1977 YEAR CLASS REPORT
FOR THE
MULTIPLANT IMPACT STUDY
HUDSON RIVER ESTUARY

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SECTION I

SUMMARY

The major goal of the Hudson River Ecological Study is to assess qualitatively the impact (via entrainment and impingement) of power plant operations on key fish species populations that utilize the Hudson River estuary during one or more phases of their life history. Empirical data were analyzed and interpreted to qualitatively assess the impact of five Hudson River power plants (Bowline, Lovett, Indian Point, Danskammer and Roseton) on striped bass, white perch, and Atlantic tomcod. Data analyses were directed toward evaluating changes produced in the adult populations as a result of power plant impact on early life stages (Figure I-1).

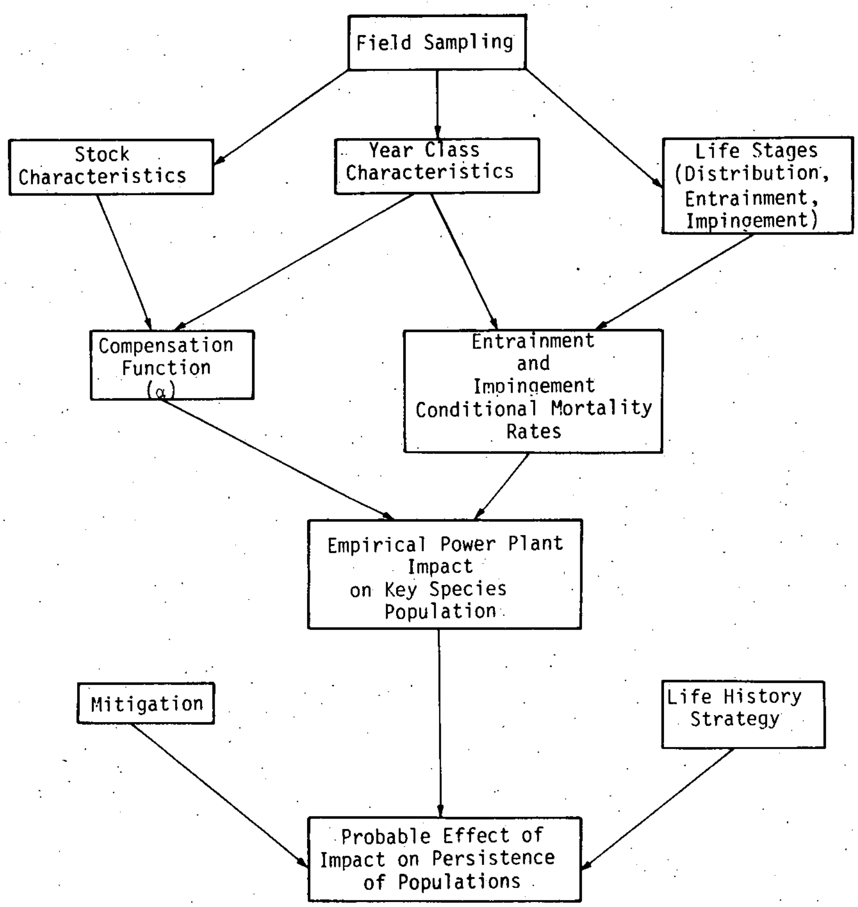

Figure I-1. Conceptual Flow Chart of the Approach to Impact Assessment for Hudson River Ecological Study

This section's summary of the qualitative impact of power plants on the 1977 year classes includes data collected through June 1978. Detailed descriptions of the sampling areas and time periods as well as the field, laboratory, and analytical methods appear in Appendix A and relevant subsections of the main text (in Sections III through V). Figure A-1 shows the locations of the five power plants and the 12 sampling regions in the study area (RM 12-153) which will be used as reference points to describe distributions and movements. A glossary of technical terms appears at the end of the Appendix.

To familiarize the reader with the basic differences and similarities among the three key fish species, their general life histories are briefly compared in the following paragraphs.

A. GENERAL LIFE HISTORIES

1. Striped Bass (*Morone saxatilis*)

- Anadromous species in the Hudson; native to the Atlantic and Gulf coasts of the United States
- Valuable commercial and sport fish rarely exceeding 27 kg (60 lb) and 1.35 m (53 in.)
- Most males mature at 4 years and most females at 7 years; longevity may reach 20 years; spawning stock is multiaged
- Individual females produce 0.5 to 2.6 million eggs, depending on age and size
- Spawn primarily during May in the Indian Point through Kingston regions of the Hudson River
- Eggs are semibuoyant, are about 3 mm in diameter when water-hardened, and hatch in 34 to 100 hr
- Major nursery areas during summer and fall are in the shoals and shore zone of the Yonkers through Croton-Haverstraw regions
- Young average about 80 to 100 mm in total length (TL) at the end of their first calendar year

2. White Perch (Morone americana)

- Resident species in the Hudson; native to the Atlantic coast of North America
- Of limited importance to commercial and sport fisheries; rarely exceeds 0.33 m (13 in.)
- Most mature at 2 to 5 years; spawning stock is multiaged
- Individual females produce 30,000 to 300,000 eggs, depending on age and size
- Spawn primarily during May and early June throughout most of the study area (Tappan Zee through Albany regions)
- Eggs are adhesive, are about 1 mm in diameter after water-hardening, and hatch in 24 to 144 hr
- Major nursery areas in summer and fall are in the shoals and shore zone of the Tappan Zee-Indian Point and Kingston-Catskill regions
- Young average about 65 to 75 mm in total length at the end of their first calendar year

3. Atlantic Tomcod (Microgadus tomcod)

- Anadromous species in the Hudson; native to the Atlantic coast of North America
- Of limited importance to commercial and sport fisheries; rarely exceeds 0.38 m (15 in.)
- Most mature at the end of the first year of life in the Hudson River; few 2-year-olds and older individuals are collected
- Individual females produce 14,000 to 20,000 eggs, depending on age and size
- Spawn primarily during December and January in the West Point through Poughkeepsie regions
- Eggs are demersal, are probably not adhesive, are about 1.5 mm in diameter after water-hardening, and hatch in 36 to 42 days

- Major nursery areas in spring, summer, and fall are in the deeper areas of the Yonkers and Tappan Zee regions and probably in areas farther downriver

- Young average about 135 to 140 mm in total length at the end of their first calendar year

The impact of power plants on fish populations can be assessed through the application of empirical data bases or models. Within the framework of either approach, impact assessments can be pursued from several levels of complexity, ranging from the least complex individual fish level, through the single species population level, the more complex level involving the interactions of several species populations, and the most complex ecosystem level where all biota (plants and animals) are included in the assessment. Our ability to assess the effects of power plant operations on fishes is at the single-species population level of complexity (Christensen et al. 1976).

Van Winkle (1977) reflected on this topic in his "Introductory Remarks" to the 1977 conference entitled Assessing the Effects of Power-Plant-Induced Mortality on Fish Populations held in Gatlinburg, Tennessee. A few quotes from his remarks are germane to this discussion.

> "The guidelines to authors excluded entrainment and impingement mortality because we considered these sources of mortality in and of themselves to be an impact that power plants may have at the individual level, whereas we were interested at this conference in assessing the subsequent population-level effects.
>
> Multispecies interactions and ecosystem effects were excluded, not because the program committee judged these areas of research and assessment to be unimportant, but rather because the committee felt that assessment at the population level was presently the most effective approach. For most assessments a sequence of broader and broader 'so what' questions can be asked, starting at the level of the individual organisms (e.g., LD_{50}) and extending to the ecosystem level. Although questions at the individual level can frequently be answered with relatively high precision and accuracy, commonly they are not the critical questions and answers that can solely and effectively serve as a basis for decision-making. On the other

> hand, the questions that can be asked at the ecosystem level certainly are critical, but these questions can rarely be answered in a sufficiently quantitative manner and with sufficient certainty to be of appreciable value for decision-making (Christensen et al. 1976, McFadden 1976)."

The major goal of the Hudson River Ecological Study is to assess the impact of power plant operations (via entrainment and impingement) on the key fish species populations (striped bass, white perch, Atlantic tomcod), which utilize the estuary during one or more phases of their life history. The study focuses on five operating power plants (Bowline, Lovett, Indian Point, Roseton, Danskammer). The approach to impact assessment taken in this study can be characterized as the analysis and interpretation of empirical data on individual species populations to determine how mortalities imposed by power plants on young fish affect the adult fish populations. The first year of life is emphasized for several reasons. Most of the entrainment and impingement involves eggs, larvae, young-of-the-year (juveniles), and early yearlings; hence, a year class is affected by power plants usually only once during its lifetime (in the first year of life). Few older age groups are vulnerable to the power plants.

The organization of this Summary generally parallels that of the main text so the reader can refer to additional or supportive information. Each of the three key species is discussed separately. Since the potential for any fish stock maintaining or changing its current status depends on age structure, growth, age at maturity, fecundity, and natural mortality, current data on the adult stocks are summarized. Distribution of early life stages are described to understand year-to-year variations in year class strength, growth rates, and mortality rates (plant-related and natural). The available data base is examined and observed trends in juvenile abundance (or year class strength), as well as growth and mortality during the first year of life, summarized. Current hypotheses concerning environmental factors influencing observed trends are summarized as the background of natural variation against which plant-related mortality is to be assessed. Exposure indices as indicators of mortality from entrainment and impingement mortality are compared to nearfield, entrainment, and impingement data. The available information is integrated to qualitatively predict the consequences of present levels of power plant impact on reductions of the three key species populations. The results are discussed with respect to the life history pattern of each species. Included in this overview of the impact of power plants on the 1977 year classes are data collected through June 1978.

B. STRIPED BASS

Approximately 70% of the age II and older striped bass caught during the spring of 1977 (which included the spawning period) were taken in March and April, indicating that the stock overwinters in the lower Hudson River estuary and/or that many spawners immigrate in March and April to spawn in May. The composition of the catch suggested that fish collected in March had overwintered and that larger adults (longer than 690 mm in total length) entered the river population in April. Immature fish may have emigrated during April. Striped bass collected near the major spawning grounds (RM 39-61) from March through June were primarily mature. Males moved onto the spawning grounds earlier than females but did not remain any longer.

Of the 2813 age II and older striped bass tagged and released from mid-March through June 1977, 331 (12%) were recovered prior to December 1977. Over half of the fish recovered outside the Hudson were within 50 km of the river mouth, but individual fish traveled as far north as Newburyport, Massachusetts, and as far south as Slaughter Beach, Delaware. Neither size, age, nor sex determined direction, distance, or recovery rates.

Although the striped bass stock during the 1977 spawning run consisted of age groups II through XIV, age group IV (the 1973 year class) dominated. The proportion of the population in each age group declined from ages IV through X; thereafter, each age group was equally abundant, perhaps because of their increased vulnerability to the sampling gear, their aging difficulties, or small sample sizes rather than increased survival after age X. From mid-April through mid-May, the relative number of ages III and IV males decreased while the number of ages III through VI females increased, suggesting that males precede females onto the spawning grounds or that young (and possibly immature) males emigrate from the river during April and early May. The overall sex ratio in 1977 was almost 1:1. Males slightly outnumbered females until about age VII, then females were most abundant. At a given age after IV, females collected during 1977 were larger (length and weight) than males.

Age at maturity has not detectably changed since 1973. During 1977, male striped bass began to mature at age II and all were generally mature by age VII; females first matured at ages III and IV, and all were mature by age IX. Faster-growing individuals within a year class tended to mature earlier. More than half the males in 1977 were mature at about 450 mm (TL) and more than half the females were mature at about 625 mm (TL).

Mean fecundity for individual age groups has not detectably changed since 1973. Mean fecundity in 1977 ranged from 578,000 eggs for age VII females to 2,214,000 eggs for age XIV females. About 174 eggs per gram (or 79,000 eggs per pound) of body weight were produced in 1977. The largest individual contributions were by age groups VI, VII, VIII, and IX.

The size of the age III and older striped bass population in 1977 was 571,000 fish, which was similar to the size of the 1976 population of 513,000 fish.

Based on 1976 and 1977 data, mean annual total mortality rates calculated for fully recruited males (ages V through VIII) were 0.54 and 0.51, respectively. Mean total annual mortality rates calculated for fully recruited females (ages VI through IX) were lower, 0.43 and 0.40, respectively.

The annual fishing exploitation rate calculated from the rate of tag returns from sport and commercial fishermen was about 0.15. Major sources of fishing mortality for Hudson River striped bass were commercial fishing within the river and sport fishing outside the river, which exploited fish of similar size. Based on these data, annual natural mortality rates were 0.36 for males and 0.25 for females.

Age at maturity was the most evident difference between the Hudson River striped bass stock and other striped bass stocks: 100% of Hudson River males and females mature 2 to 4 years later than other east and west coast stocks. Maturity rate is not solely a function of latitude. In another comparison, the range of total annual mortality rates for Hudson River striped bass (0.40 to 0.54) falls within the range for the only other stock reported in the literature, the Sacramento-San Joaquin population in California (0.321 to 0.681). Fishing exploitation rates for the Hudson River stock (0.15) are similar to recent exploitation rates for the California stock (0.144 to 0.205, 1971-76) but lower than past exploitation rates for the California stock (0.190 to 0.372) and past rates for the Chesapeake Bay stock (0.35 to 0.45, 1959-61). In age composition, the Hudson stock shows a larger proportion of older fish than the Chesapeake Bay stock but is generally similar to the California and Roanoke River, North Carolina, stocks. Hudson and Chesapeake stocks had similar incremental annual growth rates; no growth-rate comparisons with other stocks were possible. The fecundity of the Hudson stock is similar to that of other east and west coast populations.

Available data on the Hudson River striped bass stock characteristics revealed no overexploitation, either from fishing or power plants. Although the major difference between the Hudson and other stocks is the two to four year delay in maturation, the Hudson stock apparently has the capacity to mature earlier and offset a reasonable increase in exploitation.

In 1977, striped bass eggs were collected from late April through early July, but most occurred during May near the bottom of the channel in the Indian Point, West Point, Cornwall, Hyde Park, and Kingston regions. Timing and location of spawning have been consistent each year since 1974. Egg deposition peaks when water temperatures range from 14^{o} to $20^{o}C$ in areas where conductivity is less than 200 mS/cm.

Yolk-sac larvae were collected from early May through early July, and post yolk-sac larvae were first collected about 2 weeks later but were still present in small numbers through July. Larvae were distributed over a larger portion of the estuary than were eggs: yolk-sac larvae were most abundant from mid-May to early June in the Indian Point through Hyde Park regions; and post yolk-sac larvae were most abundant in the Croton-Haverstraw through Hyde Park regions during the first half of June. Striped bass larvae concentrated near the bottom during the day but dispersed upward through the water column at night. Except for the upriver shift by yolk-sac larvae in 1974, larval distributions have been similar each year. Post yolk-sac larvae move to shallow shoal areas as they transform to the juvenile stage.

Juveniles were first collected in mid- to late June but reached peak numbers by late July and early August, primarily in the shoals and shore zone of the Yonkers through Croton-Haverstraw regions. The juvenile population moved downriver and offshore during October and November as much of the population emigrated from the study area. Juvenile distribution patterns have been similar each year since 1975 except that there was a larger proportion of the summer population in the shore zone during 1975 than during 1976 and 1977. The distribution of yearling striped bass has been similar each year since 1975, with a major concentration of individuals in the Yonkers through Croton-Haverstraw regions and a minor concentration in the Saugerties through Albany regions. Most yearlings are collected in May, supporting the hypothesis that they emigrate during the summer.

The absolute size of the juvenile striped bass population in 1977 was estimated by density-area and density-volume extrapolation to standing crops and by Petersen mark and recapture procedures. The density extrapolation method (adjusted for gear efficiency) yielded a peak standing crop of 30.7 million juveniles in late July. The Petersen mark and recapture estimate was 7.0 million in late October but represented only a portion of the juvenile population, since emigration occurred during September and October. Our best estimate of the juvenile population on 1 August 1977 was 27.7 million fish. Late-summer (July-August) abundance of juveniles was moderate compared with the 1965-76 abundance indices.

Since 1965, year class strength has varied by a factor of 27.2 with no discernible trend. Year classes were relatively strong when freshwater flows in April and May were high and when the time of initial spawning was near normal for the 12-year period. This 2-variable model explained 68% of the variation in year class strength; hence, other environmental variables were probably important in the determination of year class strength. The current hypothesis is that striped bass year class strength in the Hudson

River estuary is determined primarily by high freshwater flow during April and May; transporting greater amounts of nutrients into the estuary and increasing zooplankton production, it regulates the synchrony between the abundance of larvae and appropriate food organisms. High flows may also shift major spawning grounds to areas having more favorable conditions for larval survival; thus, in years of high spring flows, food for the larvae is plentiful. Also, since food of the appropriate size must be available when larvae begin to feed, the timing of spawning is important. Optimal synchronization between larvae and food occurs when the abundance of feeding larvae is matched temporally with a rapid increase in zooplankton abundance, i.e., when the smaller stages of zooplankton, which are preyed upon by the larvae, are at peak standing crops. During years in which spring temperature patterns are abnormal and water temperatures reach 12°C earlier or later than usual, this synchrony is destroyed and relatively weak year classes result.

During 1977, two periods of constant daily morality rates were observed: 12.5% per day during 31 May-7 July and 1.1% per day during 9 July-20 October. Larval mortality rates since 1975 appear to be inversely related to late-summer juvenile abundance but directly related to the previous December water temperatures, a factor shown to be important in the Chesapeake Bay system. Year class strength is likely controlled by mortality rates in the larval stages. Comparisons of juvenile mortality rates across years are confounded by annual variations in timing and rate of emigration (influenced by rate of temperature decline in August and September) and size-related gear avoidance. Emigration rates were higher in 1977 than in 1975 or 1976, especially in August.

The seasonal pattern of growth during the first calendar year (May-November) for the 1977 year class was similar to that for the 1973-76 year classes. The mean length of the juvenile population on 15 July was positively related to the number of days and mean water temperatures since spawning; this 2-variable model explained about 88% of the variation in mean length on that date. Juvenile growth during July and August was inversely related to mean length on 15 July and to the summer abundance of juvenile white perch and was positively related to the number of temperature-growth days between 15 July and 15 August; about 84% of the variation in juvenile growth during July and August was explained by this 3-variable model.

The environmental factors that affected larval striped bass growth (time of spawning and mean water temperature since spawning) also affected juvenile growth during July and August through the inverse length-growth rate relationship. Within the framework established by this relationship, the abundance of juvenile white perch and water temperature were primary influencing factors. The current hypothesis is that years of low juvenile white perch abundance and warm summer water temperatures should result in better-than-average growth for juvenile striped bass in July and August. The factors that affect juvenile striped bass abundance control the synchrony between the larvae and appropriate food organisms and also the availability of adequate food. During larval stages, food is sufficiently abundant, so growth is controlled primarily by temperature. Later in the summer, however, when food may become limited, competition with juvenile white perch can begin to affect the growth of juvenile striped bass.

Exposure of the striped bass population to entrainment in 1977 varied among four power plants (Lovett was not addressed because nearfield and entrainment data were not collected). No eggs were entrained at Bowline and exposure was low. Exposure of eggs to entrainment at Roseton and Danskammer was low to moderate and plant region densities were unreliable predictors of peaks in egg entrainment at the plants. Exposure of eggs to entrainment was highest at Indian Point, and density trends in river samples closely paralleled entrainment trends at the plant. Larval exposure to entrainment at the four plants followed a pattern similar to that of eggs, with the highest exposure occurring at Indian Point. Larval exposure to Bowline, Roseton, and Danskammer was moderate and generally not closely related to densities.

Based on the proportion of the juvenile population present in each plant region, exposure to summer impingement was high in 1977, especially at Bowline, Lovett, and Indian Point, but relatively few juveniles were impinged before early August, and actual impingement rates were consistently low through September. Impingement rates usually increased from October through November at all plants during and after the emigration of a portion of the juvenile population from the river. Impingement rates for juveniles were highest from October through November at Roseton and Danskammer and from

January through March (as yearlings) at Bowline, Lovett, and Indian Point. The juvenile striped bass that were most susceptible to impingement apparently compose that unknown portion of the population that overwintered in the river. Exposure indices based on the proportion of the population present in each plant region were not reliable predictors of seasonal impingement trends at the plants.

The consequences of power plant-induced mortality on the populations of the three key species was determined in a qualitative manner. Four aspects of a compensatory response were identified that affect the long-term reduction in average population size (PR) resulting from a power plant-induced mortality (m):

- Alpha, the rate of population increase in a given environment without density-dependent mortality (the larger alpha, the less PR)
- The type of stock-recruitment curve (power plant-induced mortality acting in conjunction with a Ricker curve has less effect than that acting with a Beverton-Holt curve)
- The timing of power plant-induced mortality (mortality occurring before the period of compensation has less effect than that occuring after)
- The magnitude of the mortality induced by power plants

The effect of the above four points on predicting the consequences of power plant-induced mortality was demonstrated analytically by solving the two commonly used stock recruitment equations (Ricker or Beverton-Holt) for percent reduction in population size resulting from a power plant-induced mortality, m.

The consequences of power plant-induced mortality were assessed qualitatively by determining the combinations of the four points enumerated above that gave the following four consequences.

- The population could become extinct [percent reduction in average population size (PR) = 100]

- PR could be greater than the conditional mortality rate (m). This situation presents a particularly difficult problem because a large PR could result from a relatively small m

- PR could be less than or equal to the conditional mortality rate. In this consequence, m can be used as an upper limit to PR

- The population could increase in size as a result of the mortality induced by power plants reducing the mortality from density-dependent causes. This consequence is simply a special case of PR being less than m

If the conditional mortality rate can be perceived as an upper limit to PR, knowledge of the exact form of the stock-recruitment curve and the values of its parameters may not be necessary. Predictions of PR based on the conditional mortality rate would be satisfactory for most purposes. The utility of the conditional mortality rate as an upper limit to PR was therefore evaluated for striped bass.

Of the four aspects affecting the consequences of power plant-induced mortality, the magnitude of the mortality and its timing with respect to compensation are known with the greatest certainty. McFadden and Lawler (1977) estimated the conditional mortality rate due to entrainment and impingement to be 0.12 to 0.14. Entrainment mortality accounts for the greater proportion of this mortality (0.08 to 0.12). The period of greatest compensation response is thought to occur before year class strength is established during the larval stages. Year class strength is established by mid-July in Hudson River striped bass and a large proportion of the power plant-induced mortality occurs before this period.

If these levels of power plant-induced mortality are combined with levels of alpha estimated between 5.5 and 14.6 (McFadden et al. 1978), the conditional mortality rate is an upper limit to PR in all cases except that for a Beverton-Holt curve and mortality occurring after the period of compensation. Because most (entrainment) power plant-induced mortality occurs before compensation, this case is not realistic and PR is probably less than the conditional mortality rate for striped bass.

The qualitative estimates of the consequences of power plant-induced mortality were derived from two mathematical models describing the relationship between stock and recruitment. A model is never identical to the system being modeled because it is impossible to simultaneously maximize generality, realism, and precision in the construction of a model. Any model reflects a particular compromise with respect to these three factors (Levins 1968). The goal in building a model for a specific study is to maximize those features which best meet the objectives of that study. Fluctuations in the environment or changes in age structure could affect population stability and the accuracy of predictions of abundance changes in such simple models (May 1976).

Given that any model may yield unrealistic estimates of impact, what other approaches to predicting the likely outcome of power plant operations (i.e., losses of young fish) on the adult stock can be used? The concept of life history strategy (Horst 1977) and long-term trends in observed abundance (Jenkins 1977) are two supplementary methods.

Since estuarine environments are characterized by pronounced fluctuations and a high level of uncertainty (Odum 1971), environmental fluctuations may be important to striped bass spawning in the Hudson River. The Hudson River estuary is the most variable (in terms of fluctuations in flow and salinity) of the estuaries along the Atlantic coast having striped bass populations (Simpson et al. 1973). The analysis of environmental factors influencing juvenile abundance indicates that abiotic variables play a major role in controlling year class strength. Environmental fluctuations also have a major effect on the development of iteroparity (repeat spawning) in American shad populations; in this species, the degree of iteroparity has been associated with latitudinal changes in the amplitude and predictability of fluctuations in the thermal environment prevailing during the egg and larval stages (Leggett and Carscadden 1978). Latitudinal gradients have not been documented in striped bass populations, but a direct association between larval mortality and fluctuations in the thermal regime was observed in the Hudson River in 1976 when a sudden drop in temperature was followed by the disappearance of a large segment of the yolk-sac larval population.

Because of the uncertainty and rigor of estuarine environments, it is not surprising that many estuarine fish species exhibit iteroparous life history strategies. An iteroparous life history pattern enables a population to sustain a high level of egg production in a fluctuating environment and to take advantage of optimum environmental conditions whenever they occur; in fact, current evolutionary theory states that this life history pattern has the greatest selective advantage in an unpredictable environment (Giesel 1976). Fisheries biologists are well aware of the adaptive value of an iteroparous life history strategy (Leggett and Carscadden 1978). However, the recognition of this fact generates a practical problem. It is difficult to develop a more realistic quantitative model for the Hudson River striped bass population because accurate descriptions of long-term variation in the environment and related changes in population age structure are not presently available. Nevertheless, recognition of the iteroparous life history strategy can be used to evaluate the relative importance of factors influencing survival during different stages in a species' life history. Although iteroparous species can compensate for wide fluctuations in mortality during their early life history stages (when they are normally exposed to highly variable levels of mortality), they are sensitive to factors affecting survival in later life stages (Giesel 1976, Stearns 1977). Therefore, on the basis of the most current and commonly accepted interpretation of the selective value of an iteroparous life history strategy, the striped bass population in the Hudson should be resistant to mortality during the egg and larval stages, the life stages most subjected to large and unpredictable mortalities related to fluctuations in the environment. After these early life stages, however, iteroparity affords little resiliency against mortality. Thus, impingement mortality should affect the striped bass population more than entrainment mortality. However, it is unlikely that the effects of impingement-related mortality can be detected empirically because juvenile impingement conditional mortality rates are low (McFadden and Lawler 1977) and occur only during the first year of life. In contrast, fishing mortality (sport and commercial) to the Hudson River stock is estimated to be about 15% per year and occurs repeatedly, especially during ages III and VI. Moreover, fishing mortality may also be density-dependent (USNRC 1975) and can vary considerably in magnitude.

In view of the preceding, then, in a more realistic population model for Hudson River striped bass, fluctuations in both the fishery and the environment should be incorporated. However, no such model has been constructed. However, the recognition of the iteroparous life history strategy in striped bass is useful in predicting the likely outcome of entrainment, impingement, and fishing mortality on the persistence of the species.

In summary, entrainment mortality is probably least important (even though it is second in magnitude) because it operates on the population during the early life stages that are subject to unpredictable mortality due to fluctuations in environmental conditions. Impingement and fishing mortality are more important than entrainment mortality because they occur during life stages following those affected by the unpredictable environmental mortality. Impingement mortality is low compared with fishing mortality (less than 1% vs 15% annually), occurs during only the first year of life, and should not affect the striped bass population. Fishing mortality, on the other hand, can be high in magnitude and occurs repeatedly throughout the reproductive ages, the period of greatest sensitivity in an iteroparous species. As a result, exploitation by sport and commercial fisheries should have a greater impact on the striped bass population spawning in the Hudson River than the currently measured levels of impact from power plant operations. The lack of any discernible declining trends in either striped bass year class strength since 1965 or the abundance indices from commercial fishery records (1955-75) indicate that the population is not experiencing overexploitation from either the commercial and sport fisheries or the current levels of power plant impact.

C. WHITE PERCH

Recovery of tagged white perch revealed more movements during spring than summer or fall due to dispersal from overwintering habitats and spawning-related movements of mature fish. Movements upriver and downriver were about equal, supporting the observation that spawning occurs throughout the estuary.

Since all age groups of white perch congregate in shoal and channel areas to overwinter, the age composition of the population was best reflected in bottom trawl catches from October through December. Age group 0 comprised 53% to 76% of the catch. The oldest individuals collected were at least age IX, but relative contribution to the population by age group dwindled quickly after age III. The oldest white perch collected in this study was 11 years old. Sex ratios have not differed from 1:1, although more females were collected in bottom trawl catches during 1975.

Ages I and II white perch were larger in 1976 than in 1975 and 1977, reflecting the above-average growth acquired during 1975. No differences in annual growth were detected for fish ages III to V, but females were larger than males at a given age. Annual instantaneous growth rates decreased from ages I to V and became asymptotic when the fish reached about 200 mm (TL). Mean lengths of white perch collected near Indian Point were generally similar to those of fish collected elsewhere in the Hudson estuary, although O and R (1977) reported faster growth of white perch in upriver than in downriver areas.

Mean fecundity in 1977 ranged from 31,000 eggs for age II females to 104,000 eggs for age V females. Mean fecundity for individual age groups and the positive relationship between fecundity and total length have not differed significantly since 1975.

The fall 1977 estimate of yearling and older white perch was 5.1 million less than or equal to 150 mm (TL) (95% confidence interval from 3.1 to 9.1 million) and 5.7 million greater than 150 mm (TL) (95% confidence interval from 2.9 for 15.6 million), or a total of 10.8 million yearling and older individuals.

A total annual mortality rate of 0.67 was calculated from 1977 data for yearlings (age I) and older white perch. Total mortality has been similar since 1974 (range of 0.62 to 0.69). Combining all 4 years yielded a total annual mortality rate of 0.66.

The Hudson River white perch stock differed from other white perch stocks primarily in growth rate and age of sexual maturity. White perch in the Hudson were generally smaller at a given age than other populations at the same latitude, particularly age II and older individuals, suggesting that stunting may be prevalent in the Hudson population. Stunted growth is a common phenomenon in white perch populations that are lightly exploited (Marcy and Richards 1974, AuClair 1964). Although Hudson River white perch began to mature at about the same age and size as other white perch populations, their complete maturity was delayed 1 or 2 years. Seasonal movements of white perch were less dramatic (both in distance and direction) in the Hudson, especially during the spawning season, than in other systems. The age structure of the Hudson River white perch population was similar to that of other white perch populations; no single age group dominated, indicating that large variations in year class strength are uncommon in white perch. Longevity of Hudson River white perch fits well into the north-south latitudinal gradient concept proposed by Mansueti (1961b). Total annual mortality rates for the Hudson population were either similar or slightly higher than reported mortality rates in other populations.

Since Hudson River white perch grow more slowly and mature later than other white perch populations, reduced density within the Hudson population could conceivably accelerate maturation and growth rates. Mortality rates and age composition of Hudson River white perch were similar to other populations and did not suggest that the population is either near or at overexploitation by either power plant operations or commercial and sport fisheries; on the contrary, the late maturation and slow growth rates suggest that the Hudson River white perch population is only lightly exploited and is capable of withstanding additional mortality.

During 1977, white perch eggs were collected from mid-April through late June, but most occurred during May and early June near the channel bottom in the Tappan Zee through Albany regions (i.e., throughout most of the estuary). Peak spawning has been relatively consistent in timing each year since 1974 and occurs when water temperatures range from 12^{o} to $23^{o}C$.

Yolk-sac larvae were collected from late April through late June, and post yolk-sac larvae followed by about a week (in early May), transforming to the juvenile stage by late July. Yolk-sac larvae were most abundant in late May; post yolk-sac larvae were most abundant in early June. Except for low numbers in the Yonkers region, white perch larvae have been fairly evenly distributed throughout the estuary each year since 1974; most post yolk-sac larvae, however, are generally collected in areas upriver from the Cornwall region. Vertical distribution is not well defined, although post yolk-sac larvae are often more abundant near the surface at night than during the day.

Juveniles were first collected in June but reached peak abundance in mid-July in the shore zone of the upper estuary (Saugerties through Albany regions). The juvenile population gradually moved downriver from early August through November to the Yonkers through Indian Point regions. In mid-October, as water temperatures decreased, the population also began to move offshore to deeper areas, presumably to overwinter. Juvenile distribution patterns have been similar each year since 1974.

Some young perch move back upriver during the following spring. Each year since 1975, two areas of yearling concentration have been observed by late June: downriver in the shore zone of the Tappan Zee through Indian Point regions and upriver in the shore zone of the Kingston through Albany regions. The upriver segment may have overwintered there.

The absolute size of the juvenile white perch population in 1977 was estimated by density-area and density-volume extrapolations to standing crops and by Petersen mark and recapture procedures. The density extrapolation method (adjusted for gear efficiency) yielded a peak standing crop of about 70 million juveniles in mid-July. The Petersen mark and recapture estimate was 40.7 million in September, 27.2 million in October, and 13.0 million in November. Our best estimate of the juvenile populations on 1 August 1977 was 67.4 million fish.

Late-summer (July-August) abundance of juveniles in 1977 was moderate compared with 1965-76 indices. Since 1965, year class strength has varied by a factor of only 9.0, and there has been no evidence of an increasing or decreasing trend. Relatively strong year classes occurred when July water temperatures were above average, when water temperatures increased quickly from 18° to 22°C (period of transformation from yolk-sac to post yolk-sac larvae), and when April freshwater flows were above average, but May freshwater flows were below average. This 4-variable model explains the variation in white perch year class strength. The current hypothesis is that year class strength in Hudson River white perch is determined primarily by water temperatures and freshwater flows during spring and early summer. April and May freshwater flows apparently act through different mechanisms to influence juvenile white perch abundance. Relatively high freshwater flows in April may increase the nutrients available to the plankton community which, in turn, ensures ample food when white perch larvae first begin to feed. The importance of relatively low freshwater flows in May was reported previously (TI 1979a) and is probably related to the tributary spawning habits of white perch (Mansueti 1961a). High freshwater flows in the Hudson during May would also occur in the tributaries and tend to flush white perch eggs and larvae out of the tributaries into the river, where conditions for larval survival may be less than optimal. Larimore (1975) demonstrated that high flows and turbidity can disorient smallmouth bass larvae and displace them downstream; he hypothesized that this displacement from the primary nursery areas during years of high post-spawning precipitation was responsible for poor year classes. A similar situation may occur in the Hudson system. Rapid passage of white perch through the larval stages (when temperatures increase quickly) should reduce starvation and predation losses. Continued warm temperatures through July should also increase survival by increasing growth rates.

In contrast to striped bass, the timing of white perch spawning is a less important influence on year class strength. White perch have a more extended spawning period, and some larvae should almost always experience optimum conditions for survival; hence, the probability of total year class failure is greatly reduced. On the other hand, some white perch larvae almost certainly will experience poor environmental conditions. Thus, the probability of extremely large year classes is also reduced. Therefore, the observed lack of extreme fluctuations in white perch year class strength may be related to the extended spawning period.

Two periods of constant daily mortality rates were observed in 1977: 10.7% per day from 9 June through 15 August and 0.7% per day from 16 August through 27 October. The sharp decline in mortality in late July as the population completed transformation to the juvenile stage supports the current hypothesis that year class strength is determined during the larval and early juvenile stages.

The seasonal pattern of growth during the first calendar year (May-November) for the 1977 year class was similar to that for the 1975 and 1976 year classes. The mean length of juveniles on 15 July was positively related to the number of days and mean water temperature since spawning and negatively related to average freshwater flows during November and December of the previous year. This 3-variable model explained 85% of the variation in the mean length of juveniles on 15 July. Juvenile white perch growth during July and August was negatively related to abundance during July and August, mean length on 15 July, and average freshwater flows during April and May. This 4-variable model explained 92% of the variation in juvenile white perch growth during July and August. In the analysis of juvenile white perch growth during July and August, the relationship between freshwater flow (considered to be an index of nutrient levels) and abundance suggests that growth is limited by food availability and intensified by intraspecific competition but not directly by water temperature. Low flows during the previous fall may have resulted in greater nutrient availability during the following spring, since organic carbon input would be delayed rather than introduced to the system in late fall. The inverse relationships between freshwater flows during April and May and growth of juvenile white perch in July and August were similar to the pattern described by Mansueti (1961b) for juvenile white perch in the Patuxent estuary, Maryland, where growth was lower during years of high spring rainfall. Mansueti suggested that periods of high rainfall are associated with low solar radiation, resulting in reduced phytoplankton production. Alternatively, the increased turbulence associated with high spring freshwater flows in the Hudson may resuspend nutrient-rich sediments and flush a significant portion of these nutrients to areas downriver from the important juvenile nursery areas in Croton-Haverstraw Bay and Tappan Zee.

The negative relationship between predicted mean length on 15 July and instantaneous growth rate during July and August for juvenile white perch indicated that relatively large, early juveniles result from a favorable combination of environmental factors during larval development but demonstrate lower subsequent growth rates. Within the framework provided by the length/subsequent-growth relationship, summer abundance was inversely related to summer growth of juvenile white perch, suggesting intraspecific competition and resultant density-dependent growth. During July and August, juvenile white perch concentrate in the shore zone of the Tappan Zee, Croton-Haverstraw, Saugerties, and Catskill regions and juvenile densities can become extremely high. During years of relatively large white perch year classes, the demand for resources (e.g., food) necessary for growth may exceed supply, retarding growth (Mansueti 1961b).

Exposure of the white perch population to entrainment in 1977 varied among the four power plants (Lovett was not addressed because near-field and entrainment data were not collected in 1977). At Bowline and Indian Point, few eggs were entrained and exposure was low. Egg exposure to Roseton and Danskammer was moderate, and river sampling did not accurately predict egg entrainment peaks at either Roseton or Danskammer. Exposure of white perch larvae to the four sites followed the same general pattern as eggs. Larval exposure was low at Bowline, low to moderate at Indian Point, and moderate at Roseton and Danskammer. River samples were better predictors of larval entrainment peaks than egg entrainment peaks at all plants.

River samples were not particularly useful predictors of juvenile/yearling white perch impingement peaks at the four power plants in 1977 and early 1978 because most of the impingement occurred during the winter and early spring (late November-April) when river sampling was minimal. Exposure of juveniles during the summer (July-September) was relatively high at all plants, but juvenile concentration in the shore zone greatly reduced their actual impingement rates except at Roseton in August. As water temperatures decreased in the fall and fish moved offshore, impingement of young white perch increased and remained relatively high until early May when the population dispersed and returned to shallow areas.

A conditional mortality rate for the Hudson River white perch population as a result of the operation of power plants has been estimated at 0.16 from 1974 data (McFadden and Lawler 1977), and alpha approximates 3.0 (TI 1979a). With these values for the conditional mortality rate and alpha, the final reduction in population size would be substantially greater than the conditional mortality rate only for the case of mortality acting on a Beverton-Holt stock-recruitment relationship after the period of compensation.

An indication of the timing of mortality with respect to compensation can be derived from the life history of white perch. All age classes of white perch coexist in the Hudson River. This life history pattern is in contrast to the anadromous striped bass, which generally leave the river near the end of their first summer and do not return until they are close to maturity. Therefore, intraspecific competition may be relatively intense in white perch because the young compete with their parents as well as each other. Such intraspecific competition could result in density-dependent mortality that dampens differences between potentially strong and weak year classes of white perch. We observed more variation in the abundance index at age 0 (the first summer) than was evident at age I (second summer) for Hudson River white perch. For example, both the strong 1976 and 1977 year classes gave rise to relatively small yearling populations. The catch curve for 4 years of data further indicated that relatively strong juvenile year classes were not evident as strong year classes at age I and older. Strong year classes of white perch also could not be detected in the Patuxent River, Maryland (Mansueti 1961b) or the Delaware River (Wallace 1971). The dampening of white perch year class strength implies that some density-dependent mortality occurs after the main period of density-dependent mortality (thought to occur during the larval stages in most species of fishes). For example, white perch year classes of greater than average abundance apparently experience greater than average mortality during their first winter which could allow compensation for a portion of fall and winter impingement mortality.

This evidence for an extended period of density-dependent mortality, beginning during the larval stages and extending into the yearling or older age groups, suggests that impingement mortality in white perch may occur during and before the periods of compensation. Thus, the stock-recruitment curve with impact before the period of compensation is probably the most correct case. The conditional mortality rate resulting from the operation of power plants is an overestimate of the impact on the white perch population, regardless which stock-recruitment curve is appropriate.

While an iteroparous life history strategy in a fluctuating environment (as discussed for striped bass) enables species to compensate for unpredictable levels of mortality associated with fluctuations in temperature during the egg and yolk-sac larval stages, white perch exhibit several differences in their reproductive biology which suggest that the evolution of this species has tended to reduce the impact of an unpredictable thermal environment during the egg and larval stages. For example, white perch spawn over a relatively long time interval in the Hudson; thus, their egg densities peak later in the season than those of striped bass. Since water temperatures increase steadily during May and June, the probability of exposure to a lethal low temperature decreases when spawning is delayed. The spawning efforts of individual females may also be distributed throughout the extended spawning season. This reproductive strategy would further decrease the risk associated with an unpredictable thermal environment during the spawning season. Also, the white perch population apparently spreads the risk associated with unpredictable environmental conditions in the Hudson River estuary in still another way: white perch spawn throughout the entire estuary and possibly in the tributaries as well, and this utilization of the entire estuary for spawning reduces dependence on and sensitivity to any localized environmental conditions prevailing in only a few regions. Finally, white perch eggs are adhesive, which may decrease their vulnerability to variations in flow or flow-related factors. Since the level of variation in summer juvenile abundance (as measured by the coefficient of variation) is lower for white perch than for striped bass (47% vs 88%), changes in the reproductive biology of white perch may be effective in reducing the level of uncertainty during the egg and larval stages. However, a significant level of uncertainty in survival during later pre-reproductive life stages may be inferred since white perch are iteroparous.

The correlation between juvenile and yearling white perch abundance is not significant, which indicates that survival between the first and second summers of life is variable. Fluctuations in abiotic conditions during winter months could generate this variation, but white perch sensitivity to fluctuations in physical conditions should decrease as the fish increase in size; as their size and food requirement increase, however, they become increasingly susceptible to competition for food. Although both juvenile white perch and striped bass feed upon the same prey species during the summer (TI 1978a), there is no apparent correlation between juvenile white perch abundance and juvenile striped bass abundance. This is consistent with the fact that simple linear food chains involving very few interspecific regulatory mechanisms should predominate in unstable ecosystems like the Hudson River estuary (Odum 1969). In fact, the only interspecific relationship observed in the analyses conducted in this report was not regulatory (i.e., associated with abundance) but was associated with growth. When white perch juveniles were abundant in the Hudson River, striped bass grew poorly. Juvenile and adult white perch feed upon different-sized organisms from the same prey populations (TI 1978a), indicating that intraspecific competition may be more important in white perch than in striped bass. White perch in the Hudson River estuary grow more slowly and complete maturity later than other white perch populations at comparable and more northern latitudes, suggesting that the Hudson population is at or near the carrying capacity of the system and that intraspecific competition is more likely to be an important population control mechanism.

The presence of iteroparity in the white perch population suggests that the pre-adult mortality is unpredictable. Thus, if intraspecific competition between individuals age I and young-of-the-year (juveniles) controls recruitment to the yearling age class, iteroparity implies that the intensity of the intraspecific competition is unpredictable. Since white perch feed upon invertebrates and the productivity of the invertebrate populations is affected by fluctuations in abiotic conditions, the intensity of intraspecific competition should vary unpredictably and could explain the presence of the iteroparous life history strategy in the white perch population. Iteroparous species may be resilient to new sources of mortality as long as those sources affect life stages that are already subject to unpredictable natural mortality (Giesel 1979, Power 1978). In the Hudson River white perch population, unpredictable mortality apparently occurs between the first and second summers and appears to involve a density-dependent mechanism, intraspecific competition. Entrainment mortality occurs prior to this period, and impingement mortality peaks during the winter following the first summer.

In summary, the timing of plant-induced mortality appears to be compatible with the natural compensatory capabilities in the white perch population, so the current level of power plant operation should have no significant impact on the persistence of the white perch population in the Hudson River estuary. This conclusion is consistent with the empirical evidence which indicates that the white perch population exhibits no overexploitation in terms of individual growth rates, age structure of the population, age at maturity, etc. On the contrary, the data suggest that the white perch population in the Hudson River estuary is overcrowded and could withstand a reasonable increase in mortality. The lack of any discernible trend in white perch year class strength since 1965 further supports the conclusion that the population is not experiencing overexploitation from either the current levels of power plant impact or fishing.

D. ATLANTIC TOMCOD

The 1977 year class of Atlantic tomcod was produced by the strong 1976 year class, estimated to number 10.4 million spawners. Low freshwater flows during the winter of 1975-76 were probably the key factors which increased early life-stage survival in the 1976 year class (TI 1979a).

In 1977, Atlantic tomcod eggs were collected from the start of sampling in late February (spawning also occurs in December and January) through early April. Egg densities were highest from late February through mid-March in the West Point and Cornwall regions. The 1977 egg collections support the current impressions of major spawning locations but not the time of peak spawning, which probably occurs from mid-December through January rather than late February. Peak spawning has been similar in timing and location each year since 1975 and has occurred when water temperatures ranged from 1^{o} to $5^{o}C$ and conductivity was less than 300 mS/cm.

Also during the first sampling period in 1977 (late February), yolk-sac and post yolk-sac larvae were present. Yolk-sac larvae were collected until early April, peaking in early March in the regions of high egg abundance (West Point and Cornwall). Post yolk-sac larvae were collected until late May; they were most abundant in late March and early April, but the population had shifted to the most downriver study regions, Yonkers and Tappan Zee. High freshwater flows in February and March apparently produced rapid downriver displacements of tomcod larvae and generated annual variations in the spatiotemporal distribution of yolk-sac larvae. Post yolk-sac larvae distribution patterns have been consistent each year since 1975. Juveniles, first collected during April, reached peak abundance in mid-May near the bottom in deeper offshore areas of the Yonkers and Tappan Zee regions and also presumably downriver from the study area. Since juvenile tomcod are usually most abundant near the salt front, their distribution spreads during summer upriver as far as the Poughkeepsie region and perhaps farther.

Late summer (July-September) abundance of juveniles in 1977 was moderate compared with 1969-76 indices. Since 1969, juvenile abundance has varied by a factor of 13.6 and there has been no discernible trend. Relatively large numbers of juveniles have been present in late summer during years preceded by low freshwater flows in December. Since freshwater flow in December explains 59% of the variation in juvenile abundance, other influencing factors are important. The negative effect of freshwater flow in December on late-summer juvenile abundance may act through control of spawning location. Atlantic tomcod spawn primarily above the salt front (TI 1979a); thus, in years of high freshwater flow in December, spawning may occur farther downriver in areas that are less optimal for the survival of eggs and larvae. The importance of salinity in determining spawning locations may be related to its influence on sperm motility (Booth 1967); therefore, successful spawning may occur only within a relatively narrow range of salinity. Booth suggested that the tomcod find the proper salinities by seeking out microhabitats (small areas where dilution from melting snow or ice lowers salinity) within areas of higher-than-optimal salinity. Suitable microhabitats may occur only in localized areas of the Hudson River estuary, depending on salt front position. There are still many unknowns in our knowledge of environmental influences on survival of young tomcod.

Total annual mortality rates for tomcod during their first year of life ranged from 99.997% in 1977 to 99.951% in 1976. Since 1975, mortality rates have been extremely high through early June. Mortality during the first year of life may be density-dependent because egg production and total annual mortality are positively related.

The 1977 year class had a seasonal pattern of first-year growth that was similar to that of the 1974-76 year classes and exhibited two distinct growth periods: the first period ended in early July when the juveniles were about 70 mm (TL); the second period began in mid-September and continued though November when the juveniles were about 140 mm (TL). Mean lengths of juvenile tomcod at the end of November have been remarkably similar each year since 1974 and less variable than in July, indicating that juvenile tomcod possess the ability to compensate during the second growth period (September-November) for slow growth during the early life stages (prior to mid-July). The role of environmental factors in the control of juvenile tomcod growth is not yet understood.

As immature juveniles, the 1977 year class was distributed mostly near the bottom of the channel from the Yonkers through Poughkeepsie regions during spring, summer, and fall; in early November, they began to appear as mature adults in the shoals and shore zone of the Yonkers-Hyde Park regions. Males preceded females to the major spawning grounds centered in the West Point region. Spawning activity was at its peak from mid-December to mid-January. Adults did not move very far during the spawning period but, after spawning, moved downriver to areas south of Manhattan. During the spawning run, tomcod were collected to determine the age composition of the stock. The youngest age group (11 to 13 months) comprised more than 90% of the population, a pattern that had been observed during the previous three spawning seasons. Age II fish composed the remainder of the stock except during the 1976-77 season when two age III fish were caught. Sex ratios of the dominant age group assessed from catches of immature juveniles taken during June-September revealed 55% to be males. Sex ratios in age II and older tomcod ranged from 30% males during 1977-78 to 72% males during 1976-77.

All individuals are capable of spawning at 11 to 13 months old or age I. The percentage of total body weight comprised of gonadal tissue increased rapidly in mid-October for young males and in early November for young females. Annual instantaneous growth rates were higher for females, and females were consistently larger than males during their second year of life.

During the second year of life, total annual mortality rates ranged from a low of 0.809 for the intermediate-size 1975 year class to a high of 0.991 for the strong 1976 year class. The only available estimate of total mortality rate during the third year of life was 0.970 for the 1974 year class.

Mean fecundity during 1977-78 ranged from 11,000 eggs for age I females to 55,000 eggs for age II females, numbers that were similar to those for the 1976-77 spawning population; however, mean fecundities were slightly higher for age I females in 1975-76 and 1977-78 when the fish were larger. Age I females contributed 76% to 94% of the total spawn, age II females contributed 6% to 24%, and the contribution of age III females was minimal. Since egg diameter and body length were positively correlated and larger eggs produce larger larvae that have higher survival rates (Ware 1975), conditions (e.g., reduced intraspecific competition) which promote the growth of the spawning stock could result in the production of an abundant progeny population, and vice-versa. Available data suggested that egg diameter and relative abundance of spawners are inversely related, supporting the hypothesis that egg diameter is a function of density-dependent growth in the spawning stock. The number of adults in the 1977-78 spawning populations was estimated to be 2.53 million fish (fewer than in the previous three spawning populations).

Few Atlantic tomcod stocks have been studied as extensively as the Hudson stock and are all more northerly (Massachusetts, Connecticut, and Quebec). Tomcod are short-lived throughout their range and are perhaps most short-lived in the Hudson River. The paucity of repeat spawners in the Hudson population, compared with more northern populations, parallels the latitudinal gradient of repeat spawning observed in American shad (Leggett and Carscadden 1978). With regard to other stock characteristics such as growth and fecundity, the Hudson River tomcod population is similar to other populations.

Exposure of the Atlantic tomcod population to entrainment in 1977 varied among the four power plants (Lovett was not addressed because near-field and entrainment data were not collected). Exposure of eggs was low and restricted to the Roseton and Danskammer plants, the only plants that entrained more than a few tomcod eggs. Exposure of larvae was low to moderate at Bowline. At Roseton and Danskammer, exposure was moderate for yolk-sac larvae and low for post yolk-sac larvae. Very few tomcod larvae were entrained at Indian Point. Generally, plant region densities were not reliable predictors of entrainment.

Impingement of tomcod juveniles at most plants was negligible during May when most of the population was distributed downriver from the power plants and exposure of juveniles to the plants was low. During the summer, however, a portion of the juvenile population moved upriver with the salt front, and their exposure to impingement at Bowline and Indian Point increased. River samples were poor predictors of summer impingement peaks at Bowline because of the shallow intake pond and the preference of juvenile tomcod for deep water. At Indian Point, however, juvenile tomcod impingement rates increased sharply during May, as exposure increased, and remained relatively high through August. Juvenile tomcod impingement at Roseton and Danskammer was highest during the winter spawning run (November-March) and low during the rest of the year.

The same four factors that influence power plant-induced mortality of striped bass and white perch also pertain to the Atlantic tomcod population. The major difference between Atlantic tomcod and the other two species was that estimated mortality rates for Atlantic tomcod tended to be lower. McFadden and Lawler (1977) estimated a conditional mortality rate of approximately 0.05 for Atlantic tomcod. At this low level of mortality, only a narrow range of values for alpha would result in either large reduction or lack of persistence of the population.

The magnitude of alpha was estimated from the average fecundity of Atlantic tomcod and the resultant value was slightly more than 2.0 (TI 1979a). However, this value is likely a minimal estimate because many different population characteristics affect the value of alpha in addition to fecundity. The fish stocks analyzed by Cushing and Harris (1973) on which this analysis was based tended to be broadcast and pelagic spawners. Any life history characteristic that increases the probability of survival of offspring beyond that found in broadcast spawning would increase alpha beyond what was estimated by the average fecundity approach. Atlantic tomcod spawning behavior involves close proximity of the two sexes, and this behavior may ensure a higher rate of fertilization than in broadcast spawners (Klauda 1978). Thus, Atlantic tomcod exhibited a life history trait that may have increased the value of alpha beyond that estimated by the average fecundity approach (from broadcast spawners) and 2.0 is probably a minimal estimate.

Some data indicate that compensation may take place after entrainment mortality. Egg size was shown to vary with female size in Atlantic tomcod, and large egg size has been related to increased larval survival in several species of fish (Ware 1975). If Atlantic tomcod growth were density-dependent, large spawns would yield large numbers of small adults which would lay smaller eggs with poor survival. Atlantic tomcod growth was analyzed for an effect of density (subsection V.D.) and none was apparent. Although density-dependence was not evident in this analysis, the index of growth used was derived from fish caught in the summer. Three years of data suggested that density-dependent growth may be evident in the spawning population of female Atlantic tomcod in the winter. Fecundity, closely associated with growth, also varied with density. Thus, growth, fecundity, and egg size may be density dependent in the Hudson River Atlantic tomcod population.

If compensation does act through density-dependent growth associated with size-dependent fecundity and egg size, the compensatory period would span the period of impact. Any thinning of the population that took place prior to or during the period of density-dependent growth would stimulate production of new individuals through a greater number of larger eggs per female.

In summary, the available evidence suggested that much of the power plant-induced mortality in the Atlantic tomcod population occurred before or during the period of compensation and that 2.0 was a reasonable minimum value for alpha. When these possibilities, combined with low estimates of mortality from Hudson River power plants are considered, the conditional mortality rate should be a conservative estimate of PR regardless of the appropriate stock-recruitment curve.

Like striped bass, Atlantic tomcod is an anadromous species that uses the middle portion of the Hudson River estuary for spawning and the lower regions as a nursery area. Unlike striped bass, the tomcod spawning population is composed primarily of age I females; age II and older females compose only 3% to 8% of the spawning population, making Atlantic tomcod essentially semelparous. Semelparity is usually associated with an increase in the predictability of environmental conditions controlling survival during the early life stages (Giesel 1976). Atlantic tomcod spawn during late December and early January, which means that their early life stages are exposed to a colder but less variable thermal environment than that to which the corresponding life stages of striped bass are exposed.

The amount of variability in Atlantic tomcod and striped bass juvenile abundance is similar; the coefficients of variation are not significantly different (70% vs 88%; $\alpha=0.05$). Fluctuations in freshwater flow and water temperature during winter and spring apparently affect the survival of juvenile tomcod. The observed fluctuations in juvenile abundance suggest that the Atlantic tomcod population might be modeled more realistically as a single-aged stock in a fluctuating environment. However, the absence of an accurate description of the role of key environmental factors in abundance fluctuations currently precludes the development of a quantitative model that would accurately assess the impact of the power plants on the stability and abundance of Atlantic tomcod in the Hudson River estuary. The recognition of semelparity and fluctuations in environmental conditions does, however, provide valuable qualitative information concerning the probable outcome of power plant operations on the persistence of the tomcod population. For example, semelparous species have shorter generation times (and consequently, shorter time lags) and can respond more quickly to changes in environmental conditions than can iteroparous species. As a result, variations in adult abundance of a semelparous species will follow fluctuations in environmental conditions more closely than will those of an iteroparous species. Since high resiliency (response to changes in environmental conditions) is usually accompanied by a large amount of negative feedback within a population (Harrison 1979), semelparous species also should exhibit more compensatory potential than iteroparous species.

At least two density-dependent compensatory mechanisms appear to be operating in the Atlantic tomcod population in the Hudson River estuary. Phase I mortality (occurring during spring and early summer) may be density-dependent, and density-dependent regulation also appears to occur during the fall period of growth. For example, during 1974-76, late-summer juvenile densities were highest in 1976; subsequently, the females spawning during the winter of 1976-77 had significantly fewer eggs per weight class than those spawning during the winters of 1974-75 and 1975-76. The presence of these density-dependent regulatory mechanisms (density-dependent mortality and density-dependent fecundity), one operating during each period of growth, should make the tomcod population highly resistant to plant-induced mortality: a density-dependent increase in juvenile survival during the first period of growth could compensate for entrainment mortality, while a density-dependent increase in fecundity during the second period of growth could compensate for the loss of juveniles through impingement during the summer. Neither mechanism will compensate for the impingement of adult tomcod during the spawning season. Although the survival of impinged adults is high (King et al. 1978), the effect of impingement on subsequent spawning success of the survivors has not been determined; the impingement of gravid females could affect reproductive success without necessarily affecting adult survival. However, the impingement of adults is quite variable (McFadden et al. 1978), and the carryover of reproductive effort between years (via the age II females in the population) could compensate for poor spawning caused by the heavy impingement of adults during the preceding year. Age II females compose only 3% to 8% of the spawning population, but their fecundity is approximately five times that of age I females; as a result, they have contributed as much as 24% of the total spawn in a given season. Moreover, since adults are not impinged during the summer, the carryover of age II females will also provide additional compensation for any impingement of juveniles during the previous summer.

Probably the most important feature of impingement mortality is the fact that it is variable in both the juvenile and adult stages (McFadden et al. 1978). A species such as Atlantic tomcod, with a short generation time (1 year) and high compensatory potential, needs only 1 or 2 years of low mortality to recover from a year of heavy mortality. Accordingly, it is interesting to note that the juvenile Atlantic tomcod population in the Hudson River estuary increased from low abundance (9.2) in 1974 to a high level (78.1) in just 2 years (by 1976). It should be noted also that this fluctuation in abundance occurred in the presence of mortality imposed by power plants.

In summary, a semelparous species such as Atlantic tomcod closely follows fluctuations in environmental conditions. An iteroparous species, on the other hand, exhibits more resistance to changes in conditions and their numbers tend to average across fluctuations in the environment (May 1976) which results in a lower and more constant level of adult abundance. Resiliency in the Atlantic tomcod population in the Hudson River estuary appears to involve the following compensatory mechanisms:

- Density-dependent regulation of mortality during the first phase of juvenile growth
- Density-dependent regulation of adult fecundity during the second phase of juvenile growth
- Carryover of reproductive potential from the preceding year via age II females

The available empirical data (rapid increase after a year of low abundance) and the lack of any discernible trend in juvenile abundance since 1969 demonstrate that there is no overexploitation and that the Atlantic tomcod population should be resistant to the current levels of power plant impact.

SECTION II
INTRODUCTION

The 1977 Year Class Report is the fifth in a series on the individual and combined impacts of five electric generating stations (Bowline, Lovett, Indian Point, Roseton, Danskammer) on striped bass, white perch, and Atlantic tomcod populations (the three key species) in the Hudson River estuary. Initiated in 1974 and jointly financed by Consolidated Edison Company of New York, Inc. (Con Edison), Orange and Rockland Utilities (O and R), Central Hudson Gas and Electric Company, Inc. (CHG and E), and the Power Authority of the State of New York (PASNY), the Multiplant Impact Study involves an intensive year-round sampling program emcompassing the tidal portion of the estuary. The principal purpose of the 1977 study was to determine the impact of mortality on the 1977 year classes of the three key species caused by the once-through cooling systems of these electric generating stations. The following brief review of previous reports in this series places the 1977 Year Class Report in historical perspective.

The First Annual Multiplant Report (TI 1975c) focused on the 1973 year classes of striped bass, white perch, and Atlantic tomcod and described spawning stock abundance trends for American shad. This report combined objectives for the riverwide sampling approach of the Cornwall study (initiated in 1973) with an empirical estimation of the individual and combined impacts of Bowline, Lovett, Indian Point, Danskammer, and Roseton generating stations on three key species (striped bass, white perch, and Atlantic tomcod). The Multiplant Report included a compilation of a historical data base with which to assess abundance trends and compensatory mechanisms, a description of spatiotemporal distribution and exposure (vulnerability) patterns, and calculation of short-term (direct) impact of the five operating power plants (via entrainment and impingement) on the three key species. This report established the format for subsequent reports and addressed important biological questions such as: Where do the various life stages of the selected species occur in the estuary and to what extent are the populations of each life stage exposed to the power plants?...What are the magnitudes of plant impact on each species?...What data are available to assess the capacity of the populations to compensate for plant-induced mortality? Major contributions of the Multiplant Report were a compilation of the data base and methodology upon which future reports were based, the finding that there were no significant relationships between river power plant operations and trends in year class strength for striped bass and white perch, and the demonstration of a Ricker stock-recruitment relationship and density-dependent growth in striped bass.

The next report in the series was the 1974 Year Class Report (TI 1977a), an extension and refinement of the Multiplant Report. The "Year Class" title replaced the "Multiplant" title to focus on a "fish year" rather than a calendar year for the time period discussed in each report. The 1974 Year Class Report was the transition to the "fish year" approach, which was expanded in the 1975 Year Class Report (TI 1978a). A fish year encompasses the time interval from approximately early January of the calendar year in which the year class is spawned through June of the following year; e.g., the time period discussed in the 1975 Year Class Report was January 1975 through June 1976. Empirical estimates of plant impact were not calculated in the 1974 Year Class Report, but the results of a 1974-75 sampling program in the lower bay areas adjacent to the Hudson River were discussed. Major contributions of this report were descriptions of trends in year class strength of American shad and Atlantic tomcod, demonstration that spring temperatures and freshwater flow were key factors associated with variations in the year class strength of Atlantic tomcod, the finding that there was no significant relationship between year class strength trends (for both species) and power plant operations, and descriptions of microdistribution patterns (e.g., vertical, lateral, diel) for striped bass, white perch, Atlantic tomcod, and American shad.

The 1975 Year Class Report (TI 1978a) further developed the key topics presented in the Multiplant Report and 1974 Year Class Report but excluded direct impact estimates for the 1975 year classes of striped bass, white perch, and Atlantic tomcod and much of the data on striped bass. These items were presented and discussed in a major report (McFadden 1977a). Major contributions of the 1975 Year Class Report were related to refined analyses of historical trends in the abundance of white perch and Atlantic tomcod. Fluctuations in the annual abundance of juvenile white perch were negatively associated with high flows during the spawning period but were positively associated with the rate of water temperature increase from 16° to 20°C and abundance of juvenile striped bass. Annual abundance of juvenile Atlantic tomcod was most closely associated (negatively) with freshwater flows during the spawning period (December and January) and during the time of peak yolk-sac abundance (early March).

The fourth report in the series, the 1976 Year Class Report (TI 1979a), departed from the primarily descriptive approach used in the three previous reports and focused on ecological relationships within the fish populations of the Hudson River estuary. Life histories, population dynamics, distribution, and exposure to power plants were discussed for the 1976 year classes of striped bass, white perch, and Atlantic tomcod. Because 3 years of highly comparable riverwide data were available, trends in spatiotemporal distributions, biological characteristics, and abundance were examined and interpreted. This report refined analyses of factors influencing the growth and abundance of the year class of each species. Other major contributions resulted from analyses directed at compensation in the three species. Relationships between fecundity and an index to compensatory capabilities yielded more realistic, empirical estimates of alpha (α) for striped bass (6.87) and white perch (3.36) to use in calculating impact of power plants. The 1976 Year Class Report continued efforts to understand important relationships between environmental factors and population dynamics of selected fishes insofar as they relate to the effects of power plant operations on the Hudson River estuary.

The 1977 Year Class Report emphasizes data on the three key species throughout the period of exposure to entrainment and impingement. This period begins with the eggs and continues through the larval and juvenile stages to the yearling stage in June 1978. The three key species represent a cross section of life histories within the fish community, each history typifying a different aspect of the relationship between entrainment and impingement mortality and fish population dynamics: striped bass are the object of an intensive sport and commercial fishery along the Atlantic coast; white perch is a dominant species in the Hudson River, and there are large numbers of white perch in impingement collections; Atlantic tomcod is also well represented in impingement collections, and short generation time makes it a particularly useful species in the assessment of power plant impact. Each section of this report develops qualitative estimates of two variables essential for determining impact: mortality and compensation for mortality. Mortality rates due to power plants are derived from past reports. Since fish populations can compensate for mortality through increased survival of the remaining individuals, an estimate of this compensatory response is also presented. The development of these two concepts is implicit in two specific objectives of the report:

- To describe the distribution, abundance, and population characteristics of the 1977 year class of striped bass, white perch, and Atlantic tomcod and to develop and explain patterns in these variables over the years of study
- To integrate the above data into qualitative estimates of impact and the consequences of impact

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STRIPED BASS

A. GENERAL LIFE HISTORY

The striped bass (Figure III-1) is a member of the family Percichthyidae (temperate basses) and is native to the Atlantic and Gulf coasts of the United States. Because of its value as a commercial and sport fish, the striped bass was stocked on the Pacific coast in 1879 and 1882 and in inland lakes and reservoirs within the last decade (Figure III-2).

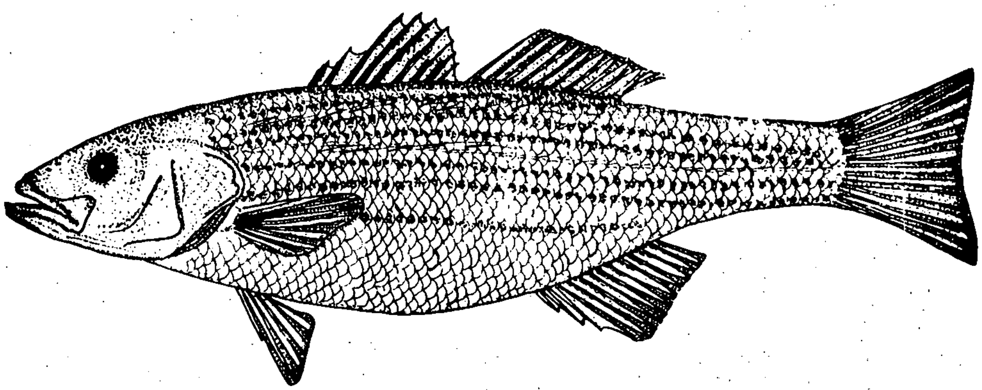


Figure III-1. Striped Bass (Morone saxatilis), [Weight and length rarely exceed 27 kg (60 lb) and 1.35 m (53 in.) respectively.]

Hudson River striped bass have a life cycle that is typical of an anadromous fish species (Figure III-3). During early spring, the adults move from overwintering areas in ocean bays or the lower estuary and swim upstream to spawn in fresh water (Figure III-3) (McFadden et al. 1978); shortly thereafter, they return to the ocean. Generally, spawning occurs in May and June and peaks in the middle estuary at water temperatures of 14 to 20°C (TI 1979a). Most males become sexually mature when 4 years old, and most females are mature at 7 years (see subsection III.B.5). Adults generally spawn annually and may live for 20 years (Merriman 1941). Fecundity increases with age and size: a female spawning in the Hudson, upon reaching maturity,

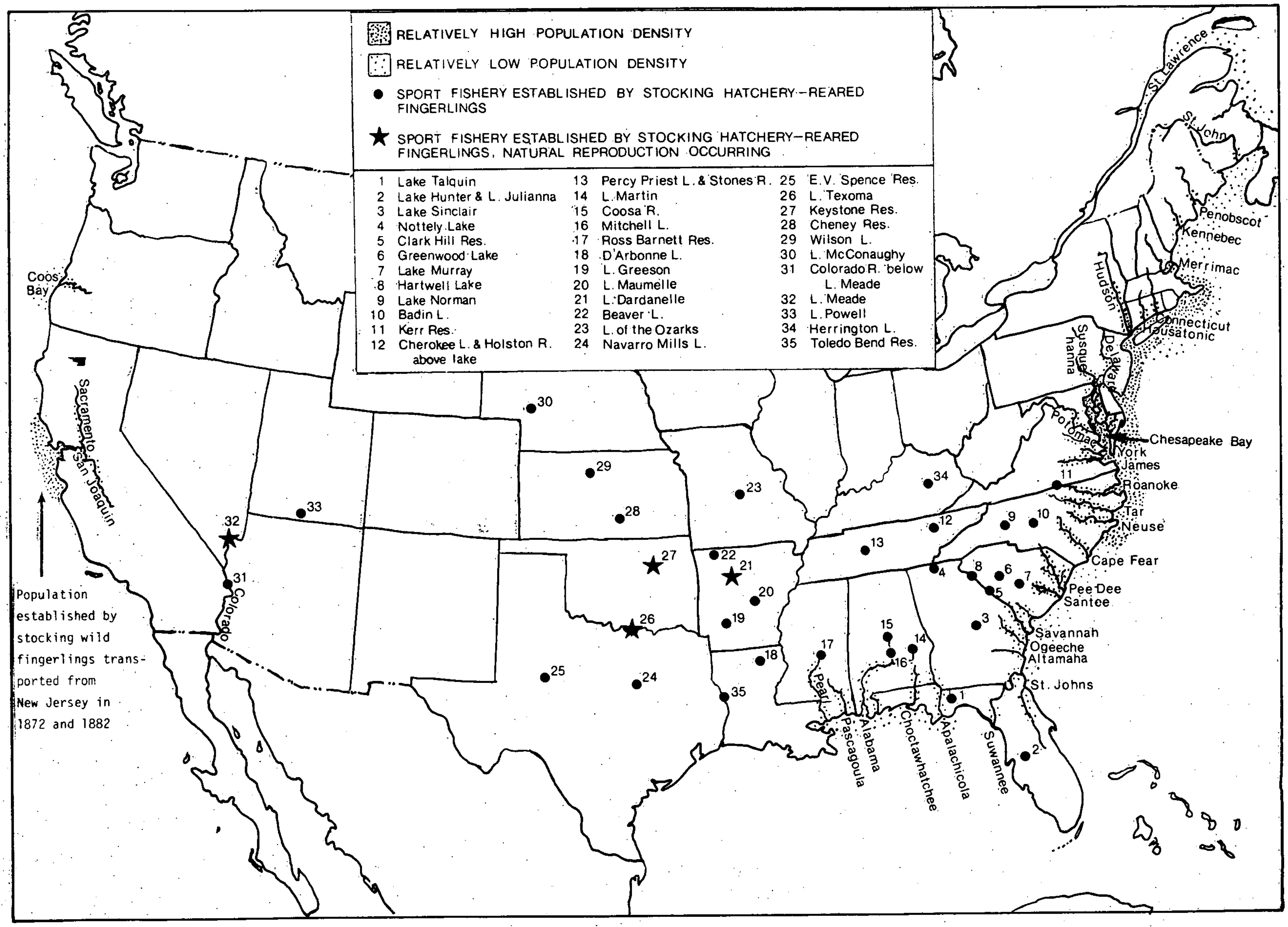


Figure III-2. Distribution of Striped Bass in North America as of 1976 (Parsons 1974, Bailey 1974, and reports of the AFS Striped Bass Committee, Southern Division, 1972-78)

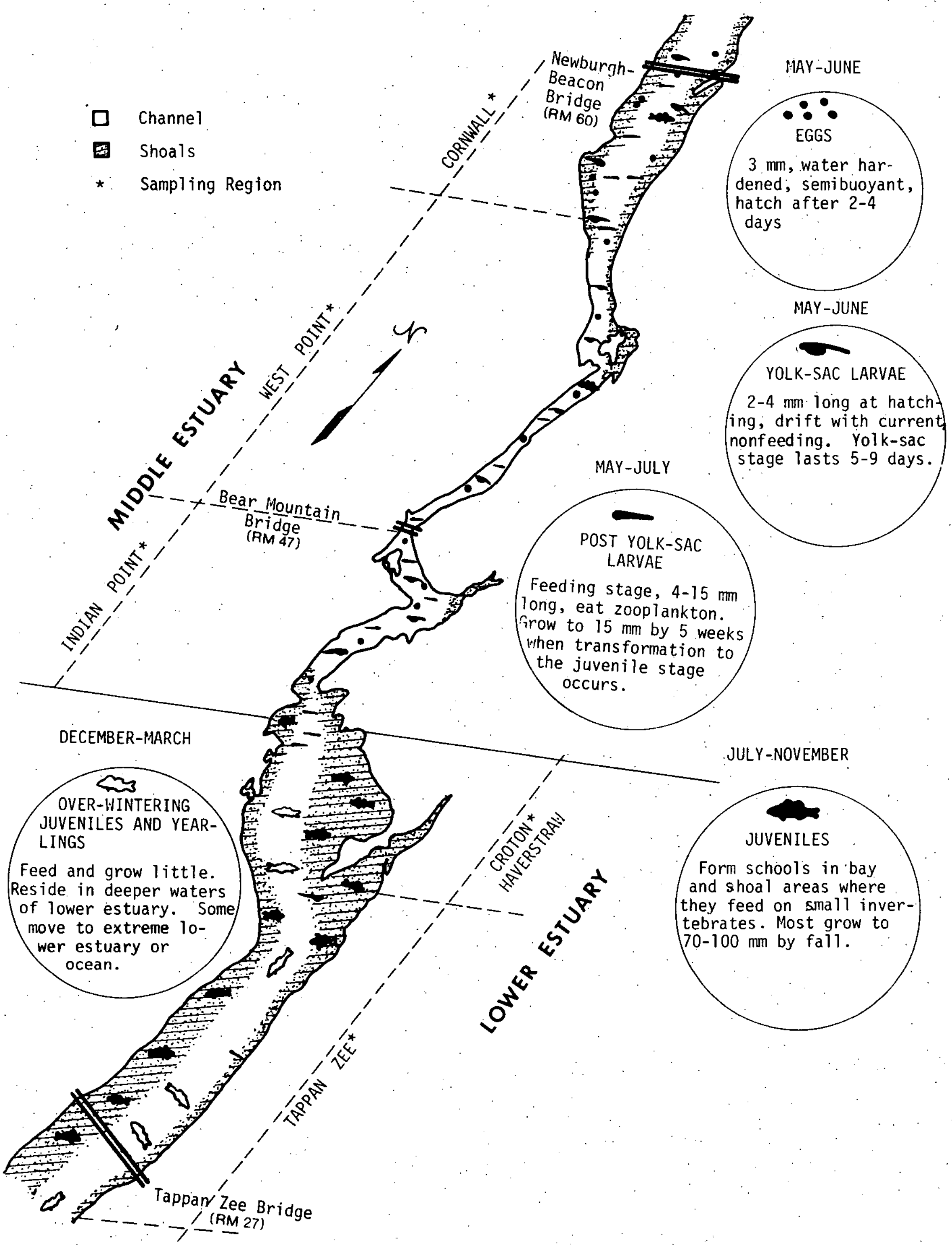
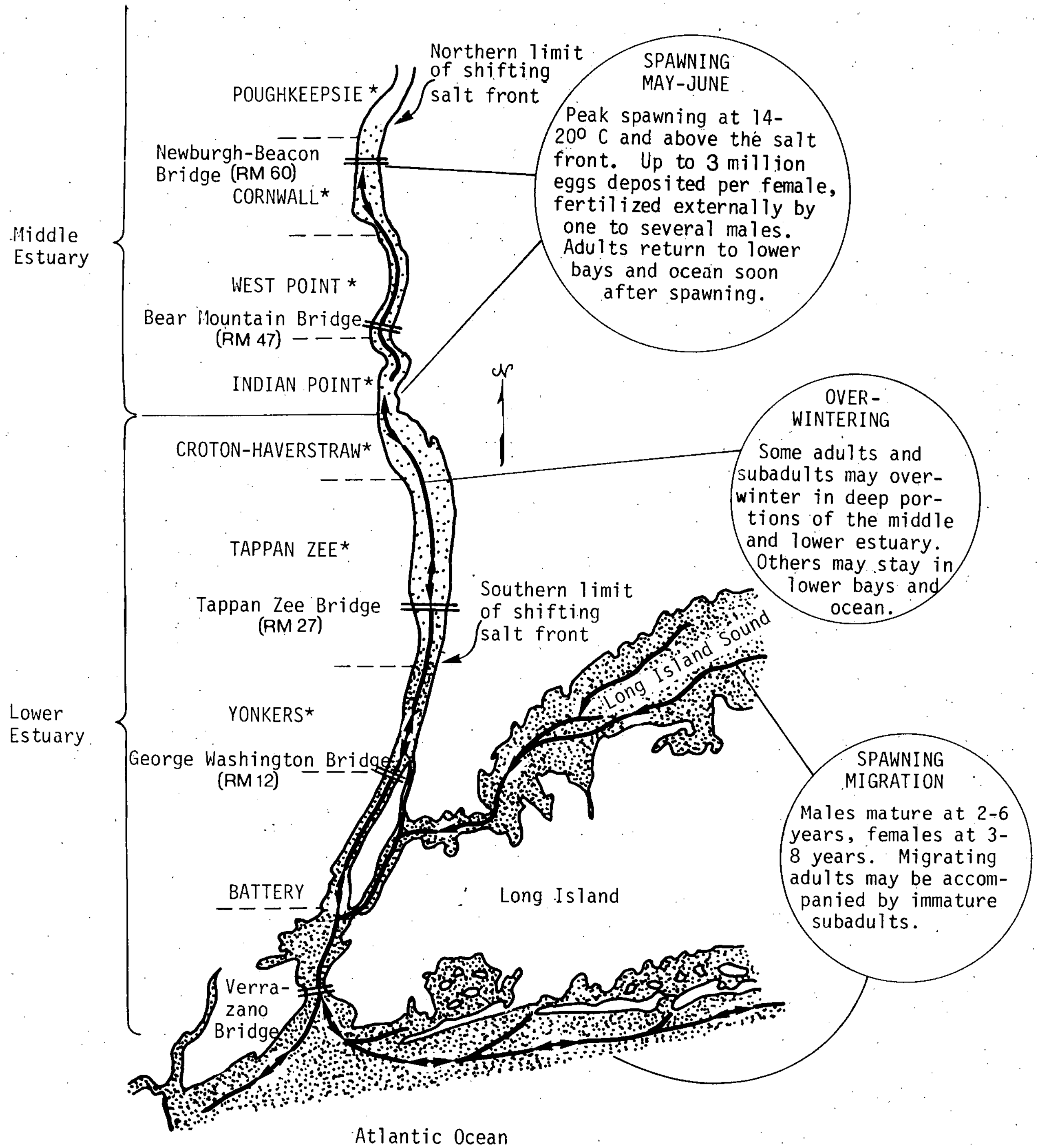


Figure III-3a. Early Life Stages in Generalized Life Cycle of Hudson River Striped Bass



*Sampling Region

Figure III-3b. Overwintering and Spawning Migration Phase of Generalized Life Cycle of Hudson River Striped Bass may produce approximately 0.6 million eggs, and when 15 years old, about 2.6 million eggs (subsection III.B.5). When spawning, a ripe female is surrounded by several males, and eggs and milt are expelled rapidly (Raney 1952). The eggs, which are semibuoyant, are about 3 mm in diameter when fully water-hardened and hatch after 34 to 100 hr, depending on temperature (TI 1975b, 1977c). Upon hatching, yolk-sac larvae (prolarvae) have a total length (TL) of 2.4 mm and are capable of limited movement (Bayless 1972). Their swimming ability increases after 5 to 9 days when they enter the post yolk-sac (post-larval) stage and begin feeding on small zooplankton (TI 1975b, 1977c). When 9 to 12 days old, most larvae have inflated gas bladders and are feeding actively, although they may still obtain nourishment from the oil of the yolk sac for another 10 days (Doroshev 1970). Post yolk-sac larvae transform into juveniles when approximately 5 weeks old and 15 mm long (Mansuetti 1958, TI 1977c).

During the summer, juveniles (young-of-the-year) assume the adult body shape and form schools in bay and shoal areas (TI 1976c). Midge larvae and zooplankton are important food items (TI 1976a). During the fall, most juveniles range from 70 to 100 mm in length and primarily consume small crustaceans, especially Gammarus spp. (TI 1979a, 1976a). Some juveniles, especially the larger ones, move to the lower estuary or to enclosed bays of the ocean before or during winter; others apparently overwinter in the deeper portions of the middle estuary (McFadden et al. 1978). Growth practically ceases during winter and early spring; thereafter, yearlings still in the estuary leave their overwintering areas, move to shore zones, and by early summer become distributed throughout the estuary (McFadden et al. 1978). As yearlings grow, the proportion of fish in their diet increases (TI 1979a).

Age II and older striped bass are generally piscivorous and inhabit waters along the coast; upon moving into coastal waters, these fish may migrate long distances, a few foraging up to 10 miles from shore (Raney 1954). Migration tends to be northeastward during spring and summer and southeastward during fall (Raney 1954).

B. STOCK CHARACTERISTICS

This section describes the current status of the Hudson River striped bass stock and its potential for change due to an altered environment. The distribution and movements of subadults and adults are studied to determine the appropriate time to sample the population during its migrations. Age composition and sex ratios are described to examine year class strength (discussed in detail for young-of-the-year in subsection III.D.1) and mortality rates. Mean size at successive ages is used to assess growth. Since growth affects both maturity and fecundity, it may strongly influence the reproductive ability of the population. Stock characteristics described for Hudson River striped bass are also compared to those known for populations in other geographic locations.

1. Distribution and Movement

Coastal populations of striped bass are anadromous: they spawn in freshwater but mature in salt water. Striped bass emigrate from freshwater areas of the Hudson River as early as fall of the first year of life. Striped bass probably inhabit the bays and rivers near the mouth of the Hudson River (TI 1977a) for about 2 years after they emigrate from the river (TI 1976b). By age III, some of the fish have begun a migratory cycle in which they return to the river to spawn.

Striped bass enter the lower portions of the Hudson River from mid- to late fall to overwinter (Raney et al. 1954, Clark 1968). This overwintering population was large enough to support an active commercial fishery from December through March prior to 1949, when the winter fishery was closed to conserve the population (New York State Conservation Department 1950).

During the winter many striped bass apparently escape the harsh physiological conditions along the Atlantic coastline by seeking the depths and lower salinities of the river. Clark (1968) hypothesized that winter temperatures in the shallow marine waters adjoining the Hudson River pose a threat of freezing the blood and tissue of striped bass, causing them to seek the less saline river water, which has a higher freezing point.

Stocks of other migratory species (e.g., the anadromous salmonids such as Atlantic and Pacific salmon) have been studied most frequently during their spawning migration to their natal streams and rivers. Salmonid spawning runs are composed of mature fish that constitute the parental stock available for production of each year class. Although iteroparous, striped bass are similar to the semelparous salmonids in that the annual spring spawning run of striped bass provides the opportunity to study the mature fish contributing to the production of a year class. However, striped bass differ from salmonids in that immature striped bass frequently accompany mature fish during the spawning run (McFadden et al. 1978, Jones et al. 1977, Trent and Hassler 1968). The degree to which the spring run represents either the spawning adults or the entire Hudson River stock is related to the timing and rate of return of both mature and immature fish. The accuracy of estimates of such stock characteristics as age composition, sex ratios, growth, age at maturity, and mortality rates are affected by the timing and rate of return of mature and immature fish each year.

The composition of both the early spring population and the spawning run in the Hudson River was evaluated through the Striped Bass Stock Assessment Program (Appendix A.I.D), conducted from mid-March through June. Because there was no winter sampling program, inferences concerning the composition of the overwintering population within the river were drawn from data collected in the late March and early April portion of the Stock Assessment Program.

Approximately 70% of the 4422 striped bass exceeding 200 mm in total length (TL) (age II and older) caught during 1977 in gill nets and haul seines used by TI were caught during March and April (Table III-1). Fish caught at this time were either overwintering or were early immigrants of the spawning run. Gill nets were fished between RM 27 and RM 59, and fishing effort was shifted spatially through time to maximize the catch and follow the run as it moved (Appendix Table B-1). Haul seines 900 ft (274 m) in length were deployed from RM 33 to RM 59. The most intensive seining was in Haverstraw Bay from RM 33 to RM 39. The areas sampled by gill nets and haul seines did not encompass the entire distribution of the run: commercial

Table III-1

Numbers of Striped Bass (>200 mm TL) Collected in Gill Nets and Haul Seines in Hudson River Estuary by Time Period and Region during 1977

	River Mile				
	27-33	34-38	39-46	47-59	Total
Mar 13-19	87	174	0	0	261
Mar 20-26	3	32	0	0	35
Mar 27-Apr 02	138	120	0	0	258
Apr 03-09	515	57	0	0	572
Apr 10-16	203	504	1	0	708
Apr 17-23	472	407	0	0	879
Apr 24-30	36	133	114	0	283
May 01-07	77	518	43	22	660
May 08-14	1	85	14	108	208
May 15-21	33	207	55	19	314
May 22-28	1	2	76	15	94
May 29-Jun 04	0	2	41	0	43
Jun 05-11	12	0	61	5	78
Jun 12-18	10	0	7	0	17
Jun 19-25	6	0	4	0	10
Jun 26-30	0	0	2	0	2
Total	1594	2241	418	169	4422

fishermen caught striped bass (McFadden et al. 1978) as far north as Hudson, New York (RM 117, KM 188), and some spawning occurred in the vicinity of Albany (subsection III.C). Nevertheless, striped bass collected from RM 27 to RM 59 represent the spring population and the spawning run because fish entering fresh water to spawn must first pass through the sampled area as they move upriver to the spawning grounds.

The size composition of the catch by gill nets and haul seines during March was diverse and probably indicative of the overwintering population (Figure III-4). By April, the most notable change in size composition was the increase in numbers of fish longer than 690 mm (TL), possibly indicating later immigration of some large fish. As the sampling season progressed, the length-frequency distribution of the catch changed significantly (X^2=1050, $p < 0.001$). The number of fish that were less than 690 mm

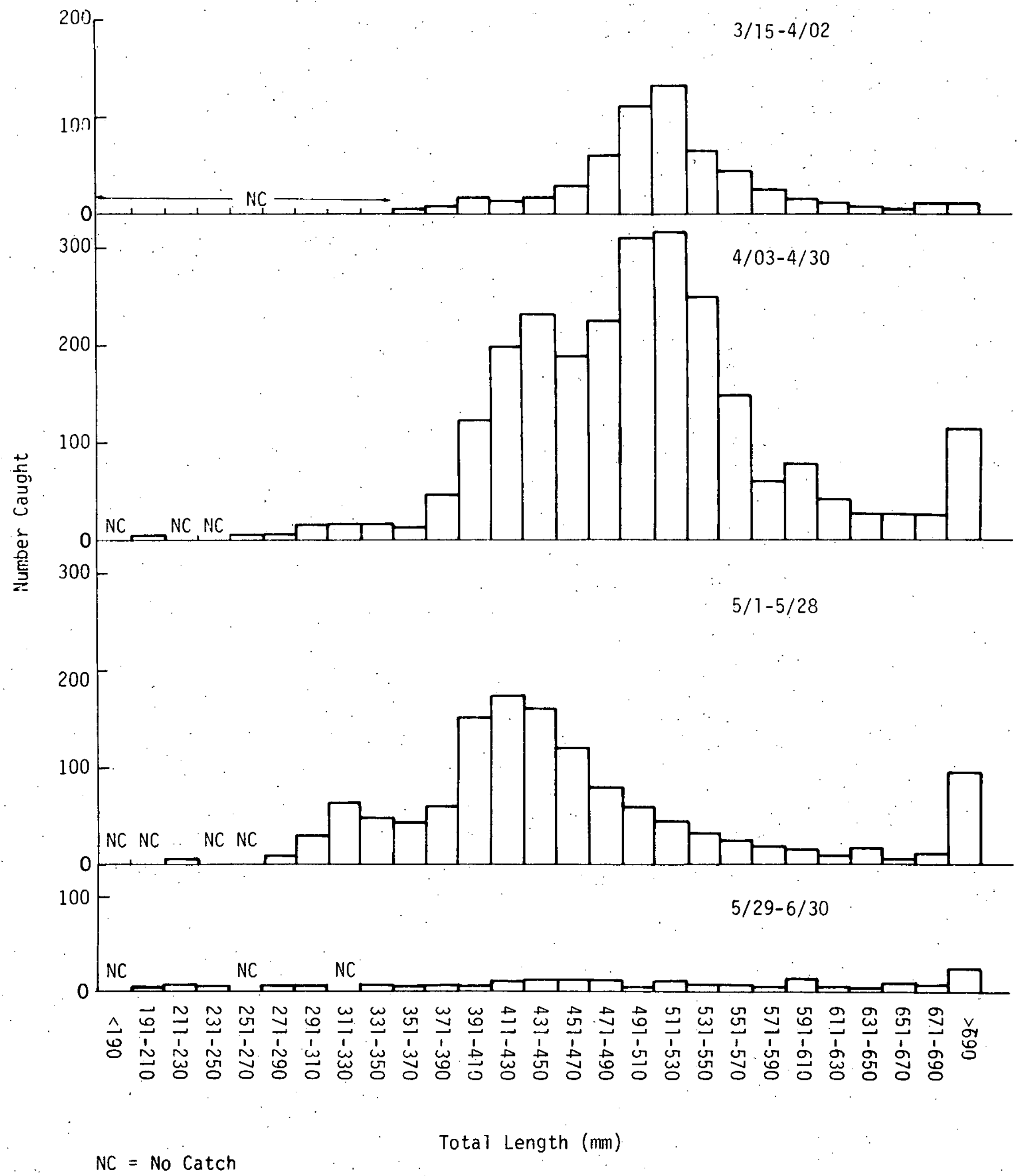


Figure III-4. Length Frequency of Striped Bass Caught by Gill Nets and Haul Seines between River Miles 27 and 59, Hudson River Estuary, 15 March-30 June 1977.

(TL) was reduced in May, while those that were longer than 690 mm (TL) remained nearly constant (Figure III-4). A similar reduction in numbers of small fish occurred in 1976 (Figure III-5). One plausible explanation of this general reduction in the number of small fish over time was an emigration of largely immature, non-spawning fish.

There were indications that fish occurring above RM 38 (KM 61) during March through June 1976 and 1977 were primarily mature, as might be expected since this area constituted the major spawning grounds. For age IV and older males and age V and older females (Tables III-2 and III-3), the percentage of mature fish within each age group during 1976 and 1977 was consistently greater above RM 38 than below (subsection III.B.5). These data are consistent with egg distributions (subsection III.C.1), which indicates that the major spawning grounds are above RM 38.

The timing of movement onto the spawning grounds appeared to differ for the two sexes, as shown by changes in sex ratio in the haul seines. Because haul seines are considered to be less size-selective than gill nets, their catches are judged to be more representative of the size composition of the population of striped bass. The proportion of males in haul seine catches in Haverstraw Bay significantly ($\alpha=0.05$) decreased from April through May in both 1976 and 1977 (Table III-4), which may reflect an earlier passage of males than females through this area and toward the spawning grounds. An earlier arrival of males on the spawning grounds was reported for striped bass also in the Roanoke River, North Carolina (Trent and Hassler 1968), in the Potomac River, Maryland (Jones et al. 1977), and for a congeneric species, the white bass, in Lake Mendota, Wisconsin (Horrall 1961).

Tag returns from 1977 were analyzed to determine the range and direction of movement of striped bass after the spawning season. From 15 March through 30 June 1977, 2813 striped bass were marked with nylon internal anchor tags (Floy FD-67c) and released at the site of capture (Tables III-5 and III-6). Tagged fish were recovered through TI sampling efforts and from other environmental studies as well as commercial and sport fishermen in the Hudson River and along the Atlantic coast. A reward of $5 per tag was paid for recapture information including tag number, date, method, and area of capture. Most fish (86%) were released between RM 30 and RM 48; 96% were between 300 and 800 mm in total length. The size distribution of tagged fish and areas of release during 1977 were similar to those during the 1976 tagging program (TI 1979a).

From March through December 1977, 378 tagged striped bass were recovered (Appendix Table B-2); 47 had been released prior to 1977, and the remaining 331 represented a 12% recovery rate for fish released in 1977. Of the 378 fish recaptured, 144 (38%) were taken outside the Hudson River and these fish were at large for an average of 150 days. Tags were returned from locations throughout the Hudson River estuary (Figure III-6); they were from as far north along the Atlantic coast as Newburyport, Massachusetts, and one from as far south as Slaughter Beach, Delaware (Figure III-7). Most (55%) of those recaptured outside the Hudson River were within 50 km of the river mouth (Figure III-8). The movement patterns shown by 1977 tag returns were similar to those shown by 1976 returns (McFadden et al. 1978, TI 1979a), particularly in that most migrating fish traveled northeastward after the spawning season. The tag recovery data substantiated the hypothesized patterns of annual migration summarized in subsection III.A.

Fish size, age, or sex did not determine the distance traveled by tagged striped bass. For fish released and recaptured during 1977 (only fish at large for at least 2 days were used for this analysis), there were no significant relationships between the distance from site of release to site of recapture and the size of the fish ($r=0.0027$, $p>0.05$) or the age of the fish ($r=0.0925$, $p>0.05$). The distances traveled by 30 males [mean of 46.8 mi or (74.9 km)] and by 19 females [mean of 49.4 mi or (79.0 km)] recaptured during 1976 and 1977 were not significantly different ($t=0.145$, $p>0.05$). Males and females were recaptured at approximately the same rate during 1977 ($\chi^2=1.09$; $p>0.05$), 6% and 9% respectively (10 of 179 males and 10 of 111 females released), considering only those fish for which sex was determined. Thus, it appears that males and females migrated in the same manner after spawning and may be equally subject to the coastal fisheries.

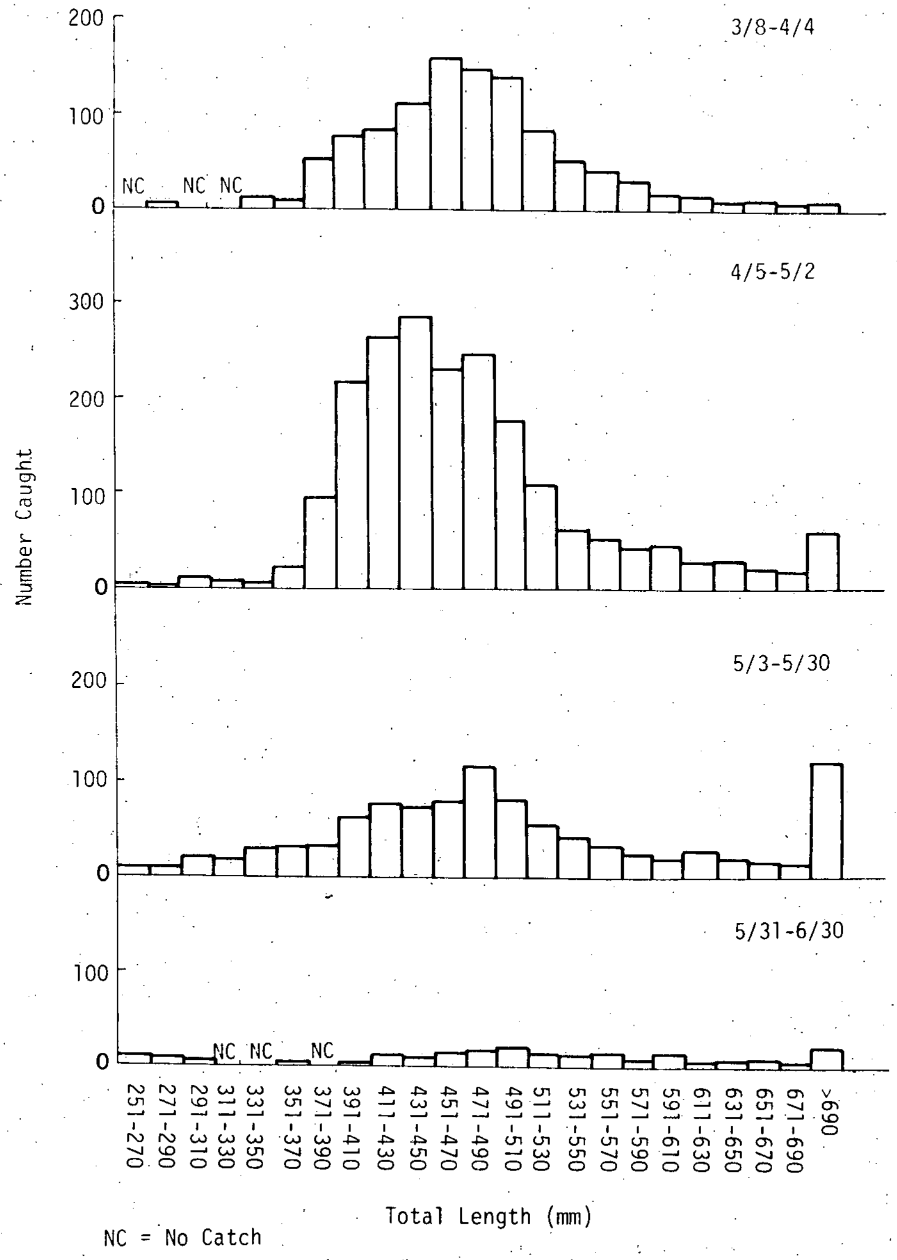


Figure III-5. Length Frequency of Striped Bass Caught by TI Gill Nets and Haul Seines between River Miles 25 and 62, Hudson River Estuary, 8 March-30 June 1976.

Table III-2

Percentage of Mature* Male Striped Bass Caught within Major Spawning Grounds of Hudson River (>RM 38) and below (<RM 38), March-June 1976 and 1977

	1976		1977		Total	
Age	>RM38	≤RM38	>RM38	≤RM38	>RM38	≤RM38
II	0 (0)**	17 (6)	0 (12)	23 (13)	0 (12)	21 (19)
III	33 (6)	50 (42)	17 (6)	39 (28)	25 (12)	46 (70)
IV	89 (9)	58 (24)	82 (17)	56 (64)	85 (26)	57 (88)
V	92 (25)	82 (28)	75 (4)	68 (19)	90 (29)	77 (47)
VI	94 (18)	67 (27)	100 (15)	80 (20)	97 (33)	72 (47)
VII	100 (9)	100 (3)	100 (6)	100 (12)	100 (15)	100 (15)
VIII	100 (9)	100 (4)	100 (3)	86 (7)	100 (12)	91 (11)
IX	100 (4)	100 (3)	100 (1)	0 (0)	100 (5)	100 (3)
X	100 (6)	100 (1)	100 (1)	100 (1)	100 (7)	100 (2)
XI	100 (8)	100 (3)	100 (2)	0 (0)	100 (10)	100 (3)
XII	100 (3)	0 (0)	100 (3)	100 (1)	100 (6)	100 (1)
XIII	0 (0)	0 (0)	100 (1)	0 (0)	100 (1)	0 (0)
XIV	0 (0)	0 (0)	0 (0)	100 (1)	0 (0)	100 (1)
XV	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
XVI	0 (0)	0 (0)	100 (1)	0 (0)	100 (1)	0 (0)

*Fish with a body weight:gonad weight ratio of < 235 were considered mature.
**Numbers in parenthesis are sample sizes.

Table III-3

Percentage of Mature* Female Striped Bass Caught within Major Spawning Grounds of Hudson River (>RM 38) and below (<RM 38), March-June 1976 and 1977

	1976		1977		Total	
Age	>RM38	≤RM38	>RM38	≤RM38	>RM38	≤RM38
II	0 (0)**	0 (1)	0 (14)	0 (10)	0 (14)	0 (11)
III	0 (2)	4 (23)	0 (4)	0 (23)	0 (6)	2 (46)
IV	0 (1)	7 (27)	0 (1)	5 (75)	0 (2)	6 (102)
V	33 (6)	20 (50)	75 (4)	7 (15)	50 (10)	17 (65)
VI	75 (12)	36 (33)	100 (15)	45 (33)	89 (27)	41 (66)
VII	82 (17)	89 (38)	96 (25)	82 (17)	90 (42)	87 (55)
VIII	89 (9)	91 (11)	100 (6)	86 (7)	93 (15)	89 (18)
IX	100 (2)	100 (2)	100 (4)	100 (1)	100 (6)	100 (3)
X	100 (11)	100 (12)	100 (3)	100 (2)	100 (14)	100 (14)
XI	100 (8)	100 (10)	100 (4)	100 (2)	100 (12)	100 (12)
XII	100 (3)	100 (7)	100 (7)	100 (1)	100 (10)	100 (8)
XIII	100 (2)	100 (3)	100 (4)	0 (0)	100 (6)	100 (3)
XIV	100 (1)	0 (0)	100 (3)	0 (0)	100 (4)	0 (0)
XV	100 (1)	0 (0)	0 (0)	100 (1)	100 (1)	100 (1)
XVI	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
XVII	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
XVIII	0 (0)	100 (1)	0 (0)	0 (0)	0 (0)	100 (1)

*Fish with a body weight:gonad weight ratio of < 70 were considered mature.
**Numbers in parenthesis are sample sizes.

Table III-4

Proportion of Male Striped Bass in Haul Seine Catches during April and May 1976 and 1977 in Hudson River Estuary below RM 38

	1976			1977		
	4/19-5/2	5/3-5/16	5/17-5/30	4/10-4/23	4/24-5/7	5/8-5/2
Number Caught	92	145	31	133	127	278
Proportion Male	0.68	0.40	0.25	0.77	0.58	0.52
		χ^2 = 24.64*			χ^2 = 24.11*	

*Significant at α=0.05; χ^2 test on numbers of males and females estimated from size-stratified subsampling for sex determinations.

Table III-5

Number of Tagged Striped Bass >200 mm in Total Length Released in Three Areas of Hudson River Estuary during 1977

	Time Interval								
River Mile (KM)	Mar 15 Mar 26	Mar 27 Apr 9	Apr 10 Apr 23	Apr 24 May 7	May 8 May 21	May 22 Jun 4	Jun 5 Jun 18	Jun 19 Jun 30	Total
Below 30 (48)	85	51	133	52	13	1	0	0	335
30 - 48 (48-77)	204	611	938	429	181	39	20	0	2422
Above 48 (77)	0	0	1	9	36	5	5	0	56
Total	289	662	1072	490	230	45	25	0	2813

Table III-6

Length Distribution of Striped Bass >200 mm in Total Length Tagged and Released in Hudson River Estuary (RM 27 to 59) during 1977

	Time Interval								
Total Length (mm)	Mar 15 Mar 26	Mar 27 Apr 09	Apr 10 Apr 23	Apr 24 May 07	May 08 May 21	May 22 Jun 04	Jun 05 Jul 18	Jun 19 Jun 30	Total
>200 - 299	0	1	1	2	9	0	1	0	14
300 - 399	8	4	30	59	63	0	3	0	167
400 - 499	81	153	501	275	81	5	3	0	1099
500 - 649	195	482	465	110	50	9	7	0	1318
650 - 799	5	22	53	25	8	5	5	0	123
>800	0	0	22	17	19	26	6	0	90
No Length	0	0	0	2	0	0	0	0	2
Total	289	662	1072	490	230	45	25	0	2813

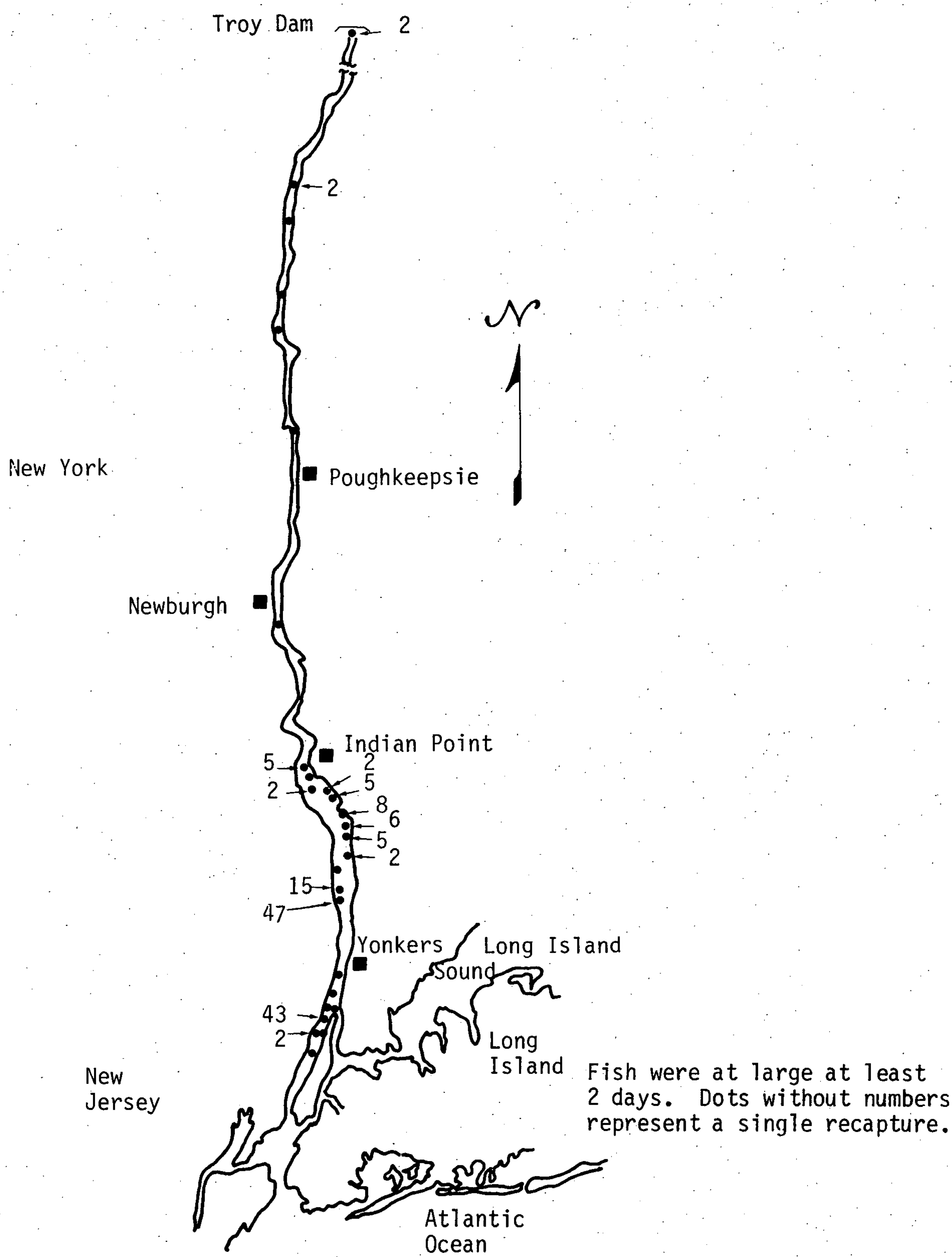
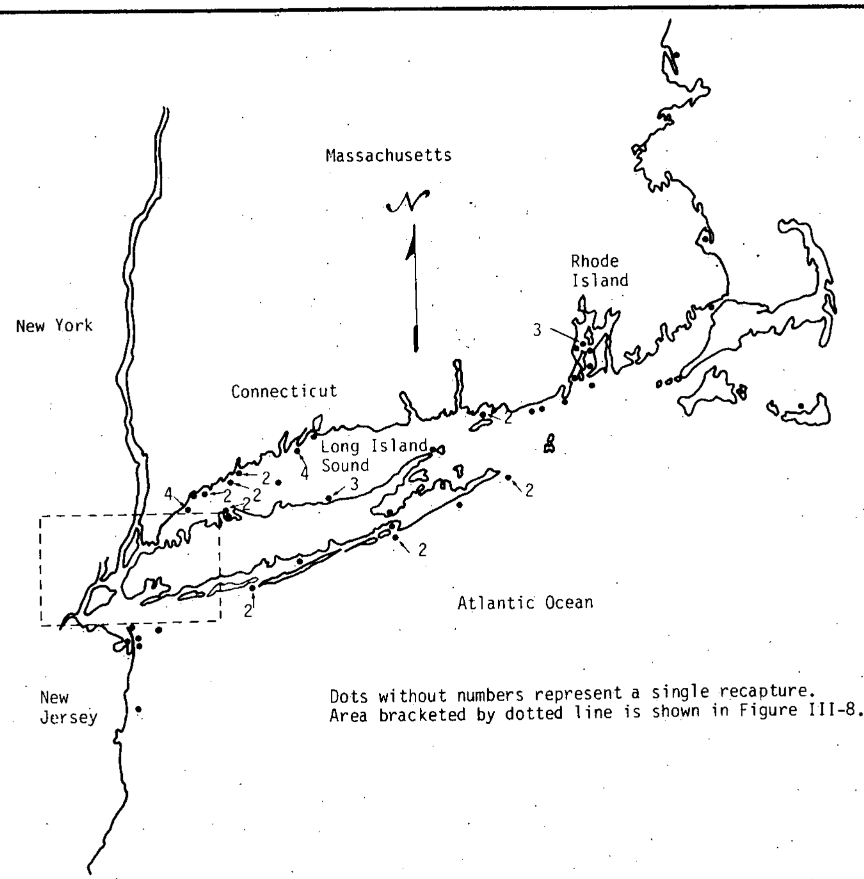


Figure III-6. Numbers and Locations of Adult Striped Bass Recaptured within Hudson River in 1977



Additionally: 1 - Atlantic City, N.J.
1 - Slaughter Beach, Del.

Figure III-7. Numbers and Locations of Adult Striped Bass Recaptured from Areas outside Hudson River in 1977

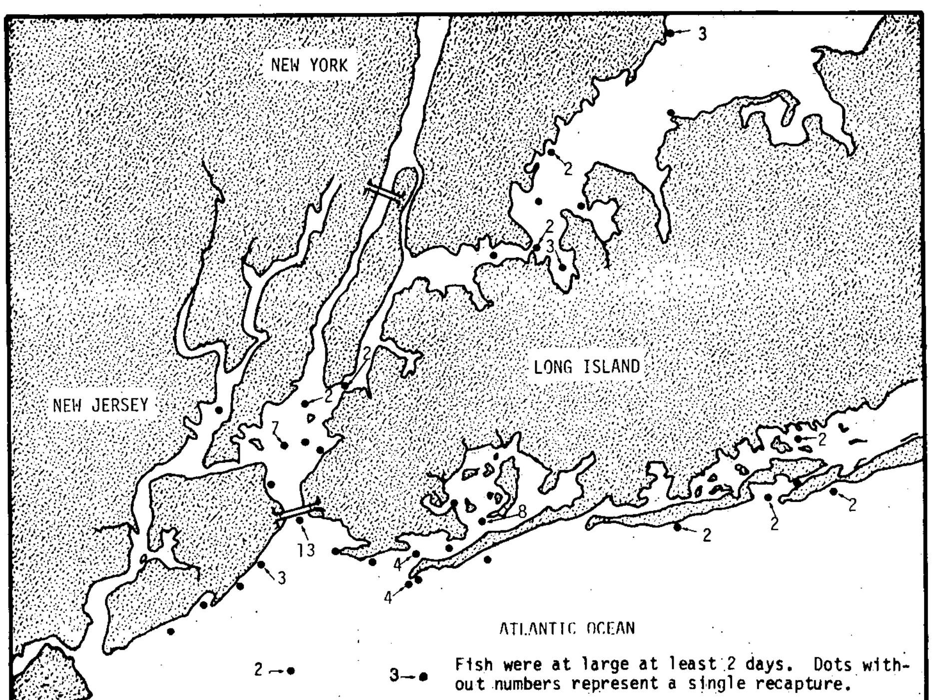


Figure III-8. Numbers and Locations of Adult Striped Bass Recaptured from Area Immediately outside Hudson River in 1977

2. Age Composition and Sex Ratio

A description of the age composition of the striped bass population within the Hudson River during the spawning run must take into account the migratory nature of the population and the selectivity of the sampling gear. As discussed in subsection III.B.1, a large portion of the population appeared to overwinter in the river and was present when sampling began in late March; by May, many of the younger fish (<550 mm TL) had emigrated while some of the older fish (>690 mm TL) were apparently joining the spawning run. This difference in migration pattern among ages, along with the earlier movement of males to the spawning grounds compared with females, influences the selection of an appropriate time and area for sampling. Descriptions of age composition may be further influenced if the sampling gear are selective toward particular sizes and therefore age groups.

Both gill nets and haul seines were used to estimate the sex ratio and age composition of striped bass since there were advantages in using the catch data from both gear. To minimize the bias introduced by size selectivity (Hamley 1975), only the catch from haul seines was used to describe size composition. Gill net data alone, while not providing an accurate representation of size (age) composition because of size selectivity, do provide additional information on the age and sex of fish within appropriate fish length intervals. Gill nets were deployed over a larger portion of the estuary than were haul seines and were fished in the shoals to supplement the haul seine sampling in the shore zone. The methods used to combine gill net and haul seine catch data are presented in Appendix B.

The catch of 538 fish in haul seines during the 6-weeks from 10 April to 21 May between RM 33 and RM 38 was chosen to estimate the size composition of the population. Since the area from RM 33 to RM 38 is downriver from the major spawning grounds, the spawners pass through this region during May and June (subsection III.B.1). The proportions of age groups and sexes within each 20 mm length interval of the haul seine catch were estimated from the combined haul seine and gill net catch of 1169 aged and sexed fish caught during 10 April-21 May below RM 39.

The population of striped bass greater than 200 mm (TL) during the 1977 spawning run consisted of age groups II through XIV (Table III-7) but was dominated by age group IV, i.e., the 1973 year class. It was estimated that 52% of the population was from the 1973 year class, the strongest within the last 8 years (subsection III.D.1.b). The proportion of the 1977 population constituting each age group declined from age IV to age X, after which each age group appeared equally abundant. Equal abundance of the older (> age X) age groups would not be expected since annual mortality should reduce each successive age group. The reason for the unexpectedly high proportion of older fish is unknown.

Age composition of the 1976 population for 19 April-30 May (in the same region and using the same methods) showed no single age group to be particularly dominant (Table III-7). One probable explanation for the lack of dominance by the 1973 year class during 1976 is that immature striped bass do not fully participate in the spring spawning run and are not fully recruited to the gill nets and haul seines until they are age IV or older. Thus, the dominant 1973 year class would not be expected to appear until 1977.

A change in sex ratio from 10 April to 21 May could be seen when age composition was estimated for each of the three biweekly periods composing the sampling interval (Figure III-9). The relative number of males ages III and IV decreased through time as the number of females ages III through VIII increased. The decline in number of males may reflect an earlier upriver movement of males or an exodus of young, possibly immature males from the river (subsection III.B.1).

The overall ratio of males to females in the 1977 population was close to 1:1, but males slightly outnumbered females until approximately age VII; after age VII, females outnumbered males. Such a change in sex ratio could be the result of recruitment of females to the migrating population at an older age than males or a lower annual mortality rate for females. The sex ratios calculated for the 1976 population appeared to differ, with females outnumbering males in all age groups (Table III-7). The reasons for the sex ratio differences in 1976 and 1977 are unknown but may have involved earlier departure of males from the major sampling area to the spawning grounds (subsection III.B.1) during 1976.

Table III-7

Age Composition of Striped Bass Collected in Gill Nets and Haul Seines in Hudson River below RM 39 from 19 April to 30 May 1976 and 10 April to 21 May 1977

Age	1976 Percent Male	1976 Percent Female	1976 Total	1977 Percent Male	1977 Percent Female	1977 Total
II	1.0	0.5	1.5	3.6	2.2	5.8
III	12.7	15.0	27.7	12.0	8.9	20.9
IV	10.1	11.0	21.1	28.5	23.2	51.7
V	6.4	11.3	17.7	4.9	3.9	8.8
VI	3.3	7.3	10.6	2.5	2.3	4.8
VII	1.3	7.5	8.8	1.4	1.5	2.9
VIII	0.5	1.8	2.3	0.4	1.4	1.8
IX	0.4	0.2	0.6	0.3	0.2	0.5
X	0	2.9	2.9	0	0.4	0.4
XI	0.5	2.5	3.0	0.1	0.5	0.6
XII	0	2.4	2.4	0	0.5	0.5
XIII	0	1.1	1.1	0.1	0.4	0.5
XIV	0	0.2	0.2	0.3	0.2	0.5
XVIII	0	0.2	0.2	0	0	0
Total	36.2	63.9	100.1	54.1	45.6	99.7

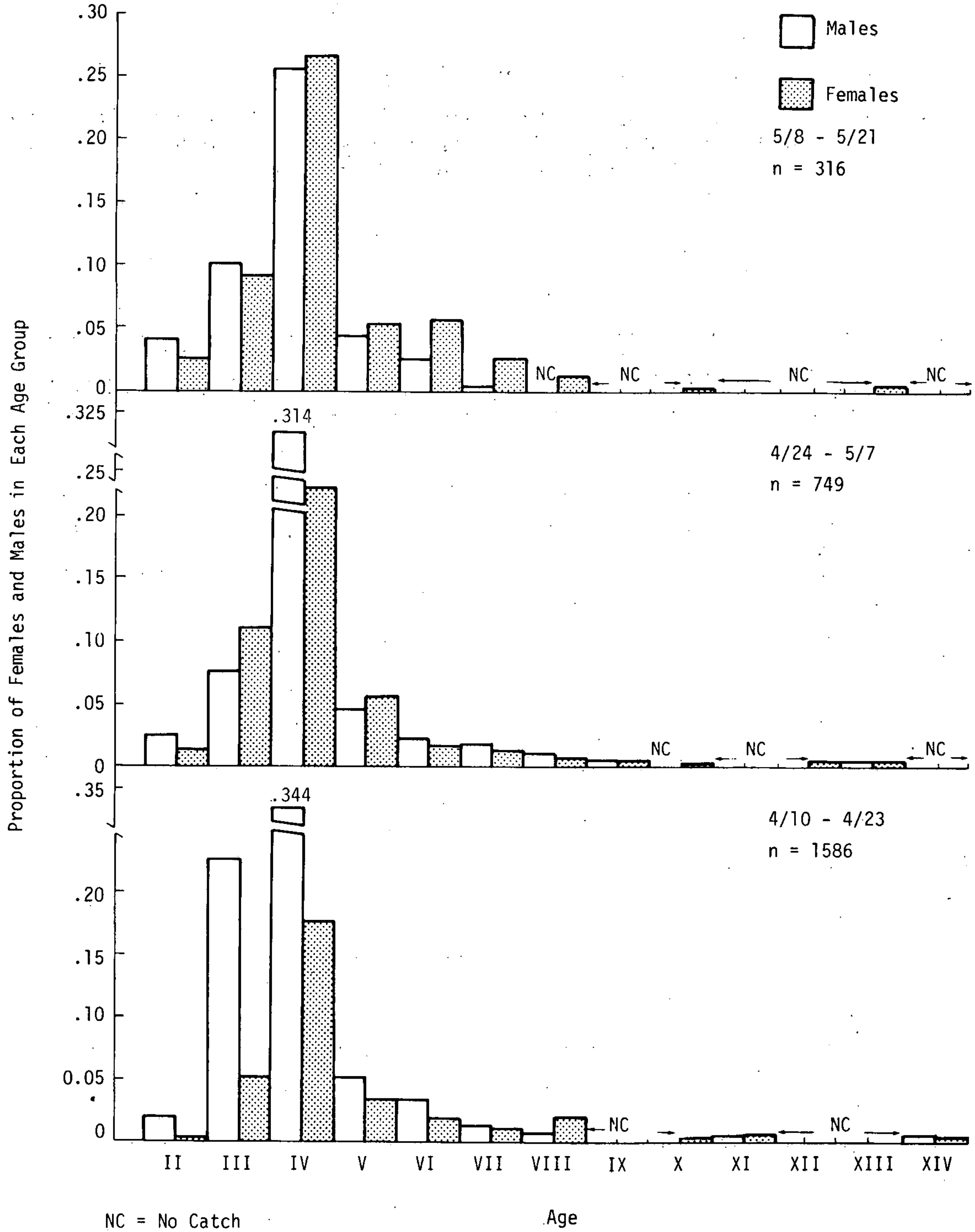


Figure III-9. Age Composition of Striped Bass Collected below RM 39, Hudson River, 1977, as Measured by Adjusted Gill Net and Haul Seine Data

3. Mortality Rates

Annual rates of mortality (or its complement, survival) based on estimates of age composition were examined. The age structure of a population reflected both reproductive success and mortality rates. Sources of mortality in fish populations were divided into two categories: natural mortality and fishing mortality (Ricker 1975). Natural mortality (expectation of natural death) includes causes over which man has little or no control, e.g. predation and disease. Fishing mortality (fishing exploitation rate, excluding impingement) results from sport and commercial fisheries; although Hudson River striped bass cannot be sold, they are caught by commercial fishermen in their pursuit of other fish species. Total annual mortality (the fraction of fish that are present at the start of a year but die during that year) is the sum of the annual fishing exploitation rate and the annual expectation of natural death:

$$A = u + v$$

where

A = total annual mortality rate
u = annual fishing exploitation rate
v = annual expectation of natural death

The total annual mortality rate can be estimated by comparing the abundance of successive age groups, as long as the size of year classes does not vary greatly and all age groups considered are equally vulnerable to capture, i.e., equally recruited to sampling gear (Ricker 1975). An examination of the abundance of year classes in the age composition of 1976 and 1977 (subsection III.B.2) revealed no great variation in year class strength except for the 1973 year class (age IV), which appeared especially strong in 1977. To avoid the potential influence of varying year class strength and to ensure full recruitment to the sampled population, ages V and VI were chosen for males and females, respectively, as the initial age groups in the calculation of total annual mortality rates. Ricker (1975) suggests an allowance of 1 year past the suspected age of recruitment, which, in the Hudson River population, was age IV for males and age V for females (subsection III.B.2).

The following general equation (Jackson 1939) was applied to calculate a mean total annual survival rate:

$$S = \frac{N_2 + N_3 \ldots N_n}{N_1 + N_2 + \ldots N_{n-1}}$$

where

S = survival rate

N_i = proportion (or number) of fish of age i caught (i = 1...N)

This equation was used for four age groups of the striped bass populations of 1976 and 1977. The relative proportions (Table III-7) of age groups V through VIII for males and age groups VI through IX for females were used in the calculation rather than numbers caught, since proportions rather than absolute numbers could be derived for age composition (Appendix B, pages B-14 through B-16). Separate estimates were made for males and females.

Mean total annual survival of male striped bass was estimated from 1976 and 1977 data to be 0.46 and 0.49, respectively (Table III-8); comparable estimates for females were 0.57 and 0.60. Therefore, total annual mortality rates (1-S) were 0.54 and 0.51 for males and 0.43 and 0.40 for females (1976 and 1977, respectively). These estimates, although not derived from data for males older than VIII and females older than IX, were assumed to apply to these older groups as well.

Table III-8

Mean Annual Survival Rates (S) Derived from Relative Proportions of Male and Female Striped Bass* in Gill Net and Haul Seine Collections below RM 39 of Hudson River, 19 April to 30 May 1976 and 10 April to 21 May 1977

Year Class	1976 Proportion Males	1976 Proportion Females	1977 Proportion Males	1977 Proportion Females
1972	-**	-	0.049	-
1971	0.064	-	0.025	0.023
1970	0.033	0.073	0.014	0.015
1969	0.013	0.075	0.004	0.014
1968	0.005	0.018	-	0.002
1967	-	0.002	-	-
	S = 0.464	S = 0.572	S = 0.489	S = 0.596
Ages:	V-VIII	VI-IX	V-VIII	VI-IX

*See Table III-7

** A dash indicates that survival was not calculated.

Annual fishing exploitation rate (u) was estimated from the rate of return from sport and commercial fishermen of striped bass tags applied during 1977. Of the 2813 fish tagged and released in the Hudson River, 108 were caught by commercial fishermen and 145 by sport fishermen (regardless of time at large) (Appendix Table B-2). Assuming negligible tag loss, these tag returns represented an annual exploitation rate of 3.9% for commercial fishing and 5.2% for sport fishing. These are minimum exploitation rates, because not all tags recovered by sport and commercial fishermen are returned and because the commercial fishery for striped bass in the Hudson River has been closed since 1976. Chadwick (1968), by assuming 100% return for tags offering a $5 reward and comparing the return of reward tags with that of tags offering no reward, reported a nonresponse rate of 38% in the sport fishery for striped bass in California. All tags applied to Hudson River striped bass offered a $5 reward, but it is doubtful that the reward provided enough incentive for all fishermen to return tags. However, if a 38% nonresponse rate is assumed, the adjusted total exploitation rate for Hudson River striped bass is approximately 15% for the combined sport and commercial fisheries.

Similar calculations for striped bass tagged and recovered in 1976 yielded a total fishing exploitation rate of approximately 10% (from a 5.0% return from sport and 1.0% return from commercial fishermen). The difference between the 1976 and 1977 exploitation rates appears to have originated from the difference in returns by commercial fishermen: a large portion of the tags returned in 1977 were from two fishermen who may not have been aware of our program during 1976 and were reluctant to return tags. Possibly, an additional year of publicity increased the response rate of commercial fishermen during 1977. Assuming an equal fishery exploitation of males and females (since they migrate similarly, subsection III.B.1), the annual expectation of natural death (A-u) for 1977 would be 0.36 for males (0.51-0.15) and 0.25 for females (0.40-0.15).

The estimated exploitation rates can be partitioned according to fisheries within and outside the Hudson River. The estimated exploitation rates (adjusted for 38% nonresponse rate) for the sport fishery within and outside the river during 1977 were 1.2% and 7.1%, respectively. Exploitation rates (adjusted) for the commercial fishery within and outside the river during 1977 were 6.1% and 0.1%, respectively. Therefore, the major sources of fishing mortality for Hudson River striped bass were the commercial fishery within the river and the sport fishery outside the river. A comparison of the reported commercial catch in the middle Atlantic region (New York, New Jersey, and Delaware) and sport catch in the north Atlantic region (New York and New England) during 1970 suggests that the sport catch exceeded the commercial catch by a factor of 16.5 along the Atlantic coast in the vicinity of New York (McFadden 1977a). Tag return data from outside the river in 1977 suggest a ratio of 124 sport returns to one commercial return. Therefore, it is possible that captures of tagged fish outside the river are not being reported as frequently by commercial fishermen as by sport fishermen. If a catch ratio of 16.5 in the sport vs commercial fishery were applied to 1977 tag return data, there should be approximately eight tag returns rather than one from the coastal commercial fishery. Therefore, it is unlikely that the suspected low response rate of coastal commercial fishermen greatly affected the overall exploitation estimates.

Commercial and sport fisheries appear to exploit fish of about the same size. There was no significant difference ($\chi^2 = 12.34$; $p > 0.05$) in the sizes of tagged striped bass (at large at least 2 days) caught by sport and commerial fishermen, TI, and in other environmental studies (Table III-9). Details of the 1977 simulated commercial fishery for striped bass in the Hudson River are described by McFadden et al. (1978) and Appendix B.

Table III-9

Total Number of Tagged Hudson River Striped Bass at Large 2 Days or More and Recaptured during 1977

Source	Total Length Interval (mm)					TOTAL
	<250	250-400	401-600	601-800	801-1000	
Commercial Fishermen	0	0	46	12	2	60
Sports Fishermen	2	13	128	13	6	162
TI and Other Studies	0	3	17	2	0	22
Total	2	16	191	27	8	244

$\chi^2 = 12.34$ (not significant at α=0.05)

4. Growth Rates (Yearling and Older)

The analysis of growth presented in this section is not intended to reveal factors controlling growth, but rather to characterize the growth of Hudson River striped bass as they age. Growth is described in this section by changes in the observed mean total length (TL) of fish in successive age groups captured in 1976 and 1977. The purpose of this analysis is to provide a basis for comparing growth in the Hudson River population to other populations (subsection III.B.7). Growth determines the age at which striped bass become available to sport and commercial fisheries [legal size in New York is 16 in. (40 cm) in fork length]; it also affects fecundity and age at maturity (subsection III.B.5). All of these variables are important in evaluating the response of the striped bass population to mortality from power plant operation (subsection III.E).

Length and weight data were recorded for age II and older fish caught by gill nets and haul seines deployed by TI and four commercial fishermen contracted by TI. (See Appendix A for field and laboratory methods.) These fish were caught from RM 27 to RM 69 during 15 March-30 June 1977. Length data for yearlings were obtained from 100-ft beach seine and bottom trawl collections from RM 24 to RM 46 during April and May 1977. From lengths and weights of aged fish, incremental growth (IG) rates were calculated as the difference between the mean total length of two consecutive age groups.

Female striped bass were significantly larger than males (ANOVA, $F=82.87$, $p<0.001$) in 1977 collections. This difference between sexes was detectable beginning at age IV (Table III-10). Mean weight data collected during 1977 (Table III-11) showed the same trends as did mean lengths. From 1973 through 1975, females were often larger than males after age III (McFadden 1977a), but such differences were rarely observed during 1976 (Table III-12). Mean lengths of fish caught in 1976 significantly differed (ANOVA, $F=6.66$, $p<0.01$) from those of fish caught in 1977, but the reasons are unknown since collection methods were similar.

Table III-10

Mean Total Lengths (TL) and Incremental Growth Rates (IG) of Striped Bass Collected in Hudson River by Gill Nets, Haul Seines, and Commercial Fishermen, March-June 1977

Age	Males: Mean TL (mm)	SE	N	IG	Range Test*	Females: Mean TL (mm)	SE	N	IG	Range Test*
I	95†	2.0	22	0	NT	95	2.0	22	0	NT
II	239	6.1	56	144	N	230	5.9	54	135	N
III	369	5.3	150	130	M	377	7.5	98	147	M
IV	453	2.3	732	84	L	469	2.7	568	92	K
V	484	3.7	222	31	J	516	4.9	156	47	I
VI	563	5.0	218	79	H	618	6.8	135	102	G
VII	606	8.9	86	43	G	669	7.4	101	51	F
VIII	647	16.7	22	41	F	728	16.8	39	59	F
IX	826	12.4	6	179	D, E	844	21.9	11	116	D, E
X	764	64.5	2	-62	F, E	926	43.8	11	82	B, C, D
XI	896	13.7	11	132	C, D, E	954	10.5	17	28	B, C
XII	929	14.6	6	33	B, C, D	992	14.6	15	38	A, B
XIII	869	27.7	5	-60	C, D, E	1011	14.0	14	19	A
XIV	945	37.0	5	76	B, C	1046	17.9	8	35	A
XV	0	0	0	0	NT	1010	0	1	-36	NT
XVI	856	0	1	0	NT	0	0	0	0	NT

*Results of Student Newman-Keuls Multiple Range Test. Means sharing a common letter are not significantly different ($p > 0.05$)
†Calculated from fish collected in beach seines and bottom trawls during April and May 1977; sex could not be determined for age I fish so data represent pooled males and females.
SE = Standard Error
N = Sample Size
NT = Not Tested

Table III-11

Mean Weights (g) and Incremental Growth Rates (IG) of Striped Bass Collected in Hudson River by Gill Nets, Haul Seines, and Commercial Fishermen, March-June 1977

Age	Males: Mean Wt. (g)	SE	N	IG	Females: Mean Wt. (g)	SE	N	IG
II	175	15.9	30	–	152	13.8	32	–
III	559	29.4	93	384	549	42.4	53	397
IV	1020	25.5	377	461	1104	29.1	273	555
V	1364	46.5	113	344	1579	64.6	85	475
VI	2198	79.0	127	834	2894	119.2	86	1316
VII	2653	154.2	50	455	3569	144.8	70	675
VIII	3244	267.3	17	591	4885	413.0	20	1316
IX	6600	50.0	2	3356	6293	889.2	7	1408
X	5250	800.0	2	-1350	9150	1660.0	6	2857
XI	7350	379.7	4	2100	9893	863.9	7	743
XII	9200	374.2	5	1850	11950	923.9	9	2057
XIII	7450	0	1	-1750	11450	417.3	4	-500
XIV	5250	0	1	-2200	13467	761.8	3	2017
XV	0	0	0	0	11850	0	1	-1617
XVI	7150	0	1	0	0	0	0	0

SE = Standard Error
N = Sample Size

Table III-12

Mean Total Length (TL) of Striped Bass Collected in Hudson River by Gill Nets, Haul Seines, and Commercial Fishermen, March-June 1976

Age	Males				Females			
	Mean TL (mm)	SE	N	Range Test*	Mean TL (mm)	SE	N	Range Test*
II	311	30.0	9	L	271	14.6	4	L
III	385	4.6	174	K	389	5.0	158	K
IV	439	4.6	145	J	456	4.2	163	I
V	521	3.6	282	H	524	3.4	312	H
VI	565	5.9	164	G	577	4.7	237	G
VII	640	13.6	52	F	690	8.7	135	E
VIII	741	18.5	23	D	737	22.2	32	D
IX	781	24.6	15	C, D	906	33.4	11	C, B
X	867	12.4	19	C	937	10.9	34	B
XI	873	12.5	24	C	958	9.1	35	A, B
XII	877	14.5	9	B, C	973	11.6	20	A, B
XIII	916	106.0	2	B, C	1010	24.4	10	A

*Results of Student Newman-Keuls Multiple Range Test. Means sharing a common letter are not significantly different ($p>.05$).
SE = Standard Error
N = Sample Size

5. Natality

Natality, an expression of the reproductive capacity or birth rate of a population, is a function of age at maturity, fecundity (egg production), age structure, and fertilization rate. Sampling and analysis during 1977 provided data on each of these variables except fertilization rate.

a. Age at Maturity

Maturity was determined for striped bass collected between RM 27 and RM 67 during April-June 1977 by TI in haul seines and gill nets and by four commercial fishermen contracted by TI. A 4-step method was used to determine maturity:

(1) All fish were classified by observation into four groups (Appendix Table B-10): obviously mature (eggs developed in females, milt running in males); obviously immature (gonads undeveloped); maturity not readily determinable; and spent (most of eggs or milt extruded).

(2) Obviously mature and immature fish were then used to calculate a body weight:gonad weight ratio that could be used as a criterion for separating mature from immature fish; spent fish were not used.

(3) Fish in the indeterminable category (29% of the 519 fish examined during 1977) and those visually classified as mature and immature were reclassified as mature or immature on the basis of their individual body weight:gonad weight ratios.

(4) All spent fish were added to fish classified as mature by the weight ratio method, and the overall percentage of mature fish in each age group was calculated. One hermaphrodite was collected in 1977, but was not used in the analysis.

The body weight:gonad weight ratios that best separated obviously mature from immature fish in 1977 were the same as those calculated by the same procedures in 1976 (McFadden et al. 1978) i.e., 235:1 for males and 70:1 for females. Scruggs (1955) also found a ratio of 70:1 best for distinguishing mature and immature female striped bass in the Santee-Cooper Reservoir, South Carolina. Of the Hudson River fish caught in 1977, three females and 13 males were visually classified as ripe but were immature by the ratio method; one male was classified mature by the ratio method but immature visually. Conflicts between the two methods occurred among only 5% of the fish visually classified as obviously mature or immature.

The percentages of males and females which were mature for each age group collected during 1977 were not significantly different ($\alpha=0.05$; multidimensional X^2 analysis, Fleiss 1972) from those in 1976 (Tables III-13 and III-14). Males begin to mature at age II, and all are generally mature by age VII. Females first mature at ages III through IV, and all are mature by age IX. Ages at maturity for females, based only on visual classification, were similar from 1973 through 1975 when sample sizes were generally smaller (McFadden 1977a).

Fish apparently ready to spawn (classified as "ripe and running") first appeared in collections during 8-14 May 1977 (Appendix Table B-4). By 15-21 May, spent fish were being caught, showing that spawning had begun by mid-May. One female (age VII) appeared to be in a "resting" condition, i.e.,

Table III-13

Age at Maturity* of Female Hudson River Striped Bass Examined from March through June 1976 and 1977

Age	1976		1977	
	Number Examined	Percent Mature	Number Examined	Percent Mature
II	1	0	24	0
III	25	4	27	0
IV	28	7	76	5
V	56	21	19	21
VI	45	47	48	62
VII	55	87	42	90
VIII	20	90	13	92
IX	4	100	5	100
X	23	100	5	100
XI	18	100	6	100
XII	10	100	8	100
XIII	5	100	4	100
XIV	1	100	3	100
XV	1	100	1	100
XVIII	1	100	0	

*Criterion - body weight:gonad weight ratio of < 70.

Table III-14

Age at Maturity* of Male Hudson River Striped Bass Examined from March through June 1976 and 1977

Age	1976		1977	
	Number Examined	Percent Mature	Number Examined	Percent Mature
II	6	17	25	12
III	48	48	34	35
IV	33	67	81	62
V	53	87	23	70
VI	45	78	35	89
VII	12	100	18	100
VIII	13	100	10	90
IX	7	100	1	100
X	7	100	2	100
XI	11	100	2	100
XII	3	100	4	100
XIII	0		1	100
XIV	0		1	100
XVI	0		1	100

*Criterion - body weight:gonad weight ratio of < 235.

there were indications of previous gonadal maturation and spawning, but her ova were not mature at time of capture. Other females in the population may have been in a similar resting stage since studies on other striped bass populations have shown that some females (e.g., ages VI to X and older) enter a refractory period when they produce no mature ova during a spawning season immediately after the year in which they spawned (Jackson and Tiller 1952, Lewis 1962, Jones et al. 1977).

Faster growing individuals within a year class appear to mature earlier. The mean length of mature males (Table III-15) and females (Table III-16) was consistently greater than that of immature fish within the same sex and age group. The largest immature fish of either sex had a TL of approximately 700 to 730 mm. More than half of the males were mature by about 450 mm TL and more than half of the females by about 625 mm TL.

Table III-15

Mean Length (mm) and Weight (g) of Immature and Mature Male Striped Bass Collected in Hudson River Estuary, April-June 1977

		Immature			Mature		
Age	Parameter	Mean	Standard Error	Number	Mean	Standard Error	Number
II	Length	231	5.9	49	288	9.0	5
	Weight	164	15.6	27	220	34.5	2
III	Length	345	8.1	60	382	11.6	33
	Weight	455	35.2	36	626	65.1	21
IV	Length	445	4.2	228	448	5.4	148
	Weight	948	41.0	119	997	47.2	82
V	Length	473	6.0	71	487	9.6	45
	Weight	1230	77.9	37	1445	103.0	29
VI	Length	510	9.5	25	599	8.7	86
	Weight	1425	97.9	12	2509	129.5	60
VII	Length	529	17.8	5	619	13.5	39
	Weight	1800	200.0	2	2802	234.8	27
VIII	Length	728	0.0	1	666	21.8	14
	Weight	4200	0.0	1	3379	335.4	12

Table III-16

Mean Length (mm) and Weight (g) of Immature and Mature Female Striped Bass Collected in Hudson River Estuary, April-June 1977

		Immature			Mature		
Age	Parameter	Mean	Standard Error	Number	Mean	Standard Error	Number
II	Length	230	5.9	54	0.0	0.0	0.0
	Weight	152	13.8	32	0.0	0.0	0.0
III	Length	377	7.6	96	0.0	0.0	0.0
	Weight	549	44.0	51	0.0	0.0	0.0
IV	Length	470	2.8	524	425	0.0	1
	Weight	1114	30.7	247	0.0	0.0	0
V	Length	499	6.3	95	568	21.3	7
	Weight	1463	85.5	50	2362	173.7	4
VI	Length	587	14.5	28	654	12.1	42
	Weight	2579	184.3	21	3490	228.7	30
VII	Length	638	26.3	5	683	8.6	53
	Weight	2880	329.6	5	3753	208.9	37
VIII	Length	701	0.0	1	777	19.5	22
	Weight	4150	0.0	1	5696	493.8	12

b. Fecundity

Fecundities were estimated by counting eggs in a sample aliquot from the ovaries of 42 ripe females collected from RM 27 to RM 67 during 3 May-16 June 1977 (McFadden and Lawler 1977). Mean fecundity ranged from 578,000 eggs at age VII to 2,214,000 eggs at age XIV (Table III-17). From 1973 through 1977, there was no obvious trend of increasing or decreasing fecundity for individual age groups.

Fecundity during 1977 was significantly correlated (Figure III-10) with weight ($r=0.9365$; $p<0.01$), length ($r=0.9390$; $p<0.01$), and age ($r=0.8218$; $p<0.01$). There were approximately 174 eggs/g of body weight (or 79,000 eggs/lb of body weight). This figure is close to 80,000 eggs/lb estimated for striped bass from the Roanoke River, North Carolina (Lewis and Bonner 1966) and 77,000 eggs/lb estimated during 1976 for Hudson River striped bass (McFadden et al. 1978).

Table III-17

Mean Fecundity (Number of Eggs per Female)* of Hudson River Striped Bass, April-June 1973-77

Year		Age IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
1973	Mean Fecundity			451,000	781,000	1,549,000	1,564,000	1,842,000		2,351,000		2,190,000	
	Standard Error			174,500	138,500	125,500	155,300	262,600		356,100		0	
	Sample Size	0	0	2	9	14	9	4	0	2	0	1	0
1974	Mean Fecundity		779,000	727,000	1,171,000	1,250,000	1,498,000	1,801,000	1,768,000				
	Standard Error		226,700	115,000	288,200	86,200	120,400	158,500	354,000				
	Sample Size	0	3	5	4	15	17	15	5	0	0	0	0
1975	Mean Fecundity	409,000	645,000	669,000	901,000	949,000	1,552,000	1,843,000	2,056,000	2,126,000			2,591,000
	Standard Error	0	0	38,600	238,200	227,200	199,700	140,200	249,700	263,300			0
	Sample Size	1	1	4	2	3	9	11	9	4	0	0	1
1976	Mean Fecundity	907,000	354,000	786,000	946,000	1,056,000	1,991,000	1,617,000	2,000,000	1,918,000	2,126,000		
	Standard Error	0	67,600	311,900	104,100	298,800	673,800	147,400	158,500	188,500	146,200		
	Sample Size	1	3	9	22	6	3	12	13	4	4	0	0
1977	Mean Fecundity			670,000	578,000	871,000	1,552,000	1,739,000	2,385,000	2,440,000		2,214,000	
	Standard Error			138,400	43,300	117,800	282,600	236,600	43,000	560,500		88,800	
	Sample Size	0	0	8	15	6	2	2	3	4	0	2	0
Avg.	Mean Fecundity	658,000	578,000	701,000	827,000	1,246,000	1,564,000	1,762,000	2,017,000	2,188,000	2,126,000	2,206,000	2,591,000
	Standard Error	249,000	120,700	106,800	60,300	74,300	87,900	78,400	115,800	180,000	146,200	51,900	0
Total	Sample Size	2	7	28	52	44	40	44	30	14	4	3	1

*Fecundity increases with age, length, and weight.

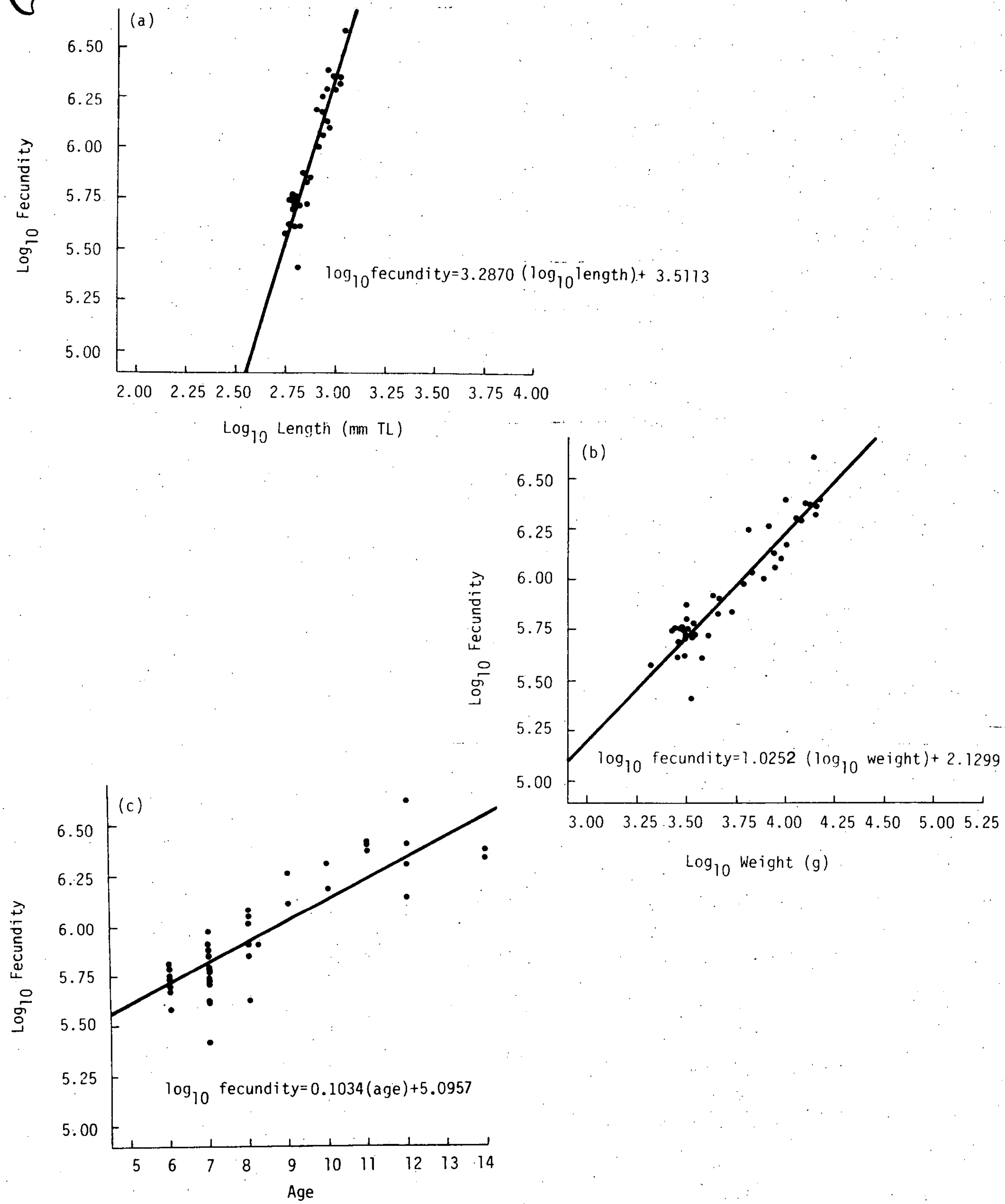


Figure III-10. Relationships between Fecundity and Length (a), Weight (b), and Age (c) for Female Striped Bass Collected from Hudson River in May and June 1977

c. Contribution to Spawn

The contribution of various age groups to the total egg production was estimated by applying the relative proportion of the total population of females that constituted each age group (corrected for percentage of mature fish) to its mean fecundity. It was assumed that mature fish of all age groups participated equally in spawning and had equal fertilization rates. The relative proportion of the population constituting each age group was derived by applying an estimated mean annual survival rate of 0.60 (subsection III.B.3) to each successive age beginning with age IV (Table III-18). Ages IV through VII females were found to contribute approximately half (46%) of the total egg production in 1977. The individual age groups contributing the largest proportions were VI, VII, VIII, and IX.

Table III-18

Contribution of Individual Age Groups to Striped Bass Egg Production in 1977

Age	Estimated* Proportion of Females	Percent Mature	Mean Fecundity	Number of Eggs (arbitrary units)	Percentage of Eggs Produced
IV	1.000	5	660,000	33,000	3.6
V	0.600	21	580,000	73,080	8.0
VI	0.360	62	700,000	156,240	17.1
VII	0.216	90	830,000	161,352	17.6
VIII	0.130	92	1,250,000	149,500	16.3
IX	0.078	100	1,560,000	121,680	13.3
X	0.047	100	1,760,000	82,720	9.0
XI	0.028	100	2,020,000	56,560	6.2
XII	0.017	100	2,190,000	37,230	4.1
XIII	0.010	100	2,130,000	21,300	2.3
XIV	0.006	100	2,210,000	13,260	1.4
XV	0.004	100	2,590,000	10,360	1.1
Total				916,282	100.0

*Based on 40% total annual mortality rate

6. Population Size

The size of the 1977 population of striped bass within the river greater than 400 mm TL (approximately age III and older) was estimated from mark and recapture methods. The estimate was made using fish larger than 400 mm (TL) tagged from RM 27 to RM 69 during 15 March-4 June 1977 and obtained from gill nets, haul seines, and four commercial fishermen contracted to TI.

The Schumacher-Eschmeyer multiple census technique (Ricker 1975) was used to calculate population size. This technique involves many of the same assumptions implicit in the mark-recapture estimates of juveniles (subsection III.D.1). The Schumacher-Eschmeyer estimate was calculated as follows:

$$1/\hat{N} = \frac{\Sigma(R_i M_i)}{\Sigma(C_i M_i^2)}$$

where

$\hat{N}$ = estimated population size

C_i = total catch during time interval i

M_i = total number of marked fish available for recapture at midpoint of time interval i

R_i = number of recaptured fish in C_i

A 90% confidence interval (CI) for $\hat{N}$ was determined from:

$$CI = \frac{\Sigma(C_i M_i^2)}{\Sigma(R_i M_i) \pm t_{k-2}\,(0.05)\left[S^2\,\Sigma\,(C_i M_i^2)\right]^{1/2}}$$

where

$t_{k-2}(0.05)$ = t value for k sampling intervals (at α=0.10)

and

$$S^2 = \frac{\Sigma \dfrac{R_i^2}{C_i} - \dfrac{\Sigma(R_i M_i)^2}{\Sigma(C_i M_i^2)}}{k - 2}$$

The Schumacher-Eschmeyer estimate is a weighted linear regression of R_i/C_i as a function of M_i with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$ where β is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber 1973). When the values of R_i/C_i are weighted by the catch (C_i), the estimate for $1/\hat{N}$ equals the slope β.

The estimate of population size was made by allowing marked fish which had been at large for at least 2 days to mix with unmarked fish and thus avoid a type C error, which was probably most severe (Appendix B). The estimate of the 1977 population was 571,000 fish with 90% confidence interval of 293,000-11,622,000. The 1977 population was therefore similar in size to the 1976 population, estimated to be 513,000 with a 90% confidence interval of 282,000-2,819,000. The higher upper confidence limit in 1977 resulted from greater variation about the regression line (Appendix B, pages B-30 through B-32).

A simple check on the accuracy of the population estimate of 571,000 fish was made by successively applying annual survival rates of 0.20 (young-of-the-year to yearling), 0.40 (yearling to age II), and 0.50 (age II and beyond) to an assumed initial population of 15 million young-of-the-year (estimates have ranged from approximately 12 to 20 million; subsection III.D.1.a). Survival rates of 0.20 and 0.50 approximate those calculated for young-of-the-year (subsection III.D.2) and age V and older (subsection III.B.3), respectively. The survival rate for yearlings (0.40) was assumed. The estimate of the combined numbers of ages IV-XV striped bass resulting from this exercise was 600,000 fish, only slightly higher than 571,000, suggesting that our estimate for the size of the striped bass population (>400 mm TL) in 1977 is reasonable.

7. Comparison with Other Striped Bass Populations

Striped bass have been studied most intensively in areas where they have supported a large commercial or sport fishery, particularly along the Atlantic and Pacific coasts. Perhaps the best outside sources of information regarding the potential for change in the Hudson River population are the studies on other coastal populations such as those in Chesapeake Bay, the

Sacramento-San Joaquin River system in California, the Roanoke River and Albemarle Sound in North Carolina, and Coos Bay in Oregon. Much of the variation observed among these populations may be attributed to differing environmental factors such as climate. However, a comparison of the Hudson River population to these other populations is useful for assessing the potential response of the Hudson River stock to the increased mortality of young striped bass due to power plant operation (subsection III.E.2). Changes in growth rates, age of maturity, mortality rates, and fecundity can occur in fish populations and thereby compensate for impingement and entrainment losses at power plants.

