		
Prionotus evolans	Striped searobin					1							
Centropristis striata	Black sea bass			2	6				1		4		
Stenotomus chrysops	Scup	15	44	20	154		66	36	3	14	12		
Cynoscion regalis	Weakfish		1	1	19		22				1		
Tautogolabrus adspersus	Cunner										1		
Peprilus triacanthus	Butterfish	2	3	8	6			4		2	6		
Etropus microstomas	Smallmouth flounder	1							1				
Paralichthys dentatus	Summer flounder								1		1		
Pseudopleuronectes americanus	Winter flounder	1		3	1			9	9		11		

[1] no sampling

22 September 2005													
		Shallow						Deep				Narragansett Bay[1]	
Station:		12	24	29	32	37	40	17	18	30	31	1	2
Mid.Temp. (C):		21.11	22.3	22.8	23	22.6	23.2	21.7	21.3	21.4	21.0		
Bot.Temp. (C):		21.11	21.5	22.5	22	22	21.8	21.5	21.2	21.3	20.4		
Bot.D.O. (ppm):		9.7	10	5.9	6	10.3	11.5	9.2	9.8	10.3	9.6		
Brevoortia tyrannus	Atlantic menhaden	8											
Anchoa mitchilli	Bay anchovy					1							
Strongylura marina	Atlantic needlefish					1							
Centropristis striata	Black sea bass	1	2		1		2			4			
Caranx hippos	Crevalle jack						1						
Stenotomus chrysops	Scup	125	137	121	140	180		27	32	84	90		
Cynoscion regalis	Weakfish		1		3	1	1				1		
Menticirrhus saxatilis	Northern kingfish									1			
Tautoga onitis	Tautog						1						
Pholis gunnellus	Rock gunnel										1		
Peprilus triacanthus	Butterfish							4			2		
Etropus microstomus	Smallmouth flounder								6	1			
Paralichthys dentatus	Summer flounder				1	1			1	1			
Scophthalmus aquosus	Windowpane								1	1			
Pseudopleuronectes americanus	Winter flounder	4			1	2	4	2	4	31	1		

[1] no sampling

Table 5-5. Numbers of finfish (by species) collected in Mount Hope Bay Wilcox trawl tows, 2005 (page 3 of 3)

31 October 2005													
		Shallow						Deep				Narragansett Bay[1]	
Station:		14	16	28	31	35	36	10	25	30	32	1	2
Mid.Temp. (C):		14.2	13.3	13.7	13.6	14.2	12.8	13.9	14.4	14.2	13.8		
Bot.Temp. (C):		14.3	14.8	14.7	18.7	14.5	14.3	14.4	14.9	15.2	14.5		
Bot.D.O. (ppm):		9.1	8.1	8.8	8.4	8.7	9.1	7.8	7.8	8.5	8.3		
Alosa pseudoharengus	Alewife				5	2	1						
Clupea harengus	Atlantic herring								1				
Anchoa mitchilli	Bay anchovy		1		14	34	32						
Merluccius bilinearis	Silver hake										1		
Syngnathus fuscus	Northrn pipefish				1								
Menidia menidia	Atlantic silverside				22								
Centropristis striata	Black sea bass								1		2		
Caranx hippos	Crevalle jack			1					1				
Stenotomus chrysops	Scup							3	7		4		
Cynoscion regalis	Weakfish								3				
Tautoga onitis	Tautog								1		1		
Tautogolabrus adspersus	Cunner								1				
Peprilus triacanthus	Butterfish								8				
Pseudopleuronectes americanus	Winter flounder			1	1	3		3	26	1	32		

[1] no sampling

28 November 2005													
		Shallow						Deep				Narragansett Bay[1]	
Station:		14	15	20	32	35	41	7	8	12	19	1	2
Mid.Temp. (C):		9.3	10.2	9.1	9.5	11.5	10.6	9.4	9.4	11.2	9.3		
Bot.Temp. (C):		8.2	10.2	9.2	10	10.2	10.5	11.6	9.1	11.6	8.4		
Bot.D.O. (ppm):		10.6	11.3	10.8	13.4	11.8	11.8	9.8	10	10	10.3		
Conger oceanalcus	Conger eel			1									
Alosa pseudoharengus	Alewife	1	1	12	18	32	6	24	11	14	18		
Brevoortia tyrannus	Atlantic menhaden	1											
Clupea harengus	Atlantic herring	1				2	1				1		
Anchoa mitchilli	Bay anchovy		1					10	5				
Merluccius bilinearis	Silver hake								2				
Menidia menidia	Atlantic silverside	17	4	79	1	3	2	5	1	1			
Syngnathus fuscus	Northern pipefish				1								
Centropristis striata	Black sea bass							1					
Etropus microstomus	Smallmouth flounder							1					
Scophthalmus aquosus	Windowpane		1										
Pseudopleuronectes americanus	Winter flounder	1	2	3	6	7	4	11	5	8	1		
Trinectes maculatus	Hogchoker									1			

[1] no sampling

12 December 2005													
		Shallow						Deep				Narragansett Bay[1]	
Station:		3	11	18	25	31	35	22	33	34	38	1	2
Mid.Temp. (C):		6.2	6.5	5.9	5.9	5.4	6.7	6.3	5.42	5.4	6.7		
Bot.Temp. (C):		6.8	6.9	6.7	6.7	6.7	6.7	6.9	7.2	6.5	6.6		
Bot.D.O. (ppm):		9.9	9.8	9.7	9.6	10	9.8	9	9.2	9.7	9		
Leucoraja erinacea	Little skate										1		
Alosa pseudoharengus	Alewife						3	1					
Brevoortia tyrannus	Atlantic menhaden				1	1	1						
Clupea harengus	Atlantic herring			5									
Microgadus tomcod	Atlantic tomcod							1			7		
Menidia menidia	Atlantic silverside	7		53	24	10	14	3	73	53	1		
Syngnathus fuscus	Northern pipefish										1		
Myoxocephalus aenaeus	Grubby			1							1		
Tautoga onitis	Tautog								1		4		
Tautogolabrus adspersus	Cunner										1		
Pholis gunnellus	Rock gunnel										1		
Etropus microstomus	Smallmouth flounder	1									1		
Scophthalmus aquosus	Windowpane										2		
Pseudopleuronectes americanus	Winter flounder	1	2		1		3	1	4	4	17		
Trinectes maculatus	Hogchoker										2		

[1] no sampling

Table 5-6. Species of finfish and years of occurrence in Mount Hope Bay Wilcox trawl collections, 1996-2005

Species		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Petromyzon marinus	Sea lamprey									x	
Mustelus canis	Smooth dogfish		x		x				x		
Leucoraja erinacea	Little skate	x	x	x	x	x	x	x	x	x	x
Anguilla rostrata	American eel				x			x			
Conger oceanicus	Conger eel				x						x
Alosa aestivalis	Blueback herring		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	x	x	x				x	
Brevoortia tryannus	Atlantic menhaden	x	x	x	x	x	x	x	x	x	x
Clupea harengus	Atlantic herring	x	x	x	x	x	x	x	x	x	x
Anchoa mitchilli	Bay anchovy	x	x	x	x	x	x	x	x	x	x
Osmerus mordax	Rainbow smelt	x	x	x	x	x	x			x	x
Synodus foetens	Inshore lizardfish		x		x	x	x			x	
Enchoelyopus cimbrius	Fourbeard rockling	x	x								
Brosme brosme	Cusk						x				
Gadus morhua	Atlantic cod	x		x		x	x		x		x
Merluccius bilinearis	Silver hake	x	x	x	x	x		x		x	x
Microgadus tomcod	Atlantic tomcod	x	x	x	x	x			x	x	x
Urophycis spp.	Hakes		x	x							
Urophycis chuss	Red hake	x	x	x	x	x	x	x	x	x	
U. regia	Spotted hake	x		x	x	x	x	x	x		x
Ophidion marginatum	Striped cusk eel										x
Ospanus tau	Oyster toadfish		x	x		x		x		x	
Fundulus heteroclitus	Mummichog					x					
Strongylura marina	Atlantic needlefish										x
Menidia menidia	Atlantic silverside	x	x	x	x	x	x	x	x	x	x
Gasterosteus aculeatus	Threespine stickleback		x	x						x	
Syngnathus fuscus	Northern pipefish	x	x	x	x	x			x	x	x
Prionotus carolinus	Northern searobin		x	x	x	x				x	
P. evolans	Striped searobin		x	x	x	x	x	x	x		x
Myoxocephalus aenaeus	Grubby	x	x	x	x	x	x		x	x	x
Cyclopterus lumpus	Lumpfish		x								
Morone americana	White perch	x	x	x	x	x			x		
M. saxatilis	Striped bass	x	x						x		
Centropristis striata	Black sea bass		x	x	x	x	x	x	x		x
Pomoatomus saltatrix	Bluefish	x	x	x	x	x	x	x	x		
Caranx chrysos	Blue runner				x						
C. hippos	Crevalle jack							x			x
Selene setapinnis	Atlantic moonfish	x		x	x	x		x	x	x	
S. vomer	Lookdown				x						
Stenotomus chrysops	Scup	x	x	x	x	x	x	x	x	x	x
Cynoscion regalis	Weakfish	x	x	x	x	x	x	x	x	x	x
Leiostomus xanthurus	Spot					x					
Menticirrhus saxatilis	Northern kingfish	x	x	x	x	x	x	x	x		x
Tautoga onitus	Tautog	x	x	x	x	x	x	x	x	x	x
Tautogolabrus adspersus	Cunner	x	x	x	x	x	x	x	x	x	x
Macrozoarces americanus	Ocean pout		x	x							
Pholis gunnellus	Rock gunnel	x	x	x	x					x	x
Gobiosoma ginsburgi	Seaboard goby		x	x	x	x	x	x	x	x	x
Peprilus triacanthus	Butterfish	x	x	x	x	x	x	x	x	x	x
Etropus microstomus	Smallmouth flounder		x	x	x	x		x	x	x	x
Parlichthys dentatus	Summer flounder	x	x	x	x	x	x	x	x	x	x
P. oblongus	Fourspot flounder	x	x	x	x	x		x	x	x	
Scopthalmus aquosus	Windowpane flounder	x	x	x	x	x	x	x	x	x	x
Pseudopleuronectes americanus	Winter flounder	x	x	x	x	x	x	x	x	x	x
Trinectes maculatus	Hogchoker	x	x	x	x	x		x	x	x	x
Sphoeroides maculatus	Northern puffer	x	x								
	Species Total	32	43	40	41	38	27	30	33	33	33

Table 5-7. Species of finfish and months of occurrence in Wilcox trawl collections from Mount Hope Bay, 2005

Species		20-Jan	15-Feb	18-Mar	11-Apr	18-May	20-Jun	13-Jul	24-Aug	22-Sep	31-Oct	28-Nov	12-Dec
Leucoraja erinacea	Little skate				x		x						x
Conger oceanicus	Conger eel											x	
Alosa aestivalis	Blueback herring												
A. pseudoharengus	Alewife	x				x			x		x	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	
Osmerus mordax	Rainbow smelt				x								
Gadus morhua	Altlantic cod					x	x						
Merluccius bilinearis	Silver hake		x								x	x	
Microgadus tomcod	Atlantic tomcod					x							x
Urophycis regia	Spotted hake				x		x						
Ophidion marginatum	Striped cusk eel							x					
Strongylura marina	Atlantic needlefish									x			
Menidia menidia	Atlantic silversides	x		x	x				x		x	x	x
Syngnathus fuscus	Northern pipefish		x				x				x	x	x
Prionotus evolans	Striped searobin								x				
Myoxocephalus aenaeus	Grubby	x	x	x	x		x	x					x
Centropristis striata	Black sea bass								x	x	x	x	
Caranx hippos	Crevalle jack									x	x		
Stenotomus chrysops	Scup					x	x	x	x	x	x		
Cynoscion regalis	Weakfish								x	x	x		
Menticirrhus saxatilis	Northern kingfish						x			x			
Tautoga onitis	Tautog		x		x	x	x	x		x	x		x
Tautogolabrus adspersus	Cunner				x	x	x		x		x		x
Pholus gunnellus	Rock gunnel		x				x			x			x
Gobiosoma ginsburgi	Seaboard goby						x	x					
Peprilus triacanthus	Butterfish							x	x	x	x		
Etropus microstomus	Smallmouth flounder							x	x	x		x	x
Paralichthys dentatus	Summer flounder								x	x			
Scophthalmus aquosus	Windowpane		x			x	x			x		x	x
Pseudopleuronectes americanus	Winter flounder	x	x	x	x	x	x	x	x	x	x	x	x
Trinectes maculatus	Hogchoker											x	x
	Number of species	4	7	3	8	8	14	8	13	15	14	13	15

Table 5-8. Dominance diversity values for Mount Hope Bay standard trawl collections, 1972-2005

Year	Dominance Diversity	Year	Dominance Diversity
1972	-0.180	1989	-0.268
1973	-0.176	1990	-0.309
1974	-0.195	1991	-0.245
1975	-0.272	1992	-0.307
1976	-0.199	1993	-0.282
1977	-0.224	1994	-0.314
1978	-0.183	1995	-0.291
1979	-0.161	1996	-0.149
1980	-0.264	1997[1]	-0.248
1981	-0.288	1998	-0.159
1982	-0.224	1999	-0.185
1983	-0.217	2000	-0.179
1984	-0.233	2001	-0.225
1985	-0.214	2002	-0.199
1986	-0.261	2003	-0.217
1987	-0.278	2004	-0.175
1988	-0.295	2005	-0.211

[1]Fixed stations only

Table 5-9. Annual abundance and variation parameters for winter flounder collected under the Mount Hope Bay standard trawl program based on the delta distribution, 1972-2005

Year	No. of tows	Delta mean catch per tow	Variance	Standard deviation	Proportion of zeros	Coefficient of variation of mean	95% Confidence limits
1972	95	43.650	112.170	10.59	0.16	0.243	±21.18
1973	103	60.370	157.340	12.54	0.08	0.208	±25.08
1974	120	36.240	40.730	6.38	0.08	0.176	±12.76
1975	120	18.890	12.380	3.52	0.17	0.186	±7.04
1976	120	10.600	3.530	1.88	0.15	0.177	±3.76
1977	100	16.460	15.410	3.93	0.21	0.239	±7.86
1978	120	48.560	75.340	8.68	0.04	0.179	±17.36
1979	120	78.020	328.000	18.11	0.08	0.232	±36.22
1980	84	15.750	10.890	3.30	0.18	0.210	±6.60
1981	84	19.350	14.380	3.79	0.17	0.196	±7.58
1982	84	49.970	152.640	12.35	0.16	0.247	±24.70
1983	84	43.010	33.880	5.82	0.00	0.135	±11.64
1984	82	17.930	10.190	3.19	0.02	0.178	±6.38
1985	81	14.970	7.170	2.68	0.06	0.179	±5.36
1986	70	5.816	1.310	1.14	0.31	0.196	±2.28
1987	72	2.089	0.160	0.40	0.49	0.191	±0.80
1988	70	0.730	0.040	0.21	0.71	0.288	±0.42
1989	72	0.366	0.010	0.10	0.79	0.273	±0.20
1990	66	0.966	0.100	0.32	0.77	0.331	±0.64
1991	71	0.569	0.030	0.16	0.76	0.281	±0.32
1992	69	0.486	0.020	0.13	0.77	0.267	±0.26
1993	69	0.992	0.030	0.16	0.48	0.161	±0.32
1994	63	0.441	0.020	0.13	0.79	0.304	±0.27
1995	69	0.905	0.040	0.21	0.64	0.230	±0.42
1996	72	0.612	0.020	0.15	0.72	0.247	±0.30
1997	63	0.904	0.040	0.21	0.71	0.228	±0.41
1998	71	0.534	0.020	0.13	0.72	0.237	±0.25
1999	72	0.255	0.005	0.07	0.81	0.270	±0.14
2000	64	0.109	0.002	0.04	0.89	0.360	±0.08
2001	58	0.206	0.005	0.07	0.85	0.328	±0.14
2002	52	0.115	0.002	0.04	0.89	0.388	±0.09
2003	67	0.346	0.007	0.08	0.75	0.238	±0.16
2004	64	0.354	0.011	0.10	0.80	0.290	±0.21
2005	57	0.894	0.034	0.183	0.579	0.205	±0.37

Note: From 1997 to 2005 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 5-10. Winter flounder abundance indices from the Standard and Wilcox trawl surveys, 1972- 2005

Year	Mount Hope Bay[1]			Narragansett Bay
	Fixed	All	Wilcox	Wilcox
1972	44			
1973	60			
1974	36			
1975	19			
1976	11			
1977	16			
1978	49			
1979	78			
1980	16			
1981	19			
1982	50			
1983	43			
1984	18			
1985	15			
1986	6			
1987	2			
1988	0.7			
1989	0.4			
1990	1			
1991	0.6			
1992	0.5			
1993	1			
1994	0.4			
1995	0.9			
1996	0.6		7	
1997	0.9	0.9	9	6
1998	0.5	1.1	9	9
1999	0.3	0.7	3	1
2000	0.1	0.2	2	1
2001	0.2	0.3	1	2
2002	0.1	0.2	1	1
2003	0.3	0.5	3	6
2004	0.4	0.3	3	8
2005	0.9	0.9	4	7

[1]Fixed - annual delta mean number per tow, fixed stations standard trawl.
All - annual stratified mean number per tow, all stations standard trawl.
Wilcox - annual stratified mean number per tow, fine-mesh trawl.

Table 5-11. Annual abundance and variation parameters for windowpane collected under the Mount Hope Bay standard trawl program based on the delta distribution, 1972-2005

Year	No. of tows	Delta mean catch per tow	Variance	Standard deviation	Proportion of zeros	Coefficient of variation of mean	95% Confidence limits
1972	95	7.120	2.126	1.46	0.44	0.205	±2.92
1973	103	7.140	1.767	1.33	0.29	0.186	±2.66
1974	120	6.920	1.605	1.27	0.24	0.183	±2.54
1975	120	4.370	0.747	0.86	0.38	0.198	±1.72
1976	120	1.550	0.087	0.29	0.54	0.190	±0.58
1977	100	1.850	0.128	0.36	0.47	0.193	±0.72
1978	120	9.360	4.027	2.01	0.29	0.214	±4.02
1979	120	11.090	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
1999	72	0.241	0.008	0.09	0.88	0.377	±0.218
2000	64	0.205	0.011	0.10	0.91	0.499	±0.205
2001	58	0.052	-	-	0.98	-	-
2002	52	0.038	0.001	0.03	0.96	0.700	± 0.054
2003	67	0.254	0.014	0.12	0.90	0.468	± 0.238
2004	64	0.109	0.003	0.05	0.92	0.459	± 0.100
2005	57	0.253	0.008	0.09	0.84	0.358	± 0.182

Note: From 1997 to 2005 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 5-12. Windowpane abundance indices from the Standard and Wilcox trawl surveys, 1972-2005

Year	Mount Hope Bay[1]			Narragansett Bay
	Fixed	All	Wilcox	Wilcox
1972	7.1			
1973	7.1			
1974	6.9			
1975	4.4			
1976	1.6			
1977	1.9			
1978	9.4			
1979	11.1			
1980	3.7			
1981	3.3			
1982	6.1			
1983	3.4			
1984	1.8			
1985	2.0			
1986	0.7			
1987	0.4			
1988	0.4			
1989	0.1			
1990	0.2			
1991	0.1			
1992	0.1			
1993	0.2			
1994	0.3			
1995	0.3			
1996	0.9		3.0	
1997	0.7	1.0	1.5	1.0
1998	0.4	0.6	0.3	0.4
1999	0.3	0.3	0.3	0.3
2000	0.2	0.5	0.2	0.1
2001	0.1	0.1	0.1	0.0
2002	0.0	0.1	0.0	0.0
2003	0.3	0.3	0.2	0.0
2004	0.1	0.1	0.2	0.5
2005	0.3	0.3	0.1	0.3

[1]Fixed - annual delta mean number per tow, fixed stations standard trawl.
All - annual stratified mean number per tow, all stations standard trawl.
Wilcox - annual stratified mean number per tow, fine-mesh trawl.

Table 5-13. Annual abundance and variation parameters for tautog collected under the Mount Hope Bay standard trawl program based on the delta distribution, 1972-2005

Year	No. of tows	Delta mean catch per tow	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	0.2	0.67	0.20	±0.40
1977	100	1.038	0.05	0.22	0.67	0.21	±0.44
1978	120	1.396	0.1	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	0.04	0.96	0.57	±0.08
1987	72	0.055	0	0.03	0.96	0.55	±0.06
1988	70	0.070	0	0.04	0.96	0.57	±0.08
1989	72	0.055	0	0.03	0.96	0.55	±0.06
1990	66	0.061	0	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	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	1.00	[1]
1995	69	0.015	[1]	[1]	0.99	1.00	[1]
1996	72	0.125	0.004	0.06	0.93	0.48	±0.12
1997	63	0.000	0	0	1.00	0.00	0
1998	71	0.113	0.001	0.04	0.89	0.34	±0.08
1999	72	0.111	0.002	0.04	0.90	0.37	±0.08
2000	64	0.063	0.001	0.03	0.94	0.49	±0.07
2001	60	0.193	0.008	0.09	0.90	0.47	± 0.18
2002	52	0.077	0.002	0.05	0.94	0.60	± 0.09
2003	67	0.060	0.001	0.03	0.94	0.49	± 0.06
2004	64	0.156	0.017	0.13	0.97	0.82	± 0.26
2005	57	0.123	0.002	0.04	0.88	0.36	± 0.09

[1]Only one fish taken.

Note: From 1997 to 2005 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 5-14. Tautog abundance indices from the Standard and Wilcox trawl surveys, 1972-2005

Year	Mount Hope Bay[1]			Narragansett Bay
	Fixed	All	Wilcox	Wilcox
1972	0.86			
1973	0.78			
1974	0.84			
1975	1.04			
1976	0.99			
1977	1.04			
1978	1.40			
1979	0.96			
1980	0.60			
1981	0.93			
1982	1.20			
1983	0.72			
1984	0.62			
1985	0.89			
1986	0.07			
1987	0.06			
1988	0.07			
1989	0.06			
1990	0.06			
1991	0.03			
1992	0.06			
1993	0.19			
1994	0.02			
1995	0.02			
1996	0.13		0.1	
1997	0.00	0.02	0.1	0.2
1998	0.11	0.10	0.2	0.2
1999	0.11	0.20	3.1	0.1
2000	0.06	0.05	0.1	0.2
2001	0.19	0.10	0.05	0.04
2002	0.08	0.06	0.2	0.2
2003	0.06	0.09	0.4	0.3
2004	0.16	0.15	0.1	0.2
2005	0.12	0.10	0.1	0.5

[1]Fixed - annual delta mean number per tow, fixed stations standard trawl.
All - annual stratified mean number per tow, all stations standard trawl.
Wilcox - annual stratified mean number per tow, fine-mesh trawl.

Table 5-15. Annual abundance and variation parameters for hogchoker collected under the Mount Hope Bay standard trawl program based on the delta distribution, 1972-2005

Year	No. of tows	Delta mean catch per tow	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	1.7	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	1.1	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	1.5	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	0.000					
1989	72	0.014	[1]				
1990	66	0.089	0.3	0.05	0.94	0.56	±0.10
1991	71	0.028	0	0.02	0.97	0.71	±0.04
1992	69	0.058	0	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	0.030	0.17	0.93	0.60	±0.35
1996	72	0.450	0.050	0.22	0.90	0.49	± 0.44
1997	63	0.352	0.030	0.18	0.91	0.51	± 0.36
1998	71	0.070	0.001	0.04	0.94	0.51	± 0.07
1999	72	0.083	0.002	0.04	0.94	0.52	± 0.08
2000	64	0.047	0.001	0.03	0.95	0.57	± 0.05
2001	60	0.091	0.004	0.06	0.97	0.70	± 0.13
2002	52	0.151	0.005	0.07	0.90	0.47	± 0.14
2003	67	0.275	0.013	0.12	0.88	0.42	± 0.23
2004	64	0.047	0.001	0.03	0.97	0.74	± 0.07
2005	57	0.245	0.013	0.12	0.90	0.47	± 0.23

[1]One individual collected.

Note: From 1997 to 2005 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 5-16. Hochocker abundance indices from the Standard and Wilcox trawl surveys, 1972-2005

Year	Mount Hope Bay[1]			Narragansett Bay
	Fixed	All	Wilcox	Wilcox
1972	0.70			
1973	0.53			
1974	2.76			
1975	1.44			
1976	0.96			
1977	0.25			
1978	0.96			
1979	1.76			
1980	1.32			
1981	1.52			
1982	1.10			
1983	1.61			
1984	0.85			
1985	1.53			
1986	0.41			
1987	0.31			
1988	0.00			
1989	0.01			
1990	0.09			
1991	0.03			
1992	0.06			
1993	0.12			
1994	0.09			
1995	0.29			
1996	0.45		0.20	
1997	0.35	0.20	0.01	0.00
1998	0.07	0.10	0.10	0.05
1999	0.08	0.10	0.10	0.00
2000	0.05	0.02	0.10	0.00
2001	0.09	0.03	0.00	0.00
2002	0.15	0.14	0.10	0.00
2003	0.28	0.24	0.10	0.00
2004	0.05	0.07	0.10	0.00
2005	0.25	0.14	0.02	0.00

[1]Fixed - annual delta mean number per tow, fixed stations standard trawl.
All - annual stratified mean number per tow, all stations standard trawl.
Wilcox - annual stratified mean number per tow, fine-mesh trawl.

Table 5-17. Annual abundance and variation parameters for scup collected under the Mount Hope Bay standard trawl program based on the delta distribution, May-October 1972-2005

Year	No. of tows	Delta mean catch per tow	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	2.3	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	0.1	0.31	0.86	0.59	±0.62
1988	35	0.000					
1989	36	2.491	3.08	1.75	0.86	0.70	±3.50
1990	36	0.000					
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
1999	36	4.137	2.68	1.64	0.56	0.40	± 3.28
2000	34	6.710	5.37	2.32	0.41	0.35	± 4.63
2001	20	10.639	20.56	4.53	0.35	0.43	± 9.07
2002	27	15.425	61.27	7.83	0.41	0.51	± 15.66
2003	34	1.244	0.2	0.45	0.68	0.36	± 0.90
2004	36	0.333	0.02	0.14	0.86	0.43	± 0.29
2005	32	6.623	17.26	4.16	0.72	0.63	± 8.31

Note: From 1997 to 2005 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 5-18. Scup abundance indices from the Standard and Wilcox trawl surveys, May - October, 1972-2005

Year	Mount Hope Bay[1]			Narragansett Bay
	Fixed	All	Wilcox	Wilcox
1972	2.1			
1973	0.6			
1974	4.6			
1975	3.8			
1976	46.6			
1977	0.6			
1978	1.9			
1979	7.8			
1980	33.1			
1981	10.1			
1982	4.1			
1983	6.8			
1984	2.6			
1985	4.7			
1986	0.5			
1987	0.5			
1988	0			
1989	2.5			
1990	0			
1991	5.7			
1992	2.9			
1993	0.8			
1994	0.1			
1995	1.3			
1996	0.2		0.5	
1997	1.4	1.8	4.7	0.5
1998	0.1	0.6	3.9	2.9
1999	4.1	2.9	35	19.2
2000	6.7	7.4	51.2	4.4
2001	10.6	6.5	40.9	62.6
2002	15.4	11.1	17.2	22.0
2003	1.2	3.0	19.1	15.9
2004	0.3	0.4	6.4	8.3
2005	6.6	5.7	23.7	4.0

[1]Fixed - annual delta mean number per tow, fixed stations standard trawl.
All - annual stratified mean number per tow, all stations standard trawl.
Wilcox - annual stratified mean number per tow, fine-mesh trawl.

Table 5-19. Annual abundance and variation parameters for butterfish collected under the Mount Hope Bay standard trawl program based on the delta distribution, May-November 1972-2005

Year	No. of tows	Delta mean catch per tow	Variance	Standard deviation	Proportion of zeros	Coefficient of variation of mean	0.950 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	0.000					
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	0.350	0.065	0.255	0.93	0.725	± 0.509
1999	42	0.258	0.011	0.103	0.83	0.398	± 0.205
2000	40	0.277	0.024	0.155	0.90	0.560	± 0.310
2001	29	0.207	[1]	[1]	0.97	[1]	[1]
2002	31	0.778	0.116	0.340	0.74	0.437	± 0.680
2003	40	1.543	1.722	1.312	0.93	0.850	± 2.625
2004	42	0.095	0.006	0.075	0.95	0.785	± 0.149
2005	38	0.079	0.002	0.044	0.92	0.562	± 0.089

[1]Individuals present in only one tow.

Note: From 1997 to 2005 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 5-20. Butterfish abundance indices from the Standard and Wilcox trawl surveys, May - November 1972-2005

Year	Mount Hope Bay[1]			Narragansett Bay
	Fixed	All	Wilcox	Wilcox
1972	0.5			
1973	0.8			
1974	0.1			
1975	1.3			
1976	0.1			
1977	1.2			
1978	0.4			
1979	1.2			
1980	0.02			
1981	0.4			
1982	0.8			
1983	0.6			
1984	0.1			
1985	0.3			
1986	0.1			
1987	0.2			
1988	0			
1989	0.2			
1990	0.1			
1991	0.02			
1992	1.5			
1993	0.9			
1994	0.1			
1995	0.1			
1996	0.4		0.4	
1997	0.1	0.8	5.6	
1998	0.4	0.7	12.1	0.9
1999	0.3	1.2	13.2	4.8
2000	0.3	0.3	1.2	0.3
2001	0.2	0.5	1.2	1.7
2002	0.8	1.9	1.3	0.2
2003	1.5	0.9	1.2	20.4
2004	0.1	0.2	0.4	0.1
2005	0.1	0.7	1.5	4.1

[1]Fixed - annual delta mean number per tow, fixed stations standard trawl.
All - annual stratified mean number per tow, all stations standard trawl.
Wilcox - annual stratified mean number per tow, fine-mesh trawl.

Table 5-21. Annual abundance and variation parameters for little skate collected under the Mount Hope Bay standard trawl program based on the delta distribution, 1972-2005

Year	No. of tows	Delta mean catch per tow	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	0.39	±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	0.04	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	±0.090
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
1999	72	0.070	0.002	0.042	0.96	0.6	±0.083
2000	64	0.078	0.003	0.056	0.97	0.72	±0.110
2001	60	0.017	[1]	[1]	0.98	[1]	[1]
2002	52	0.019	[1]	[1]	0.98	[1]	[1]
2003	67	0	0	0	0	0	0
2004	64	0	0	0	0	0	0
2005	57	0	0	0	0	0	0

[1]One fish taken.

Note: From 1997 to 2005 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 5-22. Little skate abundance indices from the Standard and Wilcox trawl surveys, 1972-2005

Year	Mount Hope Bay[1]			Narragansett Bay
	Fixed	All	Wilcox	Wilcox
1972	0			
1973	0.1			
1974	0.01			
1975	0.1			
1976	0			
1977	0			
1978	0.04			
1979	0.05			
1980	0.01			
1981	0.04			
1982	0.1			
1983	0.2			
1984	0.3			
1985	0.1			
1986	0.1			
1987	0.1			
1988	0.1			
1989	0.01			
1990	0.2			
1991	0.1			
1992	0.9			
1993	0.2			
1994	0.1			
1995	0.1			
1996	0.1		0.50	
1997	0.2	0.30	0.30	0.04
1998	0.04	0.10	0.30	0.04
1999	0.07	0.07	0.10	0.08
2000	0.08	0.08	0.05	0.05
2001	0.02	0.01	0.02	0.00
2002	0.02	0.06	0.10	0.05
2003	0.0	0.05	0.10	0.09
2004	0.0	0.01	0.00	0.00
2005	0.0	0.11	0.03	0.04

[1]Fixed - annual delta mean number per tow, fixed stations standard trawl.
All - annual stratified mean number per tow, all stations standard trawl.
Wilcox - annual stratified mean number per tow, fine-mesh trawl.

Table 5-23. Mean annual standard otter trawl catch per tow in Mount Hope Bay by species, 1972 – 2005 (page 1 of 4)

Species		1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
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	0.00	0.07	0.03	0.01
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	0.00	0.01	0.00	0.00
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	0.00	0.06
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	0.22	0.07
Osmerus mordax	Rainbow smelt	0.54	1.12	0.92	0.17	0.10	0.00	0.08	0.38	0.17	0.04	0.08	0.44	0.01	0.01	0.00	0.00
Microgadus tomcod	Atlantic tomcod	0.27	0.17	0.08	0.02	0.00	0.10	0.97	0.50	0.15	0.10	0.11	0.04	0.08	0.02	0.01	0.00
Syngnathus fuscus	Northern pipefish	0.08	0.34	1.15	0.00	0.02	0.04	0.53	0.05	0.50	0.42	0.23	0.01	0.17	0.04	0.06	0.08
Paralichthys dentatus	Summer flounder	0.04	0.02	0.12	0.07	0.20	0.04	0.00	0.00	0.05	0.04	0.13	0.01	0.11	0.17	0.30	0.17
A. pseudoharengus	Alewife	0.13	0.29	0.38	0.10	0.02	0.02	0.13	0.05	0.05	0.00	0.06	0.11	0.06	0.01	0.00	0.00
Merluccius bilinearis	Silver hake	0.29	0.41	0.17	0.10	0.05	0.10	0.15	0.05	0.00	0.02	0.87	0.18	0.11	0.01	0.00	0.00
Pomatomus saltatrix	Bluefish	0.00	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	0.15	0.07
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	0.00	0.00	0.00
Prionotus evolans	Striped searobin	0.21	0.41	0.30	0.08	0.05	0.02	0.02	0.02	0.01	0.00	0.02	0.01	0.02	0.00	0.00	0.00
Urophycis tenuis	White hake	0.38	0.58	0.18	0.52	0.07	0.00	0.10	0.05	0.06	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Clupea harengus	Atlantic herring	0.17	0.27	0.03	0.02	0.07	0.08	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.44
Menticirrhus saxatilis	Northern kingfish	0.23	0.27	0.60	0.02	0.02	0.00	0.10	0.03	0.04	0.01	0.01	0.02	0.02	0.01	0.00	0.00
Urophycis chuss	Red hake	0.11	0.03	0.03	0.00	0.07	0.04	0.17	0.05	0.20	0.00	0.04	0.18	0.01	0.14	0.06	0.00
Brevoortia tyrannus	Atlantic menhaden	0.38	0.17	0.13	0.15	0.00	0.00	0.03	0.06	0.00	0.01	0.01	0.04	0.00	0.05	0.00	0.00
Menidia menidia	Atlantic silverside	0.00	0.00	0.08	0.00	0.00	0.06	0.25	0.03	0.01	0.15	0.00	0.02	0.06	0.02	0.09	0.07
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	0.03	0.00
Selene setapinnis	Atlantic moonfish	0.00	0.03	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
Urophycis regia	Spotted hake	0.03	0.07	0.00	0.03	0.00	0.00	0.00	0.02	0.06	0.00	0.00	0.02	0.00	0.02	0.00	0.01
Prionotus carolinus	Northern searobin	0.25	0.08	0.05	0.02	0.03	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00
Myoxocephalus aenaeus	Grubby	0.04	0.00	0.02	0.00	0.02	0.00	0.07	0.15	0.06	0.00	0.05	0.08	0.01	0.00	0.00	0.00
Anguilla rostrata	American eel	0.07	0.03	0.05	0.00	0.03	0.02	0.03	0.08	0.00	0.01	0.00	0.01	0.02	0.04	0.01	0.00
Morone saxatilis	Striped bass	0.04	0.12	0.02	0.00	0.08	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Alosa aestivalis	Blueback herring	0.00	0.02	0.03	0.00	0.00	0.00	0.05	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00
'Paralichthys oblongus	Fourspot flounder	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00
Synodus foetens	Inshore lizardfish	0.00	0.00	0.15	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Mustelus canis	Smooth dogfish	0.04	0.02	0.02	0.00	0.05	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Alosa sapidissima	American shad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
Etropus microstomus	Smallmouth flounder	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Leiostomus xanthurus	Spot	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.00
Caranx hippos	Crevalle jack	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
Scomber scombrus	Atlantic mackerel	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00

Table 5-23. Mean annual standard otter trawl catch per tow in Mount Hope Bay by species, 1972 – 2005 (page 2 of 4)

Species		1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Centropristis striata	Black sea bass	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apeltes quadracus	Fourspine stickleback	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Pollachius virens	Pollock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00
M. octodecemspinosus	Longhorn sculpin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Caranx chrysos	Blue runner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Pholus gunnellus	Rock gunnel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Enchelyopus cimbrius	Fourbeard rockling	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sphoeroides maculatus	Northern puffer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
Fundulus majalis	Striped killifish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trachurus lathami	Rough scad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selene vomer	Lookdown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pomoxis nigromaculatus	Black crappie	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Conger oceanicus	Conger eel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Gasterosteus aculeatus	Threespine stickleback	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyclopterus lumpus	Lumpfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number Of Species		25	28	28	19	25	19	27	32	21	18	24	26	20	23	14	11

Little skate, tautog, scup, butterfish, windowpane, winter flounder, hogchoker not included because delta means were used.

Table 5-23. Mean annual standard otter trawl catch per tow in Mount Hope Bay by species, 1972 – 2005 (page 3 of 4)

Species		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Mean 72-04	2005
Cynoscion regalis	Weakfish	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.81	0.65	0.01	0.03	0.40	0.15	0.56	0.62	0.02	1.263	1.34
Anchoa mitchilli	Bay anchovy	0.00	0.01	0.00	0.14	0.19	0.02	0.00	0.10	0.14	0.56	0.54	0.01	0.01	0.00	0.06	0.00	0.05	1.206	0.03
Tautogolabrus adspersus	Cunner	0.03	0.08	0.00	0.04	0.01	0.04	0.00	0.00	0.00	0.08	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.316	0.07
Opsanus tau	Oyster toadfish	0.03	0.00	0.02	0.00	0.00	0.02	0.00	0.07	0.07	0.02	0.06	0.02	0.02	0.01	0.00	0.03	0.01	0.198	0.01
Osmerus mordax	Rainbow smelt	0.01	0.00	0.00	0.01	0.00	0.03	0.00	0.00	0.08	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.144	0.01
Microgadus tomcod	Atlantic tomcod	0.00	0.03	0.00	0.01	0.00	0.01	1.22	0.00	0.09	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.133	0.01
Syngnathus fuscus	Northern pipefish	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.126	0.03
Paralichthys dentatus	Summer flounder	0.03	0.00	0.03	0.00	0.06	0.03	0.03	0.03	0.11	0.09	0.16	0.14	0.32	0.28	0.56	0.44	0.25	0.093	0.19
A. pseudoharengus	Alewife	0.03	0.03	0.02	0.00	0.01	0.21	0.00	0.01	0.20	0.02	0.31	0.37	0.04	0.05	0.03	0.13	0.17	0.090	0.13
Merluccius bilinearis	Silver hake	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.01	0.06	0.00	0.00	0.01	0.13	0.02	0.088	0.00
Pomatomus saltatrix	Bluefish	0.00	0.07	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.09	0.06	0.01	0.09	0.00	0.01	0.074	0.00
Morone americana	White perch	0.00	0.00	0.05	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.068	0.00
Prionotus evolans	Striped searobin	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.10	0.02	0.00	0.19	0.15	0.08	0.20	0.05	0.05	0.02	0.065	0.40
Urophycis tenuis	White hake	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.065	0.00
Clupea harengus	Atlantic herring	0.00	0.10	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.02	0.24	0.01	0.04	0.00	0.17	0.00	0.08	0.057	0.00
Menticirrhus saxatilis	Northern kingfish	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.01	0.03	0.02	0.02	0.01	0.00	0.00	0.00	0.01	0.00	0.051	0.00
Urophycis chuss	Red hake	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.03	0.00	0.01	0.30	0.00	0.00	0.00	0.01	0.00	0.051	0.00
Brevoortia tyrannus	Atlantic menhaden	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.07	0.00	0.03	0.00	0.13	0.03	1.48	0.92	0.00	0.044	0.00
Menidia menidia	Atlantic silverside	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.01	0.07	0.00	0.02	0.13	0.01	0.00	0.13	0.03	0.07	0.040	0.07
Gobiosoma ginsburgi	Seaboard goby	0.04	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.01	0.01	0.00	0.037	0.00
Selene setapinnis	Atlantic moonfish	0.01	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.02	0.04	0.38	0.04	0.02	0.19	0.00	0.02	0.023	0.04
Urophycis regia	Spotted hake	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.08	0.00	0.12	0.03	0.08	0.01	0.06	0.08	0.00	0.019	0.00
Prionotus carolinus	Northern searobin	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.017	0.00
Myoxocephalus aenaeus	Grubby	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.017	0.05
Anguilla rostrata	American eel	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.014	0.00
Morone saxatilis	Striped bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.01	0.00	0.03	0.011	0.00
Alosa aestivalis	Blueback herring	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.01	0.00	0.09	0.03	0.00	0.01	0.00	0.00	0.00	0.37	0.010	0.00
'Paralichthys oblongus	Fourspot flounder	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.13	0.00	0.03	0.00	0.13	0.00	0.01	0.008	0.00
Synodus foetens	Inshore lizardfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.02	0.00	0.00	0.008	0.00
Mustelus canis	Smooth dogfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.007	0.00
Alosa sapidissima	American shad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.004	0.00
Etropus microstomus	Smallmouth flounder	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.01	0.02	0.03	0.01	0.00	0.004	0.04
Leiostomus xanthurus	Spot	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.003	0.00
Caranx hippos	Crevalle jack	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.003	0.00
Scomber scombrus	Atlantic mackerel	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.002	0.01

Table 5-23. Mean annual standard otter trawl catch per tow in Mount Hope Bay by species, 1972 – 2005 (page 4 of 4)

Species		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Mean 72-04	2005
Centropristis striata	Black sea bass	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.02	0.03	0.01	0.003	0.02
Apeltes quadracus	Fourspine stickleback	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.002	0.00
Pollachius virens	Pollock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.002	0.00
M. octodecemspinosus	Longhorn sculpin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.002	0.00
Caranx chrysos	Blue runner	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.002	0.00
Pholus gunnellus	Rock gunnel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.002	0.00
Enchelyopus cimbrius	Fourbeard rockling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.002	0.00
Sphoeroides maculatus	Northern puffer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.001	0.00
Fundulus majalis	Striped killifish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001	0.00
Trachurus lathami	Rough scad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001	0.00
Selene vomer	Lookdown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.001	0.00
Pomoxis nigromaculatus	Black crappie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001	0.00
Conger oceanicus	Conger eel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.001	0.01
Gasterosteus aculeatus	Threespine stickleback	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0003	0.00
Cyclopterus lumpus	Lumpfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0003	0.00
Number Of Species		10	11	6	12	12	11	6	11	17	13	24	22	18	16	19	18	18	18	17

Little skate, tautog, scup, butterfish, windowpane, winter flounder, hogchoker not included because delta means were used.

5.7 FIGURES

Figure 5-1. Fixed transects sampled in the Standard Otter Trawl Program (All transects were 1,143 m [1,250 yd] long)

Figure 5-2. Shallow- and deep-water Mount Hope Bay transects established for random sampling with standard and Wilcox trawls (Note: Squares represent shallow stations; circles represent deep stations)

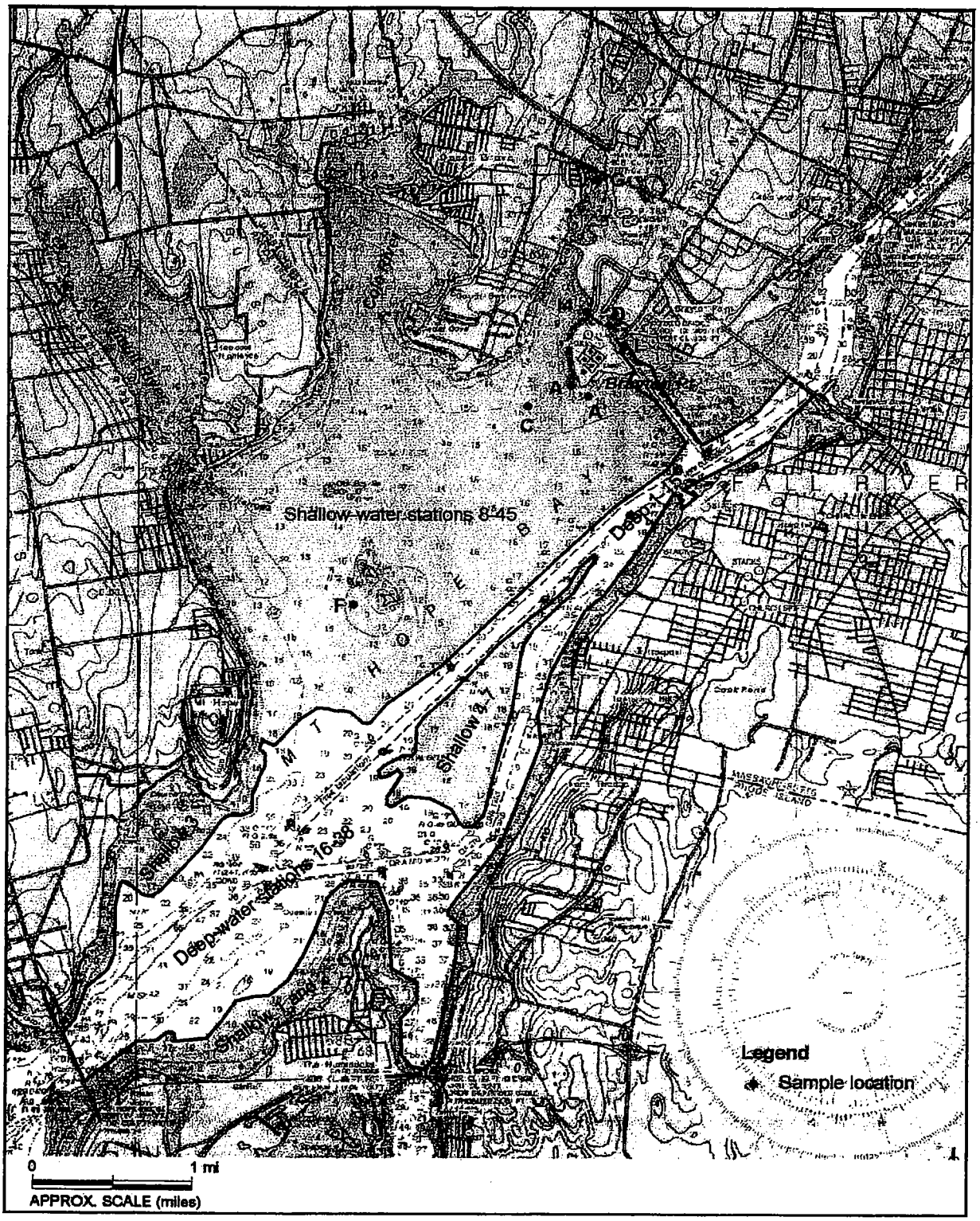


Figure 5-3. Approximate Locations of Shallow and Deep-Water Stations for Wilcox Trawl (Ichthyoplankton Sample locations A, A', C, D, F, I, and I4 are shown for reference)

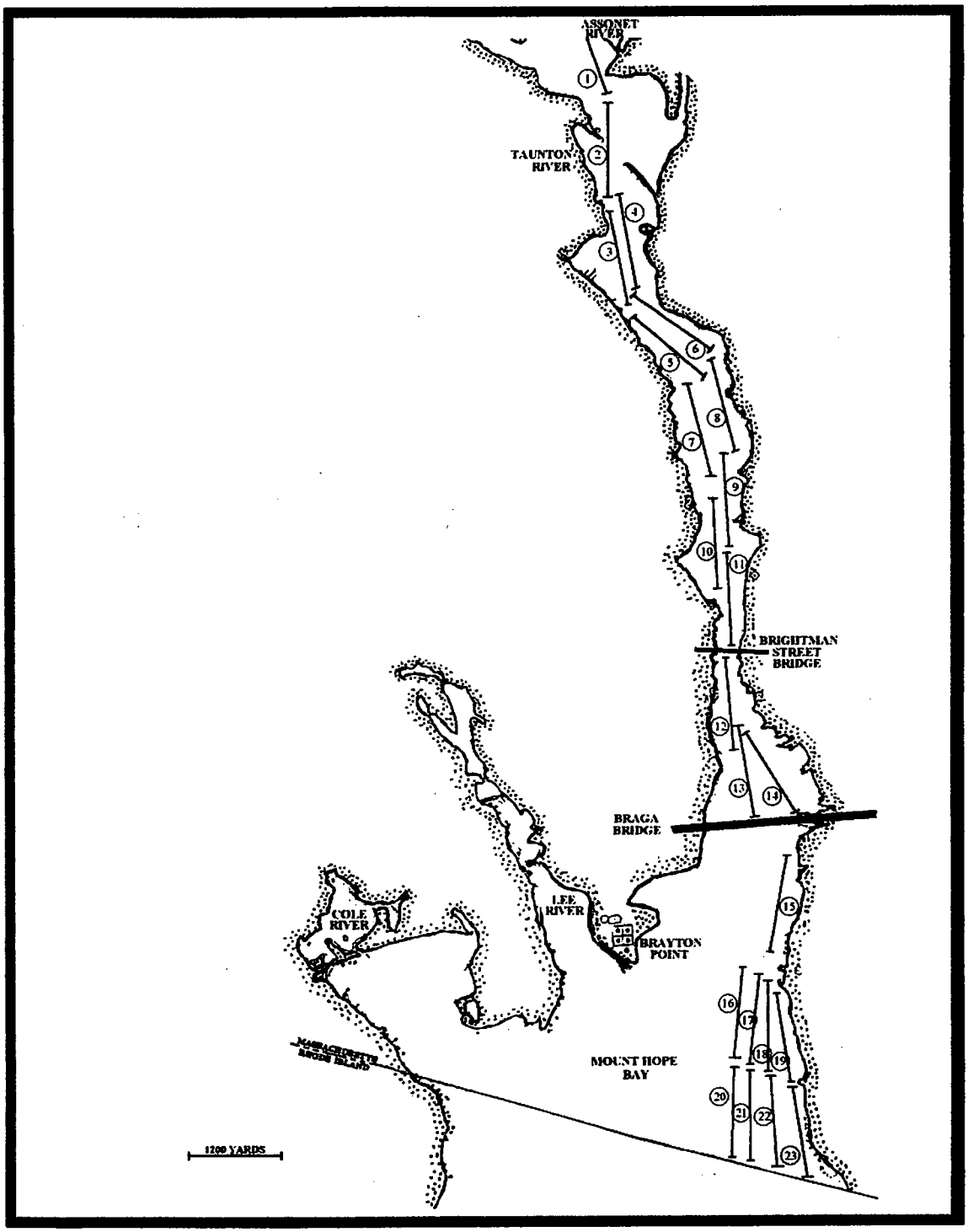


Figure 5-4. Taunton River Standard and Wilcox Trawl Sampling Transects

Figure 5-5. Approximate locations of RIDEM's Ohio Ledge (13A) and Warren River (13) Transects and RIDEM's Mount Hope Bay Transects (25 and 26)

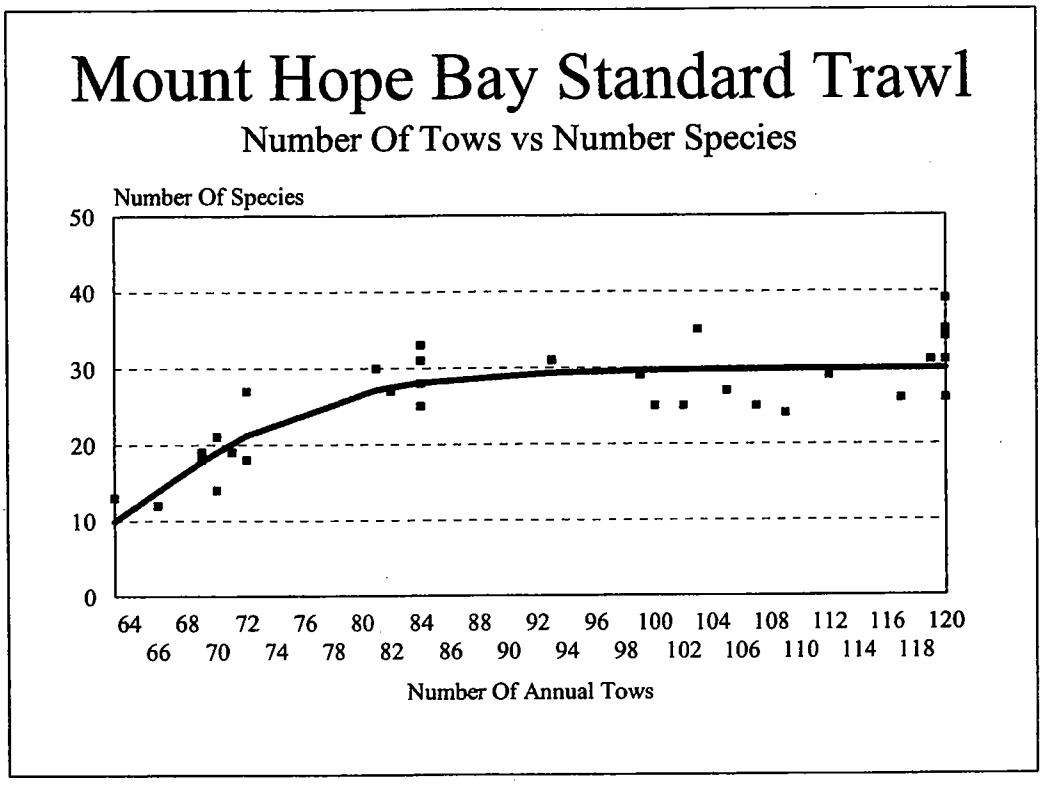


Figure 5-6. Relationship between number of standard trawl tows and number of species collected annually in Mount Hope Bay, 1972-2005

