NBP-90-27

Zooplankton and Ichthyoplankton in Narragansett Bay: Status and Trends; Part 2: Ichthyoplankton 80 pp

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Narragansett Bay Estuary Program

ZOOPLANKTON AND ICHTHYOPLANKTON IN NARRAGANSETT BAY:

STATUS AND TRENDS

PART 2: ICHTHYOPLANKTON

Prepared For

The New England Interstate Water Pollution Control Commission

by

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NBP-90-27

January 1990

FOREWORD

The United States Congress created the National Estuary Program in 1984, citing its concern for the "health and ecological integrity" of the nation's estuaries and estuarine resources. Narragansett Bay was selected for inclusion in the National Estuary Program in 1984 and designated an "estuary of national significance" in 1988. The Narragansett Bay Project (NBP) was established in 1985. Under the joint sponsorship of the U.S. Environmental Protection Agency and the Rhode Island Department of Environmental Management, the NBP's mandate is to direct a five-year program of research and planning focussed on managing Narragansett Bay and its resources for future generations. The NBP will develop a comprehensive management plan by December, 1990, which will recommend actions to improve and protect the Bay and its natural resources.

The NBP has established the following seven priority issues for Narragansett Bay:

* management of fisheries
* nutrients and potential for eutrophication
* impacts of toxic contaminants
* health and abundance of living resources
* health risk to consumers of contaminated seafood
* land-based impacts on water quality
* recreational uses

The NBP is taking an ecosystem/watershed approach to address these problems and has funded research that will help to improve our understanding of various aspects of these priority problems. The Project is also working to expand and coordinate existing programs among state agencies, governmental institutions, and academic researchers in order to apply research findings to the practical needs of managing the Bay and improving the environmental quality of its watershed.

This report represents the technical results of an investigation performed for the Narragansett Bay Project. The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement #CX812680 to the Rhode Island Department of Environmental Management. It has been subject to the Agency's and the Narragansett Bay Project's peer and administrative review and has been accepted for publication as a technical report by the Management Committee of the Narragansett Bay Project. The results and conclusions contained herein are those of the author(s), and do not necessarily represent the views or recommendations of the NBP. Final recommendations for management actions will be based upon the results of this and other investigations.

SUMMARY

There have been three major studies of fish eggs and larvae in Narragansett and Mt Hope Bays: a study at 4 stations during 1957-58 (Herman 1958, 1963); a study of 160 stations during 1972-73 by Marine Research, Inc. (1974) and a monitoring program since 1972 in Mt Hope Bay, also by MRI (1972-86).

In the 1972-73 study a total of 42 species or species groups of fish eggs and larvae were found; maximum abundance was during June-July and minimum abundance during September-January. The rank order of the more abundant species was: anchovies, menhaden, winter flounder, tautog, cunner, sand launce, weakfish, windowpane, silversides, mackerel, seaboard goby, and fourbeard rockling. Two species (sand launce and winter flounder) are winter-spring spawners, with peak abundance of larvae during April; two (fourbeard rockling and mackerel) and spring-early summer spawners with larval peaks in May-June; and 7 are late spring-early summer spawners with peak abundance of larvae in June-July (bay anchovy, tautog, cunner, silversides, weakfish, windowpane, and seaboard goby). Atlantic menhaden have a protracted spawning season with greatest intensity during spring and fall. The more abundant species could be classified into three groups according to their centers of abundance: 8 of the 12 most abundant species (menhaden, anchovy, winter flounder, tautog, weakfish, windowpane, silversides, and seaboard goby) were most abundant in the upper Narragansett / Mt Hope Bays; 3 species (sand launce, rockling, and mackerel) were most abundant in the lower East Passage; while 1 species, the cunner, seems to be abundant in both the upper and lower bay. Thus the uppermost, most environmentally impacted

areas of Narragansett and Mt Hope Bays also provide the major spawning / nursery areas for most of the locally abundant fish species.

Herman (1958) identified 34 taxa of fish larvae in his 1957-58 study, all of which were also subsequently found in the 1972-73 study by MRI. However the rank order of the most abundant species was quite different in the two studies; in Herman's study the 12 most abundant species were: sculpin, silversides, cunner, anchovy, scup, sand launce, searobin, butterfish, winter flounder, tautog, northern pipefish, and radiated shanny. Thus a list of the 12 most abundant larval fish species in both studies had only 6 species in common. The difference in rank order appeared to be due primarily to differences in the relative abundance of 5 species (winter flounder, silversides, goby, sand launce, and sculpin) which hatch from demersal eggs. Thus the relative abundance of these species as larvae could not be independently confirmed from the data on pelagic eggs. It was unclear whether the differences in the rank order of species in the two studies were due to biased data reflecting differences in sampling gear, or real differences in the fish community.

The long-term study by MRI in Mt Hope Bay has revealed that the total population of larvae has exhibited about 3-fold variation in number, with evidence of a 4-5 year periodicity, between 1972-86. However the variation in the number of individual species has been much larger than this. The most striking change since 1972 has been a 1000-fold decline in the number of Atlantic menhaden and its replacement by anchovies, predominantly bay anchovy, as the numerical dominant in the system.

RECOMMENDATIONS FOR FUTURE WORK

1. Since there has been no Bay-wide survey of icthyoplankton since 1972-73, we recommend that another seasonal study be carried out to determine whether there have been any major changes.

2. Winter flounder are an important commercial and recreational species in the Bay, which undergo large fluctuations in abundance. These changes appear to be related both to overfishing and to longer term variation in winter temperatures. Since year class strength in winter flounder appears to be established during the early life history stages, we feel that it would be useful to undertake a longer term monitoring program of winter flounder larvae in selected parts of the bay. This would provide information which could lead to a better understanding of the natural causes in the fluctuations in recruitment.

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ACKNOWLEDGEMENT

We express our thanks to T.J. Smayda for providing unpublished data on zooplankton in Narragansett Bay, S.W. Nixon for data on fish larvae in Mt Hope Bay abstracted from the MRI studies, C.A. Oviatt for permission to use unpublished data from the Marine Ecosystems Research Laboratory, A. Keller for computer analysis of MERL data, and S.N. Larimer for assistance in the literature search.

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INTRODUCTION

There have been three major studies of fish eggs and larvae in Narragansett and Mt Hope Bays: a study at 4 stations during 1957-58 (Herman MS Thesis, 1958; published 1963); a study of 160 stations during 1972-73 carried out by Marine Research, Incorporated of Falmouth, Massachusetts for Narragansett Electric; and a long term monitoring program of several stations in Mt Hope Bay since 1972, also being carried out by MRI.

METHODS

Larval fishes are difficult to sample quantitatively, and there seems to be no convenient way to adequately sample demersal eggs. Pelagic eggs and newly hatched larvae can be sampled reasonably well with a suitable net. However older larvae with better developed sensory and swimming capabilities are able to detect and avoid conventional plankton nets. They are also relatively rare and patchy in their distribution, often exhibiting tidal or diel changes in their depth distribution; thus sampling variability tends to be quite high.

The bridle on a conventional plankton net has been found to provide an "early warning" to larvae and increases net avoidance; the advent of the bridleless sampler called the "bongo" (McGowan and Brown 1966) has greatly improved the quantitative sampling of fish larvae. The bongo sampler is a frame supporting paired conical nets, towed by a wire attached to the frame between the nets. This leaves the mouth of each net open, except for a small flowmeter which is mounted in the center to provide a quantitative estimate of the volume of water filtered by the net. The bongo sampler was adopted by the US National Marine Fisheries Service in the early 1970's for their large scale surveys of ichthyoplankton and is now the generally accepted gear for this type of work. Standard mesh sizes for the nets are 333 and 505 µm; occasionally 202 µm. Smaller meshes are impractical because they clog too quickly and cannot be towed sufficiently fast to catch larvae (around 2-3 kn is a common towing speed).

In his pioneering study in Narragansett Bay, Herman used a conventional 1 meter net with a rather large mesh size (slightly larger than 1 mm) for his sampling of larvae, but he used a smaller Clarke-Bumpus sampler with 366 µm mesh to collect eggs. Both nets were metered and quantitative samples were collected, using stepped oblique hauls. Stations were occupied once weekly.

Early work by Marine Research, Inc. also employed a conventional plankton net but during 1972 they changed to a metered bongo sampler with a 505 um mesh. An oblique tow was made at each station. Weekly sampling was carried out between June-August 1972, monthly sampling between September 1972-March 1973, and weekly sampling between April-August 1973.

RESULTS

Marine Research, Inc. Survey of Narragansett / Mt Hope Bays, 1972-73

The most complete study of fish eggs and larvae in Narragansett Bay is the 1972-73 survey by Marine Research, Inc. for Narragansett Electric (1974), and we will present these results first. Narragansett and Mt Hope Bays and the

Sakonnet River were subdivided into 9 sectors in which 160 stations were sampled from June 1972 to August 1973 (Figure 1).

The raw data were summarized as the monthly mean concentration of eggs or larvae in each sector in Appendix Table 2 of MRI (1974), and we have used these data in our analysis. Annual mean values obtained in this way are slightly different from mean values given in the MRI report, e.g. in Table 2 of MRI (1974). It is not clear why this is so, but it may reflect differences in the degree to which the data were condensed by MRI and by us prior to analysis, with rounding-off errors introduced in each step.

The sectors defined by MRI differed considerably in volume, and in order to determine the population size of eggs or larvae in the different sectors it was necessary to multiply the mean concentration of plankton by the volume of the sector. MRI cited volume estimates from Hicks (1959) but did not give those figures in their data report. However in Table 2 of MRI (1974) they reported both the annual mean concentration of the more abundant species during the period they were present, and the total population size as calculated from the volume of each sector, where:

$$\text{Total population size} = \text{No} / 100\ m^3 \times 10^{-2} \times \text{Sector volume } (m^3)$$

From these data the sector volumes used by MRI were reconstructed (Table 1). These volumes were summed and the total volume compared to other figures given for the volume of Narragansett Bay by Hicks (1959) and Chinman and Nixon (1985) (Table 1).

The total volume thus calculated ($2.659 \times 10^{10}\ m^3$) is an order of magnitude larger than volume estimates by Hicks ($3.014 \times 10^9\ m^3$) and Chinman and Nixon ($2.673 \times 10^9\ m^3$). The mean concentration of eggs and larvae in Table 2 of MRI (1974) are comparable to raw data presented in their Appendix Table 2, so there appears to be an error in the caption in their Table 2, in which the reader is instructed to multiply the total abundance estimates by 10^{10}. The correct figure would appear to be 10^9, which would yield sector volumes comparable to published data for the bay. Accordingly we applied a multiplier of 10^9 to the sector volumes in Table 1 in order to convert concentration to total number of larvae in each sector.

Although MRI presented data on pelagic fish eggs as well as larvae we restricted our analysis mainly to the larvae, since a number of important species hatch from demersal eggs and are not represented in the egg counts.

Species Abundance

MRI reported a total of 42 species or species groups of fish eggs and larvae (Table 2). Maximum larval abundance occurred during April and July, with the summer maximum being by far the larger of the two (Figure 2). Larvae were least abundant between September-January. The number of species or species groups present as larvae was highest during May-July, where a maximum of 24 was observed in July 1972 and 29 in May 1973 (Table 3). The lowest number of species (5) was found in December 1972.

Species diversity was computed by MRI using Shannon's function. We have reproduced this section of their report and include it as Appendix 1 to the present report.

The monthly mean concentration of the 12 most abundant species of larvae in each sector, and the total number of larvae after correction for the volume of each sector, are presented in Tables 4a,b. Of the 12 most abundant species, two (the sand launce and winter flounder) are winter-spring spawners, with peak abundance of larvae during April; two (fourbeard rockling and mackerel) are spring-early summer spawners with larval peaks in May-June; and 7 are late spring-summer spawners with peak abundance of larvae in June-July (bay anchovy, tautog, cunner, silversides, weakfish, windowpane flounder, and seaboard goby). Atlantic menhaden have a protracted spawning season, with the greatest intensity during spring and fall. In Narragansett Bay menhaden eggs and larvae have a split season, with the first period during April-July with maximum abundance in June-early July, slightly ahead of the anchovies, and a second occurrence during October-November.

Distribution of Larvae

In order to compare the importance of different sectors in the Narragansett / Mt Hope systems as spawning and nursery grounds we considered first, the concentration of larvae in each sector and second, the total number of larvae present in each sector after correcting the concentration values for the volume of each sector (Tables 4a,b). The integrated areas under the curves of concentration or numbers vs time were used as the basis for this comparison. Although the integrated areas are not corrected for differences in the development rate of different larval species, they do permit comparison between areas and years within the same species, and provide an approximate index of the relative abundance of different species.

The totals for the integrated areas of the abundance curves are summarized in Table 5. Sectors are ranked in order of the concentration of larvae in Table 6, and in total abundance in Table 7. The percentage contribution of each sector to the total population of larvae is given in Table 8.

Comparisons between 1972 and 1973 are possible for predominantly summer spawning species. During the summer of 1972, Atlantic menhaden were by far the most abundant species, with anchovies (predominantly bay anchovy Anchoa mitchilli) second and two species in the family Labridae (tautog and cunner) third and fourth respectively (Table 5). However during the summer of 1973, menhaden were of much lower abundance and ranked second after anchovies; tautog and cunner again ranked third and fourth amongst the summer spawners.