Intensive studies on the population characteristics of adult striped bass were begun in the Hudson River in 1976. Two years of data (1976 and 1977) were available for this report to assess any changes in important population characteristics such as age composition and mortality rates. Limited sampling during 1973-75 provided additional information on growth, movements, maturation rates, and fecundity. Comparisons with data from other populations supplement the data available for the Hudson River.

a. Mortality and Exploitation

The only published estimates of total annual mortality for striped bass populations outside the Hudson River came from the Sacramento-San Joaquin River system in California (Chadwick 1968; Stevens 1973; Smith 1974, 1975, 1976; Kohlhorst 1977; Collins 1978). These estimates, which were derived from the return rate of tags over a period of several years after release, ranged from 0.321 to 0.681 compared with 0.40 to 0.54 for Hudson River striped bass. Where separate estimates for males and females were available, total mortality rates appeared to be equal for the two sexes in the California population, whereas males in the Hudson River (subsection III.B.3) had the higher estimated mortality rates.

The apparent difference between the two populations may be explained by either a higher exploitation of males or an underestimated mortality rate for females in the Hudson River populations. Since Hudson River females are recruited approximately 1 year later than males to the spring population in the Hudson River (subsection III.B.2), their total mortality rate should reflect a lower exploitation by the commercial fishery in the river. Samples from the 1977 catch of commercial fishermen (Table B-7) showed the proportion of males caught within ages III and IV was higher than that of females, but a difference in exploitation of the two sexes was not as evident from 1976 data (Appendix Table B-6). However, fishing exploitation rates for males in the Hudson River may not be sufficiently higher than that for females to account for a difference of up to 20% (40% vs 60% total mortality); tag returns from Hudson River fish indicate a total annual fishery exploitation of only 15% (subsection III.B.3). Thus, much of the difference in total mortality rates between Hudson River male and female striped bass may be due to an underestimation of mortality for females.

The possibility that female mortality was underestimated results from possible violation of a basic assumption inherent in the procedure for estimating mortality. One assumption of a mortality estimate is that the proportion of the catch in each age group accurately represents the true proportion of the population in each age group. One factor that may violate this assumption is incomplete recruitment of the younger age groups to the spawning run. The younger age groups consist of mature and some immature fish present in the spawning run. It is possible that there is a large contingency of immature females that do not make the spawning run and thus are not adequately represented in the catch. If this possibility is true, the proportion of the catch in the younger age groups would be underestimated, and lead to an underestimate of the total mortality for females.

Fishing exploitation rates for Hudson River striped bass are approximately the same as those reported recently for the California population (Stevens 1973; Smith 1974, 1975, 1976; Kohlhorst 1977; Collins 1978) but are lower than earlier estimates for the California (Chadwick 1968) and Chesapeake Bay (Mansueti and Hollis 1963) populations. The 1977 fishing exploitation estimate of 15% for Hudson River striped bass closely matches the 1971-76 annual estimates of 14.4% to 20.5% for the Sacramento-San Joaquin River system. Chadwick (1968) earlier estimated annual fishing exploitation rates of 19.0% to 37.2% for the California fishery. Chesapeake Bay fish are apparently exploited even more heavily, with annual estimates of 35% to 45% for 1959-61 (Mansueti and Hollis 1963). Morgan and Gerlach (1950) estimated a 19% annual striped bass exploitation rate in Coos Bay, Oregon, during 1950 by the commercial fishery alone. The accuracy of estimates for Hudson River fish depends greatly on the estimated nonreturn rate of recovered tags, a rate estimated to be 38% (Chadwick 1968). Also, fishing exploitation estimated for 1976 and 1977 should be lower than in previous years since the commercial fishery in the Hudson River was closed after the 1975 season.

b. Age Composition

Except for estimates from the commercial catches in some rivers and areas of the Chesapeake Bay region (Table III-19), derived from pound nets and fyke nets, which are considered to be relatively nonsize-selective (Grant 1974), there are few estimates of age composition for striped bass populations other than those in the Hudson River. Age II striped bass in Chesapeake Bay and its tributary rivers appear to be fully recruited to the commercial catch and dominate the population, while the frequency of older ages rapidly declines (at an apparent annual survival rate of 30%) until there are relatively few fish beyond age V (Table III-19). The Sacramento-San Joaquin population appears more like the Hudson River population; recruitment to the exploitable population (legal size in California is 40.6 cm) occurs at age III, after which the frequency of successive age groups reflects an approximate 50% decline each year.

Table III-19

Age Composition of Striped Bass (Age II and Older) in Several Estuarine Systems

System	Age Composition Percent						Source
	II	III	IV	V	VI	≥VII	
Chesapeake, Maryland	18	43	13	22	*	4	Tiller, 1950**
James River, Va.	53	18	9	3	4	12	Grant 1974 †
York River, Va.	66	19	6	3	2	5	Grant 1974
Rappahannock River, Va.	64	19	6	2	1	8	Grant 1974
Sacramento-San Joaquin, California	--	47	23	12	6	12	Collins 1978 ‡
Hudson River, NY	2	28	21	18	11	20	TI, 1976 data ‡
Hudson River, NY	6	21	52	9	5	7	TI, 1977 data

*Age VI fish are included with age VII or older.

**From commercial pound net catches of 1944 and 1945.

†From commercial pound net and fyke net catches of 1967-1971.

‡From stratified mark/recapture population estimates of 1969-1976; age II fish are not included.

‡See Table B-6.

The age composition of striped bass from North Carolina may be inferred from a fish kill (presumably nonsize-selective) in the Roanoke River in 1963 (Trent and Hassler 1968). Recovered males were predominantly 41 to 48 mm (16 to 19 in.) fork length (FL) or approximately ages III and IV; most females were 51 to 66 mm (20 to 26 in.) FL or ages IV through VIII. The same age groups also dominated the commercial catch by gill nets during 1963-65: 90% of the males were ages III and IV and 85% of the females were ages IV and V. The oldest reported fish were age XIII.

c. Growth

In an earlier review of growth of striped bass from anadromous and landlocked populations (McFadden et al. 1978), growth was found to be more rapid in landlocked populations. Incremental annual growth rates (Table III-20) of Hudson River striped bass based on 1977 data (subsection III.B.4) did not differ significantly (for males: t=0.174, p>0.05; for females: t=0.695, p>0.05) from those for Chesapeake fish (Mansueti 1961a). Male Chesapeake fish did appear larger at ages VII and older than Hudson River males in 1977 (Figure III-11), but this would not have been as true for males in 1976 (subsection III.B.4). Chesapeake females tended to be larger than Hudson River females up to age IX, after which they were approximately the same size (Figure III-12).

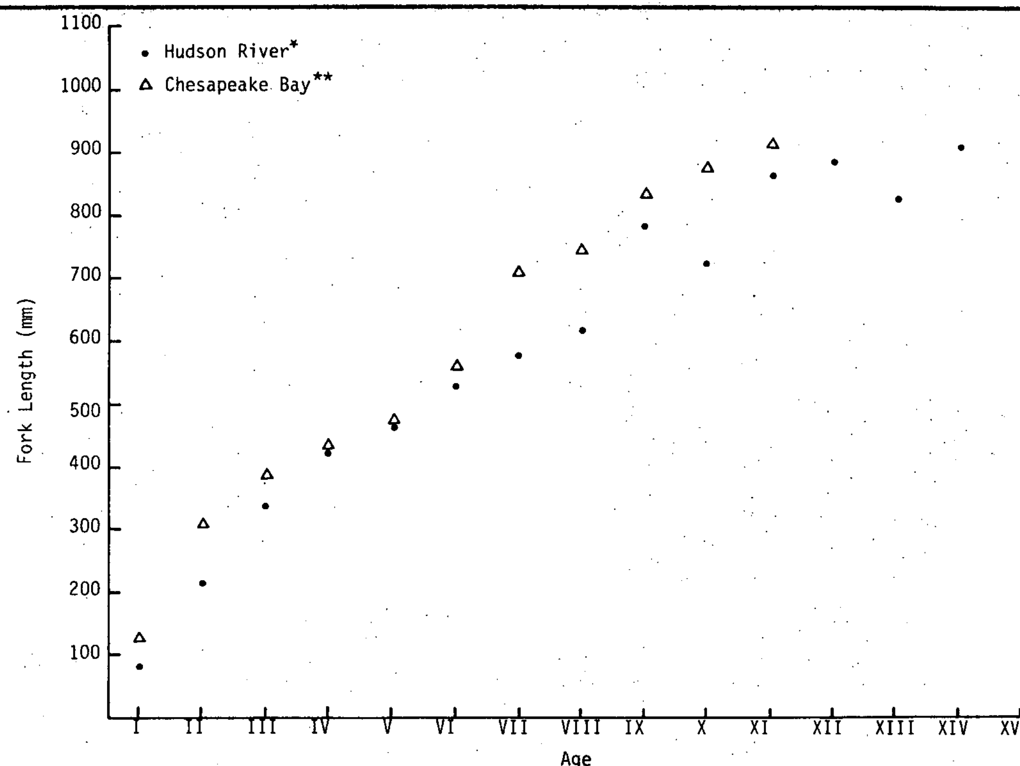
Table III-20

Incremental Growth Rates (mm) of Striped Bass from Chesapeake Bay, Maryland, and Hudson River Estuary

	Chesapeake Bay*		Hudson River**	
Age	Males	Females	Males	Females
III	65	90	126	142
IV	46	50	82	89
V	43	138	30	46
VI	99	64	76	99
VII	126	77	42	49
VIII	45	36	40	57
IX	82	62	173	113
X	45	77	-60	79
XI	50	11	128	27

*Mansueti 1961a. Back calculated and measured fork length are average.

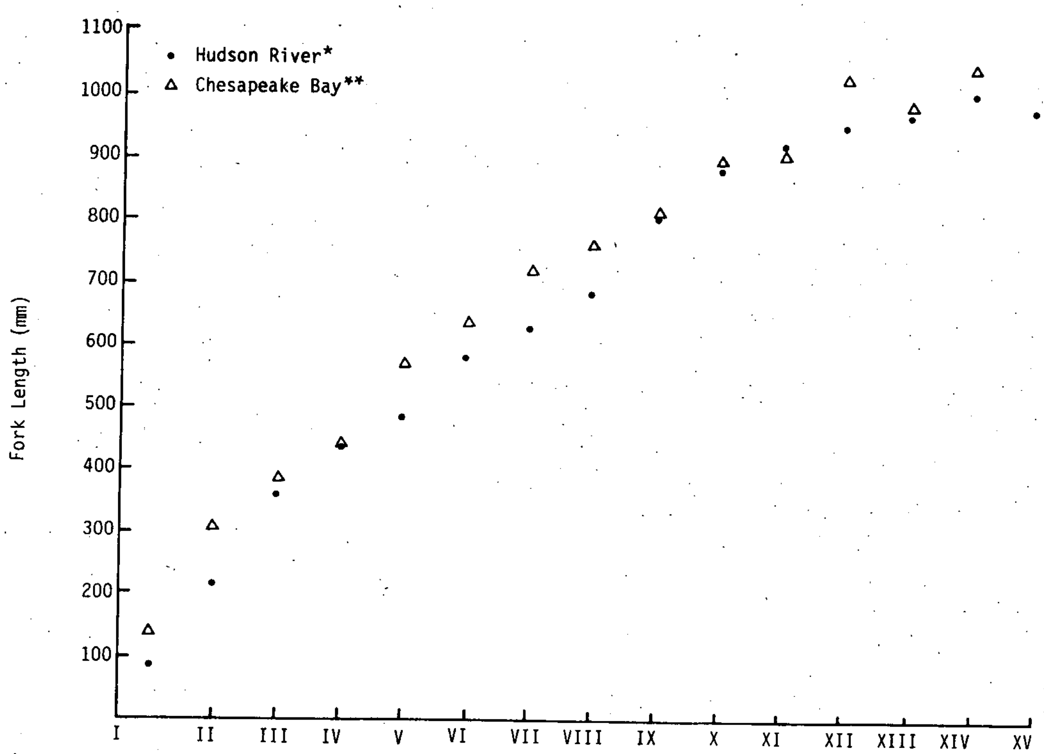
**1977 converted fork length (from total length) by FL = -13.313 + 0.969249 TL



*Collected in 1977. Fork length converted from total length by FL = 0.9692 TL - 13.313

**Mansueti 1961a. Backcalculated and measured fork length are means

Figure III-11. Mean Fork Length (mm) of Male Hudson River and Chesapeake Bay Striped Bass



*Collected in 1977. Fork length converted from total length by Fl = 0.9692 TL -13.313

**Mansueti 1961a. Backcalculated and measured fork length are means

Figure III-12. Mean Fork Length (mm) of Female Hudson River and Chesapeake Bay Striped Bass

d. Age at Maturity

The greatest difference between the Hudson River population and other striped bass populations is age at maturity. The age at which 100% of Hudson River females are mature (age IX) is delayed 2 to 4 years compared with that of other populations (Table III-21). The rate of maturity is not solely a function of latitude. On the west coast, females mature 2 years earlier in Oregon than in California; and on the east coast, females in the Santee Cooper Reservoir, South Carolina, mature 1 year later than in Maryland and 2 years later than in North Carolina. The Oregon and Hudson River populations are located at about the same latitude, yet the Hudson River female population is fully mature 3 to 4 years later.

Table III-21

Age at Maturity for Female Striped Bass in Several Estuarine Systems

System	Percent Mature by Age							Reference
	III	IV	V	VI	VII	VIII	IX+	
Sacramento San Joaquin California	*	35	87	98	100	100	100	Scofield 1931
Coos Bay, Oregon	18	68	100	100	100	100	100	Morgan and Gerlach 1950
Albemarle Sound-Roanoke R., North Carolina**	3	78	100	100	100	100	100	Lewis 1962
Albemarle Sound-Roanoke R. North Carolina*	4	94	100	100	100	100	100	Lewis 1962
Potomac R., Maryland spawning area	44	79	99	100	100	100	100	Jones et al. 1977
Potomac R., Maryland overwintering area	17	43	86	100	100	100	100	Jones et al. 1977
Santee-Cooper Reservoir South Carolina	-	23	65	85	100	100	100	Scruggs 1955
Hudson River	4	7	21	47	87	90	100	TI, 1976 data
Hudson River	0	5	21	62	90	92	100	TI, 1977 data

*Not reported
**2 years of study: 1956-57 and 1957-58

Males also mature later in the Hudson River than in other populations, particularly compared with those in the Potomac River, Maryland (Table III-22), where the difference in age of full maturity is approximately 3 years. The maturity of males has not been studied as intensively as that of females, but there are some reports of early maturity for males in other populations. Morgan and Gerlach (1950) stated that the majority of males in Coos Bay, Oregon, were mature by age III and that mature males were found in all age groups except age 0 (young-of-the-year). Scruggs (1955) found males to be mature at age I in the Santee-Cooper Reservoir, South Carolina, but the majority were mature at age II.

Maturation begins when striped bass attain a certain size, although this size may differ as much as 100 mm among several populations. Although published reports rarely provide enough detail to determine precisely the size when maturation begins, this size can be approximated. Females have been reported to start maturing at approximately 400-500 mm in length (Table III-23). Males first mature at approximately 200-300 mm.

Table III-22

Age at Maturity for Male Striped Bass, Potomac and Hudson River Systems

System	Percent Mature by Age								Reference
	II	III	IV	V	VI	VII	VIII	IX+	
Maryland, Potomac R. spawning area	93	99	100	99	100	100	100	100	Jones et al 1977
Maryland, Potomac R. overwintering area	*	92	96	100	100	100	-	-	Jones et al 1977
Hudson River	17	48	67	87	78	100	100	100	TI, 1976 data
Hudson River	12	35	62	70	89	100	90	100	TI, 1977 data

*Not reported

Table III-23

Lengths of Male and Female Striped Bass at Initiation of Maturity

Study Area	Males	Females	Reference
Chesapeake Bay	190 mm FL	432 mm FL	Vladykov and Wallace 1952
Santee-Cooper Reservoir, South Carolina	254 mm TL	508 mm TL	Scruggs 1955
Potomac River	324 mm FL	443 mm FL	Jones et al 1977
Coos Bay, Oregon	*	483 mm FL	Morgan and Gerlach 1950
Hudson River	253 mm TL	425 mm TL	TI, 1977 Data

FL = fork length
TL = total length

For Hudson River striped bass, fork length converted to total length by:

$$FL = -13.313 + 0.969249\ TL$$

*Not reported

e. Fecundity

The fecundity of Hudson River striped bass is similar to that estimated for other striped bass populations (Morgan and Gerlach 1950, Jackson and Tiller 1952, Lewis and Bonner 1966). Using reported regressions for mean fecundity on body weight, 6-kg females produced approximately 1.0 million eggs in the Roanoke River, 0.9 million eggs in Chesapeake Bay, 1.2 million eggs in Coos Bay (Oregon), and 1.0 million eggs in the Hudson River. Mean fecundities for 14-kg females are 2.3 million, 3.2 million, 3.1 million, and 2.4 million, respectively, for the four systems.

f. Population Size

The Hudson River striped bass population is considerably smaller than the populations in the Potomac River and the Sacramento-San Joaquin system. Zankel et al. (1978) estimated from the density of fish observed by acoustic surveys that in the Potomac River population there were 3 to 5 million striped bass having a fork length exceeding 500 mm. Mark-recapture estimates for age III and older striped bass in the Sacramento-San Joaquin system ranged from 1.6 to 2.0 million during 1969-76 (Collins 1978). These populations are three to ten times larger than the Hudson River population, which was estimated at approximately 570,000 (subsection III.B.6) in 1977.

g. Conclusion

In this study of stock characteristics encompassing primarily the 1962-75 year classes, there are no indications of overexploitation of the Hudson River stock of striped bass through either fishing or power plant impact. Possible symptoms of overexploitation include high total mortality rates and concomitant reduction in numbers of older fish, rapid growth leading to early maturity, and increased fecundity (Watt 1968, Royce 1972, Healey 1978). Longevity of striped bass in the Hudson River is equal to or greater than that in other systems, as shown by the relative abundance of older fishes in estimates of age composition. Total annual mortality of Hudson River striped bass recruited to the sport and commercial fisheries was similar to that in the Sacramento-San Joaquin system, where only a sport fishery exists. Total fishery exploitation in the Hudson River is lower than in the Chesapeake system and approximately equal to that in the Sacramento-San Joaquin system. Maturity in the Hudson River compared with that in other populations is delayed 2 to 4 years. Although earlier maturity in southern populations (the Hudson River) is a common phenomenon among fishes (Scott and Crossman 1973, Leggett and Carscadden 1978), late maturity in the Hudson River suggests the possibility of earlier maturity as a compensatory response to power plant impact. Growth rates and fecundity of striped bass in the Hudson River are similar to those in other systems examined.

C. LIFE STAGES

This subsection describes the distribution of the 1977 year class of striped bass in the Hudson River estuary, and relates it to that of previous years (1974-76). Discussions are based on the results of riverwide sampling conducted by TI (methods are presented in Appendix A), including the Ichthyoplankton Survey (designed to sample fish eggs and larvae) and the Fall Shoal, Beach Seine, and Bottom Trawl Surveys (designed to collect juveniles or young-of-the-year and yearlings). The early life stages are divided into three categories: (1) eggs, (2) yolk-sac and post yolk-sac larvae, and (3) juveniles and yearlings. The first subject in each category is distribution during 1977 (and during the first half of 1978 for yearling fish). This is followed by a discussion of the factors that may affect the distribution of the organisms (e.g., physicochemical conditions and behavioral traits). Finally, to detect any variation across years, distributions during 1974, 1975, and 1976 are compared with 1977 observations.

Distribution during 1977 is discussed from two perspectives on abundance, standing crop, and density (catch per volume or catch per effort). Ichthyoplankton densities are weighted by stratum or regional volumes to determine standing crop; therefore, a small region with a high number of eggs or larvae per unit volume may contain a smaller standing crop than a larger region, even though the larger region may contain a lower density. If distribution were discussed in terms of density alone, a large region containing a moderate number of organisms per unit volume might be ignored, even though standing crop estimates revealed that a large proportion of the riverwide population existed in that region. On the other hand, if distribution were described solely in terms of standing crops, the importance of a small region where the density of eggs and larvae was high might be underestimated. As an example, if three consecutive regions held identical densities of eggs but the middle region had a much smaller volume than the others, emphasis on standing crop would inflate the assessment of the importance of the larger regions relative to the smaller one, while emphasis on density would result in a truer representation of the egg distribution across the three regions. Both standing crop and density are discussed in this subsection to ensure an accurate description of distribution and exposure and thus avoid overemphasis of one or the other. The Fall Shoal and Beach Seine Survey data are analogous in that they are discussed in terms of either density (fall shaols), catch per effort (beach seine), or standing crops (both).

Comparison of the 1974 through 1977 distributions are based upon geographic and temporal standing crop indices derived from Ichthyoplankton, Fall Shoal, and Beach Seine Surveys (Appendix Subsections A.II.B.5 and 6, and A.II.C.5). These indices illustrate general trends in distribution among years rather than trends in abundance. The indices reflect the proportion of the total standing crops that exist within a given region or sampling period; the higher the index for a region or sampling period, the higher the proportion of the total standing crop that is in that region or sampling period.

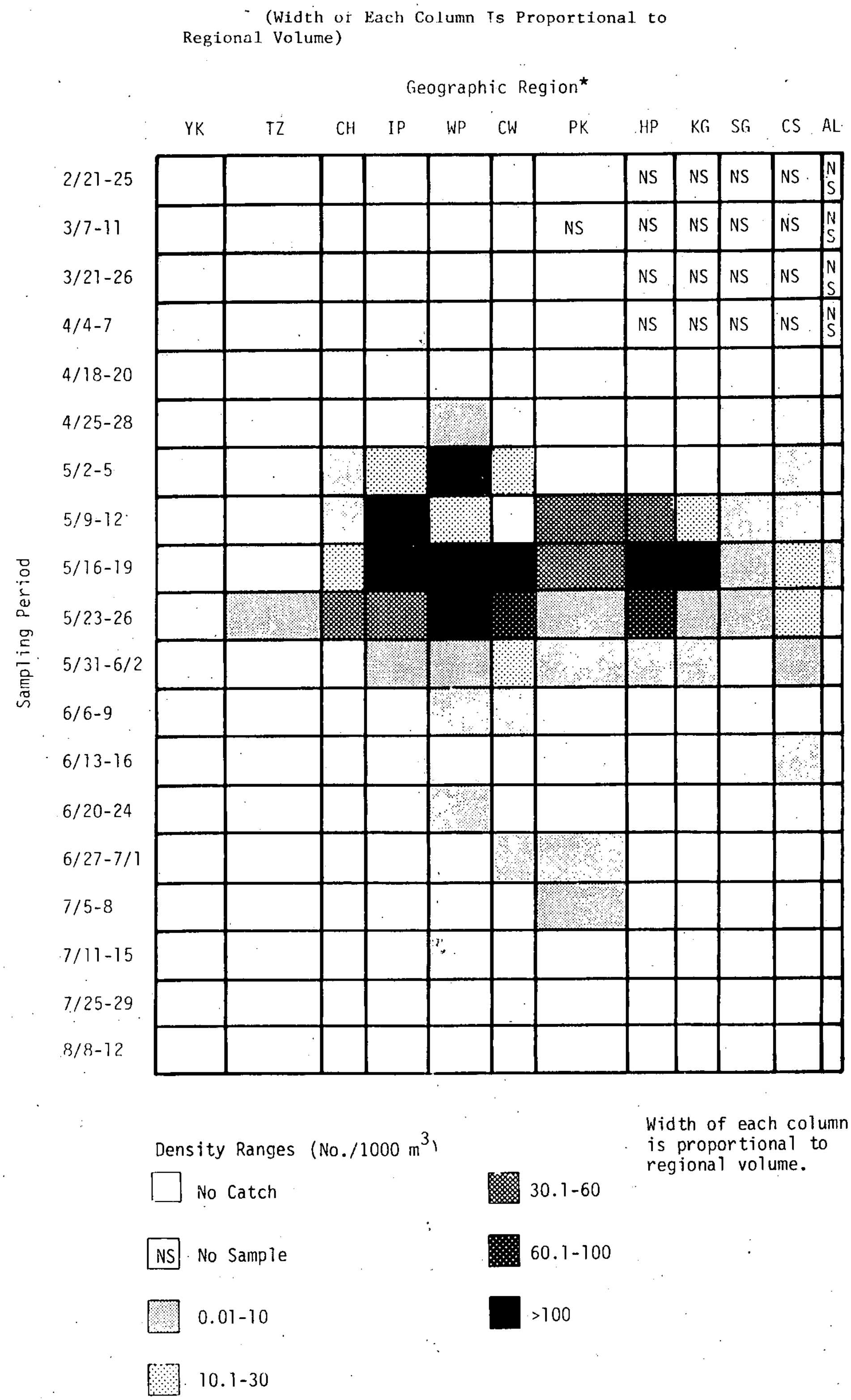
1. Eggs

a. Distribution during 1977

Striped bass eggs were first collected in late April (Appendix Tables B-13 and B-14). The standing crop of eggs increased sharply until mid-May, especially in the Indian Point, West Point, Cornwall, Hyde Park, and Kingston regions where densities exceeded 100 eggs/1000 m^3 during at least one sampling period (Figure III-13). In most other cases, however, density exceeded 10 eggs/1000 m^3. In the Tappan Zee, Saugerties, and Albany regions, densities were less than 10 eggs/1000 m^3 throughout the spawning season. Eggs were never collected in the Yonkers region. During June and early July, egg densities were low throughout the study area.

b, Factors Affecting Distribution

The major factors that affect striped bass egg distribution are spawning location and patterns of water flow. The environmental stimuli influencing adult behavior are the major determinants of timing and location of peaks in egg abundance. Spawning in the Hudson River during 1974-1977 generally began as water temperatures reached 12°C and egg deposition peaked in areas where water temperatures ranged from about 14° to 20°C and conductivity was less than 200 mS/cm (Table B-15). In other systems, water temperature during spawning has ranged from about 14° to 21°C (Calhoun et al.



*See Appendix Table A-2 and Figure A-1 for regional abbreviation definitions and river mile ranges.

Figure III-13. Distribution Matrix of Striped Bass Eggs Collected during 1977 Ichthyoplankton Survey, Hudson River Estuary

1950, Raney 1952, Tresselt 1952, Hollis and Davis 1955, Talbot 1966, Farley 1967, Turner 1976), and spawning activity usually has occurred in fresh to slightly saline tidal areas.

Water temperature, conductivity, and dissolved oxygen were often similar among Hudson River regions that contained drastically different densities of striped bass eggs. For example, during the week of 15 May 1977, water temperature in the Croton-Haverstraw region averaged 16.3°C, dissolved oxygen averaged 9.7 mg/ℓ and conductivity averaged 195 mS/cm. The corresponding measurements were similar in the adjacent Indian Point region (15.5°C, 9.2 mg/ℓ, and 154 mS/cm); yet, the density of striped bass eggs in Indian Point during that week was more than 20 times greater than in Croton-Haverstraw. Thus, although adult striped bass spawn under similar temperature, oxygen, and conductivity conditions from year to year, the presence of "right" conditions in a region is not enough to ensure that large numbers of eggs will be found there. Factors in addition to these must influence the location of spawning.

Turbulence may account for the fact that Hudson River striped bass spawn primarily in the Indian Point and West Point regions. Pearson (1938) and Kornegey and Humphries (1976) cited high turbulence and stream gradient as important to the striped bass spawning area. Hatchery observations have indicated that survival is higher among striped bass eggs that are prevented from settling to the bottom (Bayless 1972). The Indian Point and West Point regions, where the highest standing crops of eggs normally occurred (subsection III.C.2), are areas of rapid depth changes and several turns in the channel, which produce turbulence in reaches like "World's End" off West Point. The morphometry of the rest of the estuary is generally more uniform with a straighter path and less variation in depth. Despite turbulence and their semibuoyant and nonadhesive nature, however, striped bass eggs tend to concentrate near the bottom. This conclusion is supported by several Hudson River studies including the 1975 (McFadden 1977a) and 1976 (TI 1979b) Indian Point Nearfield Studies and the Cornwall Study (McFadden 1977a). Eggs collected in the Indian Point region during 1977 typically exhibited lowest densities in the shoals stratum and highest densities in the bottom stratum (Figure III-14 and Appendix Tables B-16 and B-17). On the other hand,

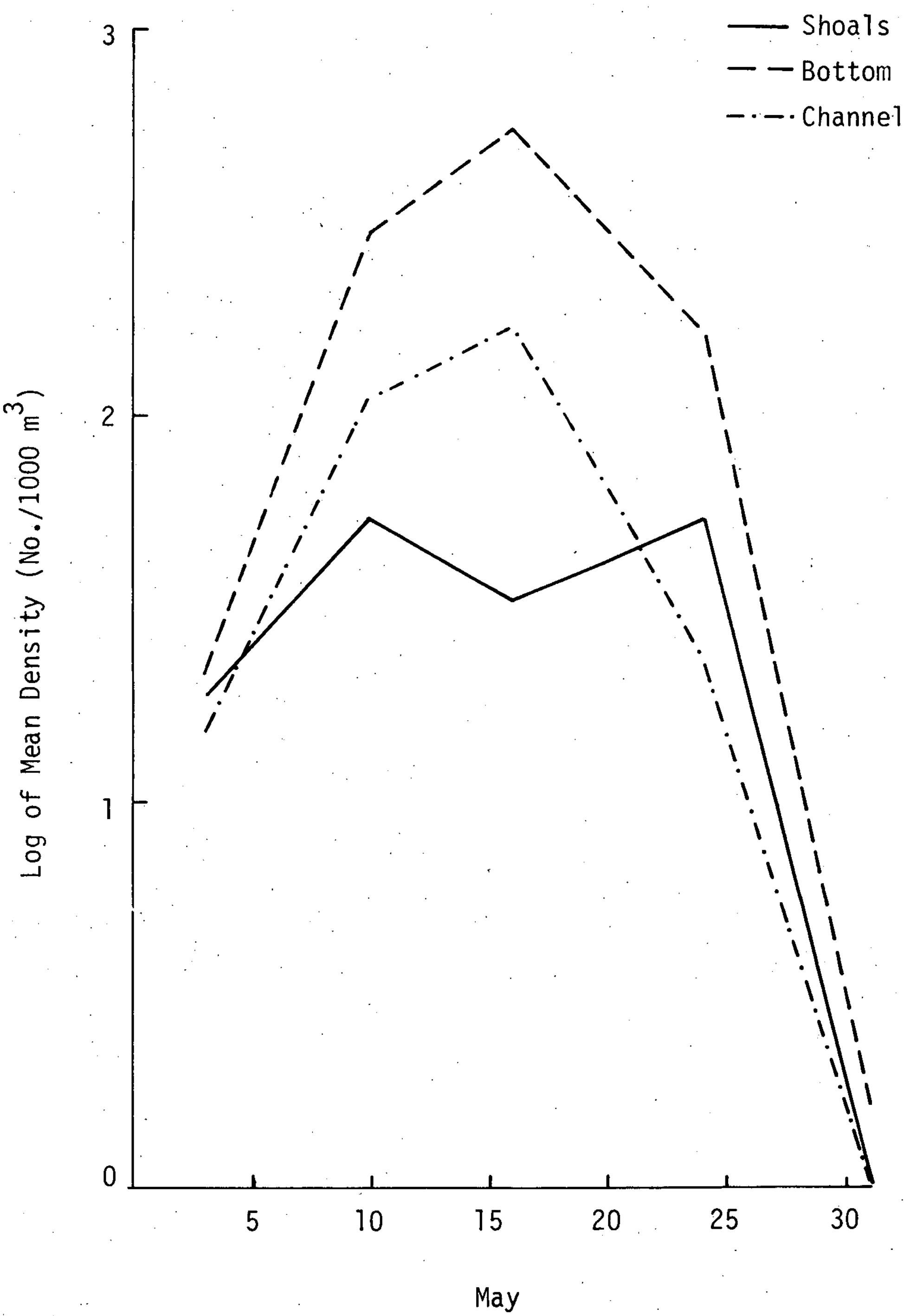


Figure III-14. Distribution of Striped Bass Eggs among Shoal, Bottom, and Channel Strata in Indian Point Region, Hudson River Estuary, May 1977

Albrecht (1964) concluded that only a 0.3 m/sec horizontal current was necessary to keep striped bass eggs suspended in the water column; also, studies on the drift of American shad eggs (Stira 1976), which are slightly less buoyant than striped bass eggs and are also nonadhesive, indicated that settling and resuspension of shad eggs occurred in the Connecticut River. Striped bass eggs which settle to the river bottom are probably periodically resuspended by tide changes and local vortices in current patterns.

c. Trends in Distribution (1974-77)

During 1974-77, eggs were most abundant during mid-May and were concentrated in the Indian Point and West Point regions (Figures III-15 and 16); 1977 had the lowest geographic index of any year in the Indian Point region. The highest index outside the West Point and Indian Point regions during 1977 was in the Hyde Park region, suggesting that a greater proportion of striped bass spawned upriver of the major spawning area (Indian Point and West Point regions) during 1977 than during previous years. Moreover, the proportion of the egg standing crop south of the Indian Point region decreased from year to year, suggesting that the upriver shift is more than a short-term phenomenon. The Crum Elbow area (RM 77 through RM 80) of the Hyde Park region, like the Indian Point and West Point regions, is an area where the topography of the river changes and is characterized by water depths exceeding 30.5 m (100 ft). Thus, the Crum Elbow area may have the proper turbulence conditions for spawning by striped bass, and depending on other environmental variables, may serve as a secondary spawning site. Water temperature may have stimulated the upriver shift, but none of the significant differences identified in an analysis of variance of mean regional temperatures in the Indian Point, West Point, and Cornwall Regions (Appendix Table B-32) seem to be related to the upriver shift in spawning. Therefore, the observed shift was apparently related to some other factor or combination of factors, possibly conductivity and freshwater flow.

2. Yolk-Sac and Post Yolk-Sac Larvae

a. Distribution during 1977

Striped bass yolk-sac larvae were first collected in early May, and post yolk-sac larvae followed about 2 weeks later (Appendix Tables B-20,

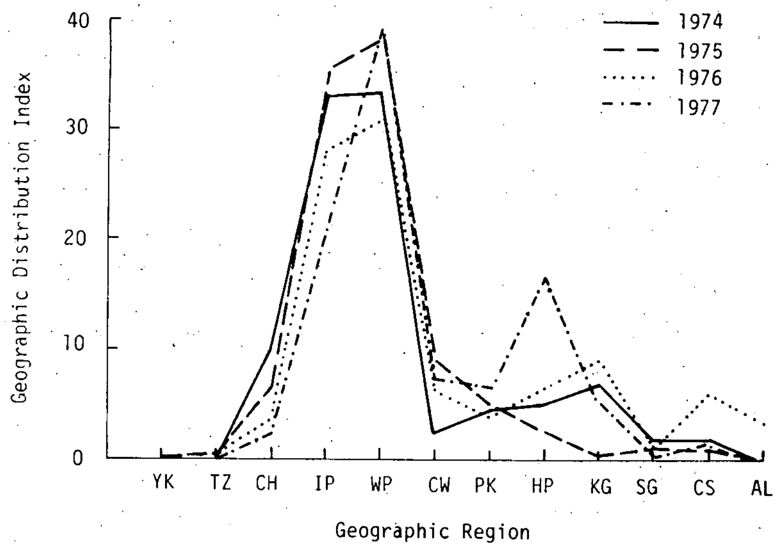


Figure III-15. Trends in Geographic Distribution of Striped Bass Eggs in Hudson River Estuary, 1974-77

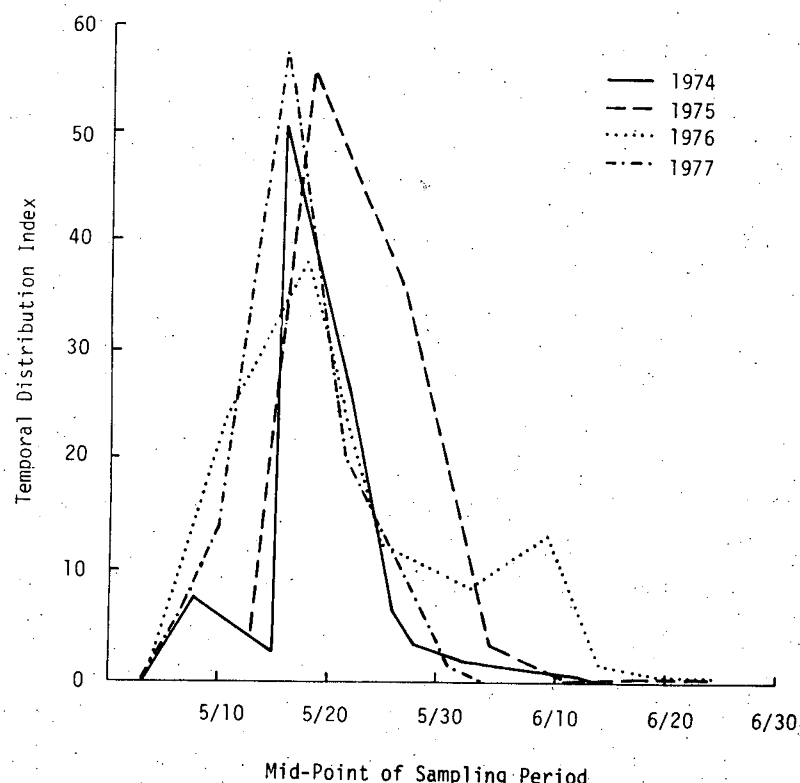


Figure III-16. Trends in Temporal Distribution of Striped Bass Eggs in Hudson River Estuary, 1974-77

B-21, B-22, and B-23). Estimated density peaked in early June for both life stages (Figures III-17 and III-18), with yolk-sac larvae being somewhat earlier than post yolk-sac larvae. Densities exceeding 200 yolk-sac larvae/ 1000 m^3 (in most other cases, densities were 20 yolk-sac larvae/1000 m^3) were encountered in the Indian Point, West Point, Cornwall, Poughkeepsie, and Hyde Park regions. Post yolk-sac larvae reached this level of abundance in these regions and the Croton-Haverstraw region, indicating greater dispersal of post yolk-sac larvae. Densities were always low (<20 yolk-sac or post yolk-sac larvae/1000 m^3) at the lower (Yonkers region) and upper (Catskill and Albany regions) ends of the study area. Both larval stages occurred over a wider area of the estuary than did eggs. Each larval stage was abundant for a 2-week period: yolk-sac larvae 23 May to 9 June and post yolk-sac larvae from 31 May to 16 June.

b. Factors Affecting Distribution

The mobility of yolk-sac larvae is limited by the prominent yolk sac and lack of fully developed musculature and fins (Mansueti 1958). Since the larvae would be unable to travel far during the 4 to 6 days between hatching and transformation into the post yolk-sac stage (McFadden 1977a), their distribution generally reflects the distribution of eggs; both distributions are bimodal, with peaks in the West Point region and upriver in either the Poughkeepsie or Hyde Park regions. Post yolk-sac larvae have lost the yolk sac and gained mobility through fin development but remain relatively weak swimmers (Sazaki et al. 1973). Currents thus continue to play a major role in larval distribution.

Both yolk-sac and post yolk-sac larvae remain concentrated near the bottom during the day but disperse throughout the water column at night (McFadden 1977a). While the larvae are near the bottom during the day, they are subject to lower current velocities because flow in most watercourses declines as distance from the bottom decreases (Hynes 1972). At night, however, as the larvae move into the upper layers, they probably become more susceptible to passive transport by tidal currents. This transport would account for the fact that larvae are more evenly distributed over their range in the estuary than eggs.

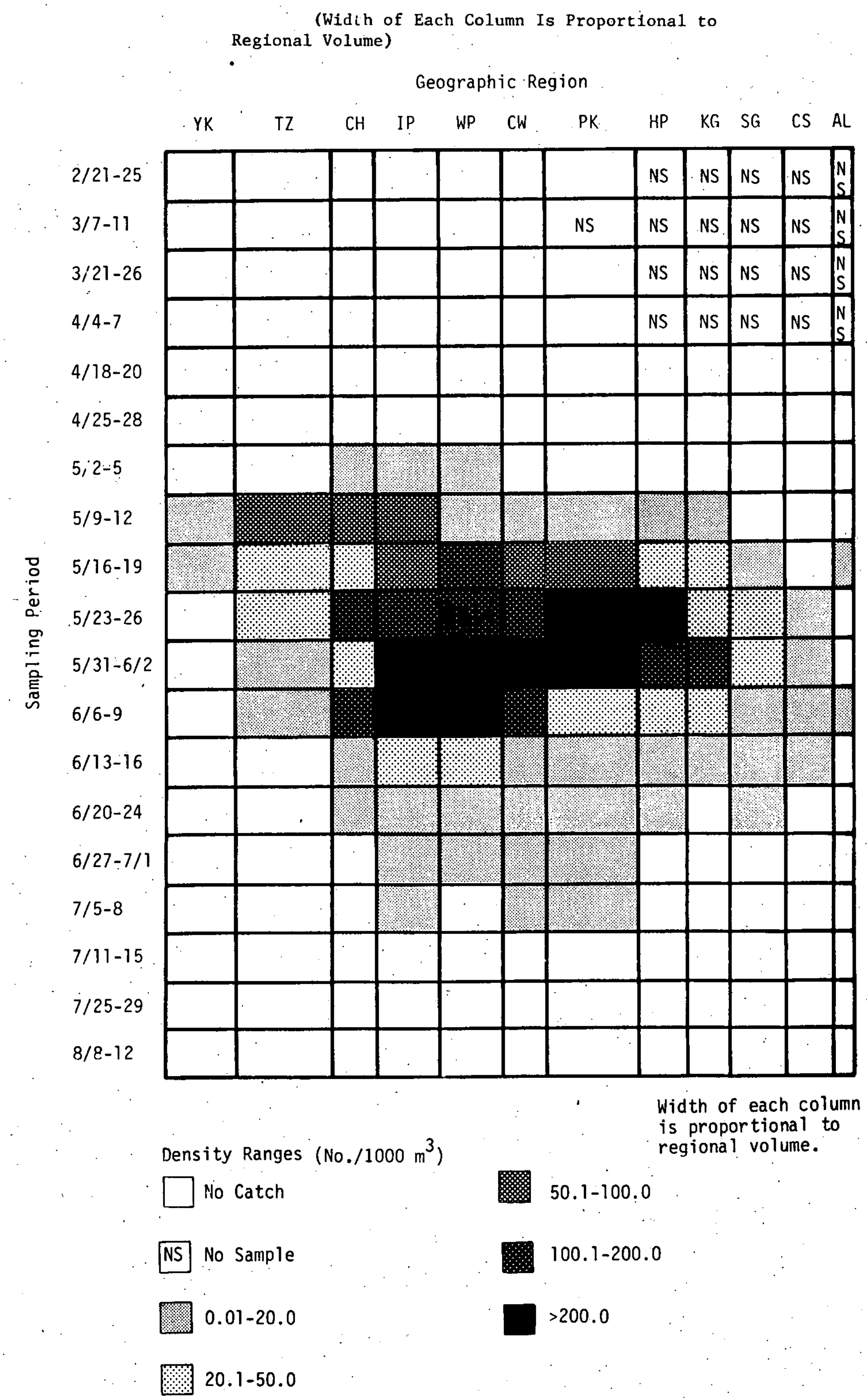


Figure III-17. Distribution Matrix of Striped Bass Yolk-Sac Larvae during 1977 Ichthyoplankton Survey, Hudson River Estuary

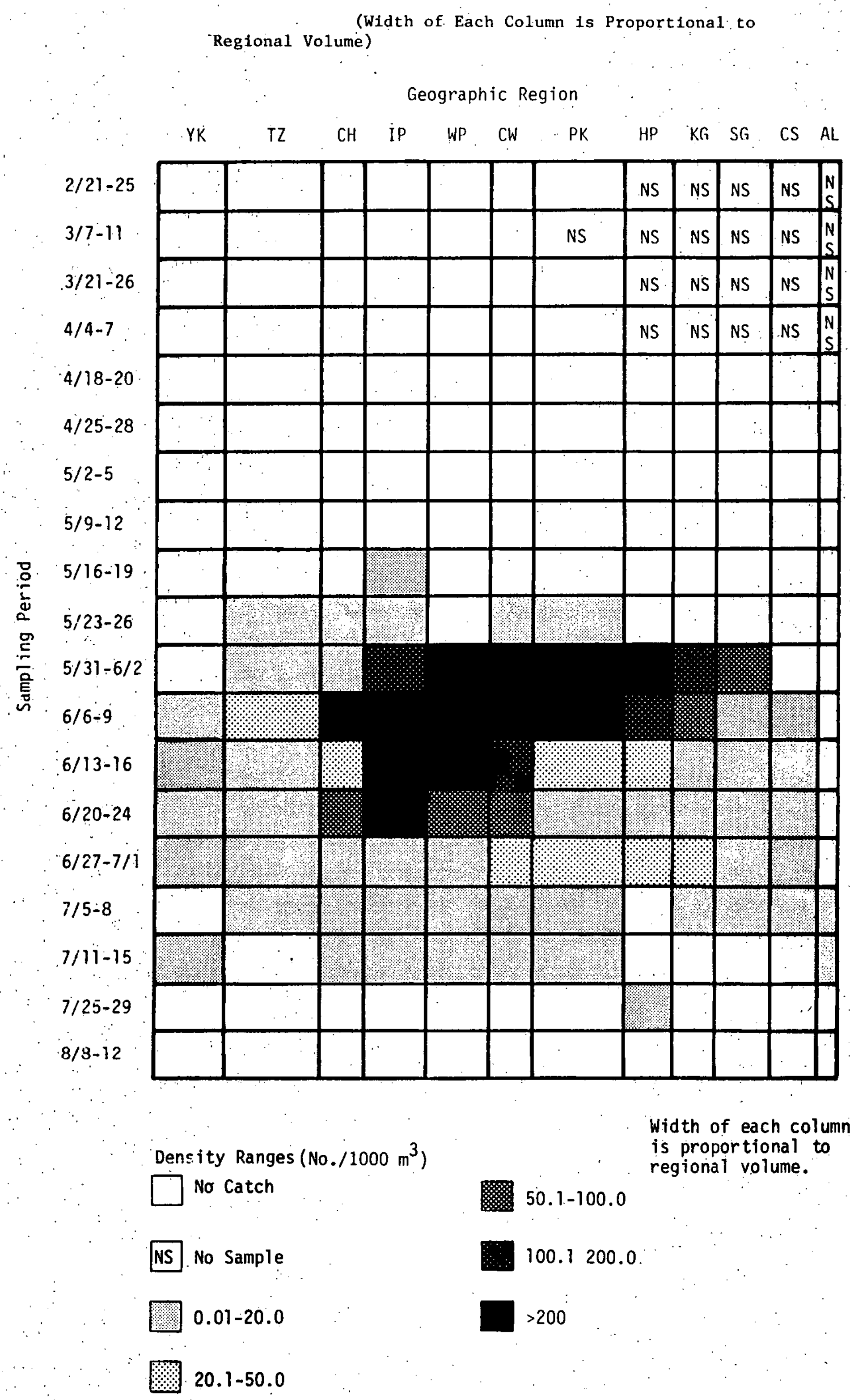


Figure III-18. Distribution Matrix of Striped Bass Post Yolk-Sac Larvae during 1977 Ichthyoplankton Survey, Hudson River Estuary

Striped bass yolk-sac and post yolk-sac larvae were most abundant when water temperature ranged from about 16.5° to 23.5°C (Appendix Tables B-30 and B-31). The year 1976 was exceptional in that an early downriver peak in the abundance of yolk-sac larvae occurred when water temperatures were 14° to 15.5°C; these larvae apparently did not survive, since the peak in numbers of post yolk-sac larvae did not occur until much later in the season (TI 1979a). Mean regional water temperatures were similar throughout the estuary, making water temperature an improbable determinant of larval distribution.

Both yolk-sac and post yolk-sac larvae were abundant under a wide range of conductivity. In areas where densities exceeded 100 yolk-sac larvae/1000 m^3, conductivity ranged from about 140 to 4630 mS/cm while the corresponding range associated with distribution of post yolk-sac larvae was 140 to 4700 mS/cm. However, neither life stage was ever abundant at the downriver end of the study area (Yonkers region) where mean conductivities exceeded 5000 mS/cm during the periods when larvae were most abundant elsewhere. Striped bass larvae may avoid areas where the conductivity exceeds some upper limit or suffer high mortality in such areas. Albrecht (1964) observed larval mortality and malformation at about 9% or 15,000 mS/cm conductivity.

In summary, striped bass larvae are distributed over a wider geographic range than eggs and exist under greater temperature and conductivity regimes. Although active movements play a role in larval distribution, passive transport is an important factor.

c. Trends in Distribution (1974-77)

The geographic distribution of striped bass yolk-sac larvae varied from 1974 through 1977 (Figure III-19). Yolk-sac larvae were more concentrated in the Poughkeepsie region in 1974 than in 1975-77 when index values were high in the Poughkeepsie, West Point, and Indian Point regions. In 1974, either survival of eggs was greater in the Cornwall and Poughkeepsie regions than in the Indian Point or West Point regions, or larvae were transported upstream from the Indian Point and West Point regions. None of the physical-chemical data (Appendix Table B-30) appear to explain the

Poughkeepsie region peak. Lowest index values were consistently encountered in the Yonkers and Kingston-Albany regions.

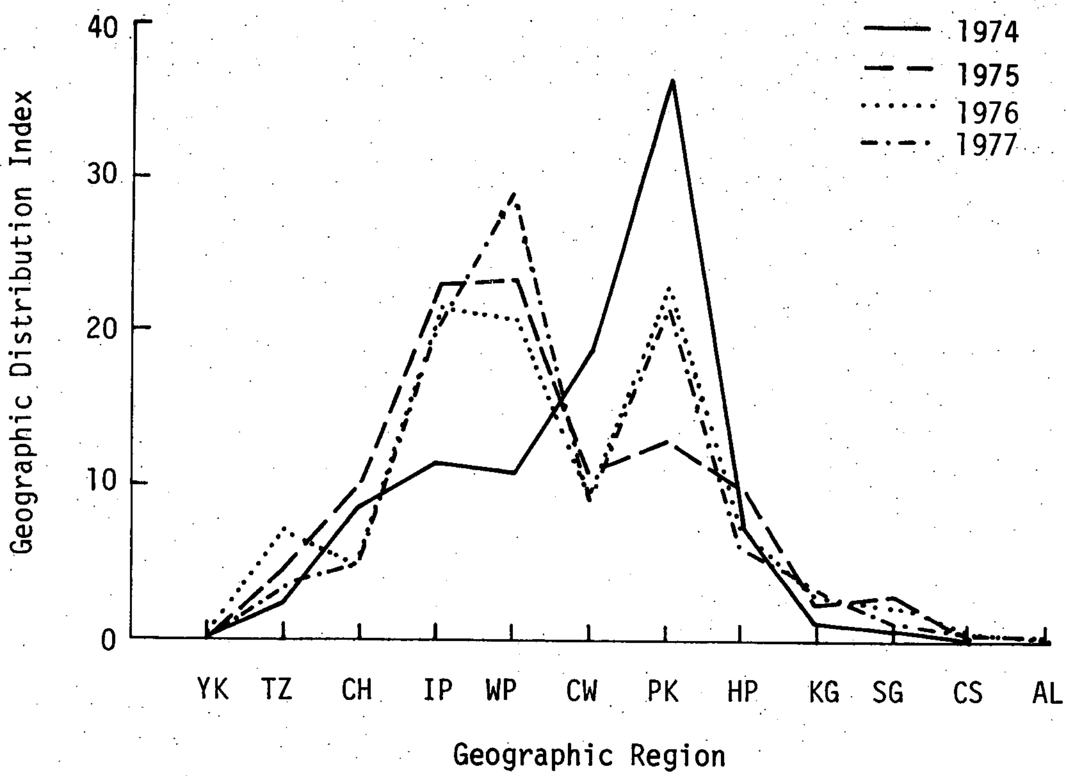


Figure III-19. Trends in Geographic Distribution of Striped Bass Yolk-Sac Larvae in Hudson River Estuary, 1974-77

Patterns in the geographic distribution of post yolk-sac larvae (Figure III-20) were similar to those of yolk-sac larvae. High values occurred in the Indian Point, West Point, and Poughkeepsie regions. The low index values in the Cornwall region for this and other life stages result from this region's small size compared with that of adjacent regions.

Yolk-sac larvae were most abundant (Figure III-21) in late May to early June in 1975 and 1977, but in 1976 did not peak until mid-June although a minor peak occurred in mid-May. The 1974 index had three minor peaks from late May to mid-June. The highest temporal indices for post yolk-sac larvae (Figure III-22) followed one of the yolk-sac larval peaks by about 2 weeks, except in 1976 when the yolk-sac larval and post yolk-sac larval peaks occurred during the same sampling period.

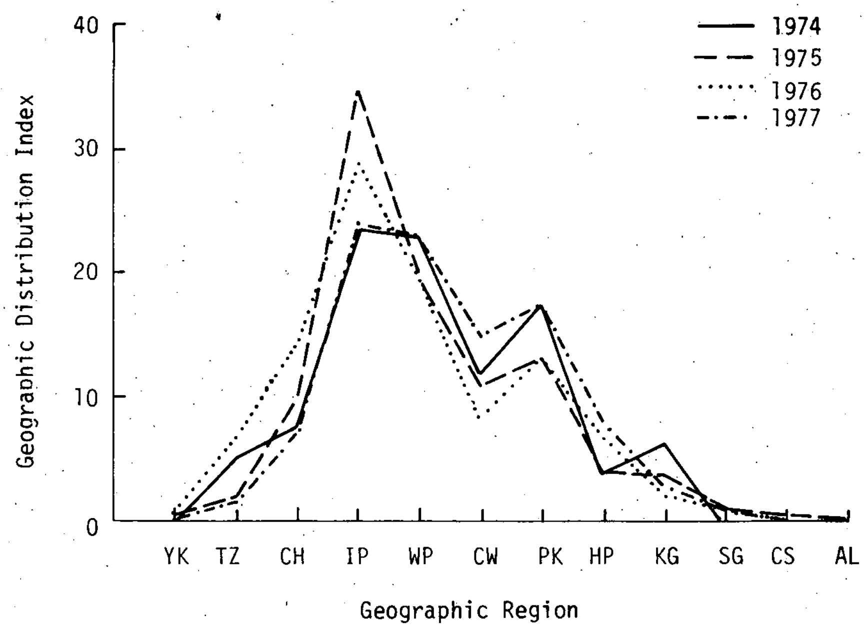


Figure III-20. Trends in Geographic Distribution of Striped Bass Post Yolk-Sac Larvae in Hudson River Estuary, 1974-77

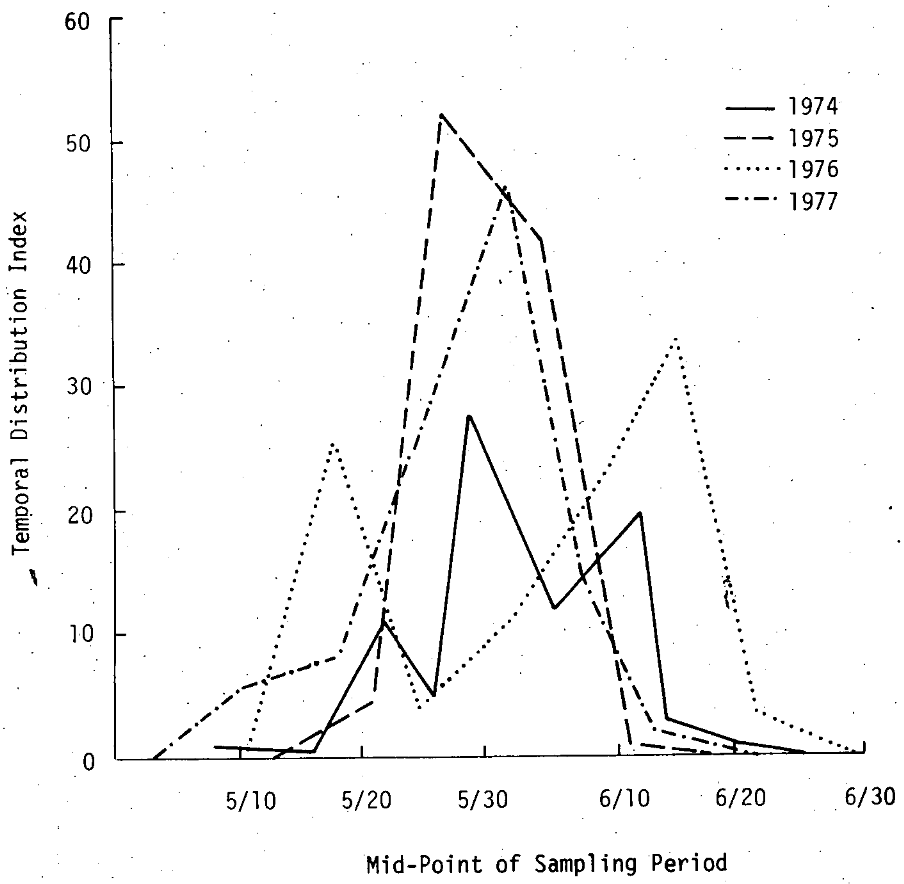


Figure III-21. Trends in Temporal Distribution of Striped Bass Yolk-Sac Larvae in Hudson River Estuary, 1974-77

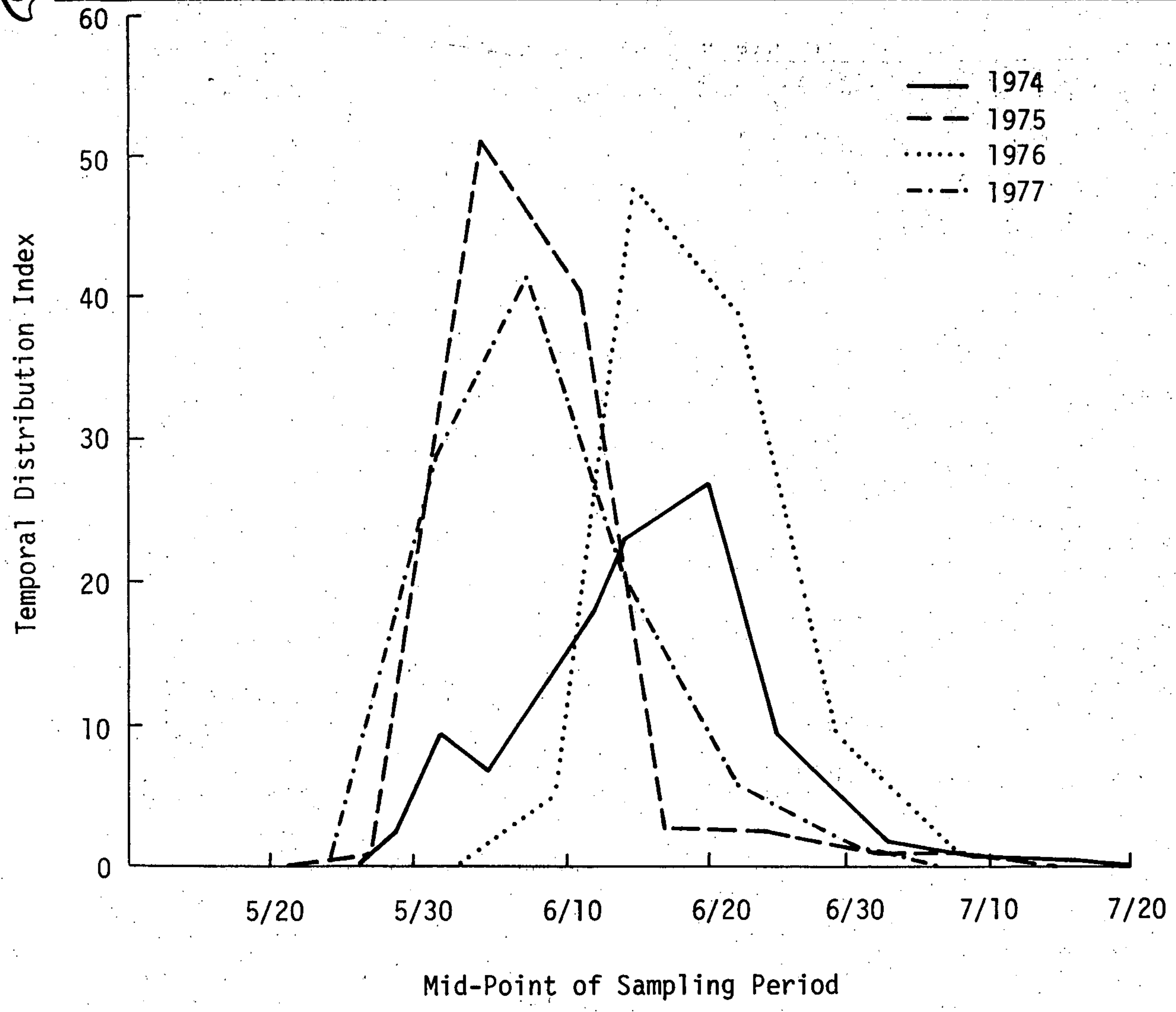


Figure III-22. Trends in Temporal Distribution of Striped Bass Post Yolk-Sac Larvae in Hudson River Estuary, 1974-77

An analysis of variance of water temperatures during April, May, and June in three regions where larvae were abundant (Indian Point, West Point, and Cornwall regions) indicated significant ($p<0.05$) differences between 1974, 1975, 1976, and 1977, especially during the second half of May (Appendix Table B-32). Temperatures during the second half of May 1976 were significantly lower than those during the second half of May 1974 and 1977. Temperatures during the second half of May 1975 were higher than those during the same period in 1974, 1976, and 1977. Water temperatures in the second half of May in 1974 and 1976 were in the lower end or below the 16^{o} to $19^{o}C$ range reported by Doroshev (1970) for optimum development of striped bass yolk-sac larvae, whereas during the same period in 1975 and 1977, water temperatures were in the middle or upper end of the range (Appendix Table B-32). Apparently striped bass yolk-sac larvae died or developed more slowly during the last half of May in 1974 or 1976 (Figure III-22), and consequently post yolk-sac larvae were abundant much later in 1974 and 1976 than in 1975 and 1977 (Figure III-23).

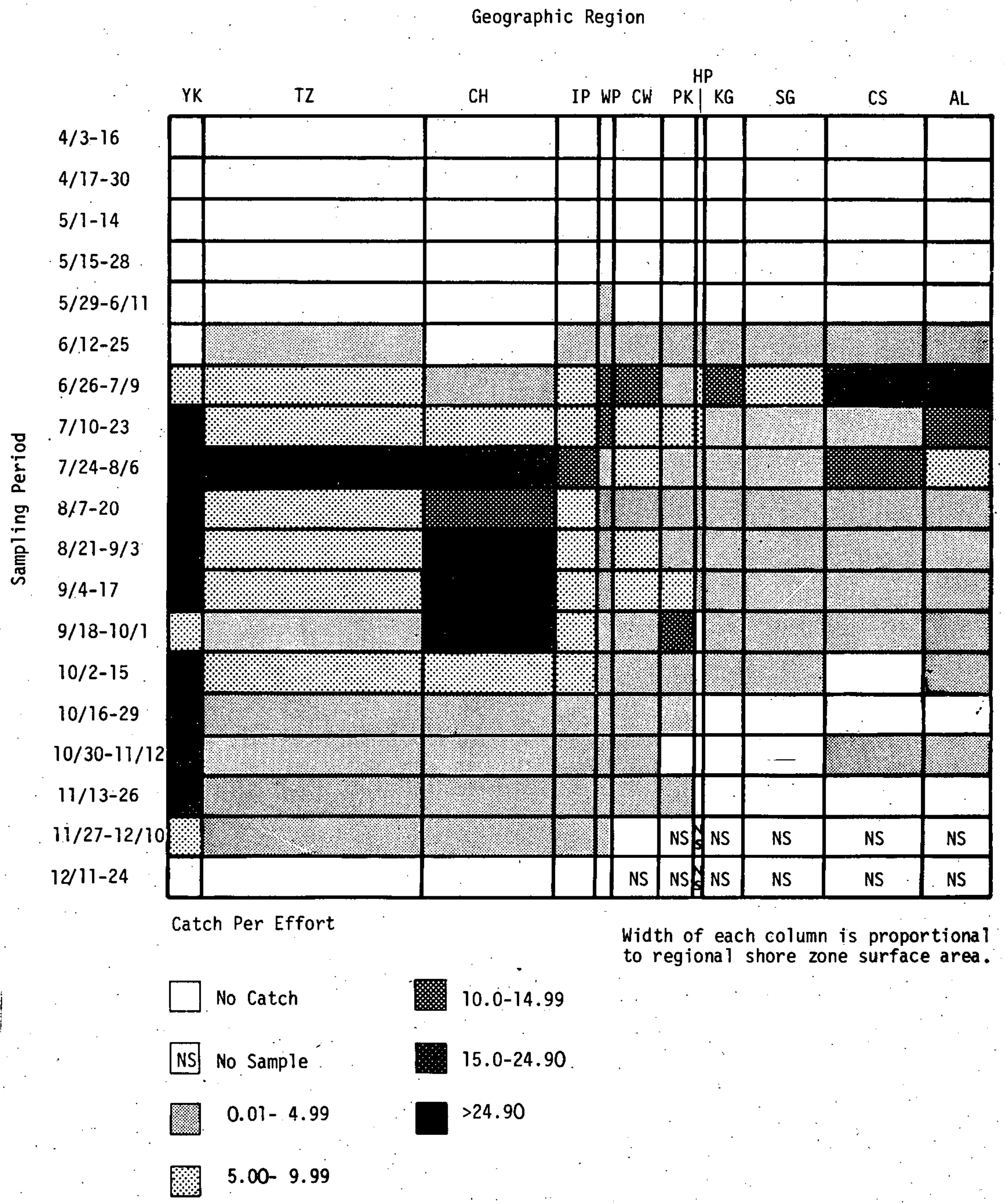


Figure III-23. Distribution Matrix of Striped Bass Juveniles Collected during 1977 Beach Seine Survey, Hudson River Estuary

3. Juveniles and Yearlings

a. Distribution from June 1977 through June 1978

The initial occurrence of striped bass juveniles within the study area (RM 12-153) was in late May to early June (Figure III-23 and Appendix Tables B-39 through B-41); shortly thereafter, they were collected throughout the study area. By the end of July, all post yolk-sac larvae had transformed into juveniles, and juvenile abundance peaked (Figure III-24). The decline in estimated standing crops after early August was due to mortality and emigration (subsection III.D.2).

Density (catch per tow) in the shore zone was generally highest in the Yonkers through Croton-Haverstraw regions (Figure III-23); however, during the first few weeks of juvenile abundance, high catches were recorded upriver in the Catskill and Albany regions. Abundance in deeper offshore areas followed a similar pattern (Appendix Tables B-42 and B-43). Both deep water and shore zone collections indicated a downriver shift during October and November when density in the shore zone declined to zero upriver from the Poughkeepsie region. After mid-September, deep water sampling yielded higher densities downriver in the Yonkers through Croton-Haverstraw regions than upriver in the Indian Point through Poughkeepsie regions.

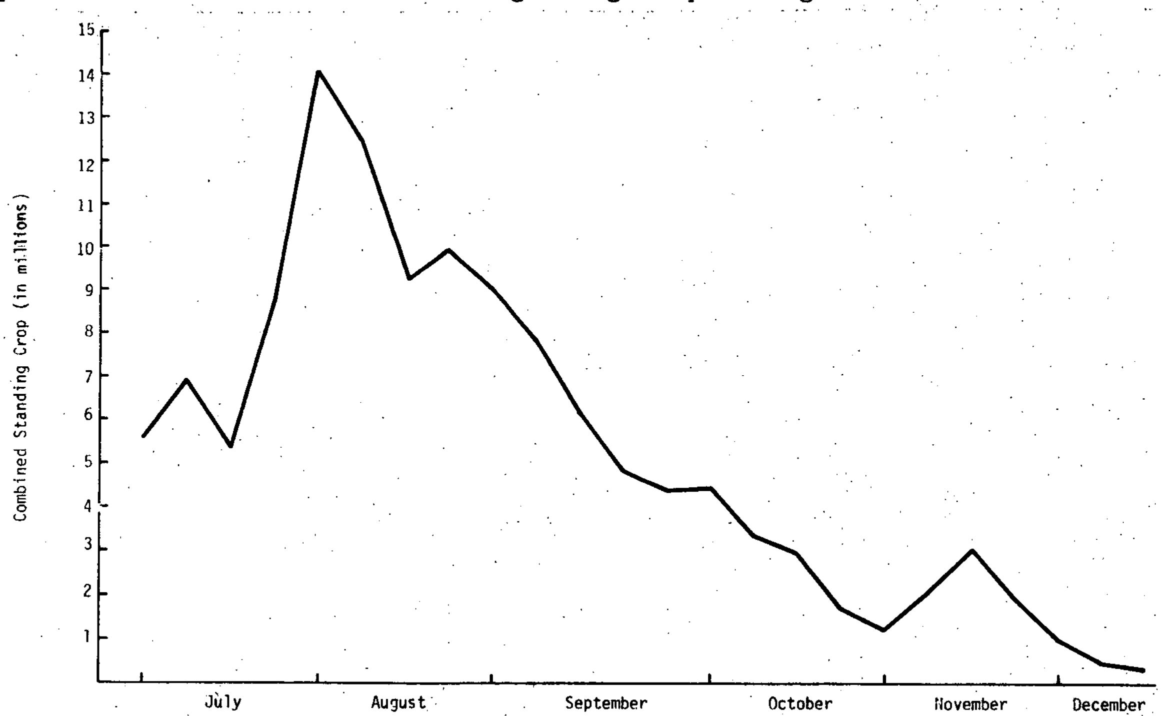


Figure III-24. Combined Standing Crops (Adjusted for Night:Day Catch Ratio) of Juvenile Striped Bass in Hudson River Estuary, 1977

Juveniles were reclassified as yearlings on 1 January. When shore zone sampling recommenced in April 1978, yearlings were most abundant in the Yonkers through Croton-Haverstraw regions (Appendix Table B-45 through B-47). In June, shore zone density increased in the Indian Point through Cornwall, Catskill, and Albany regions.

b. Factors Affecting Distribution

The geographic area over which striped bass juveniles ranged continued to expand as was previously detected (subsection III.C.1 and III.C.2) during development from egg to larval stages. By mid-June, shore zone densities were fairly high at the upper end of the estuary in the Catskill and Albany regions (Appendix Table B-38) where post yolk-sac larvae had not been abundant. In mid-July, catches at the lower end of the study area in Yonkers and Tappan Zee also increased. Peak densities of juveniles succeeded peak catches of post yolk-sac larvae by slightly more than a month. Physicochemical conditions during periods of juvenile abundance are summarized in Appendix Table B-48.

1) Movement to and from the Shore Zone

The proportion of the combined standing crop (compiled from Beach Seine and Ichthyoplankton or Fall Shoal Survey data) within the shore zone varied from month to month: it was high in late June and early July when the first juveniles were collected, but then declined until mid-August as the proportion in shoal areas increased (Figure III-25). Thereafter, the trend reversed and more than 50% of the fish occupied the shore zone until late October when juveniles apparently moved offshore. During June-October, the proportion of the combined standing crop inhabiting the bottom and channel strata varied from approximately 9% to 36%.

Water temperature varied little among the shore zone, shoals, and deep water (Figure III-26). Similarly, neither conductivity nor dissolved oxygen varied between the three areas. Therefore, none of these variables appeared to be the stimulus for the movements. The inshore/offshore movements have not been consistent; similar data collected during 1975 (McFadden 1977a) and 1976 (TI 1979a) yielded different patterns. In 1975, fish in the

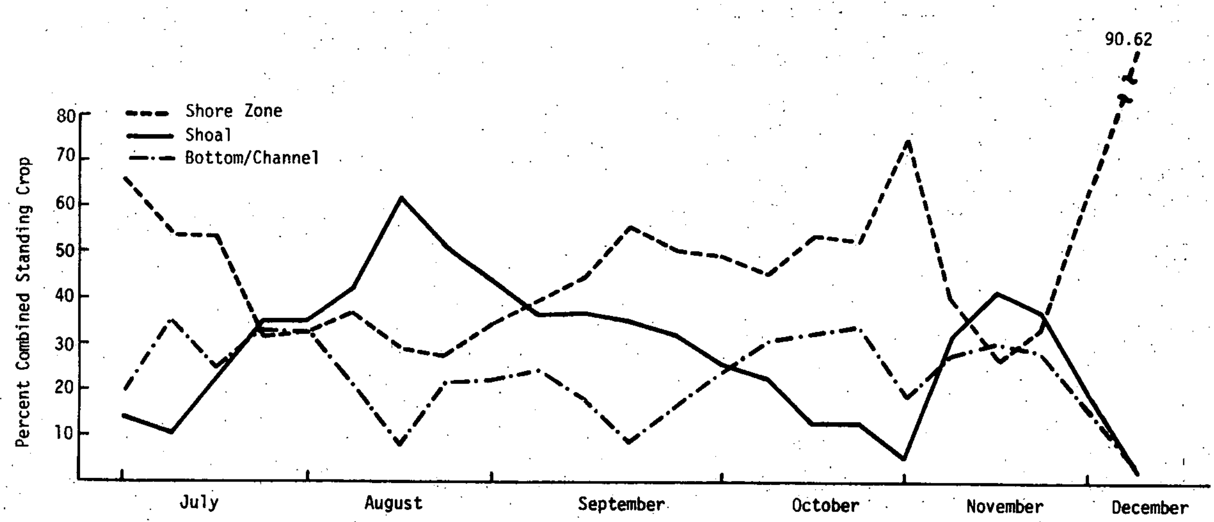


Figure III-25. Percent Combined Standing Crop (Adjusted for Night:Day Catch Ratio) of Juvenile Striped Bass in Each of Three Strata in Hudson River Estuary, 1977

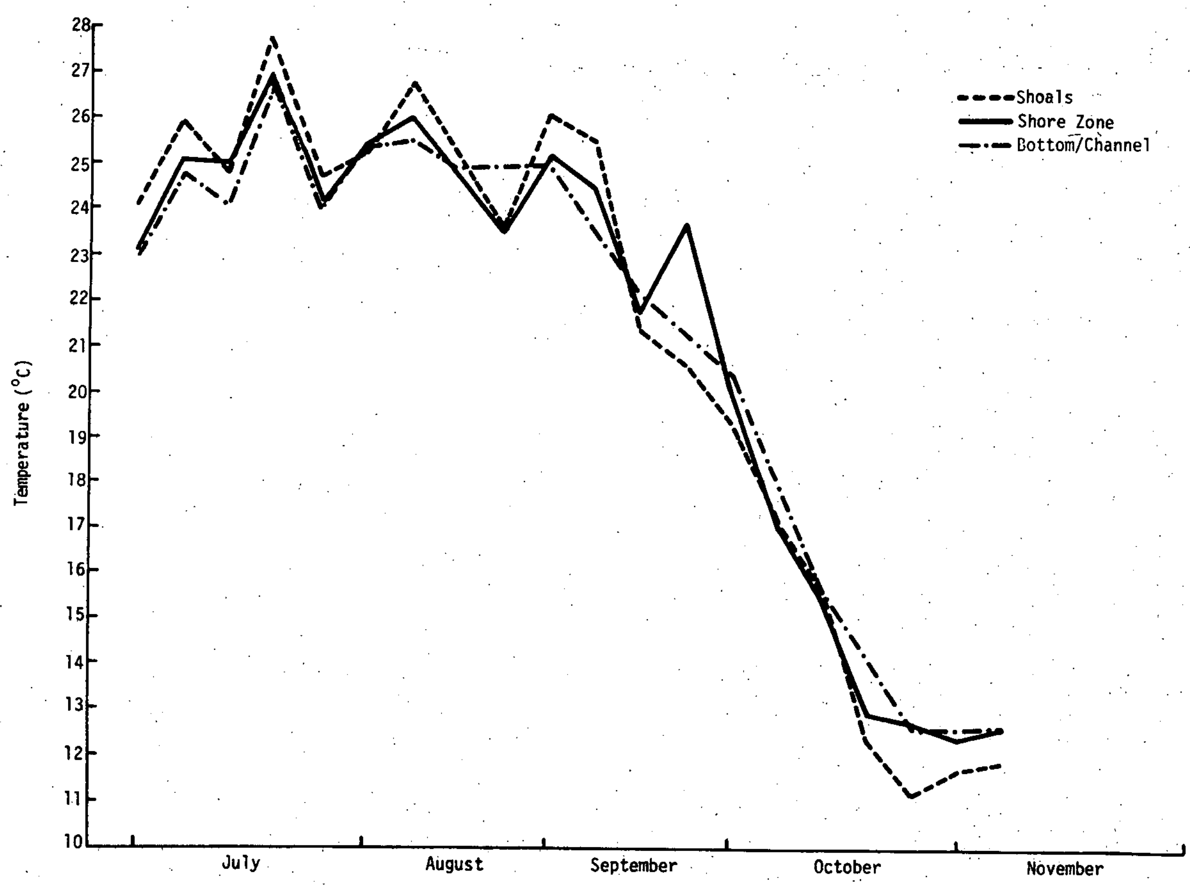


Figure III-26. Weekly Mean Water Temperatures in Each of Three Strata in Tappan Zee Region (RM 24-33), Hudson River Estuary, 1977 shore zone did not dominate the standing crop until early August. The proportion of the population in the shore zone declined in August 1977. In 1976, the proportion of fish in the shore zone was not predominant until late October. The factors causing these movements are not well understood at this time.

2) Interregional Movement of Marked Fish and Emigration

Some emigration from the study area probably occurred in late summer through November, along with the downriver shift in distribution. Environmental cues [conductivity, since bass tend to be associated with the salt front during the winter (TI 1979b, McFadden et al. 1978), water temperature, available prey species, and decreasing day length] may trigger these movements as striped bass seek overwintering areas. Environmental conditions that existed when striped bass juveniles were present in the study area are summarized in Appendix Table B-48.

Very little movement of marked fish between regions (Tables III-24 and III-25) was detected during September-November, even though emigration was suspected to have begun in late summer. This overall lack of movement had been observed in past years (TI 1078a, 1979a) and was probably a result of the fact that 90% of the marked fish were released between RM 12 and 46 (Table III-26) where juveniles may overwinter. Fish marked within this area would not have had to migrate to other areas to overwinter, and those that emigrated would have passed out of the study area. Furthermore, beach seine, bottom trawl, and epibenthic sled catches of young-of-the-year striped bass all decreased in the fall (Appendix Tables B-38, B-42, and B-43), suggesting that emigration may occur through unsampled channel areas where emigrants are not vulnerable to recapture. Few (17) fish marked in the fall were recaptured during the following spring (Table III-27), indicating that emigration probably occurred. Ritchie and Koo (1973) were successful in detecting an October emigration from the Patuxent River, Maryland, of striped bass juveniles marked during the summer; they also observed that some fish that had been marked 17 to 33 miles upstream of the river's mouth during the fall and winter remained in the Patuxent and those that overwintered in the estuary emigrated the following summer. A similar pattern is believed to occur in the Hudson River estuary. Some juveniles emigrate from the Hudson during late summer (subsection III.D.1), while others overwinter in the estuary and apparently emigrate the following year. Emigration is discussed more fully in subsection III.D.2.

Table III-24

Recapture Matrix for Striped Bass Finclips Released during September-November 1977 and Recaptured during September-December 1977, Hudson River Estuary

	Recapture Region 1	2	3	4	5
Release 1	124	2	1		
2	11	623	10		
3		7	194	2	
4		1	2	31	
5			1	1	

Region of Recapture	Number
Upriver	15
Same Region	972
Downriver	23

Table III-25

Percent of Striped Bass Recaptured above, below, or within Released Region, September-November 1977, Hudson River Estuary

Region of Recapture	Sep	Oct	Nov	Sep-Nov
Upriver	1%	3%	0%	1%
Within	97%	93%	97%	96%
Downriver	2%	4%	3%	2%

Table III-26

Number of Finclipped Striped Bass Released in Hudson River Estuary during September-November 1977 and April-June 1978

Region	1	2	3	4	5	
River Mile	12-23	24-38	39-46	47-76	77-152	Total
Sep	1272	3366	1079	583	99	6399
Oct	1419	3274	1680	364	6	6743
Nov	868	1884	903	100	2	3757
Sep-Nov	3559	8524	3662	1047	107	16899
Apr-Jun 1978	457	316	65	16	3	857

Table III-27

Recaptured Matrix for Striped Bass Finclips Released during September-November 1977 and Recaptured during January-June 1978 in Hudson River Estuary

Release	Recapture Region 1	2	3	4	5
1	1		2		
2			10		
3			3		
4			1		
5					

Region of Recapture	Number
Upriver	12
Same Region	4
Downriver	1

c. Trends in Distribution (1974 through June 1978)

The geographic distribution of juvenile striped bass in the shore zone was similar from 1974 through 1977 (Figure III-27). The distribution index was high in the Tappan Zee and Croton-Haverstraw regions every year and low in most upriver regions.

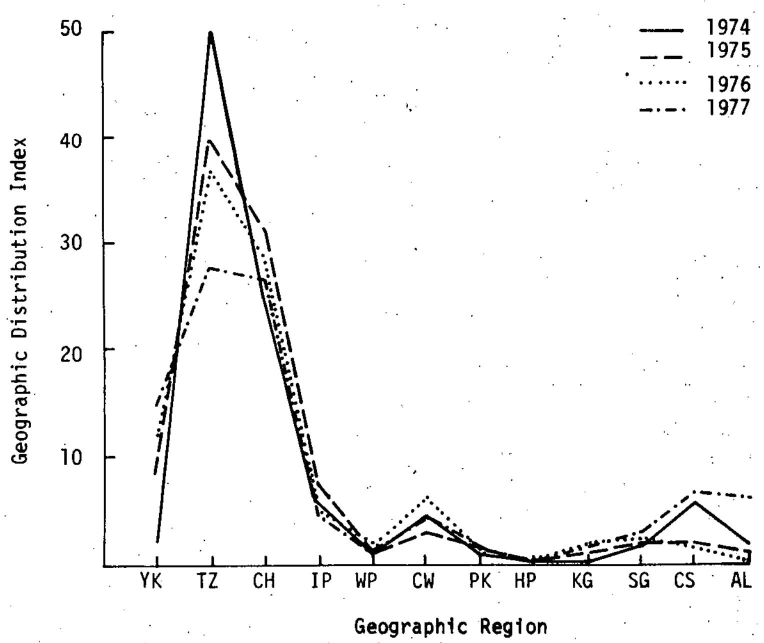


Figure III-27. Trends in Geographic Distribution of Juvenile Striped Bass in Hudson River Estuary Based on Beach Seine Survey Data, 1974-77

Temporal index values of distribution within the shore zone during 1974 and 1975 peaked later and higher than in 1976 and 1977 (Figure III-28). The observed pattern does not agree with trends in the distribution of post yolk-sac larvae (subsection III.C.2.b), which indicated that 1977 resembled 1975 more closely than 1976 in the timing of peak index values. The temporal index is based on shore zone sampling, so these discrepancies may have been the result of year-to-year variation in the use of the shore zone by striped bass juveniles. The proportion of the striped bass population that inhabited the shore zone was higher during the summer of 1975 than during the summers of 1976 and 1977 (McFadden 1977a, TI 1979a).

Yearling distribution was similar over both space and time from 1975 through June 1978. Geographic distribution has always been centered in the Tappan Zee region with a secondary area of abundance upriver in the Saugerties through Albany regions (Figure III-29). In all years, the temporal index (Figure III-30) peaked in May (as yearlings entered the shore zone) and declined thereafter.

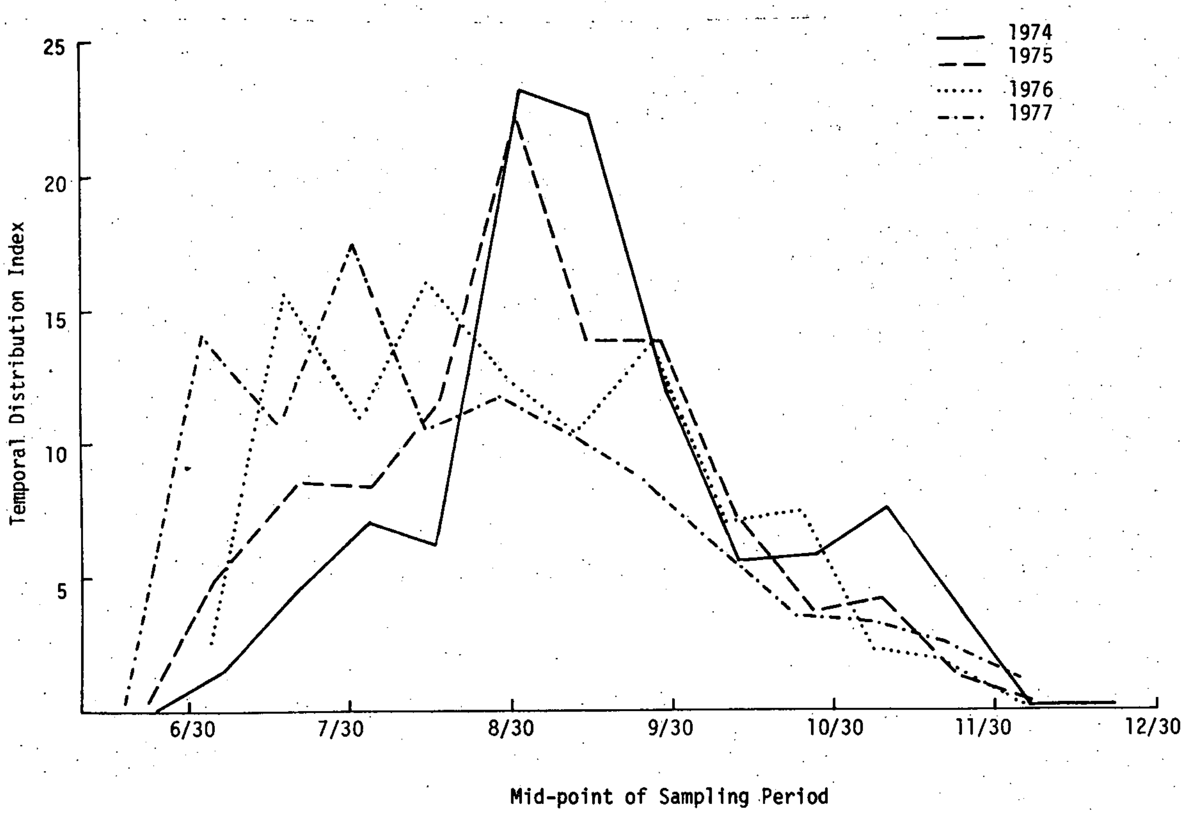


Figure III-28. Trends in Temporal Distribution of Juvenile Striped Bass in Hudson River Estuary Based on Beach Seine Survey Data, 1974-77

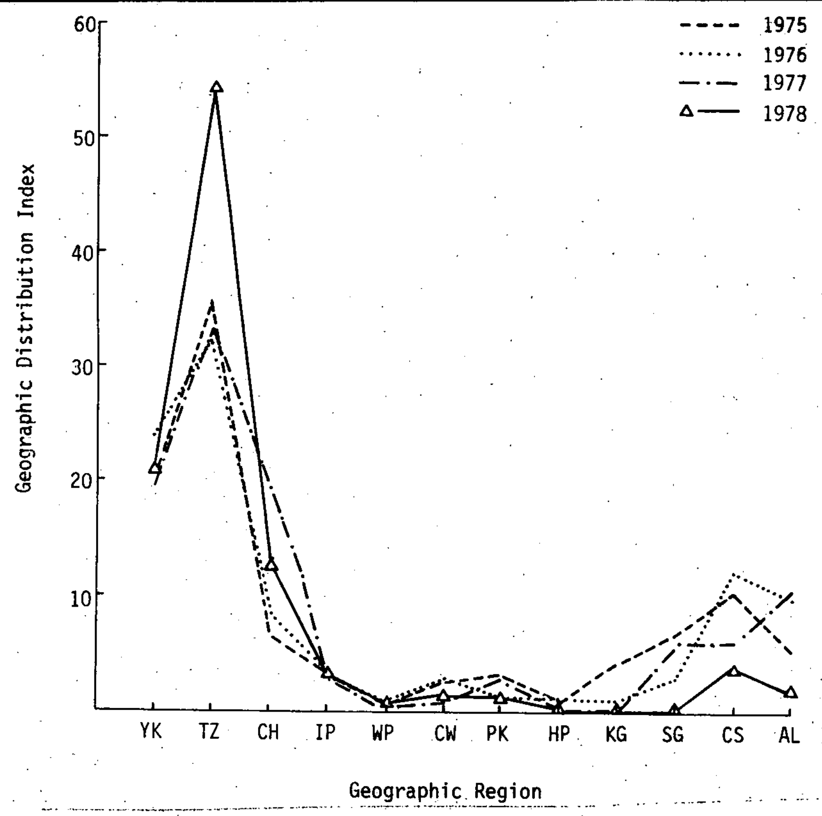


Figure III-29. Trends in Geographic Distribution of Yearling Striped Bass in Hudson River Estuary from 1975 to 1978 Based on Beach Seine Survey Data (1978 indices are based only on April through June data)

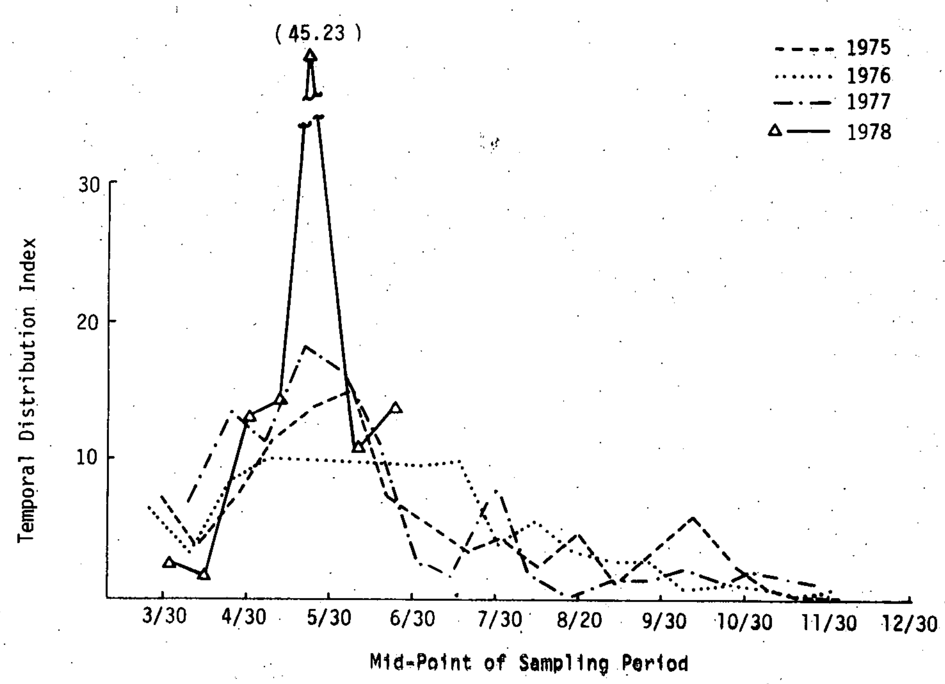


Figure III-30. Trends in Temporal Distribution of Yearling Striped Bass in Hudson River Estuary from 1975 to 1978 Based on Beach Seine Survey Data (1978 indices are based only on April-June data)

D. YEAR CLASS CHARACTERISTICS

The first year of life for a cohort of fish is often the most important period in determining the cohort's contribution to the continued existence of the population. The relationship between abundance during early life stages and subsequent abundance has been demonstrated for both fresh-water species (Forney 1971, Franklin and Smith 1973, Kramer and Smith 1962, Maloney and Johnson 1957, Summerfelt 1975) and marine species (Bannister et al. 1974, May 1974).

Striped bass spend a large part of their first year in the Hudson River estuary; thus, the potential effects of electric power generation on juvenile striped bass will be examined. One obvious effect of power generation is the removal of striped bass from the population by entrainment of eggs and larvae and impingement of juveniles. This mortality may result in an overall decline in cohort abundance or may be offset by a decrease in the natural mortality because of reduced inter- or intraspecific competition, faster growth, or less predation on the surviving members of the cohort so that the net effect of entrainment and impingement on the stock is negligible.

The objective of this subsection is to describe the abundance, mortality, and growth of the 1977 year class of striped bass and to relate these processes to variations in environmental factors. As knowledge of the factors controlling these biological processes increases, the ability to recognize and evaluate the impact of power plants on the fish populations will also increase. To the extent possible, indices of abundance, mortality, and growth will be examined for relationships with power plant operation.

1. Abundance

Abundance is probably the most studied and revealing characteristic of animal populations, and its estimation is a prime topic in ecological and fisheries literature (Seber 1973, Ricker 1975, Tepper 1967, Schultz et al. 1976). Changes in abundance are often used as an indication of the general condition (or status) of a population and therefore may be indicative of the impact of power plants on fish populations. To examine trends in abundance, either absolute or relative measures of abundance are necessary. Since relative measurements are usually less expensive to obtain than absolute measurements, abundance indices (variables or parameters thought to be highly correlated with abundance) have been widely used to examine trends.

To calculate a quantitative estimate of power plant impact on the population, an absolute estimate of population size is required. Absolute estimates usually require more extensive (and expensive) sampling programs than relative index methods but supply more specific information.

This subsection will describe the absolute abundance of the 1977 year class to be used to estimate power plant impact, examine relative abundance indices over several years to determine long-term trends in abundance, and explore factors that may control abundance.

a. Absolute Estimates of Population Size

The number of juvenile striped bass in the Hudson River estuary was estimated by mark-recapture and density extrapolation methods. Petersen first reported using mark-recapture methods for estimating fish populations in 1896. Since then, mark-recapture techniques have been refined and expanded (Seber 1973, Ricker 1975). Density extrapolation estimates have not been used as commonly as mark-recapture estimates but are sometimes more practical for large populations. Houser and Dunn (1967) demonstrated the applicability of density extrapolation methods under conditions similar to those in the Hudson River estuary, i.e., a large body of water and a large population of small fish.

1) Methods

Density extrapolation estimates were calculated by combining standing crops for the different sampling strata (Table III-28 and TI 1979a). Adjustments for sampling gear catch efficiency were either estimated empirically (TI 1978a) or chosen from the range of efficiencies reported in the literature (Kjelson and Colby 1977).

Table III-28

Sampling Strata, Gear, and Adjustment Factors Used To Calculate Combined Standing Crop of Striped Bass in Hudson River (assumed values are chosen from range of efficiencies reported in literature)

Stratum	Sampling Gear	Time	Adjustment Factors
Shore Zone [0-10ft,(0-3m)]	100ft (30m) Beach Seine	Day	• Night/Day Catch Ratio=2.1† • Catch Efficiency=39 percent†
Shoal [10-20ft,(4-7m)]	$1m^2$ Epibenthic Sled $1m^2$ Tucker Trawl	Night	• Catch Efficiency=50 percent*
Bottom [0-10ft,(0-3m) above river bottom where depth >20ft(7m)]	$1m^2$ Epibenthic Sled	Night	• Catch Efficiency=50 percent*
Channel [10ft(3m) above river bottom to surface where depth >20ft (7m)]	$1m^2$ Tucker Trawl	Night	• Catch Efficiency=50 percent*

* Assumed Value
† Estimated Empirically (TI 1978a)

Mark-recapture estimates were calculated by marking and releasing a known number of animals, then estimating the fraction of the population that the marked animals represented in a subsequent sample. Assumptions inherent in the method and the consequences of violating the assumptions were described in previous reports (TI 1978a, 1979a; Ricker 1975; Seber 1973; and Appendix B of this report).

The Petersen-type population estimate was chosen for striped bass because it is flexible with regard to the timing of a recapture sample: it allows time for the Type C error to decline (Appendix B), which is not possible in multiple census estimates. The adjusted Petersen estimate of Chapman (Ricker 1975) is statistically unbiased when numbers of recaptures are small. Using this method, 95% confidence intervals were calculated by considering the number of recaptures as a Poisson variable:

$$N^* = \frac{(M+1)\ (C+1)}{R+1}$$

with 95% confidence limits for

$$N_L^* = \frac{(M+1)\ (C+1)}{R_U+1}$$

$$N_u^* = \frac{(M+1)\ (C+1)}{R_L+1}$$

where

N^* = adjusted Petersen population estimate

M = number of fish marked

C = number of fish examined in recapture sample

R = number of marked fish recaptured

R_U and R_L = upper and lower 95% limits for a Poisson variable with u=R.

2) Results and Discussion

Using the density extrapolation method and adjustments for sampling gear efficiency, a peak standing crop of 30.8 million juveniles in late July was estimated (Figure III-31) Peak abundance was higher and earlier during July than in previous years (TI 1979a, McFadden et al. 1978). After the July peak, standing crops dropped sharply until late November when less than 1 million juveniles were estimated to be in the sampled portion of the estuary (above RM 12).

Adjustments for the efficiency of sampling gear increased the 1977 combined standing crop estimates. The upper curve in Figure III-31 represents late summer and fall standing crops if the 100-ft beach seine is assumed to be 39% efficient (TI 1978b). Other sampling gear were assumed to be 50% efficient. The lower curve represents standing crops if all gear are assumed to be 100% efficient, i.e., unadjusted standing crops (Appendix Table B-49). The negative bias introduced to the standing crop estimates when using unadjusted catches from any of the sampling gear cannot be disputed. Kjelson and Colby (1977) reviewed gear efficiency in fisheries sampling and concluded, based on the few field studies that have attempted to estimate efficiency, that most sampling gear are rather low in efficiency. Catch efficiency, except as it is related to size selectivity, has been largely neglected in fisheries research. When densities are an important study

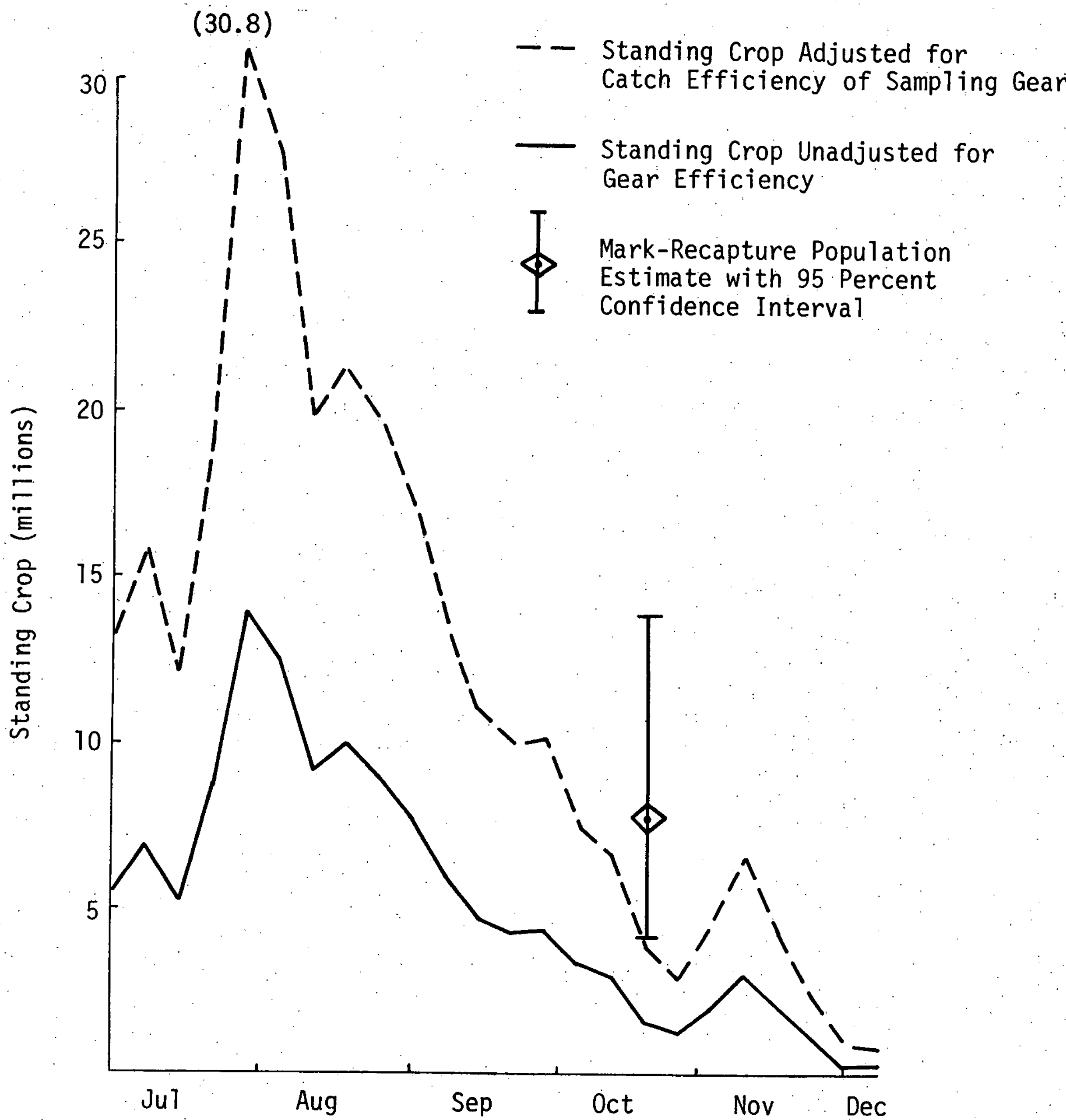


Figure III-31. Standing Crops of Striped Bass in 1977. (Single estimate in October was calculated from mark-recapture data.)

objective, the resulting population estimates are often termed "minimal" (e.g., Hatch 1978). In contrast, efficiency has long been an important consideration in plankton sampling (Clutter and Anraku 1968, Barkley 1964), in which density estimates are commonly sought. When fisheries data are to be used in a manner similar to plankton data (Houser and Dunn 1967, Robinson and Barraclough 1978, Hatch 1978), consideration of catch efficiency is particularly appropriate.

Although equal catch efficiency during day and night may be assumed, the efficiency adjustment of 39% (TI 1978b) for beach seines is the best available estimate of seine efficiency for juvenile striped bass available. Kjelson and Colby (1977) reported similar efficiencies for day and night trawl catches. For the time frame included in this report (1 January 1977-30 June 1978), empirical estimates of catch efficiency for epibenthic sleds and Tucker trawls were not available, but the assumed efficiency (50%) was within the range reported for other towed nets (Kjelson and Colby 1977).

Based on the adjusted combined standing crops, juvenile population size on 1 August (considered as the beginning date of impingement exposure for impact calculations; see subsection III.E) was approximately 30 million. This was selected as the best estimate of juvenile population size in 1977 in order to eliminate bias caused by escapement and emigration.

The Petersen mark-recapture estimate for the 1977 year class was 7.0 million striped bass in late October (Figure III-31). This estimate was much smaller than the peak standing crop in late July but slightly larger than the October standing crop based on density extrapolation. Estimates for a period earlier in the fall were not possible because the systematic error introduced by incomplete mixing of marked and unmarked fish would have severely biased the estimates.

The pattern of recaptures of marked fish was similar to that of previous years: during the latter part of 1977, fish marked in September were recaptured most frequently, followed by lower recapture rates for fish marked in October and November (Table III-29). This pattern was due primarily to the length of time the fish marked during each month were available for recapture before they left the shore zone. The recapture rates in 1977 were comparable to those in previous years (TI 1979a).

From January through June 1978, the frequency of recaptures was reversed: fish marked later in the season were more likely to be recovered than those marked earlier in the season (Table III-29). Again, this pattern followed that of previous years (TI 1979a) except that none of the 1976 year class was recaptured in 1977. The reversal of monthly recapture rates in the two time periods was probably caused by different monthly emigration rates among fish marked during the fall. If emigration is a late summer or early fall phenomenon, most of the juveniles marked in September and October should emigrate while those fish remaining in the Hudson River through November may represent a portion of the population that will overwinter in the river. Natural mortality may also play some role in the higher spring recapture rates of fish marked in November, since fish marked in September experience two to three additional months of mortality on the average compared with those marked in November.

Table III-29

Numbers of Juvenile Striped Bass Marked in Hudson River Estuary during Fall 1977 and Subsequent Recapture Rates

		Release Month		
		Sep	Oct	Nov
(1)	Number marked	6293	5091	2833
(2)	Number recaptures, Sep-Dec	808	174	32
(3)	Recapture rate	0.128	0.034	0.011
(4)	Estimated number available, Jan 1 (1)-(2)	5485	4917	2801
(5)	Number recaptured, Jan-Jun	4	6	7
(6)	Recapture rate	0.00073	0.00122	0.00250

*Number marked was adjusted for estimated marking and handling mortality of 5% for September and 25% for October and November.

Because of differences in recapture rates among months in which the fish were marked, marked fish could not be pooled over all release periods for calculating population size. October and November were selected for the release period because (1) the recovery rates for the 2 months were not significantly different (α=0.05), (2) combined, the 2 months accounted for 13 of the 17 recaptures in 1978, and (3) the same 2 months had been used in previous years (McFadden 1977a), thereby maintaining comparability.

The number of marked fish recaptured, expressed as a fraction of the catch (R/C), also exhibited the pattern of previous years, i.e., highest values in September, a sharp decline until winter, then relatively stable values through May (Figure III-32). The temporal pattern of the R/C ratio can reveal types B and C errors that may severely bias mark-recapture estimates (TI 1979a). A steep decline in the ratio during the marking months indicated a type C error. Therefore, multiple census estimates such as the Schumacher-Eschmeyer estimate would be severely biased. A selection of an unbiased subset of the recaptures, as attempted for adult striped bass in subsection III.B.6, was not possible since finclips do not provide release information with sufficient detail to select subsets of recaptures. When all the assumptions for the Petersen estimate are met, the R/C ratio will remain constant. Thus, a period of constant R/C values should be the best to use as the recapture period. Since December through April had very consistent R/C ratios (Figure III-32), these months were selected as the recapture period (Table III-30). Recapture effort included TI field sampling and impingement collections at the Bowline, Lovett, Indian Point, Roseton, and Danskammer generating stations.

The mark-recapture estimate of juvenile striped bass is less useful as the initial population size for calculating impingement impact inasmuch as it applies to a period well past the beginning of impingement exposure and after emigration from the estuary. Since type C error was severe throughout the fall, estimates for September were not possible. After the error had declined in late winter, too few fish marked in September were available for recapture. Thus, the density extrapolation method was preferred for estimating the direct impact of impingement on juvenile striped bass in 1977.

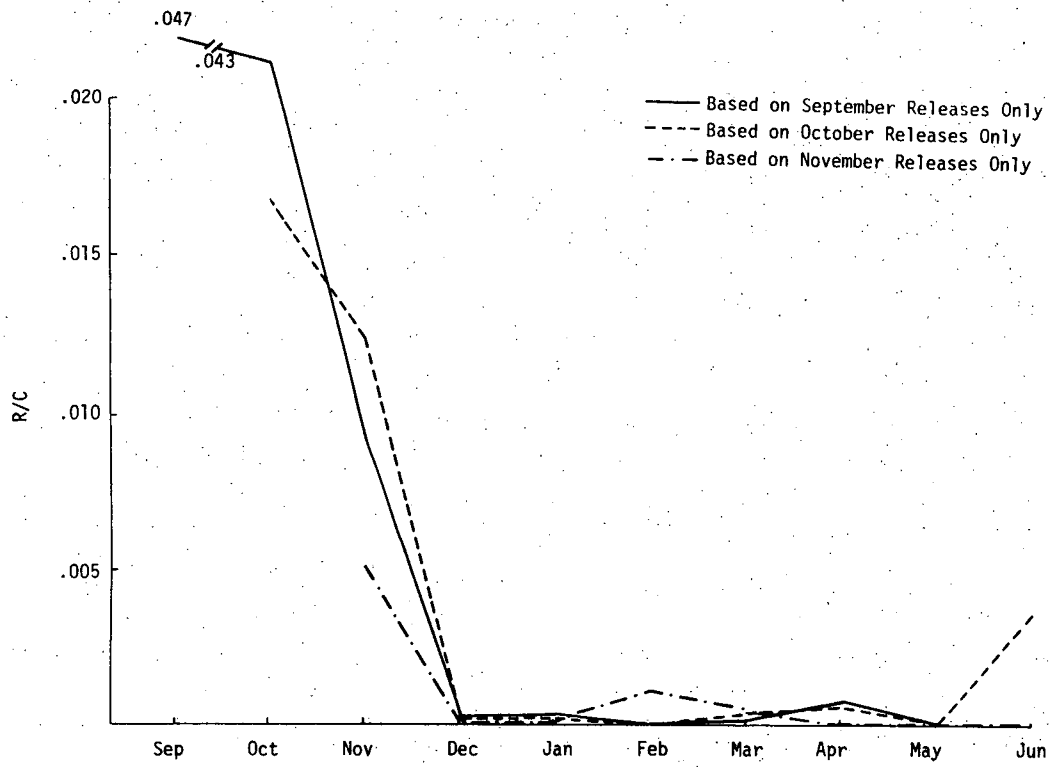


Figure III-32. Fraction of Marked Striped Bass in Total Catch (R/C) for September 1977-June 1978

Table III-30

Petersen Mark-Recapture Estimate of Juvenile Striped Bass in Hudson River Estuary, Late October 1977

Number of Fish Marked in Oct and Nov (M)	Number of Fish Examined for Marks in Dec through Apr (C)	Number of Fish Recaptured with Marks (R)	Population Estimate† N*	95 Percent Confidence Interval
7718	9109	9	$7x10^6$	$3.9x10^6$ to $14.1x10^6$

†Estimated from $N^* = \frac{(M+1)(C+1)}{(R+1)}$

b. Relative Measure of Population Size

Beach seine surveys conducted since 1965 provide the best data base for assessing long-term trends in juvenile striped bass abundance (TI 1978a, 1979a; McFadden and Lawler 1977). Although these surveys varied in intensity, gear type, and spatial and temporal distribution of sampling effort, they are sufficiently comparable to generate meaningful trends.

1) Methods

The temporal distribution of sampling effort, discussed in previous reports (TI 1978a, 1979a), allows only June through August as possible periods to calculate annual abundance indices for young-of-the-year (Figure III-33). The spatial distribution of sampling has varied (Table III-31) from a relatively restricted area (the Croton-Haverstraw through West Point regions in 1969 and 1970) to a riverwide effort (Yonkers through Albany regions in 1973 through 1977. Changes in seine length have been accommodated by expressing the index in terms of catch-per-unit-area (CPUA) rather than catch-per-unit-effort (C/f). The area swept by 50-ft (15-m) seines was measured by NYU at the time of sample collection in 1965-69 (Perlmutter et al. 1967). Areas swept by 100-ft seines used by Raytheon (1969-70) and TI (1972-77) were determined graphically from empirical results (Appendix Figure A-9) and the area swept by the 75-ft seine was calculated from those graphs. The 50- and 100-ft seines were equally efficient (TI 1977a) in catching juvenile striped bass on a catch-per-unit-area (10,000-ft^2) basis, and the 75-ft seine was assumed to be similarly efficient. Sampling effort (in total area swept) has ranged from 6.9×10^4 ft^2 (1965) to almost 2×10^6 ft^2 (1975 and 1976).

The annual abundance index for juvenile striped bass is defined as the mean catch per 10,000 ft^2 swept in the lower Hudson River (Tappan Zee through Cornwall regions) from mid-July through August. This period was selected because striped bass were not usually abundant in the shore zone until mid-July, and because August was the latest sampling month common to all years. These regions were selected because most of the juvenile population was consistently located there in July and August (Figures III-27 and III-28).

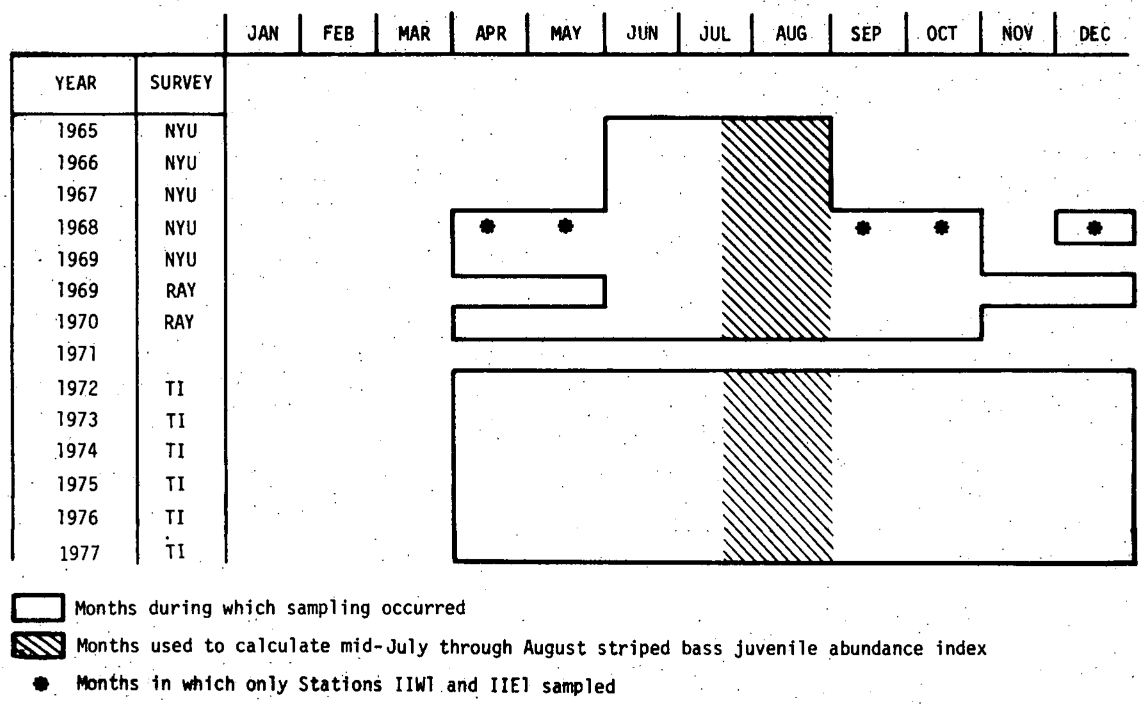


Figure III-33. Temporal Distribution of Beach Seine Sampling in Hudson River Estuary, 1965-77

The following hypotheses were explored to evaluate the usefulness of the calculated abundance index:

(1) A better index to annual abundance (i.e. year class strength) may exist for 1969-77 when the temporal distribution of sampling effort was greater than in 1965-68 (Table III-39).

(2) Year class strength is established by July-August. If this hypothesis were true, then the yearling abundance index from the following year should show a similar trend and an index of juvenile abundance in 1971 could be estimated.

2) Results and Discussion

Comparison of the mid-July through August index with the September index indicated considerable temporal variation in peak shore zone abundance (Figure III-34). September catches in 1973 were extremely high, while catches in 1969, 1974, and 1975 appeared intermediate. These apparent variations in relative size of the year classes, depending on sampling period, could have been caused by annual variations in growth, timing, and intensity

Table III-31

Geographical Regions of Hudson River Estuary Sampled by Beach Seines, 1965-77

		Region (River Mile)											
Year	Survey	YK (12-23)	TZ (24-33)	CH (34-38)	IP (39-46)	WP (47-55)	CW (56-61)	PK (62-76)	HP (77-85)	KG (86-93)[1]	SG (94-106)	SC (107-124)	AL (125-152)
1965	NYU		*		*		*	*		*	*		
1966	NYU		*		*		*	*		*	*		
1967	NYU		*		*		*	*		*	*		
1968	NYU		*		*		*	*		*	*		
1969	NYU				*		*			*			
1969	RAY			*	*	*							
1970	RAY			*	*	*							
1971***													
1972	TI		*	*	*	**	**						
1973	TI	*	*	*	*	*	*	*	*	*	*	*	*
1974	TI	*	*	*	*	*	*	*	*	*	*	*	*
1975	TI	*	*	*	*	*	*	*	*	*	*	*	*
1976	TI	*	*	*	*	*	*	*	*	*	*	*	*
1977	TI	*	*	*	*	*	*	*	*	*	*	*	*

*Beach seine samples taken in this region.
**Beach seine samples taken from October through December only.
***No surveys were conducted during 1971.

of emigration or movements from the shore zone to deeper water. Thus, the July-August index, since it encompassed the time period before most emigration and movement away from the shore zone, was selected as representative of year class strength.

Juvenile abundance from mid-July through August was significantly correlated ($r=0.765$, $p<0.01$) with abundance of yearling and older striped bass the following year (Figure III-35). Since the yearling and older striped bass caught during the mid-July through August index period were primarily yearlings (TI 1979a), juvenile abundance during mid-July and August is apparently a good prediction of year class strength as yearlings. Therefore, the yearling and older abundance index was used to estimate the previous year's juvenile abundance. For example, using the relationship that the yearling and older abundance index is 0.031 times the juvenile abundance index plus 0.08 (Figure III-35), the predicted size of the 1971 year class was also relatively large (Figure III-36). Other investigations also suggested that the striped bass year class in 1971 was relatively large (O and R 1977).

Over the years studied, the abundance of juvenile striped bass based on the July-August index varied by a factor of 27.2 but revealed no definite long-term decreasing or increasing trend (Table III-32). Three weak year classes (1965, 1967, and 1968) and two strong year classes (1969 and 1973) were apparent, while other years were intermediate. These indices were significantly correlated with the riverwide indices presented previously by TI (1979a, Table III-6, $r=0.888$, $p<0.01$).

c. Factors Affecting Abundance

The 12 years of relative abundance indices provided a data base for assessing the environmental factors influencing striped bass year class strength. Multivariate statistical procedures can be used to identify associations between these indices and selected environmental variables, enabling formation of hypotheses concerning the effects of factors important to the success of the year class. Predictive models can then be constructed and tested with data from subsequent years. Because this analysis represents an initial screening, a large number of variables were considered. The

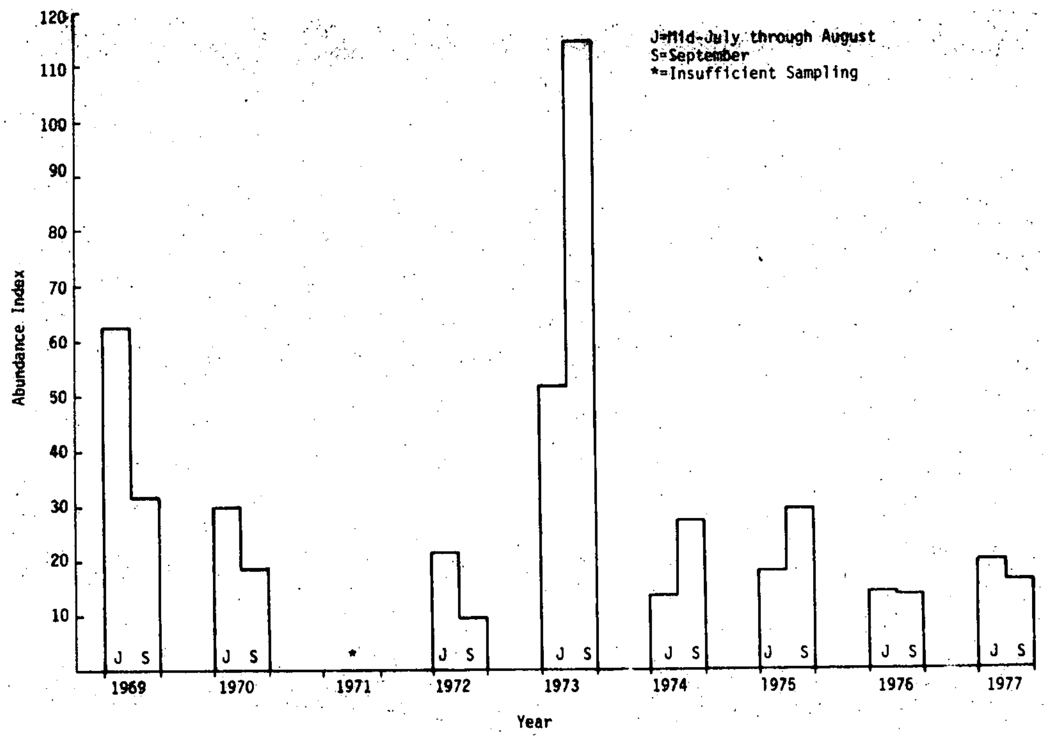


Figure III-34. Juvenile Striped Bass Abundance Indices [Catch per Unit Area (CPUA)], 1967-77 (excluding 1971), for Two Time Intervals, Mid-July through August (J) and September (S)

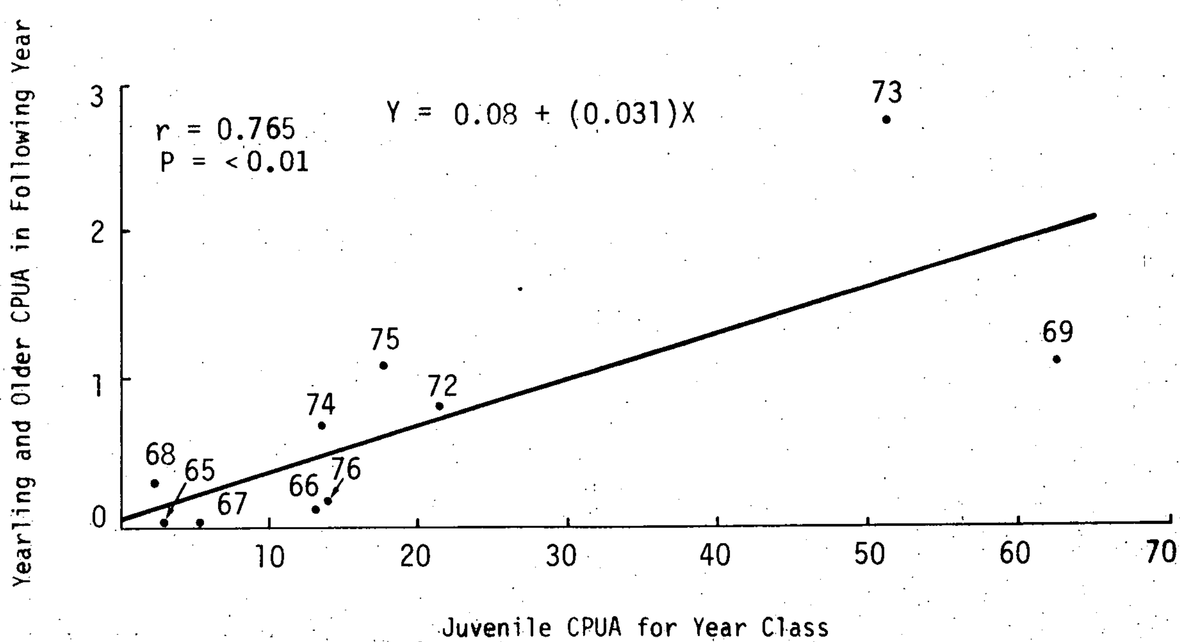


Figure III-35. CPUA of Yearling and Older Striped Bass (Y) as Function of Juvenile CPUA in Mid-July through August of Previous Year (X)

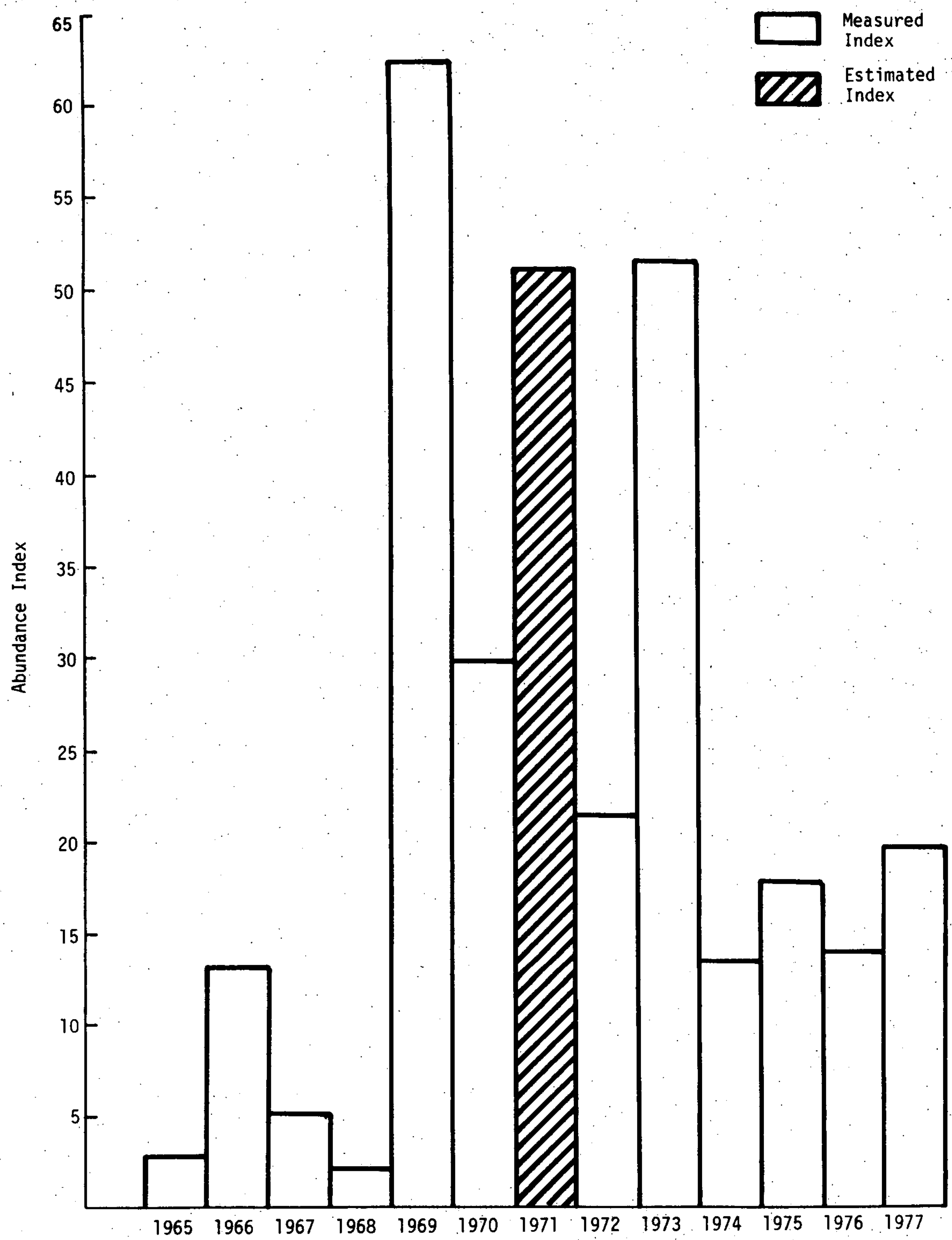


Figure III-36. Juvenile Striped Bass Abundance Indices (Catch per Unit Area) in Hudson River Estuary, Mid-July through August, 1965-77

Table III-32

Relative Abundance of Juvenile Striped Bass in Hudson River Estuary Based on Beach Seine Sampling in Tappan Zee-Cornwall Regions during Late July and August

Year	Survey	Sample Dates	Area Swept ($10^4 ft^2$)	Juveniles Number Caught	Juveniles Abundance Number
1965	NYU	Jul 18-Aug 21	6.9	20	2.9
1966	NYU	Jul 17-Aug 27	16.9	222	13.2
1967	NYU	Jul 16-Aug 26	13.0	68	5.2
1968	NYU	Jul 14-Aug 24	18.0	42	2.3
1969	NYU&RAY	Jul 13-Aug 30	12.7	792	62.5
1970	RAY	Jul 12-Aug 29	42.6	1273	29.9
1972	TI	Jul 16-Aug 26	27.8	599	21.5
1973	TI	Jul 15-Aug 25	63.5	3263	51.4
1974	TI	Jul 14-Aug 31	118.2	1612	13.6
1975	TI	Jul 13-Aug 30	196.7	3503	17.8
1976	TI	Jul 11-Aug 28	196.7	2744	14.0
1977	TI	Jul 17-Aug 27	151.1	2972	19.7

inclusion of a large number of variables increases the probability of type II error (accepting a variable as significant when it is not), but future years of testing should eliminate those variables included by chance in this analysis.

1) Methods

Multiple linear regression (MLR) was the statistical procedure used to identify associations between abundance indices and selected environmental variables. A special case of MLR (latent root analysis) is also available if significant interrelationships exist among the independent variables selected as important factors. In previous years (TI 1978a, 1979a), the latent root analysis was used exclusively. If no interdependencies exist among the independent variables, however, then the latent root procedure is identical to multiple linear regression (MLR).

In past analyses, it was assumed that the environmental factors affecting year class strength would act in an additive (linear) manner; i.e. year class strength could be described by the sum of the products of the important factors and their regression coefficients. The model was thus:

$$y = \beta_o + \beta_1 X_1 + \beta_2 X_2 \ldots$$

where

y = juvenile striped bass abundance

X_i = environmental factors (i = 1 through n)

β_o = intercept of the regression line

β_i = regression coefficients of the important factors (i = 1 through n)

In a recent analysis using this additive model (TI 1979a), no significant (α=0.05) relationships were detected. Although significant relationships were detected in previous analyses, the correlation coefficients were relatively low (McFadden and Lawler 1977).

Since many biological processes are inherently multiplicative (nonlinear) rather than additive (Ricker 1975), a multiplicative model also was tested. It assumes that year class strength can be described by the product of the environmental factors raised to a power:

$$y = e^{\beta_o} \cdot X_1^{\beta_1} \cdot X_2^{\beta_2} \ldots$$

This multiplicative model can be converted to an additive model, so that it can be derived from MLR, by taking the natural logarithm of both sides of the equation:

$$\ell n y = \beta_o + \beta_1 \cdot \ell n X_1 + \beta_2 \cdot \ell n X_2 \ldots$$

If only slight differences existed between the additive and multiplicative models, the additive was chosen so that continuity with previous analyses was provided.

A maximum R^2 improvement regression routine (Barr et al. 1976) was used to select the set of most important environmental factors. This regression routine builds increasingly complex models by adding to the model the dependent variable which produces the greatest increase in R^2 at each addition of new variables. Each time a new variable is added, all other variables already included in the model are temporarily excluded, one at a time, and replaced with each variable not presently in the model. If one of these substitutions increases R^2, the substituted variable is retained in the model. This procedure continues for each variable in the model until no further increases in R^2 and no further substitutions are made at that level of complexity (number of variables in the model).

Environmental factors selected for these analyses were classified into three categories, based on the period during which their effects on the striped bass population should occur: pre-spawning, spawning, and post-spawning. These classifications aid in interpreting the mechanisms of action of the key variables.

Pre-spawning factors must either act indirectly on the year class by determining environmental conditions at a later date (i.e., resource levels for developing fish) or affect the parental stock since they cannot affect the year class directly. These factors set the stage for spawning and the presence of early life stages and thus can be important. The most likely mechanism of action for pre-spawning variables is the determination of nutrient levels available in the spring, which, in turn, can control zooplankton abundance and food availability to striped bass larvae. Flow variables are the obvious choices for nutrient regulators since organic carbon in the Hudson River estuary is primarily allochthonous (McFadden 1977a). Late fall and early winter is a period of high carbon influx (Appendix B); thus, average freshwater flow during November, December, and November-December combined (as measured at the Green Island Dam) was selected and included in the analysis. Others (Merriman 1941, Polgar 1977, Hienle et al. 1976) have found a negative relationship between December temperature and subsequent year class strength in the Chesapeake Bay system. Heinle et al. (1976) suggested that severe winters may increase nutrient levels through scouring of marshes by ice, which would increase detrital input. The scouring of marshes may be less important in the Hudson system where marsh areas are not extensive, but mean December water temperature (from the Poughkeepsie Water Works) was also included.

Factors that act during the time of spawning are perhaps easier to visualize as important to year class strength than are pre-spawning factors. Environmental conditions during the spawning period should be particularly important because survival of the eggs and larvae may be related directly to the effects of the environment and indirectly via the spatial and temporal distribution of spawning. Spawning factors, like the pre-spawning factors, are primarily physical (abiotic) rather than biological (biotic). Freshwater flow in the spring provides an obvious mechanism of action since it not only controls organic carbon input (Appendix B) but also the salinity patterns in the estuary. Thus, flow may be important in determining the spatial distribution of eggs and early larvae. Mean freshwater flows just prior to and during the spawning run (April, May, and April and May combined) were selected and included in the analysis. Temperature apparently influences the time of spawning; the initial occurrence of striped bass eggs in ichthyoplankton samples is usually at approximately 12°C (subsection III.C.1 and Appendix Table B-15). If the timing of initial spawning is important to year class strength, the deviation (in days) from the mean date for each year when water temperature reached 12°C was entered into the regression. Years in which the initial spawning was later or earlier than the mean date should produce relatively weak year classes if synchrony with a phenomenon that is not as rigidly controlled by temperature is important.

Post-spawning factors include both physical and biological variables and, in general, are the easiest to interpret since they can act directly on the young striped bass. Physical variables selected in this category were freshwater flow during June and July and the number of days to span two temperature ranges (16° to 20°C and 18° to 22°C). These temperature ranges corresponded to the periods of peak abundance of yolk-sac and post yolk-sac larvae (subsection III.C.2 and Appendix Tables B-30 and B-31); thus, the durations of these temperatures should be related to the length of time during which the larvae are in these life stages. If the larval stages are critical periods (May 1974) due to high predation losses, then rapid passage through them should result in better survival. Water temperatures change rapidly in June and July, so the rate of temperature rise has more biological significance than the mean temperature over some fixed period. Biological factors were considered to act primarily through competition and predation. Annual abundances of juvenile white perch (from indices developed in subsection IV.D.1) were entered as an index of interspecific competitive pressure. The mean abundances (CPA) from mid-July through August for two known predators of juvenile striped bass, yearling striped bass (Stevens, D.E. 1966) and juvenile bluefish (TI 1976d), as well as both species combined (TI 1978a), were used as indices of potential predation mortality. Estimated cooling water withdrawal for the Bowline, Lovett, Indian Point, Roseton, and Danskammer generating stations in May, June, and July was included as an index of potential entrainment mortality. A final variable, the year of observation, was also included in order to detect any temporal trend in annual abundance.

The multiplicative model represents essentially a new beginning in the MLR analysis; thus, all of the factors listed (Appendix Table B-52) were tested in the model even though many had shown no previous significant relationships in the linear model (McFadden 1977a, TI 1979a).

2) Results and Discussion

The multiplicative effect model produced significantly higher R^2 values than the additive model. This was expected since biological processes tend to be multiplicative rather than additive in nature (Ricker 1975); also, the additive model had revealed inconsistent and inconclusive results in the past (TI 1979a). All the results which follow, then, are based on the multiplicative model.

The best model, i.e., the one producing the highest R^2 with all dependent variables having probability values of <0.05, was a 2-variable model with combined April-May freshwater flow (+) and deviations from mean date on which water temperature reached 12°C (-) as the important independent variables (Table III-33). This model produced an R^2 value of 0.682, which left 32% of the variation in the transformed abundance index unexplained. Thus, abundance was also controlled by factors other than the two in the model. Both of the selected factors acted before or during spawning and were physical in nature; thus, the success of striped bass year classes depended largely on the temperatures and flow occurring just prior to and during spawning or early in the larval stages.

Table III-33

Best 2-Variable Multiple Linear Regression Model of Factors Affecting Striped Bass Year Class Strength Selected by Maximum R^2 Improvement Procedure (for models with more components, not all factors were significant at $\alpha=0.05$)

	Degrees of Freedom	Sum of Squares	Mean Square	F	P>F	R^2
Regression	2	7.858	3.929	9.67	0.0057	0.682
Error	9	3.656	0.406			
Total	11	11.514				

	Value	P
Intercept	-19.890	
Apr-May Flow	2.175	0.008
Deviation from day of 12°	-0.562	0.038

Predictive Equation:

$$y = e^{-19.890} \cdot X_1^{2.175} \cdot X_2^{-0.562}$$

where

y = striped bass abundance index
e = base of natural logarithms
X_1 = average freshwater flow during April and May
X_2 deviation from mean date of 12°C

High freshwater flows in April and May were associated with relatively strong year classes, but the mechanisms of action are speculative at this time. High spring flows increase organic carbon level (Appendix B), thereby increasing the food supply for the small zooplankton, which are the initial food source of the newly hatched striped bass larvae. Increased zooplankton densities would result in better growth and survival of the larvae. A second possible mechanism is through control of the spatial distribution of spawning via the influence of April and May freshwater flows on salt front position. Striped bass consistently spawn slightly upstream from the salt front in the Hudson River and elsewhere (subsection III.C). During years of available data (1974-77), spawning occurred in the vicinity of the Hudson highlands (RM 40-60) and year classes were intermediate in strength. In years of high spring flows, the salt front would be displaced downstream and spawning could occur farther downstream, thereby placing the larvae closer to the more productive nursery areas of Croton-Haverstraw Bays and the Tappan Zee (RM 25-38).

The importance of the timing of initial spawning, as measured by the deviation from the mean date of 12°C, may be in the synchronization of the larval stages with food organisms of the appropriate size. Because of their small size and short life cycle (many of the dominant zooplankters have life cycles lasting about a month), zooplankters respond quickly to favorable conditions. When food is not a limiting factor, zooplankton can increase exponentially in a short time. Striped bass spawning, however, is controlled by both intrinsic and extrinsic mechanisms and, unless fish were nearly ready to spawn, more than a few days of optimal conditions would be required to initiate spawning. Since zooplankton react very quickly to environmental conditions and the production of feeding larvae is a slower process, a loss of synchronization between food and larvae could be expected in years of abnormal temperature patterns. Years when the larvae and zooplankton abundance did not conicide would result in the observed negative relationship between year class strength and deviations from average time of initial spawning. Natural selection should act to optimize the synchronization between larvae and zooplankton, so the average date of initial spawning should reflect optimal synchronization. Unfortunately, however, supportive evidence on the temporal abundance of zooplankton is currently unavailable.

Half of the residual variation (16%) could be explained by the third and fourth variables selected by the regression routine (days to span 16-20°C and mean December temperatures), but they were not significantly related at α=0.05 (Table III-34). These two factors may influence year class strength. In agreement with the a priori hypothesis, rapid temperature rise between 16° and 20°C may be beneficial to year class strength, possibly because the yolk-sac larvae pass rapidly through a critical period. The relationship with December temperature could be similar to that suggested by other studies

(Heinle et al. 1976, Polgar 1977, Merriman 1941), although it is apparently not the major factor controlling year class strength in the Hudson estuary. Low temperatures in December may act to increase nutrient levels available o zooplankton in the spring. The exact mechanisms of this process, however, are still obscure.

Table III-34

Multiple Linear Regression Models Selected Best by Maximum R^2 Improvement Procedure for 1, 2, 3, and 4 Independent Variables (in models with more than two independent variables, one or more variables were not significant at $\alpha = 0.05$)

Number of Independent Variables	R^2	Independent Variables	P
1	0.473	Apr-May Flow	0.0135
2	0.682	Apr-May Flow	0.0079
		Dev. From 12°	0.0375
3	0.775	Apr-May Flow	0.0049
		Dev. From 12°	0.0121
		Days to span 16°-20°C	0.1071
4	0.841	Apr-May Flow	0.0112
		Dev. from 12°	0.0091
		Days to span 16°-20°C	0.1196
		Dec Temperature	0.1319

These analyses represent the current state of knowledge but not the final definitive conclusions regarding the complex ecological relationships that affect juvenile striped bass abundance in the Hudson River. As the data base is expanded and refined and new analytical techniques are examined and tested, particular factors will appear, disappear, and reappear as being important in determining year class strength. This constant shifting of the apparently important factors and disagreement with analyses performed previously are to be expected with small data sets (Ricker 1975).

The current hypothesis is that striped bass year class strength in the Hudson River estuary is controlled primarily by freshwater flow during April and May, which may regulate the prey organisms. High freshwater flows in April and May transport greater amounts of nutrients into the estuary, thus increasing zooplankton production. High flows may also shift major spawning grounds to areas more favorable for larval survival. The timing of spawning is also an important factor, because food of the appropriate size must be available when the larvae need it. Optimal synchronization of larvae and prey occurs when the abundance of feeding larvae is matched temporally with a rapid increase in zooplankton abundance, i.e., when the smaller stages of zooplankton, which are preyed upon by the larvae, are at peak standing crops. During years in which spring temperature patterns are abnormal and water temperatures reach 12°C earlier or later than usual, this synchrony is destroyed and relatively weak year classes result. Rate of temperature rise may also be important in determining year class strength, although the relationships with these two factors were not statistically significant.

2. Mortality

Mortality rates are often extremely high in the early life stages, particularly among fishes with enormous reproductive potential such as striped bass. During these early stages, seemingly minor changes in mortality rates can result in large differences in the number of survivors. Therefore, an analysis of mortality patterns in the young-of-the-year can provide insight into the underlying mechanisms establishing year class strength and the relative size of subsequent age groups.

This subsection describes and evaluates survival patterns of the 1977 year class of striped bass through the larval and early juvenile stages. These patterns and the estimated mortality rates are compared with those of the 1975 and 1976 year classes described in previous reports (McFadden 1977a, TI 1979a). Annual differences are compared with variations in environmental factors to develop hypotheses concerning optimum conditions resulting in strong year classes.

a. Methods

Larval and juvenile mortality rates were estimated from changes in standing crops through time with a catch curve analysis (Ricker 1975). This method is identical to that which was used to estimate mortality in the 1975 and 1976 year classes (McFadden 1977a, TI 1979a) and is similar to the procedure used by Sette (1943) and Pearcy (1962) to estimate mortality rates for other fish species.

From the time of peak larval abundance through early October 1977, instantaneous daily mortality rates were determined for periods of apparent constant mortality using the model:

$$\ln (N_t) = \ln (N_o) + Z (X_t)$$

where

Z = estimated daily instantaneous mortality rate

X_t = number of days from 1 May to the midpoint of sample week t

N_t = estimated standing crop of striped bass larvae and juveniles for sample week t

N_o = initial standing crop

Estimates of daily instantaneous mortality rate (Z) were then converted to daily mortality rates as follows:

$$\text{daily mortality rate} = 1-e^{-Z}$$

To provide mortality estimates comparable with those of previous years, combined standing crops for juveniles were adjusted only for the night:day catch ratio for beach seines (subsection III.B.1); no corrections for gear efficiency were applied. Differences in the estimated mortality rates between years are discussed and compared with variations in environmental factors.

b. Results and Discussion

Two periods of constant rates of population decline were apparent in 1977: phase I from 31 May through 8 July; and phase II from 9 July through 2 October (Figure III-37). During phase I, most of the young striped

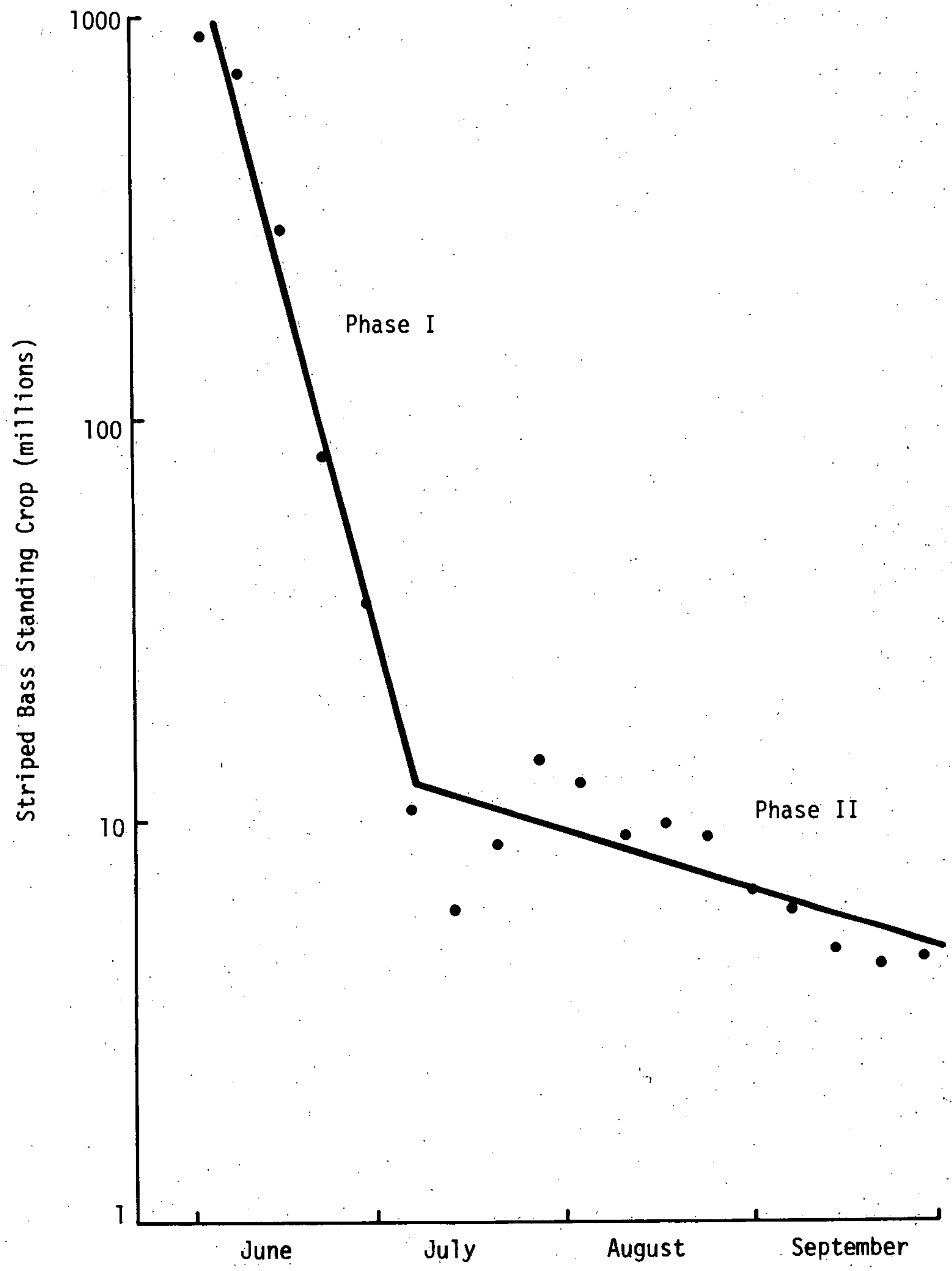


Figure III-37. Relationship between Population Size and Time for 1977 Year Class of Striped Bass during Larval and Juvenile Stages in Hudson River Estuary (Two phases of constant instantaneous mortality rate are apparent) bass were in either the yolk-sac or post yolk-sac larval stages, whereas the striped bass population during phase II was almost exclusively juveniles.

Estimated daily mortality rates in 1977 declined from 12.5% per day during phase I to 1.1% per day during phase II (Table III-35). Mortality rates during the larval stages were lower in 1977 than in the previous 2 years, whereas mortality rates during the juvenile stages were highest in 1977.

To compare larval mortality rates between years, the standing crop data for phases I and II in 1975 were used to calculate an average daily mortality rate for 2 June-7 July (Table III-36). Reasons for the annual differences in larval mortality (phase I) are not readily apparent. With only three data points, statistical analysis of factors affecting larval mortality was not warranted; however, some interesting associations exist. Mortality during the 3 years appeared to be inversely related to the juvenile striped bass abundance: the higher the larval mortality rate, the lower the juvenile abundance in July and August. Larval mortality varied directly with previous December water temperatures, a factor possibly inversely related to year class strength (subsection III.D.1).

Table III-35

Estimated Daily Mortality Rates of Young-of-the-Year Striped Bass in Hudson River Estuary during 1975, 1976, and 1977 (phases based on periods of apparently constant instantaneous mortality during each year)

1975 Year Class		1976 Year Class		1977 Year Class	
Time Interval	Daily Mortality Rate in Percent	Time Interval	Daily Mortality Rate in Percent	Time Interval	Daily Mortality Rate in Percent
May 31-Jun 24	17.5	Jun 03-Jul 13	14.9	May 31-Jul 08	12.5
Jun 25-Jul 26	5.1	Jul 14-Oct 02	0.3	Jul 09-Oct 02	1.1
Jul 27-Oct 11	0.5				

Table III-36

Estimated Larval Mortality Rates and Juvenile Abundance for Striped Bass and Previous December Water Temperatures for 1975-77 in Hudson River Estuary

Year	Estimated Larval Mortality (Jun-early Jul) in Percent	Striped Bass Juvenile Abundance Index	Previous Dec Mean Water Temperature
1975	13.6 day^{-1} *	17.81	1.75
1976	15.0 day^{-1}	13.95	3.42
1977	12.5 day^{-1}	19.66	1.30

*Differences from Table III-35 result from the use of different time periods.

Daily mortality rates for the juvenile period (from early or mid-July through early or mid-October) are directly comparable among the 3 years. The rates varied from 0.3% per day in 1976 to 1.1% per day in 1977 (Table III-37). These monthly rates are subject to at least two sources of bias: changes in gear avoidance through time and emigration from the sampling area. The magnitude of changes in gear avoidance from July to October due to growth is unknown; emigration, however, can occur as early as August and is probably almost complete by early October (TI 1976a). Both of these factors would cause mortality rates to be overestimated, because catches would decline at a greater rate than the population size.

Although the seasonal rate of emigration of Hudson River juvenile striped bass is unknown, studies of other fish species (Marcy 1976) show that downstream movements of juvenile anadromous fishes are related to changing water temperatures. To investigate the possible effect of temperature on emigration and resultant effects on estimates of mortality rates, the decline in water temperature (in ^{o}C per day) from the time of last peak temperatures in August through 1 October of 1975-77 was calculated. These rates of temperature decline appeared to be directly related to the estimates of daily mortality rates for each year (Table III-37) and provided a reasonable hypothesis explaining the differences in juvenile mortality rates estimated for 1975-77; i.e., if emigration is temperature-related, emigration rates should increase during periods of rapid temperature declines from August through 1 October. Rapid emigration during years of more rapid temperature decline (e.g., 1977) would result in rates of juvenile population decline substantially higher than would be expected from mortality alone. Thus, the regression of population size and time overestimates the true juvenile striped bass mortality rates when emigration is substantial. Since emigration rates of juvenile striped bass are not known, separation of the two components of population decline, emigration and mortality, is not presently possible.

Table III-37

Estimated Juvenile Mortality Rate for Striped Bass and Rate of Temperature Decline from Time of Peak August Water Temperatures to 1 October 1975-77 in Hudson River Estuary

Year	Estimate Juvenile Mortality Rate in Percent	Peak Aug Temperatures(°C)	Oct 1 Temperatures(°C)	Temperature Decline per Day(°C)
1975	0.5/day	27.2 (Aug 05)	16.7	0.19
1976	0.3/day	23.9 (Aug 30)	19.4	0.15
1977	1.1/day	25.6 (Aug 20)	16.7	0.22

Mortality rates calculated from exponential declines in standing crops indicated two distinct phases. Phase I (larval mortality) was extremely high (12.5% to 14.9% per day). Mortality rates for 1975-77 suggested a relationship with the previous December water temperatures, i.e., the warmer the December temperature, the higher the larval mortality. The suggestion of inverse relationship with the juvenile abundance indices (subsection III.D.1) suggests that year class strength may be controlled by mortality in the larval stages. Phase II (juvenile mortality) ranged from 0.3% to 1.1% per day for the 3 years and appeared to be inversely related to rate of decline of water temperature in late summer. Increasing gear avoidance (due to growth) and emigration certainly confound phase II rates. Thus, calculated mortality rates are probably too high.

3. Factors Affecting Growth

Growth of fishes, particularly during the early life stages, is an extremely plastic process subject to the effects of many biotic and abiotic environmental variables. Sources of mortality in the early life stages, e.g., predation and competition, can often be size-related. Descriptions of larval and early juvenile growth can provide insight into patterns of mortality during these stages. In addition, an analysis of the factors affecting early growth can be helpful in interpreting the relative importance of selected environmental parameters in the establishment of year class strength.