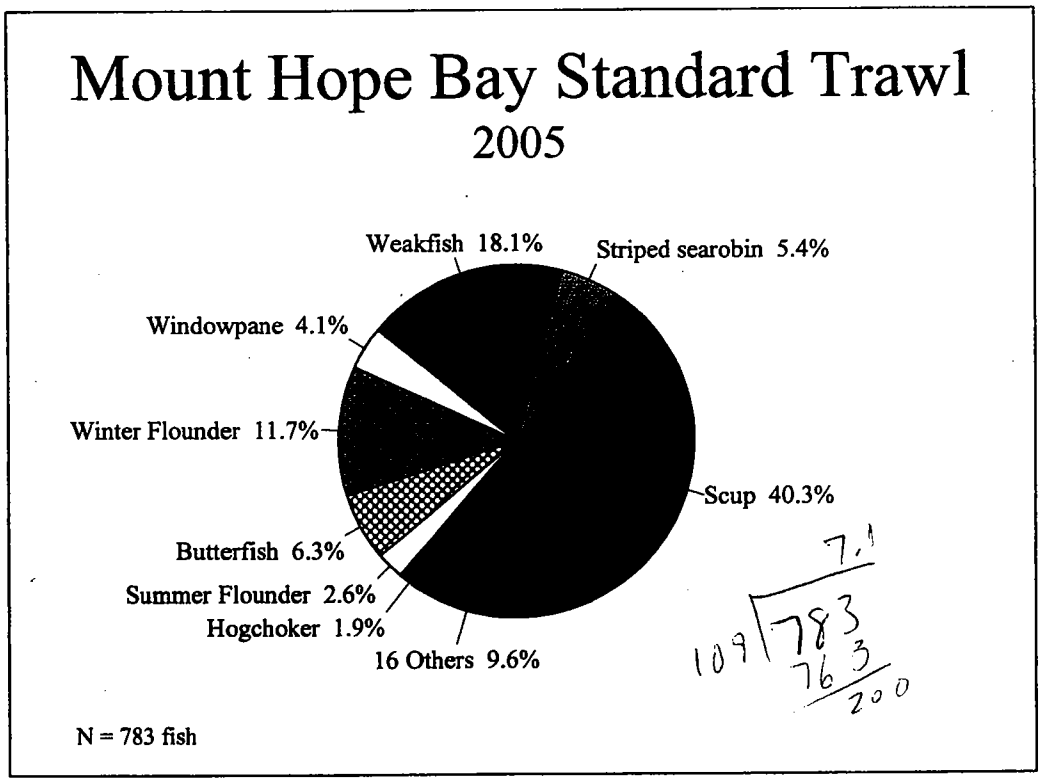


Figure 5-7. Percent contribution by species for fish taken by standard trawl, 2005

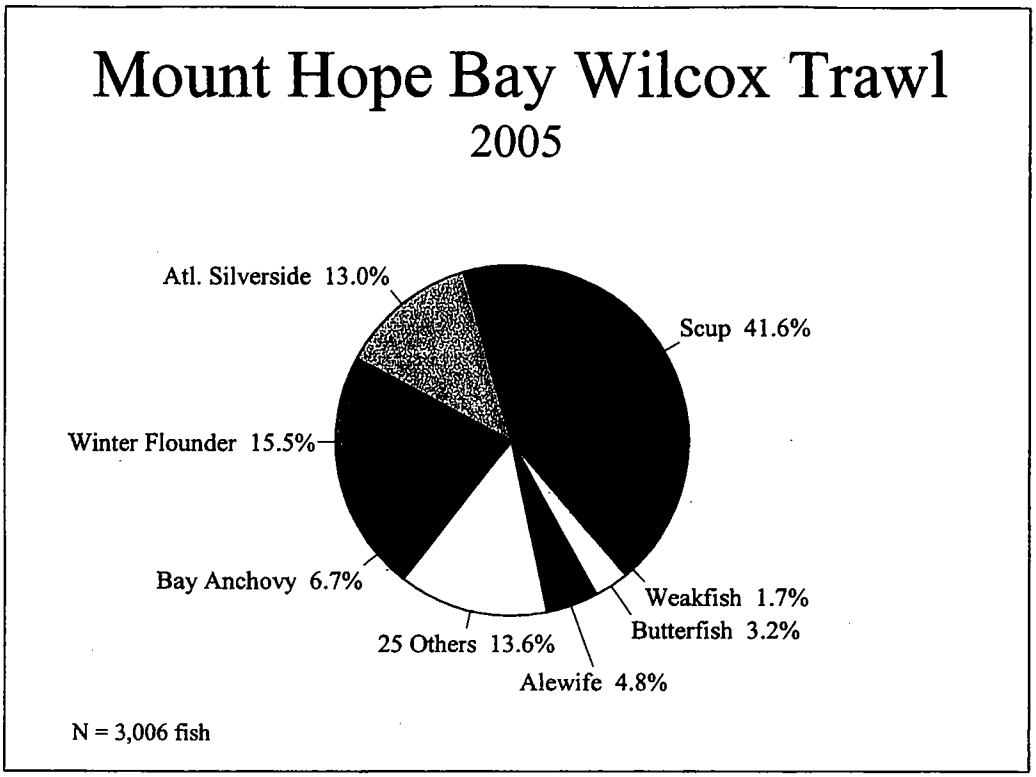


Figure 5-8. Percent contribution by species for fish taken by fine-mesh Wilcox trawl, 2005

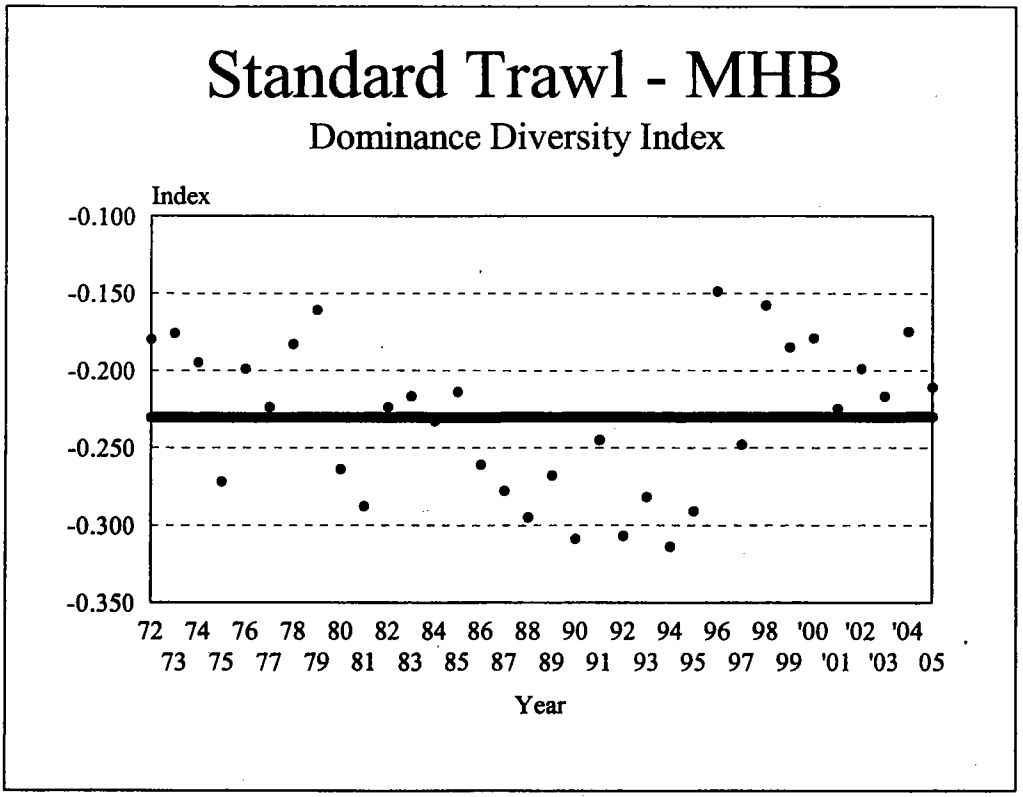
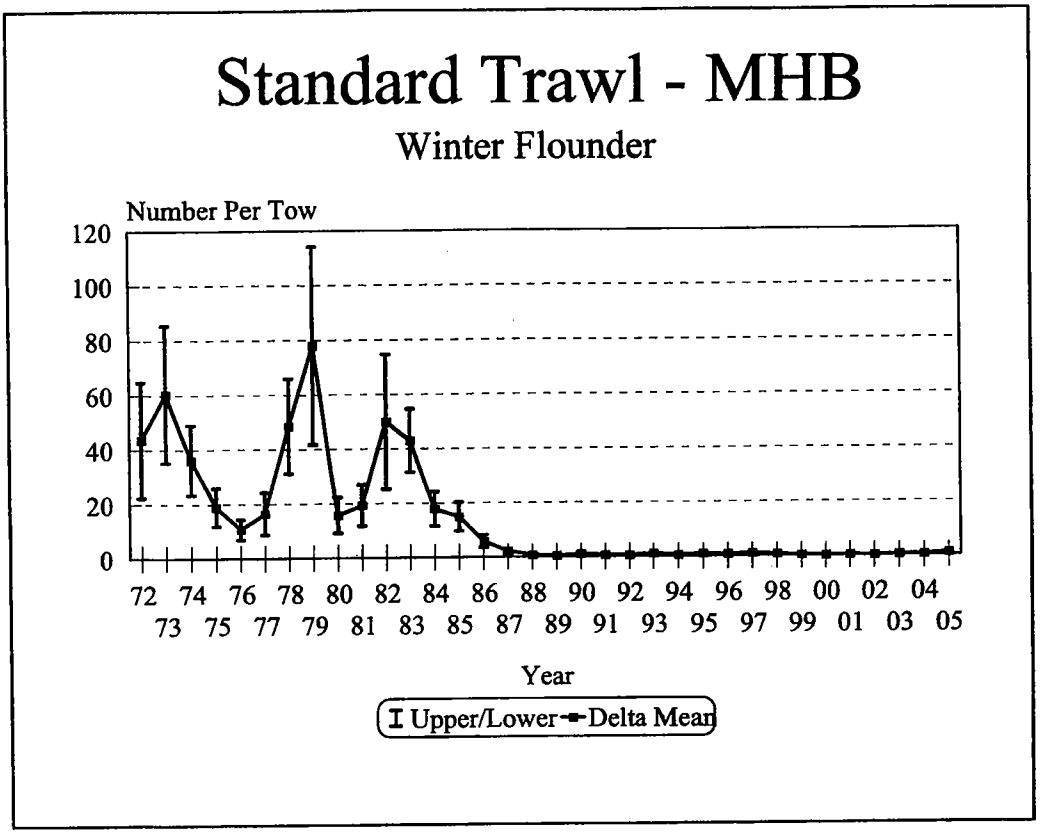


Figure 5-9. Dominance diversity values for Mount Hope Bay standard trawl, 1972-2005



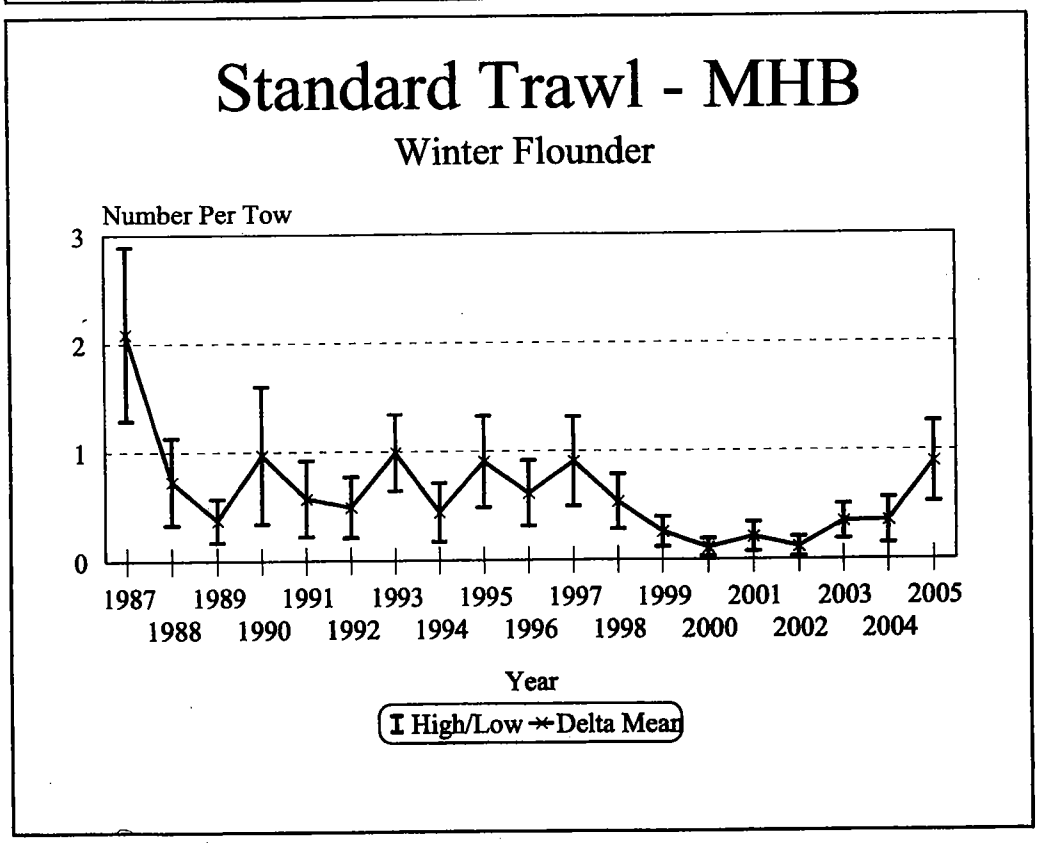


Figure 5-10. Annual delta means with confidence limits for winter flounder collected by standard trawl in Mount Hope Bay, 1972-2005 (top) and 1987-2005 (bottom)

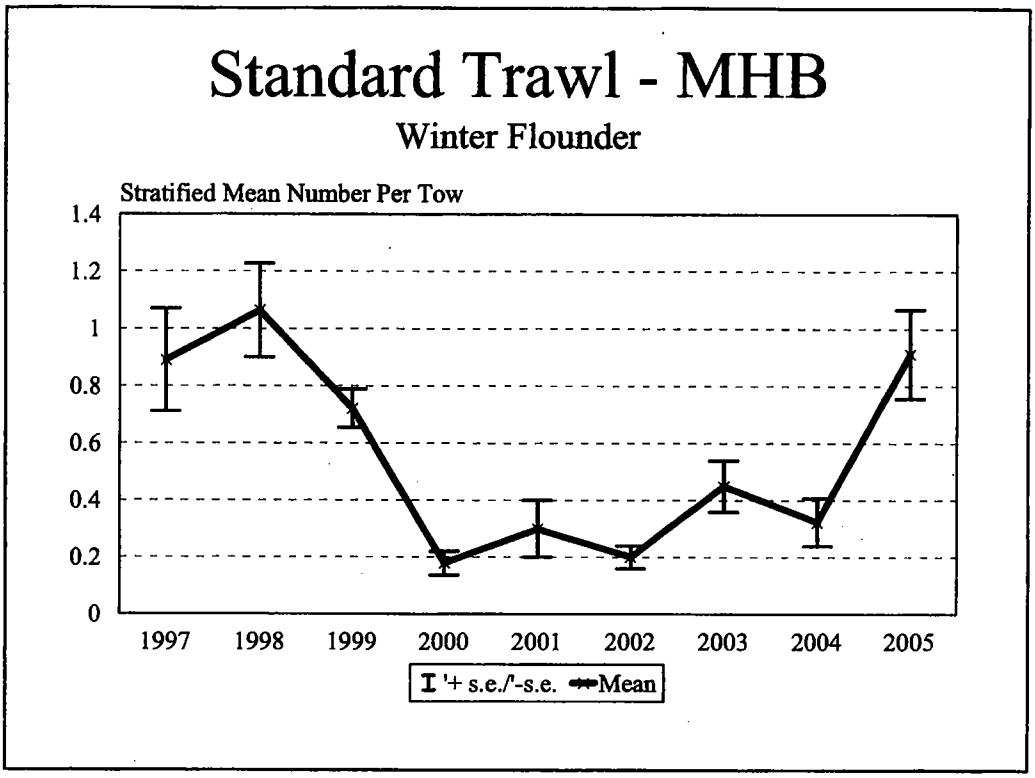


Figure 5-11. Depth-stratified mean number per standard trawl tow for winter flounder, 1997-2005

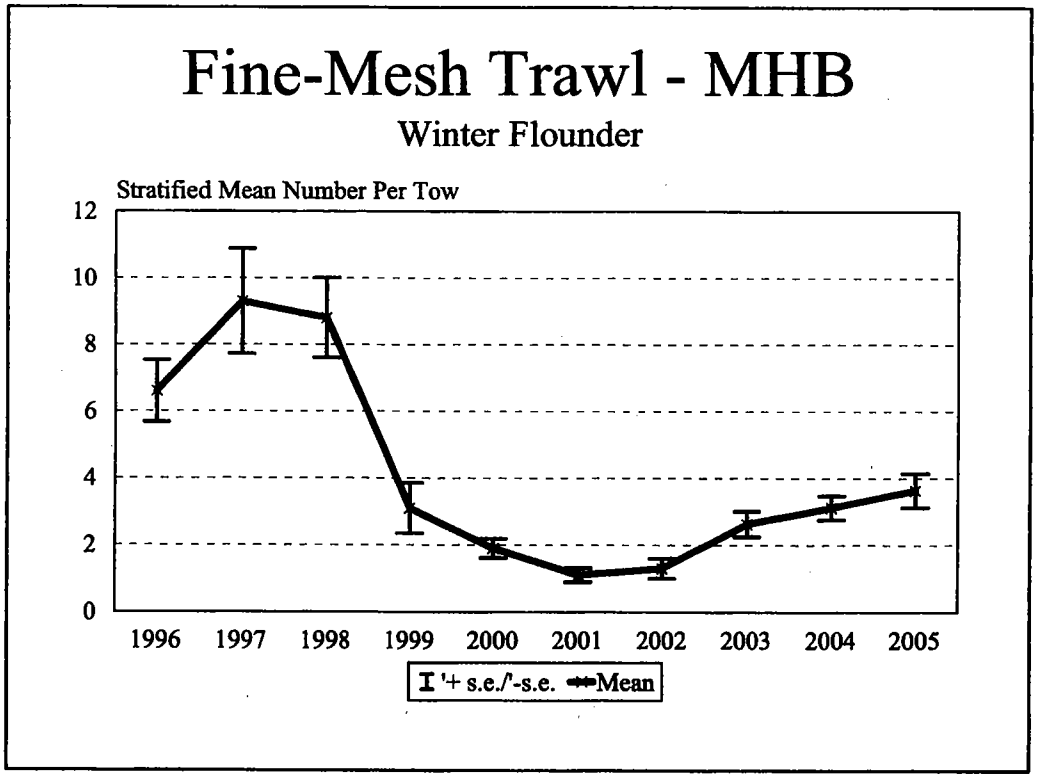


Figure 5-12. Annual stratified mean number of winter flounder per tow collected with the fine-mesh Wilcox trawl in Mount Hope Bay, 1996-2005

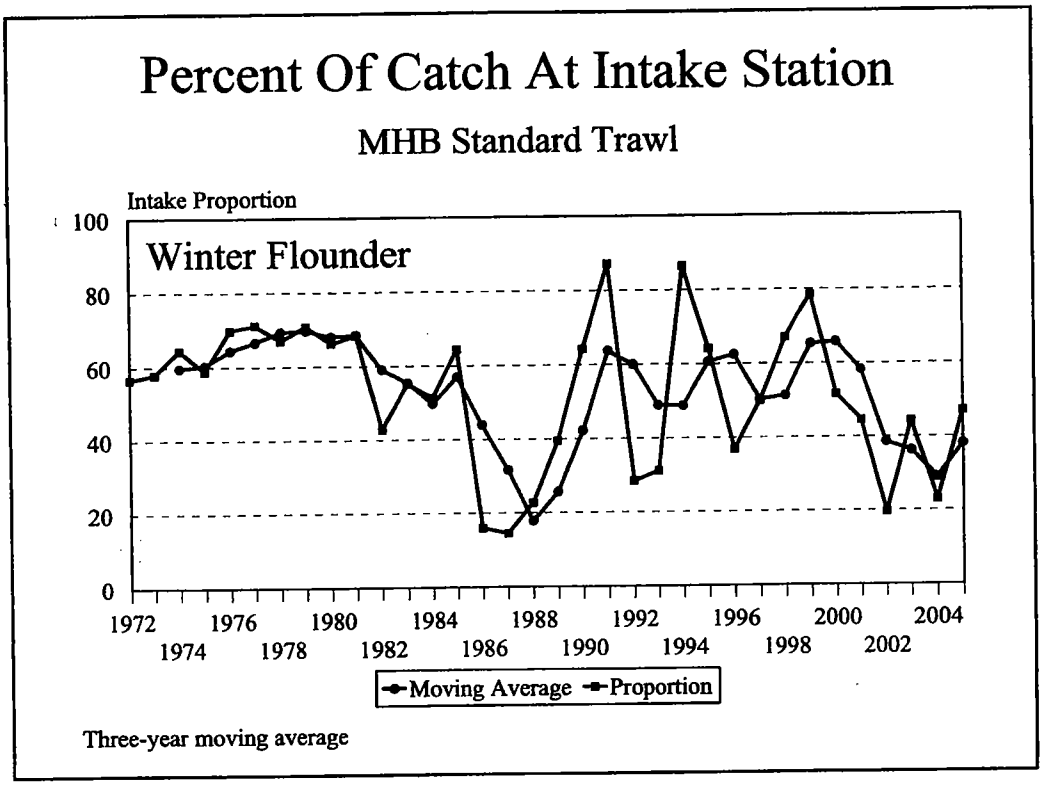
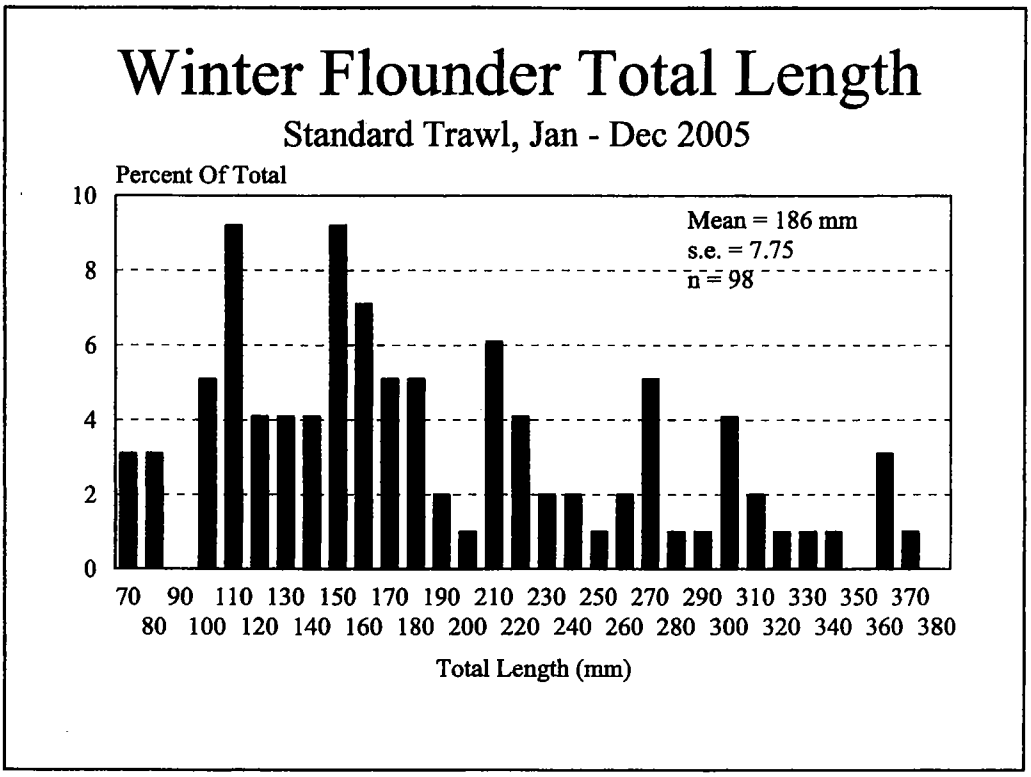


Figure 5-13. Percent of the standard trawl catch obtained at the relatively deep Intake station for winter flounder, 1972-2005



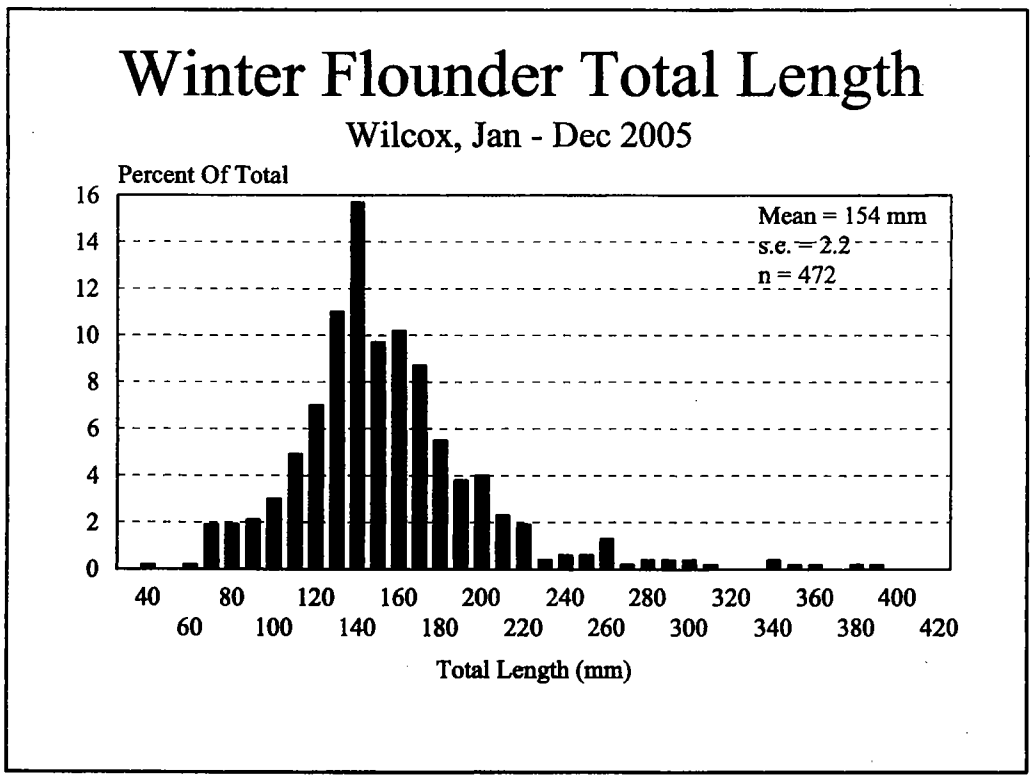
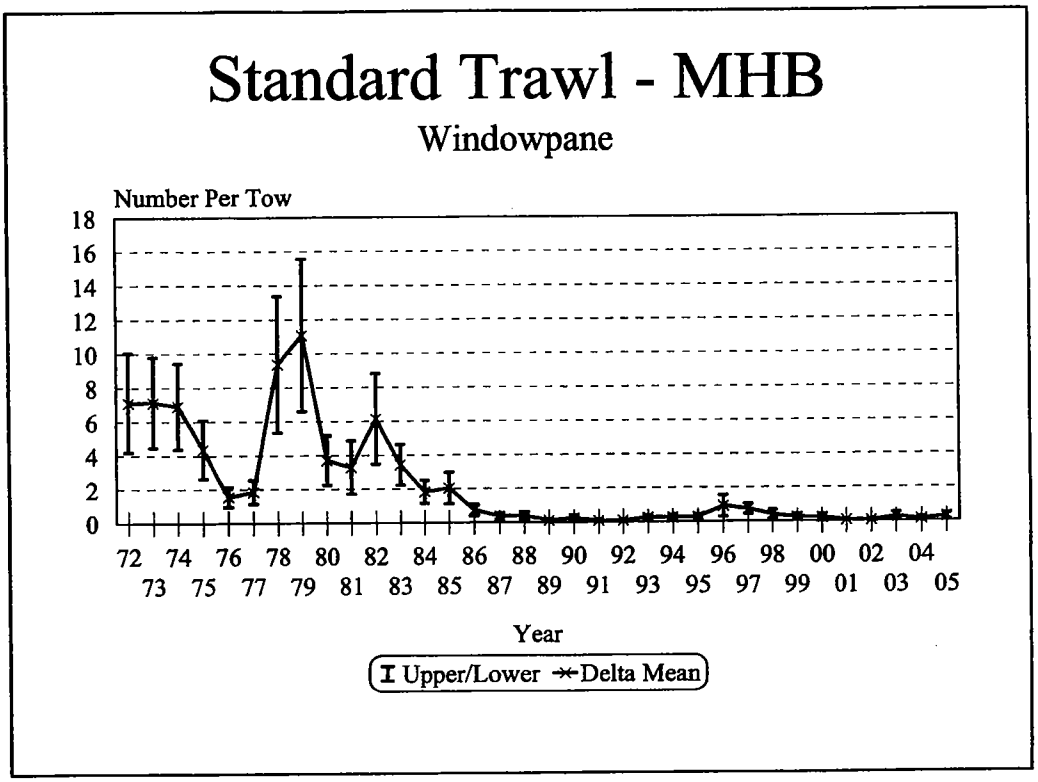


Figure 5-14. Winter flounder total length-frequency distribution for standard trawl (top) and Wilcox trawl (bottom), 2005



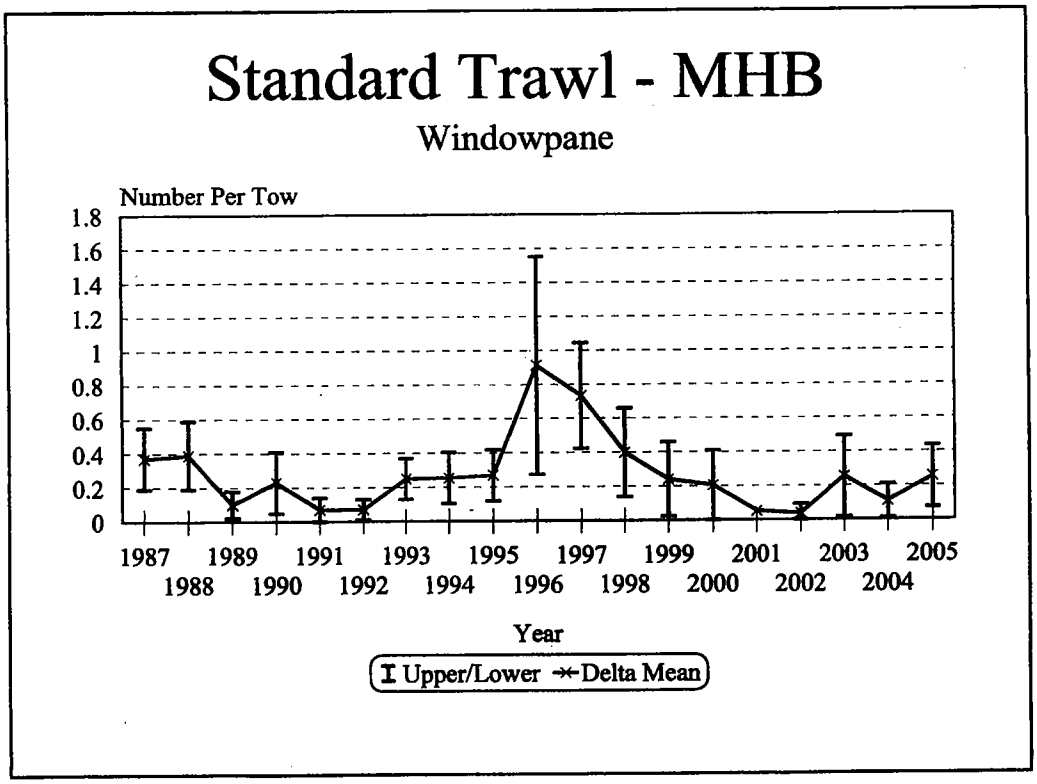


Figure 5-15. Annual delta means with confidence limits for windowpane collected by standard trawl in Mount Hope Bay, 1972-2005 (top) and 1987-2005 (bottom)

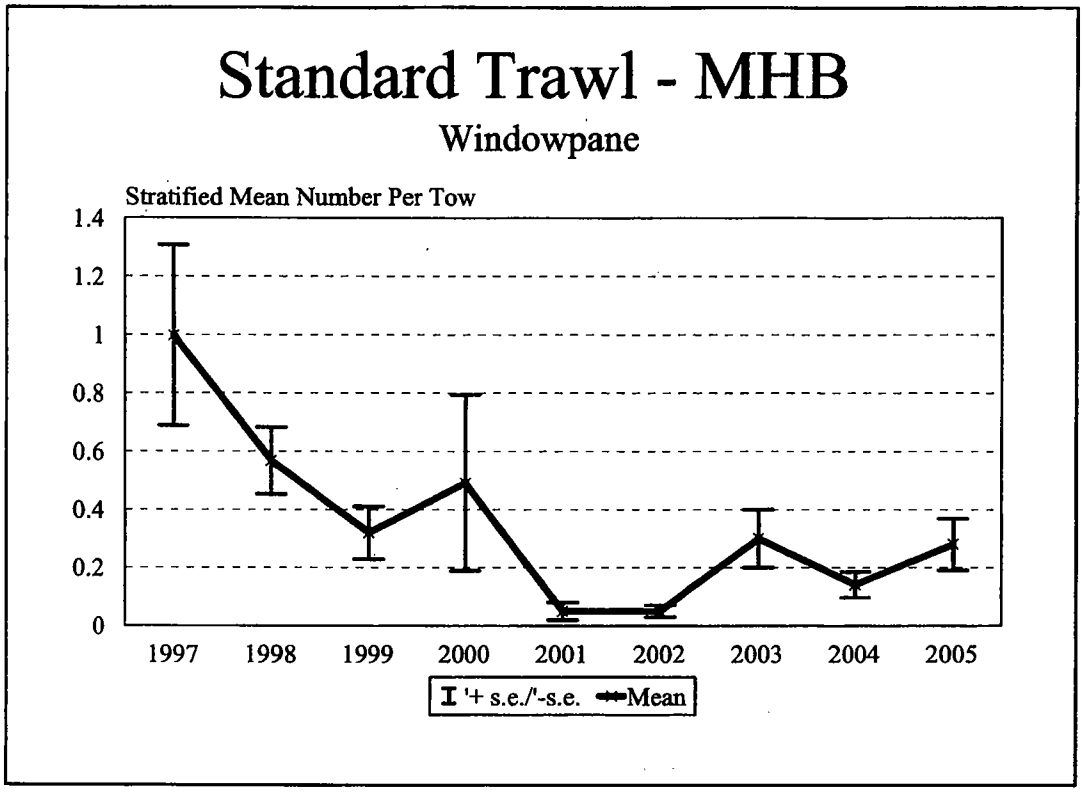


Figure 5-16. Depth-stratified mean number per standard trawl tow for windowpane, 1997-2005

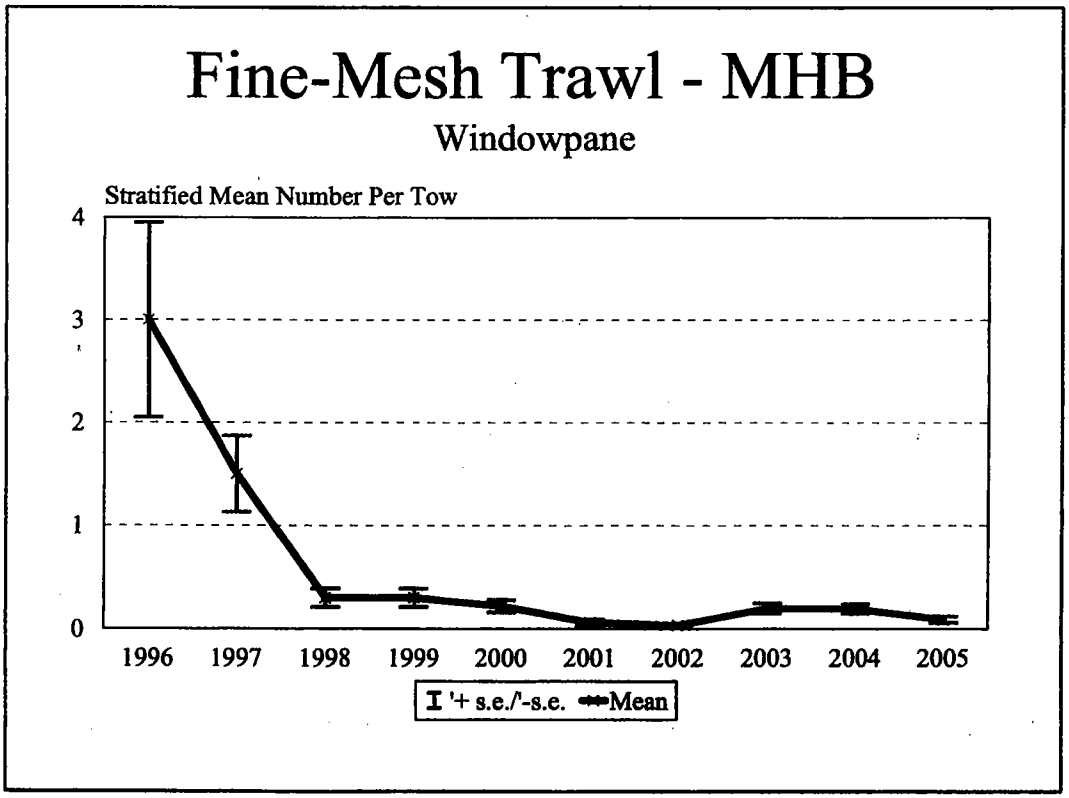
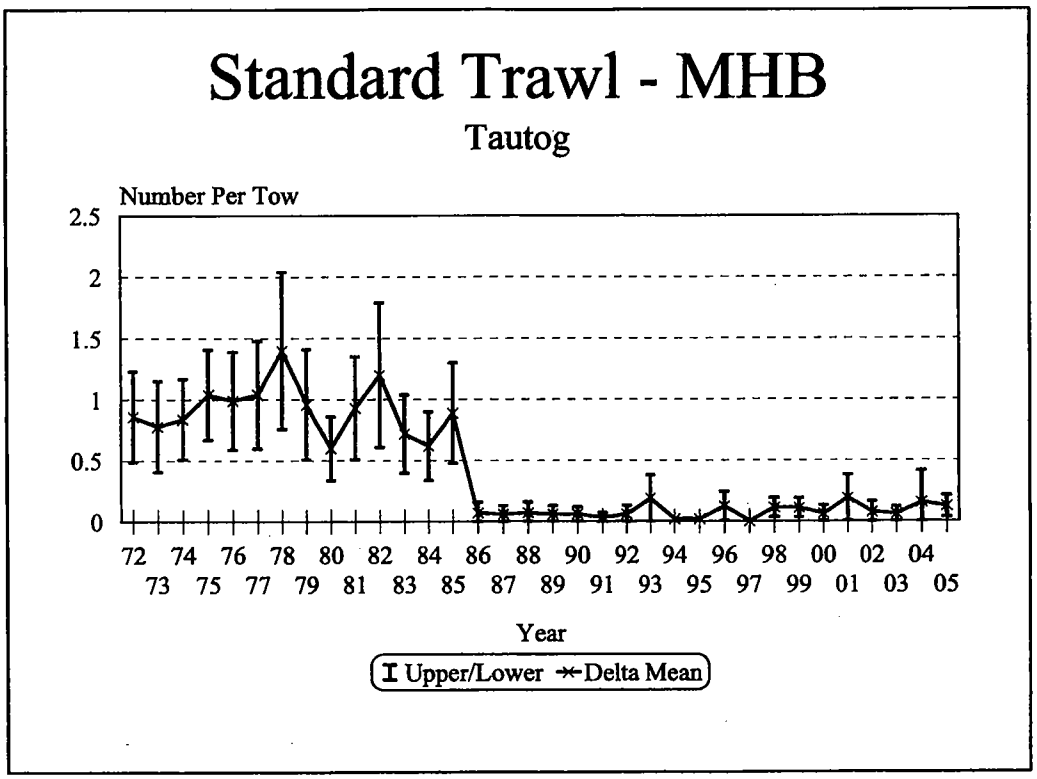


Figure 5-17. Annual stratified mean number of windowpane per tow collected with the fine-mesh Wilcox trawl in Mount Hope Bay, 1996-2005



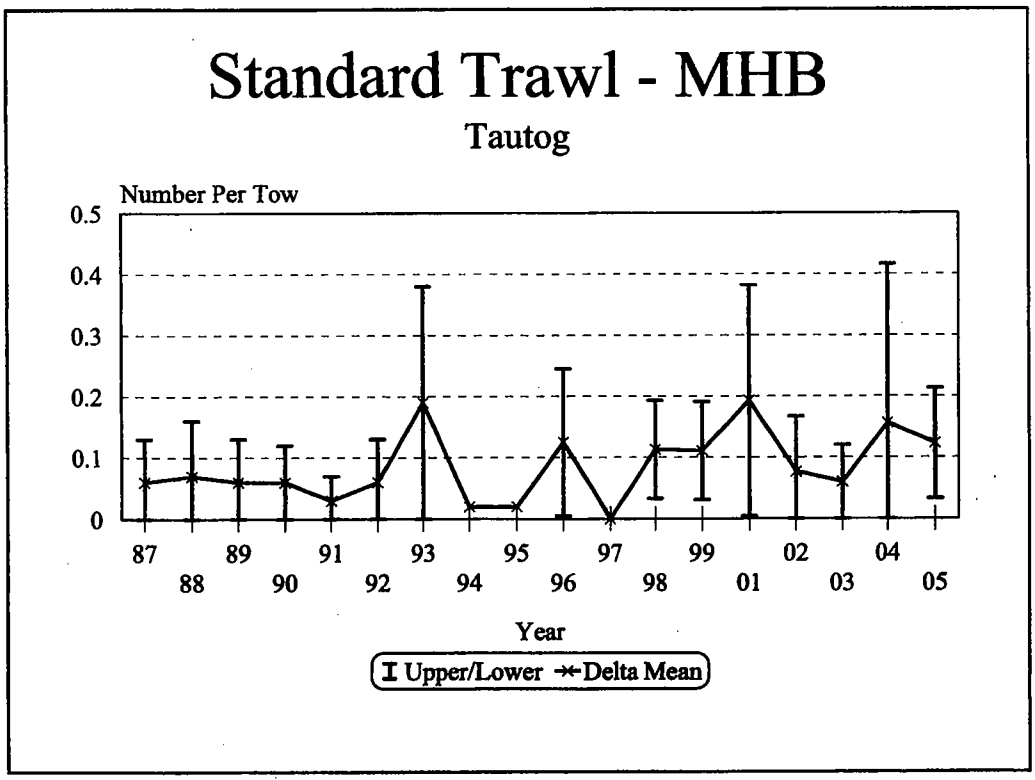


Figure 5-18. Annual delta means with confidence limits for tautog collected by standard trawl in Mount Hope Bay, 1972-2005 (top) and 1987-2005 (bottom)

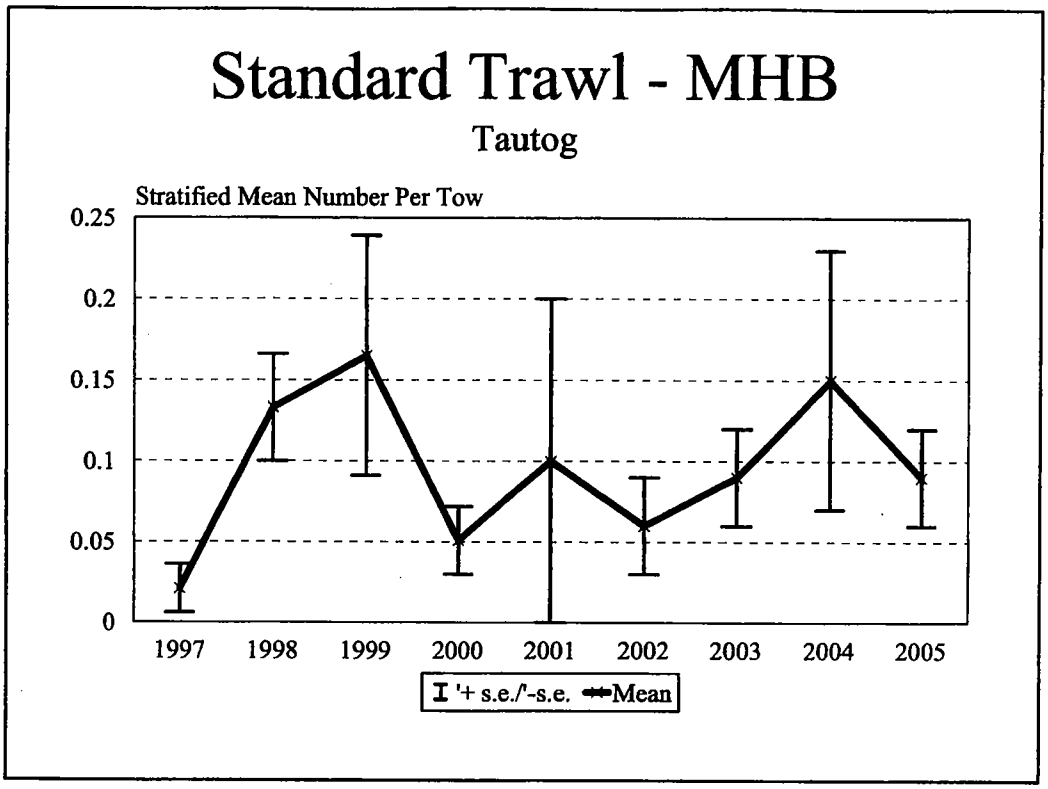


Figure 5-19. Depth-stratified mean number per standard trawl tow for tautog, 1997-2005

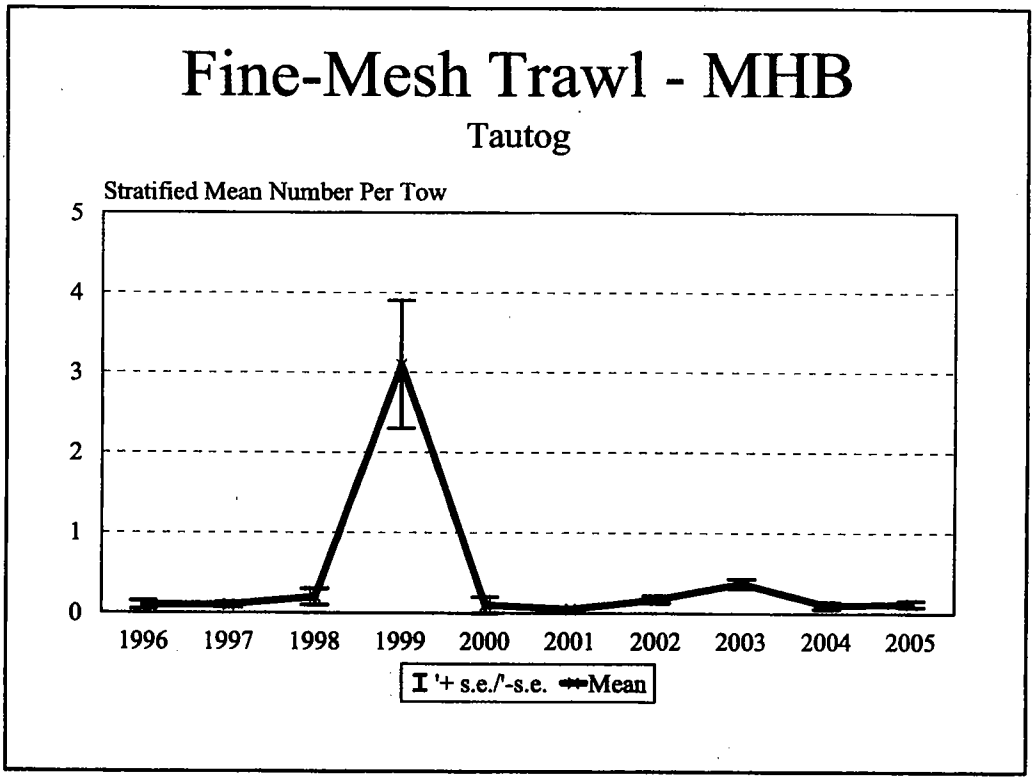


Figure 5-20. Annual stratified mean number of tautog per tow collected with the fine-mesh Wilcox trawl in Mount Hope Bay, 1996-2005

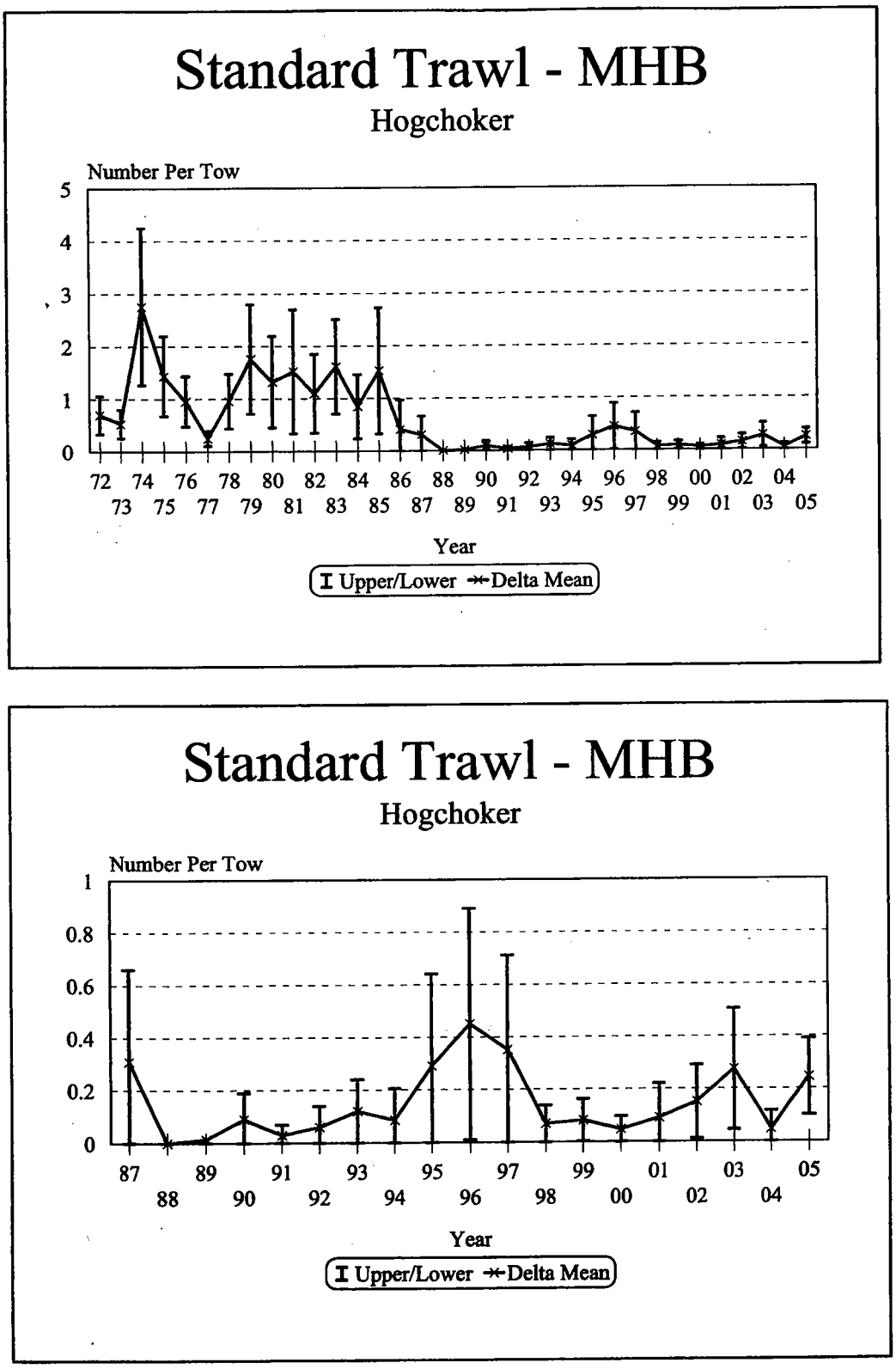


Figure 5-21. Annual delta means with confidence limits for hogchoker collected by standard trawl in Mount Hope Bay, 1972-2005 (top) and 1987-2005 (bottom)

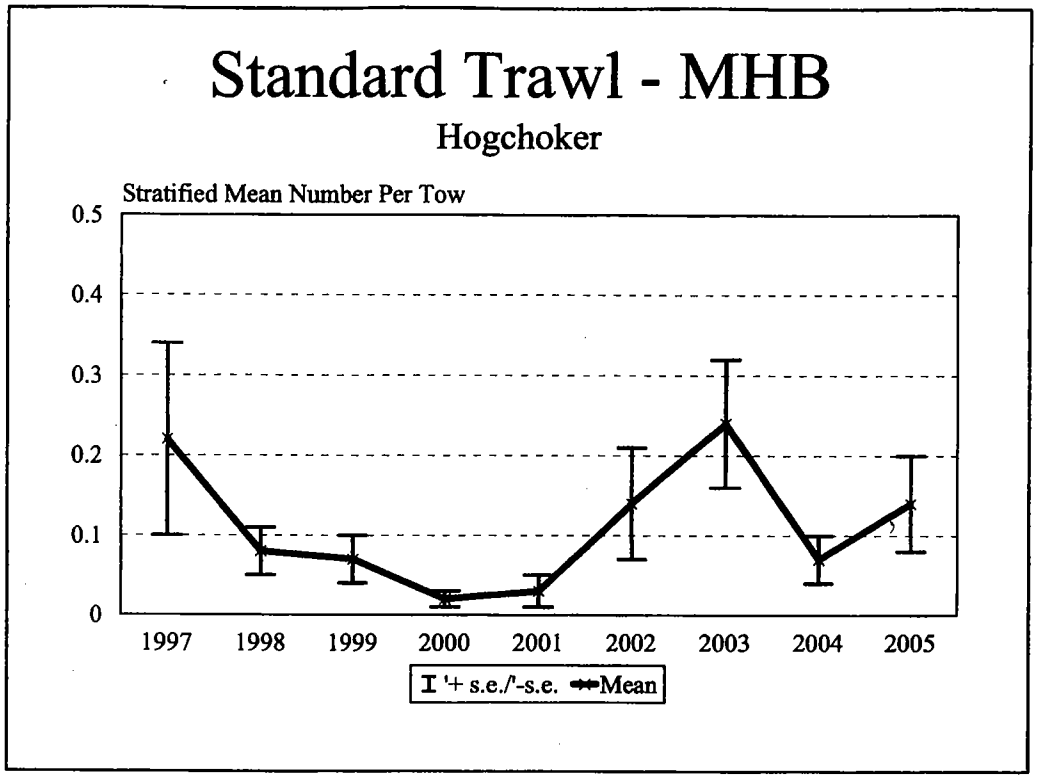


Figure 5-22. Depth-stratified mean number per standard trawl tow for hogchoker, 1997-2005