The rank order of abundance of both winter-spring and summer spawning species during the period January-August 1973 was: anchovies, menhaden, winter flounder, tautog, cunner, sand launce, weakfish, windowpane, silversides, mackerel, seaboard goby, and fourbeard rockling. Although the autumn period was not sampled during 1973, none of the major species other than menhaden spawn during that season, and the lack of data for autumn 1973 would be unlikely to alter the rank order of the most abundant species for 1973.

Overall, the larval population was numerically dominated by a small number of taxa. During 1973 anchovies and Atlantic menhaden were the most abundant larvae; together they comprised 76.4% of the total (Table 5). Six taxa (anchovies, menhaden, winter flounder, tautog, cunner, and sand launce) made up 94.0% by number of the total population of larvae.

Ichthyoplankton Concentration by Sector The distribution of eggs and larvae in the bay reflects not only the intensity of spawning in different regions, but also the physical circulation of the bay, the duration of the pelagic egg and larval stage, and the oriented swimming behavior of the larvae.

The concentration of larvae differed among the 9 sectors, indicating that spawning by different fish species was localized in different regions of the bay.

The highest concentration of the 12 most abundant species was found in the following sectors (Table 6):

In 1972, considering summer spawners only: Sector 1 (Greenwich Bay) for anchovies, weakfish and silversides; Sector 2 (upper Narragansett Bay) for menhaden and tautog; Sector 6 (upper Sakonnet River) for seaboard goby; and Sector 9 (lower Sakonnet) for cunner and windowpane.

In 1973, including winter-spring and summer spawners: Sector 1 (Greenwich Bay) for anchovies; Sector 2 (upper Narragansett Bay) for menhaden, tautog, windowpane and seaboard goby; Sector 3 (Mt Hope Bay) for winter flounder, weakfish and silversides; Sector 8 (lower East Passage) for mackerel and fourbeard rockling; and Sector 9 (lower Sakonnet) for cunner and sand launce.

Lowest concentrations of sand launce, mackerel, and fourbeard rockling were found in Sector 1 (Greenwich Bay); lowest concentrations of all other larvae were found in Sectors 7 and 8 (lower West and East Passages respectively).

<u>Total Abundance of Larvae by Sector</u> If we correct the concentration of larvae by the volume of each sector, and determine the total number of larvae, the rankings change because of the considerable differences in the volumes of each sector (Table 7).

In 1972, considering only the 8 most abundant summer spawners, Sector 2 (upper Narragansett Bay) contained the greatest numbers, and thus represented the largest percentage of the total bay-wide population, of larvae of 6 species (menhaden, tautog, cunner, silversides, windowpane flounder and seaboard goby), while Sector 4 (upper West Passage) contained the greatest numbers of the two remaining species (anchovies and weakfish).

In 1973, considering the 12 most abundant species, Sector 2 (upper Narragansett Bay) contained the greatest number of larvae of 5 species (menhaden, tautog, weakfish, windowpane, and seaboard goby); Sector 3 (Mt Hope Bay), winter flounder and silversides; Sector 4 (upper West Passage), anchovies; and Sector 8 (lower East Passage), 4 species (cunner, sand launce, mackerel, and fourbeard rockling).

Sectors 2 and 4 together contain the greatest percentage of the total population of larvae in the Narragansett / Mt Hope Bay systems, ranking first or second in at least 1 year for all species except sand launce (sixth), mackerel (eighth), and rockling (fourth). Sector 3 (Mt Hope Bay) contained the greatest number of winter flounder and (in 1973) silversides, although both species were quite abundant in Sectors 2 and 4 also. The other major center of larval abundance,Sector 8 in the lower East Passage, because of its large volume ranked first in total abundance of cunner and sand launce, although it ranked only fourth and sixth respectively in concentration of those species; Sector 8 ranked first in concentration as well as total numbers for mackerel and rockling.

Sectors 1 and 9, though exhibiting high concentration of several species of larvae, had relatively small volumes and generally contained only a minor fraction of the total population of those species. Greenwich Bay did not rank higher than 6th in the overall abundance of any species; Sector 9 ranked second for cunner in 1972 but otherwise not higher than fourth for other species; it ranked second for sand launce, but otherwise not higher than 5th overall in 1973.

Among the 8 summer-spawning species for which comparisons during 2 consecutive years could be made, 4 species (anchovies, menhaden, tautog and cunner) were very similar in their pattern of distribution in both years. Silversides and seaboard goby were also fairly similar, with two of the the three sectors containing the highest concentrations being the same in both years. Weakfish and windowpane flounder were the most different in their centers of distribution in the two years, showing preferences for both the Mt Hope Bay / Sakonnet systems and upper Narragansett Bay.

Among these 8 species, the overall abundance of anchovies and seaboard gobies increased greatly between 1972 and 1973, whereas menhaden and silversides decreased substantially, and tautog, cunner, weakfish and windowpane flounder decreased moderately.

Marine Research tested for the significance of differences in the concentration of larvae in different sectors using the Mann-Whitney U test; these results are reproduced in Appendix 2.

In summary, although most of the more abundant larval species are found throughout the Narraganset / Mt Hope systems, they may be classified into three groups according to their centers of abundance (Tables 6,7): 8 of the 12 most abundant species (menhaden, anchovy, winter flounder, tautog, weakfish, windowpane flounder, silversides, and seaboard goby) are most abundant in the upper Narragansett / Mt Hope systems; 3 species (sand launce, rockling, and mackerel) are most abundant in lower East Passage; while 1 species, the cunner, seems to be abundant in both the upper and lower bay systems. Thus the uppermost, most environmentally impacted areas of Narragansett and Mt Hope Bays also provide the major spawning / nursery areas for most of the locally abundant fish species.

Herman (1958)

Herman's stations 1 and 2 were located in the lower East and West Passages of Narragansett Bay, respectively; Station 3 was near the northern entrance to Sakonnet River and Station 4 was in lower Mt Hope Bay (Figure 3). Herman did not sample in the upper portions of Narragansett Bay. His four stations most nearly corresponded to Station 84 in Sector 8, Station 136 in Sector 7, Station 15 near the boundary of Sectors 3 and 6, and Station 23 in Sector 6 of the MRI study of 1972-73.

Data from all 4 stations were combined in Herman's dissertation although he commented on relative abundance at different stations in his discussion of individual species. Data are reported as the mean abundance of eggs and larvae during the period of occurrence, in Tables 2 and 3 of the thesis.

The overall seasonal pattern of abundance of eggs and larvae was quite similar during Herman's study in 1957-58 and in the MRI study of 1972-73 (Figure 2). Peak abundance was observed during June-July, and minimum abundance in October-November, in both studies.

Herman identified 17 species of pelagic fish eggs and 34 species or genera of larvae in his study (Table 9). MRI found the same species, with some additions of rare taxa, in their bay-wide survey in 1972-73, and their 1971-86 studies in Mt Hope Bay.

However both the rank order and the abundance of larval fishes, including species hatched from demersal eggs, were strikingly different between the two studies (Table 10). A list of the 12 most abundant larval fish species in both studies has only 6 species in common (Tables 5,9). In Herman's study the sculpin is by far the most abundant larval fish, followed by silversides and cunner. In 1972-73, these species ranked fifteenth, ninth and fifth, respectively in relative abundance (Table 10). Scup, searobin, and butterfish were also relatively abundant in Herman's study, ranking fifth, seventh, and eighth respectively, but ranked thirteenth, fourteenth, and sixteenth in 1972-73. Anchovy, menhaden, and winter flounder, which ranked first, second and third in abundance during 1972-73 ranked only fourth, thirteenth and ninth respectively in Herman's study.

The quantitative abundance of larvae was also quite different in the two studies. Peak abundance of eggs and larvae in the MRI study were of the same order of magnitude, whereas peak abundance of larvae was 2 orders of magnitude lower than eggs in Herman's study. Herman's value for the mean concentration of sculpins was about a factor of 10 greater than in the MRI study (where mean concentration can be found by dividing the total area in Table 4a by the total number of days larvae were present: e.g. for Anchoa, Sector 1, 1973 mean concentration = 82182.5 / 92 = 893). Mean concentrations of scup, searobin and butterfish in Herman's study were similar to the MRI data, while Herman's data for the remaining species in Table 10 were 1-2 orders of magnitude lower than the MRI data (Tables 6,9).

These discrepancies persist even when the comparison with Herman's data is restricted to those four sectors in the MRI study most closely corresponding to Herman's sampling locations (Sectors 3, 6, 8, 9: Table 10).

In contrast to the larvae, however, the species composition and abundance of pelagic fish eggs in Herman's study were in good agreement with the later, bay-wide survey by MRI (Table 11). Abundance estimates by Herman were, except for Labridae, somewhat lower than the overall mean values found by MRI but were of the same order of magnitude. The rank order of the 9 most abundant species or species groups of eggs was, except for menhaden and mackerel, identical in both studies. By themselves these results would seem to suggest that the fish community, or at least that portion which hatches from pelagic eggs, had remained basically stable during the 15-year interval between these studies.

Since the egg data provided an independent means of confirming the relative abundance of the majority of the more abundant species, the larvae were separated into two groups depending on whether they hatched from pelagic or demersal eggs (Table 11).

If we consider only those species which hatch from pelagic eggs, the rank order of abundance is much more consistent between the two studies (Table 11). In Herman's study the rank order of the abundance of larvae closely follows that of the eggs. The correspondence between the egg and larval data is not as close in the MRI study, the most notable discrepancy being in the Labridae, which constituted 29.8% of the eggs but only 8.9% of the larvae, a distant third place behind menhaden and anchovy. Labrid larvae were relatively less abundant than eggs in Herman's study also, although they retained first place in the relative rankings of larvae hatched from pelagic eggs. The low numbers of Labrid larvae compared to eggs could be indicative either of high mortality or low availability of larvae, perhaps because of some aspect of their behavior, to the sampling gear. Overall it appeared that the relative abundance of larvae which hatch from pelagic eggs was in most cases confirmed by the relative abundance of eggs, and there was a generally good correspondence between the two studies in the relative rankings of most species as both eggs and larvae.

In contrast there was little apparent correspondence in the relative rankings of the more abundant species that hatched from demersal eggs (Table 11). In Herman's study sculpins ranked first, constituting 80.3% by number in this group, while winter flounder ranked fourth with 2.9% of the numbers of larvae. In the MRI study winter flounder ranked first, with 63% of the numbers while sculpins ranked fifth, or 1.2% by number. Silversides and sand launce ranked second or third in both studies, while gobies ranked fourth or fifth. The rankings of these larvae could not be verified from egg data since demersal eggs are exceedingly difficult to sample quantitatively and this was not attempted in either study. Clearly, however, the poor correspondence in the larval fish data in the two studies is caused mainly by the variation in the rankings of the species hatching from demersal eggs, e.g. sculpins, silversides, sand launce, winter flounder, and gobies.

MRI (1974) suggested that the generally low catch of larvae, the preponderance of sculpins (a large, robust species) and low relative abundance of winter flounder (a small, delicate species) in Herman's study was to a large extent an artifact of the sampling gear, where the combination of a bridled net and large mesh size both undersampled the overall population, and biased the catch towards large larvae. We would agree that while the sampling gear available to Herman was quantitative for pelagic eggs, it probably biased the catch of larvae to an unknown degree. However the selectivity of the sampling gear does not rule out the possibility that at least some of the differences in the rank order of abundance within the two studies were real. For example, newly hatched scup, searobins and butterfish are about the same size as winter flounder, and gear selectivity alone would not seem to be a sufficient explanation for the greater abundance of those species than winter flounder in Herman's study. It remains possible that these three species really were more abundant than flounder in 1957-58.

Unfortunately we cannot determine the extent to which the differences in the abundance and rank order of larvae in the two studies reflects gear selectivity in Herman's study or true differences in the abundance of certain species. As will be seen in the next section, however, the differences in abundance of certain species implied in the two studies is within the range that has been observed in the long-term monitoring of Mt Hope Bay.

Long-Term Monitoring in Mt Hope Bay, 1972-Present

Marine Research, Inc. has carried out long-term monitoring at several stations in Mt Hope Bay since 1972. Data are available for the years 1972-86 (MRI 1972-86). Although Mt Hope Bay was not included in the scope of the present analysis, data on a few selected species at the control station at Spar Island (Station 10 in Sector 3, Figure 1) in central Mt Hope Bay are presented in Figure (4).

The integrated abundance curve of the total numbers of larvae has fluctuated about 3-fold over this 15-year period, with evidence of a 4-5 year periodicity. However individual species have shown much greater fluctuation in abundance than has the total number of all larvae.

The most dramatic change in the larval population since 1972 has been a precipitous decline in the abundance of the Atlantic menhaden and its replacement by anchovies, predominantly the bay anchovy Anchoa mitchilli, as the dominant species of larvae in Mt Hope Bay. Menhaden ranked first in abundance of larvae in 1972, but declined 3 orders of magnitude between 1972-76, and since then have been present in negligible numbers. Bay anchovy populations increased at the same time as menhaden declined and in 1974 replaced menhaden as the most abundant larvae in Mt Hope Bay. Since 1977, the year of maximum abundance of anchovies, their numbers have fluctuated about 3-fold, with a 4-5 year cycle. Since menhaden and later anchovies overwhelmingly dominated the numerical abundance of larvae, the temporal trend of the total population as shown in Figure (3) principally reflects the behavior of these two species.