This subsection describes and evaluates the patterns of larval and juvenile growth of the 1977 year class of striped bass and compares the 1977 patterns with those of the 4 previous years (1973-76). Indices of spring and summer growth available for 1965-67, 1969-70, and 1972-77 permitted an analysis of the effects of abiotic environmental factors as well as inter- and intraspecific competition on the growth of young striped bass from hatching through mid-August.

a. Methods

Growth of larval and juvenile striped bass from the 1977 year class was described with the same procedures used for the 1973-75 year classes (McFadden 1977a) and the 1976 year class (TI 1979a). Mean total lengths were calculated for larvae collected by other contractors (LMS and NYU) in transect sampling conducted near the Bowline, Indian Point, and Roseton generating stations. Mean total lengths for post yolk-sac larvae and early juveniles were obtained from ichthyoplankton sampling conducted throughout the estuary from early May through mid-August. Data on juvenile total lengths were obtained from beach seine samples taken from RM 34 to RM 62, Fall Shoals Survey samples taken from RM 14 to RM 76, and Interregional Bottom Trawl samples taken from RM 24 to RM 62 from mid-June through mid-December. Using these data, weekly mean length estimates were calculated and growth curves were fitted by eye.

Length data from beach seine samples taken during July and August 1965 to 1970 and 1972 to 1977 were used to investigate factors affecting growth of juvenile striped bass since this was the sampling period common to all years. Mean total length was estimated for each week of sampling. Using the mean length estimates from weeks in which five fish or more were measured, instantaneous growth rates were estimated for each year using the following linear regression model (Ricker 1975):

$$\ell n(L_t) = \ell n(L_o) + \beta (X_t)$$

where

L_t = mean length at time t
X_t = number of days since 1 July for time t
β = estimated instantaneous growth rate
L_o = estimated mean length on 1 July

Growth rates for 1968 were excluded from further analysis because of the nonsignificant correlation (α=0.05) between $\ell n(L_t)$ and X_t and the small number (3) of weekly mean length estimates.

To provide an index of cumulative growth during the larval stages, the mean total length of juveniles on 15 July for each of the 11 years was predicted from estimates of L_o and β for the July-August period as follows:

$$L_A = \exp [\ell n(L_o) + \beta (A)]$$

where

L_A = predicted length on 15 July
A = number of days from 1 July to 15 July (=15)

Since 15 July was near the end of the period of larval abundance during 1974-77 (subsection III.C), mean length estimates for that date should provide a measure of cumulative growth from hatching through the larval stages.

Instantaneous growth rate during July and August and predicted total length on 15 July for the 11 years were related to selected biotic and abiotic factors described below using the maximum R^2 improvement method of stepwise linear regression (Barr et al. 1976). This procedure indicates the relative importance of each independent variable tested in a model describing either instantaneous growth rate during July and August or predicted length on 15 July.

1) Selection of Variables

Since there was an infinite number of combinations of potentially important biotic and abiotic environmental parameters which could be entered in this analysis, selection of the independent variables was limited to those most likely to affect growth. Inclusion of many variables would have increased the chance of finding coincidental relationships and would have made biological interpretation of the results exceedingly difficult.

First-year growth in fish is controlled primarily by temperature (Kramer and Smith 1960, Goldspink 1978, Broughton and Jones 1978). Kramer and Smith (1960) also found a relationship between growth rate and feeding for largemouth bass fry. In roach, _Rutilus rutilus_, first-year growth was influenced negatively by the density of young-of-the-year roach and positively by temperature (Goldspink 1978). Broughton and Jones (1978) also suggested that food abundance, as controlled by temperature, was important to roach. These or similar relationships were expected for striped bass, so the factors examined in this report were primarily temperature, competition (inter- and intraspecific), and factors other than temperature (e.g., fresh-water flow) that may control food availability.

a) Larvae

The following independent variables were chosen for inclusion in the analysis of factors affecting cumulative larval growth from the time of spawning to 15 July (Appendix Table B-54).

- Number of days since spawning

  Since striped bass do not spawn on exactly the same date each year, the mean length of the juvenile population on 15 July could vary, depending on the number of days available for growth since hatching. The time of spawning for each of the 11 years investigated was not known, but the time of striped bass spawning was related to water temperatures (Turner 1976). In the Hudson River estuary, most striped bass eggs consistently occur over the range of 14^{o}-20^{o}C (subsection III.C.1). Therefore, the data at which water temperature attained and remained above 15^{o} was chosen as the predicted time for the beginning of peak striped bass spawning in each year. The number of days between this date and 15 July defined the duration of the larval growth period for this analysis.

- Mean water temperature as measured at Poughkeepsie, New York (RM 76) from predicted time of major spawning to 15 July

  The effects of water temperature on fish growth have been well documented in the literature (see Weatherley 1972 for a review of this topic). Since temperatures during the period of larval growth (15^{o} to 24^{o}C) are well below the optimum temperature for growth of Hudson River striped bass larvae (29.6^{o}C) as reported by Ecological Analysts Incorporated (1978), the effects of temperature on growth should be approximately linear over this range. Therefore, the mean temperature for the period from the date when water temperatures reached 15^{o}C until 15 July was chosen as the best temperature index to investigate effects of temperature on larval growth.

- Average freshwater flow into the estuary during November and December of the previous year as measured at Green Island

  Since most organic carbon in the Hudson River estuary is produced elsewhere, i.e., is allochthonous (McFadden 1977a), nutrient availability should be related to freshwater input into the estuary. Substantial organic carbon input into the estuary in the form of leaf litter and dissolved organic carbon occurs in November and December (Appendix B). Thus, freshwater flow during these months should provide an index of nutrients and, indirectly, food availability for the larvae and juveniles during the next spring and summer.

- Average freshwater flow into the estuary during April and May as measured at Green Island

  April and May comprise another period of substantial organic carbon input to the estuary (Appendix B). Thus, freshwater flow during this period should provide an indirect measure of food availability for the developing larvae and juveniles.

b) Juveniles

The following independent variables were chosen for inclusion in the analysis of factors affecting juvenile growth (instantaneous growth rate) during July and August (Appendix Table B-53).

- Number of temperature-growth days between 15 July and 15 August

  This variable, as developed in Appendix B, provided an index of the effects of temperature on juvenile striped bass growth. It is the sum of the temperature-specific growth rates based on a nonlinear temperature-growth rate relationship (EAI 1978b) assumed to apply to juveniles over the temperatures of July and August. Thus, it is a more reliable index with which to evaluate the relative importance of temperature on growth than mean temperature or degree days.

- Index of juvenile striped bass abundance in July and August

  The effect of intraspecific competition on growth has been documented in the literature for several fish species (Backiel and LeCren 1967, Goldspink 1978) and found previously for juvenile striped bass in the Hudson (TI 1978a). The juvenile abundance index (subsection III.D.1) allowed investigation of possible density-dependent growth of juvenile striped bass in the Hudson River estuary.

- Index of juvenile white perch abundance in July and August

  The effects of interspecific competition on growth in one species coincident with the introduction of other species has been noted (Fraser 1978), but direct density-growth interspecific relationships are not well documented. The abundance of juvenile white perch, a common and closely related species, was used as an index of the potential affect of interspecific competition on juvenile striped bass growth.

- Average freshwater flow into the estuary during November and December of the previous year as measured at Green Island Dam

  The rationale for inclusion of this variable was discussed above.

- Average freshwater flow into the estuary during April and May as measured at Green Island

  The rationale for inclusion of this variable was discussed above.

- Predicted mean length of the juvenile population on 15 July

  Predicted mean length on 15 July was included in the analysis to investigate a possible relationship between the size of juveniles at the beginning of the period selected for this analysis and their subsequent growth.

2) Growth Patterns

During May-July, the pattern of growth determined from the mean lengths for the 1977 year class of striped bass was the sigmoid pattern of previous years. Mean lengths in 1977 were most similar to those of the 1973 year class (Figure III-38). In August 1977, growth rates declined substantially (much earlier than in previous years). By the end of October, the mean total length of the 1977 year class was 78-80 mm, which was similar to the 1976 year class, 13 mm less than the 1974 year class, and 18 mm less than the 1975 year class.

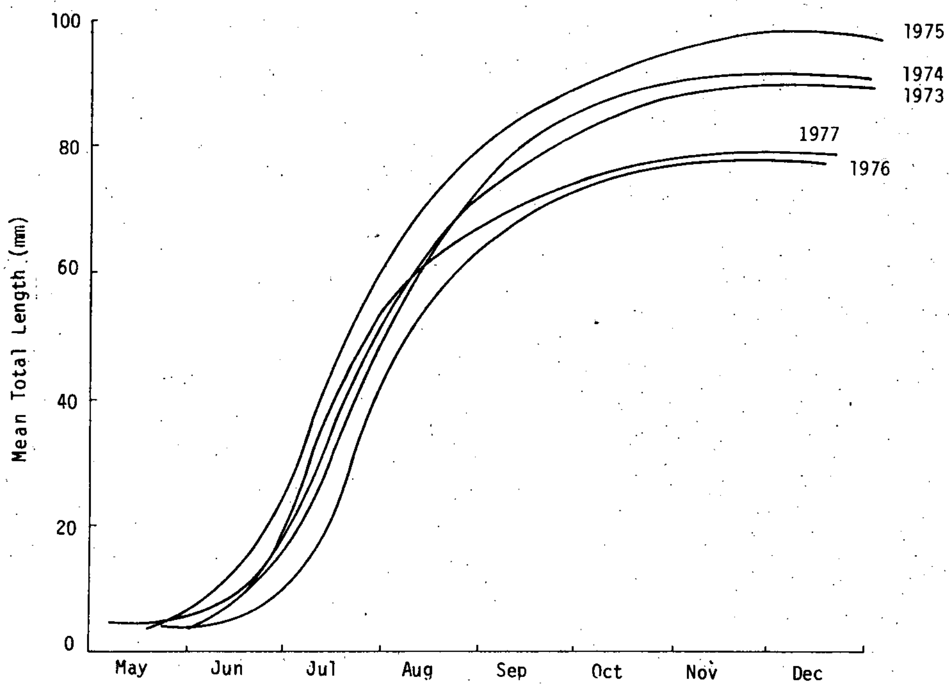


Figure III-38. Eye-Fitted Growth Curves for Larvae and Juveniles of 1973-77 Year Classes of Striped Bass in Hudson River Estuary

The reasons for the decline in juvenile growth from August through October 1977 are not readily apparent. The deviations from the typical growth pattern in 1976 were directly attributable to unusual temperature patterns (McFadden 1977a, TI 1979a). This was not the case in 1977 when the declining growth in August was not coincident with a decline in water temperatures. Furthermore, freshwater flow and striped bass and white perch abundance indices during the period in 1977 were within the ranges reported for previous years, and thus not obvious causal factors.

Patterns in the temporal abundance of juvenile striped bass during late summer 1977 were different from those of previous years (subsection III.D.1). Rates of population decline through time in 1977 were higher than in either 1975 or 1976, suggesting a relatively high rate of summer emigration for the 1977 year class. If striped bass emigration from the estuary is size-related, as with other species (Herke 1977), increased summer emigration of juveniles in 1977 could have resulted in a low mean length for the remaining smaller individuals in the population from August through October. These biased mean length estimates would give the appearance of a decreased growth rate when, in reality, the larger members of the population had emigrated and were not adequately sampled.

b. Results and Discussion

The following discussion of factors affecting growth is divided into two life stages, larvae and juveniles.

Additive and multiplicative models of factors affecting larval and juvenile growth generally produced similar results; i.e., the same variables were selected by each type of model. However, in contrast to the abundance models, additive effects models were slightly better in explaining variations in growth and were more readily comparable to past analyses, therefore, all subsequent discussion pertains to the additive models.

1) Larvae

The number of days from predicted major spawning through 15 July and the mean water temperature during the same period were selected by the stepwise procedure (Barr et al. 1976) as significantly related ($\alpha=0.05$) to the predicted mean length of the juvenile population on 15 July (Table III-38). These two variables alone accounted for more than 88% of the variation in mean length on 15 July and can serve as an accurate predictor of mid-July size for juvenile striped bass. The other two variables, average November-December freshwater flow from the previous year and average April-May freshwater flow were not significantly related to mean length on 15 July.

Table III-38

Results of Maximum R^2 Improvement Procedure of Stepwise Linear Regression Testing Effects of Four Environmental Variables on Larval Striped Bass Growth in Hudson River Estuary, 1965-67, 1969-70, and 1972-77

Source	Degrees of Freedom	Sum of Squares	Mean Square	F	P	R^2
Regression	2	199.9	99.9	30.92	>0.01	0.885
Number of Days Since Spawning	1	198.0	198.0	61.3	>0.01	
Mean Temperature Since Spawning	1	47.2	47.2	14.6	>0.01	
Error	8	25.8	3.2			
Total	10	225.7				

The selection of the duration (days) since predicted time of major spawning as an important variable influencing the length of juveniles on 15 July supports the hypothesis that the longer that larvae and early juveniles have to grow, the larger they will be.

Mean water temperature was also an important regulator of growth. Warmer water temperatures during the period of larval development resulted in larger juveniles on 15 July. The important effects of water temperature on larval and juvenile striped bass growth in the Hudson River estuary were also discussed in previous reports (McFadden 1977a, TI 1979a).

Temperature affects striped bass time of spawning and the growth rates of the larvae and early juveniles; therefore, it plays a major role in the regulation of length attained by mid-July. During years in which temperatures increase early (with a resultant early spawn) and are high during the larval period, a population of relatively large individuals will be present in mid-July. This large size may be advantageous for survival (Gerking 1957).

2) Juveniles

The predicted length of juvenile striped bass on 15 July and the abundance of juvenile white perch were selected by the stepwise procedure (Barr et al. 1976) as having significant (α=0.05) relationships with the instantaneous growth rate during July and August (Table III-39). One other variable, the number of temperature-growth days between 15 July and 15 August, had a sufficiently strong relationship (p=0.10) to warrant further consideration. These three variables together accounted for more than 83% of the variation in juvenile growth and were reasonable predictors of growth in juvenile striped bass. The other three variables (average April-May freshwater flow, average November-December flow from the previous year, and the index of juvenile striped bass abundance during July and August) were not significantly (p>0.20) related to instantaneous growth of juvenile striped bass during July and August.

Predicted mean length on 15 July and the instantaneous growth rate during July and August were inversely related, probably reflecting the genetic determinants for growth, since the growth rates of most fish species decline as fish get larger. A similar inverse relationship between length at age and subsequent annual length increments was demonstrated for yearling and older striped bass (Nicholson 1964).

Table III-39

Results of Maximum R^2 Improvement Procedure of Stepwise Linear Regression Testing Effects of Biotic and Abiotic Factors on Juvenile Striped Bass Growth in Hudson River Estuary, July and August 1965-67, 1969-70, and 1972-78

Source	Degrees of Freedom	Sum of Squares	Mean Square	F	P	R^2
Regression	3	0.00014	0.00005	11.77	>0.01	0.835
Mean Length on Jul 15	1	0.00013	0.00013	33.38	>0.01	
White Perch Juvenile Abundance	1	0.00003	0.00003	8.70	0.02	
Temperature-Growth Days	1	0.00001	0.00001	3.66	0.10	
Error	7	0.00003	0.000004			
Total	10	0.00017				

Juvenile striped bass growth was also negatively related to the abundance of juvenile white perch, strongly suggesting interspecific competition between the two closely related species. The role of interspecific competition in fishes was discussed by Larkin (1956) who defined this competition as "the demand of more than one organism for the same resources of the environment in excess of immediate supply." Since competition for food could be manifested by a decline in growth rates (Weatherley 1963, 1972), one plausible explanation for the observed relationship is that food is a limiting resource. Juveniles of both species have similar diets (predominantly copepods) in July and August, and are abundant in the shore zone of the lower estuary during the summer (subsections III.C and IV.C). The potential for competition for food is therefore great. Alternatively, because juveniles of both species are so abundant in the shore zone during the summer, they may also be competing for physical space.

The third variable, number of temperature-growth days between 15 July and 15 August, was positively related to juvenile growth during this period. Warmer water temperatures, acting through the nonlinear temperature-growth relationship, were associated with higher juvenile growth rates during July and August.

In summary, juvenile striped bass growth rates were related to larval size, water temperature, and the abundance of juvenile white perch. The current hypothesis is that years of relatively low juvenile white perch abundance and relatively warm water temperatures during the summer should result in better than average growth of juvenile striped bass from July to August. The lack of relationship between striped bass growth and striped bass abundance and the difference in the factors affecting these two variables indicate that size-related mortality is probably not a major factor in regulating year class strength. The factors that affect abundance control the synchrony between striped bass larvae and appropriate food organisms and also the abundance of food. During the larval stages, food is apparently sufficiently abundant for growth to be controlled primarily by temperature. Later in the summer, however, food may become a limiting factor as competition with juvenile white perch begins to affect growth.

E. QUALITATIVE IMPACT ASSESSMENT IN STRIPED BASS

Impact assessment can be conducted in three steps that are implicit in Figure I-1. Exposure indices are calculated (from distribution data) describing what proportion of the total river standing crop of a life stage is located in the vicinity of each power plant (Appendix A). This step is primarily an initial screening that indicates which species could be substantially impacted because a large proportion of the population is near the power plants. Conditional mortality rates are then calculated for those species with high exposure. Conditional mortality rates are the proportion by which the population of a life stage is reduced by the mortality induced by power plants in the absence of other sources of mortality. Finally, the conditional mortality rate is translated into a long-term percent reduction in average population size. A specific conditional mortality rate may produce change in average population size that could range from an extreme reduction to an increase. The change actually predicted is determined by the form of the stock-recruitment relationship applied.

Studies by Texas Instruments (TI) on the Hudson River striped bass population have gone through these three steps of impact assessment. Exposure indices have been calculated yearly from 1974 through 1977 (TI 1979a). Conditional mortality rates and the long-term percent reduction in the average population size were calculated from 1974 and 1975 data for the post-1972 power plants (McFadden and Lawler 1977). The objectives of the following section, therefore, are to evaluate whether exposure indices can be used to determine trends in entrainment and impingement and to evaluate whether conditional mortality rate can serve as the upper limit for long-term reduction in average population size. If trends in exposure indices accurately reflect trends in entrainment and impingement, monitoring of power plant-induced mortality could be accomplished through use of the exposure indices from distribution data. If under those circumstances applicable to the Hudson River striped bass population, the conditional mortality rate is greater than the long-term percent reduction in average population size (PR), precise knowledge of the stock-recruitment curve may not be necessary because the conditional mortality rate can be perceived as an upper limit to PR.

The use of exposure analysis as an accurate index of entrainment can be assessed by comparing exposure to estimates of densities nearer the plant intakes. Densities nearer the plant come from nearfield and entrainment samples. Nearfield samples are taken within a few miles up or downriver from the plant, and entrainment samples are taken in the intake and/or discharge canals of the plant. Plant region density is the component of the exposure indices with which the nearfield and entrainment density estimates are compared. Plant region density is used rather then plant region standing crop (used to calculate exposure indices) to facilitate comparison with nearfield and entrainment data that are generally expressed as densities. A plant region is defined as the river mile in which the plant is located plus 6 miles upstream and 6 miles downstream (total of 13 miles). Organisms within this region may be transported into the vicinity of the intakes by daily tidal fluctuations where they become vulnerable to entrainment. If trends in plant region densities are related to nearfield and entrainment densities, exposure indices should be related to actual entrainment. If the three density estimates are not related, the reason is not necessarily biological. Plant region, nearfield, and entrainment density estimates are based on different gear so that gear efficiencies, sampling techniques, and similar factors must be considered.

The last step in the assessment of power plant impact is the translation of conditional mortality rates into estimates of long-term reductions in the average population size. The population should equilibrate to the power plant-induced mortality at a new average density that is determined by the relationship between parental stock and subsequent recruitment to that stock (the stock-recruitment curve). Whereas the exact formula describing stock and recruitment for striped bass is unknown, two general stock-recruitment curves have been postulated (Ricker 1954, Beverton and Holt 1957). Estimation of long-term reduction in average population size due to power plant-induced mortality is sensitive to the type of stock-recruitment relationship that is assumed (Van Winkle et al. 1976).

Rather than remain dependent on a precise description of the stock-recruitment relationship, impact assessment will be approached in this section by defining, for each of the postulated stock-recruitment curves, those circumstances that could result in extinction or high PR. For each of the three key species, the utility of the conditional mortality rate as an estimate of the long-term reduction in average population size (PR) will also be evaluated.

1. Exposure to Entrainment and Impingement

a. Entrainment

Data from nearfield transect surveys conducted by NYU and LMS and data collected at the intakes or in the discharge canals by EAI, LMS, and NYU were compared to plant region densities to assess the reliability of plant region densities (as a component of the exposure index) in qualitatively determining impact. Entrainment densities at Bowline were estimated from samples collected in the discharge canal (EAI 1978a), while densities at Roseton and Danskammer were assessed from samples collected in the intake canals. Entrainment densities from Indian Point were unavailable at the time of writing because data analyses were not completed; therefore, the total catch was substituted for density in discussions of Indian Point entrainment. Nearfield and entrainment data from the Lovett site were not available for comparison.

1) Eggs

Exposure of striped bass eggs was greatest at the three downriver sites (Bowline, Lovett, and Indian Point) where up to 48% of the total standing crop was located within the plant region during a single time period (Table III-40). Exposure to Lovett and Indian Point was highest and virtually identical. Eggs were exposed less to Danskammer and Roseton than to the downriver sites.

Egg entrainment at Bowline was probably negligible. When eggs were most abundant riverwide (9 to 26 May), the proportion of the standing crop within the Bowline plant region was 12% to 30% (Table III-40). Few eggs were collected in Bowline Pond where the intakes are located, and none was collected in the intakes (EAI 1978).

Table III-40

Estimated Standing Crops (in Thousands) and Percent Total Standing Crops of Striped Bass Eggs Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of Egg Abundance, 1977

Date		Bowline Standing Crop	Bowline Percent	Lovett Standing Crop	Lovett Percent	Indian Point Standing Crop	Indian Point Percent	Roseton Standing Crop	Roseton Percent	Danskammer Standing Crop	Danskammer Percent
5/09 - 5/12	Above	43,320	69.7	32,299	51.9	31,828	51.2	20,204	32.5	19,380	31.2
	Within	18,874	30.3	29,638	47.7	29,850	48.0	8,328	13.4	9,152	14.7
	Below	0	0.0	258	0.4	516	0.8	33,663	54.1	33,663	54.1
5/16 - 5/19	Above	217,906	87.9	189,922	76.6	179,104	72.2	76,615	30.9	75,766	30.5
	Within	30,126	12.1	57,808	23.3	68,322	27.5	17,626	7.1	15,454	6.2
	Below	0	0.0	303	0.1	606	0.2	153,791	62.0	156,812	63.2
5/23 - 5/26	Above	72,802	82.2	64,513	72.8	59,958	67.7	16,809	19.0	16,645	18.8
	Within	14,844	16.8	21,081	23.8	23,994	27.1	6,435	7.3	5,001	5.6
	Below	959	1.1	3,012	3.4	4,654	5.3	65,362	73.8	66,960	75.6
Average Within Plant Region			16.0		27.2		30.6		8.1		7.4

The catch of eggs in the Indian Point intake and discharge canals closely paralleled temporal trends in nearfield and plant region densities, but entrainment at both Danskammer and Roseton peaked about one week earlier than did nearfield and plant region densities (Figure III-39). The reasons for this disparity in timing at Danskammer and Roseton are unknown. Densities of eggs in Roseton and Danskammer entrainment samples were comparable to those from both the nearfield and plant region.

2) Larvae

Exposure of yolk-sac and post yolk-sac larvae was greatest at the Indian Point and Lovett sites. Exposure indices at Bowline, Danskammer, and Roseton were approximately equal (Tables III-41 and III-42).

Temporal trends in larval densities in the intake canal at Bowline closely paralleled those of the plant region, nearfield, and pond densities (Figure III-40). Intake densities were lower than plant region and nearfield

Table III-41

Estimated Standing Crops (in Thousands) and Percent Total Standing Crops of Striped Bass Yolk-Sac Larvae Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of Yolk-Sac Larvae Abundance, 1977

Date		Bowline		Lovett		Indian Point		Roseton		Danskammer	
		Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent
5/16 - 5/19	Above	73,182	77.2	64,142	67.7	60,991	64.4	13,971	14.7	12,781	13.5
	Within	16,682	17.6	22,683	23.9	24,878	26.2	18,476	19.5	17,509	18.5
	Below	4,914	5.2	7,953	8.4	8,910	9.4	62,331	65.8	64,488	68.0
5/23 - 5/26	Above	213,173	82.3	200,073	77.3	197,721	76.4	92,638	35.8	86,030	33.2
	Within	37,696	14.6	44,064	17.0	43,154	16.7	77,691	30.0	80,655	31.1
	Below	8,097	3.1	14,829	5.7	18,091	7.0	88,636	34.2	92,281	35.6
5/31 - 6/02	Above	454,516	85.3	390,299	73.2	368,695	69.2	90,941	17.1	83,460	15.7
	Within	75,995	14.3	138,416	26.0	159,226	29.9	100,968	18.9	99,977	18.8
	Below	2,342	0.4	4,139	0.8	4,932	0.9	340,944	64.0	349,416	65.6
6/6 - 6/09	Above	125,112	73.2	100,183	58.6	91,684	53.6	10,818	6.3	10,346	6.0
	Within	45,266	26.4	66,409	38.8	71,383	41.7	13,035	7.6	10,746	6.3
	Below	613	0.4	4,400	2.6	7,924	4.6	147,138	86.0	149,899	87.7
Average Within Plant Region			16.6		25.3		28.2		19.9		19.8

Table III-42

Estimated Standing Crops (in Thousands) and Percent Total Standing Crops of Striped Bass Post Yolk-Sac Larvae Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of Post Yolk-Sac Larvae Abundance, 1977

Date		Bowline		Lovett		Indian Point		Roseton		Danskammer	
		Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent
5/31 - 6/02	Above	353,982	92.4	332,857	86.9	327,122	85.4	154,241	40.2	145,310	37.9
	Within	28,263	7.4	48,538	12.7	53,833	14.0	111,470	29.1	113,316	29.6
	Below	957	0.2	1,807	0.5	2,248	0.6	117,491	30.7	124,576	32.5
6/6 - 6/09	Above	379,059	67.8	316,556	56.6	305,396	54.6	60,769	10.9	56,382	10.1
	Within	171,274	30.6	213,530	38.2	208,326	37.2	105,369	18.8	89,366	16.0
	Below	9,091	1.6	29,339	5.2	45,702	8.2	393,288	70.3	413,676	73.9
6/13 - 6/16	Above	209,582	76.7	160,167	58.6	144,606	52.9	11,540	4.2	10,923	4.0
	Within	63,152	23.1	111,072	40.7	125,324	45.9	15,118	5.5	12,766	4.7
	Below	467	0.2	1,963	0.7	3,271	1.2	246,544	90.2	249,512	91.3
Average Within Plant Region			21.6		30.7		31.9		19.1		17.7

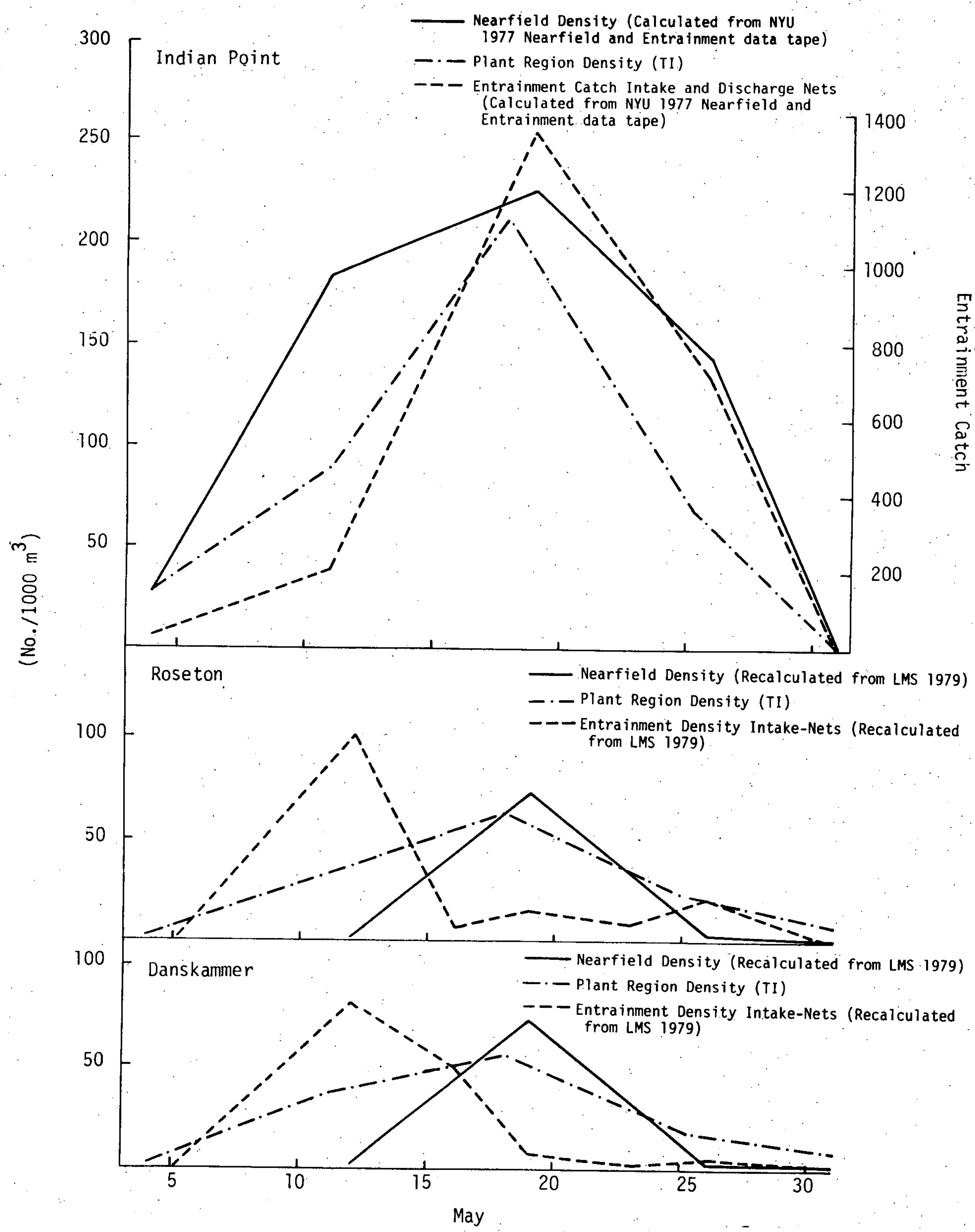


Figure III-39. Nearfield, Plant Region, and Entrainment Abundance of Striped Bass Eggs at Indian Point, Roseton, and Danskammer Power Plants, Hudson River Estuary, May 1977 densities, but generally higher than pond densities. Thus, the exposure index was related to the timing of entrainment but not necessarily to the magnitude.

At Indian Point, the plant region and nearfield densities and intake catch peaked concurrently, indicating that trends in larval plant region densities were a good indicator of the timing of expected entrainment. The Indian Point intakes are located near the river channel, and trends in the number of larvae entrained were expected to resemble trends in larval abundance in the nearfield and plant region samples.

Peak larval densities in intakes were asynchronous with nearfield and plant regions peak densities at Roseton and Danskammer which was a trend similar to the temporal trends in egg densities at these sites. Unlike eggs, however, plant region densities peaked earlier than nearfield and entrainment samples (Figure III-40). Entrainment densities were somewhat lower than plant region and nearfield densities at Roseton, but much higher at Danskammer (Figure III-40), suggesting that the larvae tend to concentrate in the Danskammer intake canal.

b. Impingement

At the juvenile stage, young striped bass are too large to pass through the screens and are impinged. Three of the factors that interact to determine when and at what power plant(s) striped bass juveniles and yearlings are impinged are: the distribution of the population in the estuary when they became impingeable; the swimming ability of individual fish; and environmental conditions. The manner in which these factors influence impingement is discussed relative to exposure indices, aspects of striped bass behavior (developed in subsection III.C.3), and the placement of each plant's intakes.

1) Summer Impingement (June through September)

Impingement of juveniles at all five power plants typically begins in June and increases slightly through July (Figure III-41) as the fish grow and become less susceptible to entrainment.

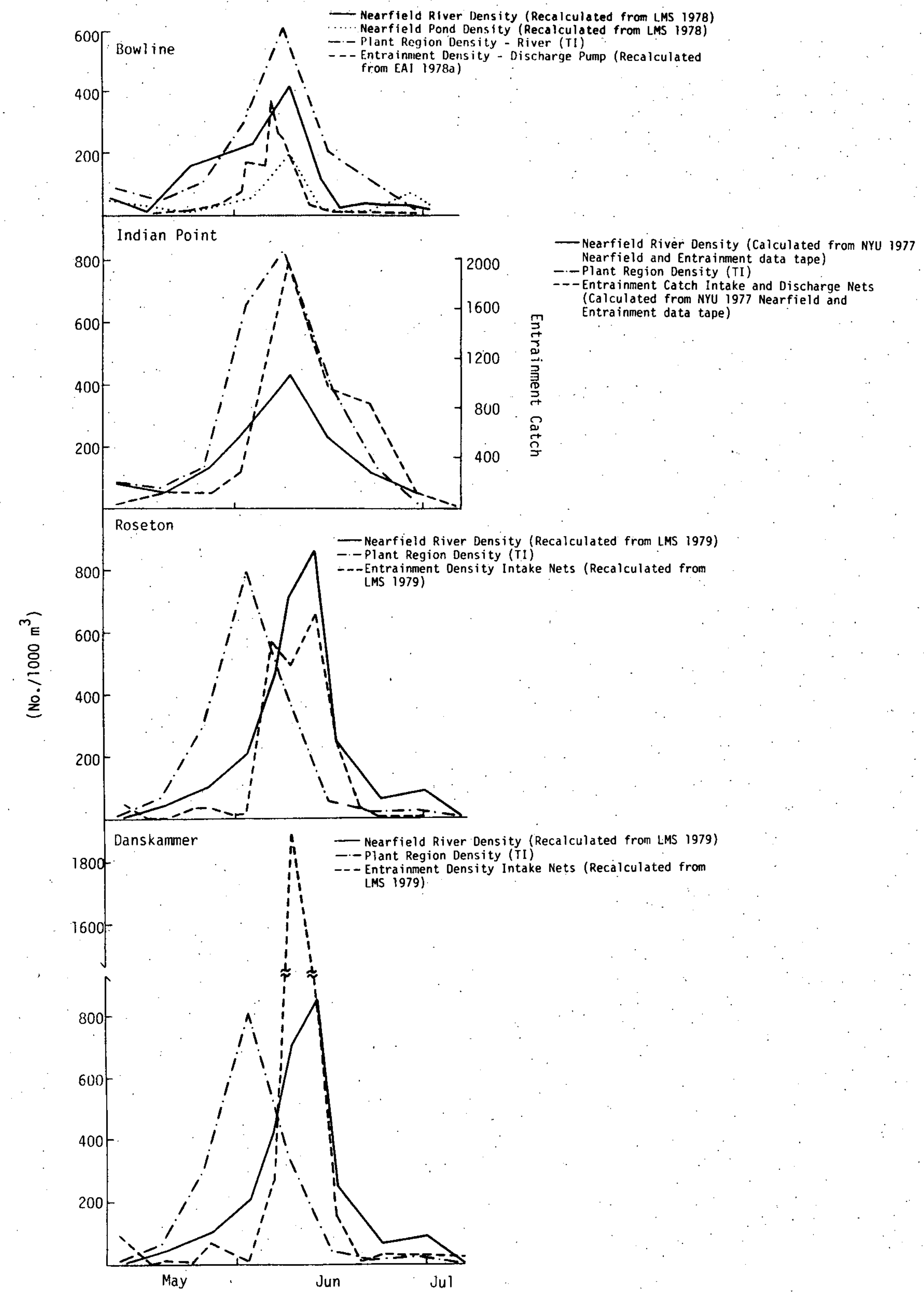


Figure III-40. Nearfield, Plant Region, and Entrainment Abundance of Striped Bass Yolk-Sac and Post Yolk-Sac Larvae (Combined) at Bowline, Indian Point, Roseton, and Danskammer Power Plants, Hudson River Estuary, May-July 1977

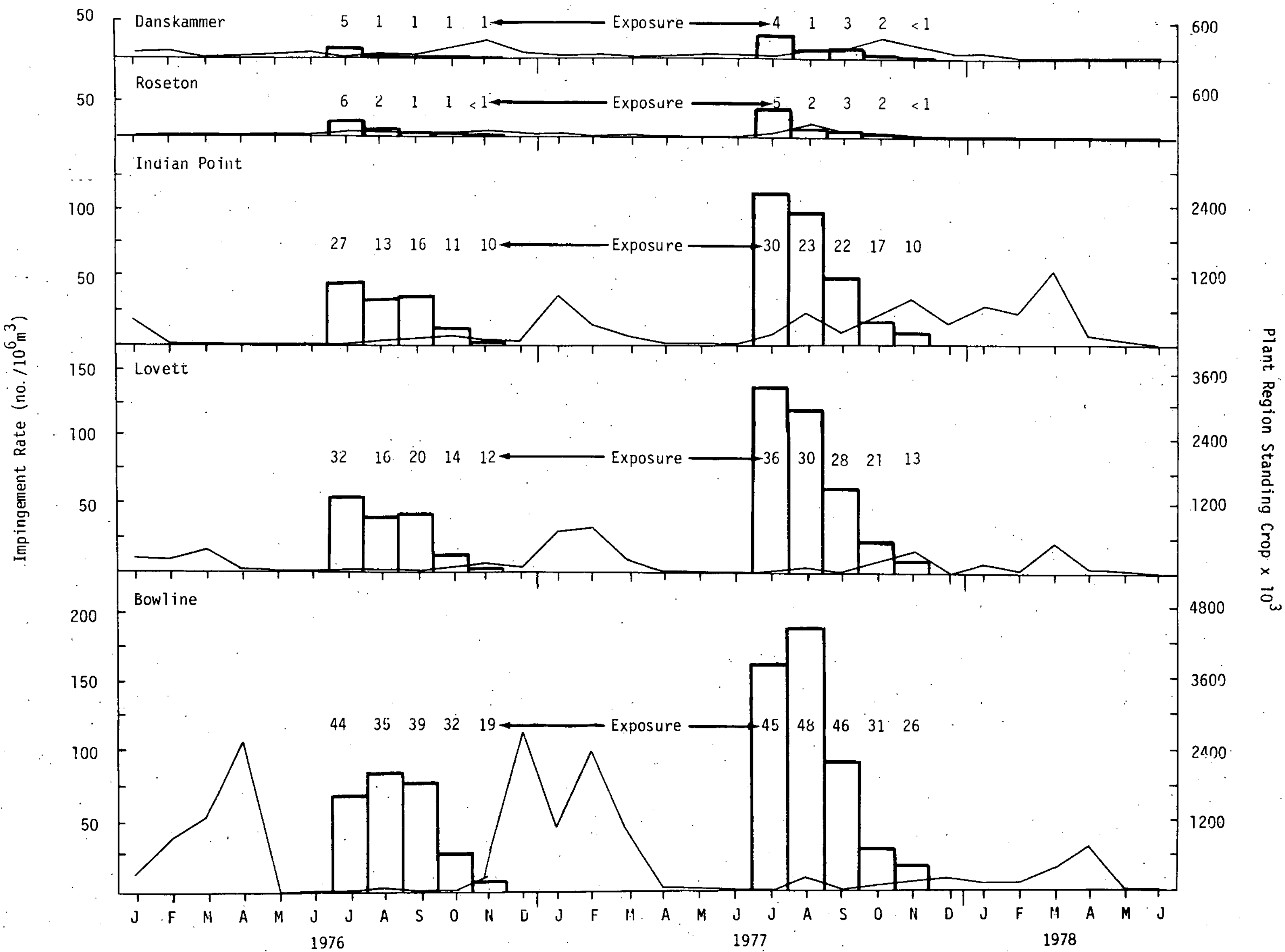


Figure III-41. Plant Region Standing Crops (Histograms Estimated from Beach Seine, Tucker Trawl, and Epibenthic Sled Samples), Exposure to Impingement (Percent of Total Standing Crop per Plant Region), and Impingement Rates (Lines Represent Number/$10^6 m^3$ of Water Circulated) of Striped Bass at Each of Five Hudson River Power Plants, 1976-78

Exposure of striped bass juveniles was generally greatest in July or August (Figure III-41) and was greater at the three downriver plants than it was at the two upriver plants. Impingement rates, however, were low at all five sites during the summer of 1977 (Figure III-41) which has been typical at the five sites since 1973 (Figure III-42). Impingement was higher than usual at Danskammer in the summers of 1973 and 1974 and at Roseton in 1973, indicating that year-to-year variations can occur (Figure III-41).

2) Fall and Winter Impingement (October through March)

Impingement rates usually increased at all sites during the fall (Figures III-41 and III-42) when juvenile striped bass were migrating downriver and exposure indices were decreasing. No indices of exposure were calculated after mid-December, but impingement rates at some of the sites continued to rise.

At the upriver sites (Roseton and Danskammer), impingement rates typically were highest in October, November, or December (Figure III-42). However, plant region standing crops at these two sites declined (Figure III-41) during this period. Fish were apparently more susceptible to impingement during the winter.

Impingement rates at Bowline, Lovett, and Indian Point reached their highest levels in 1976 and 1977 from about January through March (Figure III-41), a pattern that generally prevailed in earlier years (Figure III-42). The effect of colder water temperature on the swimming ability of fish may have increased their susceptibility to impingement. Powers (1976) suggested that reduced energy reserves caused more rapid exhaustion in cold temperature and reduced the ability of fish to sustain swimming endurance of long enough duration to escape impingement.

c. Conclusions

Actual entrainment and impingement rates for striped bass appear to be dependent on factors that can cause substantial deviation from rates predicted on the basis of exposure indices. Examples of these deviations for entrainment were evident. The virtual absence of striped bass eggs in the

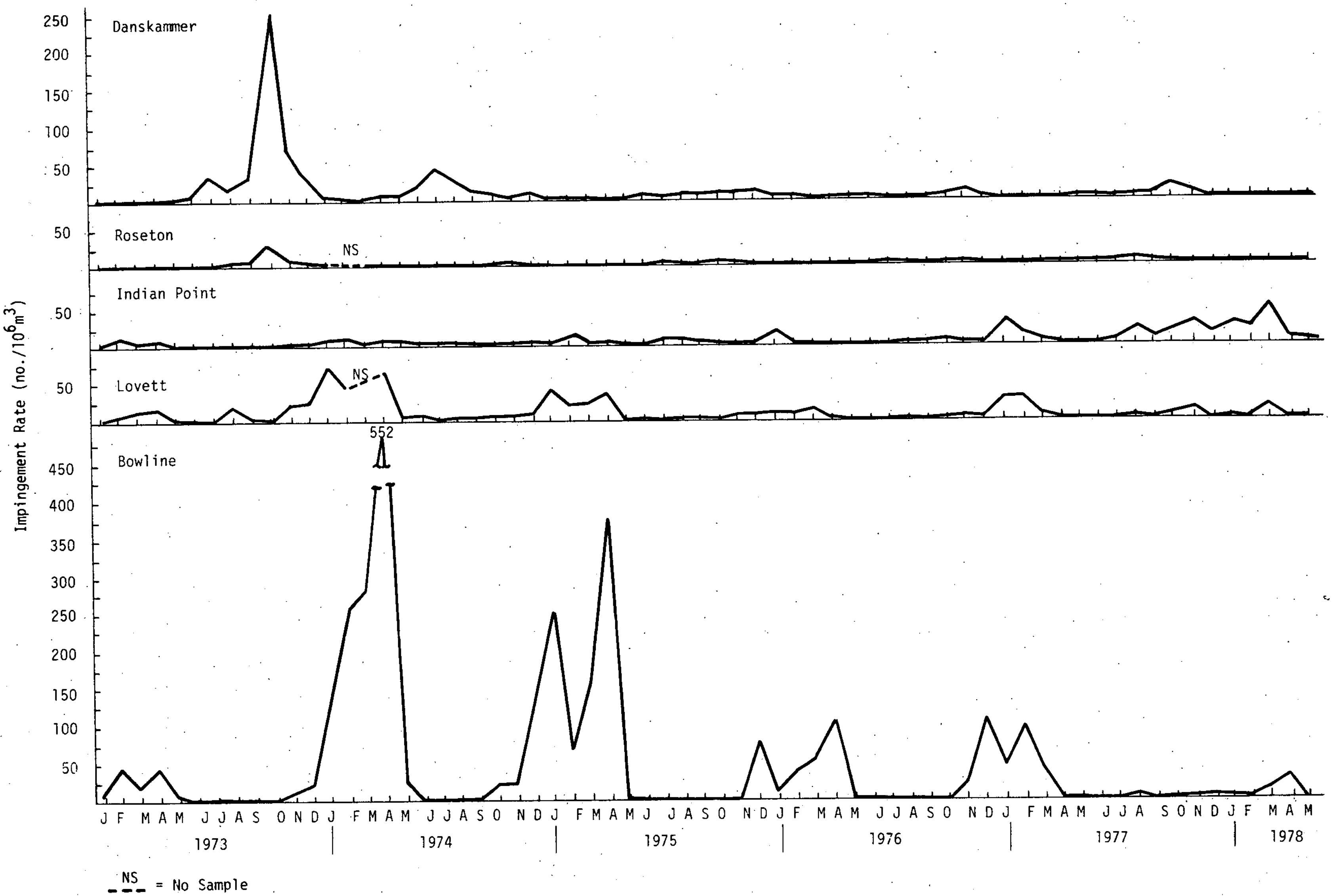


Figure III-42. Monthly Impingement Rates of Juvenile and Yearling Striped Bass at Five Hudson River Power Plants, 1973-78 intakes at the Bowline site was not predicted by the exposure index. On the other hand, larval densities were higher in the intake canal at Danskammer than would be expected based on plant region and nearfield densities. At Roseton and Danskammer the ratio of entrainment density to plant region density changed with time because peak entrainment and plant region densities failed to occur simultaneously. Impingement rates at all sites tended to be higher in the winter months even though exposure was lower than in the summer. Thus, trends in exposure indices are not always well associated with trends in entrainment and impingement rates.

2. Compensation and Impact

The consequences of the exposure of fish populations to power plants and the resultant mortality that was discussed in the previous section is dependent on a group of phenomena that are referred to as compensation. In the context of this report, compensation is the process by which natural mortality rates are lessened in response to any additional source of mortality imposed upon a population. The concept of compensation in response to the additional mortality imposed by power plant operations has been discussed in detail by McFadden (1977). Four aspects of the compensatory response have been discussed that affect prediction of the consequences of power plant-induced mortality:

- Alpha (α), the rate of population increase from the Ricker equation in a given environment and with no density-dependent mortality
- Shape of the stock-recruitment curve
- Timing of mortality induced by power plants with respect to the period of density dependent mortality (period of compensation)
- Magnitude of the mortality induced by power plants

Alpha is the number of young striped bass produced per parent in a given environment in the absence of density-dependent mortality (i.e., at lower densities than generally observed in nature). For example, if the population is reduced to a very low density, it should increase by a factor of alpha each generation. Environmental fluctuations cause alpha to oscillate around an average value. Because alpha is only observable at very low densities and subject to oscillations from environmental fluctuations, it is difficult to estimate. Available estimates of alpha for the striped bass population in the Hudson River range from 5.5 to 14.6 (McFadden et al. 1978).

Two stock-recruitment curves have been hypothesized for fish species in general (Ricker 1975). These curves are nonlinear representations of parental stock versus the subsequent recruitment. A complete description of the stock-recruitment curve for striped bass would, therefore, require observations at several different stock densities. The Ricker curve (Ricker 1954) may be more appropriate than the Beverton-Holt curve (Beverton and Holt 1957) because analysis of the Hudson River commercial catch of striped bass suggests a relationship indicative of the Ricker curve (McFadden et al. 1978). As with alpha, environmental fluctuations alter the stock recruitment curve, resulting in the need for an average curve described under a variety of environmental conditions.

Mortality, induced by power plants before the period of compensation, produces a smaller population reduction than when power plant mortality occurs after compensation. For fish species in general, most compensation is thought to take place during the larval stages before year class strength is set, (c.f. Cushing and Harris 1973). For striped bass, year class strength is established during the first two months of life, i.e., before mid-July (subsection III.D). The power plant-induced mortality can, therefore, be considered to span the period of compensation with most entrainment mortality taking place before and most impingement mortality taking place after the period of compensation.

The conditional mortality rate, m, for striped bass has been estimated from 1974 and 1975 data for the post-1972 power plants (Roseton, Indian Point, and Bowline). Its value ranges from 0.12 to 0.14 for entrainment and impingement combined. The conditional mortality rate for entrainment alone is between 0.08 and 0.12. Impingement conditional mortality is less, between 0.02 and 0.04.

The approach to impact taken in this report is to determine the range of values of alpha for which the conditional mortality rate would represent an upper limit to the long-term reduction in the average population size of striped bass. This approach is accomplished by solving each of the two commonly used stock-recruitment equations for the percent reduction in average population size (derived in Appendix B). When the Ricker stock-recruitment curve is used, the long-term percent reduction (PR) in average population size is:

$$PR = \left[1 - \frac{\ln [\alpha (1-m)]}{\ln \alpha}\right] \times 100 \qquad (1)$$

where

PR = percent reduction when the population reaches a new average density

m = conditional mortality rate resulting from the operation of power plants

α = rate of population growth per generation in the absence of density-dependent mortality

The Beverton-Holt stock-recruitment curve (Beverton and Holt 1957) can be solved for PR similarly:

$$PR = \frac{m}{1-B} (100) \qquad (2)$$

where

$B = 1/\alpha$

Both of these stock-recruitment curves pertain to a population with power plant-induced mortality occurring after the period of compensation. The formula describing PR with m occurring before compensation for the Ricker curve is:

$$PR = \left[1 - \frac{\ln [\alpha (1-m)]}{(1-m) (\ln \alpha)}\right] \times 100 \qquad (3)$$

and for the Beverton-Holt curve is:

$$PR = \frac{Bm}{(1-m) (1-B)} \qquad (4)$$

In these four equations, PR is negatively related to the rate of increase (α or $1/B$) and positively related to m. The effects of the stock-recruitment curve [equations (1) and (3) versus equations (2) and (4)] and the timing of power plant-induced mortality [equations (1) and (2) versus equations (3) and (4)] on PR can be demonstrated by a simple exercise using hypothetical values of $m = 0.15$ and $\alpha = 5.0$. With these values, equation (3) predicts a 5.8% increase in average population size; equation (4), (1) and (3) predict reductions of 4.4%, 10.1%, and 18.8% in average population size, respectively. The average reduction using the Ricker curve [equation (1) and (3)] is 2.2% versus an average reduction of 11.6% predicted by the Beverton-Holt curve [equations (2) and (4)]. If power plant-induced mortality occurred before compensation [equations (3) and (4)], a 0.7% increase in population size is predicted in contrast to a 14.5% decrease in population size if power plant-induced mortality occurred after compensation [equations (1) and (2)]. Thus, these simple derivations demonstrate the four aspects of the compensatory response mentioned above.

With these equations, values of α and m that give PR=100, PR<m and PR>m can be defined and plotted for each stock recruitment curve for each period of power plant-induced mortality (Figures III-43 through III-45). The consequences of power plant-induced mortality acting on a Ricker curve after the period of compensation are plotted in Figure III-43 for different values of m and α. Zone A of Figure III-45 represents levels of alpha under which a population cannot persist ($\alpha < 1$); each individual in the population is not replacing itself and the population growth rate is negative. A striped bass population exists in the Hudson River today in an apparently healthy state (subsection III.B and III.D), and there are no data to suggest that alpha is currently less than one.

In zone B (Figure III-43), the conditional mortality rate, m, is such that the population will not persist. This zone is bounded on the lower side by the upper edge of zone A ($\alpha = 1.0$ at any m) and by the PR = 100 isocline on the upper side. The level of α required to prevent extinction (PR = 100 isocline) increases as m increases. At higher values of m (e.g., greater than 0.8) the rate of increase of the population (α) must remain above 5.0 to assure persistence. At current levels of m estimated for the

A = Zone of no persistence
B = Zone of extinction from "m" (below the isocline PR=100)
C = Zone in which m<PR<100 (below the isocline PR=m)
D = Zone in which PR<m (above the isocline PR=m)
--- isocline for PR=50%

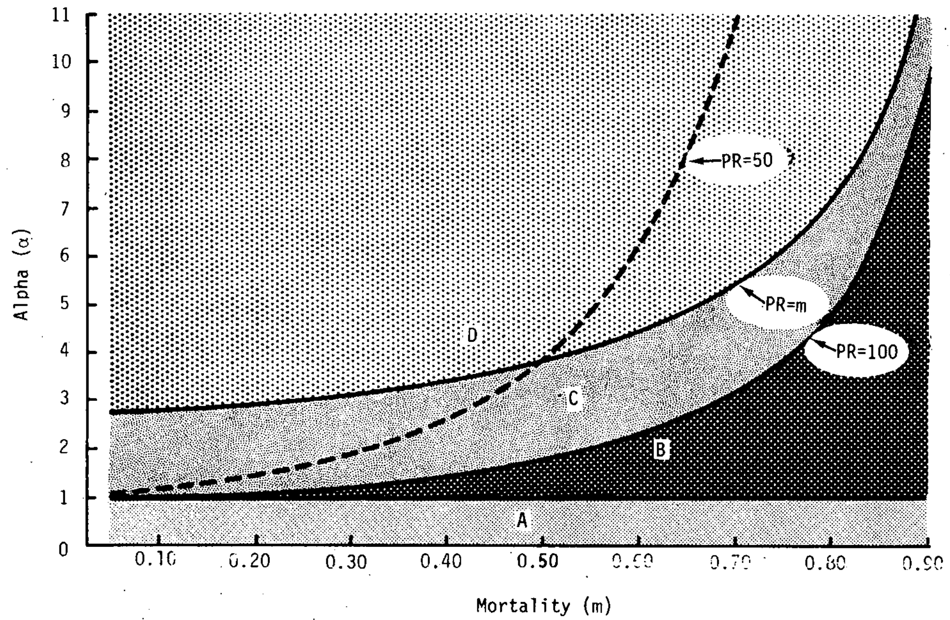


Figure III-43. Possible Consequences of Mortality Acting After Compensation on a Ricker Curve

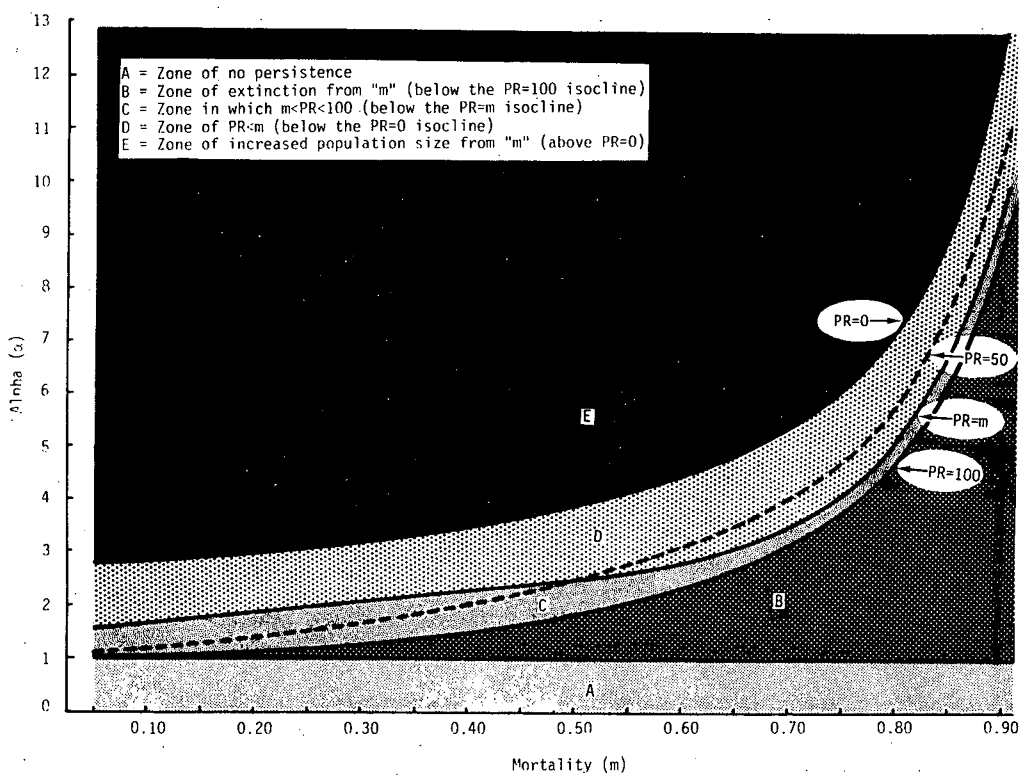


Figure III-44. Possible Consequences of Mortality Acting Before Compensation on a Ricker Curve

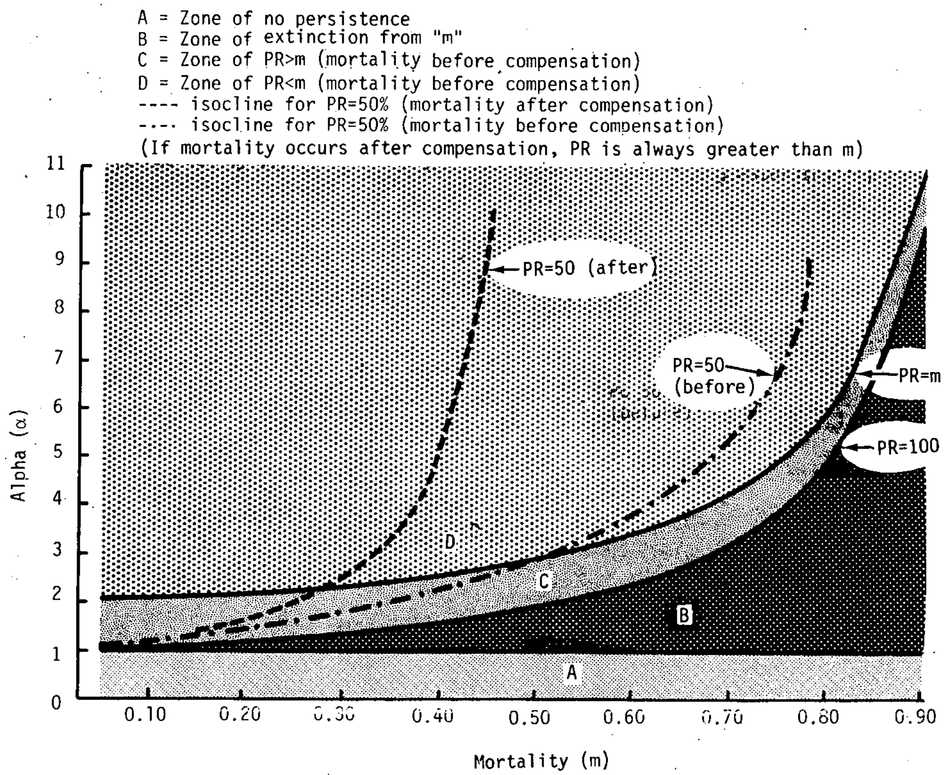


Figure III-45. Possible Consequences of Mortality Acting on Beverton-Holt Curve

Hudson River striped bass population (0.12 to 0.14), an alpha of approximately 1.2 will assure persistence of the population. Thus, for a population persisting in the absence of entrainment and impingement mortality only very low values of alpha would result in extinction from this additional mortality. At current levels of m estimated for the Hudson River striped bass population (0.12 to 0.14), an average alpha of approximately 1.2 is necessary for persistence of the population.

Although it is unlikely that the levels of conditional mortality most recently observed from Hudson River power plants would drive the striped bass population to extinction, the PR could be considerable even though m is relatively small. Zone C represents that area where PR can exceed the conditional mortality rate m. For instance, if m = 0.15 and $\alpha = 1.2$, then PR = 0.89. This reduction is greater than m and unpredictable in that a relatively low m causes a severe reduction in population size. Zone C is bordered by the PR = 100 isocline and by the PR = m isocline. A gradient exists in zone C such that as α increases for a particular m; PR goes from the PR = 100 isocline to the PR = m isocline. The dotted line is the PR = 50 isocline and is included as an arbitrary reference point. At levels of m estimated for Hudson River striped bass in 1974 and 1975 (0.12 to 0.14), the levels of α required to prevent a PR greater than 0.5 are just slightly more than those required for persistence in the absence of power plant-induced mortality. The lowest estimate of α for the Hudson River striped bass population is greater than 5 and a working value of α=10 has been chosen to assess impact (McFadden et al. 1978).

At α =5 and above, the conditional mortality rate is a gross overestimate of PR for the most recently observed values of m (0.12 to 0.14). At these levels of mortality, alpha would have to be less than approximately 2.0 before PR would be greater than m. Considering the enormous fecundity of striped bass (subsection III.B) and its explosive increase on the west coast after stocking (McFadden et al. 1978) it is likely that alpha is greater than 2.0.

Thus far, this discussion considered only cases when all power plant-induced mortality is assumed to occur after the period of compensatory mortality. However, some power plant-induced mortality occurs prior to the period of compensatory mortality, that is, during the egg and larval stages before year class strength is set. If the consequences of power plant-induced mortality occurring before the period of compensation are examined with the Ricker stock-recruitment curve, the results demonstrate that the danger of high PR is less than for the case when mortality acts after compensation (Figure III-44). The zones of no persistence in the absence of power plant-induced mortality (zone A) and in the presence of this mortality (zone B) remain the same. Zone C, the conditions for which PR is greater than m, is much reduced indicating that only a limited range of α values will result in PR exceeding the conditional mortality rate at a given m. Over the range of power plant-induced mortalities observed in 1974 and 1975 in the Hudson River striped bass population, little difference exists between those values of alpha required for persistence and those that would result in a 50% population decline. Thus, if the population is persisting without power plant-induced mortality, it will probably persist in the presence of this mortality with a reduction substantially less than 50%. When the period of compensation takes place after mortality, the density-dependent restriction on population size is relaxed and the population may be larger than if no mortality had occurred. This is the case in zone E (Figure III-44) in which there is an increase in population size as a result of power plant-induced mortality.

For the Beverton-Holt curve, the zones for no persistence in the absence of power plant-induced mortality (zone A) and in the presence of power plant-induced mortality (zone B) are the same as in the other two figures (Figure III-45). If mortality takes place after the period of compensation, PR is always greater than the conditional mortality rate. However, as noted above, it is not realistic to consider all power plant-induced mortality as occurring after compensation. When mortality occurs before compensation (Figure III-45), the results are similar to those seen for the Ricker curve. For levels of power plant-induced mortality estimated in 1974 and 1975 in the Hudson River striped bass population, an alpha of slightly more than 2.0 will assure that m is a conservative estimate of PR if the Beverton-Holt curve is used and most mortality is assumed to occur before compensation.

In summary, the long-term percent reduction in the average size of the striped bass population in the Hudson River due to entrainment and impingement mortality should be less than the conditional mortality rate. Only a narrow range of circumstances would produce a situation in which the long-term reduction in average population size is greater than the conditional mortality rate, because alpha appears to be relatively high (on the order of 10) and most mortality (entrainment) takes place before the period of compensation.

F. ECOLOGY AND IMPACT

The impact estimates presented in subsection III.E.3 were derived from a mathematical model. A model is not identical to the system being modeled: it is impossible to simultaneously maximize generality, realism, and precision in the construction of a model. Therefore, a given model reflects a particular compromise with respect to these three factors (Levins 1968). The goal in building a model for a specific study is to maximize those features which best meet the objectives of that study. In this study of the impact of power plants on selected fish species populations in the Hudson River estuary, a quantitative estimate of impact was required. Consequently, a general model that would give a quantitative estimate of impact was selected, realizing that fluctuations in the environment or changes in age structure could affect population stability and the accuracy of predictions of abundance (May 1976).

Because estuarine environments are characterized by pronounced fluctuations and a high level of uncertainty (Odum 1971), environmental fluctuations may be important to the striped bass spawning in the Hudson River estuary. In particular, the Hudson River estuary is the least stable (in terms of fluctuations in flow and salinity) of all estuaries along the Atlantic coast having striped bass populations (Simpson et al. 1973). The analysis of the factors affecting juvenile abundance (subsection III.D.1.c) indicates that abiotic variables play a major role in determining juvenile abundance of striped bass in the Hudson River estuary.

Environmental fluctuations do have a major effect on the development of iteroparity (repeat spawning) in American shad populations. In this species, the degree of iteroparity has been associated with latitudinal changes in the amplitude and predictability of fluctuations in the thermal environment prevailing during the egg and larval stages (Leggett and Carscadden 1978). Latitudinal gradients have not been documented in striped bass populations, but a direct association between larval mortality and fluctuations in the thermal regime was observed in the Hudson River striped bass population in 1976 when a sudden drop in temperature was followed by the disappearance of a large segment of the yolk-sac larval population (TI 1979a).

Because of the uncertainty and rigor of estuarine environments, it is not surprising that many estuarine species exhibit iteroparous life history patterns. An iteroparous life history pattern enables a population to sustain a high level of egg production in a fluctuating environment and to take advantage of good environmental conditions whenever they occur. In fact, current evolutionary theory states that this life history pattern has the greatest selective advantage in an unpredictable environment (Giesel 1976). Fisheries biologists are also well aware of the adaptive value of an iteroparous life history strategy (Leggett and Carscadden 1978).

However, the recognition of this fact generates a practical problem: a more realistic quantitative model cannot be developed because there are no accurate descriptions of the changes in age structure and the environment. Even so, the recognition of the iteroparous life history strategy can be used to evaluate the relative importance of those factors affecting survival during different stages in the life history of a species. Iteroparous species can compensate for wide fluctuations in mortality during the early life history stages (when they are normally exposed to highly variable levels of mortality), but they are sensitive to factors affecting survival in life stages following those controlled by the unpredictable environmental factors (Giesel 1976). Therefore, on the basis of the most current and commonly accepted interpretation of the selective value of an iteroparous life history strategy, the striped bass population should be resistant to mortality during the egg and larval stages because these life stages are the ones most subjected to large and unpredictable mortalities related to fluctuations in the environment. Iteroparity, however, affords little resiliency against mortality after the early life stages affected by the unpredictable mortality due to fluctuations in environmental conditions. Impingement mortality occurs after the stages most affected by the environmental uncertainty and should affect the striped bass population in the Hudson River estuary. However, it is unlikely that the effects of impingement-related mortality can be detected empirically because less than 1% of the juvenile population is impinged annually (subsection III.E). In contrast, fishing mortality (sport and commercial) on the Hudson River stock is estimated to be 15% per year (subsection III.B.3), and this mortality occurs repeatedly, especially during ages III-VI.

Fishing mortality is also density-dependent and can vary considerably in magnitude (USNRC 1975). Annual fishing mortality as high as 45% has been observed in the Chesapeake population of striped bass (Mansueti and Hollis 1963). Mortality of this magnitude occurring during the reproductive stages of an iteroparous species could generate fluctuations in abundance similar to those observed in the striped bass population (subsection III.E).

Thus, fluctuations in both the fishery and the environment should be incorporated into a population model for striped bass in the Hudson River estuary. Unfortunately, it is not possible to construct such a model using the empirical data currently available. However, the recognition of the iteroparous life history strategy of this species can be used to determine the general importance of entrainment, impingement, and fishing mortality.

Entrainment mortality is probably least important (even though it is second in magnitude) because it impacts the population during life stages that are subject to unpredictable mortality due to fluctuations in environmental conditions. Impingement and fishing mortality are more important than entrainment mortality because they occur during life stages following those affected by the unpredictable environmental mortality. Impingement mortality is low compared with fishing mortality (less than 1% vs 15%) and should not affect the striped bass population. Fishing mortality, on the other hand, can be high in magnitude and occurs repeatedly throughout the period of greatest sensitivity in an iteroparous species, the reproductive stages (in contrast to impingement, which impacts primarily the juvenile stage). As a result, exploitation by sport and commercial fisheries should have a greater impact on the striped bass population spawning in the Hudson River than the mortality resulting from the operation of power plants.

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WHITE PERCH

A. GENERAL LIFE HISTORY

The white perch, like the striped bass, is a euryhaline species belonging to the family Percichthyidae but attains a much smaller size (Figure IV-1). White perch naturally inhabit bays and estuaries of the Atlantic coast from the Gulf of St. Lawrence to South Carolina, but they have spread or been introduced into the lower Great Lakes and numerous inland lakes where they reproduce successfully (Figure IV-2). Popular as a pan fish, white perch also contribute to commercial fisheries, especially in the Chesapeake Bay region (Scott and Crossman 1973). In the Hudson River estuary, the white perch is one of the most abundant species collected in fisheries surveys (TI 1976c).

Although Mansueti (1961b) described white perch inhabiting the Patuxent estuary (Chesapeake Bay) as semianadromous, no consistent evidence of an upstream spawning migration has been found for Hudson River white perch (TI 1979a). Generally, adult white perch are thought to overwinter in deep water throughout the Hudson River estuary, spawn during late spring and early summer in brackish and freshwater areas throughout most of the estuary, and then move to feed in the productive shoal and shore zones of the estuary from mid-summer through fall (Figure IV-3) (TI 1979a).

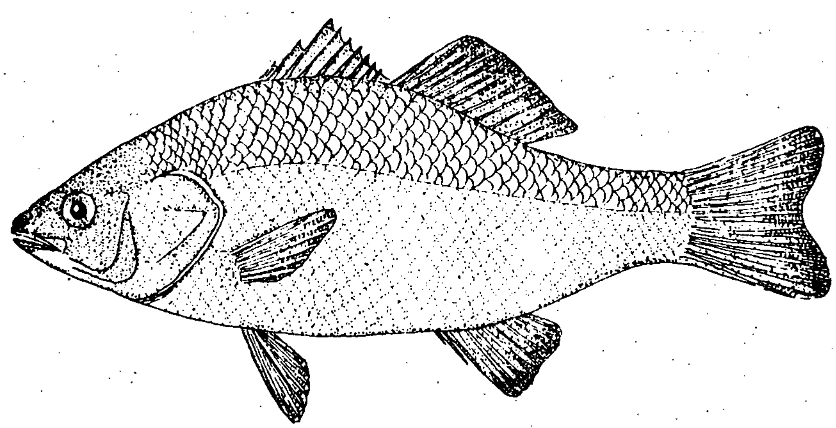
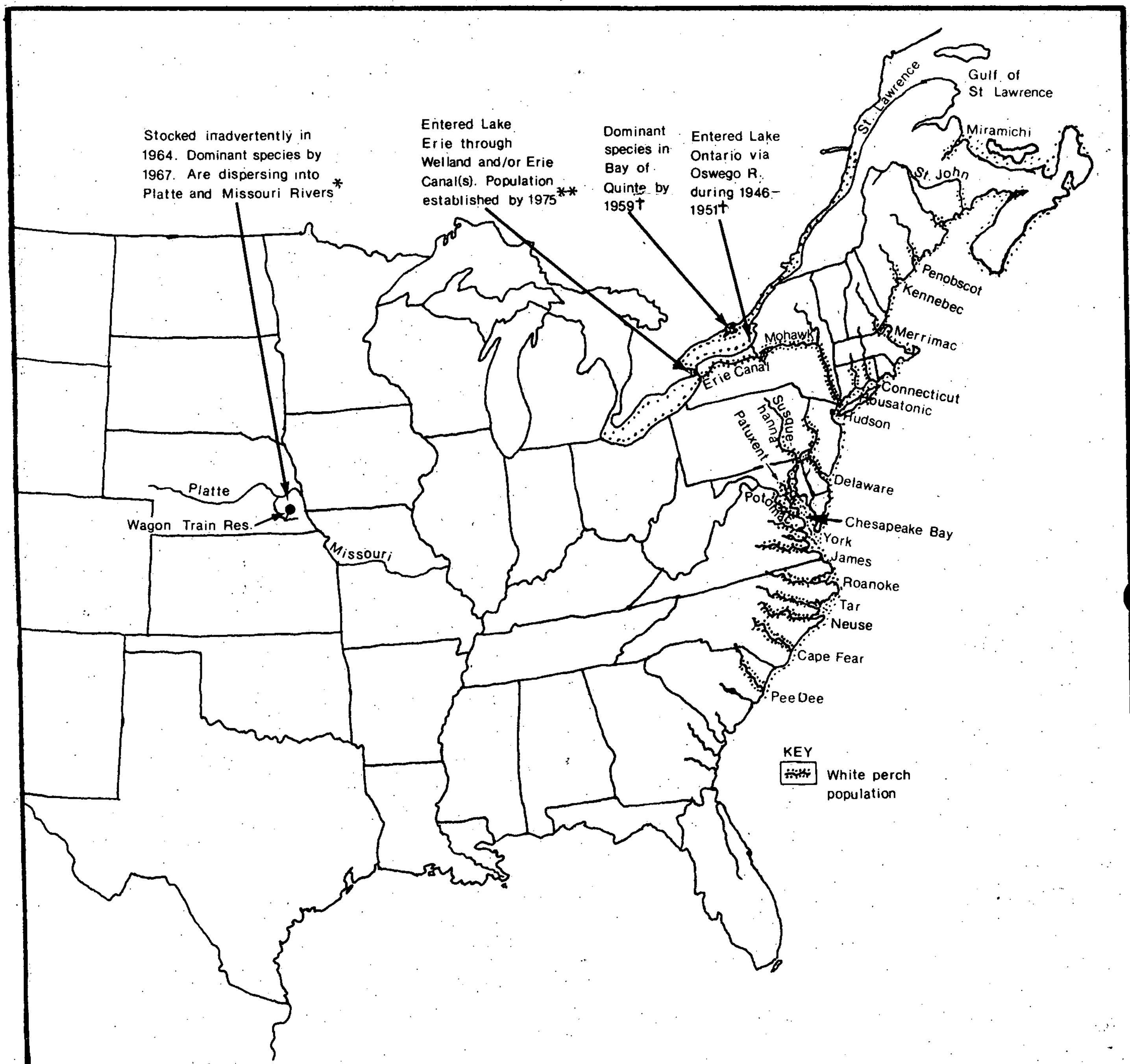


Figure IV-1. White Perch (*Morone americana*), [Total Length to 330 mm (13 in.)]



* Hergenrader and Bliss 1971

† Busch et al. 1977

** Scott and Cristie 1963

Figure IV-2. Distribution of White Perch in North America

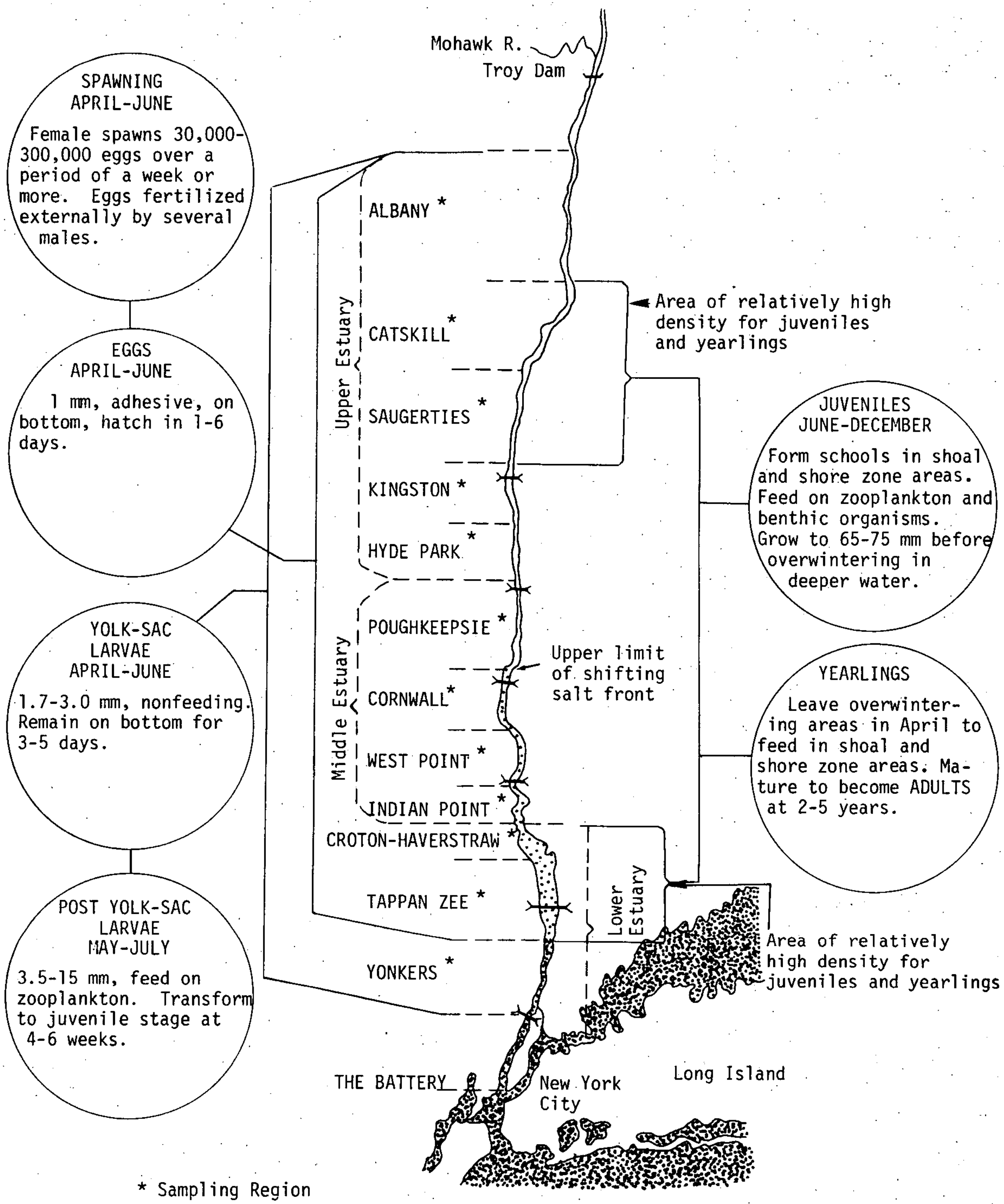


Figure IV-3. Generalized Life Cycle of Hudson River White Perch

Hudson River white perch spawn annually after reaching sexual maturity at 2 to 5 years (TI 1979a). Unlike the female striped bass which spawns the majority of its eggs at one time (Stevens, R.E. 1966), a female white perch spawns systematically in batches over a period of a week or more (Mansueti 1964, TI 1979a). Generally, fecundity increases with age and ranges from approximately 30,000 to 300,000 eggs per female (subsection IV.B.5). As a female deposits eggs on vegetation or other objects on the bottom, one to several accompanying males fertilize them (Mansueti 1961b, 1964; Scott and Crossman 1973).

White perch eggs are adhesive and about 1 mm in diameter after water-hardening (Mansueti 1964). Depending on water temperature, hatching occurs in 1 to 6 days, with eggs developing faster at higher temperatures (Mansueti 1964). Newly hatched yolk-sac larvae, 1.7 to 3.0 mm, remain on or near the bottom for 3 to 5 days as the yolk is absorbed. At 3.5 to 4.0 mm, larvae enter the post yolk-sac stage and begin to feed actively on small zooplankton (Mansueti 1964). Post yolk-sac larvae develop the adult fin complement and transform to the juvenile stage when about 20 mm long and 4 to 6 weeks old (Mansueti 1964). During early summer, juveniles move into shoal and shore zone areas and feed on zooplankton and other small crustaceans, fish eggs, and midge larvae (TI 1979a). By late fall, juveniles have grown to a length of 65 to 75 mm and have moved to deeper water where they overwinter (TI 1979a). Growth almost ceases during winter but resumes in the spring as yearlings (like adults) become more omnivorous and consume a variety of organisms (TI 1979a, Taub 1966). At about 100 mm in length, male white perch begin to mature; female white perch grow faster than yearling males (Mansueti 1961b). White perch live to an average age of 7 years, with females living longer than males (Thoits 1973).

B. STOCK CHARACTERISTICS

This subsection describes the current status of the white perch population in the Hudson River. Characteristics of mature fish constituting the spawning stock are emphasized and include distribution and movements associated with spawning, age structure, sex ratios, mortality rates, ages of maturity, fecundity, and population size. These characteristics are compared with those of white perch populations from systems other than the Hudson River to detect effects possibly associated with power plant operation.

1. Distribution and Movements

Juvenile and adult white perch are ubiquitous in the Hudson River estuary. The distribution an movement of the 1977 year class as juveniles are discussed in detail in subsection IV.C. White perch adults have been found in all river regions (from RM 12 to RM 154) sampled by beach seines and bottom trawls, but have been most abundant in the upper estuary (above RM 76) during the spring (TI 1975c, TI 1976c, TI 1977a). Information on the distribution of spawning fish can be obtained from the distribution of eggs (subsection IV.C.1) which indicates that spawning occurs throughout the estuary and possibly in tributaries to the estuary as well (McFadden 1977a).

Information on seasonal movements of adult white perch and their association with spawning was obtained from recaptures of marked white perch. Upriver and downriver movements of white perch were followed by means of a mark-recapture program (Appendix A.C.1). Movements of finclipped fish, the youngest age group of fish at the time of marking, are discussed in subsection IV.C.3.c.2. Fingerling tags (Appendix A.C.1) were used on yearlings and older fish less than 150 mm in total length (TL). These fish were primarily 1 or 2 years old and immature. Fish greater than 150 mm TL were tagged with internal anchor tags, generally were mature, and 3 years old or older (subsections IV.B.4 and IV.B.5). Seasonal differences in the distances moved by marked fish were examined using fish that were both tagged and recaptured within the same 3-month period of spring (April through June) or fall (September through November) (Table IV-1).

Dispersal of tagged white perch (yearlings and older) from the river mile of release was greater during spring than fall and was more common among small fish (<150 mm TL) than large fish (>150 mm TL). During spring, 56% of the recaptured small fish were caught outside the river mile of release compared with 35% during the fall (Table IV-2). More large fish also left the river mile of release during the spring than the fall: 40% vs 24%, respectively. These differences in frequency of movement during spring and fall for small and large fish were significant (α=0.05); however, tagged white perch were no more likely to move upriver than downriver (Table IV-3). Even though more small fish than large fish dispersed from the river mile of release, large fish traveled a greater mean distance in the spring than small

Table IV-1

Numbers of White Perch Marked with Fingerling and Internal Anchor Tags Released and Recaptured during Spring (April through June) 1977 and 1978 and Fall (September through November) 1976 and 1977

Tag Type	Released						Recaptured					
	RM 12-23	24-38	39-46	47-76	77-153	Total	RM 12-23	24-38	39-46	47-76	77-153	Total
Fingerling												
Spring	202	3,136	1,181	1,735	1,735	7,989	1	69	21	16	7	114
Fall	156	9,652	4,254	1,046	701	15,809	3	284	87	10	0	384
Grand Total						23,798						498
Internal Anchor												
Spring	766	3,208	1,243	1,754	1,003	7,974	13	61	24	6	4	108
Fall	1,215	13,443	2,062	425	180	17,325	27	193	32	8	0	260
Grand Total						25,299						368

RM = River Mile

Table IV-2

Percentage of Tagged White Perch Recaptured Upriver, Downriver, and in Hudson River Estuary in River Mile of Release and Mean Distance Moved during Fall (September through November) 1976 and 1977 and Spring (April through June) 1977 and 1978

	<150 mm TL		>150 mm TL	
	Fall	Spring	Fall	Spring
Percentage of Recaptures				
Upriver	17	34	16	25
Same River Mile	65	44	76	60
Downriver	18	22	8	15
Mean Distance Traveled (mi)				
Upriver	2.8	6.2	2.5	11.4
Downriver	3.4	17.6	2.5	21.8

fish (Table IV-2). Each size group traveled approximately the same distance during the fall.

Greater movement during the spring may have been due to a combination of at least two factors: dispersal from the overwintering habitats and migrations by mature fish to spawning grounds. Dispersal after overwintering may have been the overriding factor since more small fish than large fish dispersed and since small fish were less likely to be mature and migrating to spawn. The greater distances traveled by larger fish probably reflected spawning migration. The equal movement upriver and downriver and the lack of movement by many larger fish support the hypothesis that spawning occurs throughout the estuary. The widespread distribution of eggs (subsection IV.C.1) also supports this hypothesis. Movements of tagged white perch during spring 1977 and 1978 did not support the general pattern of upriver movement that was suggested by catch-per-effort data collected in 1973 (TI 1976c).

Table IV-3

3-Dimensional Contingency Analysis* of Effects of Season and Fish Length on Movements of Tagged White Perch in Hudson River Estuary

Hypothesis Tested	d.f.	G	
Season X fish length independence	1	4.60	
Season X movement independence	2	22.44**	
upriver vs. downriver	1		1.36
(upriver + downriver) vs. same RM	1		21.08**
fish size X movement independence	2	16.26**	
upriver vs. downriver	1		4.18
(upriver + downriver) vs. same RM	1		12.07**
Season X fish size X movement interaction	2	4.32	
Season X fish size X movement independence	7	47.62**	

*From Sokal and Rohlf 1969
**Significant at α = 0.05 and α = 0.01
Season: September-November 1976 and 1977 vs. April-June 1977 and 1978
Fish Length: <150 mm Total Length vs. ≥ 150 mm Total Length
RM = River Mile

2. Age Composition and Sex Ratio

The age composition and sex ratio of the white perch population during 1977 were estimated from data collected as part of the Indian Point Standard Stations Program (field and laboratory methods are described in Appendix A.1.c.2). The Standard Stations Program samples only in the Indian Point region; thus the results are most indicative of that portion of the white perch population in the Indian Point region. Age was determined from scales taken from subsamples of white perch larger than 50 mm in total length (TL); all white perch less than 50 mm TL were assumed to be young-of-the-year. Sex was determined for all subsampled white perch greater than 100 mm TL caught by beach seines and bottom trawls during April-June.

The age composition of white perch caught by beach seines and bottom trawl differed by gear and across months (Table IV-4). Age composition in the two gears showed a habitat segregation in which age II and older white perch preferred deep offshore areas (sampled by bottom trawls), while young-of-the-year, and possibly yearlings, preferred the shore zone (sampled by beach seines). Recruitment of the 1977 year class to the catch began in June; by July, the year class dominated beach seine catches. By October, young-of-the-year and yearlings appeared in greater numbers in bottom trawl catches, signifying a movement to deep water as temperatures decreased.

Bottom trawl catches during October-December reflected the age composition of the population of this region (Table IV-4). At this time all age groups appeared to congregate in the shoals and channel to overwinter. Approximately 50% to 75% of the bottom trawl catch (Table IV-4) at this time of year was composed of young-of-the-year; however, since many young-of-the-year remained within the shore zone through December, their contribution was underrepresented in the bottom trawl catch. For this reason, mortality based on the age composition of the bottom trawl catch excluded young-of-the-year (subsection IV.B.3).

The sex ratio of white perch within the Hudson River estuary during 1976 and 1977 was not significantly (α=0.05) different from 1:1, although a significant deviation from a 1:1 ratio was found in the bottom trawl catch of 1975 (Table IV-5). The reason for this deviation is unknown, but a temporary habitat segregation of the sexes during April-June is a possible explanation.

Table IV-4

Percent Age Composition of White Perch Captured by Standard Station Beach Seines and Bottom Trawls at Indian Point Standard Stations, Hudson River Estuary, during April through December 1977

Gear	Age	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bottom Trawl	0	0.0	0.0	4.1	4.6	9.4	5.0	55.2	75.8	52.7
	I	13.9	51.8	10.2	0.0	0.0	5.0	8.4	12.2	23.4
	II	47.2	10.9	24.5	37.2	21.9	15.3	18.2	10.1	18.2
	III	20.8	13.6	26.5	21.7	28.1	38.6	15.6	1.1	5.0
	IV	13.6	11.8	16.3	17.0	21.9	18.0	2.6	0.6	0.0
	V	3.8	9.1	14.3	7.3	18.8	10.3	0.0	0.3	0.0
	VI	0.3	1.8	4.1	12.1	0.0	5.2	0.0	0.0	0.0
	VII	0.3	0.9	0.0	0.0	0.0	2.6	0.0	0.0	0.0
	VIII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	IX and Older	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
	No. Aged	240	107	48	42	32	39	151	271	149
Beach Seine	0	0.0	0.0	2.7	82.2	93.0	86.4	96.3	92.9	100.0
	I	22.2	27.7	64.3	16.3	6.4	10.0	2.9	4.2	0.0
	II	16.7	53.8	15.1	1.0	0.3	2.3	0.4	2.1	0.0
	III	8.3	13.8	10.7	0.4	0.2	0.9	0.4	0.4	0.0
	IV	30.6	3.1	3.8	0.0	0.0	0.2	0.0	0.0	0.0
	V	19.4	1.5	3.5	0.1	0.0	0.2	0.0	0.0	0.0
	VI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
	VII	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
	VIII	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	IX and Older	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	No. Aged	36	65	259	429	327	386	200	249	7

Table IV-5

Percentage of Males in Catch of White Perch by Bottom Trawls and Beach Seines at Indian Point Standard Stations, Hudson River Estuary, during 1975-77

		Bottom Trawl			Beach Seine		
Year	Age	Percent Male	Sample Size	Z†	Percent Male	Sample Size	Z†
1975	II	32	146		45	87	
	III	37	120		36	22	
	IV	31	209		50	28	
	V	41	111		23	13	
	VI	30	23				
	Combined	34	609	-7.90*	43	150	-1.71
1976	II	34	87		55	40	
	III	47	135		48	44	
	IV	50	111		41	22	
	V	55	74		44	16	
	VI	75	24				
	Combined	48	431	-0.83	48	122	-0.44
1977	I	40	47		22	72	
	II	60	196		66	105	
	III	49	149		56	43	
	IV	48	87		52	21	
	V	36	53		50	16	
	VI	50	18		50	2	
	Combined	51	550	+0.47	50	259	0

† $Z = \frac{\hat{p}-p}{\sqrt{\frac{pq}{n}}}$ where $\hat{p}$ = proportion of males in catch, p = 0.5, q = 1-p and n = sample size (number of males plus number of females) (Steel and Torrie 1960).

*Indicated significant difference from 50% at α = 0.05.

3. Mortality

Total annual mortality of yearling and older white perch was estimated by catch curve analysis (Ricker 1975) of age composition data obtained from bottom trawls (16 mm mesh liner in cod end) from October through December 1977 at the Indian Point Standard Stations (Appendix A.I.C.2); thus the results are most indicative of that portion of the white perch population in the Indian Point region. The age composition of each subsample was weighted by the total catch for the sample and the data then pooled for analysis.

A least squares regression technique described the linear relationship:

$$\log_e N_i = \alpha - \beta(t)$$

where

$\mathrm{Log}_e\, N_i$ = natural logarithm of number of age i individuals collected

α = intercept

β = slope

t = age in years

From this regression analysis, total annual mortality was determined as follows:

$$A = 1 - e^{-\beta}$$

where

A = total annual mortality

e = 2.71828 = base of natural logarithm

β = instantaneous mortality rate from linear regression $\log_e N_i = \alpha - \beta(t)$

Total annual mortality estimated from 1977 data was 0.67. Since catch curve analysis considered several age groups collected during a single year, the mortality estimate represents an average rate across several age groups rather than mortality experienced by an individual age group during

1977. Estimates of mortality rates have been similar since 1974 (Table IV-6). Catch curves derived from each year's data set (Appendix Table C-1) had a common variance using Levene's test ($F=2.03$, $df=3, 17$; $p=0.15$: Brown and Forsythe 1974) and shared a common regression line as shown by analysis of variance ($F=1.99$, $df=6, 13$; $p=0.14$). Therefore, data from all 4 years were combined into a single catch curve (Figure IV-4), yielding a total annual mortality of 0.66. This estimate exceeds an independent estimate of 0.56 for white perch in the Hudson River made by LMS (CHG and E 1977). Differences in the methodology for estimating mortality may account for the differences in TI and LMS estimates (TI 1978a). When juveniles are included in the analysis, as done by LMS, a mortality rate of 0.61 is attained (TI 1978a).

4. Growth

Growth rates influence other stock characteristics such as age at maturity and mean fecundity (as discussed in subsection III.B.4 for striped bass). Growth of white perch in the Hudson River estuary was examined using data collected by beach seines and bottom trawls at the Indian Point Standard Stations (Appendix A.I.C.2); thus the results are most indicative of that portion of the white perch population in the Indian Point region. Data collected during 1975, 1976, and 1977 were compared for yearly differences by age, and, when possible, a typical mean size for Hudson River white perch calculated. To minimize the effects of early season growth, analyses for ages I and II included only May data; for ages III-V, only May and June data were used. Growth in length by age for males and females was compared for ages III-V fish. All lengths were transformed by $\log_{10}$ to stabilize variance homogeniety. The sex of white perch less than 125 mm in total length (TL) was occasionally difficult to determine; therefore, to avoid introduction of bias, sex was not included in growth analyses for ages I and II.

Ages I and II white perch were significantly ($\alpha=0.05$) larger in 1976 than in 1975 and 1977 (Tables IV-7 and IV-8). The greater length observed in 1976 reflected growth acquired during 1975, a year of above-average temperatures (subsection IV.D.3).

Table IV-6

Regression Results of Catch Curve Parameters and Total Annual Mortality Estimates for White Perch Caught in Bottom Trawls, Hudson River Estuary, during October-December 1974-77

Parameter	1974	1975	1976	1977	Four Years Combined
Intercept	6.08442	6.01005	7.09758	5.83280	6.17805
Slope	-1.17955	-0.97459	-1.18374	-1.10423	-1.07703
Correlation Coefficient	-0.918	-0.978	-.989	-0.967	-0.931
Total Annual Mortality (A)	0.69	0.62	0.69	0.67	0.66

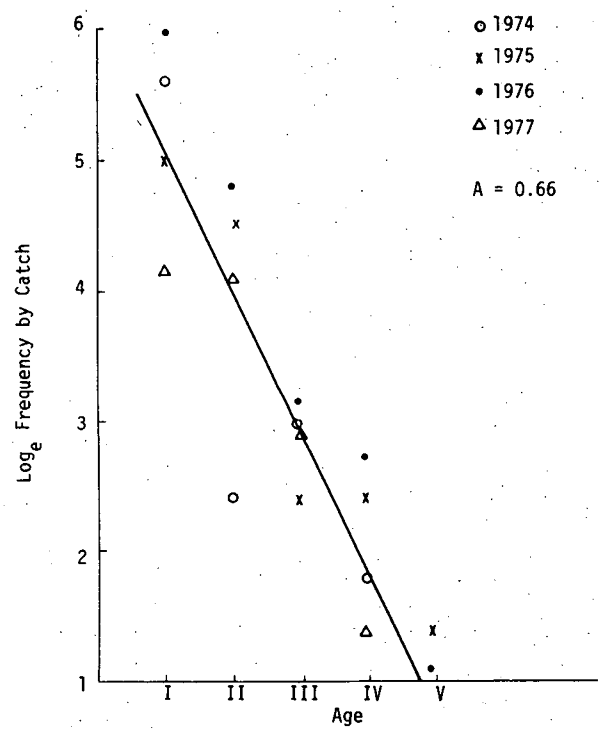


Figure IV-4. Catch Curve of White Perch Collected by Standard Station Bottom Trawls in Hudson River Estuary, October-December, 1974-77. [Annual mortality rate (A) of 0.66 represents over 4 years.]

Table IV-7

Analysis of Variance for Mean Total Length of Ages I and II White Perch (Males and Females Combined) Caught at Indian Point Standard Stations in Hudson River Estuary during May 1975-77

Age	Source of Variation	df	Mean Square	F
I	Years	2	0.02543377	9.77†
	Error	346	0.00260362	
II	Years	2	0.00712633	4.72†
	Error	166	0.00151015	

*Lengths transformed by $\log_{10}$

†Significant at $\alpha=0.05$

Table IV-8

Mean Total Length (TL), Sample Size (n), and Standard Deviation (SD) of Ages I and II White Perch (Sexes Combined), May 1975, 1976 and 1977, and of Ages III-VII Male and Female White Perch, May and June 1975-77 (Years Combined)

Year		I	II			Age III	IV	V	VI	VII
1975	TL	70.2	119.9							
	n	145	98							
	SD	8.42	11.54		TL	153.8	171.6	180.0	190.3	233
				Male	n	93	83	81	23	1
					Sd	11.88	10.25	11.09	13.59	0
1976	TL	74.2	126.2							
	n	134	24							
	SD	8.24	9.93							
					TL	158.8	173.4	187.0	199.4	216.7
				Female	n	96	144	96	19	3
					Sd	11.08	11.67	14.68	13.92	25.54
1977	TL	70.1	118.0							
	n	70	47							
	SD	9.66	9.21							
Mean Length* by Age		71.5	121.4			156.3	172.5	183.5	194.8	224.8

*Calculated as simple arithmetic mean disregarding year and sex differences.

Annual growth differences observed in the first 2 years of life were not detected for age III fish. There were no significant differences among years in the mean lengths of either male or female white perch of a given age (III-V) caught during 1975, 1976, and 1977 (Table IV-9). However, ages III-V females were significantly (α=0.05) larger than males of the same age with the differences in mean length ranging from 2 to 7 mm (Table IV-8). Since the 3 years of data did not differ for ages III-V except between sexes, the data were pooled to calculate mean lengths for each sex (Table IV-8). Yearly differences for ages VI and VII were not tested because of small sample sizes, but they did not appear to be significant.

Mean total lengths for ages I-VI, 1975-1977 (Table IV-8), were used to calculate annual instantaneous growth rates (G) by the formula:

$$G = \log_e L_2 - \mathrm{Log}_e L_1$$

where L_1 and L_2 are mean total lengths of two consecutive age groups. The annual instantaneous growth rate decreased from age I to age V (Figure IV-5), becoming asymptotic when mean total lengths approached 200 mm.

In an earlier study on the Hudson River, LMS (O and R 1977) noted that white perch from the upper freshwater portions of the estuary, near Roseton (RM 66) and Kingston (RM 95), grew more slowly than those collected from estuarine areas near Bowline area (RM 36). Growth (measured as the difference in mean length between age I and age VI fish) of white perch from Kingston was 117 mm, from Roseton 118 mm, and from Bowline 181 mm. White perch from Indian Point Standard Stations (RM 39 through RM 46) (Table IV-8), however, grew 123 mm between ages I and VI. Thus, the greater growth of white perch from the Bowline area may have been the result of other factors in addition to the effects of varying salinity.

5. Natality

Two components of natality, age at maturity and fecundity, were examined for the white perch population during 1977. White perch were obtained from samples collected at the Indian Point Standard Stations during May and June for determination of age at maturity and during May for fecundity estimates; thus the results are most indicative of that portion of the

Table IV-9

Analysis of Variances for Mean Total Length of Ages III-V White Perch Caught at Indian Point Standard Stations in Hudson River Estuary during May and June 1975-77

Source of Variation	df	Mean Square	F†
Year	2	0.000000515	0.00
Age	2	0.20895692	95.82**
Sex	1	0.01544541	73.59**
Year x Age	4	0.002180765	2.35
Year x Sex	2	0.000209895	0.23
Age x Sex	2	0.00276707	1.81
Year x Age x Sex	4	0.001532903	1.65
Error	575	0.000926702	

*Lengths transformed by $\log_{10}$

†See Appendix Table C-2 for expected mean squares

**Significant at $\alpha = 0.05$

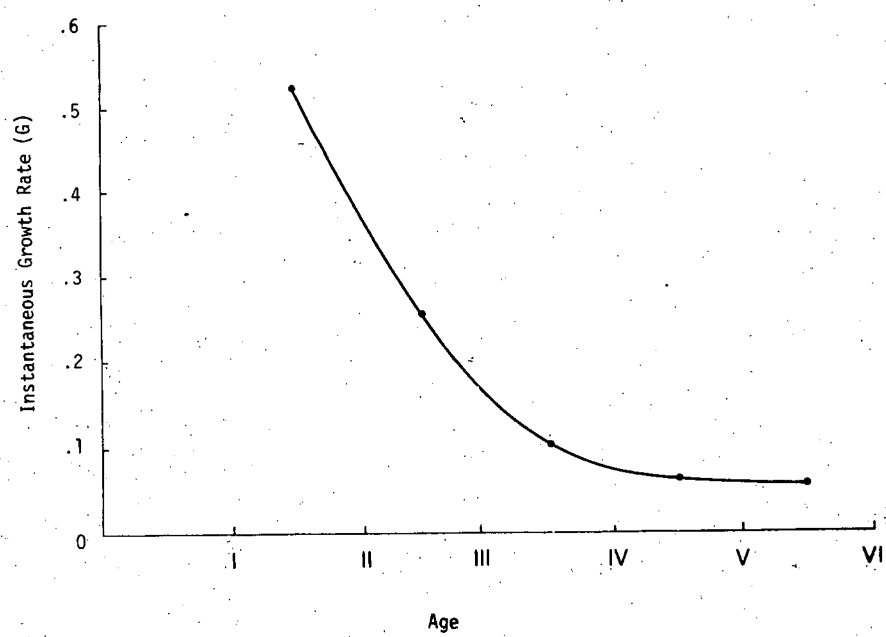


Figure IV-5. Annual Instantaneous Growth Rate (Increase in Total Length) for Hudson River White Perch 1975-77 (Data presented in Appendix Table C-2) white perch population in the Indian Point region. Previous analyses established that May samples are the most favorable time for estimating white perch fecundity in the Hudson River (TI 1978a) because they include late-maturing fish but exclude partially spent fish.

The state of maturity of white perch greater than 100 mm in total length (TL) was determined visually by examining excised gonads which had been stored in 10% formalin. Ovaries were considered immature if they were small and translucent and mature if enlarged with readily distinguishable ova visible through the ovarian wall. Testes were considered immature if they were small and translucent and mature if swollen and opaque.

Differences among the percentage of fish of a given age which are mature would be expected to appear in the younger age classes. Prior data (TI 1977b) indicated that age II white perch would probably be the age class most likely to demonstrate differences in percent mature between different years. Therefore, using age II and age III and older fish, the data were tested for independence over time (Sokal and Rohlf 1969).

Ripe females were used to determine fecundity. The fish were weighed to the nearest gram (g) for total body weight and to the nearest measured millimeter (mm) for total length. Both ovaries were removed, stored in 10% formalin, and later drained on paper towels and weighed to the nearest 0.01 g. A wedge-shaped sample weighing approximately 0.1 g was removed from a transverse section of the ovary taken midway along the long axis; the apex of the wedge approximated the central axis of the ovary. The sample was immediately weighed to the nearest 0.01 g; the eggs were then manually separated from the ovarian connective tissue and counted. Egg counts included eggs greater than or equal to 0.2 mm in diameter, as measured with an ocular micrometer.

Fecundity (F), defined as the total number of eggs greater than or equal to 0.2 mm, was estimated for each fish using the equation:

$$F = \frac{c}{w} W$$

where

F = estimated number of eggs

c = number of eggs in sample

w = weight of sample

W = weight of both ovaries

Fecundity ($\log_{10}$) was regressed on the total length ($\log_{10}$) of each fish. Data from 1975, 1976, and 1977 were tested for homogeneity of group variance with Levene's test (Brown and Forsythe 1974) and for differences between regression lines with analysis of variance (ANOVA). Fecundity ($\log_{10}$) was also regressed on weight ($\log_{10}$) and age in years. Fecundity data were collected during 1972-1974 but were not comparable because of differences in methodology (TI 1979a).

White perch in the Hudson River begin to mature at age II, and most or all males are mature by age IV and all females by age V (Table IV-10). The percentage of age III and older white perch which are mature has not differed significantly (α=0.05) among years for either males or females in collections since 1972, but the percentage of age II males and females which are mature has varied significantly (α=0.05) among years (Table IV-11). A higher percentage of age II males (66%) and females (39%) were mature in 1977 than in most other years (Table IV-10). Since age II fish were significantly smaller in 1977 than in 1975 and 1976 (Subsection IV.B.4), increased size did not explain the increase in percent maturity for two-year- olds, which is inconsistent with the hypothesis that larger animals mature earlier.

White perch in the Hudson River begin to mature at 100 to 110 mm TL for males and 111 to 120 mm TL for females (Appendix Tables C-4 and C-5). During 1977, one exceptionally fast-growing yearling male reached this size and matured, but apparently these individuals are rare. All females over 170 mm TL were mature, whereas some males during 1977 were still immature at 181 to 190 mm TL.

Table IV-10

Percentage (Number) of Sexually Mature Male and Female White Perch in Hudson River Estuary during 1972-77*

Sex	Year	Age II	III	IV	V	VI+
Male	1972	25 (16)	100 (2)	100 (8)	100 (6)	100 (2)
	1973	50 (6)	67 (3)	100 (5)	100 (4)	100 (2)
	1974	77 (13)	92 (13)	100 (5)	100 (1)	100 (2)
	1975	32 (50)	80 (20)	100 (38)	100 (27)	100 (5)
	1976	46 (28)	74 (38)	100 (27)	100 (35)	100 (14)
	1977	66 (61)	97 (35)	87 (15)	75 (16)	100 (4)
Female	1972	- (0)	75 (8)	100 (18)	100 (8)	100 (3)
	1973	24 (17)	96 (28)	96 (28)	100 (15)	100 (1)
	1974	19 (26)	95 (18)	95 (18)	100 (6)	- (0)
	1975	18 (60)	78 (23)	95 (43)	100 (34)	100 (9)
	1976	18 (33)	88 (25)	95 (21)	100 (12)	100 (3)
	1977	39 (36)	94 (32)	96 (23)	100 (23)	100 (5)

*Data for 1972-74 presented in TI 1976a; data for 1975-76 presented in TI 1979a.

Table IV-11

Tests of Independence† between Sexual Maturity (Percent) and Year of Collection for Male and Female White Perch Age II and Age III-and-Older, 1972-77

Comparison	d.f.	G
Maturity of Age II Male White Perch vs. Year	5	20.928*
Maturity of Age III+ Male White Perch vs. Year	5	5.373
Maturity of Age II Female White Perch vs. Year	5	15.456*
Maturity of Age III+ Female White Perch vs. Year	5	2.243

*G-value is significant at $\alpha = 0.05$, and the null hypothesis that maturity is independent of year is rejected. Data presented in Appendix Table C-3.
†Sokal and Rohlf 1969

Mean fecundity of white perch during 1977 ranged from approximately 31,000 eggs at age II to 104,000 eggs at age V (Table IV-12). Although mean fecundities for 1977 were consistently lower than for 1975 and 1976, there were no significant differences among the three years ($F=2.98$, $p>0.05$) when ages III-V were tested by ANOVA. Also there was not a significant difference ($\alpha=0.05$) among the 3 years (1975, 1976, 1977) for either the variance ($F=1.28$, $p=0.28$) or slope of the simple regressions of the logarithms of fecundity on total length ($F=1.68$, $p=0.16$). Therefore, data from the 3 years were pooled to yield a single regression line (Figure IV-6). These data excluded four fish (three from 1977 and one from 1975) with unusually low estimated fecundities and suspected to be partially spent (Figure IV-6). The common regression line for 1975, 1976, and 1977 indicated no detectable differences during these years in the relationship between white perch fecundity and length.

Table IV-12

Mean Number of Eggs per Female White Perch Collected in Indian Point Region during May 1975-77

Age	Year	Number of Females Examined	Mean Number of Eggs	Standard Deviation
II	1975	-*	-	-
	1976	1	32,351	-
	1977	1	31,457	-
III	1975	8	52,938	11,842
	1976	8	58,377	17,502
	1977	6	45,100	13,781
IV	1975	13	94,342	37,105
	1976	11	81,290	37,713
	1977	9	47,182	14,409
V	1975	8	104,467	35,220
	1976	9	124,289	50,764
	1977	3	103,776	39,566
VI	1975	2	153,880	74,541
	1976	1	289,740	-
	1977	-	-	-

*Dashes indicate no fish examined for fecundity estimates.

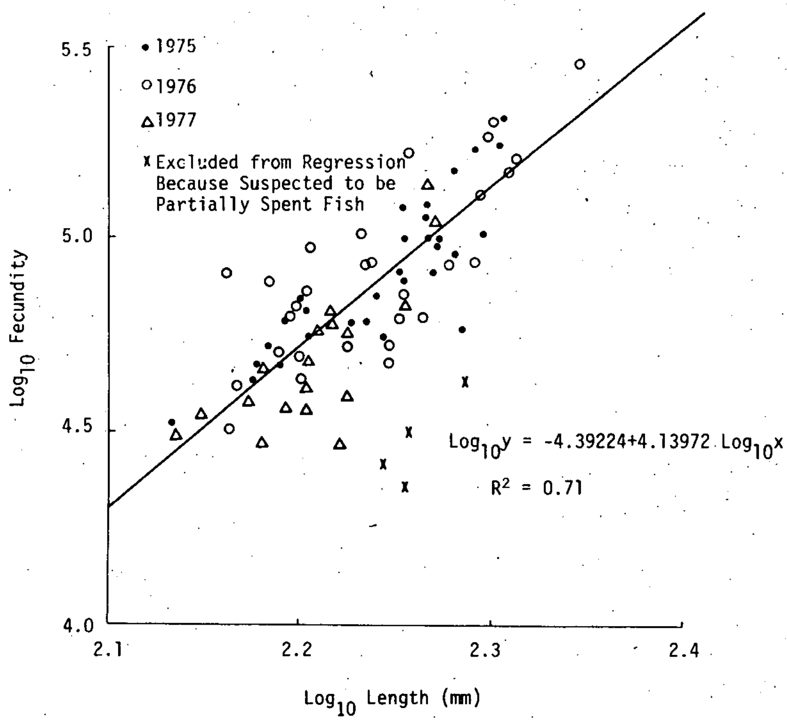


Figure IV-6. Regression of Fecundity on Total Length for White Perch, May 1975, 1976, and 1977 Combined

The results of regressions of the logarithm of fecundity on the logarithm of weight and age are presented for 1975-77 in Appendix Table C-6. More detailed analyses were not undertaken since both parameters are erratic indicators of fecundity (see R^2 values in Appendix Table C-6).

6. Population Size Estimates for Yearling and Older White Perch

The number of yearling and older white perch in the Hudson River during the fall of 1977 was estimated by mark-recapture methods. White perch were tagged with fingerling tags if greater than 50 mm but less than or equal to 150 mm in total length (TL) and with internal anchor tags if greater than 150 mm TL. Fish were marked during September-November as part of the fisheries program (see Appendix A for field methods). Catches from all TI field sampling programs and impingement collections at Bowline, Lovett, Indian Point, Roseton, and Danskammer generating stations were examined for recoveries of tagged fish. Separate population estimates were calculated for each size group ($\leq$150 mm and >150 mm).

To assess short-term mortality due to marking and handling, tagged fish were held in tanks for 14 days. Tag retention was evaluated by clipping the first (spiny) dorsal fin of all white perch tagged during September and comparing the recovery rate of fish retaining tags with the recovery rate of fish caught bearing only the finclip. The number of fish tagged and released during September-November was subsequently adjusted for the estimated survival after 14 days and for tag retention (Table IV-13). Survival was 100% for fish tagged in September, but declined to 78-81% for October releases and 35-40% for November releases. Tag retention was higher (95%) for fingerling tags than for internal anchor tags (83%). Loss of tags was expected to remain nearly constant throughout the recovery period (2 to 9 months after release).

Table IV-13

Survival Rate (14 Days), Tag Retention Rate, and Adjusted Release Totals for Adult White Perch Tagged in Hudson River Estuary during September-November 1977

	Total Length					
	≤150 mm			>150 mm		
Marking Month	Adjusted* Number of Tags Released	Survival Rate	Tag Retention Rate	Adjusted* Number of Tags Released	Survival Rate	Tag Retention Rate
Sep	3023	1.0	0.95	1820	1.0	0.83
Oct	849	0.81	0.95	904	0.78	0.83
Nov	291	0.40	0.95	583	0.35	0.83
Total	4163			3307		

*Number of tags released x (survival rate) x (tag retention rate); survival test data are presented in Appendix Table C-13

The Petersen estimate, as modified by Chapman (Ricker 1975), was chosen as the best estimator because the number of recaptures was small. The modified Petersen estimate of population size was calculated as:

$$N^* = \frac{(M+1)\ (C+1)}{R+1}$$

where

N^* = estimated number of fish

M = number of fish marked

C = number of fish examined for marks

R = number of marked fish recovered

Confidence limits (95%) for N* were determined by defining confidence limits for R (subsection III.D.1) using the Poisson distribution (Ricker 1975).

The most appropriate release and recovery periods for Petersen estimates were selected by examining the fraction of marked fish in the total catch (R/C) and the recovery rates (R/M) from January through June 1978. Stability of R/C and R/M ratios over time and across river regions indicated that marked and unmarked fish were adequately mixed, an important consideration in mark-recapture methods of population size estimation (Appendix Table B-4). Since recovery rates (R/M) significantly increase (Appendix Table C-9) from the September through November release periods, release data from all months' releases could not be pooled. September was chosen as the release period to be used in the estimate because of the greater number of marks released and recaptured compared with October and November (Appendix Tables C-7 and C-8; January-April was selected as the recovery period for fish less than 150 mm TL because of the observed stability of R/C ratios (Appendix Table C-10); January alone was selected for fish greater than 150 mm TL since only one fish was recovered in the subsequent 5 months (Appendix Table C-10). Petersen estimates of the fall 1977 population of yearling and older white perch were 5.1 million for fish less than or equal to 150 mm TL and 5.7 million for fish greater than 150 mm TL, totaling 10.8 million fish (Table IV-14).

Table IV-14

Modified Petersen Estimates for Yearling and Older White Perch in Hudson River Estuary, September 1977

	Size Group	
	≤150 mm Total Length	>150 mm Total Length
M	3023	1820
C	23674	24836
R	13	7
N*	5.11×10^6	5.65×10^6
95% Confidence Interval	$3.07 \times 10^6 - 9.06 \times 10^6$	$2.94 \times 10^6 - 15.60 \times 10^6$

7. Comparison with Other White Perch Populations

Information on the stock characteristics of white perch in populations from other geographical areas is available for a diverse set of habitats, including more northern as well as more southern estuaries and inland waters. This information has been compiled to indicate the responses of the species to differing environmental conditions and levels of exploitation and to evaluate the potential for changes in stock characteristics that may offset plant-induced mortality in Hudson River populations.

Seasonal movements of white perch have been studied in the Patuxent River, Maryland, where a well-defined spawning migration occurs (Mansueti 1961b). White perch in the Patuxent River migrate upriver in the spring from feeding areas in brackish water to spawn in tidal freshwater areas. Males precede females to the spawning grounds and remain longer much as Atlantic tomcod do in the Hudson River (subsection V.B.1). A downriver movement of white perch to feeding grounds was noted after spawning. Seasonal movements such as these have been inferred from the distribution of white perch catches in the Hudson River but have not been conclusively demonstrated by tagging studies (subsection IV.B.1). Recaptures of tagged fish, however, have indicated long-range movements in both the Patuxent and Hudson Rivers. Large-scale movements have been indicated also by the rapid dispersal of white perch into the Great Lakes after probable introduction through the New York State Barge Canal in 1950 (Scott and Christie 1963).

The age structures of white perch populations in the Patuxent River (Mansueti 1961b), Lake Ontario (Sheri and Power 1968), and the Quabbin Reservoir, Massachusetts (Taub 1966) were similar to that of the Hudson River population, with no marked dominance of a single age group, indicating that large variation in year class strength was not apparent. The oldest white perch observed in the Patuxent River, Lake Ontario, and Quabbin Reservoir populations were age X. An age XI white perch was caught in the Hudson River during 1976 (TI 1977b), but fish older than VII were uncommon. Mansueti (1961b) proposed that longevity decreased for white perch going south from Maine (maximum age, XVI) to North Carolina (maximum age, VI); in a review of early studies on white perch, he concluded that longevity and the length of the growing season were inversely related, although imperfectly. In a study of white perch in Albemarle Sound, North Carolina, (not reviewed by Mansueti), Conover (1958) found that the oldest males and females were age VIII. The longevity of white perch in the Hudson River fits well as an intermediate in the gradient of longevity from northern to southern ends of the range.

The annual mortality rate (66%) estimated for yearling and older white perch in the Hudson River was equal to or greater than rates observed for other populations. Lower mortality rates were found in the Patuxent River (0.55 for both sexes, Mansueti 1961b) and the York River, Virginia (0.59 for males and 0.57 for females, St. Pierre and Davis 1972). Mortality rates for white perch in the James River (St. Pierre and Davis 1972) were 0.69 for males and 0.68 for females. Wallace (1971) reported annual mortality rates of 0.54 for males and 0.58 for females in the Delaware River; however, when the data from Wallace (1971) were reanalyzed on a monthly basis to coincide with the months of capture (October-November) for the Hudson River population, the revised estimate of 0.69 was similar to the estimate of 0.66 for the Hudson River (TI 1978a). Differences in mortality rates among populations, therefore, may be influenced by differences in computation methods, particularly if the vulnerability of each age group to capture differs throughout the year because of habitat segregation. The computation methods used by TI are preferred over estimates that include months during which habitat segregation may occur (e.g., summer); habitat segregation is minimized during late fall and winter when the Hudson River population apparently gathers in mixed age groups in deep offshore areas.

The mean total lengths of Hudson River white perch were similar to those of white perch in many southern populations, such as from the Delaware, James, York, and Patuxent Rivers (Table IV-15). White perch in the Connecticut River and Rhode Island waters were larger, however, particularly those that were ages II and older. LMS (O and R 1977) concluded that growth of white perch taken from several areas of the Hudson River, including the highly productive Croton-Haverstraw region, was generally slower than growth in 11 other populations in systems both north and south of the Hudson River. Thus, the population of white perch in the Hudson River estuary may be stunted. Several studies (O and R 1977, Marcy and Richards 1974, AuClair

1964) concluded that stunted growth is a common phenomenon in white perch populations not subjected to heavy fishing pressure. Growth in the Hudson River may be promoted by increasing exploitation by sport and commercial fisheries, as was recommended for white perch in the lower Connecticut River (Marcy 1976), or by plant-related mortality. Any effects of past and present power plant operations on the growth of white perch in the Hudson River are not detectable.

White perch in the Hudson River began to mature at a size and age similar to those of white perch in other populations, but maturity was not complete until a later age. Maturity began at age II in the Hudson and Patuxent Rivers (Mansueti 1961b) and at age I in Lake Ontario (Sheri and Power 1968). Males reached full maturity at age II in the Patuxent River and Lake Ontario but not until age IV or later in the Hudson River. Females reached full maturity by age IV in the Patuxent River and age III in Lake Ontario, but not until age V in the Hudson River (Table IV-10). A delay in full maturation in the Hudson River may reflect differences in growth rates; growth data for Lake Ontario were not presented by Sheri and Power (1968) and mean sizes in the Patuxent River were only slightly larger than in the Hudson River (Table IV-15). White perch from the three populations (Table IV-16) exhibited similar sizes at onset and completed development of maturity.

Fecundity estimates for white perch in the Hudson River could not be reliably compared with those of other populations because of the multiplicity of egg sizes present in the ovary and because of differences in criteria for identifying mature eggs. Taub (1969) found that white perch egg diameters in the Quabbin Reservoir, Massachusetts, varied, with unfertilized (presumably mature) eggs ranging in diameter from 0.58 mm to 0.80 mm (Taub 1966). Sheri and Power (1968) used only the largest of three eggs sizes present in the ovary for fecundity estimates and did not give diameters.

In summary, Hudson River white perch grew more slowly and reached full maturity later than white perch from most other populations. Reduced density within the population conceivably could have affected both maturation and growth. Mortality rates and age composition of Hudson River white perch were similar to those in other populations and did not suggest that the

Table IV-15

Mean Total Length (mm) at Annulus Formation for White Perch (Male, Female, and Unsexed Fish Combined) Collected in Various Systems

Age	Hudson* River	Connecticut** River	Delaware*** River	Albemarle Sound-Roanoke† River	Patuxent‡ River	Rhode Island††	James‡‡ River	York ‡‡ River
I	72	87	83	74	89	99	75	78
II	121	179	134	112	137	165	120	118
III	156	225	158	150	164	208	150	146
IV	172	255	174	183	183	236	174	172
V	184	278	186	211	198	246	192	192
VI	194	308	196	234	219	269	208	213

* From 1977 TI data (see subsection IV.B.4 and Table IV-8)
** Marcy (1976). All standard lengths (SL) given were converted to total lengths (TL) by the equation: TL=1.57+1.2 SL
*** Wallace (1971) from Marcy (1976)
† Conover (1958)
‡ Mansueti (1961) from Marcy (1976)
†† Saila and Horton (1957)
‡‡ St. Pierre and Davis (1972) from Marcy (1976)

Table IV-16

Minimum Total Length of Mature White Perch and Maximum Total Length of Immature White Perch in Three North American Populations

Location	Minimum Length (mm) Mature	Maximum Length (mm) Immature	Reference
Patuxent River			
Male*	99-112	149-161	Mansueti 1961b
Female**	111-123	184-197	
Lake Ontario			
Male †	---	152	Sheri and Power 1968
Female †	---	186	
Hudson River			
Male	100-110	181-190	TI 1977 data
Female	111-120	161-170	

* TL = 1.24 (SL) from Mansueti 1961b

** TL = 1.23 (SL) from Mansueti 1961b

† TL = 6.75 + 1.04 (FL) derived from Wallace 1971 and Marcy 1974

TL = Total length

SL = Standard length

FL = Fork length

Hudson River population is experiencing excessive exploitation by either power plant operation or commercial and sport fisheries. On the contrary, the late maturation and slow growth of Hudson River white perch suggest that the population is only lightly exploited.

C. LIFE STAGES

This subsection discusses the distribution of eggs, larvae, juveniles, and yearling white perch during 1977, compares distribution from 1974 through 1977, and discusses the prevailing physicochemical conditions and their effects on distribution.

1. Eggs

a. Distribution during 1977

Standing crop estimates of white perch eggs provide a relative measure of when and where eggs occur but probably do not reflect true egg abundance in the estuary. The eggs are demersal and adhesive and are not as vulnerable to collection as are striped bass eggs. In addition, white perch probably spawn in tributaries to the Hudson River estuary where no sampling is conducted (McFadden 1977a).

Eggs were collected from mid-April through late June. Standing crops reached a peak in late May when eggs were collected in 11 of 12 sampling regions (Appendix Table C-14). Densities were greater than 50 eggs/1000 m^3 (Appendix Table C-13) during May and early June in seven regions: Tappan Zee, West Point, Poughkeepsie, Hyde Park, Kingston, Catskill, and Albany. In most other regions and time periods, densities were less than 5 eggs/1000 m^3 (Figure IV-7). White perch did not concentrate their spawning in any particular area during 1977. Yonkers was the only region where no eggs were collected. The prolonged period during which eggs were collected supports the hypothesis that individual white perch may spawn more than once during a single season (TI 1978a) or, alternatively, that individual adults achieve spawning condition at various rates.

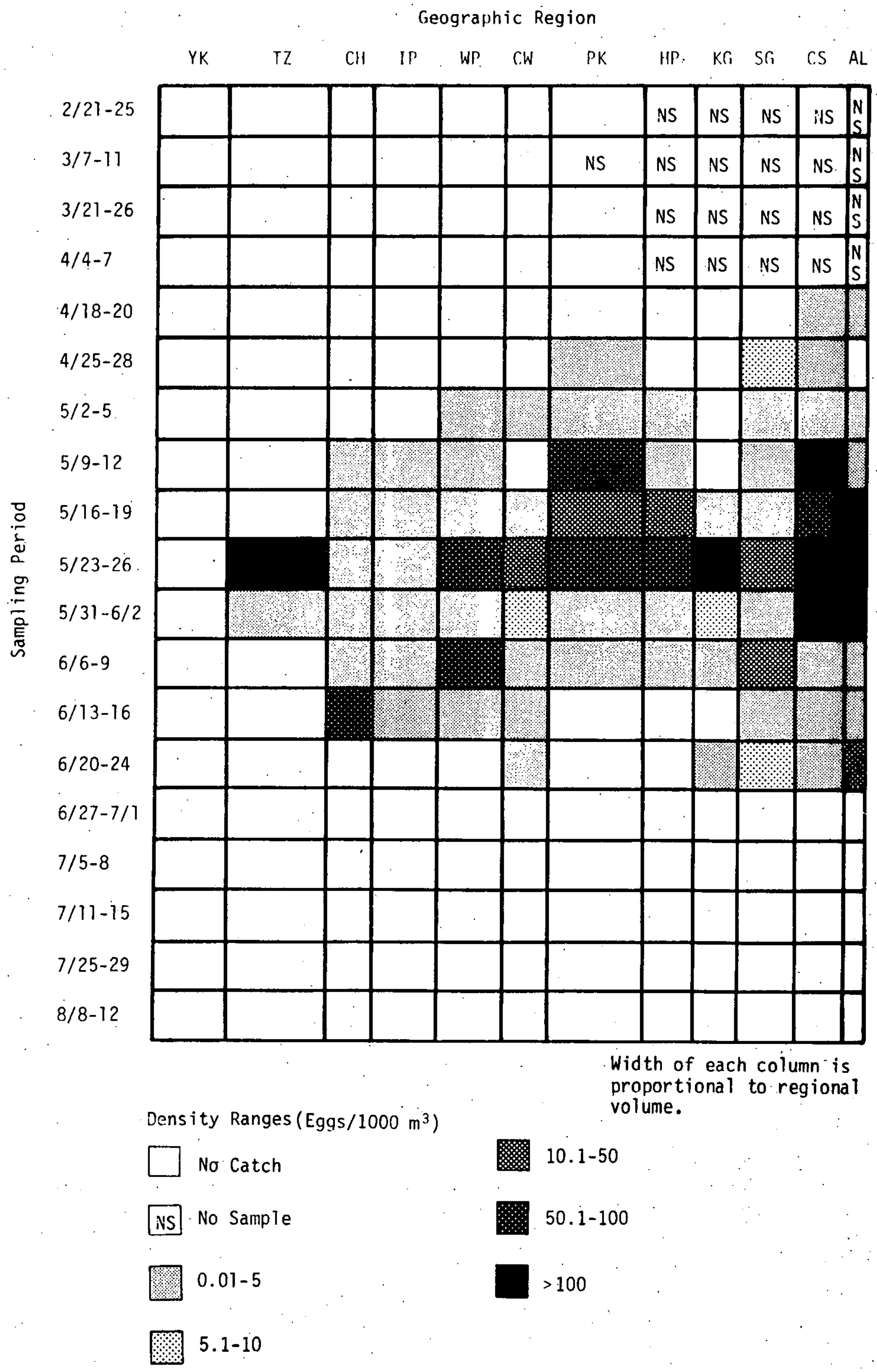


Figure IV-7. Distribution Matrix of White Perch Eggs Collected during Ichthyoplankton Survey

b. Factors Affecting Distribution

Spawning activity is not restricted to a narrowly defined set of temperature-conductivity requirements in the Hudson River estuary, but rather is triggered in the spring when temperatures reach 14^{o} to $16^{o}C$ and continues into early summer. The density of eggs during 1974-1977 (Appendix Table C-14) was moderately high (>50 eggs/1000 m^3) over a wide range of temperatures (about 12^{o} to $23^{o}C$) and conductivity (about 130 to 2000 mS/cm).

White perch eggs were heavily concentrated in the bottom stratum (Figure IV-8 and Appendix Tables C-15 and C-16) as was expected because of their adhesiveness and demersal nature. Although the eggs adhere to the substrate immediately after spawning, they do not readhere if they are dislodged from the original substrate longer than about an hour after they were spawned (Mansueti 1964); this characteristic probably accounts for those eggs collected in the channel stratum.

c. Trends in Distribution (1974-1977)

The geographic distribution index for eggs varied widely from region to region and year to year (Figure IV-9). Lowest densities consistently occurred in the Yonkers and Indian Point regions. Three general areas of relatively high egg density can be discerned: the Tappan Zee and Croton-Haverstraw region of the lower estuary; the Poughkeepsie region (middle estuary); and the Saugerties through Albany regions (upper estuary).

Temporal abundance patterns of white perch eggs were similar for 1975 and 1977, with a single dominant period during May. During 1974, three periods of abundance were observed; in 1976 there were two dominant periods (Figure IV-10). Spawning activity may have been brought to an early and more distinct peak during 1975 and 1977 (Appendix Table B-32) because temperatures were higher during late May of those years than in 1974 and 1976.

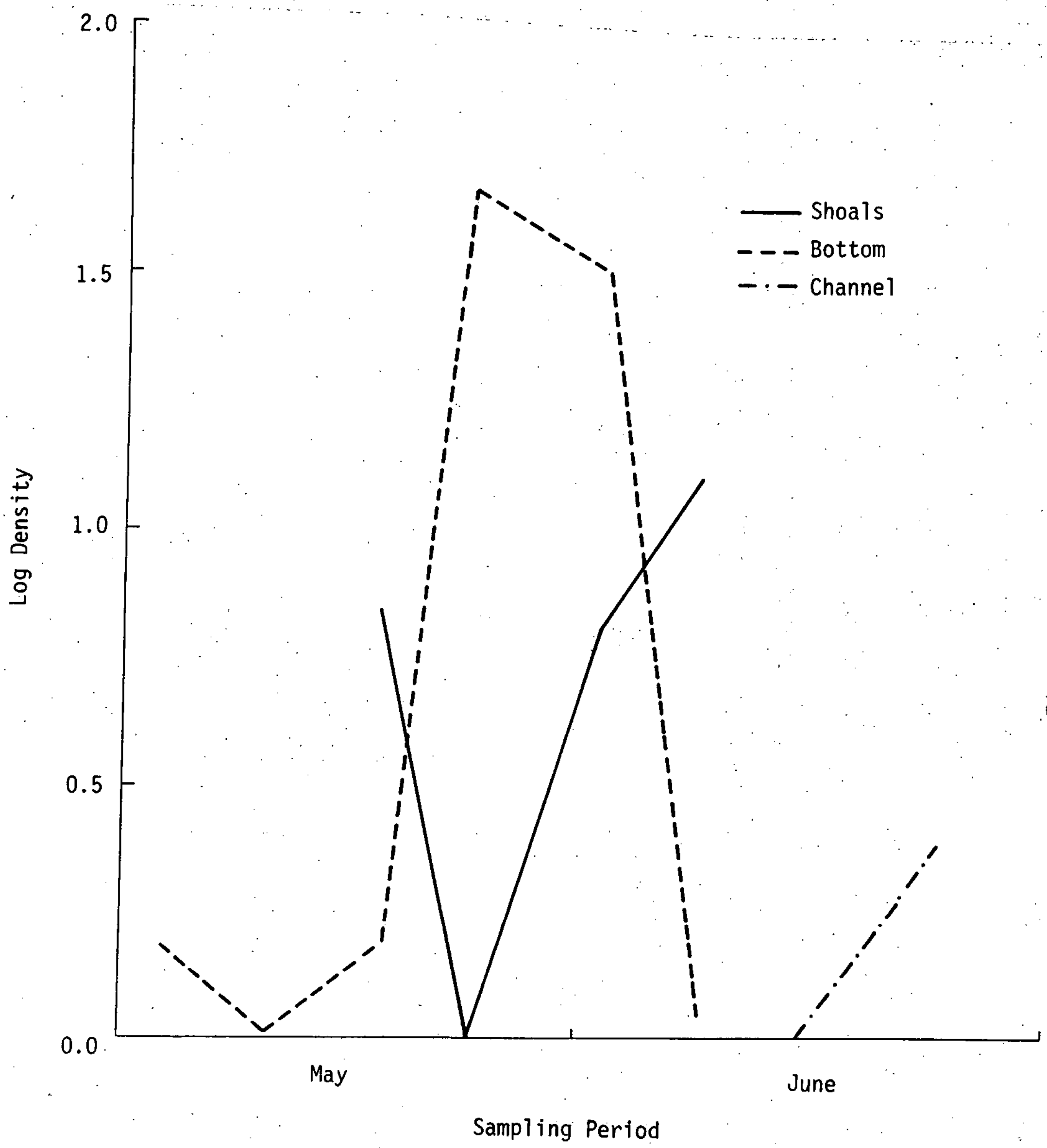


Figure IV-8. Distribution of White Perch Eggs among Shoal, Bottom, and Channel Strata in Cornwall Region, Hudson River, May-June 1977

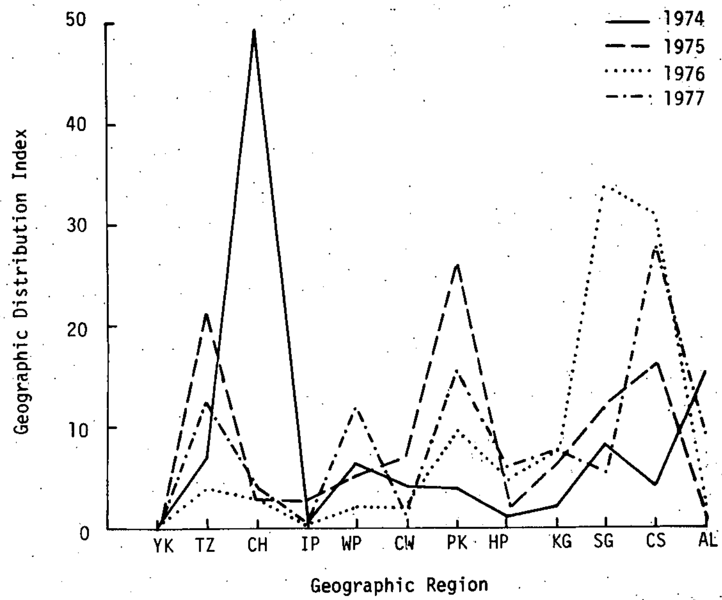


Figure IV-9. Trends in Geographic Distribution of White Perch Eggs in Hudson River Estuary, 1974-77

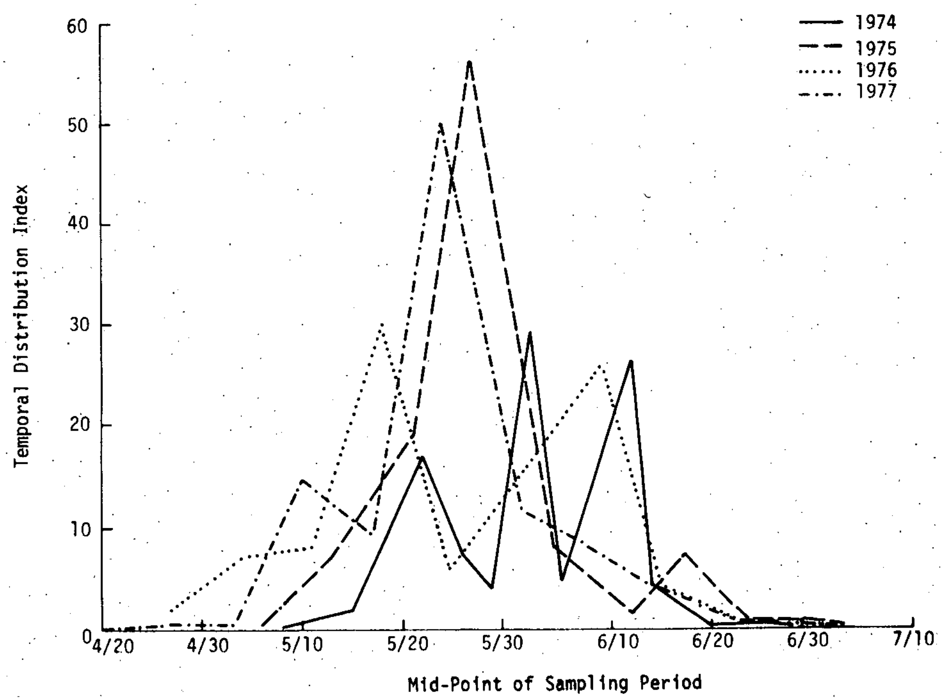


Figure IV-10. Trends in Temporal Distribution of White Perch Eggs in Hudson River Estuary, 1974-77

2. Yolk-Sac and Post Yolk-Sac Larvae

a. Distribution during 1977

White perch yolk-sac larvae were first collected in late April, and post yolk-sac larvae followed a week later in early May (Appendix Tables C-18 and C-19). The standing crop of yolk-sac larvae peaked in late May; post yolk-sac larvae peaked in early June. More than 100 yolk-sac larvae/1000 m^3 were estimated for the Tappan Zee region and all the regions from West Point through Albany during at least one sampling period; in most other cases, densities were less than 10 yolk-sac larvae/1000 m^3 (Appendix Table C-20). Still higher densities of post yolk-sac larvae (more than 1000 post yolk-sac larvae/1000 m^3; Appendix Table C-21) occurred within a somewhat smaller area from the Poughkeepsie through Saugerties regions; in most other cases, densities were less than 100 post yolk-sac larvae/1000 m^3 (Figure IV-11). Post yolk-sac larvae had higher densities (Figure IV-12) than yolk-sac larvae, partly because the post yolk-sac stage lasts about 30 to 45 days (Mansueti 1964) whereas the yolk-sac stage lasts only 3 to 5 days; therefore, post yolk-sac larvae were vulnerable to capture over a much longer period. Surviving post yolk-sac larvae had transformed into juveniles by late July.

b. Factors Affecting Distribution

Since larvae do not possess the swimming ability of fully developed juveniles, the distribution of those that hatch within the study area depends to a large extent on the location of spawning areas and on current patterns.

Yolk-sac larvae were abundant (more than 100/1000 m^3) over about the same range of water temperature (14^o to 22^oC) exhibited by eggs, and the range of conductivities was similar (about 130 to 2050 mS/cm; Appendix Table C-22). Post yolk-sac larvae were abundant (more than 1000/1000 m^3; Appendix Table C-23) when temperatures were somewhat higher (about 19^o to 24^oC); the range of conductivities however was similar (about 150 to 2250 mS/cm) than it was for eggs and yolk-sac larvae.

There are no well-defined patterns of vertical distribution for white perch larvae (Appendix Tables C-24, C-25, C-26, and C-27). White perch larvae do not display strong diel vertical migration (TI 1978a, 1979a).

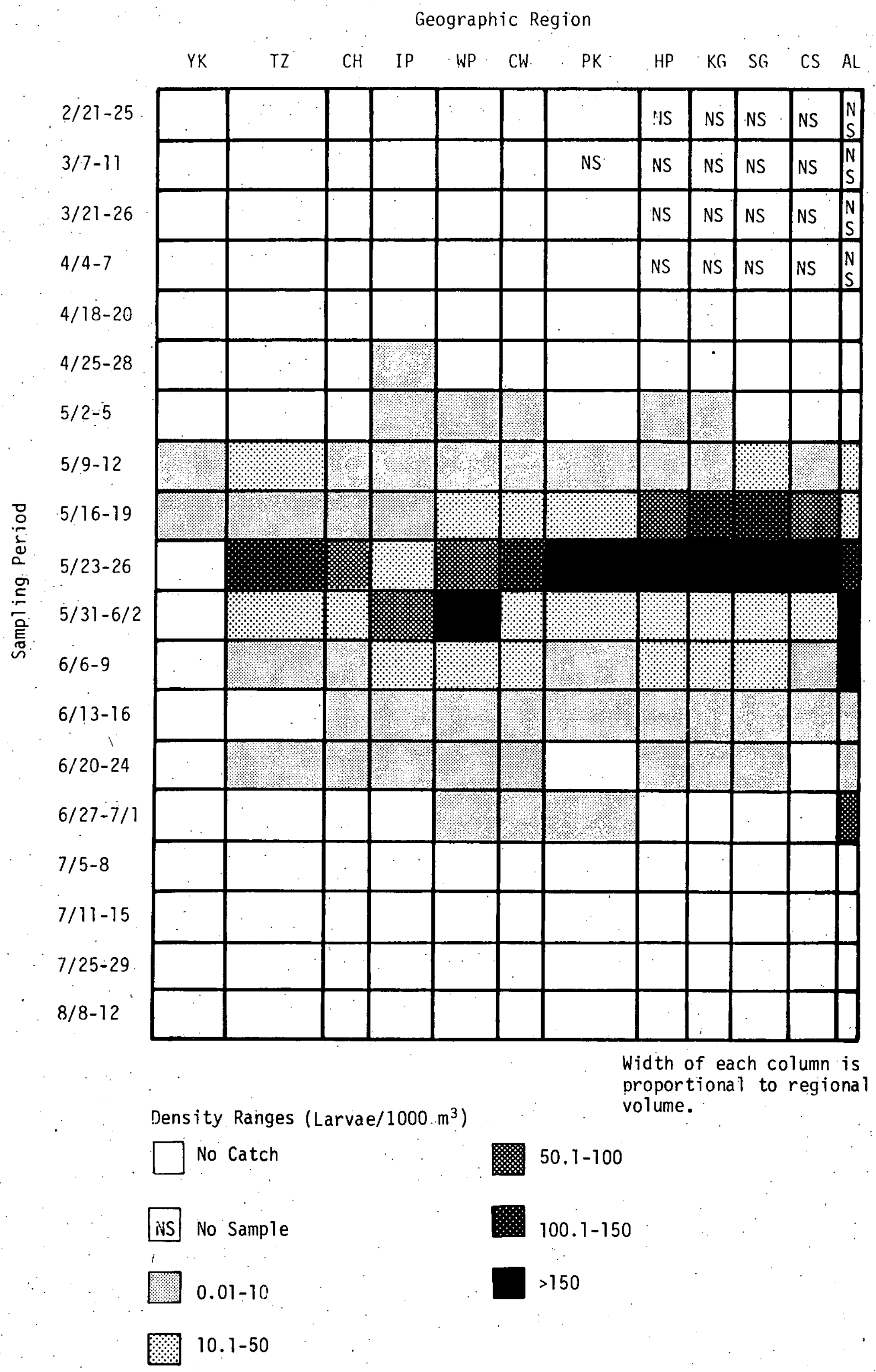


Figure IV-11. Distribution Matrix of White Perch Yolk-Sac Larvae Collected during 1977 Ichthyoplankton Survey

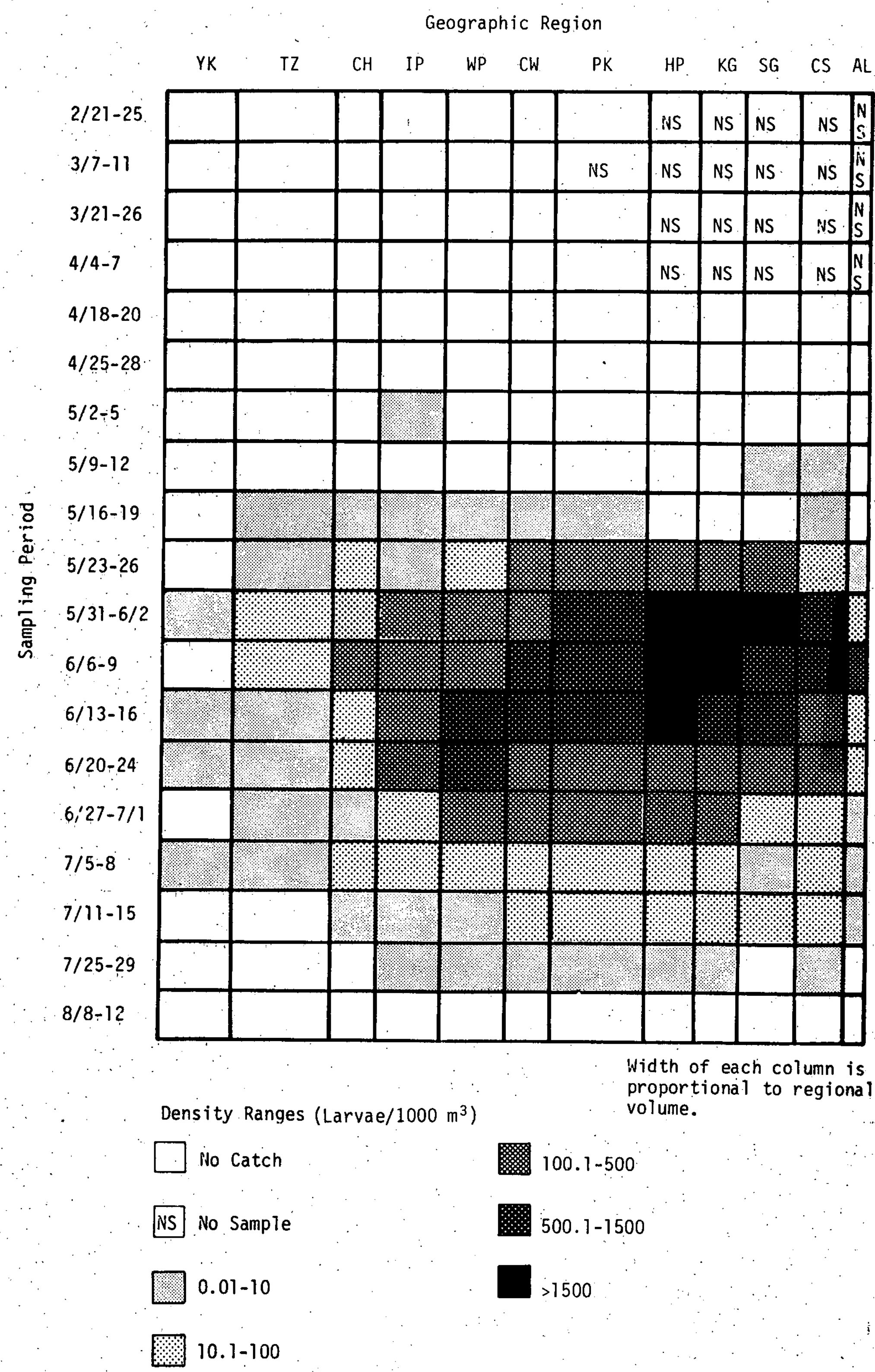


Figure IV-12. Distribution Matrix of White Perch Post Yolk-Sac Larvae Collected during 1977 Ichthyoplankton Survey

c. Trends in Distribution (1974-1977)

White perch yolk-sac larvae were most abundant in late May during 1974-1977 (Figure IV-13) but the geographic center of abundance varied from region to region (Figure IV-14). The temporal index increased sharply in late April or early May until reaching the late May peak, then declined gradually; by early July, yolk-sac larvae were absent from all collections. The geographic index showed that the larvae were most abundant in the Hyde Park region in 1974, the Tappan Zee region in 1975, the Catskill region in 1976, and the Poughkeepsie region in 1977.

The distribution of white perch in the estuary was widespread; spawning aggregation in any one area were not observed. The highest index values in 1974, 1976, and 1977 were less than 20; furthermore, during the four years many regions (especially Tappan Zee and Poughkeepsie through Albany) had index values between 10 and 15 (Figure IV-14). The only region in which white perch were never abundant was Yonkers.

Post yolk-sac larvae were most abundant in early June 1975 and 1977, mid-June 1974, and late June 1976 (Figure IV-15). In 1975 and 1977, post yolk-sac larvae were most abundant 2 weeks following the peak in yolk-sac larval abundance. The corresponding peaks during 1974 and 1976 were separated by about a month, an unexpectedly long lag time since the yolk-sac stage is relatively short and the post yolk-sac larvae that results from the peak in yolk-sac abundance should follow accordingly. Water temperature was significantly (<0.05) lower during the second half of May 1974 and 1976 than in 1975 and 1977 (Appendix Table B-32; subsection III.C.2). Water temperatures reached 19^{o}C by the end of May in 1975 and 1977, but not until mid-June in 1974 and 1976. Lower temperatures during 1974 and 1976 may have delayed the transformation of yolk-sac larvae to post yolk-sac larvae or may have increased mortality of yolk-sac larvae before transformation.

The geographic index (Figure IV-16) indicated that the Poughkeepsie through Saugerties regions encompassed the greatest concentration of post yolk-sac larvae each year from 1974 through 1977. Year-to-year variation in these regions may have resulted from irregular recruitment of larvae from nearby tributaries (Esopus Creek, Rondout Creek, etc.).