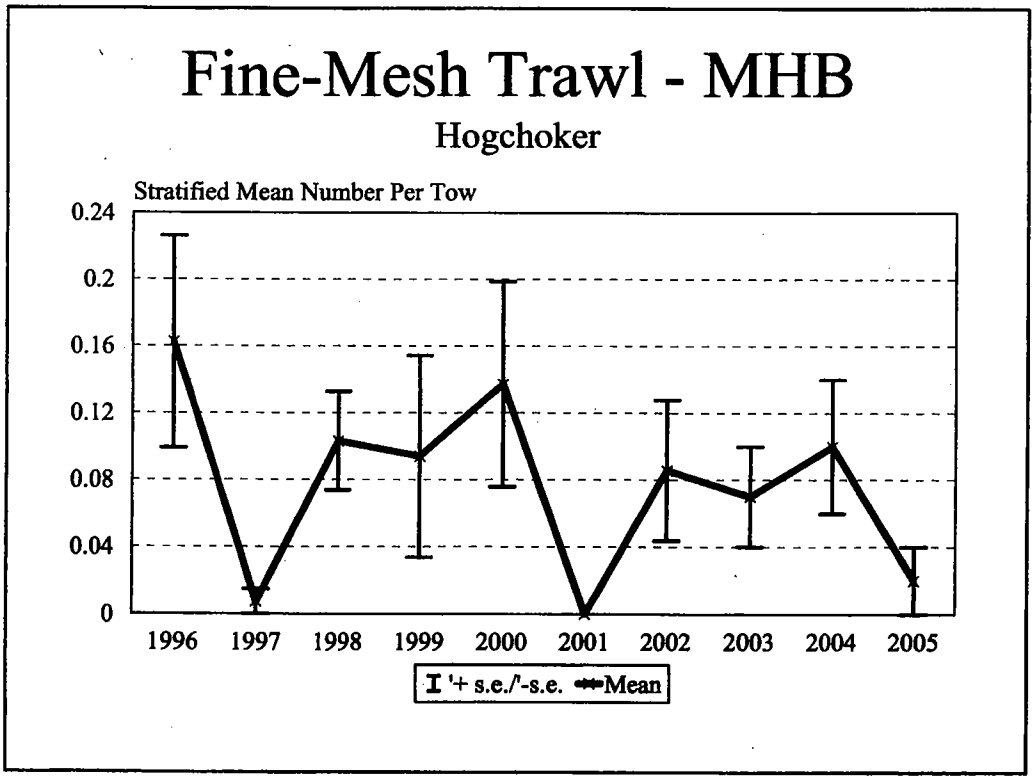


Figure 5-23. Annual stratified mean number of hogchoker per tow collected with the fine-mesh Wilcox trawl in Mount Hope Bay, 1996-2005

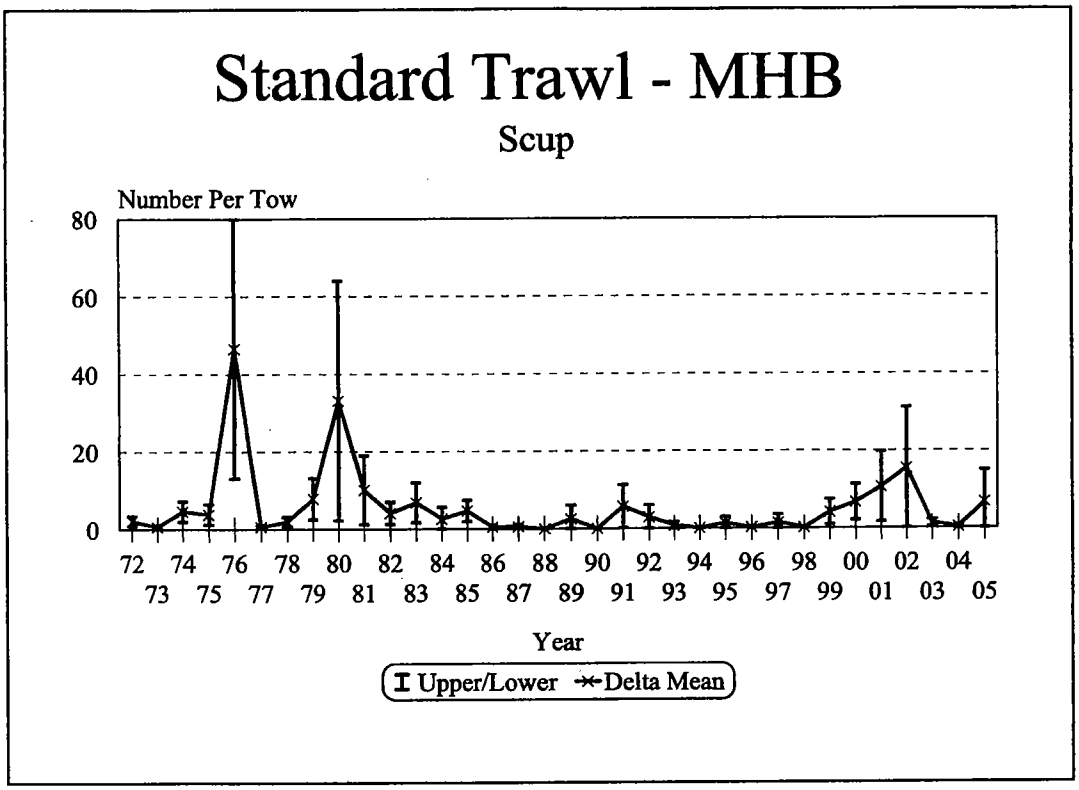


Figure 5-24. Annual delta means with confidence limits for scup collected by standard trawl in Mount Hope Bay, May-October 1972-2005

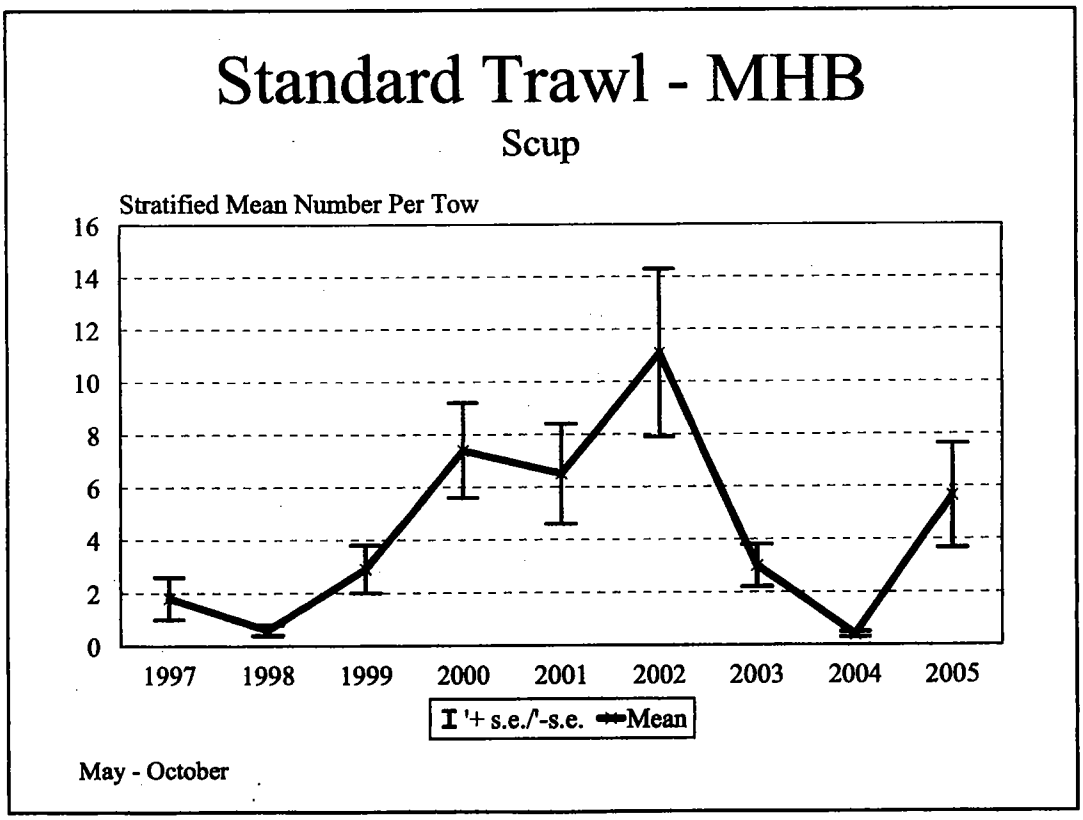


Figure 5-25. Depth-stratified mean number per standard trawl tow for scup, 1997-2005

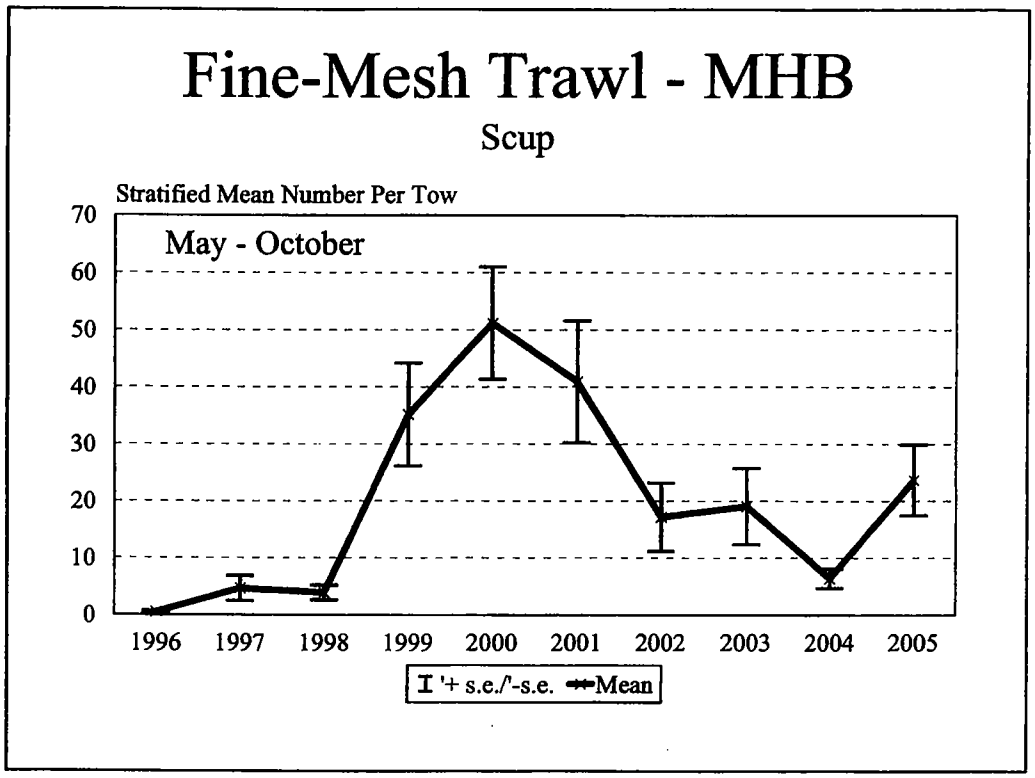


Figure 5-26. Annual stratified mean number of scup per tow collected with the fine-mesh Wilcox trawl in Mount Hope Bay, 1996-2005

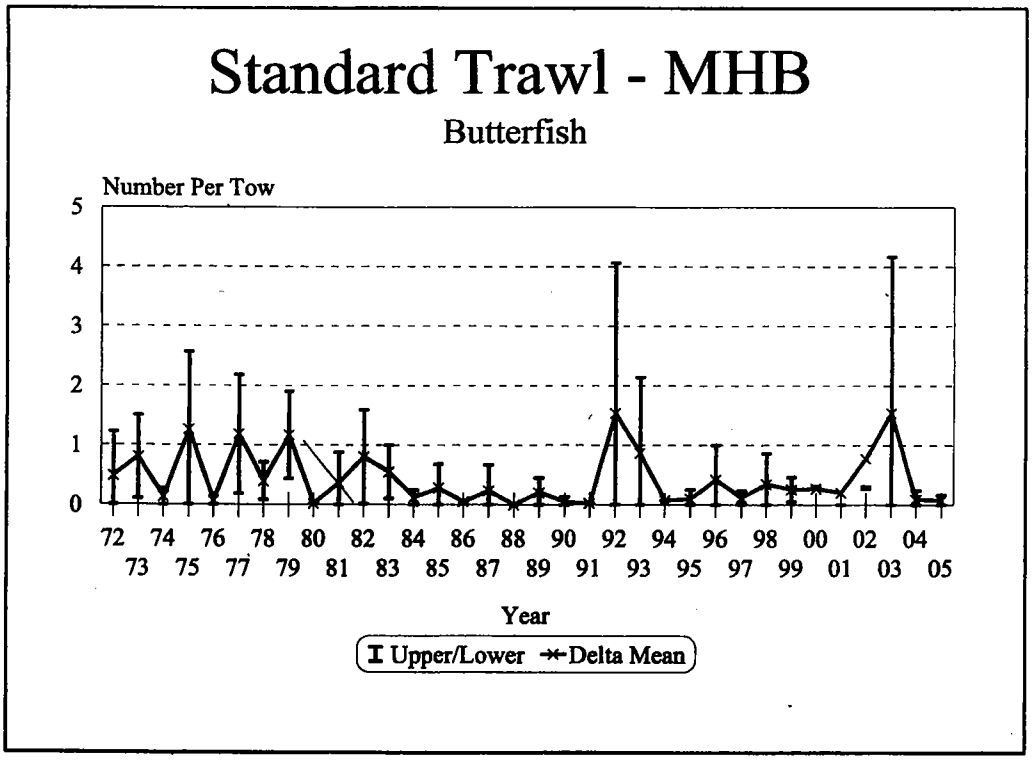


Figure 5-27. Annual delta means with confidence limits for butterfish collected by standard trawl in Mount Hope Bay, May-November 1972-2005

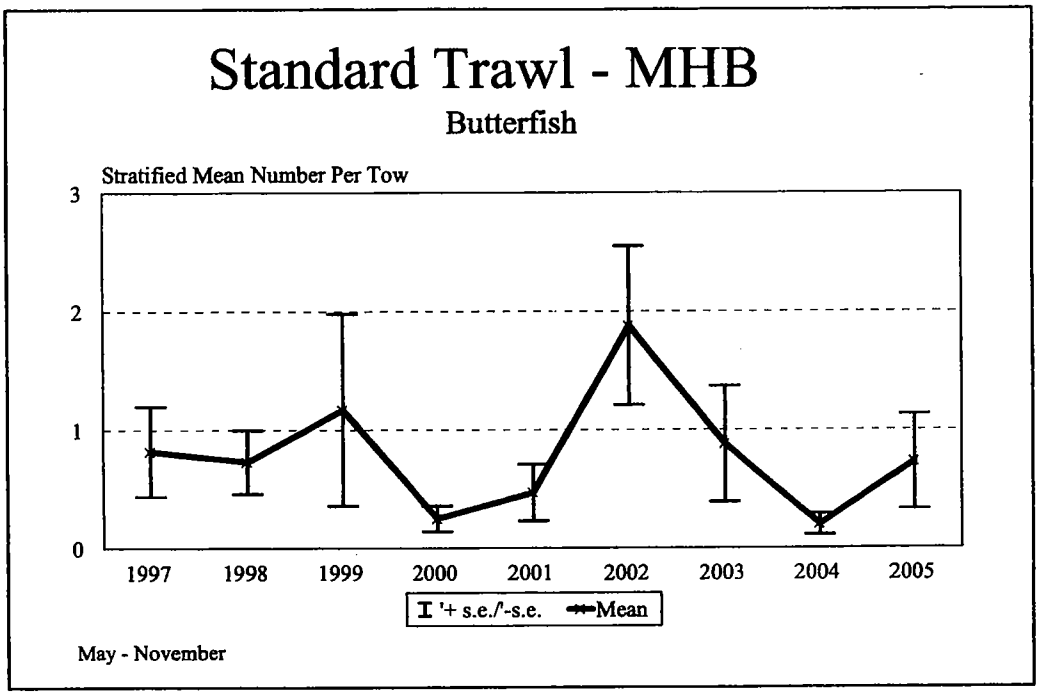


Figure 5-28. Stratified mean number per standard trawl tow for butterfish, 1997 – 2005

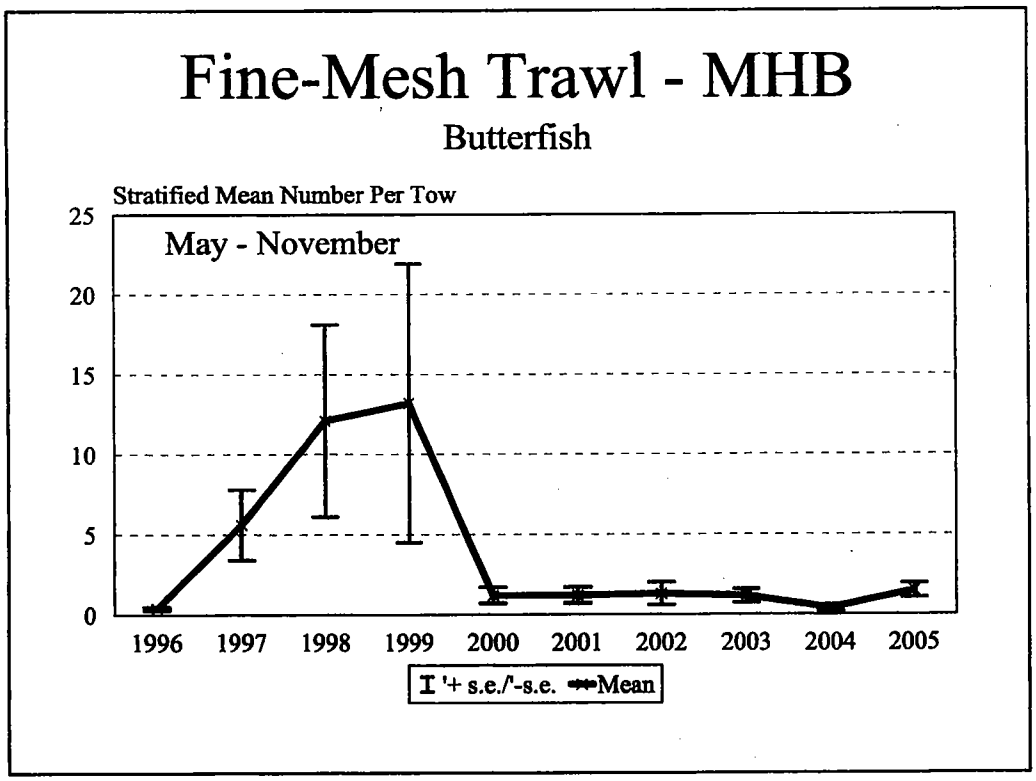


Figure 5-29. Annual stratified mean number of butterfish per tow collected with the fine-mesh Wilcox trawl in Mount Hope Bay, 1996-2005

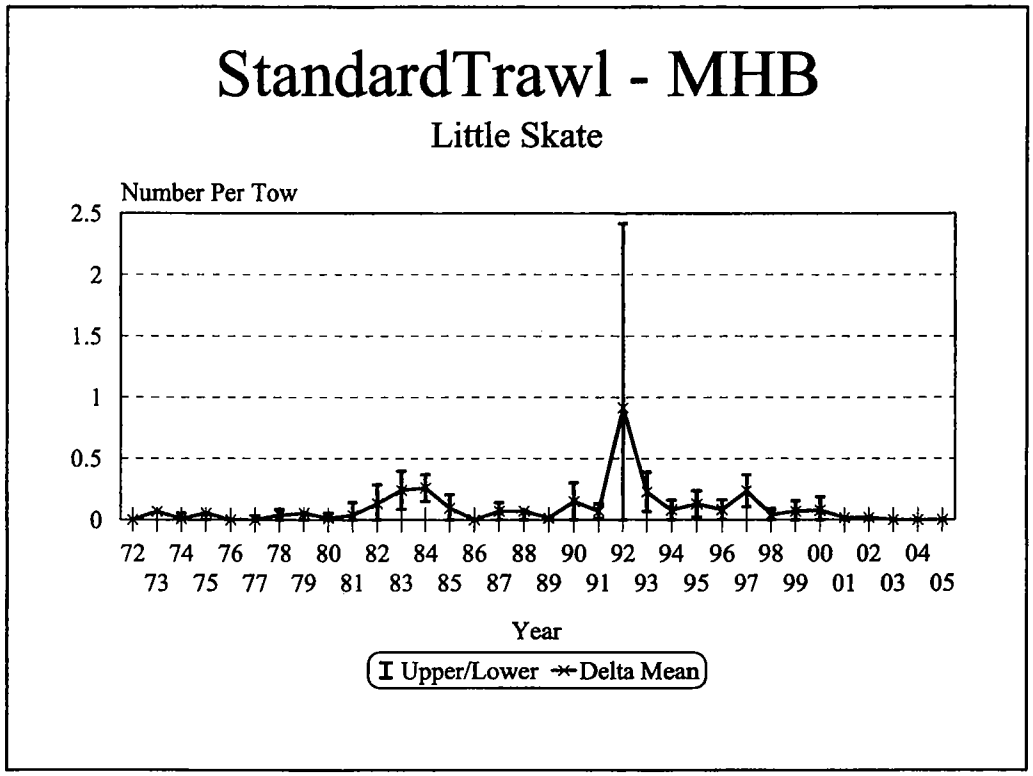


Figure 5-30. Annual delta means with confidence limits for little skate collected by standard trawl in Mount Hope Bay, 1972-2005

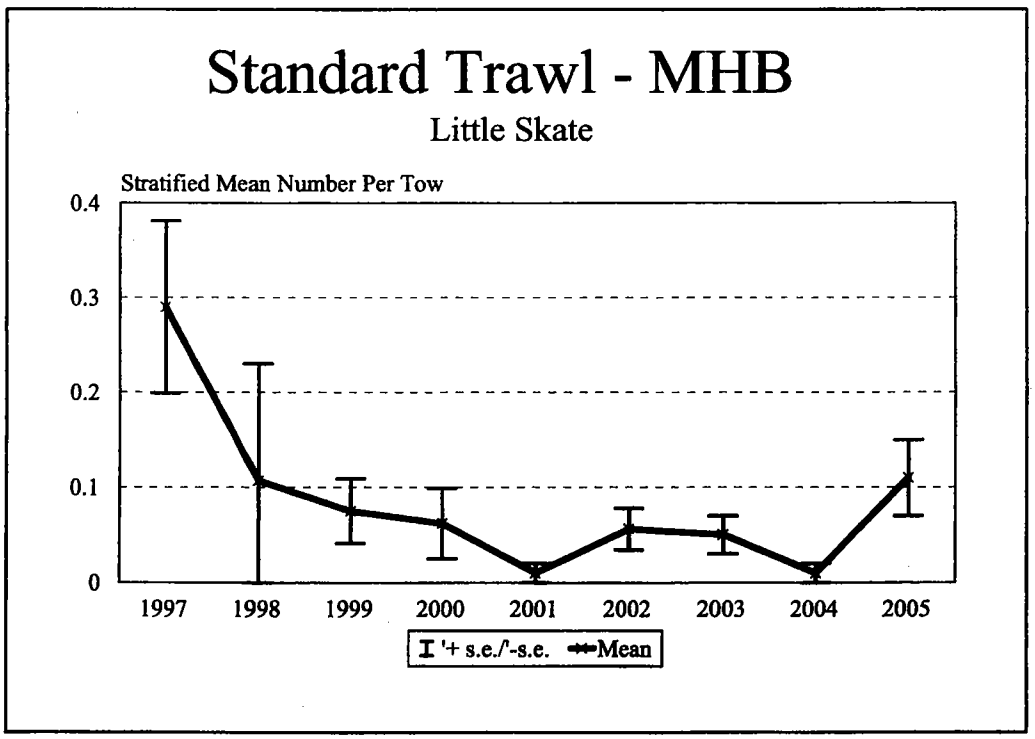


Figure 5-31. Stratified mean number per standard trawl tow for little skate, 1997-2005

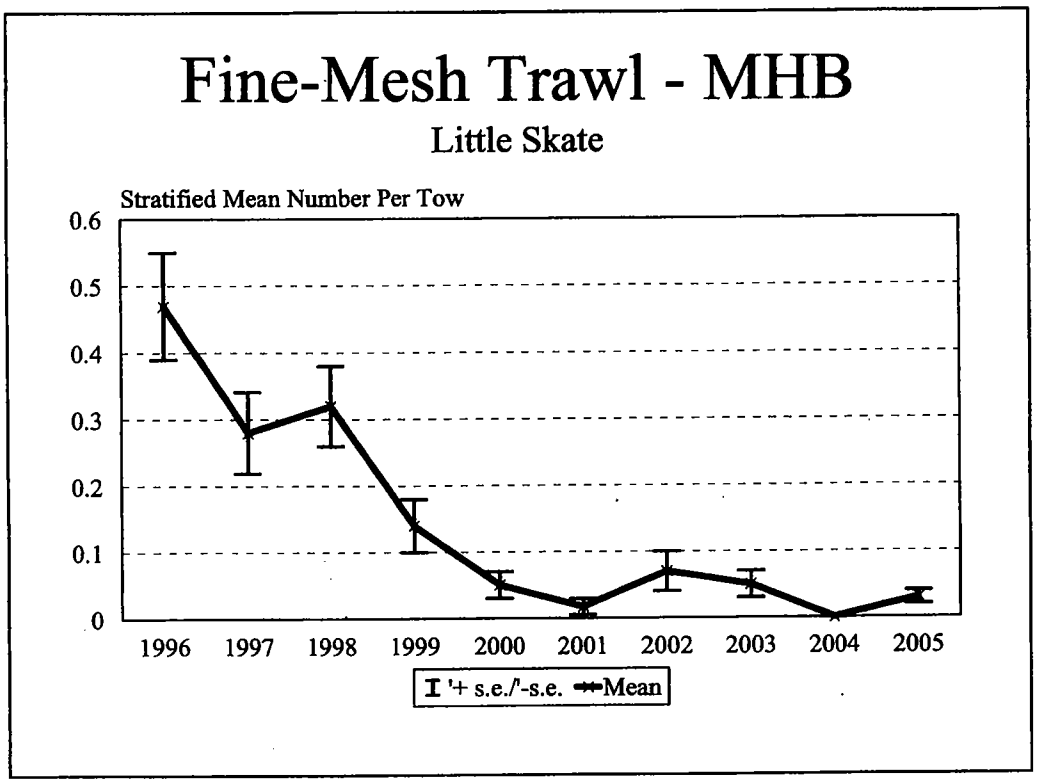
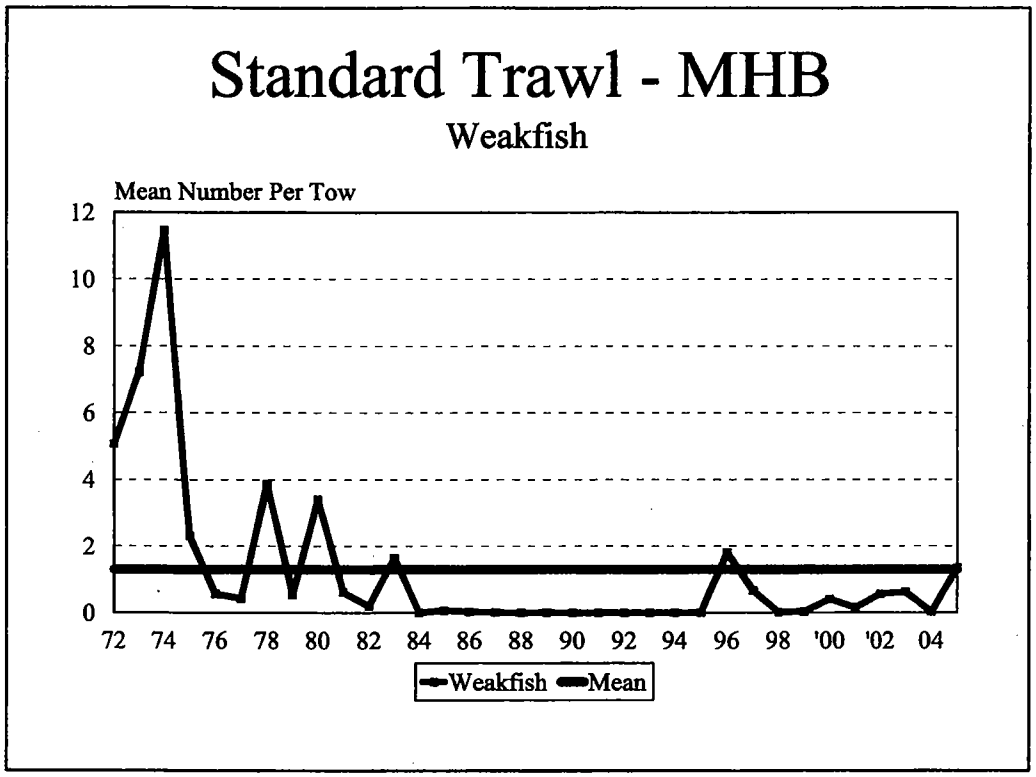


Figure 5-32. Annual stratified mean number of little skate per tow collected with the fine-mesh Wilcox trawl in Mount Hope Bay, 1996-2005



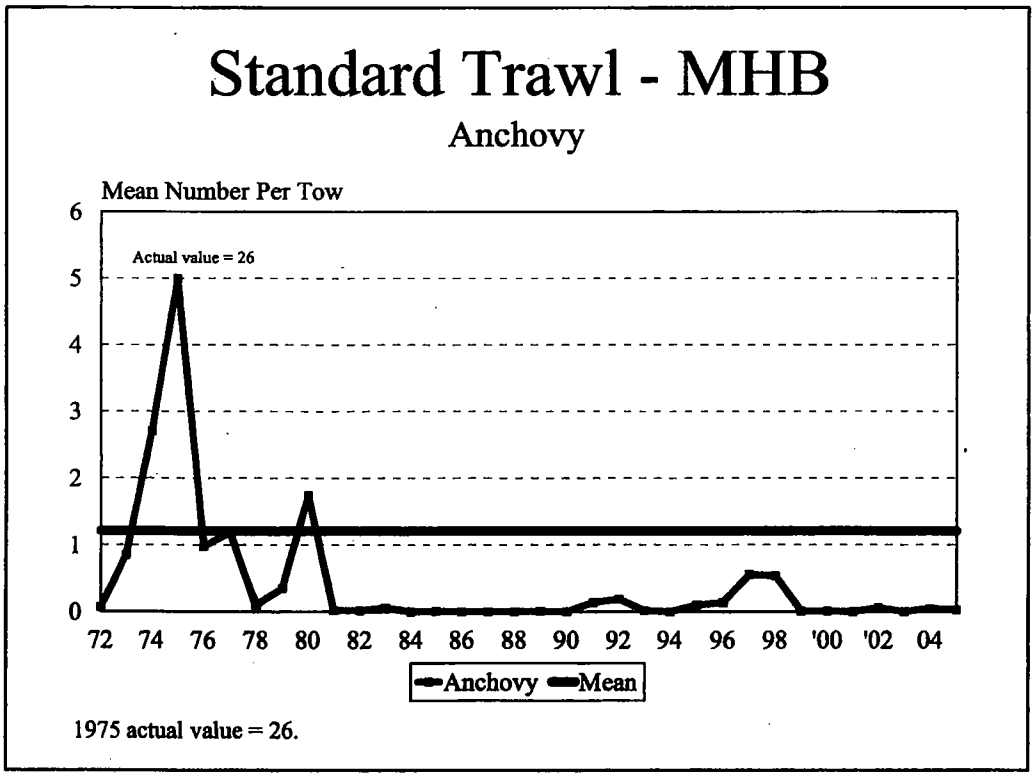
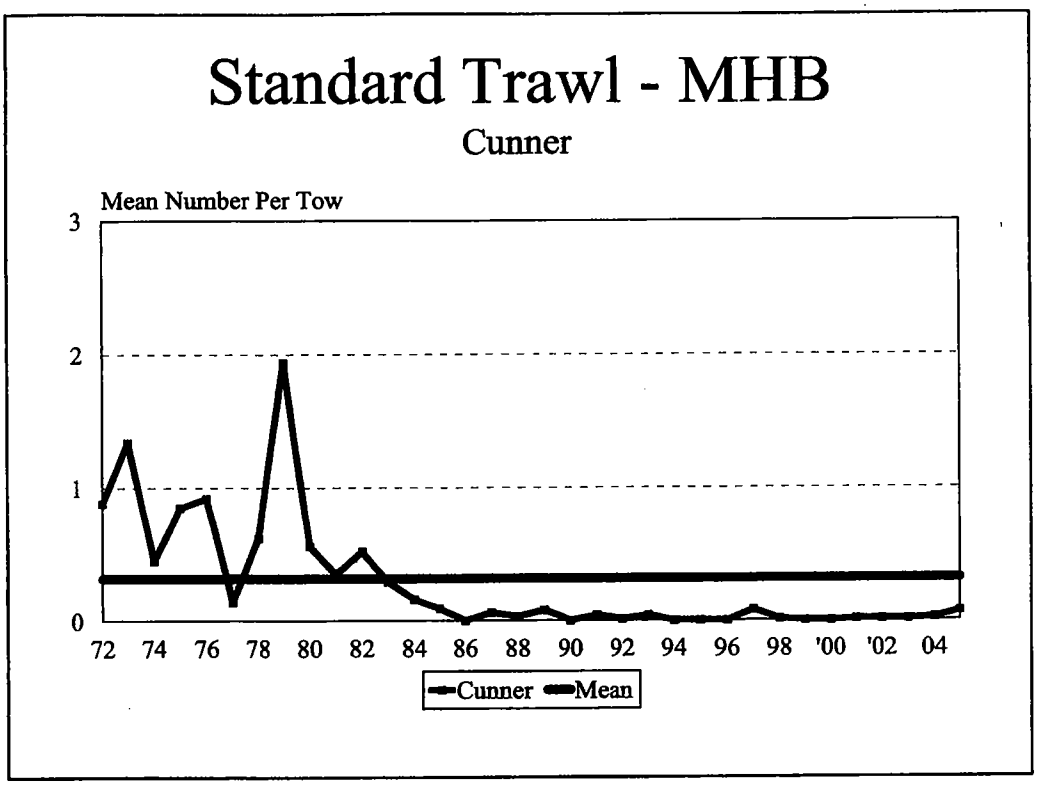


Figure 5-33. Mean number per standard trawl tow for weakfish (top) and bay anchovy (bottom), 1972-2005



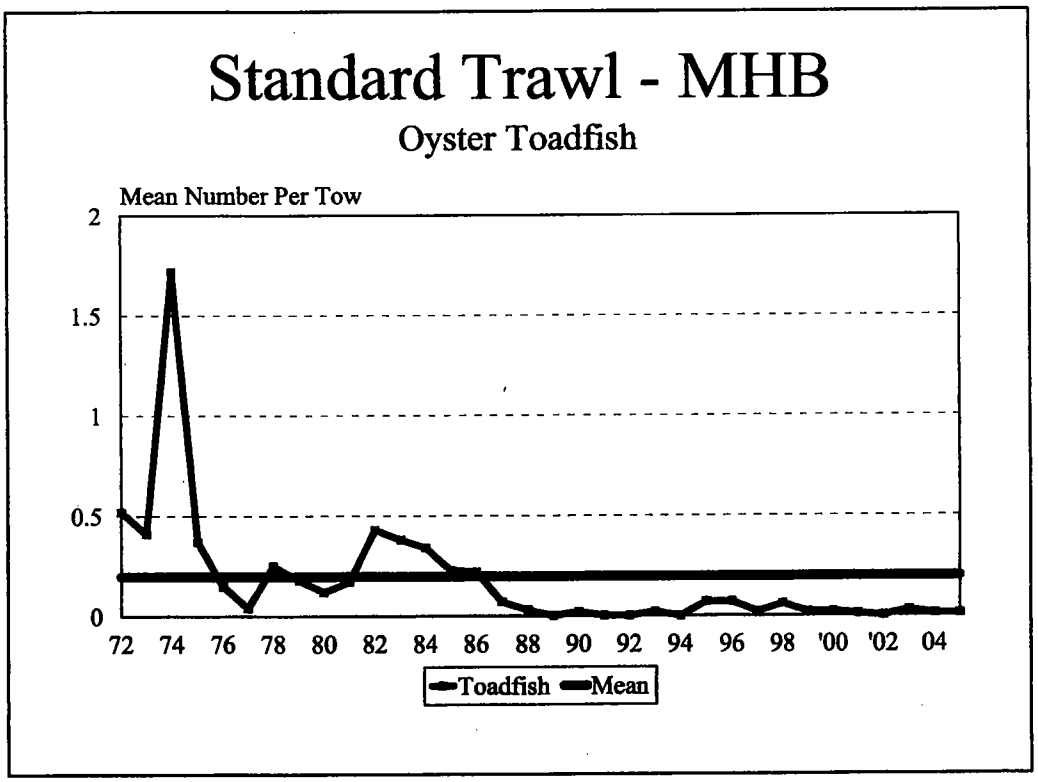
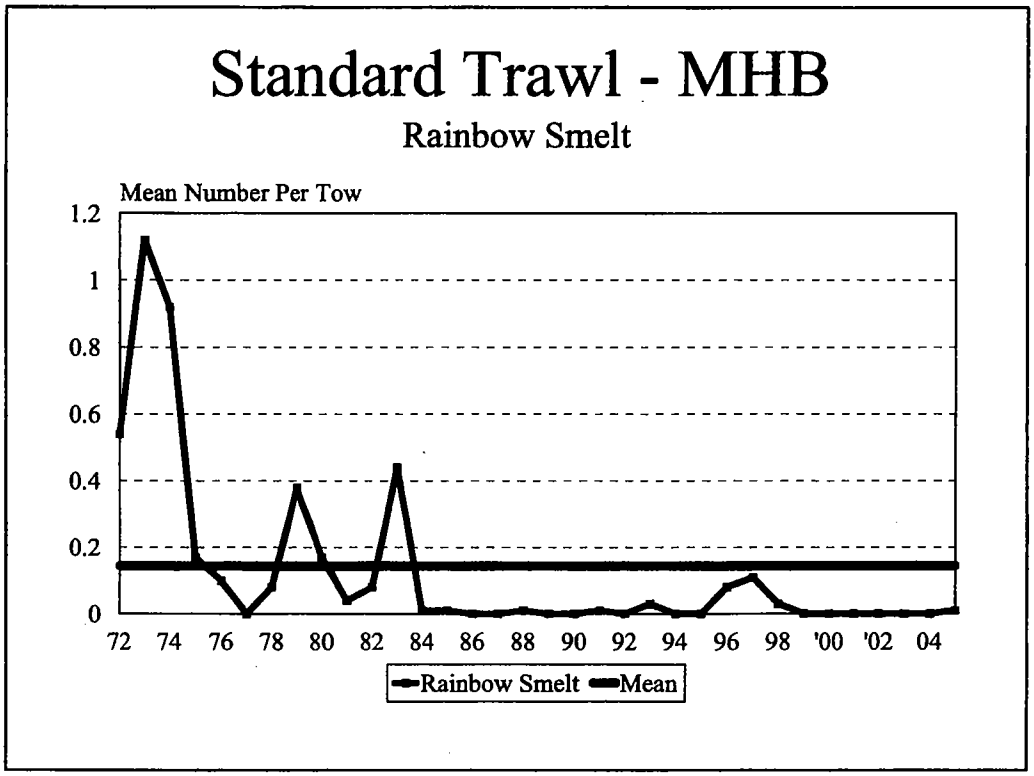


Figure 5-34 Mean number per standard trawl tow for cunner (top) and oyster toadfish (bottom), 1972-2005



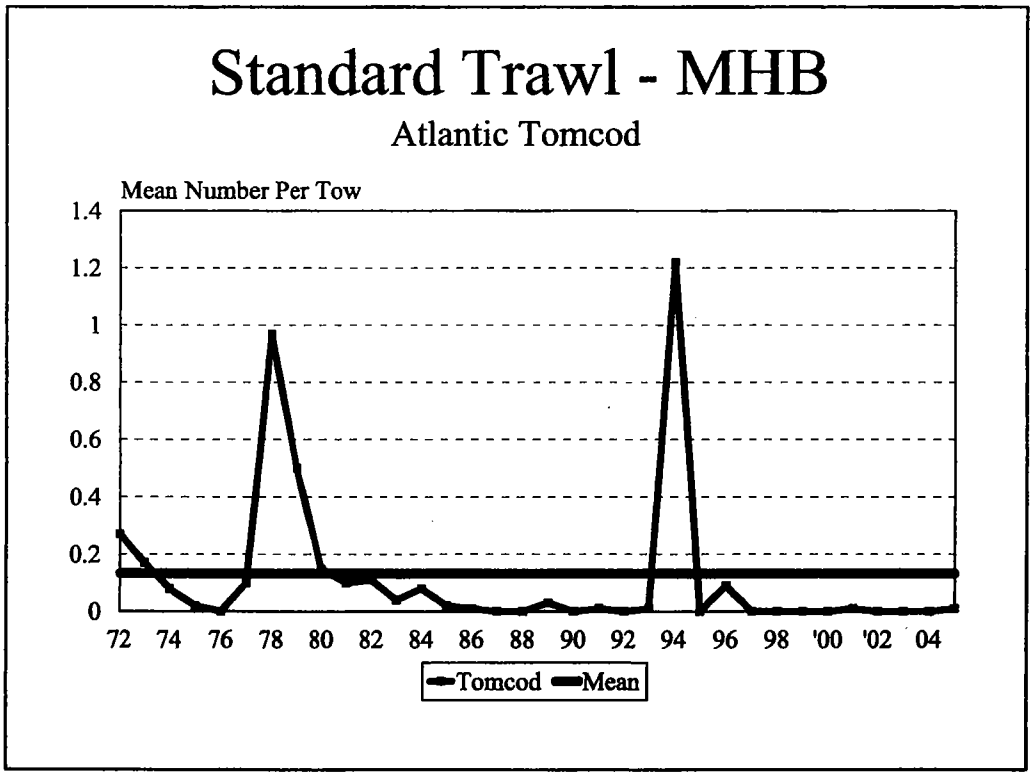


Figure 5-35. Mean number per standard trawl tow for rainbow smelt (top) and Atlantic tomcod (bottom), 1972-2005

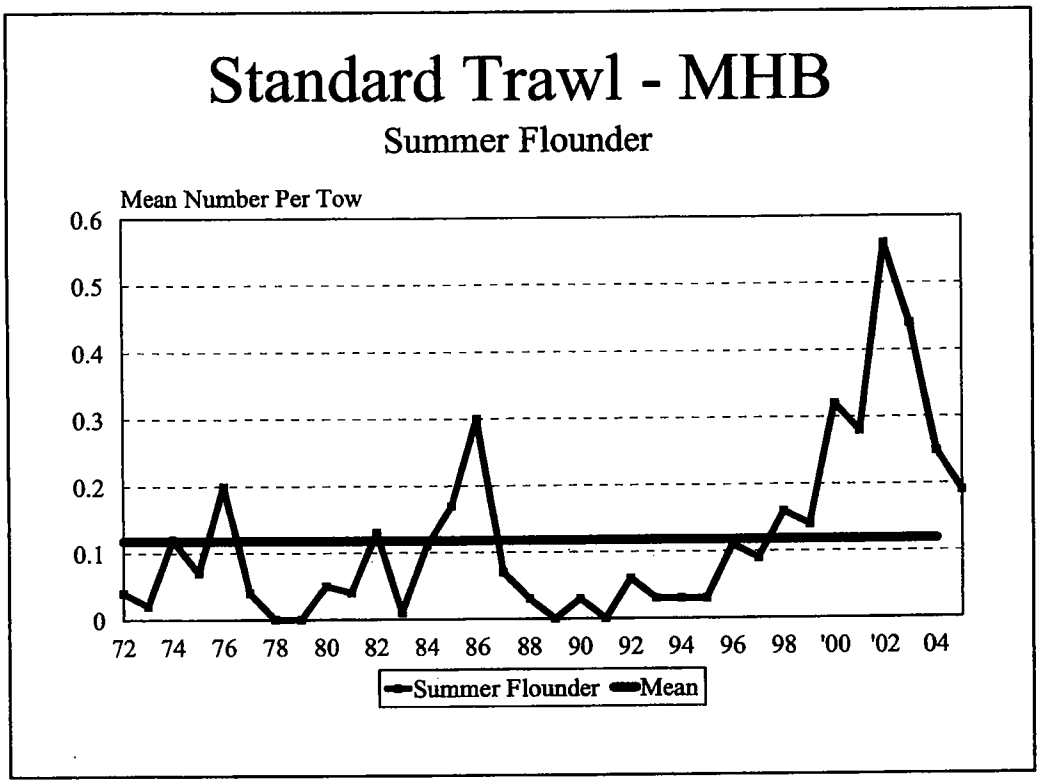


Figure 5-36. Mean number per standard trawl tow for summer flounder, 1972-2005

7 Beach Seine Studies

7.1 INTRODUCTION

A sampling program using 60- and 300-ft beach seines has been conducted since 1972 to document the near-shore abundance and community structure of young finfish in Mount Hope Bay. In 1992, an additional program using a 50-ft beach seine was initiated to focus specifically on young-of-the-year (YOY) winter flounder (*Pseudopleuronectes americanus*).

7.2 METHODS: 60- AND 300-FT BEACH SEINE PROGRAM

Details of the sampling protocol employed in the 60- and 300-ft beach seine program (also known as the "core" beach seine program), e.g., station locations, equipment used, and sampling schedule, are provided below. The analytical techniques applied to the collected data are also described.

7.2.1 Sampling Protocol

Table 7-1 summarizes the core beach seine program protocol. Figure 7-1 shows the locations of the four fixed stations at which sampling is performed: the Brayton Point Station Units 1, 2, and 3 intake, in the Cole and Lee rivers, and at Spar Island.

Sampling is done with two different bag seines: one measuring 60 ft (18.3 m) x 6 ft (1.8 m) with 1/8-in (3-mm) mesh, and the other measuring 300 ft (91.4 m) x 8 ft (2.4 m) with 1/2-in (12.5 mm) mesh. Over the years, no changes have been made to the core beach seine nets other than to replace worn gear as needed.

Each seine is hauled during daytime hours once per month at each station from March through October. On the day of sampling, each seine is hauled once off adjacent, non-overlapping areas of the beach. The large net is set by boat in a uniform semicircle as wind and tide will allow. The small net is set by anchoring one end at the shore's edge and then walking offshore to a depth of about 4 ft; from there the seine is walked parallel to the shoreline over a measured distance of 50 ft.

Consistently since the program began, sampling with the 60-ft seine has been done from March through October. Sampling with the 300-ft seine was done from June through August 1972–1980 and March through October 1981–2005. Complementing daytime seining, nighttime hauls were made at all stations during the 1973–1980 period (Table 7-1). While the program varied from year to year, night sampling typically occurred three

times during the summer using the 300-ft net at all stations and the 60-ft net at the Intake and Lee sites.

All fish are identified and counted, and total length is measured to the nearest millimeter for up to 50 individuals per species per haul. Surface water temperature is recorded at each station during the sampling event.

7.2.2 Data Analysis

Annual indices of abundance were calculated for the finfish species captured in each of the two seines. The 60-ft seine index specifies mean numbers of fish collected per haul at the four fixed stations during March–October, 1972–2005. For the 300-ft seine collections, two indices of abundance were generated because of the transition in months sampled from June–August to March–October in 1981. The first index covers the entire 1972–2005 period and was calculated as the annual mean June–August catch per haul at the four fixed stations. The second index was calculated in the same way but uses March-October data covering the 1981–2005 period. For consistency, only daytime hauls were included in the calculation of the three seine abundance indices.

Sign tests for trends (Sprent 1989; $\alpha = 0.05$) were applied to the three annual average catch-per-haul indices for numerically dominant species, over their entire respective time periods, to determine whether statistically significant trends were evident.

Long-term stability of the near-shore finfish community was evaluated through calculation of annual dominance diversity values (Whittaker 1965) for both the 300-ft seine (June–August 1972–2005) and the 60-ft seine (March–October 1972–2005). An annual dominance diversity value specifies the slope of the linear relationship between annual abundance expressed on a natural logarithmic scale and species rank. Relatively steep slopes indicate that individuals are concentrated among a small number of species. Long-term trend in dominance diversity over the 1972–2005 time series was evaluated for both gears using linear regression ($\alpha = 0.05$).

Analysis of variance (ANOVA; $\alpha = 0.05$) was applied to $\log_e$-transformed 300-ft seine catch data collected over the 1977–2005 period, with year and sampling station as main effects, to evaluate differences in catch among the four fixed stations. These years were analyzed because they represent the period of most consistent sampling (e.g., no Spar Island or Cole River sampling was performed during June and July 1975; also, no sampling was performed during July and August 1976 because the boat was being replaced). As a result of the $\log_e$ transformation, which was performed to meet the assumption of normality in the ANOVA model, this analysis produced geometric mean catch per haul at each station from 1977–2005 data. When significant differences were detected for the sampling station main effect in the ANOVA model, Newman-Keuls multiple-comparison tests ($\alpha = 0.05$) were completed to identify those stations whose catches were significantly different.

7.3 METHODS: YOUNG-OF-THE-YEAR WINTER FLOUNDER 50-FT BEACH SEINE PROGRAM

The primary objective of the YOY winter flounder beach seine program is to index spatial and temporal aspects of winter flounder abundance shortly after metamorphosis in the tributaries to Mount Hope Bay. An overview of the sampling protocol—e.g., station locations, equipment used, and sampling schedule—and the analytical techniques employed in the YOY winter flounder beach seine program are provided below. Changes made over the years to improve the monitoring program or to be responsive to changing bay conditions are also described.

7.3.1 Sampling Protocol

The YOY winter flounder beach seine sampling program was initiated in 1992, when 10 fixed sampling stations were selected from 23 Mount Hope Bay sites with suitable habitat, as described in Poole (1966) and Saucerman (1990). Habitat features of these saltwater coves include organic substrates with a minimum of 175 linear feet of seinable bottom and a good depth contour. The 10 fixed stations, which have been sampled each year since program inception, include four sites in the lower Taunton River, two each in the lower Lee and Cole rivers, one in the Kickamuit River, and one in the Brayton Point intake embayment (Figure 7-2, Table 7-2).

Beach seine hauls were collected from each of the 10 stations during two sampling surveys in June 1992. Beginning in 1993, the sampling effort was intensified both by increasing the number of annual sampling events from two June surveys to five surveys (two surveys each in June and July and one survey in August), and by increasing the number of stations sampled. Additional sites with suitable habitat were identified, resulting in a pool of 31 additional locations from which it would be possible to randomly select additional sampling stations each year. Between 1993 and 2005, in addition to the 10 fixed stations, between 4 and 11 randomly selected stations were sampled. Beginning in 1997, Station 13, initially a random station, was sampled on each occasion because hauls could be completed there independent of tidal stage. Table 7-2 indicates the number of stations sampled and sampling frequency from inception of the YOY winter flounder program through 2005.

During 1992 through 1994, triplicate samples were collected at each YOY winter flounder beach seine site. Beginning in 1995, in the interest of maintaining a three-day sampling effort while simultaneously increasing the total number of stations sampled, the number of hauls per station was reduced from three to two in cases where, in the first two hauls, inter-replicate variability was relatively low. Typically only two replicates were collected if numbers of winter flounder in the first and second hauls varied by 20% or less. Occasionally only two replicates were completed due to shoreline space limitations, which varied with tide and also with the growth of smooth cordgrass (*Spartina alterniflora*).

The gear used in the YOY winter flounder beach seine program is a 50-ft x 6-ft, ¼-inch mesh bag seine. The bottom line consists of conventional leads spaced one foot apart,

with an additional 50-ft length of lead core line secured to it. Each haul covers an estimated 2,300 ft² (214 m²). Occasionally, depending on tidal stage, the net could not be fully stretched offshore due to water depth, and in these cases the catch was scaled upward to the standard 2,300 ft^2 (214 m^2) set based on the actual bottom covered.

At each station, winter flounder were held in containers (aerated if necessary) until all replicates were completed. Then each fish was measured to the nearest millimeter in total length before release. Water temperature (°C), salinity (‰), and dissolved oxygen (mg/l) were recorded near shore and near bottom at each station.

7.3.2 Data Analysis

Annual indices of winter flounder abundance were generated for the YOY winter flounder captured in the beach seine collections. A 1993–2005 stratified index was calculated as the mean numbers of fish collected per haul during the five June–August sampling events. Additionally, because only June collections were made in 1992, a 1992–2005 stratified index was calculated as the mean numbers of winter flounder collected during the two June sampling events. Stratification in the above indices was performed by river based on the amount of shoreline in the survey area

Estimates of daily instantaneous mortality rates (Z_{day}) were calculated for each year, 1993–2005, from aggregated seine catches between the two July sampling events as:

$$Z_{day} = -\log_e(CPUE_2/CPUE_1)/t$$

where:

$CPUE_2$ = mean beach seine catch at second July survey
$CPUE_1$ = mean beach seine catch at first July survey
t = number of days between first and second July surveys.

July samples were used to calculate instantaneous mortality rates because in all years except 1998, a decline in catch was measured for this month. Daily instantaneous mortality rates were converted into monthly instantaneous mortality rates (Z_{month}) by multiplying the daily rate by thirty. It must be noted that it is not possible to separate actual mortality from movements to and from deeper water, nor can the confounding effects of changes in catchability as individuals grow be isolated and removed from this kind of analysis. Thus, these mortality estimates are considered loss rates and are recognized to be approximate.

Estimates of daily instantaneous growth rates (G_{day}) for the month of June were calculated for each year, 1992–2005, from aggregated seine catch between the two June sampling events as:

$$G_{day} = \log_e(Length_2/Length_1)/t$$

where:

$Length_2$ = mean length of beach seine catch at second June survey

$Length_1$ = mean length of beach seine catch at first June survey
t = number of days between first and second June surveys.

June samples alone allowed 1992 to be included and were less likely to be biased by movement of larger fish to deeper waters as the season progresses. Additionally, because growth was approximately linear over the four June and July sampling dates (a 42- to 55-day period) during 1993–2005, daily instantaneous summertime rates of growth were estimated using linear regression equations.

7.4 RESULTS

7.4.1 60- and 300-ft Beach Seine Program

7.4.1.1 2005 Catch Summary

In March through October 2005, the 60-ft and 300-ft beach seines collected a total of 11 and 15 species, respectively. Together, the two beach seine programs collected 19 different species. The greatest number of species taken occurred in July, when 11 species were caught—7 in the 300-ft seine and 8 in the 60-ft seine. In March, only two species were collected in 60-ft seine while no finfish were collected in the 300-ft seine. The next smallest number of species taken occurred in September, when 3 were caught—2 in the 300-ft seine and 3 in the 60-ft seine (Table 7-3).

A review of the catch by net indicates that four species accounted for 89% of the total catch in the large seine: bluefish, striped killifish, Atlantic silverside, and crevalle jack. Three species accounted for 99% of the catch in the small seine: Atlantic silverside, blueback herring, and striped killifish (Figures 7-3 and 7-4a through 7-4f).