Sand launce have undergone extreme changes in abundance, increasing from low numbers in the early-mid 1970's to a peak in 1979, followed by a return to very low abundance in 1985-86.

Winter flounder has exhibited an approximately 5-6 fold variation in numbers; like the anchovy it appears to be cyclic with a 4-5 year period.

From this limited analysis it appears that individual species are capable of extreme variation in number, and also cyclical change in numbers over periods of 4-5 years in Mt Hope Bay. The total population size of larvae is evidently more stable, with a lower amplitude of variation, than is the behavior of individual species.

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Table 1. Estimates of the volumes of Narragansett and Mt Hope Bays, and the nine sectors used by Marine Research, Inc. in their 1972-73 study. Sector volumes as computed from Table 2 in MRI (1974) appear to be an order of magnitude too high, when compared with other estimates of the total volume of Narragansett Bay. A corrected volume, shown below, was used for the present analysis.

Volume of Narragansett Bay:

From Hicks (1959) as cited in MRI (1974), at Mean Low Water:

Area = 324.5 km^2
Mean Depth = 8.8 m
Volume = 3.014×10^9 m^3

From Chinman and Nixon (1985), at Mean Low Water:

Volume = 2.673×10^9 m^3

Volume of sectors in Marine Research study, as computed from their Table 2, where:

Vol (m^3) = Concentration of larvae (No / m^3) / Total (No larvae/sector)

Sector	Vol. fromTable 2 ($\times 10^{10} m^3$)	Corrected Vol. ($\times 10^9 m^3$)
1	0.0301	0.0301
2	0.319	0.319
3	0.190	0.190
4	0.437	0.437
5	0.378	0.378
6	0.144	0.144
7	0.328	0.328
8	0.753	0.753
9	0.0802	0.0802
	Total 26.590×10^9 m^3	Total 2.659×10^9 m^3

Table 2. List of species whose eggs or larvae were found in Narragansett / Mt Hope Bays during the June 1972-August 1973 survey by Marine Research, Inc. (From Table 1 of MRI 1974__).

ANGUILLIDAE	
Anguilla rostrata	(Americal eel)
OPHICHTHIDAE	(Snake eels)
CLUPEIDAE	
Alosa spp.	(Alewife and Blueback)
Clupea harengus harengus	(Atlantic herring)
Brevoortia tyrannus	(Atlantic menhaden)
ENGRAULIDAE	
Anchoa mitchilli	(Bay anchovy)
A. hepsetus	(Striped anchovy)
OSMERIDAE	
Osmerus mordax	(Rainbow smelt)
LOPHIIDAE	
Lophius americanus	(Goosefish)
GADIDAE	
Enchelyopus cimbrius	(Fourbeard rockling)
Gadus morhua	(Atlantic cod)
Melanogrammus aeglefinus	(Haddock)
Merluccius bilinearis	(Silver hake)
Urophycis spp.	(Hakes)
Pollachius virens	(Pollock)
ATHERINIDAE	
Menidia menidia	(Atlantic silverside)
GASTEROSTEIDAE	
Gasterosteus aculeatus	(Threespine stickleback)
SYNGNATHIDAE	
Syngnathus fuscus	(Northern pipefish)
POMATOMIDAE	
Pomatomus saltatrix	(Bluefish)
SPARIDAE	
Stenotomus chrysops	(Scup)
SCIAENIDAE	
Cynoscion regalis	(Weakfish)
Menticirrhus saxitilis	(Northern kingfish)
LABRIDAE	
Tautoga onitis	(Tautcg)
Tautogolabrus adspersus	(Cunner)
STICHAEIDAE	
Ulvaria subbifurcata	(Radiated shanny)

PHOLIDAE	
Pholis gunnellus	(Rock gunnel)
AMMODYTIDAE	
Ammodytes americanus	(American sand launce)
GOBIIDAE	
Gobiosoma ginsburgi	(Seaboard goby)
SCOMBRIDAE	
Scomber scombrus	(Atlantic mackerel)
STROMATEIDAE	
Peprilus triacanthus	(Butterfish)
TRIGLIDAE	
Prionotus spp.	(Searobins)
COTTIDAE	
Myoxocephalus spp.	(Sculpins)
AGONIDAE	
Aspidophoroides monopterygius	(Alligatorfish)
CYCLOPTERIDAE	
Liparis atlanticus	(Seasnail)
BOTHIDAE	
Scopthalmus aquosus	(Windowpane)
Paralichthys dentatus	(Summer flounder)
P. oblongus	(Fourspot flounder)
PLEURONECTIDAE	
Pseudopleuronectes americanus	(Winter flounder)
Limanda ferruginea	(Yellowtail flounder)
Glyptocephalus cynoglossus	(Witch flounder)
Hippoglossoides platessoides	(American plaice)
SOLEIDAE	
Trinectes maculatus	(Hogchoker)
TETRAODONTIDAE	
Sphoeroides maculatus	(Northern puffer)

Table 3. Number of species or species groups found by MRI in Narragansett and Mt Hope Bays during 1972-73.

Year	Month	Number of Taxa
1972	June	21
	July	24
	August	18
	September	6
	October	12
	November	9
	December	5
1973	January	9
	February	7
	March	10
	April	15
	May	29
	June	28
	July	25
	August	19

Table 4a. Anchoa spp. Concentration of larvae (no / 100 cubic m.) within each sector by month

Month	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	15.52	1.51	11.43	3.37	0.83	8.37	1.86	0.37	11.37
Jul-72	1355.00	1009.00	323.30	846.00	419.60	365.30	400.80	64.05	253.90
Aug-72	56.98	329.60	72.81	283.80	87.90	74.50	121.70	18.66	40.80
Sep-72	0.01	0	0.01	0.01	0	0.01	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0
May-73	0	0	0	0	0	0	0	0	0
Jun-73	114.40	140.80	96.40	49.90	44.68	70.00	9.55	5.84	17.81
Jul-73	2478.00	2018.00	341.90	1530.00	191.30	462.70	1177.00	153.20	382.90
Aug-73	62.34	50.12	35.01	91.29	37.52	41.91	99.99	17.62	55.58
Area, 1972	44237.3	41541.9	12622.6	35125.2	15757.4	13885.2	16253.3	2575.1	9476.8
Area, 1973	82182.5	68335.7	14576.2	51757.0	8433.8	17742.9	39873.2	5470.6	14127.2

Table 4b. Anchoa spp. Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated areas of abundance vs time for larvae during the period they were present within each sector and the total bay for each year.

Month	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total Nos
Jun-72	0.467	0.482	2.172	1.473	0.314	1.205	0.610	0.279	0.912	7.913
Jul-72	40.786	321.871	61.427	369.702	158.609	52.603	131.462	48.230	20.363	1205.052
Aug-72	1.715	105.142	13.834	124.021	33.226	10.728	39.918	14.051	3.272	345.907
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0	0
May-73	0	0	0	0	0	0	0	0	0	0
Jun-73	3.443	44.915	18.316	21.806	16.889	10.080	3.132	4.398	1.428	124.408
Jul-73	74.588	643.742	64.961	668.610	72.311	66.629	386.056	115.360	30.709	2122.965
Aug-73	1.876	15.988	6.652	39.894	14.183	6.035	32.797	13.268	4.458	135.150
Area, 1972	1331.5	13251.9	2398.2	15349.6	5956.3	1999.4	5331.1	1939.1	760.0	48317.1
Area, 1973	2473.7	21799.1	2769.5	22617.8	3188.0	2555.0	13078.4	4119.4	1133.0	73733.8

Table 4a. Brevoortia tyrannus . Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	2029.00	3588.00	1663.00	1312.00	916.80	1763.00	1172.00	178.20	775.20
Jul-72	2665.00	5068.00	3140.00	2791.00	2417.00	1706.00	1545.00	773.10	757.70
Aug-72	0.67	43.57	4.72	34.20	12.96	3.95	2.27	0.48	0.39
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0.02	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0
May-73	3.35	3.87	120.00	5.76	31 69	43.69	2.70	19.10	3.91
Jun-73	358.20	1836.00	2032.00	261.40	565.10	806.70	31.20	87.32	154.90
Jul-73	756.60	479.10	157.00	126.00	76.39	172.20	27.51	22.63	64.60
Aug-73	0	0.03	0.01	0	0	0	0	0	0
Area, 1972	143505.8	266098.7	147376.3	126941.2	102832.8	105898.5	83125.4	29327.0	46756.8
Area, 1973	34304.5	70053.0	69547.3	11926.6	20303.5	30893.6	1872.5	3913.2	6770.8

Table 4b. Brevoortia tyrannus . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated areas of abundance vs time for larvae during the period they were present within each sector and the total bay during each year.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total nos
Jun-72	61.073	1144.572	315.970	573.344	346.550	253.872	384.416	134.185	62.171	3276.153
Jul-72	80.217	1616.692	596.600	1219.667	913.626	245.664	506.760	582.144	60.768	5822.137
Aug-72	0.020	13.899	0.897	14.945	4.899	0.569	0.745	0.361	0.031	36.366
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0	0
May-73	0.101	1.235	22.800	2.517	11.979	6.291	0.886	14.382	0.314	60.504
Jun-73	10.782	585.684	386.080	114.232	213.608	116.165	10.234	65.752	12.423	1514.959
Jul-73	22.774	152.833	29.830	55.062	28.875	24.797	9.023	17.040	5.181	345.415
Aug-73	0	0	0	0	0	0	0	0	0	0
Area, 1972	4319.5	84885.5	28001.5	55473.3	38870.8	15249.4	27265.1	22083.2	3749.9	279898.2
Area, 1973	1032.6	22346.6	13213.9	5211.9	7674.7	4448.7	614.2	2946.7	543.0	58032.3

Table 4a. Pseudopleuronectes americanus . Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	0	0	0	0	0	0	1.17	0.32	0.43
Jul-72	0	0.19	0	0	0	0	0.17	0	0
Aug-72	0	0	0	0	0	0	0	0	0
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0.03	0	0.02	0	0	0.01	0	0	0
Mar-73	141.80	12.05	99.57	31.62	9.22	80.10	37.36	2.29	51.72
Apr-73	131.60	196.00	298.70	117.40	112.90	211.80	76.47	31.07	193.10
May-73	9.28	20.85	11.80	16.64	15.39	9.89	24.04	12.93	15.40
Jun-73	0.08	0.40	0.23	0.67	0.45	0.10	1.15	1.58	1.65
Jul-73	0	0	0	0	0.04	0	0.02	0.01	0
Aug-73	0	0	0	0	0	0	0	0	0
Area, 1973	8634.7	6911.9	12420.9	5038.2	4164.8	9147.0	4232.6	1451.6	7923.2

Table 4b. Pseudopleuronectes americanus . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated ares of abundance ve time for larvae during the period they were present within each sector and the total bay during each year.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total nos
Jun-72	0	0	0	0	0	0	0.384	0.241	0.034	0.659
Jul-72	0	0.061	0	0	0	0	0.056	0	0	0.116
Aug-72	0	0	0	0	0	0	0	0	0	0
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0.001	0	0.004	0	0	0.001	0	0	0	0.006
Mar-73	4.268	3.844	18.918	13.818	3.487	11.534	12.254	1.723	4.148	73.994
Apr-73	3.961	62.524	56.753	51.304	42.676	30.499	25.082	23.396	15.487	311.682
May-73	0.279	6.651	2.242	7.272	5.817	1.424	7.885	9.736	1.235	42.542
Jun-73	0.002	0.128	0.044	0.293	0.170	0.014	0.377	1.190	0.132	2.350
Jul-73	0	0	0	0	0.015	0	0.007	0.008	0	0.029
Aug-73	0	0	0	0	0	0	0	0	0	0
Area, 1973	259.9	2204.9	2360.0	2201.7	1573.8	1317.2	1388.1	1092.8	635.4	13033.8

Table 4a. Tautoga onitis . Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	34.84	51.06	64.26	25.46	33.07	59.88	74.24	25.48	151.50
Jul-72	130.70	213.60	166.20	123.80	83.28	89.10	100.60	30.00	55.48
Aug-72	0.09	1.15	0.10	0.31	0.29	0.06	0.18	0.58	0.20
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0
May-73	0.19	0.25	2.39	0.49	2.32	2.44	0.49	2.80	1.24
Jun-73	24.66	119.50	99.98	53.23	43.96	93.94	15.26	34.24	40.71
Jul-73	69.63	88.41	14.66	48.44	20.25	60.61	20.23	16.26	48.08
Aug-73	0	0	0.01	0	0	0.01	0	0	0.18
Area, 1972	5099.7	8189.1	7083.1	4611.2	3582.8	4560.4	5351.4	1712.4	6271.1
Area, 1973	2904.2	6333.5	3528.3	3113.7	2018.5	4773.1	1100.1	1618.1	2755.8