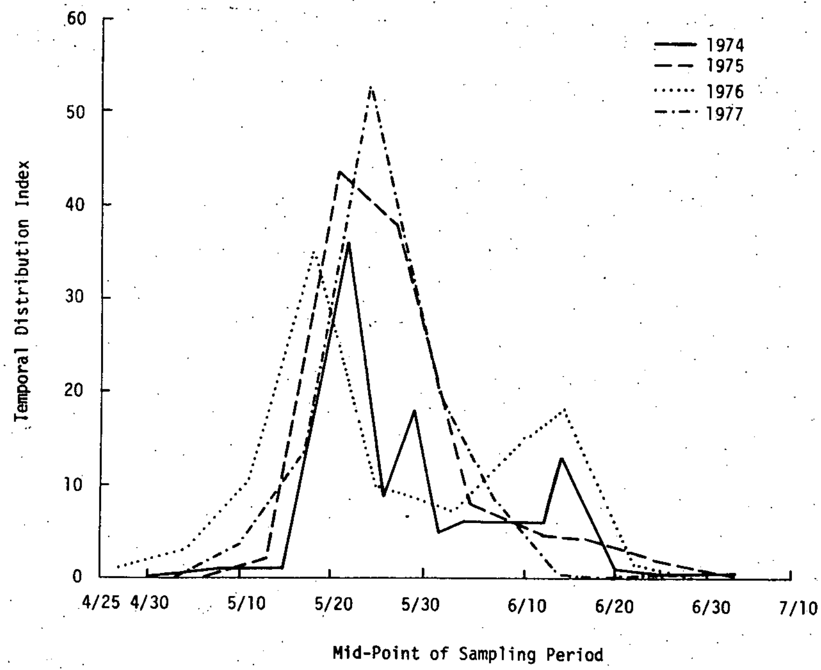


Figure IV-13. Trends in Temporal Distribution of White Perch Yolk-Sac Larvae in Hudson River Estuary, 1974-77

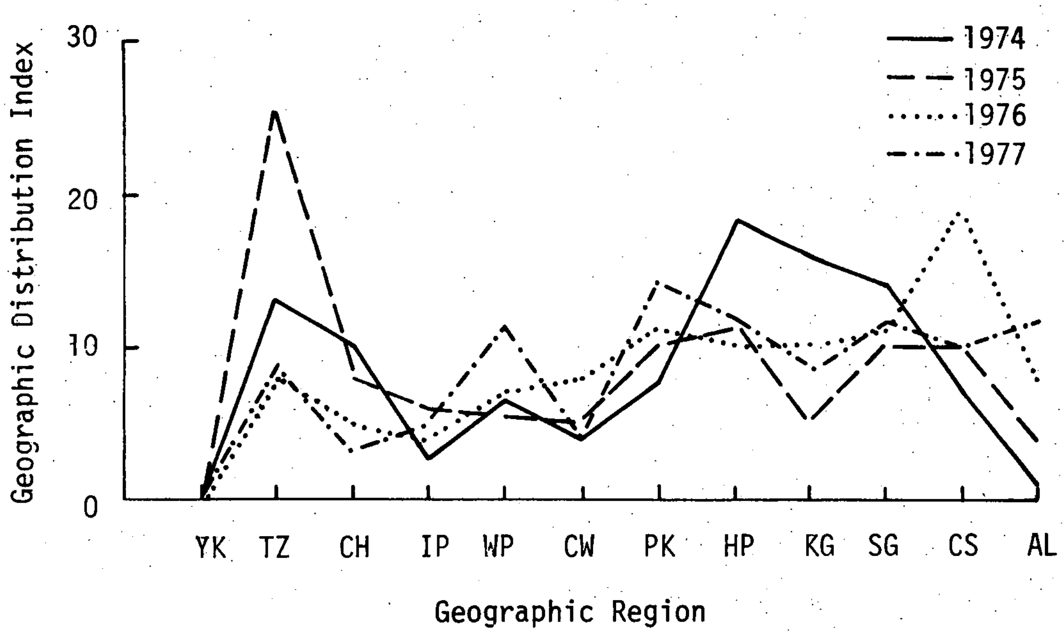


Figure IV-14. Trends in Geographic Distribution of White Perch Yolk-Sac Larvae in Hudson River Estuary, 1974-77

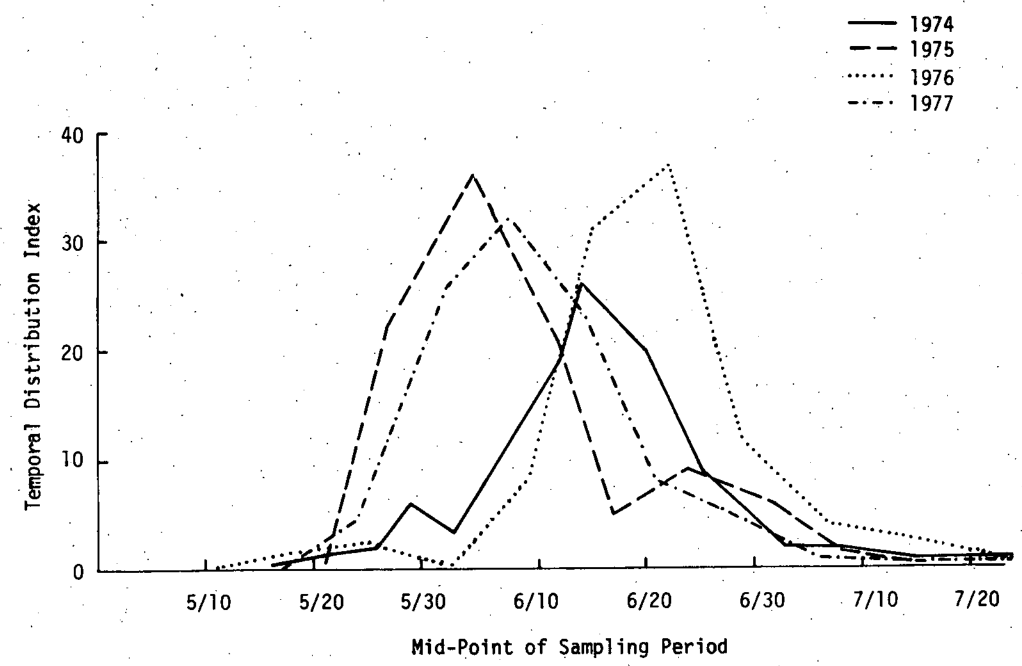


Figure IV-15. Trends in Temporal Distribution of White Perch Post Yolk-Sac Larvae in Hudson River Estuary, 1974-77

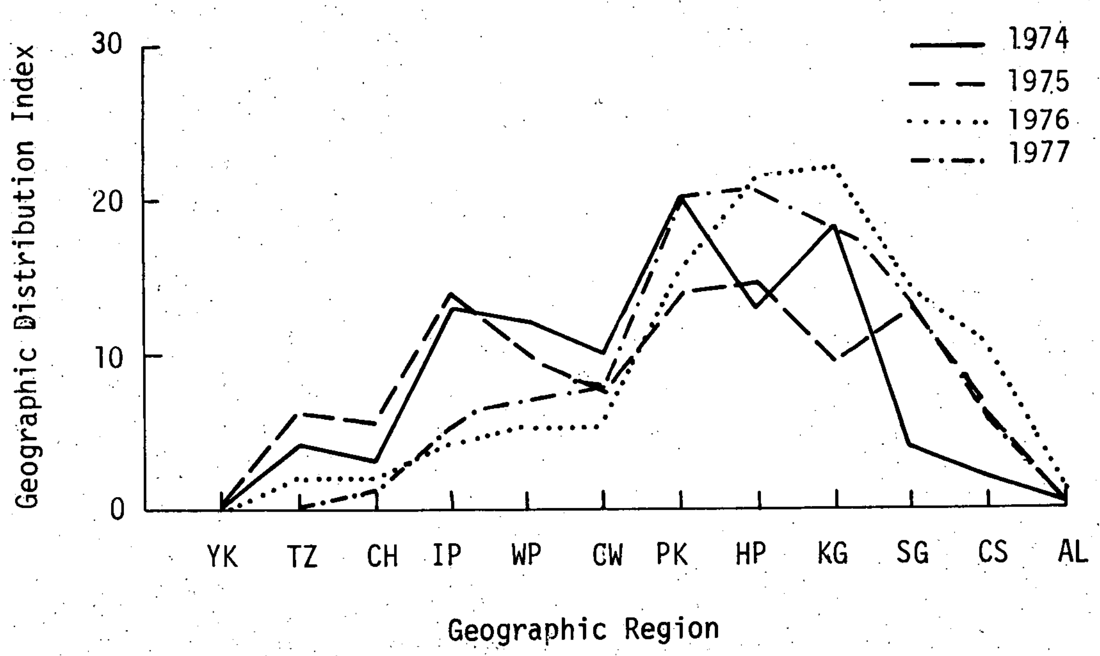


Figure IV-16. Trends in Geographic Distribution of White Perch Post Yolk-Sac Larvae in Hudson River Estuary, 1974-77

3. Juvenile and Yearlings

a. Distribution during 1977 through June 1978

White perch juveniles were first collected in June (Figure IV-17 and Appendix Tables C-30, C-31, C-32, and C-33), and their numbers increased to the peak standing crop, unadjusted for gear efficiency of mid-July, the highest of the summer (Figure IV-18). More than 65% of the riverwide shore zone standing crop occurred in the extreme upper estuary (Saugerties through Albany regions) until early August. During the rest of August and September, 35% to 64% of the standing crop occupied this area, indicating a gradual downriver movement. By mid-October, more than 60% of the shore zone population occupied the Yonkers through Indian Point regions (lower estuary). Catch in deepwater samples (bottom trawls) increased sharply during November (Figure IV-19), especially in the Tappan Zee, Croton-Haverstraw, and Indian Point regions. Shore zone and deepwater sampling (Fall Shoals Survey) indicated that juvenile white perch were most abundant in the Yonkers and Tappan Zee regions during November and December. The overall trend for the juvenile white perch population was a downriver shift from the upper end of the study area during July to the lower end by November. No deepwater sampling was conducted in the upper estuary (upriver of RM 76) after August; hence, the extent of movements to offshore areas cannot be fully described. Indirect support can be gained from mark-recapture data, which revealed movement back upriver by yearling perch during the following spring.

Yearling white perch were present in shore zone and deepwater areas in April 1978 when sampling resumed, but did not occur in the shore zone in regions upriver of West Point (Appendix Tables C-34, C-35, and C-36). The highest shore zone standing crop occurred in late May, especially in the Tappan Zee region. By late June, two areas of abundance had developed: one downriver in the Tappan Zee through Indian Point regions; the other upriver in the Kingston, Saugerties, and Albany regions. These results suggest that a significant proportion of the yearling population may move upriver during May and June. However, the lack of offshore sampling upriver from the Poughkeepsie region after mid-August presents the possibility that juvenile white perch move offshore to overwinter throughout the estuary and their apparent upriver movement in May and June is delayed movement to the shore zone in the upper estuary.

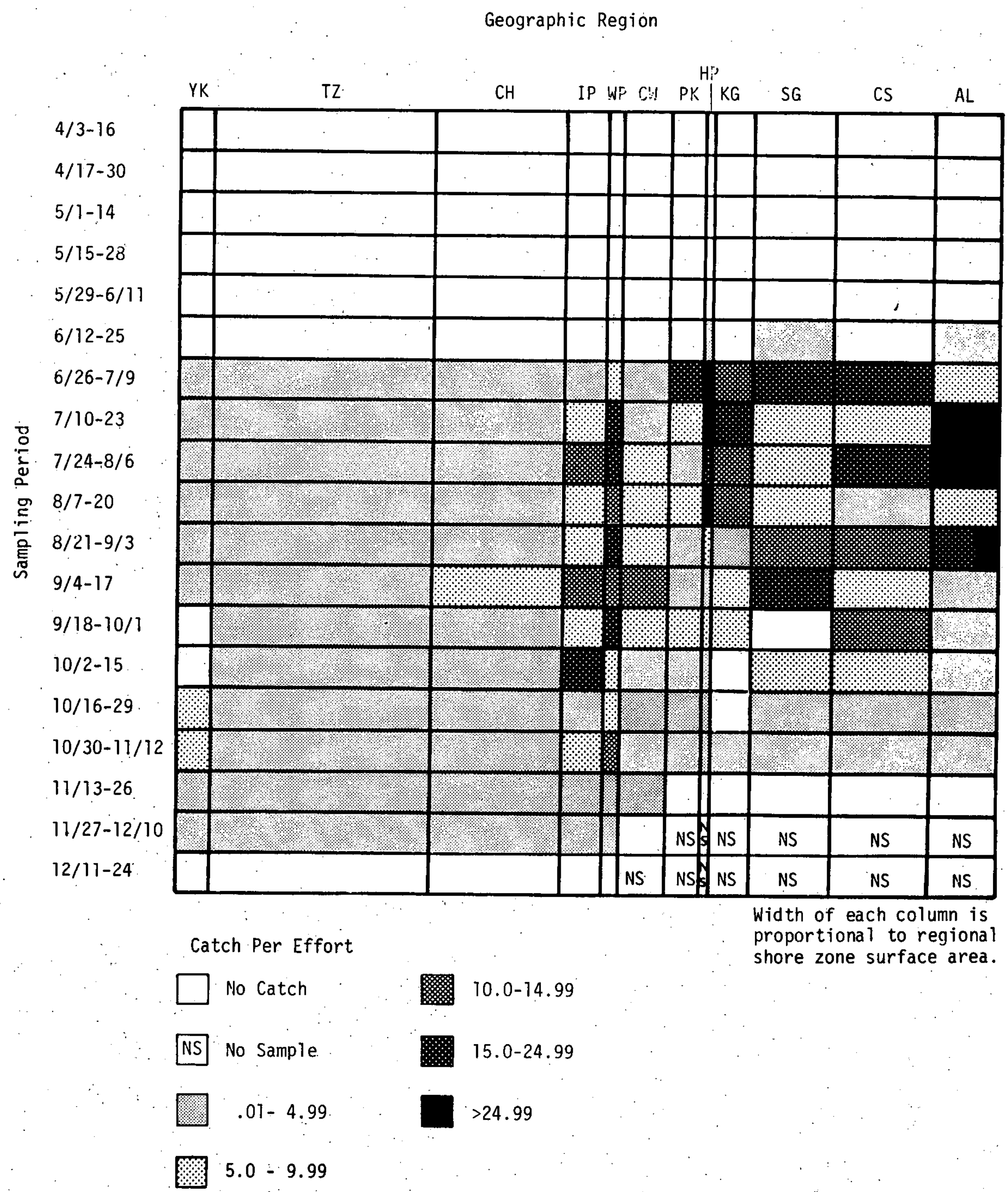


Figure IV-17. Distribution Matrix of White Perch Juveniles Collected during 1977 Beach Seine Survey, Hudson River Estuary

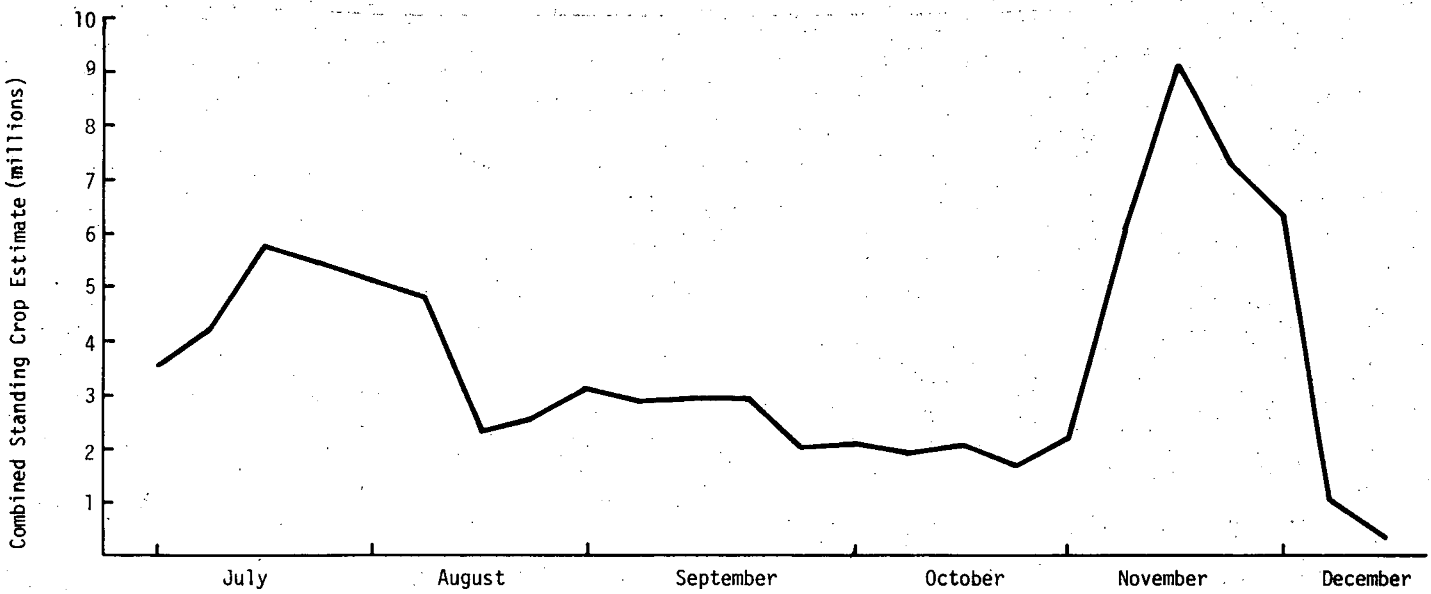


Figure IV-18. Combined Standing Crop Estimates (Adjusted for Night:Day Catch Ratio) of Juvenile White Perch in Hudson River Estuary, 1977

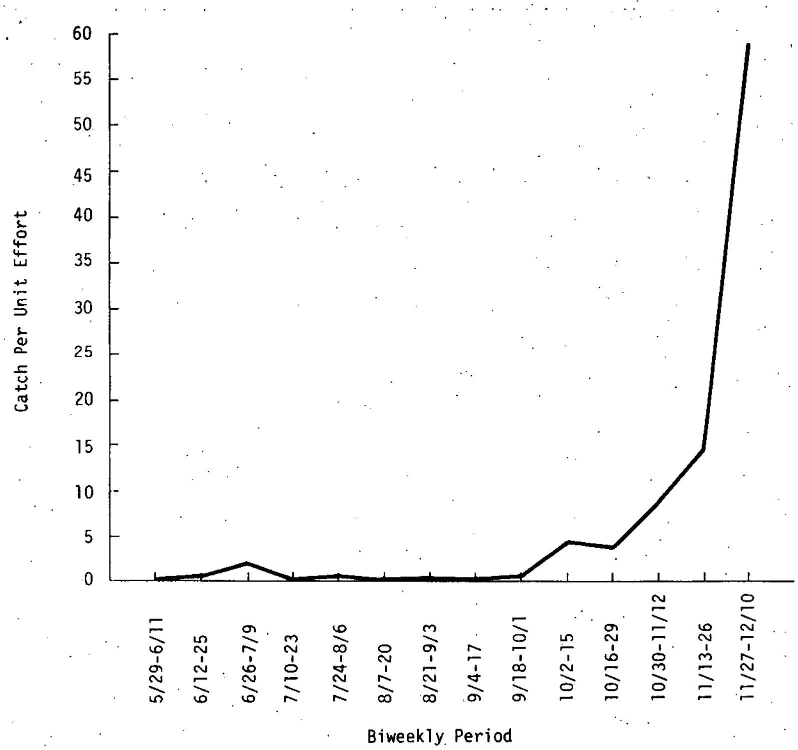


Figure IV-19. Juvenile White Perch Catch per Effort Based on Interregional Trawl Samples, 1977

b. Factors Affecting Distribution

During July and August, juvenile white perch in the shore zone were most abundant upriver of the areas where post yolk-sac larvae had been most abundant during June. Areas of abundance of the two life stages overlapped in the Saugerties region. This suggests an upriver and shoreward movement by a portion of the juvenile population in early July.

1) Movements to and from the Shore Zone

The abundance of juvenile white perch in the shore zone through the summer (July and August) and early fall (September and early October) contrasted sharply with the relatively low numbers of fish in the deeper water (Figure IV-20). The apparent preference for shallow water was much stronger and less variable than striped bass exhibited (subsection III.C.3), and it prevailed throughout the study area. During 1976, however, juvenile white perch did not move into the shore zone until mid-August (TI 1979a), indicating that annual variation occurs in the timing of the shift. The use of the shore zone as habitat during the summer is almost certainly linked with the productivity of the intertidal and littoral zones. Typically, production is greater in shallow waters than in deepwater areas (Odum 1964, Boyce-Thompson 1977), increasing the production of invertebrates upon which juvenile white perch feed. Also, fish spend less energy maintaining their position in the shore zone than they have to in channel areas since current velocity in the shoals and shore zone is slower than in the channel (McFadden et al. 1978).

As water temperature dropped in October, juvenile white perch sought deeper water. The percentage of the estimated standing crop in the shore zone decreased, accompanied by a buildup in the shoals and bottom/channel strata (Figure IV-20). The migration was probably triggered by water temperature and resulted in the movement of fish to overwintering areas where environmental conditions were relatively stable. In the spring, yearling white perch left deepwater areas and returned to the shore zone (Appendix Tables C-33 and C-34).

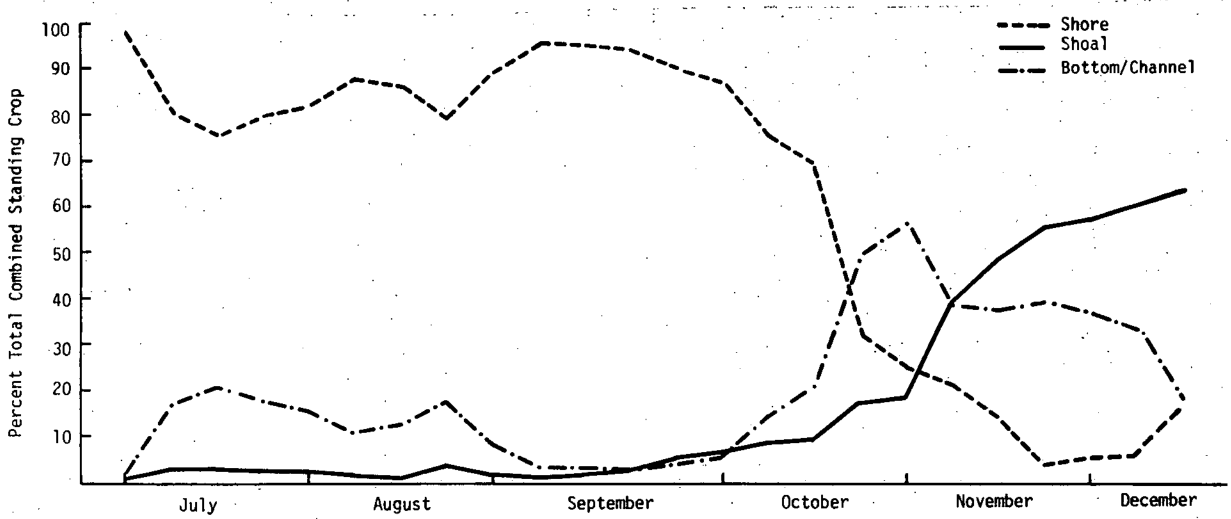


Figure IV-20. Percent Combined Standing Crop (Adjusted for Night:Day Catch Ratio) of Juvenile White Perch among Shore, Shoal and Deepwater Strata, Hudson River Estuary, 1977

2) Interregional Movements of Marked Juveniles

Most of the juvenile white perch finclipped during fall 1977 (Appendix Table C-37) and recaptured as yearlings during spring 1978 had left the region where they were marked (Table IV-17). Most of the fish that had left their respective marking regions during the spring had migrated upriver. Considerably less movement was exhibited by fish marked and recaptured during the fall (Table IV-18); the movement that occurred during November was largely in a downriver direction (Table IV-19).

3) Overwintering Areas

Since no deepwater sampling was conducted upriver of the Poughkeepsie region after mid-August, white perch that may have overwintered in the upper half of the study area were not sampled. Deepwater samples collected in the lower estuary during November and December indicated that white perch juveniles overwinter in offshore areas, especially in the Indian Point region and downriver from Indian Point. Concentration of overwintering fish in these regions is also suggested by increasing impingement rates at the downriver plants during winter (November or later); impingement rates at the upriver plants usually peak in October or November, then decline (subsection IV.C.3.d).

Table IV-17

Recapture Matrix for White Perch Finclipped during September-November 1977 and Recaptured during January-June 1978

Release Region	Recapture Region 1	2	3	4	5
1			13		
2		12	95		
3		3	95		
4		2	19		
5			5		

Region of Recapture	Number
Upriver	108
Same Region	107
Downriver	29
Total	244

Table IV-18

Recapture Matrix of White Perch Finclips Released during September-November 1977 and Recaptured during September-December 1977

Release Region	Recapture Region 1	2	3	4	5
1		1	1		
2		190	23	2	
3		9	236		
4	1	3	29	28	
5			4	1	

Region of Recapture	Number
Upriver	27
Same Region	454
Downriver	47
Total	528

Table IV-19

Percent of White Perch Finclips Released and Recaptured during September-November 1977 and Recaptured in Same Region Upriver or Downriver

Region of Recapture	Month of Release			
	Sep	Oct	Nov	Sep-Nov
Upriver	4	7	7	5
Same Region	90	85	75	86
Downriver	6	8	18	9

c. Trends in Distribution (1974 through June 1978)

During 1974-1976, white perch juveniles were particularly abundant in two areas of the estuary: the Tappan Zee and Croton-Haverstraw regions of the lower estuary; and the Saugerties and Catskill regions of the upper estuary (Figure IV-21). In 1977, however, juveniles were abundant in an expanded upper estuary area (Saugerties, Catskill and Albany regions) than they were in the lower estuary. Post yolk-sac larvae (subsection IV.C.2) were also more concentrated in the upper estuary during 1977 than they had been during 1974-1976.

Two patterns of temporal distribution emerged during 1974-77 (Figure IV-22). In 1974 and 1975, juvenile abundance peaked in mid-August to mid-September. In 1976 and 1977, abundance was moderately high over a longer period. This may have been due to variation in environmental conditions in the shore zone during the two pairs of years, 1974-1975 and 1976-1977. Temporal trends in the abundance of striped bass juveniles were similar (subsection III.C.3).

The spatial and temporal distribution of yearling white perch was consistent from 1975 through 1978 (Figures IV-23 and IV-24). Most occupied the Tappan Zee and Croton-Haverstraw regions each year, and a secondary area of concentration was in Saugerties. The temporal index (Figure IV-24) peaked during June, then declined the rest of the year except August 1975 when the index exhibited an unusual increase.

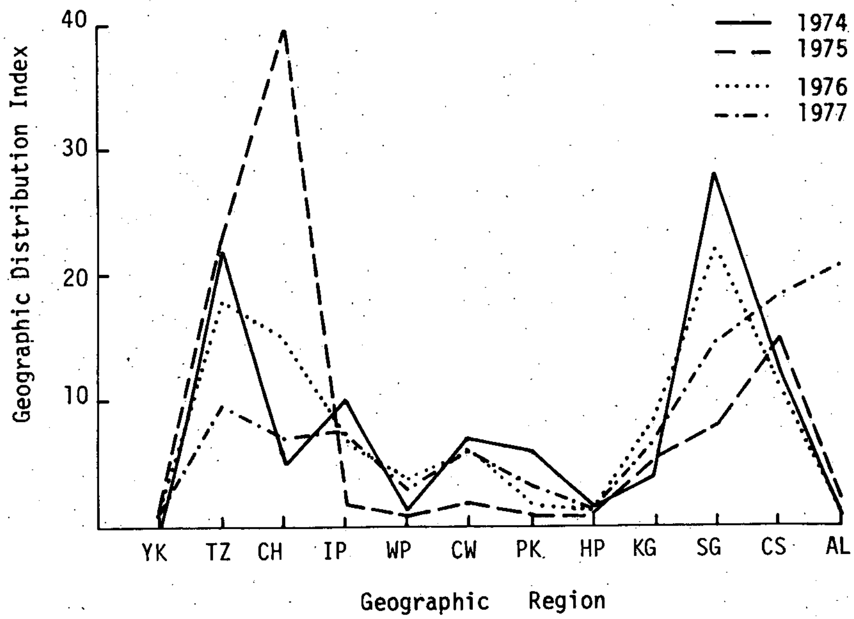


Figure IV-21. Trends in Geographic Distribution of Juvenile White Perch in Hudson River Estuary, Based on Beach Seine Data, 1974-77

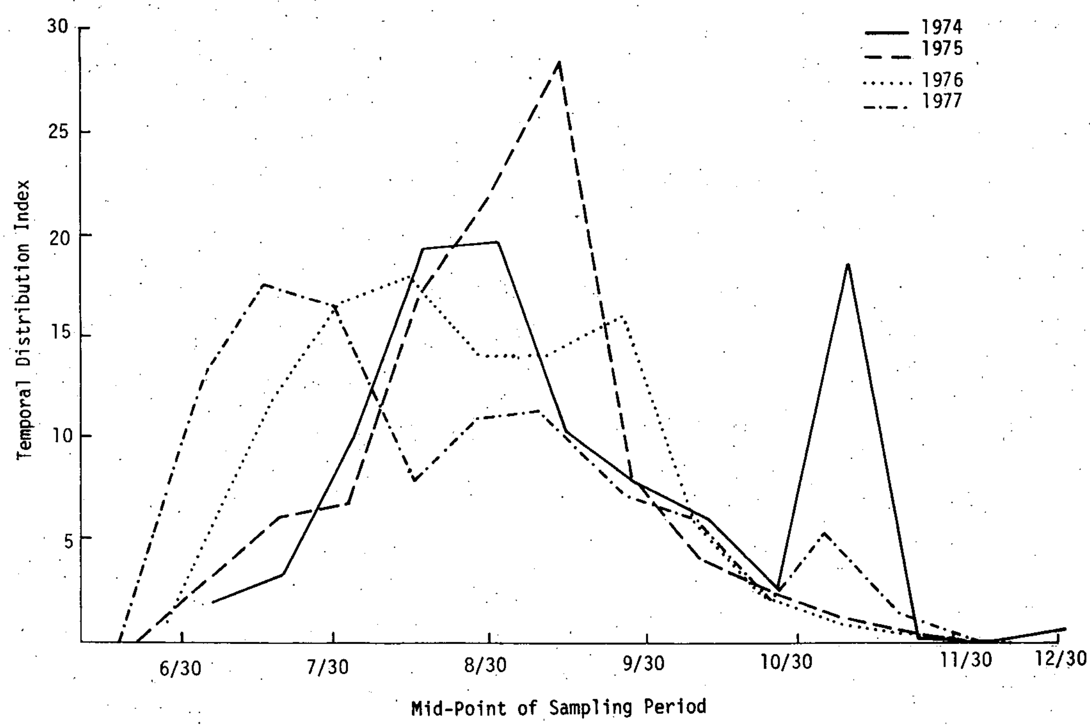


Figure IV-22. Trends in Temporal Distribution of Juvenile White Perch in Hudson River Estuary Based on Beach Seine Survey Data, 1974-77

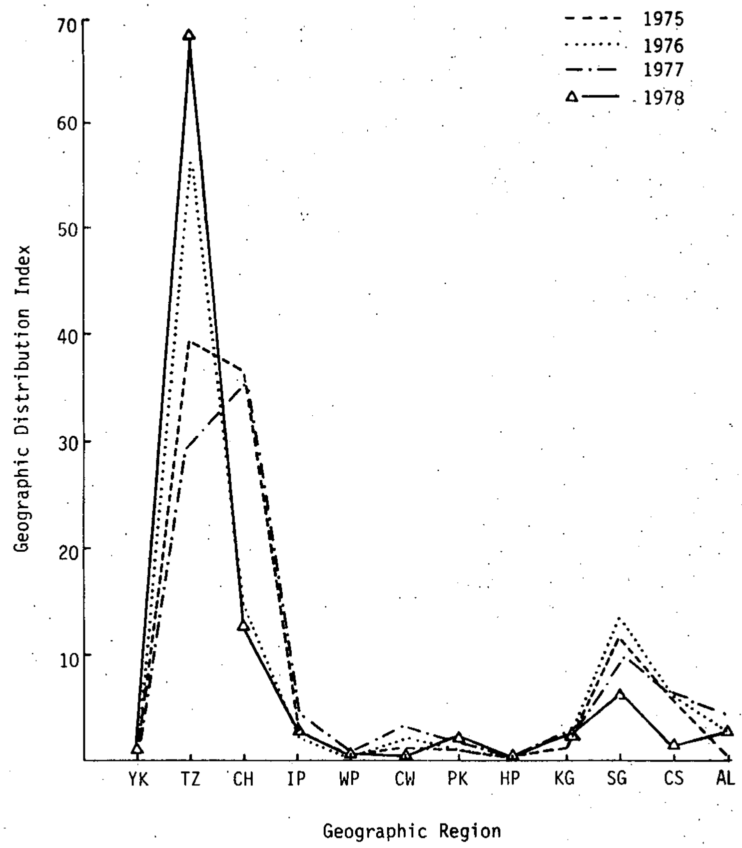


Figure IV-23. Trends in Geographic Distribution of Yearling White Perch in Hudson River Estuary Based on Beach Seine Survey Data, 1975-78. (1978 indices are based on data from April through June.)

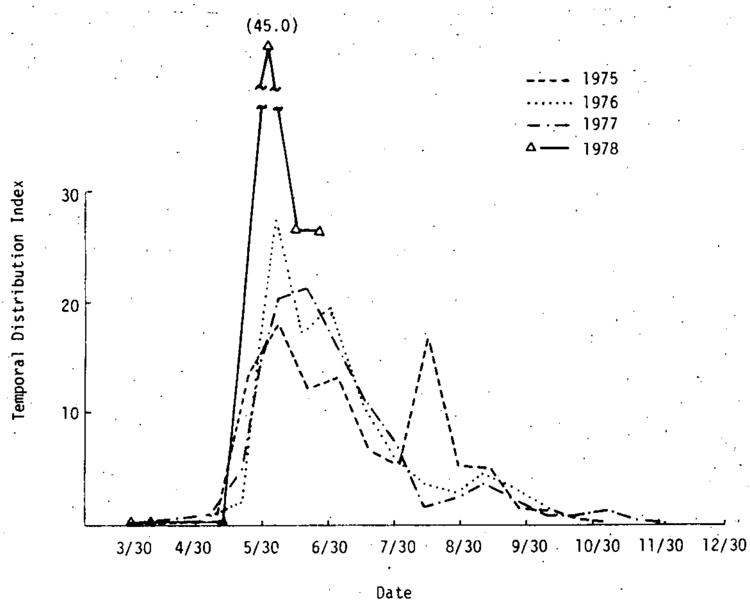


Figure IV-24. Trends in Distribution of Yearling White Perch in Hudson River Estuary Based on Beach Seine Data, 1975-78. (1978 indices are based on data from April through June.)

D. YEAR CLASS CHARACTERISTICS

White perch are residents of the Hudson River estuary and a portion of the population is exposed to operations at power stations year round. Recognizing and evaluating the impact of such exposure requires an understanding of the changes in abundance, growth, and mortality within the Hudson River population of white perch. This subsection addresses the abundance, growth, and mortality of the 1977 year class and evaluates the factors that affect those aspects.

1. Abundance

Absolute abundance of juvenile white perch in 1977 was estimated by both mark-recapture and density-volume and density-area extrapolation methods. Analytical and field procedures were described in subsection III.D.1. Relative abundance indices were generated from the same sampling surveys used for striped bass, although differences in spatial distribution dictated a wider selection of sampling sites from a larger area of the estuary. Unless otherwise noted, methods used to examine trends in white perch abundance and factors that may affect abundance (year class strength) were also similar to those used for striped bass in subsection III.D.

a. Estimates of Absolute Population Size

1) Mark-Recapture

Population estimates based on fish marked and released in September, October, and November 1977 and recaptured from December through May 1978 in field sampling and impingement collections indicated a decline in the size of the juvenile white perch population from September (40.7 million) through October (27.2 million) to November (13.0 million) (Table IV-20). The population estimate in September was much lower than that of the 1976 year class in September (209 million) but lay between the October-November estimates of the 1974 and 1975 year classes (Table IV-21). A direct comparison of mark-recapture estimates across years for populations this large was difficult because systematic errors that can cause an order of magnitude deviation of the estimate may go undetected. In addition, estimates could not be calculated for the same time period every year. The estimate of 109 million white

Table IV-20

Mark-Recapture Estimates of Population Size for 1977 Year Class of White Perch in Hudson River Estuary

Marking/Release Period (1977)	Number Marked* (M)	Recovery Period (1977-1978)	Number Examined** (C)	Number Recaptured** (R)	$\hat{N}=\frac{M \cdot C}{R}$	95% Confidence Interval
September	5014	December-May	495.5×10^3	61	40.7×10^6	31.7×10^6-52.3×10^6
October	5212	December-May	495.5×10^3	95	27.2×10^6	22.2×10^6-32.2×10^6
November	3618	December-May	495.5×10^3	138	13.0×10^6	11.0×10^6-15.3×10^6

*Adjusted for marking and handling mortality and fish recaptured before the population estimate recovery period.

**Includes TI field sampling and impingement collections at Bowline, Lovett, Indian Point, Roseton and Danskammer generating stations.

Table IV-21

Mark-Recapture Estimates of Population Size for Juvenile White Perch (1974-77 Year Classes) in Hudson River Estuary

	Marking Period			
Year Class	September	October	November	Source
1974		20.7×10^6		TI 1977
1975		42.5×10^6		TI 1977
1976	209×10^6			TI 1978
1977	40.7×10^6	27.2×10^6	13.0×10^6	

perch in the 1976 year class (TI 1979a) seemed plausible based on standing crops of fish from other systems; yet, this estimate is certainly an outlier when compared with the other mark-recapture estimates for juvenile white perch in the Hudson River. Estimates of fall population size for all other years (1974, 1975, 1977) fall in the range of 13 to 42 million juveniles.

The release and recapture periods were selected by examining the temporal patterns in R/M and R/C ratios. White perch were similar to striped bass and exhibited a pattern of decline in the number of recaptures with time (Table IV-22). However, the total recapture rates (R/M) were much higher for white perch than for striped bass (Table III-29); recapture rates were initially lower but were higher during later months. This may have been the result of differences in overwintering behavior of the two species. Most of the juvenile striped bass population may be unavailable for recapture by late fall or early winter because of emigration from the estuary, whereas juvenile white perch probably remain within the study area. The differences in recapture rate (R/M) among fish marked in different fall months made the pooling of all marked fish inadvisable for purposes of calculating population estimates. Since fall (September-October) is a period in which population size is still changing rapidly, a single estimate for the entire period would be biologically meaningless. Thus, estimates for shorter time intervals are preferred. The relatively large numbers of recaptures from all marking periods permitted a separate estimate for each month.

The fraction of marked fish in the catch (R/C) stabilized from December through May after declining from very high levels in the early fall (Table IV-22). This pattern strongly suggests a severe Type C error caused by nonrandom mixing of marked and unmarked fish in the fall; R/C values after November indicate that a Type C error vanishes quickly as the fish begin to move to deeper water in late fall. A Type B error, which would probably cause a continuous decline in R/C values, was not apparent.

The monthly trend in R/C values confirmed the relative stability of the total R/C ratio over the December-May time period (Figure IV-25). The relatively rapid stabilization was due, in large part, to the population congregating in the lower estuary in late fall (subsection IV.C). Even though a majority of the fish examined for recapture effort were collected at one place (impingement at the Indian Point power plant), the sampling effort may be random with respect to the entire population. Indeed, fish marked in all five marking regions were recovered at the Indian Point power plant throughout the winter (subsection IV.C). The similarity of recovery rates for all marking regions demonstrated that the probability of recapturing a marked fish was independent of the region in which the fish was marked (Table IV-23).

Table IV-22

Recapture Rates (R/M) and Proportion of Marked Fish in Catch (R/C) of Juvenile White Perch Marked during 1977

Marking		Recapture											
Month	Number Marked*	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total	R/M
Sep	5287	161	77	35	10	21	7	11	5	7	2	336	0.064
Oct	5314		53	49	18	46	10	13	5	3	1	198	0.037
Nov	3690			72	24	44	24	30	8	8	2	212	0.057
	Total	161	130	156	52	111	41	54	18	18	5	746	
	Number Examined, C (thousands)	12.5	52.5	152.8	85.0	197.5	63.4	79.3	34.8	35.6	3.4		
	R/C	0.0129	0.0025	0.0010	0.0006	0.0006	0.0006	0.0007	0.0005	0.0005	0.0015		

*Adjusted for estimated marking and handling mortality of 0% for September, 25% for October and November.

2) Density Extrapolation Approach

The peak of standing crop white perch juveniles in 1977, based on density-area and density-volume extrapolation methods (Table IV-24), was just over 70 million individuals in mid-July (Figure IV-26). Standing crops were stable through July, began to decline rapidly in early August and increased to a second peak in November as movements to deeper water caused an overall change in vulnerability of the population to the sampling program.

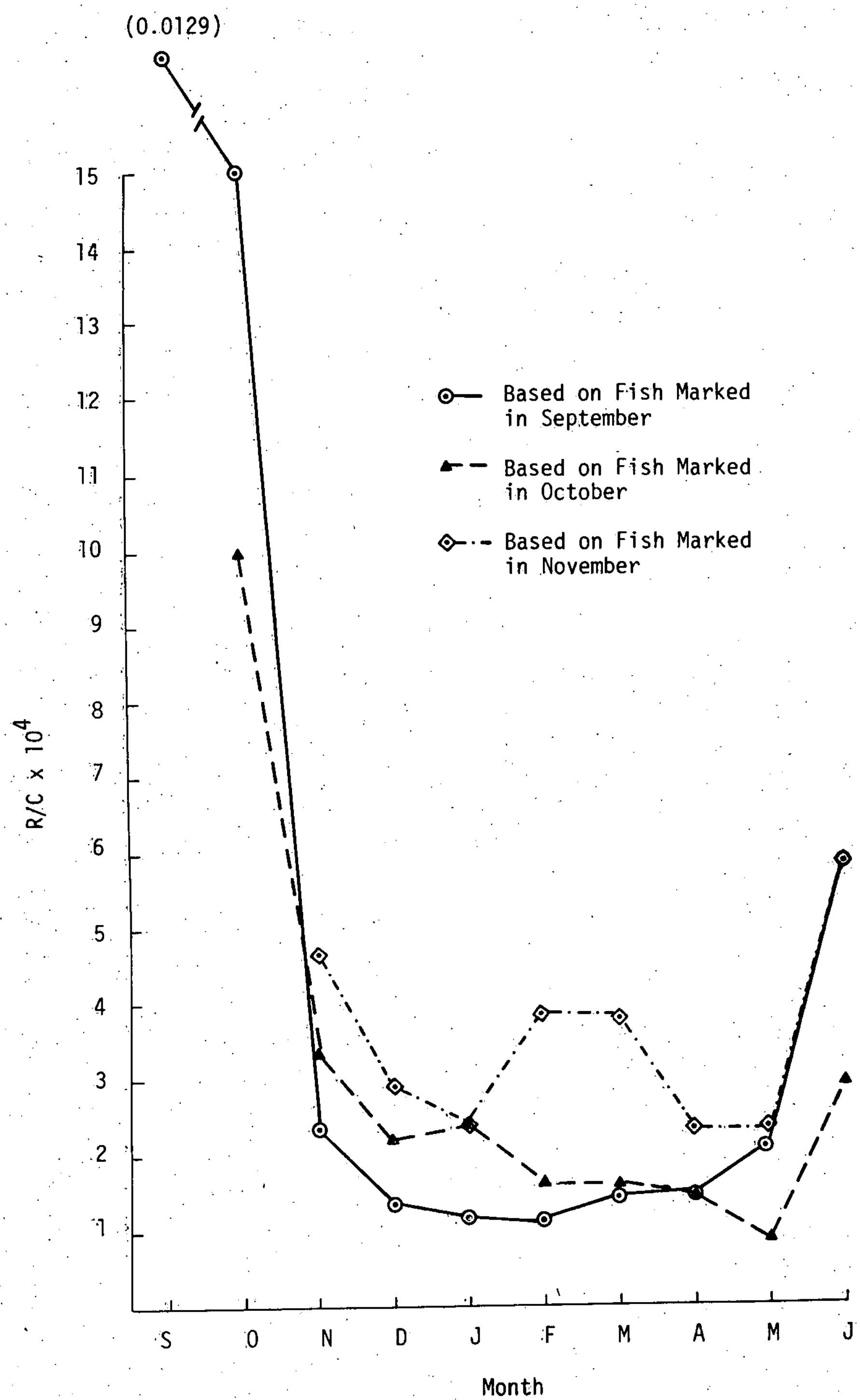


Figure IV-25. Monthly R/C Ratios for Juvenile White Perch Marked during September-November, 1977

Table IV-23

Recapture Rates (R/M) during December-May for Juvenile White Perch Finclipped in Hudson River Estuary during September-November 1977

Marking Region(RM)	September			October			November		
	M*	R	R/M	M*	R	R/M	M*	R	R/M
12-23	24	0		200	3	0.0150	241	11	0.0456
24-38	1109	16	0.0144	1975	29	0.0147	1996	76	0.0381
39-46	1682	32	0.0190	2166	54	0.0249	935	34	0.0364
47-76	1922	8	0.0042	777	9	0.0116	414	16	0.0386
77-152	277	5	0.0181	94	0	0.0000	32	1	0.0381
Total	5014	61	0.0122	5212	95	0.0182	3618	138	0.0381

M* = Number of fish marked and available for recapture on 1 December (adjusted for marking and handling mortality and for number of fish recaptured during September through November 1977).

R = Number recaptured

Table IV-24

Sampling Strata, Gear, Time and Gear Efficiency Adjustment Factors Used to Calculate Combined Standing Crops of Juvenile White Perch in 1977

Stratum	Sampling Gear	Time	Gear Efficiency
Shore zone (0-10 ft, [0-3 m] deep)	100-ft (30-m) beach seine	Day	• Night:day catch ratio = 2.5† • Catch efficiency = 6%†
Shoal (10-20 ft, [3-7 m] deep)	1-m² epibenthic sled 1-m² Tucker trawl	Night	• Catch efficiency = 50%*
Bottom [0-10 ft (0-3 m) above river bottom where depth is > 20 ft (7 m)]	1-m² epibenthic sled	Night	• Catch efficiency = 50%*
Channel** [10 ft (3 m) above river bottom to surface where depth is > 20 ft (7 m)]	1-m² Tucker trawl	Night	• Catch efficiency = 50%*

†TI 1978

*Assumed value based on range of efficiency reported in literature for towed gears (Kjelson and Colby 1977).

**Sampled only prior to mid-August.

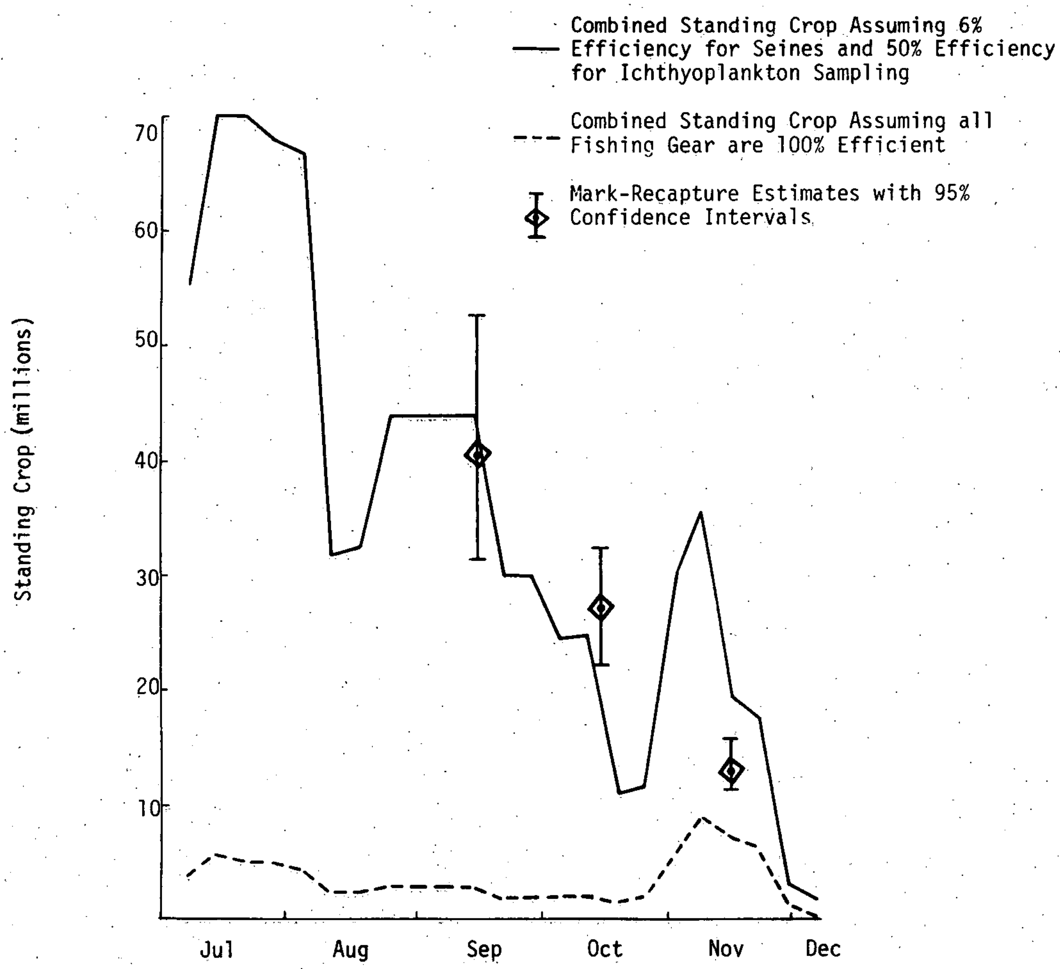


Figure IV-26. Combined Standing Crop of Juvenile White Perch in Hudson River Estuary during 1977 Based on Shore, Shoal, Bottom, and Channel Sampling

The combined standing crop adjusted for gear efficiency exhibited the temporal decline in abundance that would be expected for juvenile white perch in the summer and fall. The mark-recapture estimates of population size (subsection IV.D.1) also compared favorably with the combined standing crop. Standing crops unadjusted for catch efficiency (Appendix Table C-36) were too low to provide realistic estimates of juvenile abundance.

The efficiency-adjusted standing crops may even be biased low by the lack of offshore, deepwater (20-ft) sampling in the upper estuary (above the Poughkeepsie region) after mid-August (Appendix A). Juvenile white perch are known to concentrate in some of the upper regions (subsection IV.C) but, they are sampled only in the shore zone after mid-August. Also, any fish occupying the channel stratum are not effectively sampled after mid-August. Thus, the adjusted combined standing crops may still be underestimates of true population size.

Both the mark-recapture and density extrapolation methods of estimating juvenile white perch population size yielded similar values; however, only the density extrapolation method estimated abundance at the beginning of impingement vulnerability (1 August). This estimate was near 70 million, after which the abundance of juveniles declined sharply. After early November, the change in habitats caused the standing crop estimates to fluctuate. Mark-recapture estimates of juvenile population size in late fall were near 13 million.

b. Trends in Annual Abundance (Year Class Strength)

1) Methods

Fluctuations in white perch year class strength from 1965 through 1977 (excluding 1971) were examined with a relative index of annual juvenile abundance based on the same historical data base used to calculate the juvenile striped bass index (subsection III.D.1). The white perch index, defined as the mean catch per area from beach seines from mid-July through August, was calculated from all regions sampled (Table III-31). No adjustments were made for years when sampling was restricted to a portion of the middle estuary (1969, 1970, 1972) because spatial distribution patterns showed concentrations of juvenile white perch in the upper and lower estuary (Figure IV-21).

The July-August period was selected for the abundance index because these months were sampled each year from 1965 through 1977 (Figure III-39) and juvenile white perch were abundant in the shore zone from mid-July through September (TI 1978a, 1979a; and subsection IV of this report). Catches of juvenile white perch in seines decline sharply in early October (Figure IV-20). The July-August abundance indices were compared with indices based on September sampling during 1969-77 (no September samples were taken during 1965-68). If September abundance trends did not differ significantly from the July-August trends, it would be concluded that year class strength in Hudson River white perch is generally established prior to mid-July.

2) Results and Discussion

The relative abundance of juvenile white perch from 1965 through 1977 (excluding 1971) varied by a factor of 9.0 (Table IV-25). The strongest year class occurred in 1967. The weakest year classes were in 1972 and 1974. The abundance indices during all other years were similar. Overall, juvenile white perch showed less variability than juvenile striped bass in annual abundance (Table III-32).

Abundance indices based on July-August sampling and September sampling did not show similar patterns (Figure IV-27). Although the two indices do not agree, it is likely that year class strength is established prior to September, as for striped bass (subsection III.D.1) and that the difference in pattern of the two indices may be the result of movements into and out of the shorezone. Thus, the July-August index, with four more years of sampling, represents a longer data set for the analyses of factors affecting year class strength presented in the next subsection.

Table IV-25

Annual Abundance Indices for Juvenile White Perch Based on Beach Seine Sampling during July and August

Year	Survey	Sample Date	Number Caught	Area Swept ($10^4 ft^2$)	Index of Abundance
1965	NYU	7/18-8/21	288	22.7	12.7
1966	NYU	7/17-8/27	661	34.9	19.0
1967	NYU	7/16-8/26	944	27.5	34.3
1968	NYU	7/14-8/24	464	39.0	11.9
1969	RAY & NYU	7/13-8/30	319	13.2	24.2
1970	RAY	7/12-8/29	946	42.6	22.2
1971	*	*	*	*	*
1972	TI	7/16-8/26	105	27.8	3.8
1973	TI	7/15-8/25	3303	166.6	19.8
1974	TI	7/14-8/31	1671	264.5	6.3
1975	TI	7/13-8/30	5634	318.3	17.7
1976	TI	7/11-8/28	7892	329.4	24.0
1977	TI	7/17-8/27	6260	283.4	22.1

* Insufficient sampling

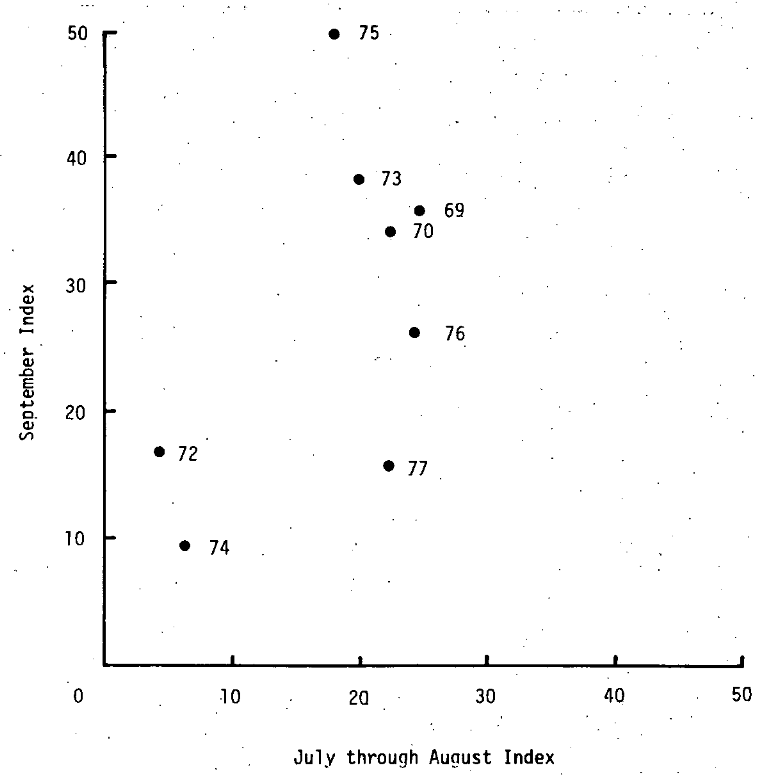


Figure IV-27. Relationship of July-August and September Abundance Index Values for Juvenile White Perch in Hudson River Estuary, 1969 through 1977 (excluding 1971)

c. Factors Affecting Juvenile White Perch Abundance (Year Class Strength)

1) Methods

Factors affecting white perch year class strength were examined by multiple linear regression (MLR) techniques using transformed (natural logarithm) abundance indices and environmental variables. This transformation makes nonlinear data linear and allows the use of MLR. Environmental variables were selected on the basis of previous analyses (TI 1978a, and 1979a), but additional variables for which plausible mechanisms could be hypothesized were also included.

Latent root regression on data collected from 1965 through 1975 (TI 1978a) retained four variables as important influences on white perch year class strength: juvenile striped bass abundance, May freshwater flow, July freshwater flow, and the temperature degree rise per day between 16° and 20°C. Three of these variables were selected in the analysis of data collected through 1976; however, June freshwater flow replaced July freshwater flow (TI 1979a). The model using data through 1976 had poor predictive capabilities (TI 1979a).

These five variables (juvenile striped bass abundance; May, June, and July freshwater flows; and temperature degree rise per day between 16° and 20° C) plus juvenile bluefish abundance were chosen for examination in the regression analysis with 1977 data included. Since previous analyses indicated that conditions during July may be important, mean July temperature was also included. Two additional variables – power plant water withdrawal during May, June, and July (index of potential entrainment mortality) and year of observation – were also entered into the regression to test for evidence of power plant impact or a temporal trend in abundance (Appendix Table C-39). Since white perch transform from yolk-sac to post yolk-sac larvae when water temperatures are between 18° and 22°C, the rate of temperature rise during this period was also entered into the pool of variables. Other factors also used in the white perch analysis included April freshwater flow, previous December freshwater flow, combined November and December freshwater flow, combined April and May freshwater flow, previous December water temperatures, yearling striped bass abundance, and predator index. Thus, the MLR procedure was able to draw upon those variables shown to be important to white perch population fluctuations in the past as well as those available to the striped bass MLR procedure.

2) Results and Discussion

Multiple linear regression produced models significant at $\alpha=0.05$ for one, two, three, and four variable levels of complexity (Table IV-26). More complex models containing more than four independent variables were not considered since increases in R^2 declined beyond the four variable models. The best four variable models selected by the maximum R^2 improvement method of stepwise regression (Barr et al. 1976) included mean July temperature, rate of temperature incease between 18° and 22°C, mean April freshwater flow, and mean May freshwater flow. The 4-variable model produced a higher R^2

(0.88) than the best 3-variable model (excluding days to span 18° to 22°C (R^2 = 0.78) and exhibited a higher statistical significance (p=0.0024). Since three factors were common to both models, the following discussion of possible mechanisms can apply to either.

Table IV-26

Multiple Linear Regression (MLR) Models for Factors Affecting White Perch Abundance

Number of Independent Variables	Independent Variables	Regression Coefficient	P	P (model)	R^2
1	July Temperature	12.74	0.005	0.005	0.56
2	July Temperature	9.40	0.026	0.004	0.70
	Days to Span 18°-22°C	-0.61	0.070		
3	July Temperature	14.10	0.002	0.005	0.78
	April Flow	0.93	0.030		
	May Flow	-0.54	0.094		
4	July Temperature	10.43	0.008	0.002	0.88
	Days to Span 18°-22°C	-0.54	0.045		
	April Flow	0.75	0.034		
	May Flow	-0.60	0.032		

The importance of high July water temperatures on white perch year class strength probably lies in the relationship between temperature and food availability. If warm temperatures stimulate production of food organisms, then temperature may also influence abundance of white perch by increasing available food resources and juvenile survival.

The second variable, days to span 18° to 22°C, exhibited a negative relationship with abundance. Thus, the faster the temperature increased from 18° to 22°C, the greater the abundance of juvenile white perch. This temperature range corresponds to the yolk-sac larval stage; rapid passage through the stage should reduce predation and possibly starvation, which are thought to be the major causes of mortality in young fish (Hunter 1976). Yolk-sac larvae may thus represent the "critical period" (May 1974) for white perch.

The last two variables, April and May freshwater flow, apparently act through different mechanisms since their regression coefficients have opposite signs. April freshwater flow was positively related to abundance, possibly due to high flows providing increased nutrients for the plankton community which, in turn, provided the initial food for the white perch larvae. The importance of May freshwater flows (negative relationship with abundance), which has been reported previously (TI 1979), is probably related to the tributary spawning habits of the white perch (Mansueti 1961b). High freshwater flow in May, which would certainly also occur in the Hudson River tributaries, would flush the white perch eggs and larvae out of the tributaries into the Hudson River, where conditions for survival may be less than optimal. Larimore (1975) demonstrated that high flows and turbidity can cause larval fish (smallmouth bass, <u>Micropterus dolomieui</u>) to become disoriented and displaced downstream and hypothesized that this displacement from the primary nursery areas was responsible for poor year classes of smallmouth bass in years of high post-spawning precipitation. A similar mechanism may occur with white perch. Conversely, low freshwater flows may result in relatively rapid temperature increases and stable flow conditions within the tributaries.

Thus, the current hypothesis is that year class strength in Hudson River white perch is controlled by temperatures during the post yolk-sac larval and early juvenile stages, nutrient levels (as measured indirectly through April freshwater flow), and access to prime nursery habitat in the tributaries. Because white perch have a more extended spawning period, the timing of the spawning should have less of an effect on white perch than striped bass. Some larvae should almost always experience optimum conditions for survival. Hence, the probability of total year class failure is greatly reduced. On the other hand, some white perch larvae will almost certainly experience poor environmental conditions. Thus, the probability of extremely large year classes is also reduced, and the lack of extreme fluctuations in white perch year class strength should be expected.

2. White Perch Mortality

White perch adults spawn over an extended period of time in many diverse habitats in the Hudson River estuary (subsection IV.B). As a result, several of the early life stages occur concurrently, and accurate estimates of larval and early juvenile mortality rates are difficult to obtain. However, a description of the patterns of larval and juvenile abundance can provide insights into patterns of mortality during the first year of life. The purpose of this subsection is to describe the patterns in abundance of the larval and juvenile white perch of the 1977 year class and to discuss the observed patterns in mortality rates.

a. Methods

Standing crops of larval white perch were derived from weekly ichthyoplankton sampling conducted throughout the estuary. Standing crops of juvenile white perch were the combined standing crops adjusted only for the night:day catch efficiency of beach seines (subsection IV.D.1). These standing crops were summed for each week, and the weekly standing crops were plotted on a semilog scale to describe the temporal patterns in abundance. Within periods of apparent constant population decline, rates of decline were estimated using the following linear regression model:

$$\ell n(N_t) = A + \beta (X_t)$$

where

β = estimated daily instantaneous decline rate

X_t = number of days from 1 May to the midpoint of sample week t

N_t = estimated standing crop of white perch larvae and juveniles for sample week t

A = constant

Estimates of the daily instantaneous decline rate (β) were then converted to daily decline rates as follows:

$$\text{Daily decline rate} = 1 - e^{-\beta}$$

b. Results and Discussion

Four distinct periods in the changing abundance patterns of young white perch were evident in 1977 (Figure IV-28). During the first period, late April through early June, standing crops increased rapidly as individuals were recruited to the larval population. This period covered the time

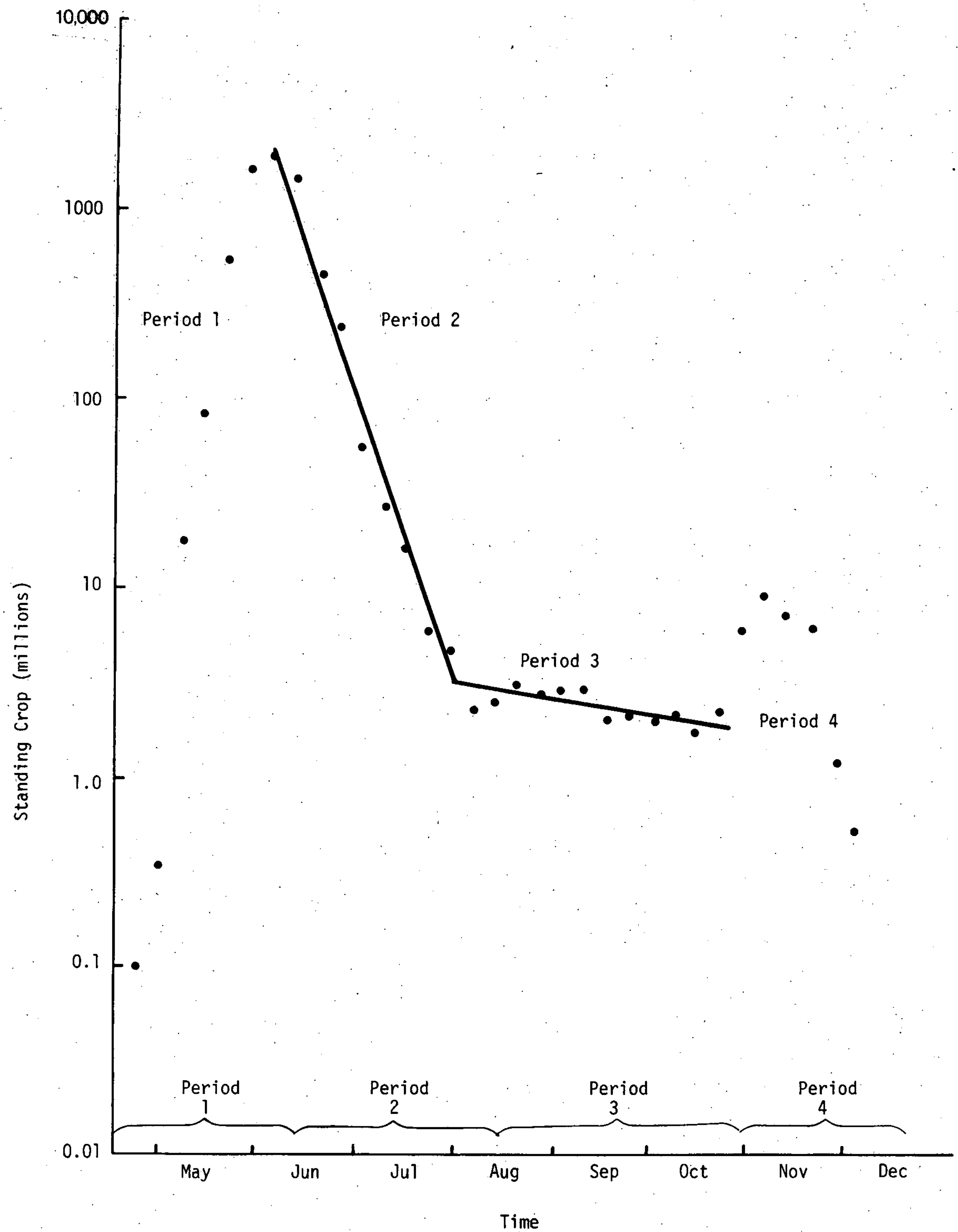


Figure IV-28. Mortality Curve for Larval and Juvenile (Young-of-the-Year) White Perch in Hudson River Estuary during 1977 [Mortality rates were calculated for linear segments during periods 2 and 3, (Appendix Table C-40)] of primary white perch spawning (subsection IV.C.1). From early June through early August, the time of peak yolk-sac and post yolk-sac larval abundance (subsection IV.C.2), larval and juvenile standing crops declined precipitously from approximately 2 billion to less than 3 million individuals. The third period, early August through mid-October, was a time of slowly declining abundance when most of the juvenile population was in shallow nursery areas (subsection IV.C.3). Finally, from late October through the end of the sampling year, juvenile white perch standing crops varied erratically as the population shifted to different habitats prior to the onset of winter (Figure IV-20). These shifting distributions among strata resulted in fluctuating population estimates since the strata are sampled with gear of differing catch efficiencies. Since mortality in the first period was severely confounded by spawning and in the fourth period by shifts among habitats, only the second and third periods were used to estimate mortality rates.

Daily rates of population decline were 10.7% during 9 June-15 August and 0.7% during 16 August-27 October. These rates of population decline included the effects of mortality, recruitment, emigration, and changing gear efficiences in the different sampling strata. If the last three factors are negligble, then these rates of population decline approximate the total mortality rates.

White perch mortality rates declined sharply in July as the population completed transformation to the juvenile stage, thereby supporting the hypothesis that year class strength is primarily determined by environmental conditions during the larval and early juvenile stages (subsection IV.D.1). White perch larval mortality was less than striped bass larval mortality [10.7% per day compared with 12-15% per day (subsection III.D.2)]. The apparent differences may have been caused by the greater degree of concurrence of the life stages in white perch. Larvae, which suffer a high mortality, were present throughout July (subsection III.C). The lower mortality of juveniles, which appeared in early July, thus placed the total white perch population mortality below that of striped bass, which have less overlap of larvae and juveniles.

3. First-Year Growth in White Perch

Growth in fishes, particularly during the early life stages, is subject to the effects of many biotic and abiotic environmental variables. Since sources of mortality such as predation and competition can often be size-related, a description of larval and early juvenile growth can provide insight into patterns of mortality during these stages. In addition, an analysis of the factors affecting early growth can be helpful in interpreting the relative importance of selected environmental parameters on the establishment of year class strength.

This subsection describes larval and juvenile growth, as inferred from changes in mean length, of the 1977 year class of white perch in the Hudson River estuary and compares growth in 1977 with patterns of growth in previous year classes (1975 and 1976). Additionally, indices of spring and summer growth, available for 1965, 1966, 1969, 1970, and 1972-1977 permitted analysis of the effects of environmental factors as well as inter- and intraspecific competition on growth from spawning through mid-August.

a. Methods

1) Growth Patterns

Growth of larvae and juvenile white perch was described using the same procedures used for striped bass (subsection III.D.3) and for the 1975 and 1976 year classes of white perch (TI 1979a). Larval length data were collected by LMS in transect sampling conducted near the Roseton power plant. Data on juvenile lengths were collected in TI's beach seine surveys from RM 34 to RM 61, fall shoals surveys from RM 14 to RM 76, and interregional bottom trawl surveys from RM 24 to RM 61 from mid-June through mid-December. Using these data, weekly mean length estimates were calculated and curves were fitted visually to the data points to describe general growth patterns.

2) Factors Affecting Growth

Length data available from beach seine sampling during July and August 1965-1970 and 1972-1977 were used to investigate factors affecting growth of juvenile white perch. From these data, weekly mean total length estimates were calculated for weeks in which sampling occurred and more than five fish were measured. Instantaneous growth rates (Ricker 1975) were estimated for each year using the following linear regression:

$$\ell n(L_t) = \ell n(L_o) + \beta(t)$$

where

L_t = mean length at time t
t = number of days since 1 July
β = estimated instantaneous growth rate
L_o = estimated mean length on 1 July

Correlations between length and time were not significant in 1967 and 1968, and these years were therefore excluded from the analysis of factors affecting growth.

An index of growth during the larval stages, defined by the mean total length of juveniles on 15 July, was predicted from estimates of L_o and β for the July-August period as follows:

$$L_A = \exp\ [\ell n(L_o) + \beta(A)]$$

where

L_A = predicted length on 15 July
A = number of days from 1 July to 15 July (=15 days)

Since 15 July was near the end of the period of larval abundance during 1974-77 (subsection IV.C.2), mean length estimates for 15 July should provide a measure of growth from the egg through the larval and early juvenile stages.

Estimates of the instantaneous growth rate during July and August and the predicted length on 15 July (for 1965, 1966, 1969, 1970, and 1972-1977) were related to the selected biotic and abiotic factors described below using the maximum R^2 improvement method of stepwise linear regression (Barr et al. 1976) to determine which set of factors had the most influence on early growth.

3) Variable Selection

a) Larval Growth

The independent variables used in the analysis were limited to those factors which could be expected a priori to affect growth (subsection III.D.3). The following independent variables were chosen for inclusion in the analysis of factors affecting larval growth from the egg stage to 15 July (Appendix Table C-41).

- Number of days since estimated time of spawning

  Although white perch spawn over an extended period in the Hudson River estuary (subsection IV.C.1), slight variations in the time of peak spawning from year to year could affect the length of time available for larval growth between hatching and 15 July. Thus, the mean length on 15 July may be a function of spawning time. In the Hudson River estuary, egg catches peak over the range of 14^{o} to 23^{o}C (subsection IV.C.1). Therefore, the last date on which water temperatures rose above 15^{o}C (and did not decrease) was chosen as the estimated spawning time. The number of days between this date and 15 July is a measure of the days available for larval growth.

- Mean water temperature at Poughkeepsie, New York (RM 76), from estimated time of spawning to 15 July

  The effects of water temperature on fish growth are well documented in the literature (see Weatherley 1972 for summary). Water temperature patterns were suggested as a regulator of first-year growth in white perch from the Patuxent estuary, Maryland (Mansueti 1961). Since the relationship between temperature and white perch growth rate was not known for the Hudson River population, the mean water temperature as measured at Poughkeepsie, New York (RM 76), from time of estimated spawning to 15 July was chosen as the best indicator of the potential temperature effects on young white perch growth.

- Average freshwater flow into the estuary during November and December of the previous year as measured at Green Island Dam (RM 153)

  November and December are times of substantial organic carbon flux in the form of leaf litter and dissolved organic substances. Thus, freshwater flow during this period may influence nutrient and, ultimately, food availability during the following spring and summer.

- Average freshwater flow into the estuary during April and May as measured at Green Island Dam (RM 153)

  Freshwater flow during April and May, a time of high freshwater runoff, and thus second type of substantial organic carbon input into the estuary (Appendix B, pages B-82 through B-89), was used as an index of food availability for the developing larvae and juveniles. Additionally, the amount of rainfall during the spring was negatively correlated with first-year growth of white perch in the Patuxent estuary, Maryland (Mansueti 1961b). Since freshwater flow into the estuary is a function of the amount of rainfall, a strong correlation between the growth of young white perch and spring freshwater flow may also be expected in the Hudson.

b) Juvenile Growth

The following independent variables were chosen for inclusion in the analysis of factors affecting the growth (instantaneous growth rate) of juvenile white perch during July and August (Appendix Table C-42).

- Mean water temperatures at Poughkeepsie, New York (RM 76) from 15 July to 15 August

  The rationale for including water temperature in the analysis of factors affecting growth was discussed previously (subsection III.D.3).

- Index of juvenile white perch abundance in July and August

  The effects of intraspecific competition on growth has been documented in the literature for several fish species (Backiel and LeCren 1967). The availability of a juvenile abundance index (subsection IV.D.1) allows investigation of possible density-dependent growth of juvenile white perch. A highly significant negative correlation between density and first-year growth of white perch was shown by Mansueti (1961b).

- Index of juvenile striped bass abundance in July and August

  The effect of interspecific competition on growth in fish has not been extensively investigated. Decreased growth in one species coincident with the introduction of another species has been noted (Fraser 1978), but direct density-growth relationships between two species are not well documented. The availability of a juvenile striped bass abundance index (subsection III.D.1) allows investigation of possible effects of the abundance of a closely related species (striped bass) on summer growth of juvenile white perch.

- Average freshwater flow into the estuary during November and December of the previous year as measured at Green Island Dam (RM 153)

  The rationale for including this variable was presented earlier.

- Average freshwater flow into the estuary during April and May as measured at Green Island Dam (RM 153)

  The rationale for including this variable was presented earlier.

- Predicted mean length of juvenile white perch on 15 July

  To investigate a possible relationship between the size of the juveniles and their subsequent growth rates, the predicted mean length on 15 July was used in the analysis of factors affecting juvenile growth during July and August.

b. Results

1) Growth Patterns

The pattern of growth for the 1977 year class was similar to that of the previous two year classes (Figure IV-29). Mean lengths throughout most of the 1977 growing season were intermediate between those of the 1975 and 1976 year classes; however, mean size at growth cessation was less in 1976 than in 1975 or 1977. Water temperatures during the late spring and early summer were generally warmer in 1975 and cooler in 1976 than in 1977, paralleling the observed yearly differences in mean length.

2) Factors Affecting Growth

a) Larval Growth

Three variables (the number of days since spawning, the mean water temperature since spawning, and average freshwater flow during November and December of the previous year) were selected by the stepwise procedure as having a significant (α=0.05) relationship with predicted mean length of young white perch on 15 July (Table IV-27). These three variables accounted for more than 85% of the variation in mean length. The other variable, average April-May freshwater flow, was not significant.

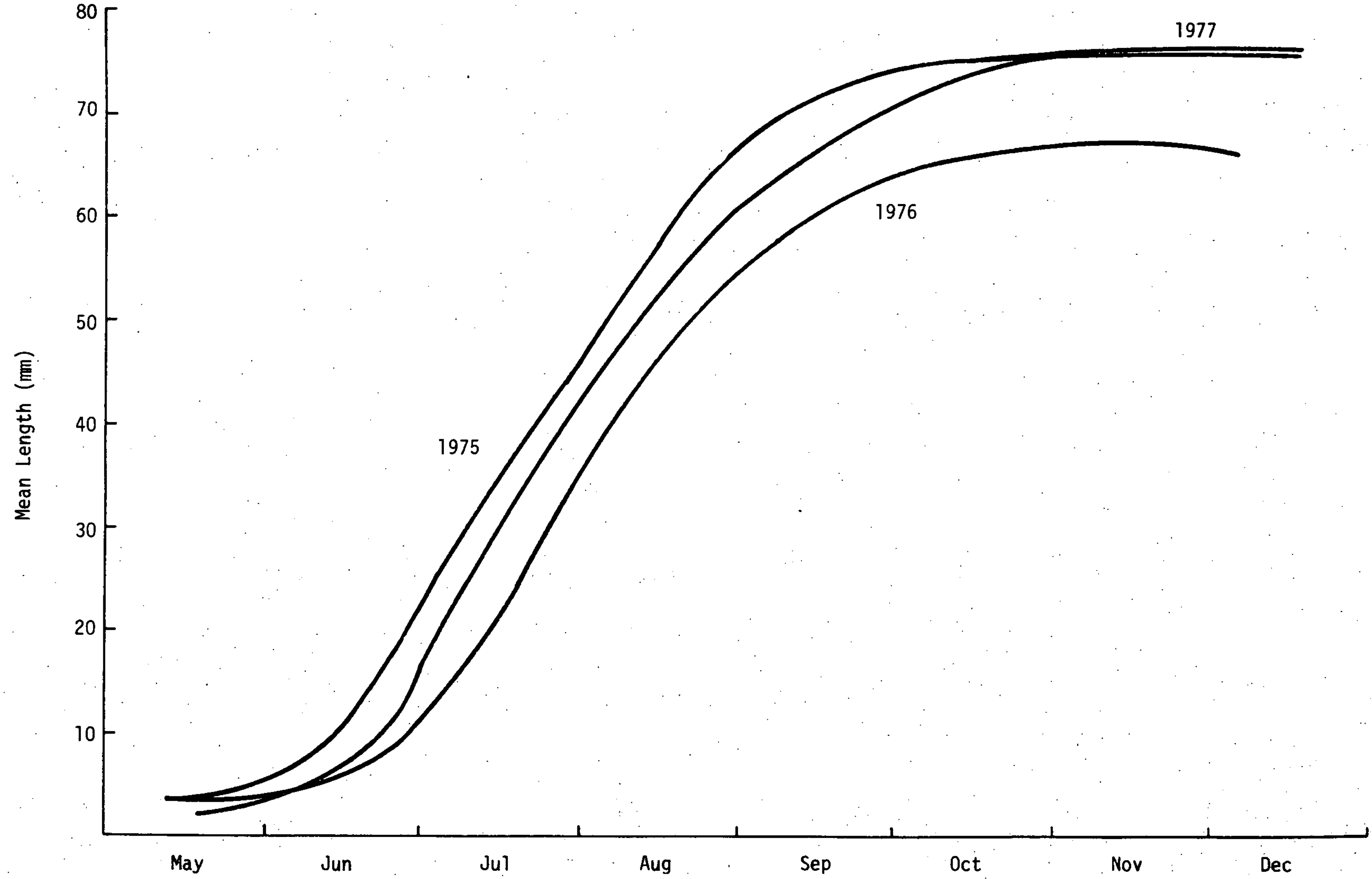


Figure IV-29. Eye-Fitted Curve for Larvae and Juveniles of 1975-1977 Year Class of White Perch in Hudson River Estuary

Table IV-27

Results of Maximum R^2 Improvement Procedure of Stepwise Linear Regression Testing Effects of Four Environmental Variables on Larval White Perch Growth in Hudson River Estuary, 1965-66, 1969-70, and 1972-77

Source	d.f.	Sum of Squares	Mean Square	F	P	R^2
Regression	3	194.53	64.84	11.43	0.007	0.8511
Number of days since spawning	1	100.99	100.99	17.81	0.006	
Mean water temperature since spawning	1	58.52	58.52	10.32	0.018	
Average freshwater flow (November-December of previous year)	1	35.01	35.01	6.17	0.048	
Error	6	34.03	5.67			
Total	9	228.56				

The number of days and mean water temperature since spawning were also directly related to larval growth in striped bass (subsection III.D.3). Early spawning and warm temperatures during larval development resulted in exceptionally large juveniles in mid-July for both white perch and striped bass.

Average freshwater flow during November and December of the previous year was inversely related to white perch larval growth. Of the possible mechanisms for this relationship, one is suggested by the presence of fall and spring peaks in organic input into the Hudson River (Appendix B, pages B-82 to B-89). During years of low freshwater flows in November and December, leaf litter may remain on the ground in the watershed and not be flushed into the river until the spring thaw and rains occur. Nutrients entering the river in spring rather than fall would support early spring zooplankton production and increase food abundance and white perch larval growth rates.

b) Juvenile Growth

Four variables (predicted mean length on 15 July, juvenile white perch abundance in July and August, average freshwater flow during November and December of the previous year, and average freshwater flow during April and May) were selected by the stepwise regression as having a significant (α=0.10) relationship with instantaneous growth rate of juvenile white perch during July and August (Table IV-28). These four variables accounted for more than 91% of the variation in instantaneous growth rates for juvenile white perch. The other two variables, juvenile striped bass abundance in July and August and mean water temperature from 15 July to 15 August, were not significant.

Table IV-28

Results of Maximum R^2 Improvement Procedure of Stepwise Linear Regression Testing Effects of Six Biotic and Abiotic Factors on Juvenile Growth Rate of White Perch in Hudson River Estuary during July-August 1965-66, 1969-70, and 1972-77

Source	d.f.	Sum of Squares	Mean Square	F	P	R^2
Regression	4	0.000081	0.000020	13.85	0.006	0.917
Predicted length 15 July	1	0.000008	0.00008			
Juvenile white perch abundance	1	0.000010	0.000010	7.26	0.043	
Average freshwater flow during November-December of the previous year	1	0.000055	0.000055	37.27	0.002	
Average freshwater flow during April and May	1	0.000008	0.000008	5.59	0.064	
Error	5	0.000007	0.000001			
Total	9	0.000089				

The inverse relationship between predicted mean larval length on 15 July and instantaneous growth rate of juveniles during July and August for white perch is similar to that reported for striped bass (subsection III.D.3). Low November and December freshwater flows apparently enhance larval growth by permitting the retention of nutrients in the estuary in late fall, thus making them available to prey organisms in the spring. The large early juveniles that resulted from such a favorable combination of environmental factors during larval development (discussed on previous pages) demonstrated lower subsequent growth rates. The action of November and December freshwater flows on juvenile growth rates could have acted through the increased larval size to cause the subsequent lower growth rates for juveniles.

Freshwater flow during April and May was inversely related to instantaneous growth of juvenile white perch in July and August. This inverse relationship is in contrast to the positive relationship that April and May flow exhibited with juvenile striped bass abundance (subsection III.D.1). The increased striped bass abundance was thought to be caused by increased nutrient availability, but such a mechanism is not plausible for decreased white perch growth. Mansueti (1961b) also reported lower growth for juvenile white perch in the Patuxent estuary, Maryland, during years of high spring rainfall. Mansueti suggested that periods of high rainfall are associated with low solar radiation, resulting in reduced phytoplankton production and presumably less available food for juvenile white perch. Alternatively, the increased turbulence associated with high spring freshwater flows may resuspend nutrient-rich sediments and flush a significant portion of these nutrients to areas downstream from Croton-Haverstraw Bay and Tappan Zee, the important juvenile nursery areas. This phenomenon would also reduce the amount of food available to juvenile white perch.

Abundance was inversely related to summer growth rate of juvenile white perch. This relationship suggests intraspecific competition and resultant density-dependent growth. During July and August, juvenile white perch are concentrated in the shore zone of the Tappan Zee, Croton-Haverstraw, Saugerties, and Catskill regions (subsection IV.C.3) where juvenile densities can become extremely high. During years of relatively large juvenile white perch densities in the Hudson, the demand for food may exceed the supply, thus retarding growth of both white perch and striped bass. Competition for resources with striped bass may occur only during times of high white perch abundance. Mansueti (1961b) also reported density-dependent growth in the white perch population in the Patuxent estuary, Maryland. Because abundance was negatively rather than positively related to juvenile white perch growth, it is unlikely that size-related mortality is a significant aspect of white perch population dynamics.

E. QUALITATIVE IMPACT ASSESSMENT IN WHITE PERCH

The objectives of this section are to evaluate whether exposure indices may be used to predict entrainment and impingement trends at the five Hudson River power plants and to evaluate how conditional mortality rates may serve to indicate long-term reductions in average population size. If trends in exposure indices accurately reflect trends in entrainment and impingement, power plant-induced mortality could be monitored through the use of distribution data. As discussed in subsection III.E, power plant-induced mortality could produce a variety of results ranging from a large reduction to a slight increase in average population size. However, as described in this subsection, there are circumstances in which the conditional mortality rate can be perceived as an upper limit to the long term percent reduction in average population size. If the white perch conditional mortality rate is greater than the long-term percent reduction in average population size (PR), yearly impact assessment may not require input from any stock-recruitment curve (see subsection III.E).

1. Exposure to Entrainment and Impingement

a. Entrainment

Data from nearfield surveys conducted by NYU and LMS, and data collected at the intakes or in the discharge canals by EAI, LMS, and NYU are compared to plant region densities to assess the reliability of plant region densities (as a component of the exposure index) in qualitatively determining impact. Entrainment densities at Bowline were estimated from samples collected in the discharge canal (EAI 1978a), and entrainment at Roseton and Danskammer was assessed from samples collected in the intake canals. Entrainment densities from Indian Point were unavailable at the time of writing because data analyses were not completed; therefore, the total catch was substituted for density in discussions of Indian Point entrainment. Nearfield and entrainment data from the Lovett site were not available.

1) Eggs

Exposure of white perch eggs to entrainment mortality was lower at the three downriver sites (Bowline, Lovett, and Indian Point) than at the two upriver sites (Roseton and Danskammer). Of the three downriver sites, exposure indices (proportion within the plant region) at Bowline were generally highest, but the differences in the average exposure indices were not large (Table IV-29). As expected, exposure to Danskammer and Roseton was nearly identical because these two plants are approximately one mile apart.

Nearfield and entrainment egg densities were available from Bowline, Roseton, and Danskammer for comparison with plant region densities (Figure IV-30). At Bowline, densities from all three efforts were comparatively low but generally peaked at the same time (Figure IV-30). At Roseton, entrainment densities peaked later than nearfield densities, and both were higher than the plant region densities (Figure IV-30). Asynchronous peaks in entrainment, nearfield, and plant region densities were also observed at the upriver plants for striped bass eggs and larvae (subsection III.E.1). Entrainment samples at Danskammer revealed that white perch eggs were more concentrated in the intake canal than in either the plant region or nearfield areas.

2) Larvae

Although yolk-sac larvae were equally exposed to all five sites (Table IV-30), exposure of post yolk-sac larvae was greater at the two upriver sites than at the three downriver sites (Table IV-31).

Trends in plant region densities of white perch larvae were closely related to the timing of larval entrainment at Bowline, but plant region densities were greater in magnitude than nearfield and entrainment densities at that site (Figure IV-31). Plant region densities at Indian Point were closely related to nearfield density and entrainment catch. At Roseton and Danskammer, plant region density was greater than both nearfield and entrainment densities, but peaked at the same time (Figure IV-31).

b. Impingement

Impingement of white perch begins when the fish are too large to be entrained (approximately 30 mm total length) and is related to both seasonal movement of fish and water temperature. These factors interact in a complex

Table IV-29

Estimated Standing Crops (in Thousands) and Percent Total Standing Crops of White Perch Eggs Above, Within, and Below Five Power-Plant Regions Determined from Ichthyoplankton Survey during Periods of White Perch Egg Abundance, 1977

Date		Bowline Standing Crop	Bowline Percent	Lovett Standing Crop	Lovett Percent	Indian Point Standing Crop	Indian Point Percent	Roseton Standing Crop	Roseton Percent	Danskammer Standing Crop	Danskammer Percent
5/9 - 5/12	Above	41,138	99.9	41,124	99.9	41,113	99.8	30,466	74.0	29,420	71.4
	Within	43	0.1	50	0.1	54	0.1	10,568	25.7	11,614	28.2
	Below	0	0.0	7	<0.1	15	<0.1	147	0.4	197	0.4
5/16 - 5/19	Above	25,692	97.9	25,532	97.3	25,431	96.9	21,960	83.7	21,698	82.7
	Within	539	2.1	612	2.3	625	2.4	2,711	10.3	2,955	11.3
	Below	0	0	88	0.3	175	0.7	1,560	5.9	1,579	6.0
5/23 - 5/26	Above	102,547	73.8	100,503	72.3	98,638	70.9	71,371	51.3	70,136	50.4
	Within	11,314	8.1	2,521	1.8	4,341	3.1	13,338	9.6	14,285	10.3
	Below	25,182	18.1	36,019	25.9	36,063	25.9	54,334	39.1	54,622	39.3
5/31 - 6/2	Above	32,714	99.4	32,631	99.2	32,598	99.1	30,433	92.5	30,363	92.3
	Within	129	0.4	182	0.6	211	0.6	1,321	4.0	1,186	3.6
	Below	62	0.2	93	0.3	97	0.3	1,152	3.5	1,357	4.1
6/6 - 6/9	Above	22,735	97.2	21,320	91.2	19,911	85.1	9,242	39.5	9,183	39.3
	Within	650	2.8	1,938	8.3	3,218	13.8	695	3.0	718	3.1
	Below	0	0.0	128	0.5	255	1.1	13,448	57.5	13,483	57.7
Average Within Plant Region			4.8		2.0		3.2		10.9		11.7

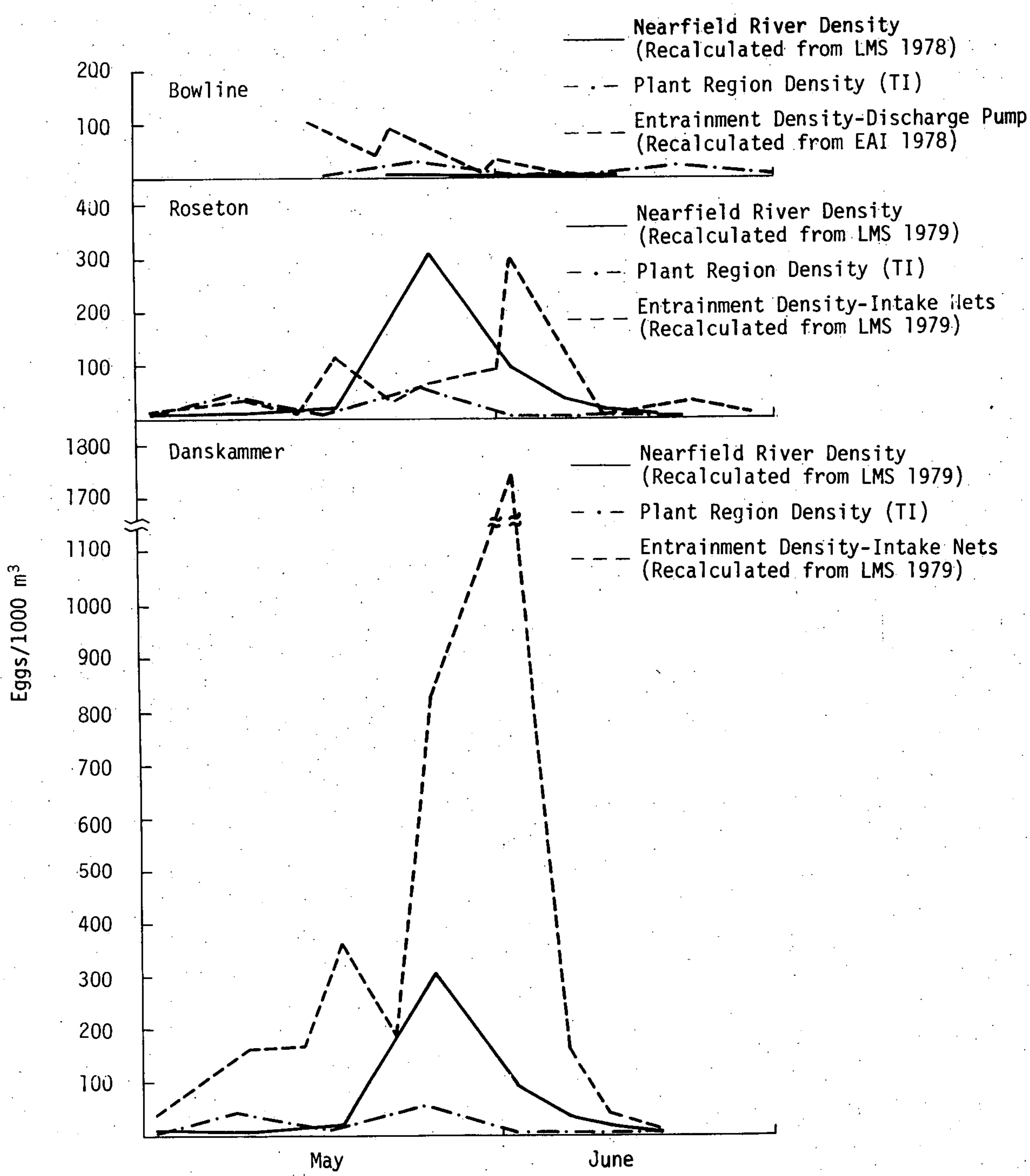


Figure IV-30. Nearfield, Plant Region, and Entrainment Abundance of White Perch Eggs at Bowline, Roseton, and Danskammer Power Plants, Hudson River Estuary, May-June 1977

Table IV-30

Estimated Standing Crops (in Thousands) and Percent Total Standing Crops of White Perch Yolk-Sac Larvae Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of White Perch Yolk-Sac Larvae Abundance, 1977

Date		Bowline		Lovett		Indian Point		Roseton		Danskammer	
		Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent
5/16 - 5/19	Above	76,767	96.4	76,252	95.8	76,021	95.5	64,318	80.8	63,757	80.1
	Within	1,449	1.8	1,331	1.7	1,476	1.9	7,880	9.9	7,705	9.7
	Below	1,411	1.8	2,044	2.6	2,130	2.7	7,429	9.3	8,165	10.3
5/23 - 5/26	Above	250,233	83.2	246,431	81.9	244,327	81.2	176,787	58.8	172,987	57.5
	Within	26,462	8.8	17,296	5.8	16,734	5.6	45,602	15.2	47,002	15.6
	Below	24,039	8.0	37,007	12.3	39,673	13.2	78,344	26.1	80,746	26.8
5/31 - 6/2	Above	95,012	81.8	83,301	71.7	78,890	67.9	42,051	36.2	41,756	35.9
	Within	17,407	15.0	26,772	23.0	30,459	26.2	4,450	3.8	4,253	3.7
	Below	3,788	3.3	6,135	5.3	6,858	5.9	69,707	60.0	70,199	60.4
6/6 - 6/9	Above	49,039	92.4	47,466	89.5	47,201	89.0	41,404	78.0	41,245	77.7
	Within	3,683	6.9	4,843	9.1	4,835	9.1	2,774	5.2	2,544	4.8
	Below	326	0.6	739	1.4	1,012	1.9	8,870	16.7	9,259	17.5
Average Within Plant Region			8.9		9.1		9.7		11.0		11.2

Table IV-31

Estimated Standing Crops (in Thousands) and Percent Total Standing Crops of White Perch Post Yolk-Sac Larvae Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of Post Yolk-Sac Larvae Abundance, 1977

Date		Bowline Standing Crop	Bowline Percent	Lovett Standing Crop	Lovett Percent	Indian Point Standing Crop	Indian Point Percent	Roseton Standing Crop	Roseton Percent	Danskammer Standing Crop	Danskammer Percent
5/31 - 6/2	Above	1,447,645	97.1	1,418,598	95.2	1,411,784	94.7	1,186,144	79.6	1,171,633	78.6
	Within	40,324	2.7	67,792	4.5	74,183	5.0	162,265	10.9	171,561	11.5
	Below	2,776	0.2	4,356	0.3	4,778	0.3	142,336	9.5	147,552	9.9
6/6 - 6/9	Above	1,751,642	94.9	1,713,592	92.8	1,706,703	92.4	1,287,549	69.7	1,264,063	68.5
	Within	89,343	4.8	117,977	6.4	117,868	6.4	304,109	16.5	305,298	16.5
	Below	5,641	0.3	15,056	0.8	22,055	1.2	254,968	13.8	277,265	15.0
6/13 - 6/16	Above	1,384,480	98.0	1,355,180	95.9	1,341,854	94.9	848,533	60.0	821,427	58.1
	Within	28,429	2.0	57,226	4.0	70,226	5.0	336,930	23.8	342,998	24.3
	Below	438	0.0	940	0.0	1,266	0.0	227,883	16.1	249,121	17.6
6/20 - 6/24	Above	428,758	92.6	397,060	85.7	382,295	82.6	195,249	42.2	192,339	41.5
	Within	33,656	7.3	64,112	13.8	77,829	16.8	56,484	12.2	50,352	10.9
	Below	650	0.1	1,893	0.4	2,940	0.6	211,331	45.6	220,373	47.6
Average Within Plant Region			3.6		5.9		6.5		16.5		16.7

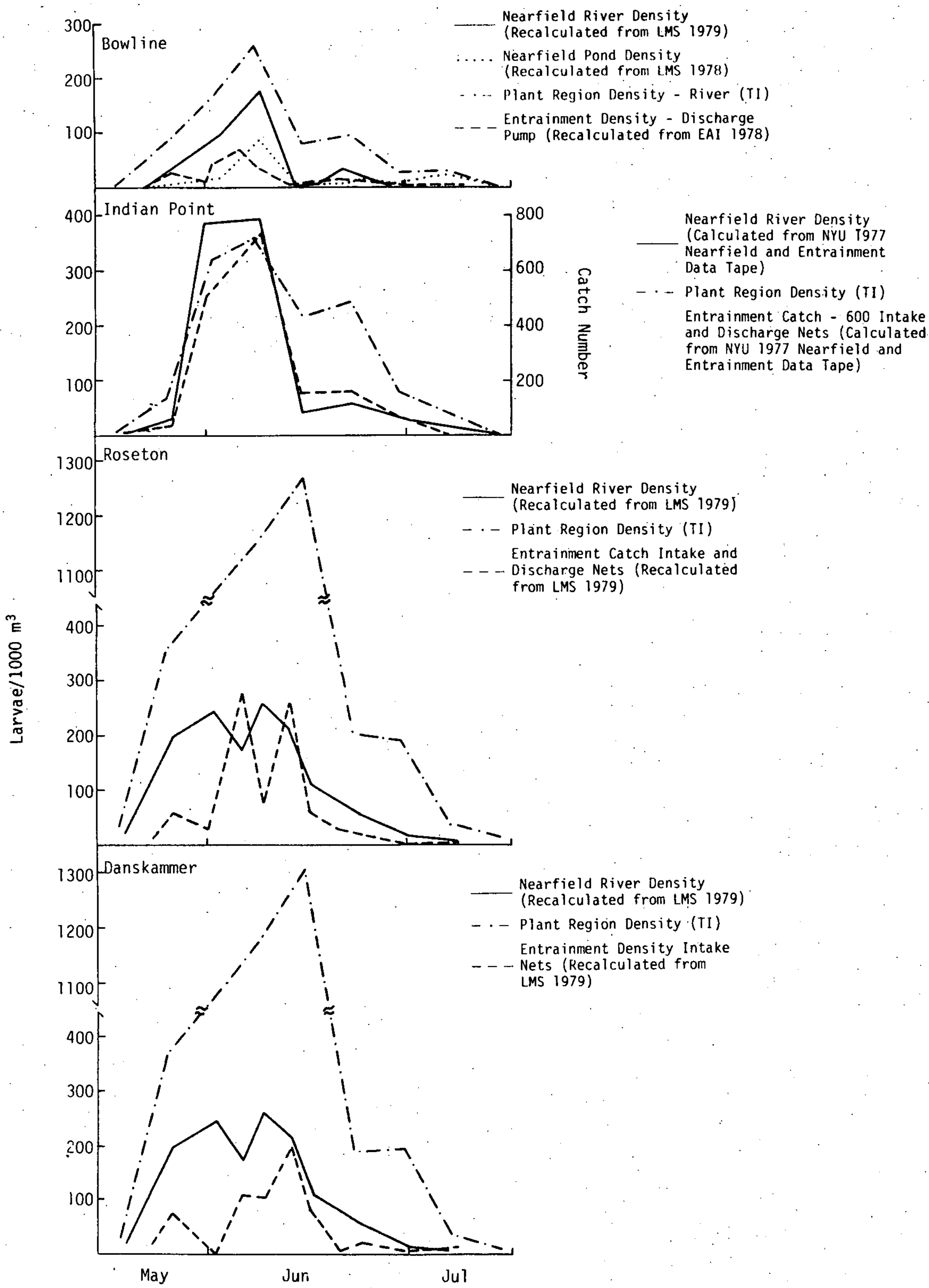


Figure IV-31. Nearfield, Plant Region, and Entrainment Abundance of White Perch Yolk-Sac and Post Yolk-Sac Larvae (Combined) at Bowline, Indian Point, Roseton, and Danskammer Power Plants, Hudson River Estuary, May-July 1977 manner with intake location to produce the impingement patterns described below.

1) Summer Impingement (July-September)

Although exposure was relatively high at all sites during the summers of 1976 and 1977, impingement was low (Figure IV-32). Low impingement rates during July-September have been the general rule every year since 1973 (Figure IV-33), but rates have been somewhat more variable at the two upriver sites (Roseton and Danskammer) than at the three downriver sites. The consistent pattern of relatively low summer impingement is probably related to the fact that most white perch occupy the shore zone during the summer (subsection IV.C.3) where they should be less vulnerable to most of the power plant intakes.

2) Fall and Winter Impingement (October-April)

Impingement rates at all sites usually increased during October or November (Figure IV-33), a trend that has been observed since 1973. Impingement rates at the upriver sites (Roseton and Danskammer) generally increased during October or November as the fish moved out of the shore zone and downriver (subsection IV.C.3). At the three downriver sites, movement to the lower estuary and the accompanying increase in exposure to these plant regions (Figure IV-32) resulted in high impingement rates in November or later. Increased winter impingement rates were probably related to several factors including the concentration of white perch in downriver areas and the reduced swimming endurance at low winter temperatures (Powers 1976) (subsection III.C.3).

Impingement rates at downriver sites often remained relatively high throughout the winter and early spring (December-April). At Roseton and Danskammer, midwinter impingement of juvenile white perch was nearly nonexistent from 1973 through 1977, but impingement rates at these sites increased in March, April, and May. These late winter and spring increases in impingement rates at Roseton and Danskammer were probably coincident with upriver movements of white perch, presumably triggered by warming water temperatures and longer days.

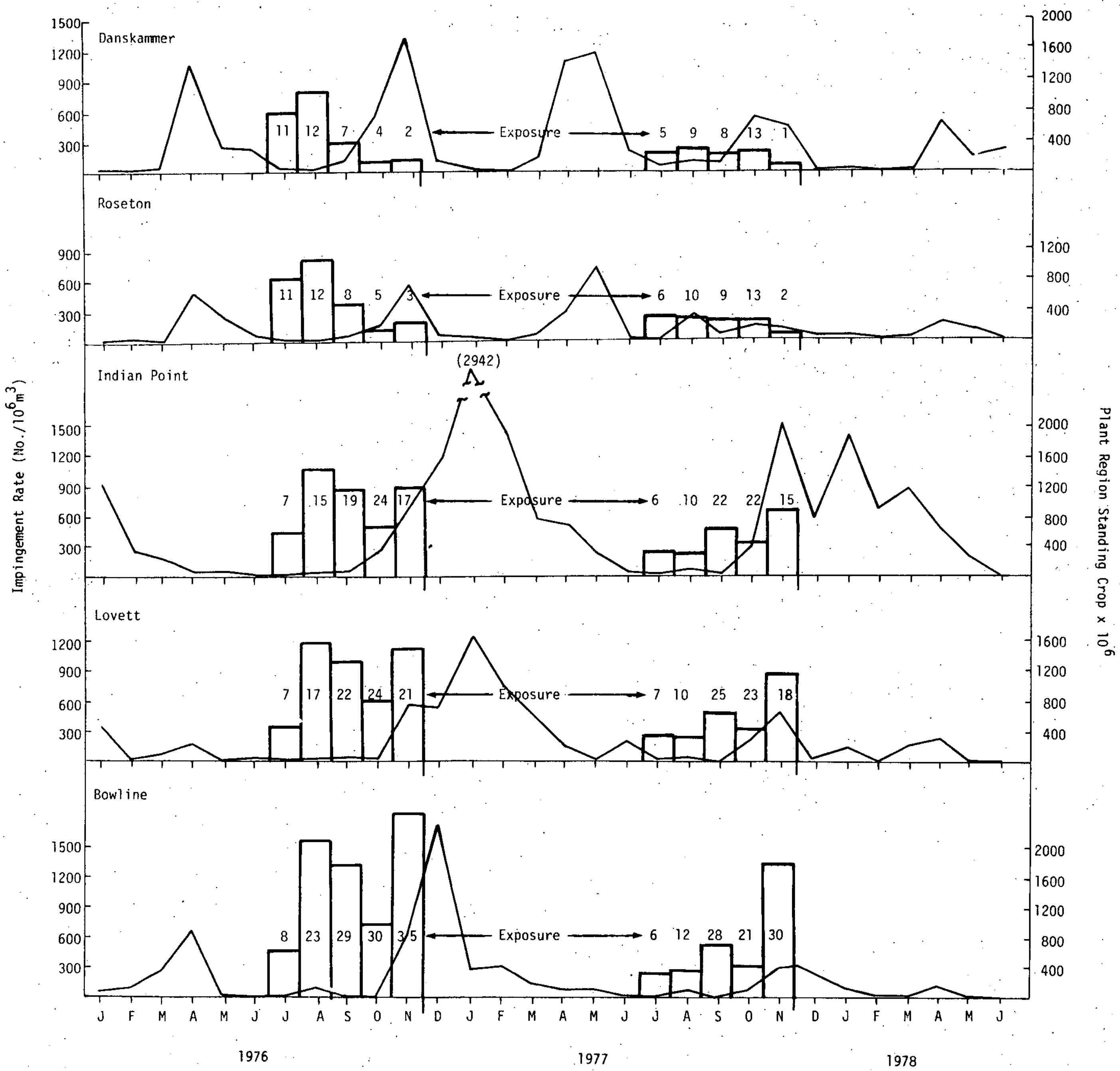


Figure IV-32. Plant Region Standing Crops (Histograms Estimated from Beach Seine, Tucker Trawl, and Epibenthic Sled Samples; not adjusted for gear efficiencies), Exposure to Impingement (Percent of Total Standing Crop per Plant Region), and Impingement Rates (Lines Represent Number/10^6 m^3 of Water Circulated) of White Perch at Each of Five Hudson River Power Plants, 1976-78

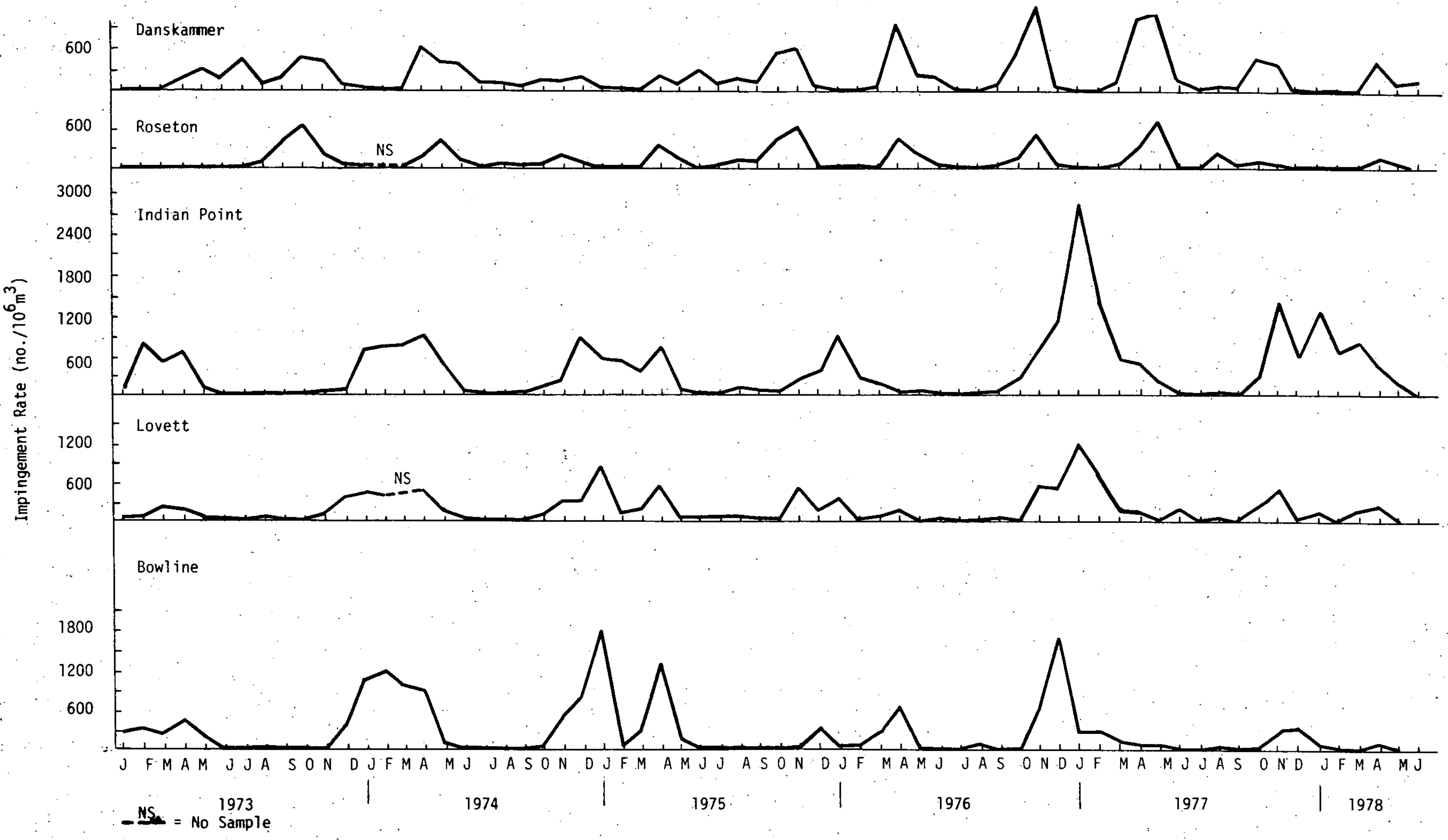


Figure IV-33. Monthly Impingement Rates of Juvenile and Yearling White Perch at Five Hudson River Power Plants, 1973-78

c. Conclusions

Trends in exposure indices based on plant region densities did not appear to consistently reflect trends in actual entrainment or impingement rates in white perch. Plant region densities deviated substantially from nearfield and entrainment densities in both timing and magnitude, and the direction of the bias was not predictable. Similar to striped bass, impingement rates for white perch appeared to be more closely related to season than exposure. Thus, trends in entrainment and impingement appear to be related to factors other than riverwide distribution.

2. Compensation and Impact

Because the biological principles involved in the interpretation of white perch mortality are the same as those for striped bass (subsection III.E), the possible consequences of power plant-induced mortality resulting from exposure of the population to the plants are also the same. This section discusses the alpha value, the stock recruitment curve, and the timing and value of power plant-induced mortality that are most appropriate for the white perch population in the Hudson River estuary (see subsection III.E for definitions and explanations of these terms).

McFadden and Lawler (1977) estimated the conditional mortality rate resulting from the combined effects of entrainment and impingement to be 0.16 i.e., 0.06 from entrainment and 0.11 from impingement (competing mortalities are not additive). Alpha has been estimated to be approximately 3 (TI 1979a). When conditional mortality and alpha values such as these are combined (Figures III-43 through III-45), the final reduction in average population size (PR) could be substantially greater than the conditional mortality rate (and, therefore, not predictable from the conditional mortality rate) in only one case: power plant-induced mortality acting on a Beverton-Holt stock-recruitment relationship after the period of compensation. If power plant-induced mortality occurred in conjunction with either a Beverton-Holt or Ricker curve before compensation or in conjunction with a Ricker curve after the period of compensation, the conditional mortality rate would be a conservative estimate of PR.

Although no data exist to clarify the type of stock-recruitment curve most appropriate for the Hudson River white perch population (e.g., Ricker or Beverton-Holt), there is some indication that much of the power plant-induced mortality occurs before compensation. A general argument is made in subsection III.E that the period of greatest compensatory response for fishes occurs during the larval stages. At this time, a critical period is thought to be present during which intraspecific competition (among other factors) may adjust population size to the available environmental resources and excess organisms (those for which there are not enough resources) die.

Some evidence exists suggesting that the period of greatest compensatory response may extend into the yearling stage for white perch. Both mature and immature white perch coexist in the Hudson River and probably compete for resources. This life history pattern is in contrast to that of anadromous striped bass which generally leave the river near the end of their first summer and do not return until mature. Intraspecific competition should be more intense in white perch than in striped bass because young white perch may compete with subadults and adults as well as each other. This intraspecific competition may be inferred from examination of age structure in white perch. Because variations in year class strength (at age 0) were not evident in the yearling (age I) white perch abundance index (subsection IV.B and Table IV-32), intraspecific competition may have resulted in density-dependent mortality that dampened the differences between strong and weak year classes. Both the strong 1976 and 1977 year classes gave rise to relatively small yearling populations, but the relatively weak 1974 year class was moderately abundant as yearlings (Table IV-32). The lack of a significant difference in the catch curve for four years of data (subsection IV.B.3) further indicated that relatively strong year classes as juveniles were not evident as age I and older individuals. Strong year classes of white perch were not observed in the Patuxent (Mansueti 1961b) or Delaware (Wallace 1971) rivers either. The dampening of white perch year class strength implies density-dependent mortality during the first winter of life as well as during the larval stages. Strong year classes apparently experienced above average mortality, and their numerical strength was not evident at age I. By contrast, strong year classes remain obvious in the age structure of striped bass (subsection III.B).

Table IV-32

Relationship between Index to Juvenile Abundance and Index to Yearling Abundance Following Year in White Perch. (Poor Survival of 1976 Year Class Suggested Density Dependent Mortality Occurred After Juvenile Index was Calculated)

Year of Spawn	Abundance Index*	
	Juvenile	Yearling
1973	19.82	17.6
1974	6.32	9.3
1975	17.70	10.8
1976	23.96	2.7
1977	22.09	11.3

*Calculated from beach seine data, July through August

This evidence for an extended period of density-dependent mortality for white perch suggests that all of the entrainment mortality and most of the impingement mortality occur before the period of compensation. The curve for impact before the period of compensation (Figures III-44 and III-45) is probably more correct because much of the power plant-induced mortality appears to occur before the period of compensation. Therefore, the conditional mortality rate resulting from the operation of power plants is an overestimate of the long-term percent reduction of the white perch population regardless of which stock-recruitment curve is considered.

F. ECOLOGY AND IMPACT

In subsection III.F, the selective advantage of an iteroparous life history pattern in a fluctuating environment was discussed. In the case of American shad and striped bass, iteroparity enabled these species to compensate for unpredictable levels of mortality associated with fluctuations in temperature during the egg and yolk-sac larval stages. However, white perch exhibit a number of differences in reproductive biology that suggest that the evolution of this species has tended to reduce the impact of the unpredictable thermal environment during the egg and larval stages. For example, white perch spawn over a broader time interval; thus, the peak egg densities occur later in the season compared with either American shad (McFadden et al. 1978) or striped bass (subsection III.C). Since water temperatures increase steadily during May and June, the probability of exposure to a lethal low temperature decreases when the spawning efforts are delayed. There is an indication that the spawning efforts of individual females may also be distributed throughout the extended spawning season (subsection IV.C.1.a). This would further decrease the risk associated with an unpredictable thermal environment during the spawning season.

The white perch population apparently spreads the risk associated with unpredictable conditions in the estuary in still another way. White perch spawn throughout the entire estuary and possibly its tributaries as well (subsections IV.C and IV.E). Utilization of the entire estuary for spawning reduces dependence on, and sensitivity to, the environmental conditions prevailing in any one river region.

Finally, white perch eggs are adhesive, which may decrease their vulnerability to variations in flow or flow-related factors. The level of variation in juvenile abundance (as measured by the coefficient of variation for the juvenile abundance indices, subsections III.D.1 and IV.D.1) is lower in the white perch population than in the striped bass population (47% vs 88%, respectively), which suggests that the changes in reproductive biology have been effective in reducing the level of uncertainty during the egg and larval stages. However, a significant level of uncertainty in survival during later pre-reproductive life stages must be present since white perch are iteroparous.

The correlation between juvenile and yearling abundance is not significant (subsection IV.E) which indicates variable survival between the first and second summers of life. Fluctuations in abiotic conditions during the winter could generate this variation, but, as the white perch increase in size, their sensitivity to fluctuations in physical conditions should decrease. However, they do become increasingly susceptible to competition for food as their size and food requirements increase.

Both juvenile white perch and striped bass feed upon the same species but not the same size classes of prey during the summer (TI 1978a), and analysis of the factors affecting juvenile abundance in the white perch population does not demonstrate any correlation between the abundance of juvenile striped bass and that of juvenile white perch (subsection IV.D.1.c). This is also consistent with the fact that simple linear food chains involving very few interspecific regulatory mechanisms predominate in unstable ecosystems (Odum 1969).

Juvenile and adult white perch feed upon different sized prey from the same populations (TI 1978a), indicating that the intraspecific competition which could occur may be more important in this species than in striped bass. White perch grow more slowly and mature later in the Hudson River estuary than in other populations at comparable and more northern latitudes (subsection IV.B), which suggests that the Hudson River population is at or near the carrying capacity of the system, increasing the likelihood that intraspecific competition is an important process in this system.

The presence of iteroparity in the white perch population indicates that pre-adult mortality is unpredictable. Thus, if intraspecific competition between age 1+ and young-of-the-year fish in the Hudson River population controls the recruitment into the yearling age class, the iteroparity implies that the intensity of the intraspecific competition in unpredictable. White perch feed upon invertebrates, and the productivity of the invertebrate populations is affected by fluctuations in abiotic and biotic conditions. Thus, the intensity of intraspecific competition will vary unpredictably and could be responsible for the iteroparous life history pattern in the white perch population.

Iteroparous species are resilient to new sources of mortality as long as those sources affect life stages that are already subject to unpredictable natural mortality (Giesel 1979, Power 1978). In the Hudson River white perch population, the unpredictable mortality apparently occurs between the first and second summers (subsection IV.B) and appears to involve a density-dependent mechanism, intraspecific competition (subsection IV.E). Entrainment mortality occurs prior to this period and impingement mortality peaks during the winter (subsection IV.C). Thus, the timing of the power plant mortality appears to be compatible with the natural compensatory response in the white perch population, and the power plants should have no significant impact on the white perch population in the Hudson River estuary. Moreover, this conclusion is consistent with the empirical fact that the white perch population exhibits no overcropping in terms of individual growth rates or the age structure of the population (subsections IV.D and IV.E).

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ATLANTIC TOMCOD

A. GENERAL LIFE HISTORY

The Atlantic tomcod (Figure V-1) belongs to the codfish family (Gadidae) and is an inshore, bottom-dwelling species that inhabits coastal and brackish waters from southern Labrador to Virginia. Tomcod are harvested commercially and for sport mainly in Canada, where they also exist landlocked in several freshwater lakes. Details concerning the biology of tomcod are lacking for most of its range (Scott and Crossman 1973), but it is known that the Hudson River is the southernmost major spawning area for the species (Grabe 1978).

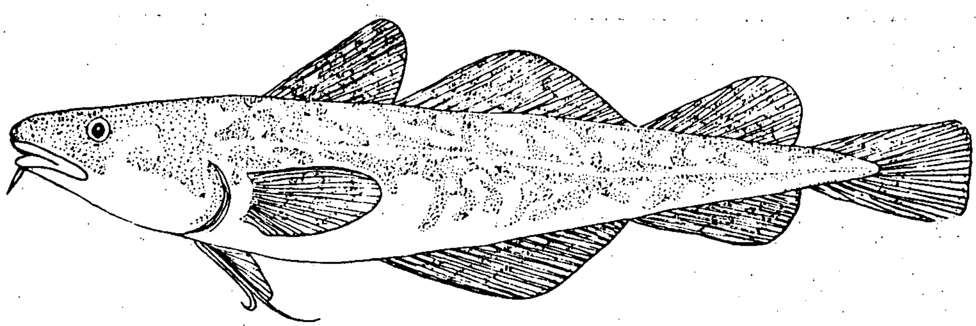


Figure V-1. Atlantic Tomcod (Microgadus tomcod), [Length to 380 mm (15 in)]

The life cycle of Atlantic tomcod inhabiting the Hudson estuary is basically that of an anadromous species (Figure V-2). Adult tomcod begin ascending the Hudson River in mid-November and spawn in the shoals and shore zone of the middle estuary during December and January; shortly thereafter, they move back to the lower estuary or enclosed bays of the ocean (TI 1978a). At least 90% of the spawning adults are fish hatched from the previous winter (subsection V.E.2). Therefore, most tomcod complete their life cycle in approximately 1 year. From 1973 to 1977, fecundity increased with size, averaging from 14,000 to 20,000 eggs per female (TI 1979a).

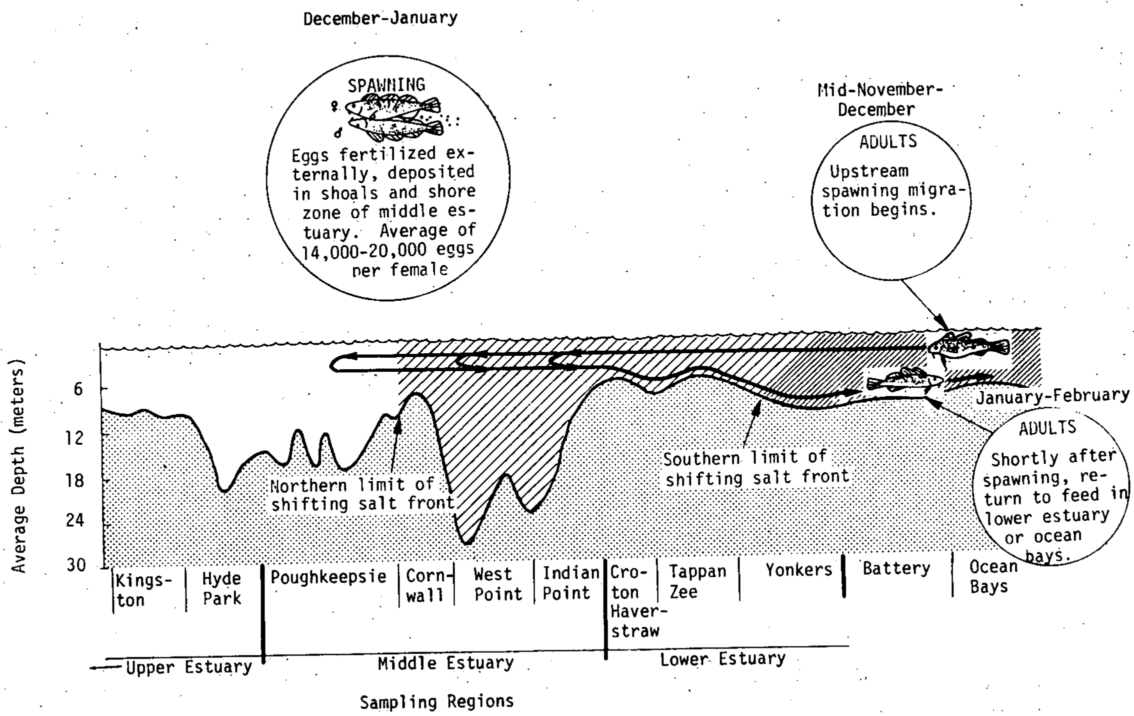


Figure V-2a. Spawning Migration in Generalized Life Cycle of Atlantic Tomcod in Hudson River Estuary

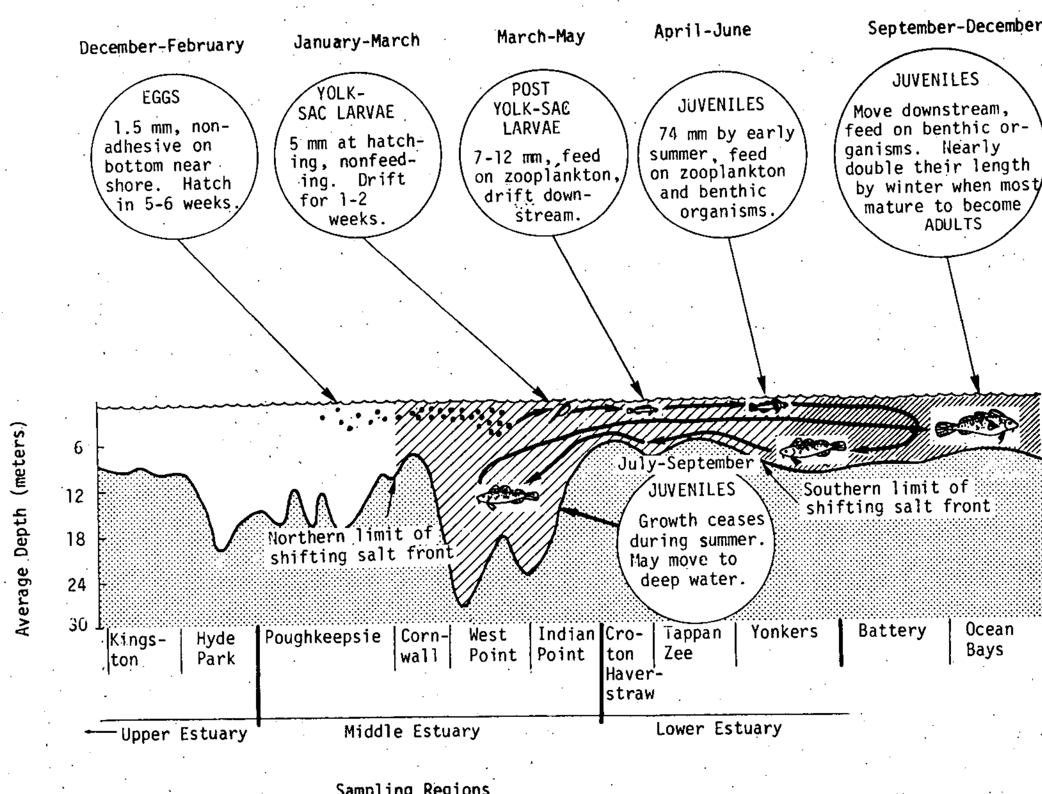


Figure V-2b. Early Life Stages in Generalized Life Cycle of Atlantic Tomcod in Hudson River Estuary

Atlantic tomcod eggs, which are fertilized externally, are about 1.5 mm in diameter, demersal (sinking), and nonadhesive after water-hardening (Mather 1887, Watson personal communication). Several reports describing eggs as adhesive (Mather 1886) probably resulted from the stripping of unripe or overripe eggs or from misidentification. Length of incubation varies with water temperature; at a mean of 3.4°C, hatching occurs in 36 to 42 days (Hardy and Hudson 1975).

At hatching, yolk-sac larvae (prolarvae) are approximately 5 mm long and swim in brief bursts toward the surface, falling back head first between bursts (Booth 1967). By the time they are 7 mm long (probably 1 to 2 weeks after hatching), the gas bladder is inflated, the mouth and gut are functional, and the yolk-sac is fully absorbed (Booth 1967). Post yolk-sac larvae (postlarvae) feed on zooplankton and apparently drift downstream from the spawning areas (McFadden et al. 1978).

By mid-spring, most young-of-the-year tomcod have attained the juvenile form and move downstream, although many are also found in the deeper portions of the middle Hudson River estuary (McFadden et al. 1978). Having evolved as a cold-water species, tomcod grow rapidly during early spring, feeding mainly on copepods and Gammarus (TI 1976a). Juveniles grow to approximately 70 mm (TL) by early summer and then almost cease growing until water temperature declines in the fall (TI 1975a). During the summer, juvenile tomcod may move to deeper, cooler water as the salt front intrudes upstream (McFadden 1977a).

With the onset of fall, a general downstream movement occurs (TI 1978a) and rapid growth resumes. Juvenile diets may include a variety of benthic organisms and small fish but mainly the crustaceans Gammarus, Monoculodes, and Neomysis (TI 1977b, Grabe 1978). Juveniles nearly double their summer lengths by early winter, when most become sexually mature (TI 1975a).

B. SYNOPSIS OF PARENTAL STOCK FOR 1977 YEAR CLASS OF ATLANTIC TOMCOD

Since the Atlantic tomcod in the Hudson River can complete its life cycle within 1 year, a single year of sampling can follow the progress of a year class from its parental stock through its growth to maturity and spawning. The parental stock (primarily 1976 year class) of Atlantic tomcod generating the 1977 year class was discussed in detail in a previous report (TI 1979a). Because of the short life cycle of Atlantic tomcod, this section uses a different format from that used for striped bass and white perch. After a brief synopsis of the parental stock, the successive life stages of the 1977 year class are discussed chronologically, ending with a description of the year class as a spawning population.

The 1976 year class was the largest since 1970 (TI 1979a). An index of relative abundance of juvenile tomcod was developed from bottom trawl data collected during 1969-1970 and 1972-1976 within RM 34-46 (KM 54-74). This index showed relatively strong year classes in 1969 and 1970, weaker year classes during 1972-1974, and increasingly strong year classes in 1975 and 1976. Population size estimates using mark-recapture methods also demonstrated the relative strength of the 1976 year class. The spawning population during December 1976-February 1977 was estimated to be 10.4 million fish – approximately three times the size of the population during the 2 previous years.

Low freshwater flow during the previous December and January apparently was responsible for an increase in the early survival of the 1976 year class. Freshwater flow during December and January was the only variable tested that was significantly (α=0.05) correlated (negatively) with the abundance of juvenile tomcod during July-September 1969-1970 and 1972-1976 (TI 1979a). It has been hypothesized, therefore, that freshwater flow determined the location of spawning. Other biological parameters studied for the 1976 year class of tomcod (TI 1979a), such as mean fecundity, will be incorporated into this report for describing the population dynamics of the 1977 year class.

C. LIFE STAGES

This subsection is similar in purpose to subsection III.C and IV.C but, since the life history of tomcod differs from that of striped bass and white perch (subsections III.A, IV.A, and V.A), emphasis is placed on different aspects of the sampling program. Generally, juvenile tomcod are not abundant in the shore zone but inhabit deeper offshore areas. Beach seine data therefore, were less useful than they were for the other two species; epibenthic sled and bottom trawl data, however, became more important. Since most tomcod mature during their first year of life, this subsection describes the distribution of young tomcod of the 1977 year class through 15 November. The distribution of this year class as adults is discussed in subsection V.E.

1. Eggs

a. Distribution during 1977

Atlantic tomcod eggs were collected in ichthyoplankton (mostly epibenthic sled) samples from the beginning of sampling in late February until early April (Appendix Tables D-1 and D-2). Egg densities were highest between 21 February and 11 March in the West Point and Cornwall regions. As in previous years, ice precluded ichthyoplankton sampling during January through mid-February when most spawning probably occurred (subsection V.E).

b. Trends in Distribution (1976 and 1977)

The only years in which eggs were collected were 1976 and 1977, and eggs were taken over about the same period (late February to early April) during both years. During 1976, eggs were collected only in the Cornwall and West Point regions (TI 1979a); in 1977, however, a few were taken in the Yonkers through Indian Point regions (lower estuary).

c. Factors Affecting Distribution

The distribution of Atlantic tomcod eggs in the estuary is determined almost entirely by the location of spawning activity (subsection V.E). Although the eggs are not adhesive, they are dense. Therefore, currents should have little effect on egg distribution; they should remain near the spawning areas. Midwinter conditions prevailed in these areas; water temperatures ranged from about 1° to 5°C, and conductivity was low (less than 300 mS/cm).

2. Yolk-Sac and Post Yolk-Sac Larvae

a. Distribution during 1977

Yolk-sac and post yolk-sac larvae were collected during the first sampling period in late February (Figures V-3 and V-4). The standing crop of yolk-sac larvae was highest in early March (Appendix Tables D-3 and D-4) followed by peaks in the abundance of post yolk-sac larvae in late March and early April (Tables D-5 and D-6). A downriver shift in the geographic distribution of larvae occurred during this time span. Yolk-sac larvae were abundant in the middle estuary (West Point and Cornwall regions), but post yolk-sac larvae were most abundant downriver in the Yonkers and Tappan Zee regions. This shift was distinct and occurred in mid-March. Yolk-sac larvae were present in the study area (RM 14-76) until early April, and post yolk-sac larvae until late May.

b. Factors Affecting Distribution

The two overriding factors that determined the distribution of tomcod larvae were the distribution of eggs and the downriver displacement of larvae by runoff (i.e., freshwater flows) during March. The importance of runoff was illustrated in 1977 when 61% of the total standing crop of yolk-sac and post yolk-sac larvae occupied the West Point and Cornwall regions until the occurrence of a week of high freshwater discharge (14-20 March), after which 96% of the estimated standing crop occurred downriver in the Yonkers and Tappan Zee regions.

Since yolk-sac and/or post yolk-sac larvae are usually present in the estuary from March through May, they occur when water temperature is increasing rapidly (Appendix Tables D-7 and D-8). Densities greater than 250 yolk-sac or post yolk-sac larvae/1000 m^3 were estimated for areas in which water temperature ranged from 1.9° through 12.5°C. Conductivity in these areas ranged from 169 through 6733 mS/cm.

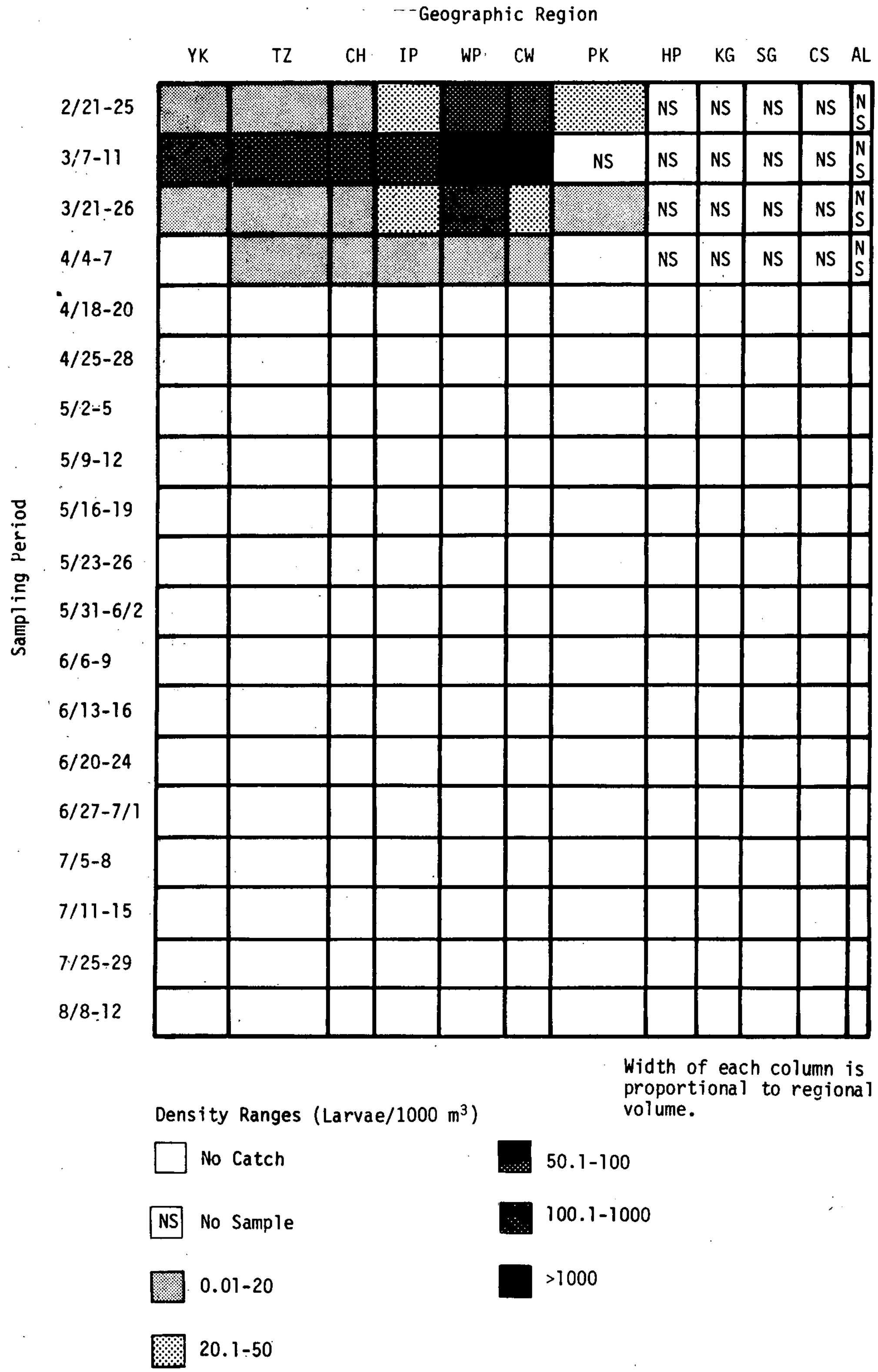


Figure V-3. Distribution Matrix of Atlantic Tomcod Yolk-Sac Larvae Collected during 1977 Ichthyoplankton Survey

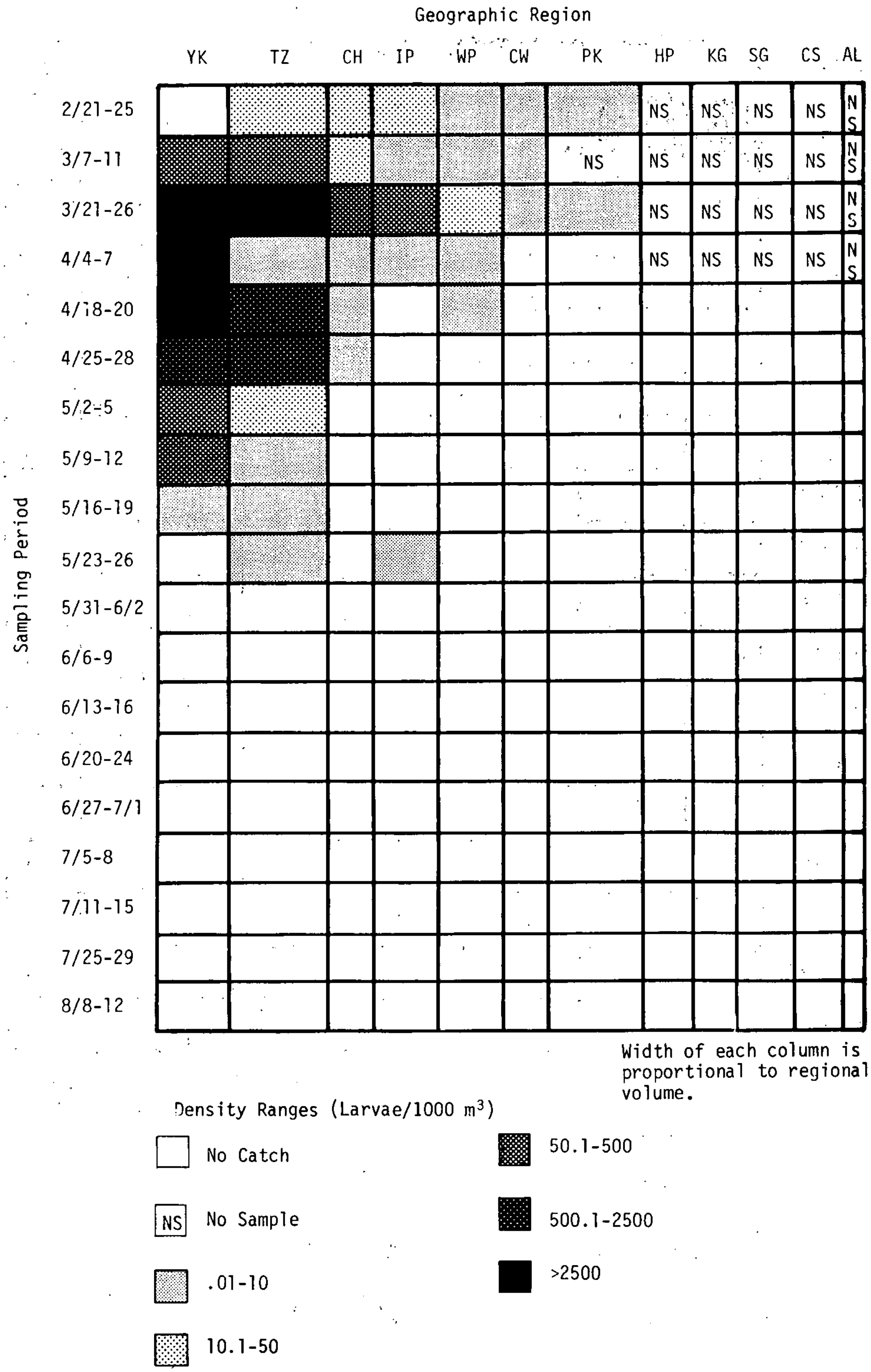


Figure V-4. Distribution Matrix of Atlantic Tomcod Post-Yolk-Sac Larvae Collected during 1977 Ichthyoplankton Survey

c. Trends in Distribution (1975-1977)

Patterns in the temporal index for yolk-sac larvae were consistent from 1975 through 1977. A sharp peak occurred in early March (Figure V-5). No tomcod larvae were collected in 1974 (TI 1975c). Temporal trends for post yolk-sac larvae were less consistent; a single early April peak appeared in 1975, and double peaks occurred in late March and mid to late April in 1976 and 1977 (Figure V-6).

Trends in geographic distribution (Figures V-7 and V-8) usually showed a preponderance of larvae in the three most downriver regions (Yonkers, Tappan Zee, Croton-Haverstraw) in 1975 and 1976. During 1977, yolk-sac larvae were most abundant in the West Point and Cornwall regions, which was not surprising since tomcod eggs presumably hatch near where they are spawned (subsection V.C.1). In 1975 and 1976, yolk-sac larvae were abundant downriver, probably because they were transported there by high flows during February. By the time that yolk-sac larvae had developed into post yolk-sac larvae, distributions during 1975, 1976, and 1977 were similar. During all 3 years, post yolk-sac larvae were most abundant in downriver regions, especially Yonkers and Tappan Zee.

3. Juveniles

a. Distribution during 1977

Atlantic tomcod juveniles were first collected during April in the Ichthyoplankton Survey and standing crops peaked in mid-May (Appendix Tables D-9 and D-10). Beach seine and bottom trawl catch per effort (C/f) were highest in early June (Appendix Tables D-11 and D-12) when most tomcod juveniles were recruited to these gears.

Juveniles were most abundant downriver in the Yonkers and/or Tappan Zee regions during May (Figure V-9), but catches increased in the Indian Point through Cornwall regions during June and July; more than 85% of the juvenile standing crop (Ichthyoplankton Survey) was consistently found in the Yonkers through West Point regions, especially in the deeper, offshore area. Because no sampling was conducted below RM 12, the proportion of the tomcod

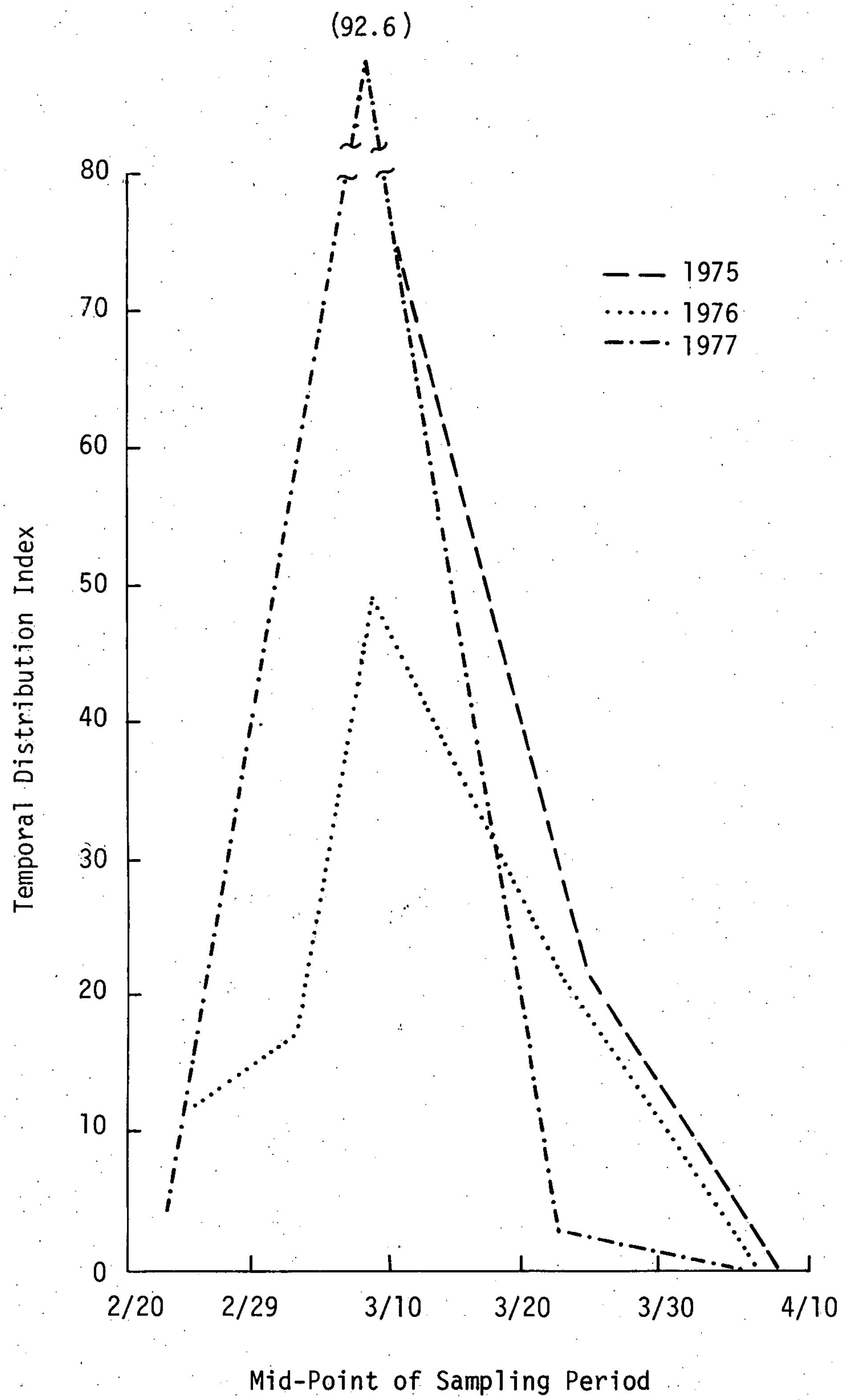


Figure V-5. Trends in Temporal Distribution of Atlantic Tomcod Yolk-Sac Larvae in Hudson River Estuary, 1975 through 1977

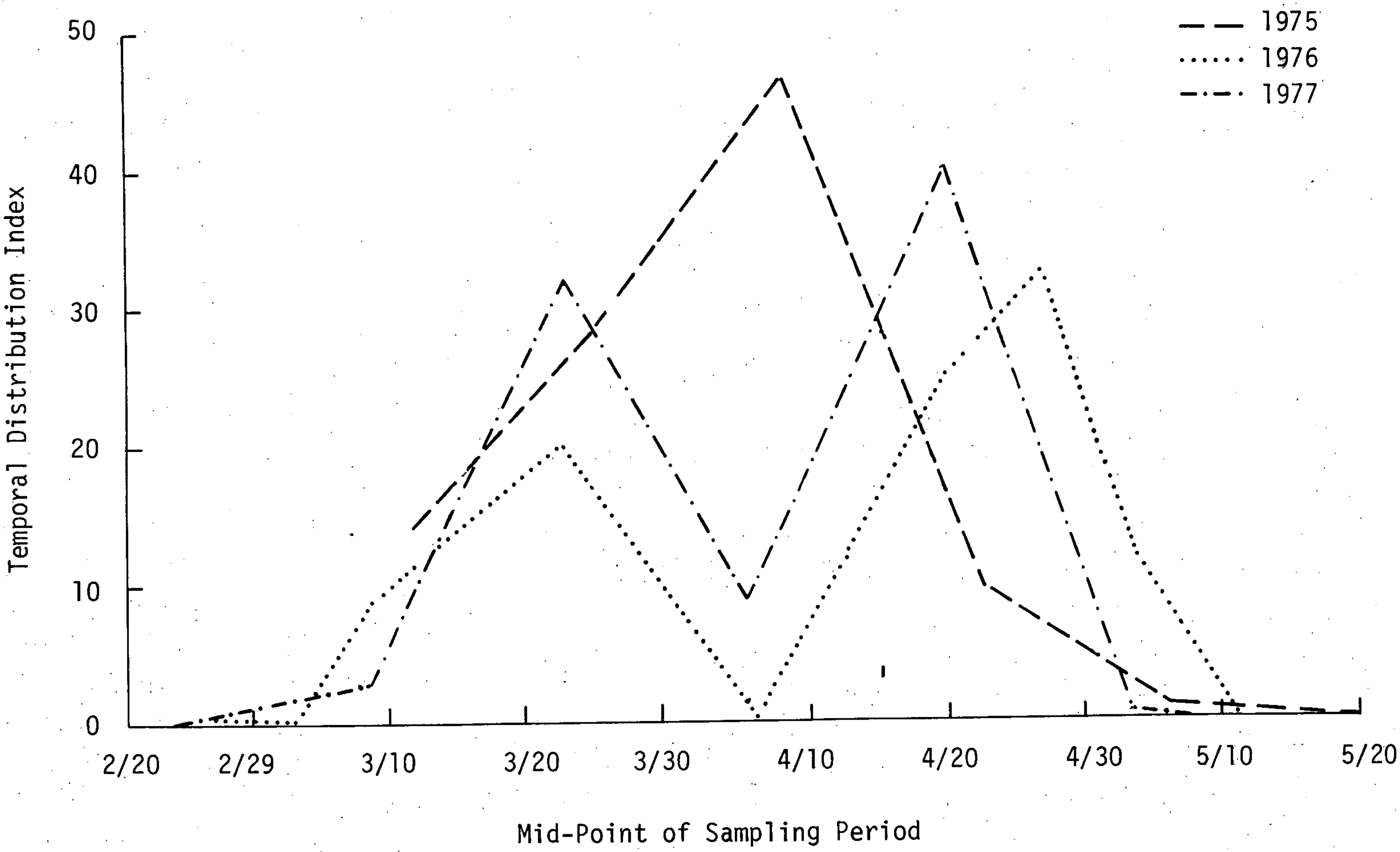


Figure V-6. Trends in Temporal Distribution of Atlantic Tomcod Post Yolk-Sac Larvae in Hudson River Estuary, 1975 through 1977

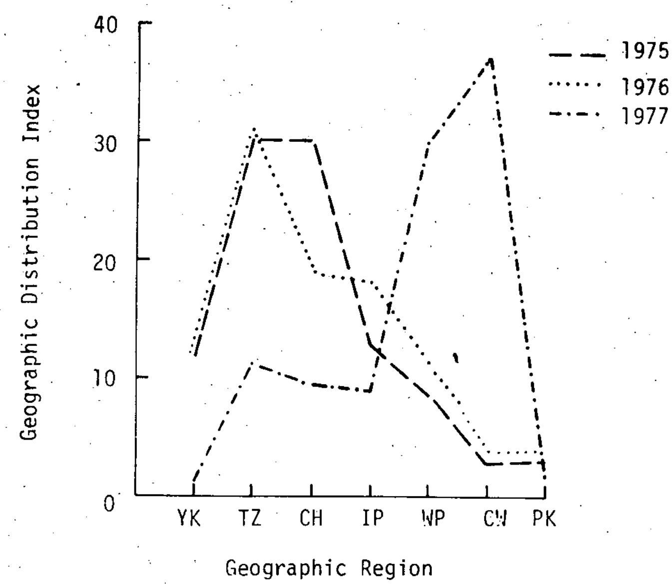


Figure V-7. Trends in Geographic Distribution of Atlantic Tomcod Yolk-Sac Larvae in Hudson River Estuary, 1975 through 1977

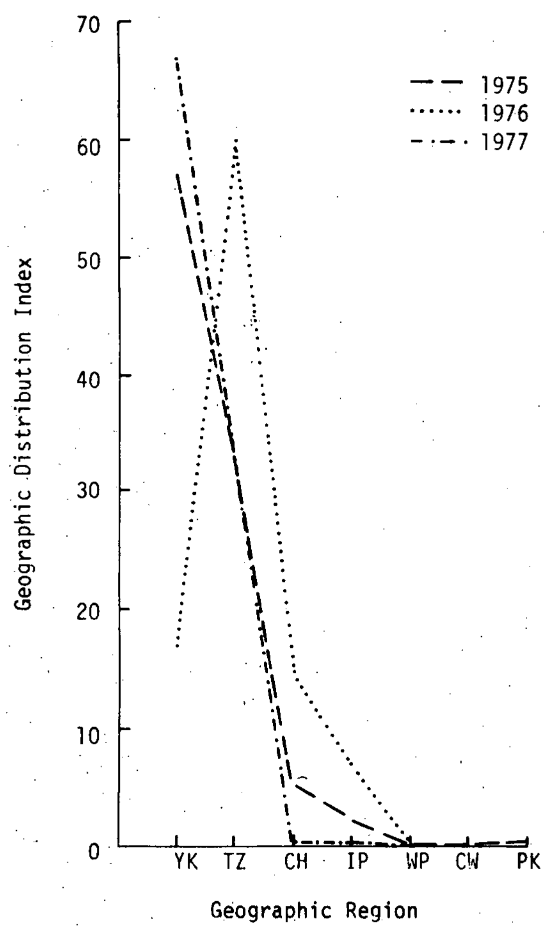


Figure V-8. Trends in Geographic Distribution of Atlantic Tomcod Post Yolk-Sac Larvae in Hudson River Estuary, 1975 through 1977

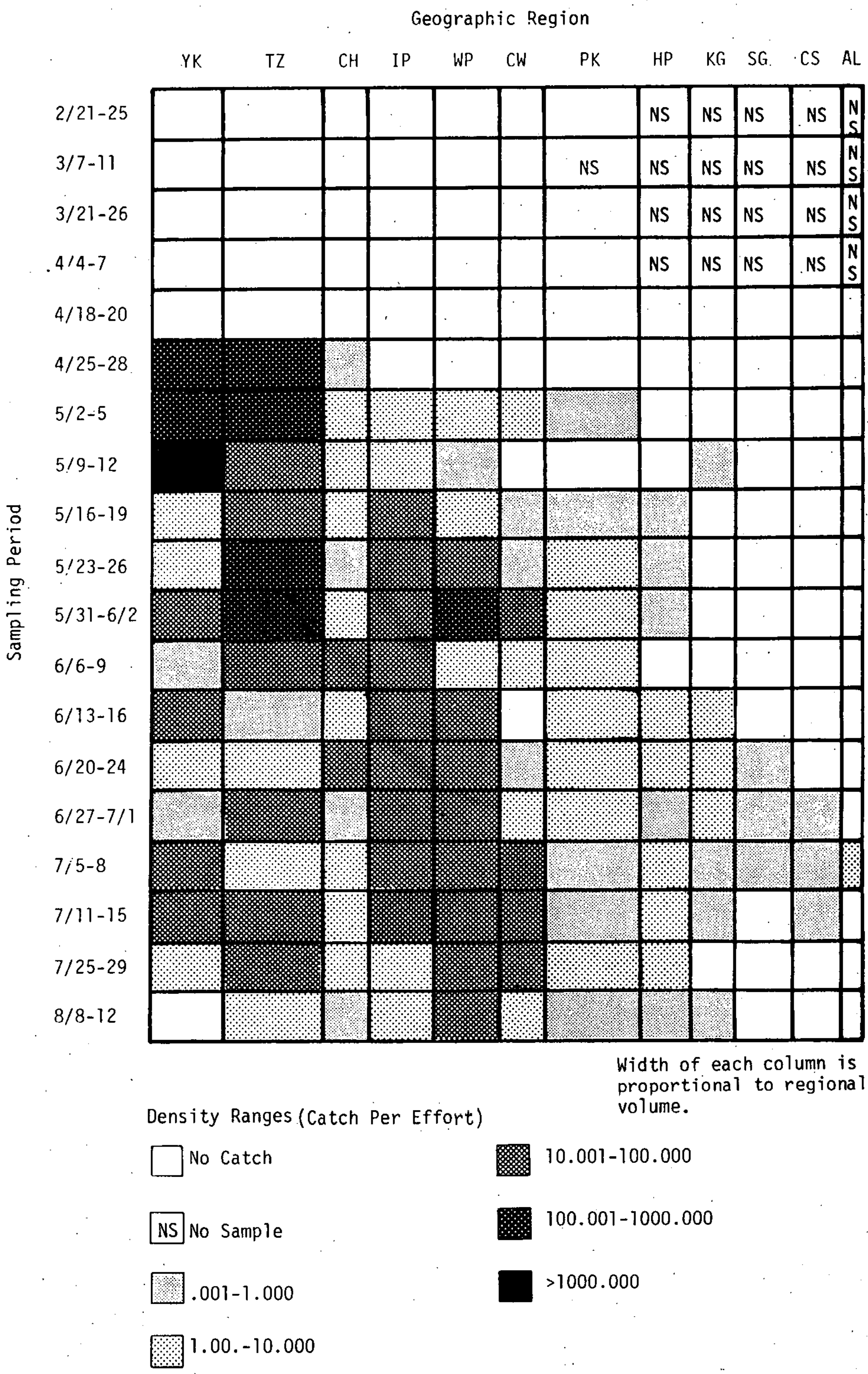


Figure V-9. Distribution Matrix of Juvenile Atlantic Tomcod Collected during Ichthyoplankton Survey population that may have moved in and out of the lower end of the study area is unknown. Other data indicate that tomcod juveniles occur below RM 12 (Dew and Hecht 1976, TI 1977a).