Bluefish dominated numerically in the 300-ft seine catches, accounting for 60.6% of the total catch. This high proportion of the total catch is attributable to the catch of 272 individuals at the Spar Island station in August. Bluefish is a fast-swimming schooling fish, and the frequency with which it is caught varies considerably because of the species' high mobility, particularly within the intertidal zone. As a result, the proportion of bluefish in the 300-ft seine total catch has been highly variable over the tenure of the program. Bluefish are not typically caught with the same frequency in the 60-ft seine as in the 300-ft seine, which samples deeper water.

Silversides dominated numerically within the near-shore fish community, accounting for 78.7% of the 60-ft seine catch. Silversides were particularly abundant in this gear beginning in July 2005, when YOY fish reached about 30 mm total length, a size sufficiently large to permit retention by the 1/8-in mesh of this gear. During the two July sampling events and the August sampling event, juvenile silversides were captured in relatively high numbers in the 60-ft seine (1170, 1339, and 1388, respectively). Collections of silversides with the 300-ft seine made up just 4.5% of the total large-net

catch, likely because these fusiform-shaped species are able to pass through the gear's ½-in mesh.

7.4.1.2 Finfish Abundance Differences Among Sampling Stations (1977-2005)

Catch data collected with the 300-ft seine over the 1977–2005 time series were used to evaluate differences in capture rates of the dominant species among sampling stations. As detailed in section 7.2.2, these years were analyzed because they represents the period of most consistent sampling. Analysis of variance (ANOVA) was used to analyze collections of alewife, silversides, mummichog, bluefish, and striped killifish. Multiple comparison tests were run on the data only for cases where ANOVA found a significant station effect. Statistically significant station effects ($p < 0.05$) were detected for all species except alewife. In the discussion that follows, all fish-per-seine-haul values are geometric means calculated from the ANOVA.

Numbers of alewife were greatest at Spar Island (4.4 per haul) followed by Lee River (2.4 per haul), Cole River (1.5 per haul) and Intake (0.6 per haul). ANOVA detected a significant difference between two of the stations ($p = 0.010$), Spar Island and Intake.

A significant difference among stations was also detected for silversides ($p = 0.010$) from the ANOVA. Collections of this species were highest at Cole River (14.0 per haul), followed by Lee River (8.9 per haul), Spar Island (6.0 per haul) and Intake (5.6 per haul). Multiple comparison tests showed a statistically significant difference in catch between Cole River and both Spar Island and Intake. Mean catch at Spar and Intake were not found to be different from each other. Mean catch at Lee River was intermediate between the Cole River and Spar-Intake catches and not statistically different from either of those two groups.

For mummichog large enough to be retained by the ½-in mesh of the large seine, ANOVA detected a highly significant station effect ($p < 0.0001$). Averaged over the time series, mummichog collections were highest at Intake (3.1 per haul), followed by Cole River (0.7 per haul), Lee River (0.6 per haul), and Spar Island (0.1 per haul). Multiple comparison tests showed that mummichog collections at Intake were significantly different from those taken at the other three stations, which were not found to be different from each other.

Striped killifish were found to have a highly significant station effect ($p < 0.0001$). Multiple comparison tests indicated that stations formed two groups. Cole River (7.0 per haul) and Intake (5.4 per haul) were not statistically different from each other, but both were significantly greater than the catches at Spar Island (0.3 per haul) and Lee River (0.7 per haul). Mean catch at the latter two stations were not statistically different from each other.

The station effect in the ANOVA for bluefish was not statistically significant ($p = 0.123$). Over the time series the Intake station produced the highest catches (mean = 14.9 per

haul). Lee River, Cole River, and Spar Island followed in descending order with respective means of 10.3, 7.2, and 6.5 per haul.

Overall, this analysis showed that while there are differences in the abundance of certain species across stations, that difference is not consistent across species suggesting that a complex of habitats exists at the stations sampled in Mount Hope Bay.

7.4.1.3 Trends in Finfish Abundance (1972-2005)

Over the 1972–2005 core beach seine time series, silversides, alewife, bluefish, mummichog, and striped killifish have been the numerically dominant species. Changes in catch among each of these species over the 1972–2005 period are discussed below.

Alewife

No alewife were collected during 2005 sampling with the 60-ft seine. This has occurred during nine of the 34 years of sampling with this gear, but generally prior to 1989 (Table 7-4). For the 300-ft seine summer hauls (i.e., June through August), the 2005 alewife mean catch of 0.7 per haul was well below the 1972-2004 series mean of 32.8 per haul (Table 7-5; Figure 7-5a). Similarly, for the 1981–2005 March through October time series, 2005 alewife mean catch (0.3) was well below the time-series mean of 15.2 (Table 7-6). While no significant time-series trend was noted for alewives their numbers in both nets have generally increased since approximately 1990. The fact that 2005 catches were low relative to other post-1990 values is not unusual given the highly variable nature of alewife catches.

Silversides

Silversides (primarily YOY fish) have consistently been dominant species in the Mount Hope Bay near-shore fish community as indexed in the core beach seine program. The 60-ft seine annual mean catch per haul ranged from a low of 57 in 1979 to a high of 1,409 in 1993 (Table 7-4). The 2005 mean of 189.5 per haul, however, was less than half of the 1972–2004 time-series mean of 535.7 per haul. While not statistically significant over the entire 1972–2005 time series, 60-ft seine silverside mean catch increased from the 1972–1980 period, when they were found in numbers ranging from 57 to 379 per haul, to the 1982–1994 period, when they ranged from 315 to 1,409 per haul. Catches have been variable since the early 1990s and the 2005 catch represents a relative low for the more recent period.

Silversides collected in the large seine were one-year-old spawning-age fish and larger YOY. During June, July, and August of the 1972–2005 period, silverside abundance ranged from less than one fish in 1976 and 2002 to the time-series high of 157 in 1977 (Table 7-5; Figure 7-5b). In 2005, the mean of 0.8 silversides per haul was 2.5% of the June through August 1972–2004 mean of 32.2 fish per haul. For the March through October 2005 large-seine collections, the mean of 0.7 fish per haul was 3.3% of the March through October 1981–2004 mean of 21.5 fish per haul (Table 7-6). Silverside abundance in the large seine for both the June through August and March through October sampling seasons varied without significant trend until 1998 when they began an apparent downward trend. Over the two respective time series a significant downward

trend was detected for the 1972-2005 period (June-August; p = 0.006) but not for the 1981-2005 series (March-October).

Striped Killifish

Striped killifish were caught with the 60-ft net in 2005 at a mean of 5.0 fish per haul compared to the times series mean of 27.7 fish per haul. This is low relative to recent years including 2002 and 2003 which ranked third and eighth highest, respectively, over the 1972–2005 time series. In general, catches of striped killifish in the 60-ft net have shown an increasing trend over the 1972–2005 series although this trend was not significant based on the sign test (Figure 7-5c).

Catches of striped killifish in the 300-ft net typically are lower than in the 60-ft net in spite of its greater areal coverage due to the greater mesh size of that net. The striped killifish March through –October 2005 mean catch of 3.2 per haul in the large seine was below 1981–2004 time-series mean of 4.1 fish per haul (Table 7-6). Striped killifish are generally more abundant in the summer period; 2005 June through August collections produced a mean catch of 8.3 fish per haul, above the 1972–2004 time-series mean of 6.7 fish per haul (Table 7-5). No significant long-term trend was detected in either large seine index.

Mummichog

Mummichog were relatively uncommon in 2005 in both the 60- and 300-ft seine collections. Collections in the 60-ft net averaged 2.0 fish per haul, well below the time-series mean of 25.1 fish per haul (Table 7-4). Mummichog mean catch in the 60-ft seine gradually increased from 1978 to 1996 then declined for several years before increasing from 2001 to 2003 and declining thereafter. Over the entire time series (1972–2005) there has been no significant trend in abundance (Figure 7-5d).

As is true for striped killifish, mummichog are caught less often in the 300-ft seine, probably because many individuals pass through that gear's larger mesh. The 2005 mummichog mean summer catch was below-average compared to summer 1972–2004 large-seine time-series catches, with a mean of 0.2 fish per haul compared with the time-series mean of 3.1 fish per haul (Table 7-5). Mummichog appeared uncommon in 1976 and 1977 when none were taken in the 300-ft net. Over the March–October large-seine time series, a 2005 mean of 0.1 per haul was obtained, 10% of the 1981–2004 time-series mean of 1.0 per haul (Table 7-6). Over both 300-ft long-term time series (1972–2005 and 1981–2005), mummichog abundance has varied without significant trend.

Bluefish

Bluefish are not typically caught with the same frequency in the 60-ft seine as in the 300-ft seine, which samples deeper water. In 2005, the bluefish catch in the 60-ft seine (0.13 fish per haul) was well below the 1972–2004 time-series average of 0.55 per haul (Table 7-4). Bluefish collections in the 300-ft seine for the 2005 summer period averaged 22.8 fish per haul, just below the 1972–2004 time series mean of 23.8 (Table 7-5; Figure 7-5e). Over the March through October 1981–2005 sampling period, the 2005 300-ft seine

bluefish collection averaged 9.5 fish per haul, also just below the 1981–2004 time-series mean of 12.8 fish per haul (Table 7-6).

Bluefish is a fast-swimming schooling fish, and the frequency with which it is caught varies considerably because of the species' high mobility, particularly within the intertidal zone. Bluefish mean catch in the seine collections has shown four- to five-year periods of increasing abundance (e.g., 1983–1987) followed by five- to six-year periods of decreasing abundance (1987–1991). Over all three long-term time series, however, bluefish collections have varied without significant trend.

Atlantic Menhaden

Atlantic menhaden capture rates have varied considerably in both the 60- and 300-ft seines, most likely due to the relative large size and dense nature of the schools and natural fluctuations in year-class strength (Figure 7-5f). Atlantic menhaden have not been collected consistently every year and in fact have been present in the catch only about half the time. Numbers in the seine also do not reflect strong year classes known to be produced in the region such as those in 1999 (see Chapter 6 Revolving Screen Studies).

Menhaden were not captured in the 60-ft seine in 2005 and have only been captured in the smaller net in 13 years of the 34-year series (Table 7-4). The time series mean was 1.0 per haul, a value that reflects the likelihood that this species does not often move into the shallow near-shore waters sampled by the small seine. In 2005, the menhaden summer catch in the 300-ft seine (0.6 fish per haul) represented a below average catch of this species in the 1972–2004 time series, which had an overall mean of 21.1 menhaden per haul (Table 7-5). Over the March through October 1981–2005 period, the 2005 300-ft seine mean menhaden catch (0.2 fish per haul) ranked relatively low across the time series and represented 1.6% of the 1981–2004 time series mean of 12.3 per haul (Table 7-6). No trends were detected in the menhaden catch over the time series.

Other Species Captured

Among the remaining, less abundant species in the seine collections, Atlanitc cod was collected in the 60-ft seine during 2005 for the first time with either seine gear. The same is true of the collection of red hake in the 300-ft seine in 2005. Striped searobin were captured with the 60-ft net during 2005 for the second time since 1972. Striped searobin have been captured during four years with the 300-ft net.

7.4.1.4 Dominance Diversity

Dominance diversity values calculated for 2005 for both the 60-ft (March through October) and 300-ft (June through August) seines were within the range of values for the 1972–2004 historical period (Figure 7-6). Evaluation of trend in dominance diversity values over the historical period indicates no evidence of long-term change in the community structure of the finfish sampled with these gears (60-ft seine: slope = 0.0021, $p = 0.62207$; 300-ft seine: slope = 0.00192, $p = 0.56980$). Overall, the dominance diversity evaluation suggests that the Mount Hope Bay near-shore finfish community has remained stable since 1972 with respect to dominance diversity.

7.4.2 Young-of-the-Year Winter Flounder 50-Ft Beach Seine Program

7.4.2.1 2005 Catch Summary

Catches of YOY winter flounder in 2005 were typical of the 1992-2005 time series. The 2005 June stratified mean (4.9) and summer stratified mean (5.1) (all five sampling events) winter flounder beach seine catch per haul values were the eighth and sixth highest of their time series, respectively. Winter flounder seine catches in 2005 are summarized by station and sample date in Table 7-7.

Consistent with all previous years except 1996 and 1999, numbers of winter flounder increased from the first to the second survey conducted each June, suggesting that young winter flounder continued to move into shoal areas during this month. In 2005, stratified mean abundance generally followed a declining trend after the second June sampling event (Figure 7-7). This is consistent with Sogard et al. (2001) who suggested that newly settled winter flounder in New Jersey estuaries disperse from early settlement sites which may contain high densities as a result of local hydrodynamics.

In 2005, the Cole River stations produced the highest mean catch values during June through the first July sampling event. Thereafter, Taunton River produced the highest mean catches. Viewing the catch by river system, 2005 collections completed in June averaged highest in the Cole River followed by the Lee River, the Taunton River, and the Kickamuit River (Figure 7-8). The same catch ranking persisted when catches were averaged over the five summer sampling series (Figure 7-9).

7.4.2.2 Long-Term Abundance Trends

Over the 1992-2005 sampling period, June YOY winter flounder catch has been variable but generally increasing since 1993. However, mean catch during 2005 (4.9 per haul) was lower than those recorded for 2001 through 2004 (Figure 7-10, Table 7-8). Considering all five surveys completed during June, July, and August, a summertime mean of 5.1 winter flounder per haul was obtained in 2005, ranking sixth highest in the 1993-2005 summer time series (Figure 7-11, Table 7-9). Overall, YOY winter flounder abundance appears to have been higher in Mount Hope Bay in the 2000s relative to the 1990s and 2005 maintains that trend.

7.4.2.3 YOY Winter Flounder Mortality Rates

Since young winter flounder are reported to move relatively little during the summer (Saucerman and Deegan 1991), catch per seine haul can be used to approximate natural mortality rates. However, since it is not possible to separate mortality from, for example, movements in and out of the sampling area and changes in catchability resulting from growth, these estimates are considered loss rates and are recognized to be approximate. Jager et al. (1995) applied the phrase "instantaneous rate of decrease" to account for the confounding effects of movement.

During each YOY winter flounder season except for 1996 and 1999, stratified mean catch per haul increased from the first to second June sampling series, suggesting that young winter flounder continue to disperse into shoal areas during that period. Whether these are individuals metamorphosing in the open waters of Mount Hope Bay that then move inshore is unknown. Beyond the typical increase in catch between the first and second June series, various differences have occurred among the 13 years of the time series. For example, in some years catch has progressively declined over time following June (1995), progressively increased over the first three surveys and then declined (1997 and 2000), or varied both up and down from one series to the next through the summer (1993 and 1994).

Focusing on the decline in catch between the two July series, common to all years except 1998, the change in stratified mean number per haul over the two-week period provided monthly mortality rates ranging from 0.18 in 2001 to 0.84 in 1996. These are equivalent to monthly survival rates of 0.82 and 0.16, respectively. In 2005 the calculated monthly mortality rate was a fairly typical 0.47 (survival = 0.53). The 1997 through 2002 survival values reversed an increase in mortality rates observed from 1994 through 1996; survival rates declined somewhat during 2001 through 2005 (Figure 7-12, Table 7-10). These trends in survival rates are consistent with the observation of higher YOY winter flounder abundance in the 2000s relative to the 1990s.

7.4.2.4 YOY Winter Flounder Growth

Young-of-the-year growth-in-length patterns for each year in which young winter flounder were sampled are shown in Figure 7-13 and Table 7-11. Mean total length when sampling commenced each year (second week of June) ranged from 38.6 mm in 1998 to 51.2 mm in 1999. Five seasons (1996, 1997, 1998, 2002 and 2003) of the thirteen in the current time series showed apparent continued growth into the August sampling period. In each of the remaining years, mean length dropped by 0.3 to 3.9 mm between the second July and August sampling dates, suggesting that larger individuals moved to deeper water late in summer leaving smaller fish behind during these years. For 2005 the average size decreaed by 1.8 mm for this period. Absolute growth in length measured during August sampling was greatest in 1996 (mean total length = 67.0 mm, s.e. = 0.9), 4.8 mm larger then in 2004, the second highest year. Absolute growth in August 2005 was a relatively large 60.1 mm (s.e. = 0.9). Growth appeared slowest in 1995 (August mean = 51.5 mm, s.e. = 1.4) although the greatest observed drop in length also occurred into August of that year along with a pronounced drop in catch.

Daily instantaneous growth rate, 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) and slowest in 2000 (G = 0.0036). Daily instantaneous growth rate for June 2005 was 0.0118 (Table 7-11). Daily growth ranged from 0.17 (2000) to 0.77 mm (1998) averaging 0.47 mm for 1992-2005, assuming growth to be linear over the 14 to 15 day period between the two June sampling periods (Figure 7-14). Daily growth rate in June 2005 was 0.64 mm. Consistent with Sogard (1991) and Meng et al. (2000), growth appeared to be most rapid early in summer, declining later in July and August. However,

as mentioned above, this pattern is likely confounded by late season movement to deeper water.

Consistent with the observed growth rates, mean lengths attained in Mount Hope Bay tributaries over the past eleven seasons were also similar to mean lengths recorded in Rhode Island coastal ponds in 1996 (Gray 1996) and 2000 (Temple 2001). Similar lengths were also obtained in five Long Island Sound river systems (48-67 mm TL, July-August 1991-1993; Howell and Molnar 1995). Similar observations have been made with young-of-the year plaice, *Pleuronectes platessa,* a congener with similar life history (Zijlstra et al. 1982, Van Der Veer 1986).

7.5 CONCLUSIONS

Analyses of data collected in the 60- and 300-ft beach seine program found no long-term statistically significant declines apparent for the species examined except silversides. For this species, a single significant decline was noted out of the three indices of abundance that were examined. In addition to the apparent stability of various individual species abundance, the near-shore fish community as a whole has been and remains quite stable, as evidenced by a lack of significant temporal trend in the dominance diversity index calculated for both seines.

Analyses of data collected in the YOY winter flounder beach seine program suggest increases in winter flounder abundance since 1993. While YOY winter flounder catches have been somewhat variable over the 1992-2005 period, there appears to be an increasing trend in the YOY winter flounder catch since 1993. Catches in recent years (2001 through 2003) have yielded the highest average catches on record in June through August sampling, with the 2003 catch being the highest among them. The 2005 mean catch rate estimated from the five surveys conducted from June to August ranked sixth highest in the 1993-2005 time series. Similarly, 2005 mean catch rate estimated from the two surveys conducted in June ranked eighth highest in the 1992-2005 time series. Observed growth rates in 2005 are in line with those calculated in other studies in the region.

7.6 REFERENCES

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7.7 TABLES

Table 7-1. 60- and 300-ft seine (core beach seine program) sampling protocol, 1972-2005

Stations Sampled	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981 - 2005
Cole										
Lee										
Intake										
Spar										
Months Sampled										
60-ft seine										
March-October										
300-ft seine										
June-August										
March-October										
Sampling Time of Day										
Daytime - as indicated above										
Nighttime: June, July										

Table 7-2. Program summary for Mount Hope Bay young-of-the-year winter flounder seine survey, 1992-2005

Stations Sampled	1992	1993	1994	1995 - 2005
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		■	■	■

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

Table 7-3. Species and numbers of finfish collected by 300-ft and 60-ft (300/60) beach seines (page 1 of 3)

30 March 2005						
Station:		Intake	Spar	Cole	Lee	Total
Temp. (C):		5.8	5.5	6.9	7.0	
Gadus morhua	Atlantic cod				0/2	0/2
Menidia menidia	Atlantic silverside	0/3				0/3
22 April 2005						
Station:		Intake	Spar	Cole	Lee	Total
Temp. (C):		11.6	11.6	13.5	13.6	
Microgadus tomcod	Atlantic tomcod			0/1		0/1
Fundulus heteroclitus	Mummichog			1/0		1/0
F. majalis	Striped killifish	0/1		0/1		0/2
Menidia menidia	Atlantic silverside		0/7	3/21	0/52	3/80
Syngnathus fuscus	Northern pipefish	1/0		2/3	0/2	3/5
Pseudopleuronectes americanus	Winter flounder	5/1		2/0		7/1
27 May 2005						
Station:		Intake	Spar	Cole	Lee	Total
Temp. (C):						
Microgadus tomcod	Atlantic tomcod	1/5				1/5
F. majalis	Striped killifish			0/2		0/2
Menidia menidia	Atlantic silverside	0/1		3/0	6/57	9/58
Tautoga onitis	Tautog		3/0			3/0

Table 7-3. Species and numbers of finfish collected by 300-ft and 60-ft (300/60) beach seines (page 2 of 3)

1 July 2005 (for June)						
Station:		Intake	Spar	Cole	Lee	Total
Temp. (C):		22.6	23.4	24.1	23.6	
Alosa aestivalis	Blueback herrring	0/720		0/1	0/620	0/1341
Microgadus tomcod	Atlantic tomcod				0/1	0/1
Fundulus heteroclitus	Mummichog	2/0				2/0
F. majalis	Striped killifish	85/0		11/20	0/1	96/21
Menidia menidia	Atlantic silverside	1/0	0/30	0/20	0/1120	1/1170
Morone saxatilis	Striped bass		1/0	3/0		4/0
Tautoga onitis	Tautog	5/0	1/0		0/4	6/4
Pseudopleuronectes americanus	Winter flounder	1/0				1/0
28 July 2005						
Station:		Intake	Spar	Cole	Lee	Total
Temp. (C):		25.98	24.4	26.5	25.2	
Alosa pseudoharengus	Alewife		8/0			8/0
Microgadus tomcod	Atlantic tomcod				1/0	1/0
Urophycis chuss	Red hake	0/1		2/0		2/1
Fundulus heteroclitus	Mummichog	0/15		0/6	0/2	0/23
F. majalis	Striped killifish	0/2		2/40	0/4	2/46
Menidia menidia	Atlantic silverside	0/104	2/682	7/153	0/400	9/1339
Syngnathus fuscus	Northern pipefish	0/1				0/1
Prionotus evolans	Striped searobin	0/1				0/1
Cynoscion regalis	Weakfish				3/0	3/0
Tautoga onitis	Tautog		0/4	0/1	2/1	2/6
Tautogolabrus adspersus	Cunner		0/3			0/3

Table 7-3. Species and numbers of finfish collected by 300-ft and 60-ft (300/60) beach seines (page 3 of 3)

23 August 2005						
Station:		Intake	Spar	Cole	Lee	Total
Temp. (C):		25.5	24.8	25.4	25.3	
Brevoortia tyrannus	Atlantic menhaden	7/0				7/0
Fundulud heteroclitus	Mummichog	0/4		0/36		0/40
F. majalis	Striped killifish		1/0	0/5		1/5
Menidia menidia	Atlantic silverside	0/160	0/950	0/278		0/1388
Pomatumus saltatrix	Bluefish		272/0	1/0		273/0
Caranx hippos	Crevalle jack	13/0				13/0
Menticirrhus saxatilis	Northern kingfish	2/0		1/0		3/0
Tautoga onitis	Tautog		0/1	1/0		1/1

28 September 2005						
Station:		Intake	Spar [1]	Cole	Lee	Total
Temp. (C):		21.3		19.3	20.6	
F. majalis	Striped killifish	0/33		1/42	0/1	1/76
Menidia menidia	Atlantic silverside	0/666		0/75	0/45	0/786
Pomatomus saltatrix	Bluefish	10/0		1/4	11/0	22/4

[1] Spar Island not sampled; boat engine died.

21 October 2005						
Station:		Intake	Spar	Cole	Lee	Total
Temp. (C):		14.29	13.9	12.75	14.52	
Fundulus. majalis	Striped killifish	0/3			0/2	0/5
Menidia menidia	Atlantic silverside	0/85		0/365		0/450
Morone saxatilis	Striped bass				1/0	1/0
Lepomis macrochirus	Bluegill		1/0			1/0

Table 7-4. Species and mean numbers per haul collected by 60-ft beach seine at four fixed stations in Mount Hope Bay, March-October, 1972-2005 (page 1 of 2)

Scientific Name	Common Name	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Albula vulpes	Bonefish																	
Anguilla rostrata	American eel	0.1		0.1	0.1	0.2	0.1	0.2	0.1			0.04						
Alosa aestivalis	Blueback herring											6.0					0.04	
A. pseudoharengus	Alewife		4.4				11.1	0.1	27.8	0.2		2.7	0.3	38.4			0.4	
Brevoortia tyrannus	Atlantic menhaden	0.1	0.2		0.1		0.1			31.9		0.04			0.04			
Clupea harengus	Atlantic herring				0.1										1.3			
Anchoa mitchilli	Bay anchovy		0.2	1.7					4.2				0.04	1.5				
Anchoa spp.	Anchovy	19.7																
Unidentified clupeiforms	Unidentified herrings			15.0														
Opsanus tao	Oyster toadfish																	
Gadus morhua	Atlantic cod																	
Microgadus tomcod	Atlantic tomcod	0.4	0.5		0.1	0.1	0.1	1.9		1.6	0.04	0.2	0.1		0.5	0.2	3.7	0.1
Urophycis regia	Spotted hake					0.1												
Strongylura marina	Atlantic needlefish				0.2		0.2				0.04							
Cyprinodon variegatus	Sheepshead minnow	0.3								0.1								0.2
Fundulus heteroclitus	Mummichog	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
F. majalis	Striped killifish	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
Fundulus spp.	Killifishes	2.3		0.8	2.8													
Lucania parva	Rainwater killifish																	4.3
Menidia beryllina	Inland silverside											0.0	0.4				0.5	0.04
M. menidia	Atlantic silverside	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
Apeltes quadracus	Fourspine stickleback						0.1	0.2		0.1		0.04	0.2	0.2		0.1	0.04	
Gasterosteus aculeatus	Threespine stickleback								0.6		0.04				0.3			0.1
G. wheatlandi	Blackspotted stickleback																	
Pungitius pungitius	Ninespine stickleback																	0.04
Syngnathus fuscus	Northern pipefish	0.4	0.1	0.6	0.3	0.4		0.3	0.3			0.2	0.3	0.4	0.1	0.0	0.2	0.1
Prionotus carolinus	Northern searobin																	
Prionotus evolans	Striped searobin																	
Myoxocephalus aenaeus	Grubby																	
Morone americana	White perch	2.1	0.1		0.1	0.9		0.1										
Lepomis macrochirus	Bluegill								0.1									
Pomatomus saltatrix	Bluefish	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
Caranx hippos	Crevalle jack	0.1	0.2									0.04		0.1				0.8
Caranx spp.	Jacks																	
Selar crumenophthalmus	Bigeye scad			0.1														
Selene vomer	Lookdown													0.04				
Trachinotus falcatus	Permit	0.04					0.1											0.3
Stenotomus chrysops	Scup								0.1									
Cynoscion regalis	Weakfish	0.04		0.4														0.1
Leiostomus xanthurus	Spot																	
Menticirrhus saxatilis	Northern kingfish	0.9	0.2	0.1	1.1			0.1		0.2	0.04	0.04	0.04				0.04	
Mugil cephalus	Striped mullet		0.7											0.2				
M. curema	White mullet												0.04					0.5
Tautoga onitis	Tautog	0.9		0.1	0.8	0.3	1.0	0.7	0.4			0.2	0.3	0.04	0.04		0.1	0.04
Tautogolabrus adspersus	Cunner	0.04										0.04						0.04
Ammodytes sp.	Sand lance								0.1								0.04	
Gobiosoma ginsburgi	Seaboard goby												0.04					
Paralichthys dentatus	Summer flounder																	
Scophthalmus aquosus	Windowpane flounder																	
Pseudopleuronectes americanus	Winter flounder	0.04		0.4		0.1		0.1	0.1	0.1			0.04		0.3		0.04	
Trinectes maculatus	Hogchoker																	
Sphoeroides maculatus	Northern puffer								0.1									
Number of species		19	13	14	14	11	12	13	15	11	8	16	15	12	11	7	14	17

Table 7-4. Species and mean numbers per haul collected by 60-ft beach seine at four fixed stations in Mount Hope Bay, March-October, 1972-2005 (page 2 of 2)

Scientific name	Common Name	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	1972-2004 mean	2005
Albula vulpes	Bonefish					0.04												0.001	
Anguilla rostrata	American eel			0.04														0.023	
Alosa aestivalis	Blueback herring	0.4				2.4					0.2				1.1	0.5		0.323	43.3
A. pseudoharengus	Alewife	0.04	0.04	0.04	105.2	0.2	0.4		42.1	0.1	7.2	0.5	9.4	18.7	26.0	30.6	5.5	10.040	
Brevoortia tyrannus	Atlantic menhaden	0.1		0.1	0.04				0.04				0.1			0.1		0.997	
Clupea harengus	Atlantic herring																0.1	0.043	
Anchoa mitchilli	Bay anchovy																	0.233	
Anchoa spp.	Anchovy														0.2			0.603	
Unidentified clupeiforms	Unidentified herrings																	0.455	
Opsanus tao	Oyster toadfish										0.04							0.001	
Gadus morhua	Atlantic cod																	0.000	0.1
Microgadus tomcod	Atlantic tomcod	0.04	0.04		1.2	0.8	1.0	0.04	0.3	1.0	0.1	0.4	0.3	9.9	0.04	0.3	0.3	0.761	0.2
Urophycis regia	Spotted hake																	0.002	
Strongylura marina	Atlantic needlefish								0.1									0.018	
Cyprinodon variegatus	Sheepshead minnow	0.04	0.04	0.3		8.2		3.0		0.2	0.1	0.2			0.3	0.2		0.394	
Fundulus heteroclitus	Mummichog	3.5	11.8	61.7	17.3	54.5	246.0	131.5	58.3	7.5	10.2	5.6	5.4	2.5	8.2	24.3	7.3	25.090	2.0
F. majalis	Striped killifish	19.1	9.5	74.5	47.4	59.8	31.4	104.0	62.2	17.2	13.2	55.3	27.4	10.3	61.0	33.0	4.2	27.732	5.0
Fundulus spp.	Killifishes																	0.182	
Lucania parva	Rainwater killifish	0.04				0.04		0.3	0.1					0.04				0.146	
Menidia beryllina	Inland silverside					0.1			0.1									0.034	
M. menidia	Atlantic silverside	1330.8	729.5	1308.8	412.1	1408.8	1245.5	194.7	811.6	266.6	396.0	359.5	193.4	594.0	941.0	537.5	173.5	535.690	189.5
Apeltes quadracus	Fourspine stickleback	0.04	0.1				0.04	0.04	0.1	0.1			0.0	0.1		0.1		0.042	
Gasterosteus aculeatus	Threespine stickleback	1.8	0.04		0.1	0.3			0.1	0.1	4.1		0.0	0.7	2.0	0.1		0.314	
G. wheatlandi	Blackspotted stickleback	0.04																0.001	
Pungitius pungitius	Ninespine stickleback	0.04	0.04		0.04										0.2			0.010	
Syngnathus fuscus	Northern pipefish	0.04		0.1	0.04	0.8	0.2	0.4	0.2	0.1	0.2	0.2	0.6	0.3	0.2	0.4	0.2	0.229	0.2
Prionotus carolinus	Northern searobin									0.1								0.003	
Prionotus evolans	Striped searobin												0.1					0.002	0.0
Myoxocephalus aenaeus	Grubby								0.04				0.0					0.002	
Morone americana	White perch										6.1							0.284	
Lepomis macrochirus	Bluegill										0.04							0.003	
Pomatomus saltatrix	Bluefish	0.3	1.1	0.2	0.04		0.2		1.6	0.2	3.2	5.3	0.1	0.7	0.1	0.2	0.03	0.551	0.13
Caranx hippos	Crevalle jack	0.04					1.4					0.1				0.1		0.085	
Caranx spp.	Jacks									0.1	0.04							0.004	
Selar crumenophthalmus	Bigeye scad																	0.002	
Selene vomer	Lookdown																	0.001	
Trachinotus falcatus	Permit															0.1		0.014	
Stenotomus chrysops	Scup		0.04	0.04														0.004	
Cynoscion regalis	Weakfish									0.3				0.04		0.03		0.022	
Leiostomus xanthurus	Spot																	0.004	
Menticirrhus saxatilis	Northern kingfish			0.04	0.4	0.04	0.2		0.9	0.1	3.0	0.04	0.1		3.5	0.4		0.348	
Mugil cephalus	Striped mullet																	0.026	
M. curema	White mullet	0.04	2.9						0.04			0.4				0.7		0.136	
Tautoga onitis	Tautog				0.5	1.0	0.1			0.3	0.9	0.8	4.6		1.4	5.5	0.2	0.610	0.4
Tautogolabrus adspersus	Cunner		0.04	0.6	0.04	0.9	0.1	0.04	0.2			0.6	0.5			0.3		0.104	0.1
Ammodytes sp.	Sand lance												0.2				0.03	0.009	
Gobiosoma ginsburgi	Seaboard goby			0.04		0.3	0.04				0.04			0.04	0.04	0.2		0.021	
Paralichthys dentatus	Summer flounder											0.04						0.001	
Scophthalmus aquosus	Windowpane flounder										0.2							0.006	
Pseudopleuronectes americanus	Winter flounder		0.2	0.1	4.3	0.4	0.04	0.3	0.04		0.4	0.3	0.1	0.04	0.6	0.4	0.2	0.254	
Trinectes maculatus	Hogchoker															0.03		0.001	
Sphoeroides maculatus	Northern puffer			0.04									0.04					0.004	
Number of species		17	14	15	14	17	14	10	18	15	19	15	18	13	16	22	11		11

Table 7-5. Species and mean numbers per haul collected by 300-ft beach seine at four fixed stations in Mount Hope Bay, June-August, 1972-2005 (page 1 of 2)

Scientific Name	Common Name	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
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
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
A. sapidissima	American shad																	
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
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			
Unidentified clupeiforms	Unidentified herrings	0.5		0.3														
Osmerus mordax	Rainbow smelt	0.1									0.1							
Synodus foetens	Inshore lizardfish	0.02		0.1	0.1				0.1									
Opsanus tau	Oyster toadfish	0.1			0.1				0.1							0.1		
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
Urophycis chuss	Red hake																	
Hyporhamphus unifasciatus	Halfbeak															0.1		
Cyprinodon variegatus	Sheepshead minnow	0.0																
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
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
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
Apeltes quadracus	Fourspine stickleback	0.02																
Gasterosteus aculatus	Threespine stickleback																	
Pungitius pungitius	Ninespine stickleback																	0.1
Syngnathus fuscus	Northern pipefish	0.3	0.1	0.04	0.3			0.5		0.3		0.2	0.1	0.5		0.2	0.1	0.3
Prionotus evolans	Striped searobin																	
Myoxocephalus aenaeus	Grubby																	
Morone americana	White perch	1.4	0.2	0.2		3.3						0.1		0.3				
M. saxatilis	Striped bass				0.1													
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
Caranx crysos	Blue runner																	0.1
C. hippos	Crevalle jack	1.3	0.8											0.3			8.4	0.2
Caranx spp.	Jacks																	
Trachinotus falcatus	Permit																	0.5
Lutjanus griseus	Gray snapper																	
Stenotomus chrysops	Scup					26.3			5.8	0.9		2.1			0.6			
Cynoscion regalis	Weakfish	2.1	0.3															
Leiostomus xanthurus	Spot																	
Menticirrhus saxatilis	Northern kingfish	9.8	1.5	0.1	0.2							0.2						
Mugil cephalus	Striped mullet	0.02	0.4															
M. curema	White mullet																	
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
Tautogolabrus adspersus	Cunner	0.02							0.1				0.2					
Scomber scombrus	Atlantic mackerel								1.0					1.3				
Peprilus triacanthus	Butterfish																	
Scophthalmus aquosus	Windowpane flounder	0.02			0.1				0.3	0.1		0.4	0.1	0.4		0.1		
Pseudopleuronectes 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
Trinectes maculatus	Hogchoker	0.04							0.4			0.2	0.3		0.3	0.2	0.2	
Sphoeroides maculatus	Northern puffer	0.1																0.1
Number of species		29	18	14	14	9	7	11	16	11	10	16	12	16	13	15	11	17

Table 7-5. Species and mean numbers per haul collected by 300-ft beach seine at four fixed stations in Mount Hope Bay, June-August, 1972-2005 (page 2 of 2)

Scientific Name	Common Name	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	1972-2004 mean	2005
Anguilla rostrata	American eel																	0.17	
Alosa aestivalis	Blueback herring	4.3	0.1	13.6	0.1													0.65	
A. pseudoharengus	Alewife	4.3	0.1	13.6	0.1	0.5	46.5	21.3	6.9	1.10	0.50	0.08	3.92	2.42	340.30	11.83	311.4	32.82	0.7
A. sapidissma	American shad																0.1	0.00	
Alosa spp.	Herring																	1.08	
Brevoortia tyrannus	Atlantic menhaden	0.1		462.4	0.1						15.8		170.4	1.3	12.0	0.08	6.4	21.05	0.6
Clupea harengus	Atlantic herring																	0.03	
Anchoa mitchilli	Bay anchovy				0.2										0.1			0.41	
Unidentified clupeiforms	Unidentified herrings																	0.02	
Osmerus mordax	Rainbow smelt																	0.00	
Synodus foetens	Inshore lizardfish																	0.01	
Opsanus tau	Oyster toadfish		0.1		0.2											0.1		0.02	
Microgadus tomcod	Atlantic tomcod		0.1		0.2	1.5	0.1						0.08					0.30	0.1
Urophycis chuss	Red hake																	0.00	0.2
Hyporhamphus unifasciatus	Halfbeak																	0.00	
Cyprinodon variegatus	Sheepshead minnow														0.1			0.00	
Fundulus heteroclitus	Mummichog	2.3	1.3	9.4	2.5	1.8	2.60	0.80	0.60	1.00	4.90	6.00	0.67	0.42	0.25	0.17	0.5	3.05	0.2
F. majalis	Striped killifish	4.0	1.3	15.6	3.3	8.4	23.6	10.5	2.8	0.9	8.1	11.4	4.9	8.7	2.3	0.6	10.3	6.66	8.3
Fundulus spp.	Killifishes																	0.07	
Menidia beryllina	Inland silverside																	0.00	
M. menidia	Atlantic silverside	12.2	9.1	31.9	15.4	59.6	7.3	15.3	37.7	123.3	16.1	3.2	2.8	1.4	0.7	1.3	1.4	32.15	0.8
Apeltes quadracus	Fourspine stickleback																	0.00	
Gasterosteus aculatus	Threespine stickleback					0.7												0.02	
Pungitius pungitius	Ninespine stickleback			0.2														0.01	
Syngnathus fuscus	Northern pipefish	0.3		0.2		0.9	0.1			0.1	0.3			0.3		0.2	0.1	0.16	
Prionotus evolans	Striped searobin			0.3	0.1								0.1	0.9				0.04	
Myoxocephalus aenaeus	Grubby																0.1	0.00	
Morone americana	White perch										5.2							0.32	
M. saxatilis	Striped bass		0.1	0.3		0.4		0.2	0.9	0.3	0.1	0.2		0.08	0.50	4.08	0.9	0.25	0.3
Lepomis macrochirus	Bluegill																	0.01	
Pomatomus saltatrix	Bluefish	26.3	17.1	6.6	13.6	7.2	0.2	22.7	44.7	42.3	3.1	94.9	10.8	32.8	15.8	7.2	21.2	23.76	22.8
Caranx crysos	Blue runner																	0.00	
C. hippos	Crevalle jack			0.1			1.8					0.8				0.8		0.44	1.3
Caranx spp.	Jacks									0.1	0.2							0.01	
Trachinotus falcatus	Permit	0.1																0.02	
Lutjanus griseus	Gray snapper						0.1											0.00	
Stenotomus chrysops	Scup			38.1		0.1						0.2	0.3				0.1	2.25	
Cynoscion regalis	Weakfish															0.2		0.08	0.3
Leiostomus xanthurus	Spot												0.17					0.01	
Menticirrhus saxatilis	Northern kingfish			1.0	0.8	0.1	0.1		3.3	0.4	17.1	0.3	0.7	0.2	1.1		0.4	1.13	
Mugil cephalus	Striped mullet			0.4		2.3												0.09	
M. curema	White mullet	2.6														1.2		0.11	
Mugil spp.	Mullets											0.1						0.00	
Tautoga onitis	Tautog	0.3		0.2	0.3	0.3	0.2	0.2	0.3	0.1	1.7	0.9	1.3	2.3	0.3	2.7	0.8	1.06	0.8
Tautogolabrus adspersus	Cunner		0.5	0.2		0.1	0.1		0.3								0.2	0.05	
Scomber scombrus	Atlantic mackerel																	0.07	
Peprilus triacanthus	Butterfish									0.1		0.1					0.1	0.01	
Scophthalmus aquosus	Windowpane flounder	0.1							0.1		0.1							0.05	
Pseudopleuronectes americanus	Winter flounder	1.8	1.1	3.4	38.5	1.8	0.6	0.1	0.1	0.6	0.7		0.8	0.6		0.5	2.3	1.96	0.1
Trinectes maculatus	Hogchoker										0.1					0.1		0.06	
Sphoeroides maculatus	Northern puffer			0.8	0.3	0.1						0.2					0.1	0.05	
Number of species		13	11	19	15	16	13	8	11	12	15	13	13	12	11	15	17		13

Table 7-6. Species and mean numbers per haul collected by 300-ft beach seine at four fixed stations in Mount Hope Bay, March-October, 1981-2005

Scientific Name	Common Name	1981	1982	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	1981-2004 Mean	2005
Anguilla rostrata	American eel	0.1		0.03		0.03																			0.01	
Alosa aestivalis	Blueback herring		0.1			0.9	0.1	0.03			0.1			0.5	0.1	0.03	0.1	0.5	0.7			4.8			0.36	
A. pseudoharengus	Alewife	0.1	2.6	0.2	0.0	1.8	0.1	0.1	1.6	0.03	5.4	0.1	0.2	23.1	8.1	2.6	0.8	0.2	0.03	1.4	1.5	178.0	4.4	116.8	15.19	0.3
A. sapidissma	American shad																							0.03	0.00	
Brevoortia tyrannus	Atlantic menhaden				0.1	0.1		0.2	0.03		203.7	0.1		0.5			0.03	5.9	0.1	60.0	0.7	9.0	0.03	2.4	12.30	0.2
Clupea harengus	Atlantic herring				0.3	0.2		0.7	0.1																0.05	
Anchoa mitchilli	Bay anchovy	1.4	0.1	0.1	0.5																				0.09	
Osmerus mordax	Rainbow smelt	0.03			0.0			0.1					0.03				0.03								0.01	
Synodus foetens	Inshore Lizardfish																			0.03					0.00	
Gadus morhua	Atlantic cod																		0.2						0.01	
Microgadus tomcod	Atlantic tomcod	0.3	0.7	0.1	0.3	5.1	0.03	0.4	5.3	0.03	0.03	3.4	0.8	8.2		0.03	0.1			0.03					1.07	0.1
Pollachius virens	Pollock		0.1					0.03																	0.01	
Urophycis chuss	Red hake																								0.00	0.1
Urophycis regia	Spotted hake			0.1																					0.01	
Hyporhamphus unifasciatus	Halfbeak					0.03																			0.00	
Opsanus tau	Oyster toadfish	0.1				0.03														0.03			0.03		0.01	
Strongylura marina	Atlantic needlefish	0.2								0.2				0.03											0.02	
Cyprinodon variegatus	Sheepshead minnow								0.1				0.1									0.03			0.01	
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	2.3	0.2	0.4	0.1	0.1	0.2	1.03	0.1
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	5.0	1.8	5.1	4.0	0.7	4.2	4.13	3.2
Menidia beryllina	Inland silverside				0.03	0.03		0.03																	0.00	
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	11.3	7.6	9.0	4.4	1.5	2.6	21.46	0.7
Apeltes quadracus	Fourspine stickleback				0.03																0.1				0.00	
Gasterosteus aculatus	Threespine stickleback												0.3			0.03	0.03			0.03					0.02	
Pungitius pungitius	Ninespine stickleback							0.03																	0.00	
Syngnathus fuscus	Northern pipefish		0.1	0.03		0.2	0.1	0.2	0.3		0.1		0.4	0.2		0.03	0.03	0.1	0.03		0.1	0.1	0.1	0.03	0.09	0.10
Cyclopterus lumpus	Lumpfish																		0.03						0.00	
Morone saxatilis	Striped bass																				0.8	0.2	1.5	0.4	0.13	0.2
Prionotus evolans	Striped searobin																				0.5				0.02	
Myoxocephalus aenaeus	Grubby																							0.03	0.00	
Morone americana	White perch		0.03					0.03	0.03									1.9							0.09	
Lepomis macrochirus	Bluegill						0.03																		0.00	0.03
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	40.4	3.7	17.3	38.7	3.2	1.2	12.80	9.5
Caranx hippos	Crevalle jack		0.1					3.4	0.1		1.8			2.2				0.6	1.4			2.7	0.4	0.03	0.55	0.52
C. latus	Horse-eye jack							0.03																	0.00	
Caranx spp.	Jacks																0.5	0.1							0.02	
Trachinotus falcatus	Permit							0.4	0.03																0.02	
Lutjanus griseus	Gray snapper													0.03											0.00	
Stenotomus chrysops	Scup		0.8		0.2						14.8		0.03						0.1	0.1		0.9	0.03	0.03	0.74	
Cynoscion regalis	Weakfish																						0.1		0.00	0.1
Leiostomus xanthurus	Spot																			0.1					0.00	
Menticirrhus saxatilis	Northern kingfish		0.9	0.03							0.4	0.4	0.03	0.03		1.2	0.1	6.4	0.1	0.2	0.3	0.8	0.5	0.4	0.51	
Mugil cephalus	Striped mullet			0.3		0.03							0.9												0.06	
M. curema	White mullet			0.2				1.5											0.5				0.4		0.11	
Mugil spp.	Mullet										0.2						0.3		0.03	1.4					0.08	
Tautoga onitis	Tautog	0.1	0.3	0.8	1.0	0.6	1.5	0.8	0.3	0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.7	0.5	0.8	1.7	0.4	1.2	0.3	0.51	0.4
Tautogolabrus adspersus	Cunner			0.1						0.2	0.1			0.03		0.1		0.03						0.1	0.02	
Scomber scombrus	Atlantic mackerel			0.5																					0.02	
Peprilus triacanthus	Butterfish			0.03													0.03		0.03					0.03	0.01	
Etropus microstomus	Smallmouth flounder																						0.03		0.00	
Scophthalmus aquosus	Windowpane flounder	0.03	0.2	0.1	0.2	0.03	0.03	0.1	0.03							0.03		0.03							0.03	
Pseudopleuronectes americanus	Winter flounder	0.03	0.2	3.8	1.7	0.5	0.3	0.9	0.8	0.4	1.3	17.1	1.3	0.5	0.03	0.1	0.2	0.3		0.3	0.3	0.1	0.3	1.0	1.37	0.3
Trinectes maculatus	Hogchoker		0.1	0.2		0.1	0.1						0.03					0.03					0.03		0.02	
Sphoeroides maculatus	Northern puffer	0.03						0.03			0.4	0.1							0.1					0.03	0.03	
Number of species		15	18	20	16	19	13	23	16	10	17	11	16	16	8	14	17	17	18	16	13	15	18	18		15

Table 7-7. 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, 2005 (page 1 of 5)

7 - 8 June 2005									
	Replicate				River Mean	Temp	Salinity	D.O.	Percent
Station	I	II	III	Mean	(S.E.)	(° C)	‰	(mg/l)	Saturation
Taunton River									
A	1	1		1.0		21.1	14.9	11.9	143.1
B	2	1	1	1.3		19.8	17.0	9.5	115.2
C	7	7		7.0		19.5	20.2	11.0	132.6
D	0	0	0	0.0		18.8	22.8	9.0	110.3
E	0	0	0	0.0		18.7	22.3	7.6	93.4
1	0	0		0.0		18.7	22.4	10.7	132.5
4	0	0		0.0		18.3	22.1	9.7	115.6
5	1	5	6	4.0		18.9	21.2	10.9	136.0
13	9	11	4	8.0		21.5	13.9	9.9	120.1
					2.4				
Lee River									
F	9	13	9	10.3		22.9	22.0	10.4	137.6
G	0	0		0.0		22.2	22.1	10.1	132.2
1	3	2	5	3.3		23.1	21.5	10.7	144.7
5	0	2	10	4.0		23.0	21.8	11.6	155.4
					4.4				
Cole River									
H	6	11	12	9.7		21.4	22.0	9.4	121.6
I	0	0		0.0		22.5	20.4	8.8	116.4
					4.8				
Kickamuit River									
J	0	0		0.0		19.6	23.3	9.7	122.6
1	0	0		0.0		21.1	22.0	9.0	115.4
4	1	0	0	0.3		21.8	21.6	9.5	121.2
5	2	4	1	2.3		21.6	21.5	10.2	133.7
					0.7				

Table 7-7. 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, 2005 (page 2 of 5)

20 - 21 June 2005									
	Replicate				River Mean	Temp	Salinity	D.O.	Percent
Station	I	II	III	Mean	(S.E.)	(° C)	‰	(mg/l)	Saturation
Taunton River									
A	5	5	5	5.0		20.6	18.9	8.2	108.1
B	11	4	11	8.7		18.5	22.0	6.6	84.6
C	2	10	19	10.3		18.2	25.2	7.6	95.7
D	0	1		0.5		19.9	25.9	8.3	111.8
E	8	7	9	8.0		21.1	26.4	6.3	87.2
5	13	4	16	11.0		18.4	25.2	8.7	115.0
8	1	0	3	1.3		19.2	22.0	8.7	110.0
9	14	14	5	11.0		20.3	20.8	7.3	91.2
13	8	12	5	8.3		20.6	19.5	6.4	84.0
					7.1				
Lee River									
F	13	16	9	12.7		23.6	25.8	10.0	136.8
G	0	5	1	2.0		19.9	26.6	8.6	110.8
5	9	24	29	20.7		21.7	26.4	8.6	113.8
					11.8				
Cole River									
H	27	34	15	25.3		21.8	25.3	9.5	125.0
I	18	10	8	12.0		22.2	23.4	9.8	129.3
					18.7				
Kickamuit River									
J	4	12	12	9.3		20.7	26.2	9.5	123.8
2	0	0		0.0		21.3	25.7	11.6	146.2
5	0	0		0.0		20.9	25.6	7.8	101.0
8	0	3	0	1.0		21.4	25.4	10.6	136.9
					2.6				

Table 7-7. 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, 2005 (page 3 of 5)

6 - 8 July 2005									
	Replicate				River Mean	Temp	Salinity	D.O.	Percent
Station	I	II	III	Mean	(S.E.)	(° C)	‰	(mg/l)	Saturation
Taunton River									
A	0	1	2	1.0		22.4	24.7	7.7	102.3
B	4	5		4.5		22.6	24.3	8.5	112.9
C	22	29	26	25.7		23.4	25.6	7.7	105.2
D	1	0	1	0.7		23.7	24.8	8.5	116.2
E	8	4	0	4.0		23.2	26.4	5.6	74.9
8	9	4	3	5.3		22.7	24.1	8.5	113.4
9	5	3	10	6.0		22.5	24.6	7.5	100.0
13	0	2	5	2.3		22.7	23.0	7.9	106.2
14	1	0	1	0.7		22.6	24.1	7.9	105.3
					5.6				
Lee River									
F	7	14	15	12.0		20.5	26.7	4.6	59.9
G	3	3		3.0		22.0	27.0	8.0	107.8
5	11	18	14	14.3		20.2	26.6	5.9	76.7
7	7	4		5.5					
					8.7				
Cole River									
H	24	19	17	20.0		21.8	26.8	6.3	84.5
I	0	2	7	3.0		21.8	26.4	6.7	91.2
					11.5				
Kickamuit River									
J	0	0		0.0		22.3	27.0	7.2	96.9
2	0	0		0.0		22.0	26.7	7.4	99.2
5	0	2	2	1.3		21.5	26.7	6.3	26.7
8	1	0	2	1.0		22.1	25.9	5.7	75.9
					0.6				

Table 7-7. 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, 2005 (page 4 of 5)

19 - 21 July 2005									
	Replicate				River Mean	Temp	Salinity	D.O.	Percent
Station	I	II	III	Mean	(S.E.)	(° C)	‰	(mg/l)	Saturation
Taunton River									
A	0	1	3	1.3		27.2	21.5	12.0	173.9
B	2	10	12	8.0		25.1	23.2	9.0	120.1
C	4	3	1	2.7		25.7	23.0	9.1	124.6
D	0	0		0.0		23.9	26.6	7.8	106.5
E	6	9	9	8.0		25.1	26.8	6.9	97.1
2	19	6	3	9.3		24.1	26.1	8.1	111.2
4	11	6	3	6.7		24.3	24.7	7.8	106.2
7	3	0	4	2.3		25.6	23.9	9.8	135.3
13	4	4		4.0		26.1	22.6	9.2	127.8
					4.7				
Lee River									
F	0	1	2	1.0		25.9	27.2	8.4	120.0
G	0	0		0.0		25.5	27.3	7.8	112.3
1	2	3	6	3.7		26.9	27.2	9.0	130.4
5	4	30	9	14.3		27.5	27.1	9.9	145.7
					6.0				
Cole River									
H	0	0		0.0		26.7	26.9	6.8	96.8
I	1	0	2	1.0		27.0	26.4	6.3	90.2
					0.5				
Kickamuit River									
J	12	13	9	11.3		27.3	27.3	8.6	126.1
1	0	2		1.0		27.8	27.0	10.2	150.4
2	1	0	1	0.7		26.6	27.3	8.4	122.4
5	0	0		0.0		26.8	27.3	9.5	137.1
					3.3				

Table 7-7. 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, 2005 (page 5 of 5)

15 - 17 August 2005									
	Replicate				River Mean	Temp	Salinity	D.O.	Percent
Station	I	II	III	Mean	(S.E.)	(° C)	‰	(mg/l)	Saturation
Taunton River									
A	2	12	2	5.3		26.7	25.9	5.3	75.5
B	16	12	17	15.0		26.5	25.9	5.8	83.3
C	5	41	10	18.7		26.7	26.9	6.6	95.2
D	0	0		0.0		26.0	27.5	7.7	111.1
E	12	21	8	13.7		26.2	28.4	5.9	86.0
7	0	11	2	4.3		26.1	25.9	6.6	94.5
10	5	9	11	8.3		26.6	24.8	5.9	86.6
11	5	6	7	6.0		26.6	25.1	5.6	79.9
13	5	4	5	4.7		26.6	26.0	5.5	79.6
					8.4				
Lee River									
G	8	1	0	3.0		25.8	28.6	5.8	85.5
3	0	0		0.0		24.8	28.6	4.4	61.6
5	0	0	0	0.0		24.8	28.5	4.6	64.8
					1.0				
Cole River									
H	0	4	4	2.7		25.0	28.2	3.8	54.7
I	0	0		0.0		24.9	28.1	3.6	51.8
					1.3				
Kickamuit River									
J	5	10	5	6.7		26.8	28.4	8.1	119.2
2	0	4	4	2.7		25.9	28.5	6.0	85.4
4	0	0		0.0		25.3	28.4	5.9	75.6
8	0	0		0.0		25.5	27.9	5.1	70.4
					2.3				

Table 7-8. Stratified mean number of young-of-the-year winter flounder obtained per haul during two June sampling series, Mount Hope Bay tributaries, 1992-2005

Year	Number of samples	Mean	S.E.	95% confidence limits
1992	20	34.56	7.929	±15.858
1993	24	0.42	0.164	±0.328
1994	30	1.74	0.421	±0.842
1995	36	6.34	0.882	±1.764
1996	41	2.46	0.467	±0.934
1997	37	3.99	0.944	±1.953
1998	41	1.25	0.367	±0.768
1999	38	9.47	0.388	±0.811
2000	40	2.22	0.289	±0.605
2001	37	9.76	1.920	±4.019
2002	33	12.29	2.083	±4.165
2003	35	10.60	1.655	±3.310
2004	36	6.20	0.820	±1.706
2005	36	4.92	0.867	±1.803

Table 7-9. Stratified mean number of young-of-the-year winter flounder obtained per haul during five June-August sampling periods, Mount Hope tributaries, 1992-2005

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	±0.529
1999	95	5.74	1.206	±2.424
2000	95	2.52	0.234	±0.467
2001	80	6.89	0.993	±1.844
2002	83	10.01	2.083	±2.167
2003	85	11.86	1.297	±2.593
2004	88	5.46	0.504	±1.008
2005	89	5.11	0.617	±1.209

[1]Sampled in June only.