Table 4b. Tautoga onitis . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated areas of abundance vs time for larvae during the period they were present within each sector and the total bay during each year.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total nos
Jun-72	1.049	16.288	12.209	11.126	12.500	8.623	24.351	19.186	12.150	117.483
Jul-72	3.934	68.138	31.578	54.101	31.480	12.830	32.997	22.590	4.449	262.098
Aug-72	0.003	0.367	0.019	0.135	0.110	0.009	0.059	0.437	0.016	1.154
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0	0
May-73	0.006	0.080	0.454	0.214	0.877	0.351	0.161	2.108	0.099	4.351
Jun-73	0.742	38.121	18.996	23.262	16.617	13.527	5.005	25.783	3.265	145.318
Jul-73	2.096	28.203	2.785	21.168	7.655	8.728	6.635	12.244	3.856	93.370
Aug-73	0	0	0.002	0	0	0.001	0	0	0.014	0.017
Area, 1972	153.5	2612.3	1345.8	2015.1	1354.3	656.7	1755.3	1289.4	502.9	11685.3
Area, 1973	87.4	2020.4	670.4	1360.7	763.0	687.3	360.8	1218.4	221.0	7389.4

Table 4a. Tautogolabrus adspersus . Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	16.05	27.10	29.08	12.39	8.81	71.19	22.65	26.75	495.00
Jul-72	43.30	167.90	94.12	64.51	56.67	78.67	24.76	29.83	78.63
Aug-72	0.11	2.11	0.05	0.28	0.57	0.15	0.05	2.52	0.23
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0
May-73	0.03	0.09	0.32	0.14	0.77	0.86	0.20	1.15	1.15
Jun-73	11.29	39.61	51.25	32.25	39.90	83.22	10.96	40.26	96.11
Jul-73	25.34	71.46	14.93	26.63	28.04	49.10	12.36	37.91	99.00
Aug-73	0	0	0.01	0.01	0	0	0	0	0.06
Area, 1972	1827.2	6083.3	3791.7	2380.2	2038.7	4579.1	1448.6	1805.4	17294.7
Area, 1973	1125.2	3406.4	2010.6	1797.7	2090.1	4045.4	718.2	2418.7	5989.8

Table 4b. Tautogolabrus adspersus . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated areas of abundance vs time for larvae during the period they were present within each sector and the total bay during each year.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total nos
Jun-72	0.483	8.645	5.525	5.414	3.330	10.251	7.429	20.143	39.699	100.920
Jul-72	1.303	53.560	17.883	28.191	21.421	11.328	8.121	22.462	6.306	170.576
Aug-72	0.003	0.673	0.010	0.122	0.215	0.022	0.016	1.898	0.018	2.978
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0	0
May-73	0.001	0.029	0.061	0.061	0.291	0.124	0.066	0.866	0.092	1.590
Jun-73	0.340	12.636	9.738	14.093	15.082	11.984	3.595	30.316	7.708	105.491
Jul-73	0.763	22.796	2.837	11.637	10.599	7.070	4.054	28.546	7.940	96.242
Aug-73	0	0	0.002	0.004	0	0	0	0	0.005	0.011
Area, 1972	55.0	1940.6	720.4	1040.1	770.6	659.4	475.1	1359.4	1387.0	8407.8
Area, 1973	33.9	1086.6	382.0	785.6	790.1	582.5	235.6	1821.3	480.4	6197.9

Table 4a. Ammodytes americanus. Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	0	0	0	0	0	0	0	0	0
Jul-72	0	0	0	0	0	0	0	0	0
Aug-72	0	0	0	0	0	0	0	0	0
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	5.05	3.21	12.29	6.43	7.20	44.08	6.01	12.17	70.20
Apr-73	14.07	30.56	30.00	23.31	24.04	79.21	19.43	16.10	201.00
May-73	1.54	1.02	1.41	2.66	2.88	4.13	4.60	5.46	25.39
Jun-73	0	0	0	0	0	0	0	0	0
Jul-73	0	0	0	0	0	0	0	0	0
Aug-73	0	0	0	0	0	0	0	0	0
Area, 1973	626.2	1047.8	1324.7	980.9	1033.6	3870.8	911.8	1029.5	8993.3

Table 4b. Ammodytes americanus . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated areas of abunndance vs time for the larvae during the period they were present for each sector and the total bay during each year.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	Tot. nos
Jun-72	0	0	0	0	0	0	0	0	0	0
Jul-72	0	0	0	0	0	0	0	0	0	0
Aug-72	0	0	0	0	0	0	0	0	0	0
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0.152	1.023	2.335	2.808	2.720	6.348	1.971	9.164	5.630	32.151
Apr-73	0.424	9.749	5.700	10.186	9.087	11.406	6.373	12.123	16.120	81.169
May-73	0.046	0.325	0.268	1.162	1.089	0.595	1.509	4.111	2.036	11.142
Jun-73	0	0	0	0	0	0	0	0	0	0
Jul-73	0	0	0	0	0	0	0	0	0	0
Aug-73	0	0	0	0	0	0	0	0	0	0
Area, 1973	18.8	334.3	251.7	428.7	390.7	557.4	299.1	775.2	721.3	3777.1

Table 4a. Cynoscion regalis . Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	44.99	14.50	21.60	6.95	3.53	36.73	13.00	0.73	116.10
Jul-72	113.60	81.34	32.06	76.35	8.26	23.16	33.95	5.07	17.67
Aug-72	0.08	0.46	0	0.15	0.01	0	0.01	0	0
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0		0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0
May-73	0	0	0	0	0	0	0	0	0
Jun-73	8.33	33.59	74.43	9.48	29.40	42.34	3.49	5.98	17.34
Jul-73	30.11	39.08	5.64	16.70	6.68	11.32	7.79	5.60	16.47
Aug-73	0	0	0.01	0	0	0	0	0	0
Area, 1972	4871.3	2956.5	1641.9	2575.4	362.0	1819.9	1442.5	179.1	4030.8
Area, 1973	1183.3	2219.2	2407.7	802.1	1089.1	1621.1	346.2	353.0	1030.8

Table 4b. Cynoscion regalis . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated ares of abundance vs time for larvae during the period they were present within each sector and the total bay during each year.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total nos
Jun-72	1.354	4.626	4.104	3.037	1.334	5.289	4.264	0.550	9.311	33.869
Jul-72	3.419	25.947	6.091	33.365	3.122	3.335	11.136	3.818	1.417	91.651
Aug-72	0.002	0.146	0	0.065	0.004	0	0.003	0	0	0.221
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0	0
May-73	0	0	0	0	0	0	0	0	0	0
Jun-73	0.251	10.715	14.142	4.143	11.113	6.097	1.145	4.503	1.391	53.499
Jul-73	0.906	12.467	1.072	7.298	2.525	1.630	2.555	4.217	1.321	33.990
Aug-73	0	0	0.002	0	0	0	0	0	0	0.002
Area ,1972	146.7	947.7	312.0	1127.4	136.9	262.1	473.2	134.8	323.3	3864.1
Area, 1973	35.6	707.9	457.5	350.5	411.7	233.4	113.6	265.8	82.7	2658.7

Table 4a. Scophthalmus aquosus . Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	11.16	28.47	24.65	12.47	16.57	17.76	10.49	8.45	54.74
Jul-72	7.86	38.05	27.54	27.14	13.94	10.69	9.00	5.21	14.96
Aug-72	0	0.18	0.12	0.18	0.80	0.14	0.14	0.26	0.26
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0
May-73	1.79	1.83	5.20	2.41	3.65	3.75	1.89	2.36	2.51
Jun-73	9.19	47.16	14.99	14.92	18.46	16.51	6.08	6.91	16.72
Jul-73	4.61	11.08	2.98	3.58	6.86	7.3	2.69	4.14	7.54
Aug-73	0	0.06	0	0.34	0.01	0	0.01	0.03	0.02
Area, 1972	578.5	2039.2	1597.0	1221.0	954.0	868.5	598.0	423.1	2114.0
Area, 1973	474.1	1816.9	703.3	643.8	879.9	837.9	324.7	409.7	813.8

Table 4b. Scophthalmus aquosus . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated areas of abundance vs time for larvae during the period they were present within each sector and the total bay during each year.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total nos
Jun-72	0.336	9.082	4.684	5.449	6.263	2.557	3.441	6.363	4.390	42.565
Jul-72	0.237	12.138	5.233	11.860	5.269	1.539	2.952	3.923	1.200	44.351
Aug-72	0	0.057	0.023	0.079	0.302	0.020	0.046	0.196	0.021	0.744
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0	0
May-73	0.054	0.584	0.988	1.053	1.380	0.540	0.620	1.777	0.201	7.197
Jun-73	0.277	15.044	2.848	6.520	6.978	2.377	1.994	5.203	1.341	42.583
Jul-73	0.139	3.535	0.566	1.564	2.593	1.051	0.882	3.117	0.605	14.053
Aug-73	0	0.019	0	0.149	0.004	0	0.003	0.023	0.002	0.199
Area, 1972	17.4	650.5	303.4	533.6	360.6	125.1	196.2	318.6	169.5	2674.9
Area, 1973	14.3	579.6	133.6	281.4	332.6	120.7	106.5	308.5	65.3	1942.4

Table 4a. Menidia menidia . Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	560.80	123.50	133.10	56.47	28.59	28.55	158.60	3.47	6.97
Jul-72	51.61	68.04	37.36	17.79	44.13	39.56	9.39	6.91	3.70
Aug-72	0.16	0.14	0.01	0.09	0.23	0.06	0	0.01	0
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0
May-73	0.79	0.43	15.86	0.43	0.35	1.68	0.18	0.29	0.36
Jun-73	25.21	17.38	105.60	2.31	8.85	74.75	0.59	0.39	8.07
Jul-73	44.25	5.92	21.15	7.54	4.98	17.57	0.55	0.75	1.17
Aug-73	0	0	0	0	0.57	0	0	0.06	0
Area, 1972	18428.9	5818.6	5151.5	2248.4	2232.9	2084.7	5049.1	318.6	323.8
Area, 1973	2152.5	718.3	4315.3	316.4	448.4	2839.3	40.3	45.8	289.5

Table 4b. Menidia menidia . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated areas of abundance vs time for larvae during the period they were present within each sector and the total bay during each year.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total nos
Jun-72	16.880	39.397	25.289	24.677	10.807	4.111	52.021	2.613	0.559	176.354
Jul-72	1.553	21.705	7.098	7.774	16.681	5.697	3.080	5.203	0.297	69.089
Aug-72	0.005	0.045	0.002	0.039	0.087	0.009	0	0.008	0	0.194
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0	0
May-73	0.024	0.137	3.013	0.188	0.132	0.242	0.059	0.218	0.029	4.043
Jun-73	0.759	5.544	20.064	1.009	3.345	10.764	0.194	0.294	0.647	42.620
Jul-73	1.332	1.888	4.019	3.295	1.882	2.530	0.180	0.565	0.094	15.785
Aug-73	0	0	0	0	0.215	0	0	0.045	0	0.261
Area, 1972	554.7	1856.1	978.8	982.5	844.0	300.2	1656.1	239.9	26.0	7438.4
Area, 1973	64.8	229.1	819.9	138.3	169.5	408.9	13.2	34.5	23.2	1901.4

Table 4a. Scomber scombrus . Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	0	0.56	1.08	0	0.99	0.53	1.13	9.84	34.93
Jul-72	0	0.48	0	0	0.28	0.19	0	1.22	0.02
Aug-72	0	0	0	0	0	0	0	0	0
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0
May-73	0.14	0.80	2.38	2.77	5.[illegible]1	3.76	[illegible].02	28.52	11.36
Jun-73	0.12	2.18	6.59	3.42	5.51	5.02	2.06	30.24	10.85
Jul-73	0	0.14	0.07	0.06	0.08	0.1	0.12	0.09	0
Aug-73	0	0	0	0	0	0	0	0	0
Area, 1973	7.9	94.5	273.7	190.3	332.4	270.3	221.1	1794.1	677.7

Table 4b. Scomber scombrus . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated areas of abundance vs time of larvae during the period they were present for each sector and the total bay for each year.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total nos
Jun-72	0	0.179	0.205	0	0.374	0.076	0.371	7.410	2.801	11.416
Jul-72	0	0.153	0	0	0.106	0.027	0	0.919	0.002	1.207
Aug-72	0	0	0	0	0	0	0	0	0	0
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0	0
May-73	0.004	0.255	0.452	1.210	2.007	0.541	1.647	21.476	0.911	28.504
Jun-73	0.004	0.695	1.252	1.495	2.083	0.723	0.676	22.771	0.870	30.568
Jul-73	0	0.045	0.013	0.026	0.030	0.014	0.039	0.068	0	0.236
Aug-73	0	0	0	0	0	0	0	0	0	0
Area, 1973	0.2	30.2	52.0	83.2	125.6	38.9	72.5	1351.0	54.3	1808.0

Table 4a. Gobiosoma ginsburgi. Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	0	0	5.58	0.34	0	1.86	0.26	0.22	2.37
Jul-72	6.18	7.09	24.6	6.05	2.96	31.42	0.45	0.03	9.93
Aug-72	0.97	7.21	3.67	1.98	0.5	4.79	0.57	0.52	3.52
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0
May-73	0	0	0.19	0	0	0.02	0	0	0
Jun-73	2.56	3.36	18.71	0.04	1.85	7.26	0.01	0.05	1.01
Jul-73	19.5	77.99	21.55	14.32	4.2	28.59	1.85	0.78	22.12
Aug-73	3.45	3.85	2.62	4.88	0.28	3.46	1.26	0.09	1.06
Area, 1972	221.7	443.3	1043.8	259.1	107.3	1178.3	39.4	23.7	488.1
Area, 1973	788.3	2637.8	1316.5	596.4	194.4	1212.0	96.7	28.5	748.9

Table 4b. Gobiosoma ginsburgi . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated areas of abundance vs time for larvae during the period they were present within each sector and the total bay during each year.