Standing crops and catch per effort declined precipitously after peaking from mid-May to mid-June (Figure V-10 and Appendix Tables B-9, B-11, and B-12).

b. Factors Affecting Distribution

Juvenile tomcod were abundant in regions of the lower estuary where conductivity was relatively high. During 1977, 87% of the juveniles and 60% of the Ichthyoplankton Survey samples which contained juvenile tomcod (Appendix Table D-15) were collected below the salt front (defined as 0.3 mS/cm). This association with the salt front was observed in earlier studies (TI 1975a, 1978a).

c. Trends in Distribution (1974 through 1977)

The temporal and geographic distribution of juveniles was fairly consistent from 1974 through 1977. The spring and summer temporal index peaked in May (Figure V-11), then declined gradually, with some fluctuation, through mid-August. Deep-water sampling during late summer and fall showed an extension of this trend inasmuch as index values were highest in mid-August when this sampling began; then, the index generally declined through mid-December (Figure V-12). During spring and early summer, most juveniles occupied the lower estuary (Figure V-13). Index values were highest in the Yonkers region in 1974, 1975, and 1977 and in the Tappan Zee region in 1976. During late summer and fall 1974, 1975, and 1977, juveniles were abundant in the Indian Point through Cornwall regions (Figure V-14).

Since the Atlantic tomcod is a bottom-dwelling species preferring relatively deep water (TI 1978a), they were scarce in the shore zone (Table D-13). Catch-per-effort values were significantly greater ($p>0.05$) in bottom trawl samples collected at depths exceeding 30 ft than in areas of less than

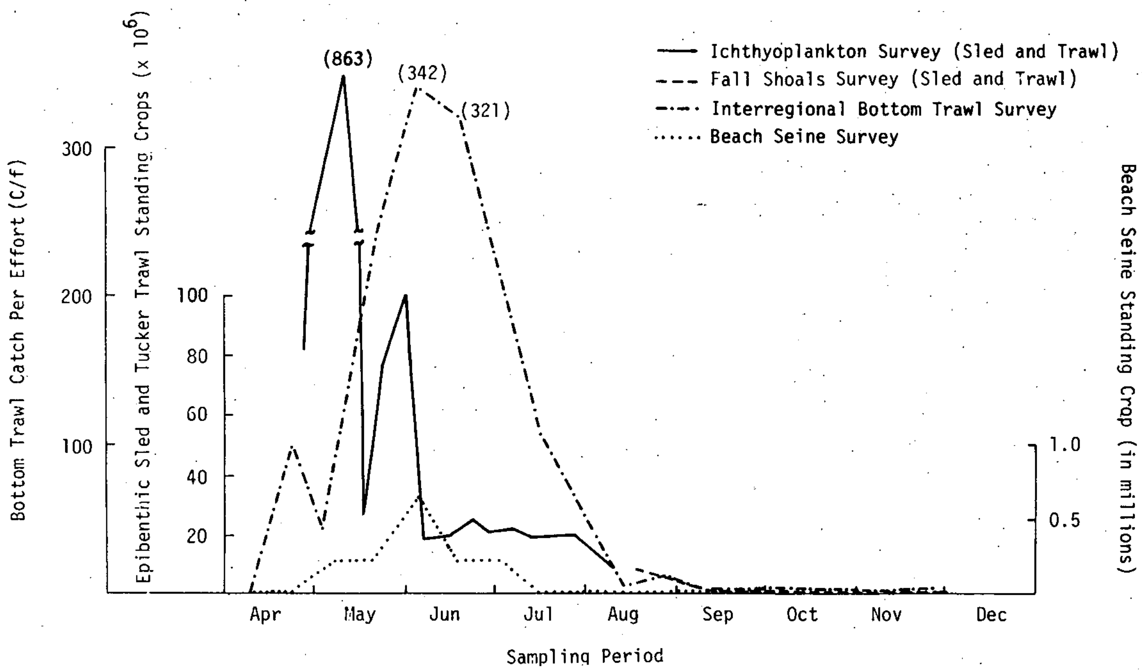


Figure V-10. Catch per Effort (C/f) by Bottom Trawl and Estimated Standing Crop from Ichthyoplankton Beach Seine, and Fall Shoal Surveys of Atlantic Tomcod Juveniles in Hudson River Estuary, 1977

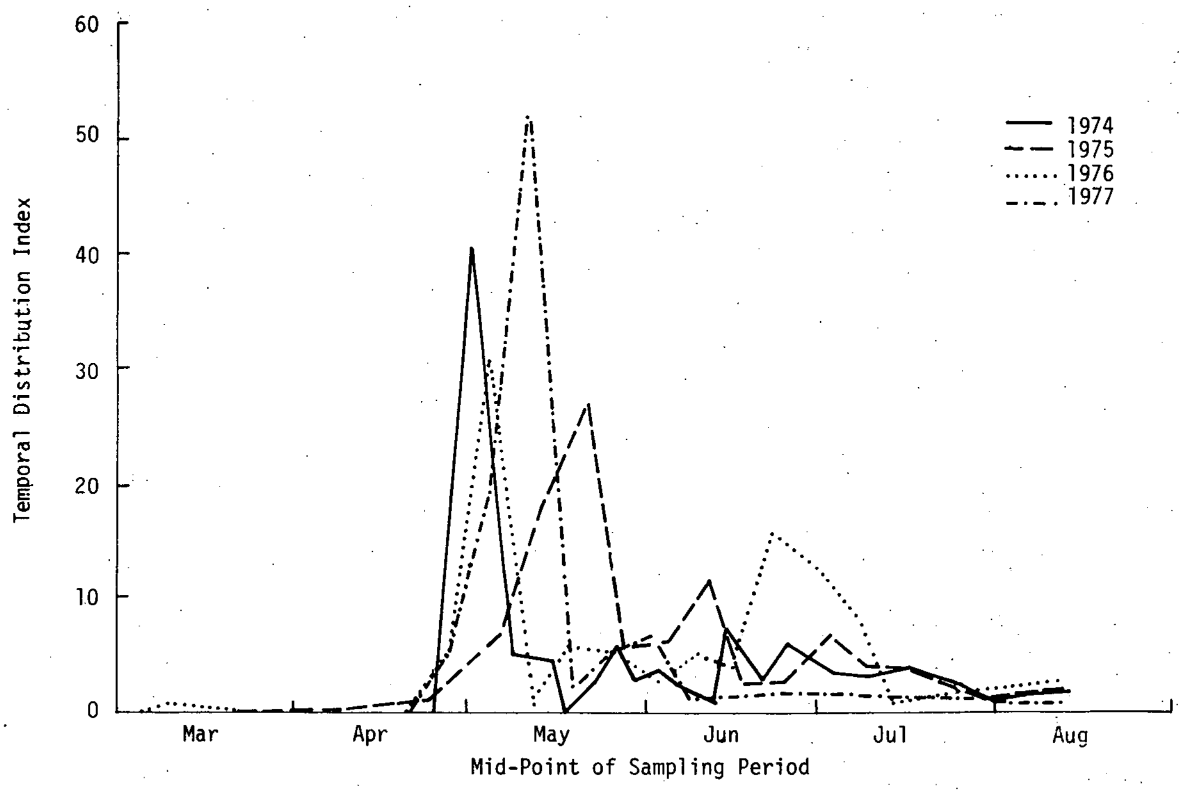


Figure V-11. Trends in Temporal Distribution of Juvenile Atlantic Tomcod in Hudson River Estuary Based on Ichthyoplankton Survey from March through Mid-August 1974-77

30 ft (Table D-16). The density of tomcod juveniles in the bottom stratum was usually greater than in the shoals or channel (Tables D-17 and D-18). Transect studies conducted by LMS near Bowline and Lovett (TI 1977a) and by TI near the proposed Cornwall site (TI 1978a) found significantly higher numbers of juveniles near the bottom than elsewhere.

In summary, conductivity, depth, and the tomcod's bottom-dwelling behavior are the major factors affecting the distribution of juvenile tomcod.

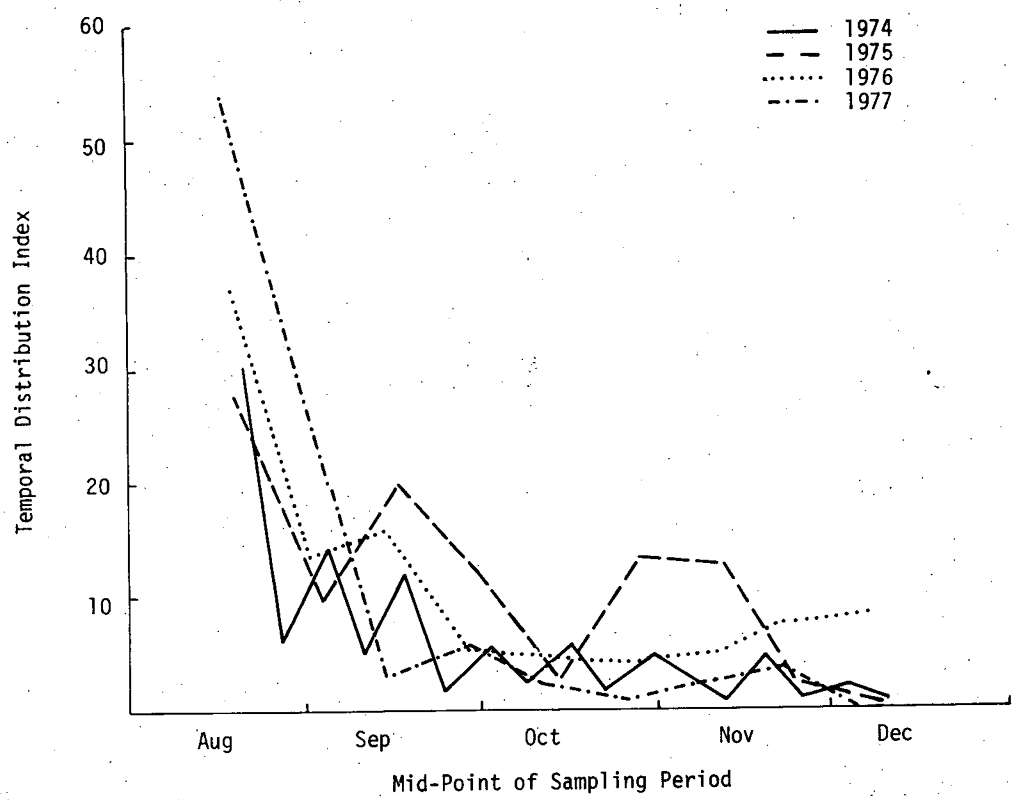


Figure V-12. Trends in Temporal Distribution of Juvenile Atlantic Tomcod in Hudson River Estuary Based on Fall Shoals Survey from Mid-August through Mid-December 1974-77

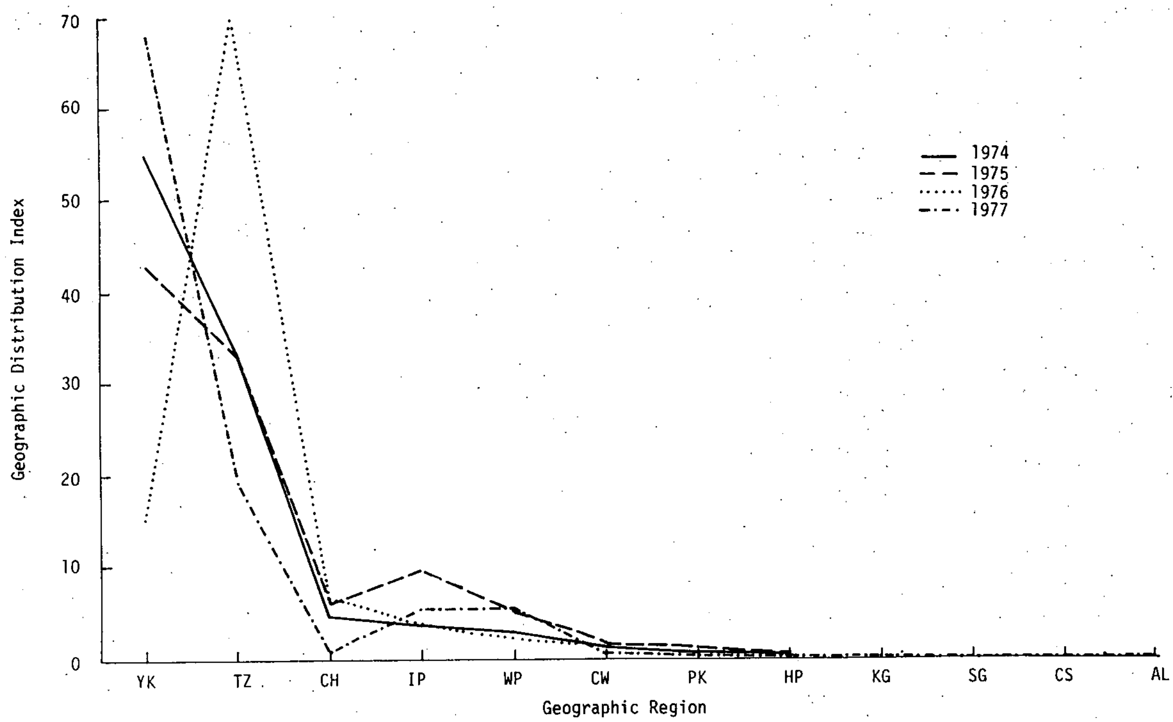


Figure V-13. Trends in Geographic Distribution of Juvenile Atlantic Tomcod in Hudson River Estuary Based on Ichthyoplankton Survey, 1974-77

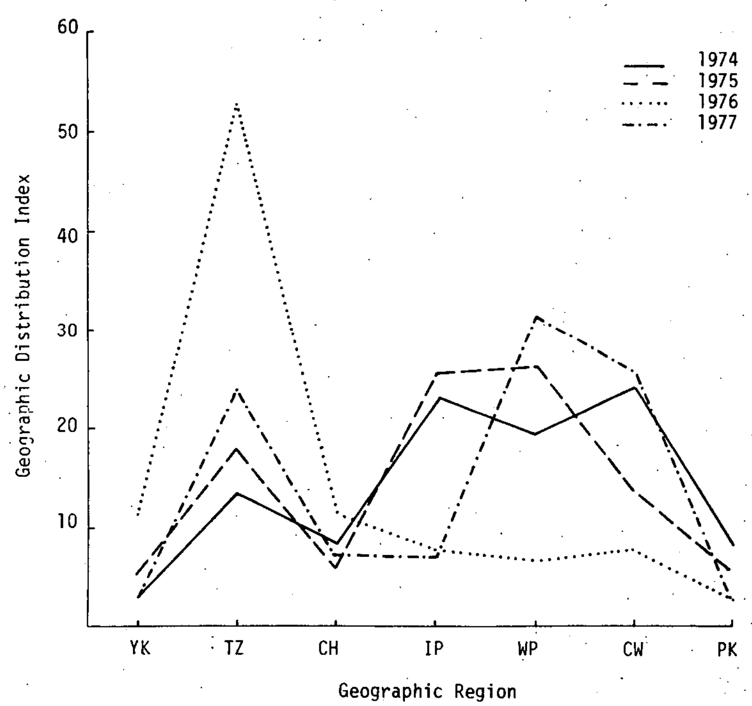


Figure V-14. Trends in Geographic Distribution of Juvenile Atlantic Tomcod in Hudson River Estuary Based on Fall Shoals Survey, 1974-77

D. YOUNG-OF-THE-YEAR CHARACTERISTICS

Young-of-the-year Atlantic tomcod are subject to entrainment and impingement at Hudson River power plants. Their anadromous life history affords some degree of protection by removing the population from the influence of the power plants over a portion of the year. However, to evaluate the effects of power plants on the year class and the entire Hudson River population, several biological parameters, (abundance, mortality, and growth of juvenile fish) must be examined.

The differences between Atlantic tomcod life history and the life histories of striped bass and white perch (e.g., winter vs spring and summer spawning, deep water vs shore zone habitat preference, and high salinity vs moderate salinity preference) limit the effectiveness of some of the sampling programs for obtaining adequate data on tomcod. Thus, sampling programs such as the Atlantic tomcod larval survey and winter box trap sampling have been designed specifically to overcome the problems of adequately sampling this species. The analyses presented in this subsection are based, at least partly, on these sampling programs; thus, the analytical methods are somewhat different from those used in subsections III.D and IV.D.

This subsection examines trends in annual abundance and environmental factors which affect it, mortality patterns during the first-year of life, and first-year growth and its relationship with the environment. Because of the habitat preferences of Atlantic tomcod, absolute abundance of the year class could not be adequately assessed until the winter spawning season; thus, absolute abundance is addressed in subsection V.E.

1. Abundance

a. Abundance Trends

Relative abundance indices for juveniles during 1969-1977 (excluding 1971) were developed from bottom trawl data collected in the Croton-Haverstraw and Indian Point regions during July, August, and September to assess fluctuations in year class strength. Although other regions were sampled only the Croton-Haverstraw and Indian Point regions were used because there was no sampling with bottom trawls downriver from the Croton-Haverstraw region during 1969-70 or upriver from Indian Point in 1972 (Table V-1).

Table V-1

Geographic Distribution of Bottom Trawl Sampling during July, August, and September 1969-77

Year	Geographic Region (River Miles)					
	YK (12-23)	TZ (24-33)	CH (34-38)	IP (39-46)	WP (47-55)	CW (56-61)
1969			*	*	*	
1970			*	*	*	
1971 †						
1972		*	*	*		
1973		*	*	*	*	*
1974	*	*	*	*	*	*
1975		*	*	*	*	*
1976		*	*	*	*	*
1977		*	*	*	*	*

*Regions sampled
†No sampling during 1971

The mean catch per tow was selected as the abundance index for each year. Catches in 1972 and 1973 were not directly comparable to other years because the trawls used in 1972-73 had cod ends (1.5-in. stretch mesh) without a smaller mesh liner or cover and, escapement through the net thus would have occurred. To adjust for this escapement, a monthly adjustment ratio was calculated for 1974-1977 when a cod-end cover (0.5 in. stretch mesh) was used (TI 1979a). The mean monthly ratios over all 4 years (Table D-22) were used to adjust the 1972 and 1973 catches. Adjustments for differences in tow duration and speed across years were not attempted as tow speeds were measured relative to the water; thus, distance traveled could not be calculated (TI 1977a).

The abundance index for juvenile tomcod (defined as mean catch per tow) fluctuated widely among years (Table V-2). The highest abundance index, 125.4 in 1970, was almost 14 times as large as the lowest, 9.2 in 1974, but there was no distinct trend of increasing or decreasing abundance. A

Friedman test and distribution-free multiple comparison analysis (Hollander and Wolfe 1973) indicated that the 1970 year class was significantly (α=0.05) more abundant than the 1973, 1974, and 1977 year classes. Other comparisons were not significant (Table D-23).

Table V-2

Juvenile Atlantic Tomcod Annual Abundance Indices (Catch per Tow) Based on Bottom Trawl Samples from Croton-Haverstraw and Indian Point Regions during July, August, and September

Year	Survey	Time Period	No. Tows	Abundance Index
1969	RAY	6/29-09/27	130	76.6
1970	RAY	6/28-09/26	176	125.4
1972	TI	7/03-09/25	98	26.1*
1973	TI	7/01-10/06	99	26.4*
1974	TI	6/29-10/04	80	9.2
1975	TI	7/13-10/04**	73	44.6
1976	TI	6/27-10/02	98	78.1
1977	TI	6/26-10/01	96	43.1

*Adjusted for trawl used without a fine mesh cod-end liner or a cover
**No sampling during the first half of July

The relationship between juvenile abundance measured by the index and actual year class strength is still not entirely clear. Although the timing of spawning (winter) and transformation to the juvenile stage (spring) suggest that year class strength would largely be determined by July, the shifting distribution of the juveniles (subsection V.C) made the fraction of the population available to a fixed region index extremely variable. Thus, years of high abundance in the Croton-Haverstraw and Indian Point regions may reflect distribution as well as population size. However, since the effects of distribution and abundance cannot at this point be distinguished, changes in the abundance index will be assumed to be primarily caused by real changes in abundance.

b. Factors Affecting Juvenile Abundance

Environmental factors affecting juvenile abundance in late summer were examined through correlation and multiple linear regression (MLR) analysis. Environmental factors which had the highest correlation with juvenile abundance in post analyses (TI 1979a) were reexamined with the 1977 data included (Table V-3). The highest correlates were then analyzed with MLR to build predictive models, and both additive and multiplicative effects models were tested.

Variables were included in the MLR model sequentially based on the simple correlation coefficients. The independent variable with the highest correlation was selected first, then the second highest, then the third. Complex models with more than three independent variables were not attempted because only 8 years of abundance data were available. January freshwater flow was not used in the MLR because it was highly correlated with December freshwater flow (Table D-24). Only single-variable models with December freshwater flow as the independent variable were statistically significant at $\alpha=0.05$ (Table V-4). The multiplicative model produced a slightly higher R^2 value than the additive model. The predictive equation produced was:

$$\ell n(ATC) = 25.061 - 2.176\ \ell n(X)$$

where

ATC = juvenile Atlantic tomcod abundance index
X = December freshwater flow

Examination of the deviations from predicted values for the 1969-1977 data revealed no temporal trend in the sign of the deviations (Table V-5). If the population had been declining during this time, deviations in earlier years would have tended to be positive (i.e., higher than predicted values) and in later years to be negative.

The relatively large deviations from predicted values were undoubtedly due to the low predictive power of a single-variable model and to sampling error inherent in the late summer abundance index. The variable distribution of the tomcod over the summer months because of shifts in the position of the salt front suggests that the accuracy of the fixed-area (Croton-Haverstraw and Indian Point regions) bottom trawl index may vary substantially among years.

Table V-3

Data Used in Analyses To Determine Environmental Factors Affecting Annual Abundance of Juvenile Atlantic Tomcod

Year	Juvenile Atlantic Tomcod Abundance Index	Mean Monthly Freshwater Flow (ft^3/sec) December*	January	Mean February Temperature (°C)	Juvenile Bluefish Abundance	Power Plant Maximum Withdrawal Capacity ($10^3 m^3/d$)
1969	76.62	15597	11683	1.59	0.08	5183
1970	125.40	11801	8206	1.14	0.77	5183
1972	26.06	16998	13412	0.63	3.81	5183
1973	26.41	27010	26213	0.60	3.05	12019
1974	9.24	26419	22010	0.80	9.16	14113
1975	44.64	19381	19068	1.20	4.36	15873
1976	78.09	18784	14739	1.19	5.39	20616
1977	43.14	14078	7956	0.71	5.06	20616

* of previous year

Table V-4

Multiple Linear Regression Models of Factors Affecting Juvenile Atlantic Tomcod Abundance

Number of Independent Variables	Model* Type	Independent Variables X_1	X_2	X_3	R^2	F	df	P
1	Additive	Dec Flow			0.52	6.52	1 6	<0.05
	Multiplicative	Dec Flow			0.59	8.56	1 6	<0.05
2	Additive	Dec Flow	Bluefish		0.62	4.04	2 5	<0.10
	Multiplicative	Dec Flow	Bluefish		0.65	4.65	2 5	<0.10
3	Additive	Dec Flow	Bluefish	Feb Temp	0.70	3.18	3 4	>0.10
	Multiplicative	Dec Flow	Bluefish	Power Plant Capacity	0.72	3.50	3 4	>0.10

*Additive models are of the form $y = A + Bx_1 + Cx_2 + \ldots$
Multiplicative models are of the form $\ell n\ y = A + B\ell n x_1 + C\ell n x_2 + \ldots$

Table V-5

Comparison of Observed and Predicted Atlantic Tomcod Indices

Year	Atlantic Tomcod Abundance Index	Predicted Abundance* from ℓn Dec Flow	Deviation
1969	76.62	57.51	19.11
1970	125.40	105.53	19.87
1972	26.06	47.70	-21.64
1973	26.41	17.41	9.00
1974	9.24	18.27	- 9.03
1975	44.64	35.85	8.79
1976	78.09	38.38	39.71
1977	43.14	71.88	-28.74

*Predicted from the equation ℓn (Atlantic tomcod abundance index) = 25.061-2.176 ℓn (December freshwater flow) from 1969-1977 data.

The relationship between late summer juvenile abundance and freshwater flow in December may act through control of the location of spawning. Atlantic tomcod seem to spawn primarily above the salt front (TI 1979a); thus, in years of high freshwater flow in the winter, spawning may occur farther downriver in areas that are less than optimal for tomcod survival. The importance of salinity in determining spawning location may be due to its influence on sperm motility (Booth 1967); therefore, successful spawning occurs within a relatively narrow range of salinity. Booth suggested that the proper salinities were found by seeking out microhabitats (small areas where dilution from melting snow or ice lowers salinity) within areas of higher than optimal salinity. Suitable microhabitats may only occur in a limited area of the Hudson River, depending on the salt front position.

Ichthyoplankton sampling is not possible during December and January, so the location of major spawning grounds (1974-1977) have been inferred from the collection of ripe adults in box traps (catch per hour). In 1974, catches were unusually high in the Indian Point region (Table V-6), in 1975-1977, most spawning adults were caught in the West Point and Cornwall

Table V-6

Box Trap Regional Catch per Hour of Atlantic Tomcod in Hudson River Estuary, January 1974-77

Year	Date	REGION CH	IP	WP	CW	PK
1974	1/ 1-1/ 5	NE	18.8	NE	2.7	NE
	1/ 6-1/12	NE	11.9	5.4	2.5	NE
	1/13-1/19	0.0	8.1	15.4	0.7	NE
	1/20-1/26	0.2	9.1	2.2	0.2	NE
1975	1/ 1-1/ 4	0.2	1.2	9.1	8.8	0.1
	1/ 5-1/11	<0.1	0.4	8.5	9.5	0.2
	1/12-1/18	0.1	0.1	7.4	0.4	0.1
	1/19-1/25	<0.1	0.1	2.3	0.1	0.1
	1/26-2/ 1	0.1	0.2	2.4	< 0.1	0.1
1976	1/ 1-1/ 3	4.4	1.1	19.0	7.5	0.1
	1/ 4-1/10	2.6	0.3	23.3	3.9	<0.1
	1/11-1/17	1.8	0.7	15.4	2.7	<0.1
	1/18-1/24	1.2	0.4	7.2	0.4	<0.1
	1/25-1/31	0.2	0.1	3.6	0.1	<0.1
1977	1/ 2-1/ 8	5.6	0.2	10.4	2.2	3.0
	1/ 9-1/15	3.7	0.1	8.4	NE	3.4
	1/16-1/22	1.7	0.2	5.0	0.4	3.2
	1/23-1/29	0.3	0.1	1.6	NE	1.0

NE = No effort

regions. Although a mechanism was not readily apparent, downriver shift in spawning activity in 1974 may have contributed to the low abundance of juveniles later in the summer. In years in which spawning occurred farther upriver (1975-77), juveniles were more abundant in late summer.

The multiplicative model with December flow accounted for only 59% of the variation in the observed values of juvenile Atlantic tomcod abundance; hence, much variation remains to be explained by fluctuation in other environmental variables which may influence either abundance or the measurement of abundance. It is improbable that one variable alone controls the success or failure of a year class (Ricker 1975). In future years, other controlling factors may emerge.

2. Mortality

Mortality in early life stages may determine relative year class strength in Atlantic tomcod as in many other fish species. As tomcod are almost semelparous (i.e., spawn only once) in the Hudson River, the strength of any year class largely determines the number of spawners which produce the following year class. Thus, first-year mortality is reflected immediately in the size of the spawning stock. This subsection describes temporal patterns in mortality and estimates total annual mortality for young-of-the-year Atlantic tomcod in 1975-77.

a. Methods

Mortality rates were calculated from a combination of mark-recapture and density extrapolation methods for estimating population sizes. The initial and final points of the mortality time interval calculated for each of 3 years (1975, 1976, 1977) were taken from mark-recapture estimates of population size during the spawning season. Mark-recapture estimates of spawning stock size (subsection V.E.6), sex ratios (V.E.2), and mean fecundity estimates (V.E.5) were combined to provide an estimate of egg deposition, i.e., the initial population size of each year class ($\hat{E}$). Standing crops from ichthyoplankton surveys were used to estimate the size of the year class through the spring and summer months. The mark-recapture estimate for the size of the next spawning population and the age composition of that population (V.E.6) provided the final population size for each year class at the end of its first year of life ($\hat{P}$).

A linear regression model was used to delineate periods (phases) of constant instantaneous mortality:

$$\ln N_t = a + \beta(t)$$

where

N_t = estimated population size at time t
a = value of regression line at time t=0
β = instantaneous mortality rate
t = Julian date

Instantaneous mortality rates for each phase (period of constant instantaneous rate) were then converted to total mortality rates by the equation:

$$A = 1-e^{-\beta T}$$

where

A = total mortality rate for the phase

β = instantaneous mortality rate for the phase

T = duration of the phase in days

Phase durations were determined from the point at which two of the linear regression lines intersected. Total annual mortality for each year was then calculated by:

$$A_t = 1 - (1-A_1)\ (1-A_2)\ldots$$

where

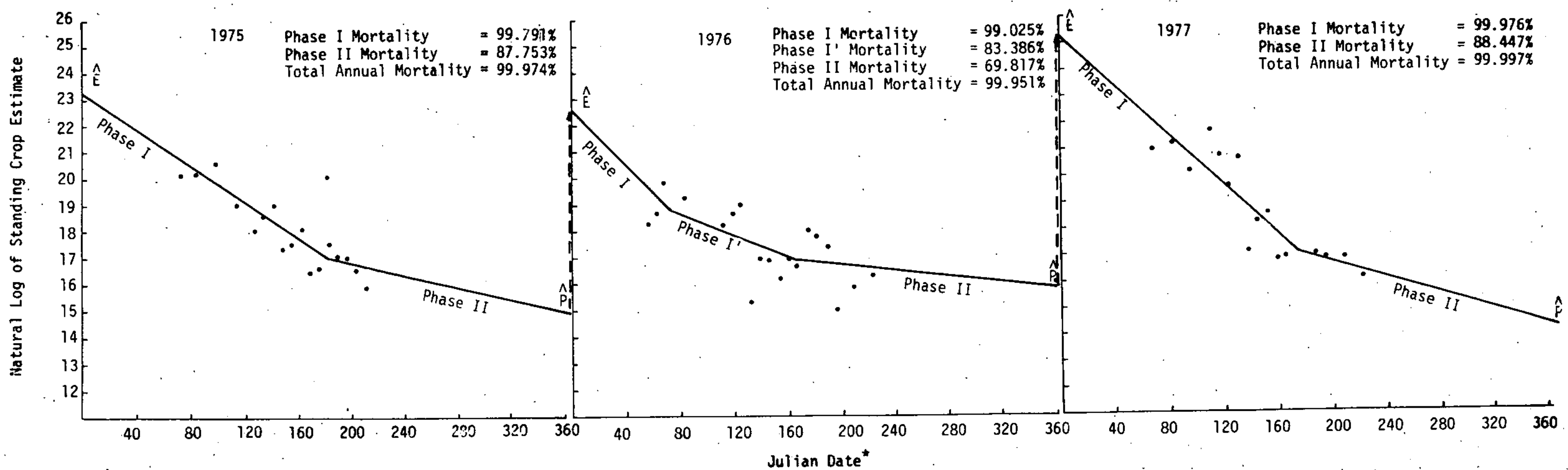
A_t = total annual mortality

$A_1, A_2, \ldots$ = total mortality rate for each phase

b. Results and Discussion

Total annual mortality of tomcod during their first year ranged from a high of 99.997% in 1977 to a low of 99.951% in 1976 (Figure V-15). Although these differences in total annual mortality seem small, they represent a 16-fold difference in the fraction of tomcod which survived through the end of the first year. The slopes of the regression lines are determined, to a great extent, by the egg deposition estimate ($\hat{E}$) and the number of age 0 spawners ($\hat{P}$). Thus, the total annual mortality rate is largely independent of the ichthyoplankton density extrapolation estimates.

Ichthyoplankton data are more important in determining the phase mortality rates, the accuracy of which depends on the ability of the ichthyoplankton sampling program to sample the entire tomcod population. Since varying and unknown portions of the juvenile population lie within the sampling area throughout the year, each weekly standing crop is potentially biased low by an unknown amount. If a large part of the population remains outside the sampling area, phase I mortality will be biased high and phase II mortality biased low (phases I and II mortality rates will always have opposite biases). However, the total annual mortality estimate is controlled primarily by the values of $\hat{E}$ and $\hat{P}$ and would not be seriously affected by biases in the phase mortality rates.



*Julian Date 40 = 9 February, 120 = 30 April, 200 = 19 July, 280 = 7 October, 360 = 26 December.

Figure V-15. Total Mortality (by Phase and Annually) for Young-of-the-Year Atlantic Tomcod in Hudson River Estuary, 1975-77

In all 3 years, mortality was extremely high through Julian day 120 but declined substantially after day 160 (mid-June) (Figure V-15). In 1976, the change in mortality was apparently more gradual; also, a period of intermediate mortality (phase I) could be identified. As in many other fish species, most first-year mortality occurs during the egg and larval stages; lower mortality occurs after transformation to the juvenile stage. The variability of the standing crop estimates due to the distributional changes in the population (discussed earlier in this section) makes selection of precise phase durations highly subjective; thus, apparent differences in the lengths of the phases among years cannot be analyzed further.

The 3 years of data (1975-1977) suggest that tomcod mortality during the first year of life may be density-dependent. The egg deposition estimates ($\hat{E}$) and total annual mortality appear to be positively related (Figure V-16). Estimates of egg deposition ($\hat{E}$) were similar in 1975 and 1976 and highest in 1977. Total annual mortality was also highest in 1977. No statistical analysis of factors affecting annual mortality was attempted since only three mortality estimates are currently available.

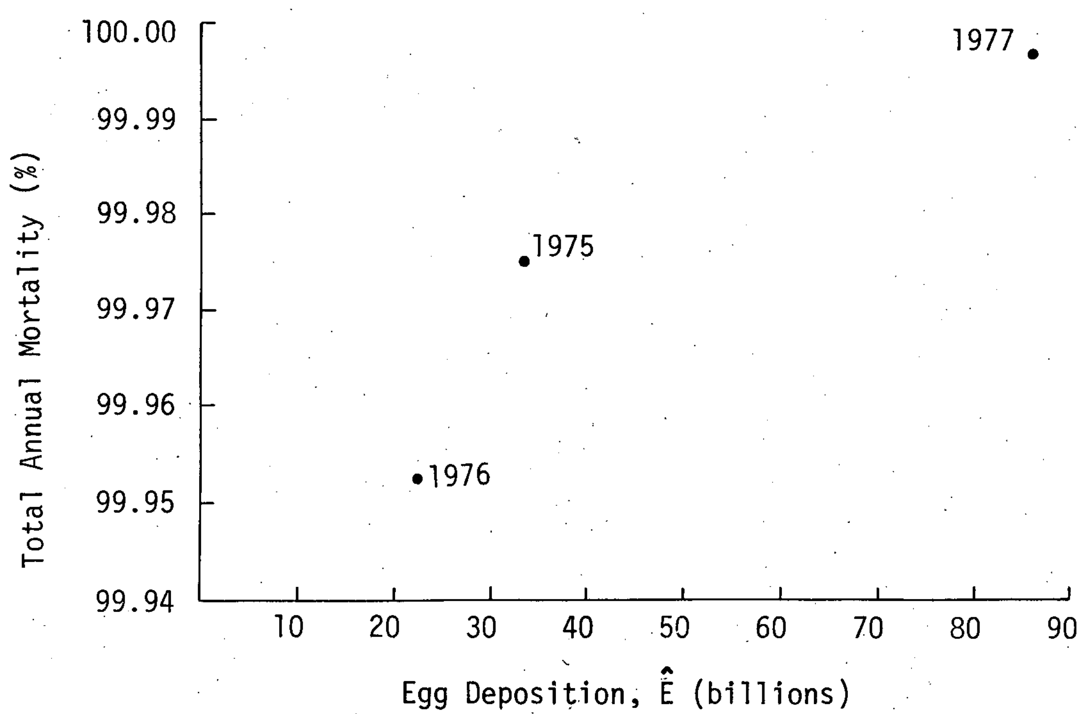


Figure V-16. Relationship between Egg Deposition and Total Annual Mortality for Juvenile Atlantic Tomcod

3. Growth

Atlantic tomcod grow from eggs to mature adults during the first year of life; therefore, first-year growth is extremely important from a population viewpoint. Fecundity and possibly egg viability are directly related to fish size (subsection V.E), so poor growth of juveniles in one year will directly affect the potential number of juveniles the following year. As growth and mortality are often closely related in fish populations, analyses of factors which affect growth can provide insight into factors which affect mortality. This subsection examines the pattern of growth of juvenile Atlantic tomcod in 1977 and explores factors which control first-year growth.

a. Growth Patterns

Atlantic tomcod exhibit two distinct periods of growth in their first year: the first extends from hatching until approximately early July when water temperatures exceed 25°C (TI 1979a); the second, which is typical of the growth of sexually maturing fish as the spawning season approaches, runs from September through December, during which energy available for growth is diverted from somatic growth to gonad growth (Jones and Johnston 1977). These two periods make analysis of first-year growth of Atlantic tomcod much more complex than that of most other fish species.

1) Methods

Mean lengths and weights of juvenile Atlantic tomcod collected in bottom trawls from early May through November were plotted as a function of time, and growth curves were fitted visually. Information on growth before May is lacking since Atlantic tomcod caught during ichthyoplankton sampling were not measured. Instantaneous growth rates (weight) were estimated from the rate of change in the natural logarithms of weights selected from the curves at approximately 10-day intervals. Changes in the instantaneous growth rate (weight) indicate sexual maturity inasmuch as gonads increase in size faster than the body.

2) Results and Discussion

The growth pattern for the 1977 year class (based on changes in mean length and weight) contained the two distinct growth periods (Figure V-17) described previously: the first ended in early July when the juveniles were approximately 70 mm in total length (TL) (the shape of the growth curve before May could not be determined); in mid-September, growth resumed and continued until the fish were approximately 150 mm by the end of November. Changes in mean weight followed a similar pattern, but instantaneous growth rate declined after mid-October, even though the fish were still growing rapidly. This was probably due to the initiation of gonadal maturation in October (subsection V.E). If the gonads contain more energy per gram than body tissue (as hypothesized by Jones and Johnston 1977 for other gadids), then a shift to production of gonadal tissue would cause a decline in instantaneous growth in weight. The patterns of growth and instantaneous growth rate (G) for the 1977 year class were similar to those of the previous year classes of 1974-76 (TI 1979a).

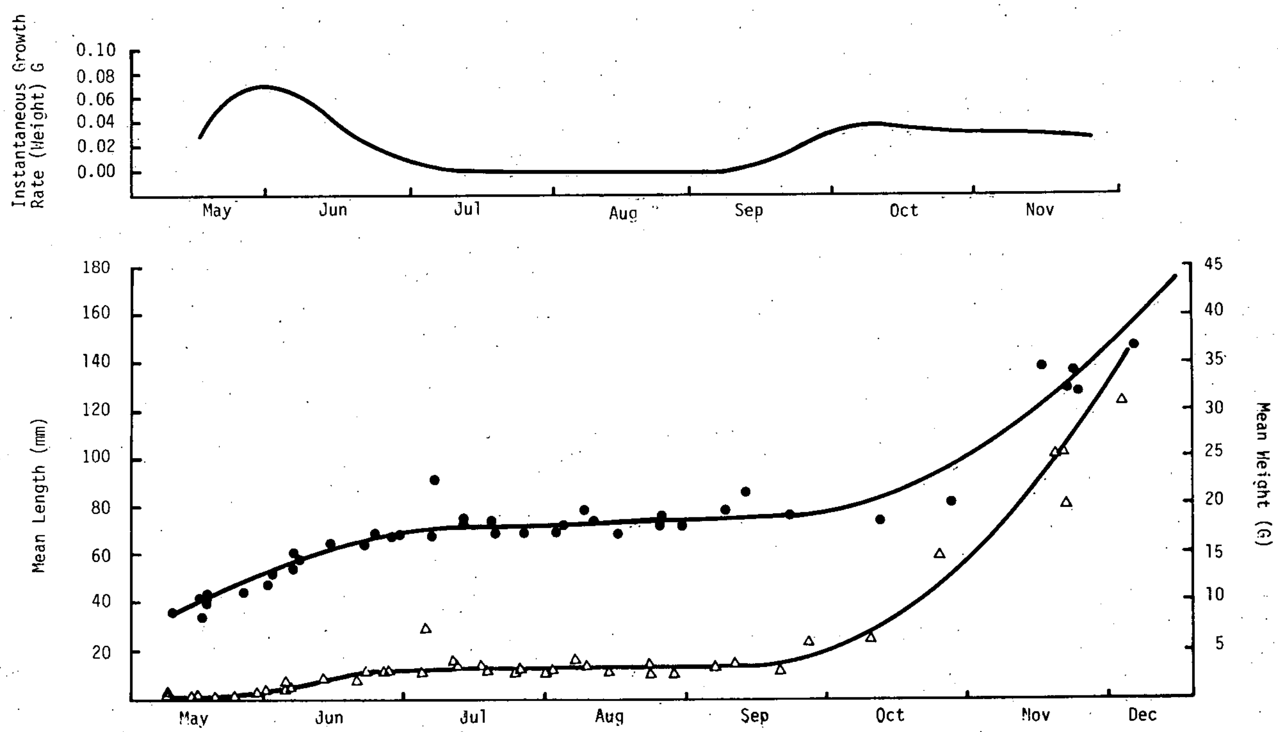


Figure V-17. Mean Length (●), Weight (x), and Instantaneous Growth Rate for Juvenile Atlantic Tomcod in Hudson River Estuary in 1977 Based on Bottom Trawl Samples

Mean lengths of juvenile tomcod at the end of November have varied less than 20 mm since 1974 (134 mm in 1974, 143 mm in 1975, and 140 mm in both 1976 and 1977). Thus, environmental factors which may accelerate or retard growth during the earlier life stages appear to have little effect on the mean length attained by the juvenile population at the end of their first year of life. The extremely rapid growth exhibited by tomcod during the high growth periods suggests that tomcod have the potential to compensate for periods of slow growth in early life stages.

b. Factors Affecting Growth

Factors affecting Atlantic tomcod growth can be assessed only within the bounds of the available data, i.e., bottom trawl surveys from 1969 through 1977 (excluding 1971). Since tomcod were not readily caught in bottom trawls until late May of most years, little is known about growth patterns or the most critical times for growth during the first growth period (before 1 July). Thus, growth during the first growth period, which is the cumulative result of environmental conditions since January, can be assessed only through length attained at the end of the period. As a result, environmental factors can be examined only on a broad scale.

Analysis of growth during the second period (September-December) would only be appropriate based on weights since growth in weight and gonadal maturation are the more important aspects of growth at this time. Since weights were not available for the early years (1969-70), no analysis of factors affecting growth in the fall was attempted.

1) Methods

The mean length of the juvenile population on 1 July was selected as the annual index of early growth for this analysis; since 1 July is approximately the end of the first growth phase, the index should be a good measure of growth during the first growth period. The estimated length was derived from an eye-fitted growth curve based on mean lengths of juvenile tomcod caught in bottom trawls from May through November. Data from 1972 and 1973 were excluded from these analyses because the difference in mesh size (subsection V.D.1), which biased numbers caught, would also have produced a bias in mean length by allowing the smallest fish to escape through the mesh. In fact, mean lengths based on bottom trawl samples for these 2 years were much greater than in all other years (85 mm and 83 mm), so their exclusion is justified.

Simple linear correlations of the growth index with freshwater flow and temperature factors were used rather than the multivariate analyses used for striped bass and white perch (subsections III.D.3 and IV.D.3). Simple correlations were most appropriate since the small number of observations (six) was not well suited to multivariate methods.

Since data were not available to identify particularly critical times for growth during the first period (January-June), factors were averaged over the months of January-March and April-June to determine whether early or later conditions were more important. Previous analyses (TI 1979a) suggested that mean monthly temperature and freshwater flows over these periods may influence growth; thus, these same factors were examined (Table V-7).

2) Results and Discussion

No significant relationships between water temperature or freshwater flow and juvenile tomcod growth could be found (Table V-8). The relationships previously described (TI 1979a) between tomcod growth and both April-June freshwater flow (partial correlation of 0.51) and January-March water temperature (partial correlation of -0.52) appear to be exclusively a result of the large mean sizes for the 1972 and 1973 year classes (TI 1979a). When these values were removed from the analysis, the relationships (previously described) disappeared entirely.

It is apparent from the results of this excercise that the presently available data base on juvenile Atlantic tomcod growth is not sufficient, either in number of comparable years available or extent of average in early spring, to identify the important factors in the complex relationship between growth and various environmental variables.

Table V-7

Factors Used in Correlation Analysis To Determine Effects on First-Phase Growth of Atlantic Tomcod

Year	Jul 1 Length	Mean Freshwater Flow (cfs) Jan-Mar	Mean Freshwater Flow (cfs) Apr-Jun	Mean Temperature (°C) Jan-Mar	Mean Temperature (°C) Apr-Jun
1969	77	14011	23847	1.56	14.58
1970	78	12784	20032	1.38	14.51
1972	85*				
1973	83*				
1974	76	20521	20666	1.70	13.75
1975	73	20752	19524	2.06	14.23
1976	78	25776	27969	1.83	13.81
1977	71	20237	21246	1.34	14.47

* Not used in correlation analysis

Table V-8

Correlation of Mean Length of Atlantic Tomcod on July 1 with Environmental Factors

Environmental Factor	Correlation Coefficient(r)	Probability Level
Jan-Mar Flow	-0.27	>0.05
Apr-Jun Flow	0.36	>0.05
Jan-Mar Temp	-0.04	>0.05
Apr-Jun Temp	-0.15	>0.05

E. STOCK CHARACTERISTICS

1. Distribution and Movements of Spawning Adults

Atlantic tomcod are considered to be anadromous (Scott and Crossman 1973) and, like the striped bass (subsection III.B.1), ascend estuaries to spawn in fresh water. The migration and distribution of spawning adults in the Hudson River were studied to determine the timing and location of spawning and to delineate the geographic range of tomcod originating in the Hudson River.

Most of the Atlantic tomcod in the December 1977-February 1978 spawning population (hereafter designated as 1977-78) were from the 1977 year class, were 11 to 13 months old (referred to as age I), and matured during October and November (subsection V.E.5). While maturing during fall 1977, they occupied the estuary from the Poughkeepsie region (RM 62-76) downriver through the Yonkers region (RM 12-23) and possibly beyond. Tomcod moved from their fall habitat to spawn near or above the salt front, then migrated downriver after spawning. These movements during 1977 and early 1978 were evident from both the catch by box traps set near the shoreline (see Appendix A for field and laboratory methods) and the recaptures of marked tomcod.

Tomcod appeared to have spawned in the shore zone and shoals of much of the river between RM 18 and RM 85, as shown by box trap collections during November 1977-February 1978 (Figure V-18). Catch per hour (Figure V-19) was less than in previous years, coinciding with a low estimate of the spawning population size for the 1977 year class (from mark-recapture methods in subsection V.E.6) and the late summer abundance indices (subsection V.D.1). The 1977-78 spatial distribution of catch also differed from that of previous years. While the catch-per-hour was lower during 1977-78 than during previous years in most river regions, the Tappan Zee region (RM 25-29) did not exhibit a similar reduction in catch; but appeared to hold a greater proportion of the population than in previous years. After sampling five year classes (1973-77), it has been observed that the distribution of spawning fish has varied somewhat from year to year and that the center of distribution has most often been in the vicinity of the West Point region (RM 47-55) (TI 1978a, 1979a).

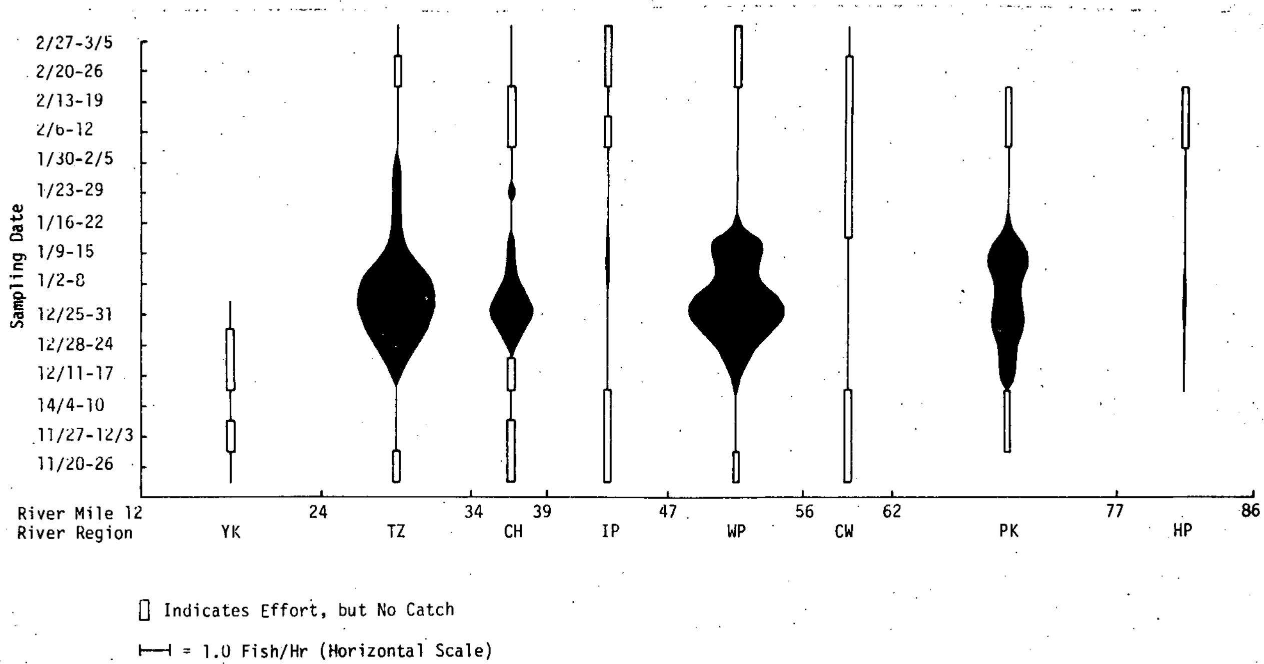


Figure V-18. Catch per Hour of Atlantic Tomcod in Box Traps Set in Hudson River Estuary during November-March 1977-78

Box trap catches increased from mid-December to early January in all river regions sampled, indicating a movement to shallow water to spawn (Figure V-18). Atlantic tomcod have been reported to spawn in shallow water at other locales (Bigelow and Schroeder 1953, Booth 1967). Males preceded females to the shallow water and remained longer, as shown by the high percentage of males in box trap catches in early and late collections (Figure V-19). This pattern has been consistent in all spawning seasons since 1974.

Spawning activity was probably at its peak during the last 2 weeks of December 1977; each year since 1974, peak spawning has occurred within a 2- to 3-week period (late December to mid-January). The peak of spawning activity in most river regions was judged to occur during the period of largest catches (Figure V-19). This period was also the time when the sex ratio approximated 1:1 [except during 1975-76 when there were 35% females for a maximum sex ratio of approximately 1.85:1 (Figure V-20)]. Differences in sex ratio during the spawning period have been attributed to behavioral differences for the two sexes with respect to movement into the area sampled by box traps (TI 1979a).

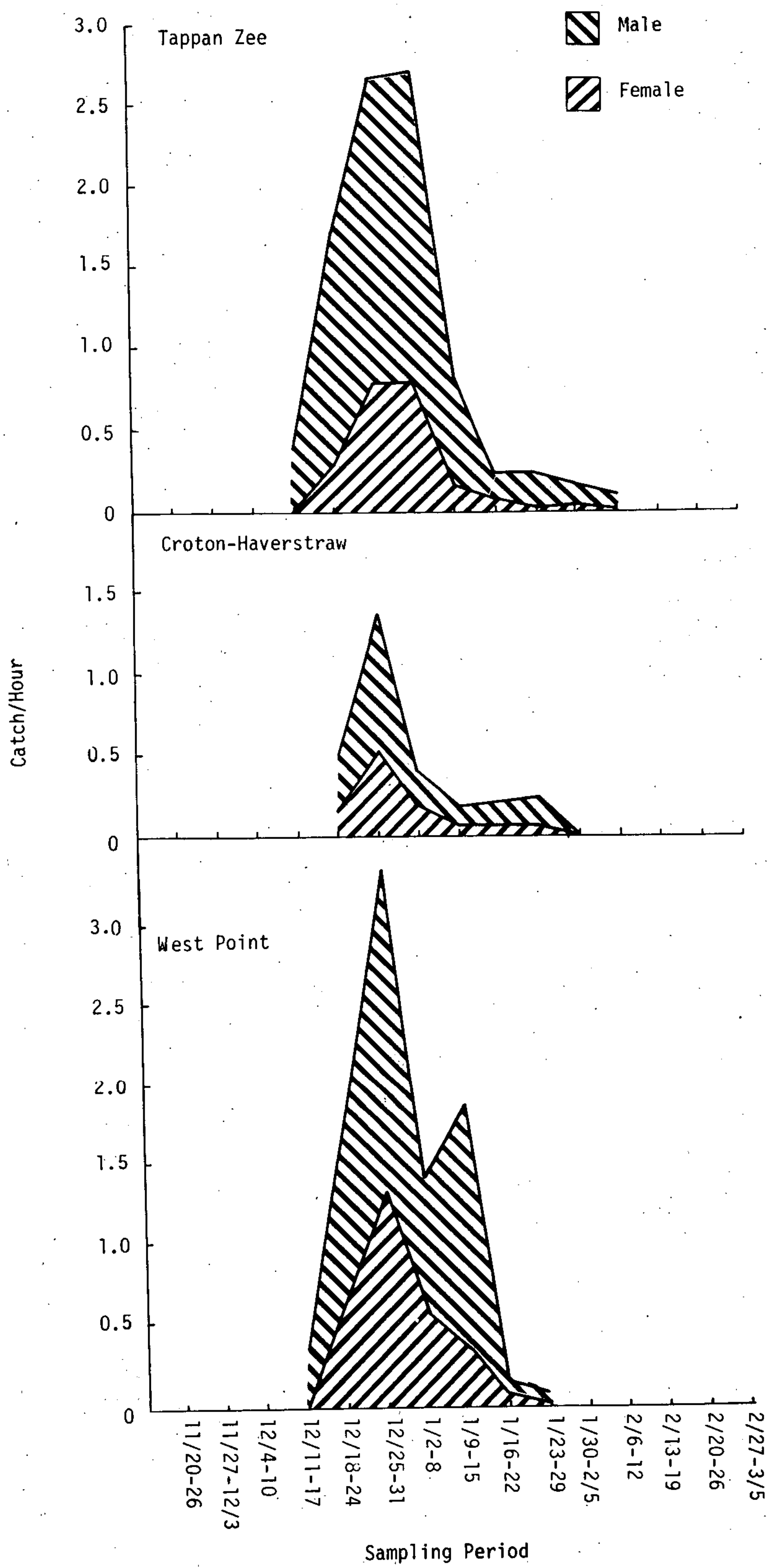


Figure V-19. Box Trap Catch per Hour of Male and Female Atlantic Tomcod in Tappan Zee, Croton-Haverstraw, and West Point Regions, November-March 1977-78

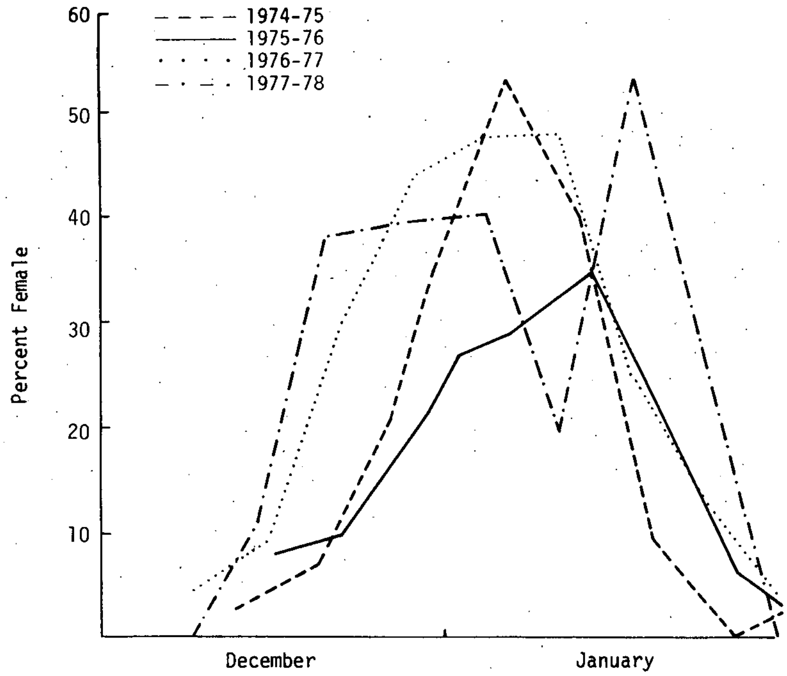


Figure V-20. Percentage of Female Atlantic Tomcod Captured in Box Traps between RM 47 and RM 56 of Hudson River during 1974-75, 1975-76, 1976-77, and 1977-78

Release and recapture sites for individually marked tomcod were compared to determine the extent of movements. From 20 November 1977 to 18 February 1978, 9272 tomcod were marked with Carlin tags and 1601 were finclipped (Appendix Table D-24). Over half of the marked fish (tagged and finclipped) were marked during the presumed peak of spawning, 15 December to 7 January. Recaptures of 108 tagged fish (Figure V-21) and 8 finclipped fish (Appendix Tables D-25 and D-26) indicated increased movements after December when the peak period of spawning was nearing completion. Since most recaptures came from box traps, movements within shallow water were more evident than offshore movements. Most tag recaptures during December were within the river mile of release. This suggested that the tomcod, once they entered shallow water to spawn, limited their movements. The fish probably traveled up the channel of the river until they reached the spawning area and then moved toward the shore. By January, movements of more than 5 miles from the release site were significantly more frequent (χ^2=4.37; 1df; $p<0.05$) than for fish recaptured in December. The long-distance movements were usually downriver (Figure V-21). During March, two tagged tomcod were caught near Hoboken, New Jersey, at RM 3 (KM 5). In May, sport fishermen returned tags from two tomcod caught in New York outside the river: one from the East River near the Whitestone Bridge and another from Staten Island. Tag returns from previous tagging programs showed a similar downriver movement after December (TI 1975a, 1978a, and 1979a).

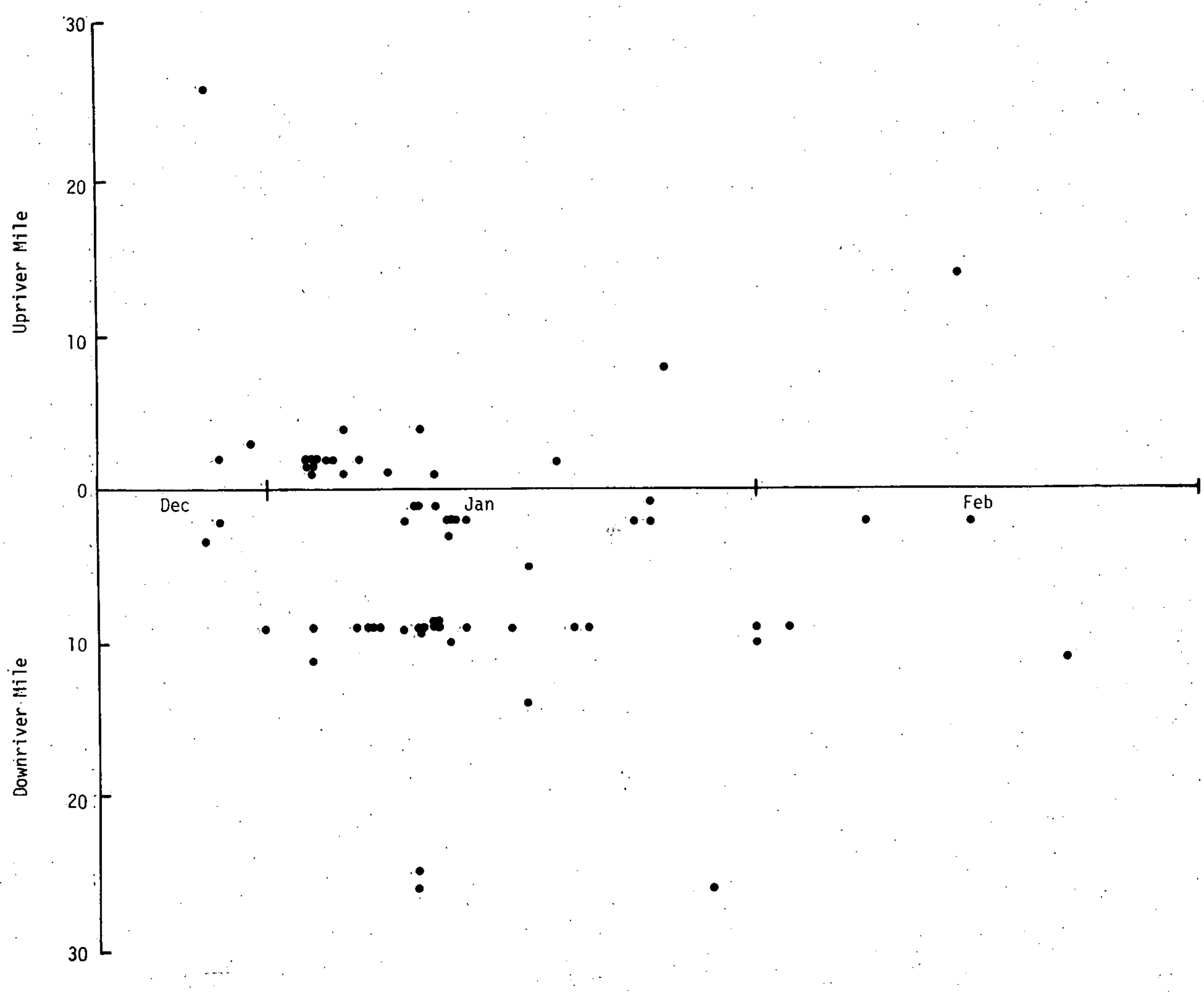


Figure V-21. Recapture Data and Distance Moved for Atlantic Tomcod in Hudson River Estuary during December 1977-78* (Excluding tomcod recaptured in river mile of release)

2. Age Composition and Sex Ratio

As for striped bass (subsection III.B.2), the best opportunity to determine the age composition of the Atlantic tomcod population was during the spawning run. Data were collected from box trap catches from December 1977 through February 1978. On a weekly basis, the entire catch of tomcod in at least six preselected box traps (from RM 25 to RM 76) was sorted into 25-mm length strata, and length, weight, and sex were recorded for up to 20 fish in each length stratum per sample. Age was determined for all subsampled fish greater than 150 mm (TL) by examining otoliths; fish less than or equal to 150 mm (TL) were classified as age I (11 to 13 months old). The length-frequency distribution of the entire sample and subsampled age and sex data was used to estimate the monthly age composition (Appendix Tables D-27, D-28, and D-29).

During the past three spawning seasons (1975-76, 1976-77, 1977-78), the youngest age group (11 to 13 months old, defined as age I) has composed more than 90% of the overall spawning populations, ranging from 93% in 1976-77 to 98% in 1975-76 (Table V-9). The remainder of each spawning population has consisted of age II fish, except during 1976-77 when two age III tomcod (less than 1% of the population) were caught.

The sex ratio of young-of-the-year tomcod was estimated from June-September 1974-77 bottom trawl and epibenthic sled catches (Appendix Table D-30). Analysis of variance tested for differences in the percentage of males within and between years. No significant (α=0.05) differences among monthly or yearly sex ratios were found (Table V-10). Therefore, the data were pooled to provide an overall estimate of 55% males in the juvenile tomcod populations during June-September. This pooled estimate was found to differ significantly (α=0.05) from 50% by computing a Z value (Steel and Torrie 1960) as follows:

$$Z = \frac{\hat{p} - p}{\sqrt{\frac{pq}{n}}}$$

Table V-9

Age Composition by Sex, Month, and Spawning Season for Hudson River Atlantic Tomcod

Month	Sex	1975-76 Age I	1975-76 Age II	1975-76 Age III	1975-76 Number Fish Aged	1976-77 Age I	1976-77 Age II	1976-77 Age III	1976-77 Number Fish Aged	1977-78 Age I	1977-78 Age II	1977-78 Age III	1977-78 Number Fish Aged
Dec	Male[1]	0.9809	0.0191	0	69	0.9132	0.0866	0.0002	519	0.9775	0.0225	0	161
	Female[1]	0.9243	0.0757	0	94	0.8727	0.1265	0.0008	383	0.8778	0.1222	0	250
	Combined[1]	0.9742	0.0258	0	163	0.9056	0.0942	0.0003	902	0.9458	0.0542	0	411
Jan	Male	0.9899	0.0101	0	111	0.9712	0.0288	0	128	0.9933	0.0067	0	303
	Female	0.9812	0.0188	0	269	0.9636	0.0364	0	253	0.9659	0.0341	0	277
	Combined	0.9874	0.0126	0	380	0.9685	0.0315	0	381	0.9856	0.0144	0	580
Feb	Male	0.9697	0.0303	0	42	0.9421	0.0579	0	25	0.9583	0.0417	0	13
	Female	1.0000	0	0	14	0.7778	0.2222	0	12	1.0000	0	0	1
	Combined	0.9705	0.0295	0	56	0.9347	0.0653	0	37	0.9655	0.0345	0	14
Dec to Feb	Male	0.9846	0.0154	0	222	0.9359	0.0640	0.0001	672	0.9848	0.0152	0	477
	Female	0.9683	0.0317	0	377	0.9265	0.0732	0.0003	648	0.9163	0.0837	0	528
	Combined	0.9812	0.0188	0	599	0.9335	0.0664	0.0002	1320	0.9642	0.0358	0	1005

[1]Estimated proportions of all males, all females, or sexes combined within each age group

Table V-10

Two-Factor ANOVA To Test for Differences in Percentages of Juvenile Male Atlantic Tomcod within and between Years, June-September 1974-77

Source	Sum of Squares**	d.f.	Mean Square	F
Month	39.011	3	13.003	.313*
Year	350.953	3	116.984	2.816*
Month/Year	404.523	9	44.947	1.082*
Error	581.550	14	41.539	

*Non-significant at $\alpha = 0.05$
**Unadjusted

where

$\hat{p}$ = observed proportion of males = $\frac{n_1}{n}$

p = expected proportion of males = 0.5

q = expected proportion of females = 1-p

n = the number of young-of-the-year tomcod = $n_1 + n_2$

n_1 = the numbers of males

n_2 = the numbers of females

To estimate the number of eggs spawned during a spawning season, an accurate estimate of the sex ratio within the spawning population is required (subsection V.D.2). Direct estimates of the sex ratio of adults have been shown to fluctuate throughout the spawning season (Figure V-20) and thus are judged unreliable. Since the juvenile sex ratio has been shown not to deviate within or across years (Table V-11), it has been used as a best estimate of the spawning population sex ratio for the 1975-76, 1976-77, and 1977-78 spawning seasons.

The sex ratio of age II and older tomcod was estimated during the spawning period. Most (65% and 72%) of the age II fish during 1975-76 and 1976-77, respectively, were males; during 1977-78, only 30% were males (Table V-11). Sex ratio estimates for age II fish may be less accurate than those for juveniles if the period of residency within shallow water differed for males and females, as suggested for age I fish. Only two age III tomcod have been caught (1976-77): one male and one female.

3. Mortality of Yearling and Older Tomcod

The total annual mortality rate of yearling and older tomcod was estimated from the age composition (subsection V.E.2) and population size (subsection V.E.6) of the spawning population during December-February of successive years. Mortality estimates (M_{ij}) for each year class and sex were converted from estimates of annual survival rates (S_{ij}) by the following equations:

$$S_{ij} = N_2/N_1$$

$$M_{ij} = 1-S_{ij}$$

Table V-11

Percentage of Atlantic Tomcod Male and Female, Ages II and III Caught in Box Traps in Hudson River Estuary during 1975-76, 1976-77, and 1977-78 Spawning Seasons

1975-76

Year Class		Dec Male	Dec Female	Jan Male	Jan Female	Feb Male	Feb Female	Combined Male	Combined Female
		Age II							
1974	N	43	23	25	19	10	0	78	42
	Percent	65	35	57	43	100	0	65	35
1975	N								
	Percent								
1976	N								
	Percent								

1976-77

Year Class		Dec Male	Dec Female	Jan Male	Jan Female	Feb Male	Feb Female	Combined Male	Combined Female
		Age III							
1974	N	1	1	0	0	0	0	1	1
	Percent	50	50	-	-	-	-	50	50
		Age II							
1975	N	484	164	101	70	22	4	607	238
	Percent	75	25	59	41	85	15	72	28
1976	N								
	Percent								

1977-78

Year Class		Dec Male	Dec Female	Jan Male	Jan Female	Feb Male	Feb Female	Combined Male	Combined Female
1974	N								
	Percent								
1975	N								
	Percent								
		Age II							
1976	N	26	66	7	14	1	0	34	80
	Percent	28	72	33	67	100	0	30	70

N = Sample size

where

N_1 = estimated number of tomcod for sex j in year class i when age I (or II)

N_2 = estimated number of tomcod for sex j in year class i when age II (or III)

Data used to estimate mortality rates are presented in Appendix Table D-33. Mortality rates for young-of-the-year tomcod (from eggs to age I spawners) were discussed in subsection V.D.2.

Estimated total annual mortality during the second year of life (age I to age II) was 0.980 for the 1974 year class and 0.991 for the 1976 year class (Table V-12). These estimates were similar to those found for juvenile tomcod (subsection V.D.2). A high mortality rate (0.970) was also estimated for the third year of life (age II to age III), as shown for the 1974 year class (Table V-12) and by the absence of age III tomcod in other spawning seasons.

The 1975 year class appeared to have a lower total annual mortality rate during 1976, its second year of life, than did the 1974 and 1976 year classes. Likewise, juvenile tomcod mortality during 1976 appeared to be lower than for the other two year classes examined (subsection V.D.2). The largest spawning population observed since 1970 occurred during 1976-77 (subsection V.E.6) coincident with a relatively low mortality rate.

Table V-12

Total Annual Mortality Estimates for Yearling and 2-Year-Old Atlantic Tomcod of 1974-76 Year Classes in Hudson River Estuary

Year Class	Yearling			Two Year Old		
	Male	Female	Combined	Male	Female	Combined
1974	0.977	0.985	0.980	0.977	0.957	0.970
1975	0.749	0.881	0.809	-	-	-
1976	0.995	0.987	0.991	-	-	-

4. Growth Rates of Yearling and Older Tomcod

Previous discussion of tomcod growth (subsection V.D.3) was restricted to young-of-the-year fish from the 1977 year class and previous year classes. This subsection examines the growth of tomcod within individual year classes, particularly during the second and third years of life.

Mean total lengths of fish that were 11 to 13 months, 23 to 25 months, and 35 to 37 months old (ages I, II and III, respectively) were derived from length-frequency data used to estimate age composition (Appendix Tables D-27 through D-29). Annual instantaneous growth rates in length from age I to age II and age II to age III were calculated using the formula:

$$G = \log_e L_{X+1} - \log_e L_X$$

where

G = instantaneous growth rate (length)

L_X = mean total length at age X

L_{X+1} = mean total length at age X+1

Females were consistently larger than males from the same year class at ages I and II (Table V-13) during the 1975-76, 1976-77, and 1977-78 spawning seasons. Annual instantaneous growth rates were also higher for females than males during their second year of life. Only one male and one female at age III (1974 year class) were collected, and they were identical in length (298 mm TL).

5. Natality

Natality, or the production of new individuals in the population, was investigated through studies of the age at maturity as well as fecundity and the relationship between fish length and egg diameter. These parameters provide information on the potential level of production by the population (Krebs 1972).

Age at maturity was investigated by monitoring the ratio of gonad weight to body weight through the late summer and fall of 1974-77. The mean gonad weight, expressed as percentage of total body weight, increased

Table V-13

Mean Total Lengths and Annual Instantaneous Growth Rates (G) of Male and Female Tomcod Collected during 1975-76, 1976-77, and 1977-78 Spawning Seasons

Year Class		Spawing Season 1975-1976		1976-1977		1977-1978	
1974		Age II		Age III			
		Male	Female	Male	Female		
	Mean Total Length (mm)	219.9	250.9	298.0	298.0		
	Sample Size	78	42	1	1		
	G*	-	-	0.304	0.172		
1975		Age I		Age II			
		Male	Female	Male	Female		
	Mean Total Length (mm)	156.2	171.2	214.4	251.5		
	Sample Size	4983	1283	607	239		
	G*	-	-	0.317	0.385		
1976				Age I		Age II	
				Male	Female	Male	Female
	Mean Total Length (mm)			141.1	156.0	223.7	257.4
	Sample Size			8871	3027	34	80
	G*			-	-	0.461	0.501
1977						Age I	
						Male	Female
	Mean Total Length (mm)					157.6	176.8
	Sample Size					2197	876
	G*					-	-

*Annual instantaneous growth rate (in length)

rapidly, beginning in mid-October for males (Figure V-22) and early November for females (Figure V-23). Within 4 to 6 weeks after the onset of maturation, mean gonad weights were approximately 15% to 20% of total body weight. All individuals were judged to be capable of spawning at 11 to 13 months of age (age I).

Mean fecundity by age group was estimated for spawning populations in those years for which age composition data were available and laboratory methods of fecundity determination were identical: 1975-76, 1976-77, and 1977-78. Age-specific fecundity estimates were made using the following formulas:

$$\bar{F}_j = \frac{\sum_{i=1}^{8} \frac{N_i M_{ij}}{M_i} \bar{F}_{ij}}{\sum_{j=1}^{8} \frac{N_i}{M_{ij}} M_{ij}}$$

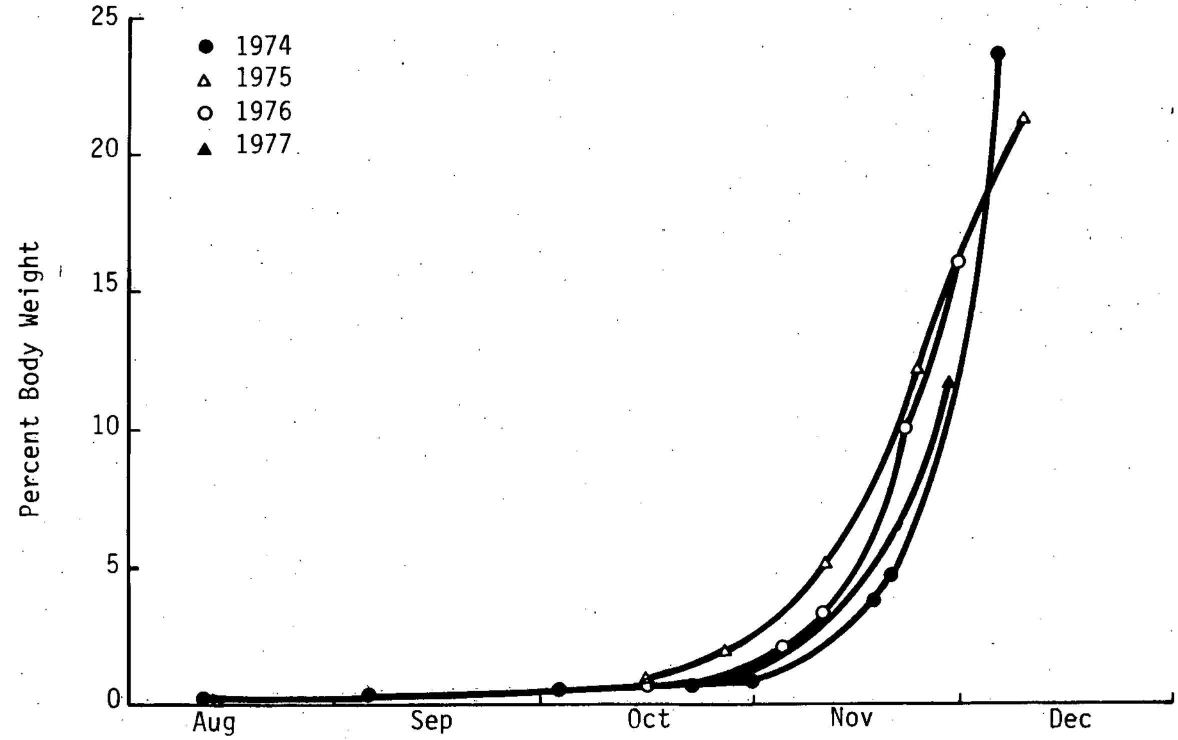


Figure V-22. Mean Testes Weight Expressed as Percentage of Total Body Weight for Young-of-the-Year Atlantic Tomcod, Hudson River, 1974-77

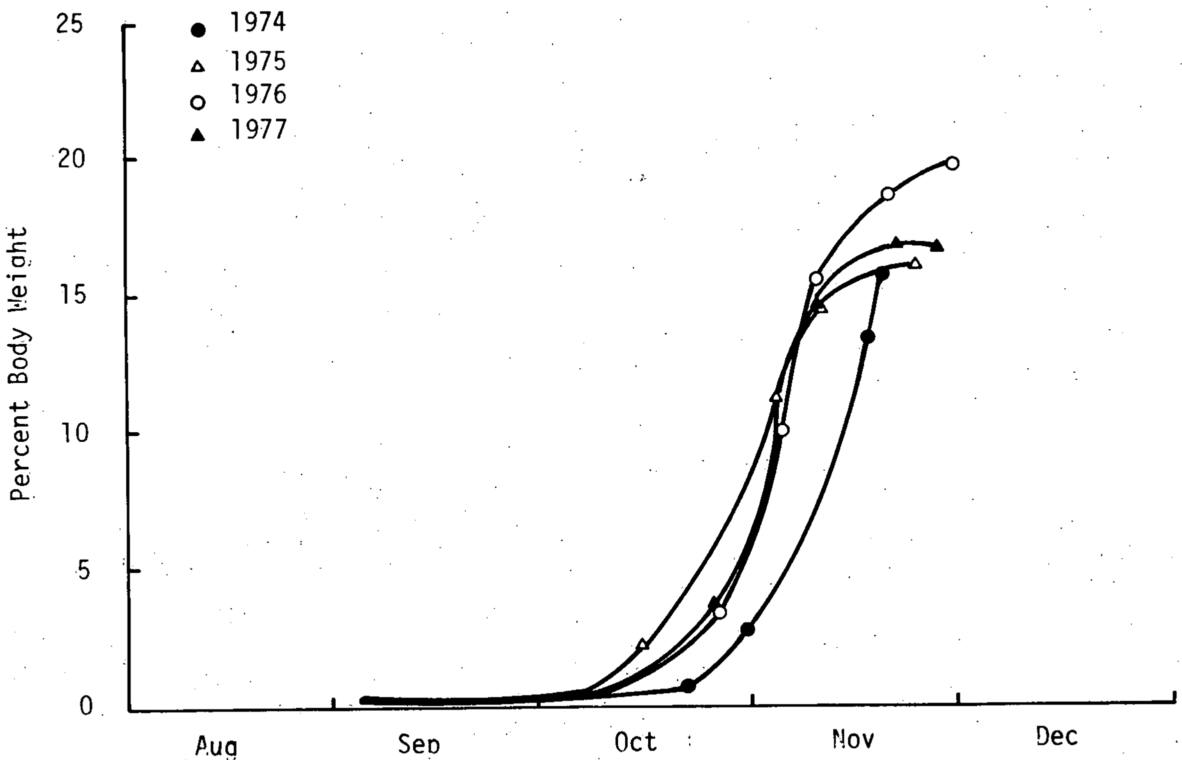


Figure V-23. Mean Ovary Weight Expressed as Percentage of Total Body Weight for Young-of-the-Year Atlantic Tomcod, Hudson River, 1974-77

where

$\bar{F}_j$ = weighted mean fecundity for age j (j=1,2)

N_i = number of females in length group i (i=1, 2...8)

M_i = number of females in length group i with known age and fecundity

M_{ij} = number of females in length group i of age j

$\bar{F}_{ij}$ = estimated mean fecundity for category M_{ij}

and

$$\bar{F}_{ij} = \frac{1}{M_{ij}} \sum_{k=1}^{M_{ij}} \hat{F}_{ijk}$$

where

$\hat{F}_{ijk}$ = estimated fecundity of fish k in length group i and age j

Mean fecundity of age I tomcod ranged from approximately 8000 eggs during 1976-77 to 12,000 eggs during 1975-76. Many of the differences in mean fecundity among years were due to differences in fish length. The logarithm of fecundity was significantly correlated (α=0.05) with the logarithm of total length for each of the three spawning populations (1975-76, r=0.919; 1976-77, r=0.949; 1977-78, r=0.954). Since fecundity is a function of length (Figure V-24), mean fecundity was highest (Table V-14) when age I females were largest (1975-76 and 1977-78).

Mean fecundity of age II tomcod ranged from approximately 49,000 eggs during 1975-76 to 55,000 eggs during 1977-78 (Table V-14). Based on estimated age composition (subsection V.E.2), age II fish contributed approximately 6% to 24% of the total spawn. Although age III tomcod have been caught (1976-77), the contribution of this oldest age group was considered minimal.

Since natality should include estimates of egg and larval survival as well as fecundity and age at maturity, egg diameters were measured as a possible indicator of survival of early life stages. Ware (1975), reviewing

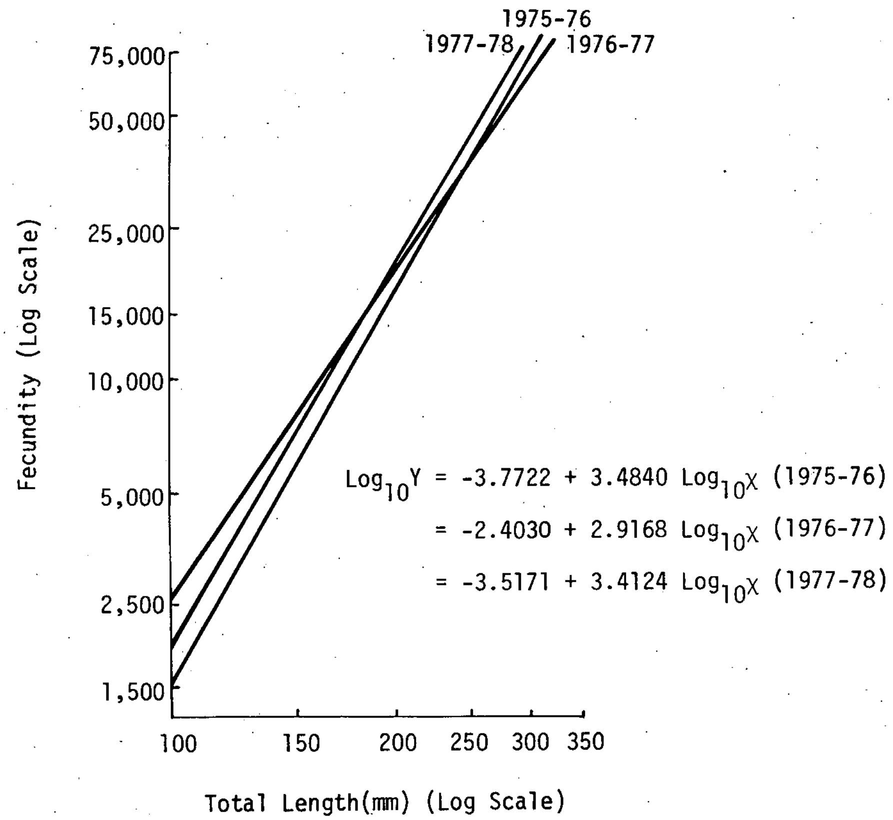


Figure V-24. Regressions of Log_{10} Fecundity on Log_{10} Total Length for Atlantic Tomcod, Hudson River, during Spawning Seasons of 1975-76, 1976-77, and 1977-78

Table V-14

Mean Fecundity (Age I, Age II, and Combined) and Proportion of Total Number of Eggs Spawned (by Age) of Atlantic Tomcod in Hudson River, 1975-76 through 1977-78 Spawning Seasons

		Mean Fecundity			Proportion of Spawn	
Spawning Season		Age I	Age II	Combined Ages	Age I	Age II
1975-76	Mean Fecundity	11731	48788	14228	0.942	0.058
	Sample Size	45	24	-		
	Mean Total Length (mm)*	171	251	-		
1976-77	Mean Fecundity	8213	52030	16850	0.921	0.079
	Sample Size	42	41	-		
	Mean Total Length (mm)*	156	251	-		
1977-78	Mean Fecundity	11160	55336	16834	0.760	0.240
	Sample Size	62	42	-		
	Mean Total Length (mm)*	177	257	-		

*From Appendix Table D-29, D-30, and D-31 studies on growth and mortality of fish eggs and larvae, concluded that larger eggs produce larger larvae that survive better. Egg diameters were measured by counting the number of eggs in a random sample which extended 30 mm when aligned in a trough. Egg diameters for samples collected from 1974-75 through 1976-77 had a common variance (Levene's test, $F=2.034$, $p>0.10$) and were compared statistically. Samples collected from 1973-1974 were not comparable (because of nonhomogeneity of variance) with samples collected during later years ($F=4.891$, $p>0.01$), possibly because the 1973-74 samples were preserved in 10% formalin rather than Gilson's fluid as in later collections.

Significant ($\alpha=0.05$) positive correlations (1974-75; $r=0.492$; 1975-76, $r=0.580$; 1976-77, $r=0.658$) were found between fish length and egg diameter. Regression lines (Figure V-25) fitted to each year's data shared a common slope (ANOVA, $F=0.931$, $p=0.40$) but had different y-intercepts (ANOVA, $F=123.698$, $p>0.01$). In any year, therefore, an increase in mean length of females due to improved growth results in a predictable increase in egg diameter, although the mean diameter of eggs may differ from year to year for fish of the same size. An increase in egg diameter could improve survival in early life stages and thus provide a compensatory mechanism whereby increased growth due to reduced intraspecific competition would increase survival of the progeny as well as the present generation. The reason for differences in egg diameters among years for fish of the same size (as shown above by the y-intercept) is presently unknown, but it may be a further reflection of growth differences. Although only 3 years of data were available, egg diameter and the late summer abundance of each year class were inversely related. The 1976 year class was most abundant (subsection V.D.1.a), and the mean egg diameter from this year class was smallest (Figure V-25) of the three year classes (1974, 1975, 1976). The 1974 year class was least abundant but had the largest eggs, and the 1975 year class was intermediate. Such a relationship implies that egg diameter is a density-dependent function of growth.

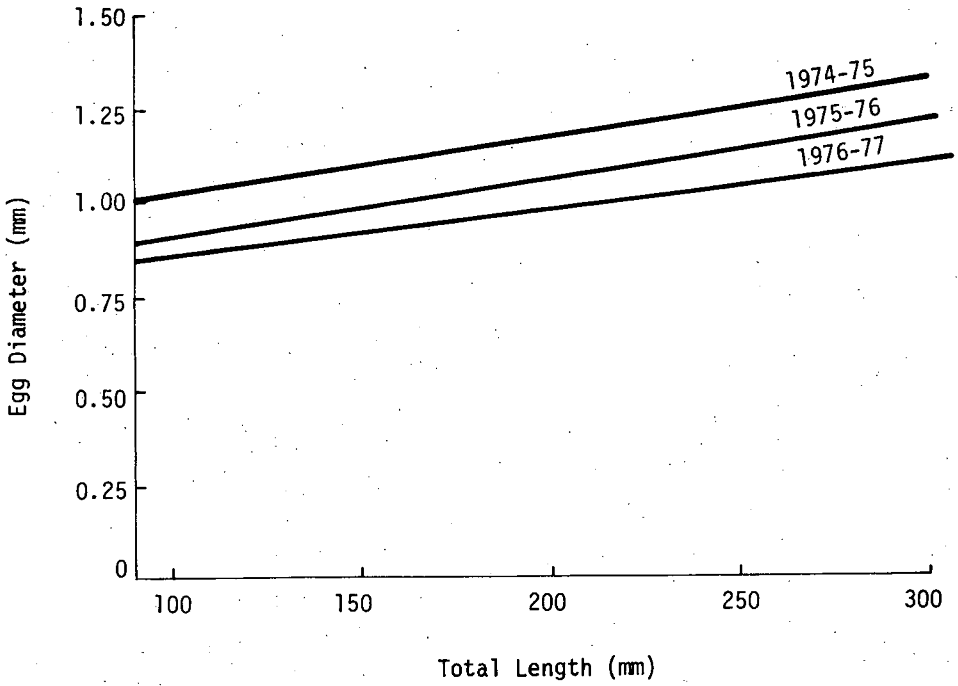


Figure V-25. Relation between Total Length of Atlantic Tomcod and Egg Diameter in Three Spawning Populations (1974-75, 1975-76, 1976-77) in Hudson River Estuary

6. Population Size Estimates

Estimates of the number of spawning Atlantic tomcod were based solely on mark-recapture methods because ice conditions during the December-January spawning period prevented the use of sampling gear that would permit estimates based on density-standing crop extrapolations as calculated for juvenile striped bass (subsection III.D.1). Box traps and impingement were the most effective recovery gear for marked fish released from box traps (Appendix A).

The size of the 1977-78 spawning stock of Atlantic tomcod was estimated by the Petersen method (Ricker 1975). The simple Petersen estimate was calculated by the formula:

$$N = \frac{M \cdot C}{R}$$

where

N = estimated population size

M = total number of fish marked and released

C = total number of fish examined for marks

R = total number of marked fish recaptured

The use of a Petersen estimate required that a particular collection of tomcod be used for either marking or recovery but not for both. Although collections are usually assigned to marking or recovery on a temporal basis (i.e., recovery conducted after marking is completed), tomcod collections were assigned on a spatial basis because the population was migratory (subsection V.E.1). This method permitted simultaneous marking and recovery efforts in separate locations. The marking region was designated as RM 47-77, the region of highest box trap catches. RM 24-46 was used as the recovery region to coincide with the downstream movement observed during and after spawning (subsection V.E.1). Box trap catches in the recovery region were augmented by impingement collections made at the Bowline, Lovett, and Indian Point power plants.

To obtain a valid Petersen estimate when stratification was spatial rather than temporal, all fish must have either the same probability of being captured in the marking area or the same probability of being captured in the recovery area (Ricker 1975). These conditions were tested by examining M_i/R_i and C_j/R_j ratios through time,

where

M_i = number of fish marked in i^{th} marking marking period ($\Sigma M_i = M$)

R_i = number of recaptured fish marked in i^{th} marking period

R_j = total number of fish recaptured in j^{th} recovery period ($\Sigma R_j = R$)

C_j = number of fish caught and examined in j^{th} recovery period ($\Sigma C_j = C$)

The time intervals used for marking and recovery and the values for M_i, R_i, and C_j are presented in Appendix Table D-32.

The C_j/R_j ratios differed significantly (α=0.10) through time for the 1977-78 collections, indicating that the probability of capture did not remain constant throughout the recovery period. There was no significant (α=0.10) difference, however, in M_i/R_i ratios through time (Table V-15), indicating that all fish had the same probability of being captured in the marking area. Therefore, the use of the simple Petersen estimate was justified for the 1977-78 population, as it had been for the 1974-75 and 1975-76 populations. However, the 1976-77 population did not meet either condition (unchanging M_i/R_i or C_j/R_j ratios) necessary for a Petersen estimate, so a more complex Schaefer estimate (discussed in TI 1979a) had to be calculated.

Table V-15

Test of Assumptions of Equal Catchability and Population Estimates for Atlantic Tomcod Spawning Stocks in Hudson River Estuary

Year	M_i/R_i Release Period 1	2	3	4	$x^{2\dagger}$	C_j/R_j Recovery Period 1	2	3	4	$x^{2\dagger}$	Population Estimate in Millions: Petersen	Schaefer	Adjusted Schaefer
1974-1975	426	615	421	–	1.00	1842	142	107	139	23.78*	3.67	3.67	
1975-1976	338	475	246	–	3.84	513	75	50	–	35.98*	3.68	3.51	
1976-1977	687	842	4322	7167	20.96*	1287	308	323	168	10.87*	19.63	16.19	10.41**
1977-1978	180	223	527††	–	2.51	-	707	145	129	32.44*	2.53	1.63	

†Chi-square test of null hypothesis that all M_i/R_i are equal or all C_j/R_j are equal with k-1 degrees of freedom where k = number of release or recovery periods

††Release periods 3 and 4 have been pooled in calculating the x^2 value

*Significant at α = 0.10 level

**Denotes preferred estimate

The size of the 1977-78 spawning population was estimated to be 2.53 million fish, which is smaller than the three previous spawning populations (Table V-15). The total number of fish marked and recaptured was also less in 1977-78 (Appendix Table D-32) than it had been in past years. The ranking of size estimates for the four spawning populations based on mark-recapture methods from largest to smallest (by year class that dominated the spawning populations) was 1976, 1974, 1975, and 1977. Ranking of year classes (largest to smallest) based on bottom trawl indices of abundance (1976, 1975, 1977, 1974; see subsection V.D.1) differed from the ranking of mark-recapture population estimates, especially for the 1974 and 1977 year classes. However, the 1976 year class was shown to be the strongest by both the juvenile index during late summer and the population estimate of adults. One possible explanation for the discrepancy in rankings between the two measures of year class strength is that some tomcod may not return as yearlings (11-13 months of age) to spawn, and the proportion of the population not returning differs among years and is independent of year class strength. Therefore, an index of year class strength based on spawning population size may not be as reliable as that based on the abundance of juveniles during late summer (subsection V.D.1).

7. Comparison with Other Population

Few other Atlantic tomcod populations have been as extensively studied as the Hudson River population. Early records and publications have been summarized by Howe (1971). The Hudson River population is the southernmost of the recently studied populations, which have included the Weweantic River estuary, Massachusetts (Howe 1971); Mystic River, Connecticut (Booth 1967); Lake St. John, Quebec (Legendre and Lagueux 1948); and Hull Harbor, Massachusetts (Schaner and Sherman 1960).

Studies to determine the range and seasonal characteristics of tomcod movements are rare for areas other than the Hudson River. Published accounts have usually described a movement to shallow fresh or brackish water from November to February to spawn (Scott and Crossman 1973). Tomcod occur in landlocked, freshwater lakes such as Lake St. John, Quebec (Legendre and Laquenx 1948) or in small estuaries such as the Weweantic River estuary, which is only 7.5 km long with mean depths of 0.5 m to 7 m (Howe 1971). Except when spawning in shallow water, tomcod have been described as demersal and especially abundant near mouths of rivers and streams (Bigelow and Schroeder 1953).

Atlantic tomcod are short-lived throughout their range of distribution and are perhaps most short-lived in the Hudson River. The oldest tomcod in our collections were age III, and the largest tomcod was 338 m (TL). Nichols and Breder (1926) reported a maximum length of 15 in. (381 mm) for tomcod. Three-year-old tomcod are apparently more common in Lake St. John

(Legendre and Laquenx 1948) than in the Hudson River. Howe (1971) estimated that 33% of the tomcod collected in the Weweantic River were older than young-of-the-year; however, since his data were pooled over 2 years, it is not clear whether fish that were aged as young-of-the-year and yearlings were actually the same year class. By comparison, more than 90% of the Hudson River tomcod were from the most recent year class (young-of-the-year in December and yearlings in January) during the spawning run.

Hudson River tomcod grew at approximately the same rate during their first year of life as tomcod in other populations, although Howe (1971) felt there was evidence that tomcod grew more rapidly in New England than in Canada. Length ranges reached by young-of-the-year in mid- or late summer were similar in several populations (Table V-16).

Table V-16

Range of Lengths of Young-of-the-Year Atlantic Tomcod Caught at Several Locations in Northeastern United States and Canada

Location	Source	Time Period	Length Range (mm)
Southern New England	Nichols and Breder (1926)	Autumn	63-77
Weweantic River, Mass.	Howe (1971)	Mid-August	85-90
Pine Orchard, Conn.	Merriman (1947)	August	71-110
Woods Hole, Mass.	Lux and Nichy (1971)	August	80-120
Cape Breton Coast, Bay of St. Lawrence	Cox (1921)*	Late July	40-90
Hudson River	TI Data (1977)	Mid-August	55-106

*Cited in Howe (1971)

Fecundity of tomcod in the Hudson River was similar to that of the Massachusetts population but higher than estimates from Quebec (TI 1979a). The difference between the Hudson River and Quebec populations was attributed to the climatological effects of latitude, but this hypothesis cannot be further tested since data are lacking for other locations.

Tomcod also mature and spawn at 11 to 13 months of age in systems other than the Hudson River. Although age or size at maturity were not addressed specifically, fecundity data for Quebec (Vladylov 1955 cited in Scott and Crossman 1973) and Massachusetts (Schaner and Sherman 1960) indicated that fish 180 mm and 170 mm in length, respectively, were capable of spawning. Fish 11 to 13 months old will reach these sizes in the Hudson River and most likely elsewhere as seen in the comparisons of growth in these systems (Table V-16). A 97-mm (TL) male was collected in spawning condition during December 1976 in the Hudson River and a 97-mm (TL) female in January 1975.

In summary, the Hudson River tomcod population has stock characteristics similar to those of other populations, particularly in New England. Data for comparing age structure and mortality rates among populations are needed in order to detect stress induced by power plant operation in the Hudson River, but such data are almost totally lacking for other populations. Available data indicate a possibly lower reliance on the spawning of 11- to 13-month-old tomcod in other systems than in the Hudson River. Growth is not greatly different among tomcod populations; however, improved growth within a population (e.g., because of decreased density and intraspecific competition for food) would increase the fecundity of Hudson River tomcod and result in possibly larger, more viable eggs and larvae.

F. QUALITATIVE IMPACT ASSESSMENT IN ATLANTIC TOMCOD

An approach similar to that presented in subsections III.E and IV.E is used in this section to describe exposure to power plants and subsequent long-term impact in the Atlantic tomcod population. The objectives of this section are to evaluate whether exposure indices may be used to predict entrainment and impingement trends at the five Hudson River power plants and to evaluate how conditional mortality rates may serve to indicate long-term reductions in average population size. If trends in exposure indices accurately reflect trends in entrainment and impingement, power plant-induced mortality could be monitored through the use of distribution data. As discussed in subsection III.E, power plant-induced mortality could produce a variety of results ranging from a large reduction to a slight increase in average population size. However, as described in this subsection, there are circumstances in which the conditional mortality rate can be perceived as an upper limit to the long-term percent reduction in average population size. If the Atlantic tomcod conditional mortality rate is greater than the long-term percent reduction in average population size (PR), yearly impact assessment may not require input from any stock-recruitment curve (see subsection III.E).

1. Exposure to Entrainment and Impingement

a. Entrainment

Densities of ichthyoplankton entrained during 1977 were available for Bowline, Danskammer, and Roseton (see subsection III.E.). Since only the Bowline nearfield sampling program collected Atlantic tomcod ichthyoplankton, comparisons of plant region densities with nearfield densities were limited.

1) Eggs

Nearfield and plant region sampling for Atlantic tomcod eggs during the peak abundance period (January-February) was not performed because of ice conditions. Most Atlantic tomcod spawning apparently occurred in the middle estuary, especially the West Point region (subsection V.E.). Roseton and Danskammer were the only sites where appreciable numbers of tomcod eggs were detected in entrainment samples. Danskammer entrained up to 353 eggs/1000 m^3

from January through March, while Roseton entrained less than 8 eggs/1000 m^3 in January and up to 216/1000 m^3 in March (CHG and E 1977). These rates indicate that overall entrainment mortality of Atlantic tomcod eggs was probably negligible.

2) Larvae

Exposure of Atlantic tomcod yolk-sac larvae was virtually identical (13.1 - 21.2%) at all five sites (Table V-17). By the time tomcod grew to the post yolk-sac stage, however, most larvae were downstream of the plants and exposure was minimal except at Bowline where up to 18% of the post yolk-sac larval population was located within the plant region (Table V-18).

At Roseton and Danskammer in 1977, peaks in entrainment and plant region densities were generally similar in timing, but Atlantic tomcod larvae occurred at higher densities in entrainment samples than in river samples (Figure V-26). At Bowline, the magnitude of the densities were similar, but plant region densities failed to manifest a late March increase in nearfield and entrainment density (Figure V-26).

b. Impingement

The exposure of juvenile tomcod to impingement is primarily affected by four factors; their bottom-dwelling habits, their general association with areas of elevated conductivity during the summer, their winter spawning behavior, and the intake location and configuration at each power plant. The manner in which these factors may interact to produce observed patterns in impingement is discussed below.

1) Summer and Early Fall Impingement (April-October)

By the time Atlantic tomcod grew to the juvenile stage in 1977, the distribution of the portion of the total population which remained within the sampled area of the river was centered in the Yonkers and Tappan Zee regions, downriver from most of the power plant sites. As freshwater discharge declined and the salt front progressed upriver during the summer (Appendix Table D-19), a portion of the juvenile population shifted upriver into the

Table V-17

Estimated Standing Crops (in Thousands) and Percent Total Standing Crops of Atlantic Tomcod Yolk-Sac Larvae Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of Yolk-Sac Larval Abundance, 1977

Date		Bowline Standing Crop	Bowline Percent	Lovett Standing Crop	Lovett Percent	Indian Point Standing Crop	Indian Point Percent	Roseton Standing Crop	Roseton Percent	Danskammer Standing Crop	Danskammer Percent
3/7 - 3/11	Above	809,299	72.8	736,274	66.3	698,800	62.9	0	0.0	0	0.0
	Within	204,567	18.4	219,502	19.8	235,170	21.2	218,070	19.6	145,235	13.1
	Below	97,129	8.7	155,219	14.0	177,026	15.9	892,925	80.4	965,760	86.9
Average Within Plant Region			18.4		19.8		21.2		19.6		13.1

Table V-18

Estimated Standing Crops (in Thousands) and Percent Total Standing Crops of Atlantic Tomcod Post Yolk-Sac Larvae Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of Post Yolk-Sac Larval Abundance, 1977

Date		Bowline Standing Crop	Bowline Percent	Lovett Standing Crop	Lovett Percent	Indian Point Standing Crop	Indian Point Percent	Roseton Standing Crop	Roseton Percent	Danskammer Standing Crop	Danskammer Percent
3/21 - 3/26	Above	17,458	0.9	10,961	0.6	9,874	0.5	368	<0.1	295	0.1
	Within	358,090	18.0	29,833	1.5	27,340	1.4	1,313	0.1	1,194	0.1
	Below	1,611,384	81.1	1,946,138	97.9	1,949,718	98.1	1,985,250	99.9	1,985,443	99.9
4/4 - 4/7	Above	478	0.1	37	<0.1	33	<0.1	0	0.0	0	0.0
	Within	1,575	0.3	1,699	0.3	1,570	0.3	0	0.0	0	0.0
	Below	579,125	99.6	579,441	99.7	579,574	99.7	581,177	100.0	581,177	100.0
4/18 - 4/20	Above	4	<0.1	4	<0.1	3	<0.1	0	0.0	0	0.0
	Within	68,451	2.7	16	<0.1	12	0.1	0	0.0	0	0.0
	Below	2,420,904	97.3	2,489,340	100.0	2,489,344	100.0	2,489,359	100.0	2,489,359	100.0
4/25 - 4/28	Above	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Within	137,849	14.4	169	<0.1	127	<0.1	0	0.0	0	0.0
	Below	818,755	85.6	956,435	100.0	956,477	100.0	956,604	100.0	956,604	100.0
Average Within Plant Region			9.4		0.5		0.5		0.0		0.0

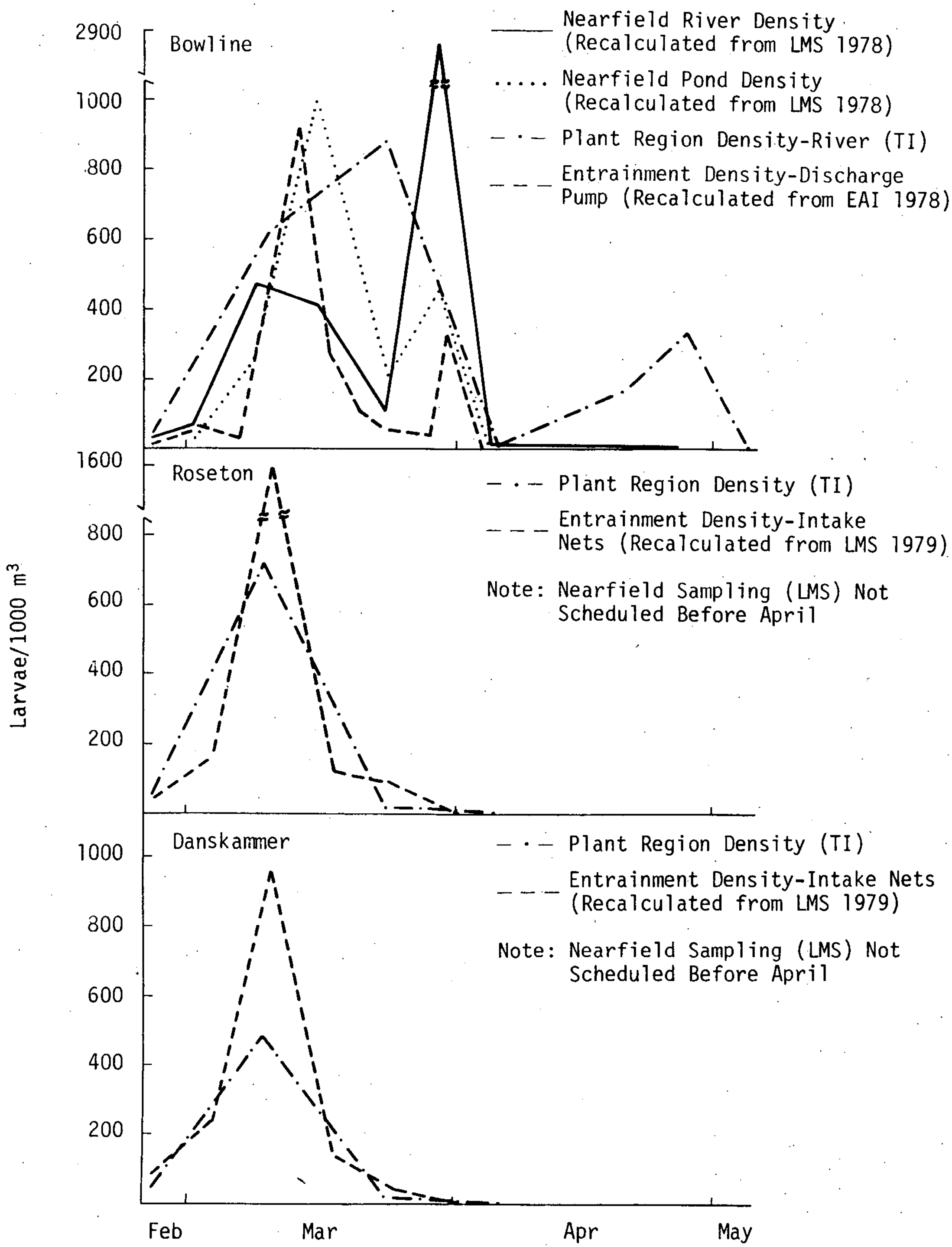


Figure V-26. Nearfield, Plant Region, and Entrainment Abundance of Atlantic Tomcod Yolk-Sac and Post Yolk-Sac Larvae at Indian Point, Roseton, and Danskammer Power Plants, Hudson River Estuary, February-May 1977

Yonkers through West Point regions (Appendix Tables D-20 and D-21). Despite this increase in exposure at the three downriver plants during the summer of 1977 (Figure V-27), impingement rates at Bowline and Lovett remained low (Figure V-28). Preference for deeper waters outside the influence of the plants' intakes may explain the low summer impingement rates at Bowline and Lovett. The Bowline intakes are in a shallow pond, and the Lovett intakes are located in a shoal area where the depth is approximately 4.5 m.

The Indian Point intakes are in 9-10 m of water immediately adjacent to the channel (with depths of 20 m or more). In addition, an increase in conductivity near the plant starting in May and continuing through the summer (Figure V-29) resulted in high standing crops of Atlantic tomcod in the Indian Point plant region during the summer (Figure V-27). These high standing crops were associated with the midsummer peaks in impingement rate (Figure V-28). The association between conductivity and impingement is also supported by earlier data which showed that yearly impingement rates from 1973 through 1977 at Indian Point were highest in 1974 and 1977 (Figure V-28), the two years in which conductivities in that region during July and August were highest (Figure V-29).

Plant region standing crops of juvenile tomcod and summer impingement rates at Roseton and Danskammer were low during 1977 (Figure V-27). Since conductivity values are normally low throughout the year near these plants (Figure V-29), most juvenile tomcod occupy areas farther downriver in more saline water.

2) Winter Impingement (November-March)

Tomcod distribution and impingement patterns changed rapidly as the fish matured. Impingement rates were reduced at the three downriver sites but increased at the two upriver sites, Roseton and Danskammer (Figure V-27), which are nearer the presumed spawning areas. The pattern of lower impingement rates observed during the summer for sites with intake locations in shallow water was reversed at the upriver sites in the winter. Impingement rates at Danskammer, which has a long intake canal located inshore at a depth of 3-4 m, were higher than at Roseton where intakes are nearer the river

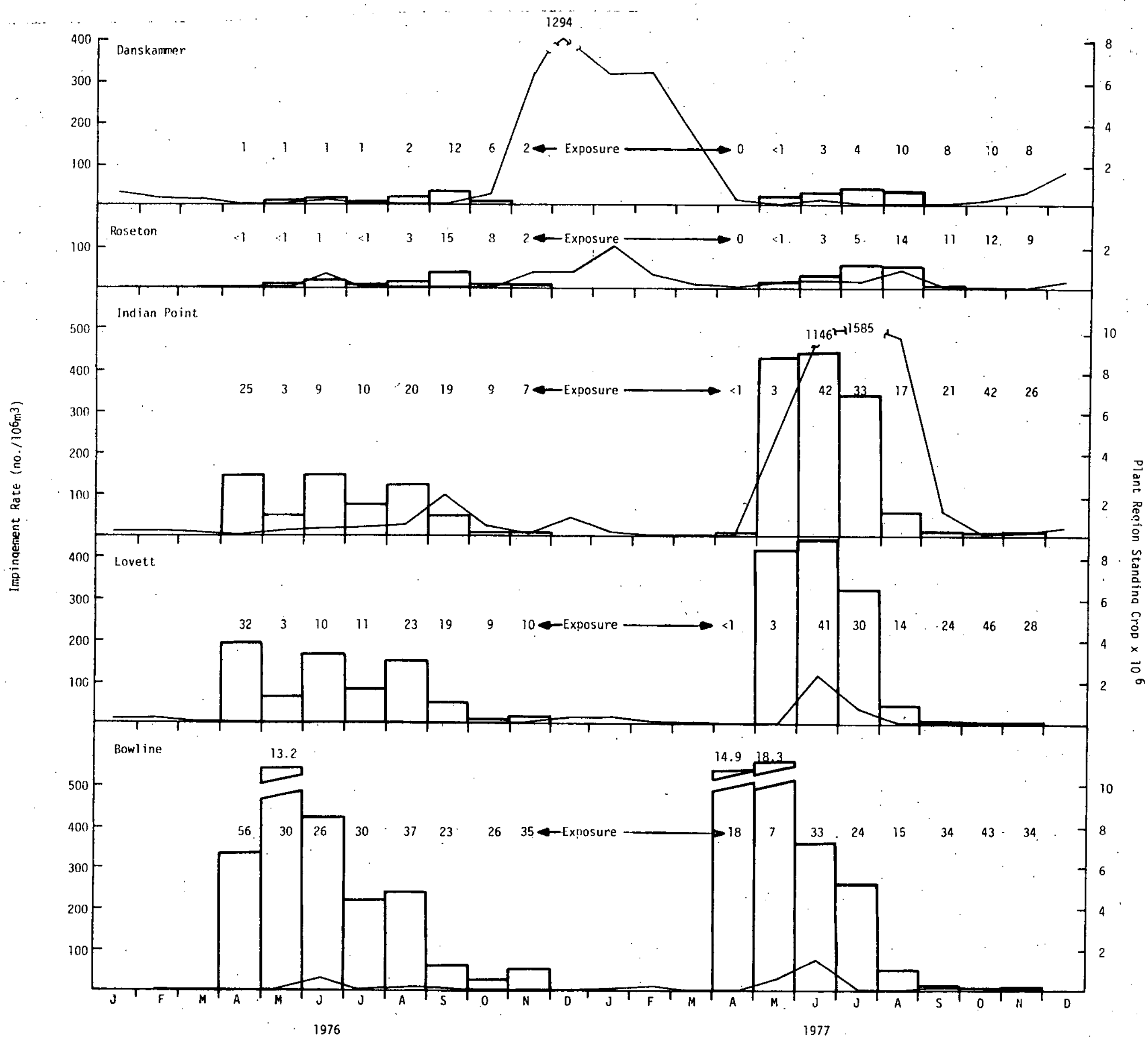


Figure V-27. Plant Region Standing Crops (Histograms Estimated from Tucker Trawl and Epibenthic Sled Samples), Exposure to Impingement (Percent of Total Standing Crop per Power Plant Region), and Impingement Rates (Lines Represent No./$10^6 m^3$ Water Circulated) of Atlantic Tomcod at Each of Five Hudson River Power Plants during 1976 and 1977

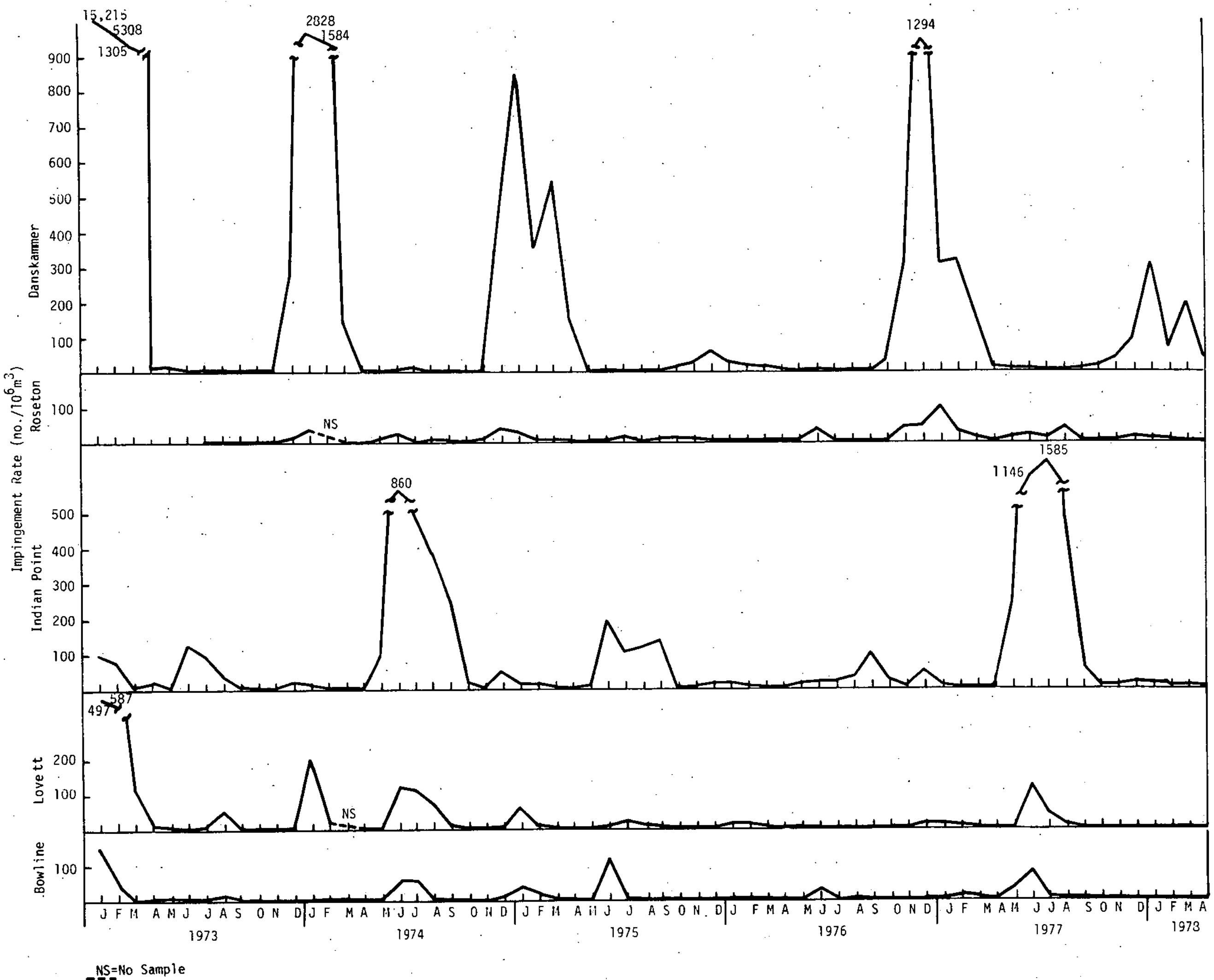


Figure V-28. Impingement Rates of Atlantic Tomcod at Five Hudson River Power Plants, 1973-1978

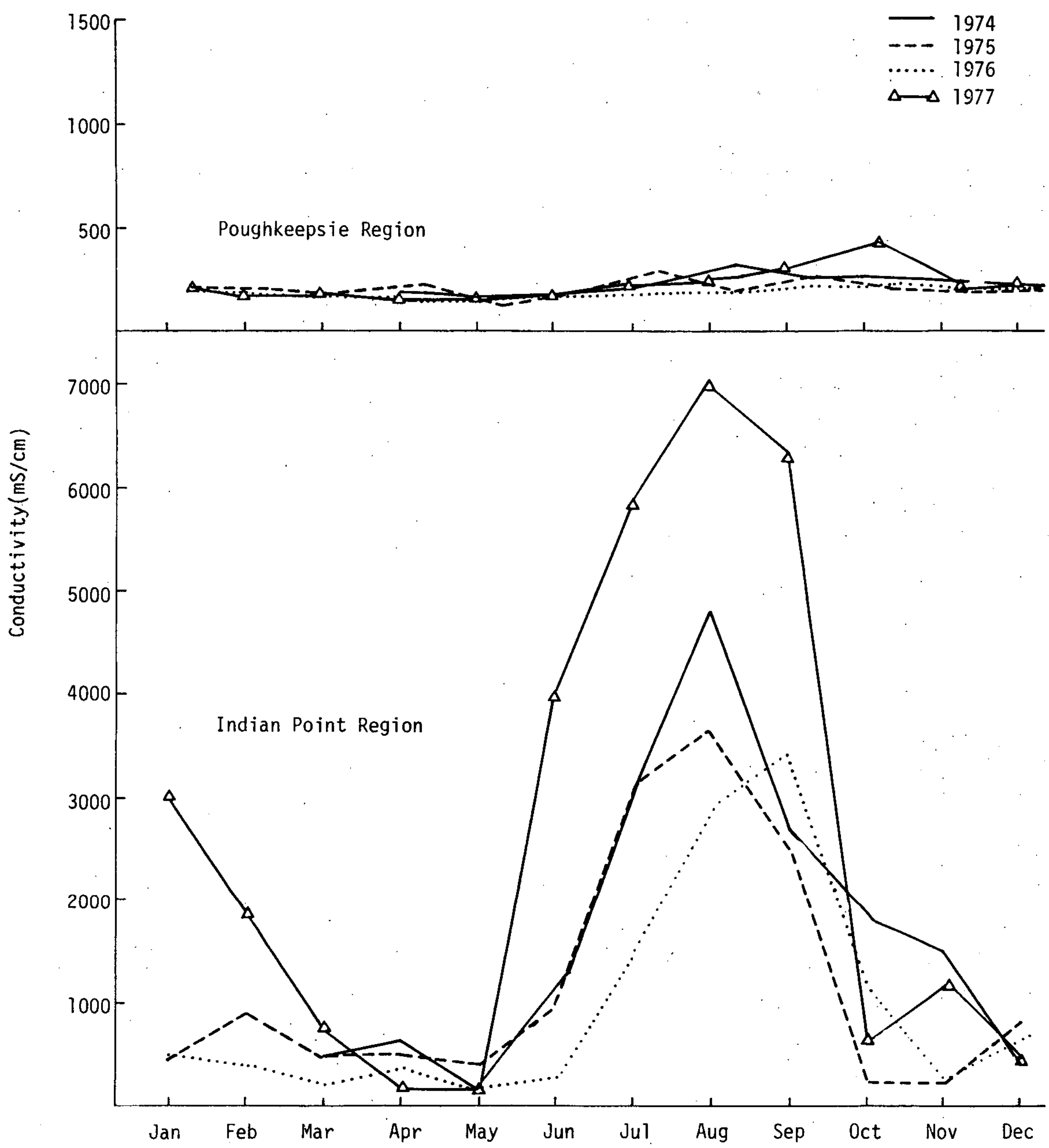


Figure V-29. Mean Monthly Conductivity in Indian Point and Poughkeepsie Regions, Hudson River Estuary, 1974-77 channel and located at a depth of 9-10 m. This winter impingement pattern supports the observation that adult Atlantic tomcod move to shoal and shore zone areas to spawn (subsection V.E).

Most tomcod spawning within the sampled area occurs in the West Point, Cornwall, and Poughkeepsie regions (subsection V.E). Annual variation in the impingement rate at Danskammer (Figure V-28) may be due to the variation in spawning location (TI 1979a).

c. Conclusions

Trends in Atlantic tomcod entrainment and impingement patterns were not closely associated with trends in corresponding exposure indices. Rather, the magnitude and time of occurrence in peaks for larval entrainment density often deviated substantially from larval plant region density. Impingement appears to be more related to seasonal conductivity values and the location of power plant intakes than to exposure. When exposure indices deviated substantially from actual entrainment and impingement rates, the direction of the bias was not predictable and varied among the power plant sites.

2. Compensation and Impact

The same four factors that influenced the effects of power plant-induced mortality on the striped bass and white perch populations (subsections III-E and IV-E) also pertain to the Atlantic tomcod population. These four factors are:

- Alpha (α), the rate of population increase from the Ricker equation in a given environment and with no density-dependent mortality
- Shape of the stock-recruitment curve
- Timing of mortality induced by power plants with respect to the period of density dependent mortality (period of compensation)
- Magnitude of the mortality induced by power plants.

The greatest difference in terms of these four factors between Atlantic tomcod and the other two species is that the most recent estimates of mortality due to power plants (conditional mortality) tend to be lower for the Atlantic tomcod population. McFadden and Lawler (1977) estimated a combined conditional mortality of 0.05; i.e., rates of 0.04 and 0.01 for entrainment of the 1975 year class and impingement of the 1974 year class, respectively.

Alpha (see subsection III-E for the definition of alpha) has been related to mean fecundity in 21 stocks of fish (TI 1979a). Generally, the higher the mean fecundity for a species, the higher the value of alpha that can be expected in that species. This value represents a minimal estimate, because several population characteristics other than fecundity also affect alpha. The average fecundity of Atlantic tomcod would be consistent with a value of alpha slightly greater than 2 (TI 1979a). This average fecundity approach was based on analyses (Cushing and Harris 1973) involving fish stocks that are generally broadcast and pelagic spawners; any life history characteristic that increases the probability of survival beyond that expected for broadcast and pelagic spawners would also increase the projected value of alpha. Atlantic tomcod do not appear to be broadcast and pelagic spawners; rather, their spawning behavior involves close proximity of the two sexes and this behavior may ensure a higher rate of fertilization than in striped bass and white perch (Klauda 1978). Thus, Atlantic tomcod exhibit a life history trait that would increase the value of alpha beyond that estimated by the mean fecundity approach.

If a conditional mortality rate of 0.05 (McFadden and Lawler 1977) and an alpha that is probably greater than 2.0 (TI 1979a) are projected onto Figures III-43 through III-45 the ultimate reduction in population size due to power plants could be greater than the conditional mortality rate only if all of the power plant-induced mortality occurred after the period of compensation. However, based on three years of data (Table V-19), it appears that a portion of the power plant-induced mortality may take place before or during the period of compensation. For example, Atlantic tomcod egg size was shown to vary with female size (subsection V.E.5), and large egg size has been related to increased larval survival in several species of fish (Ware

1975). If Atlantic tomcod growth were density-dependent, large spawns would yield large numbers of small adults which would, in turn, deposit smaller eggs with reduced survival. Although density dependence was not evident as one of the factors affecting growth (subsection V.D), the index of growth used in that analysis was for juveniles in the late summer. Three years of data suggest that the effects of density-dependent growth are more evident in the spawning population of female Atlantic tomcod rather than in juveniles. Thus, any mortality that occurred before spawning would tend to increase the size of the spawning females. Fecundity, which is closely associated with size (subsection V.E), also varied inversely with densities for years of available data (Table V-19). Entrainment and impingement mortality would, therefore, decrease the abundance of females and tend to increase the size of the remaining females, resulting in the deposition of more and larger eggs per female.

Table V-19

Summary of Factors Associated with Density of Atlantic Tomcod that May Act as Compensatory Mechanisms

Year of Index	Juvenile* Atlantic Tomcod Index	Year of Spawn†	Spawning Female Mean Length	Egg Diameter**	Fecundity (Age I)
74	9.2	74 - 75		L	
75	44.6	75 - 76	171	M	11,731
76	78.1	76 - 77	156	S	8,213
77	43.1	77 - 78	177	***	11,160

* Index calculated from July - September data
** L = largest, M = medium, S = smallest
***Data not currently available
† For example, December 1974 through February 1975

Because compensation may act through density-dependent growth associated with size-dependent fecundity and egg size in tomcod, the compensatory period probably spans the period of impact. Any thinning of the population that took place prior to or during the period of density-dependent growth would stimulate production of a greater number of larger eggs per female. If this timing of power plant-induced mortality is combined with an m of 0.05 and an α of at least 2.0, the conditional mortality rate due to entrainment and impingement is an underestimate of the reduction in population size of the Atlantic tomcod (Figures III-43 through III-45).

G. ECOLOGY AND IMPACT

Like the striped bass, the Atlantic tomcod is an anadromous species that uses the middle portion of the Hudson River estuary for spawning and the lower regions as a nursery area. Unlike striped bass, the spawning population of tomcod is composed primarily of age I females; age II and older females compose only 3% to 8% of the spawning population, making Atlantic tomcod essentially semelparous. Semelparity is usually associated with an increase in the predictability of environmental conditions controlling survival during early life history stages (Giesel 1976). Atlantic tomcod spawn in the Hudson River estuary during late December and early January, which means that the early life stages of this species are exposed to a colder but less variable thermal environment than that to which the corresponding life stages of striped bass are exposed.

Atlantic tomcod and striped bass are similar in the amount of variability in abundance during the juvenile stages; the coefficients of variation for the juvenile abundance indices (subsections III.D.1 and V.D.1) were similar (70% vs 88% for Atlantic tomcod and striped bass, respectively). Thus, it appears that the fluctuations in flow and temperature during the spring (subsection III.F) do affect the survival of juvenile tomcod. The fluctuation in juvenile abundance indicates that the Atlantic tomcod population might be modeled more realistically as a single-aged stock in a fluctuating environment. However, just as in the case of the striped bass population, the absence of an accurate description of the fluctations in important factors affecting abundance precludes the development of a quantitative model that will accurately assess the impact of the power plants on the stability and abundance of Atlantic tomcod in the Hudson River estuary. However, the recognition of semelparity and fluctuations in environmental conditions does provide valuable qualitative information concerning the impact of the power plants on the tomcod population. For example, semelparous species have shorter generation times (and consequently, shorter time lags) and can respond more quickly to changes in environmental conditions than iteroparous species can. As a result, the variation in the adult abundance of a semelparous species will follow the fluctuations in environmental conditions more closely than that of an iteroparous species. However, high resiliency (response to changes in environmental conditions) could be accompanied by a large amount of negative feedback within the population (Harrison 1979).

At least two density-dependent compensation mechanisms appear to be present in the Atlantic tomcod population in the Hudson River estuary. Phase I mortality (occurring during the spring and early summer) appears to be density-dependent (subsection V.D.2); also, density-dependent regulation appears to occur during the fall period of growth. During 1974-76, juvenile densities were highest during the summer of 1976; subsequently, the females spawning in the winter of 1976 had a significantly lower number of eggs per weight class (subsection V.E.5) than those spawning in the winters of 1974 and 1975. The presence of these density-dependent regulatory mechanisms (density-dependent mortality and density-dependent fecundity), one operating during each period of growth, should make the tomcod population highly resistant to power plant mortality. A density-dependent increase in juvenile survival during the first period of growth could compensate for entrainment mortality, while a density-dependent increase in fecundity during the second period of growth could compensate for the loss of juveniles through impingement during the summer.

Neither of these mechanisms will compensate for the impingement of adults during the spawning season. Although the survival of impinged adult tomcod is high (King et al. 1978), the effect of impingement on the subsequent spawning success of survivors has not been determined. However, the impingement of adults is quite variable (McFadden et al. 1978), and the carry-over of reproductive effort between years (via the age II females in the population) could compensate for poor spawning caused by heavy impingement of adults in the preceding year. Age II females compose only 3% to 8% of the spawning population, but their fecundity is approximately five times that of age I females; as a result, they can contribute as much as 24% of the total spawn (subsection V.E.5.c). Moreover, since adults are not impinged during the summer, the carry-over of age II females also provides additional compensation for heavy impingement of juveniles during the previous summer.

Probably the most important feature of the impingement mortality is the fact that it is variable in both the juvenile and adult stages (McFadden et al. 1978). A species with a short generation time (1 year) and high compensatory potential, such as Atlantic tomcod, requires only 1 to 2 years of low impingement mortality in order to recover from a year of heavy mortality. Accordingly, it is interesting to note that the Atlantic tomcod population in the Hudson River estuary went from a low level of abundance (in 1974, the juvenile abundance index was only 9.2) to a high level of abundance in just 2 years (by 1976, the juvenile abundance index had rebounded to 78.1). It should also be noted that this fluctuation in abundance occurred in the presence of the mortality imposed by the power plants.

In summary, a semelparous species closely follows fluctuations in environmental conditions. An iteroparous species, on the other hand, exhibits more resistance to changes in conditions and averages across fluctuations in the environment (May 1976). Consequently, an iteroparous species maintains a lower and more constant level of adult abundance and is less resilient to change than a semelparous species. Resiliency in the Atlantic tomcod population in the Hudson River estuary appears to involve the following compensatory mechanisms:

- Density-dependent regulation of mortality during the first phase of juvenile growth
- Density-dependent regulation of adult fecundity during the second phase of juvenile growth
- A carry-over of reproductive potential from the preceding year via age II females

Furthermore, the empirical data (rapid increase after a year of low abundance) demonstrate that this population is resistant to the mortality imposed by the power plants.

SECTION VI

LITERATURE CITED

Albrecht, A.B. 1964. Some observations on factors associated with survival of striped bass eggs and larvae. Calif. Fish & Game J. 50(2):100-113.

AuClair, R.P. 1964. White perch in Maine. Maine Dept. Inland Fish, and Game. 16 p.

Auerbach, S.I. 1977. Welcoming remarks. Pages xvii - xix. In: Proceedings of the conference on assessing the effects of power-plant-induced mortality on fish populations. W. VanWinkle (ed.). Pergamon Press, New York. 380 p.

Backiel, T. and E.D. LeCren. 1967. Some density relationships for fish population parameters. Pages 261-293. In: The biological basis of freshwater fish production. S.D. Gerking (ed.). John Wiley & Sons Inc., New York, NY. 495 p.

Bailey, W.M. 1974. An evaluation of striped bass introductions in the Southeastern United States. Mimeo. Arkansas Game and Fish Commission, Lonoke. 21 p.

Bannister, R.C.A., D. Harding and S.J. Lockwood. 1974. Larval mortality and subsequent year-class strength in the plaice (*Pleuronectes platessa* L.). Pages 21-37. In: The early life history of fish. J.H.S. Blaxter (ed.). Springer-Verlag, N.Y. 765 p.

Barkley, R.A. 1964. The theoretical effectiveness of towed-net samplers as related to sampler size and to swimming speed of organisms. J. Cons. Int. Explor. Mer. 29(2):146-157.

Barr, A.J., J.H. Goodnight, J.P. Sall and J.T. Helwig. 1976. A user's guide to SAS 76. SAS Institute Inc., Raleigh, N.C. 329 p.

Bayless, J.D. 1972. Artificial propagation and hybridization of the striped bass, *Morone saxatilis* (Walbaum). S.C. Wild. Mar. Res. Dept. 135 p.

Beverton, R.J.H. and S.J. Holt. 1957. On the dynamics of exploited fish populations. Fisheries Investigations, Series 2, Volume 19. Ministry of Agriculture, Fisheries and Food, London.

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. USFWS Fish. Bull. 74(53):1-577.

Booth, R.A. 1967. A description of the larval stages of the tomcod, *Microgadus tomcod*, with comments on its spawning ecology. Ph.D. thesis. Univ. Connecticut, Storrs. 53 p.

Boyce Thompson. 1977. An atlas of biologic resources of the Hudson estuary. Boyce Thompson Institute for the Plant Research. Yonkers, N.Y. 104 p.

Broughton, N.M. and N.V. Jones. 1978. An investigation into the growth of 0-group roach (Rutilus rutilus L.) with special reference to temperature. J. Fish Biol. 12:345-357.

Brown, M.B. and A.B. Forsythe. 1974. Robust tests for the equality of variances. Am. Stat. Assoc. J. 69(346):364-367.

Busch, W.N., D.H. Davies and S.J. Nepszy. 1977. Establishment of white perch, Morone americana, in Lake Erie. J. Fish. Res. Bd. Can. 34(7):1039-1041.

Calhoun, J., C.A. Woodhull, and W.C. Johnson. 1950. Striped bass reproduction in the Sacramento River system in 1948. Bur. Fish. Cons., Calif. Fish & Game 36(2):135-145.

Central Hudson Gas and Electric Corporation. 1977. Roseton Generating Sta-Station. Nearfield effects of once-through cooling system operation on Hudson River biota.

Chadwick, H.K. 1964. Annual abundance of young striped bass, Roccus saxatilis, in the Saramento-San Joaquin Delta, California. Calif. Fish and Game 50(2):69-99.

Chadwick, H.K. 1968. Mortality rates in the California striped bass population. Calif. Dept. of Fish and Game. 51(4):228-246.

Christensen, S.W., W. Van Winkle, and J.S. Mattice. 1976. Defining and determining the significance of impacts: concepts and methods. Pages 191-219. In: Proceedings of the conference on the biological significance of environmental impacts. R.K. Sharma, J.D. Buffington, and J.T. McFadden (eds.). Report No. NR-CONF-002. U.S. Nuclear Regulatory Commission, Washington, D.C. 327 p.

Clark, J. 1968. Seasonal movements of striped bass contingents of Long Island Sound and the New York Bight. Trans. Amer. Fish. Soc. 97(4): 320-343.

Clutter, R.I. and M. Anraku. 1968. Avoidance of samplers. Pages 57-76. Part I, Reviews on zooplankton sampling methods. D.J. Tranter (ed.). UNESCO Monogr. Aceanogr. Methodol. 2, Zooplankton sampling.

Cochran, W.G. 1954. Some methods of strengthening the common ^{2} tests. Biometrics. 10:417-451.

Collins, B.W. 1978. Age composition and population size of striped bass in California's Sacramento-San Joaquin estuary. Period covered: July 1, 1977 through June 30, 1978. Project No.: F-9-R-24. Calif. Dept. Fish and Game. Sacramento, Ca. 9 p.

Conover, H.R. 1958. Investigations of the white perch, Morone americana (Gmelin), in Albermarle Sound and the lower Roanoke River, North Carolina. M.S. Thesis, N.C. State Univ. 58 p.

Cummins, K.W. 1974. Structure and function of stream ecosystems. Bio-Science 24(11):631-641.

Cushing, D.H. and J.G.K. Harris. 1973. Stock and recruitment and the problem of density dependence. Rapp. R.V. Reun. Cons. Explo. Perm. Int. Mer. 164:142-155.

Dew, C.B. 1977. In: Transcripts for EPA region 2 WPDES Adjudicator. Hearing No. C/11-WP-77-01. New York, N.Y. p. 1025.

Dew, C.B. and J. Hecth. 1976. Ecology and population dynamics of Atlantic tomcod (Microgadus tomcod) in the Hudson River estuary. Paper No. 25. In: Hudson River Ecology. Fourth Symposium on Hudson River Ecology. Hudson River Environmental Society, Inc., Bear Mountain, N.Y.

Doroshev, S.I. 1970. Biological features of the eggs, larvae and young of the striped bass [Roccus saxatilis (Walbaum)] in connection with the problem of its acclimatization in the USSR. J. Ichthy. 10:235-248.

Duncan, A.J. 1974. Quality control and industrial statistics. Richard D. Irwin, Inc., Homewood, Ill. 1047 p.

Eberhardt, L.L. 1978. Appraising variability in population studies. J. Wildl. Manage. 42(2):207-238.

Ecological Analysts Inc. 1978a. Progress report for 1977 entrainment abundance studies at Bowline point. Prepared for Orange and Rockland Utilities, Inc.

Ecological Analysts Inc. 1978b. Final Report: Hudson River thermal effects studies for representative species. Prepared for Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., and Orange and Rockland Utilities, Inc.

Farley, T.C. 1967. Striped bass, Roccus saxatilis, spawning in the Sacramento-San Joaquin River systems during 1963 and 1964. Pages 29-43. In: Ecological studies of the Sacramento-San Joaquin estuary. J.L. Turner and D.W. Kelley. Pt. II. Calif. Dept. Fish & Game Fish. Bull. 136:28-43.

Fisher, S.G. and G.E. Likens. 1973. Energy flow in Bear Brook New Hampshire: An integrative approach to stream ecosystem metabolism. Ecol. Monogr. 43(4):421-439.

Fleiss, J.L. 1972. Statistical methods for rates and proportions. Wiley-Interscience Publication. John Wiley & Sons, Inc., New York, N.Y. 215 p.

Forney, J.L. 1971. Development of dominant year classes in a yellow perch population. Trans. Am. Fish. Soc. 100(4):739-749.

Franklin, D.R. and L.L. Smith. 1963. Early life history of the northern pike, Esox lucius L., with special reference to the factors affecting the numerical strength of year classes. Trans. Am. Fish. Soc. 92(2):91-110.

Fraser, J.M. 1978. The effects of competition with yellow perch on the survival and growth of planted brook trout, splake, and rainbow trout in a small Ontario lake. Trans. Am. Fish. Soc. 107(4):505-517.

Gerking, S.D. 1957. Evidence of aging in natural population of fishes. Gerontological. 1:287-305.

Giesel, J.T. 1976. Reproductive strategies as adaptations to life in temporally heterogeneous environments. Ann. Rev. Ecol. Syst. 7:57-79.

Goldspink, C.R. 1978. Comparative observations on the growth rate and year class strength of roach *Rutilus rutilus* L. in two Cheshire lakes, England. J. Fish. Biol. 12(5):421-433.

Goodyear, C.P. 1977. Assessing the impact of power plant mortality on the compensatory reserve of fish populations. Pages 186-195. *In*: Proceedings of the conference on assessing the effects of power-plant-induced mortality on fish populations. W. Van Winkle (ed.). Pergamon Press, New York. 380 p.

Goodyear, C.P. 1978. Management problems of migratory stocks of striped bass. Pages 75-98. *In*: Proceedings of the second annual Marine Recreational Fisheries Symposium. H. Clepper (ed.). Sport Fishing Institute, Washington D.C.

Grabe, S.A. 1978. Food and feeding habits of juvenile Atlantic tomcod, *Microgadus tomcod*, from Haverstraw Bay, Hudson River. Fish. Bull. 76(1):89-94.

Grant, G.C. 1974. The age composition of striped bass catches in Virginia rivers, 1967-1971, and a description of the fishery. Fish. Bull. 72(1):193-199.

Hamley, J.M. 1975. Review of gill net selectively. J. Fish. Res. Bd. Can. 32(11):1943-1969.

Hardy, J.D. and L.L. Hudson. 1975. Descriptions of the eggs and juveniles of the Atlantic tomcod, *Microgadus tomcod*. Ref. 75-11. Ches. Biol. Lab., Soloman, Md. 14 p.

Harrison, G. 1979. Stability under environmental stress: resistance, resilience, persistence, and variability. Am. Nat. 113(5):659-669.

Hatch, R.W. 1978. Minimum estimates of alewife biomass in Lake Michigan 1973-1977. An oral presentation at the 40th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 10-13, 1978.

Haven, K.F. and T.C. Ginn. 1978. A mathematical model of the interactions of an aquatic ecosystem and a thermal power station cooling system. Pages 321-341. *In*: Fourth national workshop on entrainment and impingement: impact assessment techniques. L.D. Jensen (ed.). E.A. Communications, Ecological Analysts, Inc. Melville, New York. 424 p.

Healey, M.C. 1978. Fecundity changes in exploited populations of lake whitefish (Coregonus clupeaformis) and lake trout (Salvelinus namaycush). J. Fish. Res. Bd. Can. 35(7):945-950.

Heinle, D.R., D.A. Flemer and J.F. Ustach. 1976. Contribution of tidal marshlands to mid-Atlantic estuarine food chains. Pages 309-320. In: Estuarine Processes. Vol. II. Circulation sediments and transfer of material in the estuary. M.L. Wiley (ed.). Academic Press, N.Y. 424 p.

Hergenrader, G.L. and Q.P. Bliss. 1971. The white perch in Nebraska. Trans. Amer. Fish. Soc. 100(4):734-738.

Herke, W.H. 1977. Life history concepts of motile estuarine dependent species should be re-evaluated. Louisiana Cooperative Fisheries Research Unit, Louisiana State University, Baton Rouge, L.A. 97 p.

Hetling, L.J. 1976. An analysis of past, present, and future Hudson River wastewater loadings. Paper No. 14. In: Hudson River Ecology. Fourth Symposium on Hudson River Ecology. Hudson River Environmental Society, Inc., Bear Mountain, N.Y.

Hildebrand, S.F. and W.C. Schroeder. 1928. Fishes of Chesapeake Bay. Bull. of U.S. Bur. Fish. 43:247-250.

Hollis, E.H. 1952. Variations in the feeding habits of the striped bass (Roccus saxatilis) in Chesapeake Bay. Bingham. Ocean. Coll. Bull. 14(1):111-131.

Hollis, E.H. and H.A. Davis, Jr. 1955. Report of striped bass studies in Maryland. 18th Ann. Mtg., Atlantic St. Mar. Fish. Comm. Virginia Beach, Va. Appendix CB:1-8.

Horst, T.J. 1977. Effects of power station mortality on fish population stability in relationship to life history strategy. Pages 297-310. In: Proceedings of the conference on assessing the effects of power-plant-induced mortality on fish populations. W. Van Winkle (ed.). Pergamon Press, New York. 380 p.

Horrall, R.M. 1961. A comparative study of two spawning populations of the white bass, (Roccus chrysops) (Rafinesque), in Lake Mendota, Wisconsin, with special reference to homing behavior. Ph.D. thesis. Univ. of Wisconsin. 181 p.

Houser, A. and J.E. Dunn. 1967. Estimating the size of the threadfin shad population in Bull Shoals Reservoir from midwater trawl catches. Trans. Am. Fish. Soc. 96(2):176-184.

Howe, A.B. 1971. Biological investigations of Atlantic tomcod (Microgadus tomcod) (Walbaum), in the Weweantic River estuary, Massachusetts, 1967. Masters thesis, Univ. of Massachusetts at Amherst. 82 p.

Hunter, J.R. 1976. Report of a colloquium on larval fish mortality studies and their relation to fishery research, January 1975. NOAA. Technical Report NMFS CIRC-395. 5 p.

Hynes, H.B. 1972. The ecology of running waters. Univ. of Toronto. Press, Toronto. 555 p.

Jackson, C.H.N. 1939. The analysis of an animal population. J. Anim. Ecol. 8(2):238-246.

Jackson, H.W. and Tiller, R.E. 1952. Preliminary observations on spawning potential in the striped bass [Roccus saxatilis (Walbaum)]. Ches. Biol. Lab. Solomons Island, Md. Publ. #9. pp 3-16.

Jaworski, N.A., D.W. Lear, Jr. and O. Villa, Jr. 1972. Nutrient management in the Potomac Estuary. Pages 246-273. In: Nutrients and eutrophication: the nutrient limiting controversy. G.E. Likens (ed.). Special Symposia Vol. I. Amer. Soc. Limnol. and Oceanogr.

Johnson, W.C. and A.J. Calhoun. 1952. Food habits and California striped bass. Calif. Fish and Game. 38(4):531-534.

Jones, P.W., J.S. Wilson, R.P. Morgan II, H.R. Lunsford Jr., and J. Lawson. 1977. Potomac River fisheries study striped bass spawning stock assessment. Interpretive Report 1974-1976. Ches. Biol. Lab. and Cntr. Environmental. Est. Stds. Univ. Md. 94 p.

Jones, R. 1977. Tagging: theoretical methods and practical difficulities. Pages 46-65. In: Fish population dynamics. J.A. Gulland, ed. John Wiley & Sons, London. 372 p.

Jones, R. and C. Johnston. 1977. Growth, reproduction and mortality in gadoid fish species. Pages 37-62. In: Fisheries mathematics. J.H. Steele (ed.). Academic Press, New York. 198 p.

King, L.R., J.B. Hutchinson, Jr., and T.G. Huggins. 1978. Impingement survival studies on white perch, striped bass, and Atlantic tomcod at three Hudson River power plants. Pages 217-233. In: Fourth national workshop on entrainment and impingement: impact assessment techniques. L.D. Jensen (ed.). E.A. Communications, Ecological Analysts, Inc. Melville, New York. 424 p.

Kjelson, M.A. and D.R. Colby. 1977. The evaluation and use of gear efficiencies in the estimation of estuarine fish abundance. Pages 416-424. In: Estuarine Processes. Vol. II. Circulation, sediments, and transfer of material in the estuary. M. Wiley (ed.). Academic Press, Inc. New York.

Klauda, R.J. 1978. Courtship behavior of Atlantic tomcod (Microgadus tomcod).

Paper presented at the northeast meeting of the animal behavior society, Monmouth, New Jersey, October, 1978.

Kohlhorst, D.W. 1977. Age composition and population size of striped bass in California's Scacramento-San Joaquin estuary. Period covered: July 1, 1976 through June 30, 1977. Study No. 1, Job No. 2. Project No.: F-9-R-23. Calif. Dept. Fish and Game. Sacramento, Ca. 8 p.

Kornegay, J.W. and E.T. Humphries. 1976. Spawning of the striped bass in the Tar River, North Carolina. Proc. 29th Ann. Conf. Southeastern Game & Fish. Comm. p. 317-325.

Kramer, R.H. and L.L. Smith, Jr. 1960. First-year growth of the largemouth bass, Micropterus salmoides (Lacepede) and some related ecological factors. Trans. Am. Fish. Soc. 89(2):222-233.

Kramer, R.H. and L.L. Smith, Jr. 1962. Formation of year classes in largemouth bass. Trans. Am. Fish. Soc. 91(1):29-42.

Krebs, C.J. 1972. Ecology: The experimental analysis of the distribution and abundance of animals. Harper and Row, N.Y. 694 p.

Larimore, R.W. 1975. Visual and tactile orientation of smallmouth bass fry under floodwater conditions. Pages 323-332. In: Black bass biology and management. H. Clepper (ed.). Sports Fishing Institute, Washington, D.C.

Larkin, P.A. 1956. Interspecific competition and population control in freshwater fish. J. Fish. Res. Bd. Canada. 13(3):327-342.

Lawler, Matusky and Skelly and Ecological Analysts, Inc. 1973. 1973 Hudson River aquatic ecological studies at Roseton and Danskammer Point. Vol. III. Central Hudson Gas and Electric Corporation.

Lawler, Matusky, and Skelly Engineers, Inc. 1978. 1977 Hudson River aquatic ecology studies at Bowline Point Generating Station. Prepared for Orange and Rockland Utilities, Inc.

Lawler, Matusky, and Skelly Engineers, Inc. 1979. Annual progress report 1977. Prepared for Central Hudson Gas and Electric Corporation.

Legendre, V. and R. Lagueux. 1948. The tomcod (Microgadus tomcod) as a permanent fresh-water resident of Lake St. John, Province of Quebec. Can. Field-Nat. 65(5):157.