Table 7-10. July mortality rates, young-of-the-year winter flounder, Mount Hope Bay, 1992 - 2005

Year	Survival Rate	Mortality Rate	Z_{mon}
1992	-		
1993	0.445	0.555	0.810
1994	0.487	0.513	0.720
1995	0.407	0.593	0.900
1996	0.162	0.838	1.818
1997	0.259	0.741	1.350
1998 [1]	-	-	-
1999	0.657	0.343	0.420
2000	0.533	0.467	0.630
2001	0.822	0.178	0.195
2002	0.703	0.297	0.353
2003	0.525	0.475	0.645
2004	0.517	0.483	0.660
2005	0.527	0.473	0.641

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

Table 7-11. Total length data (mm) for young-of-the-year (age 0) winter flounder collected by beach seine, 1992-2005 (page 1 of 2)

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	0.01572
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	0.00423
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	0.01292
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	0.00433
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	0.00662
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	0.00203
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	0.01242
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	0.00503
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	0.00952
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	0.00343
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	0.8	24-97	178	
17-19 August	60.7	11	1	33-89	128	0.0065
1999						
9-11 June	51.2	7.7	0.3	30-69	495	
23-25 June	57.3	9	0.5	35-81	291	0.008
12-14 July	55.8	9.4	0.7	35-77	193	
26-28 July	57.3	8.6	0.7	38-81	167	
23-25 August	57	8.5	0.7	41-81	128	0.0014
2000						
12-14 June	46.5	11.3	1.2	25-70	98	
26-28 June	48.9	11.4	0.9	22-82	162	0.0036 [2]
11-13 July	53.2	12.4	1.0	26-83	154	
24-26 July	54.7	11.9	1.2	25-85	115	
14-16 August	53	14.2	1.3	26-88	115	0.002 [3]

[1] $g_i = \frac{\ln(L_t/L_o)}{t}$

Table 7-11. Total length data (mm) for young-of-the-year (age 0) winter flounder collected by beach seine, 1992-2005 (page 2 of 2)

Date	Mean	s	s.e..	Range	n	Daily Instantaneous Growth (g_i)[1]
2001						
6-8 June	45.7	6.9	0.4	30-66	270	
19-21 June	50.2	8.2	0.3	15-70	559	0.0078 [2]
16-18 July	55.2	11.2	0.7	23-85	266	
30 July - 1 August	57.3	11.4	0.7	25-81	242	
15-18 August	56.1	12.9	1.1	26-90	145	0.0029 [3]
2002						
11-13 June	48.1	7.9	0.4	25-72	469	
25-27 June	51.3	8.9	0.3	30-96	721	0.0046 [2]
9-11 July	50.8	9.4	0.4	28-74	445	
23-25 July	53.5	11.3	0.6	29-96	385	
20-22 August	55.7	12.8	1	33-99	182	0.0021 [3]
2003						
11-13 June	38.7	7.1	0.3	22-63	443	
25-27 June	43.5	7.3	0.3	25-69	541	0.0084 [2]
9-11 July	48.7	7.5	0.3	25-78	685	
23-25 July	50.8	9.4	0.4	30-79	603	
27-28 August	54.3	10.3	0.7	29-81	217	0.0044 [3]
2004						
14-16 June	50.9	8.2	0.5	14 - 75	263	
28-29 June	56.3	11.3	0.7	29 - 84	299	0.0072 [2]
12-13 July	60.3	14.3	0.97	31 - 95	215	
26-27 July	62.6	13.6	0.82	26 - 100	271	
9-10 August	62.2	13.2	0.98	26 - 95	180	0.0036 [3]
2005						
7-8 June	46.4	5.3	0.5	35 - 63	141	
20-21 June	54.1	8.2	0.4	20 - 74	402	0.01181 [2]
6 - 8 July	58.1	10.9	0.6	25 - 76	309	
19-20 July	61.9	13.3	0.9	22 -88	221	
15-17 August	60.1	14.1	0.9	30 - 90	269	0.0038 [3]

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

[2] For June only.

[3] June to August.

7.8 FIGURES

Figure 7-1. Four fixed stations in Mount Hope Bay sampled by 60- and 300-ft beach seines (core beach seine program), 1972–2005

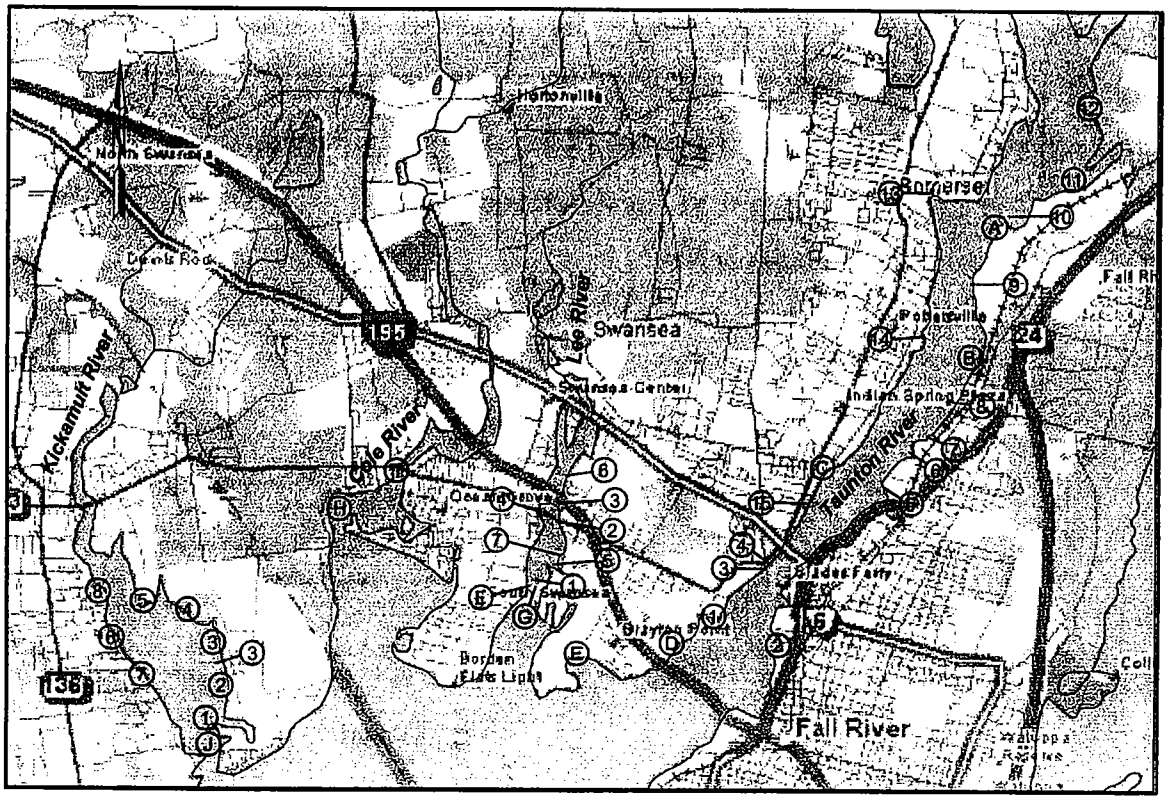


Figure 7-2. Mount Hope Bay YOY winter flounder beach seine stations, 1992-2005

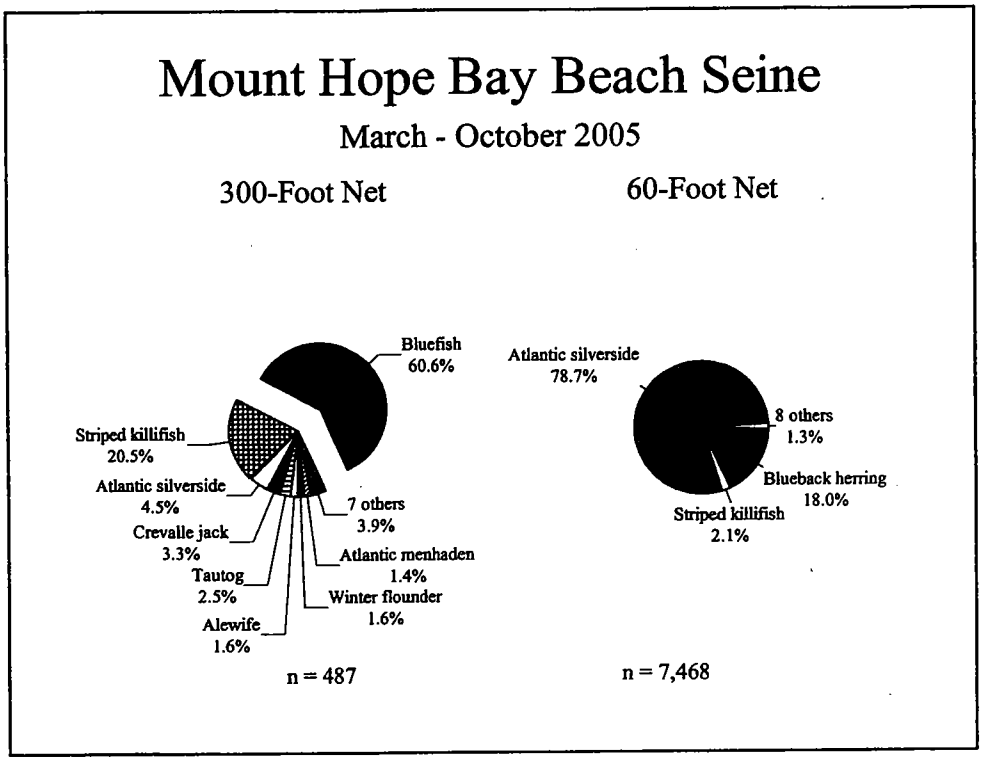
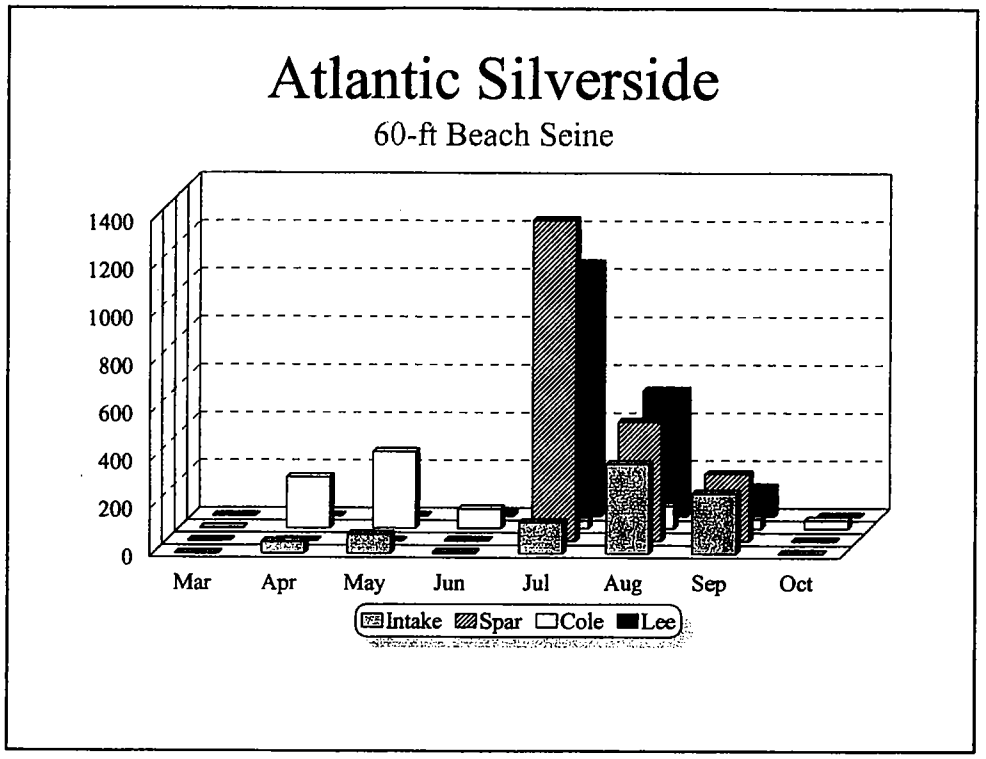


Figure 7-3. Percent of contribution for the numerically dominant species of finfish taken in 300- and 60-ft beach seines in Mount Hope Bay, March-October, 2005



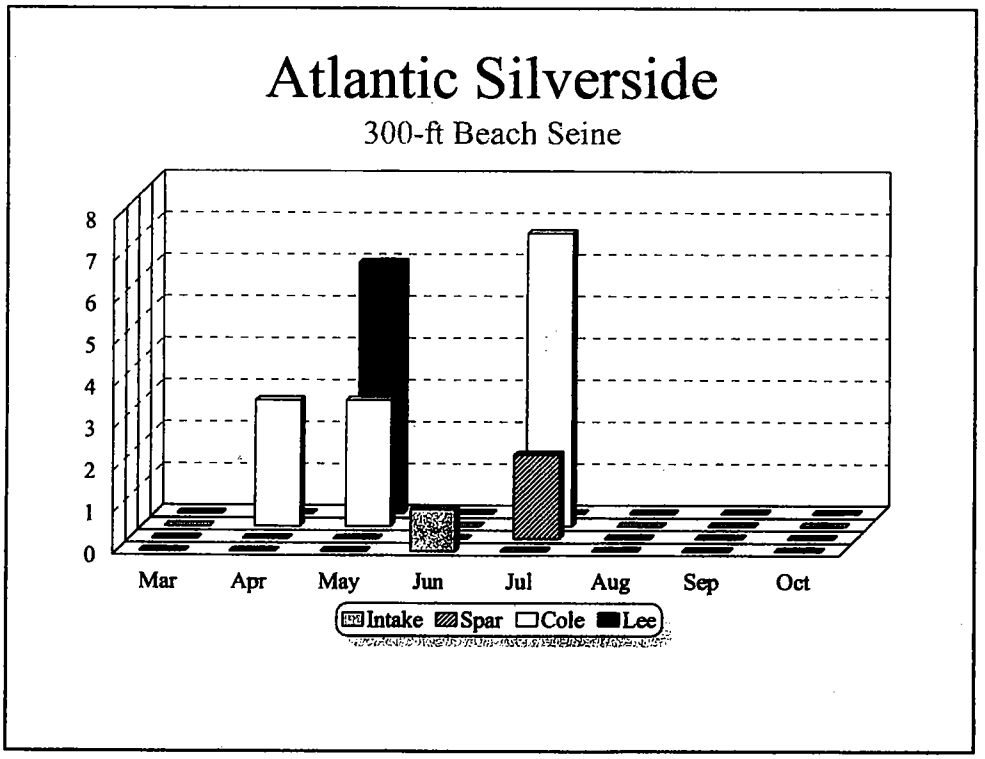
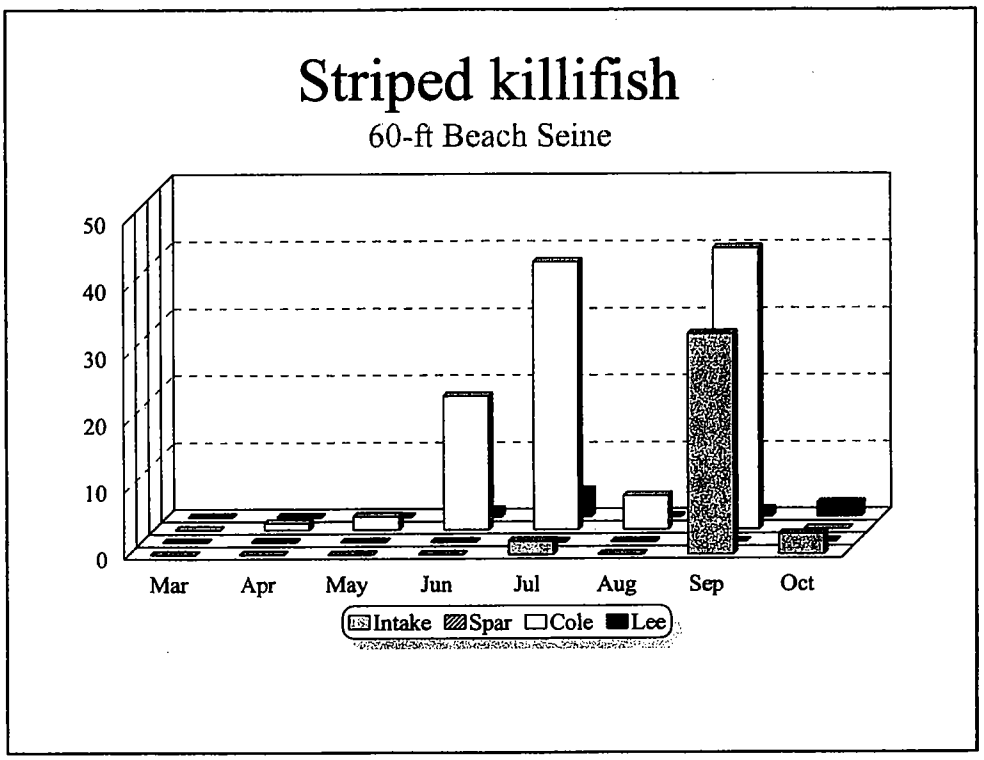


Figure 7-4a. Numbers of Atlantic silversides collected in each monthly haul of 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, March–October 2005



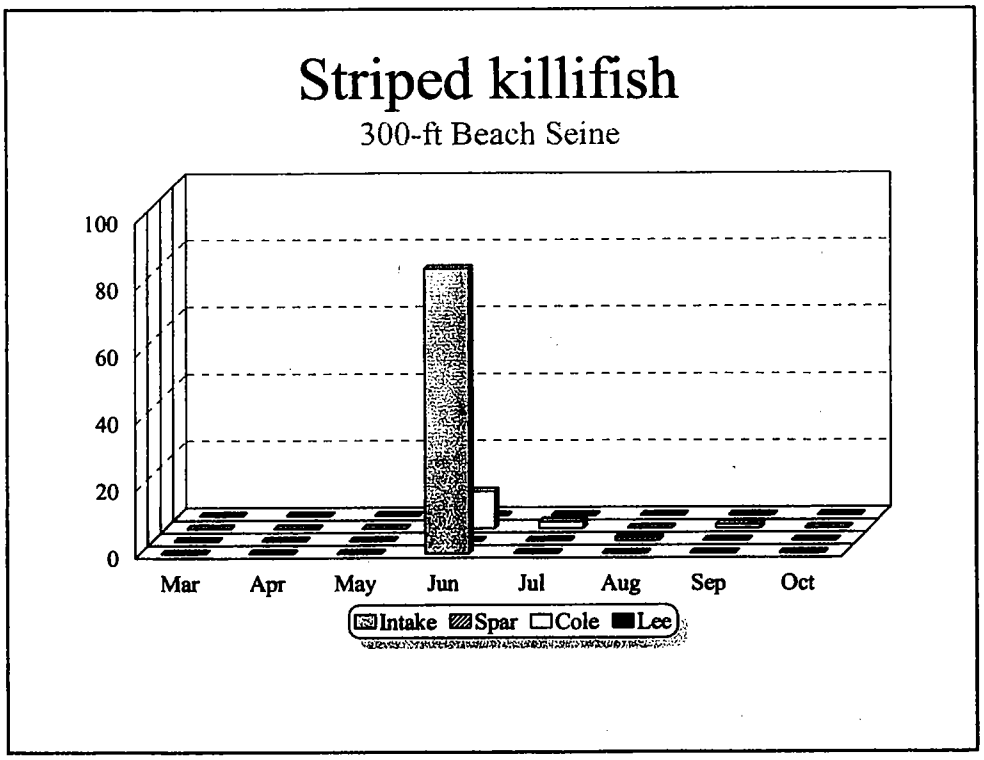
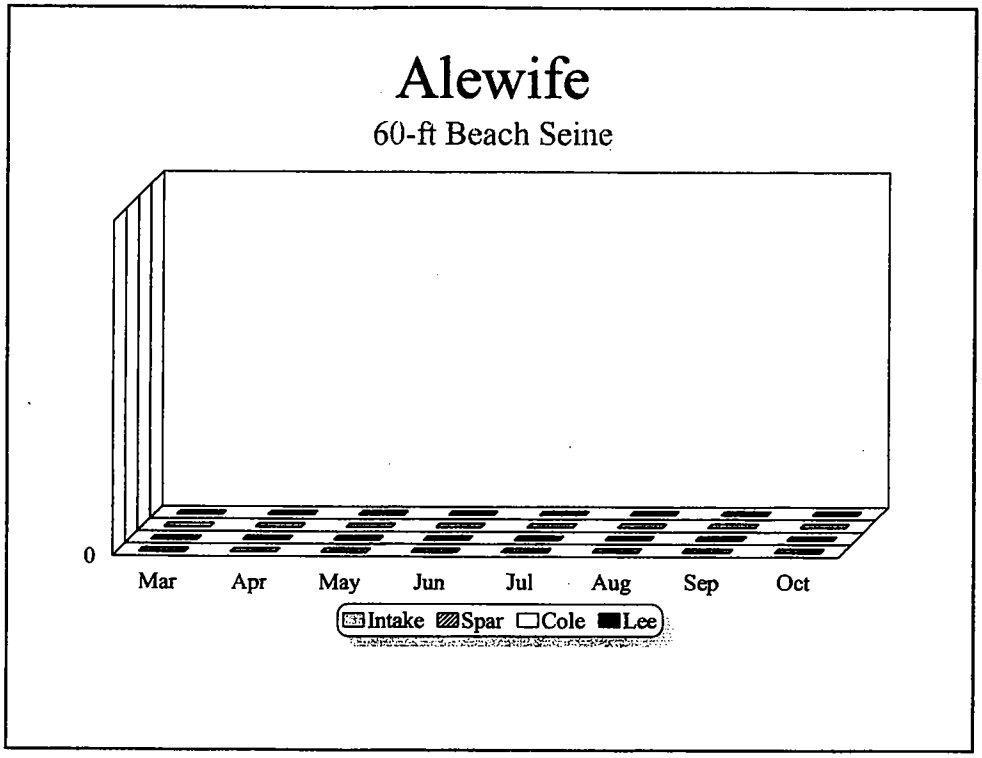


Figure 7-4b. Numbers of striped killifish collected in each monthly haul of 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, March–October 2005



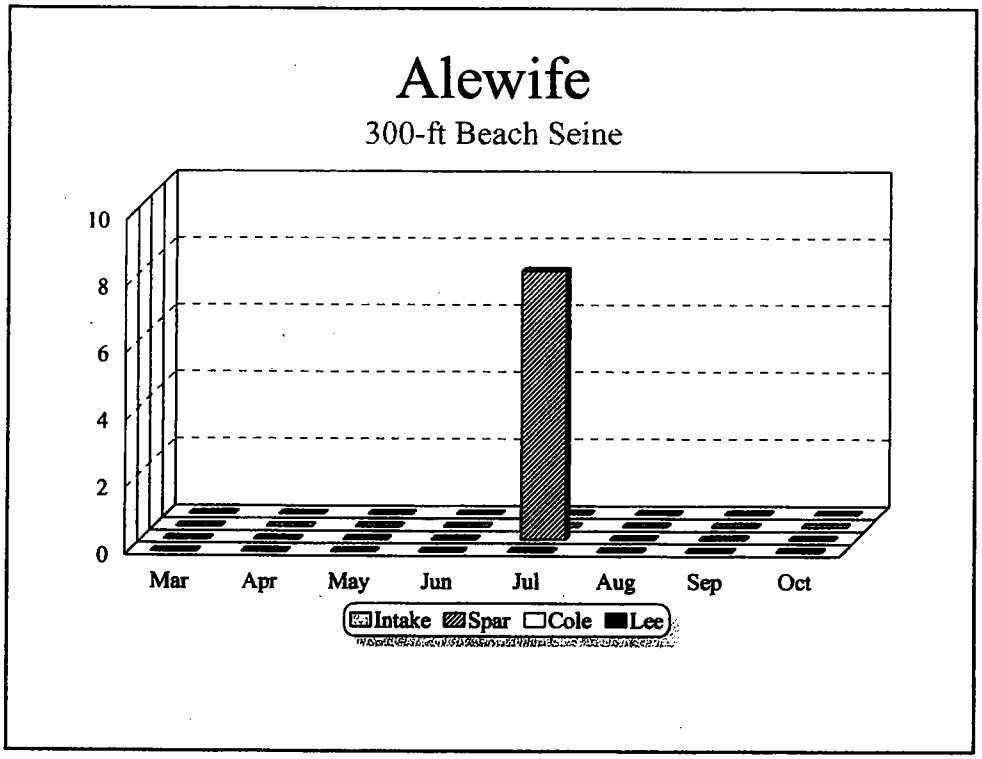
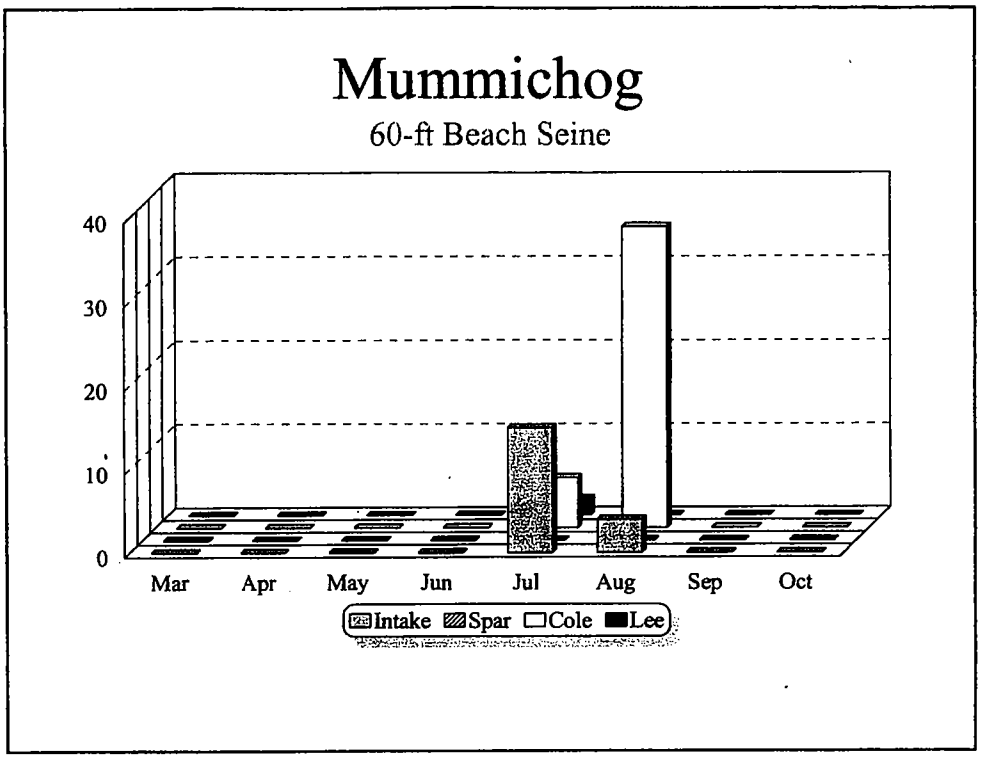


Figure 7-4c. Numbers of alewife collected in each monthly haul of 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, March–October 2005



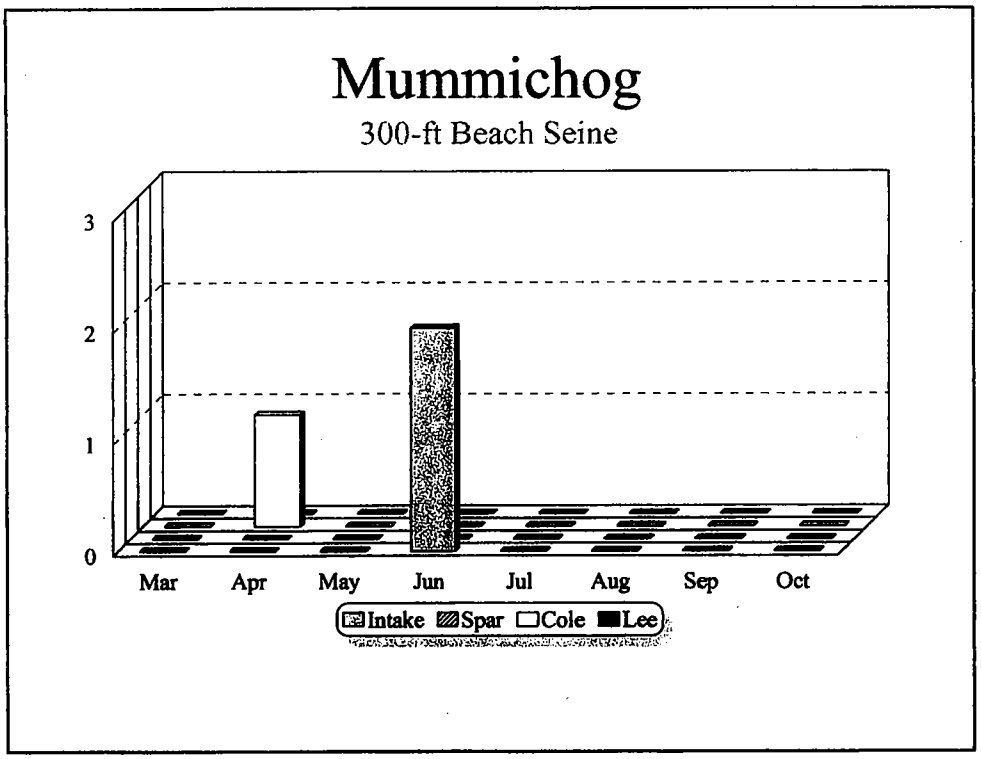
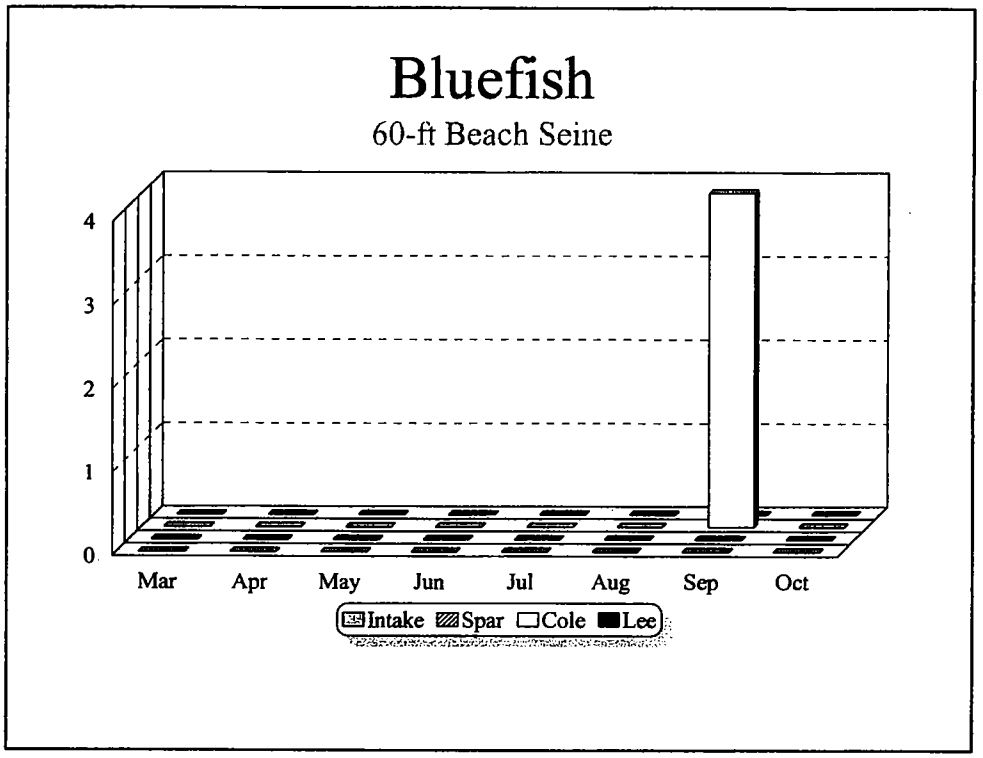


Figure 7-4d. Numbers of mummichog collected in each monthly haul of 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, March–October 2005



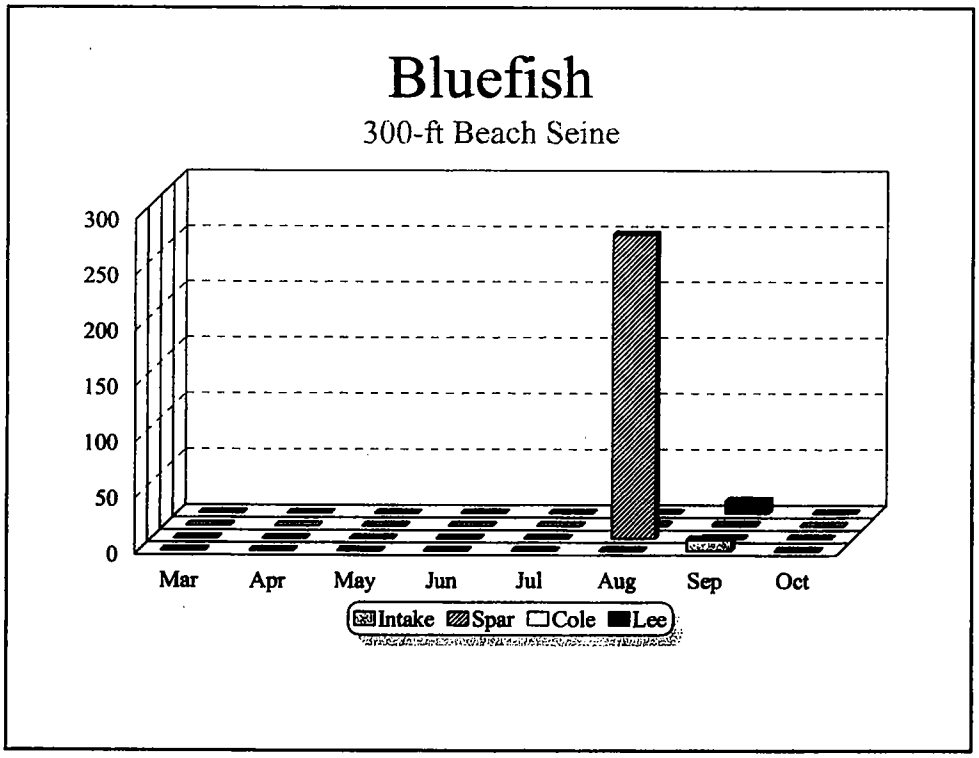
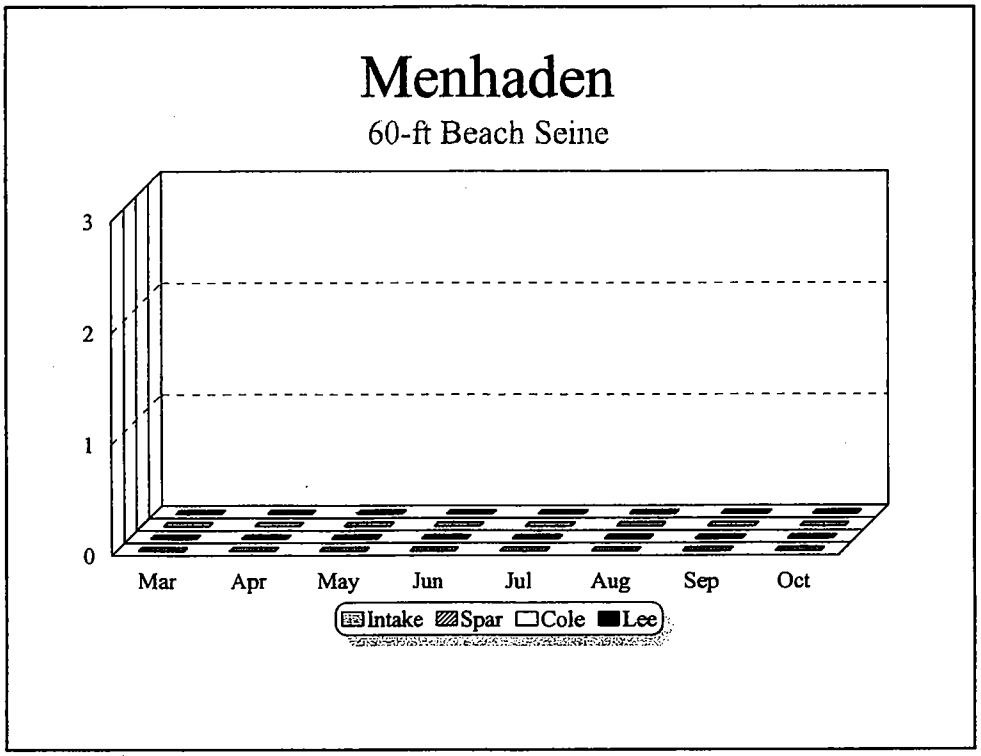


Figure 7-4e. Numbers of bluefish collected in each monthly haul of 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, March–October 2005



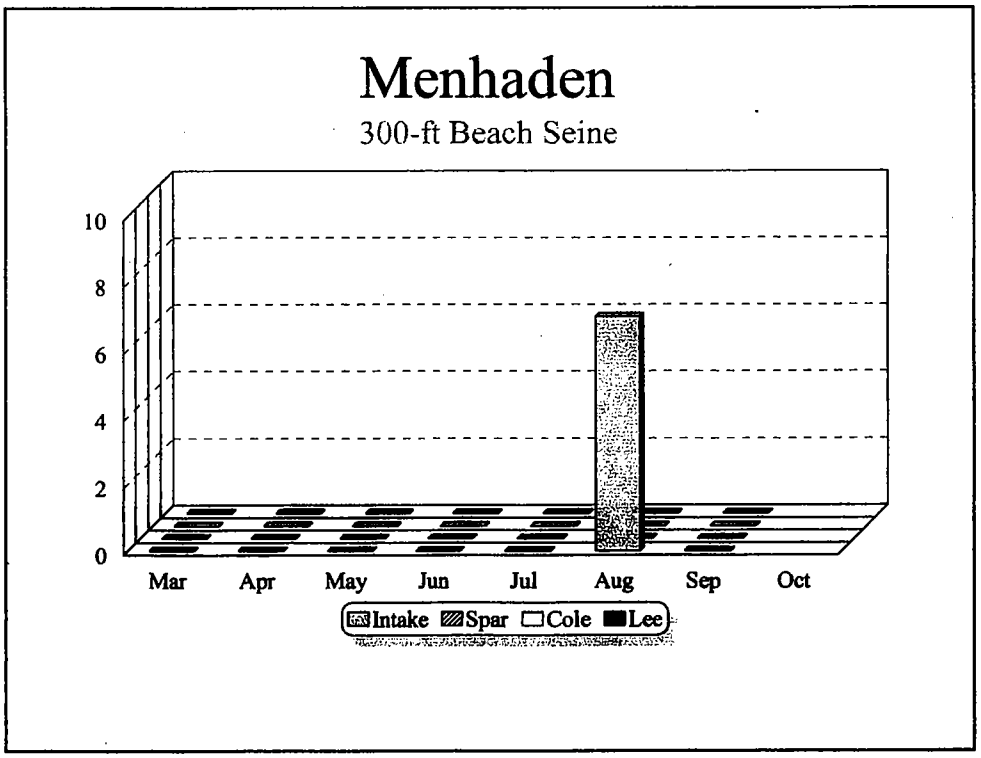
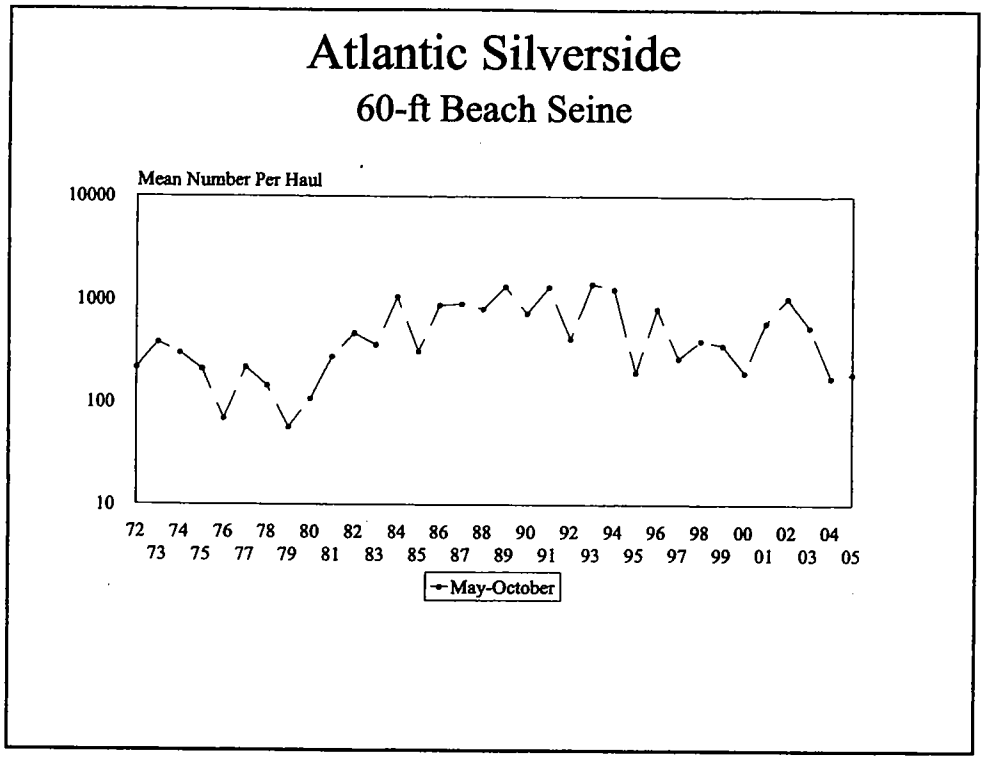


Figure 7-4f. Numbers of menhaden collected in each monthly haul of 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, March–October 2005



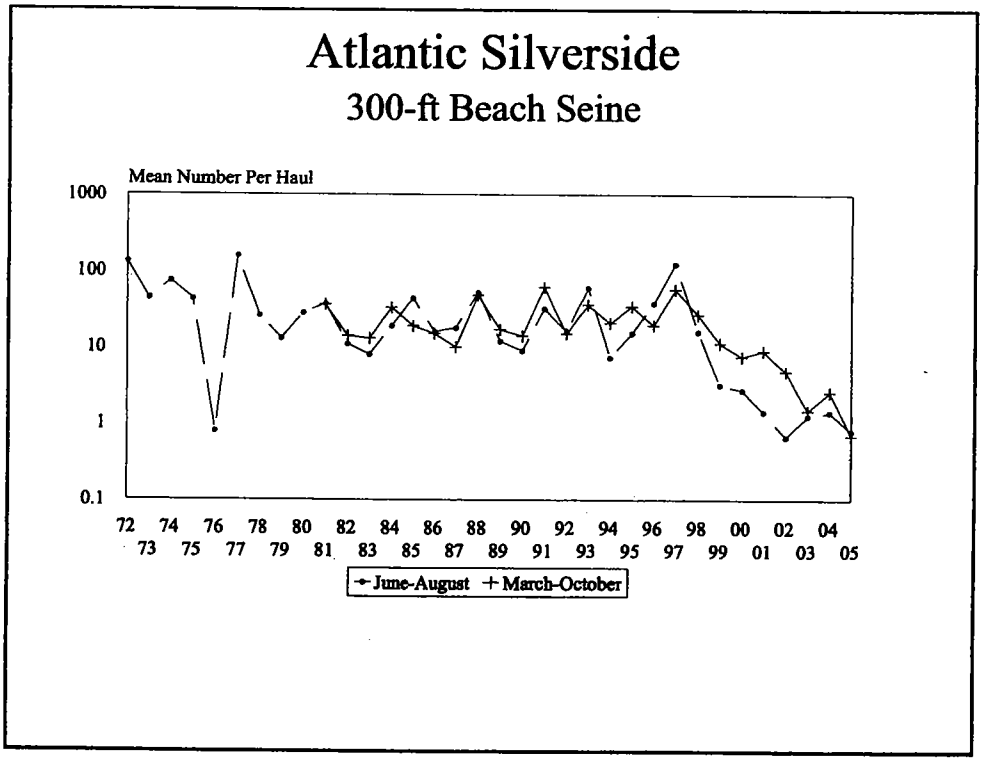
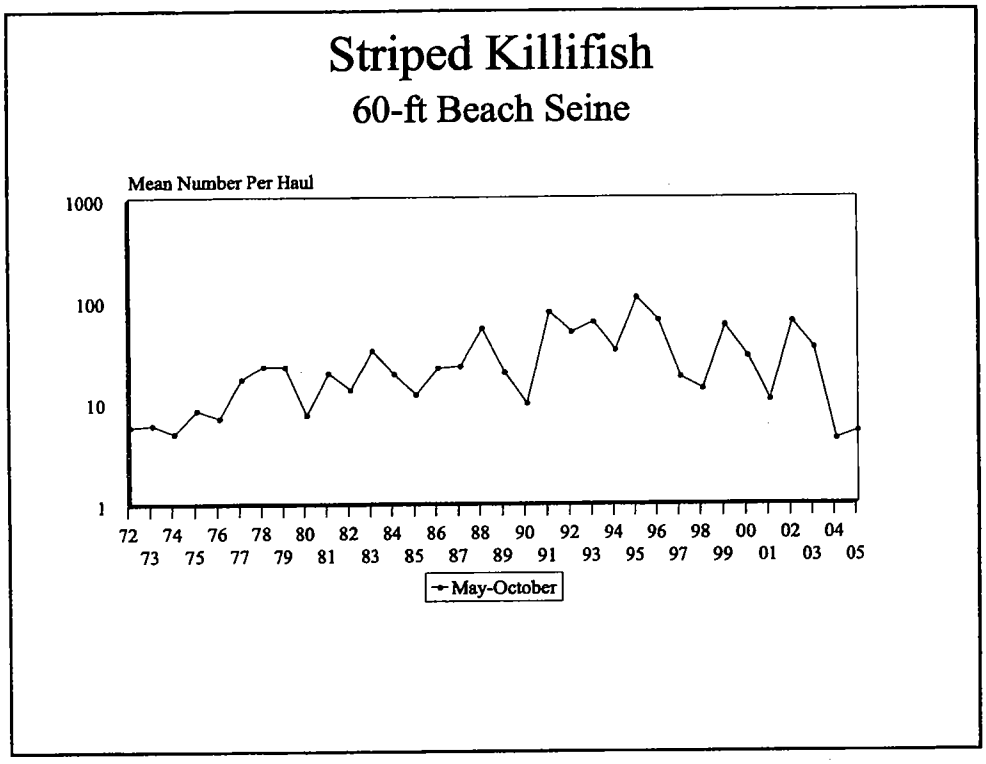


Figure 7-5a. Silverside annual mean numbers per haul collected by 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, 1972–2005



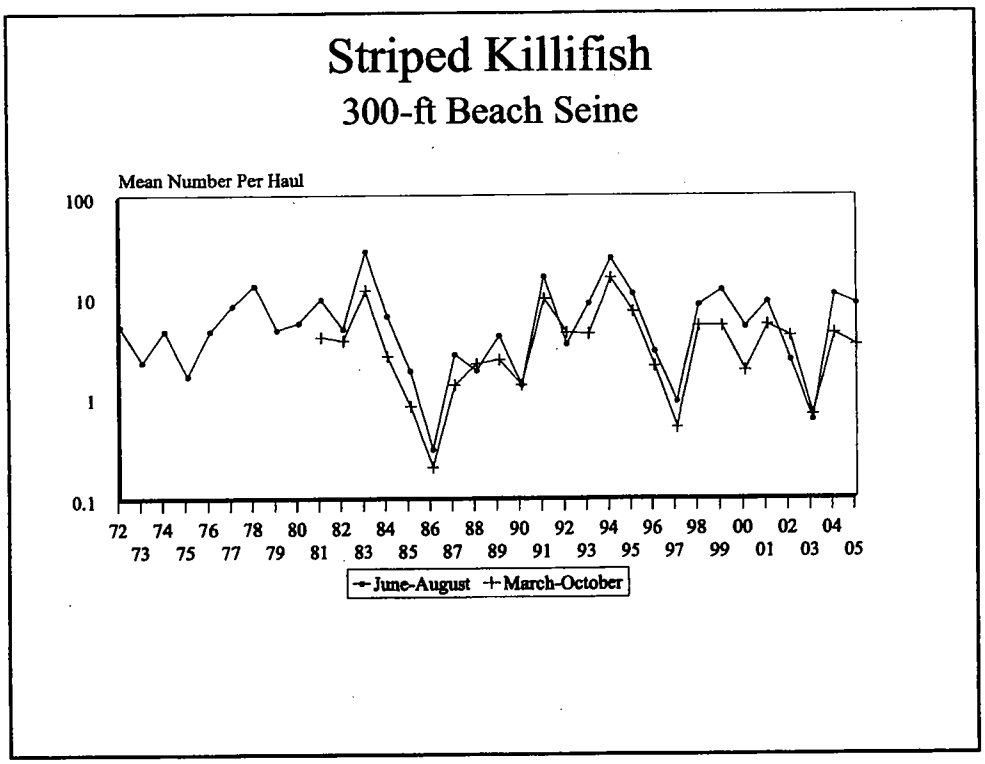
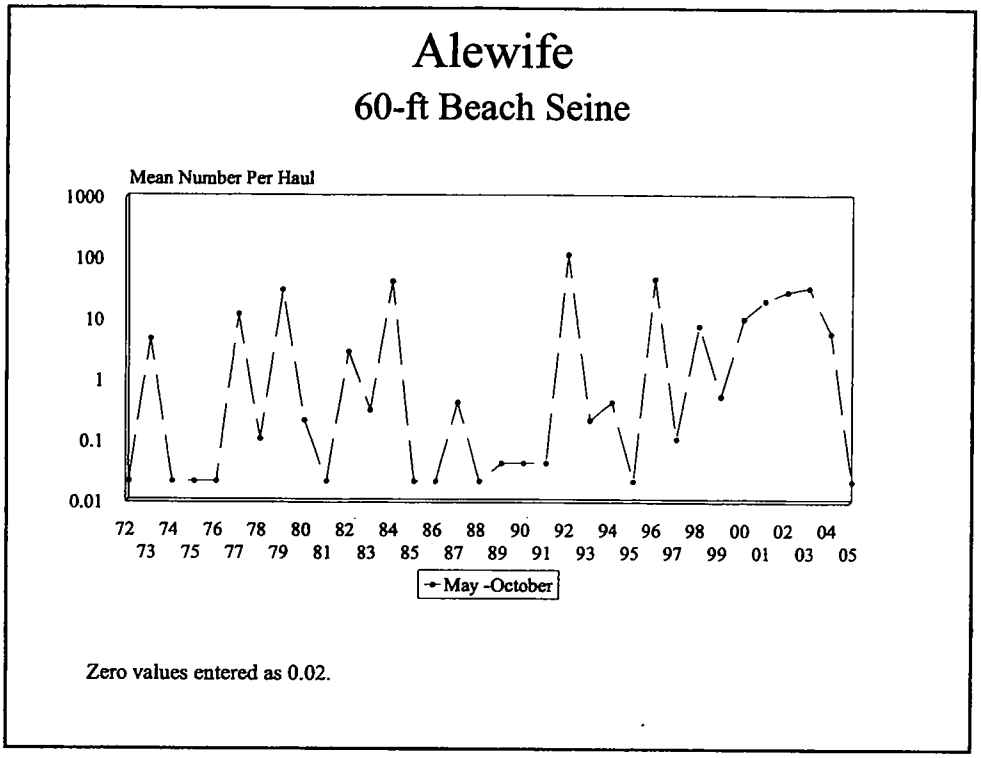


Figure 7-5b. Striped killifish annual mean numbers per haul collected by 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, 1972–2005