Date	S1	S2		S4	S5	S6	S7	S8	S9	Total nos
Jun-72	0	0	1.060	0.149	0	0.268	0.085	0.166	0.190	1.918
Jul-72	0.186	2.262	4.674	2.644	1.119	4.524	0.148	0.023	0.796	16.376
Aug-72	0.029	2.300	0.697	0.865	0.189	0.690	0.187	0.392	0.282	5.631
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0	0
Apr-73	0	0	0	0	0	0	0	0	0	0
May-73	0	0	0.036	0	0	0.003	0	0	0	0.039
Jun-73	0.077	1.072	3.555	0.017	0.699	1.045	0.003	0.038	0.081	6.588
Jul-73	0.587	24.879	4.095	6.258	1.588	4.117	0.607	0.587	1.774	44.491
Aug-73	0.104	1.228	0.498	2.133	0.106	0.498	0.413	0.068	0.085	5.132
Area, 1972	1.8	142.6	75.0	58.1	11.7	50.8	14.1	29.2	23.2	406.7
Area, 1973	23.7	841.5	250.1	260.6	73.5	174.5	31.7	21.4	60.1	1737.2

Table 4a. Enchelyopus cimbrius . Concentration of larvae (no/100 cubic m.) within each sector by month.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
Jun-72	1.07	0.61	0.65	0.97	0.51	0	0.35	0.29	0
Jul-72	0.62	0.02	0	0.14	0.33	0.93	0	0.23	0.48
Aug-72	0	0	0	0	0	0	0	0.02	0
Sep-72	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0
Apr-73	0.04	0.14	0.12	0.04	0.18	0.16	0	0.05	0.08
May-73	0.55	0.79	2.96	1.62	2.78	2.09	1.30	4.33	3.06
Jun-73	0.26	2.01	0.54	1.04	0.55	1.04	0.73	1.68	1.60
Jul-73	0	0.05	0	0.03	0.08	0.12	0	0.11	0.02
Aug-73	0	0	0	0	0	0	0	0	0
Area, 1973	26.1	90.5	111.6	83.6	122.6	104.5	62.2	189.5	145.9

Table 4b. Enchelyopus cimbrius . Numbers of larvae (*10^7) within each sector and the total bay by month. Also shown are the mean integrated ares of abundance vs time for larvae during the period they were present within each sector and the total bay for each year.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total nos
Jun-72	0.032	0.195	0.124	0.424	0.193	0	0.115	0.218	0	1.300
Jul-72	0.019	0.006	0	0.061	0.125	0.134	0	0.173	0.038	0.557
Aug-72	0	0	0	0	0	0	0	0.015	0	0.015
Sep-72	0	0	0	0	0	0	0	0	0	0
Oct-72	0	0	0	0	0	0	0	0	0	0
Nov-72	0	0	0	0	0	0	0	0	0	0
Dec-72	0	0	0	0	0	0	0	0	0	0
Jan-73	0	0	0	0	0	0	0	0	0	0
Feb-73	0	0	0	0	0	0	0	0	0	0
Mar-73	0	0	0	0	0	0	0	0	0	0
Apr-73	0.001	0.045	0.023	0.017	0.068	0.023	0	0.038	0.006	0.221
May-73	0.017	0.252	0,562	0.708	1.051	0.301	0.426	3.260	0.245	6.823
Jun-73	0.008	0.641	0.103	0.454	0.359	0.150	0.239	1.265	0.128	3.348
Jul-73	0	0.016	0	0.013	0.030	0.017	0	0.083	0.002	0.161
Aug-73	0	0	0	0	0	0	0	0	0	0
Area, 1973	0.8	29.3	20.8	36.3	45.7	14.9	20.2	140.8	11.6	320.3

Table 5. Integrated areas of abundance vs time of the more abundant species of larvae by sector and the total Bay. Species are ranked by decreasing abundance. Species denoted with an asterisk were rare in 1972-73 but reported as abundant by Herman (1958).

	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total	Percent
1972 (June-December, does not include spring spawners).											
Brevoortia tyrannus	4320	84885	28002	55473	38871	15249	27265	22083	3750	279898	
Anchoa spp.	1332	13252	2398	15350	5956	1999	5331	1939	760	48317	
Tautoga onitis	154	2612	1346	2015	1354	657	1755	1289	503	11685	
Tautogolabrus adspersus	55	1941	720	1040	771	659	475	1359	1387	8408	
Menidia menidia	555	1856	979	983	844	300	1656	240	26	7438	
Cynoscion regalis	147	948	312	1127	137	262	473	135	323	3864	
Scophthalmus aquosus	17	651	303	534	361	125	196	319	170	2675	
Gobiosoma ginsbeurgi	2	143	75	58	12	51	14	29	23	407	
*Prionotus spp	3	54	64	86	22	19	67	49	5	369	
*Stenotomus chrysops	0	7	2	25	0	0	1	15	8	58	
*Peprilus triacanthus	0	0	6	0	0	1	1	4	4	16	
1973 (January - August, includes spring and summer spawners)											
Anchoa spp.	2474	21799	2769	22618	3188	2555	13078	4119	1133	73734	42.7
Brevoortia tyrannus	1033	22347	13214	5212	7675	4449	614	2947	543	58032	33.6
Pseudopleuronectes americanus	260	2205	2360	2202	1574	1317	1388	1093	635	13034	7.6
Tautoga onitis	87	2020	670	1361	763	687	361	1218	221	7389	4.3
Tautogolabrus adspersus	34	1087	382	786	790	583	236	1821	480	6198	3.6
Ammodytes americanus	19	334	252	429	391	557	299	775	721	3777	2.2
Cynoscion regalis	36	708	458	351	412	233	114	266	83	2659	1.5
Scophthalmus aquosus	14	580	134	281	333	121	106	309	65	1942	1.1
Menidia menidia	65	229	820	138	169	409	13	34	23	1901	1.1
Scomber scombrus	0	30	52	83	126	39	73	1351	54	1808	1.0
Gobiosoma ginsbeufgi	24	841	250	261	73	175	32	21	60	1737	1.0
Enchelyopus cimbrius	1	29	21	36	46	15	20	141	12	320	0.2
*Stenotomus chrysops	5	65	51	55	39	28	7	64	7	321	
*Prionotus spp	1	78	21	43	17	24	4	39	12	239	
*Myoxocephalus spp	1	17	12	38	29	16	37	76	13	239	
*Peprilus triacanthus	1	30	16	53	15	26	9	63	7	220	

Table 6. Ranking of each Sector in order of the concentration of larvae.

	S1	S2	S3	S4	S5	S6	S7	S8	S9
1972 (June-December, does not include spring spawners).									
Brevoortia tyrannus	3	1	2	4	6	5	7	9	8
Anchoa spp.	1	2	7	3	5	6	4	9	8
Tautoga onitis	5	1	2	6	8	7	4	9	3
Tautogolabrus adspersus	7	2	4	5	6	3	9	8	1
Menidia menidia	1	2	3	5	6	7	4	9	8
Cynoscion regalis	1	3	6	4	8	5	7	9	2
Scophthalmus aquosus	8	2	3	4	5	6	7	9	1
Gobiosoma ginsbeurgi	6	4	2	5	7	1	8	9	3
1973 (January - August, includes spring and summer spawners)									
Anchoa spp.	1	2	6	3	8	5	4	9	7
Brevoortia tyrannus	3	1	2	6	5	4	9	8	7
Pseudopleuronectes americanus	3	5	1	6	8	2	7	9	4
Tautoga onitis	5	1	3	4	7	2	9	8	6
Tautogolabrus adspersus	8	3	6	7	5	2	9	4	1
Ammodytes americanus	9	4	3	7	5	2	8	6	1
Cynoscion regalis	4	2	1	7	5	3	9	8	6
Scophthalmus aquosus	7	1	5	6	2	3	9	8	4
Menidia menidia	3	4	1	6	5	2	9	8	7
Scomber scombrus	9	8	4	7	3	5	6	1	2
Gobiosoma ginsbeurgi	4	1	2	6	7	3	8	9	5
Enchelyopus cimbrius	9	6	4	7	3	5	8	1	2

Table 7. Ranking of each Sector in order of the percent contribution of that Sector to the total population of the more abundant species in the Bay.

	S1	S2	S3	S4	S5	S6	S7	S8	S9
1972 (June-December, does not include spring spawners).									
Brevoortia tyrannus	8	1	4	2	3	7	5	6	9
Anchoa spp.	8	2	5	1	3	6	4	7	9
Tautoga onitis	9	1	5	2	4	7	3	6	8
Tautogolabrus adspersus	9	1	6	4	5	7	8	3	2
Menidia menidia	6	1	4	3	5	7	2	8	9
Cynoscion regalis	7	2	5	1	8	6	3	9	4
Scophthalmus aquosus	9	1	5	2	3	8	6	4	7
Gobiosoma ginsbeurgi	9	1	2	3	8	4	7	5	6
1973 (January - August, includes spring and summer spawners)									
Anchoa spp.	8	2	5	1	6	7	3	4	9
Brevoortia tyrannus	7	1	2	4	3	5	8	6	9
Pseudopleuronectes americanus	9	2	1	3	4	6	5	7	8
Tautoga onitis	9	1	6	2	4	5	7	3	8
Tautogolabrus adspersus	9	2	7	3	4	5	8	1	6
Ammodytes americanus	9	6	8	4	5	3	7	1	2
Cynoscion regalis	9	1	2	4	3	6	7	5	8
Scophthalmus aquosus	9	1	5	4	2	6	7	3	8
Menidia menidia	6	3	1	5	4	2	9	7	8
Scomber scombrus	9	8	6	3	2	7	4	1	5
Gobiosoma ginsbeurgi	8	1	3	2	5	4	7	9	6
Enchelyopus cimbrius	9	4	5	3	2	7	6	1	8

Table 8. Percent contribution of each Sector to the total abundance of the more abundant species in the whole Bay.

	S1	S2	S3	S4	S5	S6	S7	S8	S9
1972 (June-December, does not include spring spawners).									
Brevoortia tyrannus	1.5	30.3	10.0	19.8	13.9	5.4	9.7	7.9	1.3
Anchoa spp.	2.8	27.4	5.0	31.8	12.3	4.1	11.0	4.0	1.6
Tautoga onitis	1.3	22.4	11.5	17.2	11.6	5.6	15.0	11.0	4.3
Tautogolabrus adspersus	0.7	23.1	8.6	12.4	9.2	7.8	5.7	16.2	16.5
Menidia menidia	7.5	25.0	13.2	13.2	11.3	4.0	22.3	3.2	0.3
Cynoscion regalis	3.8	24.5	8.1	29.2	3.5	6.8	12.2	3.5	8.4
Scophthalmus aquosus	0.7	24.3	11.3	19.9	13.5	4.7	7.3	11.9	6.3
Gobiosoma ginsbeurgi	0.4	35.1	18.5	14.3	2.9	12.5	3.5	7.2	5.7
1973 (January - August, includes spring and summer spawners)									
Anchoa spp.	3.4	29.6	3.8	30.7	4.3	3.5	17.7	5.6	1.5
Brevoortia tyrannus	1.8	38.5	22.8	9.0	13.2	7.7	1.1	5.1	0.9
Pseudopleuronectes americanus	2.0	16.9	18.1	16.9	12.1	10.1	10.7	8.4	4.9
Tautoga onitis	1.2	27.3	9.1	18.4	10.3	9.3	4.9	16.5	3.0
Tautogolabrus adspersus	0.5	17.5	6.2	12.7	12.7	9.4	3.8	29.4	7.8
Ammodytes americanus	0.5	8.8	6.7	11.3	10.3	14.8	7.9	20.5	19.1
Cynoscion regalis	1.3	26.6	17.2	13.2	15.5	8.8	4.3	10.0	3.1
Scophthalmus aquosus	0.7	29.8	6.9	14.5	17.1	6.2	5.5	15.9	3.4
Menidia menidia	3.4	12.1	43.1	7.3	8.9	21.5	0.7	1.8	1.2
Scomber scombrus	0.0	1.7	2.9	4.6	6.9	2.2	4.0	74.7	3.0
Gobiosoma ginsbeurgi	1.4	48.4	14.4	15.0	4.2	10.0	1.8	1.2	3.5
Enchelyopus cimbrius	0.2	9.2	6.5	11.3	14.3	4.7	6.3	43.9	3.6

Table 9. Mean concentration of fish larvae during the period they were present in Narragansett Bay (from Herman, 1958). Data from four different stations are combined. Also shown are the months during which each species were present and the temperature range they experienced. Data are ranked in order of decreasing abundance. The percent contribution of each species to the overall average larval fish abundance is also shown.