Leggett, W.C. and J.E. Carscadden. 1978. Latitudinal variation in reproductive characteristics of American shad (Alosa sapidissima): Evidence for population specific life history strategies in fish. J. Fish. Res. Bd. Can. 35:1469-1478.

Levins, R. 1968. Evolution in changing environments. Princeton University Press. Princeton, N.J. 120 p.

Lewis, R.M. 1962. Sexual maturity as determined from ovum diameters in striped bass from North Carolina. Trans. Am. Fish. Soc. 91(3):279-282.

Lewis, R.M. and R.R. Bonner. 1966. Fecundity of the striped bass, Roccus saxatilis (Walbaum). Trans. Am. Fish. Soc. 95(3):328-331.

Lewis, S.A. and D.D. Garriott. 1970. A modified folsom plankton splitter for for analyses of meter net samples. Proc. 24th Ann. Conf. S.E. Assoc. of Game and Fish. p. 332-337.

Lippson, A.J. and R.L. Moran. 1974. Manual for identification of early de-development stages of fishes of the Potomac River estuary. Martin-Marietta Corp., Baltimore, Md. 282 p.

Lux, F.E. and F.E. Nichy. 1971. Number and lengths, by season, of fishes caught with an otter trawl near Woods Hole, Massachusetts, September 1961 to Decemer 1962. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Special Scientific Report - Fisheries No. 622. 15 p.

McFadden, J.T. 1976. Environmental impact assessment for fish populations. Pages 89-137. In: Proceedings of the conference on the biological significance of environmental impacts. R.K. Sharma, J.D. Buffington, and J.T. McFadden (eds.). Report No. NR-CONF-002. U.S. Nuclear Regulatory Commission, Washington, D.C. 327 p.

McFadden, J.T. ed. 1977a. Influence of Indian Point Unit 2 and other steam electric generating plants on the Hudson River estuary, with emphasis on striped bass and other fish populations. Prepared for Consolidated Edison Company of New York, Inc.

McFadden, J.T. 1977b. An argument supporting the reality of compensation in fish populations and a plea to let them exercise it. Pages 153-183. In: Proceedings of the conference on assessing the effects of power-plant-induced mortality on fish populations. W. Van Winke (ed.). Pergamon Press, New York. 380 p.

McFadden, J.T. and J.P. Lawler ed. 1977. Supplement I to influence of Indian Point Unit 2 and other steam electric generating plants on the Hudson River estuary with emphasis on striped bass and other fish populations. Prepared for Consolidated Edison Company of New York, Inc.

McFadden, J.T., Texas Instruments Incorporated and Lawler, Matusky & Skelly Engineers. 1978. Influence of the proposed Cornwall pumped storage project and steam electric generating plants on the Hudson River estuary with emphasis on striped bass and other fish populations, revised. Prepared for Consolidated Edison Company of New York, Inc.

Maloney, J.E. and F.H. Johnson. 1957. Life histories and inter-relationships of walleye and yellow perch, especially during their first summer, in two Minnesota lakes. Trans. Am. Fish. Soc. 85:191-202.

Manooch, C.S. III. 1973. Food habits of yearling and adult striped bass, Morone saxatilis (Walbaum), from Albermarle Sound, North Carolina. Ches. Sci. 14(2):73-86.

Mansueti, R.J. 1958. Eggs, larvae and young of the striped bass, Roccus saxatilis. Md. Dept. Res. and Ed., Ches. Biol. Lab. Contr. #112. 35 p.

Mansueti, R.J. 1961a. Age, growth, and movements of striped bass, Roccus saxatilis, taken in size selective fishing gear in Maryland. Ches. Sci. 2(1-2):9-36.

Mansueti, R.J. 1961b. Movements, reproduction and mortality of the white perch Roccus americanus, in the Patuxent estuary, Maryland. Ches. Sci. 2(3-4):142-205.

Mansueti, R.J. 1964. Eggs, larvae, and young of the white perch, Roccus americanus, with comments on its ecology in the estuary. Ches. Sci. 5(1-2):3-45.

Mansueti, R.J. and E.H. Hollis. 1963. Striped bass in Maryland tidewaters. Nat. Res. Inst., Univ. Md. Ed. Ser. No. 61. 28 p.

Marcy, B.C., Jr. 1976. Fishes of the lower Connecticut River and the effects of the Connecticut Yankee Plant. In: The Connecticut River ecological study. D. Merriman and L. Thorpe (eds.). Am. Fish. Soc. Monogr. 1:61-113.

Marcy, B.C. and F.P. Richards. 1974. Age and growth of the white perch, Morone americana, in the lower Connecticut River. Trans. Am. Fish. Soc. 103(1):117-120.

Mather, F. 1886. Work at Cold Spring Harbor, Long Island during 1883 and 1884, Appendix: 129-142. Rep. U.S. Fish. Common., 1884. p.22. cited by Booth, R.A. 1967. In: A description of larval stages of the Ph.D. Thesis. U. Conn., Storrs. 53 p.

Mather, R. 1887. Report of the operation at Cold Spring Harbor, New York during the season of 1885. Rep. U.S. Commn. Fish., 1885, Appendix: 109-116.

May, R.M. 1976. Models for single populations. Pages 20-23. In: Theoretical Ecology, Principles and Applications. R.M. May (ed.). W.B. Saunders Company, Philadelphia.

May, R.C. 1974. Larval mortality in marine fishes and the critical period concept. Pages 3-19. In: The early life history of fish. J.H.S. Blaxter (ed.). Springer-Verlag, N.Y. 765 p.

Merriman, D. 1941. Studies on the striped bass (Roccus saxatilis) of the Atlantic coast. U.S. Fish & Wild. Ser., Fish. Bull. 50(35):1-77.

Merriman, D. 1947. Notes on the midsummer ichthyofauna of a Connecticut beach at different tide levels. Copeia. (4):281-286.

Morgan, A.R. and A.R. Gerlach. 1950. Striped bass studies on Coos Bay, in 1949 and 1950. Oregon Fish & Game Comm. 14:31.

New York Conservation Department. 1950. 1949 annual report to legislature. 158 p.

New York University. 1977. Hudson River ecosystem studies. Effects of entrainment by the Indian Point power plant on biota in the Hudson River Estuary Progress Report for 1975. Prepared for Consolidated Edison Company of New York, Inc.

Nichols, J.T. and C.M. Breder, Jr. 1926. The marine fishes of New York and Southern New England. Zool. 9(1):1-192.

Nicholson, W.R. 1964. Growth compensation in four year classes of striped bass, Roccus saxatilis, from Albemarle Sound, North Carolina. Ches. Sci. 5. (3):145-149.

Odum, E.P. 1969. The strategy of ecosystem development. Science. 164:262-270.

Odum, E.P. 1971. Fundamentals of ecology. 3rd ed. W.B. Saunders Co., Philadelphia. 574 p.

Orange and Rockland Utilities, Inc. 1977. Bowline Point Generating Station nearfield effects of once-through cooling system operation on Hudson River biota.

Parsons, J.W. 1974. Striped bass (Morone saxatilis): distribution, abundance, biology, and propagation in North America and suitability for introduction into the Great Lakes. U.S. Fish & Wildl. Serv. Ann Arbor, Michigan. 74 p.

Pearcy, W.G. 1962. Ecology of an estuarine population of winter flounder. Pages 16-38. Yale University Peabody Museum of Natural History. Bingham Oceanographic Foundation. Bulletin of the Bingham Oceanographic Collection 18. #1.

Pearson, J.C. 1938. The life history of the striped bass, or rockfish, Roccus saxatilis (Walbaum). U.S. Bur. Fish. Bull. 49:825-851.

Perlmutter, A., E. Schmidt and E. Leff. 1967. Distribution and abundance of fish along the shores of the lower Hudson River during the summer of 1965. N.Y. Fish and Game J. 14(1):47-75.

Pikitch, E.K., R.A. Alveras, J.M. Hillegas, Jr., and D.T. Logan. 1978. Possibilities for the assessment of the effects of power plant operations at the ecosystem level. Pages 315-320. In: Fourth national workshop on entrainment and impingement: impact assessment techniques. L.D. Jensen (ed.). E.A. Communications, Ecological Analysts, Inc. Melville, New York. 425 p.

Polgar, T.T. 1977. Striped bass ichthyoplankton abundance, mortality, and production estimation for the Potomac River population. Pages 110-126. In: Proceedings of the conference on assessing the effects of power-plant-induced mortality on fish populations. W. Van Winkle (ed.). Pergamon Press, New York. 380 p.

Power, G. 1978. Fish population structure in Arctic Lakes. J. Fish. Res. Bd. Can. 35(1):53-59.

Powers, D.A. 1976. Physiology of fish impingement: role of hemoglobin and its environmental modifiers. Pages 241-254. In: Third national workshop in entrainment and impingement. Section 316(b). L.D. Jensen (ed.). Ecological Analysts, Inc. 425 p.

Raney, E.C. 1952. The life history of the striped bass, Roccus saxatilis (Walbaum). Bull. Bingham Oceanogr. Coll. 14(1):5-97.

Raney, E.C. 1954. The striped bass in New York waters. New York State Conservationist. 8(4):14-16.

Raney, E.C., W.S. Woolcutt, and A.G. Mehring. 1954. Migratory pattern and racial structure of Atlantic coast striped bass. Trans. 19th N. Amer. Wild. Conf. p. 376-396.

Ricker, W.E. 1954. Stock and recruitment. J. Fish. Res. Bd. Can. 11:559-623.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish population. Fish. Res. Bd. Can. Bull. 191:382 p.

Ritchie, D.E. and T.S.Y. Koo. 1973. Movements of juvenile striped bass in the estuary as determined by tagging and recapture. Pages 126-128. In: Proceedings of a workshop on egg, larval and juvenile stages of fish in Atlantic coast estuaries. L. Pacheco (ed.). NOAA Tech. Publ. No. 1. 338 p.

Robinson, D.G. and W.E. Barraclough. 1978. Population estimates of sockeye salmon (Oncorhynchus nerka) in a fertilized oligotrophic lake. J. Fish. Res. Board. Can. 35(6):851-860.

Royce, W.F. 1972. Introduction to the fishery sciences. Academic Press., New York. 351. p.

St. Pierre, R.A. and J. Davis. 1972. Age, growth, and mortality of the white perch, Morone americana, in the James and York rivers. Ches. Sci. 13(4):272-281.

Sazaki, M., W. Heubach and J.E. Skinner. 1973. Some preliminary results on the swimming ability and impingement tolerance of young-of-the-year steelhead trout, king salmon and striped bass. Final Report for Anadromous Fisheries Act Project, Calif AFS-13. 31 p.

Schaner, E. and K. Sherman. 1960. Observations on the fecundity of tomcod, Microgadus tomcod (Walbaum). Copeia 4:347-348.

Schultz, V., L.L. Eberhardt, J.M. Thomas, and M.I. Cochran. 1976. A bibliography of quantitave ecology. Halsted Press, New York. 361 p.

Scofield, E.C. 1931. The striped bass of California (Roccus lineatus). Calif. Div. Fish & Game Fish. Bull. 29:1-84.

Scofield, N.B. and H.C. Bryant. 1926. The striped bass in California. Calif. Fish and Game. 12(2):55-74.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. J. Fish. Res. Bd. Can. Bull. 184: 966 p.

Scott, W.B. and W.J. Christie. 1963. The invasion of the lower great lakes by the white perch, Roccus americanus (Gmelin). J. Fish. Res. Bd. Can. 20(5):1189-1195.

Scruggs, G.D., Jr. 1955. Reproduction of resident striped bass in Santee-Cooper Reservoir, South Carolina. Trans. Amer. Fish. Soc. 85:144-159.

Seber, G.A.F. 1973. The estimation of animal abundance and related parameters. Hafner Press, New York. 506 p.

Sette, O.E. 1943. Biology of the Atlantic mackeral Scomber scombrus of North America, Part I, early life history including growth, drift, mortality of the egg, and larval populations. U.S. Fishery Bulletin 50. #38. p. 149-237.

Shapovalov, L. 1936. Food of the striped bass. Calif. Fish and Game. 22(4):261-271.

Sheri, A.N. and G. Power. 1968. Reproduction of white perch, Roccus americanus, in the Bay of Quinte, Lake Ontario. J. Fish. Res. Bd. Can. 25(10):2225-2231.

Simpson, H.J., R. Bopp, and D. Thurber. 1973. Salt movement patterns in the lower Hudson. Paper No. 9. In: Hudson River Ecology. Third symposium on Hudson River ecology. Hudson River Environmental Society, Inc., Bear Mountain, N.Y.

Smith, G.E. 1974. Age composition and population size of striped bass in California's Sacramento-San Joaquin estuary. Period covered: July 1, 1973 to June 30, 1974. Project No.: DJF9R-20. Calif. Dept. Fish and Game. Sacramento. Ca. 4 p.

Smith. G.E. 1975. Age composition and population size of striped bass in Californa's Sacramento-San Joaquin estuary. Period covered: July 1, 1974 to June 30, 1975. Project No.: DJF9R-21. Calif. Dept. Fish and Game. Sacramento, Ca. 7 p.

Smith, G.E. 1976. Age composition and population size of striped bass in California's Sacramento-San Joaquin estuary. Period covered: July 1, 1975 to June 30, 1976. Project No.: F-9-R-22. Calif. Dept. Fish. and Game. Sacramento, Ca. 7 p.

Sokal, R.R. and F.T. Rohlf. 1969. Biometry. W.H. Freeman and Company. San Francisco, Calif. 776 p.

Steel, R.G.D. and J.H. Torrie. 1960. Principles and procedures of statistics with special reference to the biological sciences. McGraw Hill Book Co., Inc., New York. 481 p.

Stevens, D.E. 1973. Age composition and population size of striped bass in California's Sacramento-San Joaquin estuary. Period Covered: July 1, 1972 to June 30, 1973. Project No.: D-J F-9-R-19. Calif. Dept. Fish and Game. Sacramento, Ca. 3 p.

Stevens, D.E. 1966. Food habits of striped bass Roccus saxatilis in the Sacramento-San Joaquin delta. Fish. Bull. 136(2):68-96.

Stevens, D.E. 1977. Striped bass (Morone saxatilis) year class strength in relation to river flow in the Sacramento-San Joaquin Estuary, California. Trans. Am. Fish. Soc. 106(1):34-42.

Stevens, R.E. 1966. Hormone-induced spawning of striped bass for reservoir stocking. Progressive Fish Culturist 28(1):19-28.

Stira, R.J. 1976. Sinking rate and drift distance of eggs of American shad (Alosa sapidissima) in the Connecticut River, Massachusetts. M.S. thesis. Univ. of Massachusetts. 59 p.

Summerfelt, R.C. 1975. Relationship between weather and year-class strength of largemouth bass. Pages 166-174. In: Black bass biology and management. R. Stroud and H. Clepper (eds.). Sport Fishing Institute, Washington, D.C. 534 p.

Talbot, G.B. 1966. Estuarine environmental requirements and limiting factors for striped bass. Pages 37-49. In: Symposium on estuarine fisheries. R.F. Smith, A.H. Swartz and W.H. Massmann (ed.). Am. Fish. Soc. Spec. Pub. 3. 154 p.

Taub, S.H. 1966. Some aspects of the life history of the white perch, Roccus americanus (Gmelin), in Quabbin Reservoir, Massachusetts. M.S. thesis. Univ. Massachusetts, Amherst. 63 p.

Taub, S.H. 1969. Fecundity of the white perch, Roccus americanus (Gmelin). Prog. Fish. Cult. 31(3):166-168.

Tepper, E.E. 1967. Statistical methods in using mark-recapture data for population estimation. U.S. Dept. of the Interior. Washington, D.C. Bibliography No. 4. 65 p.

Texas Instruments Incorporated. 1975a. Hudson River ecological study in the area of Indian Point. 1974 Annual Report. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1975b. Feasibility of culturing and stocking Hudson River striped bass. 1975 Annual Report. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1975c. First annual report for the multi-plant impact study of the Hudson River estuary. Vol. 2. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1976a. Hudson River ecological study in the area of Indian Point. 1975 Annual Report. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1976b. Report on relative contribution of Hudson River striped bass to the Atlantic coastal fishery. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1976c. Fisheries survey of the Hudson River. March-December 1973. Vol. IV. Revised edition June 1976. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1976d. Predation by bluefish in the lower Hudson River. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorportated. 1977a. 1974 year-class report for the multi-plant impact study of the Hudson River estuary. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1977b. Hudson River ecological study in the area of Indian Point. 1976 Annual Report. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1977c. Production of striped bass for power plant entrainment studies. 1977 Hatchery Report. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1978a. 1975 year-class report for the multi-plant impact study of the Hudson River estuary. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1978b. Catch efficiency of 100-ft (30-m) beach seines for estimating density of young-of-the-year striped bass and white perch in the shore zone of the Hudson River estuary. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1979a. 1976 year-class report for the multi-plant impact study of the Hudson River estuary. Prepared for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1979b. Hudson River ecological study in the area of Indian Point. 1977 Annual Report. Prepared for Consolidated Edison Company of New York, Inc.

Thoits, Charles F. III. 1973. A compendium of the life history and ecology of the white perch, Morone americana (Gmelin). Mass. Div. of Fish and Game. Fish. Bull. 24. 18 p.

Thomas, J.L. 1967. The diet of juvenile and adult striped bass, Roccus saxatilis, in the Sacramento-San Joaquin River system. Calif. Fish & Game. 53(1):49-62.

Tiller, R.E. 1950. A five-year study of the striped bass fishery of Maryland, based on analysis of the scales. Ches. Biol. Lab. Pub. No. 85: 30 p.

Trent, L. and W.W. Hassler. 1966. Feeding behavior of adult striped bass, Roccus saxatilis, in relation to stages of sexual maturity. Ches. Sci. 7(4):189-192.

Trent, L. and W.W. Hassler. 1968. Gill net selection, migration, size and age composition, sex ratio, harvest efficiency, and management of striped bass in the Roanoke River, North Carolina. Ches. Sci. 9(4):217-232.

Tresselt, E.F. 1952. Spawning grounds of the striped bass or rock, Roccus saxatilis (Walbaum), in Virginia. Bull. Bingham Oceanogr. Coll. 14(1): 98-110.

Turner, J.L. and H.K. Chadwick. 1972. Distribution and abundance of young-of-the-year striped bass, Morone saxatilis, in relation to river flow in the Sacramento-San Joaquin estuary. Trans. Am. Fish. Soc. 101(3):442-452.

Turner, J.L. 1976. Striped bass spawning in the Sacramento and San Joaquin rivers in central California from 1963 to 1972. Calif. Fish and Game J. 62(2):106-118.

United States Geological Survey (USGS). 1975. Water resources data for New York 1974: Part 2. Water Quality Records. 360 p.

United States Geological Survey (USGS). 1976. Water resources data for New York: Water year 1975. NY-75-1. 735 p.

United States Geological Survey (USGS). 1977. Water resources data for New York: Water year 1976. Vol. 1. New York excluding Long Island. NY-76-1. 615 p.

United States Geological Survey (USGS). 1978. Water resourses data for New York: Water year 1977. Vol. 1. New York excluding Long Island. NY-77-1. 566 p.

United States Nuclear Regulatory Commission (USNRC). 1975. Final environmental statement related to operation of Indian Point Nuclear Generating Plant Unit No. 3. Consolidated Edison Company of New York, Inc. Docket No. 50-286. Vol II.

Van Winkle, W., S.W. Christensen, and G. Kauffman. 1976. Critique and sensitivity analysis of the compensation function used in the LMS Hudson River striped bass models. ORNL/TM-5437, ESD-944. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 100 p.

Van Winkle, W. 1977. Introductory remarks. p. xxi-xxiv. In: Proceedings of the conference on assessing the effects of power-plant-induced mortality on fish populations. W. VanWinkle (ed.). Pergamon Press, New York. 380 p.

Van Winkle, W., D.L. DeAngelis, and S.R. Blum. 1978. A density-dependent function for fishing mortality rate and a method for determining elements of a Leslie matrix with density-dependent parameters. Trans. Am. Fish. Soc. 107(3):395-401.

Wallace, D.C. 1971. Age, growth, year class strength, and survival rates of the white perch Morone americana (Gmelin) in the Delaware River in the vicinity of Artificial Island. Ches. Sci. 12(4):205-218.

Ware, D.M. 1975. Relation between egg size, growth, and natural mortality of larval fish. J. Fish. Res. Bd. Can. 32(12):2503-2512.

Watson, L.C. 1978. Tomcod eggs: sticky or slippery? Texas Instruments Science Services News. 4(2):3.

Watt, K.E.F. 1968. Ecology and resource management. McGraw-Hill Company, New York. 450 p.

Weatherley, A.H. 1963. Notions of niche and competition among animals, with special reference to freshwater fish. Nature. 197:14-17.

Weatherley, A.H. 1972. Growth and ecology of fish populations. Academic Press., London. 293 p.

Woodhull, C. 1947. Spawning habits of the striped bass (Roccus saxatilis) in California waters. Calif. Fish and Game. 44(2):97-102.

Zankel, K.L., W.A. Richkus, M.S. Haire and B. Kobler. 1978. Use of acoustic survey and commercial landing data to describe spatial distribution of a striped bass spawning stock. Presented at Northeast Am. Fish. Soc. White Sulphur Springs, West Virginia.

I. FIELD AND LABORATORY PROCEDURES

A. INTRODUCTION

The Hudson River estuary between the George Washington Bridge and Albany (RM 12-152, KM 19-243) was divided into 12 geographic regions for field sampling (Figure A-1). This appendix briefly describes the equipment and procedures used in the field and laboratory operations conducted by Texas Instruments in 1977 and identifies sources of data utilized in this report other than those collected by TI. Table A-1 indicates the schedule for each field task and outlines the uses of the data collected.

B. ICHTHYOPLANKTON SAMPLING TASKS

Sampling in the 12 regions defined within the Hudson River estuary (Figure A-1) obtained data on the following early life stages of fish:

Egg	The embryonic stage commencing with spawning and lasting until hatching
Yolk-Sac Larva	The transitional stage from hatching through development of a complete and functional digestive system
Post Yolk-Sac Larva	The stage from initial development of a complete and functional digestive system (regardless of degree of yolk and/or oil retention) to transformation (having a full complement of fin rays)
Juvenile (also called young-of-the-year)	From completed transformation to Age I (December 31).

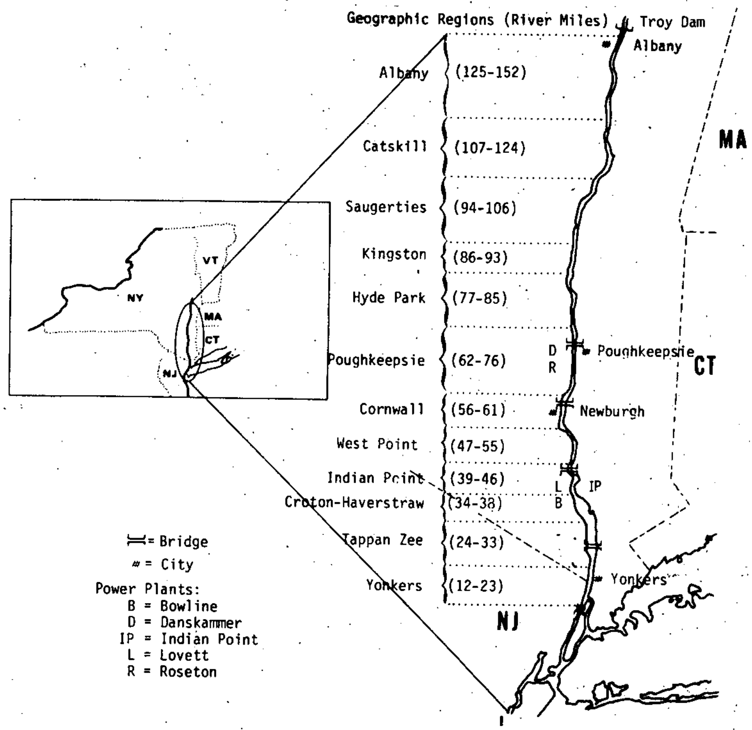
Each of the 12 geographic regions sampled for ichthyoplankton was subdivided into three strata: shoals, bottom, and channel (Table A-2, Figure A-2). The shoal stratum was the portion of the river 20 ft (6 m) or less in depth at mean low tide; the bottom stratum was the zone extending 10 ft (3 m) from the bottom in depths exceeding 20 ft (6 m); and the area not defined as shoal or bottom was considered to be the channel stratum.

Table A-1

Schedule of 1977 Field Tasks and Uses of Data

Task	J	F	M	A	M	J	J	A	S	O	N	D	Data Collected	Data Uses
Ichthyoplankton Surveys														
Larval Atlantic Tomcod		—	—	—									Numbers and densities of eggs, larvae, and early juvenile fish	Population size estimation; Spatiotemporal distribution and abundance for exposure assessment; Species composition for historical data base; Biological characteristics
Longitudinal River				—	—	—	—	—					Numbers and densities of eggs, larvae, and early juvenile fish	
Fall Shoal									—	—	—	—	Numbers and densities of juvenile and adult fish primarily in shoals	
Fisheries Surveys														
Mark-Recapture	—	—	—	—	—	—	—	—	—	—	—	—	Mark release and recovery data on striped bass, white perch, and Atlantic tomcod collected by all programs	Movement of marked individuals for vulnerability assessment; Spatiotemporal distribution and abundance for exposure assessment; Year-class comparisons and species composition for historical data base; Population estimates and relative abundance indices; Biological characteristics
Standard Station				—	—	—	—	—	—	—	—	—	Numbers and size of juveniles and adult fish in shoals, channel, and shore zone in the vicinity of the Indian Point Generating Station	
Beach Seine				—	—	—	—	—	—	—	—	—	Numbers of juvenile and adult fish in shore zone	
Interregional Trawl				—	—	—	—	—	—	—	—		Numbers of juvenile and adult fish in shoals and channel	
Adult Striped Bass Program			—	—	—	—							Number, size, age, sex, mark-recovery, fecundity, age at maturity	Population estimate, movement, year-class comparisons, biological characteristics, age composition
Water Quality Program	—	—	—	—	—	—	—	—	—	—	—	—	Temperature, dissolved oxygen, conductivity, pH, and turbidity	Yearly comparisons of physical and chemical variables for historical data base; Fish distribution in relation to chemical and physical variables

Figure A-1. Location of 12 Geographic Regions (with River Mile Boundaries) Used during 1976 Field Sampling Programs in Hudson River Estuary



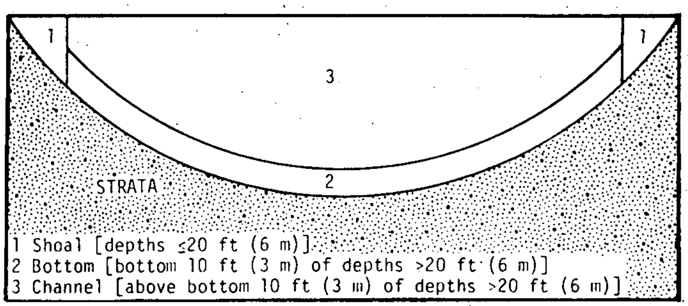


Figure A-2. Cross Section of Estuary Showing Strata Sampled in 1977 Larval Atlantic Tomcod Survey and Longitudinal River Survey. (Only shoal and bottom strata sampled in Fall Shoal Survey.)

Table A-2

Strata Sampled within Geographic Regions of Hudson River Estuary during 1977

Geographic Region		Available Strata: Bottom	Channel	Shoal
Albany	(AL)	✓	**	**
Catskill	(CS)	✓	✓	**
Saugerties	(SG)	✓	✓	**
Kingston	(KG)	✓	✓	**
Hyde Park	(HP)	✓	✓	**
Poughkeepsie	(PK)	✓	✓	**
Cornwall	(CW)	✓	✓	✓
West Point	(WP)	✓	✓	**
Indian Point	(IP)	✓	✓	✓
Croton-Haverstraw	(CH)	✓	✓	✓
Tappan Zee	(TZ)	✓	✓	✓
Yonkers	(YK)	*	✓	✓

✓ Sampled
* Not sampled due to obstructions
**Stratum too limited to sample

1. Larval Atlantic Tomcod Survey

This survey, which was conducted in late winter and early spring of 1977 (Table A-1 and Table A-3), obtained data on Atlantic tomcod ichthyoplankton and juvenile distribution and population dynamics in the Hudson River estuary. Samples were collected biweekly during the daytime within the seven geographic regions from Yonkers through Poughkeepsie (RM 14-76, Figure A-1). On the basis of observed distribution of Atlantic tomcod larvae in 1975 and 1976 (TI 1978a), effort was allocated to regions and strata randomly selected for both location and depth. During each biweekly sampling run (river run), 100 samples were collected using a 1.0-m^2 epibenthic sled (505-μm mesh, Figure A-3) in the shoal and bottom strata and a 1.0-m^2 Tucker trawl (505-μm mesh, Figure A-4) in the channel stratum (Table A-4). Calibrated digital flowmeters were placed within the net to record sample volume, and calibrated electronic flowmeters were mounted on the cable above the net to record tow speed. Standard tow duration for both gear was 5 min. When a tow was completed, the net was rinsed and the contents of the collection cup poured into a pan. Yearling and older *Morone* spp. and Atlantic tomcod having tags, finclips, or tag wounds were preserved in 10% buffered formalin and taken to the laboratory for verification. All unmarked yearling and older fish were released and the remaining sample placed in a labeled container and preserved with 10% buffered formalin for laboratory processing.

2. Longitudinal River Survey

Between mid-April and mid-August 1977 (Table A-1, Table A-3), the Longitudinal River Survey sampled all available strata (Table A-2) in the Yonkers through Albany regions (RM 14-140, KM 22-224) to provide data on the early life history, distribution, and population dynamics of striped bass, white perch, and Atlantic tomcod. Each of 15 river runs yielded approximately 200 samples. In late June, the time of sampling was shifted from day to night to reduce possible gear avoidance by the more motile post yolk-sac larvae and juvenile *Morone* spp.

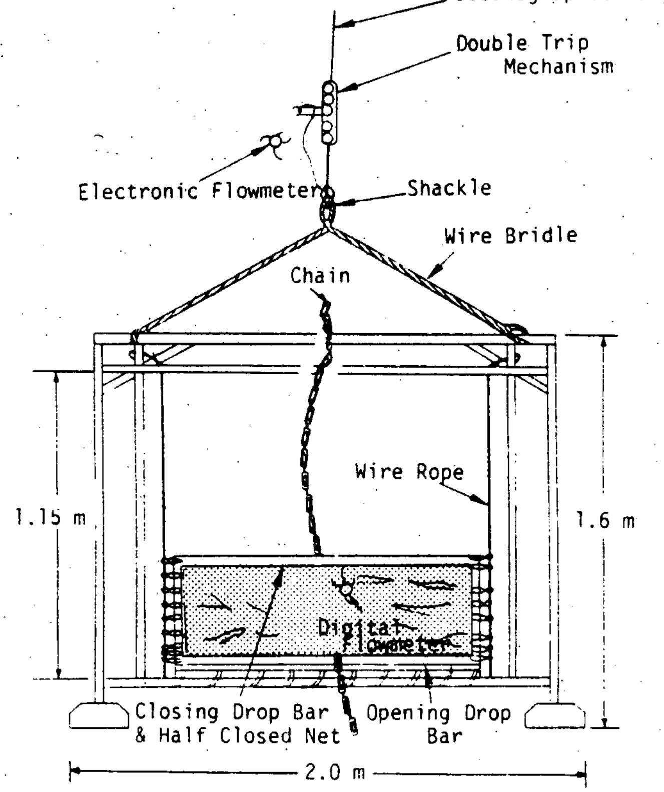
Sampling effort within each geographical region was distributed using a stratified random design. Effort was allocated to regions and strata on the basis of previous years' observed distribution of striped bass

Table A-3

Ichthyoplankton Surveys Conducted in Hudson River Estuary (RM 14-140, KM 22-244) during 1977

	Survey No.	Dates	River Miles (Kilometers)	Time
Larval Atlantic Tomcod Survey	1†	-	-	-
	2	21-25 Feb	71-23 (113.6-36.8)	Day
	3	07-11 Mar	61-14 (97.6-22.4)	Day
	4	21-26 Mar	73-14 (116.8-22.4)	Day
	5	04-07 Apr	73-14 (116.8-22.4)	Day
Longitudinal Ichythyoplankton River Survey	6	18-20 Apr	136-14 (217.6-22.4)	Day
	7	25-28 Apr	132-14 (211.2-22.4)	Day
	8	02-05 May	137-16 (219.2-25.6)	Day
	9	09-12 May	136-15 (217.6-24.0)	Day
	10	16-19 May	132-14 (211.2-22.4)	Day
	11	23-26 May	138-14 (220.8-22.4)	Day
	12	31 May-2 Jun	133-14 (212.8-22.4)	Day
	13	06-09 Jun	134-15 (214.4-24.0)	Day
	14	13-16 Jun	137-14 (219.2-22.4)	Day
	15	20-24 Jun	139-15 (222.4-24.0)	Day
	16	27 Jun-1 Jul	136-16 (217.6-25.6)	Night
	17	05-08 Jul	131-16 (209.6-25.6)	Night
	18	11-15 Jul	131-14 (209.6-22.4)	Night
	19	25-29 Jul	134-15 (214.4-24.0)	Night
	20	08-12 Aug	132-18 (211.2-28.8)	Night
Fall Shoals Survey	21	15-19 Aug	68-16 (108.8-25.6)	Night
	22	29 Aug-2 Sep	74-15 (118.4-24.0)	Night
	23	12-16 Sep	71-14 (113.6-22.4)	Night
	24	26-30 Sep	67-15 (107.2-24.0)	Night
	25	10-13 Oct	68-14 (108.8-22.4)	Night
	26	24-29 Oct	75-16 (120.0-25.6)	Night
	27	07-11 Nov	68-14 (108.8-22.4)	Night
	28	20-22 Nov	72-17 (115.2-27.2)	Night
	29	05-06 Dec	42-36 (67.2-57.6)	Night

†No sampling conducted because of heavy ice floe



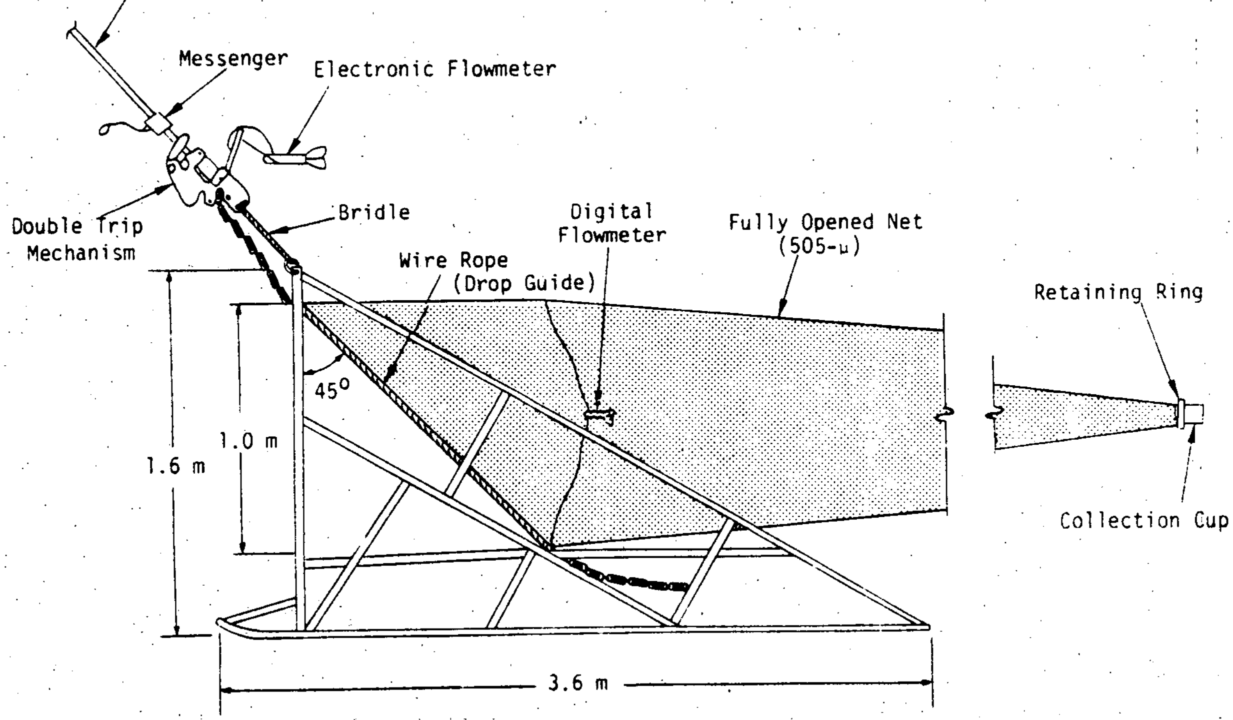
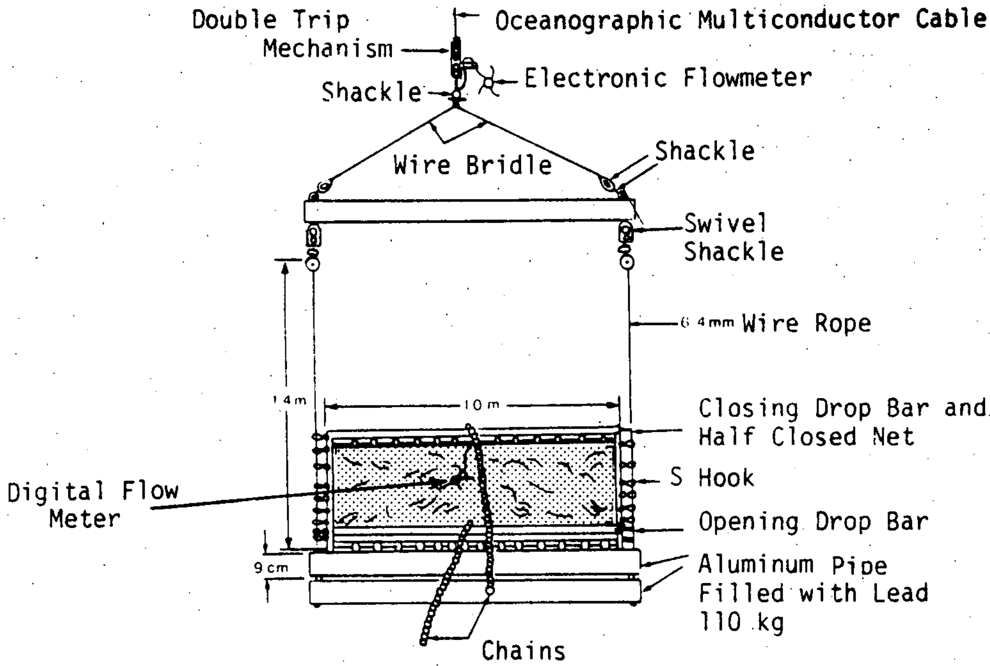


Figure A-3. Epibenthic Sled (front view, top; side view, bottom)



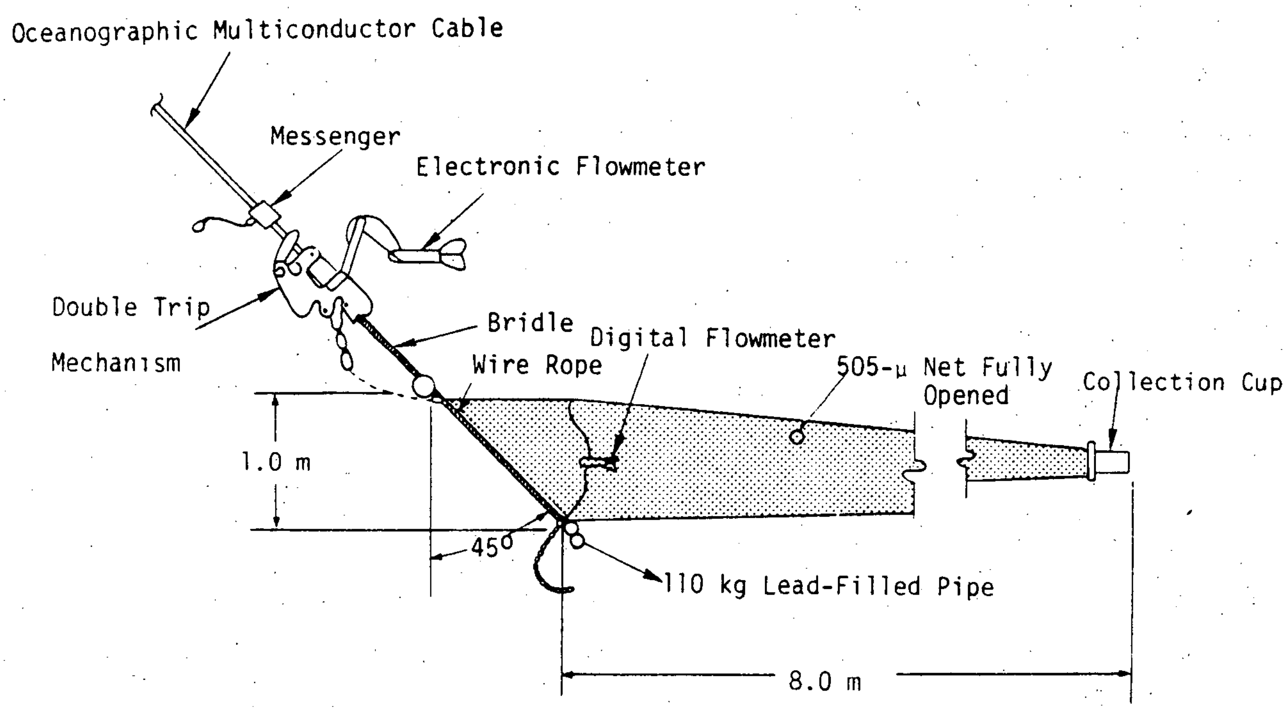


Figure A-4. Tucker Trawl (front view, top; side view, bottom)

Table A-4

Details of 1.0-m^2 Plankton Nets Used during Ichthyoplankton Surveys in Hudson River Estuary during 1977

Mesh Size (micron)	Mesh Aperture	Mesh Weave	Material	Net Design	Open-Area Ratio*	Modification	Estimated Filtration Efficiency (%)
505	Square	Plain	Nytex	Truncated pyramid	8	None	95
3000	Hexagonal	Twist-locking braid	Knotless nylon	Truncated pyramid	5	Conical fyke cod end extending 7 ft beyond net	95 to fyke; 100 through fyke

*Ratio of area of filtering surface to area to mouth

ichthyoplankton, with sample location and depth selected using a stratified random sampling design (TI 1978a). Sampling and processing procedures were identical to those used in the Larval Atlantic Tomcod Survey.

3. Fall Shoal Survey

Fall Shoal Survey data were used to determine the distribution and abundance of key fish species (primarily juveniles) in the shoal and bottom strata of the Hudson River estuary during late summer and fall (Table A-1, Table A-3). Every other week from mid-August to early December (Table A-3), 100 samples were collected at night in the shoal or bottom strata from the Yonkers through Poughkeepsie regions (RM 14-76, KM 22-122). Sampling effort was distributed and sites selected as described for the Longitudinal River Survey. A 1.0-m^2 epibenthic sled equipped with a 3000-μm mesh net with an enlarged conical fyke attached to the cod end (Table A-4, Figure A-5) was used. During the standard 5-min tow, an electronic flowmeter measured tow speed and a digital flowmeter measured the volume of water sampled.

All juvenile fish were preserved in 10% formalin and transported to the laboratory. Yearling and older striped bass, white perch, and Atlantic tomcod were checked for finclips, tags, and tag wounds and were processed as described for the Larval Atlantic Tomcod Survey.

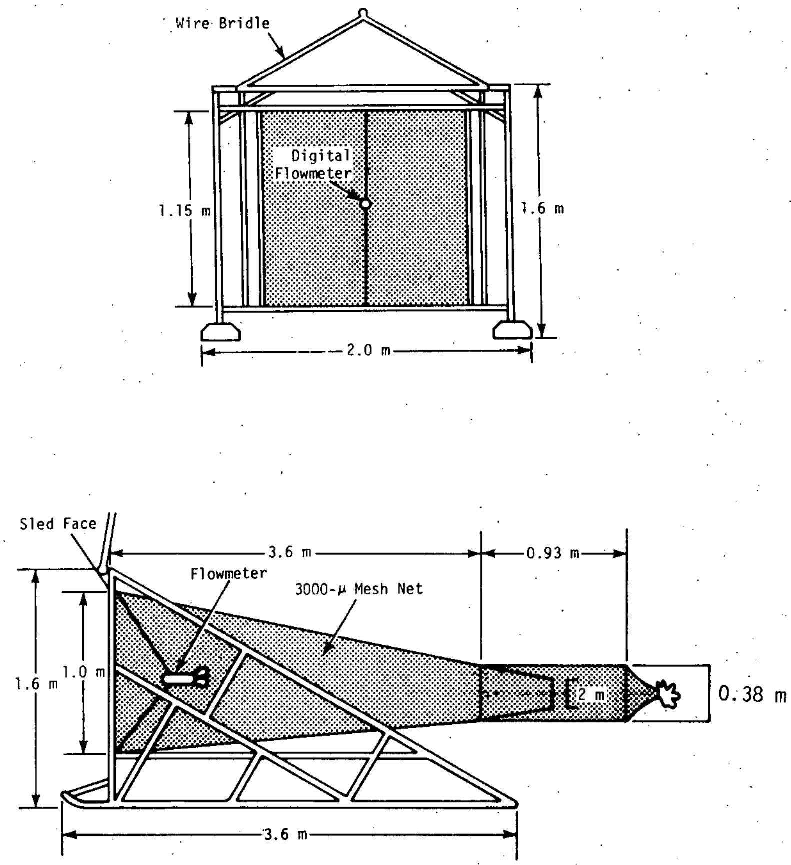


Figure A-5. Epibenthic Sled Used for 1977 Fall Shoal Survey (front view, top; side view, bottom)

4. Laboratory Processing

Fish eggs, larvae, and juveniles collected in the Larval Atlantic Tomcod and Longitudinal River Surveys were sorted, identified, and counted. Of the 200 samples collected per sampling period in the Longitudinal River Survey, 157 were processed. A representative proportion of samples was randomly chosen from each stratum and region for processing. Fish specimens were removed from detritus and inorganic material and placed in vials according to taxonomic groups (species or family) and stage of development (egg, yolk-sac larva, post yolk-sac larva, or juvenile). Identifications within each stage of development of each taxonomic group were aided by a reference collection and verified from pertinent literature (e.g., Lippson and Moran 1974, Booth 1967). Lengths of striped bass larvae and juveniles were measured.

Samples containing more than 400 eggs and larvae were subsampled using a plankton splitter similar to that described by Lewis and Garriott (1970). Samples were split to no fewer than 200 specimens exclusive of _Morone_ spp., and/or no more than three times (i.e., one-eighth) the original sample. All life stages of _Morone_ spp. in a sample were removed and counted before splitting. Each step in laboratory processing for the Larval Atlantic Tomcod and Longitudinal River Survey was subjected to a zero-fraction-defective quality control (Duncan 1974). Juvenile fish caught in Fall Shoal Survey samples were identified to species and counted; a subsample of 25 fish per species measured and the length measurements subjected to continuous sampling plan (CSP-1) quality control (Duncan 1974); and enumeration and identification subjected to zero-fraction-defective quality control.

C. FISHERIES SAMPLING

Programs designed to collect data on the distribution, relative abundance, movement, biological characteristics, and population size of juvenile and older fishes in the Hudson River estuary included a Mark-Recapture Program, a Standard Station Program, a Beach Seine Survey, and an Interregional Bottom Trawl Survey.

Several types of gear were used to collect fish in each river strata:

- The shore zone [the water from shoreline to a depth of approximately 10 ft (3 m)] was sampled with 100-, 200-, and 500-ft (30.5-, 61.0-, 152.4-m) beach seines.
- Box traps also sampled shallow water [3 to 10 ft (1-3 m)] as well as rocky shorelines, steep banks, and areas near breakwaters and bulkheads not sampled with a beach seine.
- Bottom trawls collected fish near the river bottom in depths exceeding 10 ft (3 m).
- Surface trawls collected fish near the surface of the water column in areas deeper than 10 ft (3 m).

Table A-5 and Figures A-6 through A-9 detail each gear.

Table A-5

Fisheries Sampling Gear Used in 1977

Gear Type	Dimensions
Beach Seines	
100-ft beach seine	
Wings	40.0 ft x 8.0 ft (12.2 m x 2.4 m); 0.375-in. (0.95-cm) mesh
Bunt	20.0 ft x 10.0 ft (6.1 m x 3.0 m); 0.187-in. (0.48-cm) mesh
200-ft beach seine	
Wings	90.0 ft x 12.0 ft (27.4 m x 3.7 m); 0.375-in. (0.95-cm) mesh
Bunt	20.0 ft x 15.0 ft (6.1 m x 4.6 m); 0.187-in. (0.48-cm) mesh
500-ft beach seine	
Wings	375.0 ft x 10.0 ft (114.4 m x 3.0 m); 0.375-in. (0.95-cm) mesh 75.0 ft x 10.0 ft (22.9 m x 3.0 m); 0.375-in. (0.95-cm) mesh
Bunt	50.0 ft x 12.0 ft (15.2 m x 3.7 m); 0.25-in. (0.64-cm) mesh
Box Traps*	
Trap size	3.0 ft x 3.0 ft x 6.0 ft (0.915 m x 0.915 m x 1.83 m)
Wings (2)	20.0 ft (6.1 m) of 0.375-in. (0.95-cm) mesh
Lead	50.0 ft (15.25 cm) of 0.375-in. (0.95-cm) mesh
Fyke opening	4 in. (10.2 cm)
Surface Trawl	
Total length	49.2 ft (15 m)
First section	6.9 ft (2.1 m), 1.7-in. (4.3-cm) mesh
Second section	10.8 ft (3.3 m), 1.4-in. (3.5-cm) mesh
Third section	9.8 ft (3.0 m), 1.2-in. (3.0-cm) mesh
Fourth section	12.1 ft (3.7 m), 1.0-in. (2.5-cm) mesh
Cod end	9.5 ft (2.9 m), 0.2-in. (4.0-mm) mesh
Head rope	17.4 ft (5.3 m)
Head rope float-size	4.7 in. x 5.5 in. (12.0 cm x 14.0 cm)
Number of floats	8
Spreader bar length	10.0 ft x 1.2 in. (3.0 m x 3.0 cm)
Spreader bar float size	6.3 in. x 15.7 in. (16.0 cm x 40.0 cm)
Foot rope	17.4 ft (5.3 m)
Weights	38.9-ft link tickler chain of 0.2-in. (0.6 cm) galvanized chain
Bottom Trawl	
Total length	44.3 ft (13.5 m)
First section	32.8 ft (10 m) of 1.5-in. (3.8-cm) mesh
Cod end	11.5 ft (3.5 m) of 1.3-in. (3.3-cm) mesh
Fine mesh liner (standard stations only)	0.5-in. (1.27-cm) mesh
Cod-end cover (interregional trawl only)	21.8 ft (6.7 m) of 0.5-in. (1.27-cm) mesh
Chafing cloth (interregional trawl only)	9.8 x 22.0 ft (3.0 m x 6.7 m)
Head rope length	25.6 ft (7.8 m)
Floats	1.6-in. x 3.2-in. (4-cm x 8-cm) Spongex
Foot rope length	30.5 ft (9.3 m)
Weights	43.3 ft (13.2 m) of 0.2-in. (0.6-cm) galvanized chain
Trawl doors	
Standard stations	1.25 ft x 2.5 ft (0.4 m x 0.8 m)
Interregional trawl	2.5 ft x 4.0 ft (0.8 m x 1.2 m)

*Dimensions are same for box traps used in winter Atlantic Tomcod Study, except no wings or leads were used.

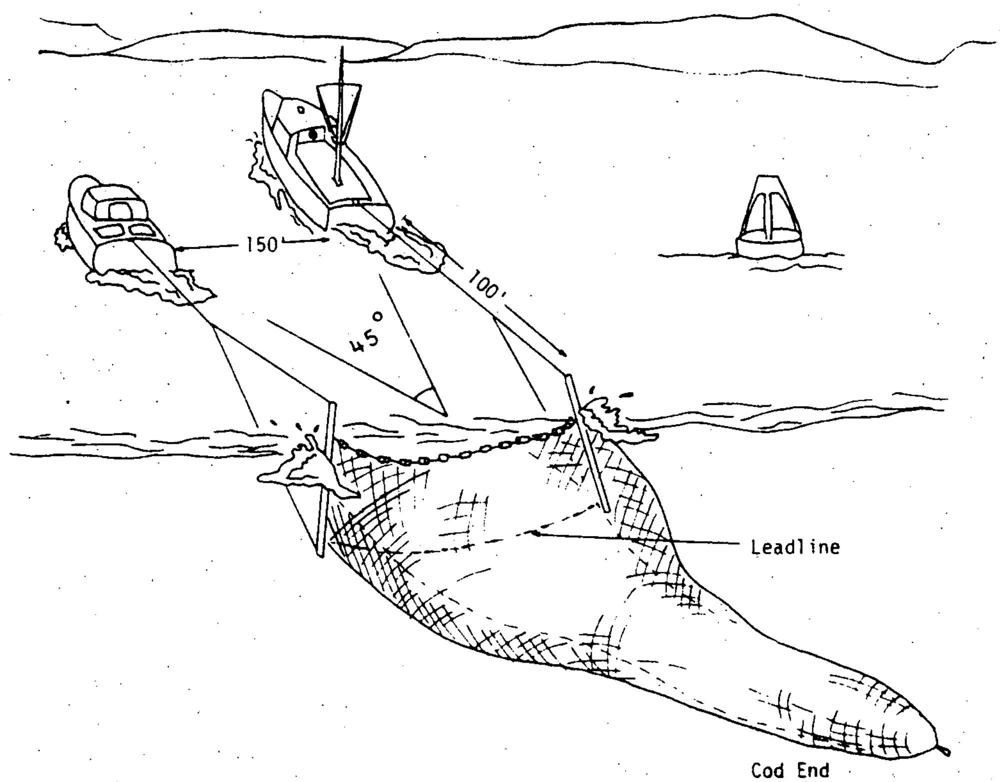


Figure A-6. Standard Station Surface Trawl Used in 1977

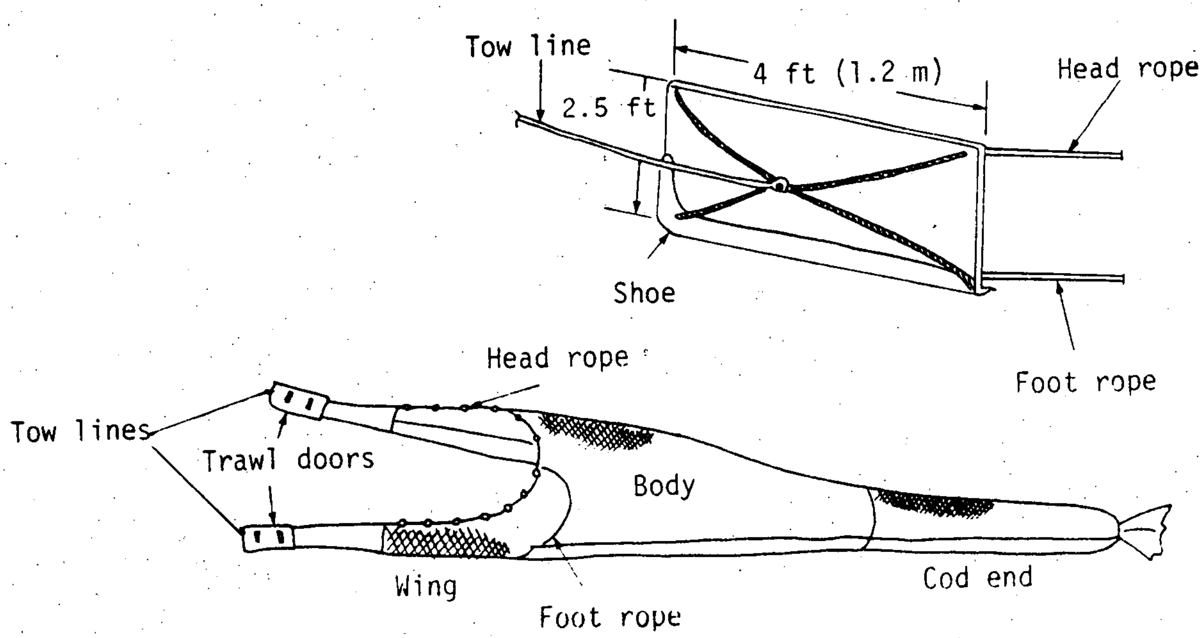


Figure A-7. Otter-Type Bottom Trawl and Trawl Door Used in 1977

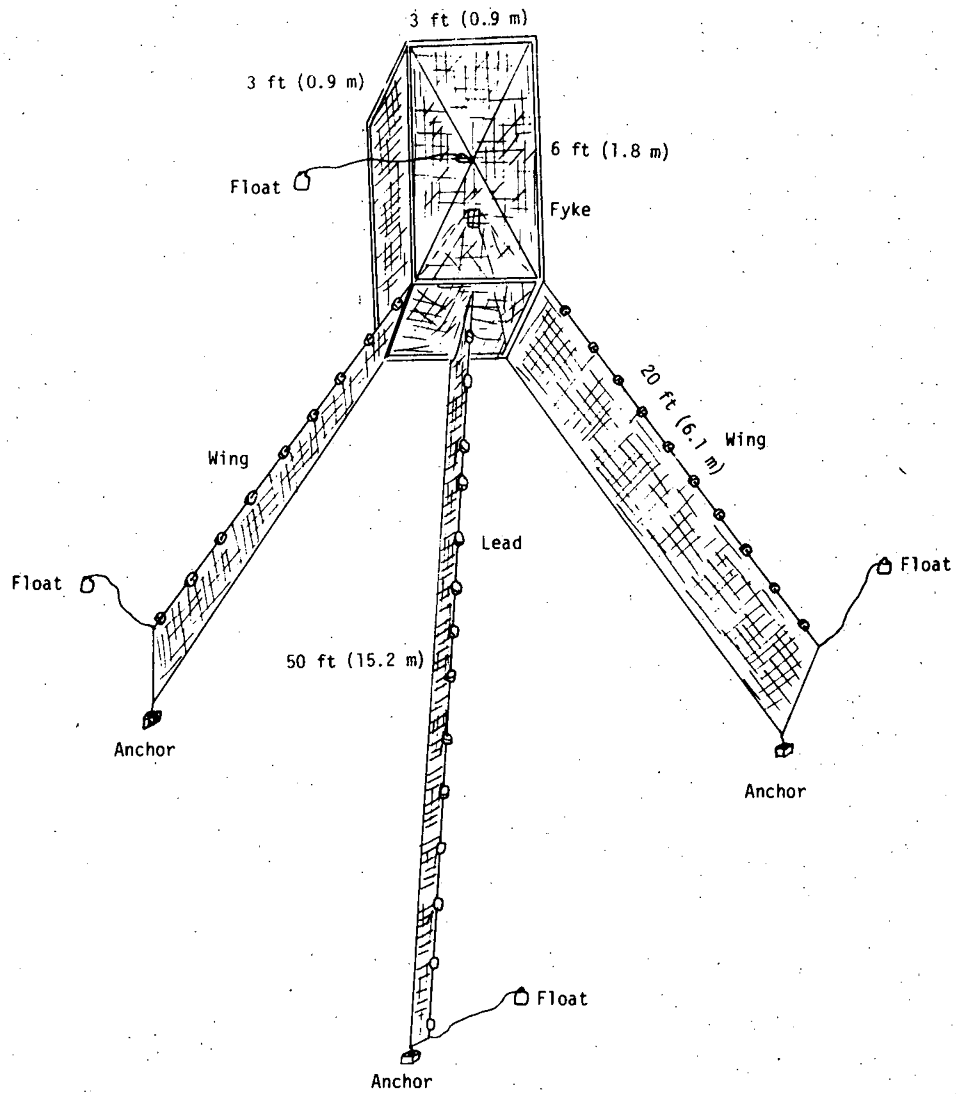


Figure A-8. Box Trap with Lead and Wings Used in 1977

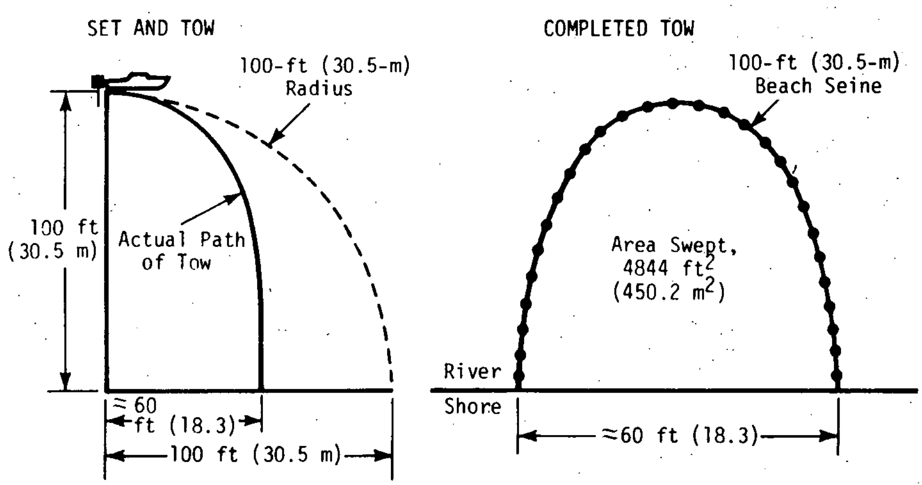


Figure A-9. Deployment of 100-Ft Beach Seine Used in 1977 Beach Seine Survey and Standard Station Program

1. Mark-Recapture Program

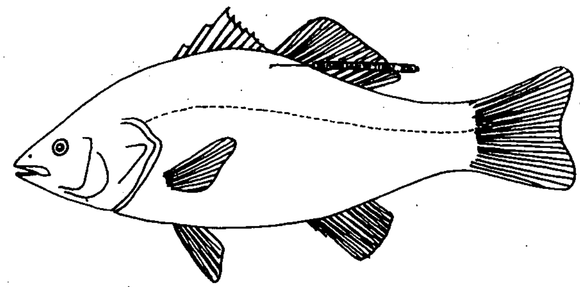
The objectives of the Mark-Recapture Program were to estimate population sizes and determine movements of striped bass, white perch, and Atlantic tomcod. To accomplish these objectives, white perch were collected with 100-ft (30.5-m), 200-ft (61.0-m), and 500-ft (152.4-m) beach seines; box traps; and epibenthic sleds. Striped bass (usually juvenile and yearling) were collected with beach seines and box traps. Atlantic tomcod were collected in box traps. The fish captured throughout the study area (RM 12-152, KM 19-243; Table A-6) were marked, although most fishing effort during this program was concentrated in areas where juvenile striped bass and white perch were abundant. Marking was done during two periods: spring (April-June) and fall (September-November). Marking was not done during July and August because previous studies had shown extremely low survival rates for fish marked during those months. Survival tests were run for 14 days after marking and were used to adjust the number of marks released for mortality caused by marking.

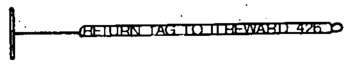
Table A-6

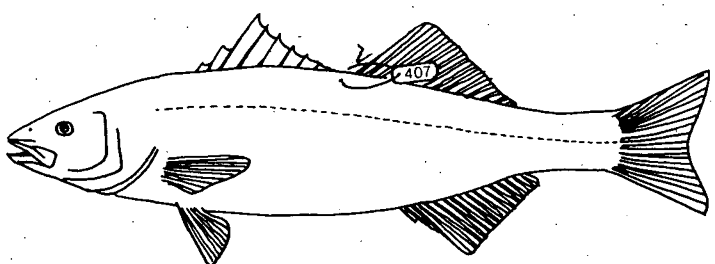
Marking Regions in Relation to Geographic Region during 1977 Mark-Recapture Program

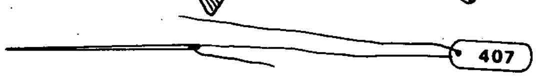
Species	Region Number	Geographic Regions	River Miles	(Kilometers)
Striped bass and White perch	1	Yonkers	12-23	(19-37)
	2	Tappan Zee & Croton-Haverstraw	24-38	(38-61)
	3	Indian Point	39-46	(62-74)
	4	West Point through Poughkeepsie	47-76	(75-122)
	5	Hyde Park through Albany	77-152	(123-243)
Atlantic tomcod	1	Tappan Zee & Croton-Haverstraw	24-38	(38-61)
	2	Indian Point	39-46	(62-74)
	3	West Point & Cornwall	47-61	(75-98)
	4	Poughkeepsie	62-76	(99-122)

Two fins of juvenile striped bass and white perch were clipped during fall. Yearlings were finclipped during spring and tagged during fall with either a Floy fingerling tag or a nylon internal anchor tag (Figure A-10), depending on the size of the fish. Adult striped bass (rarely caught by beach seine or box trap) and adult white perch were tagged during both spring and fall.

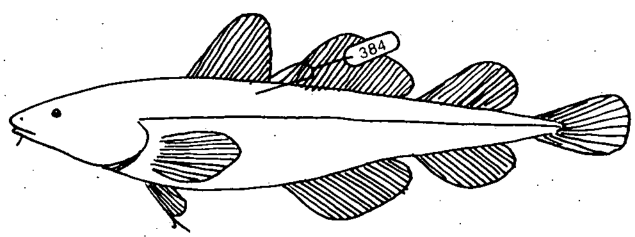


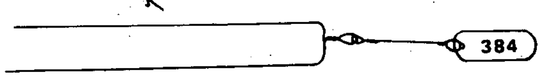
Internal anchor tag  **Used on adult white perch >150 mm TL and striped bass ≥250 mm TL**



Fingerling tag 

Used on juvenile striped bass <250 mm TL and juvenile white perch ≤150 mm TL



Carlin tag 

Used on adult Atlantic tomcod

Figure A-10. Tag Types, Area of Application, and Categories of Fish Tagged

During December 1977-March 1978, Atlantic tomcod were collected for marking from box traps (without wing and lead nets, Figure A-11) set along the shore. Several sites from RM 18 to RM 84 (KM 29 to 134) were sampled (Figure A-12). Since Atlantic tomcod mature in approximately 11 months, all fish marked at this time were adult. Fish were either finclipped or Carlin-tagged without regard to size. For 14 days after being tagged, Atlantic tomcod were held in aquaria supplied with river water for observation of survival.

Box trap catches of Atlantic tomcod, representing approximately 24 hr of fishing effort, were collected at weekly intervals from several sites within the river from December through February. The entire catch was sorted into length groups [<125, 126-150, 151-175, 176-200, 201-225, 226-250, 251-275 and ≥ 276 mm total length (TL)]; counted and sexed; and a random subsample of up to 20 fish per length group weighed and measured. Otoliths were removed from all subsampled fish less than or equal to 151 mm (TL). To maintain quality control, a continuous sampling plan (CSP-1) was used on all length, weight, and sex data and a lot-by-lot plan on all age data (Duncan 1974).

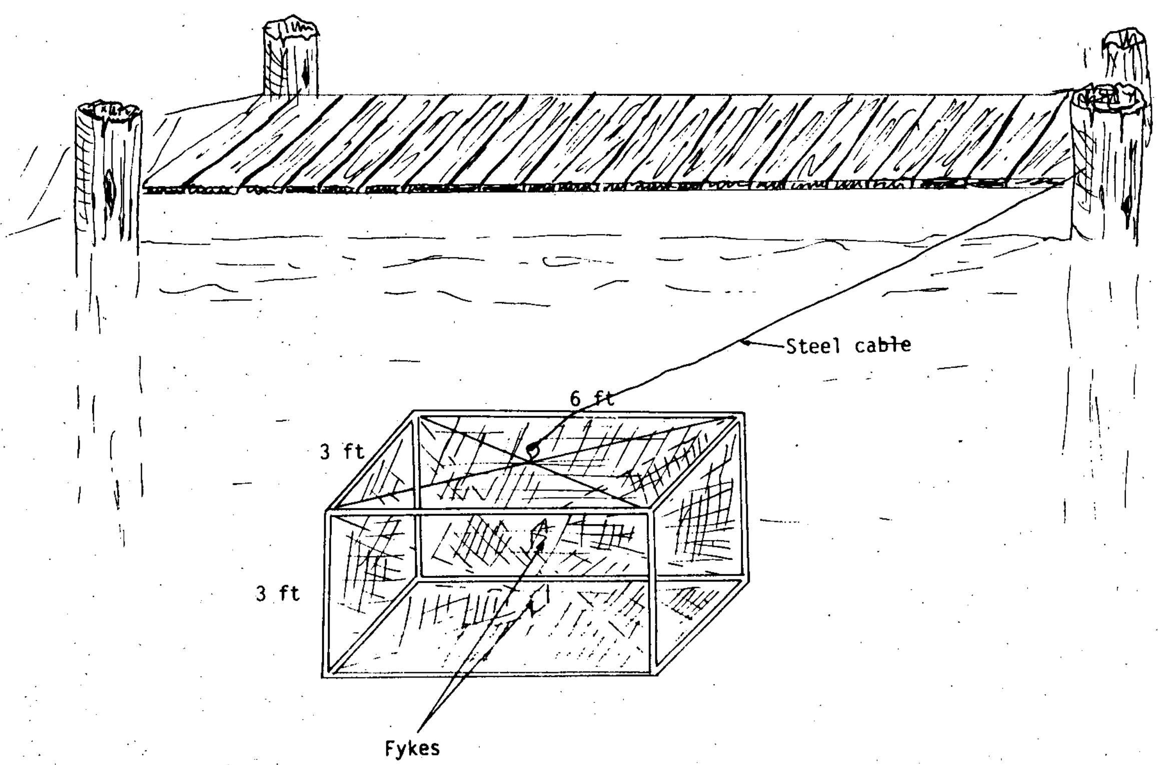


Figure A-11. Box Trap for Atlantic Tomcod Collection

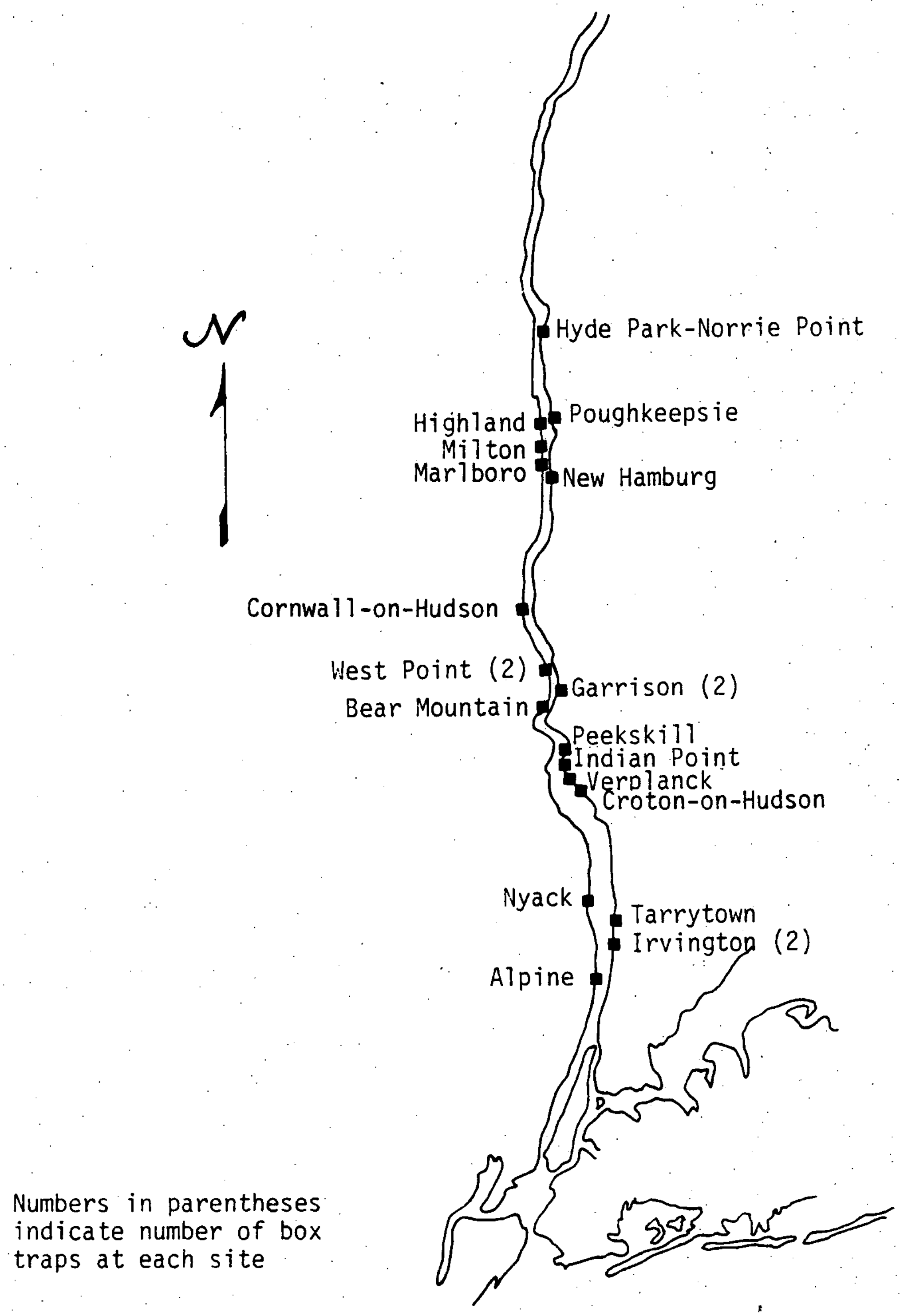


Figure A-12. Box Trap Sites Used during 1977-78 Atlantic Tomcod Spawning Season

2. Standard Station Program

a. Indian Point Generating Station

The Standard Station Program directed toward juvenile and older fishes in the vicinity of the Indian Point generating station produced a long-term data series (sampling began in 1969) that can be examined for trends in species composition, relative abundance, distribution, and biological characterisitcs (age, fecundity, sex, maturity, diet, length, and weight). Sampling during 1977 (Figure A-13) involved 14 fixed stations between RM 39 and RM 43 (KM 62 and KM 69). Beginning in April and continuing through December (Table A-1), seven shore zone stations were sampled weekly with a 100-ft (30.5-m) beach seine approximately 2 hr prior to low tide (Table A-5 and Figure A-8) and seven trawl stations were sampled biweekly using a bottom trawl with and without a fine mesh liner to permit comparison with data from previous years (Table A-5). From July through December, each trawl site was also sampled biweekly with a surface trawl (Table A-5). The entire catch from each sample was kept on ice for laboratory processing.

Each sample was sorted by species into four length classes [0-x, (x+1)-150, 151-250, 251+mm TL] and the number in each length class recorded for each species.* A random subsample (maximum of 20 fish) from each length class for each species was measured and weighed. To determine age, scales were removed from a subsample of five young-of-the-year striped bass and white perch per sample and all yearling and older striped bass and white perch. Sex determination was attempted on all subsampled white perch exceeding 150 mm TL. During May, June, and July, the gonads were removed from all subsampled white perch exceeding 100 mm TL to determine age at maturity. Quality control was maintained with a lot-by-lot technique on the identification and total count of each species and with continuous sampling plan (Duncan 1974) on lengths and weights. Atlantic tomcod from two standard station bottom trawl samples (collected on different days) were processed for biological characteristics. The total lengths and weights of up to 80 juvenile and 40 adult Atlantic tomcod per sample were recorded and quality control monitored using a continuous sampling plan (CSP-1) described by Duncan (1974).

*The value x is the maximum size of the youngest age group of fish for each species and is adjusted regularly during the sampling period to reflect growth.

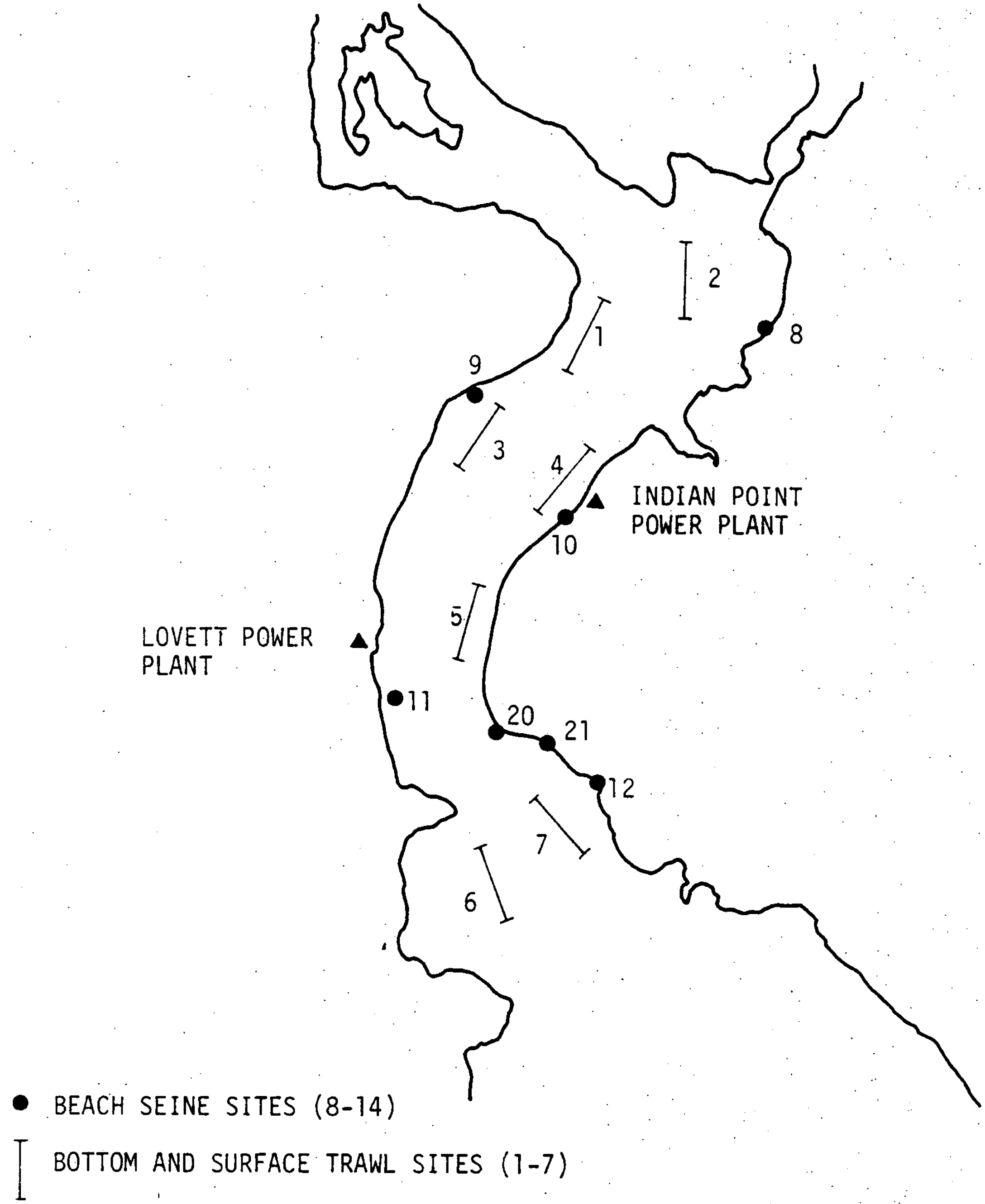


Figure A-13. Standard Station Beach Seine and Bottom and Surface Trawl Sites in Hudson River Estuary, Indian Point Region, RM 39-43 (KM 62-74) during 1977

3. Beach Seine Survey

The Beach Seine Survey provided data on abundance, distribution, and population characteristics of juvenile and older fishes in the shore zone and information on the growth of juvenile and older striped bass, white perch, and Atlantic tomcod. Each week, approximately 100 samples were collected with 100-ft (30.5-m) beach seines (Table A-5). During April-June and September-December, samples were collected from Yonkers through Cornwall (RM 12-61, KM 19-98) where juvenile striped bass and white perch were concentrated. On alternate weeks, sampling was extended to include Poughkeepsie through Albany (RM 62-152, KM 99-243). During July and August when juveniles first appeared in the shore zone, weekly sampling was conducted in all regions (Yonkers through Albany).

Catches were sorted by species and length groups (as was done for standard stations) and counted. Juvenile fishes, except striped bass and white perch that were finclipped and released during the marking period (September through November), were usually retained in sampling jars containing 10% formalin for identification and enumeration by species in the laboratory. Yearling and older striped bass and white perch were processed as described in the mark-recapture procedures (subsection C.1). Yearling and older Atlantic tomcod were examined for marks, and unmarked fish were released. Suspected finclip recaptures were preserved for verification. Tag number, length, and recovery information for recaptured tagged fishes were recorded and the fish again released if alive and in good condition. Yearling and older of other species were counted and released. Striped bass, white perch, and Atlantic tomcod length and weight quotas (20 per length group for the Croton-Haverstraw, West Point, and Cornwall regions) were filled on alternate weeks using fishes processed in either the field or laboratory. An additional 40 young-of-the-year striped bass, white perch, and Atlantic tomcod from each of the three regions just mentioned were measured. The continuous sampling plan (CSP-1) quality control procedure (Duncan 1974) was used for laboratory processing.

4. Interregional Bottom Trawl Survey

The Interregional Bottom Trawl Survey (previously termed the Axial Trawl Survey) provided data on the relative abundances, distributions, and population characteristics of juvenile and older fishes inhabiting the bottom strata of the river, as well as the deep-water, offshore recapture effort for marked fish. Every other week from April through November (Figure A-14), 32 fixed stations from RM 27 to RM 62 (KM 43 to KM 99) were sampled with an otter-type bottom trawl that had a fine mesh cod-end cover (Table A-5).

Catches were sorted by species and length group as for standard stations. Yearling and older fish were identified, counted, and released, and juvenile fish were preserved in 10% formalin for laboratory processing. Random subsamples (maximum of 20) of striped bass, white perch, and Atlantic tomcod from each region and for each length group were weighed and measured. During each biweekly period, the entire catch of Atlantic tomcod from two samples (collected on different days when possible) were processed for biological characteristics using methods identical to those used to process standard station bottom trawl samples. Identifications, total counts, lengths, and weights taken in the laboratory were subjected to continuous sampling plan (CSP-1) quality control (Duncan 1974).

D. ADULT STRIPED BASS STOCK ASSESSMENT PROGRAM

A comprehensive field and laboratory study of adult striped bass ($\geq$200 mm TL) was conducted from mid-March through June 1977 to determine the structure of the Hudson River spawning population, mortality rates, movements, and biological characteristics. Texas Instruments (TI) personnel as well as commercial fishermen collected the samples. Since the commercial fishery for striped bass in the Hudson River has been officially closed since early 1976, age and size composition of the commercial catch were estimated by contracting with commercial fishermen to fish in their usual manner and provide striped bass catches directly to TI. In addition, tag returns (reward of $5.00 per tag) from sport and commercial fishermen provided information on movements and exploitation rates.

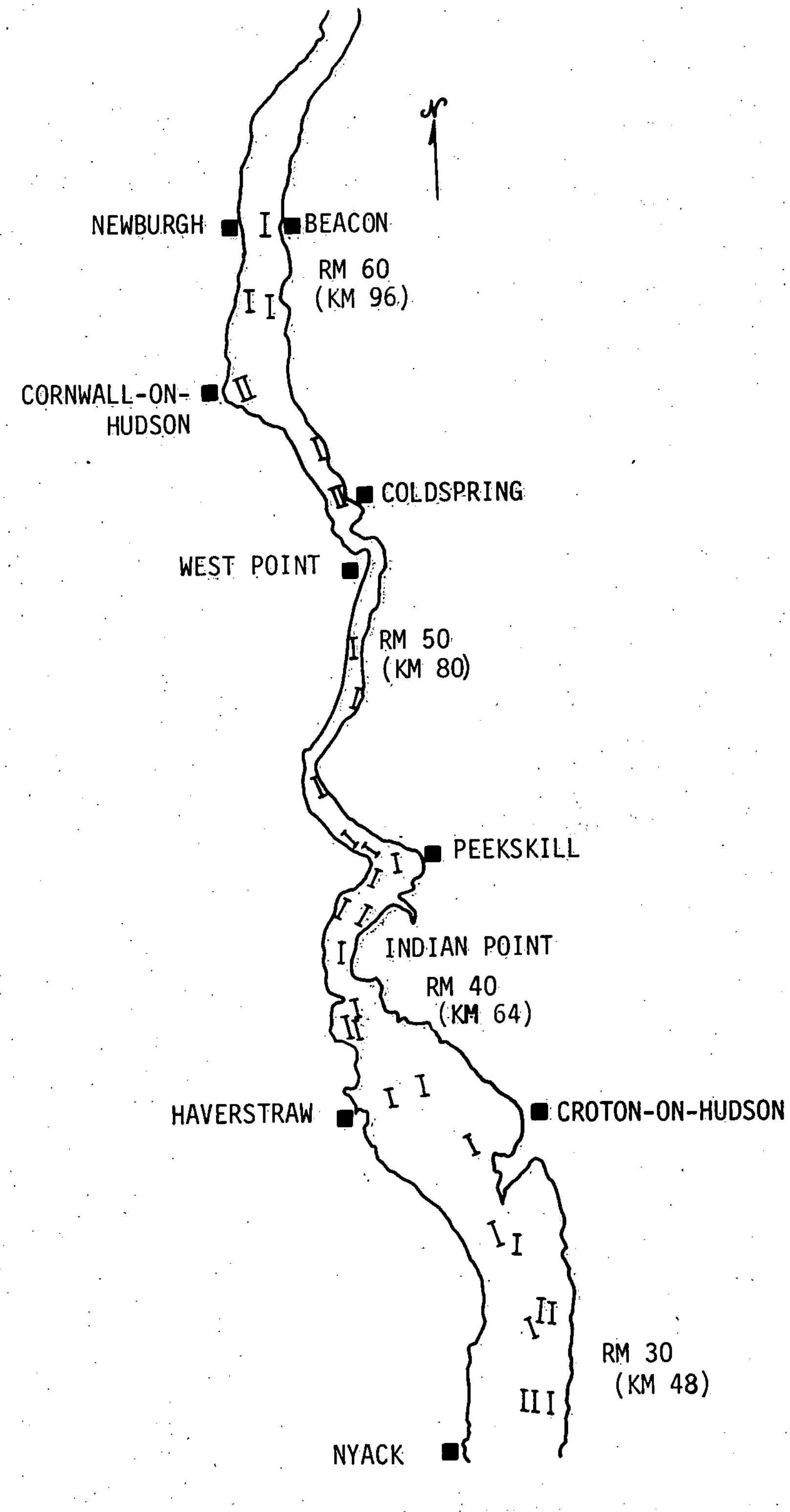


Figure A-14. Interregional Bottom Trawl Survey Sampling Sites during 1977, Hudson River Estuary, RM 27-62 (KM 43-99)

1. Field Methods

Sampling effort, which was allocated on the basis of adult striped bass distribution in 1976, was concentrated in the vicinity of the Tappan Zee Bridge and Croton-Haverstraw Bay early in the spawning season (March-April), upriver to the Indian Point area as the season progressed (May), and downriver in June at the end of the spawning season (Figure A-15). Two clusters of anchored gill nets (Table A-7) were separated longitudinally in the river (designated north or south). Each cluster contained a minimum of four nets of different standard mesh sizes (4-, 5-, 6-, and 7-in. stretch multifilament) and usually from one to four additional nets (4-, 5-, 6-, or 7-in. stretch multifilament). A 900-ft (294-m) haul seine (Table A-7), which has less size selectivity, was used only at night to sample beaches primarily in Haverstraw Bay (RM 33-39, KM 53-63).

Four commercial fishermen (Figure A-15) were contracted to fish for striped bass 2 days per week using their own fishing gear (Table A-7) and techniques. Each fisherman was accompanied by TI personnel during net-tending.

Fish were measured and scale samples removed. Live fish that were in good condition and were not needed for measurement of biological characteristics in the laboratory were tagged and released. Dead and dying fish were taken to the laboratory for processing.

2. Laboratory Methods

Striped bass were examined in the laboratory to determine sex ratio, fecundity, age at maturity, diet, and age composition. Daily quotas were established by length group (200-299, 300-399, 400-499, 500-649, 650-799, 800-1000, and 1001+ mm TL) for each of the gill net clusters and each commercial fisherman. Quotas also were established for each haul seine sample (Table A-8). These quotas assured an adequate sample size, yet minimized the need for sacrificing live fish. The fish were sent to the laboratory for further examination if their sex could not be determined in the field.

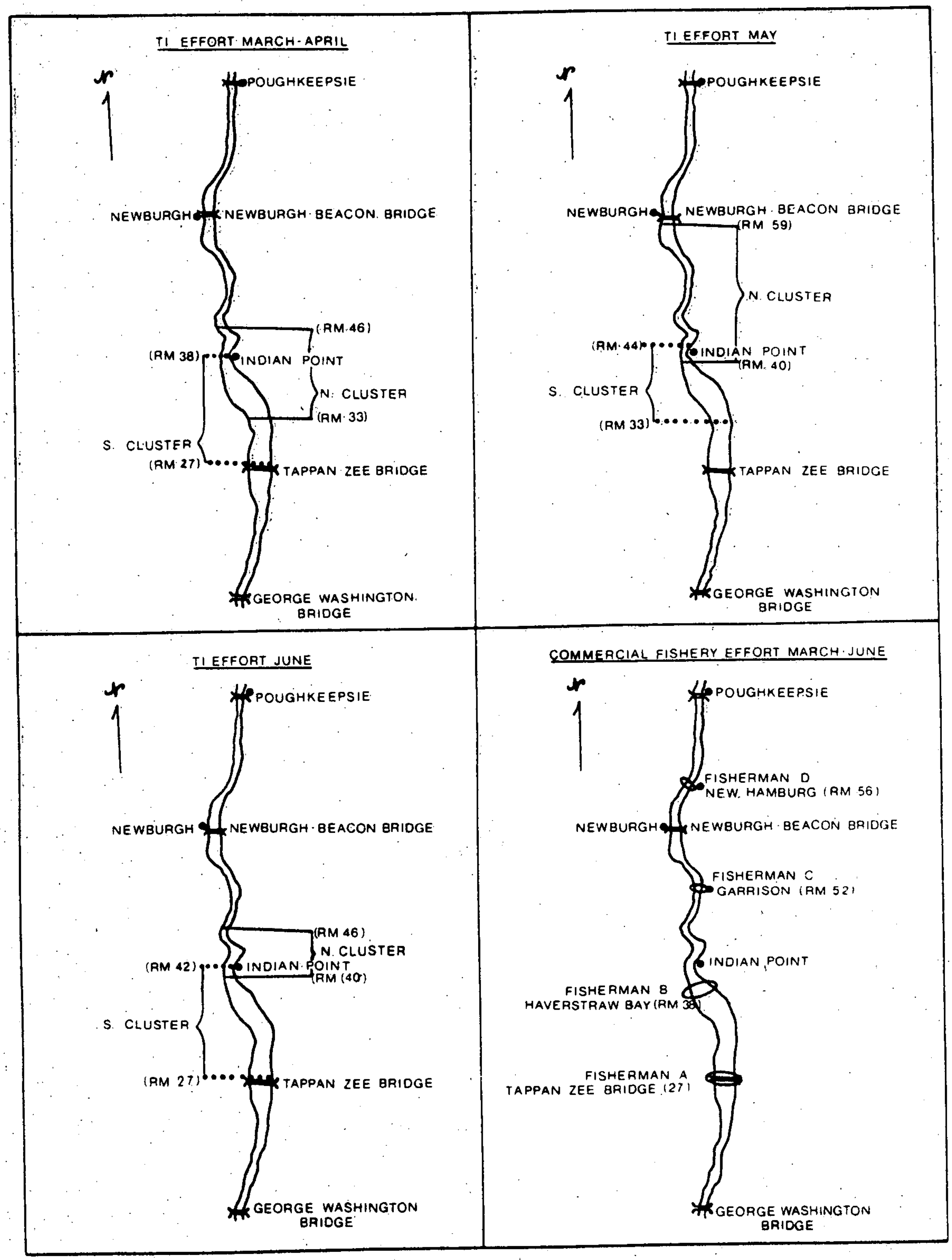


Figure A-15. TI Striped Bass Sampling Effort by North and South Gill Net Clusters during March-April (upper left), May (upper right), and June (lower left), and Commercial Fishery Effort (lower right) during 1977

Table A-7

Dimensions of Gill Nets and Haul Seine Used by TI and Gill Nets Used by Four TI-Contracted Commercial Fishermen on Hudson River during 1977

	Stretch Mesh (in.)	Length (ft)*	Gill Net Type	Depth (ft)
TI gill nets	4	300	anchored multifilament	8
	5	300	anchored multifilament	8
	6	300	anchored multifilament	8
	7	300	anchored multifilament	8
TI 900-ft haul seine				
Wing (short end)	4	180		
	3	60		
Bag	1.625	100		
Wing (long end)	3	60		
	4	500		
Commercial fishermen gill nets				
Fisherman A	4-1/2	200	staked monofilament	15
Nyack-Tappan Zee Bridge area (RM 27)	4-3/4	200	staked monofilament	15
	5-1/2	200	staked monofilament	15
	5-1/2	200	staked nylon	15
	12	200	staked nylon	12
Fisherman B	4-5/8	600	staked nylon	**
Haverstraw Bay (RM 38)	5-3/8	250	anchored nylon	**
	5-1/2	300	anchored monofilament	**
	5-1/2	600	anchored monofilament	**
	5-1/2	150	anchored nylon	**
	5-1/2	270	anchored monofilament	**
	6	75	anchored nylon	**
	8-1/2	90	anchored nylon	**
	12	300	anchored nylon	**
	7	300	anchored nylon	**
	5-1/2	80	anchored nylon	16
	5-1/2	350	anchored nylon	25
	5-1/2	400	anchored nylon	16
	5-1/2	80	anchored monofilament	16
	5-1/2	400	anchored monofilament	16
	5-1/2	500	anchored monofilament	20
	5-1/2	350	anchored monofilament	16
	5-1/2	150	anchored monofilament	16
	5-1/2	450	anchored monofilament	**
	10	160	anchored nylon	12
	7	130	anchored nylon	12
	10	325	anchored nylon	12
	8-1/2	120	anchored nylon	25
	12	150	anchored nylon	25
	14	300	anchored nylon	30
Fisherman C	6	300	staked nylon	**
Garrison area (RM 52)	6	600	staked nylon	**
Fisherman D	5-1/2	900	drift nylon	**
New Hamburg area (RM 66)	5-1/2	940	drift nylon	25
	5-1/2	840	drift nylon	25
	5-1/2	400	staked nylon	12
	5-1/2	1440	drift nylon	**
	5-1/2	840	staked nylon	12
	5-1/2	600	drift nylon	25
	5-1/2	160	staked nylon	12
	5-1/2	120	drift monofilament	15
	5-1/2	100	drift monofilament	15

*Several individual nets are often strung together in a series.
**Not available

Table A-8

Sex Subsample Quotas for Adult Striped Bass
Sex Ratio Determination, 1977

Length Classes (mm)	Number of Fish (gill nets)	Number of Fish (haul seine)
200-299	2	3
300-399	5	5
400-499	5	5
500-649	3	4
650-799	3	3
800-1000	2	3
>1000	0	0

Up to 10 ripe female striped bass per month from the smallest length group (200-299mm TL) and 30 per month from each of the other six length groups in the combined catches of haul seines, gill nets, and commercial fishermen were used to determine fecundity. To estimate fecundity, eggs in an aliquot were counted and the total ovarian count extrapolated on the basis of weight.

A biweekly subsample of up to 10 fish per sex per length group in the combined catches of haul seines, gill nets, and commercial fishermen was used to assess age at maturity. Gonad maturity was classified visually (Table A-9). This classification method was subsequently used in conjunction with the ratio of body weight to gonad weight to estimate the percentage of mature fish by age group.

Only fish collected in haul seines were used for analysis of stomach contents. Immediately after capture, the fish were injected through the esophagus with 10% formalin to preserve the stomach contents. In the laboratory, organisms in the excised stomach were identified to the lowest practical taxonomic group.

Table A-9

Definition of Codes Used in Visual Classification of Striped Bass Gonads for Analysis of Age at Maturity

Code	Classification	Definition
1	Ripe	Adult in spawning condition and having well developed gonads, but no milt or eggs extruded upon application of pressure to gonadal area. Will spawn in current season.
2	Ripe and running	Adult prepared to spawn immediately; expulsion of eggs or milt from body with little provocation.
3	Partially spent	Sexual products partially discharged; gonads somewhat flaccid rather than firm as a developing gonad; genital aperture usually inflamed, with some hemorrhaging present.
4	Spent	Applies to adult specimens at completion of spawning activity. The sexual products have been discharged, with the genital aperture usually inflamed and with hemorrhaging present. The gonads have the appearance of deflated sacs; the ovaries are usually left with a few eggs (in a state or reabsorption), and the testes contain some residual sperm; the ovarian wall becomes leathery.
5	Immature	A specimen that is either male or female but is too young to spawn (subadult). Gonads, which have not developed, are transparent or pinkish.
6	Resting	Applies to adult fish with underdeveloped gonads.
7	Indeterminate	Applicable to subripe fish heading into spawning season but which may or may not spawn. Testes and ovaries are opaque and reddish to reddish-white (ovaries may appear orange); eggs are visible to the naked eye, and granular, and whitish to orange-reddish.
8	Hermaphrodite	A specimen with both male and female gonads.

All striped bass having a total length (TL) exceeding 1000 mm were aged by the scale method (Mansueti 1961a). Fish less than 1000 mm TL were subsampled by length group. All recaptured fish were aged.

Adult striped bass processed in the laboratory for length, weight, sex, and fecundity were subjected to quality control procedures using the continuous sampling plan described by Duncan (1974). Analyses of stomach contents and age were subjected to lot-by-lot quality control (Hansen 1963).

E. WATER QUALITY

Data on water quality (water temperature, dissolved oxygen, pH, conductivity, and turbidity) were collected concurrently with or subsequently to each ichthyoplankton and fisheries sampling. The instruments used to measure water quality parameters, as well as other details, are indicated in Table A-10. All instruments and thermometers were calibrated prior to daily sampling and were checked for accuracy periodically during the sampling day. All turbidity and conductivity measurements done in the laboratory were subjected to quality control using a continuous sampling plan (CSP-1).

At the completion of each standard station surface and bottom trawl tow and each interregional bottom trawl tow, all of the mentioned water quality variables except turbidity were measured in the field and a water sample collected at the surface for subsequent measurement of turbidity. For the Standard Station Beach Seine and Beach Seine Surveys, surface water temperature and dissolved oxygen concentration were measured in situ. A water sample was collected at each sampling site and delivered to the laboratory for determination of pH, conductivity, and turbidity.

Water quality measurements made during mark-recapture efforts differed according to gear type. During each epibenthic sled tow for fall mark-recapture of adult white perch, a water sample was collected at sampling depth in a modified Van Dorn 2-ℓ sampler (Figure A-16). After the sample was transferred to a widemouth bottle, water temperature was measured. In the laboratory, pH, conductivity, and turbidity were measured.

Water quality sampling during bottom trawl mark-recapture efforts utilized the same procedures described for the Standard Station Interregional Trawl Surveys. During mark-recapture efforts utilizing beach seines, box traps, gill nets, or other gear types, water quality was measured according to the Standard Station and Beach Seine Survey water quality procedures.

During adult striped bass sampling, water samples were taken at mid-depth with a modified Van Dorn 2-ℓ sampler for gill net samples and at the surface for haul seine samples. Samples were delivered to the laboratory

Table A-10

Water Quality Parameters Measured during Each Task in 1977

Task	Sample Depth*	Water Temperature	pH	Dissolved Oxygen	Conductivity	Turbidity
Standard Station Trawls	S,M,B	+F(a)**	F(a)	F(a)	F(a)	L(i)
Interregional Bottom Trawl	S,M,B	F(a)	F(a)	F(a)	F(a)	F(a)
Standard Stations Beach Seines	S	F(b)	L(g)	F(b)	L(h)	L(i)
Beach Seine Survey	S	F(b)	L(g)	F(b)	L(h)	L(i)
Mark/Recapture						
-Epibenthic Sled	B	F(f)	L(g)	NS	L(h)	L(i)
-Bottom Trawl	S,M,B	F(a)	F(a)	F(a)	F(a)	L(i)
-Beach Seine	S	F(b)	L(g)	F(b)	L(h)	L(i)
-Box Trap, or other Gear types	S	F(b)	L(g)	F(b)	L(h)	L(i)
Stock Assessment						
-Gill Net	MD	F(f)	L(g)	NS	L(h)	L(i)
-Haul Seine	S			NS		
Ichthyoplankton/ Fall Shoals Surveys	SD	F(c)	F(d)	F(c)	F(e)	L(i)

*S = Surface
M = Middle
B = Bottom
SD = Sample Depth
MD = Mid-Depth of Gill Net

+F = Field Determination
L = Laboratory Determination
NS = No Sample

** (a) Hydrolab Surveyor Model 6D _In Situ_ Water Quality Analyzer. Reserve Equipment:
YSI Model 57 Dissolved Oxygen Meter
YSI Model 33 S-C-T Meter

(b) YSI Model 57 Dissolved Oxygen Meter

(c) Weston and Stack Model 330 or 300 Dissolved Oxygen Analyzer (a mercury thermometer is used if a temperature response time problem is encountered with the instrument)

(d) Instrument Laboratories, Inc. IL 175 Porto-matic pH meter

(e) YSI Model 33 S-C-T Meter

(f) Thermometer

(g) Sargent-Welch Model PBL or LSX pH Meter

(h) YSI Model 31 Conductivity Bridge

(i) Hach Model 2100-A Laboratory Turbidimeter

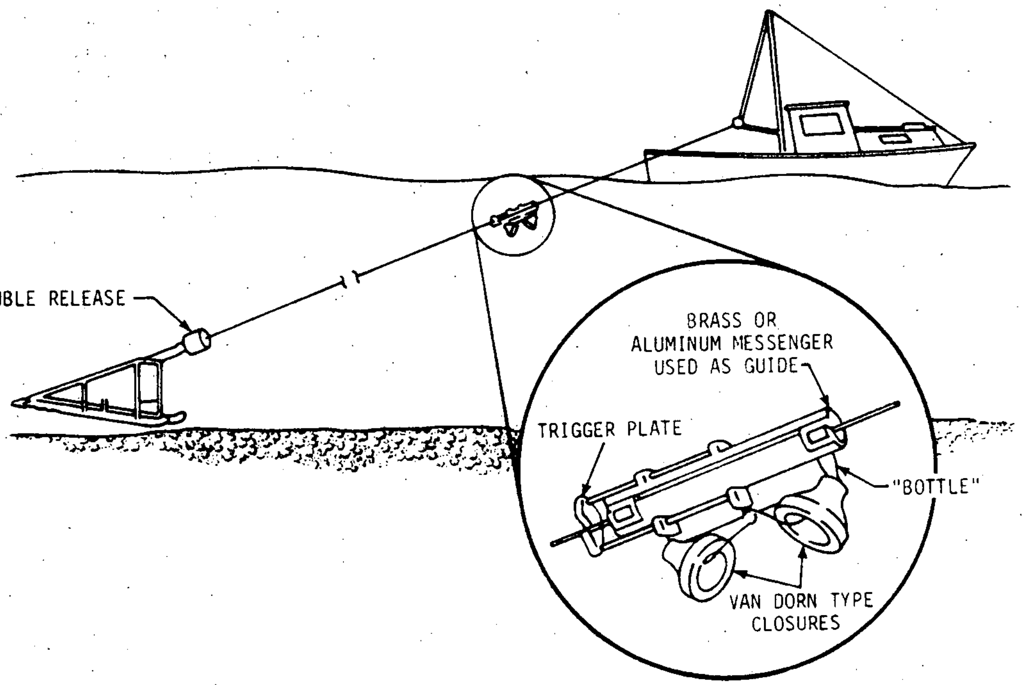


Figure A-16. Modified Van Dorn 2-ℓ Sampler Used during 1977 Ichthyoplankton and Fall Shoal Surveys and Fall Shoal Mark-Recapture

for subsequent determination of pH, conductivity, and turbidity. Water temperature was measured in situ using a dial thermometer. Water samples and measurements were taken for the first and last gill nets tended per cluster per night and for each haul seine sample.

After each tow during the Larval Atlantic Tomcod, Longitudinal River, and Fall Shoal Surveys, water samples were collected in a modified Van Dorn 2-ℓ sampler (Figure A-16) attached to the tow cable. Temperature and dissolved oxygen concentration were measured and the sample then poured into a widemouth sample bottle for conductivity and pH measurements. The bottle was then capped and delivered to the laboratory for turbidity analysis.

Two additional water quality data sources were utilized for analyses. Daily Hudson River water temperatures (^{o}F) that had been collected at the Poughkeepsie Water Works, Poughkeepsie, New York, since 1951 were transcribed by TI, converted to ^{o}C by a computer program, and entered into physicochemical data files for analyses. Values for missing data on a given day were interpolated using the mean of the values 2 days before and 2 days after the day for which data were missing. Water temperature was measured as it entered the plant (RM 76). The water intake is located 300 m from shore directly in front of the plant (at a depth of about 14 m) and thus represents conditions in the bottom stratum. Daily freshwater release (discharge) in cubic feet per second for the Hudson River Basin measured at Green Island, New York, were transcribed from Water Resources Data for New York, United States Department of the Interior, United States Geological Survey. These data are available from January 1948 to December 1977 and, coupled with the Poughkeepsie Water Works temperature data, provide a long-term data base for the Hudson River. Mean monthly values for temperature and freshwater release fom 1965 to 1977 appear in Table A-11.

F. IMPINGEMENT

1. Indian Point Generating Station

Impingement samples were collected daily from each Indian Point Generating Station operating unit from 1972 through June 1978 (McFadden et al 1978). Sampling was generally over a continuous 24-hr interval. Fish were collected from a screen positioned to strain the entire washwater flow from the traveling screens. The mesh of the sampling screen was equal to the mesh of the traveling screen, thereby preventing the escape of impinged fish as they were washed from the traveling screens.

2. Other Power Plants

Impingement samples were collected weekly or biweekly from 1973 through June 1978 at the Bowline Point (RM 37), Lovett (RM 41), Roseton (RM 65), and Danskammer Point (RM 66) generating stations, the exceptions being March 1974 at Lovett when no impingement samples were collected while the plant was in operation and in February 1974 at Roseton when the plant was shut down. Sampling at all plants was generally over a 24-hr period (LMS 1977a, 1977b). Information regarding impingement rates was obtained from Orange and Rockland Utilities for Bowline and Lovett and from Central Hudson Gas & Electric Corporation for Danskammer and Roseton.

Table A-11

Monthly and Yearly Mean Values for Freshwater Release (in cubic feet per second) at Green Island, New York (Hudson River Basin, USGS) and Hudson River Water Temperature (^{o}C) (Poughkeepsie Water Works), 1965-77

Year		Monthly Mean Values												Yearly Mean Values
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1965	Freshwater release	53.4	9108	9123	19284	8309	3573	3082	2912	4009	7298	10681	10654	7750
	Water temperature	1.2	0.6	2.0	6.5	14.5	21.1	23.6	24.4	22.5	17.4	11.2	9.4	12.5
1966	Freshwater release	8130	11628	23090	15627	18406	8270	3674	4233	5630	5847	7042	9118	10055
	Water temperature	1.5	1.1	2.5	7.7	12.9	20.2	25.6	25.4	23.0	16.4	11.4	4.8	12.8
1967	Freshwater release	9616	7633	11364	30937	17061	6197	5075	5749	4934	6973	11742	16509	11149
	Water temperature	1.5	1.1	1.2	6.3	11.8	19.2	24.5	25.5	22.3	18.4	9.7	2.6	12.1
1968	Freshwater release	8867	9513	24862	18299	18487	15707	9795	4440	4463	5173	14400	15597	12467
	Water temperature	1.2	1.5	2.8	10.7	15.8	20.0	23.6	25.4	22.5	19.7	11.0	2.7	13.1
1969	Freshwater release	11683	12762	17466	40730	20913	9995	5430	6102	4133	4856	14271	11801	13307
	Water temperature	1.1	1.6	2.0	8.0	14.8	21.0	24.1	24.8	23.1	17.8	9.6	2.8	12.6
1970	Freshwater release	8206	15336	15059	39347	14546	6387	5997	3923	6165	8186	9333	11386	11925
	Water temperature	1.0	1.1	2.0	7.1	15.4	21.0	23.5	26.0	22.9	18.0	11.3	3.5	12.8
1971	Freshwater release	9002	12111	20216	37273	35239	7334	6233	8929	9315	7811	7291	16998	14830
	Water temperature	0.7	0.8	1.9	6.8	11.7	20.0	24.7	25.0	22.4	17.8	11.8	3.5	12.3
1972	Freshwater release	13412	10928	26861	37963	40522	29630	18379	7616	6309	7291	26152	27010	21006
	Water temperature	1.0	0.6	1.7	6.0	12.9	19.3	22.4	24.3	22.9	16.2	7.2	1.6	11.4
1973	Freshwater release	26213	20464	29413	30957	27603	13053	10390	5591	4791	5650	8280	26419	17411
	Water temperature	0.8	0.6	3.6	8.6	13.9	29.1	23.7	24.8	23.7	18.0	10.5	4.0	12.8
1974	Freshwater release	22010	18639	20732	30167	22964	8700	11784	6359	10388	9049	17177	19381	16434
	Water temperature	0.9	0.8	3.3	7.8	14.4	19.0	22.9	24.4	21.1	13.9	8.5	1.8	11.6
1975	Freshwater release	19068	19371	23684	25583	19999	12973	7461	8966	17027	23400	22497	18784	18211
	Water temperature	1.3	1.2	3.6	6.9	14.6	21.2	24.9	25.0	20.8	14.6	10.4	3.4	12.4
1976	Freshwater release	14739	31255	31687	36757	31800	15223	15277	14631	9573	23235	17930	14078	21349
	Water temperature	0.6	1.2	3.7	8.6	13.2	19.6	24.5	23.3	21.7	13.8	5.5	1.3	11.4
1977	Freshwater release	7956	8032	43542	40563	16023	7325	5735	5439	14410	30142*	23443*	26583*	19091*
	Water temperature	0.6	0.7	2.6	8.7	14.4	20.3	24.4	25.1	22.1	12.7	9.4	2.1	12.0
1975-77	Mean freshwater release	12632	14368	22854	31037	22452	11112	8332	6530	7781	11147	14634	17248	14999
	Mean freshwater temperature	1.0	1.0	2.5	7.7	13.9	20.2	24.0	24.9	22.4	16.5	9.8	3.0	12.3

*Provisional Data

G. ENTRAINMENT

Ichthyoplankton sampling at nearfield sites and at the intake and discharge of the Indian Point (NYU), Bowline Point, and Roseton/Danskammer generating stations (LMS) has been conducted by various contractors since 1974 (McFadden et al. 1978). The sampling schedules have varied from year to year and from plant to plant. Lawler, Matusky, and Skelly Engineers (LMS) obtained entrainment estimates for Roseton, Danskammer, and Bowline Point generating stations in 1977. New York University (NYU) obtained entrainment estimates and nearfield ichthyoplankton densities for the Indian Point generating station, and Ecological Analysts, Inc. (EAI) obtained entrainment estimates for the Bowline Point plant (EAI 1978b).

II. TI ANALYTICAL PROCEDURES

A. INTRODUCTION

This portion of Appendix A describes some of the basic procedures utilized by Texas Instruments in the analysis of data presented in this report. Other analytical procedures are described in those sections of the text that specifically address the data.

B. ICHTHYOPLANKTON (LARVAL ATLANTIC TOMCOD AND LONGITUDINAL RIVER, SUBSECTIONS III-C, IV-C, AND V-C)

1. Geographical Region Density Estimates

A density estimate (d_i) by life stage for ichthyoplankton captured in each tow was calculated for each time interval as follows:

$$d_i = \frac{C_i}{V_i}$$

where

C_i = number of ichthyoplankton organisms (eggs, larvae, etc.) captured in i^{th} tow

V_i = volume (m^3) of water strained in i^{th} tow

An estimate of the mean density (d_k) in each stratum (k) within a geographical region was calculated by:

$$d_k = \frac{\sum_i d_i}{n}$$

where

n = number of samples taken in k^{th} stratum

The standard error of the mean density was calculated as:

$$SE_{d_k} = \sqrt{\frac{\sum_i \left(d_i - d_k\right)^2}{n\ (n-1)}}$$

The volume of water in the Hudson River for each 1-mi segment from river mile (RM) 14 to RM 140 (km 22 to km 224) (Table A-12) and for three strata within each mile was calculated using United States Geological Survey (USGS) maps. A polar planimeter was used to integrate over the irregular shoreline boundaries and estimate (in hectares) the total surface area of each mile segment. A grid was placed over each segment, and the number of grid units at each river depth, as recorded on the USGS maps, was tabulated. Depths, number of grid units at each depth, and surface hectares were recorded for each river mile. Volume (V_i) in cubic meters for each stratum in the i^{th} river mile segment was computed as follows:

$$V_i = A_i \sum_j d_{ij} \left(\frac{n_{ij}}{n_i} \right)$$

where

A_i = area (in hectares) of i^{th} river mile segment

d_{ij} = j^{th} recorded depth in i^{th} river mile segment of each stratum

n_{ij} = number of grid units counted for d_{ij}

n_i = Σn_{ij} = total number of grid units in i^{th} river mile segment

Geographical region density estimates (d_r) and the estimated standard errors (SE_{d_r}) were calculated from the strata densities (d_k) by the following formulas:

$$d_r = \frac{\sum_k \left(V_k \; d_k \right)}{\sum_k V_k}$$

and

$$SE_{d_r} = \sqrt{\sum_k \left(\frac{V_k}{V_r} \right)^2 \left(SE_{d_k} \right)^2}$$

where

V_k = river volume (m^3) of k^{th} stratum within r^{th} geographical region

V_r = sum of volumes (V_c) of river mile segments within r^{th} geographical region (Table A-13)

Table A-12

Hudson River Volumes (m^3) by River Mile and Stratum (Page 1 of 4)

River Mile	Channel Stratum	Bottom Stratum	Shoal Stratum	Total Across Strata
14	10,536,300	5,058,324	3,312,266	18,906,890
15	11,139,333	5,511,940	2,707,554	19,358,827
16	15,588,045	6,772,503	2,709,002	25,069,550
17	15,091,400	6,743,958	2,302,990	24,138,348
18	16,267,955	6,695,652	1,768,975	24,732,582
19	16,177,339	6,459,701	2,142,535	24,779,575
20	13,138,039	5,761,273	2,304,510	21,203,822
21	16,404,229	6,491,553	2,204,889	25,100,671
22	16,122,564	5,426,220	3,025,304	24,574,088
23	12,987,339	4,391,854	4,176,742	21,555,935
24	13,513,099	4,305,566	6,831,499	24,650,164
25	10,455,005	4,185,009	7,856,289	22,496,303
26	13,153,048	5,467,867	14,442,710	33,063,625
27	15,931,503	7,146,931	15,761,113	38,839,547
28	14,258,553	6,018,343	16,154,899	36,431,795
29	15,378,568	6,991,816	13,616,905	35,987,289
30	9,242,051	3,742,037	20,682,548	33,666,636
31	12,040,000	7,336,875	8,939,071	28,315,946
32	16,817,129	8,617,042	6,857,894	32,292,065
33	17,211,812	8,314,219	10,542,064	36,068,095
34	11,818,216	4,490,165	4,941,705	21,250,086
35	11,905,762	5,386,273	15,329,893	32,621,928
36	12,085,226	7,883,085	14,639,084	34,607,395
37	12,486,104	7,946,331	11,788,209	32,220,644
38	13,013,708	6,811,779	7,211,214	27,036,701
39	19,069,629	6,589,422	3,735,329	29,394,380
40	21,427,274	3,804,875	2,505,733	27,737,882
41	19,965,423	4,690,848	1,132,399	25,788,670
42	17,584,098	5,701,718	1,090,929	24,376,745
43	24,092,597	5,161,661	3,046,107	32,300,365
44	20,297,060	3,057,536	575,954	23,930,550
45	21,265,694	2,285,340	32,075	23,583,109

Table A-12 (Page 2 of 4)

River Mile	Channel Stratum	Bottom Stratum	Shoal Stratum	Total Across Strata
46	18,567,696	2,127,232	529,637	21,224,565
47	18,584,251	2,182,398	75,256	20,841,905
48	17,201,521	2,703,427	482,755	20,387,703
49	20,404,062	2,713,306	188,122	23,305,490
50	17,086,694	2,602,382	1	19,689,077
51	17,222,930	3,113,631	20,991	20,357,552
52	30,528,512	2,913,881	168,108	33,610,501
53	19,318,166	2,744,491	750,923	22,813,580
54	19,626,148	3,229,895	584,284	23,440,327
55	18,857,738	3,774,451	377,445	23,009,634
56	14,916,982	4,568,859	1,169,491	20,655,332
57	15,553,130	6,258,064	2,109,335	23,920,529
58	15,770,672	6,662,324	1,760,756	24,193,752
59	16,650,209	6,610,953	1,376,378	24,637,540
60	15,740,230	6,326,092	560,870	22,627,192
61	16,251,044	6,342,337	1,163,293	23,756,674
62	15,781,248	6,246,601	1,221,863	23,249,712
63	17,613,549	5,777,770	792,282	24,183,601
64	16,960,467	5,343,837	590,308	22,894,612
65	15,696,474	4,554,169	421,175	20,671,818
66	19,096,116	4,283,241	882,606	24,261,963
67	16,802,387	3,733,136	255,425	20,790,948
68	17,474,019	5,809,323	276,297	23,559,639
69	15,344,108	3,927,361	54,801	19,326,270
70	13,650,042	3,123,728	65,078	16,838,848
71	13,801,636	3,739,530	48,476	17,589,642
72	12,807,234	3,576,191	37,253	16,420,678
73	13,103,481	3,085,905	66,363	16,255,749
74	14,282,976	3,668,573	<1	17,951,549
75	13,958,938	3,538,347	57,379	17,554,664
76	12,602,377	2,760,420	1,220,954	16,583,751

Table A-12 (Page 3 of 4)

River Mile	Channel Stratum	Bottom Stratum	Shoal Stratum	Total Across Strata
77	15,585,784	3,448,876	56,436	19,091,096
78	14,354,918	3,605,784	<1	17,960,702
79	17,594,787	2,406,181	32,961	20,033,929
80	13,913,286	2,787,091	348,386	17,048,763
81	14,601,019	3,810,979	265,111	18,677,109
82	13,256,001	3,760,083	410,190	17,426,274
83	14,219,360	3,744,835	110,142	18,074,337
84	13,456,429	4,725,729	537,169	18,719,327
85	14,183,457	3,722,442	547,230	18,453,129
86	12,937,732	2,489,867	1,742,907	17,170,506
87	14,355,392	3,812,360	1,811,715	19,979,467
88	12,913,213	4,742,360	1,290,543	18,946,116
89	12,294,692	4,664,442	1,072,821	18,031,955
90	12,568,726	4,275,346	2,604,694	19,448,866
91	10,022,179	4,759,422	698,505	15,480,106
92	9,144,437	6,473,308	1,881,529	17,499,274
93	9,420,650	4,262,885	1,230,054	14,913,589
94	10,996,883	3,799,801	1,236,546	16,033,230
95	9,821,812	3,494,418	1,279,207	14,595,437
96	7,640,692	3,782,192	1,884,461	13,307,345
97	12,102,469	4,381,668	1,792,958	18,277,095
98	11,432,215	5,047,029	2,356,823	18,836,067
99	8,450,008	2,398,398	3,090,110	13,938,516
100	7,160,667	3,591,921	1,058,265	11,810,853
101	9,585,227	2,504,358	1,102,725	13,192,310
102	9,872,693	2,992,859	1,354,268	14,219,820
103	7,348,190	3,085,950	1,158,139	11,592,279
104	6,430,956	2,863,989	1,254,080	10,549,025
105	6,915,421	2,729,772	906,284	10,551,477
106	5,386,063	2,172,722	1,833,472	9,392,257
107	5,531,882	3,076,266	3,033,090	11,641,238

Table A-12 (Page 4 of 4)

River Mile	Channel Stratum	Bottom Stratum	Shoal Stratum	Total Across Strata
108	6,610,199	4,131,374	1,117,349	11,858,922
109	6,530,388	3,802,505	1,526,512	11,859,405
110	6,644,152	3,156,724	2,337,479	12,138,355
111	5,104,112	2,246,827	241,640	7,592,579
112	4,068,908	1,826,857	1,599,884	7,495,649
113	3,268,401	1,404,202	1,965,883	6,638,486
114	4,502,434	2,312,428	1,489,476	8,304,338
115	5,280,363	2,679,587	1,655,040	9,614,990
116	3,086,338	1,580,205	2,533,266	7,199,809
117	3,403,060	1,704,279	2,583,906	7,691,245
118	3,707,005	1,745,681	2,182,101	7,634,787
119	3,668,296	1,802,342	3,058,681	8,529,319
120	6,910,734	2,963,437	2,026,990	11,901,161
121	6,120,460	2,884,643	733,702	9,738,805
122	4,506,518	2,667,409	1,698,719	8,872,646
123	2,446,607	978,643	2,659,606	6,084,856
124	2,534,224	1,317,797	2,083,132	5,935,153
125	3,322,542	1,446,913	1,511,220	6,280,675
126	3,492,381	1,518,427	1,933,463	6,944,271
127	1,773,675	744,505	2,272,931	4,791,111
128	2,524,416	1,009,766	2,181,095	5,715,277
129	1,941,888	776,755	2,718,643	5,437,285
130	1,974,610	955,457	1,631,354	4,561,421
131	2,889,976	1,298,866	1,489,057	5,677,899
132	1,647,194	658,878	1,894,273	4,200,345
133	1,620,012	648,005	2,178,916	4,446,933
134	1,838,470	812,347	1,180,042	3,830,859
135	945,145	378,058	1,254,680	2,577,883
136	1,410,970	564,388	1,248,708	3,224,066
137	1,519,245	607,698	1,351,234	3,478,177
138	1,616,388	646,555	1,147,636	3,410,579
139	1,852,738	741,095	1,002,658	3,596,491
140	1,655,430	709,470	610,932	2,975,832
Total	1,461,633,658	479,425,027	326,757,424	2,267,816,109

Table A-13
Strata Volumes (m^3) Utilized in Analysis of 1977 Longitudinal Ichthyoplankton Survey (computer programs utilize following volumes, rounded to nearest 100,000 m^3)

Geographical Region	River Miles (km)	Channel Stratum	Bottom Stratum	Shoal Stratum	Total Across Strata	Regional Rank
Yonkers	14-23 (22-37)	202,765,521	*	26,654,767	229,420,228	3
Tappan Zee	24-33 (38-53)	138,000,768	62,125,705	121,684,992	321,811,465	1
Croton-Haverstraw	34-38 (54-61)	61,309,016	32,517,633	53,910,105	147,736,754	9
Indian Point	39-46 (62-74)	162,269,471	33,418,632	12,648,163	208,336,266	4
West Point	47-55 (75-88)	178,830,022	28,625,747	**	207,455,769	5
Cornwall	56-61 (89-98)	94,882,267	36,768,629	8,140,123	139,791,019	11
Poughkeepsie	62-76 (99-122)	228,975,052	69,158,392	**	298,133,444	2
Hyde Park	77-85 (123-136)	131,165,041	34,319,625	**	165,484,666	7
Kingston	86-93 (137-149)	93,657,021	47,812,858	**	141,469,879	10
Saugerties	94-106 (150-170)	113,143,296	63,152,415	**	176,295,711	6
Catskill	107-124 (171-199)	83,924,081	76,807,662	**	160,731,743	8
Albany	125-140 (200-224)	**	71,149,105	**	71,149,105	12

*Volume added to channel stratum for analytical purposes
**Volume added to bottom stratum for analytical purposes

2. Geographical Region Standing Crop Estimates

In 12 geographical regions, ichthyoplankton standing crops by life stage were estimated for each time interval from the weighted mean densities in the bottom, shoal, and channel strata. Standing crop estimates in each geographical region (N_r) and the standard errors of the standing crops (SE_{N_r}) were calculated as follows:

$$N_r = \sum_k V_k d_k$$

$$SE_{N_r} = \sqrt{\sum_k \left(V_k\right)^2 \left(SE_{d_k}\right)^2}$$

A standing crop estimate for the entire river (N) and the associated standard error (SE_N) were calculated as follows:

$$N = \sum_r N_r$$

$$SE_N = \sqrt{\sum_r \left(SE_{N_r}\right)^2}$$

3. Power Plant Region Standing Crop Estimates

Plant region standing crops (N_p) were based on a proportion of the standing crop estimates of the overlapping geographical regions as follows:

$$N_p = \sum_r PM_{rw} N_r$$

where

PM_{rw} = proportion of total river miles in geographical region r contained within plant region P (Table A-14)

N_r = standing crop estimate for geographical region r

Table A-14
Power Plant Regions in Hudson River Estuary, Defined as 6.5 Miles above and below Power Plant River Mile Location

Power Plant	Region (RM/KM)
Bowline	31-43 (50-69)
Lovett	35-47 (56-75)
Indian Point	36-48 (58-77)
Roseton	59-71 (94-114)
Danskammer	60-72 (96-115)

4. Plant Exposure Indices

The percent of the ichthyoplankton standing crop estimates within the entire sample area occurring within (W_p) each plant region (r) was calculated as follows:

$$W_p = \frac{N_p}{N} \times 100$$

5. Distribution Indices

Distribution indices were computed by life stage for ichthyoplankton to determine yearly trends in geographic and temporal distribution. The geographical distribution index (D_g) for a particular life stage was calculated by:

$$D_g = \frac{\sum_i N_{ij}}{\sum_i \sum_j N_{ij}} \times 100$$

where

N_{ij} = standing crop for i^{th} sampling period in region j

The temporal distribution index (D_t) was calculated as follows:

$$D_t = \frac{\sum_j N_{ij}}{\sum\sum_{ij} N_{ij}} \times 100$$

The higher the resulting index value, the more abundant the standing crops in a particular region or sampling period relative to the surrounding regions or sampling periods during the same year.

6. Fall Shoals (Night Samples)

Fall shoal samples were taken in the shoal and bottom strata only. The shoal survey density and standing crop estimates were calculated in the same manner as the ichthyoplankton density estimated except that only the shoal and bottom strata were used in the calculations.

C. FISHERIES

1. Geographical Region Catch per Effort (C/f)

Beach seine C/f values were calculated for each geographical region (r) as follows:

$$C/f_r = \frac{\sum C_i}{n}$$

where

C_i = number of individuals caught in i^{th} seine haul taken during each time interval within geographical region r

n = total number of tows taken during each time interval within geographical region r

The standard error of C/f_r (SE_{C/f_r}) was calculated as follows:

$$SE_{C/f_r} = \sqrt{\frac{\sum_i (C_i - C/f_r)^2}{n(n-1)}}$$

Interregional bottom trawl C/f values were calculated as follows:

$$C/f = \frac{\Sigma\, C_i \left(F_T\right)}{n}$$

C_i was multiplied by F_t to provide comparability of the interregional trawl C/f values with standard station C/f values. The deviation of F_t was as follows:

$$F_t = \frac{10}{\left(\begin{array}{c}\text{Tow Duration}\\ \text{of } i^{th} \text{ tow}\end{array}\right)\left(\begin{array}{c}\text{Tow Speed}\\ \text{of } i^{th} \text{ tow}\end{array}\right)}$$

where

10 = a constant based on standard station trawl tows which had a 10 min. duration at a tow speed of 1.0 m/sec

Tow Duration = elapsed time of interregional trawl tow measured in minutes

Tow Speed = speed of the interregional trawl tow (relative to the water) measured in m/sec

In most cases interregional trawl tows had a duration of 5 minutes at a speed of 1.3 m/sec, and the resulting F_t value was approximately 1.54. The standard error of the interregional trawl C/f was calculated similarly to the beach seine C/f standard error.

2. Estimation of Surface Area Sampled by 100-ft Beach Seine

The average area swept per tow for a 100-ft beach seine was computed to be 4844 ft^2 or 450 m^2 based on measurements taken from 10 tows conducted in 1973. To further document the accuracy of 4844 ft^2 (450 m^2) as the average area swept and to obtain more information on the range of area swept per tow, TI measured the inter-jack distance (interval on the shoreline between the ends of the 100-ft seine when the semicircle initially closes) of 99 tows during a routine beach seine survey in 1976. The 99 tows sampled all 12 regions (RM 12-152). Regional means ranged from a low of 44.4 ft in the Yonkers region to a high of 63.4 ft in the Albany region (Table A-15). The overall mean for the entire study area was 52.7 ft, with values ranging from 31 to 92 ft.

Table A-15

Regional Means and Ranges of Interjack Distance Measurements Taken from 99 Beach Seine Survey Tows, July 1976

Region	YK	TZ	CH	IP	WP	CW
Range	36-56	31-64	34-66	40-74	33-62	33-64
Mean	44.44	55.50	47.57	52.60	46.22	49.75
Standard Error	2.15	5.15	2.85	2.15	3.19	4.54
Number of Tows	9	6	14	20	9	8
Region	**PK**	**HP**	**KG**	**SG**	**CS**	**AL**
Range	40-60	48-74	56-58	44-67	34-92	50-77
Mean	50.80	59.33	57.00	57.40	59.86	63.45
Standard Error	3.56	7.69	1.00	3.74	7.80	2.36
Number of Tows	5	3	2	5	7	11

To ascertain the area swept per tow for a given interjack distance, the shapes of 100-ft seine tows were plotted on grid paper based on interjack distances of 20, 30, 40, 50, and 60 ft (Figure A-17). The area swept for each distance was estimated by counting the number of grids enclosed in the paths of the net. Based on these estimates a graph of interjack distance vs area swept was plotted (Figure A-18). The overall mean value of 52.7 ft represents an area swept per tow of 4900-5000 ft^2.

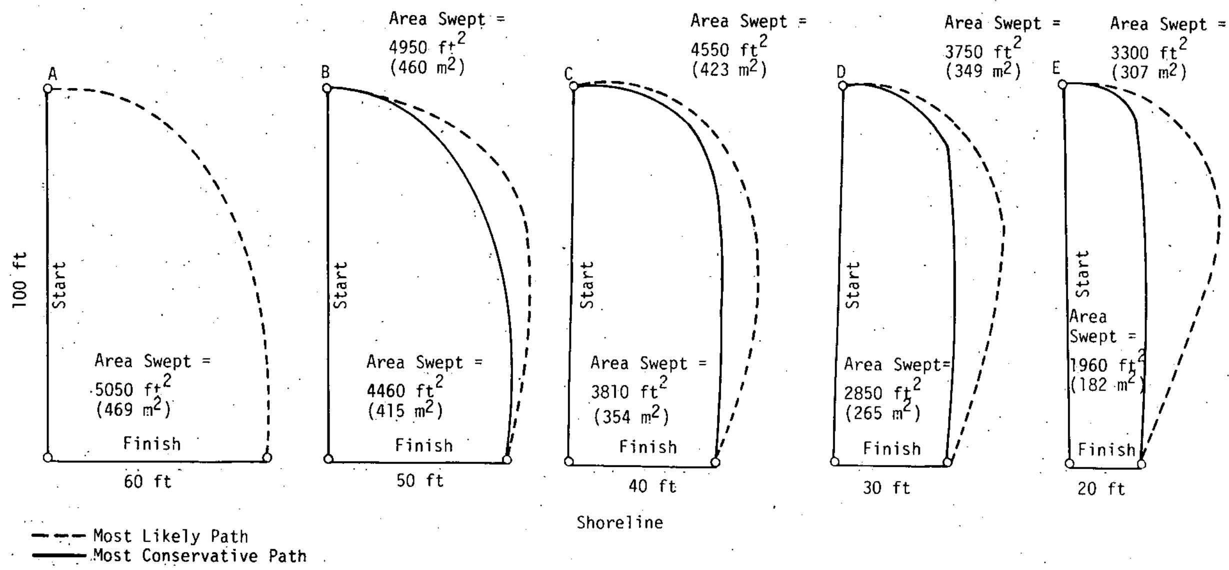


Figure A-17. Estimated Area Swept by 100-Ft Beach Seine for Various Tow Paths

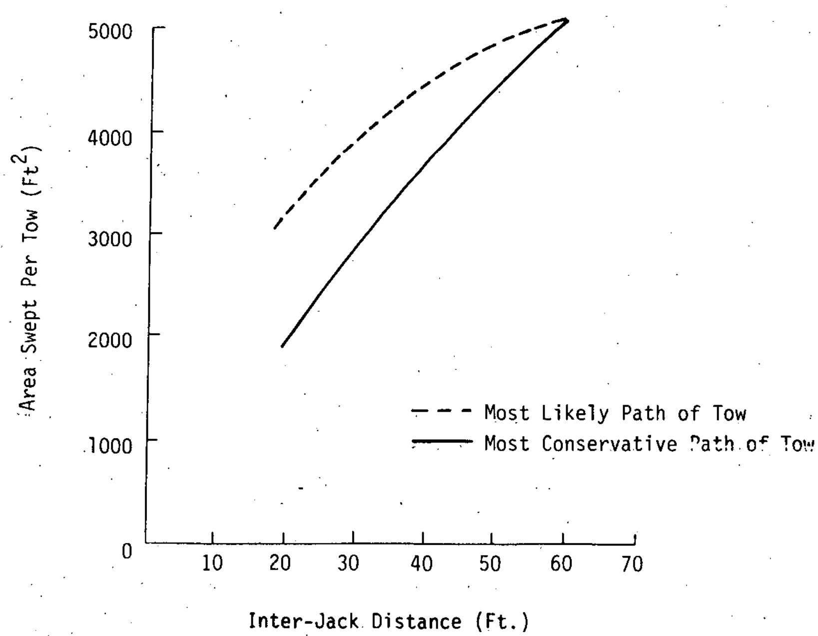


Figure A-18. Plot of Area Swept per Tow Vs Interjack Distance (52.7 ft = 4900-5000 ft^2)

Although there was variation in the average area swept per tow among regions, it was not great enough to warrant separate calculations by region. Also, since the new y computed value of 4900-5000 ft^2 as the average area swept per tow was so close to the original estimate, TI has continued to use 4844 ft^2 (450 m^2) as the mean area swept by a standard 100-ft seine tow.

3. Geographical Region Standing Crop Estimates (Based on Beach Seine Survey Data)

From the 100-ft (30.5-m) beach seine C/f values, standing crop estimates (N_r) and the associated standard errors (SE_{N_r}) were calculated for each of the 12 geographic regions as follows:

$$N_r = C/f_r \left(\frac{A_r}{A_s}\right)$$

where

C/f_r = mean catch per unit effort during each time interval in geographical region r

A_r = shore zone surface area (m^2) from 0 to 10 ft (3 m) deep for geographical region r

A_s = estimated surface area (m^2) sampled by 100-ft (30.5-m) beach seine set perpendicular to shoreline and towed in a semicircular path to the beach (450 m^2) (see preceding section)

and

$$SE_{N_r} = \sqrt{\left(\frac{A_r}{A_s}\right)^2 \quad \left(SE_{C/f_r}\right)^2}$$

The shore zone surface area (m^2) from 0 to 10 ft (3 m) deep for each of the 129 river mile segments from RM 12 to RM 152 (km 19 to km 243) was calculated from USGS depth contour maps. A polar planimeter was used to integrate the irregular shoreline boundaries and estimate the total shore zone surface area in square meters for each mile segment. Surface areas of the shore zone for RM segments 141-152 (km 226-243) were estimated as the mean of RM segments 135-140 (km 216-224).

Shore zone surface area estimates by river mile (Table A-16) were summed to obtain a total shore zone area estimate for each of the 12 geographical regions (Table A-17).

Standing crop estimates for each geographical region (N_r) were summed to estimate a standing crop for the entire sampling area (N) and associated standard error (SE_N) as follows:

$$N = \sum_r N_r$$

and

$$SE_N = \sqrt{\sum_r \left(SE_{N_r}\right)^2}$$

4. Plant Region Standing Crop Estimates (Based on Beach Seine Survey Data)

Standing crops of juvenile fish based on beach seine survey data were estimated for each of the 13-mi power plant regions (Table A-14). These plant region standing crops were calculated using the same method described for ichthyoplankton data (subsection B). The associated standard error (SE_{N_p}) was calculated from the relationship:

$$SE_{N_p} = \sqrt{\Sigma \left(PM_{rw}\right)^2 \left(SE_{N_r}\right)^2}$$

5. Distribution Indices

Distribution indices for juvenile and yearling life stages based on beach seine survey standing crops were calculated using the same method described for ichthyoplankton data (subsection B-5).

Table A-16

Surface Area (rounded to the nearest thousand m^2) of Shoreline 0 to 10 ft Deep by River Mile in Hudson River Estuary [RM 12-152 (km 19-243)] Used to Calculate Standing Crop Estimate from Beach Seine Catches

River Mile	Shoreline Surface Area from 0 to 10 Ft Deep	River Mile	Shoreline Surface Area from 0 to 10 Ft Deep
12	249,000	84	167,000
13	238,000	85	63,000
14	135,000	86	691,000
15	318,000	87	1,361,000
16	321,000	88	383,000
17	165,000	89	102,000
18	95,000	90	338,000
19	237,000	91	146,000
20	153,000	92	490,000
21	367,000	93	363,000
22	415,000	94	560,000
23	696,000	95	788,000
24	931,000	96	261,000
25	2,031,000	97	364,000
26	2,697,000	98	441,000
27	4,581,000	99	832,000
28	373,000	100	507,000
29	855,000	101	517,000
30	1,752,000	102	933,000
31	1,368,000	103	596,000
32	1,472,000	104	569,000
33	4,386,000	105	669,000
34	1,258,000	106	863,000
35	3,305,000	107	602,000
36	3,260,000	108	1,371,000
37	1,961,000	109	832,000
38	2,317,000	110	173,000
39	1,459,000	111	250,000
40	517,000	112	254,000
41	120,000	113	429,000
42	62,000	114	558,000
43	1,610,000	115	827,000
44	198,000	116	275,000
45	53,000	117	289,000
46	128,000	118	354,000
47	0	119	557,000
48	63,000	120	272,000
49	166,000	121	617,000
50	0	122	507,000
51	69,000	123	321,000
52	196,000	124	366,000

Table A-16 (Contd)

River Mile	Shoreline Surface Area from 0 to 10 Ft Deep	River Mile	Shoreline Surface Area from 0 to 10 Ft Deep
53	275,000	125	246,000
54	143,000	126	282,000
55	274,000	127	230,000
56	246,000	128	265,000
57	1,232,000	129	238,000
58	1,332,000	130	128,000
59	1,102,000	131	609,000
60	599,000	132	446,000
61	282,000	133	585,000
62	552,000	134	295,000
63	738,000	135	155,000
64	438,000	136	127,000
65	135,000	137	164,000
66	319,000	138	172,000
67	226,000	139	157,000
68	244,000	140	155,000
69	90,000	141	155,000*
70	107,000	142	155,000*
71	80,000	143	155,000*
72	61,000	144	155,000*
73	109,000	145	155,000*
74	0	146	155,000*
75	94,000	147	155,000*
76	0	148	155,000*
77	93,000	149	155,000*
78	0	150	155,000*
79	54,000	151	155,000*
80	0	152	155,000*
81	0		
82	0		
83	181,000		

*$\bar{X}$ of RM 135-140

Table A-17

Extent of Shore Zone Surface Area (M^2) from 0 to 10 ft (3 m) Deep in 12 Geographic Regions of Estuary Used to Calculate Standing Crop Estimates from Beach Seine Catches

Geographic Region	River Mile*	Length**	Shore Zone Surface Area (M^2)	Region*** Rank
Yonkers	12-23 (19-37)	12	3,389,000	9
Tappan Zee	24-33 (38-53)	10	20,446,000	1
Croton-Haverstraw	34-38 (54-61)	5	12,101,000	2
Indian Point	39-46 (62-74)	8	4,147,000	7
West Point	47-55 (75-88)	9	1,186,000	11
Cornwall	56-61 (89-98)	6	4,793,000	6
Poughkeepsie	62-76 (99-122)	15	3,193,000	10
Hyde Park	77-85 (123-136)	9	558,000	12
Kingston	86-93 (137-149)	5	3,874,000	8
Saugerties	94-106 (150-170)	13	7,900,000	4
Catskill	107-124 (171-199)	18	8,854,000	3
Albany	125-152 (200-243)	28	6,114,000	5
Total	12-152 (19-243)		76,555,000	

*Numbers in parentheses indicate kilometers
**In river miles
***Based on shore zone surface area

D. IMPINGEMENT

Impingement rates were derived by dividing the estimated number of impinged fish by the volume of cooling water circulated through each plant. The volume of flow through each plant during sampling intervals was obtained from plant operators in order to relate the number of fish collected to the extent of plant operation. Monthly impingement rates (number impinged x $10^6 m^3$ of water circulated through the plant) were calculated as the mean of the weekly estimated rates for all plants except Indian Point. Due to the daily collections at Indian Point, rates were expressed as the total monthly collection divided by the total monthly volume pumped.

Table B-1

Number of Days Each Gill Net Was Fished (Approximately 24-Hr Period) by Region, Mesh Size, and Week, Hudson River Estuary, 1977

	RM 27-33					RM 34-38					RM 39-46					RM 47-59					TOTAL				
	4"	5"	6"	7"	Total	4"	5"	6"	7"	Total	4"	5"	6"	7"	Total	4"	5"	6"	7"	Total	4"	5"	6"	7"	Total
Mar 15-19	3	3	3	2	11	NS	2	NS	NS	2	NS	NS	NS	NS	-	NS	NS	NS	NS	-	3	5	3	2	13
Mar 20-26	1	1	1	2	5	1	1	1	NS	3	NS	NS	NS	NS	-	NS	NS	NS	NS	-	2	2	2	2	8
Mar 27-Apr 2	5	9	5	4	23	3	3	4	2	12	NS	NS	NS	NS	-	NS	NS	NS	NS	-	8	12	9	6	35
Apr 3-9	6	9	10	3	28	4	4	4	4	16	NS	NS	NS	NS	-	NS	NS	NS	NS	-	10	13	14	7	44
Apr 10-16	4	5	4	5	18	4	14	5	5	28	NS	NS	5	NS	5	NS	NS	NS	NS	-	8	19	14	10	51
Apr 17-23	8	5	4	4	21	10	9	10	5	34	NS	NS	NS	NS	-	NS	NS	NS	NS	-	18	14	14	9	55
Apr 24-30	5	NS	1	NS	6	10	5	9	5	29	10	10	4	11	35	NS	NS	NS	NS	-	25	15	14	16	70
May 1-7	4	NS	4	NS	8	9	9	NS	4	22	4	15	10	5	34	NS	4	4	NS	8	17	28	18	9	72
May 8-14	NS	NS	NS	NS	-	4	4	NS	4	12	3	4	5	4	16	8	8	8	4	28	15	16	13	12	56
May 15-21	NS	NS	NS	NS	-	NS	NS	NS	NS	-	10	10	10	10	40	10	10	10	5	35	20	20	20	15	75
May 22-28	NS	NS	NS	NS	-	10	4	5	5	24	10	15	14	15	54	NS	6	NS	NS	6	20	25	19	20	84
May 29-Jun 4	4	NS	NS	4	8	4	8	8	4	24	8	8	8	8	32	NS	NS	NS	NS	-	16	16	16	16	64
Jun 5-11	8	10	8	9	35	NS	NS	NS	NS	-	4	12	12	4	32	NS	NS	NS	NS	-	12	22	20	13	67
Jun 12-18	9	9	4	5	27	NS	NS	NS	NS	-	5	9	10	5	29	NS	NS	NS	NS	-	14	18	14	10	56
Jun 19-25	4	4	4	2	14	NS	4	NS	NS	4	5	5	5	9	24	NS	NS	NS	NS	-	9	13	9	11	42
Jun 26-30	NS	NS	NS	NS	-	NS	NS	NS	NS	-	6	6	6	6	24	NS	NS	NS	NS	-	6	6	6	6	24
Total	61	55	48	40	204	59	67	46	38	210	65	94	89	77	325	18	28	22	9	77	203	244	205	164	816

Table B-2

Recaptured Striped Bass Tagged and Released (Sorted by Days at Large)
Hudson River Esutary during 1976 and 1977 (Page 1 of 12)

RELEASE					RECAPTURE								
DATE	RIVER MI	RIVER KM	LENGTH	AGE	DATE	LOCATION / RIVER MI	RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
4 16 75	35	56	583	.	4 . 76	26	42	93	O	.	9	14	.
3 25 76	27	43	438	.	5 . 76	ROBBIN REEF, N.Y.	.	98	O	.	30	48	.
3 26 76	37	59	525	.	6 . 76	RARITAN BAY, N.J.	.	98	O	.	52	83	.
4 6 76	33	53	471	4	5 . 77	37	59	98	O	.	-4	-6	.
4 6 76	35	56	473	.	7 . 76	VERRAZANO BRIDGE, N.Y.	.	98	O	.	42	67	.
4 8 76	38	61	484	5	5 . 77	26	42	93	O	.	12	19	.
4 9 76	33	53	466	6	5 . 77	26	42	93	O	.	7	11	.
4 12 76	27	43	542	.	4 . 76	26	42	93	O	.	1	1	.
4 15 76	38	61	472	5	3 . 77	FULTON FISH MARKET	.	88	O	.	.	.	.
4 15 76	35	56	587	.	4 . 76	26	42	93	O	.	9	14	.
4 15 76	33	53	473	.	7 . 76	VERRAZANO BRIDGE, N.Y.	.	98	O	.	42	67	.
4 15 76	34	54	482	6	5 . 77	26	42	93	O	.	8	12	.
4 20 76	34	54	472	.	4 . 76	32	51	98	O	.	2	3	.
4 20 76	35	56	515	.	4 . 76	35	56	98	O	.	0	0	.
4 22 76	33	53	391	3	5 . 77	26	42	93	O	.	7	11	.
4 27 76	27	43	555	.	4 . 76	26	42	93	M	.	1	1	.
* 5 4 76	33	53	488	.	5 . 76	UPPER N.Y. BAY	.	98	O	.	35	56	.
5 13 76	33	53	468	5	5 . 77	26	42	93	O	.	7	11	.
5 20 76	40	64	482	4	5 . 77	26	42	93	M	.	14	22	.
6 9 76	44	70	748	7	3 . 77	FULTON FISH MARKET	.	88	F	.	.	.	.
3 15 77	27	43	501	4	5 . 77	26	42	93	O	.	1	1	.
3 18 77	34	54	533	4	5 . 77	26	42	93	O	.	8	12	.
3 18 77	34	54	533	4	5 . 77	26	42	93	O	.	8	12	.
3 18 77	34	54	480	4	6 . 77	STATEN IS., N.Y.	.	98	O	.	43	69	.
3 28 77	35	56	404	4	7 . 77	LONG BEACH, N.Y.	.	98	O	.	155	248	.
3 30 77	33	53	485	4	5 . 77	26	42	93	O	.	7	11	.
3 31 77	33	53	510	4	5 . 77	26	42	93	O	.	7	11	.
4 1 77	33	53	495	4	5 . 77	26	42	93	O	.	7	11	.
4 4 77	27	43	564	.	5 . 77	26	42	93	M	.	1	1	.
4 5 77	34	54	495	4	5 . 77	26	42	93	O	.	8	12	.
4 5 77	33	53	556	4	5 . 77	26	42	93	O	.	7	11	.
4 5 77	27	43	476	7	5 . 77	26	42	93	O	.	1	1	.
4 5 77	33	53	527	7	6 . 77	STATEN IS., N.Y.	.	98	O	.	42	67	.
4 5 77	33	53	531	4	5 . 77	26	42	93	O	.	7	11	.
4 5 77	33	53	517	5	5 . 77	26	42	93	O	.	7	11	.
4 6 77	33	53	511	4	6 . 77	UNKNOWN	.	98	O	.	.	.	.
4 6 77	33	53	560	7	5 . 77	26	42	93	O	.	7	11	.
4 6 77	38	61	455	4	5 . 77	26	42	93	O	.	12	19	.
4 6 77	33	53	515	4	5 . 77	26	42	93	O	.	7	11	.
4 6 77	33	53	495	4	5 . 77	26	42	93	O	.	7	11	.
4 11 77	28	45	474	5	5 . 77	26	42	93	O	.	2	3	.
4 11 77	27	43	549	4	5 . 77	26	42	93	O	.	1	1	.
4 11 77	34	54	505	5	5 . 77	26	42	93	O	.	8	12	.
4 12 77	28	45	463	4	5 . 77	26	42	93	O	.	2	3	.
4 12 77	28	45	473	5	5 . 77	26	42	93	O	.	2	3	.
4 12 77	33	53	509	4	5 . 77	26	42	93	O	.	7	11	.
4 12 77	34	54	566	4	5 . 77	26	42	93	O	.	8	12	.
4 12 77	34	54	599	6	4 . 77	12	19	93	O	.	22	35	.
4 13 77	34	54	527	4	5 . 77	26	42	93	O	.	8	12	.
4 13 77	34	54	486	4	5 . 77	26	42	93	O	.	8	12	.
4 13 77	34	54	491	4	5 . 77	26	42	93	O	.	8	12	.
4 14 77	33	53	531	4	5 . 77	26	42	93	O	.	7	11	.
4 14 77	30	48	509	4	5 . 77	26	42	93	O	.	4	6	.
4 14 77	34	54	510	5	5 . 77	26	42	93	O	.	8	12	.
4 14 77	34	54	577	4	5 . 77	26	42	93	O	.	8	12	.
4 14 77	39	62	629	7	5 . 77	26	42	93	O	.	13	20	.
4 14 77	33	53	559	4	5 . 77	37	59	98	O	.	-4	-6	.
4 14 77	34	54	535	4	5 . 77	26	42	93	O	.	8	12	.
4 14 77	35	56	565	6	5 . 77	26	42	93	O	.	9	14	.
4 15 77	33	53	792	8	6 . 77	NORWALK, CT.	.	98	F	RR	83	133	.