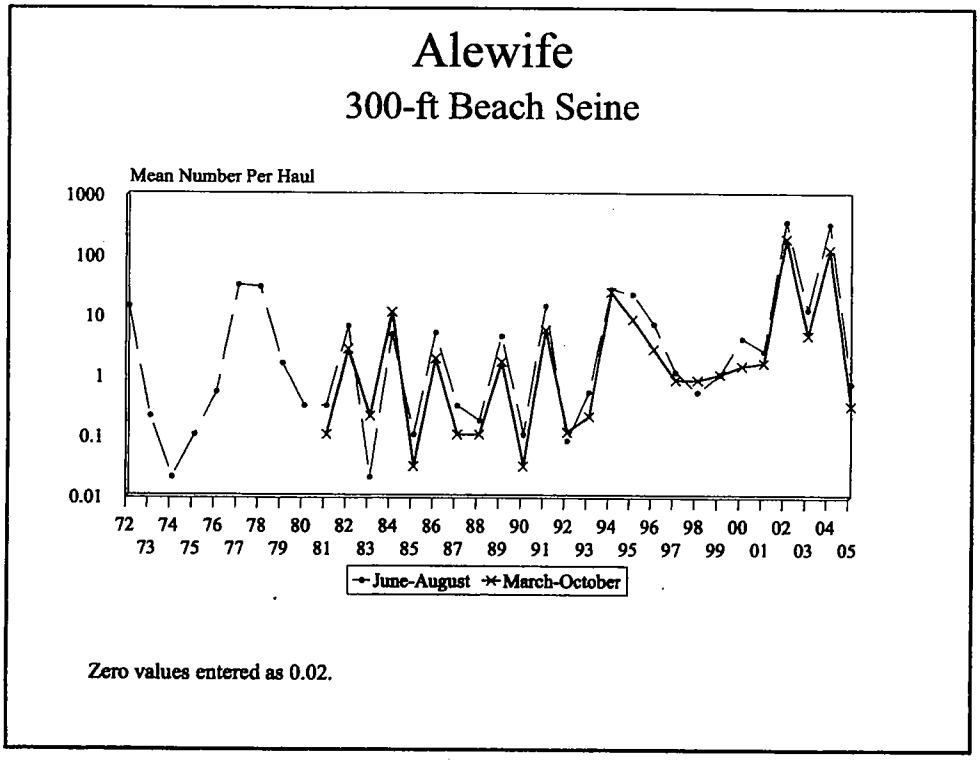
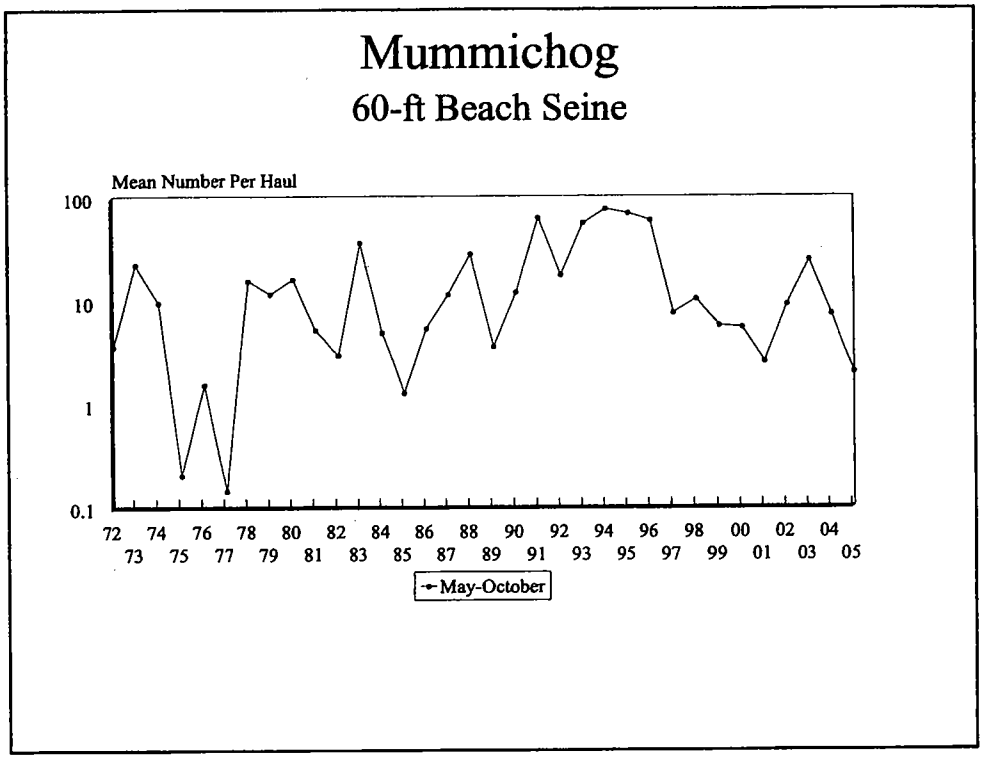


Figure 7-5c. Alewife annual mean numbers per haul collected by 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, 1972–2005



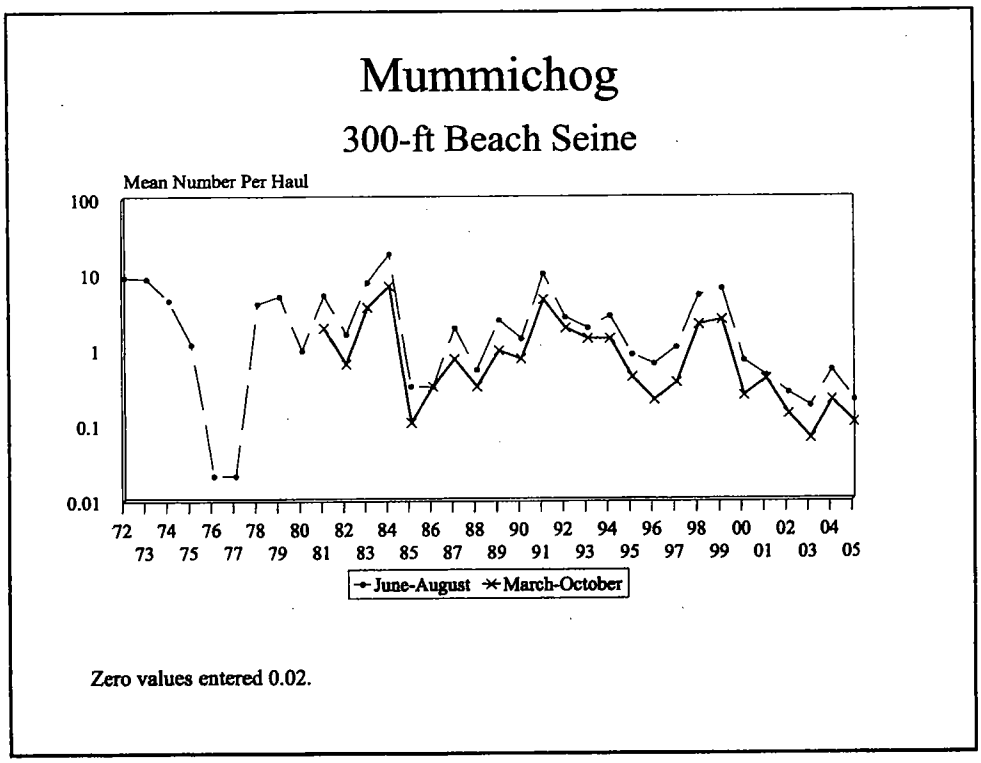
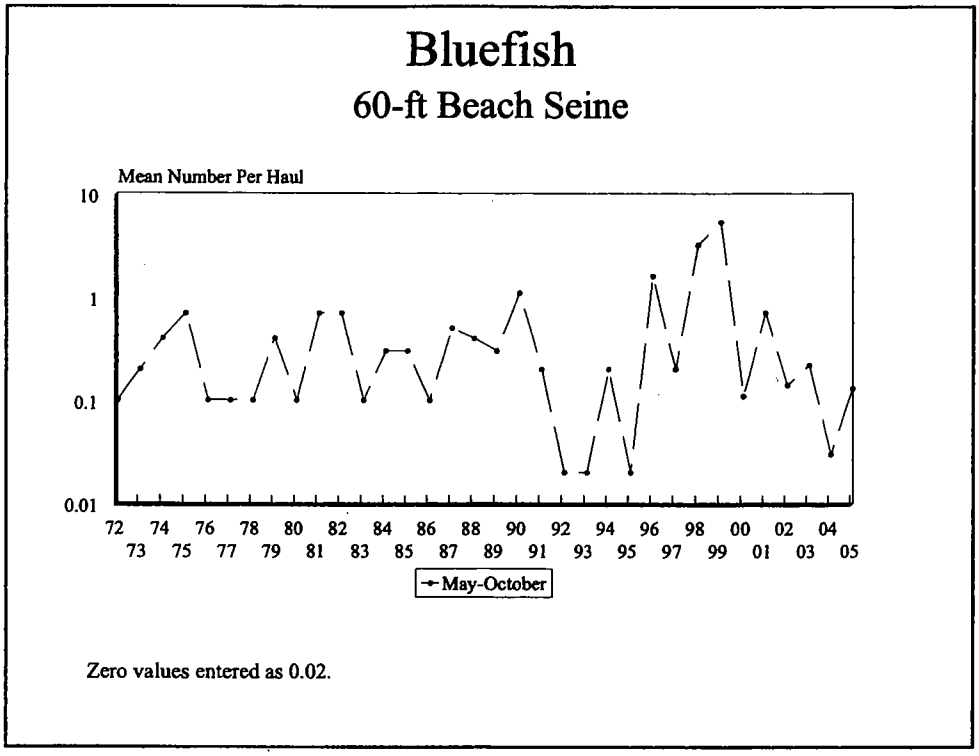


Figure 7-5d. Mummichog annual mean numbers per haul collected by 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, 1972–2005



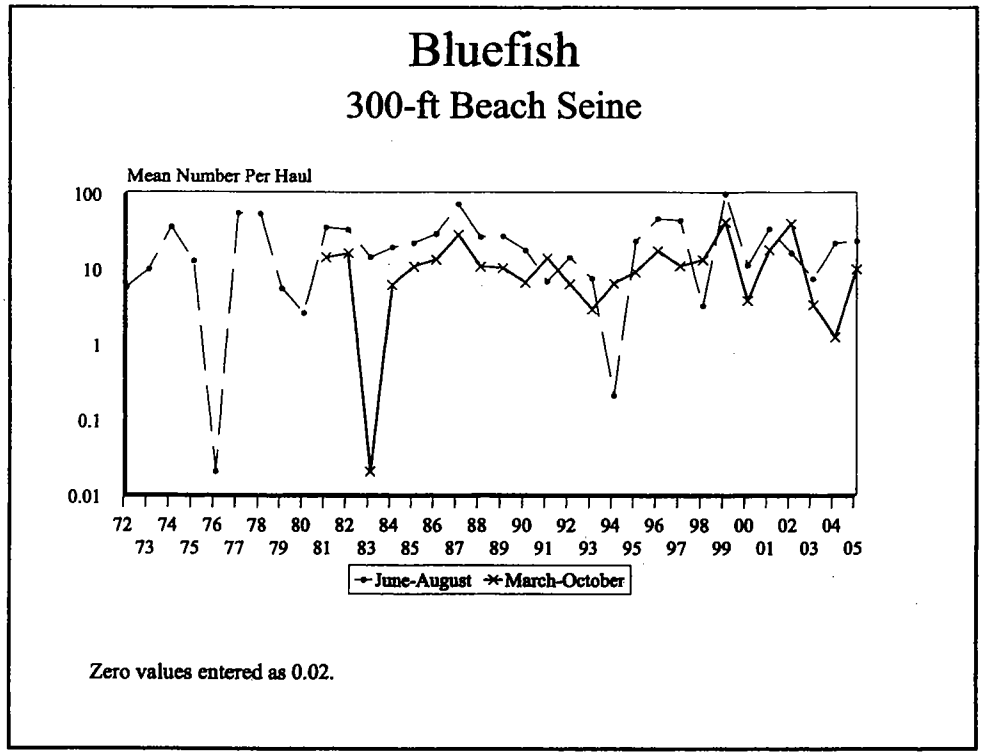
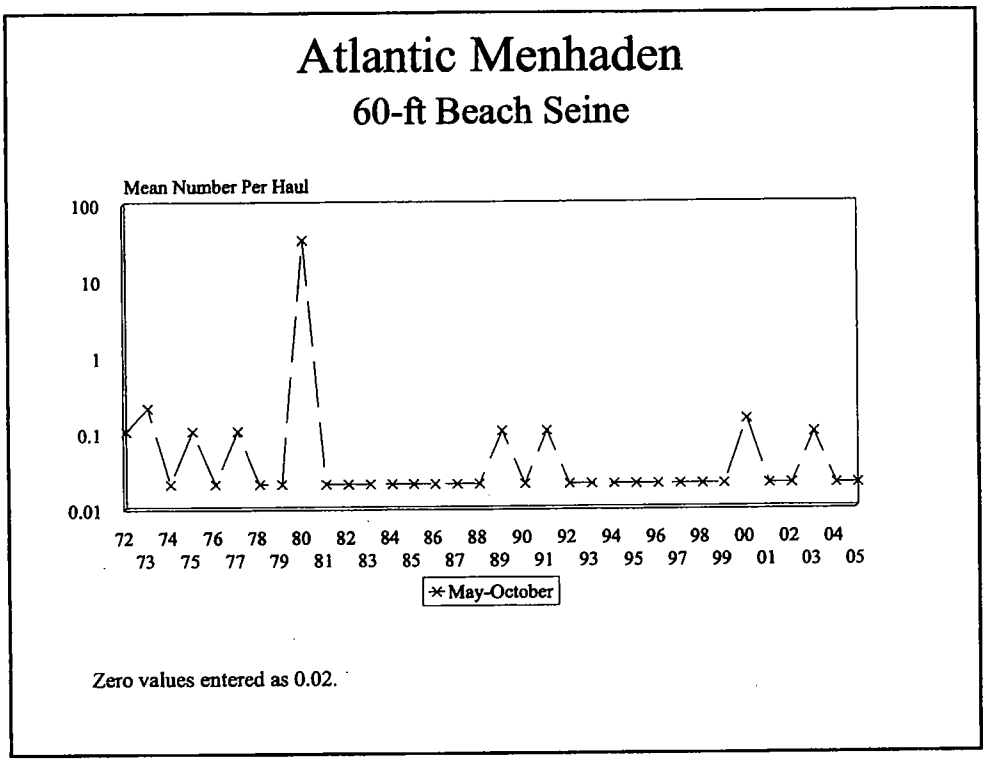


Figure 7-5e. Bluefish annual mean numbers per haul collected by 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, 1972–2005



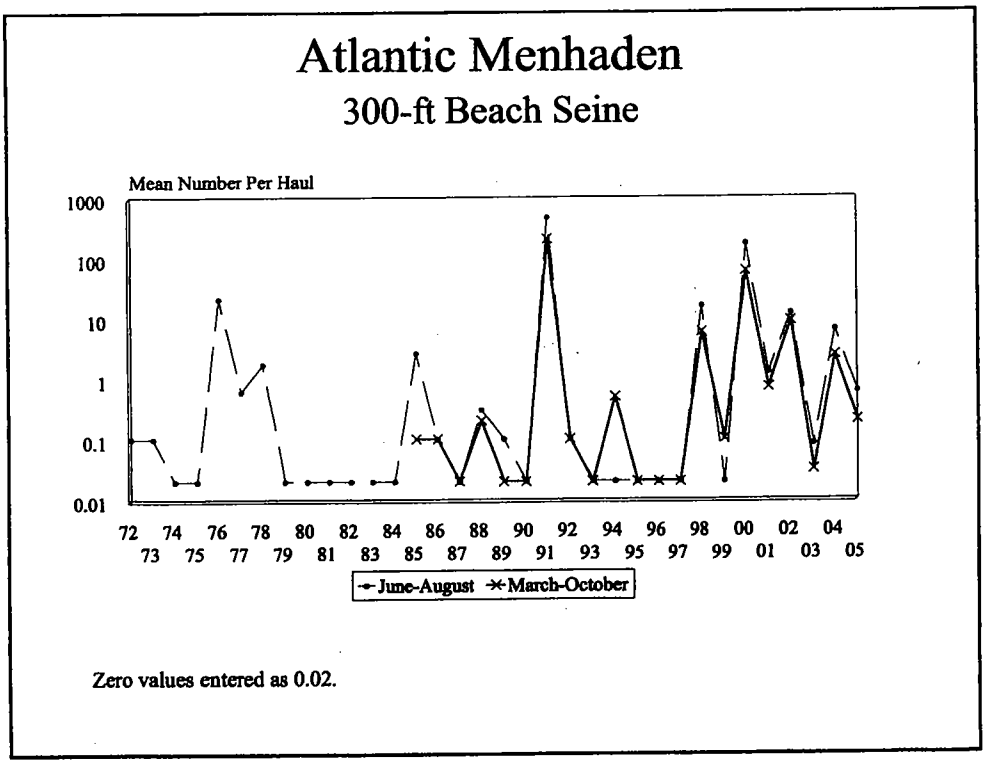
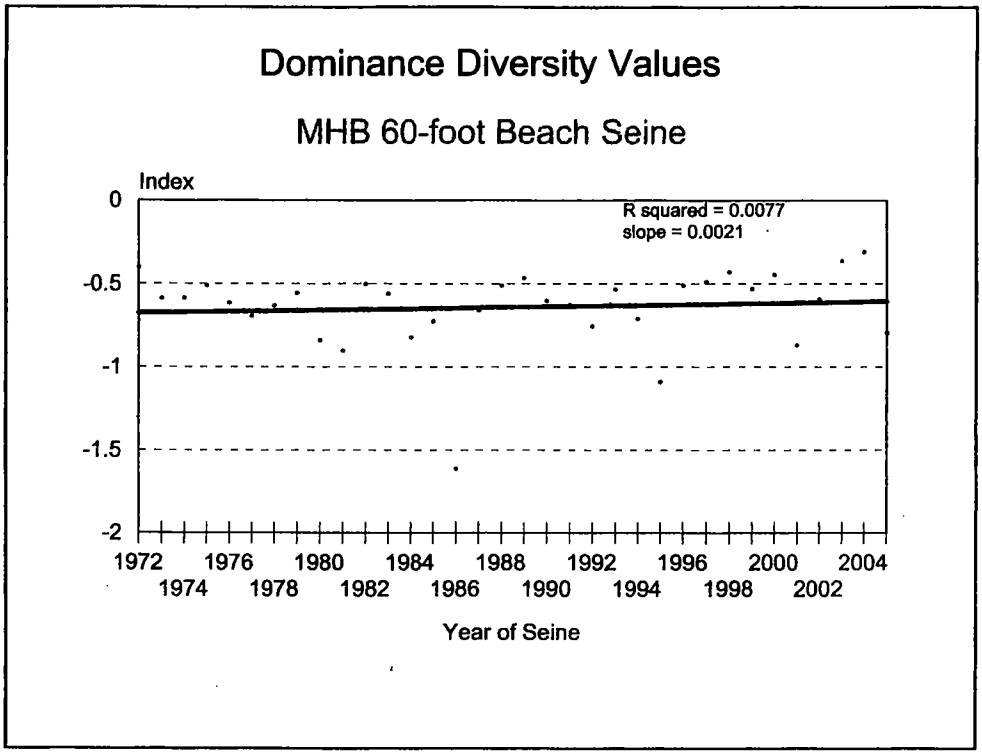


Figure 7-5f. Atlantic menhaden annual mean numbers per haul collected by 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, 1972–2005



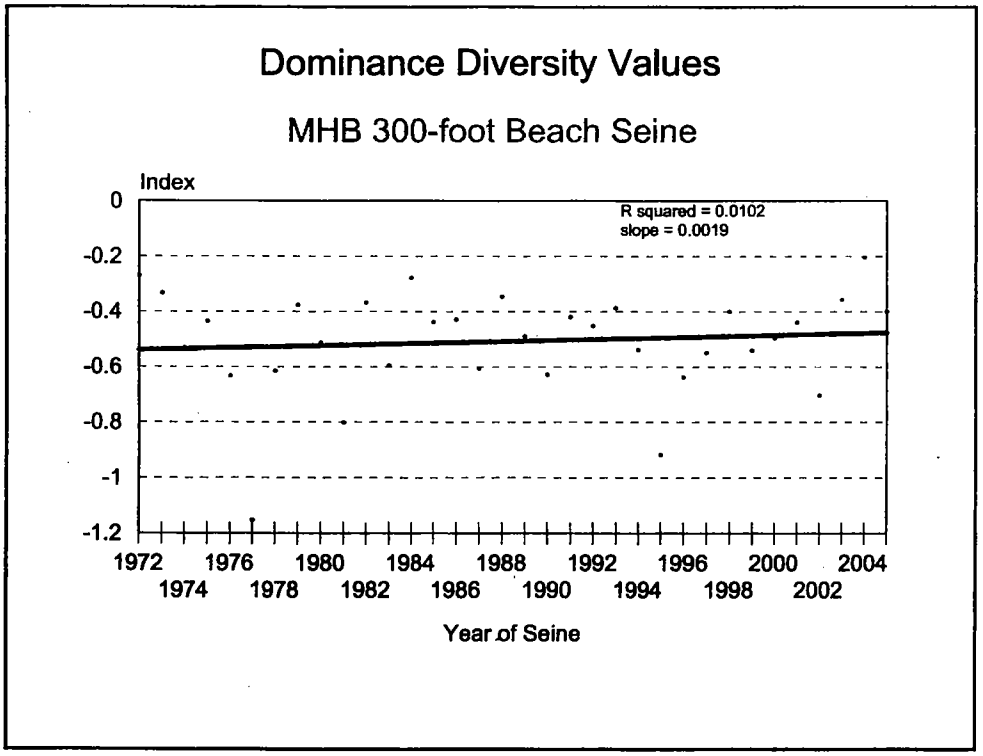


Figure 7-6. Annual dominance diversity values for finfish collected by 60- and 300-ft beach seines at four fixed stations in Mount Hope Bay, 1972–2005

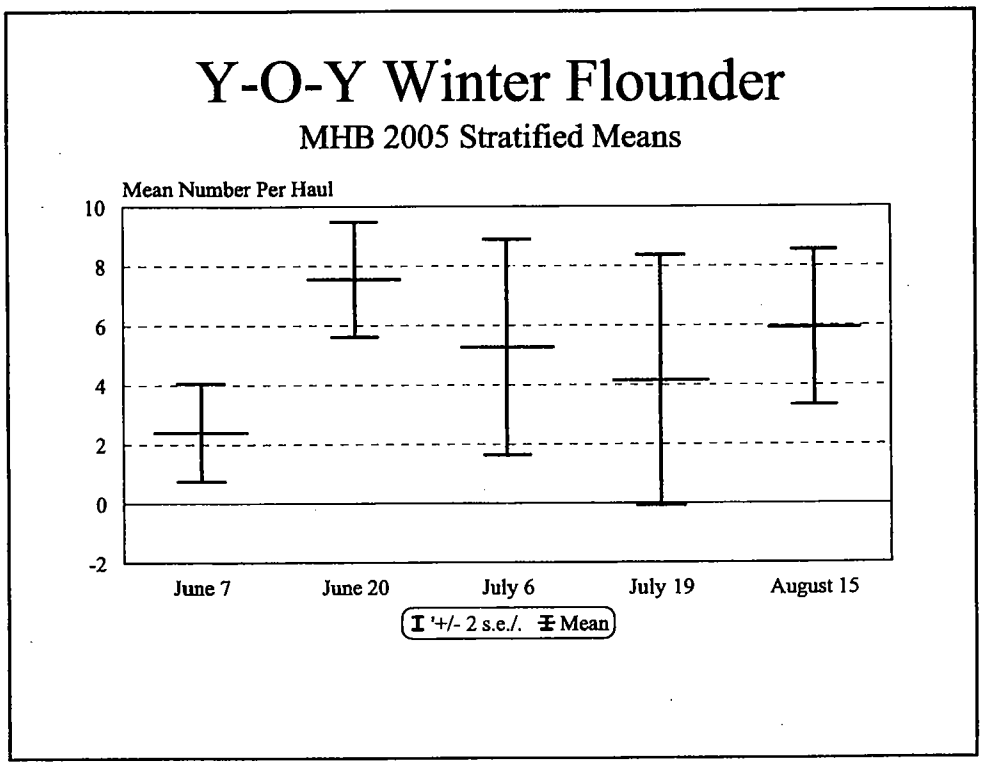


Figure 7-7. Stratified mean number of young-of-the-year winter flounder by sampling date, 2005

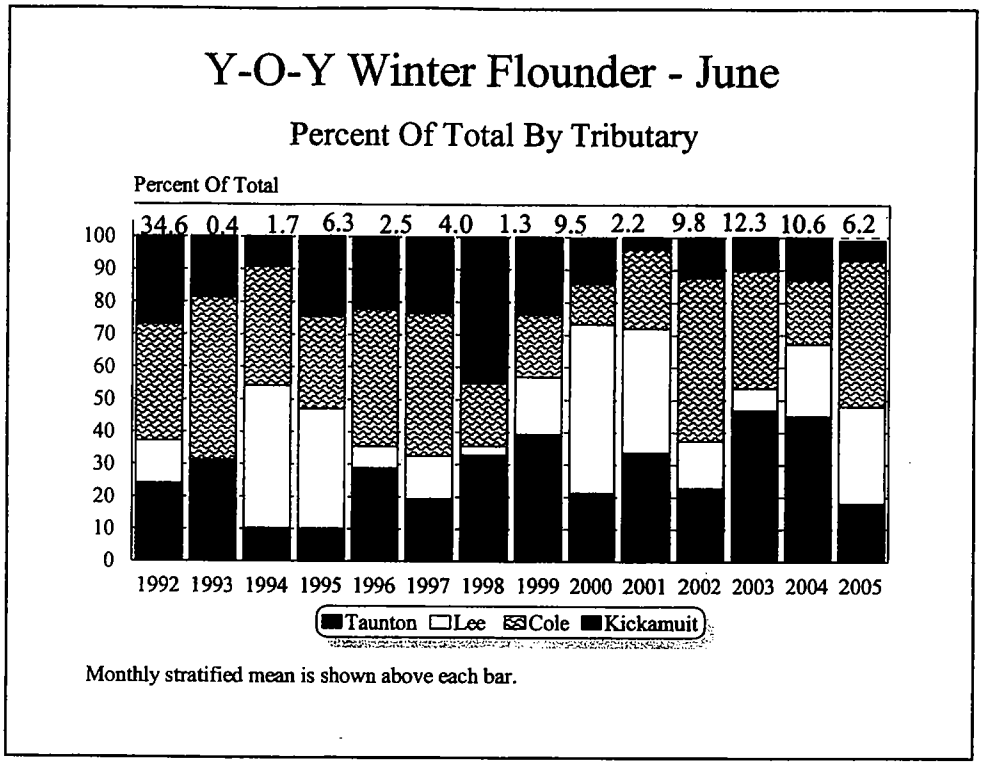


Figure 7-8. Percent of young-of-the-year catch by tributary during June 1992-2005

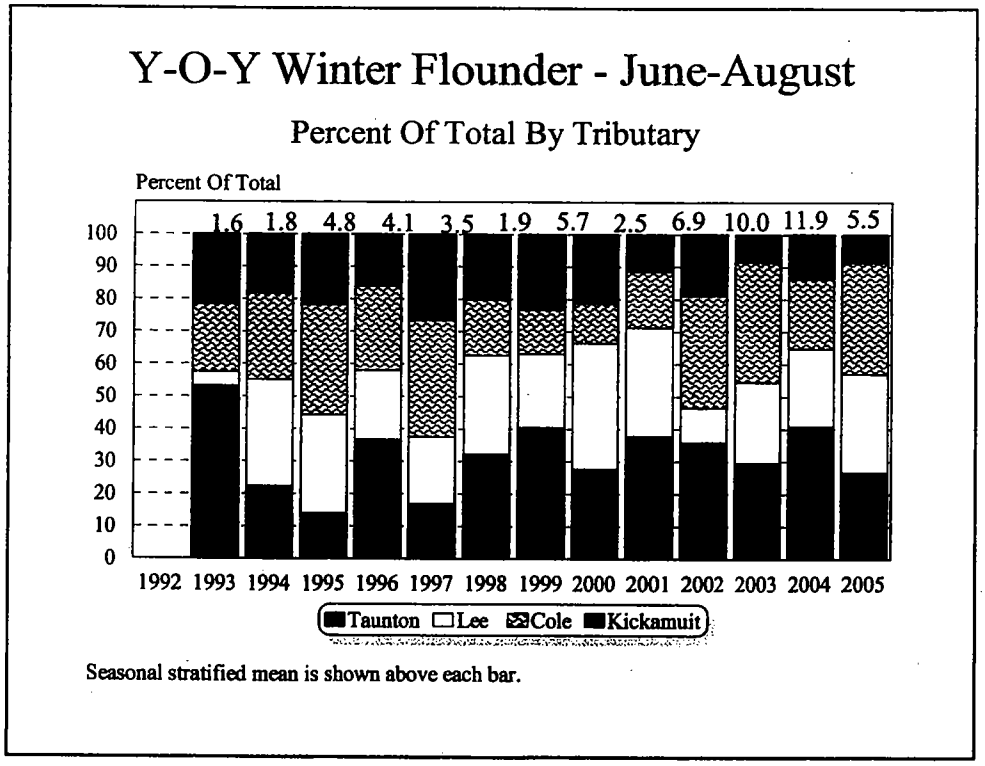


Figure 7-9. Percent of young-of-the-year catch by tributary during June through August, 1993-2005

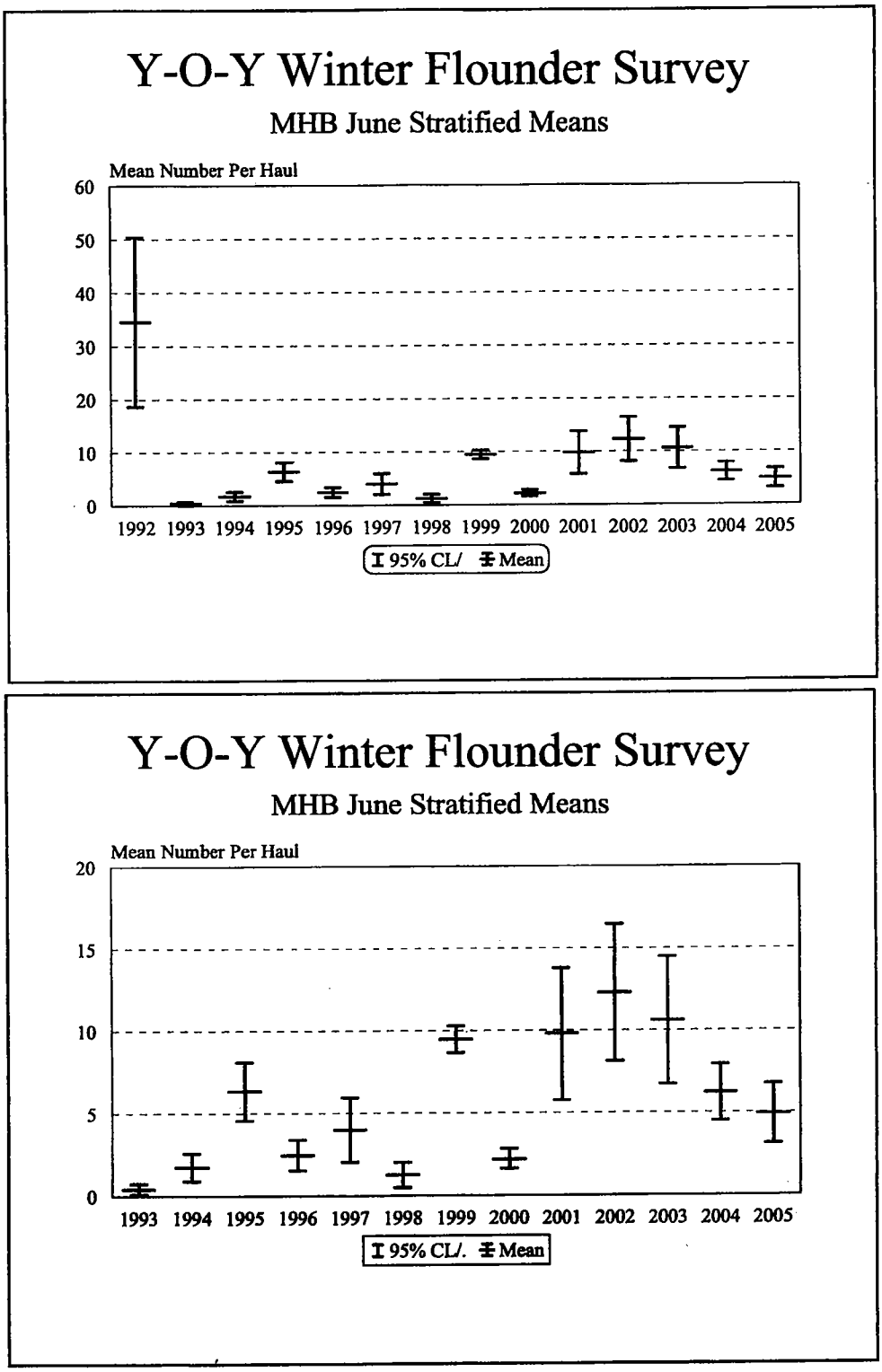


Figure 7-10. Stratified mean number of young-of-the-year winter flounder per seine haul during June 1992-2005 (top) and June 1993-2005

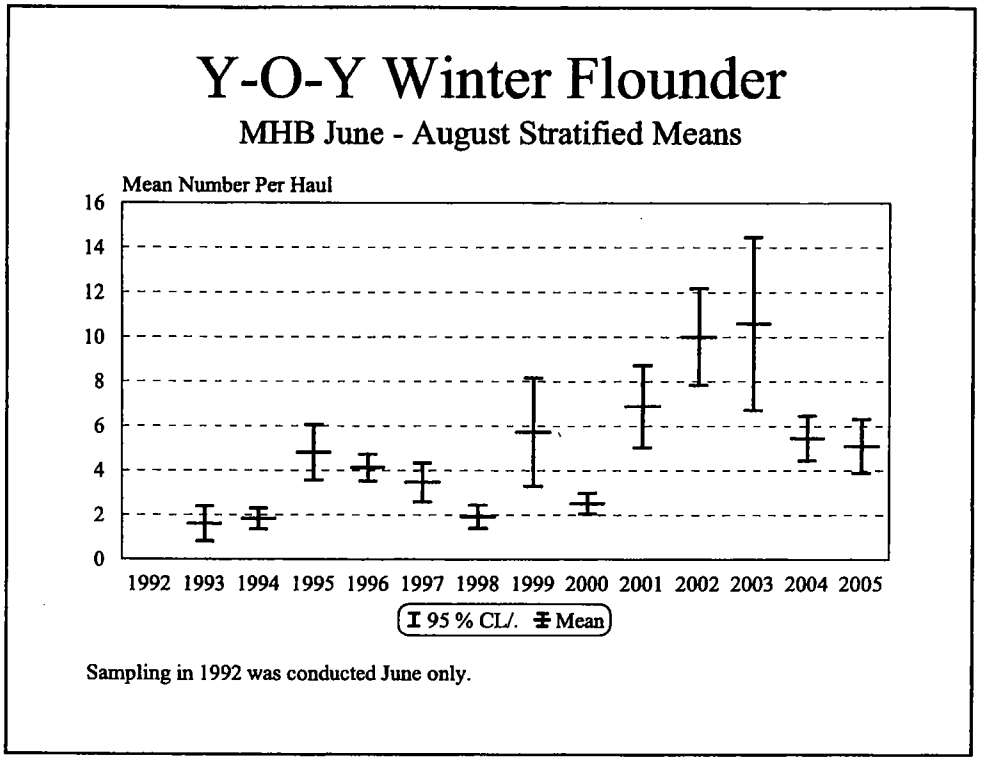


Figure 7-11. Stratified mean number of young-of-the-year winter flounder per seine haul, June-August 1992-2005

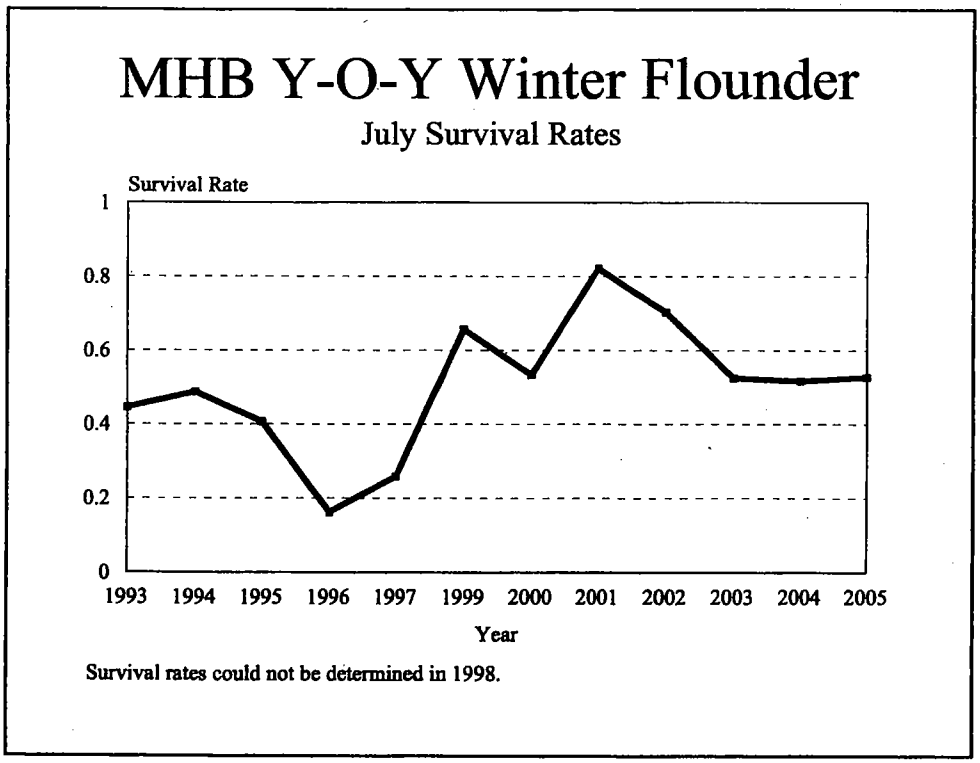
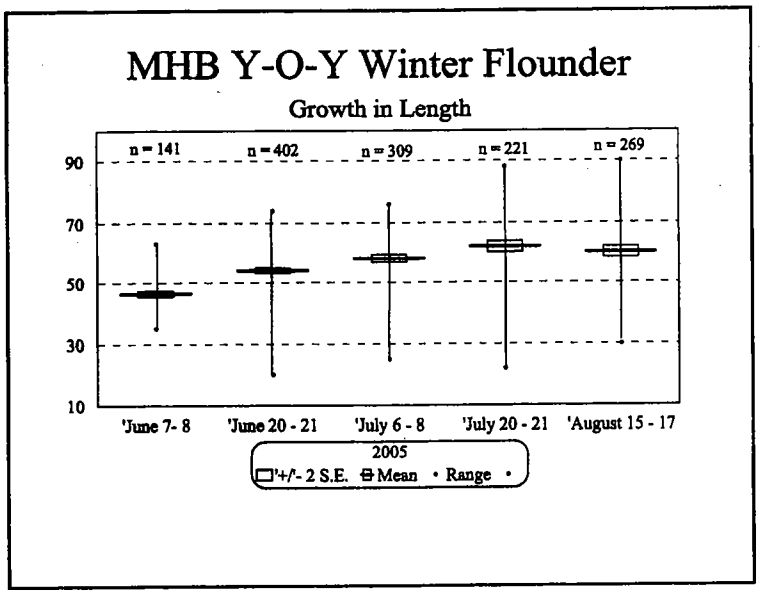
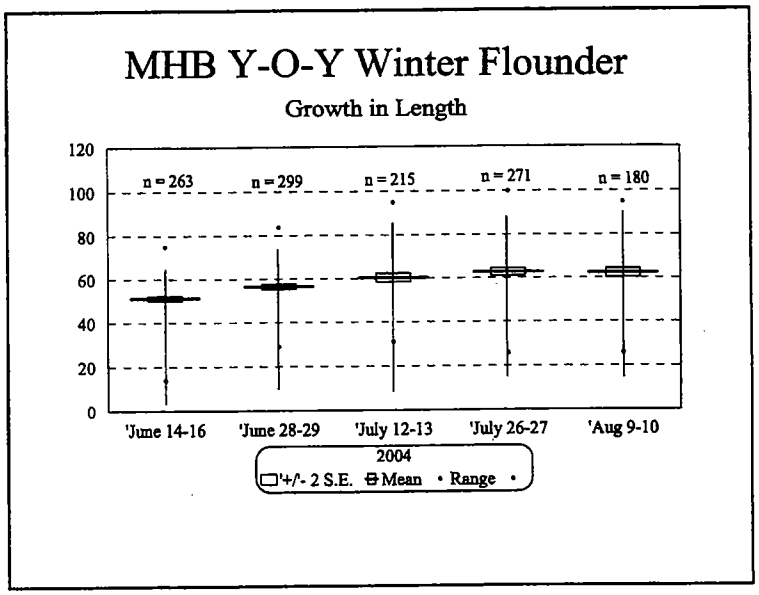
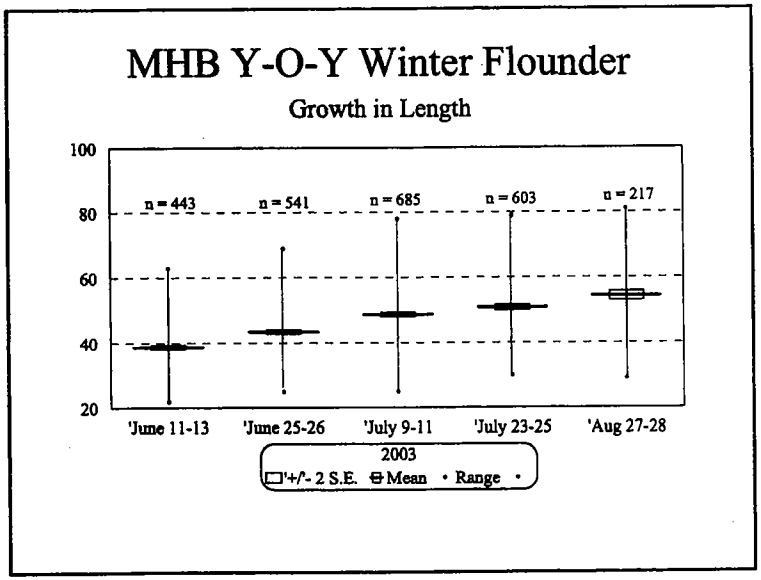


Figure 7-12. Survival rates calculated over 30 days in July, young-of-the-year winter flounder, 1993-2005







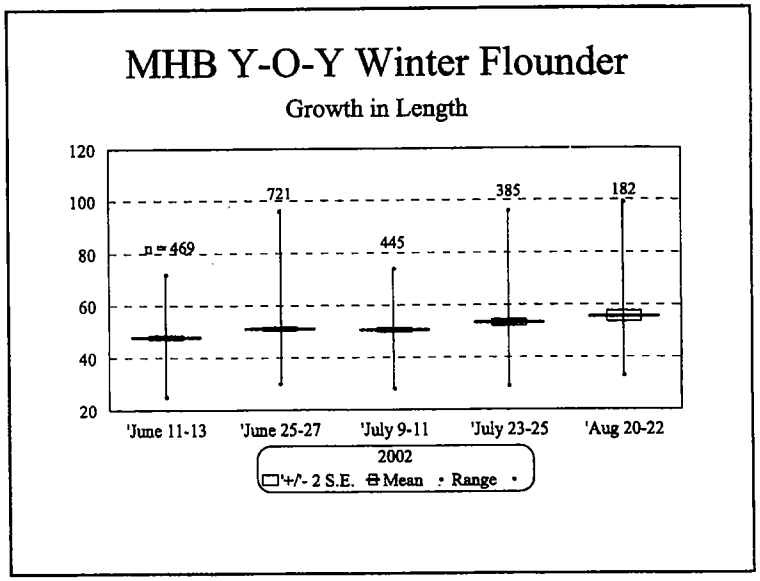
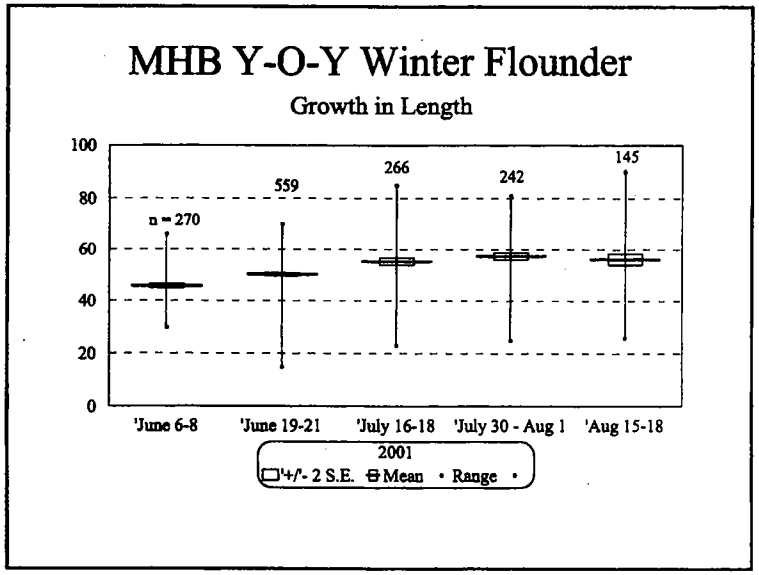
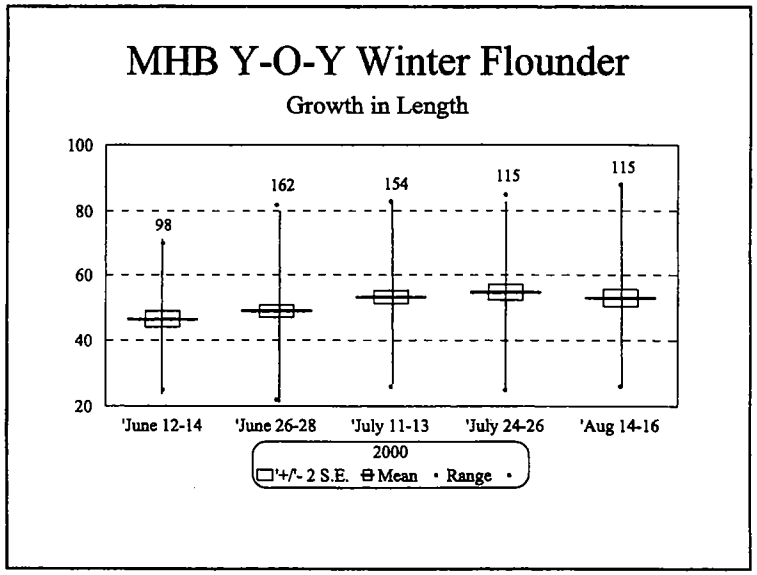
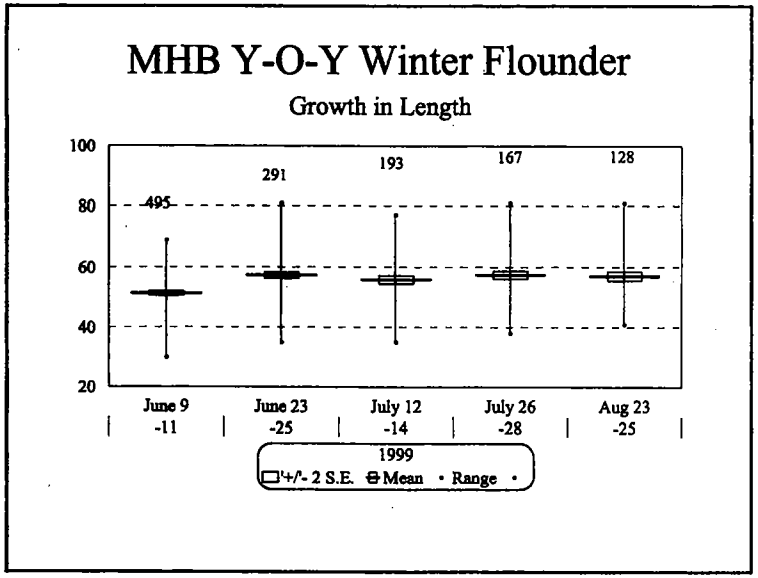


Figure 7-13. Total length data for age-0 winter flounder by sampling dates, 1992-2005 (page 1 of 4)







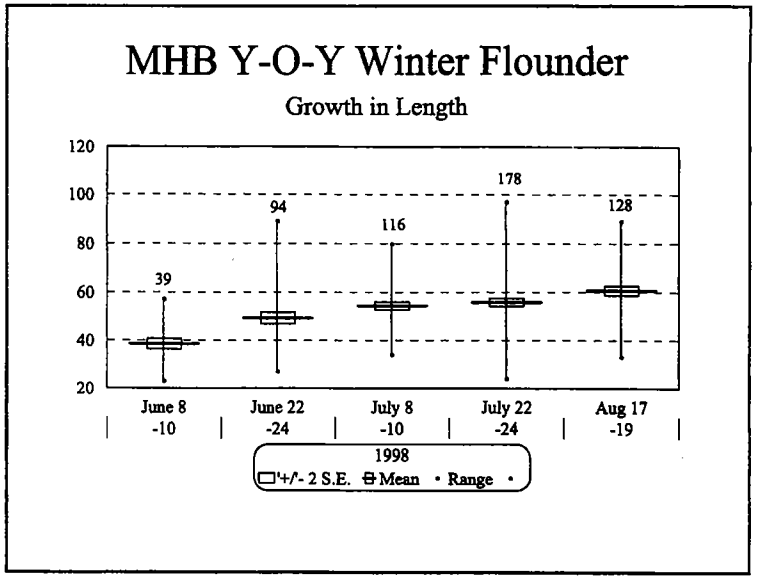
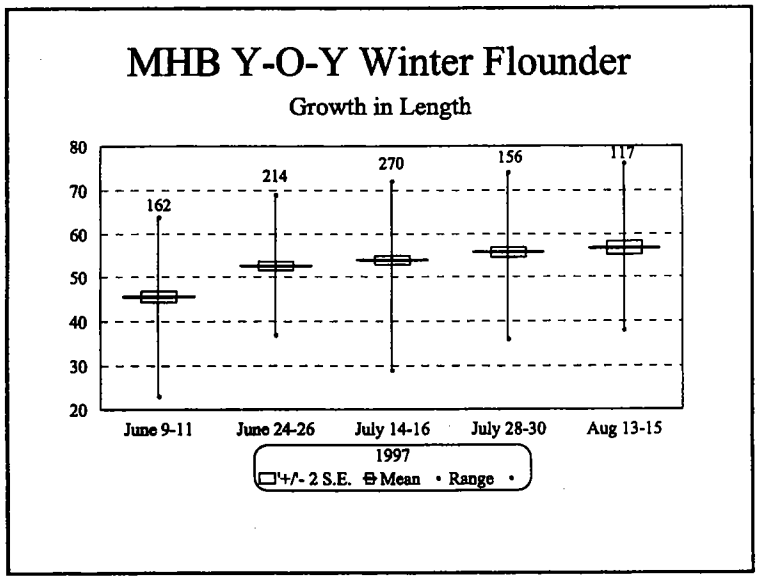
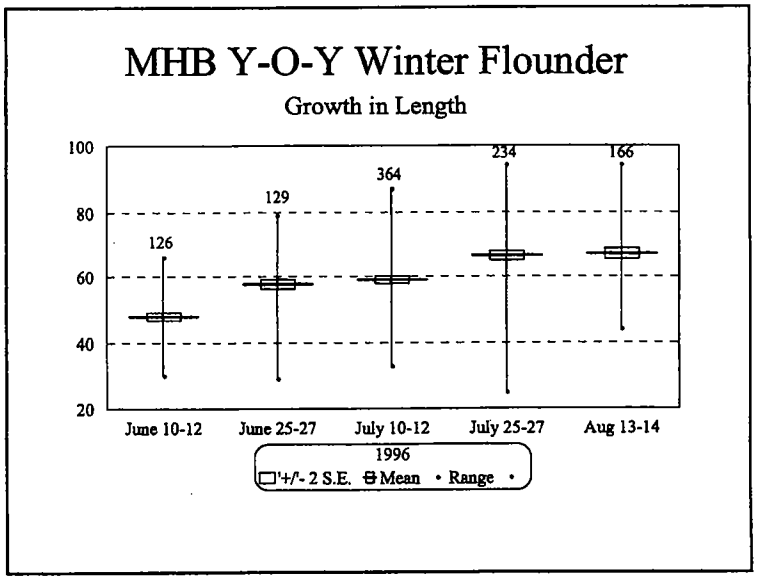
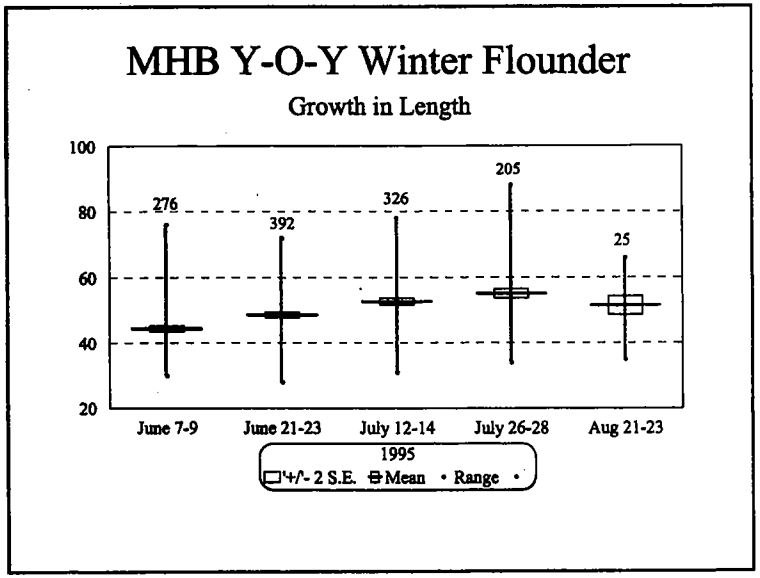


Figure 7-13. Total length data for age-0 winter flounder by sampling dates, 1992-2005 (page 2 of 4)







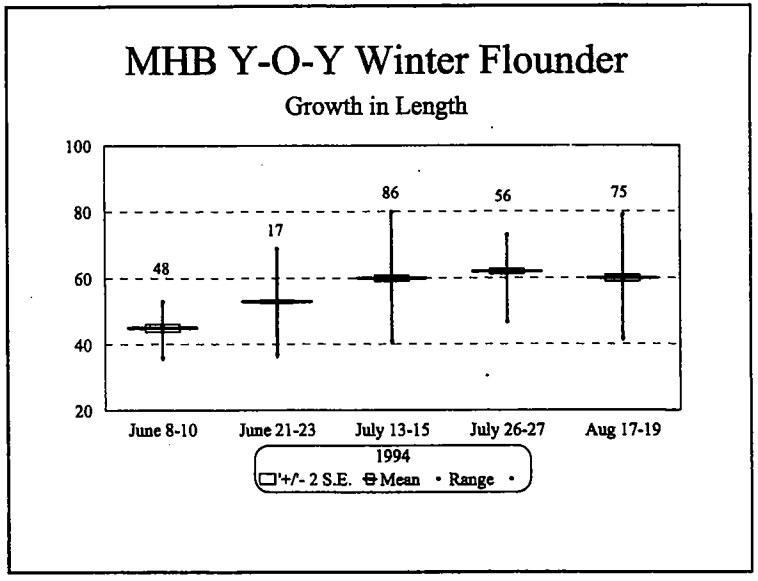
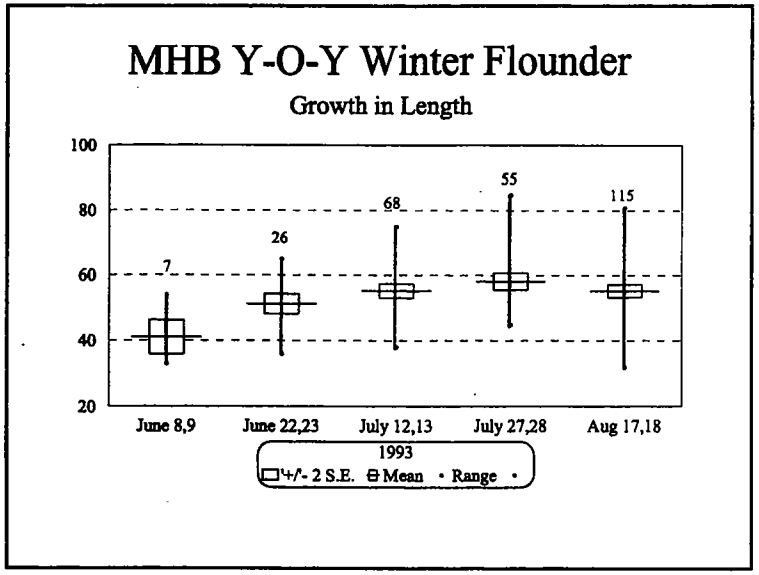


Figure 7-13. Total length data for age-0 winter flounder by sampling dates, 1992-2005 (page 3 of 4)



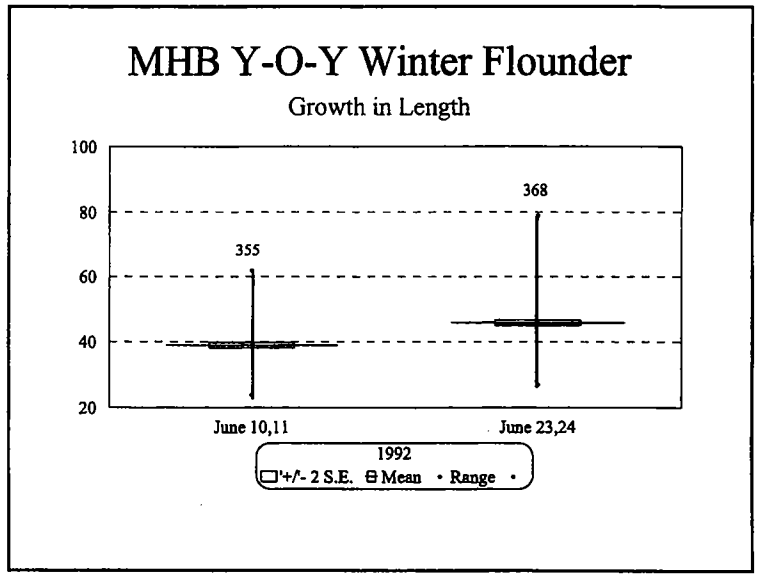


Figure 7-13. Total length data for age-0 winter flounder by sampling dates, 1992-2005 (page 4 of 4)

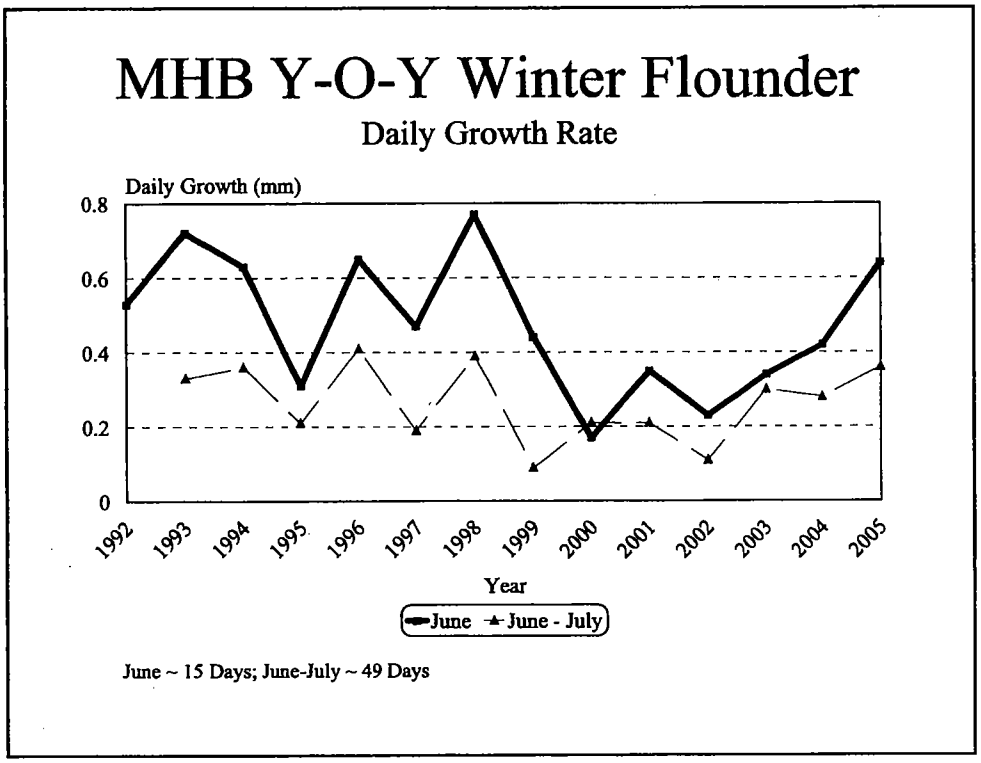


Figure 7-14. Linearized daily growth rates for young-of-the-year winter flounder, June 1992-2005, June-July 1993-2005

9 Finfish Abundance Studies

9.1 INTRODUCTION

The objective of this chapter is to utilize data available from finfish sampling programs conducted throughout Narragansett Bay to evaluate whether finfish populations in Mount Hope Bay may have been differentially affected by operations at Brayton Point Station. The following five fish species[1] are evaluated herein, based on their historical abundance in Mount Hope Bay and Narragansett Bay and their susceptibility to capture in the various sampling gears: winter flounder (*Pseudopleuronectes americanus*), windowpane (*Scophthalmus aquosus*), hogchoker (*Trinectes maculatus*), tautog (*Tautoga onitis*) and scup (*Stenotomus chrysops*).