Species	Size,mm	Dates	Number/ 100 m3	% of Total	Temp range,C
Myoxocephalus spp. (Sculpin)	5.2 - 10.4	Jan-May	18.6	53.60	-2.0 - 11.5
Menidia menidia (Atlantic silverside)	3.2 - 29.0	May-July	2.5	7.20	14.8 - 23.0
Tautogolabrus adspersus (Cunner)	2.6 - 8.4	June-Aug	1.45	4.18	20.1 - 24.4
Anchoa mitchilli (Anchovy)	2.4 - 40.0	June-Nov	1.4	4.03	10.1 - 24.4
Stenotomus chrysops (Scup)	2.1 - 10.3	June -Sept	1.13	3.26	20.0 - 23.5
Ammodytes americanus (Sand launce)	5.4 - 26.0	Jan-May	0.98	2.82	-2.0 - 15.5
Prionotus spp. (Searobin)	3.0 - 8.6	July-Sept	0.94	2.71	20.6 - 23.2
Peprilus triacanthus Butterfish)	3.3 -12.3	July-Oct	0.7	2.02	15.8 - 24.4
Pseudopleuronectes americanus (w.flounder)	3.2 - 7.2	Feb-June	0.68	1.96	-0.8 - 17.4
Tautoga onitis (Tautog)	2.2 - 5.2	June-Aug	0.56	1.61	20.0 - 23.5
Syngnathus fuscus (Northern pipefish)	8.5 -105	June-Oct	0.54	1.56	5.8 - 24.4
Ulvaria subbifurcata (Radiated shanny)	4.7 -10.6	May-June	0.52	1.50	11.5 - 18.2
Brevoortia tyrannus (Menhaden)	3.2 - 26.6	J-J,Oct-Feb	0.4	1.15	1.2 - 22.2
Gadus morhua (Cod)	3.8 - 23.0	Dec-May	0.4	1.15	-2.0 - 13.4
Gobiosoma spp. (Goby)	2.3 - 11.2	July-Aug	0.4	1.15	20.1 - 23.0
Merluccius bilinearis (Silver hake)	3.2 - 6.6	June-Aug	0.4	1.15	12.0 - 22.4
Sphaeroides maculatus (Northern puffer)	2.4 - 9.0	June-Sept	0.4	1.15	20.0 - 23.0
Clupea harengus (Herring)	35.0 - 38.0	Mar-April	0.3	0.86	6.5
Cynoscion regalis (Weakfish)	2.2 - 8.0	July-Sept	0.3	0.86	19.7 - 23.0
Scophthalmus (Lophsetta) aquosus (Sanddab)	2.1 - 9.4	June-Nov	0.3	0.86	9.3 - 23.0
Paralichthys oblongus (Fourspot flounder)	2.4 -11.0	July-Sept	0.3	0.86	20.0 - 20.5
Pholis gunnelus (Rock gunnel)	5.6 - 22.0	Dec-Mar	0.3	0.86	-2.0 - 6.4
Anguilla rostrata (Eel)	48.0 - 60.0	Feb-Apr	0.2	0.58	-0.8 - 6.5
Cyclopterus lumpus (Lumpfish)	3.4 - 7.0	May	0.2	0.58	10.0 - 14.8
Menticirrhus saxatilis (Northern kingfish)	2.6 - 6.0	June-Aug	0.2	0.58	21.2 - 23.2
Urophycis spp. (Hakes)	1.8 - 19.0	May-Nov	0.2	0.58	10.1 - 21.4
Centropristes striatus (Wrymouth)	3.5 - 3.6	July	0.1	0.29	20.7
Enchelyopus cimbrius (Rockling)	13.4	July	0.1	0.29	21.6
Gasterosteus aculeatis (Threespine stickleback	15.0	June	0.1	0.29	23
Paralichthys dentatus (Summer flounder)	4.8 - 12.0	July-Jan	0.1	0.29	2.6 - 22.4

Table 10. Rank order of selected species in 1957-58, and 1973 for total bay and sectors (3,6,8,9) most closely corresponding to Herman stations 1,2,3,4 respectively. Species marked with an asterisk were abundant in 1957-58 but rare in 1973.

Species	Herman 1957-58	MRI January-August 1973				
	Stations 1-4	S3	S6	S8	S9	Total Bay
Anchoa spp.	4	2	2	1	1	1
Brevoortia tyrannus	11	1	1	2	4	2
Pseudopleuronectes americanus	9	3	3	6	3	3
Tautoga onitis	10	5	4	5	6	4
Tautogolabrus adspersus	3	7	5	3	5	5
Ammodytes americanus	6	9	6	7	2	6
Cynoscion regalis	13	6	8	9	7	7
Scophthalmus aquosus	14	11	10	8	8	8
Menidia menidia	2	4	7	15	11	9
Scomber scombrus	not found	15	11	4	10	10
Gobiosoma ginsbeurgi	12	10	9	16	9	11
Enchelyopus cimbrius	15	13	16	10	13	12
*Stenotomus chrysops	5	12	12	12	15	13
*Prionotus spp	7	14	14	14	14	14
*Myoxocephalus spp	1	16	15	11	12	15
*Peprilus triacanthus	8	15	13	13	16	16

Table 11a. Comparison of relative abundance of selected, abundant pelagic fish eggs and larvae found at 4 stations by Herman in 1957-58, and at 160 stations by MRI in 1973, in Narragansett and Mt Hope Bays. Data from Tables 5 and 10.

Species	Herman, Eggs		Herman, Larvae		MRI, Eggs		MRI, Larvae	
	Rank Order	Percent	Rank Order	Percent	Rank Order	Percent	Rank Order	Percent
Labridae (Tautoga / Tautogolabrus)	1	62.0	1	27.6	1	29.8	3	8.9
Anchoa	2	10.7	2	19.2	2	24.8	1	48.2
Cynoscion/Stenotomus	3	10.7	3	19.6	4	18.4	4	1.9
Prionotus	4	4.9	4	12.9	5	10.1	8	0.2
Brevoortia	5	4.4	6	5.5	3	4.7	2	38.0
Scopthalmus	6	2.4	7	4.1	6	4.6	5	1.3
Peprilus	7	1.9	5	9.6	7	3.6	9	0.1
Enchelyopus	8	1.4	8	1.4	8	2.1	7	0.2
Scomber	not found	0.0	not found	0.0	9	1.3	6	1.2

Table 11b. Comparison of relative abundance of selected, abundant larvae hatched from demersal eggs as found by Herman in 1957-58, and MRI in 1973. Data from Tables 5 and 10.

Species	Herman, Eggs		Herman, Larvae		MRI, Eggs		MRI, Larvae	
	Rank Order	Percent	Rank Order	Percent	Rank Order	Percent	Rank Order	Percent
Myoxocephalus			1	80.3			5	1.2
Menidia			2	10.8			3	9.2
Ammodytes			3	4.2			2	18.3
Pseudopleuronectes			4	2.9			1	63.0
Gobiosoma			5	1.7			4	8.4

Figure 1. Ichthyoplankton stations and sampling sectors in the Marine Research, Inc. study of 1972-73.

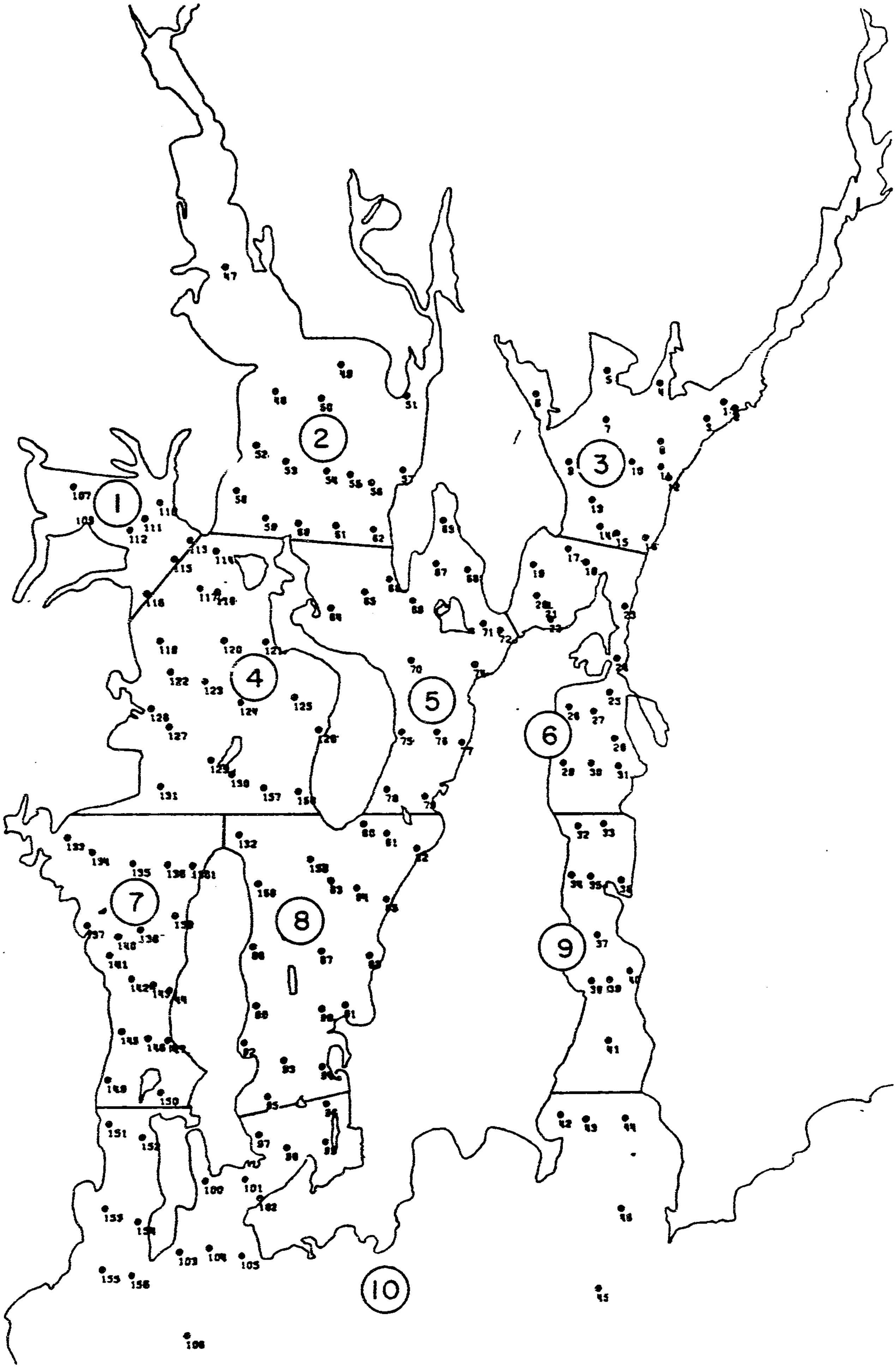
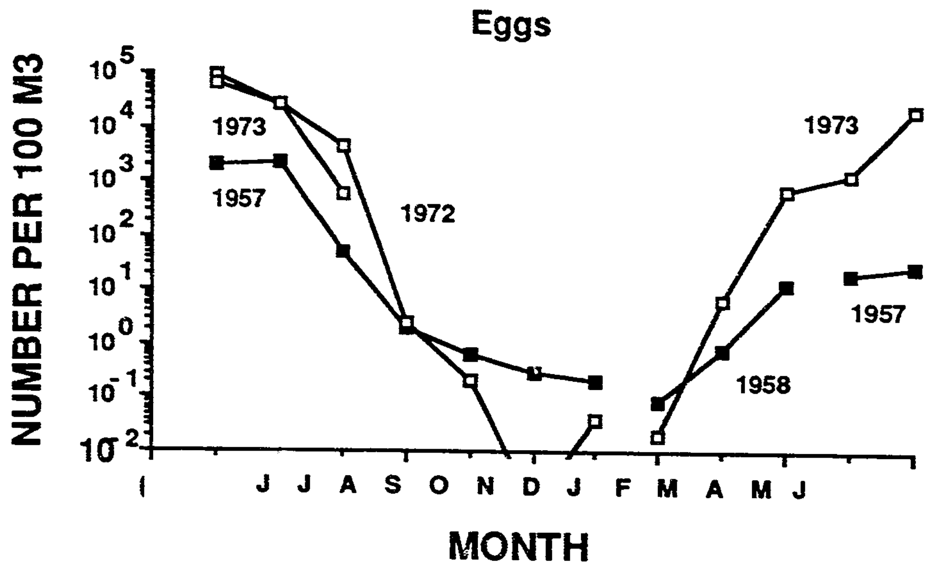

1
2
3
4
5
6
7
8
9
10

Figure 2. Comparison of total densities of fish eggs and larvae collected during the 1957-58 survey (closed symbols) of Herman and the 1972-73 survey (open symbols) of MRI .