Table B-2 (Page 2 of 12)

	RELEASE					RECAPTURE								
	DATE	RIVER MI	RIVER KM	LENGTH	AGE	DATE	LOCATION / RIVER MI	RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
	4 19 77	36	58	540	4	5 . 77	26	42	93	O	.	10	16	.
	4 19 77	36	58	515	4	5 . 77	26	42	93	O	.	10	16	.
	4 20 77	35	56	490	4	5 . 77	26	42	93	O	.	9	14	.
	4 21 77	35	56	468	4	5 . 77	26	42	93	O	.	9	14	.
	4 21 77	34	54	469	6	9 . 77	32	51	98	O	.	2	3	.
	4 22 77	37	59	492	4	5 . 77	26	42	93	O	.	11	17	.
	4 22 77	36	58	501	7	5 . 77	26	42	93	O	.	10	16	.
	4 25 77	26	42	619	6	5 . 77	26	42	93	O	.	0	0	.
	4 26 77	27	43	527	5	5 . 77	27	43	93	O	.	0	0	.
	4 27 77	26	42	552	6	5 . 77	26	42	93	O	.	0	0	.
	5 11 77	59	94	404	4	8 . 77	JAMAICA BAY, N.Y.	.	98	M	R	83	133	.
*	4 7 76	33	53	453	.	4 7 76	33	53	55	O	.	0	0	0
	4 13 76	34	54	488	5	4 13 76	34	54	20	M	M	0	0	0
	4 14 76	33	53	400	4	4 14 76	33	53	38	O	.	0	0	0
	4 21 76	33	53	423	.	4 21 76	33	53	38	F	I	0	0	0
	4 21 76	33	53	406	.	4 21 76	33	53	38	F	I	0	0	0
	4 21 76	35	56	524	.	4 21 76	35	56	20	M	I	0	0	0
	4 21 76	35	56	486	7	4 21 76	35	56	20	F	D	0	0	0
	4 21 76	35	56	492	.	4 21 76	35	56	20	F	I	0	0	0
	4 22 76	33	53	438	.	4 22 76	35	56	94	F	I	-2	-3	0
	4 22 76	33	53	421	.	4 22 76	33	53	38	F	I	0	0	0
*	4 29 76	44	70	587	.	4 29 76	44	70	25	M	.	0	0	0
*	5 4 76	40	64	371	.	5 4 76	40	64	38	M	.	0	0	0
*	5 4 76	33	53	485	3	5 4 76	33	53	55	O	.	0	0	0
*	5 5 76	35	56	405	.	5 5 76	35	56	38	O	.	0	0	0
*	5 5 76	35	56	416	3	5 5 76	35	56	38	O	.	0	0	0
	5 5 76	33	53	412	.	5 5 76	33	53	55	O	.	0	0	0
	5 6 76	44	70	732	8	5 6 76	44	70	25	F	R	0	0	0
	5 7 76	35	56	489	5	5 7 76	35	56	20	O	.	0	0	0
	5 13 76	33	53	770	7	5 13 76	33	53	54	F	D	0	0	0
	5 13 76	33	53	485	5	5 13 76	33	53	55	F	I	0	0	0
*	5 13 76	33	53	704	.	5 13 76	33	53	54	O	.	0	0	0
	5 25 76	44	70	654	6	5 25 76	44	70	56	M	R	0	0	0
	5 26 76	33	53	595	6	5 26 76	33	53	25	F	D	0	0	0
	5 27 76	33	53	873	8	5 27 76	33	53	25	O	.	0	0	0
	5 27 76	35	56	634	6	5 27 76	35	56	54	F	R	0	0	0
	5 27 76	35	56	603	.	5 27 76	35	56	54	O	.	0	0	0
	4 5 77	33	53	523	4	4 5 77	33	53	20	O	.	0	0	0
*	4 5 77	33	53	546	4	4 5 77	33	53	20	O	.	0	0	0
	4 5 77	33	53	512	4	4 5 77	33	53	20	O	.	0	0	0
	4 5 77	33	53	537	4	4 5 77	33	53	20	O	.	0	0	0
	4 6 77	33	53	524	4	4 6 77	33	53	20	O	.	0	0	0
	4 11 77	34	54	553	4	4 11 77	12	19	93	O	.	22	35	0
	4 13 77	34	54	535	4	4 13 77	12	19	93	O	.	22	35	0
	4 13 77	35	56	588	6	4 13 77	34	54	20	O	.	1	2	0
	4 14 77	33	53	474	4	4 14 77	33	53	20	O	.	0	0	0
	4 14 77	34	54	520	4	4 14 77	34	54	20	O	.	0	0	0
	4 19 77	36	58	495	4	4 19 77	36	58	20	O	.	0	0	0
	4 20 77	35	56	621	5	4 20 77	35	56	25	F	I	0	0	0
	5 4 77	35	56	513	4	5 4 77	35	56	20	O	.	0	0	0
*	5 5 77	39	62	.	7	5 5 77	39	62	93	M	.	0	0	0
*	5 5 77	35	56	553	7	5 5 77	39	62	93	O	.	-4	-6	0
	6 8 77	40	64	600	6	6 8 77	40	64	25	O	.	0	0	0
	6 9 77	43	69	1042	10	6 9 77	42	67	25	F	.	1	2	0
	3 23 76	33	53	497	.	3 24 76	33	53	55	M	M	0	0	1
*	3 23 76	33	53	459	.	3 24 76	33	53	20	O	.	0	0	1
	3 23 76	33	53	498	.	3 24 76	33	53	55	O	.	0	0	1
	3 23 76	33	53	470	.	3 24 76	33	53	55	O	.	0	0	1
	3 23 76	33	53	504	.	3 24 76	33	53	20	O	.	0	0	1
*	3 23 76	33	53	484	.	3 24 76	33	53	20	O	.	0	0	1

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	RELEASE					RECAPTURE								
	DATE	RIVER MI	RIVER KM	LENGTH	AGE	DATE	LOCATION / RIVER MI	RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
	3 23 76	33	53	471	.	3 24 76	33	53	20	O	.	0	0	1
	3 23 76	33	53	465	.	3 24 76	33	53	55	O	.	0	0	1
*	3 23 76	33	53	477	.	3 24 76	33	53	55	O	.	0	0	1
	3 23 76	33	53	460	.	3 24 76	33	53	55	O	.	0	0	1
	3 23 76	33	53	471	.	3 24 76	33	53	55	O	.	0	0	1
	3 23 76	33	53	520	.	3 24 76	33	53	20	M	D	0	0	1
	3 23 76	33	53	472	4	3 24 76	33	53	55	F	I	0	0	1
	3 23 76	33	53	482	.	3 24 76	33	53	55	O	.	0	0	1
*	3 24 76	33	53	458	.	3 25 76	33	53	20	M	D	0	0	1
*	3 24 76	33	53		.	3 25 76	33	53	20	M	D	0	0	1
	3 24 76	26	42	423	3	3 25 76	26	42	38	O	.	0	0	1
	3 24 76	26	42	379	.	3 25 76	26	42	38	O	.	0	0	1
*	3 24 76	33	53	477	.	3 25 76	33	53	55	O	.	0	0	1
	3 24 76	33	53	573	.	3 25 76	33	53	20	O	.	0	0	1
*	3 24 76	33	53	491	.	3 25 76	33	53	55	O	.	0	0	1
*	3 24 76	33	53	525	.	3 25 76	33	53	55	O	.	0	0	1
	3 24 76	33	53	521	.	3 25 76	33	53	55	M	M	0	0	1
	3 24 76	33	53	494	5	3 25 76	33	53	55	F	M	0	0	1
	3 24 76	33	53	480	.	3 25 76	33	53	20	O	.	0	0	1
	3 25 76	33	53	490	.	3 26 76	33	53	20	O	.	0	0	1
	3 25 76	33	53	506	.	3 26 76	33	53	55	O	.	0	0	1
	3 25 76	33	53	484	.	3 26 76	33	53	55	O	.	0	0	1
	3 25 76	33	53	490	.	3 26 76	33	53	55	O	.	0	0	1
	3 25 76	33	53	464	.	3 26 76	33	53	55	O	.	0	0	1
	3 25 76	33	53	501	.	3 26 76	33	53	55	O	.	0	0	1
	3 25 76	33	53	464	.	3 26 76	33	53	55	O	.	0	0	1
	3 25 76	33	53	449	.	3 26 76	33	53	55	O	.	0	0	1
	3 25 76	33	53	500	.	3 26 76	33	53	55	M	I	0	0	1
	3 25 76	33	53	445	.	3 26 76	33	53	55	F	I	0	0	1
*	3 25 76	33	53	492	.	3 26 76	33	53	55	F	I	0	0	1
*	3 25 76	33	53	524	.	3 26 76	33	53	55	F	I	0	0	1
	3 25 76	34	54	471	.	3 26 76	34	54	20	F	I	0	0	1
	3 25 76	37	59	468	.	3 26 76	37	59	39	M	I	0	0	1
	3 30 76	34	54	489	.	3 31 76	34	54	20	F	I	0	0	1
	3 31 76	36	58	623	5	4 1 76	35	56	25	O	.	1	2	1
	4 5 76	35	56	469	5	4 6 76	35	56	39	M	D	0	0	1
	4 6 76	33	53	458	.	4 7 76	33	53	55	O	.	0	0	1
	4 6 76	33	53	508	.	4 7 76	33	53	55	M	D	0	0	1
	4 6 76	33	53	440	.	4 7 76	33	53	55	O	.	0	0	1
*	4 6 76	33	53	452	.	4 7 76	33	53	55	O	.	0	0	1
	4 6 76	33	53	472	.	4 7 76	33	53	55	F	I	0	0	1
	4 6 76	33	53	471	4	4 7 76	33	53	55	F	D	0	0	1
	4 6 76	26	42	455	.	4 7 76	26	42	39	M	D	0	0	1
	4 6 76	26	42	437	.	4 7 76	26	42	39	O	.	0	0	1
	4 6 76	27	43	447	3	4 7 76	27	43	38	O	.	0	0	1
	4 6 76	33	53	502	.	4 7 76	33	53	55	O	.	0	0	1
	4 6 76	34	54	508	.	4 7 76	34	54	20	F	I	0	0	1
	4 6 76	34	54	503	6	4 7 76	34	54	20	O	.	0	0	1
	4 6 76	35	56	599	5	4 7 76	35	56	39	F	D	0	0	1
	4 6 76	35	56	456	.	4 7 76	35	56	39	M	D	0	0	1
	4 6 76	35	56	472	.	4 7 76	35	56	39	O	.	0	0	1
	4 7 76	33	53	476	.	4 8 76	33	53	55	M	D	0	0	1
*	4 7 76	33	53	501	.	4 8 76	33	53	55	O	.	0	0	1
	4 7 76	34	54	590	6	4 8 76	34	54	25	O	.	0	0	1
	4 7 76	35	56	457	.	4 8 76	35	56	39	O	.	0	0	1
	4 7 76	35	56	487	.	4 8 76	35	56	39	M	D	0	0	1
	4 7 76	35	56	456	.	4 8 76	35	56	39	M	D	0	0	1
	4 7 76	35	56	473	.	4 8 76	35	56	39	O	.	0	0	1
	4 7 76	35	56	508	.	4 8 76	35	56	39	M	D	0	0	1
	4 7 76	35	56	471	.	4 8 76	35	56	39	O	.	0	0	1

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	RELEASE DATE	RELEASE RIVER MI	RELEASE RIVER KM	RELEASE LENGTH	RELEASE AGE	RECAPTURE DATE	RECAPTURE LOCATION / RIVER MI	RECAPTURE RIVER KM	RECAPTURE GEAR	RECAPTURE SEX	RECAPTURE SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
	4 7 76	35	56	462	.	4 8 76	35	56	39	M	D	0	0	1
	4 7 76	35	56	441	.	4 8 76	35	56	39	M	D	0	0	1
	4 7 76	38	61	438	4	4 8 76	38	61	93	M	M	0	0	1
	4 7 76	33	53	463	.	4 8 76	33	53	55	O	.	0	0	1
	4 7 76	35	56	589	7	4 8 76	27	43	93	F	D	8	13	1
	4 7 76	35	56	433	.	4 8 76	36	58	38	O	.	-1	-2	1
	4 7 76	35	56	430	.	4 8 76	36	58	38	O	.	-1	-2	1
	4 7 76	35	56	433	.	4 8 76	36	58	38	M	D	-1	-2	1
*	4 8 76	33	53	503	.	4 9 76	33	53	55	F	D	0	0	1
	4 8 76	36	58	462	.	4 9 76	36	58	38	M	D	0	0	1
	4 8 76	33	53	523	5	4 9 76	33	53	55	F	I	0	0	1
	4 8 76	33	53	463	.	4 9 76	33	53	55	O	.	0	0	1
	4 13 76	33	53	426	.	4 14 76	33	53	38	O	.	0	0	1
	4 13 76	33	53	419	.	4 14 76	33	53	38	O	.	0	0	1
	4 13 76	42	67	418	.	4 14 76	42	67	38	O	.	0	0	1
	4 14 76	34	54	477	.	4 15 76	34	54	39	F	D	0	0	1
	4 19 76	34	54	479	4	4 20 76	34	54	20	O	.	0	0	1
	4 19 76	34	54	489	.	4 20 76	34	54	20	M	D	0	0	1
	4 19 76	34	54	432	.	4 20 76	34	54	38	F	I	0	0	1
	4 19 76	34	54	441	.	4 20 76	34	54	38	O	.	0	0	1
	4 19 76	34	54	420	.	4 20 76	34	54	38	O	.	0	0	1
	4 19 76	34	54	448	.	4 20 76	34	54	38	M	D	0	0	1
	4 20 76	33	53	415	.	4 21 76	33	53	38	F	I	0	0	1
	4 20 76	34	54	510	.	4 21 76	34	54	20	M	D	0	0	1
	4 20 76	34	54	427	.	4 21 76	34	54	38	M	D	0	0	1
	4 20 76	34	54	482	.	4 21 76	34	54	20	O	.	0	0	1
	4 20 76	35	56	650	5	4 21 76	35	56	57	F	M	0	0	1
	4 21 76	35	56	619	6	4 22 76	35	56	57	O	.	0	0	1
	4 21 76	35	56	591	5	4 22 76	35	56	20	O	.	0	0	1
	4 21 76	33	53	394	4	4 22 76	33	53	38	F	I	0	0	1
*	4 21 76	33	53	443	.	4 22 76	33	53	38	O	.	0	0	1
	4 21 76	33	53	409	.	4 22 76	33	53	38	O	.	0	0	1
	4 21 76	34	54	399	.	4 22 76	33	53	38	O	.	1	1	1
*	4 22 76	33	53	447	.	4 23 76	33	53	39	F	I	0	0	1
	4 22 76	33	53	620	5	4 23 76	33	53	25	F	I	0	0	1
	4 22 76	34	54	435	.	4 23 76	34	54	38	F	I	0	0	1
	4 27 76	44	70	604	6	4 28 76	44	70	25	M	.	0	0	1
	4 27 76	33	53	490	5	4 28 76	33	53	20	F	I	0	0	1
	4 27 76	33	53	508	4	4 28 76	33	53	20	F	I	0	0	1
	4 27 76	33	53	456	.	4 28 76	33	53	20	M	D	0	0	1
	5 3 76	35	56	440	3	5 4 76	35	56	38	O	.	0	0	1
	5 3 76	42	67	454	.	5 4 76	42	67	39	M	.	0	0	1
	5 4 76	52	83	603	6	5 5 76	52	83	93	M	R	0	0	1
	5 4 76	52	83	585	5	5 5 76	52	83	93	M	R	0	0	1
*	5 4 76	35	56	405	3	5 5 76	35	56	38	M	.	0	0	1
*	5 4 76	40	64	373	3	5 5 76	40	64	38	M	R	0	0	1
	5 4 76	33	53	494	6	5 5 76	33	53	55	O	.	0	0	1
*	5 5 76	35	56	408	.	5 6 76	35	56	38	F	D	0	0	1
	5 6 76	34	54	616	5	5 7 76	34	54	25	M	R	0	0	1
	5 10 76	58	93	794	8	5 11 76	58	93	28	M	R	0	0	1
	5 12 76	35	56	390	4	5 13 76	35	56	20	F	I	0	0	1
*	5 12 76	33	53	704	7	5 13 76	33	53	55	O	.	0	0	1
	5 12 76	33	53	612	5	5 13 76	33	53	55	F	I	0	0	1
	5 13 76	33	53	680	6	5 14 76	33	53	54	O	.	0	0	1
	5 27 76	35	56	424	.	5 28 76	35	56	94	O	.	0	0	1
	6 8 76	44	70	679	7	6 9 76	44	70	25	M	.	0	0	1
	6 10 76	44	70	822	7	6 11 76	44	70	54	F	S	0	0	1
	3 17 77	34	54	489	6	3 18 77	34	54	20	O	.	0	0	1
	3 17 77	34	54	507	4	3 18 77	34	54	20	O	.	0	0	1
	3 17 77	34	54	566	.	3 18 77	34	54	20	O	.	0	0	1

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RELEASE DATE	RELEASE RIVER MI	RELEASE RIVER KM	LENGTH	AGE	RECAPTURE DATE	LOCATION / RIVER MI	RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
3 17 77	34	54	518	.	3 18 77	34	54	20	O	.	0	0	1
3 17 77	34	54	500	4	3 18 77	34	54	20	O	.	0	0	1
3 30 77	27	43	521	5	3 31 77	27	43	20	O	.	0	0	1
3 30 77	33	53	563	4	3 31 77	33	53	20	O	.	0	0	1
4 4 77	27	43	532	5	4 5 77	27	43	93	O	.	0	0	1
4 4 77	27	43	601	4	4 5 77	27	43	93	M	R	0	0	1
4 5 77	33	53	493	4	4 6 77	33	53	20	M	.	0	0	1
4 5 77	36	58	475	4	4 6 77	36	58	20	M	.	0	0	1
* 4 5 77	33	53	546	4	4 6 77	33	53	20	M	I	0	0	1
4 5 77	34	54	463	4	4 6 77	34	54	38	F	.	0	0	1
4 5 77	33	53	565	4	4 6 77	33	53	25	O	.	0	0	1
4 5 77	33	53	522	5	4 6 77	33	53	20	M	.	0	0	1
4 5 77	33	53	512	4	4 6 77	33	53	20	O	.	0	0	1
4 5 77	33	53	537	4	4 6 77	33	53	20	O	.	0	0	1
4 5 77	33	53	534	5	4 6 77	33	53	20	F	.	0	0	1
4 5 77	33	53	488	4	4 6 77	33	53	20	O	.	0	0	1
4 5 77	33	53	507	4	4 6 77	33	53	20	O	.	0	0	1
4 5 77	33	53	540	5	4 6 77	33	53	20	M	I	0	0	1
4 5 77	33	53	507	4	4 6 77	33	53	20	O	.	0	0	1
4 5 77	33	53	528	4	4 6 77	33	53	20	O	.	0	0	1
4 6 77	33	53	585	6	4 7 77	33	53	25	O	.	0	0	1
4 6 77	33	53	500	4	4 7 77	33	53	20	O	.	0	0	1
4 6 77	33	53	558	4	4 7 77	33	53	20	O	.	0	0	1
4 6 77	33	53	632	6	4 7 77	33	53	25	O	.	0	0	1
4 6 77	33	53	610	.	4 7 77	33	53	25	O	.	0	0	1
4 6 77	33	53	542	5	4 7 77	33	53	20	O	.	0	0	1
4 6 77	33	53	507	4	4 7 77	33	53	20	O	.	0	0	1
4 6 77	33	53	516	4	4 7 77	33	53	20	O	.	0	0	1
4 6 77	33	53	522	5	4 7 77	33	53	20	O	.	0	0	1
4 6 77	36	58	508	4	4 7 77	36	58	20	O	.	0	0	1
4 11 77	28	45	544	4	4 12 77	28	45	93	F	I	0	0	1
4 11 77	52	83	965	12	4 12 77	52	83	93	O	.	0	0	1
4 11 77	34	54	550	4	4 12 77	34	54	20	O	.	0	0	1
4 11 77	34	54	521	4	4 12 77	34	54	20	O	.	0	0	1
4 11 77	33	53	627	6	4 12 77	33	53	54	O	.	0	0	1
4 12 77	33	53	536	4	4 13 77	33	53	20	F	I	0	0	1
4 13 77	30	48	417	4	4 14 77	30	48	38	M	I	0	0	1
4 13 77	34	54	510	4	4 14 77	34	54	20	O	.	0	0	1
4 14 77	37	59	485	4	4 15 77	37	59	93	M	.	0	0	1
4 14 77	37	59	533	4	4 15 77	37	59	93	M	RR	0	0	1
4 18 77	33	53	419	4	4 19 77	33	53	38	O	.	0	0	1
4 18 77	33	53	409	4	4 19 77	33	53	38	O	.	0	0	1
4 19 77	36	58	483	5	4 20 77	36	58	20	F	I	0	0	1
4 20 77	35	56	519	7	4 21 77	12	19	93	O	.	23	37	1
4 20 77	33	53	565	4	4 21 77	33	53	38	M	I	0	0	1
4 21 77	34	54	442	4	4 22 77	34	54	98	O	.	0	0	1
4 21 77	34	54	443	5	4 22 77	34	54	98	O	.	0	0	1
4 26 77	33	53	444	4	4 27 77	33	53	38	M	I	0	0	1
4 28 77	40	64	538	4	4 29 77	40	64	93	O	.	0	0	1
5 2 77	35	56	520	4	5 3 77	35	56	20	O	.	0	0	1
5 4 77	35	56	388	4	5 5 77	35	56	38	F	I	0	0	1
5 17 77	40	64	1083	14	5 18 77	40	64	54	F	R	0	0	1
6 8 77	42	67	910	11	6 9 77	42	67	20	M	RR	0	0	1
3 16 76	33	53	428	.	3 18 76	34	54	39	O	.	-1	-1	2
3 23 76	33	53	446	.	3 25 76	33	53	55	M	M	0	0	2
4 6 76	34	54	500	.	4 8 76	34	54	20	M	D	0	0	2
4 7 76	33	53	480	.	4 9 76	33	53	55	M	D	0	0	2
* 4 7 76	33	53	673	.	4 9 76	33	53	54	F	R	0	0	2
4 7 76	35	56	416	.	4 9 76	36	58	38	F	I	-1	-2	2
4 14 76	33	53	437	.	4 16 76	27	43	93	F	D	6	10	2

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	RELEASE					RECAPTURE								
	DATE	RIVER MI	RIVER KM	LENGTH	AGE	DATE	LOCATION / RIVER MI	RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
	4 19 76	36	58	832	9	4 21 76	36	58	25	M	.	0	0	2
	4 19 76	34	54	386	.	4 21 76	34	54	38	M	D	0	0	2
	4 20 76	35	56	581	6	4 22 76	12	19	93	O	.	23	37	2
	3 15 77	27	43	510	4	3 17 77	27	43	20	O	.	0	0	2
	3 15 77	27	43	507	.	3 17 77	27	43	20	O	.	0	0	2
	3 30 77	35	56	516	4	4 1 77	35	56	38	M	.	0	0	2
	3 30 77	36	58	529	4	4 1 77	36	58	20	O	.	0	0	2
	4 19 77	35	56	555	6	4 21 77	12	19	93	O	.	23	37	2
	4 22 77	36	58	612	4	4 24 77	27	43	93	O	.	9	15	2
	4 28 77	44	70	535	4	4 30 77	27	43	93	O	.	17	27	2
	4 23 76	35	56	586	6	4 26 76	12	19	93	O	.	23	37	3
	4 5 77	33	53	560	4	4 8 77	12	19	98	O	.	21	34	3
	4 14 77	37	59	556	7	4 17 77	12	19	93	O	.	25	40	3
	4 19 77	34	54	612	7	4 22 77	34	54	25	M	.	0	0	3
	4 25 77	35	56	319	3	4 28 77	34	54	88	M	RR	1	2	3
	4 19 76	35	56	598	.	4 23 76	12	19	93	O	.	23	37	4
	5 6 76	40	64	435	5	5 10 76	40	64	94	O	.	0	0	4
	5 13 76	35	56	960	12	5 17 76	39	62	61	F	.	-4	-6	4
	4 13 77	37	59	522	4	4 17 77	12	19	93	O	.	25	40	4
	4 14 77	34	54	575	7	4 18 77	12	19	93	O	.	22	35	4
	4 15 77	37	59	530	6	4 19 77	12	19	93	O	.	25	40	4
	4 5 77	33	53	500	6	4 10 77	27	43	93	M	I	6	10	5
	4 5 77	27	43	566	4	4 10 77	27	43	93	F	I	0	0	5
	4 13 77	34	54	534	4	4 18 77	27	43	93	O	.	7	11	5
	4 14 77	33	53	561	5	4 19 77	12	19	93	O	.	21	34	5
	4 19 77	36	58	448	6	4 24 77	12	19	93	O	.	24	39	5
	4 21 77	35	56	576	5	4 26 77	12	19	93	O	.	23	37	5
	5 5 77	43	69	526	.	5 10 77	12	19	93	O	.	31	50	5
	4 22 76	33	53	495	.	4 28 76	35	56	93	O	.	-2	-3	6
	5 7 76	40	64	650	6	5 13 76	35	56	61	O	.	5	8	6
	3 22 77	35	56	600	.	3 28 77	34	54	25	O	.	1	2	6
	3 22 77	34	54	513	4	3 28 77	33	53	20	O	.	1	1	6
	4 5 77	33	53	515	4	4 11 77	12	19	93	O	.	21	34	6
	4 5 77	33	53	530	4	4 11 77	28	45	93	F	I	5	8	6
	4 12 77	28	45	488	4	4 18 77	12	19	93	O	.	16	26	6
	4 12 77	35	56	551	6	4 18 77	12	19	93	O	.	23	37	6
	4 28 77	52	83	825	7	5 4 77	12	19	93	O	.	40	64	6
*	5 3 77	27	43	566	6	5 9 77	27	43	93	O	.	0	0	6
	10 8 76	34	54	559	.	10 15 76	14	22	98	O	.	20	32	7
	4 6 77	33	53	617	6	4 13 77	12	19	93	O	.	21	34	7
	4 12 77	34	54	535	4	4 19 77	12	19	93	O	.	22	35	7
	4 19 77	34	54	940	11	4 26 77	12	19	93	F	RR	22	35	7
	4 20 77	36	58	545	8	4 27 77	12	19	93	O	.	24	39	7
	5 2 77	27	43	456	4	5 9 77	12	19	93	O	.	15	24	7
	5 6 77	35	56	457	4	5 13 77	33	53	88	O	.	2	3	7
*	3 30 76	36	58	677	6	4 7 76	33	53	54	O	.	3	5	8
	4 19 76	34	54	444	.	4 27 76	32	51	98	O	.	2	3	8
	4 12 77	32	51	594	6	4 20 77	12	19	93	O	.	20	32	8
	4 1 77	33	53	695	6	4 10 77	27	43	93	F	.	6	10	9
	4 5 77	27	43	563	6	4 14 77	12	19	93	O	.	15	24	9
	4 12 77	28	45	472	5	4 21 77	12	19	93	O	.	16	26	9
*	4 29 76	44	70	595	.	5 9 76	34	54	98	O	.	10	16	10
	4 5 77	33	53	473	4	4 15 77	12	19	93	O	.	21	34	10
	4 13 76	33	53	424	.	4 24 76	GOVERNORS IS., N.Y.	.	98	O	.	35	56	11
	4 15 76	34	54	551	.	4 26 76	66	106	93	M	M	-32	-52	11
	5 27 76	35	56	840	7	6 7 76	LOWER BAY, N.Y.	.	98	O	.	47	75	11
	5 28 76	40	64	584	6	6 8 76	27	43	93	F	D	13	21	11
	4 13 77	35	56	630	7	4 24 77	27	43	93	O	.	8	13	11
	4 15 76	38	61	525	.	4 27 76	41	66	93	O	.	-3	-5	12
	3 18 77	34	54	520	4	3 30 77	33	53	20	O	.	1	1	12

Table B-2 (Page 7 of 12)

RELEASE DATE	RELEASE RIVER MI	RELEASE RIVER KM	RELEASE LENGTH	RELEASE AGE	RECAPTURE DATE	RECAPTURE LOCATION / RIVER MI	RECAPTURE RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
4 18 77	27	43	424	4	4 30 77	36	58	98	O	.	-9	-15	12
4 28 77	42	67	626	7	5 10 77	12	19	93	M	RR	30	48	12
6 9 76	35	56	982	.	6 22 76	FIRE IS., N.Y.	.	98	F	.	117	187	13
4 11 77	33	53	513	5	4 24 77	27	43	93	O	.	6	10	13
4 14 77	37	59	480	4	4 27 77	NEW ROCHELLE, N.Y.	.	98	O	.	62	99	13
4 19 77	35	56	523	5	5 2 77	12	19	93	O	.	23	37	13
4 21 77	35	56	510	4	5 4 77	32	51	98	O	.	3	5	13
4 9 76	33	53	472	5	4 23 76	12	19	93	O	.	21	34	14
4 14 76	35	56	796	6	4 28 76	34	54	98	O	.	1	2	14
3 31 77	34	54	620	6	4 14 77	12	19	93	O	.	22	35	14
4 5 77	33	53	530	4	4 19 77	12	19	93	O	.	21	34	14
5 3 77	35	56	394	4	5 17 77	NEWARK BAY, N.J.	.	94	O	.	47	75	14
5 24 77	27	43	808	7	6 7 77	LIBERTY IS., N.Y.	.	98	O	.	29	46	14
4 7 76	35	56	632	7	4 22 76	12	19	93	O	.	23	37	15
4 12 76	27	43	520	.	4 27 76	12	19	93	O	.	15	24	15
4 5 77	33	53	612	6	4 20 77	12	19	93	O	.	21	34	15
4 6 77	33	53	541	4	4 21 77	34	54	88	O	.	-1	-1	15
4 13 77	35	56	594	6	4 28 77	35	56	25	O	.	0	0	15
4 19 77	34	54	699	8	5 4 77	31	50	93	F	RR	3	4	15
5 6 77	35	56	380	5	5 21 77	11	18	98	O	.	24	38	15
5 18 77	39	62	484	4	6 2 77	JAMAICA BAY, N.Y.	.	98	O	.	63	101	15
5 25 77	44	70	719	6	6 9 77	ROCKAWAY, N.Y.	.	98	F	.	62	99	15
4 11 77	35	56	530	4	4 27 77	33	53	98	O	.	2	3	16
4 30 76	34	54	485	.	5 17 76	36	58	14	O	I	-2	-4	17
4 12 77	35	56	553	4	5 1 77	11	18	98	O	.	24	38	19
6 2 77	43	69	857	7	6 21 77	HOFFMAN IS., N.Y.	.	98	M	.	52	83	19
6 4 76	52	83	942	11	6 24 76	ATLANTIC BEACH, N.Y.	.	98	F	.	78	125	20
* 4 12 77	33	53	556	6	5 3 77	27	43	93	O	.	6	10	21
4 7 76	34	54	785	.	4 30 76	NORTHPORT, N.Y.	.	98	M	.	73	117	23
4 11 77	28	45	495	4	5 4 77	31	50	93	O	.	-3	-5	23
4 11 77	34	54	552	6	5 4 77	32	51	98	O	.	2	3	23
4 7 76	33	53	448	.	5 1 76	ROCKAWAY, N.Y.	.	98	O	.	48	77	24
3 17 77	34	54	550	4	4 10 77	12	19	93	O	.	22	35	24
5 18 77	33	53	562	5	6 11 77	VERRAZANO BRIDGE, N.Y.	.	98	O	.	41	66	24
9 23 76	60	96	257	.	10 18 76	EAST RIVER, N.Y.	.	98	O	.	40	64	25
4 6 77	33	53	481	4	5 1 77	11	18	98	O	.	22	35	25
4 7 77	33	53	608	6	5 2 77	40	64	93	O	.	-7	-11	25
3 24 76	33	53	481	.	4 19 76	JERSEY CITY, N.J.	.	98	O	.	33	53	26
3 31 76	36	58	611	7	4 26 76	12	19	93	O	.	24	39	26
4 13 77	33	53	553	6	5 9 77	27	43	93	O	.	6	10	26
3 17 77	34	54	565	.	4 13 77	12	19	93	O	.	22	35	27
4 6 77	33	53	592	6	5 3 77	12	19	93	O	.	21	34	27
4 21 77	32	51	525	4	5 18 77	STAMFORD, CT.	.	98	O	.	71	114	27
4 27 76	59	94	530	5	5 25 76	JAMAICA BAY, N.Y.	.	98	M	.	81	130	28
4 6 77	33	53	624	7	5 4 77	32	51	98	O	.	1	2	28
4 14 77	35	56	560	5	5 12 77	UNKNOWN	.	98	O	.	.	.	28
5 31 77	35	56	649	6	6 28 77	VERRAZANO BRIDGE, N.Y.	.	98	F	.	43	69	28
4 6 76	33	53	509	.	5 5 76	34	54	61	O	.	-1	-1	29
4 14 76	35	56	606	8	5 13 76	33	53	61	M	D	2	3	29
5 4 77	35	56	480	4	6 2 77	CATSKILL CREEK, N.Y.	.	98	O	.	-77	-122	29
6 1 77	39	62	997	13	6 30 77	FIRE ISLAND, N.Y.	.	98	O	.	91	146	29
4 9 76	26	42	455	.	5 9 76	EAST RIVER, N.Y.	.	98	O	.	28	45	30
5 24 76	44	70	546	7	6 23 76	VERRAZANO BRIDGE, N.Y.	.	98	M	.	52	83	30
4 6 77	33	53	579	4	5 6 77	12	19	93	O	.	21	34	30
5 18 77	35	56	449	4	6 17 77	THROGGS NECK BRIDGE, N.Y.	.	98	O	.	51	82	30
5 18 77	33	53	453	4	6 17 77	JAMAICA BAY, N.Y.	.	98	O	.	57	91	30
3 23 76	33	53	522	.	4 23 76	34	54	98	O	.	-1	-1	31
9 22 77	34	54	410	.	10 23 77	ROCKAWAY , N.Y.	.	98	O	.	51	82	31
4 1 77	35	56	703	7	5 3 77	12	19	93	O	.	23	37	32
4 7 76	33	53	465	5	5 10 76	33	53	55	F	I	0	0	33

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	RELEASE DATE	RELEASE RIVER MI	RELEASE RIVER KM	RELEASE LENGTH	RELEASE AGE	RECAPTURE DATE	RECAPTURE LOCATION / RIVER MI	RECAPTURE RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
	4 19 76	34	54	452	.	5 22 76	JAMESTOWN, R.I.	.	98	O	.	159	254	33
	3 18 77	34	54	485	4	4 20 77	33	53	38	M	.	1	1	33
	4 6 77	33	53	552	4	5 9 77	12	19	93	O	.	21	34	33
	4 21 77	35	56	515	4	5 24 77	MONTAUK PT., N.Y.	.	93	O	.	177	283	33
	4 21 77	34	54	545	5	5 24 77	98	157	98	O	.	-64	-103	33
	3 30 76	34	54	534	6	5 3 76	40	64	98	O	.	-6	-10	34
*	3 31 77	33	53	503	4	5 4 77	35	56	20	O	.	-2	-3	34
	3 22 77	35	56	645	6	4 26 77	40	64	93	O	.	-5	-8	35
	3 31 77	33	53	515	4	5 5 77	35	56	20	O	.	-2	-3	35
	5 27 76	46	74	871	9	7 2 76	ROCKAWAY, N.Y.	.	98	M	.	61	98	36
	4 20 77	32	51	493	5	5 26 77	15	24	98	O	.	17	27	36
	6 8 77	38	61	818	9	7 14 77	SANDY HOOK, N.J.	.	98	M	RR	58	93	36
*	4 20 76	35	56	631	6	5 27 76	33	53	38	O	.	2	3	37
	4 22 77	34	54	418	4	5 29 77	CONEY ISLAND, N.Y.	.	98	O	.	46	74	37
	5 27 76	39	62	383	.	7 4 76	39	62	98	O	.	0	0	38
	6 10 76	52	83	957	11	7 18 76	CHATHAM, MA.	.	98	M	.	283	453	38
	3 26 76	37	59	488	.	5 4 76	72	115	93	O	.	-35	-56	39
	3 30 77	33	53	516	4	5 8 77	39	62	93	O	.	-6	-9	39
	4 26 77	35	56	713	7	6 4 77	NANTUCKET IS., MA.	.	98	O	.	285	456	39
	5 17 76	40	64	560	.	6 26 76	WHITESTONE, N.Y.	.	98	O	.	52	83	40
	3 17 77	34	54	524	.	4 26 77	RED BANK, N.J.	.	98	O	.	64	102	40
	4 5 77	33	53	518	3	5 16 77	35	56	61	O	.	-2	-3	41
	5 3 77	35	56	346	4	6 14 77	CATSKILL CREEK, N.Y.	.	98	O	.	-77	-122	42
	4 7 76	35	56	448	.	5 20 76	AMAGANSETT, N.Y.	.	98	O	.	147	235	43
	4 7 76	35	56	550	5	5 21 76	ORIENT, N.Y.	.	93	O	.	134	214	44
	4 13 76	33	53	459	.	5 27 76	HUNTINGTON, N.Y.	.	98	O	.	66	106	44
	4 14 77	33	53	775	7	5 28 77	CONEY IS., N.Y.	.	98	O	.	43	69	44
	5 4 77	33	53	630	6	6 17 77	WATCH HILL, R.I.	.	98	O	.	177	283	44
	3 17 77	34	54	525	.	5 1 77	STATEN IS., N.Y.	.	98	O	.	49	78	45
	3 31 77	33	53	513	4	5 15 77	34	54	98	O	.	-1	-1	45
	5 17 76	36	58	945	9	7 2 76	CONEY IS., N.Y.	.	98	O	.	46	74	46
	4 5 77	33	53	484	6	5 21 77	91	146	88	O	.	-58	-93	46
	4 19 76	34	54	488	.	6 5 76	LOWER N.Y. BAY	.	98	O	.	47	75	47
	3 18 77	34	54	685	7	5 4 77	40	64	20	O	.	-6	-10	47
	3 18 77	34	54	567	6	5 4 77	32	51	98	O	.	2	3	47
	5 4 77	34	54	433	.	6 20 77	NEWPORT, R.I.	.	98	O	.	214	342	47
	4 6 76	33	53	501	.	5 25 76	JAMAICA BAY, N.Y.	.	98	O	.	52	83	49
	4 20 76	35	56	672	6	6 8 76	SANDYHOOK, N.J.	.	98	O	.	66	106	49
	3 18 77	34	54	514	4	5 6 77	12	19	93	O	.	22	35	49
	5 5 76	34	54	491	5	6 24 76	BROOKLYN, N.Y.	.	98	O	.	42	67	50
	4 5 77	33	53	526	4	5 25 77	RYE, N.Y.	.	98	O	.	64	102	50
	4 8 76	27	43	412	.	5 29 76	NORWALK, CT.	.	98	O	.	44	70	51
	5 18 77	58	93	515	5	7 8 77	VERRAZANO BRIDGE,N.Y.	.	98	O	.	66	106	51
	3 17 77	34	54	555	.	5 8 77	12	19	93	O	.	22	35	52
	4 25 77	27	43	543	7	6 16 77	HOFFMAN IS., N.Y.	.	98	O	.	36	58	52
*	5 4 77	35	56	502	4	6 25 77	MILFORD, CT.	.	98	O	.	103	165	52
	5 5 77	35	56	497	4	6 26 77	18	29	98	O	.	17	27	52
	3 26 76	26	42	424	.	5 18 76	112	179	98	O	.	-86	-137	53
	4 12 77	28	45	473	3	6 4 77	COS COB, CT.	.	98	O	.	65	104	53
	3 24 76	34	54	540	7	5 17 76	91	146	98	O	.	-57	-92	54
	5 27 76	33	53	644	5	7 20 76	HAMPTON BAY, N.Y.	.	98	F	.	130	208	54
	4 5 77	33	53	547	4	5 29 77	MILFORD, CT.	.	98	O	.	98	157	54
	4 12 77	28	45	491	3	6 5 77	HIGHLANDS, N.J.	.	98	O	.	51	82	54
*	5 27 76	33	53	642	.	7 21 76	HOFFMAN IS., N.Y.	.	98	O	.	45	72	55
	4 21 77	33	53	493	4	6 15 77	RYE, N.Y.	.	98	O	.	62	99	55
	4 28 77	43	69	490	4	6 22 77	LITTLE NECK BAY, N.Y.	.	98	O	.	61	98	55
	4 14 77	34	54	532	4	6 9 77	GREENWICH, CT.	.	98	O	.	71	114	56
	4 19 76	34	54	438	.	6 15 76	HUNTINGTON, N.Y.	.	98	O	.	72	115	57
	3 15 77	27	43	445	4	5 11 77	BRISTOL, R.I.	.	98	O	.	219	350	57
	4 13 77	34	54	508	4	6 9 77	GREENWICH, CT.	.	98	O	.	67	107	57

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RELEASE DATE	RELEASE RIVER MI	RELEASE RIVER KM	LENGTH	AGE	RECAPTURE DATE	LOCATION / RIVER MI	RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
3 24 76	27	43	522	.	5 22 76	MANHASSETT BAY, N.Y.	.	98	O	.	48	77	59
5 5 77	35	56	551	4	7 3 77	SHINNECOCK, N.Y.	.	98	O	.	137	219	59
3 30 77	34	54	620	4	5 30 77	HUNTINGTON BAY, N.Y.	.	98	O	.	79	126	61
4 8 76	36	58	415	3	6 9 76	JAMAICA BAY, N.Y.	.	98	O	.	58	93	62
5 11 76	27	43	439	4	7 12 76	VERRAZANO BRIDGE, N.Y.	.	98	M	.	35	56	62
5 12 76	27	43	590	5	7 13 76	BREEZY PT., N.Y.	.	98	O	.	42	67	62
4 2 76	26	42	465	.	6 4 76	CONNECTICUT RIVER, CT.	.	98	O	.	126	202	63
5 20 76	39	62	642	3	7 22 76	HOFFMAN IS., N.Y.	.	98	O	.	45	72	63
6 3 77	42	67	445	4	8 5 77	VERRAZANO BRIDGE, N.Y.	.	98	M	.	50	80	63
4 6 77	33	53	535	4	6 9 77	WADING RIVER, N.Y.	.	98	O	.	107	171	64
4 12 77	28	45	505	4	6 16 77	HOFFMAN IS., N.Y.	.	98	O	.	37	59	65
3 23 76	33	53	524	.	5 28 76	MOTTS PT., N.Y.	.	98	O	.	59	94	66
3 15 77	27	43	515	.	5 21 77	MILFORD, CT.	.	98	O	.	97	155	67
3 30 77	33	53	502	4	6 6 77	SEBONAC NECK, N.Y.	.	98	O	.	169	270	68
4 28 77	40	64	482	4	7 5 77	DEAD HORSE CREEK, N.Y.	.	98	M	RR	56	90	68
3 24 76	26	42	386	3	6 1 76	COS COB, CT.	.	98	O	.	61	98	69
4 6 77	33	53	661	6	6 14 77	ROBBINS REEF, N.Y.	.	98	O	.	37	59	69
4 11 77	33	53	505	4	6 19 77	FIRE IS., N.Y.	.	98	O	.	61	98	69
4 18 77	27	43	530	.	6 26 77	HOFFMAN IS., N.Y.	.	98	O	.	36	58	69
4 11 77	33	53	527	6	6 20 77	MONTAUK PT.,N.Y.	.	98	O	.	174	278	70
4 22 76	34	54	415	.	7 2 76	64	102	98	O	.	-30	-48	71
3 30 76	33	53	467	4	6 10 76	PELHAM BAY, N.Y.	.	98	O	.	52	83	72
5 27 76	33	53	468	3	8 7 76	PLUMBEACH, N.Y.	.	98	O	.	40	64	72
4 5 77	36	58	510	4	6 16 77	HOFFMAN IS., N.Y.	.	98	O	.	45	72	72
4 6 77	33	53	521	4	6 17 77	VERRAZANO BRIDGE, N.Y.	.	98	O	.	41	66	72
4 22 77	35	56	448	4	7 4 77	LIBERTY IS., N.Y.	.	98	O	.	36	58	73
4 13 76	33	53	404	4	6 27 76	55	88	98	O	.	-22	-35	75
4 12 77	28	45	528	4	6 27 77	COS COB, CT.	.	98	O	.	65	104	76
4 13 77	34	54	496	.	6 28 77	VERRAZANO BRIDGE, N.Y.	.	98	O	.	42	67	76
4 21 77	32	51	452	3	7 6 77	NORWALK, CT.	.	98	O	.	79	126	76
4 6 76	35	56	502	.	6 23 76	SHINNECOCK BAY, N.Y.	.	98	O	.	135	216	78
3 18 77	34	54	573	4	6 4 77	STOCKPORT CREEK, N.Y.	.	98	O	.	32	51	78
4 7 76	35	56	410	.	6 25 76	MAMARONECK, N.Y.	.	98	O	.	58	93	79
5 17 76	36	58	449	.	8 4 76	UNKNOWN	.	93	O	.	.	.	79
6 23 76	27	43	531	5	9 10 76	MONTAUK PT., N.Y.	.	98	O	.	161	258	79
4 5 77	33	53	499	5	6 23 77	STATEN IS., N.Y.	.	98	O	.	44	70	79
4 20 76	34	54	415	5	7 10 76	STOCKPORT CREEK, N.Y.	.	98	O	.	-86	-138	81
5 12 76	35	56	781	7	8 1 76	MONTAUK PT., N.Y.	.	98	O	.	169	270	81
4 5 77	34	54	537	.	6 25 77	MANHASSETT BAY, N.Y.	.	98	O	.	56	90	81
4 11 77	34	54	571	4	7 2 77	ROCKAWAY, N.Y.	.	98	O	.	50	80	82
4 13 77	33	53	517	4	7 4 77	JAMAICA BAY, N.Y.	.	98	O	.	54	86	82
6 6 77	44	70	908	.	8 27 77	BREEZY PT., N.Y.	.	98	F	S	58	93	82
4 8 76	36	58	432	.	6 30 76	HART IS., N.Y.	.	98	O	.	57	91	83
4 21 77	33	53	468	4	7 14 77	VERRAZANO BRIDGE, N.Y.	.	98	O	.	41	66	84
3 23 76	33	53	463	.	6 16 76	SEABRIGHT, N.J.	.	98	O	.	58	93	85
3 17 77	34	54	493	.	6 11 77	NARRAGANSETT, R.I.	.	98	O	.	220	352	86
4 6 77	33	53	487	4	7 1 77	MERRICK, N.Y.	.	98	O	.	73	117	86
4 12 77	34	54	498	4	7 7 77	JONES BEACH, N.Y.	.	98	O	.	70	112	86
4 22 76	35	56	640	6	7 18 76	JAMAICA BAY, N.Y.	.	98	O	.	57	91	87
3 23 76	33	53	566	5	6 19 76	MAMARONECK, N.Y.	.	98	O	.	56	90	88
3 24 76	37	59	465	.	6 20 76	DEMOCRAT PT., N.Y.	.	98	O	.	86	138	88
3 26 76	27	43	479	.	6 22 76	VERRAZANO BRIDGE, N.Y.	.	98	O	.	35	56	88
4 21 76	34	54	381	.	7 19 76	STAMFORD, CT.	.	98	O	.	70	112	89
4 21 77	33	53	887	8	7 20 77	CAPE COD CANAL,MA.	.	98	F	RR	263	421	90
4 26 77	40	64	443	4	7 25 77	CITY IS., N.Y.	.	98	O	.	61	98	90
3 31 77	33	53	545	5	6 30 77	STATEN IS., N.Y.	.	98	O	.	45	72	91
4 13 77	34	54	548	4	7 13 77	WADING RIVER, N.Y.	.	98	O	.	108	173	91
5 5 76	34	54	399	.	8 5 76	JAMAICA BAY, N.Y.	.	98	O	.	56	90	92
4 2 76	26	42	665	.	7 4 76	SHORT BEACH, N.Y.	.	98	M	.	62	99	93
4 6 76	33	53	519	.	7 8 76	GREENWICH, CT.	.	98	O	.	64	102	93

Table B-2 (Page 10 of 12)

RELEASE DATE	RELEASE RIVER MI	RELEASE RIVER KM	LENGTH	AGE	RECAPTURE DATE	LOCATION / RIVER MI	RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
4 26 77	27	43	565	.	7 28 77	S. ROCKAWAY, N.Y.	.	98	O	.	43	69	93
3 15 77	27	43	500	.	6 17 77	DAVISVILLE, R.I.	.	98	O	.	221	354	94
3 30 77	35	56	488	.	7 2 77	MILFORD, CT.	.	98	O	.	103	165	94
3 23 76	33	53	519	.	6 26 76	WHITESTONE, N.Y.	.	98	O	.	52	83	95
4 19 76	34	54	692	5	7 23 76	MONTAUK PT., N.Y.	.	98	M	.	168	269	95
4 19 76	34	54	387	.	7 23 76	BROOKLYN, N.Y.	.	98	O	.	42	67	95
4 21 77	34	54	499	4	7 25 77	JAMAICA BAY, N.Y.	.	98	O	.	55	88	95
4 9 76	33	53	481	.	7 14 76	91	146	98	O	.	-58	-93	96
5 27 76	44	70	557	5	8 31 76	JAMAICA BAY, N.Y.	.	98	M	.	72	115	96
4 7 76	35	56	395	.	7 13 76	69	110	94	O	.	-34	-54	97
4 19 77	33	53	497	4	7 25 77	VERRAZANO BRIDGE, N.Y.	.	98	O	.	41	66	97
4 21 77	34	54	493	5	7 28 77	VERRAZANO BRIDGE, N.Y.	.	98	O	.	42	67	98
3 30 76	27	43	424	.	7 7 76	ROCKAWAY, N.Y.	.	98	O	.	42	67	99
3 30 77	33	53	525	4	7 7 77	JAMAICA BAY, N.Y.	.	98	O	.	54	86	99
4 12 77	28	45	494	4	7 20 77	ROCKAWAY INLET, N.Y.	.	98	O	.	42	67	99
5 11 77	56	90	418	5	8 19 77	40	64	98	O	.	16	26	100
4 8 76	38	61	699	7	7 18 76	SANDS POINT, N.Y.	.	98	O	.	59	94	101
4 7 77	33	53	624	4	7 17 77	STATFORD CREEK, N.Y.	.	98	O	.	94	150	101
3 17 77	34	54	514	4	6 27 77	BARN IS., CT.	.	98	O	.	160	256	102
3 26 76	37	59	472	.	7 7 76	VERRAZANO BRIDGE, N.Y.	.	98	O	.	45	72	103
4 5 77	33	53	547	4	7 17 77	DUXBURY, MA.	.	98	O	.	291	466	103
4 9 76	26	42	460	.	7 22 76	LORDSHIP, CT.	.	98	O	.	83	133	104
4 19 77	33	53	617	7	8 1 77	LITTLE NECK BAY, N.Y.	.	98	O	.	51	82	104
3 30 77	36	58	555	4	7 13 77	JONES BEACH, N.Y.	.	98	O	.	77	123	105
3 23 76	33	53	526	5	7 7 76	EAST HAMPTON, N.Y.	.	98	O	.	146	234	106
3 24 76	37	59	457	.	7 8 76	MORICHES, N.Y.	.	98	O	.	119	190	106
4 2 76	26	42	588	7	7 17 76	BELMAR, N.J.	.	98	O	.	65	104	106
3 18 77	34	54	512	4	7 2 77	NEWBURYPORT, MA.	.	98	O	.	262	419	106
3 30 77	36	58	530	4	7 15 77	LONG BEACH, N.Y.	.	98	O	.	68	109	107
3 15 77	27	43	480	4	7 1 77	MERRICK, N.Y.	.	98	O	.	67	107	108
4 13 77	34	54	533	6	7 30 77	VERRAZANO BRIDGE, N.Y.	.	98	O	.	42	67	108
4 19 77	35	56	474	4	8 5 77	JONES BEACH, N.Y.	.	98	O	.	74	118	108
3 16 76	33	53	446	.	7 3 76	GREENWICH, CT.	.	98	O	.	64	102	109
4 5 77	33	53	512	4	7 23 77	RYE, N.Y.	.	98	O	.	64	102	109
4 5 77	33	53	551	5	7 24 77	JONES INLET, N.Y.	.	98	O	.	69	110	110
4 12 77	35	56	461	3	7 31 77	WADING RIVER, N.Y.	.	98	O	.	109	174	110
3 30 76	36	58	559	.	7 19 76	ROCKAWAY, N.Y.	.	98	O	.	51	82	111
4 9 76	33	53	508	.	7 30 76	JAMAICA, N.Y.	.	98	O	.	36	58	112
5 4 77	33	53	489	4	8 24 77	ROCKAWAY PT., N.Y.	.	98	O	.	49	78	112
4 9 76	33	53	494	5	7 31 76	NEW ROCHELLE, N.Y.	.	98	O	.	53	85	113
4 6 77	33	53	493	4	7 28 77	VERRAZANO BRIDGE, N.Y.	.	98	O	.	41	66	113
4 8 76	36	58	650	7	7 31 76	AMBROSE CHANNEL, N.Y.	.	98	O	.	66	106	114
3 18 77	34	54	500	4	7 10 77	PATCHOGUE BAY, N.Y.	.	98	O	.	104	166	114
4 5 77	27	43	558	4	7 28 77	SHINNECOCK BAY, N.Y.	.	98	O	.	129	206	114
4 19 77	33	53	424	4	8 14 77	RYE, N.Y.	.	98	O	.	64	102	117
4 21 77	35	56	425	3	8 16 77	TIN CAN GROUNDS, N.Y.	.	98	O	.	57	91	117
3 28 77	35	56	473	4	7 25 77	JAMAICA BAY, N.Y.	.	98	O	.	56	90	119
4 13 77	33	53	532	6	8 10 77	JAMAICA BAY, N.Y.	.	98	O	.	54	86	119
4 19 76	34	54	387	.	8 17 76	151	242	98	O	.	-117	-188	120
4 6 77	33	53	520	7	8 4 77	ASBURY PARK, N.J.	.	98	O	.	70	112	120
3 24 76	26	42	413	.	7 24 76	RYE BEACH, N.Y.	.	98	O	.	55	88	122
4 22 76	33	53	390	4	8 22 76	BAYONNE, N.J.	.	98	O	.	36	58	122
4 13 77	34	54	757	6	8 14 77	NEW HAVEN, CT.	.	98	F	.	106	170	123
3 23 76	33	53	536	.	7 25 76	GREENWICH, CT.	.	98	O	.	65	104	124
4 12 77	28	45	464	4	8 17 77	SHINNECOCK BAY, N.Y.	.	98	O	.	132	211	127
4 21 77	32	51	405	3	8 27 77	NARAGANSETT, R.I.	.	98	O	.	218	349	128
4 13 77	33	53	510	4	8 20 77	BREEZY PT., N.Y.	.	98	O	.	49	78	129
5 27 76	39	62	400	.	10 4 76	VERRAZANO BRIDGE, N.Y.	.	98	O	.	47	75	130
3 18 77	34	54	625	7	7 30 77	BROOKLYN BRIDGE, N.Y.	.	98	O	.	35	56	134
3 23 76	33	53	450	4	8 5 76	BROOKLYN, N.Y.	.	98	O	.	48	77	135

Table B-2 (Page 11 of 12)

RELEASE DATE	RELEASE RIVER MI	RELEASE RIVER KM	LENGTH	AGE	RECAPTURE DATE	LOCATION / RIVER MI	RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
3 16 76	33	53	440	3	7 31 76	CAPE COD, MA.	.	98	0	.	286	458	137
4 6 76	33	53	464	.	8 21 76	ZACHS BAY, N.Y.	.	98	0	.	73	117	137
4 13 76	33	53	400	3	8 30 76	NEW ROCHELLE, N.Y.	.	98	0	.	55	88	139
3 25 76	35	56	630	5	8 12 76	CITY IS., N.Y.	.	98	0	.	55	88	140
4 1 77	33	53	529	4	8 19 77	GREENWICH, CT.	.	98	0	.	69	110	140
4 13 76	33	53	441	.	9 5 76	152	243	98	0	.	-119	-190	145
3 17 77	27	43	514	4	8 9 77	MILFORD, CT.	.	98	0	.	93	149	145
4 30 76	34	54	409	3	9 23 76	ROCKAWAY PT., N.Y.	.	98	0	.	48	77	146
4 14 76	33	53	394	.	9 10 76	S.OYSTER BAY, N.Y.	.	98	0	.	73	117	149
4 7 76	35	56	485	4	9 4 76	VERRAZANO BRIDGE, N.Y.	.	98	0	.	43	69	150
4 8 76	33	53	474	.	9 6 76	CONEY IS., N.Y.	.	98	0	.	42	67	151
5 13 76	35	56	729	6	10 11 76	CUTTYHUNK IS., R.I.	.	98	0	.	209	334	151
4 7 77	33	53	606	7	9 5 77	152	243	98	0	.	-119	-190	151
4 12 77	28	45	484	4	9 14 77	PORTSMOUTH, R.I.	.	98	0	.	217	347	155
4 7 76	35	56	463	3	9 10 76	STAMFORD, CT.	.	98	0	.	70	112	156
3 30 77	33	53	495	3	9 3 77	MATUNUCK, R.I.	.	98	0	.	194	310	157
3 30 77	36	58	530	5	9 3 77	ROCKAWAY PT., N.Y.	.	98	0	.	52	83	157
4 11 77	34	54	533	4	9 17 77	PT. JUDITH, R.I.	.	98	0	.	199	318	159
3 23 76	33	53	506	.	9 1 76	VERRAZANO BRIDGE, N.Y.	.	98	0	.	41	68	162
4 12 77	28	45	510	4	9 27 77	ROCKAWAY, N.Y.	.	98	0	.	43	69	168
3 18 77	34	54	505	4	9 3 77	ROCKAWAY PT., N.Y.	.	98	0	.	50	80	169
4 26 76	27	43	570	.	10 13 76	JAMAICA BAY, N.Y.	.	98	M	.	49	78	170
4 26 76	27	43	586	3	10 17 76	PLUM GUT ORIENT PT., N.Y.	.	98	M	.	130	208	174
3 26 76	26	42	375	.	9 17 76	GREENWICH, CT.	.	98	0	.	58	93	175
4 14 76	33	53	425	3	10 7 76	MILFORD, CT.	.	98	0	.	96	154	176
4 12 77	34	54	510	4	10 5 77	JONES BEACH, N.Y.	.	98	0	.	70	112	176
3 31 76	33	53	563	6	9 24 76	JAMAICA BAY, N.Y.	.	98	0	.	55	88	177
4 9 76	33	53	528	.	10 10 76	HOFFMAN IS., N.Y.	.	98	0	.	40	64	184
4 12 77	28	45	538	4	10 15 77	FISHER'S IS., N.Y.	.	98	0	.	154	246	186
5 16 77	35	56	375	4	11 18 77	TRIBOROUGH BRIDGE, N.Y.	.	98	0	.	49	78	186
4 18 77	34	54	301	3	10 25 77	9	14	98	0	.	25	40	190
4 7 76	27	43	641	6	10 16 76	28	45	98	0	.	-1	-2	192
3 25 76	34	54	497	4	10 4 76	JAMAICA BAY, N.Y.	.	98	0	.	73	117	193
4 9 76	33	53	487	.	10 19 76	ROCKAWAY, N.Y.	.	98	0	.	49	78	193
9 18 75	35	56	676	.	3 31 76	36	58	25	0	.	-1	-2	195
4 27 77	34	54	445	4	11 10 77	LLOYD'S NECK, N.Y.	.	98	0	.	72	115	197
10 20 76	59	94	363	.	5 7 77	40	64	98	0	.	19	30	199
3 16 76	33	53	418	3	10 3 76	NARRAGANSETT, R.I.	.	98	0	.	184	294	201
4 15 76	34	54	479	.	11 2 76	LOWER BAY, N.Y.	.	98	0	.	42	67	201
3 24 76	33	53	500	.	10 12 76	JAMAICA BAY, N.Y.	.	98	0	.	49	78	202
3 18 77	34	54	554	5	10 8 77	SPUYTEN DUVIL, N.Y.	.	98	0	.	20	32	204
4 19 77	35	56	438	5	11 15 77	E. ROCKAWAY, N.Y.	.	98	0	.	61	98	210
4 20 76	35	56	596	.	11 17 76	SEA ISLE CITY, N.J.	.	93	0	.	169	270	211
9 21 76	59	94	550	.	4 20 77	12	19	93	0	.	47	75	211
4 12 77	35	56	415	3	11 10 77	LLOYDS NECK, N.Y.	.	98	0	.	73	117	212
3 16 76	30	48	493	.	10 16 76	PEACOCK PT., N.Y.	.	98	0	.	70	112	214
4 14 77	34	54	565	4	11 19 77	PLUM GUT, N.Y.	.	98	0	.	148	237	219
3 30 76	34	54	497	.	11 7 76	BREEZY PT., N.Y.	.	98	0	.	53	85	222
10 12 76	34	54	427	.	6 13 77	NEW ROCHELLE, N.Y.	.	98	0	.	60	96	244
3 16 76	33	53	426	.	11 24 76	STATEN IS., N.Y.	.	98	0	.	42	67	253
6 19 75	JAM	.	244	2	4 21 76	33	53	61	0	.	52	83	307
3 23 76	26	42	387	3	3 3 77	SLAUGHTER BEACH, DE.	.	98	0	.	211	338	345
9 20 76	60	96	305	.	9 3 77	101	162	98	0	.	-41	-66	348
4 13 76	33	53	384	3	3 28 77	33	53	20	0	.	0	0	349
9 19 75	34	54	392	.	9 12 76	VERRAZANO BRIDGE, N.Y.	.	98	0	.	42	67	359
4 19 76	34	54	406	3	4 17 77	34	54	98	0	.	0	0	363
3 26 76	33	53	546	5	4 1 77	ATLANTIC CITY, N.J.	.	98	0	.	143	229	371
4 27 76	33	53	525	6	5 4 77	12	19	93	0	.	21	34	372
4 27 76	33	53	514	6	5 8 77	12	19	93	0	.	21	34	376
4 10 75	34	54	532	.	4 21 76	36	58	25	0	.	-2	-4	377

Table B-2 (Page 12 of 12)

RELEASE DATE	RELEASE RIVER MI	RELEASE RIVER KM	LENGTH	AGE	RECAPTURE DATE	LOCATION / RIVER MI	RIVER KM	GEAR	SEX	SEXUAL COND	DISTANCE TRAVELLED MI	DISTANCE TRAVELLED KM	DAYS AT LARGE
4 21 76	35	56	690	5	5 6 77	12	19	93	0	.	23	37	380
4 7 76	33	53	542	4	4 24 77	27	43	93	0	.	6	10	382
4 22 76	34	54	535	5	5 10 77	12	19	93	0	.	22	35	383
4 19 76	34	54	416	3	5 9 77	MATINICOCK PT., N.Y.	.	98	0	.	62	99	385
3 26 76	33	53	527	5	4 19 77	34	54	98	0	.	-1	-1	389
10 25 76	42	67	232	.	11 22 77	BROOKLYN BRIDGE, N.Y.	.	98	0	.	43	69	393
5 5 76	34	54	410	3	6 17 77	THROGGS NECK BRIDGE, N.Y.	.	98	M	.	50	80	408
4 8 76	36	58	425	4	5 23 77	152	243	98	0	.	-116	-185	410
4 7 76	35	56	425	.	5 25 77	CHARLESTOWN, R.I.	.	93	0	.	191	306	413
4 14 76	34	54	472	5	6 3 77	HOFFMAN ISLAND, N.Y.	.	98	0	.	43	69	415
3 24 76	34	54	532	6	5 26 77	56	90	20	F	.	-22	-36	428
4 21 76	33	53	400	3	6 28 77	JAMAICA BAY, N.Y.	.	98	0	.	54	86	433
4 19 76	34	54	480	5	6 28 77	SWINEBURNE ISLAND, N.Y.	.	98	0	.	43	69	435
4 29 75	38	61	663	.	7 13 76	BREEZY PT., N.Y.	.	98	0	.	53	85	440
3 31 76	34	54	514	6	6 20 77	STATEN ISLAND, N.Y.	.	98	0	.	41	66	446
4 14 76	33	53	400	3	7 12 77	SWINEBURNE ISLAND, N.Y.	.	98	0	.	42	67	454
4 19 76	34	54	441	3	7 18 77	STAMFORD, CT.	.	98	0	.	70	112	455
3 23 76	33	53	547	5	6 27 77	13	21	98	0	.	20	32	461
4 14 76	33	53	402	5	7 23 77	34	54	98	0	.	-1	-1	465
3 26 76	33	53	490	5	7 9 77	STATEN IS., N.Y.	.	98	0	.	47	75	470
4 9 76	33	53	504	4	7 29 77	VERRAZANO BRIDGE, N.Y.	.	98	0	.	41	66	476
3 25 76	27	43	458	4	7 29 77	LONG BEACH, N.J.	.	88	0	.	47	75	491
5 26 76	43	69	467	4	10 30 77	AMBROSE CHANNEL, N.Y.	.	98	0	.	63	101	522
11 11 74	41	66	264	.	5 21 76	38	61	98	0	.	3	5	557
4 14 76	33	53	321	3	11 4 77	NARRAGANSETT, R.I.	.	98	0	.	219	350	569
4 2 76	27	43	387	3	11 28 77	BROOKLYN, N.Y.	.	98	0	.	30	48	605
10 14 75	33	53	315	.	8 16 77	TIN CAN GROUNDS, N.Y.	.	98	0	.	55	88	672
5 27 75	MAN	.	231	.	4 21 77	LITTLE NECK BAY, N.Y.	.	98	0	.	6	10	695
6 19 75	JAM	.	286	.	6 21 77	VERRAZANO BRIDGE, N.Y.	.	98	0	.	13	21	733

Explanation of Codes and Symbols

- • (in any column) = information unavailable
- * (beside release date) = multiple recapture
- MAN (in RELEASE RIVER MI column) = release location in Manhasset Bay, Long Island, N.Y.
- JAM (in RELEASE RIVER MI column) = release location in Jamaica Bay, Long Island, N.Y.

Gear:
- 14 = 200' Haul Seine
- 20 = Gill Net, 300' x 8', 5" stretch (multifilament nylon)
- 25 = Gill Net, 300' x 8', 6" stretch (multifilament nylon)
- 28 = Gill Net, 300' x 8', 8" stretch (monofilament)
- 38 = Gill Net, 300' x 8', 4" stretch (multifilament nylon)
- 39 = Gill Net, 300' x 8', 4.5" stretch (multifilament nylon)
- 54 = Gill Net, 300' x 8', 7" stretch (multifilament nylon)
- 55 = Gill Net, 300' x 8', 4.5" stretch (monofilament)
- 56 = Gill Net, 300' x 8', 5" stretch (monofilament)
- 57 = Gill Net, 300' x 8', 6" stretch (monofilament)
- 61 = 900' Haul Seine
- 88 = Other Mark/Recapture
- 93 = Commercial Fisherman
- 94 = Other Environmental Firms
- 98 = Sports Fisherman

Sexual Cond. = Sexual Condition:
- R = ripe
- RR = ripe and running
- PS = partially spent
- S = spent
- I = immature
- RS = resting
- M = mature
- D = developing

Sex:
- M = Male
- F = Female
- 0 = Undetermined

METHODOLOGY FOR ESTIMATION OF ADULT STRIPED BASS AGE COMPOSITION

The 1976 and 1977 sex ratios and age composition of striped bass greater than 200 mm in total length (TL) were computed from the combined TI gill net and haul seine catch data since there were advantages to using the data from both gear. To minimize size selectivity encountered with gill net data (Hamley 1975), only catches from the 900-ft haul seines were used to describe size composition. The haul seines were deployed throughout the sampling seasons (mid-March through June) but 89% (538) of the 606 fish caught in 1977 and 94% (320) of the 339 fish caught in 1976 were caught during a 6-week period (10 April to 21 May 1977 and 19 April to 30 May 1976). The seine catches were heavily concentrated between river miles (RM) 33 and 39. Sampling in these river miles monitored movements and associated changes in population structure. Seining in a limited area was comparable to collecting migrating fish during the spawning season with a fixed pound net, as is commonly done (Grant 1974).

Gill nets were deployed over a larger portion of the estuary (RM 27-59) than haul seines and were fished in the shoals to supplement sampling in the shore zone with haul seines. Gill nets provided data on the ages and sex of fish within appropriate length intervals (20 mm) but, by themselves, were unable to give an accurate representation of size composition. Gill net catches were adjusted using the length frequency of fish caught in haul seines. The sex ratio and age composition presented in this section best represent the population just prior to, and during, spawning immediately below the major spawning areas.

Age proportions and age-specific sex ratios were calculated from the striped bass falling within 20-mm length intervals where:

k = sex (1 or 2); 1 = male, 2 = female

j = age (1, 2, 3,... N_a)

i = length group (1, 2, 3,... N_ℓ)

P_{jk} = proportion of population for fish age j and sex k

ℓ_i = fraction of haul seine catch falling in length group i

S_{ijk} = number of fish of length (i), age (j), and sex (k) in combined haul seine-gill net catch

$$P_{jk} = \sum_{i=1}^{N_\ell} \ell_i \left(\frac{S_{ijk}}{T_i}\right) \quad \text{where } T_i = \sum_{k=1}^{2} \sum_{j=1}^{N_a} S_{ijk}$$

In the equation,

$$\frac{S_{ijk}}{T_i}$$

is the proportion of fish of the length class i which are age j and sex k. This proportion is independent of the sample size and the other length classes. Because fish of the same age and sex may occur in other length classes, this proportion must be combined with the comparable proportion in other length classes on the basis of the relative abundance of the various length classes in the river. These proportions are weighted by the fraction of the haul seine catch (ℓ_i) that represents the least size-selective estimate of relative abundance of the various length classes in the river before the proportion within each fraction is combined.

An illustration of a hypothetical example of age composition and sex ratio calculations is presented in Table B-3.

Table B-3

Example of Estimation of Age Composition of Hypothetical Sample of Striped Bass in Three Length Groups and Three Age Groups

	S_{ijk} Matrix AGE 1	2	3	Proportion by Sex	Length	Total Catch by Length	Combined Catch Length Frequency	Haul Seine Catch Length Frequency
Male	14	21	7	0.6	Short	70	0.7	0.2
Female	7	14	7	0.4				
Male	0	8	2	0.5	Medium	20	0.2	0.5
Female	0	6	4	0.5				
Male	0	0	1	0.1	Long	10	0.1	0.3
Female	0	2	7	0.9				
	S_{i1k}	S_{i2k}	S_{i3k}			T_i		ℓ_i

	P_{jk} Matrix* AGE 1	2	3	Computed Sex Proportion	Observed Sex Proportion
Male	0.04	0.26	0.10	0.40	0.53
Female	0.02	0.25	0.33	0.60	0.47
Computed Age Proportion	0.06	0.51	0.43		
Observed Age Proportion	0.21	0.51	0.28		

$^{*}P_{11}$ = (0.2) (14)/(70) + (0.5) (0)/(20) + (0.3) (0)/(10) = 0.04

P_{32} = (0.2) (7)/(70) + (0.5) (4)/(20) + (0.3) (7)/(10) = 0.33 etc.

SIMULATED COMMERCIAL STRIPED BASS FISHERY

Inasmuch as the Hudson River commercial striped bass fishery was closed in early 1976 by the New York Department of Environmental Conservation because of high levels of polychlorinated biphenyls (PCBs) in the fish, TI established a simulated fishery by contracting four commercial fishermen to collect striped bass for 2 days per week from April through June in 1976 and in 1977. These fishermen employed their usual fishing gear (gill nets) and techniques as if the striped bass fishery were open. Twice a week, TI personnel examined fisherman's catch and recorded net size and fishing duration. The objectives of this simulated fishery were to:

- Describe the size, maturity, sex ratio, and age composition of the catch of representative commercial fishermen
- Determine the age of recruitment of striped bass to the Hudson River commercial fishery
- Supplement the data collected in the adult striped bass program

Data from striped bass collected in this simulated commercial fishery contributed to the analysis of fecundity, growth, ages of maturity, population estimates, and movements (subsection III.B.). Portions of these data concerning the age of recruitment to the Hudson River commercial fishery and the size and age composition of the simulated commercial catch were previously described by McFadden et al (1978). The data presented here will supplement that report and form the basis for comparisons of size, ages of maturity, sex ratio, and age composition among the catches of the four commercial fishermen.

When commercial fishing for striped bass was legal in the Hudson River, it was heterogeneous and consisted of several large full-time fishing operations and many smaller part-time operations. Of the four fishermen contracted by TI, fishermen A and C used staked gill nets, fisherman B used staked and anchored gill nets, and fisherman D used drift gill nets. In Appendix A, Figure A-14 shows the fishing areas used by these four fishermen and Table A-7 gives the dimensions of the individual gear used by each.

More than 80% of the fish which the four commercial fishermen took in 1976 and 1977 had total lengths (TL) of between 351 and 650 mm (Tables B-4 and B-5) and approximately 50% of their catches were between 451 and 550 mm TL. Length frequencies of total catches for fishermen A and B were similar in 1976, but the time of maximum catches was later for fisherman A. In 1977, the catches of fishermen A and B were similar in length frequencies and the time of the majority of the catches appeared to be more synchronized. Fishermen C fished near the principlal spawning grounds (subsection III.D) and caught larger striped bass. In 1977, fisherman D caught 183 fish, with small fish (≤250 mm TL) composing the major portion of the catch. Fisherman D caught only seven fish in 1976. The length distribution and timing of the catch for fishermen B and C appeared to be similar in 1976 and 1977, and only a large late catch in 1976 for fisherman A caused differences between the 2 years.

Table B-4

Size Distribution of 1976 Commercial Catch of Striped Bass in Hudson River

	Total Length (mm)									
	<250	250-350	351-450	451-550	551-650	651-750	751-850	851-950	951+	Total
Fisherman A										
April 1-May 2	1	7	37	104	64	7	4	1	0	225
May 3-May 30	2	29	32	38	47	7	1	3	1	160
May 31-June 30	0	19	28	127	66	5	1	0	0	246
TOTAL	3	55	97	269	177	19	6	4	1	631
Fisherman B										
April 1-May 2	0	2	79	317	36	6	1	0	2	443
May 3-May 30	0	0	8	16	7	7	9	3	5	55
May 31-June 30	0	0	0	0	6	3	4	12	6	31
TOTAL	0	2	87	333	49	16	14	15	13	529**
Fisherman C										
April 1-May 2	0	0	0	0	5	1	0	0	0	6
May 3-May 30	0	0	0	0	15	4	1	2	4	26
May 31-June 30	0	0	0	0	9	4	4	2	2	21
TOTAL	0	0	0	0	29	9	5	4	6	53
Fisherman D										
April 1-May 2	0	0	0	2	1	0	0	0	0	3
May 3-May 30	0	0	0	1	1	1	0	1	0	4
May 31-June 30	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	3	2	1	0	1	0	7
TOTAL										
April 1-May 2	1	9	116	423	106	14	5	1	2	677
May 3-May 30	2	29	40	55	70	19	11	9	10	245
May 31-June 30	0	19	28	127	81	12	9	14	8	298
TOTAL	3	57	184	605	257	45	25	24	20	1220*

*One additional fish caught by fisherman A was not measured.

**Two additional fish caught by fisherman B were not measured.

Table B-5

Size Distribution of 1977 Commercial Catch of Striped Bass in Hudson River

	Total Length (mm)									
	≤250	251-350	351-450	451-550	551-650	651-750	751-850	851-950	951+	Total
Fisherman A										
April 3-April 30	0	3	37	222	100	10	1	0	2	375
May 1-May 28	1	30	54	57	58	14	4	0	0	218
May 29-June 30	2	7	2	1	1	0	0	0	0	13
TOTAL	3	40	93	280	159	24	5	0	2	606
Fisherman B										
April 3-April 30	0	1	17	440	59	0	2	0	0	519
May 1-May 28	1	11	30	32	27	8	3	2	12	126
May 29-June 30	0	0	2	1	0	4	5	3	3	18
TOTAL	1	12	49	473	86	12	10	5	15	663
Fisherman C										
April 3-April 30	0	0	0	0	3	4	1	0	2	10
May 1-May 28	0	0	1	0	5	5	0	6	5	22
May 29-June 30	0	0	0	0	3	5	0	3	1	12
TOTAL	0	0	1	0	11	14	1	9	8	44
Fisherman D										
April 3-April 30	0	0	0	18	16	2	0	0	0	36
May 1-May 28	0	0	2	18	12	0	1	0	1	34
May 29-June 30	99	13	1	0	0	0	0	0	0	113
TOTAL	99	13	3	36	28	2	1	0	1	183
TOTAL										
April 3-April 30	0	4	54	680	178	16	4	0	4	940
May 1-May 28	2	41	87	107	102	27	8	8	18	400
May 29-June 30	101	20	5	2	4	9	5	6	4	156
TOTAL	103	65	146	789	284	52	17	14	26	1496

Catches by all four fishermen consisted principally of age V fish in 1976 and age IV fish in 1977 (Tables B-6 and B-7), although catches by fisherman C had a greater percentage of older fish than did catches by the other three fishermen. The estimated age composition of the simulated commercial fishery appeared similar to the age composition of striped bass collected by TI in gill nets and haul seines in 1977 (Table IV-7). However, the age distribution of the commercial catch was slightly more spread and both younger and older age groups were more abundant than in the TI gill net and haul seine catches. This spread was probably the result of the wider range of gill net meshes used by the commercial fishery (Table A-7). The dominance of age IV fish in the 1977 commercial catch (as in the TI gill net and haul seine catch) was the result of the heavy recruitment of the strong 1973 year class. The dominance of this year class is expected to continue through at least 1978 when the 1973 year class fish will be age V.

Table B-6

Age and Sex Composition of Striped Bass in 1976 Commercial Catch from Hudson River*

	Sex	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Total
		Age (Percentage)												
Fisherman A (RM 27) Sample Size = 631*	Male	.005	.089	.047	.100	.057	.016	.002	.0	.002	.0	.0	.0	.318
	Female	.002	.087	.071	.239	.209	.060	.011	.0	.003	.002	.0	.0	.684
Fisherman B (RM 37-39) Sample Size = 529*	Male	.0	.064	.181	.238	.104	.023	.011	.002	.008	.008	.004	.002	.645
	Female	.0	.068	.070	.098	.068	.015	.004	.002	.011	.015	.002	.002	.355
Fisherman C (RM 52) Sample Size = 53	Male	.0	.0	.0	.226	.226	.057	.019	.0	.038	.019	.0	.0	.585
	Female	.0	.0	.0	.019	.113	.075	.019	.019	.038	.057	.019	.057	.416
Fisherman D (RM 65-67) Sample Size = 7	Male	.0	.0	.0	.429	.143	.0	.0	.0	.0	.0	.0	.0	.572
	Female	.0	.0	.0	.0	.143	.143	.0	.0	.0	.143	.0	.0	.429
TOTAL (RM 27-67) Sample Size = 1220*	Male	.002	.074	.103	.167	.085	.020	.007	.001	.006	.004	.002	.001	.472
	Female	.001	.075	.067	.167	.143	.042	.008	.002	.008	.011	.002	.003	.529

†Results of each age and sex category calculated based on total catch by each fisherman.

*One fish caught by fisherman A and two caught by fisherman B were not measured.

Table B-7

Age and Sex Composition of Striped Bass in 1977 Commercial Catch from Hudson River*

	Sex	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	Total
		Age (Percentage)														
Fisherman A (RM 27-28) Sample Size = 606	Male	.025	.095	.121	.037	.053	.024	.015	.0	.008	.033	.0	.033	.0	.0	.444
	Female	.067	.030	.150	.058	.142	.078	.030	.0	.0	.0	.0	.0	.0	.0	.555
Fisherman B (RM 36-39) Sample Size = 663	Male	.015	.046	.221	.086	.098	.071	.019	.029	.0	.010	.015	.010	.022	.0	.642
	Female	.029	.010	.047	.010	.032	.043	.025	.0	.039	.059	.022	.015	.022	.007	.360
Fisherman C (RM 50-53) Sample Size = 44	Male	.0	.0	.056	.0	.208	.028	.014	.0	.0	.111	.028	.0	.028	.0	.473
	Female	.0	.0	.0	.0	.028	.153	.097	.028	.0	.056	.111	.056	.0	.0	.529
Fisherman D * (RM 63-69) Sample Size = 182	Male	.136	.038	.277	.060	.077	.014	.021	.0	.0	.0	.0	.0	.0	.0	.623
	Female	.080	.065	.0	.003	.052	.094	.0	.042	.0	.0	.042	.0	.0	.0	.378
TOTAL (RM 27-69) Sample Size = 1495	Male	.047	.042	.229	.071	.101	.042	.014	.003	.001	.005	.003	.003	.004	.0	.565
	Female	.051	.023	.147	.061	.072	.043	.016	.003	.003	.005	.008	.004	.003	.001	.440

†Results of each age and sex category calculated based on total catch by each fisherman.

*Fisherman D caught one yearling fish also.

The overall sex ratios of the commercial catch (Tables B-6 and B-7) were similar to the ratios estimated with TI gill net and haul seine data (Table III-7), i.e., a majority of the fish were females in 1976 and males in 1977. However, the catch by fishermen C contained mostly males in 1976 and females in 1977. The sex ratios of the catches of fishermen A and B were consistent between years but differed between the two men: fisherman A caught a higher proportion of females and fisherman B more males. The two fishermen fished similarly and less than 12 river miles apart.

The ages of maturity of the commercial catch appeared similar between years (Tables B-8 and B-9) and to ages of maturity of TI catches (subsection IV.B.5). Most males were mature by age IV and all were mature by age IX. Females began to mature at age III, a majority were mature by ages VI to VII, and 100% were mature by age VIII. Individual comparisons among the four fishermen were limited due to small sample sizes; however, a high percentage of the catch by fisherman B was mature (both in 1976 and 1977) and a low percentage of the catch by fisherman D was mature in 1977. The major portion of the catch by fisherman D in 1977 occurred in late June and was composed of fish that were < 250 mm TL.

In summary, since the commercial fishery for striped bass in the Hudson River was closed in 1976 and 1977, TI attempted to simulate this catch by hiring four representative commercial fishermen. Although the size, age composition, sex ratio, and ages of maturity between the simulated commercial fishery catches and the TI gill net and haul seine catches were similar, differences existed among the four fishermen, probably because of their fishing locations and types of gill net.

Table B-8

Ages of Maturity* of Striped Bass in 1976 Commercial Catch from Hudson River

	Sex	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	Total
		Percent Mature by Age													
Fisherman A	Male	0 (2)**	41 (22)	55 (11)	85 (13)	69 (13)	100 (1)	100 (1)							59 (63)
Sample Size = 151	Female		8 (12)	8 (12)	28 (25)	37 (19)	80 (15)	100 (3)		100 (2)					38 (88)
Fisherman B	Male		100 (1)	100 (1)	100 (4)	100 (3)	100 (6)	100 (5)	100 (1)	100 (3)	100 (3)	100 (2)			100 (29)
Sample Size = 45	Female				0 (1)	100 (1)	60 (5)	100 (1)		100 (4)	100 (3)	100 (1)			81 (16)
Fisherman C	Male						100 (3)	100 (1)		100 (1)					100 (6)
Sample Size = 10	Female						100 (1)	100 (1)		100 (1)	100 (1)	100 (1)	100 (1)		100 (4)
Fisherman D	Male				100 (1)										100 (1)
Same Size = 1	Female														
TOTAL	Male	0 (2)	43 (23)	58 (12)	89 (18)	79 (19)	100 (8)	100 (7)	100 (1)	100 (4)	100 (3)	100 (2)			74 (99)
Sample Size = 207	Female		8 (12)	8 (12)	27 (26)	40 (20	76 (21)	100 (5)		100 (6)	100 (4)	100 (1)	100 (1)		46 (108)

*Fish with body/gonad weight ratio of <70 for females and <235 for males were considered mature.

**Numbers in parentheses represent number of fish examined.

Table B-9

Ages of Maturity* of Striped Bass in 1977 Commercial Catch in Hudson River

	SEX	Percent Mature by Age														
		II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	Total
Fisherman A Sample Size = 131	Male	50 (2)**	22 (9)	58 (19)	50 (6)	75 (12)	100 (7)	67 (3)		100 (1)						61 (59)
	Female	0 (4)	0 (4)	3 (30)	0 (8)	38 (16)	71 (7)	100 (3)								21 (72)
Fisherman B Sample Size = 29	Male	0 (1)	100 (1)	100 (1)		100 (3)	100 (1)	100 (1)	100 (1)		100 (1)	100 (1)	100 (1)	100 (1)		92 (13)
	Female					100 (2)	100 (2)	100 (1)		100 (2)	100 (3)	100 (3)	100 (1)	100 (1)	100 (1)	100 (16)
Fisherman C Sample Size = 16	Male					100 (1)		100 (1)				100 (1)				100 (3)
	Female						100 (5)	100 (4)	100 (1)		100 (1)	100 (1)	100 (1)			100 (13)
Fisherman D Sample Size = 43	Male	0 (11)	0 (4)	67 (3)	0 (1)											11 (19)
	Female	0 (14)	0 (2)			100 (4)	100 (2)		100 (1)			100 (1)				33 (24)
TOTAL Sample Size = 219	Male	7 (14)	21 (14)	61 (23)	43 (7)	81 (16)	100 (8)	80 (5)	100 (1)	100 (1)	100 (1)	100 (2)	100 (1)	100 (1)		56 (94)
	Female	0 (18)	0 (6)	3 (30)	0 (8)	55 (22)	88 (16)	100 (8)	100 (2)	100 (2)	100 (4)	100 (5)	100 (2)	100 (1)	100 (1)	42 (125)

*Fish with body/gonad weight ratio of <70 females and <235 for males were considered mature.

**Numbers in parentheses represent number of fish examined.

Table B-10

Numbers of Striped Bass in April-June 1977 Collections in Hudson River Estuary Visually Classified in Each Sexual Condition Category

	Category							
Week	Ripe	Ripe and Running	Partially Spent	Spent	Immature	Resting	Indeterminate	Total
Apr 01-02	12				17		12	41
Apr 03-09	2				8		14	24
Apr 10-16	2				6		5	13
Apr 17-23	4				33		42	79
Apr 24-30	4						3	7
May 01-07	11				43		38	92
May 08-14	6	1			2		1	10
May 15-21	15	4		3	45		22	89
May 22-28	10	2		11	3		2	28
May 29-Jun 04	15	13	3	9	3			43
Jun 05-11	3	4	1	2	9	1	5	25
Jun 12-18	4	2		4	4		3	17
Jun 19-25	2		1	5	18		2	28
Jun 26-30				2	21			23
Total	90	26	5	36	212	1	149	519

*Classification Criteria are defined in Table A-9.

SUPPLEMENTAL DATA AND INFORMATION FOR ADULT STRIPED BASS POPULATION ESTIMATE (SECTION III.B.6.)

The Schumacher-Eschmeyer mark-recapture technique (Ricker 1975) was used to estimate the 1977 population of striped bass larger than 400 mm total length (TL) that were within the river from 13 March through 4 June (Section III.B.6). This estimate is the inverse of the slope of the line of weighted linear regression of R_i/C_i (recaptures/catch in time interval i) as a function of M_i (marks), with the intercept forced through the origin; i.e., the model is $(R_i/C_i) = \beta M_i$.

The proper use of the Schumacher-Eschmeyer estimate is similar to most other mark-recapture methods in requiring that several basic assumptions be met: marked and unmarked fish suffer the same mortality; marked and unmarked fish are equally vulnerable to the fishing or sampling gear; marked fish do not lose their marks and all marked fish in the recapture sample are recognized; marked fish either become randomly mixed with unmarked or the recapture samples are selected randomly from the entire population; and recruitment and emigration are negligible. Violation of assumptions introduces error into the resultant population estimates and reduces the accuracy. Ricker (1975) classified error as one of three types, based on the effect that each would have on the parameters (slope or intercept) of the regression of R_i/C_i through time. Type A errors are those that affect only the intercept of a regression analysis of mark-recapture data over time (Figure B-1). This type of error could be caused by mark-related mortality that was manifested immediately after release of the fish but that did not affect subsequent survival; thus, the actual number of marked fish available for recapture would be less than the total number marked. Other causes of Type A error would be a consistent failure to report a fraction of the recaptured fish or immediate tag loss (Type 1, error of Beverton and Holt 1957).

Type B errors are those that affect the slope of the regression line but not the intercept (Figure B-1). Factors that cause Type B errors include continued higher mortality of marked fish or continuous tag loss (Type 2 error of Beverton and Holt 1957). In both cases, the decreasing fraction of marked fish in the catch through time underestimates the fraction of the total population originally marked.

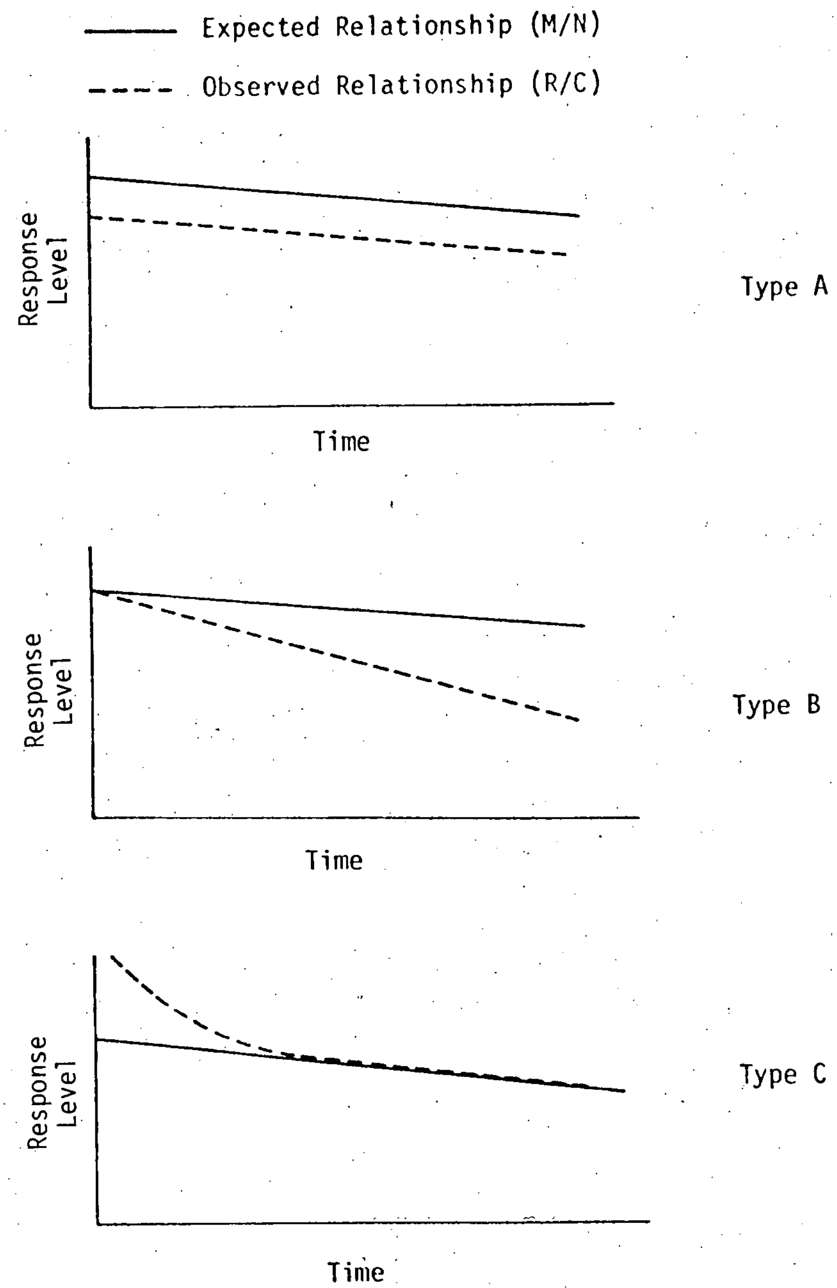

Figure B-1. Diagrammatic Representation of Types of Systematic Errors Possible in Mark-Recapture Data (Jones 1977). (M/N) represents fraction of total population (N) that is marked (M); (R/C) represents fraction of sample (C) that is marked (R).

Type C errors are those having an effect immediately after marking, but observed values would approximate expected values after some period of time (Figure B-1). Thus, some "waiting period" would be required before unbiased population estimates could be made. Causes of Type C error include abnormal behavior of marked fish immediately after release and incomplete mixing of marked and unmarked fish.

Few mark-recapture studies can meet all of the necessary assumptions; thus, adjustments must be made to the data so that the assumptions are approximately true. Many of these adjustments have been reported in the fisheries literature (see Seber 1973 and Ricker 1975 for thorough reviews of mark-recapture methods) and are now well-accepted.

Analysis of Systematic Errors

Type A error was assumed to be negligible even thougn no tagging survival tests or quality control procedures for tag recognition were conducted. Only fish in good condition were marked and released, and the tags were checked for correct implant in order to minimize immediate tag loss. All fish in good condition were tagged on the left side, midway between the origin of the second dorsal and the lateral line. All others were taken to the laboratory for additional analysis, including examination for tags. It is unlikely that any recaptured fish was not recognized.

The most likely source of any Type B error in this study resulted from emigration of fish marked early in the season. Type B error was probably small early in the season but could have become sizeable by the end of sampling, as indicated by the number of fish recaptured outside the river (Table B-2). Other sources of Type B error, including continuous long-term tag loss or greater mortality of marked fish, were considered negligible.

As with juvenile striped bass, Type C error for adults appeared to be the most likely type of error due to delayed mixing of marked and unmarked fish. In an attempt to identify the magnitude of Type C error and find a subset of the recaptured fish which might be randomly distributed (R_i', Marten 1970 in Seber 1973), the relationship of the fraction of marked fish in the

the catch (R_i/C_i) to the total number of marked fish available (M_i) was examined for fish at large for different lengths of time. When marked fish are randomly distributed, R_i/C_i increases in direct proportion to M_i; an inverse relationship between R_i/C_i and M_i would indicate either a Type B or a Type C error. If the inverse relationship is apparent for small values of M_i, Type C error is suggested. Since Type B error generally increases with time, it would not be severe for the earliest samples which have the smallest values of M_i. Type B error, due to emigration of the earliest marked fish, probably causes some error in later samples. If the inverse relationship occurs only for intermediate and high values of M_i, then Type B error is more likely to be the cause.

An inverse relationship was evident when all recaptured fish or fish at large for at least 1 day were used to calculate R_i/C_i (Figure B-2). If fish that had been at large for at least 2 or 3 days were used, Type C error was greatly reduced but not entirely eliminated. Fish that had been at large at least 2 days rather than at least 3 days were chosen for the population estimate since only a slight difference existed in the R_i/C_i and M_i relationship. There were four additional recaptures that had been at large for 2 days, and the 1976 data were analysed using recaptures that had been at large for at least 2 days.

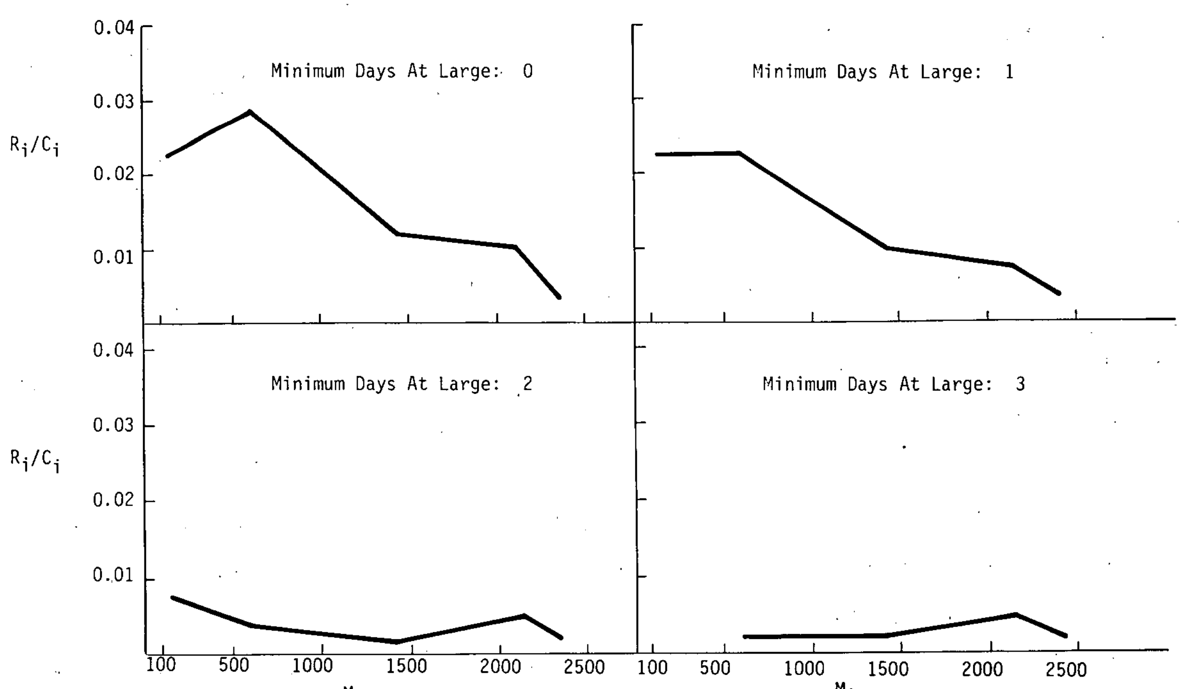

Figure B-2. Fraction of Marked Fish in Sample R/C vs M_i when Recaptured Fish at Large Less than Minimum Number of Days Are Excluded

Population Estimate

Steps taken to reduce Type C error also reduced to 17 the number of recaptured fish available for a population estimate (Table B-11). The estimate N, based on fish that had been at large for 2 days or more was 571,000 with a 90% confidence interval of 293,000 to 11,622,000. The estimate of $\hat{N}$ for the striped bass collected in 1976 (TI 1979a) was 513,000 with a 90% confidence interval of 282,000 to 2,819,000 (Table B-12). The fit to the calculated regression line of R_i/C_i on M_i was relatively poor in 1977 (Figure B-3) causing the estimate of β (which is equal to $^1/N$) to be imprecise with wide confidence intervals. Large deviations of the data points above the line for the first two sampling periods (those with the smallest values of M_i) suggest that Type C error could still be substantial. These points should be much closer to the regression line if marked fish were randomly distributed during the sampling period.

Table B-11

Schumacher-Eschmeyer Population Estimate of Adult Striped Bass in Hudson River during Spring 1977

Period	M_i*	C_i	R'_i†	R'_iM_i	$C_iM_i^2$	R'_i/C_i
3/13-3/26	140	288	2	280	5,644,800	0.00694
3/27-4/ 9	601	1277	5	3005	461,253,677	0.00392
4/10-4/23	1424	1876	4	5696	3,804,107,736	0.00213
4/24-5/ 7	2104	1014	5	10520	4,488,791,424	0.00493
5/ 8-5/21	2352	488	1	2352	2,699,569,152	0.00205
5/22-6/ 4	2438	172	0	0	1,022,341,168	0
Total		5115	17	21853	12,481,707,990	

$$\beta = \frac{\Sigma(R_iM_i)}{\Sigma(C_iM_i^2)} = \frac{2.1853 \times 10^4}{1.248170799 \times 10^{10}} = 1.7508 \times 10^{-6}$$

$$\hat{N} = \beta^{-1} = 571{,}000$$

90% Confidence Interval = 293,000 - 11,622,000

*Total marked fish at large at middle of period.

†Fish at large for two days or more

Table B-12

Schumacher-Eschmeyer Population Estimate of Adult Striped Bass in Hudson River during Spring 1976

Period	M_i*	C_i	R_i'†	$R_i'M_i$	$C_iM_i^2$	R_i'/C_i
1	235	725	2	470	40,038,125	0.00276
2	758	1325	5	3790	761,297,300	0.00377
3	1392	1414	2	2784	2,739,856,896	0.00141
4	1831	634	1	1831	2,125,523,674	0.00158
5	1986	582	5	9930	2,295,522,072	0.00859
6	2102	375	1	2102	1,656,901,000	0.00267
7	2170	233	0	0	1,097,173,700	0
Total			16	20907	10,716,313,270	

$$\beta = \frac{\Sigma(R_i'M_i)}{\Sigma(C_iM_i^2)} = \frac{2.0907 \times 10^4}{1.071631327 \times 10^{10}} = 1.951 \times 10^{-6}$$

$$\hat{N} = \beta^{-1} = 513,000$$

90 Percent Confidence Interval = 282,000 - 2,819,000

*Total marked fish at large at middle of period

†Fish at large for two days or more

The population estimate of 571,000 represented fish having 400 mm total length (approximately age III and older) in the lower Hudson River estuary during the spawning season. Even though some age III fish were not mature, especially females, their inclusion did not seriously bias N as an estimate of the spawning stock. More serious biases were the Type C error still inherent in the data and the increasing Type B error in the later time periods. While restricting R_i' to fish that had been at large 2 days or more, the greatly reduced Type C error, an inverse relationship of R_i'/C_i and M_i, was still suggested when data were examined graphically. The choice of a minimum of 2 days at large was a compromise between eliminating Type C error and having sufficient recaptures with which to make an estimate and comparison with 1976. The magnitude of the Type B error could not be evaluated from the R_i/C_i graphs since decreasing Type C error and increasing Type B error would produce similar trends. Thus, 571,000 is likely to be an underestimate of fish age III and older since the values of R_i/C_i associated with small values of M_i (Type C error present) are weighted more heavily than values associated with large M_i (Type B error present); Type C errors would cause an underestimate of population size, and Type B errors would cause an overestimate, as observed for this population.

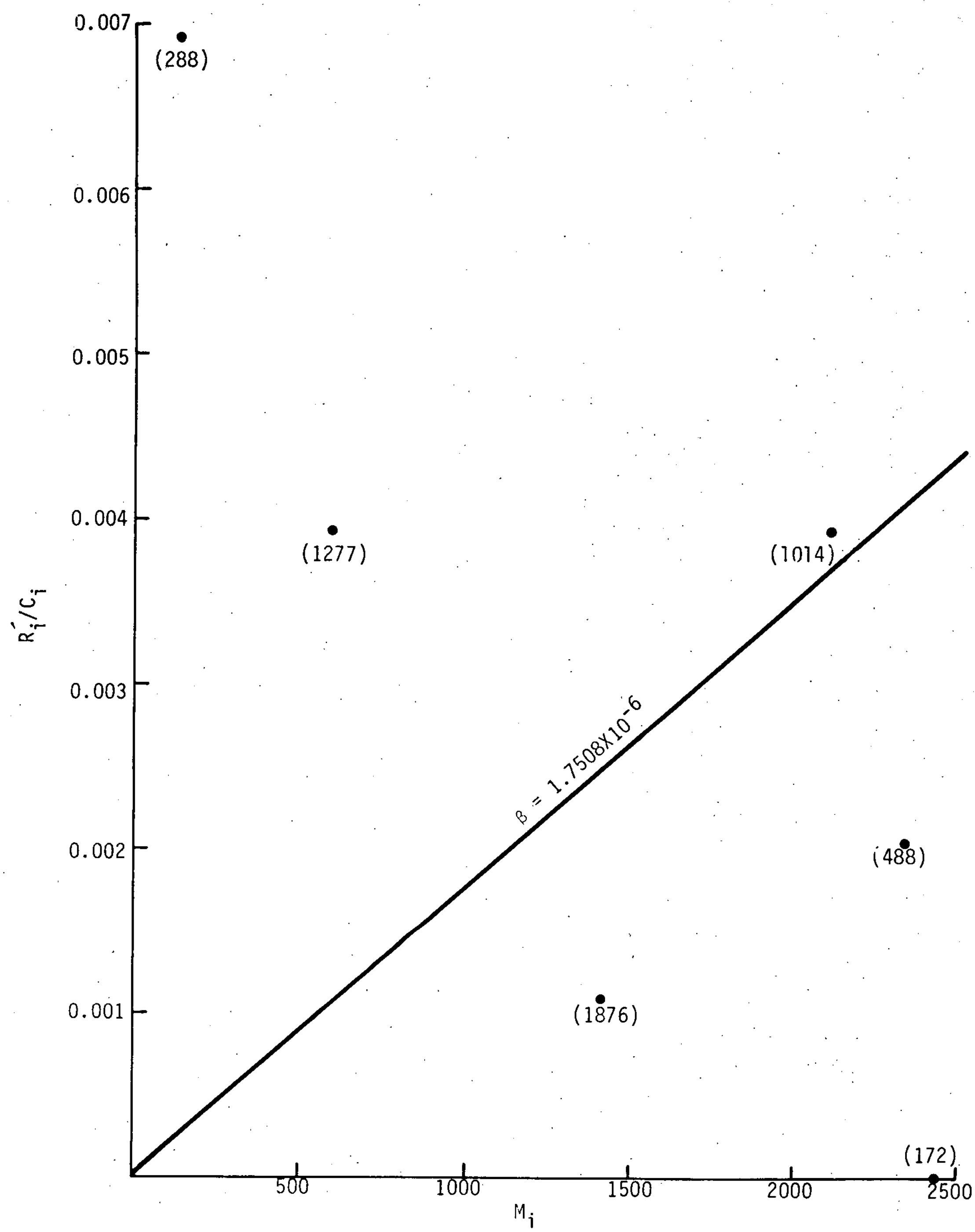

Figure B-3. Weighted Linear Regression through the Origin of R_i/C_i M_i. R_i Includes Only Fish at Large for Two Days or More. (Weights for Each Point, C_i, Are Shown in Parentheses)

Table B-13

Estimated Standing Crops (in Thousands) of Striped Bass Eggs in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
		REGION												
2/21-2/25	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/7-3/11	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21-3/26	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/4-4/7	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/18-4/20	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
4/25-4/28	SC	0	0	0	0	315	0	0	0	0	0	72	235	622
	SE	0	0	0	0	222	0	0	0	0	0	72	135	269
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3	156
5/2-5/5	SC	0	0	191	3354	22884	1545	0	0	0	0	356	0	28330
	SE	0	0	112	1296	6287	1006	0	0	0	0	356	0	6508
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
5/9-5/12	SC	0	0	1289	28136	4238	0	12485	9624	5129	685	608	0	62195
	SE	0	0	555	7354	1795	0	7813	1313	4619	419	295	0	11915
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3	157
5/16-5/19	SC	0	0	1514	45779	97453	18090	12865	49105	18643	890	3522	171	248033
	SE	0	0	499	15493	25023	11359	8182	30621	14964	373	2456	87	47226
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3	157
5/23-5/26	SC	0	1370	8211	9956	41043	9565	2477	13020	354	180	2430	0	88605
	SE	0	1370	2369	4403	15693	4460	802	4647	354	137	1215	0	17802
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3	157
5/31-6/2	SC	0	0	0	156	576	3961	821	285	440	0	463	0	6702
	SE	0	0	0	89	357	1781	385	285	287	0	463	0	1957
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3	155
6/6-6/9	SC	0	0	0	0	582	83	0	0	0	0	0	0	665
	SE	0	0	0	0	190	61	0	0	0	0	0	0	199
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/13-6/16	SC	0	0	0	0	0	0	0	0	0	0	263	0	263
	SE	0	0	0	0	0	0	0	0	0	0	200	0	200
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/20-6/24	SC	0	0	0	0	36	0	0	0	0	0	0	0	36
	SE	0	0	0	0	36	0	0	0	0	0	0	0	36
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/27-7/1	SC	0	0	0	0	0	26	610	0	0	0	0	0	636
	SE	0	0	0	0	0	26	610	0	0	0	0	0	611
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3	157
7/5-7/8	SC	0	0	0	0	0	0	43	0	0	0	0	0	43
	SE	0	0	0	0	0	0	43	0	0	0	0	0	43
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/11-7/15	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/25-7/29	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
8/8-8/12	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157

Table B-14

Estimated Density (No./1000 m^3) of Striped Bass Eggs in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION											
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
4/25-4/28	DEN	0.0	0.0	0.0	0.0	1.5171	0.0	0.0	0.0	0.0	0.0	0.4501	3.3042
	SE	0.0	0.0	0.0	0.0	1.0692	0.0	0.0	0.0	0.0	0.0	0.4501	1.8934
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3
5/ 2-5/ 5	DEN	0.0	0.0	1.2958	16.0996	110.3369	11.0512	0.0	0.0	0.0	0.0	2.2139	0.0
	SE	0.0	0.0	0.7555	6.2238	30.3118	7.1937	0.0	0.0	0.0	0.0	2.2139	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
5/ 9-5/12	DEN	0.0	0.0	8.7279	135.0752	20.4317	0.0	41.8695	58.1513	36.2499	3.8856	3.7839	0.0
	SE	0.0	0.0	3.7558	35.3026	8.6529	0.0	26.1989	7.9339	32.6417	2.3775	1.8360	0.0
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3
5/16-5/19	DEN	0.0	0.0	10.2496	219.7755	469.8806	129.4012	43.1413	296.7064	131.7558	5.0501	21.9196	2.3981
	SE	0.0	0.0	3.3804	74.4001	120.6501	81.2542	27.4380	185.0184	105.7502	2.1140	15.2802	1.2203
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3
5/23-5/26	DEN	0.0	4.2571	55.5897	47.7954	197.8938	68.4164	8.3068	78.6678	2.5039	1.0234	15.1213	0.0
	SE	0.0	4.2571	16.0413	21.1390	75.6675	31.9050	2.6895	28.0757	2.5039	0.7771	7.5590	0.0
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3
5/31-6/ 2	DEN	0.0	0.0	0.0	0.7486	2.7775	28.3331	2.7532	1.7204	3.1115	0.0	2.8798	0.0
	SE	0.0	0.0	0.0	0.4275	1.7220	12.7363	1.2904	1.7204	2.0267	0.0	2.8798	0.0
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3
6/ 6-6/ 9	DEN	0.0	0.0	0.0	0.0	2.8042	0.5942	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.9150	0.4398	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/13-6/16	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6387	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2432	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/20-6/24	DEN	0.0	0.0	0.0	0.0	0.1757	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.1757	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/27-7/ 1	DEN	0.0	0.0	0.0	0.0	0.0	0.1885	2.0456	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.1885	2.0456	0.0	0.0	0.0	0.0	0.0
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3
7/ 5-7/ 8	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.1456	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.1456	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
8/ 8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3

Table B-15

Mean Regional Water Temperature (°C), Dissolved Oxygen (mg/ℓ), Conductivity (mS/cm), and Striped Bass Egg Density (No./1ooo m^3) during and Prior to Periods of Striped Bass Egg Abundance, 1974 through 1977

Year	Date		Region											
			YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
1974	Apr 28 - May 04	Temp.	11.0	12.7	13.3	12.1	11.8	12.8	12.3	13.0	13.6	13.3	13.0	12.8
		D.O.	8.6	9.3	9.5	8.6	8.9	9.0	9.0	9.6	8.9	9.2	9.0	9.0
		Cond.	6798	870	178	168	152	139	140	143	147	136	126	136
		Den.	0.0	0.0	0.0	0.0	4.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0
	May 05 - May 11	Temp.	13.6	13.3	13.6	12.7	12.8	13.4	13.8	13.4	13.4	13.1	12.7	13.1
		D.O.	9.1	9.1	9.7	8.4	9.7	9.6	9.4	9.4	9.3	8.8	8.9	9.5
		Cond.	2854	2339	163	151	139	148	147	136	142	141	142	151
		Den.	0.0	0.1	55.2	17.2	5.4	4.6	1.6	16.2	0.0	0.2	0.0	0.0
	May 12 - May 18	Temp.	18.2	17.5	16.1	15.0	15.6	16.0	14.6	14.4	14.5	14.3	12.6	12.5
		D.O.	6.7	7.3	8.4	8.8	8.9	9.0	9.1	8.2	8.7	8.3	9.1	9.4
		Cond.	2946	254	154	146	157	165	163	158	157	150	157	186
		Den.	NS	NS	NS	725.8	829.5	48.2	57.0	0.0	13.8	0.0	0.0	0.0
	May 19 - May 25	Temp.	16.9	17.6	17.7	16.8	16.8	16.4	16.0	16.4	16.8	16.5	16.7	16.8
		D.O.	6.9	10.8	0.4	9.6	9.6	9.4	8.8	8.6	8.3	8.7	8.5	9.3
		Cond.	10085	948	179	175	172	171	168	148	147	144	144	144
		Den.	0.0	0.9	414.2	330.4	12.2	37.0	14.2	54.5	222.5	5.8	0.2	0.0
1975	May 04 - May 10	Temp.	12.0	12.5	12.6	11.8	11.9	12.0	12.2	12.4	12.6	12.3	11.6	10.8
		D.O.	10.0	9.5	10.0	10.1	9.8	9.9	10.8	10.6	10.4	10.2	10.5	11.3
		Cond.	4282	3296	1657	1135	180	163	139	127	129	129	128	128
		Den.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	May 11 - May 17	Temp.	15.2	16.0	16.1	13.9	14.4	15.0	14.4	15.0	14.4	14.1	14.2	13.4
		D.O.	8.4	10.0	9.7	10.1	9.8	10.3	9.8	9.8	9.9	10.1	10.2	10.4
		Cond.	7489	2759	956	241	160	180	137	131	126	126	118	115
		Den.	0.0	0.0	3.8	27.5	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	May 18 - May 24	Temp.	17.6	17.7	18.5	17.5	18.0	18.2	18.6	18.1	19.8	19.6	19.4	19.0
		D.O.	8.1	9.8	10.0	9.1	9.0	8.7	9.8	9.9	9.3	9.4	8.7	8.0
		Cond.	5475	350	188	155	142	149	136	131	134	166	175	151
		Den.	0.0	0.8	27.5	177.0	205.8	42.4	18.6	15.6	4.7	5.1	2.9	2.1
	May 25 - May 31	Temp.	18.7	19.8	20.7	19.5	19.6	20.2	20.7	21.2	21.2	21.0	20.9	20.5
		D.O.	7.8	9.8	11.1	9.4	9.1	9.0	9.2	8.3	8.4	9.3	8.9	8.2
		Cond.	6287	1166	171	149	148	166	146	150	152	150	154	153
		Den.	0.0	0.2	47.5	99.5	98.6	62.1	10.8	9.4	1.4	4.2	8.8	0.0

Table B-15 (Contd)

1976	May 02 - May 08	Temp.	13.3	13.0	13.0	13.6	13.4	13.1	13.1	11.8	11.2	11.4	11.2	10.5
		D.O.	10.2	10.3	10.0	9.6	9.5	9.4	9.5	10.0	10.2	10.2	10.5	11.0
		Cond.	2019	500	207	162	153	161	158	154	146	140	142	165
		Den.	0.0	0.0	0.0	9.3	8.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	May 09 - May 15	Temp.	15.2	15.7	15.4	14.9	14.3	14.4	13.9	13.8	14.0	14.0	13.6	13.0
		D.O.	9.0	10.1	10.0	9.6	9.9	9.8	9.5	9.9	10.3	10.3	10.4	10.8
		Cond.	5320	1061	206	165	164	175	144	132	139	139	140	139
		Den.	0.0	0.0	10.1	91.9	126.5	3.1	1.9	2.6	1.1	0.0	0.0	0.0
	May 16 - May 22	Temp.	16.9	15.5	15.4	14.7	15.0	15.2	14.3	14.1	14.0	15.0	14.8	15.2
		D.O.	9.3	10.9	10.3	9.6	9.8	9.9	9.7	9.5	9.9	9.8	10.3	9.6
		Cond.	3011	207	165	157	145	159	142	139	144	147	156	156
		Den.	0.1	1.5	43.9	96.7	49.8	15.9	11.5	62.2	104.5	1.8	7.4	90.4
	Jun 06 - Jun 12	Temp.	19.0	20.2	19.8	17.9	17.1	17.7	18.1	19.0	20.5	20.1	20.8	21.0
		D.O.	5.1	10.3	10.8	9.4	9.3	9.2	8.3	8.2	9.2	9.7	9.8	9.6
		Cond.	12505	2453	284	169	158	164	147	152	155	157	187	208
		Den.	0.0	0.0	0.2	3.5	36.7	62.6	7.9	1.0	3.2	10.0	26.9	0.0
1977	May 01 - May 07	Temp.	13.2	14.4	13.6	13.5	12.3	126	11.9	12.2	12.8	12.3	12.0	12.0
		D.O.	8.4	10.2	9.6	9.2	9.4	10.0	10.2	10.3	10.2	10.4	11.0	11.4
		Cond.	6344	369	153	156	155	165	136	126	124	119	118	109
		Den.	0.0	0.0	1.3	16.1	110.3	11.1	0.0	0.0	0.0	0.0	2.2	0.0
	May 08 - May 14	Temp.	13.1	13.1	13.6	13.1	12.8	12.9	14.0	13.5	13.1	12.6	12.6	12.7
		D.O.	9.2	10.0	10.2	9.8	9.6	9.7	9.5	9.7	9.9	9.8	9.6	9.4
		Cond.	3022	549	164	156	147	147	132	133	133	144	158	174
		Den.	0.0	0.0	8.7	135.1	20.4	0.0	41.9	58.2	362	3.9	3.8	0.0
	May 15 - May 21	Temp.	16.0	16.3	16.3	15.5	15.4	16.2	16.5	16.3	16.9	17.1	16.4	15.4
		D.O.	8.4	9.1	9.7	9.2	9.0	9.2	8.9	9.7	10.1	10.1	10.1	10.0
		Cond.	8109	1622	195	154	148	166	154	161	177	180	166	143
		Den.	0.0	0.0	10.2	219.8	469.9	129.4	43.1	296.7	131.8	5.1	21.9	2.4
	May 22 - May 28	Temp.	19.1	18.6	20.7	19.1	18.0	18.9		18.9	19.7	20.4	21.7	21.9
		D.O.	8.3	9.3	10.8	9.4	9.4	9.6	9.2	10.0	9.6	10.4	9.3	8.3
		Cond.	7524	2048	285	441	158	175	192	179	173	164	169	160
		Den.	0.0	4.3	55.6	47.8	197.9	68.4	8.3	78.7	2.5	1.0	15.1	0.0

Table B-16

Estimated Density (No./1000 m^3) of Striped Bass Eggs in Shoal, Bottom, and Channel Strata of Five Regions during Ichthyoplankton Survey of Hudson River Estuary, 1977

		REGION AND STRATUM*														
		YK			TZ			CH			IP			CW		
DATE		S	B	C	S	B	C	S	B	C	S	B	C	S	B	C
2/21- 2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	0	0	1	6	6	9	7	10	11	3	5	7	3	4	5
3/ 7- 3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	0	3	8	7	11	6	13	6	4	5	9	3	4	4
3/21- 3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	6	18	9	3	5	3	3	4	3	3	3	3
4/ 4- 4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	5	18	10	3	5	3	3	4	3	3	3	3
4/18- 4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
4/25- 4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	6	10	17	3	8	6
5/ 2- 5/ 5	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.00	1.53	18.86	21.59	14.75	0.0	17.60	9.46
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.00	0.89	11.62	15.24	7.29	0.0	12.34	9.46
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
5/ 9- 5/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	1.56	2.90	18.12	53.59	295.16	108.46	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	1.03	0.93	8.99	21.97	141.34	34.70	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	12	16	3	7	6
5/16- 5/19	DEN	0.0	0.0	0.0	0.0	0.0	0.0	8.25	3.21	15.74	32.89	545.76	167.20	298.50	379.23	18.09
	SE	0.0	0.0	0.0	0.0	0.0	0.0	3.80	0.97	7.41	22.87	327.53	67.61	107.56	304.70	16.81
	TOWS	3	0	3	2	4	3	6	5	4	5	11	17	3	8	6
5/23- 5/26	DEN	0.0	0.0	0.0	0.0	0.0	9.93	41.11	112.90	37.94	53.81	161.56	23.92	4.81	183.39	29.26
	SE	0.0	0.0	0.0	0.0	0.0	9.93	28.21	50.56	12.65	16.96	121.76	10.32	4.81	111.03	18.85
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	2	11	11
5/31- 6/ 2	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.61	0.63	54.79	35.77	23.19
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.61	0.44	47.61	28.51	14.61
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	3	10	11
6/ 6- 6/ 9	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.48	0.30
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.48	0.30
	TOWS	3	0	3	3	3	3	4	3	5	4	5	16	3	6	10
6/13- 6/16	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	6	2	4	3	5	17	3	6	10
6/20- 6/24	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	7	15	3	5	11
6/27- 7/ 1	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.28
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.28
	TOWS	2	0	3	4	3	3	4	2	5	3	6	17	3	6	10
7/ 5- 7/ 8	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10
7/11- 7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	5	3	4	3	5	17	3	6	10
7/25- 7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	2	4	3	5	3	5	17	3	7	9
8/ 8- 8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10

*S = shoal strata B = bottom stratum C = channel stratum

Table B-17

Estimated Density (No./1000 m^3) of Striped Bass Eggs in Bottom and Channel Strata in Seven Regions during Ichthyoplankton Survey of Hudson River Estuary, 1977

REGION AND STRATUM*

DATE		WP B	WP C	PK B	PK C	HP B	HP C	KG B	KG C	SG B	SG C	CS B	CS C	AL B	AL C
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	6	3	4	0	0	0	0	0	0	0	0	0	0
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	7	0	0	0	0	0	0	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	3	3	3	0	0	0	0	0	0	0	0	0	0
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	2	3	3	0	0	0	0	0	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	4	3	3	3	3	0
4/25-4/28	DEN	9.63	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.94	0.0	3.30	0.0
	SE	7.63	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.94	0.0	1.89	0.0
	TOWS	17	17	6	6	3	4	3	3	3	4	3	3	3	0
5/ 2-5/ 5	DEN	44.77	120.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.24	0.0	0.0
	SE	10.41	35.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.24	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	3	4	3	3	3	0
5/ 9-5/12	DEN	109.72	6.15	6.56	52.54	23.38	67.24	97.71	4.90	6.46	2.45	5.09	2.59	0.0	0.0
	SE	54.33	5.02	4.91	34.08	4.63	9.93	96.15	4.90	4.98	2.45	3.58	1.30	0.0	0.0
	TOWS	18	17	7	6	3	4	3	3	3	4	3	3	3	0
5/16-5/19	DEN	381.73	483.98	153.52	9.79	533.99	234.67	44.97	176.03	6.90	4.02	33.44	11.38	2.40	0.0
	SE	133.88	138.17	115.39	7.79	304.26	219.42	17.40	159.45	4.02	2.41	31.71	3.74	1.22	0.0
	TOWS	19	17	6	6	3	4	3	3	3	4	3	3	3	0
5/23-5/26	DEN	490.47	151.10	17.47	5.54	26.13	92.40	0.0	3.78	0.87	1.11	10.68	19.19	0.0	0.0
	SE	343.89	68.40	8.50	2.33	19.04	35.06	0.0	3.78	0.87	1.11	5.81	13.47	0.0	0.0
	TOWS	5	11	8	20	6	8	5	3	4	3	3	3	3	0
5/31-6/ 2	DEN	3.69	2.63	6.38	1.66	0.0	2.17	5.63	1.83	0.0	0.0	0.0	5.52	0.0	0.0
	SE	2.17	1.97	5.06	0.70	0.0	2.17	5.63	1.05	0.0	0.0	0.0	5.52	0.0	0.0
	TOWS	6	10	8	19	6	7	4	4	4	3	3	3	3	0
6/ 6-6/ 9	DEN	4.00	2.61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	3.11	0.94	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	7	16	12	14	5	5	5	5	4	3	5	2	3	0
6/13-6/16	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.38	0.96	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.38	0.96	0.0	0.0
	TOWS	6	17	11	15	5	5	5	5	3	4	4	3	3	0
6/20-6/24	DEN	1.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	1.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	5	18	11	15	4	6	5	5	3	4	4	3	3	0
6/27-7/ 1	DEN	0.0	0.0	0.0	2.66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	2.66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/ 5-7/ 8	DEN	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	13	13	4	6	5	5	2	5	4	3	3	0
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
8/ 8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0

*B = bottom stratum C = channel stratum

Table B-18

Estimated Standing Crops (in Thousands) and Percent Standing Crops of Striped Bass Eggs Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of Egg Abundance, 1977

		Bowline		Lovett		Indian Point		Roseton		Danskammer	
Date		Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent
5/09 - 5/12	Above	43,320	69.7	32,299	51.9	31,828	51.2	20,204	32.5	19,380	31.2
	Within	18,874	30.3	29,638	47.7	29,850	48.0	8,328	13.4	9,152	14.7
	Below	0	0.0	258	0.4	516	0.8	33,663	54.1	33,663	54.1
5/16 - 5/19	Above	217,906	87.9	189,922	76.6	179,104	72.2	76,615	30.9	75,766	30.5
	Within	30,126	12.1	57,808	23.3	68,322	27.5	17,626	7.1	15,454	6.2
	Below	0	0.0	303	0.1	606	0.2	153,791	62.0	156,812	63.2
5/23 - 5/26	Above	72,802	82.2	64,513	72.8	59,958	67.7	16,809	19.0	16,645	18.8
	Within	14,844	16.8	21,081	23.8	23,994	27.1	6,435	7.3	5,001	5.6
	Below	959	1.1	3,012	3.4	4,654	5.3	65,362	73.8	66,960	75.6

Table B-19

Friedman Rank Sums and Multiple Comparisons Test of Striped Bass Egg Densities at Three Depths, Indian Point Nearfield Sampling, May-June 1977

	Surface		Middle		Bottom	
Date	No. of Larvae Collected	Rank	No. of Larvae Collected	Rank	No. of Larvae Collected	Rank
5/4	5	(1)	23	(2)	58	(3)
5/11	13	(1)	95	(2)	502	(3)
5/19	43	(1)	129	(2)	550	(3)
5/26	11	(1)	81	(2)	326	(3)
6/1	0	(1.5)	0	(1.5)	1	(3)
Sum of Ranks		(5.5)		(9.5)		(15)

S statistic = 9.1, significant at α = 0.5

Multiple Comparisons Test		S	M	B
		5.5	9.5	15
S	5.5	–	4	9.5*
M	9.5		–	5.5
B	15			–

*Significant at α = 0.05

Table B-20

Estimated Standing Crops (in Thousands) of Striped Bass Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
		REGION												
2/21-2/25	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/ 7-3/11	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21-3/26	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/ 4-4/ 7	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/18-4/20	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
4/25-4/28	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3	156
5/ 2-5/ 5	SC	0	0	48	19	42	0	0	0	0	0	0	0	109
	SE	0	0	48	13	33	0	0	0	0	0	0	0	60
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
5/ 9-5/12	SC	469	16869	14039	20367	520	907	4431	491	268	0	0	0	58361
	SE	469	7775	1746	2927	186	435	1101	153	120	0	0	0	8589
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3	157
5/16-5/19	SC	55	6941	4784	15705	28389	12914	18020	4337	3447	91	0	95	94778
	SE	55	3482	1365	3290	5269	3928	5404	1657	1207	91	0	95	10071
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3	157
5/23-5/26	SC	0	11567	16310	28665	21184	21821	100121	44304	3840	8700	2454	0	258966
	SE	0	6897	3037	8890	5676	6022	26632	14310	1229	3123	1027	0	33625
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3	157
5/31-6/ 2	SC	0	3345	3968	113638	194626	50733	113346	19114	24675	7447	1961	0	532853
	SE	0	3345	2176	33284	33900	8424	26311	5053	13804	3328	1193	0	57138
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3	155
6/ 6-6/ 9	SC	0	876	17619	43815	76562	16532	7150	4242	3244	729	49	173	170992
	SE	0	359	9057	7392	10743	2809	1079	993	647	389	49	173	16212
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/13-6/16	SC	0	0	1355	7303	9810	1328	815	194	198	173	202	0	21379
	SE	0	0	486	2779	2235	339	285	164	91	123	105	0	3635
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/20-6/24	SC	0	0	75	80	413	74	18	182	0	295	0	0	1139
	SE	0	0	53	69	148	53	18	101	0	191	0	0	282
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/27-7/ 1	SC	0	0	0	106	225	26	75	0	0	0	0	0	432
	SE	0	0	0	58	80	26	46	0	0	0	0	0	112
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3	157
7/ 5-7/ 8	SC	0	0	0	54	0	34	19	0	0	0	0	0	107
	SE	0	0	0	37	0	34	19	0	0	0	0	0	54
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/11-7/15	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/25-7/29	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
8/ 8-8/12	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157

Table B-21

Estimated Density (No./1000 m^3) of Striped Bass Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
		REGION											
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/4-4/7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3
5/2-5/5	DEN	0.0	0.0	0.3276	0.0903	0.2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.3276	0.0606	0.1585	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
5/9-5/12	DEN	2.0455	52.4198	95.0478	97.7784	2.5090	6.4896	14.8576	2.9653	1.8925	0.0	0.0	0.0
	SE	2.0455	24.1621	11.8220	14.0510	0.8953	3.1131	3.6910	0.9233	0.8496	0.0	0.0	0.0
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3
5/16-5/19	DEN	0.2415	21.5685	32.3915	75.3955	136.8787	92.3774	60.4280	26.2055	24.3622	0.5161	0.0	1.3300
	SE	0.2415	10.8195	9.2396	15.7960	25.4056	28.0942	18.1236	10.0108	8.5310	0.5161	0.0	1.3300
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3
5/23-5/26	DEN	0.0	35.9456	110.4274	137.6126	102.1428	156.0863	335.7518	267.6952	27.1396	49.3463	15.2715	0.0
	SE	0.0	21.4327	20.5592	42.6770	27.3664	43.0781	89.3104	86.4643	8.6859	17.7162	6.3893	0.0
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3
5/31-6/2	DEN	0.0	10.3939	26.8662	545.5473	938.4076	362.8985	380.1017	115.4917	174.3826	42.2411	12.2023	0.0
	SE	0.0	10.3939	14.7333	159.7867	163.4507	60.2576	88.2321	30.5317	97.5547	18.8757	7.4268	0.0
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3
6/6-6/9	DEN	0.0	2.7220	119.2862	210.3464	369.1532	118.2580	23.9784	25.6300	22.9272	4.1324	0.3060	2.4353
	SE	0.0	1.1144	61.3211	35.4857	51.7969	20.0913	3.6172	5.9981	4.5706	2.2060	0.3060	2.4353
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/13-6/16	DEN	0.0	0.0	9.1739	35.0610	47.3009	9.5012	2.7327	1.1737	1.4010	0.9817	1.2572	0.0
	SE	0.0	0.0	3.2910	13.3405	10.7754	2.4219	0.9543	0.9926	0.6461	0.6960	0.6550	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/20-6/24	DEN	0.0	0.0	0.5111	0.3858	1.9933	0.5323	0.0602	1.1009	0.0	1.6714	0.0	0.0
	SE	0.0	0.0	0.3618	0.3314	0.7145	0.3308	0.0602	0.6114	0.0	1.0859	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/27-7/1	DEN	0.0	0.0	0.0	0.5106	1.0830	0.1877	0.2512	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.2763	0.3836	0.1877	0.1553	0.0	0.0	0.0	0.0	0.0
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3
7/5-7/8	DEN	0.0	0.0	0.0	0.2588	0.0	0.2416	0.0644	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.1776	0.0	0.2416	0.0644	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
8/8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3

Table B-22

Estimated Standing Crops (in Thousands) of Striped Bass Post Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
		REGION												
2/21-2/25	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/ 7-3/11	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21-3/26	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/ 4-4/ 7	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/18-4/20	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
4/25-4/28	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3	156
5/ 2-5/ 5	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
5/ 9-5/12	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3	157
5/16-5/19	SC	0	0	0	9	0	0	0	0	0	0	0	0	9
	SE	0	0	0	9	0	0	0	0	0	0	0	0	9
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3	157
5/23-5/26	SC	0	353	684	448	0	586	287	0	0	0	0	0	2358
	SE	0	308	234	180	0	246	150	0	0	0	0	0	515
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3	157
5/31-6/ 2	SC	0	1367	2202	41041	51669	42424	135319	77094	21522	10564	0	0	383203
	SE	0	763	1311	11239	19175	8689	22766	15838	5192	3024	0	0	37108
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3	155
6/ 6-6/ 9	SC	27	12949	81816	136918	100534	122087	66455	22271	12198	3539	631	0	559425
	SE	27	9911	27767	18190	24676	36101	7426	5843	2002	776	309	0	56624
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/13-6/16	SC	27	628	6539	90280	140183	17773	9342	6098	1115	93	1123	0	273199
	SE	27	274	2763	26885	36515	3344	1664	2346	346	93	505	0	45648
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/20-6/24	SC	55	1832	10739	41800	12082	8248	2347	348	590	662	166	0	78867
	SE	55	1277	3218	18152	2614	6156	1486	170	367	354	166	0	19717
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/27-7/ 1	SC	543	1772	1842	3689	3743	2924	6492	3928	2983	573	625	0	29112
	SE	388	638	614	749	411	743	1709	3213	1505	515	205	0	4247
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3	157
7/ 5-7/ 8	SC	0	129	934	258	120	694	980	0	119	238	165	95	3732
	SE	0	129	414	83	82	237	500	0	72	185	165	95	764
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/11-7/15	SC	163	0	131	26	91	133	81	0	0	0	0	64	688
	SE	163	0	131	26	49	75	37	0	0	0	0	64	240
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/25-7/29	SC	0	0	0	0	0	0	0	59	0	0	0	0	59
	SE	0	0	0	0	0	0	0	59	0	0	0	0	59
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
8/ 8-8/12	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157

Table B-23

Estimated Density (No./1000 m^3) of Striped Bass Post Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
		REGION											
2/21- 2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/ 7- 3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21- 3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/ 4- 4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/18- 4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
4/25- 4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3
5/ 2- 5/ 5	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
5/ 9- 5/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3
5/16- 5/19	DEN	0.0	0.0	0.0	0.0410	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0410	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3
5/23- 5/26	DEN	0.0	1.0973	4.6278	2.1517	0.0	4.1915	0.9634	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.9579	1.5856	0.8650	0.0	1.7574	0.5016	0.0	0.0	0.0	0.0	0.0
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3
5/31- 6/ 2	DEN	0.0	4.2483	14.9098	197.0306	249.1265	303.4601	453.7861	465.8269	152.1011	59.9223	0.0	0.0
	SE	0.0	2.3701	8.8747	53.9579	92.4548	62.1496	76.3448	95.6977	36.6934	17.1523	0.0	0.0
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3
6/ 6- 6/ 9	DEN	0.1195	40.2387	553.9358	657.3137	484.7330	873.2964	222.8530	134.5687	86.2027	20.0765	3.9255	0.0
	SE	0.1195	30.7980	187.9972	87.3269	118.9776	258.2330	24.9015	35.3031	14.1498	4.4042	1.9212	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/13- 6/16	DEN	0.1159	1.9504	44.2696	433.4116	675.9041	127.1344	31.3269	36.8447	7.8823	0.5271	6.9855	0.0
	SE	0.1159	0.8500	18.7091	129.0683	176.0623	23.9220	5.5798	14.1780	2.4455	0.5271	3.1446	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/20- 6/24	DEN	0.2396	5.6914	72.7071	200.6709	58.2523	59.0020	7.8700	2.1008	4.1692	3.7527	1.0339	0.0
	SE	0.2396	3.9687	21.7903	87.1446	12.6057	44.0311	4.9833	1.0265	2.5961	2.0086	1.0339	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/27- 7/ 1	DEN	2.3661	5.5054	12.4698	17.7104	18.0453	20.9127	21.7690	23.7326	21.0805	3.2527	3.8985	0.0
	SE	1.6905	1.9826	4.1597	3.5939	1.9794	5.3137	5.7317	19.4157	10.6338	2.9223	1.2744	0.0
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3
7/ 5- 7/ 8	DEN	0.0	0.4009	6.3218	1.2372	0.5793	4.9669	3.2863	0.0	0.8404	1.3512	1.0282	1.3326
	SE	0.0	0.4009	2.8007	0.4211	0.3968	1.6988	1.6760	0.0	0.5058	1.0475	1.0282	1.3326
	TOWS	6	9	12	25	23	19	25	10	10	7	7	3
7/11- 7/15	DEN	0.7114	0.0	0.8844	0.1268	0.4366	0.9481	0.2702	0.0	0.0	0.0	0.0	0.8977
	SE	0.7114	0.0	0.8844	0.1268	0.2365	0.5332	0.1235	0.0	0.0	0.0	0.0	0.8977
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/25- 7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3583	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3583	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
8/ 8- 8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3

Table B-24

Estimated Density (No./1000 m^3) of Striped Bass Yolk-Sac Larvae in Shoal, Bottom, and Channel Strata of Five Regions during Ichthyoplankton Survey Hudson River Estuary, 1977

		REGION AND STRATUM*														
		YK			TZ			CH			IP			CW		
DATE		S	B	C	S	B	C	S	B	C	S	B	C	S	B	C
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	0	0	1	6	6	9	7	10	11	3	5	7	3	4	5
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	0	3	8	7	11	6	13	6	4	5	9	3	4	4
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	6	18	9	3	5	3	3	4	3	3	3	3
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	5	18	10	3	5	3	3	4	3	3	3	3
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	6	10	17	3	8	6
5/ 2-5/ 5	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.79	0.0	0.56	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.79	0.0	0.38	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
5/ 9-5/12	DEN	0.0	0.0	2.31	38.93	8.85	83.92	125.17	40.17	97.66	77.61	101.74	98.53	1.11	6.51	6.94
	SE	0.0	0.0	2.31	17.70	3.09	54.12	24.58	12.88	17.26	39.02	26.30	16.93	1.11	3.21	4.41
	TOWS	3	0	3	3	4	3	6	5	4	5	12	16	3	7	6
5/16-5/19	DEN	2.08	0.0	0.0	20.48	54.01	7.93	46.45	30.58	20.99	60.29	76.57	76.33	134.47	205.21	45.03
	SE	2.08	0.0	0.0	20.48	38.76	2.49	22.92	10.36	7.69	28.31	19.41	19.75	80.24	49.33	36.06
	TOWS	3	0	3	2	4	3	6	5	4	5	11	17	3	8	6
5/23-5/26	DEN	0.0	0.0	0.0	17.15	13.95	62.42	86.42	148.66	111.27	22.24	124.92	149.18	73.22	457.70	46.20
	SE	0.0	0.0	0.0	11.23	13.95	48.58	9.40	52.30	40.21	10.41	83.98	51.97	45.45	157.60	16.65
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	2	11	11
5/31-6/ 2	DEN	0.0	0.0	0.0	0.0	0.0	24.24	5.81	49.02	33.63	38.39	872.30	517.68	126.80	490.72	333.49
	SE	0.0	0.0	0.0	0.0	0.0	24.24	4.92	19.83	33.63	33.74	543.48	171.87	39.37	137.90	70.77
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	3	10	11
6/ 6-6/ 9	DEN	0.0	0.0	0.0	1.18	4.20	3.42	85.85	137.38	139.09	45.04	169.57	231.57	147.27	94.76	124.89
	SE	0.0	0.0	0.0	1.18	2.76	2.03	66.81	85.71	127.73	19.38	81.50	42.32	79.49	31.85	26.03
	TOWS	3	0	3	3	3	3	4	3	5	4	5	16	3	6	10
6/13-6/16	DEN	0.0	0.0	0.0	0.0	0.0	0.0	2.37	27.88	5.24	0.0	52.64	34.16	8.91	11.20	8.89
	SE	0.0	0.0	0.0	0.0	0.0	0.0	1.15	11.07	5.24	0.0	26.16	16.25	7.18	5.57	2.77
	TOWS	3	0	3	3	3	3	6	2	4	3	5	17	3	6	10
6/20-6/24	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.11	0.64	0.99	2.03	0.0	0.0	0.0	0.78
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.11	0.64	0.99	2.03	0.0	0.0	0.0	0.56
	TOWS	3	0	3	3	3	3	4	3	5	3	7	15	3	5	11
6/27-7/ 1	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.66	0.0	0.0	0.28
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.35	0.0	0.0	0.28
	TOWS	2	0	3	4	3	3	4	2	5	3	6	17	3	6	10
7/ 5-7/ 8	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.33	0.0	0.0	0.36
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.23	0.0	0.0	0.36
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	5	3	4	3	5	17	3	6	10
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	2	4	3	5	3	5	17	3	7	9
8/ 8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10

*S = shoal strata B = bottom stratum C = channel stratum

Table B-25

Estimated Density (No./1000 m^3) of Striped Bass Yolk-Sac Larvae in Bottom and Channel Strata in Seven Regions of Hudson River Estuary, during Ichthyoplankton Survey, 1977

DATE		WP B	WP C	PK B	PK C	HP B	HP C	KG B	KG C	SG B	SG C	CS B	CS C	AL B	AL C
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	6	3	4	0	0	0	0	0	0	0	0	0	0
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	7	0	0	0	0	0	0	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	3	3	3	0	0	0	0	0	0	0	0	0	0
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	2	3	3	0	0	0	0	0	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	4	3	3	3	3	0
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	17	17	6	6	3	4	3	3	3	4	3	3	3	0
5/ 2-5/ 5	DEN	0.34	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.23	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	3	4	3	3	3	0
5/ 9-5/12	DEN	3.19	2.40	18.70	13.70	4.83	2.48	0.99	2.36	0.0	0.0	0.0	0.0	0.0	0.0
	SE	1.36	1.02	7.54	4.23	3.14	0.83	0.99	1.18	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	7	6	3	4	3	3	3	4	3	3	3	0
5/16-5/19	DEN	124.55	138.85	82.99	53.61	58.09	17.87	22.13	25.50	0.0	0.80	0.0	0.0	1.33	0.0
	SE	12.94	29.40	41.29	20.03	23.66	11.01	3.21	12.78	0.0	0.80	0.0	0.0	1.33	0.0
	TOWS	19	17	6	6	3	4	3	3	3	4	3	3	3	0
5/23-5/26	DEN	135.75	96.77	404.87	314.86	179.08	290.86	53.45	13.72	121.77	8.88	11.47	18.75	0.0	0.0
	SE	78.68	29.14	67.96	113.22	75.44	107.27	21.38	7.29	46.80	8.88	6.16	10.86	0.0	0.0
	TOWS	5	11	8	20	6	8	5	3	4	3	3	3	3	0
5/31-6/ 2	DEN	1095.32	913.31	416.77	369.02	241.12	82.65	153.78	184.90	40.46	43.23	7.08	16.89	0.0	0.0
	SE	287.62	183.93	156.78	104.67	46.75	36.52	73.25	142.50	15.47	28.13	4.12	13.72	0.0	0.0
	TOWS	6	10	8	19	6	7	4	4	4	3	3	3	3	0
6/ 6-6/ 9	DEN	359.59	370.68	22.04	24.56	9.90	29.74	17.10	25.90	5.48	3.38	0.64	0.0	2.44	0.0
	SE	85.85	58.49	5.94	4.36	8.68	7.22	12.60	2.51	1.16	3.38	0.64	0.0	2.44	0.0
	TOWS	7	16	12	14	5	5	5	5	4	3	5	2	3	0
6/13-6/16	DEN	29.27	50.19	3.54	2.49	0.97	1.23	3.07	0.55	1.47	0.71	1.64	0.91	0.0	0.0
	SE	13.28	12.32	1.90	1.10	0.97	1.23	1.58	0.55	1.47	0.71	0.95	0.91	0.0	0.0
	TOWS	6	17	11	15	5	5	5	5	3	4	4	3	3	0
6/20-6/24	DEN	1.46	2.08	0.26	0.0	0.85	1.17	0.0	0.0	0.0	2.61	0.0	0.0	0.0	0.0
	SE	0.90	0.82	0.26	0.0	0.85	0.74	0.0	0.0	0.0	1.69	0.0	0.0	0.0	0.0
	TOWS	5	18	11	15	4	6	5	5	3	4	4	3	3	0
6/27-7/ 1	DEN	0.48	1.18	0.51	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.48	0.44	0.34	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/ 5-7/ 8	DEN	0.0	0.0	0.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	13	13	4	6	5	5	2	5	4	3	3	0
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
8/ 8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0

REGION AND STRATUM*: WP, PK, HP, KG, SG, CS, AL

*B = bottom stratum C = channel stratum

Table B-26

Estimated Density (No./1000 m^3) of Striped Bass Post Yolk-Sac Larvae in Shoal, Bottom, and Channel Strata of Five Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

		REGION AND STRATUM*														
		YK			TZ			CH			IP			CW		
DATE		S	B	C	S	B	C	S	B	C	S	B	C	S	B	C
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	0	0	1	6	6	9	7	10	11	3	5	7	3	4	5
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	0	3	8	7	11	6	13	6	4	5	9	3	4	4
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	6	18	9	3	5	3	3	4	3	3	3	3
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	5	18	10	3	5	3	3	4	3	3	3	3
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	6	10	17	3	8	6
5/ 2-5/ 5	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
5/ 9-5/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	12	16	3	7	6
5/16-5/19	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.68	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.68	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	2	4	3	6	5	4	5	11	17	3	8	6
5/23-5/26	DEN	0.0	0.0	0.0	2.50	0.78	0.0	2.40	6.31	5.69	3.32	0.88	2.32	11.23	0.88	4.88
	SE	0.0	0.0	0.0	2.50	0.78	0.0	1.50	4.73	2.57	0.17	0.88	1.10	11.23	0.88	2.38
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	2	11	11
5/31-6/ 2	DEN	0.0	0.0	0.0	7.62	0.0	3.19	2.14	24.87	20.85	7.81	239.54	202.97	285.34	181.79	352.19
	SE	0.0	0.0	0.0	5.12	0.0	3.19	1.36	8.66	20.85	4.10	51.80	68.43	181.10	75.74	85.33
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	3	10	11
6/ 6-6/ 9	DEN	1.03	0.0	0.0	7.45	26.95	75.14	342.09	978.62	515.05	330.07	466.38	722.01	235.75	824.19	946.75
	SE	1.03	0.0	0.0	4.44	11.91	71.51	102.89	564.24	327.89	95.16	180.34	105.50	120.62	302.64	361.71
	TOWS	3	0	3	3	3	3	4	3	5	4	5	16	3	6	10
6/13-6/16	DEN	1.00	0.0	0.0	3.07	4.09	0.0	30.49	135.74	7.89	2.69	756.72	400.32	46.93	317.03	60.34
	SE	1.00	0.0	0.0	1.78	2.69	0.0	22.99	75.21	5.77	1.46	310.73	152.81	34.75	66.13	23.99
	TOWS	3	0	3	3	3	3	6	2	4	3	5	17	3	6	10
6/20-6/24	DEN	2.06	0.0	0.0	11.23	7.49	0.0	27.34	263.83	11.27	37.91	58.91	242.48	0.0	215.84	3.22
	SE	2.06	0.0	0.0	9.77	7.49	0.0	15.17	95.16	5.74	18.67	21.09	111.75	0.0	167.23	1.44
	TOWS	3	0	3	3	3	3	4	3	5	3	7	15	3	5	11
6/27-7/ 1	DEN	20.34	0.0	0.0	6.99	1.08	6.18	19.47	4.31	10.64	22.69	33.79	14.01	29.45	25.53	18.39
	SE	14.53	0.0	0.0	4.62	1.08	2.13	10.85	1.01	3.01	12.55	3.40	4.45	15.96	11.99	6.15
	TOWS	2	0	3	4	3	3	4	2	5	3	6	17	3	6	10
7/ 5-7/ 8	DEN	0.0	0.0	0.0	0.0	0.0	0.93	16.06	2.09	0.0	1.00	1.79	1.14	27.36	2.03	4.20
	SE	0.0	0.0	0.0	0.0	0.0	0.93	7.65	1.04	0.0	1.00	1.20	0.47	13.96	2.03	2.06
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10
7/11-7/15	DEN	0.0	0.0	0.81	0.0	0.0	0.0	2.42	0.0	0.0	0.0	0.0	0.16	3.87	0.0	1.07
	SE	0.0	0.0	0.81	0.0	0.0	0.0	2.42	0.0	0.0	0.0	0.0	0.16	3.87	0.0	0.71
	TOWS	3	0	3	3	3	3	5	3	4	3	5	17	3	6	10
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	2	4	3	5	3	5	17	3	7	9
8/ 8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10

*S = shoal strata   B = bottom stratum   C = channel stratum

Table B-27

Estimated Density (No./1000 m^3) of Striped Bass Post Yolk-Sac Larvae in Bottom and Channel Strata in Seven Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

DATE		WP B	WP C	PK B	PK C	HP B	HP C	KG B	KG C	SG B	SG C	CS B	CS C	AL B	AL C
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	6	3	4	0	0	0	0	0	0	0	0	0	0
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	7	0	0	0	0	0	0	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	3	3	3	0	0	0	0	0	0	0	0	0	0
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	2	3	3	0	0	0	0	0	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	4	3	3	3	3	0
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	17	17	6	6	3	4	3	3	3	4	3	3	3	0
5/ 2-5/ 5	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	3	4	3	3	3	0
5/ 9-5/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	7	6	3	4	3	3	3	4	3	3	3	0
5/16-5/19	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	19	17	6	6	3	4	3	3	3	4	3	3	3	0
5/23-5/26	DEN	0.0	0.0	0.90	0.98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.90	0.59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	5	11	8	20	6	8	5	3	4	3	3	3	3	0
5/31-6/ 2	DEN	150.34	264.93	332.63	490.40	188.38	538.36	43.46	207.52	98.43	38.40	0.0	0.0	0.0	0.0
	SE	58.49	106.83	155.91	87.54	66.40	119.46	13.53	54.98	43.86	10.69	0.0	0.0	0.0	0.0
	TOWS	6	10	8	19	6	7	4	4	4	3	3	3	3	0
6/ 6-6/ 9	DEN	215.94	527.73	193.59	231.69	136.35	134.10	70.02	94.46	14.46	23.22	4.72	3.20	0.0	0.0
	SE	50.50	137.77	35.15	30.64	92.10	37.46	29.35	15.25	3.76	6.54	1.99	3.20	0.0	0.0
	TOWS	7	16	12	14	5	5	5	5	4	3	5	2	3	0
6/13-6/16	DEN	765.10	661.64	65.52	21.00	74.33	27.04	9.27	7.17	1.47	0.0	12.58	1.86	0.0	0.0
	SE	149.45	202.82	19.91	4.07	38.96	14.70	3.46	3.24	1.47	0.0	6.50	0.93	0.0	0.0
	TOWS	6	17	11	15	5	5	5	5	3	4	4	3	3	0
6/20-6/24	DEN	83.90	54.15	30.51	1.03	10.14	0.0	12.34	0.0	8.97	0.84	2.16	0.0	0.0	0.0
	SE	41.80	13.00	21.37	0.64	4.95	0.0	7.69	0.0	5.40	0.84	2.16	0.0	0.0	0.0
	TOWS	5	18	11	15	4	6	5	5	3	4	4	3	3	0
6/27-7/ 1	DEN	18.80	17.92	44.84	14.80	9.78	27.38	9.57	26.95	0.98	4.52	7.12	0.93	0.0	0.0
	SE	7.91	1.92	16.02	5.68	7.99	24.40	2.77	16.00	0.98	4.52	2.46	0.93	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/ 5-7/ 8	DEN	0.46	0.60	1.63	3.79	0.0	0.0	1.18	0.67	1.04	1.53	2.15	0.0	1.33	0.0
	SE	0.46	0.45	0.81	2.17	0.0	0.0	0.72	0.67	1.04	1.53	2.15	0.0	1.33	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/11-7/15	DEN	0.0	0.51	1.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.90	0.0
	SE	0.0	0.27	0.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.90	0.0
	TOWS	6	17	13	13	4	6	5	5	2	5	4	3	3	0
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
8/ 8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0

*B = bottom stratum C = channel stratum

Table B-28

Mean Length (mm) and Length Frequency of Striped Bass Post Yolk-Sac Larvae and Juveniles from Hudson River Estuary (RM 14-140; KM 22-224) during Ichthyoplankton Survey, 1977