9.2 METHODS

9.2.1 Mount Hope Bay vs. Narragansett Bay Abundance Trends Analysis – ANCOVA (Update of DeAlteris et al. (In Press))

Analysis of Covariance (ANCOVA) and Tukey-Kramer multiple comparison tests were applied to detect statistically significant differences in trends in abundance for the five target species in Mount Hope Bay relative to Narragansett Bay. Cooling water withdrawn from Mount Hope Bay for all units combined at Brayton Point Station has fluctuated from year to year but averaged 0.74 BGD from 1972 to 1985 and 0.98 BGD from 1986 to 2005. Due to the difference in average flows between the pre- and post-1985 periods, and because the plant flows and thermal discharge from the Station were highest between 1986 and 1996 and 1987 and 1991, respectively , the analysis contained herein was performed for the 1972 to 1985, 1986 to 2005 and 1972 to 2005 periods. The data sources and methods applied in this analysis are identical to those in DeAlteris et al. (In Press) with the exception that this annual report updates the time periods analyzed to include the years 2002 through 2005.

9.2.1.1 Indices of Fish Abundance

There are five primary sampling programs conducted within the Mount Hope Bay / Narragansett Bay estuary that can be used to calculate long-term indices of fish abundance. Data collected in these programs were used to generate indices of abundance for the five fish species.

[1] These species were identified by Lawton and Correia (1996) as being the only species captured in the MRI standard trawl survey at levels sufficient for documenting abundance trends.

The MRI trawl[2] abundance index (1972-2005) was calculated using all fixed station data collected within a given year except tows conducted at the Spar Island station located in Rhode Island waters of lower Mount Hope Bay and tows of a 3-minute duration at the discharge station (i.e., discharge station tows prior to 1979). The sampling program is described in detail in Chapter 5, Section 5.2.1. The Spar Island station was excluded from the MRI trawl index in order to analyze fish abundance trends in upper Mount Hope Bay separate from lower Mount Hope Bay. The annual catch-per-unit-effort (CPUE) values for the MRI trawl are the delta mean (Pennington 1983, 1986, 1996; Smith 1988) catch per tow. The MRI fixed station CPUE indexes fish abundance in approximately the upper 1/3 of Mount Hope Bay (Figure 9-1).

The BPS impingement index (1973-2005) was calculated from individual impingement collection data recorded at Brayton Point Station's units 1, 2 and 3 intake screens. The sampling program is described in detail in Chapter 6, section 6.2.1. The index was calculated by dividing the total number of fish of a given species captured during each year in the impingement sampling program by the total intake volume sampled during that year (expressed as number per million m^3 of intake water). The BPS impingement index documents fish abundance in the vicinity of the Station's Units 1, 2 and 3 intake in upper Mount Hope Bay (Figure 9-1).

Tow data from the RIDFW fixed and random trawl programs were combined to calculate two different indices of abundance (1979-2005) for each species – one for lower Mount Hope Bay and another for Narragansett Bay exclusive of Mount Hope Bay (Figure 9-1). The RIDFW trawl sampling program is described in detail in Lynch (2000). Lower Mount Hope Bay was defined to the north by the Rhode Island/Massachusetts state border and to the south by the Mt. Hope and Sakonnet Bridges. The Narragansett Bay exclusive of Mount Hope Bay index was calculated with data from all Narragansett Bay tows, except those defined as being in Lower Mount Hope Bay. To generate the annual index for each area, all fish captured in the random and fixed station tows made in that area were summed and divided by the total number of tows. In generating the indices, only April to May and September to October fixed station tows were used because only these time periods were sampled consistently throughout the duration of the random trawl program.

The URIGSO trawl index (1972-2005) was provided by J. Collie (pers. comm). The URIGSO trawl sampling program is described in detail in Jefferies and Johnson (1974). The index is the annual geometric mean catch per tow at the Fox Island station, calculated from all tows made within a given year for all species except scup where the annual geometric mean catch per tow is based on May through October tows. Hogchoker are rarely collected in lower Narragansett Bay; as a result there is no index for this species for the URIGSO trawl. The URIGSO Fox Island index documents fish abundance in the West Passage of Narragansett Bay (Figure 9-1).

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[2] MRI (Marine Research, Inc.) is currently operating as Normandeau Associates, Inc. "MRI" is used in this report for consistency with DeAlteris et al (In Press).

9.2.1.2 Statistical Analysis of Fish Abundance Trends

Analysis of Covariance (ANCOVA) and Tukey-Kramer multiple comparison tests were used to test for differences among trends in abundance for each species in each of the five indices of abundance during each of the three time periods studied (1972 to 1985, 1986 to 2005 and 1972 to 2005). Prior to running the statistical analyses on the abundance indices, the following transformation was applied to each index so as to meet the assumption of linearity in the ANCOVA model:

$$CPUE_{i,j,transformed} = \ln(CPUE_{i,j} + CPUE_{j,mean1972\text{-}2005} \times m) \quad \textbf{Equation 1.}$$

where:

CPUE = catch per unit effort
i = year
j = index
m = 0.01

This particular transformation was used because the more typical transformations of ln(CPUE) and ln(CPUE + 1) resulted in, respectively, the loss of information when CPUE was equal to zero (i.e., the natural log of zero is undefined) and unreasonable minimization of the variance among annual abundance values where abundance values were small relative to a value of 1. Alternative values of m in Equation 1 were found to either unreasonably minimize variance (e.g., 0.1) or create unreasonable outliers from the zero catch values (e.g., 0.001). The transformation performed in equation 1 linearizes the relationship between fish abundance and year while maintaining variance among the low CPUE values and not creating unreasonable outliers when CPUE values are zero.

Analysis of Covariance (ANCOVA; $\alpha = 0.05$) was used to evaluate differences among the slopes of the various transformed indices of abundance for the five species of fish during each cooling water regime, and for the entire time series (Sokal and Rohlf, 1995). Each ANCOVA was implemented in SAS software using Proc GLM (SAS Institute Inc., 2000). Significance of the type III sum of squares of the interaction term (i.e., year x abundance index) indicated whether any one index demonstrated a slope significantly different from any other. Given the large number of ANCOVA results concluding significant differences among at least one pair of slopes (7 of 15 tests), differences among individual slopes were evaluated using Gabriel's approximate method for the Tukey-Kramer multiple comparison test (Sokal and Rolf, 1995; $\alpha = 0.05$) implemented in Excel. This procedure produced 95% confidence intervals around each calculated slope. Statistical difference among individual slopes was determined based on non-overlap of the 95% confidence intervals.

9.2.2 Comparison of Wilcox Trawl Catch Rates in Mount Hope Bay and Narragansett Bay - ANOVA

The Wilcox trawl program started limited sampling in Mount Hope Bay in 1993, with year-round monthly sampling at random stations throughout Mount Hope Bay beginning

in 1996 (Figure 9-1). In 1997, two stations in Narragansett Bay were added to the program, Ohio Ledge (deep = >20 feet) and Warren River (shallow <20 feet) (Figure 9-2). The Wilcox trawl program is the only trawl program which has sampled finfish abundance concurrently in upper and lower Mount Hope Bay and Narragansett Bay. The 1997 and later Wilcox trawl data allow direct comparison of catch rates among these three areas without the complications related to trawl catch efficiency that arise when comparisons are made across different gears. All five target species were analyzed as described below.

A fixed-effects (year and depth stratum) Analysis of Variance (ANOVA) model (NCSS 2000) was used to test for differences in catch per unit effort (CPUE) of each target species in the three regions. The regions were defined as follows: Upper Mount Hope Bay – Massachusetts waters of Mount Hope Bay sampled with the Wilcox trawl; Lower Mount Hope Bay – Rhode Island waters of Mount Hope Bay sampled with the Wilcox trawl; and Narragansett Bay – Warren River and Ohio Ledge fixed stations in Narragansett Bay. CPUEs in the ANOVA were calculated as ln[(catch/tow duration)+1]. Because catches of winter flounder tend to be higher at deep water stations than at shallow water stations, the ANOVA was run for shallow and deep stations separately and for shallow and deep stations combined for winter flounder. Depth strata were defined as shallow (<20 feet) and deep (>20 feet). The year-region interaction term in the ANOVA (i.e., "AB" in the ANOVA results tables) tests whether there is a significant difference in the annual catch values among the three regions within any given year.

9.3 RESULTS AND DISCUSSION

Results and discussion for the analyses described above are provided below for each of the five target species.

9.3.1 Winter Flounder

9.3.1.1 Mount Hope Bay vs. Narragansett Bay Trends Analysis – ANCOVA (Update of DeAlteris et al. In Press)

The update of the ANCOVA and Tukey-Kramer multiple comparison tests with 2002 through 2005 data for winter flounder produced the following results. For the early time period, 1972 to 1985, there is one significant difference among the slopes of the five indices ($p = 0.040$); that is, the Brayton Point Station impingement index slope for upper Mount Hope Bay has a significantly steeper negative slope than the RIDFW trawl index slope for lower Mount Hope Bay (Table 9-1, Figure 9-4). For the later time period, 1986 to 2005, there is no significant difference in the slopes of the five indices ($p = 0.819$). For the entire time series, 1972 to 2005, there are significant differences among the slopes ($p < 0.001$). The slope of the MRI trawl index has a significantly steeper negative slope than the slopes of all the other indices.

These results reach the same statistical conclusions as DeAlteris et al. (In Press) with the exception of the MRI trawl slope for the 1972-2005 period. While in DeAlteris et al. (In Press), the slope of the MRI trawl index for this period was not found to be significantly different from the RIDFW trawl index slope for Narragansett Bay, incorporation of 2002 through 2005 data resulted in these slopes being statistically different from one another. However, while the slopes were found to be statistically different, the lower and upper confidence limits of the MRI trawl and RIDFW trawl slopes were separated by only 0.011 (Figure 9-4) and thus are only barely different from one another at $\alpha = 0.05$. Contradicting this finding is the fact that the BPS impingement index slope for upper Mount Hope Bay was not significantly different from either the RIDFW or URIGSO trawl index slopes for Narragansett Bay for the same time period. Therefore the results are equivocal as to whether or not abundance trends in upper Mount Hope Bay are different from those in Narragansett Bay over the period 1972-2005. A more important finding regarding the effect of Brayton Point Station on winter flounder in Mount Hope Bay is the fact that there was no statistically significant difference among abundance trends for Mount Hope Bay and Narragansett Bay during the most recent period analyzed, 1986-2005, which includes the periods when the station's cooling water intake flows (1986-1996) and thermal discharge (1987-1991) were highest. Overall, these results suggest that abundance trends of winter flounder in Mount Hope Bay were not differentially affected by operations at Brayton Point Station, even during the periods of high thermal discharge and cooling water intake flows.

Beyond the results of the statistical analyses provided above, it is notable that winter flounder catch rates have generally increased throughout Mount Hope Bay since 2000 and in Narragansett Bay since 2002 (Figure 9-4). For example, winter flounder average catch in the RIDFW trawl in lower Mount Hope Bay increased from a low of 3.6 in 2000 to a high of 13.9 in 2005, representing greater than a 3–fold increase. Similarly large increases were also evident in Wilcox trawl catches (Figure 5-10) and Brayton Point Station Impingement (Figure 9-4); catch increased from a low of 1.1 in 2001 to 3.6 in 2005 (representing greater than a 3–fold increase) and 0.4 in 2000 to 2.5 in 2005 (representing greater than a 6–fold increase) in these programs, respectively. Increases were also evident in the Narragansett Bay indices — e.g., Wilcox trawl catches in Narragansett Bay increased from 1.0 in 2002 to 7.0 in 2005 (representing greater than a 7–fold increase; Figure 5-10), while URIGSO trawl catches increased from 6 to 17 for the same years (representing greater than a 2–fold increase; Figure 9-4). The more northern winter flounder stocks, which were not included in the statistical analysis because of their distance from Mount Hope Bay, have experienced declines in abundance rather than increases during the same period. For example, the Massachusetts Division of Marine Fisheries Southern and Northern Stocks (Vincent Manfredi, personal communication, April 2005) and the Northeast Fisheries Science Center Gulf of Maine (Paul Nitschke, personal communication, December 2004) indices experienced greater than a 2-, 2- and 3-fold decrease, respectively, from 2000 to 2004.

9.3.1.2 Comparison of Wilcox Trawl Catch Rates in Mount Hope Bay and Narragansett Bay - ANOVA

Results of the Wilcox trawl ANOVA showed that there was no significant difference in winter flounder abundance among upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay during any year, 1997-2005 (Table 9-2). The result was the same whether the deep and shallow stations were analyzed separately or were kept together. As is evident in Figure 9-5, average catch values for 1997-2005 were similar across the three regions within each depth strata and overall. Average catch was consistently higher at the deep-water stations than at the shallow-water stations across all three regions.

9.3.2 Windowpane

9.3.2.1 Mount Hope Bay vs. Narragansett Bay Trends Analysis – ANCOVA (Update of DeAlteris et al. In Press)

The update of the ANCOVA and Tukey-Kramer multiple comparison tests with 2002 through 2005 data for windowpane produced the following results which support the same statistical conclusions as DeAlteris et al. (In Press). Windowpane is the only species examined for which all slopes are not significantly different from one another within each of the three time periods examined (1972 to 1985, $p = 0.464$; 1986 to 2005, $p = 0.128$; 1972-2005, $p = 0.179$) (Table 9-1, Figure 9-6). Similar to winter flounder, windowpane abundance has generally shown increases relative to 2000 throughout Mount Hope Bay and Narragansett Bay (Figure 9-6).

9.3.2.2 Comparison of Wilcox Trawl Catch Rates in Mount Hope Bay and Narragansett Bay - ANOVA

Average windowpane CPUE, 1997-2005 (Figure 9-7), was higher in both upper and lower Mount Hope Bay than in Narragansett Bay, however, results of the Wilcox trawl ANOVA showed that there was no significant difference in windowpane abundance among upper Mount Hope Bay, lower Mount Hope Bay, and Narragansett Bay during any year, 1997-2005 (Table 9-3).

9.3.3 Hogchoker

9.3.3.1 Mount Hope Bay vs. Narragansett Bay Trends Analysis – ANCOVA (Update of DeAlteris et al. In Press)

The update of the ANCOVA and Tukey-Kramer multiple comparison tests with 2002 through 2005 data for hogchoker produced the following results which support the same statistical conclusions as DeAlteris et al. (In Press). For the early time period, 1972 to 1985, there are significant differences in the slopes among the four indices ($p = 0.003$), with the Brayton Point Station impingement index slope being significantly less steep than both the RIDFW trawl lower Mount Hope Bay and Narragansett Bay index slopes (Table 9-1, Figure 9-8). The MRI trawl index slope for this period was also found to be

significantly less steep than the RIDFW lower Mount Hope Bay index slope. There is no significant difference among slopes during the later time period, 1986 to 2005 (p = 0.151). For the entire time series, 1972 to 2005, there are significant differences in slopes among the four indices (p = 0.009). The estimated slope for the MRI trawl index and BPS impingement index are significantly less steep than the slope of the RIDFW trawl Narragansett Bay index.

9.3.3.2 Comparison of Wilcox Trawl Catch Rates in Mount Hope Bay and Narragansett Bay - ANOVA

Similar to windowpane, average hogchoker CPUE, 1997-2005 (Figure 9-9), was higher in both upper and lower Mount Hope Bay than in Narragansett Bay. However, results of the Wilcox trawl ANOVA showed that there was no significant difference in hogchoker abundance among upper Mount Hope Bay, lower Mount Hope Bay, and Narragansett Bay during any year, 1997-2005 (Table 9-4).

9.3.4 Scup

9.3.4.1 Mount Hope Bay vs. Narragansett Bay Trends Analysis – ANCOVA (Update of DeAlteris et al. In Press)

The update of the ANCOVA and Tukey-Kramer multiple comparison tests with 2002 through 2005 data for scup produced the following results. There is no significant difference among slopes within the 1972 to 1985 period (p = 0.980). For the latter time period, 1986 to 2005, there is a significant difference among the slopes (p = 0.013). The BPS impingement index has a slope significantly steeper than those of the MRI trawl and RIDFW trawl for both lower Mount Hope Bay and Narragansett Bay (Table 9-1, Figure 9-10). For the long time series, 1972 to 2005, there are also significant differences among the slopes of the five indices ($p < 0.001$). While the estimated slopes for the MRI trawl and the Brayton Point Station impingement indices are not significantly different for the long time period, both were found to have significantly steeper slopes than the RIDFW lower Mount Hope Bay and RIDFW Narragansett Bay indices, while neither was significantly steeper than the URIGSO trawl index slope.

These results differ from DeAlteris et al. (In Press) in that the former analysis found no significant difference for the 1986 to 2001 period. Additionally, while DeAlteris et al. (In Press) found the MRI trawl index slope for the 1972-2005 period to be significantly different from the URIGSO trawl index slope for Narragansett Bay, incorporation of 2002 through 2005 data resulted in these slopes not being significantly different from one another.

Outside of the results of the statistical analyses provided above, scup abundance appears to have increased in recent years and reached near record levels in both lower Mount Hope Bay and Narragansett Bay. Long-term (1972-2005) abundance trends in upper Mount Hope Bay were negative for scup, but this may be due in large part to the fact that even in the early 1970s, neither gear sampling this area collected scup in large numbers.

For example, the largest MRI trawl annual CPUE value for scup during the 1972 to 2005 period is 62 fish. This value, which is nearly twice as large as the next largest CPUE value of 36 fish, is considerably lower than catches in the other trawl gears. The time series high annual CPUE values in the RIDFW trawl in lower Mount Hope Bay and Narragansett Bay and the URIGSO trawl in Narragansett Bay were 428, 713, and 331, respectively.

9.3.4.2 Comparison of Wilcox Trawl Catch Rates in Mount Hope Bay and Narragansett Bay - ANOVA

Catches of scup were greater in lower Mount Hope Bay than in either upper Mount Hope Bay or Narragansett Bay (Figure 9-11), however, results of the Wilcox trawl ANOVA showed that there was no significant difference in scup abundance among upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay during any year, 1997-2005 (Table 9-5).

9.3.5 Tautog

9.3.5.1 Mount Hope Bay vs. Narragansett Bay Trends Analysis – ANCOVA (Update of DeAlteris et al. In Press)

The update of the ANCOVA and Tukey-Kramer multiple comparison tests with 2002 through 2005 data for tautog produced the following results which support the same statistical conclusions as DeAlteris et al. (In Press). Tautog were found to have no significant differences among slopes within either the 1972 to 1985 ($p = 0.087$) or 1986 to 2005 ($p = 0.547$) time periods (Table 9-1, Figure 9-12). However, while the ANCOVA results reported above show no significant difference among the slopes for the 1972 to 1985 period, the Tukey-Kramer multiple comparison test results suggest that there was in fact a significant difference between the slopes for the BPS impingement and the URIGSO trawl indices. This inconsistency in the results from ANCOVA and the multiple comparison tests, which is the only inconsistency of this kind encountered in the analysis, can be attributed to subtle differences in the two analytical methods and the truly border-line statistical significance in this particular case (i.e., $p = 0.087$ while $\alpha = 0.05$). If a significant difference was concluded for this case, it would be determined that tautog fared better in upper Mount Hope Bay than Narragansett Bay during this period based on these indices. However, this analysis determines that results are equivocal as to whether a difference in these two trends in fact exists. For the long time series, 1972 to 2005, there are significant differences among the slopes of the five indices ($p < 0.001$). The estimated slope of the Brayton Point Station impingement index is significantly less steep than the URIGSO trawl index slope, while the MRI trawl index slope is significantly steeper than all other index slopes except the URIGSO trawl slope.

A review of the catch rates in the various gears representing Mount Hope Bay and Narragansett Bay shows that catch rates for this species have always been extremely low. For example, catches of tautog in the RIDFW trawl in Narragansett Bay were typically well below one fish per tow since the early 1990s, while the URIGSO and MRI trawls

recorded even lower catch rates. These low catch rates are likely attributable to tautog's known affinity to structure which makes them less susceptible to research trawls.

9.3.5.2 Comparison of Wilcox Trawl Catch Rates in Mount Hope Bay and Narragansett Bay - ANOVA

Abundance of tautog was higher in Narragansett Bay than in Mount Hope Bay (Figure 9-13), however, results of the Wilcox trawl ANOVA showed that there was no significant difference in tautog abundance among upper Mount Hope Bay, lower Mount Hope Bay, and Narragansett Bay during any year, 1997-2005 (Table 9-6).

9.4 CONCLUSIONS

The update of the DeAlteris et al. (In Press) ANCOVA and Tukey-Kramer multiple comparison tests with data for 2002 through 2005 did not produce any change in the conclusions of the original analysis. Overall, the update showed that trends in abundance of the five species in both upper and lower Mount Hope Bay are not substantively different from those in Narragansett Bay during any of the three time periods evaluated (1972-1985, 1986-2005, and 1972-2005). The finding that is most important in terms of evaluating what effect operations at Brayton Point Station have on populations of these five species in Mount Hope Bay is the fact that, with the exception of scup, there was no significant difference among abundance trends for Mount Hope Bay and Narragansett Bay during the most recent period analyzed, 1986-2005, which includes the period of both highest cooling water intake flows (1986-1996) and highest thermal discharge (1987-1991) from Brayton Point Station. For scup, results were equivocal for this time period (i.e., the MRI trawl index slope displayed an increasing abundance trend not significantly different from the Narragansett Bay indices while the BPS impingement index displayed a decreasing abundance trend significantly different from the RIDFW Narragansett Bay index slope) as to whether there was a difference between upper Mount Hope Bay and Narragansett Bay.

When catches of the five target species in the Wilcox trawl were compared between Mount Hope Bay and Narragansett Bay, no statistically significant differences were detected among upper Mount Hope Bay, lower Mount Hope Bay and Narragansett Bay during any year for any of the five species analyzed. A comparison of average catch rates of winter flounder in shallow-water and deep-water tows among the three areas also showed no significant difference within any year.

Overall, the results from the ANOVA and ANCOVA comparisons of Mount Hope Bay and Narragansett Bay suggest that the factors driving abundance in these areas are similar. Natural and anthropogenic stressors unique to Mount Hope Bay, including Brayton Point Station, do not appear to have caused Mount Hope Bay fish stocks to change at rates different from those observed for the same stocks in Narragansett Bay. Finally, the recent increase in winter flounder, windowpane, and scup catch rates in Mount Hope Bay and Narragansett Bay is an encouraging development for these species.

9.5 REFERENCES

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9.6 TABLES

Table 9-1. ANCOVA equality of slopes test results (α = 0.05) for five indices of fish abundance (MRI trawl and BPS impingement for upper Mount Hope Bay, RIDFW trawl for lower Mount Hope Bay, RIDFW trawl and URIGSO trawl for Narragansett Bay) for each of five species during each of three time periods (1972-1985, 1986-2005, 1972-2005)

Species	Years	Type III Sum of Squares	Mean Square	*F* value	*p* value*
Winter flounder	1972-1985	5.079	1.27	2.74	0.040
	1986-2005	0.651	0.16	0.38	0.819
	1972-2005	22.027	5.51	9.92	<0.001
Windowpane	1972-1985	2.209	0.55	0.91	0.464
	1986-2005	7.962	1.99	1.84	0.128
	1972-2005	6.124	1.53	1.59	0.179
Hogchoker	1972-1985	12.474	4.16	5.72	0.003
	1986-2005	10.689	3.56	1.82	0.151
	1972-2005	23.486	7.83	4.07	0.009
Scup	1972-1985	0.580	0.14	0.1	0.980
	1986-2005	26.806	6.70	3.38	0.013
	1972-2005	50.525	12.63	6.53	<0.001
Tautog	1972-1985	5.170	1.29	2.18	0.087
	1986-2005	3.195	0.80	0.73	0.574
	1972-2005	27.754	6.94	6.23	<0.001

**p* values less than 0.05 (shaded in grey) indicate that at least one slope was significantly different from one other for the specified species and time period.

Table 9-2. ANOVA of mean winter flounder CPUE by region and depth stratum for Upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay in the Wilcox Trawl program, 1997 – 2005

Depth = Shallow

Analysis of Variance Table

Source Term	DF	Sum of Squares	Mean Square	*F* ratio	*p* value[1]
A: Region	2	0.152699	0.0763499	2.14	0.118016
B: Year	8	1.794255	0.2242819	6.30	0.000000*
AB	16	0.363395	0.0271219	0.64	0.854299
S	683	24.32646	0.0356171		
Total (Adjusted)	709	28.08396			
Total	710				

* Term significant at alpha = 0.05

Depth = Deep

Analysis of Variance Table

Source Term	DF	Sum of Squares	Mean Square	*F* ratio	*p* value[1]
A: Region	2	0.6406207	0.3203104	2.64	0.072215
B: Year	8	8.329508	1.041188	8.58	0.000000*
AB	16	2.943278	0.1839549	1.52	0.088568
S	538	65.25092	0.1212842		
Total (Adjusted)	564	81.73337			
Total	565				

* Term significant at alpha = 0.05

Depth = Shallow or Deep

Analysis of Variance Table

Source Term	DF	Sum of Squares	Mean Square	*F* ratio	*p* value[1]
A: Region	2	0.145967	0.072984	0.90	0.404845
B: Year	8	8.725669	1.090709	13.52	0.000000*
AB	16	1.621803	0.1013627	1.26	0.217547
S	1248	100.6554	0.0806534		
Total (Adjusted)	1274	116.2913			
Total	1275				

* Term significant at alpha = 0.05

[1] *p* values less than 0.05 indicate significant difference. Of interest to this analysis is the "AB" interaction term which tests whether abundance in any area (upper Mount Hope Bay, lower Mount Hope Bay and Narragansett Bay) was different from any other area during any year, 1997-2005.

Table 9-3. ANOVA of mean windowpane CPUE in Upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay in the Wilcox Trawl program, 1997 – 2005

Analysis of Variance Table					
Source Term	DF	Sum of Squares	Mean Square	*F* ratio	*p* value[1]
A: Region	2	2.260553E-03	1.130276E-03	0.23	0.795352
B: Year	8	0.3915509	4.894386E-02	9.92	0.000000*
AB	16	5.154746E-02	3.221716E-03	0.65	0.841577
S	1249	6.164346	4.935425E-03		
Total (Adjusted)	1275	6.750923			
Total	1276				
* Term significant at alpha = 0.05					
* Term significant at alpha = 0.05					

[1] *p* values less than 0.05 indicate significant difference. Of interest to this analysis is the "AB" interaction term which tests whether abundance in any area (upper Mount Hope Bay, lower Mount Hope Bay and Narragansett Bay) was different from any other area during any year, 1997-2005.

Table 9-4. ANOVA of mean hogchoker CPUE in Upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay in the Wilcox Trawl program, 1997 – 2005

Analysis of Variance Table

Source Term	DF	Sum of Squares	Mean Square	*F* ratio	*p* value[1]
A: Region	2	6.579618E-03	3.289809E-03	5.70	0.003443*
B: Year	8	4.342494E-03	5.428118E-04	0.94	0.482136
AB	16	5.854413E-03	3.659008E-04	0.63	0.858449
S	1249	0.7212124	5.774319E-04		
Total (Adjusted)	1275	0.7417778			
Total	1276				

* Term significant at alpha = 0.05

[1] *p* values less than 0.05 indicate significant difference. Of interest to this analysis is the "AB" interaction term which tests whether abundance in any area (upper Mount Hope Bay, lower Mount Hope Bay and Narragansett Bay) was different from any other area during any year, 1997-2005.

Table 9-5. ANOVA of mean scup CPUE in Upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay in the Wilcox Trawl program, 1997 – 2005

Analysis of Variance Table

Source Term	DF	Sum of Squares	Mean Square	*F* ratio	*p* value[1]
A: Region	2	1.836243	0.9181216	2.92	0.054100
B: Year	8	9.784903	1.223113	3.89	0.000149*
AB	16	5.718444	0.3574027	1.14	0.313469
S	1249	392.2145	0.3140228		
Total (Adjusted)	1275	418.3477			
Total	1276				

* Term significant at alpha = 0.05

[1] *p* values less than 0.05 indicate significant difference. Of interest to this analysis is the "AB" interaction term which tests whether abundance in any area (upper Mount Hope Bay, lower Mount Hope Bay and Narragansett Bay) was different from any other area during any year, 1997-2005.

Table 9-6. ANOVA of mean tautog CPUE in Upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay in the Wilcox Trawl program, 1997 – 2005

Analysis of Variance Table					
Source Term	DF	Sum of Squares	Mean Square	*F* ratio	*p* value[1]
A: Region	2	7.034027E-03	3.517013E-03	3.10	0.045290*
B: Year	8	9.656851E-03	1.207106E-03	1.06	0.385323
AB	16	1.547405E-02	9.671281E-04	0.85	0.624657
S	1249	1.415941	1.133659E-03		
Total (Adjusted)	1275	1.450786			
Total	1276				
* Term significant at alpha = 0.05					

[1] *p* values less than 0.05 indicate significant difference. Of interest to this analysis is the "AB" interaction term which tests whether abundance in any area (upper Mount Hope Bay, lower Mount Hope Bay and Narragansett Bay) was different from any other area during any year, 1997-2005.

9.7 FIGURES

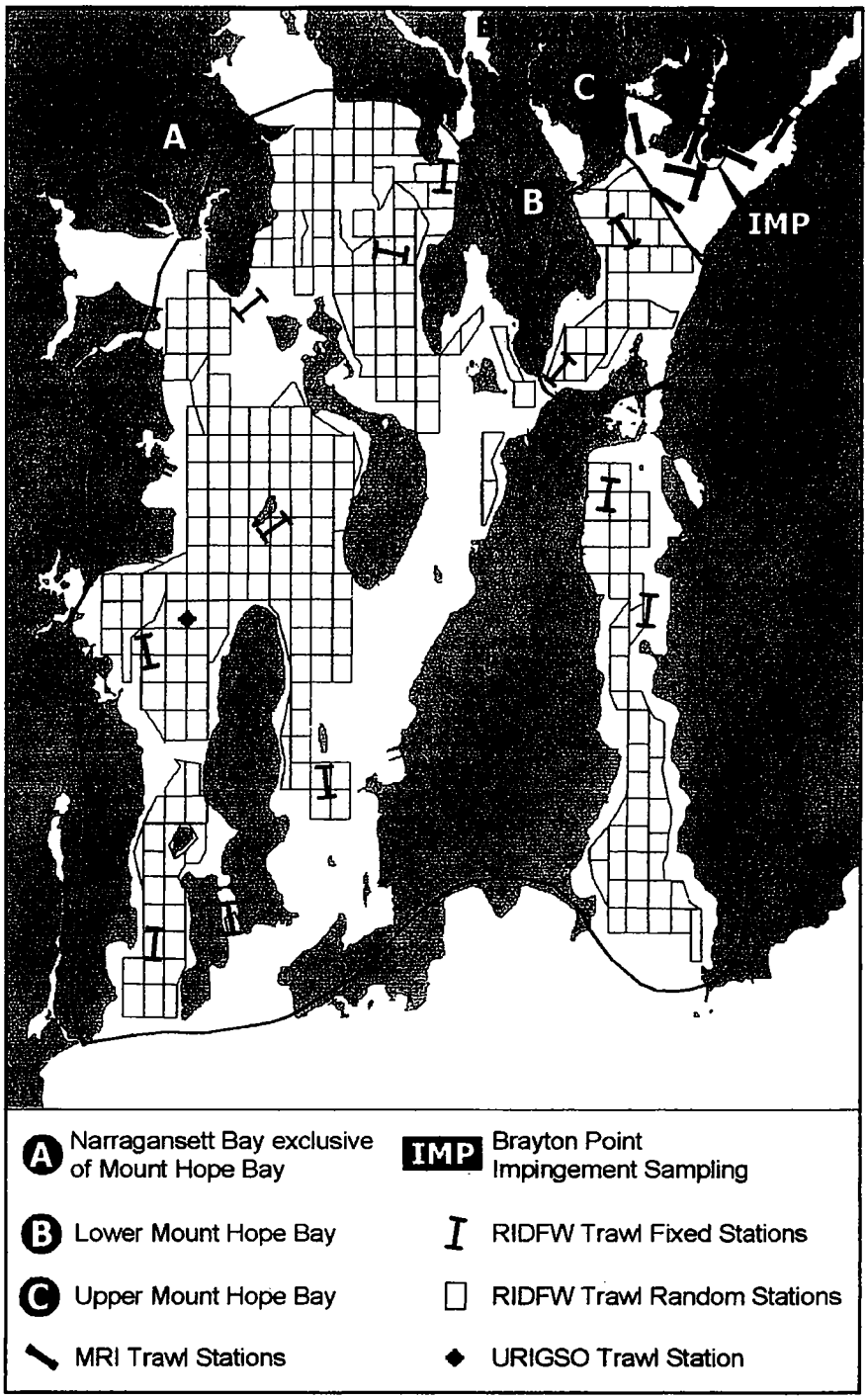
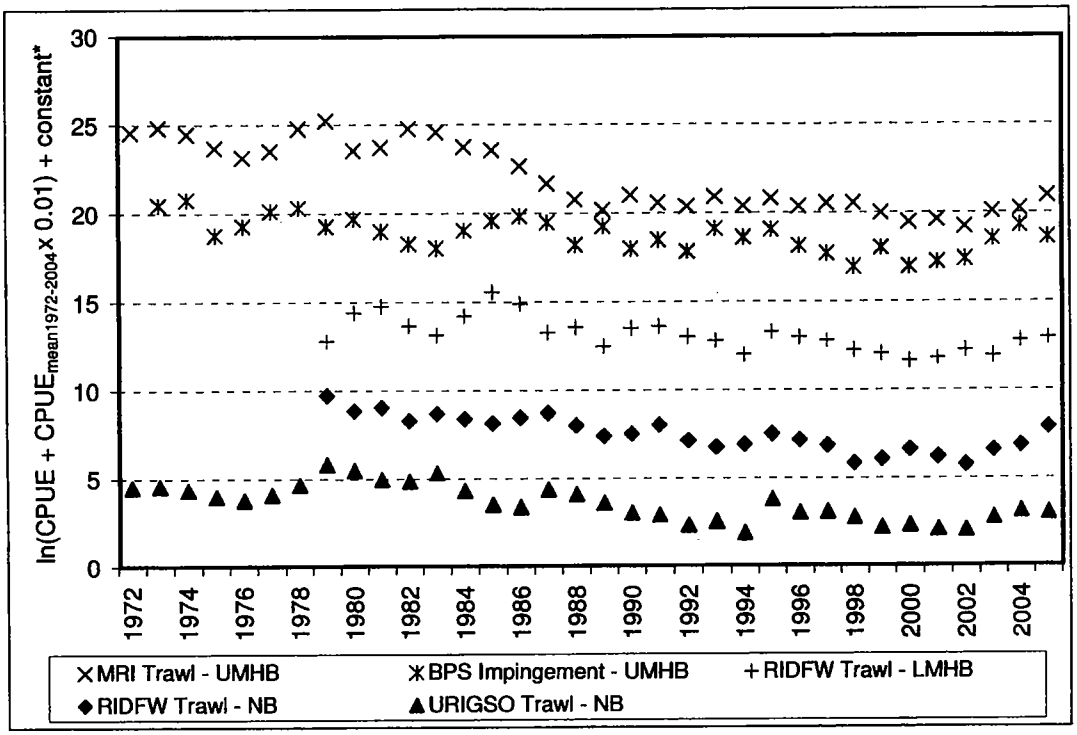


Figure 9-1. Map of the study area showing the trawl and impingement sampling locations used to calculate the fish abundance indices for Narragansett Bay exclusive of Mount Hope Bay, lower Mount Hope Bay, and upper Mount Hope Bay

a.



b.

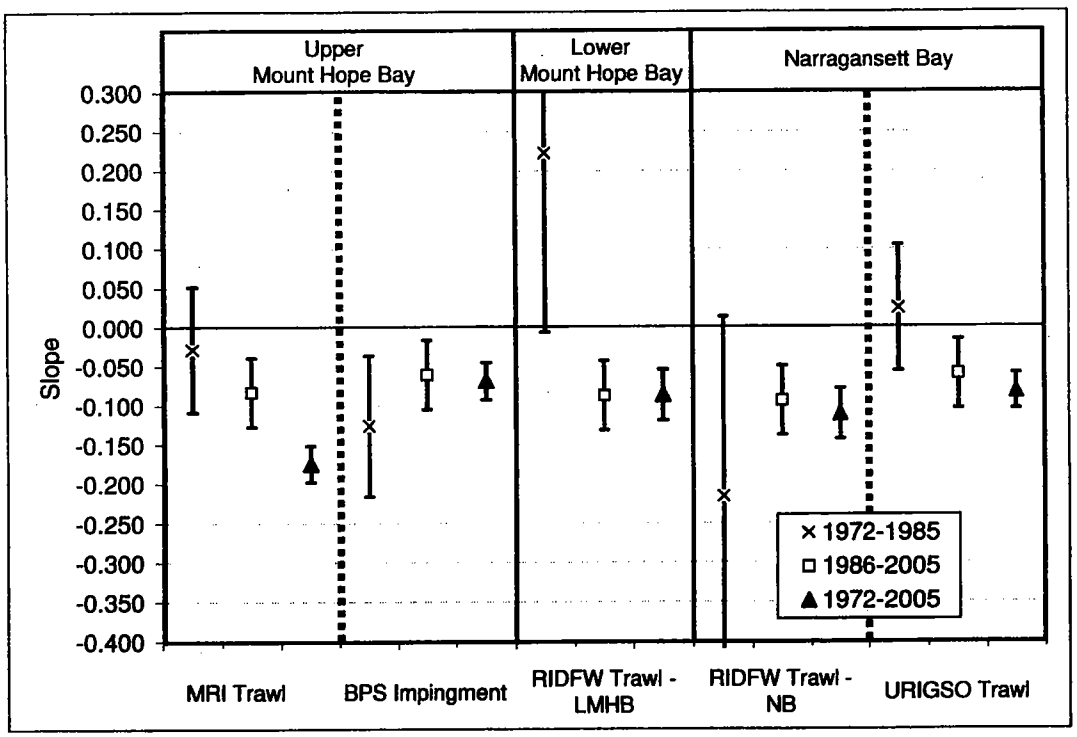


Figure 9-4. a. Winter flounder abundance indices for the MRI trawl survey, BPS impingement survey, the RIDFW trawl survey in lower Mount Hope Bay, and the URIGSO and RIDFW trawl surveys in Narragansett Bay (*post-analysis constants have been applied to the transformed indices from equation 1 to achieve separation of the indices for visual presentation). b. Slopes with Tukey-Kramer 95% confidence intervals for the periods 1972 to 1985, 1986 to 2005 and 1972 to 2005

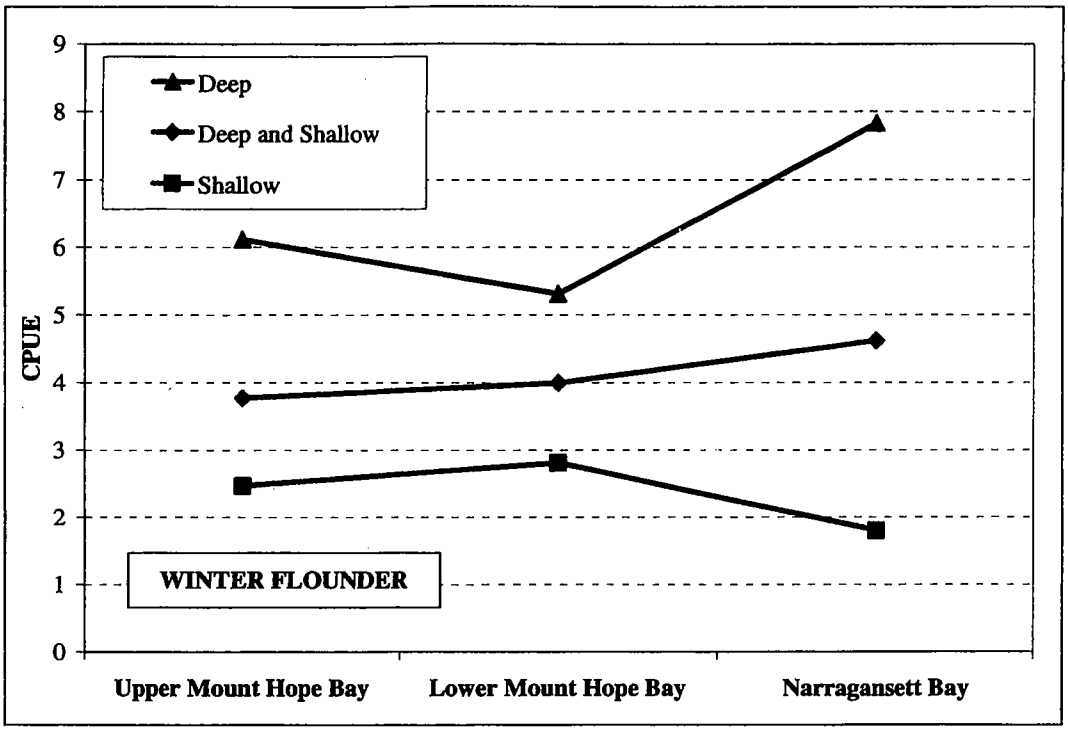
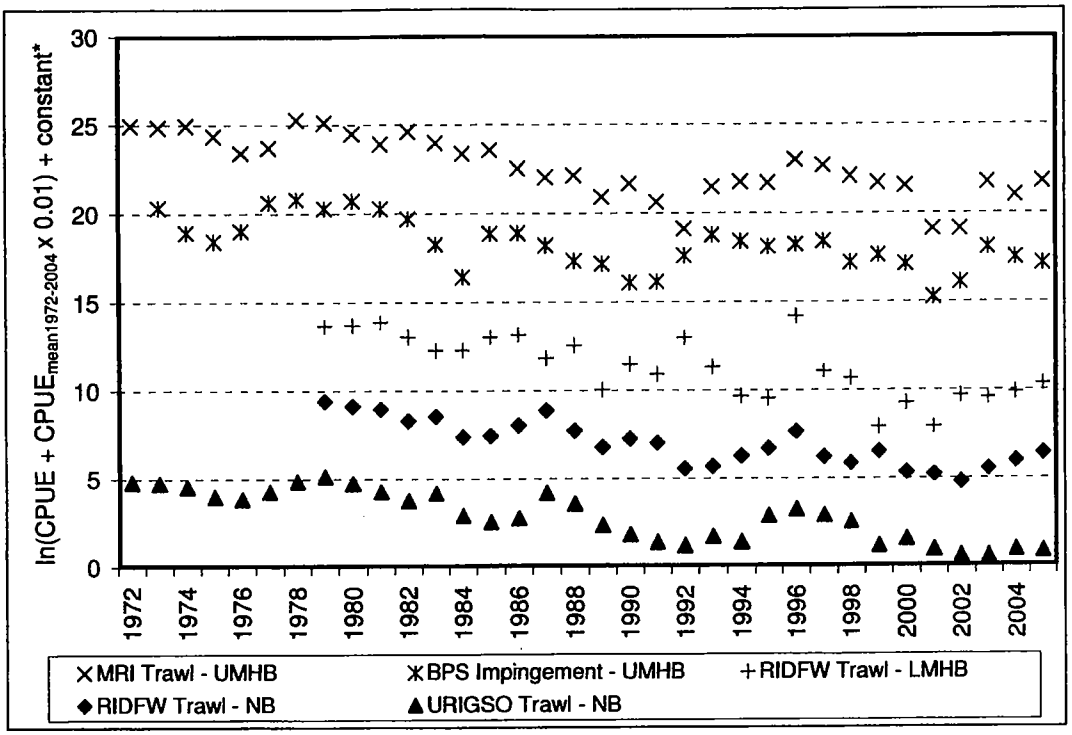


Figure 9-5. Mean CPUE of winter flounder in Wilcox trawl catches by depth strata in Upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay, 1997-2005

a.



b.