Eggs
NUMBER PER 100 M3
1973
1957
1972
1973
1957
1958
J J A S O N D J F M A M J
MONTH

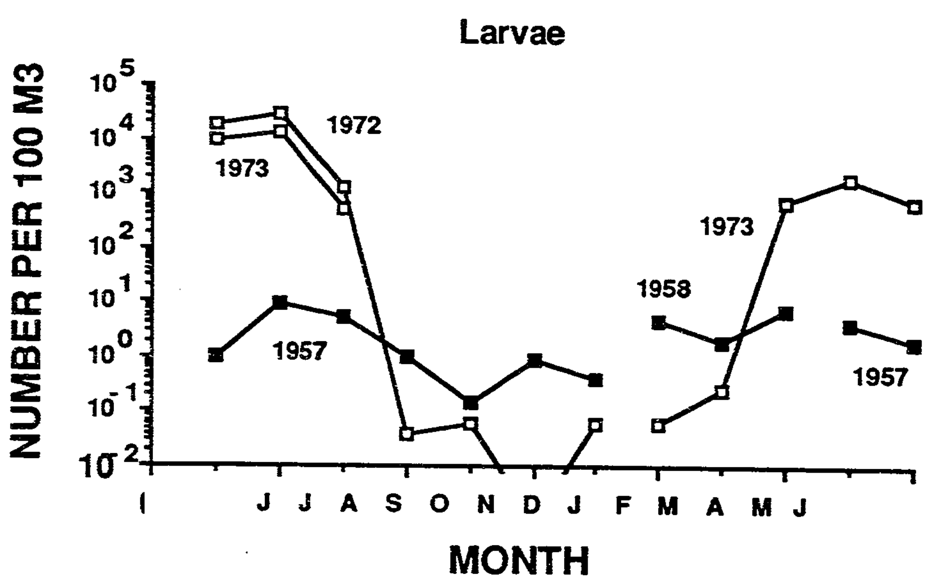

Larvae
NUMBER PER 100 M3
1972
1973
1957
1973
1958
1957
J J A S O N D J F M A M J
MONTH

Figure 3. Station locations in Narragansett Bay in the 1957-58 survey by Herman (1958).

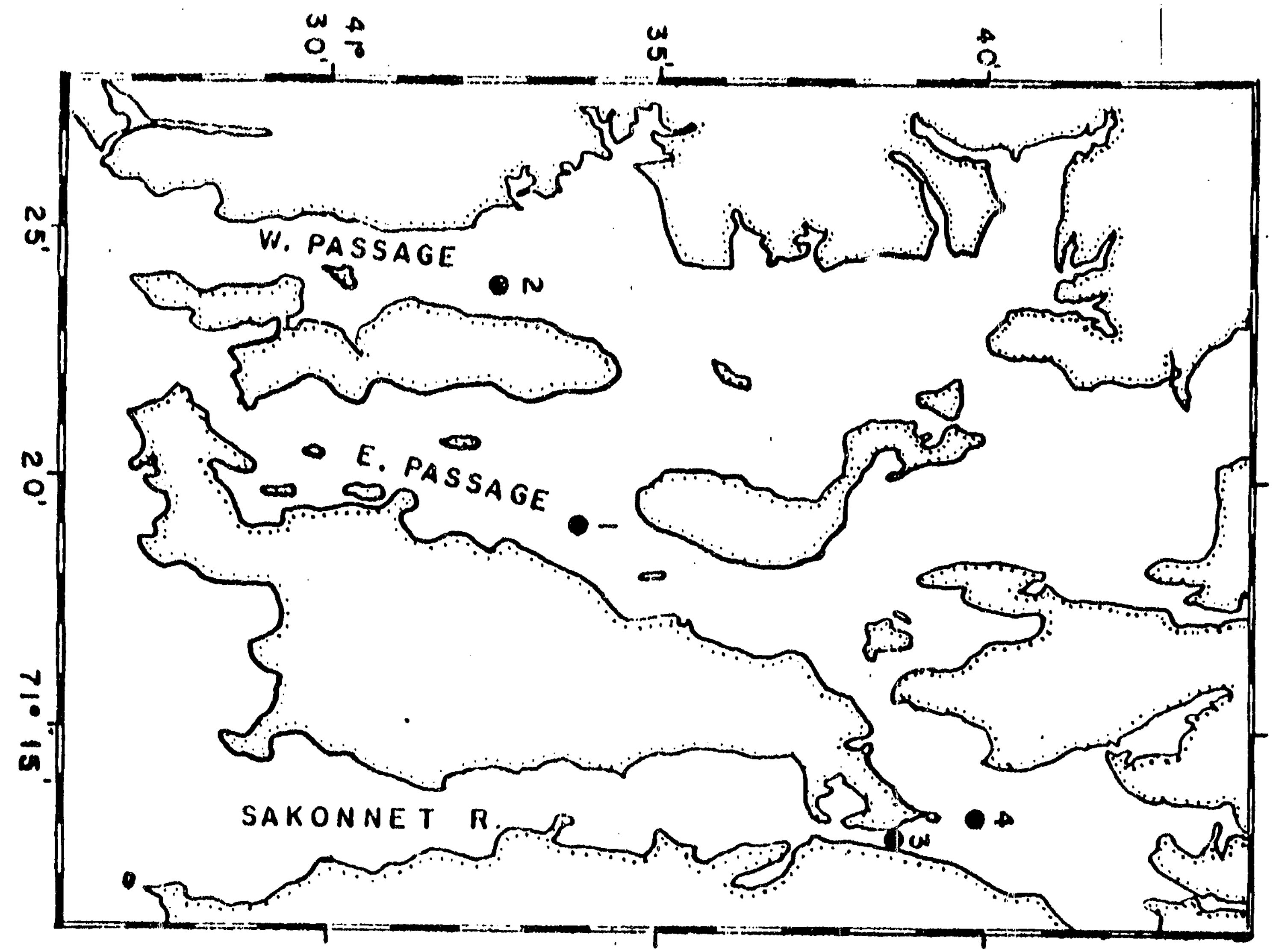
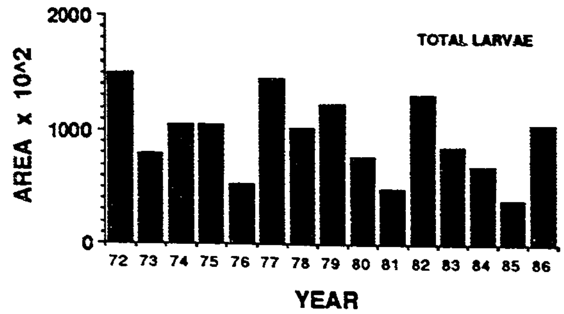
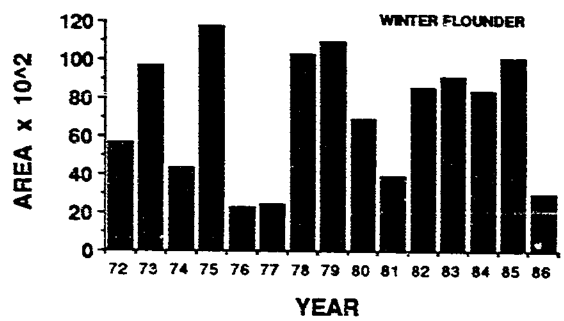
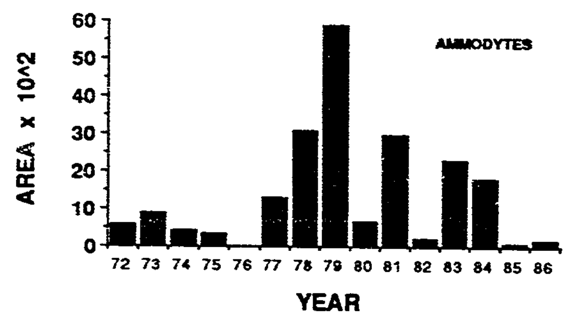
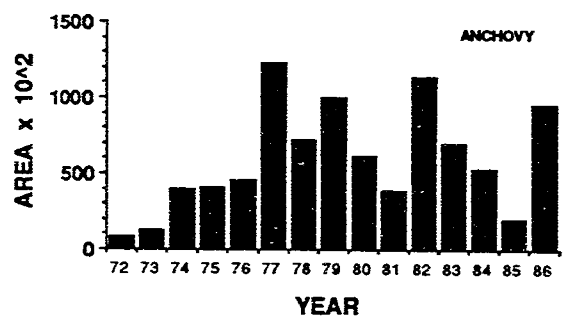

41°
30'
35'
40'
25'
20'
71° 15'
W. PASSAGE
E. PASSAGE
SAKONNET R.
1
2
3
4

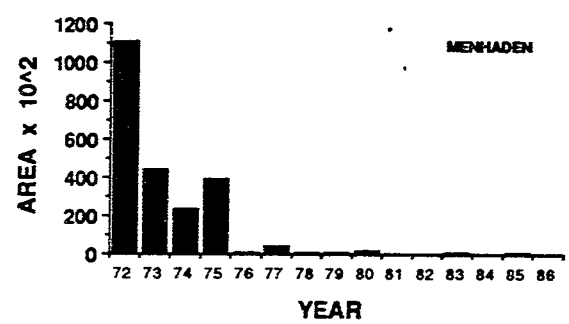
Figure 4. Time series showing the integrated area under the curve of abundance of selected species, and total numbers, of larval fishes collected at Spar island in central Mt Hope Bay, 1972-86. From MRI (1972-86).


TOTAL LARVAE
AREA x 10^2
2000
1000
0
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEAR


WINTER FLOUNDER
AREA x 10^2
120
100
80
60
40
20
0
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEAR


AMMODYTES
AREA x 10^2
60
50
40
30
20
10
0
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEAR


ANCHOVY
AREA x 10^2
1500
1000
500
0
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEAR


MENHADEN
AREA x 10^2
1200
1000
800
600
400
200
0
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEAR

Appendix 1. Analysis of species diversity of icthyoplankton in Narragansett and Mt Hope Bays during 1972-73. Reproduced from MRI (1974).

DIVERSITY

Species diversity for the 1973 spawning period has been calculated from data in Appendix Table 2, using Shannon's information function

$$H_s = -\sum p_i \ln p_i$$

where p_i is the percent (or probability) of occurrence of each species in a given month and sector (Pielou, 1969).

The value of H_s depends both on the number of species present, and on the "evenness" of the number of individuals in each species. This evenness has been separately calculated from the formula

$$J = \frac{H_s}{H_{max}} = \frac{H_s}{\ln S}$$

where H_{max} is the theoretical maximum value of H_s for a given number of species, S (Pielou, 1969).

Values for H_s and J are presented in Table 6, and in Fig. 97, which gives averages for Sectors 1-3, 4-6, 7-9 (Upper, Middle, and Lower Bay, respectively), compared with Sector 10.

Dominance in a population by a single species has the effect of lowering H_s. Low diversity is widely considered to reflect a relatively unstable population, or one on a "stressed" condition, as from pollution. But low diversity is commonly found in upper estuaries, even when they are unpolluted: only a few species can tolerate the fluctuations in temperature and salinity encountered there.

Annual ranges of H_s for adult fish populations sampled in a number of estuaries and sounds suffering various degrees of pollution have been given by Haedrich and Haedrich (1974). The lowest values, for Galveston Bay, Texas, were 0.13 to 0.91 (Bechtel and Copeland, 1970). The highest cited, for a relatively unpolluted estuary in Georgia (Dahlberg and Odum, 1970) were 1.7 to 1.8. The Haedrichs suggest that "...such diversity levels may be characteristic of all temperate estuaries." Using data of Richards (1963), and Merriman and Warfel (1948), they calculated a seasonal range in diversity for bottom trawl collections made in Block Island and Long Island Sounds of 1.7 to 1.7.

Direct comparisons should not be made, however, between values of H_s derived from samples of adult populations, and our own, based on fish larvae. Our data reflect the diversity only of those species which are present in Narragansett Bay, and also spawning at a given time. The list of larvae at any season will be shorter than the list of adult fishes present.

Further, without knowledge (most of it presently lacking) of the size-frequency and fecundity of the parent population, and the mortality rates of their eggs and larvae, it is not possible to use ichthyoplankton diversity as a measure of diversity among spawning adults.

We offer these data, then, primarily for the purpose of comparing Narragansett Bay's ichthyoplankton with that of other areas for which similar indices might be calculated.

The diversity indices, H_s, for Narragansett Bay show a small March peak followed by a sharp drop in the middle and upper parts of the Bay, due to the dominance of winter flounder larvae in the April populations there (notwithstanding the fact that more species were actually present in April). All sectors rose to a seasonal high in early and midsummer. The lower Bay and ocean sectors showed the highest diversity, partly due to the number of species present (a number of migratory, more or less marine, species do not penetrate very far up the Bay), and partly because the most abundant summer spawners, anchovies and menhaden, concentrate their efforts in the upper Bay, with the consequent depressing effect on H_s already described.