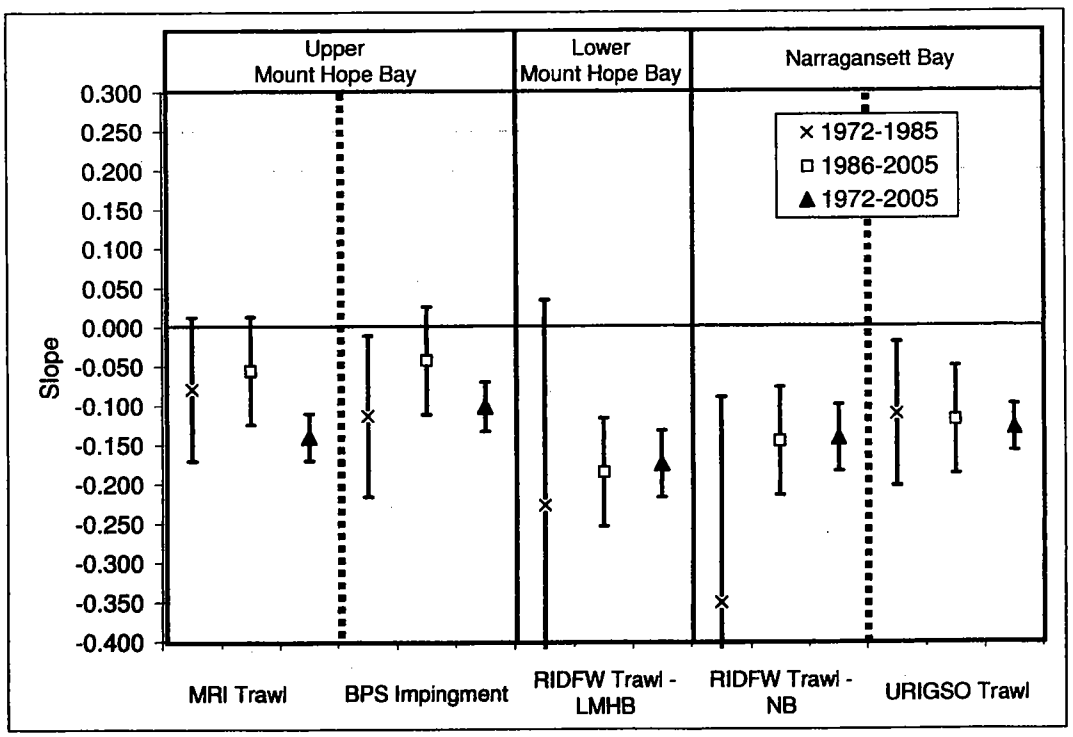


Figure 9-6. a. Windowpane flounder abundance indices for the MRI trawl survey, BPS impingement survey, the RIDFW trawl survey in lower Mount Hope Bay, and the URIGSO and RIDFW trawl surveys in Narragansett Bay (*post-analysis constants have been applied to the transformed indices from equation 1 to achieve separation of the indices for visual presentation). b. Slopes with Tukey-Kramer 95% confidence intervals for the periods 1972 to 1985, 1986 to 2005 and 1972 to 2005

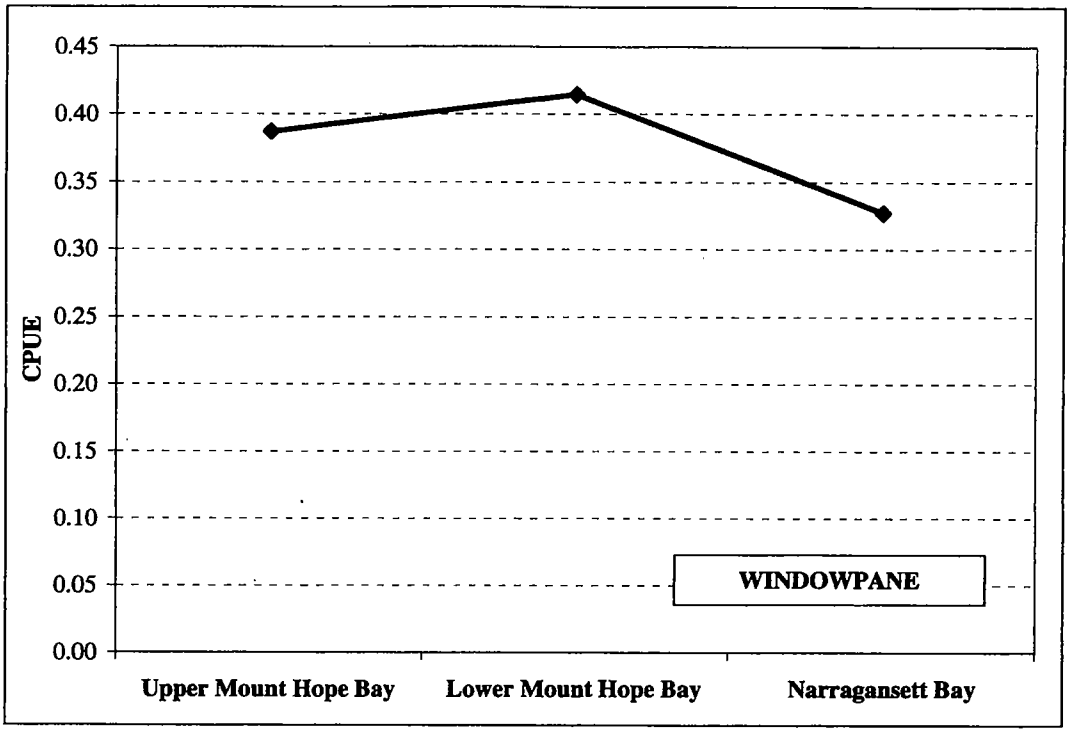
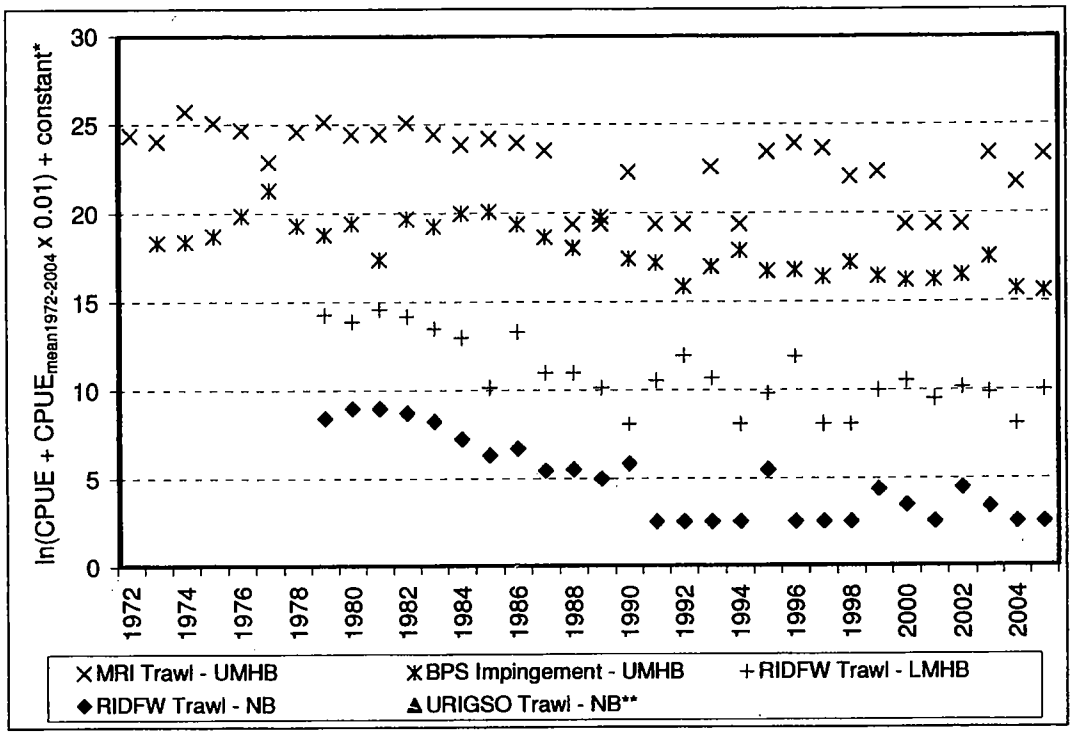
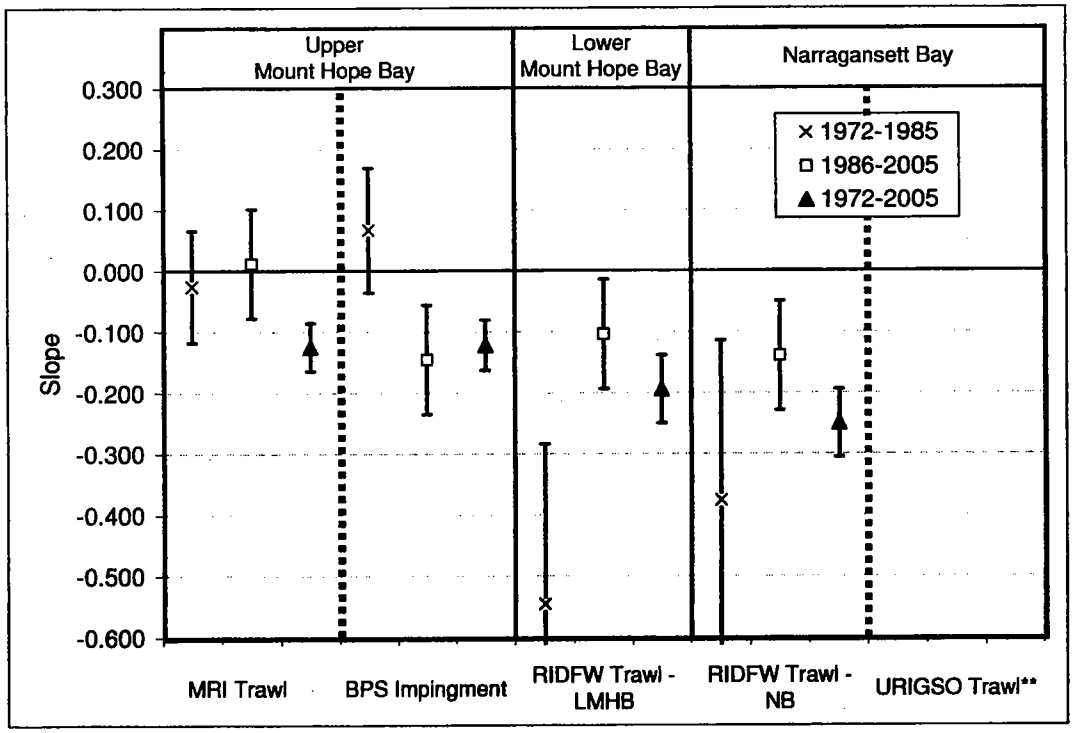


Figure 9-7. Mean CPUE of windowpane in Wilcox trawl catches in Upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay, 1997-2005

a.



b.



** URIGSO index not available

Figure 9-8. a. Hogchoker abundance indices for the MRI trawl survey, BPS impingement survey, the RIDFW trawl survey in lower Mount Hope Bay, and RIDFW trawl surveys in Narragansett Bay (*post-analysis constants have been applied to the transformed indices from equation 1 to achieve separation of the indices for visual presentation). b. Slopes with Tukey-Kramer 95% confidence intervals for the periods 1972 to 1985, 1986 to 2005 and 1972 to 2005

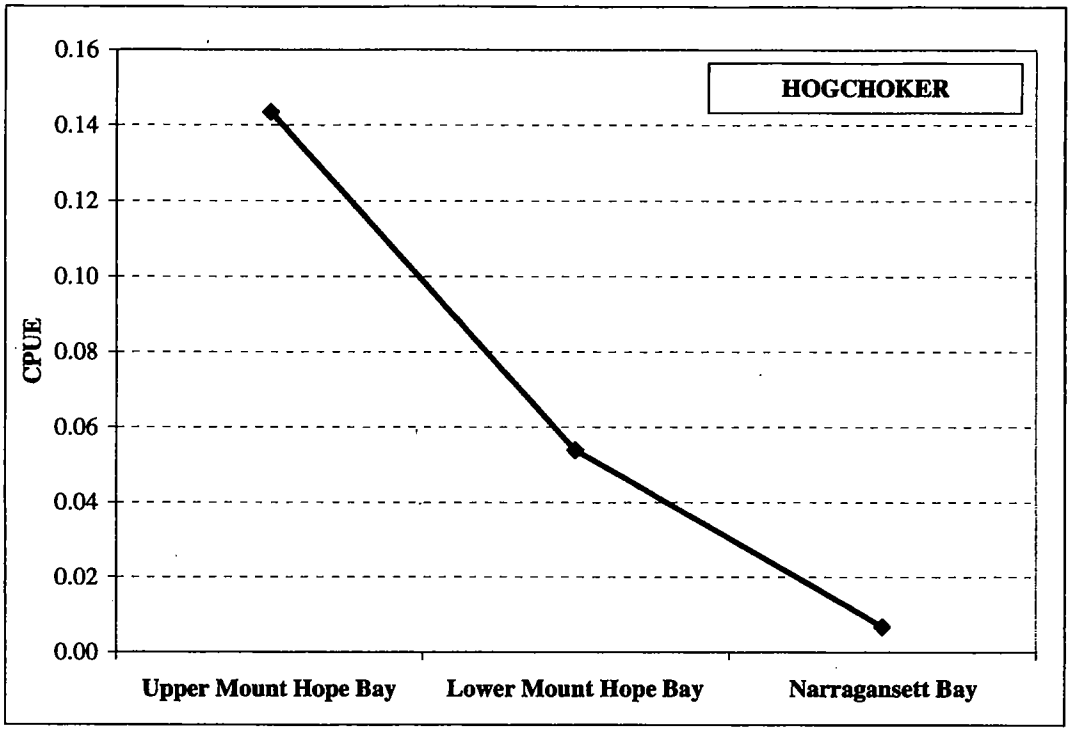
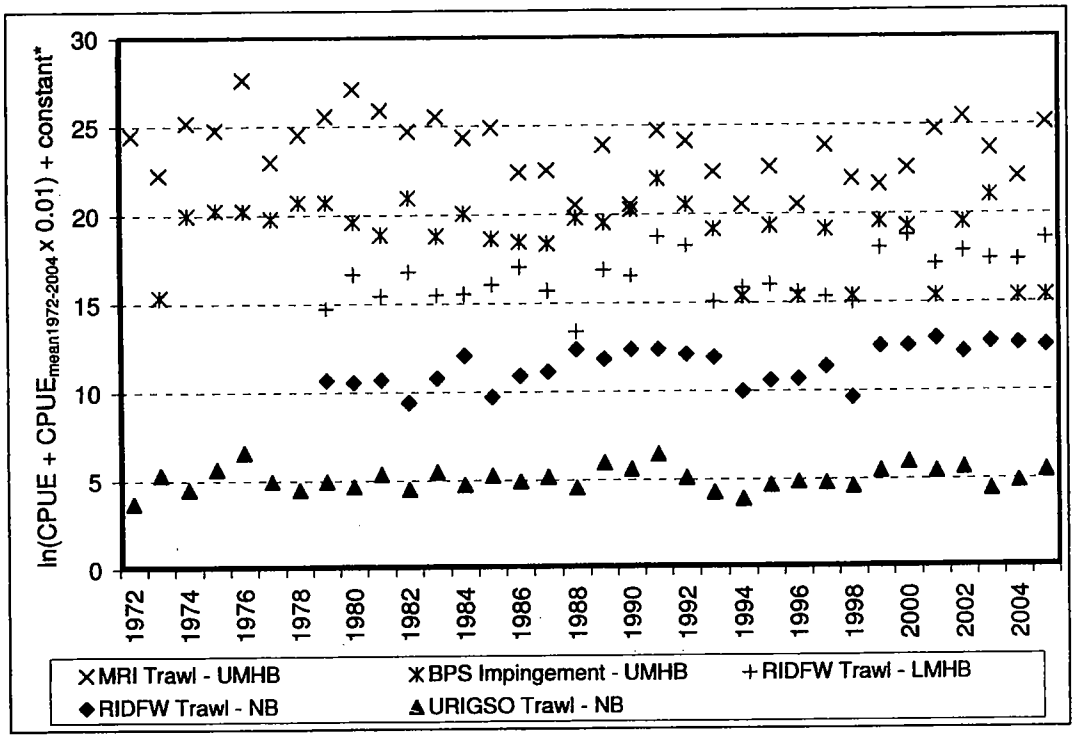


Figure 9-9. Mean CPUE of hogchoker in Wilcox trawl catches in Upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay, 1997-2005

a.



b.

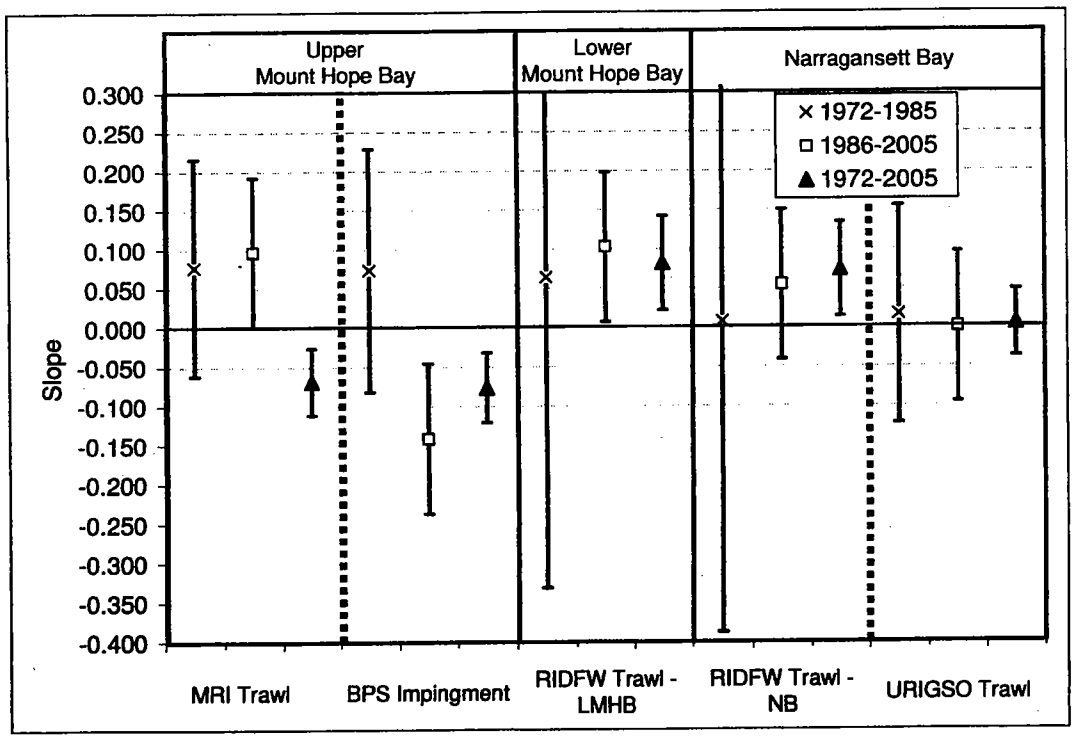


Figure 9-10. a. Scup abundance indices for the MRI trawl survey, BPS impingement survey, the RIDFW trawl survey in lower Mount Hope Bay, and the URIGSO and RIDFW trawl surveys in Narragansett Bay (*post-analysis constants have been applied to the transformed indices from equation 1 to achieve separation of the indices for visual presentation). b. Slopes with Tukey-Kramer 95% confidence intervals for the periods 1972 to 1985, 1986 to 2005 and 1972 to 2005

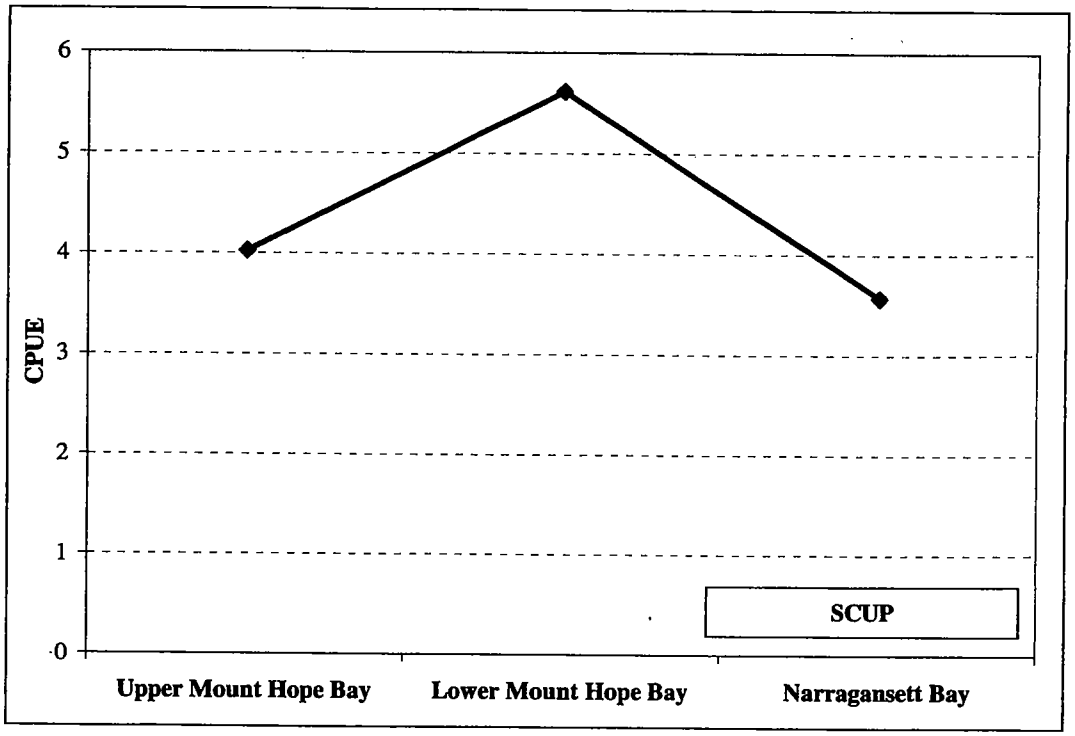
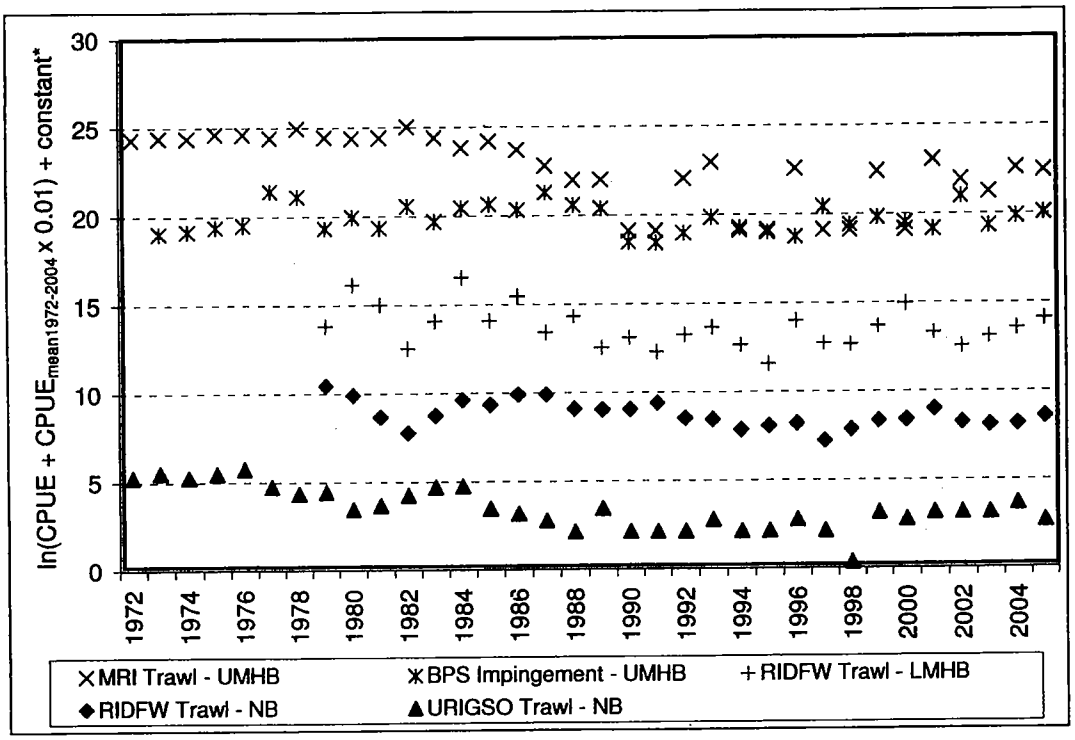


Figure 9-11. Mean CPUE of scup in Wilcox trawl catches in Upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay, 1997-2005

a.



b.

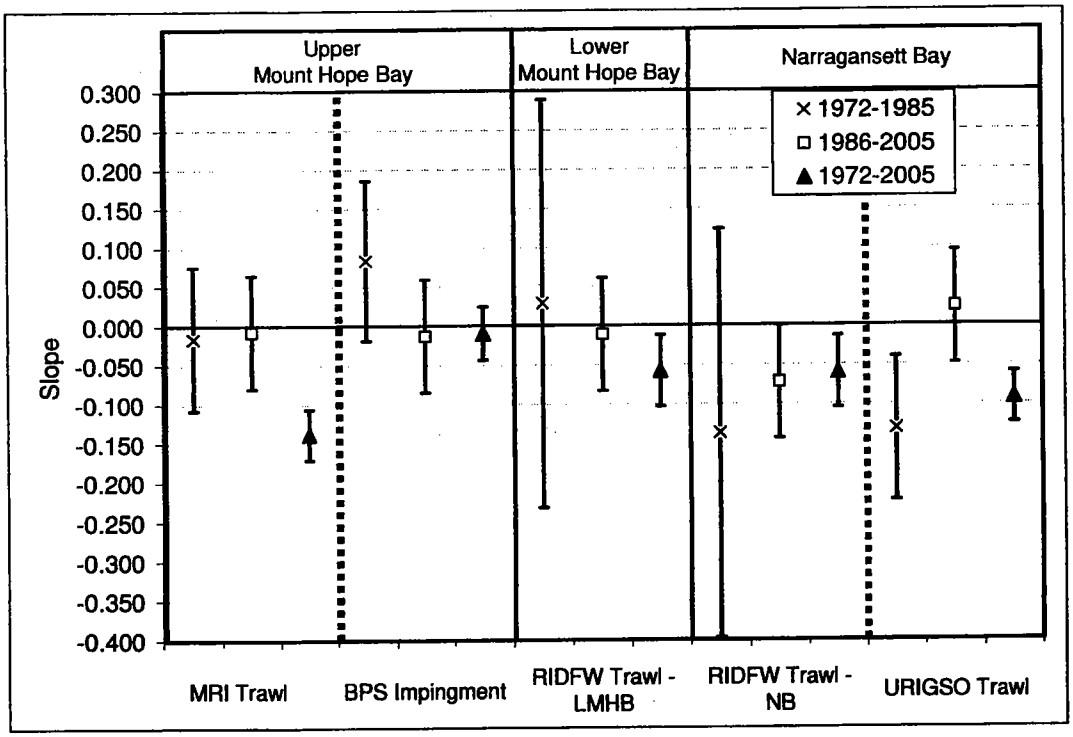


Figure 9-12. a. Tautog abundance indices for the MRI trawl survey, BPS impingement survey, the RIDFW trawl survey in lower Mount Hope Bay, and the URIGSO and RIDFW trawl surveys in Narragansett Bay (*post-analysis constants have been applied to the transformed indices from equation 1 to achieve separation of the indices for visual presentation). b. Slopes with Tukey-Kramer 95% confidence intervals for the periods 1972 to 1985, 1986 to 2005 and 1972 to 2005

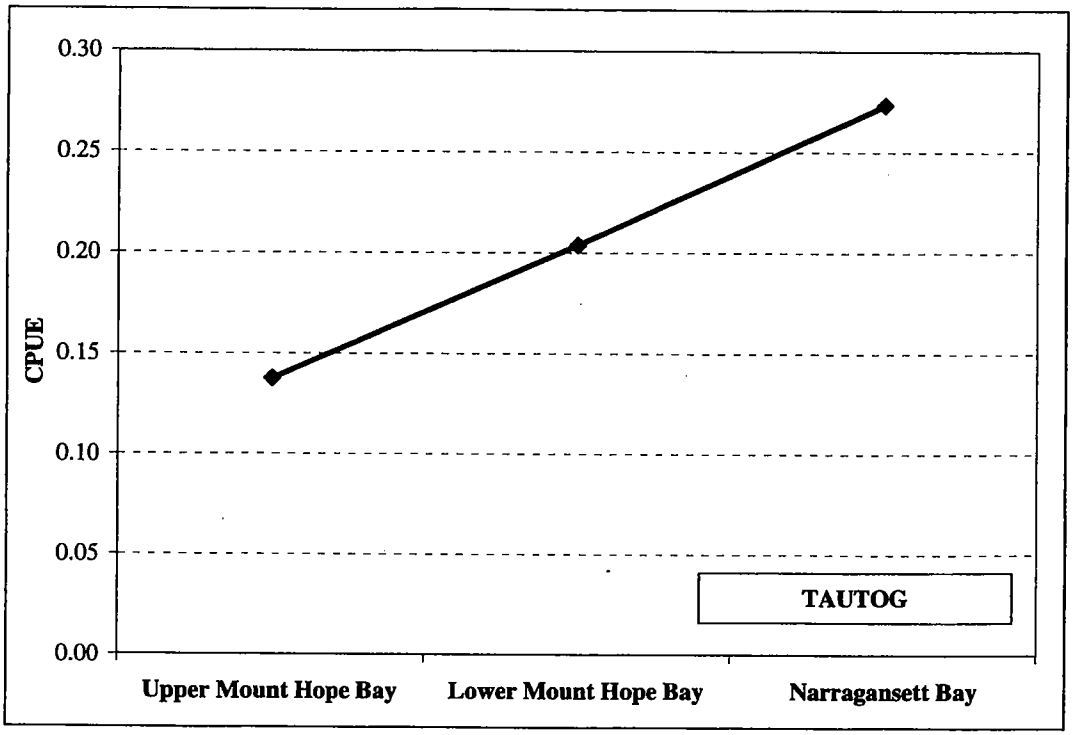


Figure 9-13. Mean CPUE of tautog in Wilcox trawl catches in Upper Mount Hope Bay, Lower Mount Hope Bay, and Narragansett Bay, 1997-2005

10 Winter Flounder Collection Temperature Analysis

10.1 INTRODUCTION

In addition to the evaluation of macro-trends in species abundance and diversity within Mount Hope Bay, the ongoing fish collection programs and the associated water temperature measurements provide an opportunity to assess how winter flounder abundance varies with water temperature. The focus of this analysis is to discern if age-0 winter flounder continue to be collected at representative levels as water temperatures rise during the warm summer season.

10.2 METHODS: BEACH SEINE PROGRAMS AND ANALYSIS

As detailed in Section 7.3, the objective of the young-of-the-year winter flounder 50-ft beach seine program is to index spatial and temporal trends of age-0 winter flounder abundance in the tributaries to Mount Hope Bay. Two beach seine surveys are performed each month during June and July and one survey is performed in August. This program began in 1992 with collections at 10 stations; in more recent years up to 21 stations have been sampled during each survey. In addition to the collection of winter flounder in hauls of the beach seine, supplementary water temperature data are also collected with each seine haul.

A second data set is collected by the Rhode Island Division of Fish and Wildlife (RIDFW), which conducts beach seine surveys at 18 shallow or littoral stations in Narragansett Bay. This is done on a monthly basis from June through October. Water temperature is also recorded at each station, and the catch of the seine is enumerated by species, which includes catches of age-0 winter flounder.

These data were evaluated by developing histograms (i.e., frequency distributions) comparing water temperature to the number of age-0 winter flounder collected. The analysis accounts for the fact that beach seine sampling events were not evenly distributed over the range of observed temperatures by indexing winter flounder catch per seine haul for each 1°C temperature increment.

Both data sets were examined using two periods of interest, the most recent 2005 calendar year information and an aggregate historical data set ending in 2004.

10.3 RESULTS

10.3.1 50-ft Beach Seine Program

Figure 10-1 shows the average number of age-0 winter flounder caught per seine haul for the 50-ft beach seine aggregate historical data set from 1992 to 2004. Also included in the figure is the number of sampling events that occurred within each 1°C temperature increment. The overall average number of age-0 winter flounder caught per seine haul over the observed temperature range was 4.5.

Figure 10-2 shows the average number of age-0 winter flounder caught per seine haul for the 2005 50-ft beach seine data set. The overall average number of age-0 winter flounder caught per seine haul over the observed temperature range was 5.1.

As shown in Figure 10-1, the temperature range of the 1992 to 2004 50-ft beach seine age-0 winter flounder catch results extended up to 32°C and the mean catch per seine haul at 30°C (3.75) was close to the overall mean catch (4.5). Catch results at water temperatures of 19°C through 27°C were equal to or greater than the average. The 2005 data in Figure 10-2 show that the highest catch (per seine haul) was observed at the highest sampled water temperature increment (28°C). The average catch results exceeded the overall average at the low, middle and upper portions of the observed water temperature range (i.e., 18°C, 22°C to 24°C and 27°C and 28°C).

An additional method of evaluating how abundance varies with temperature is provided in Figure 10-3, which depicts water temperature versus the cumulative proportion of 50-ft beach seine age-0 winter flounder collected from 1992 through 2005. The rate of change in the cumulative proportion curve remains relatively constant (i.e., linear) through the collection temperature range of 22°C to 27°C. Linearity through this temperature range indicates that each 1°C increase in water temperature corresponds to a steady incremental increase in the cumulative proportion of age-0 winter flounder (i.e., average catch within each of these temperature intervals was generally similar in size).

10.3.2 RIDFW Age-0 Winter Flounder Program

Figure 10-4 shows the average number of age-0 winter flounder caught per seine haul for the RIDFW aggregate historical data set from 1992 to 2004. The observed temperature range for the RIDFW data is lower than the 50-ft beach seine June through August data set because the sampling extends into October. The average number of age-0 winter flounder caught over the observed temperature range was 11.8. As shown in Figure 10-4, the average catch results at water temperatures of 18°C to 20°C and 22°C to 28°C exceeded this overall average.

Figure 10-5 shows the average number of age-0 winter flounder caught per seine haul for the 2005 RIDFW data. The overall average number of age-0 winter flounder caught over the observed temperature range was 4.6. The average catch results at water temperatures of 21°C, 25°C and 26°C exceeded this overall average.

Figure 10-6 depicts water temperature versus the cumulative proportion of RIDFW age-0 winter flounder collected from 1992 through 2005. A linear rate of change in the cumulative proportion curve is shown through the temperature range of 22°C to 28°C, which indicates that each 1°C increase in water temperature corresponds to a steady incremental increase in the cumulative proportion of age-0 winter flounder (i.e., average catch within each of these temperature intervals was generally similar in size).

The RIDFW data show that when water temperatures rise during the summer, age-0 winter flounder continue to occupy the near-shore habitat. As shown in Figure 10-4, the 1992 to 2004 catch results exceeded the overall mean catch (per seine haul) at water temperature increments from 22°C through 28°C. The 2005 RIDFW data in Figure 10-5 show that the catch per seine haul was greater than the overall 2005 mean at two of the three highest water temperature increments (i.e., overall mean of 4.6 versus 12.0 at 25°C and 12.9 at 26°C). Similar to catches in the 50-ft beach seine in Mount Hope Bay, no deflection in the cumulative proportion of age-0 winter flounder collected in the RIDFW beach seine was observed from 22°C to 28°C (Figure 10-6).

10.4 CONCLUSIONS

Analysis of collection temperatures shows that age-0 winter flounder occupy the near-shore habitat over a broad range of water temperatures and are routinely found at above-average abundance levels at temperatures between 24°C and 28°C and have been collected at temperatures as high as 32°C. During the 2005 sampling season, above average winter flounder catches in Mount Hope Bay and Narragansett Bay occurred at a variety of temperatures, 18°C and 28°C (50-ft beach seine in Mount Hope Bay) and 21°C, 25°C and 26°C (RIDFW beach seine in Narragansett Bay).

10.5 FIGURES

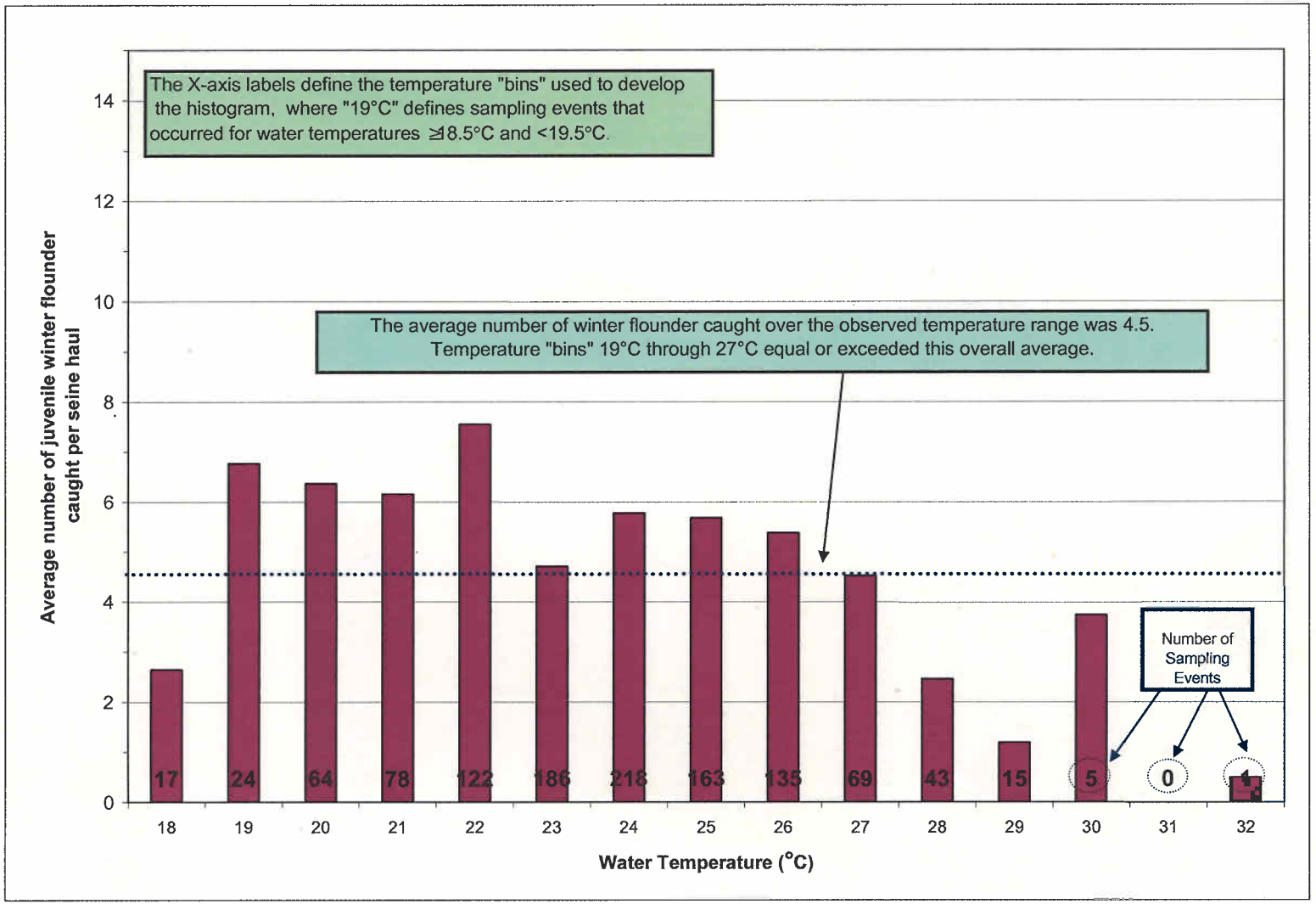


Figure 10-1. Average number of winter flounder caught per seine haul (and number of sampling events) for water temperatures represented in the 1992-2004 50-ft beach seine data for Mount Hope Bay

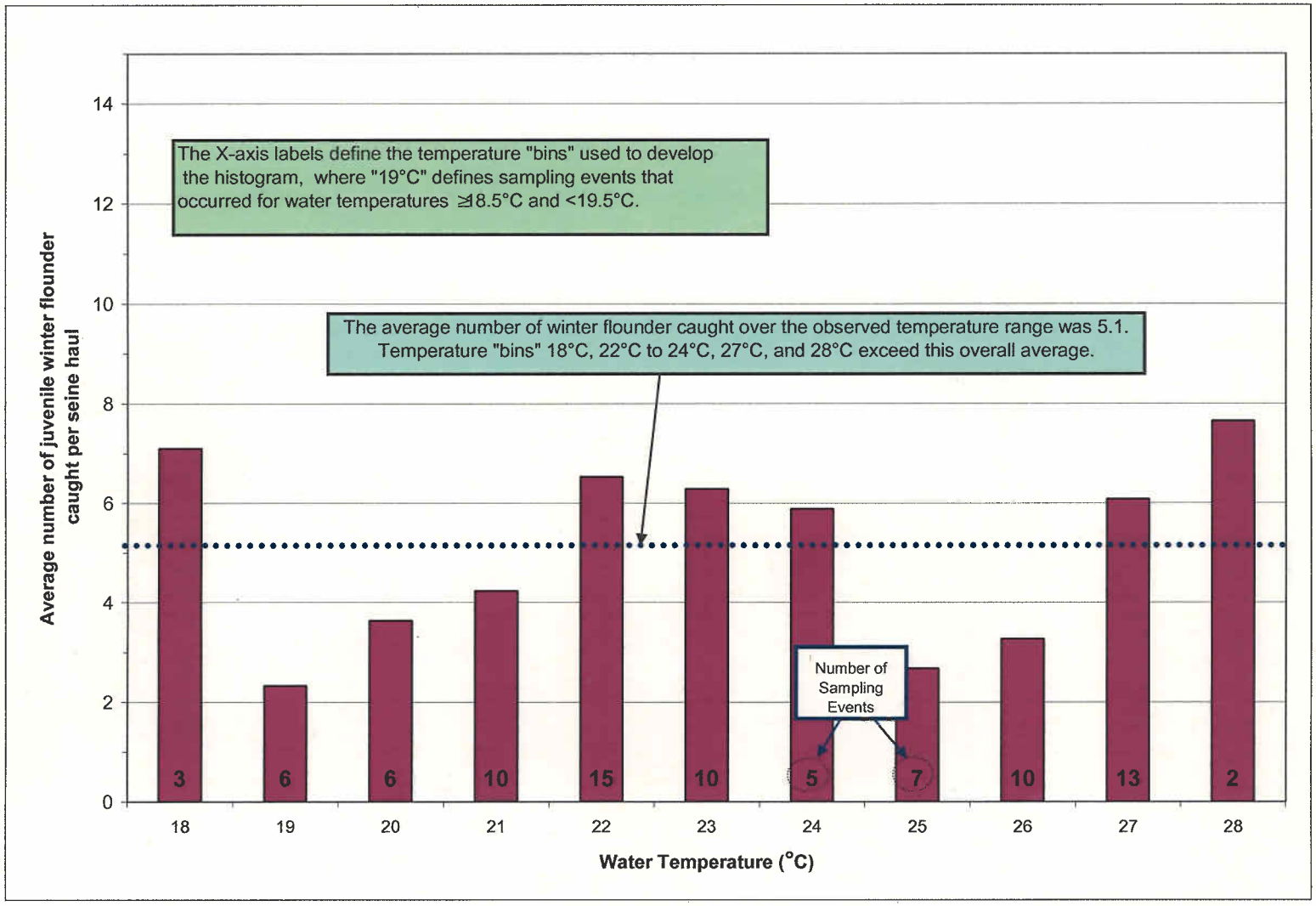


Figure 10-2. Average number of winter flounder caught per seine haul (and number of sampling events) for water temperatures represented in the 2005 50-ft beach seine data for Mount Hope Bay

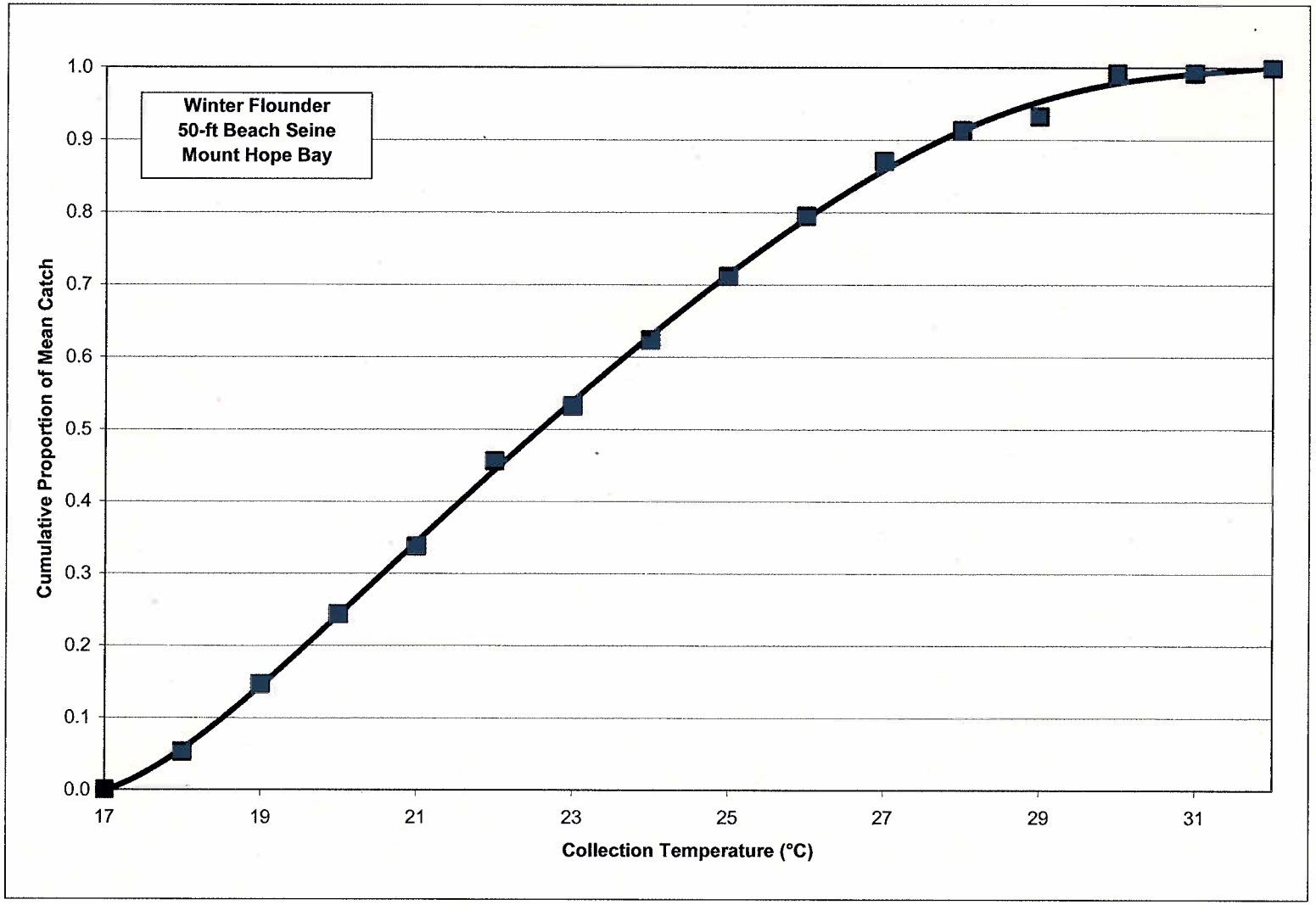


Figure 10-3. Cumulative proportion of mean number of winter flounder collected per seine haul at water temperatures represented in 1992-2005 50-ft beach seine data for Mount Hope Bay

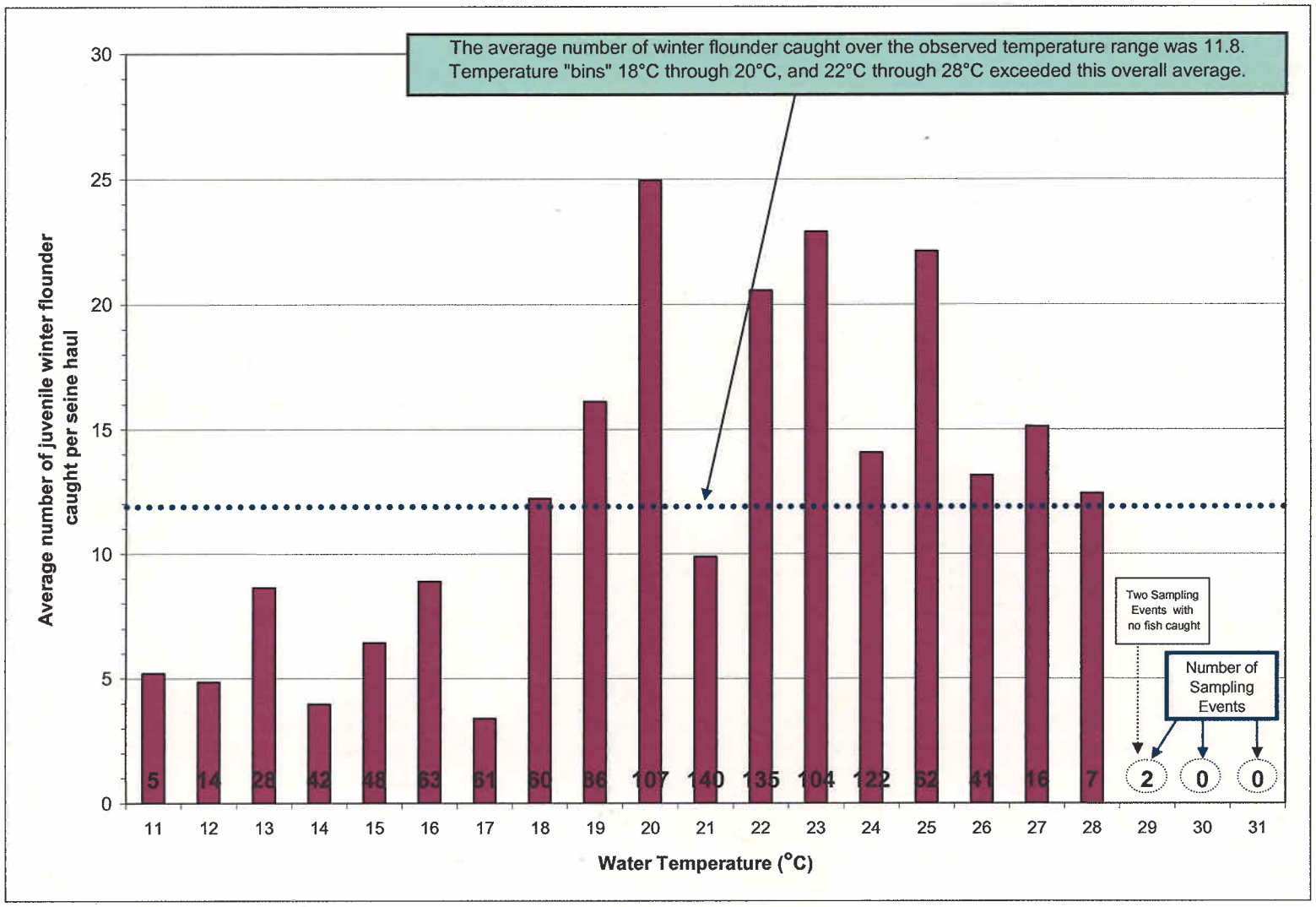


Figure 10-4. Average number of winter flounder caught per seine haul (and number of sampling events) for water temperatures represented in 1992-2004 RIDFW beach seine data for Narragansett Bay

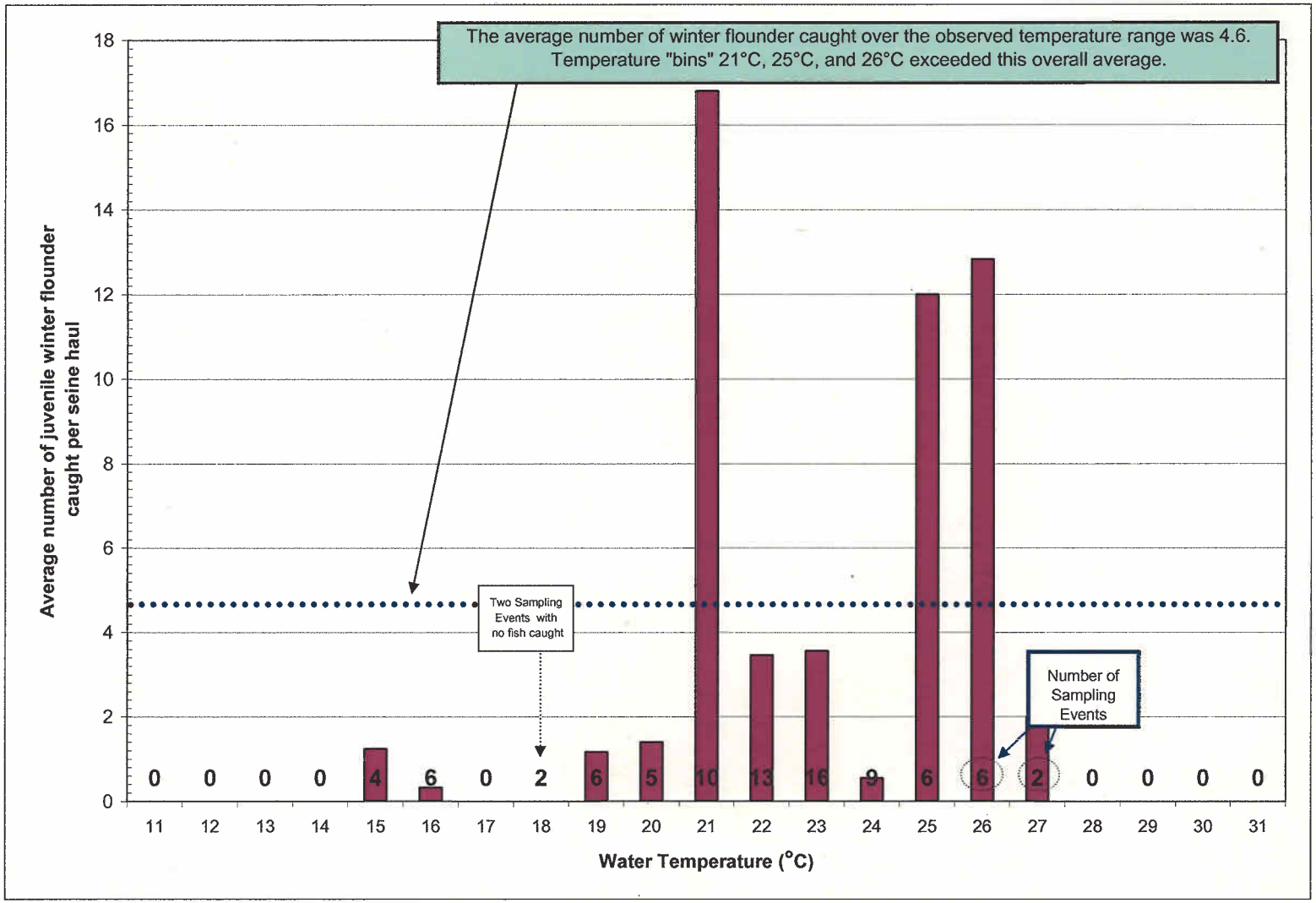


Figure 10-5. Average number of winter flounder caught per seine haul (and number of sampling events) for water temperatures represented in 2005 RIDFW beach seine data for Narragansett Bay

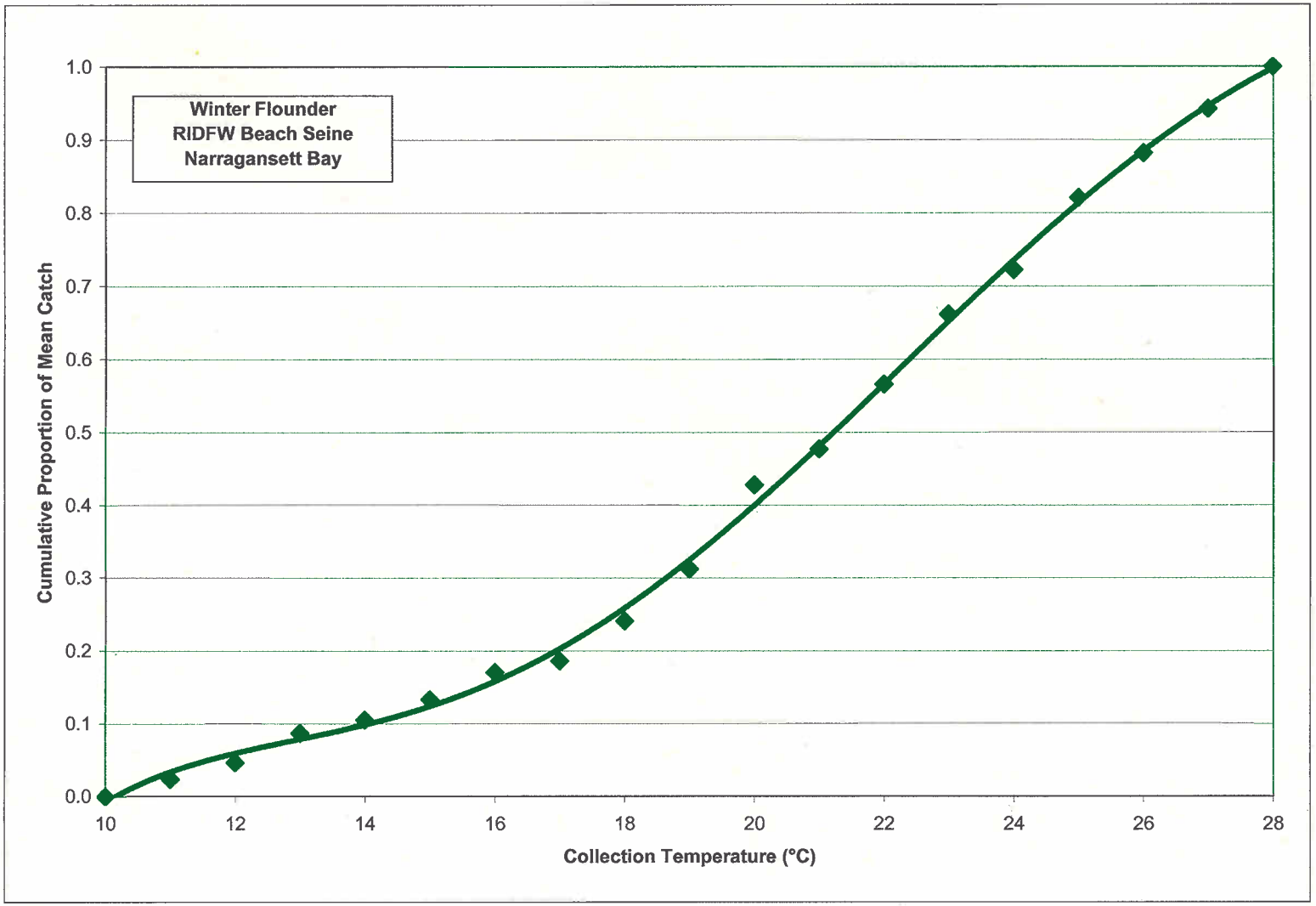


Figure 10-6. Cumulative proportion of mean number of winter flounder collected per seine haul at water temperatures represented in 1992- 2005 RIDFW beach seine data for Narragansett Bay