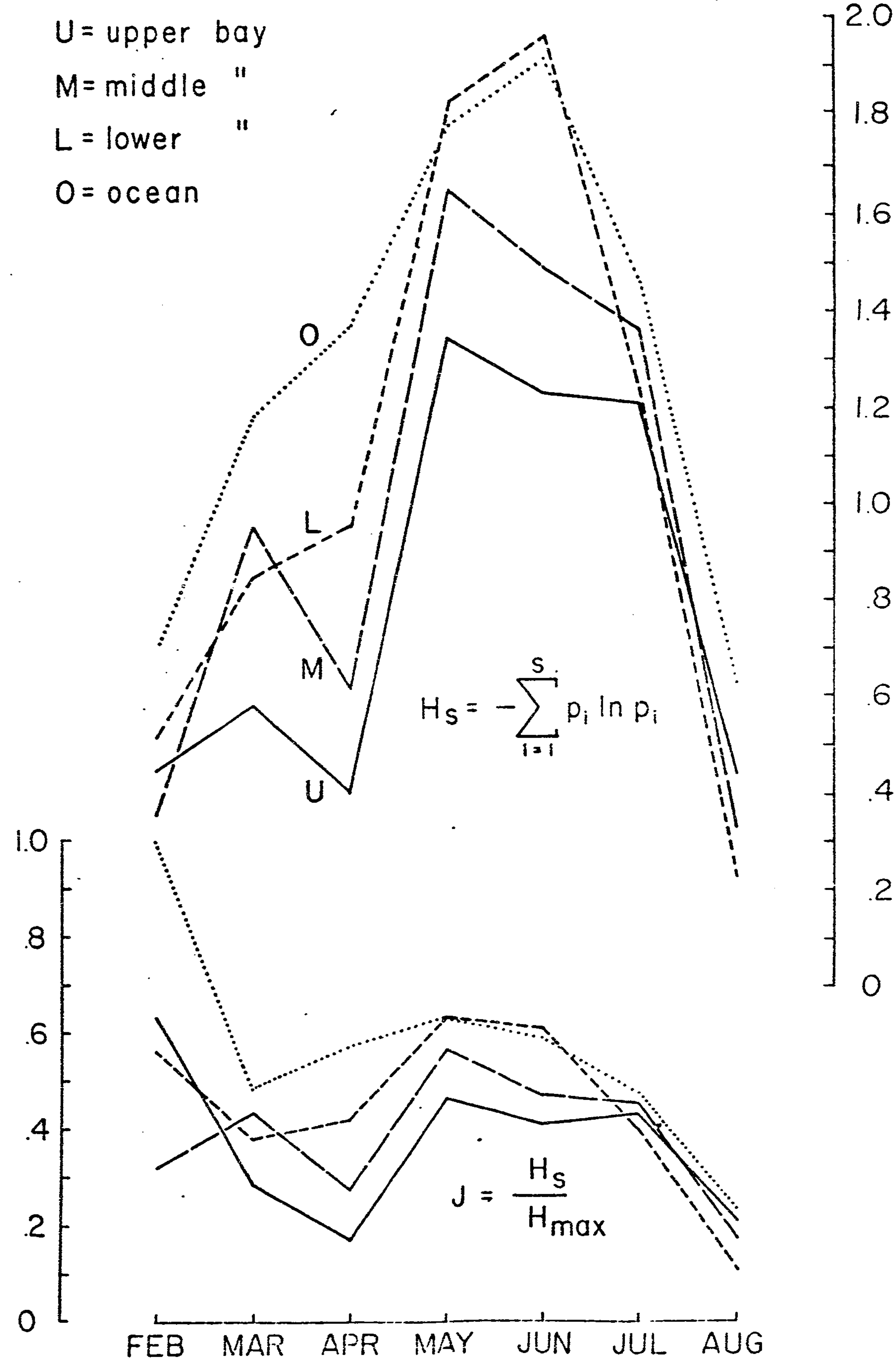
Using data from Wheatland's (1956) study of Long Island Sound, we have calculated a peak value for H_s of 1.32 (June, 1952 collections). This is based on numbers of fish eggs. Larval indices derived from her data at the peak seasons were lower, the highest being 0.96 (June, 1953 collections). These values are lower than those we calculated for Narragansett Bay (Table 6; Fig. 27), though Wheatland's report is based upon far fewer collections. (The probability of catching rarer species and thus increasing the diversity index is strongly dependent on sampling effort.)

Sector	June '72 H	June '72 J	July '72 H	July '72 J	August '72 H	August '72 J	February '73 H	February '73 J	March '73 H	March '73 J
1	1.05	.42	1.11	.41	.27	.12	.67	.97	.26	.15
2	.67	.24	.97	.33	.63	.26	0	0	1.04	.47
3	1.07	.40	.90	.32	.56	.23	.64	.93	.45	.22
4	.78	.28	1.02	.35	.44	.17	0	0	.91	.41
5	.81	.34	.84	.29	.55	.22	0	0	1.15	.50
6	.94	.37	1.09	.37	.56	.24	1.04	.95	.78	.38
7	1.05	.36	1.00	.35	.19	.08	0	0	.67	.29
8	1.37	.48	.88	.29	1.02	.35	1.04	.95	.97	.44
9	1.62	.57	1.25	.46	.57	.26	.50	.72	.88	.42
10	1.77	.65	1.23	.40	.99	.36	.69	1.00	1.17	.49

Sector	April '73 H	April '73 J	May '73 H	May '73 J	June '73 H	June '73 J	July '73 H	July '73 J	August '73 H	August '73 J
1	.39	.18	1.57	.57	1.50	.52	.99	.37	.44	.27
2	.46	.19	1.30	.46	1.11	.37	1.27	.43	.39	.19
3	.34	.15	1.15	.36	1.07	.34	1.38	.48	.42	.18
4	.60	.26	1.74	.63	1.63	.52	.85	.29	.43	.21
5	.61	.25	1.68	.56	1.33	.42	1.62	.52	.18	.09
6	.65	.30	1.53	.49	1.51	.47	1.61	.53	.42	.23
7	.83	.40	1.58	.54	2.02	.64	.59	.20	.23	.13
8	1.20	.50	2.06	.71	1.96	.59	1.55	.49	.21	.10
9	.81	.37	1.85	.64	1.91	.61	1.54	.52	.22	.10
10	1.37	.57	1.78	.63	1.92	.59	1.46	.47	.62	.22

Table 6: Shannon's index of diversity (H), and the ratio of observed to theoretically maximum values of H, (J), for collections of fish larvae from Narragansett Bay, 1972-3.

Fig. 97: Shannon's index of diversity, H_s, and the ratio of observed to theoretical maximum diversity, J, for fish larvae in Narragansett Bay, 1973. Values for upper, middle, and lower Bay are means for sectors 1-3, 4-6, and 7-9, respectively (data from Table 6).



Unfortunately, the other, major surveys of Block Island and Long Island Sounds (Perlmutter, 1938; Richards, 1959; Merriman and Sclar, 1952) and Herman's Narragansett Bay study (1963) are not reported in ways that permit similar computations.

Appendix 2. Mann-Whitney U Tests of the significance in the differences in concentration of the more abundant species in the 9 sectors of the 1972-73 survey in Narragansett and Mt Hope Bays by MRI. Reproduced from MRI (1974).

RELATIVE ABUNDANCE OF SECTOR POPULATIONS

Inasmuch as the population sample sizes were far from normally distributed, a non-parametric statistical method, the Mann-Whitney U Test, was chosen to determine whether individual sampling sectors were significantly richer or poorer in individual ichthyoplankton species than other sectors in the Bay. Using population densities for 21 species of fish eggs and larvae taken during the first ten weeks of sampling (June 22 to August 24, 1972), and the last ten weeks (June 19 to August 30, 1973), each of the ten sectors was individually compared with each other sector.

The results for six important larval species are presented in Table 5. Except for winter flounder (Pseudopleuronectes americanus), for which only one year's data was in hand, the results for two seasons' sampling are represented in the table.

Taking those cells in Table 5 which were scored the same for two years running, as a percentage of the total number in the matrix, the consistency between 1972 and 1973 ranged from a low of 44% for weakfish larvae (Cynoscion regalis), to a high of 82% for anchovies (Anchoa spp.). Seventy-one percent of the cells were the same both years for tautog (Tautoga onitis), 69% for cunner (Tautogolabrus adspersus), and 72% for larval menhaden (Brevoortia tyrannus).

Figs. 13-94 show spawning typically beginning in the northern tier of sampling sectors, with the center of abundance moving southward in successive weeks. This probably reflects the combined effects of water flow down the estuary, and a progressive wave of spawning activity from north to south correlated with rising water temperature.

Interestingly (and perhaps surprisingly) the highly polluted waters of the Providence and Taunton Rivers and Mt. Hope Bay (EPA, 1971) do not appear to be a barrier to spawning or the development of the larvae.

Sector 2 (Providence River), seems outstandingly productive for many species, while Sector 3 (upper Mt. Hope Bay) is in most cases either more productive, or not significantly different in productivity, than Sectors 1, and 4-10. (In 49% of the cases given in Table 5, Sector 3 was significantly richer, and in 34% not significantly different in larval population densities than the the other sectors tested against it statistically.)

This test in no way compares absolute population densities from year to year, but only the production of one sector relative to that of each other sector within a year. For example, the Mann-Whitney U Test for larval anchovies shows Sector 2 to have been significantly more productive than all other sectors except nos. 1 and 4 both in 1972 and 1973; the patterns are identical (Table 5).

Quantitative comparisons of sector populations from year to year are the subject of the next section.

Table 5: Sectors listed horizontally are significantly richer (+) or poorer (-) in a given species than the sector numbered at the left-hand edge of the matrix. Results of Mann-Whitney U Test of 1972 and 1973 Narragansett Bay mean (unweighted) sector population densities, interpreted at the 95% confidence level.

	sector 1	2	3	4	5	6	7	8	9	10
1			- -		- -	- -	-	- -	- -	- -
2			- -		- -	- -	- -	- -	- -	- -
3	+ +	+ +		+ +	-		+	- -		- -
4			- -		- -	- -		- -	- -	- -
5	+ +	+ +	+	+ +		+	+	- -		- -
6	+ +	+ +		+ +	-		+	- -		- -
7	+	+ +	-		-	-		- -	-	- -
8	+ +	+ +	+ +	+ +	+ +	+ +	+ +		+ +	-
9	+ +	+ +		+ +			+	- -		- -
10	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+	+ +	

<u>Anchoa</u> spp. larvae

	sector									
	1	2	3	4	5	6	7	8	9	10
1		+		-	-		- -	- -	- -	- -
2	-		-	- -	- -	- -	- -	- -	- -	- -
3		+		-	-	- -	- -	- -	- -	- -
4	+	+ +	+			+	- -	- -	- -	- -
5	+	+ +	+			+	-	- -	- -	- -
6		+ +	+ +	-	-		-	- -	- -	- -
7	+ +	+ +	+ +	+ +	+	+		-	-	- -
8	+ +	+ +	+ +	+ +	+ +	+ +	+			- -
9	+ +	+ +	+ +	+ +	+ +	+ +	+			- -
10	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	

Brevoortia tyrannus larvae

	sector 1	2	3	4	5	6	7	8	9	10
1		-		-	-		-	-		-
2	+		+	+	-		-	-		-
3		-		-	-	-	-	-	-	-
4	+	+	+			+		-		-
5	+	+	+			+		-		-
6			+	-	-		-	-		-
7	+	+	+			+		-	+	-
8	+	+	+	+	+	+	+		+	
9			+				-	-		-
10	+	+	+	+	+	+	+		+	

Pseudopleuronectes americanus larvae

s e c t o r

	1	2	3	4	5	6	7	8	9	10
1	—	+ +					-	- -		- -
2	- -	—	-	- -	- -	- -	- -	- -	- -	- -
3		+	—		- -	- +	- -	- -		- -
4		+ +		—	-	+	-	- -		- -
5		+ +	+ +	+	—	+	-	- -		- -
6		+ +	+ -	-	-	—	-	- -	-	- -
7	+	+ +	+ +	+	+	+	—	-	-	-
8	+ +	+ +	+ +	+ +	+ +	+ +	+	—	+ +	
9		+ +				+	-	- -	—	- -
10	+ +	+ +	+ +	+ +	+ +	+ +	+		+ +	—

Tautoga onitis larvae

	sector 1	2	3	4	5	6	7	8	9	10
1		+ +	+		+	+ +		+	+ +	+ +
2	- -		- -	- -	- -	-	- -	- -		-
3	-	+ +		-	-	+	- -	-	+ +	+
4		+ +	+			+ +	- -		+ +	+
5	-	+ +	+			+ +	- -		+ +	+ +
6	- -	+	-	- -	- -		- -	- -	+	
7		+ +	+ +	+ +	+ +	+ +		+	+ +	+ +
8	-	+ +	+			+ +	-		+ +	+ +
9	- -		- -	- -	- -	-	- -	- -		-
10	- -	+	-	-	- -		- -	- -	+	

Tautogolabrus adspersus larvae

s e c t o r

	1	2	3	4	5	6	7	8	9	10
1		+	-	-	-	-	-	- -		- -
2	-		-	-	- -	- -	- -	- -	-	- -
3	+	+		-	- -		-	- -		- -
4	+	+	+		-	+	-	- -		- -
5	+	+ +	+ +	+		+	+ -	-	+	-
6	+	+ +		-	-		-	- -	+	- -
7	+	+ +	+	+	- +	+		-	+	- -
8	+ +	+ +	+ +	+ +	+	+ +	+		+	-
9		+			-	-	-	-		- -
10	+ +	+ +	+ +	+ +	+	+ +	+ +	+	+ +	

Cynoscion regalis larvae

Appendix 3. Correspondence with Marine Research, Inc. regarding an error in their larval fish data report (MRI 1974). The caption to their Table 2, summarizing the abundance of different larval fishes in different sectors of Narragansett Bay, incorrectly instructed the reader to multiply the figures by 10^{10}. The correct multiplier was 10^9.