DATE	STRATUM	MEAN LENGTH	S.E.	NUMBER OF STRIPED BASS PER LENGTH INTERVAL (MM)											NUMBER MEASURED
				<5	5-6.9	7-8.9	9-11.9	12-14.9	15-19.9	20-24.9	25-34.9	35-44.9	45-64.9	>65	
5/16-5/19	SHOALS	7.3	0.0	0	0	1	0	0	0	0	0	0	0	0	1
	BOTTOM	NC													NC
	CHANNEL	NC													NC
5/23-5/26	SHOALS	6.6	0.134	0	12	3	0	0	0	0	0	0	0	0	15
	BOTTOM	6.8	0.123	0	9	8	0	0	0	0	0	0	0	0	17
	CHANNEL	6.7	0.078	0	23	17	0	0	0	0	0	0	0	0	40
5/31-6/ 2	SHOALS	7.1	0.085	0	41	50	5	0	0	0	0	0	0	0	96
	BOTTOM	6.8	0.028	1	480	333	11	0	0	0	0	0	0	0	825
	CHANNEL	6.9	0.020	0	812	674	22	0	0	0	0	0	0	0	1508
6/ 6-6/ 9	SHOALS	7.4	0.073	0	103	152	27	1	0	0	0	0	0	0	283
	BOTTOM	8.0	0.047	1	251	468	262	10	0	0	0	0	0	0	992
	CHANNEL	7.5	0.034	3	652	783	275	9	0	0	0	0	0	0	1722
6/13-6/16	SHOALS	7.9	0.239	0	34	20	18	3	0	0	0	0	0	0	75
	BOTTOM	9.4	0.079	0	97	199	317	92	3	0	0	0	0	0	708
	CHANNEL	8.5	0.069	0	301	299	315	79	3	0	0	0	0	0	997
6/20-6/24	SHOALS	11.4	0.284	0	4	16	27	31	10	0	0	0	0	0	88
	BOTTOM	12.0	0.134	0	5	47	158	128	72	2	0	0	0	0	412
	CHANNEL	10.2	0.107	0	38	134	209	103	20	0	0	0	0	0	504
6/27-7/ 1	SHOALS	19.1	0.394	0	0	0	2	11	53	33	10	0	0	0	109
	BOTTOM	16.9	0.256	0	0	3	36	84	99	71	16	0	0	0	309
	CHANNEL	17.0	0.194	0	1	1	57	103	172	108	16	0	0	0	458
7/ 5-7/ 8	SHOALS	27.0	0.491	0	0	0	1	0	4	20	59	6	0	0	90
	BOTTOM	23.3	1.313	0	0	1	3	4	11	2	18	3	0	0	42
	CHANNEL	22.1	0.844	0	0	1	7	7	15	16	27	3	0	0	76
7/11-7/15	SHOALS	30.7	0.673	0	0	0	0	0	1	5	34	12	0	0	52
	BOTTOM	33.6	1.870	0	0	0	0	0	2	4	7	12	2	0	27
	CHANNEL	26.7	2.987	0	1	1	2	1	0	1	7	4	0	0	17
7/25-7/29	SHOALS	48.2	0.880	0	0	0	0	0	0	0	4	39	64	8	115
	BOTTOM	48.0	0.873	0	0	0	0	0	0	0	2	24	45	2	73
	CHANNEL	49.2	1.749	0	0	0	0	0	0	0	1	11	21	2	35
8/ 8-8/12	SHOALS	58.2	1.230	0	0	0	0	0	0	0	0	1	33	7	41
	BOTTOM	60.8	2.891	0	0	0	0	0	0	0	0	0	7	6	13
	CHANNEL	49.9	1.984	0	0	0	0	0	0	0	0	1	6	0	7

Table B-29 (Page 1 of 5)

Mean Length (mm) of Striped Bass Post Yolk-Sac Larvae and Juveniles by Strata in 12 Geographic Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE	STRATUM		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
5/16- 5/19	SHOALS	MEAN LENGTH	NC	NC	NC	7.3		NC						
		S.E.				0.0								
		N MEASURED				1								
	BOTTOM	MEAN LENGTH		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
		S.E.												
		N MEASURED												
	CHANNEL	MEAN LENGTH	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	
		S.E.												
		N MEASURED												
5/23- 5/26	SHOALS	MEAN LENGTH	NC	7.1	6.3	6.6		6.4						
		S.E.		0.32	0.39	0.32		0.10						
		N MEASURED		3	3	3		6						
	BOTTOM	MEAN LENGTH		8.0	6.7	7.0	NC	6.3	6.9	NC	NC	NC	NC	NC
		S.E.		0.0	0.10	0.0		0.33	0.40					
		N MEASURED		1	10	1		3	2					
	CHANNEL	MEAN LENGTH	NC	NC	6.6	6.7	NC	6.7	6.6	NC	NC	NC	NC	
		S.E.			0.13	0.19		0.12	0.27					
		N MEASURED			9	9		16	6					

Table B-29 (Page 2 of 5)

DATE	STRATUM		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
			REGIONS											
5/31- 6/2	SHOALS	MEAN LENGTH	NC	7.7	6.6	6.9		7.1						
		S.E.		0.41	0.48	0.35		0.08						
		N MEASURED		10	3	8		75						
	BOTTOM	MEAN LENGTH		NC	7.0	7.4	6.6	6.7	6.7	6.9	6.4	7.0	NC	NC
		S.E.			0.12	0.09	0.06	0.05	0.06	0.06	0.11	0.11		
		N MEASURED			43	100	95	165	154	134	56	78		
	CHANNEL	MEAN LENGTH	NC	7.1	7.1	7.4	7.0	6.8	6.7	6.7	6.7	6.3	NC	
		S.E.		0.41	0.12	0.05	0.05	0.04	0.03	0.06	0.07	0.11		
		N MEASURED		4	25	220	212	258	478	185	95	31		
6/6 - 6/9	SHOALS	MEAN LENGTH	11.5	8.0	7.3	7.3		7.7						
		S.E.	0.0	0.52	0.11	0.13		0.13						
		N MEASURED	1	7	100	100		75						
	BOTTOM	MEAN LENGTH		8.1	7.3	8.0	7.6	8.3	8.3	8.3	7.8	7.3	7.2	NC
		S.E.		0.24	0.14	0.14	0.08	0.10	0.09	0.19	0.21	0.40	0.60	
		N MEASURED		27	75	125	175	134	290	66	77	16	7	
	CHANNEL	MEAN LENGTH	NC	7.3	6.5	7.5	7.6	7.9	7.6	8.0	6.3	7.5	8.3	
		S.E.		0.13	0.07	0.07	0.06	0.10	0.08	0.14	0.09	0.38	0.20	
		N MEASURED		27	81	390	400	229	344	117	113	19	2	

Table B-29 (Page 3 of 5)

DATE	STRATUM		REGIONS YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
6/13- 6/16	SHOALS	MEAN LENGTH	11.6	8.3	7.9	9.7		7.5						
		S.E.	0.0	0.90	0.31	2.77		0.35						
		N MEASURED	1	3	36	3		32						
	BOTTOM	MEAN LENGTH		9.2	9.3	8.4	9.3	9.1	9.5	11.7	10.3	7.0	10.5	NC
		S.E.		0.14	0.30	0.19	0.14	0.15	0.18	0.22	0.49	0.0	0.43	
		N MEASURED		4	43	116	150	150	157	62	10	1	15	
	CHANNEL	MEAN LENGTH	NC	NC	8.4	8.7	8.5	7.5	8.2	10.4	9.9	NC	6.9	
		S.E.			0.83	0.12	0.10	0.17	0.22	0.30	0.56		0.65	
		N MEASURED			9	322	393	119	96	43	13		2	
6/20- 6/24	SHOALS	MEAN LENGTH	13.3	11.4	12.5	10.1		NC						
		S.E.	2.75	0.63	0.35	0.45								
		N MEASURED	2	12	36	38								
	BOTTOM	MEAN LENGTH		10.8	11.1	11.4	10.6	12.1	14.1	14.7	15.6	13.5	15.2	NC
		S.E.		0.44	0.23	0.25	0.30	0.27	0.34	0.82	0.59	0.30	0.30	
		N MEASURED		9	75	97	64	73	54	12	20	6	2	
	CHANNEL	MEAN LENGTH	NC	NC	11.4	10.6	9.6	10.2	10.3	NC	NC	12.8	NC	
		S.E.			0.51	0.15	0.16	0.50	1.63			0.0		
		N MEASURED			19	222	244	13	5			1		

DATE	STRATUM		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AI
			REGIONS											
6/27- 7/1	SHOALS	MEAN LENGTH	20.0	21.0	16.0	18.9		20.3						
		S.E.	0.66	1.16	0.43	0.88		0.75						
		N MEASURED	14	19	26	23		27						
	BOTTOM	MEAN LENGTH		9.9	14.2	14.8	12.6	20.5	17.4	18.1	19.4	15.2	16.7	NC
		S.E.		0.0	2.68	0.47	0.46	0.55	0.38	0.83	1.12	0.0	1.29	
		N MEASURED		1	3	58	38	52	118	14	16	1	8	
	CHANNEL	MEAN LENGTH	25.0	18.3	16.0	17.0	16.5	16.7	16.4	19.9	18.4	14.1	16.0	
		S.E.	0.0	1.42	0.40	0.49	0.43	0.53	0.38	0.33	0.53	0.80	0.0	
		N MEASURED	1	8	21	73	131	68	80	30	39	6	1	
7/5 - 7/8	SHOALS	MEAN LENGTH	30.5	NC	28.3	27.2		25.9						
		S.E.	0.50		0.84	1.27		0.68						
		N MEASURED	2		29	17		42						
	BOTTOM	MEAN LENGTH		NC	20.1	26.0	30.0	15.2	20.3	30.3	25.3	28.3	17.8	11.5
		S.E.			3.78	4.44	1.53	1.01	1.92	1.26	4.15	6.17	5.63	0.0
		N MEASURED			3	6	3	4	8	6	4	3	4	1
	CHANNEL	MEAN LENGTH	NC	26.2	NC	21.7	29.8	22.2	17.8	33.0	26.3	13.8	NC	
		S.E.		1.88		2.88	2.11	1.08	1.25	2.00	3.71	1.35		
		N MEASURED		8		12	6	21	22	2	3	2		

Table B-29 (Page 5 of 5)

DATE	STRATUM		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
			REGIONS											
7/11- 7/15	SHOALS	MEAN LENGTH	33.2	NC	30.7	33.0		29.3						
		S.E.	1.40		0.62	0.0		2.25						
		N MEASURED	6		33	1		12						
	BOTTOM	MEAN LENGTH		NC	39.0	NC	29.0	37.0	27.4	NC	43.5	NC	39.0	30.5
		S.E.			0.0		0.0	0.0	2.75		12.50		1.60	7.52
		N MEASURED			1		1	1	10		2		9	3
	CHANNEL	MEAN LENGTH	31.0	NC	NC	29.9	10.5	29.2	NC	34.0	NC	NC	34.0	
		S.E.	0.0			6.30	1.54	4.74		0.0			0.0	
		N MEASURED	1			4	3	7		1			1	
7/25- 7/29	SHOALS	MEAN LENGTH	41.0	51.4	51.1	45.3		40.2						
		S.E.	0.0	1.41	1.30	1.89		1.66						
		N MEASURED	1	20	52	25		17						
	BOTTOM	MEAN LENGTH		43.0	47.9	47.6	NC	NC	47.2	53.0	47.7	49.0	61.0	NC
		S.E.		0.0	0.98	1.46			4.59	0.0	5.36	0.0	0.0	
		N MEASURED		1	40	17			9	1	3	1	1	
	CHANNEL	MEAN LENGTH	NC	NC	40.0	49.9	54.7	53.3	45.8	26.0	NC	NC	NC	
		S.E.			0.0	2.04	5.24	4.41	5.92	0.0				
		N MEASURED			1	23	3	3	4	1				
8/ 8- 8/12	SHOALS	MEAN LENGTH	NC	58.4	50.0	NC		NC						
		S.E.		1.24	0.0									
		N MEASURED		40	1									
	BOTTOM	MEAN LENGTH		62.5	NC	46.0	NC	NC	53.0	51.0	NC	65.0	74.0	62.8
		S.E.		13.50		0.0			0.0	0.0		0.0	0.0	3.37
		N MEASURED		2		1			1	1		1	1	6
	CHANNEL	MEAN LENGTH	NC	NC	NC	51.5	40.6	NC	NC	NC	NC	NC	NC	
		S.E.				1.45	0.0							
		N MEASURED				6	1							

Table B-30

Mean Regional Water Temperature (°C), Dissolved Oxygen (mg/ℓ), Conductivity (mS/cm), and Striped Bass Yolk-Sac Larvae Density (No./1000 m^3) during Periods of Striped Bass Yolk-Sac Larvae Abundance, 1974-1977

		REGION											
1974		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
May 26-Jun 1	Temp.	17.5	17.1	17.0	16.8	16.5	16.7	18.0	18.5	18.0	16.8	16.9	15.7
	D.O.	8.2	9.4	8.8	8.3	8.6	4.8	5.3	5.0	6.6	8.2	8.6	9.4
	Cond.	4245	1138	185	180	176	173	151	153	150	152	161	177
	Dens.	0.0	9.4	127.7	36.9	38.4	242.4	214.7	121.0	9.0	5.8	0.0	0.0
Jun 2-Jun 8	Temp.	18.6	19.6	19.6	19.1	19.1	18.0	19.6	18.7	18.6	17.7	17.0	17.5
	D.O.	6.7	9.4	9.3	7.9	7.7	7.3	7.7	8.5	8.5	10.2	9.3	8.9
	Cond.	9951	1811	185	153	152	146	149	155	169	181	188	185
	Dens.	0.0	0.1	2.7	0.2	42.9	208.5	202.6	35.9	14.0	0.0	0.0	0.0
Jun 9-Jun 15	Temp.	21.1	20.8	21.4	20.5	20.2	20.8	20.3	21.0	21.5	22.9	21.9	22.2
	D.O.	9.0	9.2	8.8	8.1	7.7	8.2	7.6	8.9	9.5	6.9	8.4	6.7
	Cond.	6618	2997	1196	858	226	147	156	153	164	166	168	162
	Dens.	0.0	0.1	19.4	210.5	145.1	115.9	61.4	0.0	3.8	0.4	2.0	0.0
1975													
May 25-May 31	Temp.	18.6	19.8	20.7	19.5	19.6	20.2	20.7	21.2	21.2	21.0	20.9	20.5
	D.O.	7.8	9.8	11.1	9.4	9.1	9.0	9.2	8.3	8.4	9.3	8.9	8.2
	Cond.	6287	1166	171	149	148	166	146	150	156	150	154	153
	Dens.	0.1	103.5	206.4	491.3	461.5	336.5	229.5	440.2	134.5	128.6	3.2	0.0
Jun 1-Jun 7	Temp.	20.5	20.5	21.0	20.5	20.2	20.2	20.7	21.5	21.7	22.6	21.9	22.5
	D.O.	9.4	8.3	9.3	9.0	9.2	8.8	8.6	8.7	8.5	9.0	7.3	7.4
	Cond.	5798	4754	1627	1052	210	166	154	140	148	151	157	158
	Dens.	0.0	1.3	380.9	482.4	580.2	390.1	151.5	101.3	3.6	19.4	0.0	0.0
1976													
May 16-May 22	Temp.	16.9	15.5	15.4	14.7	15.0	15.2	14.3	14.1	14.0	15.0	14.8	15.2
	D.O.	9.3	10.9	10.3	9.6	9.8	9.9	9.7	9.5	9.9	9.8	10.3	9.6
	Cond.	3011	207	165	157	145	159	142	139	144	147	156	156
	Dens.	2.8	66.3	65.3	188.4	114.4	55.8	41.3	6.6	3.8	0.0	0.0	0.7
Jun 6-Jun 12	Temp.	19.0	20.2	19.8	17.9	17.1	17.7	18.1	19.0	20.5	20.1	20.8	21.0
	Cond.	5.1	10.3	10.8	9.4	9.3	9.2	8.3	8.2	9.2	9.7	9.8	9.6
	D.O.	12505	2453	284	169	158	164	147	152	155	157	187	208
	Dens.	0.0	6.2	18.8	71.0	82.2	80.9	118.9	51.4	14.3	35.8	2.8	0.0
Jun 13-Jun 19	Temp.	20.2	21.2	20.6	19.6	19.3	20.4	20.2	21.4	21.6	21.7	22.3	22.4
	D.O.	6.5	10.3	10.3	9.2	8.7	8.5	8.7	8.8	8.8	8.8	8.7	9.0
	Cond.	7122	795	314	163	151	152	150	160	165	183	200	[illegible]
	Dens.	0.0	0.0	24.0	124.1	174.0	120.9	115.9	134.3	49.4	22.1	13.7	0.0
1977													
May 27-May 28	Temp.	19.1	18.6	20.7	19.1	18.9	18.9	--	18.9	19.7	20.4	21.7	21.9
	D.O.	8.3	9.3	10.8	9.4	9.4	9.6	9.2	10.0	9.6	10.4	9.3	8.3
	Cond.	7524	2048	285	441	158	175	192	179	173	164	169	160
	Dens.	0.0	35.9	110.4	137.6	102.1	156.1	335.8	267.7	27.1	49.3	15.3	0.0
May 29-Jun 4	Temp.	18.5	19.3	20.0	20.0	19.2	18.5	19.8	20.5	20.3	20.6	21.3	21.9
	D.O.	7.1	9.0	9.6	9.0	9.6	10.0	8.9	8.7	8.7	8.6	7.9	7.0
	Cond.	17515	9367	5910	3255	382	173	170	166	162	157	158	158
	Dens.	0.0	10.4	26.9	545.5	938.4	362.4	380.1	115.5	174.4	42.2	12.2	0.0
Jun 5-Jun 11	Temp.	17.7	18.6	19.3	19.6	19.1	19.2	18.9	19.0	19.3	19.3	19.5	19.6
	D.O.	7.2	8.0	8.3	7.8	9.2	9.6	8.1	8.0	7.8	8.2	7.5	7.0
	Cond.	13256	7814	4633	2562	329	192	177	197	166	168	179	191
	Dens.	0.0	2.7	119.3	219.3	369.2	118.3	24.0	25.6	22.9	4.1	0.3	2.4

Table B-31

Mean Regional Water Temperature (°C), Dissolved Oxygen (mg/ℓ), Conductivity (mS/cm) and Striped Bass Post Yolk-Sac Larvae Density (No./1000 m^3) during Periods of Striped Bass Post Yolk-Sac Larvae Abundance, 1974-1977

		REGION											
1974		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
Jun 9-Jun 15	Temp	21.1	20.8	21.4	20.5	20.2	20.8	20.3	21.0	21.5	22.9	21.9	22.2
	D.O.	9.0	9.2	8.8	8.1	7.7	8.2	7.6	8.9	9.5	6.9	8.4	6.7
	Cond.	6618	2997	1196	858	226	147	156	153	164	166	168	162
	Dens.	0.2	4.2	64.6	551.7	213.5	134.8	80.0	4.5	2.0	0.6	2.1	0.[illegible]
Jun 16-Jun 22	Temp.	22.1	22.2	22.7	21.5	21.6	21.4	21.0	21.0	21.4	21.9	22.5	22.7
	D.O.	5.1	6.8	7.1	6.9	7.8	8.2	8.0	8.1	8.1	8.2	8.0	5.9
	Cond.	14417	7911	4957	2269	394	166	176	159	161	166	175	193
	Dens.	0.0	8.7	23.8	376.7	335.7	183.9	303.4	67.9	154.6	54.6	54.8	0.3
1975													
Jun 1-Jun 7	Temp.	20.5	20.5	21.0	20.5	20.2	20.2	20.7	21.5	21.7	22.6	21.9	22.5
	D.O.	9.4	8.3	9.3	9.0	9.2	8.8	8.6	8.7	8.5	9.0	7.3	7.4
	Cond.	5798	4754	1627	1052	210	166	154	140	148	151	157	158
	Dens.	1.9	20.9	318.4	651.3	752.5	933.0	581.8	232.8	170.7	11.9	12.2	0.0
Jun 8-Jun 14	Temp	20.2	20.0	20.5	21.0	20.9	21.3	21.2	20.4	19.9	20.0	18.1	17.6
	D.O.	6.1	6.7	7.7	7.2	8.0	8.1	7.5	8.4	8.7	9.3	--	--
	Cond.	12019	7554	4462	2246	394	186	157	161	177	173	206	215
	Dens.	1.2	2.5	513.3	1607.4	578.0	106.3	34.1	17.6	85.4	6.8	0.8	0.0
1976													
Jun 13-Jun 19	Temp.	20.2	21.2	20.6	19.6	19.3	20.4	20.2	21.4	21.6	21.7	22.3	22.4
	D.O.	6.5	10.3	10.3	9.2	8.4	8.5	8.7	8.8	8.8	8.8	8.7	9.0
	Cond.	7122	795	314	168	151	152	150	160	165	183	200	186
	Dens.	0.0	48.0	97.3	275.4	258.9	211.9	121.5	166.0	46.0	7.8	0.0	0.0
Jun 20-Jun 26	Temp.	23.5	23.0	23.4	22.3	21.4	22.7	23.4	23.3	24.3	23.7	23.8	24.0
	D.O.	9.9	9.4	9.5	8.8	8.5	8.5	8.0	7.7	7.7	7.8	6.5	6.3
	Cond.	6357	2272	605	247	149	161	170	188	201	197	201	207
	Dens.	1.6	19.4	303.2	319.5	191.1	83.8	35.0	12.4	18.9	1.2	0.8	0.0
1977													
May 29-Jun 4	Temp.	18.5	19.3	20.0	20.0	19.2	18.5	19.8	20.5	20.3	20.6	21.3	21.9
	D.O.	7.1	9.0	9.6	9.0	9.6	10.0	8.9	8.7	8.7	8.6	7.9	7.0
	Cond.	17515	9367	5910	3255	382	173	170	166	162	157	158	158
	Dens.	0.0	4.2	14.9	197.0	249.1	303.5	453.8	465.8	152.1	59.9	0.0	0.0
Jun 5-Jun 11	Temp.	17.7	18.6	19.3	19.6	19.1	19.2	18.9	19.0	19.3	19.3	19.5	19.6
	D.O.	7.2	8.0	8.3	7.8	9.2	9.6	8.1	8.0	7.8	8.2	7.5	7.0
	Cond.	13256	7814	4633	2562	329	192	177	197	166	168	179	191
	Dens.	0.1	40.2	553.9	657.3	484.7	873.3	226.6	134.6	86.2	20.1	3.9	0.0
Jun 12-Jun 18	Temp.	20.6	20.8	21.2	20.6	19.7	21.0	20.9	20.2	20.0	19.7	20.0	19.3
	D.O.	7.7	8.2	9.2	7.4	9.0	10.0	7.7	7.6	8.1	7.7	8.2	7.6
	Cond.	13283	8071	6251	4703	851	269	200	180	183	184	198	208
	Dens.	0.1	2.0	44.3	433.4	675.9	127.1	31.3	36.8	7.9	0.5	7.0	0.0

Table B-32

Analysis of Variance of Water Temperature Regions of Indian Point, West Point, and Cornwall, April-June 1974-1977, and Test of Interaction between Year and Sampling Period

Source	DF	Sum of Squares	Mean Squares	F Value	PR>F†
Time	4	1815.69	453.92	308.18	0.0001
Year	3	37.89	12.64	8.58	0.0001
Time/Year	12	97.97	8.16	5.54	0.0001
Region	2	2.94	1.47	1.00	0.3741
Time/Region	8	3.02	0.38	0.26	0.9773
Year/Region	6	2.25	0.37	0.25	0.9555
Time/Year/Region	24	5.02	0.21	0.14	1.0000
Error	60	88.38	1.47		

Period	Year	Mean Water Temperature
Second Half Jun	1975	23.2*
	1974	21.2
	1977	21.2
	1976	21.0
First Half Jun	1975	20.7
	1974	19.6
	1977	19.3
Second Half May	1975	18.8
	1977	17.2
	1974	16.7
First Half Jun	1976	16.5
Second Half May	1976	15.3
First Half May	1974	14.2
	1976	14.0
	1975	13.2
	1977	12.9
Second Half Apr	1974	11.2
	1976	11.0
	1977	11.0
	1975	9.5

*No significant ($\alpha>0.05$) difference exists between any two means encompassed by the same line

†Probability of exceeding F value

Table B-33

Chi-Square Test of Length Frequency Distribution of Striped Bass Larvae in Bowline, Nearfield, and Pond Samples, June 1977

Length (mm)	<4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0 8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	<13
6/8 - River	5	90	266	224	127	50	20	7	1	2
6/14 - Pond	5	29	66	51	41	18	8	4	7	7

df = 9 $\chi^2 = 45.5$ $\alpha = 0.005$

Length (mm)	<8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0 16.9	>17
6/16 - River	87	21	31	25	43	32	27	14	6	0
6/24 - Pond	4	2	4	2	10	8	8	13	10	20

df = 9 $\chi^2 = 121.5$ $\alpha = .005$

Length (mm)	<10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16-0-16.9	17.0-17.9	18.0-18.9	19.0-19.9	20.0-20.9	<21
6/21 - River	3	4	10	16	30	26	16	7	6	4	6	4
7/1 - Pond	2	1	3	3	9	15	23	15	12	7	5	12

df = 11 $\chi^2 = 37.8$ $\alpha = 0.005$

Table B-34

Estimated Standing Crops (in Thousands) and Percent Standing Crops of Striped Bass Yolk-Sac Larvae Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of Yolk-Sac Larvae Abundance, 1977

Date		Bowline		Lovett		Indian Point		Roseton		Danskammer	
		Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent
5/16 - 5/19	Above	73,182	77.2	64,142	67.7	60,991	64.4	13,971	14.7	12,781	13.5
	Within	16,682	17.6	22,683	23.9	24,878	26.2	18,476	19.5	17,509	18.5
	Below	4,914	5.2	7,953	8.4	8,910	9.4	62,331	65.8	64,488	68.0
5/23 - 5/26	Above	213,173	82.3	200,073	77.3	197,721	76.4	92,638	35.8	86,030	33.2
	Within	37,696	14.6	44,064	17.0	43,154	16.7	77,691	30.0	80,655	31.1
	Below	8,097	3.1	14,829	5.7	18,091	7.0	88,636	34.2	92,281	35.6
5/31 - 6/02	Above	454,516	85.3	390,299	73.2	368,695	69.2	90,941	17.1	83,460	15.7
	Within	75,995	14.3	138,416	26.0	159,226	29.9	100,968	18.9	99,977	18.8
	Below	2,342	0.4	4,139	0.8	4,932	0.9	340,944	64.0	349,416	65.6
6/ 6 - 6/09	Above	125,112	73.2	100,183	58.6	91,684	53.6	10,818	6.3	10,346	6.0
	Within	45,266	26.4	66,409	38.8	71,383	41.7	13,035	7.6	10,746	6.3
	Below	613	0.4	4,400	2.6	7,924	4.6	147,138	86.0	149,899	87.7

Table B-35

Estimated Standing Crops (in Thousands) and Percent Standing Crops of Striped Bass Post Yolk-Sac Larvae Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of Post Yolk-Sac Larvae Abundance, 1977

Date		Bowline		Lovett		Indian Point		Roseton		Danskammer	
		Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent
5/31 - 6/02	Above	353,982	92.4	332,857	86.9	327,122	85.4	154,241	40.2	145,310	37.9
	Within	28,263	7.4	48,538	12.7	53,833	14.0	111,470	29.1	113,316	29.6
	Below	957	0.2	1,807	0.5	2,248	0.6	117,491	30.7	124,576	32.5
6/ 6 - 6/09	Above	379,059	67.8	316,556	56.6	305,396	54.6	60,769	10.9	56,382	10.1
	Within	171,274	30.6	213,530	38.2	208,326	37.2	105,369	18.8	89,366	16.0
	Below	9,091	1.6	29,339	5.2	45,702	8.2	393,288	70.3	413,676	73.9
6/13 - 6/16	Above	209,582	76.7	160,167	58.6	144,606	52.9	11,540	4.2	10,923	4.0
	Within	63,152	23.1	111,072	40.7	125,324	45.9	15,118	5.5	12,766	4.7
	Below	467	0.2	1,963	0.7	3,271	1.2	246,544	90.2	249,512	91.3

Table B-36

Friedman Rank Sums and Multiple Comparisons Tests of Lateral Distribution of Striped Bass Larvae in Indian Point Nearfield Samples, May-July 1977

	East		Channel		West	
Date	No. Larvae Collected	Rank	No. Larvae Collected	Rank	No. Larvae Collected	Rank
5/11	58	(1)	103	(3)	75	(2)
5/19	50	(1)	55	(3)	54	(2)
5/26	95	(1)	105	(2)	183	(3)
6/1	245	(2)	348	(3)	106	(1)
6/9	457	(2)	493	(3)	321	(1)
6/15	141	(1)	226	(2)	281	(3)
6/29	19	(1)	54	(3)	43	(2)
7/6	9	(2)	12	(3)	4	(1)
Sum of Ranks		11		22		15

S = 7.75, significant at α = 0.05

Multiple Comparisons Test

	E 11	C 22	W 15
E 11	-	11*	4
C 22		-	7
W 15			-

*Significant at α = 0.018

Table B-37

Chi-Square Test of Length Frequency Distribution of Striped Bass Larvae in Indian Point Nearfield and Discharge Samples, May and June 1977

df = 4 χ^2 = 3.5 not significant

Length (mm)	<3.9	4.0-4.9	5.0-5.9	6.0-6.9	>7
5/24 - River	159	399	927	695	67
5/26 - Discharge	4	7	12	15	0

df = 6 χ^2 = 98.9 α = 0.005

Length (mm)	<3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	>9
5/31 - River	11	37	302	451	182	47	11
6/1 - Discharge	5	6	31	82	77	36	14

df = 10 χ^2 = 139.5 α = 0.005

Length (mm)	<3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	>13
6/7 - River	20	44	1203	1424	974	457	164	88	24	12	2
6/9 - Discharge	0	9	186	125	112	82	41	32	15	5	7

df = 12 χ^2 = 319.4 α = 0.005

Length (mm)	-	<4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	>16
6/14 - River		25	208	241	147	108	76	63	35	17	0	2	1	2
6/15 - Discharge		0	18	45	37	61	64	91	70	33	21	6	3	2

Table B-38

Catch per Tow of Young-of-the-Year Striped Bass in 12 Geographic Regions Of Hudson River Estuary (RM 12-152; KM 19-243) Determined from 100-ft (30.5-m) Beach Seine during Daytime, 1977 (Page 1 of 2)

		Region												
DATE		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTAL
APR 3-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
APR 16	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	30	27	35	24	20	6	3	3	5	7	11	199
APR 17-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
APR 30	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	34	37	27	20	22	5	2	2	4	5	4	190
MAY 1-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAY 14	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	21	41	35	49	15	12	2	3	1	4	7	9	199
MAY 15-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAY 28	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	21	26	33	51	21	29	3	3	2	5	8	12	214
MAY 29-	CPUE	0.0	0.0	0.0	0.0	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
JUN 11	SE	0.0	0.0	0.0	0.0	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
	TOWS	18	25	24	51	13	24	4	2	2	4	7	10	184
JUN 12-	CPUE	0.0	0.05	0.0	0.91	0.63	0.18	0.33	4.33	0.33	0.50	0.29	0.18	0.44
JUN 25	SE	0.0	0.05	0.0	0.37	0.38	0.10	0.33	3.84	0.33	0.29	0.29	0.18	0.12
	TOWS	38	22	15	57	24	28	3	3	3	4	7	11	215
JUN 26-	CPUE	9.38	9.25	3.72	8.25	14.24	10.96	1.83	7.33	13.50	7.00	19.43	19.42	10.06
JUL 9	SE	4.12	4.44	1.39	1.43	3.55	3.82	0.75	3.18	11.50	1.87	11.77	12.52	1.29
	TOWS	26	16	18	63	29	24	6	3	2	4	7	12	210
JUL 10-	CPUE	32.24	5.84	8.59	5.88	12.90	6.89	8.50	5.00	2.17	4.25	2.92	14.95	10.33
JUL 23	SE	6.46	1.00	2.14	1.14	4.99	2.39	2.99	2.68	1.08	1.63	1.41	6.02	1.25
	TOWS	21	19	17	41	21	19	12	6	6	8	13	21	204
JUL 24-	CPUE	30.26	16.53	20.56	11.30	3.56	8.38	2.27	1.60	1.83	1.75	12.42	7.05	11.90
AUG 6	SE	5.26	3.96	8.36	2.27	0.95	1.89	1.01	0.75	0.91	0.80	6.14	2.77	1.34
	TOWS	23	15	16	40	18	16	11	5	6	8	12	22	192
AUG 7-	CPUE	26.61	9.64	11.75	6.24	3.82	4.45	1.08	2.80	0.80	3.50	3.86	4.45	8.28
AUG 20	SE	7.26	2.84	2.79	0.96	1.98	1.14	0.34	2.56	0.58	1.07	2.50	2.06	1.24
	TOWS	28	14	12	42	17	20	12	5	5	8	14	22	199

Table B-38 (Page 2 of 2)

DATE		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTAL
		Region												
AUG 21-	CPUE	18.96	6.36	26.57	5.08	3.67	5.71	1.00	1.00	2.80	0.75	4.07	4.95	9.40
SEP 3	SE	3.45	1.39	5.71	0.97	1.27	1.05	0.37	0.52	0.97	0.37	1.87	2.00	1.19
	TOWS	24	14	30	36	15	14	10	6	5	8	14	22	198
SEP 4-	CPUE	29.45	6.91	15.89	5.91	2.87	6.24	7.00	1.50	2.00	2.33	0.14	4.27	9.09
SEP 17	SE	8.64	1.59	2.55	1.10	0.57	0.69	2.86	0.50	1.00	1.86	0.14	2.15	1.12
	TOWS	20	23	36	34	39	25	4	2	3	3	7	11	207
SEP 18-	CPUE	7.63	4.88	18.14	7.40	3.52	4.78	10.20	0.0	1.67	1.67	0.17	2.00	6.16
OCT 1	SE	1.23	0.71	3.78	1.42	0.77	0.80	7.05	0.0	0.88	0.88	0.17	1.64	0.56
	TOWS	30	33	14	30	29	27	5	2	3	3	6	9	191
OCT 2-	CPUE	29.58	5.30	5.06	7.76	4.38	3.45	0.83	0.0	0.50	0.25	0.0	0.30	5.78
OCT 15	SE	10.86	0.98	1.61	2.25	1.01	0.95	0.40	0.0	0.50	0.25	0.0	0.15	0.94
	TOWS	12	30	31	17	34	31	6	2	2	4	6	10	185
OCT 16-	CPUE	16.26	3.21	4.46	2.84	0.93	0.64	0.67	0.0	0.0	0.0	0.0	0.0	3.92
OCT 29	SE	3.90	0.62	0.75	0.81	0.20	0.19	0.49	0.0	0.0	0.0	0.0	0.0	0.64
	TOWS	27	29	35	25	29	28	6	3	3	4	7	10	206
OCT 30-	CPUE	16.25	2.65	4.17	2.04	2.27	0.63	0.0	0.0	0.0	0.0	0.13	0.13	3.44
NOV 12	SE	5.27	0.69	1.34	0.49	0.67	0.19	0.0	0.0	0.0	0.0	0.13	0.13	0.66
	TOWS	20	37	30	28	26	30	4	3	2	3	8	8	199
NOV 13-	CPUE	16.24	2.31	2.56	1.11	0.19	0.08	0.17	0.0	0.0	0.0	0.0	0.0	2.81
NOV 26	SE	4.35	0.41	0.44	0.30	0.09	0.06	0.17	0.0	0.0	0.0	0.0	0.0	0.58
	TOWS	21	32	39	28	21	24	6	3	3	4	8	8	197
NOV 27-	CPUE	7.63	1.41	0.65	0.45	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.59
DEC 10	SE	2.32	0.81	0.26	0.15	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.42
	TOWS	19	17	34	33	17	10	0	0	0	0	0	0	130
DEC 11-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEC 24	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	2	13	16	17	13	0	0	0	0	0	0	0	61

Table B-39

Estimated Standing Crops (in Thousands) of Striped Bass Juveniles in 12 Geographic Regions of Hudson River Estuary (RM 12-152; KM 19-243) Determined from 100-ft (30.5-m) Beach Seine during Daytime, 1977

DATES		REGIONS												
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
5/29- 6/11														
	SC	0	0	0	0	203	0	0	0	0	0	0	0	203
	SE	0	0	0	0	203	0	0	0	0	0	0	0	203
	TOWS	18	25	24	51	13	24	4	2	2	4	7	10	184
6/12- 6/25														
	SC	0	2065	0	8407	1647	1902	2365	5373	2870	8778	5622	2470	41499
	SE	0	2065	0	3408	1013	1103	2365	4767	2870	5068	5622	2470	10866
	TOWS	38	22	15	57	24	28	3	3	3	4	7	11	215
6/26- 7/ 9														
	SC	70677	420279	100095	76065	37534	116718	13009	9093	116220	122889	387268	263808	1728651
	SE	31066	201686	37264	13210	9368	40692	5315	3943	99002	32843	231488	170047	371989
	TOWS	26	16	18	63	29	24	6	3	2	4	7	12	210
7/10- 7/23														
	SC	242789	265439	230947	54169	34011	73437	60312	6200	18653	74611	57513	203153	1321232
	SE	48652	45603	57558	10464	13155	25445	21188)(	3327)(	9276)(	28684	27777	81840	132392
	TOWS	21	19	17	41	21	19	12	6	6	8	13	21	204
7/24- 8/ 6														
	SC	227898	751201	552948	104136	9371	89203	16126	1984	15783	30722	244305	95724	2139397
	SE	39615	179832	224893	20935	2505	20159	7166	928)(	7833	13978	120742	37678	318816
	TOWS	23	15	16	40	18	16	11	5	6	8	12	22	192
8/ 7- 8/20														
	SC	200381	438129	315971	57488	10077	47397	7687	3472	6887	61444	75891	60522	1285344
	SE	54696	129005	75126	8854	5228	12180	2385	3171	5020	18768	49237	28009	170687
	TOWS	28	14	12	42	17	20	12	5	5	8	14	22	199
8/21- 9/ 3														
	SC	142777	288840	714407	46846	9664	60863	7096	1240	24105	13167	80108	67316	1456422
	SE	26004	63117	153607	8974	3340	11133	2591	640	8347	6425	36865	27224	175183
	TOWS	24	14	30	36	15	14	10	6	5	8	14	22	198
9/ 4- 9/17														
	SC	221791	314098	427270	54480	7569	66463	49669	1860	17218	40963	2811	58052	1262239
	SE	65067	72033	68532	10141	1494	7386	20277	620	8609	32582	2811	29260	129190
	TOWS	20	23	36	34	39	25	4	2	3	3	7	11	207
9/18-10/ 1														
	SC	57487	221670	487882	68195	9270	50889	72375	0	14348	29259	3279	27173	1041827
	SE	9245	32476	101672	13052	2029	8515	50043	0	7592	15483	3279	22302	122614
	TOWS	30	33	14	30	29	27	5	2	3	3	6	9	191
10/ 2-10/15														
	SC	222795	240808	136190	71556	11550	36763	5913	0	4304	4389	0	4076	738346
	SE	81811	44653	43270	20735	2654	10109	2848	0	4304	4389	0	2075	105587
	TOWS	12	30	31	17	34	31	6	2	2	4	6	10	185
10/16-10/29														
	SC	122450	145707	119858	26172	2454	6847	4730	0	0	0	0	0	428218
	SE	29401	28198	20278	7462	538	2065	3508	0	0	0	0	0	46296
	TOWS	27	29	35	25	29	28	6	3	3	4	7	10	206
10/30-11/12														
	SC	122381	120343	112046	18760	5981	6746	0	0	0	0	2459	1698	390414
	SE	39674	31258	36080	4558	1758	2073	0	0	0	0	2459	1698	62370
	TOWS	20	37	30	28	26	30	4	3	2	3	8	8	199
11/13-11/26														
	SC	122291	105070	68952	10203	502	688	1183	0	0	0	0	0	309087
	SE	32724	18747	11928	2778	231	614	1183	0	0	0	0	0	39675
	TOWS	21	32	39	28	21	24	6	3	3	4	8	8	197
11/27-12/31														
	SC	57474	64144	17400	4189	155	0	0	0	0	0	0	0	143363
	SE	17480	36973	6988	1395	155	0	0	0	0	0	0	0	41514
	TOWS	19	17	34	33	17	10	0	0	0	0	0	0	130

Table B-40

Estimated Density (No./1000 m^3) of Striped Bass Juveniles in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/4-4/7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3
5/2-5/5	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
5/9-5/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3
5/16-5/19	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3
5/23-5/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3
5/31-6/2	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3
6/6-6/9	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/13-6/16	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/20-6/24	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/27-7/1	DEN	0.8877	3.4301	0.2656	0.9076	1.7421	1.1379	0.4017	0.1617	0.2735	0.0	0.0	0.0
	SE	0.8377	2.7190	0.2656	0.4347	0.8428	0.5276	0.3082	0.1617	0.2735	0.0	0.0	0.0
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3
7/5-7/8	DEN	0.2533	2.8140	2.8146	1.8170	0.6886	3.2387	0.4319	2.0270	1.3495	0.7441	1.0282	0.0
	SE	0.2533	2.2398	0.8959	0.7134	0.5755	1.5736	0.2447	1.0513	0.7119	0.7441	1.0282	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/11-7/15	DEN	0.7837	0.0	6.7033	0.5316	0.0791	1.8052	0.2580	0.3701	0.3708	0.0	3.8156	2.1608
	SE	0.7837	0.0	3.4072	0.3360	0.0791	1.1266	0.1410	0.3701	0.2271	0.0	1.3379	2.1608
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/25-7/29	DEN	0.1312	7.5293	39.0516	9.3797	0.4612	1.5676	1.2082	0.1756	0.6297	0.4166	0.4008	0.0
	SE	0.1312	7.3613	18.2735	5.0548	0.4612	0.9581	0.6091	0.1756	0.2572	0.4166	0.4008	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
8/8-8/12	DEN	0.0	23.3194	0.2632	1.0567	0.1400	0.0	0.0565	0.1594	0.0	0.3833	0.3278	5.8100
	SE	0.0	15.3335	0.2632	0.9614	0.1400	0.0	0.0555	0.1594	0.0	0.3333	0.3278	3.4435
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3

Table B-41

Estimated Standing Crops (in Thousands) of Striped Bass Juveniles in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
2/21-2/25	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/7-3/11	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21-3/26	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/4-4/7	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/18-4/20	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
4/25-4/28	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3	156
5/2-5/5	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
5/9-5/12	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3	157
5/16-5/19	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3	157
5/23-5/26	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3	157
5/31-6/2	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3	155
6/6-6/9	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/13-6/16	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/20-6/24	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/27-7/1	SC	204	1104	39	189	361	159	120	27	39	0	0	0	2241
	SE	204	875	39	91	175	74	92	27	39	0	0	0	929
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3	157
7/5-7/8	SC	58	906	416	378	143	453	129	335	191	131	165	0	3305
	SE	58	721	132	149	119	220	73	174	101	131	165	0	845
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/11-7/15	SC	180	0	990	111	16	252	77	61	52	0	613	154	2507
	SE	180	0	503	70	16	158	42	61	32	0	215	154	626
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/25-7/29	SC	30	2423	5768	1954	96	219	360	29	89	73	64	0	11106
	SE	30	2369	2699	1053	96	134	182	29	36	73	64	0	3752
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
8/8-8/12	SC	0	7504	39	220	29	0	17	26	0	68	53	413	8369
	SE	0	4934	39	200	29	0	17	26	0	68	53	245	4946
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157

Table B-42

Adjusted* Catch per Unit Effort of Young-of-the-Year Striped Bass by Bottom Trawl in Hudson River Estuary, 1977

DATE		TZ	CH	IP	WP	CW	TOTAL
		Region					
APR 3- APR 16	CPUE	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	8	3	11	5	5	32
APR 17- APR 30	CPUE	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	8	3	11	5	5	32
MAY 1- MAY 14	CPUE	0.0	0.0	0.0	0.0	0.92	0.0
	SE	0.0	0.0	0.0	0.0	0.92	0.0
	TOWS	8	3	11	5	5	32
MAY 15- MAY 28	CPUE	0.0	0.0	0.0	0.0	3.69	0.0
	SE	0.0	0.0	0.0	0.0	1.79	0.0
	TOWS	8	3	11	5	5	32
MAY 29- JUN 11	CPUE	0.0	0.0	0.14	0.0	12.00	0.05
	SE	0.0	0.0	0.14	0.0	5.62	0.05
	TOWS	8	3	11	5	5	32
JUN 12- JUN 25	CPUE	1.10	0.0	3.64	0.62	5.23	4.87
	SE	0.55	0.0	1.14	0.38	2.65	2.95
	TOWS	7	2	11	5	5	30
JUN 26- JUL 9	CPUE	0.38	0.0	3.64	2.15	4.00	3.46
	SE	0.38	0.0	1.73	0.92	1.86	1.58
	TOWS	8	3	11	5	5	32
JUL 10- JUL 23	CPUE	0.0	0.0	0.28	0.0	0.0	0.14
	SE	0.0	0.0	0.19	0.0	0.0	0.08
	TOWS	8	3	11	5	5	32
JUL 24- AUG 6	CPUE	0.0	0.0	0.14	0.0	0.0	0.05
	SE	0.0	0.0	0.14	0.0	0.0	0.05
	TOWS	7	3	11	5	5	31
AUG 7- AUG 20	CPUE	0.19	0.0	0.0	0.0	0.0	0.05
	SE	0.19	0.0	0.0	0.0	0.0	0.05
	TOWS	8	3	11	5	5	32
AUG 21- SEP 3	CPUE	0.0	0.0	0.31	0.31	0.0	0.15
	SE	0.0	0.0	0.31	0.31	0.0	0.11
	TOWS	8	3	10	5	5	31
SEP 4- SEP 17	CPUE	0.38	0.0	0.14	0.0	0.0	0.14
	SE	0.38	0.0	0.14	0.0	0.0	0.11
	TOWS	8	3	11	5	5	32
SEP 18- OCT 1	CPUE	0.77	0.0	0.0	0.26	0.0	0.34
	SE	0.41	0.0	0.0	0.26	0.0	0.15
	TOWS	8	3	10	6	5	32
OCT 2- OCT 15	CPUE	1.54	0.0	0.0	0.31	0.0	0.43
	SE	1.54	0.0	0.0	0.31	0.0	0.39
	TOWS	8	3	11	5	5	32
OCT 16- OCT 29	CPUE	0.19	0.0	0.28	0.62	0.0	0.43
	SE	0.19	0.0	0.19	0.38	0.0	0.12
	TOWS	8	3	11	5	5	32
OCT 30- NOV 12	CPUE	0.19	0.51	0.42	0.62	0.0	0.38
	SE	0.19	0.51	0.22	0.38	0.0	0.12
	TOWS	8	3	11	5	5	32
NOV 13- NOV 26	CPUE	0.96	0.0	0.28	0.0	0.0	0.34
	SE	0.65	0.0	0.19	0.0	0.0	0.18
	TOWS	8	3	11	5	5	32
NOV 27- DEC 10	CPUE	1.15	0.0	0.0	0.31	0.0	0.65
	SE	0.76	0.0	0.0	0.31	0.0	0.34
	TOWS	8	1	0	5	5	19

*Adjustment procedure is described on page A-44.

Table B-43

Estimated Density (No./1000 m^3) of Juvenile Striped Bass in Seven Geographic Regions of Hudson River Estuary (RM 14-76; KM 22-122) Determined from Fall Shoals Survey, 1977

DATE		Region YK	TZ	CH	IP	WP	CW	PK
8/15-	DEN	11.104	21.432	39.606	6.711	1.005	4.464	0.581
8/19	SE	2.690	4.660	11.813	3.071	0.703	2.365	0.581
	TOWS	6	35	28	12	6	11	4
8/29-	DEN	4.141	15.399	25.700	3.083	0.0	1.492	0.0
9/ 2	SE	2.035	3.238	4.008	0.899	0.0	0.610	0.0
	TOWS	6	36	28	12	4	10	4
9/12-	DEN	4.262	11.800	1.070	0.541	0.0	0.368	0.0
9/16	SE	2.993	4.929	0.803	0.315	0.0	0.302	0.0
	TOWS	6	36	28	12	4	10	4
9/26-	DEN	1.792	8.765	8.845	2.162	0.0	0.0	0.0
9/30	SE	0.862	2.194	2.404	0.992	0.0	0.0	0.0
	TOWS	6	36	28	12	4	10	4
10/10-	DEN	12.586	1.172	1.677	1.049	0.0	0.0	0.0
10/13	SE	3.567	0.411	0.465	0.460	0.0	0.0	0.0
	TOWS	6	36	28	12	4	9	5
10/24-	DEN	2.457	0.212	0.166	0.258	0.0	0.162	0.526
10/29	SE	0.919	0.118	0.118	0.258	0.0	0.099	0.526
	TOWS	6	36	28	12	4	10	4
11/ 7-	DEN	13.972	6.902	1.654	0.109	0.449	0.0	0.0
11/11	SE	6.864	1.759	0.467	0.109	0.449	0.0	0.0
	TOWS	6	36	30	12	4	10	3
11/20-	DEN	2.367	0.871	0.804	0.102	0.0	0.0	0.0
11/22	SE	1.850	0.306	0.418	0.102	0.0	0.0	0.0
	TOWS	5	36	28	12	4	10	4
12/ 5-	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12/ 6	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	0	0	14	9	0	0	0

Table B-44

Estimated Standing Crops (in Thousands) of Striped Bass Juveniles in Seven Geographic Regions of Hudson River Estuary (RM 14-76; KM 22-122) Determined from Fall Shoals Survey, 1977

DATE		YK	TZ	CH	IP	WP	CW	PK	TOTL
8/15-	SC	296	3939	3422	309	29	200	40	8235
8/19	SE	72	857	1021	141	20	106	40	1347
	TOWS	6	35	28	12	6	11	4	102
8/29-	SC	111	2830	2221	142	0	67	0	5370
9/ 2	SE	54	595	346	41	0	27	0	692
	TOWS	6	36	28	12	4	10	4	100
9/12-	SC	114	2169	92	25	0	17	0	2417
9/16	SE	80	906	69	15	0	14	0	912
	TOWS	6	36	28	12	4	10	4	100
9/26-	SC	48	1611	764	99	0	0	0	2523
9/30	SE	23	403	208	46	0	0	0	456
	TOWS	6	36	28	12	4	10	4	100
10/10-	SC	336	215	145	48	0	0	0	745
10/13	SE	95	76	40	21	0	0	0	130
	TOWS	6	36	28	12	4	9	5	100
10/24-	SC	66	39	14	12	0	7	36	174
10/29	SE	25	22	10	12	0	4	36	51
	TOWS	6	36	28	12	4	10	4	100
11/ 7-	SC	373	1269	143	5	13	0	0	1802
11/11	SE	183	323	40	5	13	0	0	374
	TOWS	6	36	30	12	4	10	3	101
11/20-	SC	63	160	69	5	0	0	0	298
11/22	SE	49	56	36	5	0	0	0	83
	TOWS	5	36	28	12	4	10	4	99
12/ 5-	SC	0	0	0	0	0	0	0	0
12/ 6	SE	0	0	0	0	0	0	0	0
	TOWS	0	0	14	9	0	0	0	23

Table B-45

Catch per Tow of Yearling Striped Bass in 12 Geographic Regions of Hudson River Estuary (RM 12-152; KM 19-243) Determined from 100-ft (30.5-m) Beach Seine, during Daytime, 1978

DATE		Region YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTAL
MAR 26-	CPUE	1.55	0.19	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.20
APR 8	SE	0.62	0.10	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08
	TOWS	11	16	26	12	21	10	8	0	0	0	0	0	104
APR 9-	CPUE	1.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.19
APR 22	SE	0.99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.11
	TOWS	22	24	35	31	30	25	19	3	4	4	3	10	210
APR 23-	CPUE	8.73	0.74	0.12	0.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.09
MAY 6	SE	2.03	0.24	0.06	0.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.29
	TOWS	22	23	26	48	26	15	15	3	3	5	6	11	203
MAY 7-	CPUE	4.56	1.31	0.31	0.20	0.04	0.0	0.56	0.0	0.0	0.0	0.0	0.0	0.86
MAY 20	SE	1.27	0.35	0.14	0.10	0.04	0.0	0.44	0.0	0.0	0.0	0.0	0.0	0.20
	TOWS	25	26	39	30	24	22	9	3	2	5	8	8	201
MAY 21-	CPUE	3.53	6.33	1.75	0.57	0.0	0.0	0.22	0.0	0.0	0.0	0.0	0.0	1.34
JUN 3	SE	1.43	4.42	1.56	0.30	0.0	0.0	0.22	0.0	0.0	0.0	0.0	0.0	0.51
	TOWS	19	18	32	44	26	20	18	1	0	4	6	10	198
JUN 4-	CPUE	1.68	0.79	1.00	0.38	0.11	0.0	0.25	0.0	0.0	0.0	0.17	0.25	0.59
JUN 17	SE	0.60	0.23	0.61	0.18	0.08	0.0	0.25	0.0	0.0	0.0	0.17	0.13	0.13
	TOWS	25	28	32	34	18	20	16	3	3	4	6	12	201
JUN 18-	CPUE	0.47	0.38	0.77	1.76	0.69	1.16	0.17	0.0	0.0	0.0	1.33	0.89	0.83
JUL 1	SE	0.16	0.17	0.20	0.65	0.27	0.45	0.12	0.0	0.0	0.0	0.33	0.35	0.14
	TOWS	19	29	39	37	16	19	18	2	2	4	3	9	197

Table B-46

Estimated Standing Crops of Yearling Striped Bass in 12 Geographic Regions of Hudson River Estuary (RM 12-152; KM 19-243) Determined from 100-ft (30.5-m) Beach Seine during Daytime, 1977

DATES		REGIONS												
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
4/ 3- 4/16														
	SC	14255	15145	0	0	0	0	0	0	0	0	0	0	29400
	SE	3957	7003	0	0	0	0	0	0	0	0	0	0	8043
	TOWS	28	30	27	35	24	20	6	3	3	5	7	11	199
4/17- 4/30														
	SC	30662	25390	1454	0	0	0	0	0	0	0	0	0	57506
	SE	6388	7719	1454	0	0	0	0	0	0	0	0	0	10124
	TOWS	28	34	37	27	20	22	5	2	2	4	5	4	190
5/ 1- 5/14														
	SC	23311	25488	0	0	0	0	0	0	0	0	0	0	48799
	SE	6754	8552	0	0	0	0	0	0	0	0	0	0	10397
	TOWS	21	41	35	49	15	12	2	3	1	4	7	9	199
5/15- 5/28														
	SC	6455	40193	27706	4156	0	0	0	0	0	0	0	0	78510
	SE	3574	10491	15722	2102	0	0	0	0	0	0	0	0	19350
	TOWS	21	26	33	51	21	29	3	3	2	5	8	12	214
5/29- 6/11														
	SC	837	10905	23530	1988	405	0	3548	0	0	4389	2811	21739	70150
	SE	574	4751	11481	829	405	0	3548	0	0	4389	2811	14773	20336
	TOWS	18	25	24	51	13	24	4	2	2	4	7	10	184
6/12- 6/25														
	SC	991	10326	10756	1940	110	380	2365	0	0	13167	0	8646	48682
	SE	419	5928	7329	823	110	380	2365	0	0	13167	0	6151	17512
	TOWS	38	22	15	57	24	28	3	3	3	4	7	11	215
6/26- 7/ 9														
	SC	290	0	5976	1317	91	1775	0	0	0	0	0	1132	10580
	SE	290	0	4640	505	91	1228	0	0	0	0	0	1132	4967
	TOWS	26	16	18	63	29	24	6	3	2	4	7	12	210
7/10- 7/23														
	SC	717	0	3164	0	126	1121	0	0	0	0	0	4529	9656
	SE	717	0	2166	0	126	770	0	0	0	0	0	3424	4188
	TOWS	21	19	17	41	21	19	12	6	6	8	13	21	204
7/24- 8/ 6														
	SC	0	3029	3361	0	439	0	645	496	1435	4389	14757	5558	34109
	SE	0	3029	3361	0	439	0	645	304	1435	2873	11392	2919	13030
	TOWS	23	15	16	40	18	16	11	5	6	8	12	22	192
8/ 7- 8/20														
	SC	269	3245	0	219	0	0	0	0	0	4389	0	0	8123
	SE	269	3245	0	219	0	0	0	0	0	4389	0	0	5469
	TOWS	28	14	12	42	17	20	12	5	5	8	14	22	199
8/21- 9/ 3														
	SC	0	0	0	0	0	0	0	0	0	0	0	1235	1235
	SE	0	0	0	0	0	0	0	0	0	0	0	852	852
	TOWS	24	14	30	36	15	14	10	6	5	8	14	22	198
9/ 4- 9/17														
	SC	0	0	747	0	0	0	1774	0	0	0	2811	1235	6567
	SE	0	0	747	0	0	0	1774	0	0	0	2811	1235	3624
	TOWS	20	23	36	34	39	25	4	2	3	3	7	11	207
9/18-10/ 1														
	SC	753	0	1921	307	91	0	2838	0	0	0	0	0	5910
	SE	554	0	1921	307	91	0	2838	0	0	0	0	0	3486
	TOWS	30	33	14	30	29	27	5	2	3	3	6	9	191
10/ 2-10/15														
	SC	1883	0	1735	542	310	344	1183	0	0	0	3279	0	9275
	SE	1351	0	1206	542	243	344	1183	0	0	0	3279	0	3988
	TOWS	12	30	31	17	34	31	6	2	2	4	6	10	185
10/16-10/29														
	SC	0	0	2305	737	0	380	0	0	0	0	0	1359	4781
	SE	0	0	1698	510	0	380	0	0	0	0	0	1359	2266
	TOWS	27	29	35	25	29	28	6	3	3	4	7	10	206
10/30-11/12														
	SC	0	6140	896	987	0	0	0	0	0	0	2459	0	10483
	SE	0	4000	896	725	0	0	0	0	0	0	2459	0	4835
	TOWS	20	37	30	28	26	30	4	3	2	3	8	8	199
11/13-11/26														
	SC	359	1420	0	0	0	0	0	0	0	0	0	0	1778
	SE	359	1420	0	0	0	0	0	0	0	0	0	0	1464
	TOWS	21	32	39	28	21	24	6	3	3	4	8	8	197

Table B-47

Adjusted Catch per Unit Effort of Yearling
Striped Bass by Bottom Trawl in Hudson River Estuary, 1978

DATE		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTAL
JAN 1-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JAN 14	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	0	0	0	0	0	0	0	0	0	0	0	0	0
APR 9-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
APR 22	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	0	5	3	11	5	5	6	0	0	0	0	0	35
APR 23-	CPUE	0.0	0.19	0.51	0.84	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.32
MAY 6	SE	0.0	0.19	0.51	0.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.12
	TOWS	0	8	3	11	5	5	6	0	0	0	0	0	38
MAY 7-	CPUE	0.0	1.15	0.0	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.28
MAY 20	SE	0.0	0.48	0.0	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.13
	TOWS	0	8	3	11	5	5	6	0	0	0	0	0	38
MAY 21-	CPUE	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08
JUN 3	SE	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08
	TOWS	0	8	3	11	5	5	6	0	0	0	0	0	38
JUN 4-	CPUE	0.0	0.19	0.0	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08
JUN 17	SE	0.0	0.19	0.0	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06
	TOWS	0	8	3	11	5	5	6	0	0	0	0	0	38
JUN 18-	CPUE	0.0	0.19	0.0	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08
JUL 1	SE	0.0	0.19	0.0	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06
	TOWS	0	8	3	11	5	5	6	0	0	0	0	0	38

Table B-48

Range of Mean Water Temperature (°C) Dissolved (mg/ℓ) Oxygen and Conductivity (mS/cm) All Strata Combined in Hudson River Estuary (RM 12-152; KM 19-243) from First Appearance of Juvenile Striped Bass and White Perch (Late June-July) through Period of Declining Abundance (Mid to Late November) in Each Year, 1974 to 1977

	Parameter	1974 Range	1974 Time	1975 Range	1975 Time	1976 Range	1976 Time	1977 Range	1977 Time
Riverwide Range for each Parameter at Time of First Appearance of Juveniles	Temp. (°C)	21.0 - 22.7	Mid to Late Jun	20.3 - 22.8	Mid to Late Jun	23.7 - 25.2	Late Jun	21.3 - 22.6	Mid to Late Jun
	D.O.(PPM)	5.1 - 8.2	Mid to Late Jun	7.1 - 9.2	Mid to Late Jun	6.4 - 8.0	Late Jun	7.3 - 10.2	Mid to Late Jun
	Cond. (μS/cm)	161-14,417	Mid to Late Jun	182-6,881	Mid to Late Jun	163-10,910	Late Jun	185-15,068	Mid to Late Jun
Riverwide Range and Time of Highest Values for Each Parameter	Temp.	24.6 - 26.0	Mid to Late Aug	22.7 - 28.2	Early Aug	23.5 - 25.9	Late Jul	26.5 - 28.2	Mid to Late Jul
	D.O.	10.2 - 11.5	Late Nov	11.1 - 12.3	Early Dec	11.2 - 13.9	Late Nov	10.6 - 13.3	Late Nov
	Cond.	231-21,563	Late Aug	172-14,265	Mid to Late Aug	170-19,491	Late Jul	234-22,514	Late Jul
Riverwide Range and Time of Lowest Values for Each Parameter	Temp.	7.1 - 10.9	Late Nov	4.9 - 7.9	Early Dec	0.4 - 5.7	Late Nov	4.3 - 7.2	Late Nov
	D.O.	3.4 - 8.8	Late Aug	4.3 - 8.1	Early Sep	5.9 - 8.6	Mid Jul	3.9 - 8.7	Mid to Late Aug
	Cond.	217-3,997	Late Nov	177-427	Mid to Late Oct	202-1,208	Late Oct	165-825	Mid Nov

Table B-49 (Page 1 of 12)

Combined Standing Crops (in Thousands, Unadjusted for Catch Efficiency) of Juvenile Striped Bass In Hudson River Estuary Based on Sampling in Shore, Shoal, Bottom, and Channel Strata of Hudson River Estuary, July-December 1977

6/26/77 - 7/ 2/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	151	0	0*****	144	295
	SE	69	0	0	144	160
TAPPAN ZEE (24-33)	SC	898	730	0	130	1758
	SE	447	649	0	130	799
CROTON-HAVER.(34-38)	SC	214	29	0	0	243
	SE	85	29	0	0	90
INDIAN POINT (39-46)	SC	162	20	60	102	344
	SE	35	20	42	76	96
WEST POINT(47-55)	SC	80	0***	0	361	441
	SE	23	0	0	175	177
CORNWALL (56-61)	SC	249	32	39	87	407
	SE	93	21	39	62	120
POUGHKEEPSIE (62-76)	SC	28	2***	32	85	147
	SE	12	2	32	85	92
HYDE PARK (77-85)	SC	19	1***	25	0	45
	SE	9	1	25	0	27
KINGSTON (86-93)	SC	248	8***	29	0	285
	SE	214	8	29	0	216
SAUGERTIES (94-106)	SC	262	0***	0	0	262
	SE	78	0	0	0	78
CATSKILL (107-124)	SC	817	0***	0	0	817
	SE	507	0	0	0	507
ALBANY (125-153)	SC	563	0***	0	0****	563
	SE	371	0	0	0	371
STRATUM TOTAL	SC	3691	822	185	909	5607
	SE	818	650	76	292	1088

7/ 3/77 - 7/ 9/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	151	44	131*****	0	326
	SE	69	44	131	0	154
TAPPAN ZEE (24-33)	SC	898	0	0	906	1804
	SE	447	0	0	721	848
CROTON-HAVER.(34-38)	SC	214	287	33	0	534
	SE	85	96	33	0	132
INDIAN POINT (39-46)	SC	162	140	62	131	495
	SE	35	100	43	51	125
WEST POINT(47-55)	SC	80	2***	24	116	222
	SE	23	2	24	116	121
CORNWALL (56-61)	SC	249	123	0	290	662
	SE	93	100	0	176	223
POUGHKEEPSIE (62-76)	SC	28	2***	33	93	156
	SE	12	2	33	64	73
HYDE PARK (77-85)	SC	19	9***	168	156	352
	SE	9	7	134	98	166
KINGSTON (86-93)	SC	248	13***	48	127	436
	SE	214	13	48	78	233
SAUGERTIES (94-106)	SC	262	32***	89	0	383
	SE	78	32	89	0	123
CATSKILL (107-124)	SC	817	56***	91	0	964
	SE	507	56	91	0	518
ALBANY (125-153)	SC	563	0***	0	0****	563
	SE	371	0	0	0	371
STRATUM TOTAL	SC	3691	708	679	1819	6897
	SE	818	189	241	766	1162

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table B-49 (Page 2 of 12)

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
7/10/77 - 7/16/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	519	135	401*****	0	1055
	SE	125	135	401	0	441
TAPPAN ZEE (24-33)	SC	567	0	0	0	567
	SE	123	0	0	0	123
CROTON-HAVER.(34-38)	SC	493	720	30	0	1243
	SE	139	377	30	0	403
INDIAN POINT (39-46)	SC	116	15	0	91	222
	SE	27	15	0	67	74
WEST POINT(47-55)	SC	73	1***	15	0	89
	SE	30	1	15	0	34
CORNWALL (56-61)	SC	157	105	17	96	375
	SE	58	105	17	73	141
POUGHKEEPSIE (62-76)	SC	129	5***	70	0	204
	SE	48	3	38	0	61
HYDE PARK (77-85)	SC	13	0***	0	61	74
	SE	7	0	0	61	61
KINGSTON (86-93)	SC	40	10***	39	0	89
	SE	21	6	24	0	32
SAUGERTIES (94-106)	SC	159	0***	0	0	159
	SE	65	0	0	0	65
CATSKILL (107-124)	SC	123	177***	289	88	677
	SE	62	66	108	88	166
ALBANY (125-153)	SC	434	41***	29	69****	573
	SE	184	41	29	69	203
STRATUM TOTAL	SC	2823	1209	890	405	5327
	SE	316	422	420	161	693

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
7/17/77 - 7/23/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	519	79**	234**	0**	832
	SE	125	79	234	0	277
TAPPAN ZEE (24-33)	SC	567	888**	27**	0**	1482
	SE	123	888	27	0	897
CROTON-HAVER.(34-38)	SC	493	1485**	1381**	18**	3377
	SE	139	862	1022	18	1344
INDIAN POINT (39-46)	SC	116	387**	162**	356**	1021
	SE	27	387	106	141	426
WEST POINT(47-55)	SC	73	0**	7**	48**	128
	SE	30	0	7	48	57
CORNWALL (56-61)	SC	157	104**	8**	88**	357
	SE	58	93	8	77	134
POUGHKEEPSIE (62-76)	SC	129	7**	106**	102**	344
	SE	48	6	80	61	112
HYDE PARK (77-85)	SC	13	0**	13**	30**	56
	SE	7	0	13	30	33
KINGSTON (86-93)	SC	40	13**	52**	0**	105
	SE	21	6	25	0	33
SAUGERTIES (94-106)	SC	159	9**	25**	0**	193
	SE	65	9	25	0	70
CATSKILL (107-124)	SC	123	99**	162**	44**	428
	SE	62	43	71	44	113
ALBANY (125-153)	SC	434	20**	14**	34**	502
	SE	184	20	14	34	189
STRATUM TOTAL	SC	2823	3091	2191	720	8825
	SE	316	1303	1060	190	1720

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table B-49 (Page 3 of 12)

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	487	23	68*****	0	578
	SE	107	23	68	0	129
TAPPAN ZEE (24-33)	SC	1605	1776	55	0	3436
	SE	440	1776	55	0	1831
CROTON-HAVER.(34-38)	SC	1181	2251	2733	36	6201
	SE	505	1348	2015	36	2477
INDIAN POINT (39-46)	SC	222	760	324	622	1928
	SE	54	760	213	215	820
WEST POINT(47-55)	SC	20	0***	0	96	116
	SE	6	0	0	96	96
CORNWALL (56-61)	SC	191	104	0	81	376
	SE	50	81	0	81	125
POUGHKEEPSIE (62-76)	SC	34	10***	143	204	391
	SE	16	9	123	122	174
HYDE PARK (77-85)	SC	4	1***	27	0	32
	SE	2	1	27	0	27
KINGSTON (86-93)	SC	34	17***	66	0	117
	SE	17	7	27	0	33
SAUGERTIES (94-106)	SC	66	18***	50	0	134
	SE	31	18	50	0	62
CATSKILL (107-124)	SC	522	21***	35	0	578
	SE	267	21	35	0	270
ALBANY (125-153)	SC	204	0***	0	0****	204
	SE	85	0	0	0	85
STRATUM TOTAL	SC	4570	4981	3501	1039	14091
	SE	739	2357	2033	280	3211

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	487	11**	34**	0**	532
	SE	107	11	34	0	113
TAPPAN ZEE (24-33)	SC	1605	3654**	91**	0**	5350
	SE	440	2738	59	0	2774
CROTON-HAVER.(34-38)	SC	1181	1140**	1366**	18**	3705
	SE	505	688	1007	18	1320
INDIAN POINT (39-46)	SC	222	380**	172**	410**	1184
	SE	54	380	117	207	452
WEST POINT(47-55)	SC	20	0**	0**	62**	82
	SE	6	0	0	62	62
CORNWALL (56-61)	SC	191	52**	0**	40**	283
	SE	50	40	0	40	75
POUGHKEEPSIE (62-76)	SC	34	5**	79**	102**	220
	SE	16	5	69	61	94
HYDE PARK (77-85)	SC	4	1**	26**	0**	31
	SE	2	1	26	0	26
KINGSTON (86-93)	SC	34	8**	33**	0**	75
	SE	17	3	13	0	22
SAUGERTIES (94-106)	SC	66	17**	48**	0**	131
	SE	31	17	48	0	60
CATSKILL (107-124)	SC	522	19**	32**	0**	573
	SE	267	19	32	0	270
ALBANY (125-153)	SC	204	56**	39**	93**	392
	SE	85	33	23	55	109
STRATUM TOTAL	SC	4570	5343	1920	725	12558
	SE	739	2849	1021	235	3124

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
8/ 7/77 - 8/13/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	428	0	0*****	0	428
	SE	130	0	0	0	130
TAPPAN ZEE (24-33)	SC	936	5532	127	0	6595
	SE	303	3700	63	0	3713
CROTON-HAVER.(34-38)	SC	675	29	0	0	704
	SE	184	29	0	0	186
INDIAN POINT (39-46)	SC	123	0	21	199	343
	SE	25	0	21	199	202
WEST POINT(47-55)	SC	22	0***	0	29	51
	SE	12	0	0	29	31
CORNWALL (56-61)	SC	101	0	0	0	101
	SE	29	0	0	0	29
POUGHKEEPSIE (62-76)	SC	16	1***	15	0	32
	SE	5	1	15	0	16
HYDE PARK (77-85)	SC	7	1***	25	0	33
	SE	6	1	25	0	26
KINGSTON (86-93)	SC	15	0***	0	0	15
	SE	11	0	0	0	11
SAUGERTIES (94-106)	SC	131	16***	46	0	193
	SE	44	16	46	0	66
CATSKILL (107-124)	SC	162	18***	29	0	209
	SE	107	18	29	0	112
ALBANY (125-153)	SC	129	112***	79	187****	507
	SE	62	67	47	111	151
STRATUM TOTAL	SC	2745	5709	342	415	9211
	SE	402	3701	102	230	3731

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
8/14/77 - 8/20/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	428	222	659*****	0*	1309
	SE	130	54	160	0	213
TAPPAN ZEE (24-33)	SC	936	2479	633	0*	4048
	SE	303	575	382	0	754
CROTON-HAVER.(34-38)	SC	675	2123	592	0*	3390
	SE	184	744	241	0	803
INDIAN POINT (39-46)	SC	123	226	9	0*	358
	SE	25	106	9	0	109
WEST POINT(47-55)	SC	22	2***	26	0*	50
	SE	12	1	18	0	22
CORNWALL (56-61)	SC	101	18	177	0*	296
	SE	29	8	105	0	109
POUGHKEEPSIE (62-76)	SC	16	3***	37	0*	56
	SE	5	3	37	0	37
HYDE PARK (77-85)	SC	7	0*	0*	0*	7
	SE	6	0	0	0	6
KINGSTON (86-93)	SC	15	0*	0*	0*	15
	SE	11	0	0	0	11
SAUGERTIES (94-106)	SC	131	0*	0*	0*	131
	SE	44	0	0	0	44
CATSKILL (107-124)	SC	162	0*	0*	0*	162
	SE	107	0	0	0	107
ALBANY (125-153)	SC	129	0*	0*	0*	129
	SE	62	0	0	0	62
STRATUM TOTAL	SC	2745	5073	2133	0	9951
	SE	402	948	492	0	1141

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table B-49 (Page 5 of 12)

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
8/21/77 - 8/27/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	305	152**	452**	0*	909
	SE	69	47	141	0	164
TAPPAN ZEE (24-33)	SC	617	1857**	908**	0*	3382
	SE	158	423	427	0	621
CROTON-HAVER.(34-38)	SC	1526	1749**	489**	0*	3764
	SE	386	474	226	0	652
INDIAN POINT (39-46)	SC	100	160**	12**	0*	272
	SE	23	67	12	0	72
WEST POINT(47-55)	SC	21	1**	13**	0*	35
	SE	8	0	9	0	12
CORNWALL (56-61)	SC	130	19**	108**	0*	257
	SE	29	9	64	0	71
POUGHKEEPSIE (62-76)	SC	15	1**	18**	0*	34
	SE	6	1	18	0	19
HYDE PARK (77-85)	SC	3	0*	0*	0*	3
	SE	2	0	0	0	2
KINGSTON (86-93)	SC	51	0*	0*	0*	51
	SE	19	0	0	0	19
SAUGERTIES (94-106)	SC	28	0*	0*	0*	28
	SE	14	0	0	0	14
CATSKILL (107-124)	SC	171	0*	0*	0*	171
	SE	82	0	0	0	82
ALBANY (125-153)	SC	144	0*	0*	0*	144
	SE	61	0	0	0	61
STRATUM TOTAL	SC	3111	3939	2000	0	9050
	SE	437	641	508	0	927

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
8/28/77 - 9/ 3/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	305	83	246*****	0*	634
	SE	69	41	122	0	146
TAPPAN ZEE (24-33)	SC	617	1235	1183	0*	3035
	SE	158	271	473	0	568
CROTON-HAVER.(34-38)	SC	1526	1376	387	0*	3289
	SE	386	205	212	0	486
INDIAN POINT (39-46)	SC	100	95	16	0*	211
	SE	23	29	16	0	40
WEST POINT(47-55)	SC	21	0***	0	0*	21
	SE	8	0	0	0	8
CORNWALL (56-61)	SC	130	21	39	0*	190
	SE	29	10	24	0	39
POUGHKEEPSIE (62-76)	SC	15	0***	0	0*	15
	SE	6	0	0	0	6
HYDE PARK (77-85)	SC	3	0*	0*	0*	3
	SE	2	0	0	0	2
KINGSTON (86-93)	SC	51	0*	0*	0*	51
	SE	19	0	0	0	19
SAUGERTIES (94-106)	SC	28	0*	0*	0*	28
	SE	14	0	0	0	14
CATSKILL (107-124)	SC	171	0*	0*	0*	171
	SE	82	0	0	0	82
ALBANY (125-153)	SC	144	0*	0*	0*	144
	SE	61	0	0	0	61
STRATUM TOTAL	SC	3111	2810	1871	0	7792
	SE	437	344	533	0	770

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
9/ 4/77 - 9/10/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	474	84**	249**	0*	807
	SE	153	50	150	0	220
TAPPAN ZEE (24-33)	SC	671	1381**	657**	0*	2709
	SE	178	474	263	0	571
CROTON-HAVER.(34-38)	SC	913	719**	197**	0*	1829
	SE	190	128	110	0	254
INDIAN POINT (39-46)	SC	116	52**	13**	0*	181
	SE	27	18	13	0	35
WEST POINT(47-55)	SC	16	0**	0**	0*	16
	SE	4	0	0	0	4
CORNWALL (56-61)	SC	142	12**	26**	0*	180
	SE	25	6	18	0	31
POUGHKEEPSIE (62-76)	SC	106	0**	0**	0*	106
	SE	46	0	0	0	46
HYDE PARK (77-85)	SC	4	0*	0*	0*	4
	SE	1	0	0	0	1
KINGSTON (86-93)	SC	37	0*	0*	0*	37
	SE	19	0	0	0	19
SAUGERTIES (94-106)	SC	87	0*	0*	0*	87
	SE	70	0	0	0	70
CATSKILL (107-124)	SC	6	0*	0*	0*	6
	SE	6	0	0	0	6
ALBANY (125-153)	SC	124	0*	0*	0*	124
	SE	65	0	0	0	65
STRATUM TOTAL	SC	2696	2248	1142	0	6086
	SE	323	494	323	0	673

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
9/11/77 - 9/17/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	474	85	252*****	0*	811
	SE	153	60	178	0	242
TAPPAN ZEE (24-33)	SC	671	1527	132	0*	2330
	SE	178	678	54	0	703
CROTON-HAVER.(34-38)	SC	913	63	8	0*	984
	SE	190	52	8	0	197
INDIAN POINT (39-46)	SC	116	10	11	0*	137
	SE	27	7	11	0	30
WEST POINT(47-55)	SC	16	0***	0	0*	16
	SE	4	0	0	0	4
CORNWALL (56-61)	SC	142	3	13	0*	158
	SE	25	3	13	0	28
POUGHKEEPSIE (62-76)	SC	106	0***	0	0*	106
	SE	46	0	0	0	46
HYDE PARK (77-85)	SC	4	0*	0*	0*	4
	SE	1	0	0	0	1
KINGSTON (86-93)	SC	37	0*	0*	0*	37
	SE	19	0	0	0	19
SAUGERTIES (94-106)	SC	87	0*	0*	0*	87
	SE	70	0	0	0	70
CATSKILL (107-124)	SC	6	0*	0*	0*	6
	SE	6	0	0	0	6
ALBANY (125-153)	SC	124	0*	0*	0*	124
	SE	65	0	0	0	65
STRATUM TOTAL	SC	2696	1688	416	0	4800
	SE	323	683	187	0	778

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table B-49 (Page 7 of 12)

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
9/18/77 - 9/24/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	123	60**	179**	0*	362
	SE	26	38	114	0	123
TAPPAN ZEE (24-33)	SC	473	1086**	441**	0*	2000
	SE	94	427	190	0	477
CROTON-HAVER.(34-38)	SC	1042	253**	90**	0*	1385
	SE	258	91	59	0	280
INDIAN POINT (39-46)	SC	146	28**	24**	0*	198
	SE	34	19	14	0	41
WEST POINT(47-55)	SC	20	0**	0**	0*	20
	SE	5	0	0	0	5
CORNWALL (56-61)	SC	109	1**	6**	0*	116
	SE	23	1	6	0	24
POUGHKEEPSIE (62-76)	SC	155	0**	0**	0*	155
	SE	109	0	0	0	109
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	31	0*	0*	0*	31
	SE	17	0	0	0	17
SAUGERTIES (94-106)	SC	62	0*	0*	0*	62
	SE	34	0	0	0	34
CATSKILL (107-124)	SC	7	0*	0*	0*	7
	SE	7	0	0	0	7
ALBANY (125-153)	SC	58	0*	0*	0*	58
	SE	48	0	0	0	48
STRATUM TOTAL	SC	2226	1428	740	0	4394
	SE	306	439	230	0	582

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
9/25/77 - 10/ 1/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	123	36	107*****	0*	266
	SE	26	17	50	0	59
TAPPAN ZEE (24-33)	SC	473	646	751	0*	1870
	SE	94	177	327	0	384
CROTON-HAVER.(34-38)	SC	1042	444	172	0*	1658
	SE	258	131	111	0	310
INDIAN POINT (39-46)	SC	146	47	37	0*	230
	SE	34	32	17	0	50
WEST POINT(47-55)	SC	20	0***	0	0*	20
	SE	5	0	0	0	5
CORNWALL (56-61)	SC	109	0	0	0*	109
	SE	23	0	0	0	23
POUGHKEEPSIE (62-76)	SC	155	0***	0	0*	155
	SE	109	0	0	0	109
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	31	0*	0*	0*	31
	SE	17	0	0	0	17
SAUGERTIES (94-106)	SC	62	0*	0*	0*	62
	SE	34	0	0	0	34
CATSKILL (107-124)	SC	7	0*	0*	0*	7
	SE	7	0	0	0	7
ALBANY (125-153)	SC	58	0*	0*	0*	58
	SE	48	0	0	0	48
STRATUM TOTAL	SC	2226	1173	1067	0	4466
	SE	306	223	349	0	515

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table B-49 (Page 8 of 12)

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
10/ 2/77 - 10/ 8/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	476	144**	427**	0*	1047
	SE	186	44	130	0	231
TAPPAN ZEE (24-33)	SC	514	375**	413**	0*	1302
	SE	117	114	180	0	243
CROTON-HAVER.(34-38)	SC	291	234**	142**	0*	667
	SE	100	71	74	0	143
INDIAN POINT (39-46)	SC	153	29**	35**	0*	217
	SE	49	21	16	0	56
WEST POINT(47-55)	SC	25	0**	0**	0*	25
	SE	7	0	0	0	7
CORNWALL (56-61)	SC	79	0**	0**	0*	79
	SE	24	0	0	0	24
POUGHKEEPSIE (62-76)	SC	13	0**	0**	0*	13
	SE	6	0	0	0	6
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	9	0*	0*	0*	9
	SE	9	0	0	0	9
SAUGERTIES (94-106)	SC	9	0*	0*	0*	9
	SE	9	0	0	0	9
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	9	0*	0*	0*	9
	SE	5	0	0	0	5
STRATUM TOTAL	SC	1578	782	1017	0	3377
	SE	248	143	235	0	370

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
10/ 9/77 - 10/15/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	476	252	748*****	0*	1476
	SE	186	71	211	0	290
TAPPAN ZEE (24-33)	SC	514	105	75	0*	694
	SE	117	51	34	0	132
CROTON-HAVER.(34-38)	SC	291	25	112	0*	428
	SE	100	12	37	0	107
INDIAN POINT (39-46)	SC	153	11	33	0*	197
	SE	49	11	15	0	52
WEST POINT(47-55)	SC	25	0***	0	0*	25
	SE	7	0	0	0	7
CORNWALL (56-61)	SC	79	0	0	0*	79
	SE	24	0	0	0	24
POUGHKEEPSIE (62-76)	SC	13	0***	0	0*	13
	SE	6	0	0	0	6
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	9	0*	0*	0*	9
	SE	9	0	0	0	9
SAUGERTIES (94-106)	SC	9	0*	0*	0*	9
	SE	9	0	0	0	9
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	9	0*	0*	0*	9
	SE	5	0	0	0	5
STRATUM TOTAL	SC	1578	393	968	0	2939
	SE	248	89	217	0	341

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
10/16/77 - 10/22/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	262	150**	446**	0*	858
	SE	72	44	132	0	157
TAPPAN ZEE (24-33)	SC	311	56**	51**	0*	418
	SE	73	29	26	0	83
CROTON-HAVER.(34-38)	SC	256	15**	59**	0*	330
	SE	55	8	22	0	60
INDIAN POINT (39-46)	SC	56	5**	22**	0*	83
	SE	18	5	13	0	23
WEST POINT(47-55)	SC	5	0**	0**	0*	5
	SE	1	0	0	0	1
CORNWALL (56-61)	SC	15	2**	0**	0*	17
	SE	5	1	0	0	5
POUGHKEEPSIE (62-76)	SC	10	1**	16**	0*	27
	SE	8	1	16	0	18
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
STRATUM TOTAL	SC	915	229	594	0	1738
	SE	118	54	138	0	189

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
10/23/77 - 10/29/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	262	49	145*****	0*	456
	SE	72	18	53	0	91
TAPPAN ZEE (24-33)	SC	311	8	28	0*	347
	SE	73	8	19	0	76
CROTON-HAVER.(34-38)	SC	256	5	7	0*	268
	SE	55	5	7	0	56
INDIAN POINT (39-46)	SC	56	0	12	0*	68
	SE	18	0	12	0	22
WEST POINT(47-55)	SC	5	0***	0	0*	5
	SE	1	0	0	0	1
CORNWALL (56-61)	SC	15	5	0	0*	20
	SE	5	3	0	0	6
POUGHKEEPSIE (62-76)	SC	10	2***	33	0*	45
	SE	8	2	33	0	34
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
STRATUM TOTAL	SC	915	69	225	0	1209
	SE	118	21	67	0	137

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
10/30/77 - 11/ 5/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	261	164**	486**	0*	911
	SE	91	77	229	0	258
TAPPAN ZEE (24-33)	SC	257	460**	39**	0*	756
	SE	75	124	28	0	148
CROTON-HAVER.(34-38)	SC	239	44**	20**	0*	303
	SE	83	16	12	0	85
INDIAN POINT (39-46)	SC	40	2**	6**	0*	48
	SE	11	2	6	0	13
WEST POINT(47-55)	SC	13	0**	6**	0*	19
	SE	4	0	6	0	7
CORNWALL (56-61)	SC	14	2**	0**	0*	16
	SE	5	1	0	0	5
POUGHKEEPSIE (62-76)	SC	0	1**	16**	0*	17
	SE	0	1	16	0	16
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	5	0*	0*	0*	5
	SE	5	0	0	0	5
ALBANY (125-153)	SC	4	0*	0*	0*	4
	SE	4	0	0	0	4
STRATUM TOTAL	SC	833	673	573	0	2079
	SE	145	147	232	0	311

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
11/ 6/77 - 11/12/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	261	279	828*****	0*	1368
	SE	91	137	406	0	438
TAPPAN ZEE (24-33)	SC	257	913	51	0*	1221
	SE	75	241	38	0	255
CROTON-HAVER.(34-38)	SC	239	83	33	0*	355
	SE	83	27	18	0	89
INDIAN POINT (39-46)	SC	40	4	0	0*	44
	SE	11	4	0	0	12
WEST POINT(47-55)	SC	13	1***	12	0*	26
	SE	4	1	12	0	13
CORNWALL (56-61)	SC	14	0	0	0*	14
	SE	5	0	0	0	5
POUGHKEEPSIE (62-76)	SC	0	0***	0	0*	0
	SE	0	0	0	0	0
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	5	0*	0*	0*	5
	SE	5	0	0	0	5
ALBANY (125-153)	SC	4	0*	0*	0*	4
	SE	4	0	0	0	4
STRATUM TOTAL	SC	833	1280	924	0	3037
	SE	145	279	408	0	515

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
11/13/77 - 11/19/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	261	163**	483**	0*	907
	SE	78	87	258	0	283
TAPPAN ZEE (24-33)	SC	224	516**	25**	0*	765
	SE	50	137	19	0	147
CROTON-HAVER.(34-38)	SC	147	55**	32**	0*	234
	SE	32	23	21	0	45
INDIAN POINT (39-46)	SC	22	4**	0**	0*	26
	SE	7	4	0	0	8
WEST POINT(47-55)	SC	1	0**	6**	0*	7
	SE	0	0	6	0	6
CORNWALL (56-61)	SC	2	0**	0**	0*	2
	SE	1	0	0	0	1
POUGHKEEPSIE (62-76)	SC	3	0**	0**	0*	3
	SE	3	0	0	0	3
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
STRATUM TOTAL	SC	660	738	546	0	1944
	SE	98	164	260	0	323

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
11/20/77 - 11/26/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	261	47	139*****	0*	447
	SE	78	37	110	0	140
TAPPAN ZEE (24-33)	SC	224	120	0	0*	344
	SE	50	34	0	0	60
CROTON-HAVER.(34-38)	SC	147	28	32	0*	207
	SE	32	19	25	0	45
INDIAN POINT (39-46)	SC	22	4	0	0*	26
	SE	7	4	0	0	8
WEST POINT(47-55)	SC	1	0***	0	0*	1
	SE	0	0	0	0	0
CORNWALL (56-61)	SC	2	0	0	0*	2
	SE	1	0	0	0	1
POUGHKEEPSIE (62-76)	SC	3	0***	0	0*	3
	SE	3	0	0	0	3
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
STRATUM TOTAL	SC	660	199	171	0	1030
	SE	98	54	113	0	159

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table B-49 (Page 12 of 12)

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
11/27/77 - 12/ 3/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	123	0*	0*	0*	123
	SE	41	0	0	0	41
TAPPAN ZEE (24-33)	SC	137	0*	0*	0*	137
	SE	81	0	0	0	81
CROTON-HAVER.(34-38)	SC	37	14**	16**	0*	67
	SE	16	9	12	0	22
INDIAN POINT (39-46)	SC	9	2**	0**	0*	11
	SE	3	2	0	0	4
WEST POINT(47-55)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CORNWALL (56-61)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
POUGHKEEPSIE (62-76)	SC	3	0*	0*	0*	3
	SE	3	0	0	0	3
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
STRATUM TOTAL	SC	309	16	16	0	341
	SE	92	9	12	0	93

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

JUVENILE S. BASS
COMBINED STANDING CROP (1000'S)
AND STANDARD ERROR
12/ 4/77 - 12/10/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	123	0*	0*	0*	123
	SE	41	0	0	0	41
TAPPAN ZEE (24-33)	SC	137	0*	0*	0*	137
	SE	81	0	0	0	81
CROTON-HAVER.(34-38)	SC	37	0	0	0*	37
	SE	16	0	0	0	16
INDIAN POINT (39-46)	SC	9	0	0	0*	9
	SE	3	0	0	0	3
WEST POINT(47-55)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CORNWALL (56-61)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
POUGHKEEPSIE (62-76)	SC	3	0*	0*	0*	3
	SE	3	0	0	0	3
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
STRATUM TOTAL	SC	309	0	0	0	309
	SE	92	0	0	0	92

NIGHT/DAY CATCH RATIO =SBR= 2.1360 VAR(SBR) = 0.0810
BEACH SEINE EFFICIENCY =SBE= 1.0000 VAR(SBE) = 0.0
ICHTHOPLANKTON EFFICIENCY =SBS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

ORGANIC INPUT TO THE HUDSON RIVER

Introduction

The synthesis of reduced carbon compounds by plants forms the basis for all animal production in ecosystems. The energy contained in organic molecules consumed by animals and heterotrophic microorganisms is passed through food webs and supports the respiration, growth, and reproduction in consumer populations.

Maintenance of the trophic structure of stream ecosystems is considered to be primarily dependent on the input of allochthonous organic matter from surrounding terrestrial areas rather than from primary production within the stream itself (Cummins 1974). Fisher and Likens (1973), for example, showed that more than 99% of the biologically available energy (in a first-order stream in New Hampshire) was allochthonous rather than autochthonous in origin. Thus, the rates and timing of allochthonous organic matter input should have a major influence on the production of stream consumer populations. The objective of this appendix section is to outline the patterns and magnitude of allochthonous organic carbon inputs on the Hudson River ecosystem.

Methods

Data on total organic carbon (TOC) concentrations and streamflow in the Hudson and Mohawk Rivers and several smaller tributaries within the Hudson Basin were obtained from USGS records of surface water quality (USGS 1975, 1976, 1977, 1978).

To estimate the movement of organic matter into the Hudson River, TOC concentrations in stream water were converted to watershed organic carbon output: The daily watershed organic carbon output was calculated as:

$$O_t = \frac{C(D)}{1000}$$

where

O_t = daily watershed organic carbon output (kg C/d). (This value can be standardized for watersheds of different areas by dividing by the watershed area (km^2) above the sampling station).

C = total organic carbon concentration in stream water ($mg/\ell = g/m^3$)

D = daily stream discharge. (Values were reported in ft^3/s and converted to m^3/d by multiplying by $0.02832\ m^3/ft^3$ and 86400 s/d, where s represents seconds and d represents days.)

Unit area organic carbon output from a given stream over a sampling interval was calculated by:

$$O_i = \left(\frac{O_b + O_e}{2}\right) t$$

where

O_i = organic carbon output during time interval between concurrent measurements of carbon concentration and streamflow (kg C/km^2)

O_b = organic carbon output at beginning of interval (kg C/km^2/d)

O_e = organic carbon output at end of interval (kg C/km^2/d)

t = days in interval

These carbon output values can then be summed over an annual cycle to provide estimates of annual organic carbon output from a watershed or an average daily carbon output weighted by the different number of days in each sampling interval.

Sewage treatment plants also release organic carbon into the Hudson River. Hetling (1976) provided estimates of the magnitude of biological oxygen demand (BOD) releases from municipal and industrial sources along the lower Hudson River in 1974, summing the data by river region and dividing by river volume in each region (TI 1975c) to estimate the influence of sewage carbon inputs on river water TOC concentrations. BOD values were multiplied by 0.3295 to convert to kilogram carbon (kg C).

Results

TOC concentrations on the Hudson River and its tributaries ranged from <2 to 25 mg/ℓ during 1974-77 (Figure B-4), and the majority of the values were between 3 and 8 mg/ℓ. Values above 10 mg/ℓ occurred on both the Hudson and Mohawk Rivers but were largely restricted to the February-May period in each year. It is not known exactly what produced these exceptionally high values, but most of the sites are near large urban centers and sewage outfalls (Helting 1976). Fisher and Likens (1973) also showed that concentrations of dissolved and particulate organic matter in stream water are positively correlated with streamflow rates and that particulate detritus concentrations may be sharply elevated during high runoff in spring. Thus, these high values likely were influenced primarily by very local events rather than by more generalized processes.

There is little evidence to suggest a seasonal pattern of change in TOC concentrations in the Hudson River or its tributaries (Figure B-4). Although most TOC values appeared somewhat lower in winter and spring than in fall, TOC concentrations in the Mohawk and Hudson Rivers had a much larger range of variation in the late winter and spring. TOC concentrations in the small tributaries (Figure B-4) also had large variations in the fall.

The total movement of organic matter from the terrestrial watershed into the Hudson River is determined by both the TOC concentration in water and the magnitude of streamflow. Examination of estimated unit area TOC release rates (kg C/km^2/d) from several Hudson River watersheds suggests a bimodal pattern of organic carbon input into the Hudson River (Figure B-5). Maximum TOC input rates occurred in late fall and early spring. The late fall maximum was probably a result of the coincident leaf loss from trees in the watershed and increased precipitation and freshwater runoff. Northeastern watersheds are normally covered by snow in winter; increased runoff during snowmelt, combined with heavy spring rains, results in another large pulse of organic carbon into the streams and rivers during spring. The fall and spring peaks of organic matter output from Hudson River watersheds fit very closely the patterns observed by Fisher and Likens (1973).

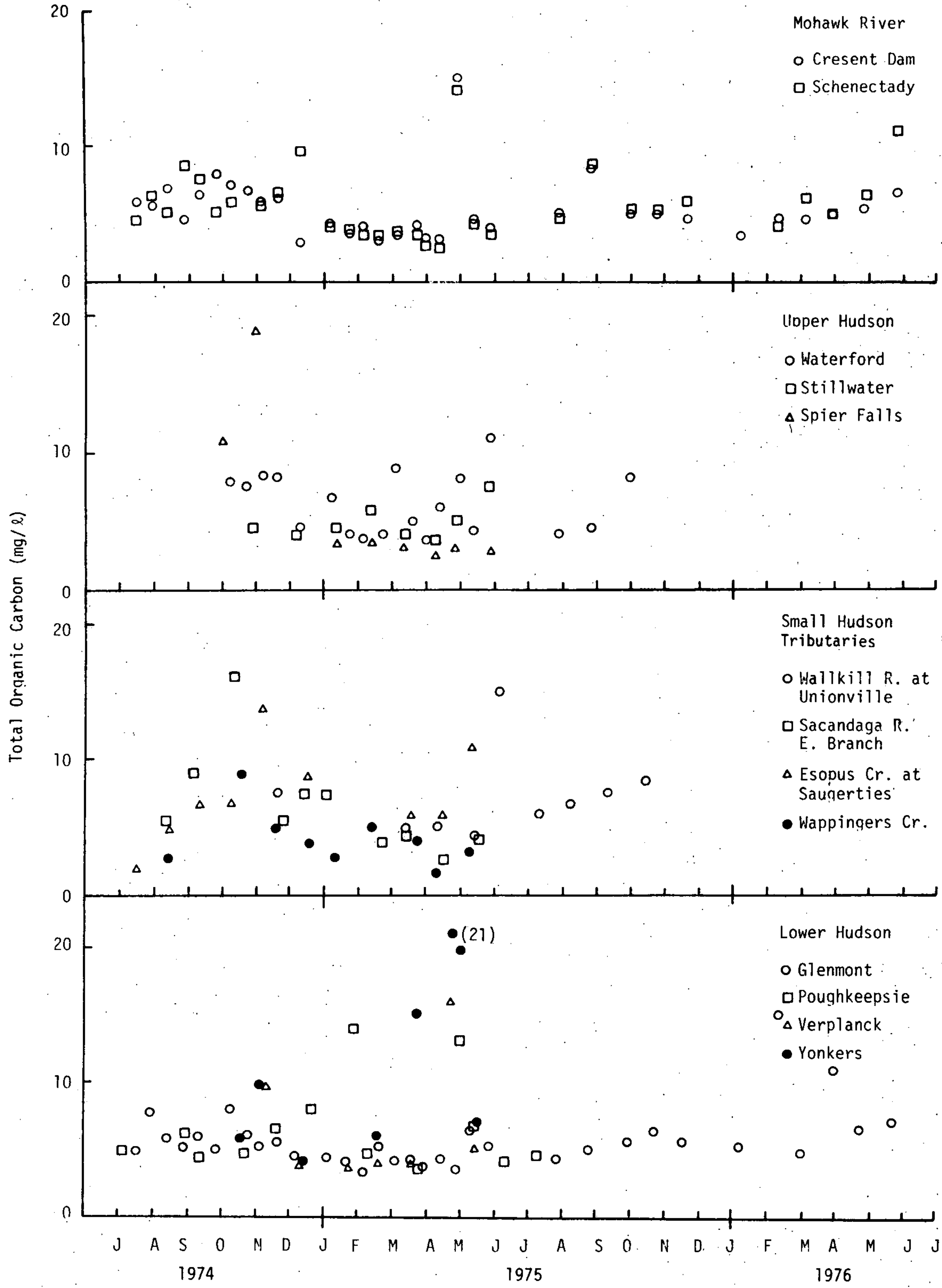

Figure B-4. Total Organic Carbon Concentrations (mg/ℓ) in Water of Hudson River and Several Tributaries, July 1974 to June 1976 (USGS 1975-77). (Data plotted on log scale.)

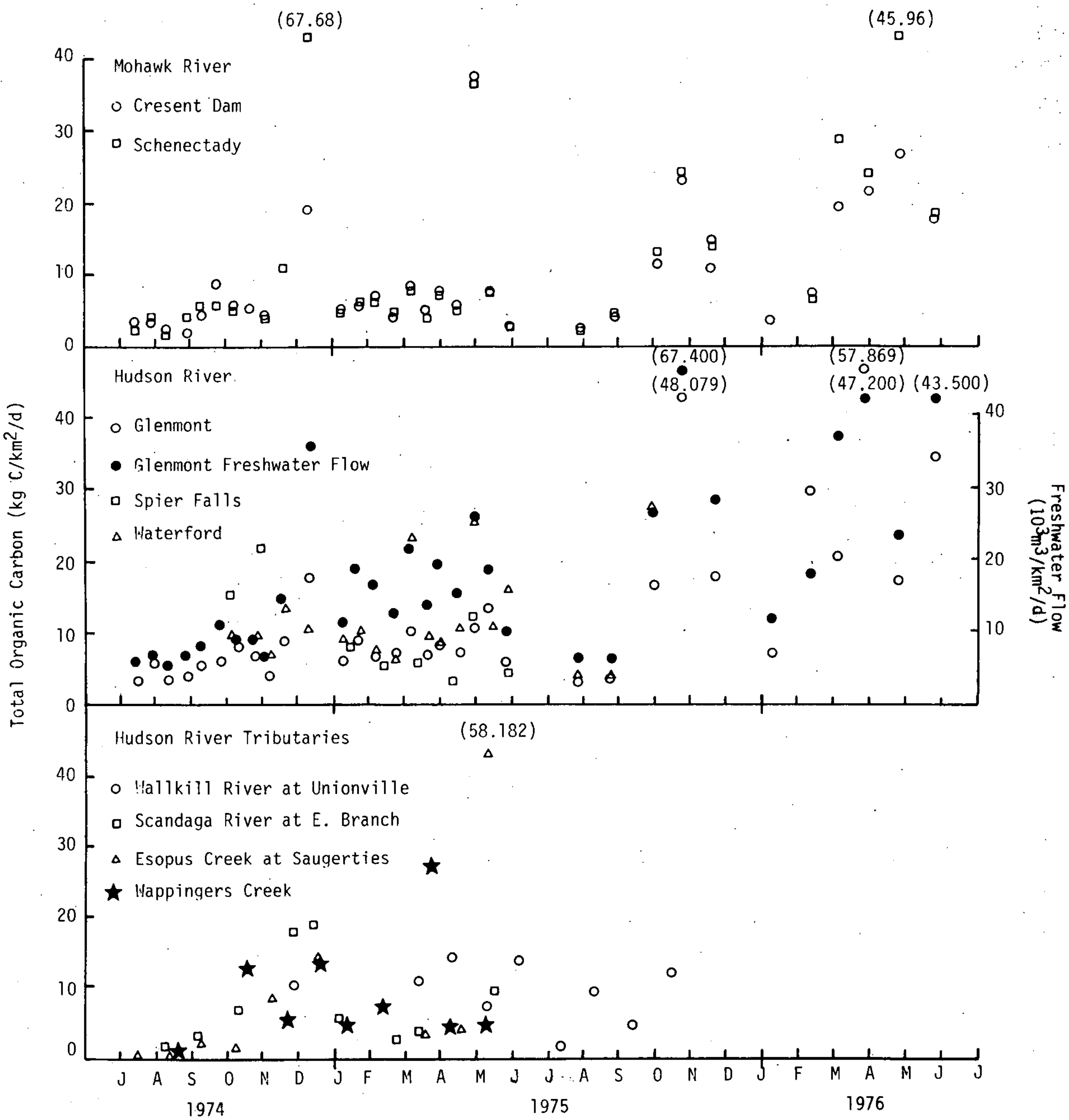

Figure B-5. Unit Area Organic Carbon Output from Several Portions of Hudson River Watershed and Freshwater Flow at Glenmont, New York, from July 1974 to June 1976. (Data Plotted on log scale.)

Over a 9-month period in 1974-75, the total organic carbon output was calculated for five sites within the overall Hudson River watershed. Comparable and relatively complete TOC concentration and instantaneous discharge data were available for these sites from approximately August 1974 through May 1975. The average daily carbon output for these five sites was 9.313 kg C/km^2 of watershed area (Table B-50). The similarity of values allowed extrapolation of unit area organic carbon values measured in one or a few watersheds to the entire Hudson River Basin. These estimates were derived from data for a single year and are probably minimum estimates because carbon output values were integrated over periods as long as a month and because short-term events such as storm runoff periods can produce a very large carbon movement from the watersheds (Fisher and Likens 1973).

Table B-50

Average Daily Organic Carbon Output from Several Watersheds in Hudson River Basin, 1974-75*

Watershed	Watershed Area (km^2)	Sampling Interval Begin	Sampling Interval End	Average Daily Carbon Output (kg C/km^2/d)
Sacandaga River (E. Branch)	295	8/08/74	5/15/75	7.168
Wappinger Creek	469	8/14/74	5/07/75	9.102
Esopus Creek (Saugerties)	1101	8/12/74	5/13/75	9.084
Mohawk River (Schenectady)	8552	8/12/74	5/12/75	12.031
Mohawk River (Crescent Dam)	8943	8/12/74	5/12/75	9.178
Mean ± One Standard Error				9.313 ± 0.696

*USGS 1975, 1976. Rates are time-weighted averages.

Additional organic carbon inputs to the Hudson River occur from anthropogenic sources such as sewage outfalls. However, analysis of Hetling's (1976) data shows that, while the input of sewage may be locally significant, the overall impact on the river organic carbon budget is minimal. The total sewage organic carbon input (as BOD) to the lower Hudson River was about 57.6 X 10^3 kg C/d, with inputs in the Albany (RM 125-152) and Yonkers (RM 14-24) regions constituting about two thirds of the total (Table B-51). After dividing the sewage carbon input in each region by the river volume in which the effluent was diluted, however, it can be seen that in no case would sewage elevate the average river region TOC concentrations by more than 0.18 mg/ℓ. The average riverwide sewage loading results in a TOC concentration increase of only 24.9 μg/ℓ.

Table B-51

Organic Carbon Inputs from Sewage Treatment Facilities along Hudson River in 1974

Name	Mile Range	Volume ($10^6 m^3$)	Municipal (kg C/d)**	Industrial (kg C/d)**	Total (kg C/d)**	Diluted Concentration † (μg/ℓ)
Albany	152-125*	120	8047	13283	21330	177.8
Catskill	124-107	161	1017	197	1214	7.54
Saugerties	106- 94	176	343	1	344	1.95
Kingston	93- 86	141	1037	5	1042	7.39
Hyde Park	85- 77	165	0	4	4	0.02
Poughkeepsie	76- 62	298	2942	3	2945	9.88
Cornwall	61- 56	140	1346	1643	2989	21.35
West Point	55- 47	207	110	989	1099	5.31
Indian Point	46- 39	208	1235	0	1235	5.94
Croton-Haverstraw	38- 34	148	1778	724	2502	16.91
Tappan Zee	33- 24	322	3361	494	3855	11.97
Yonkers	23- 14	229	19036	10	19046	83.17
Total	14-152	2317	40252	17353	57605	24.86

†BOD values are from Hetling (1976) and river region volumes were estimated by Texas Instruments (TI unpublished data).

*TI designated region extends to RM 140. Volume was extrapolated to RM 152 by assuming a constant river length:volume ratio within the Albany river region.

**BOD (pounds per day) was summed by river region and multipled by 0.3295 kg C/lb BOD to convert to kilograms of carbon (kg C). Conversion was derived from Jaworski et al. (1972).

Overall, the organic carbon inputs to the Hudson River are clearly dominated by inputs from the natural watershed. While sewage effluents may be locally significant, the overall contribution of carbon derived from sewage is minimal. Furthermore, the importance of nutrients derived from sewage in the Hudson River should decrease considerably as sewage treatment facilities are improved, particularly in the Albany and Yonkers regions. The natural organic carbon inputs are strongly pulsed seasonally and largely controlled by the movements of water from the watershed. Thus, one peak of organic carbon input to the Hudson River occurs in fall when (1) rainfall increases, (2) evapotranspiration decreases, and (3) leaves fall from the trees. A second peak will occur in late winter or early spring when snowmelt and increased rainfall combine to produce the highest freshwater flows of the year.

DEVELOPMENT OF TEMPERATURE-GROWTH RATE VARIABLE

Recent studies conducted by Ecological Analysts Incorporated (EAI 1978b) indicate a specific nonlinear temperature-growth rate relationship for larval striped bass (Figure B-6). To include this relationship in the multiple regression analysis of factors affecting striped bass growth, the temperature-growth curve was extrapolated back to 15°C and each day between July 15 and August 15 assigned a weight equal to the growth rate expected for that temperature. The relationship between juvenile growth rate and water temperature was assumed to be similar to that derived for larval growth. For each year, the expected effects of temperature on juvenile growth based on the known temperature-growth rate relationship (Figure B-6) are defined as follows:

$$TGD_i = \sum_{t=1}^{31} ti$$

where

TGD_i = number of temperature-growth days between July 15 and August 15 for year $_i$

γ_{ti} = temperature-specific growth rate for day t of year $_i$

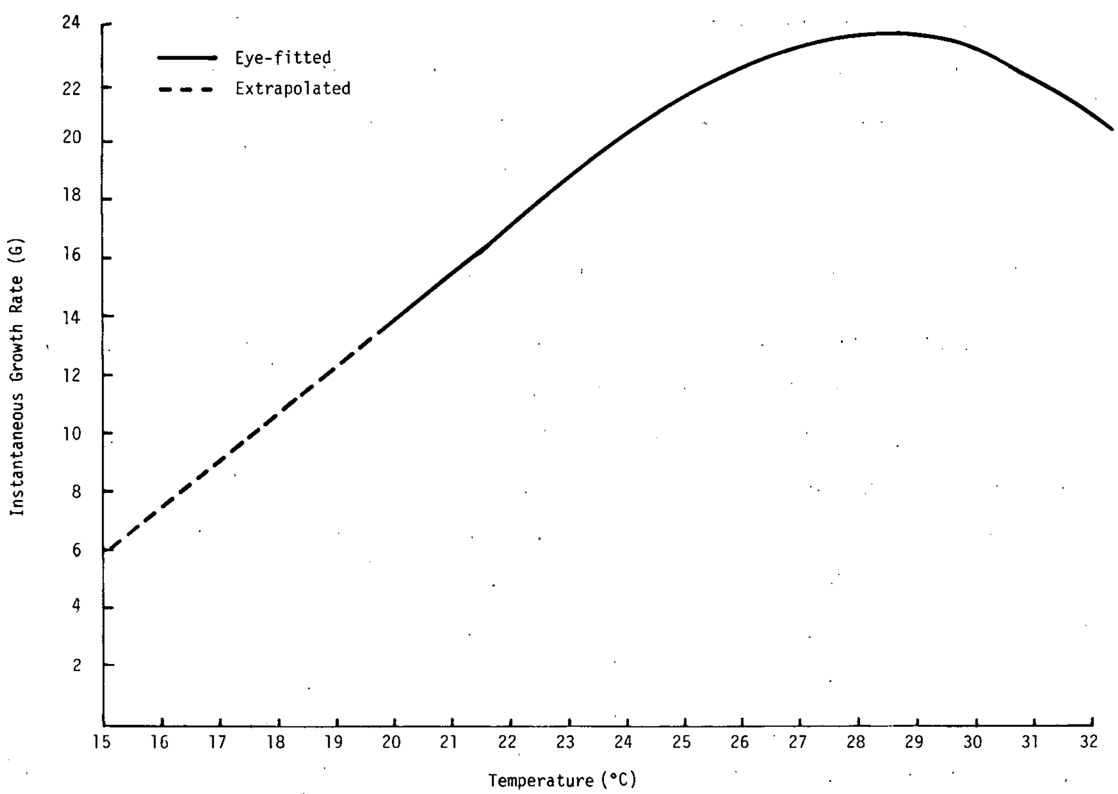

Figure B-6. Relationship between Temperature and Growth Rate for Larval Striped Bass Redrawn from Figure 9.2-2 and Table 9.2-2 of EAI (1978b)

Table B-52

Data Used in Multiple Linear Regresion to Identify Factors Affecting Juvenile Striped Bass Abundance

Year	Juvenile Striped Bass Abundance	Juvenile White Perch Abundance	Juvenile Bluefish Abundance	Yearling Striped Bass Abundance	Combined Predator Index	Days to Span 16°-20°C	Days to Span 18°-22°C	Mean Water Temperature (°C) Dec*	Days from Mean Date of 12° C
1965	2.90	12.69	0.87	0.26	1.13	13	27	5.2	4
1966	13.17	18.95	0.00	0.03	0.03	9	17	4.4	9
1967	5.23	34.33	0.15	0.11	0.26	10	16	4.8	13
1968	2.34	11.91	0.33	0.03	0.36	21	34	2.6	15
1969	62.49	24.21	0.08	0.30	0.38	19	19	2.7	1
1970	29.86	22.19	0.77	1.10	1.87	22	19	2.8	2
1972	21.53	3.77	3.81	1.65	5.46	15	48	3.5	14
1973	51.42	19.82	3.05	0.82	3.87	8	14	1.6	5
1974	13.64	6.32	9.16	2.72	11.88	26	24	4.1	3
1975	17.81	17.70	4.36	0.68	5.04	9	31	1.8	7
1976	13.95	23.96	5.39	1.09	6.48	9	10	3.4	7
1977	19.66	22.09	5.06	0.18	5.24	14	31	1.3	10

Year	Mean Month Freshwater Flow (ft^3/sec) Nov*	Dec*	Nov-Dec*	Apr	May	Apr-May	Jun	Jul	Estimated Daily Water Withdrawal ($m^3 \times 10^3$/d) May-Jul
1965	3270	6096	9366	19284	8309	27593	3573	3082	3072
1966	10681	10654	21335	15627	18406	34033	8270	3674	3663
1967	7042	9118	16160	30937	17061	47998	6197	5075	3677
1968	11742	16509	28251	18299	18487	36786	15707	9795	4382
1969	14400	15597	29997	40730	20912	61642	9995	5430	4724
1970	14271	11801	26072	39347	14546	53893	6387	5997	4580
1972	7291	16998	24289	37963	40522	78485	29630	18379	4402
1973	26152	27010	53162	30957	27603	58560	13053	10390	7390
1974	8280	26419	34699	30167	22965	53132	8791	11784	10145
1975	17177	19381	36558	25583	19999	45582	12973	7464	12351
1976	22497	18784	41281	36757	31800	68557	15223	15277	10938
1977	17930	14078	32008	40563	16023	56586	7325	5735	15137

*From winter preceding that listed for year class indices.

Table B-53

Data Used in Multiple Linear Regression to Identify Factors Affecting Juvenile Striped Bass (Phase I)

Year	Predicted Mean Total Length on July 15 (mm)	Number of Days Since Spawning	Mean Temperature Since Spawning (°C)	Mean Monthly Freshwater Flow ($ft^3 \times 10^3$/sec) Nov and Dec of Previous Year	Apr and May
1965	41.2	57	20.65	4706.4	13706.6
1966	37.7	47	21.43	10666.9	17039.2
1967	28.0	41	21.08	8097.0	23885.1
1969	43.7	59	20.54	15008.3	30659.0
1970	43.3	64	20.01	13015.7	26743.3
1972	35.4	54	19.14	12223.9	39263.8
1973	35.7	47	20.64	26588.0	29252.5
1974	37.2	57	19.07	17498.0	26506.6
1975	44.0	59	21.04	18296.7	22745.2
1976	35.5	41	21.78	20609.8	34237.7
1977	38.5	57	20.35	15972.5	28091.8

Table B-54

Data Used in Multiple Linear Regression to Identify Factors Affecting Larval Striped Bass Growth (Phase II)

Year	Instantaneous Growth Rate	Growth Days	Juvenile Striped Bass Abundance Index	Juvenile White Perch Abundance Index	Mean Monthly Freshwater Flow ($ft^3 \times 10^3$/sec) Nov and Dec of Previous Year	Apr and May	Predicted Total Length on July 15 (mm)
1965	0.0161	665.6	2.90	12.69	4706.4	13706.6	41.2
1966	0.0189	704.7	13.17	18.95	10666.9	17039.2	37.7
1967	0.0214	700.7	5.23	34.33	8097.0	23885.1	28.0
1969	0.0096	671.9	62.49	24.21	15008.3	30659.0	43.7
1970	0.0085	682.0	29.86	22.19	13015.7	26743.3	43.3
1972	0.0199	668.3	21.53	3.77	12223.9	39263.8	35.4
1973	0.0192	675.6	51.42	19.82	26588.0	29252.5	35.7
1974	0.0174	645.4	13.64	6.32	17498.0	26506.6	37.2
1975	0.0153	710.4	17.81	17.70	18296.7	22745.2	44.0
1976	0.0157	644.3	13.95	23.96	20609.8	34237.7	35.5
1977	0.0137	700.4	19.66	22.09	15972.5	28091.8	38.5

DIET OF STRIPED BASS AGE II AND OLDER

Although the diets of several striped bass populations have been studied both on the west coast (Scofield and Bryant 1926, Scofield 1931, Shapovalov 1936, Johnson and Calhoun 1952, Stevens, D.E. 1966, and Thomas 1967) and on the east coast (Hildebrand and Schroeder 1928, Hollis 1952, Trent and Hassler 1966, and Manooch 1973), no detailed investigations of feeding habits have been reported for the Hudson River population. The purpose of this study was to determine whether feeding occurred during the spawning run and describe the diet of adult striped bass collected during April and May of 1976 and 1977. In addition, the data were analyzed to determine whether there were dietary differences between mature and immature striped bass and between different size groups.

Methods

Striped bass examined for this study were collected with a 900-ft haul seine at night in Croton Bay [RM 33-39 (KM 53-62)] or near the Newburgh Beacon Bridge [RM 57-59 (KM 91-94)] during the spring spawning run (April and May). Fish collected for stomach analysis were immediately injected through the esophagus with 10% formalin. Stomach contents were sorted in the laboratory, identified to the lowest taxon possible and counted. Items such as filamentous algae, animal and plant remains, and detritus were not counted but were noted as being present or absent.

The frequency of occurrence of recognizable food items was calculated for fish in each length and maturity category using the following formula:

$$F_i = \frac{\text{Number of fish containing food item i}}{\text{Number of fish containing recognizable food items}}$$

where

F_i = frequency of occurrence of food item i

Results and Discussion

Large striped bass (greater than 200 mm in total length) fed prior to and during the 1976 and 1977 spawning season. Fish, the major food items, had been consumed by all of the length and maturity groups of striped bass examined (Table B-62). Fish species eaten by striped bass included *Morone americana*, *Microgadus tomcod*, *Notropis hudsonius*, *Alosa aestivalis*, and unidentified clupeids. Although cannibalism by large striped bass during the spawning season has been reported in the Hudson River (Dew 1977), no cannibalism was observed in this study. During 1976 and 1977, 380 striped bass larger than 200 mm (TL) were collected during the spawning seasons (Table B-62); 102 striped bass stomachs contained recognizable food items. A total of 73.2% of the stomachs were empty (66) or contained detritus* only (212), an observation typical of large striped bass during the spawning season (Scofield 1931, Woodhull 1947, Hollis 1952, Stevens, D.E. 1966, Trent and Hassler 1966, and Manooch 1973).

Larger striped bass were more piscivorous than smaller individuals. The percent frequency of occurrence of fish (total) increased consistently from the smallest to the largest length group (Table B-62). In general, the percent frequency of occurrence of invertebrate and plant remains decreased for the larger fish. Although only 12 stomachs contained invertebrates, the frequency of occurrence of invertebrates in the smallest length group was 19.2%. *Cyathura* and nematodes were the only invertebrates which were found in more than one stomach. Vegetative material was found in half the stomachs that contained food. Plant remains were probably consumed incidental to the capture of other prey items.

*"Detritus" is defined here as inorganic material (sand) and decomposed organic material unidentifiable as either vegetative or animal matter. The frequent presence of detritus in striped bass stomachs should not be misinterpreted as detrital feeding by this species.

A comparison of mature* and immature individuals revealed that stomachs of mature fish contained a higher frequency of occurrence of fish and a lower frequency of occurrence of invertebrates than did immature fish (Table B-62). Mature striped bass generally reduce feeding during the spawning season (Hollis 1952, Stevens, D.E. 1966, Trent and Hassler 1966); however, there is no apparent reason why only 23.8% of the immature striped bass (48 out of 202) were feeding, unless perhaps active feeding by all individuals had not yet begun. Sample sizes of mature fish were not large enough to representatively describe the food items consumed by fish immediately before (ripe and running) or during (partially spent) spawning. Since the bulk of spawning occurs in May and mature fish were collected during April and May, analysis of mature fish is reflective of dietary trends over several weeks and not daily cessation of feeding while spawning.

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*Mature striped bass were defined as those fish which were ripe, ripe and running, partially spent, or spent (McFadden and Lawler 1977) and would have spawned or did spawn during that spring.

Table B-55

Comparison of Food Items Consumed by Striped Bass in Different Length and Maturity Categories Collected by Haul Seines in Hudson River Estuary during 1976 and 1977 Spawning Seasons (Values are expressed as percent frequency of occurrence)

	Total Length (mm)				Maturity			
Food Items	200-399	400-599	600-799	800+	Immature	Mature	Undet*	All Fish Combined
Fish (Total)	30.8	50.9	71.4	85.7	43.8	70.4	48.1	52.0
Fish Remains	26.9	50.9	71.4	78.6	41.7	66.7	48.1	50.0
Fish Eggs	---	---	14.3	---	---	---	3.7	1.0
Clupeidae (unidentified)	---	---	---	7.1	---	3.7	---	1.0
Alosa aestivalis	---	---	---	7.1	---	3.7	---	1.0
Notropis hudsonius	---	---	---	7.1	---	3.7	---	1.0
Microgadus tomcod	3.8	1.8	---	---	2.1	3.7	---	2.0
Morone americana	---	5.5	---	7.1	---	11.1	3.7	3.9
Invertebrates (Total)	19.2	10.9	14.3	---	18.8	3.7	7.4	11.8
Insect Remains	---	1.8	---	---	---	3.7	---	1.0
Decapoda	---	1.8	---	---	---	---	3.7	1.0
Amphipoda	---	1.8	---	---	---	---	3.7	1.0
Gammarus	3.8	---	---	---	2.1	---	---	1.0
Cyathura	15.4	1.8	---	---	10.4	---	---	4.9
Nematoda	---	3.6	14.3	---	6.3	---	---	2.9
Plant Remains	61.5	47.3	71.4	28.6	54.2	37.0	55.6	50.0
Number of Stomachs:								
(1) Recognizable Food Items	26	55	7	14	48	27	27	102 (26.8)**
(2) Detritus only	94	89	22	7	123	27	62	212 (55.8)
(3) Empty	32	24	6	4	31	17	18	66 (17.4)
(4) Examined	152	168	35	25	202	71	107	380

*Undetermined

**Numbers in parentheses are percentage of total number of stomachs examined.

The equations describing the long-term reduction in average population size (PR) for the Ricker curve are derived analytically from the Ricker stock-recruitment equation (Ricker 1975), which represents a theoretical description of the relationship between parental stock and subsequent recruitment to that stock for a species with discrete generations in a constant environment. Recruitement (R) is the product of a linear function of parental stock (αP), and a nonlinear density-dependent function ($e^{-\beta P}$).

$$R = \alpha P e^{-\beta P} \tag{1}$$

where

R = recruits

α = growth rate per parent in the absence of density dependent mortality

P = parental stock measured in the same units as R

β = index to density dependent mortality

Ricker (1975) derived a series of equations from equation (1) that are useful in the management of fish populations. The equilibrium population where parents (P_r) are just replaced by recruits (R_r) is described by equation (2):

$$P_r = R_r = \ell n\alpha/\beta \tag{2}$$

A new equilibrium in response to some conditional mortality rate m imposed on recruits is described by equation (3):

$$P_E = \frac{\ell n\alpha(1-m)}{\beta} \tag{3}$$

The long-term percent reduction in average population size (PR) of a population undergoing the mortality m is:

$$PR = \frac{P_r - P_E}{P_r} x\ 100 \tag{4}$$

Equation (5) describes this percent reduction and can be derived by substituting equations (2) and (3) into equation (4):

$$PR = \left[1 - \frac{\ell n\alpha(1-m)}{\ell n\alpha}\right] x\ 100 \tag{5}$$

In the above equations, mortality is applied to the recruit population after the period of compensation. Since timing of mortality with respect to the compensatory period has been shown to be important to PR, an equation was derived for the case when power plant-induced mortality is applied before the period of compensation. The population equilibrates at a new level in response to mortality m described by equation (6):

$$P = \frac{\ell n \alpha(1-m)}{(1-m)\beta} \tag{6}$$

A new equation describing PR is developed by substituting equations (6) and (2) into equation (4):

$$PR = 1 - \frac{\ell n\left[\alpha(1-m)\right]}{(1-m)\ell n \alpha} \times 100 \tag{7}$$

Now the mortality is applied to the parental generation and thus reduces the negative feedback ($e^{-\beta P}$) as well as production (αP). Because of the decrease in negative feedback, a slight increase in the population may occur depending on the numerical values of α and m.

Similar sets of equations have been derived for the stock-recruitment curve developed by Beverton and Holt (1957). This curve is described by equation (8):

$$R = \frac{1}{a + B/P} \tag{8}$$

where

R and P = recruits and parents as before
a = an index of density dependent mortality
B = an index to population growth such that $1/B = \alpha$ of the Ricker curve

The equation describing PR can be developed for a population experiencing mortality after the compensatory period by defining P_r as:

$$P_r = \frac{1 - B}{a} \tag{9}$$

and P_E as:

$$P_E = \frac{1-m-B}{a} \tag{10}$$

Equations (9) and (10) are substituted into equation (4) and PR is:

$$PR = \frac{m}{1 - B} \times 100 \tag{11}$$

If the impact occurs before the compensatory period, the equilibrium reached in response to a mortality m is given by equation (12):

$$P_E = \frac{1-m-B}{a(1-m)} \tag{12}$$

Again, by substitution of equations (12) and (9) into equation (4), the equation describing PR is developed:

$$PR = \frac{Bm}{(1-m)(1-B)} \times 100 \tag{13}$$

Table C-1

Numbers of White Perch by Age in Bottom Trawl Catches, October-December 1974-77

Age	1974	1975	1976	1977
I	269	151	385	64
II	11	81	126	61
III	19	11	23	19
IV	6	11	15	4
V	1	4	3	1
VI		1		

Table C-2

Expected Mean Squares Used to Calculate F Values for Mixed ANOVA Model Analyzing Effects of Year, Age, and Sex on White Perch Mean Lengths

Source	Expected Mean Square	Calculated Mean Square	F Value
Year (Random)	$\sigma_E^2 + \sigma_Y^2$	0.00000052	0.00
Age (Fixed)	$\sigma_E^2 + \sigma_{YA}^2 + \sigma_A^2$	0.20895692	95.82*
Sex (Fixed)	$\sigma_E^2 + \sigma_{YS}^2 + \sigma_S^2$	0.01544541	73.59*
Year x Age	$\sigma_E^2 + \sigma_{YA}^2$	0.00218076	2.35
Year x Sex	$\sigma_E^2 + \sigma_{YS}^2$	0.00020990	0.23
Age x Sex	$\sigma_E^2 + \sigma_{YAS}^2 + \sigma_{AS}^2$	0.00276707	1.81
Year x Age x Sex	$\sigma_E^2 + \sigma_{YAS}^2$	0.00153290	1.65
Error	σ_E^2	0.00092670	

*Significant at $\alpha = 0.05$

Table C-3

White Perch Categorized by Sex, Age, and Maturity Collected during 1972-77 in Hudson River Estuary and Employed in RxC Test of Independence Using G-Test*

Sex	Age	Maturity	1972	1973	1974	1975	1976	1977
Male	II	Mature	4	3	10	16	13	40
		Immature	12	3	3	34	15	21
	III +	Mature	16	11	18	81	90	59
		Immature	0	1	1	4	10	7
Female	II	Mature	0	4	5	11	6	14
		Immature	19	13	21	49	27	22
	III +	Mature	32	69	40	93	54	75
		Immature	2	2	2	7	4	3

* Sokal and Rohlf 1969
Data analysis presented in Table IV-11

Table C-4

Percentage of Sexually Mature and Immature Male White Perch by Age and Length, Indian Point Region of Hudson River Estuary, May and June 1977

Total Length (mm)	Age / Sexual Condition	I		II		III		IV		V+		Combined	
		M	I	M	I	M	I	M	I	M	I	M	I
100-110	Percent	100		50.0	50.0							55.6	44.4
	N	1		4	4							5	4
111-120	Percent			54.5	45.5							54.5	45.5
	N			12	10							12	10
121-130	Percent			68.2	31.8	100						72.0	28.0
	N			15	7	3						18	7
131-140	Percent			100		100		100				100	
	N			7		1		1				9	
141-150	Percent			100		100						100	
	N			1		7						8	
151-160	Percent			100		100						92.9	7.1
	N			1		12						13	1
161-170	Percent					88.9	11.1	100		50.0	50.0	82.4	17.6
	N					8	1	4		2	2	14	3
171-180	Percent					100		85.7	14.3	80.0	20.0	86.7	13.3
	N					3		6	1	4	1	13	2
181-190	Percent							66.7	33.3	100		83.3	16.7
	N							2	1	3		5	1
191-200	Percent									100		100	
	N									6		6	
201-210	Percent												
	N												
211-220	Percent												
	N												
221-230	Percent									100		100	
										1		1	
Combined	Percent	100		65.6	34.4	97.1	2.9	86.7	13.3	80.0	20.0		
	N	1		40	21	34	1	13	2	16	4		

Table C-5

Percentage of Sexually Mature and Immature Female White Perch by Age and Length, Indian Point Region of Hudson River Estuary, May and June 1977

Total Length (mm)	Age / Sexual Condition	I		II		III		IV		V+		Combined	
		M	I	M	I	M	I	M	I	M	I	M	I
100-110	Percent		100		100								100
	N		1		4								5
111-120	Percent			22.2	77.8							25.0	77.8
	N			2	7							2	7
121-130	Percent			20.0	80.0							20.0	80.0
	N			2	8							2	8
131-140	Percent			81.8	18.2	100						83.3	16.7
	N			9	2	1						10	2
141-150	Percent				100	100		100				83.3	16.7
	N				1	4		1				5	1
151-160	Percent					90.0	10.0	100				93.8	6.2
	N					9	1	6				15	1
161-170	Percent			100		88.9	11.1	83.3	16.7	100		90.0	10.0
	N			1		8	1	5	1	4		18	2
171-180	Percent					100		100		100		100	
	N					5		4		5		14	
181-190	Percent					100		100		100		100	
	N					3		3		6		12	
191-200	Percent							100		100		100	
	N							3		5		8	
201-210	Percent									100		100	
	N									4		4	
211-220	Percent									100		100	
	N									2		2	
221-230	Percent									100		100	
	N									2		2	
Combined	Percent		100	38.9	61.1	93.8	6.2	95.7	4.3	100			
	N		1	14	22	30	2	22	1	28			

Table C-6

Summary of Results of Log_{10} Fecundity Data Regressed on Log_{10} Weight and Age, Hudson River White Perch Collected during May 1975-77

	Year	α	β	R^2	N
Log_{10} Fecundity	1975	2.6944	1.1349	0.8034	31
vs	1976	2.7480	1.1232	0.7598	30
Log_{10} Weight	1977	2.5554	1.2001	0.6776	19
Log_{10} Fecundity	1975	4.3382	0.1391	0.4049	31
vs	1976	4.1750	0.1808	0.5136	30
Age	1977	4.1747	0.1393	0.3633	19

Table C-7

Regional Recovery Rates (R_i/M_i) for Yearling and Older White Perch ≤150 mm Total Length Marked in Hudson River Estuary September-November 1977 and Recaptured January-June 1978

River Miles	Release Months								
	September			October			November		
	M_i	R_i	R_i/M_i	M_i	R_i	R_i/M_i	M_i	R_i	R_i/M_i
12-23	12	0	0.0000	12	0	0.0000	14	1	0.0714
24-38	1846	9	0.0049	469	1	0.0021	178	6	0.0337
39-46	778	9	0.0114	232	4	0.0172	38	2	0.0526
47-76	334	0	0.0000	114	1	0.0088	41	0	0.0000
77-153	53	0	0.0000	22	1	0.0455	20	0	0.0000
Total	3023	17	0.0056	849	7	0.0082	291	9	0.0309

Table C-8

Regional Recovery Rates (R_i/M_i) for White Perch ≥150 mm Total Length Marked in Hudson River Estuary September–November 1977 and Recaptured January–June 1978

River Miles	September			October			November		
	M_i	R_i	R_i/M_i	M_i	R_i	R_i/M_i	M_i	R_i	R_i/M_i
12-23	173	2	0.0116	157	1	0.0064	53	1	0.0189
24-38	1222	4	0.0033	649	6	0.0092	465	6	0.0129
39-46	339	1	0.0029	58	0	0.0000	37	1	0.0270
47-76	76	0	0.0000	33	1	0.0303	13	0	0.0000
77-153	10	1	0.1000	7	0	0.0000	15	2	0.1333
Total	1820	8	0.0044	904	8	0.0088	583	10	0.0172

(Release Months)

Table C-9

Chi-Square (X^2) Analysis for Equality of Recovery Rates for White Perch Tagged from September through November, 1977

	White Perch >150mm TL Observed			
	Sep.	Oct.	Nov.	Total
Number Recaptures	8	8	10	26
Number Marks - Number Recaptures	1,812	896	573	3,281
Total Number Marks	1,820	904	583	3,307

$$X^2 = 9.37$$

$$X^2_{(2,\ 0.05)} = 5.99$$

	White Perch ≥150mm TL Observed			
	Sep.	Oct.	Nov.	Total
Number Recaptures	17	7	9	33
Number Marks - Number Recaptures	3,006	842	282	4,130
Total Number Marks	3,023	849	291	4,163

$$X^2 = 21.63$$

$$X^2_{(2,\ 0.05)} = 5.99$$

Table C-10

Fraction of Marked Fish (R) in Total Catch (C) for White Perch Tagged in September 1977 and Recovered January-June 1978

	Size Group					
	≤ 150 mm Total Length			> 150 mm Total Length		
Month	R	C	R/C	R	C	R/C
January	7	9818	0.00071	7	24836	0.00028
February	0	2331	0.00000	0	6463	0.00000
March	3	2362	0.00127	0	1650	0.00000
April	3	9163	0.00033	0	6412	0.00000
May	1	4571	0.00022	0	5425	0.00000
June	3	5852	0.00051	1	5296	0.00019

Table C-11

Summary of Survival Tests for Adult White Perch Tagged in Hudson River Estuary during September-November 1977

Start Date	Duration (Days)	Initial Number	Tag Type	Percent Survival	Gear
Sep 08	14	20	Dennison	45	Beach Seine
	14	20	Control	40	Beach Seine
09	14	20	Floy	100*	Beach Seine
	14	20	Control	100	Beach Seine
13	16	20	Dennison	100*	Beach Seine
	16	20	Control	100	Beach Seine
Oct 06	13	20	Dennison	0	Epibenthic Sled
	13	20	Control	91	Beach Seine
	13	16	Floy	81†	Beach Seine
	13	16	Control	56	Beach Seine
21	18	20	Dennison	15	Epibenthic Sled
26	14	20	Floy	40**	Beach Seine
	14	20	Control	40	Beach Seine
Nov 17	7	20	Dennison	0‡	Beach Seine
	7	20	Control	0	Beach Seine

*Used for September survival adjustment

†Used for October survival adjustment

**Used for November survival adjustment

‡Dennison tagged white perch data were inadequate to estimate survival from 1978 data alone, thus the October adjustment factor used represents an average of October test results from 1974 through 1977. Survival in November was assumed to be 50% of that for October as found with the smaller (Floy tagged) fish

Table C-12

Estimated Standing Crops (in Thousands) of White Perch Eggs in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION												
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
2/21-2/25	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/ 7-3/11	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21-3/26	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/ 4-4/ 7	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/18-4/20	SC	0	0	0	0	0	0	0	0	0	0	94	94	188
	SE	0	0	0	0	0	0	0	0	0	0	94	94	133
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
4/25-4/28	SC	0	0	0	0	0	0	117	0	0	899	498	0	1515
	SE	0	0	0	0	0	0	117	0	0	414	186	0	469
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3	156
5/ 2-5/ 5	SC	0	0	0	0	39	57	324	50	0	76	105	170	819
	SE	0	0	0	0	39	41	287	50	0	76	105	170	366
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
5/ 9-5/12	SC	0	0	37	9	101	0	15844	391	0	460	24257	82	41180
	SE	0	0	37	9	29	0	10300	305	0	460	6612	82	12252
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3	157
5/16-5/19	SC	0	0	438	161	905	112	3980	1908	633	496	9875	7723	26232
	SE	0	0	393	78	570	43	2641	988	340	332	5444	3324	7025
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3	157
5/23-5/26	SC	0	35974	223	478	16800	1719	18708	13018	17051	3122	23521	8429	139043
	SE	0	27545	103	367	16068	1087	9889	6002	16874	2046	6537	4028	38729
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3	157
5/31-6/ 2	SC	0	89	19	134	296	1228	1060	644	1043	602	19711	8080	32908
	SE	0	89	19	134	171	847	685	284	1043	260	7423	3993	8574
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3	155
6/ 6-6/ 9	SC	0	0	638	19	12687	209	885	140	209	8126	205	267	23385
	SE	0	0	638	19	9000	92	518	140	147	6468	205	267	11120
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/13-6/16	SC	0	0	8571	253	71	29	0	0	0	93	362	80	9461
	SE	0	0	6365	222	71	29	0	0	0	93	233	80	6375
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/20-6/24	SC	0	0	0	0	0	223	0	0	31	1505	87	849	2695
	SE	0	0	0	0	0	223	0	0	31	1505	87	464	1593
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/27-7/ 1	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3	157
7/ 5-7/ 8	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/11-7/15	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/25-7/29	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
8/ 8-8/12	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157

Table C-13

Estimated Density (No./1000 m^3) of White Perch Eggs in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

		REGION											
DATE		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/4-4/7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5872	1.3237
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5872	1.3237
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.3928	0.0	0.0	5.0997	3.1014	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.3928	0.0	0.0	2.3502	1.1555	0.0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3
5/2-5/5	DEN	0.0	0.0	0.0	0.0	0.1862	0.4057	1.0861	0.3001	0.0	0.4292	0.6523	2.3843
	SE	0.0	0.0	0.0	0.0	0.1862	0.2963	0.9635	0.3001	0.0	0.4292	0.6523	2.3843
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
5/9-5/12	DEN	0.0	0.0	0.2509	0.0420	0.4864	0.0	53.1330	2.3632	0.0	2.6081	150.9430	1.1470
	SE	0.0	0.0	0.2509	0.0420	0.1409	0.0	34.5400	1.8401	0.0	2.6081	41.1424	1.1470
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3
5/16-5/19	DEN	0.0	0.0	2.9650	0.7712	4.3628	0.8021	13.3465	11.5286	4.4761	2.8151	61.4529	108.6234
	SE	0.0	0.0	2.6532	0.3733	2.7482	0.3105	8.8580	5.9670	2.4054	1.8813	33.8742	46.7469
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3
5/23-5/26	DEN	0.0	111.7913	1.5075	2.2947	81.0029	12.2948	62.7354	78.6563	120.5052	17.7103	146.3685	118.5487
	SE	0.0	85.5960	0.6947	1.7620	77.4721	7.7771	33.1640	36.2639	119.2490	11.6024	40.6782	56.6576
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3
5/31-6/2	DEN	0.0	0.2781	0.1295	0.6456	1.4294	8.7842	3.5541	3.8939	7.3732	3.4142	122.6580	113.6410
	SE	0.0	0.2781	0.1295	0.6456	0.8232	6.0593	2.2965	1.7183	7.3732	1.4766	46.1897	56.1560
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3
6/6-6/9	DEN	0.0	0.0	4.3180	0.0923	61.1705	1.4952	2.9680	0.8479	1.4772	46.0891	1.2752	3.7614
	SE	0.0	0.0	4.3180	0.0923	43.3920	0.6614	1.7375	0.8479	1.0380	36.6863	1.2752	3.7614
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/13-6/16	DEN	0.0	0.0	58.0288	1.2169	0.3410	0.2090	0.0	0.0	0.0	0.5302	2.2548	1.1315
	SE	0.0	0.0	43.0948	1.0664	0.3410	0.2090	0.0	0.0	0.0	0.5302	1.4489	1.1315
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/20-6/24	DEN	0.0	0.0	0.0	0.0	0.0	1.5923	0.0	0.0	0.2166	8.5377	0.5425	11.9432
	SE	0.0	0.0	0.0	0.0	0.0	1.5923	0.0	0.0	0.2166	8.5377	0.5425	6.5265
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/27-7/1	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3
7/5-7/8	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
8/8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3

Table C-14

Mean Regional Water Temperature (°C), Dissolved Oxygen (mg/ℓ), Conductivity (mS/cm), and White Perch Egg Density (No./1000 m^3), during Periods of White Perch Egg Abundance, 1974-77

		REGION											
1974		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
May 19-May 25	Temp.	16.9	17.6	17.7	16.8	16.8	16.4	16.0	16.4	16.8	16.5	16.7	16.8
	D.O.	6.9	10.8	10.4	9.6	9.6	9.4	8.8	8.6	8.3	8.7	8.5	9.3
	Cond.	10084	948	179	175	172	171	168	148	147	144	144	144
	Dens.	0.0	42.1	6.1	2.6	0.0	2.7	0.7	2.4	4.0	0.6	47.1	1269.2
Jun 2-Jun 8	Temp.	18.6	19.6	19.6	19.1	19.1	18.0	19.6	18.7	18.6	17.7	17.0	17.5
	D.O.	6.7	9.4	9.3	7.9	7.7	7.3	7.7	8.5	8.5	10.2	9.3	8.9
	Cond.	9951	1811	185	153	152	146	149	155	169	181	188	185
	Dens.	0.0	3.5	1194.7	0.0	7.9	0.2	15.4	1.5	5.3	20.4	1.6	0.0
Jun 9-Jun 15	Temp.	21.1	20.8	21.4	20.5	20.2	20.8	20.3	21.0	21.5	22.9	21.9	22.2
	D.O.	9.0	9.2	8.8	8.1	7.7	8.2	7.6	8.9	9.5	6.9	8.4	6.7
	Cond.	6618	2997	1196	858	226	147	156	153	164	166	168	162
	Dens.	0.0	4.2	766.6	5.7	18.0	0.0	24.7	1.0	0.0	156.1	105.3	0.0
1975													
May 18-May 24	Temp.	17.6	17.7	18.5	17.5	18.0	18.2	18.6	18.1	19.8	19.6	19.4	19.0
	D.O.	8.1	9.8	10.0	9.1	9.0	8.7	9.8	9.9	9.3	9.4	8.7	8.0
	Cond.	5475	350	188	155	142	149	136	131	134	166	175	151
	Dens.	0.0	6.6	9.8	6.1	39.3	206.9	97.5	68.0	195.8	254.0	46.3	0.0
May 25-May 31	Temp.	18.7	19.8	20.7	19.5	19.6	20.2	20.7	21.2	21.2	21.0	20.9	20.5
	D.O.	7.8	9.8	11.1	9.4	9.1	9.0	9.2	8.3	8.4	9.3	8.9	8.2
	Cond.	6287	1166	171	149	148	166	146	152	150	150	154	153
	Dens.	0.0	546.5	3.9	32.7	55.4	121.8	446.3	3.4	35.4	142.0	595.9	85.9
1976													
May 23-May 29	Temp.	16.2	16.3	16.4	16.0	15.1	15.6	13.8	13.2	12.4	12.3	12.2	12.0
	D.O.	10.7	10.6	10.1	9.1	9.1	9.0	9.6	9.4	10.7	11.4	11.9	11.8
	Cond.	2143	874	196	166	156	184	157	155	151	142	139	139
	Dens.	0.0	4.5	183.0	1.6	2.7	97.2	62.6	3.3	32.2	86.2	3.1	10.1
May 30-Jun 5	Temp.	16.7	17.6	17.2	16.1	15.1	14.9	15.6	15.6	16.4	16.7	16.7	17.5
	D.O.	8.5	8.9	9.9	9.3	9.8	9.7	9.3	9.0	9.4	9.3	9.2	9.7
	Cond.	6498	1453	474	169	159	182	167	143	145	148	145	146
	Dens.	0.0	93.2	6.9	14.2	53.6	36.1	70.2	33.5	35.7	67.6	806.3	280.2
Jun 6-Jun 12	Temp.	19.0	20.2	19.8	17.9	17.1	17.7	18.1	19.0	20.5	20.1	20.8	21.0
	D.O.	5.1	10.3	10.8	9.4	9.3	9.2	8.3	8.2	9.2	9.7	9.8	9.6
	Cond.	12505	2453	284	169	158	164	147	152	155	157	187	208
	Dens.	0.0	33.6	20.7	5.2	35.0	21.3	26.2	16.1	189.8	1582.3	208.2	12.3
1977													
May 22-May 28	Temp.	19.1	18.6	20.7	19.1	18.0	18.9	14.7	18.9	19.7	20.4	21.7	21.9
	D.O.	8.3	9.3	10.8	9.4	9.4	9.6	9.2	10.0	9.6	10.4	9.3	8.3
	Cond.	7524	2048	285	441	158	175	192	179	173	164	169	160
	Dens.	0.0	111.8	1.5	2.3	81.0	12.3	62.7	78.7	120.5	17.7	146.4	118.5

Table C-15

Estimated Density (No./1000 m^3) of White Perch Eggs in Shoal, Bottom, and Channel Strata of Five Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

REGION AND STRATUM *

DATE		YK S	YK B	YK C	TZ S	TZ B	TZ C	CH S	CH B	CH C	IP S	IP B	IP C	CW S	CW B	CW C
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	0	0	1	6	6	9	7	10	11	3	5	7	3	4	5
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	0	3	8	7	11	6	13	6	4	5	9	3	4	4
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	6	18	9	3	5	3	3	4	3	3	3	3
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	5	18	10	3	5	3	3	4	3	3	3	3
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	6	10	17	3	8	6
5/ 2-5/ 5	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.54	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.13	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
5/ 9-5/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.14	0.0	0.0	0.26	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.14	0.0	0.0	0.26	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	12	16	3	7	6
5/16-5/19	DEN	0.0	0.0	0.0	0.0	0.0	0.0	7.24	0.0	0.77	0.0	3.91	0.19	6.85	1.54	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	7.24	0.0	0.77	0.0	2.15	0.19	3.85	0.82	0.0
	TOWS	3	0	3	2	4	3	6	5	4	5	11	17	3	8	6
5/23-5/26	DEN	0.0	0.0	0.0	84.21	0.0	186.42	0.77	3.20	1.26	2.13	12.25	0.26	0.0	45.93	0.30
	SE	0.0	0.0	0.0	84.21	0.0	185.27	0.77	2.49	0.77	1.07	10.91	0.26	0.0	29.53	0.30
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	2	11	11
5/31-6/ 2	DEN	0.0	0.0	0.0	0.74	0.0	0.0	0.0	0.59	0.0	0.0	4.03	0.0	6.58	31.13	0.31
	SE	0.0	0.0	0.0	0.74	0.0	0.0	0.0	0.59	0.0	0.0	4.03	0.0	6.58	22.96	0.31
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	3	10	11
6/ 6-6/ 9	DEN	0.0	0.0	0.0	0.0	0.0	0.0	11.83	0.0	0.0	0.0	0.58	0.0	12.32	1.48	0.58
	SE	0.0	0.0	0.0	0.0	0.0	0.0	11.83	0.0	0.0	0.0	0.58	0.0	8.03	1.48	0.39
	TOWS	3	0	3	3	3	3	4	3	5	4	5	16	3	6	10
6/13-6/16	DEN	0.0	0.0	0.0	0.0	0.0	0.0	159.01	0.0	0.0	0.0	6.57	0.21	0.0	0.0	0.31
	SE	0.0	0.0	0.0	0.0	0.0	0.0	118.09	0.0	0.0	0.0	6.57	0.21	0.0	0.0	0.31
	TOWS	3	0	3	3	3	3	6	2	4	3	5	17	3	6	10
6/20-6/24	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.35
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.35
	TOWS	3	0	3	3	3	3	4	3	5	3	7	15	3	5	11
6/27-7/ 1	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	2	0	3	4	3	3	4	2	5	3	6	17	3	6	10
7/ 5-7/ 8	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	5	3	4	3	5	17	3	6	10
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	2	4	3	5	3	5	17	3	7	9
8/ 8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10

* S = shoal strata
B = bottom stratum
C = channel stratum

Table C-16

Estimated Density (No./1000 m^3) of White Perch Eggs in Bottom and Channel Strata in Seven Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

DATE		WP B	WP C	PK B	PK C	HP B	HP C	KG B	KG C	SG B	SG C	CS B	CS C	AL B	AL C
		REGION AND STRATUM*													
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	6	3	4	0	0	0	0	0	0	0	0	0	0
3/7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	7	0	0	0	0	0	0	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	3	3	3	0	0	0	0	0	0	0	0	0	0
4/4-4/7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	2	3	3	0	0	0	0	0	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.23	0.0	1.32	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.23	0.0	1.32	0.0
	TOWS	18	17	6	6	3	4	3	3	4	3	3	3	3	0
4/25-4/28	DEN	0.0	0.0	0.0	0.51	0.0	0.0	0.0	0.0	12.80	0.80	4.31	1.99	0.0	0.0
	SE	0.0	0.0	0.0	0.51	0.0	0.0	0.0	0.0	6.40	0.80	2.16	1.00	0.0	0.0
	TOWS	17	17	6	6	3	4	3	3	3	4	3	3	3	0
5/2-5/5	DEN	0.0	0.22	0.57	1.24	1.45	0.0	0.0	0.0	1.20	0.0	1.36	0.0	2.38	0.0
	SE	0.0	0.22	0.57	1.24	1.45	0.0	0.0	0.0	1.20	0.0	1.36	0.0	2.38	0.0
	TOWS	18	17	6	6	3	4	3	3	3	4	3	3	3	0
5/9-5/12	DEN	3.53	0.0	212.40	5.00	8.33	0.80	0.0	0.0	0.0	4.07	209.93	96.95	1.15	0.0
	SE	1.02	0.0	147.92	5.00	8.33	0.80	0.0	0.0	0.0	4.07	67.87	48.48	1.15	0.0
	TOWS	18	17	7	6	3	4	3	3	3	4	3	3	3	0
5/16-5/19	DEN	22.09	1.53	22.17	10.68	25.91	7.77	10.89	1.20	4.98	1.61	105.80	20.85	108.62	0.0
	SE	19.07	0.92	18.73	10.05	13.00	6.72	6.72	1.20	4.98	0.93	69.63	12.14	46.75	0.0
	TOWS	19	17	6	6	3	4	3	3	3	4	3	3	3	0
5/23-5/26	DEN	16.60	91.30	126.90	43.35	151.03	59.74	356.73	0.0	49.40	0.0	91.49	196.60	118.55	0.0
	SE	7.67	89.86	98.56	31.27	88.52	39.46	353.01	0.0	32.37	0.0	61.29	54.06	56.66	0.0
	TOWS	5	11	8	20	6	8	5	3	4	3	3	3	3	0
5/31-6/2	DEN	2.08	1.32	3.78	3.49	0.65	4.74	21.83	0.0	3.11	3.58	123.50	121.89	113.64	0.0
	SE	2.08	0.89	2.41	2.90	0.65	2.16	21.83	0.0	2.09	1.98	58.98	70.09	56.16	0.0
	TOWS	6	10	8	19	6	7	4	4	4	3	3	3	3	0
6/6-6/9	DEN	161.07	45.19	5.71	2.14	4.09	0.0	4.37	0.0	123.92	2.60	2.67	0.0	3.76	0.0
	SE	158.47	43.48	4.05	1.90	4.09	0.0	3.07	0.0	102.23	2.60	2.67	0.0	3.76	0.0
	TOWS	7	16	12	14	5	5	5	5	4	3	5	2	3	0
6/13-6/16	DEN	0.0	0.40	0.0	0.0	0.0	0.0	0.0	0.0	1.48	0.0	4.72	0.0	1.13	0.0
	SE	0.0	0.40	0.0	0.0	0.0	0.0	0.0	0.0	1.48	0.0	3.03	0.0	1.13	0.0
	TOWS	6	17	11	15	5	5	5	5	3	4	4	3	3	0
6/20-6/24	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.64	0.0	23.82	0.0	1.14	0.0	11.94	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.64	0.0	23.82	0.0	1.14	0.0	6.53	0.0
	TOWS	5	18	11	15	4	6	5	5	3	4	4	3	3	0
6/27-7/1	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/5-7/8	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	13	13	4	6	5	5	2	5	4	3	3	0
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
8/8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0

* B = bottom stratum
C = channel stratum

Table C-17

Estimated Standing Crops (in Thousands) and Percent Standing Crops of White Perch Eggs Above, Within, and Below Five Power-Plant Regions Determined from Ichthyoplankton Survey during Periods of White Perch Egg Abundance, 1977

Date		Bowline		Lovett		Indian Point		Roseton		Danskammer	
		Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent	Standing Crop	Percent
5/ 9-5/12	Above	41,138	99.9	41,124	99.9	41,113	99.8	30,466	74.0	29,420	71.4
	Within	43	0.1	50	0.1	54	0.1	10,568	25.7	11,614	28.2
	Below	0	0.0	7	< 0.1	15	< 0.1	147	0.4	147	0.4
5/16-5/19	Above	25,692	97.9	25,532	97.3	25,431	96.9	21,960	83.7	21,698	82.7
	Within	539	2.1	612	2.3	625	2.4	2,711	10.3	2,955	11.3
	Below	0	0	88	0.3	175	0.7	1,560	5.9	1,579	6.0
5/23-5/26	Above	102,547	73.8	100,503	72.3	98,638	70.9	71,371	51.3	70,136	50.4
	Within	11,314	8.1	2,521	1.8	4,341	3.1	13,338	9.6	14,285	10.3
	Below	25,182	18.1	36,019	25.9	36,063	25.9	54,334	39.1	54,622	39.3
5/31-6/ 2	Above	32,714	99.4	32,631	99.2	32,598	99.1	30,433	92.5	30,363	92.3
	Within	129	0.4	182	0.6	211	0.6	1,321	4.0	1,186	3.6
	Below	62	0.2	93	0.3	97	0.3	1,152	3.5	1,357	4.1
6/ 6-6/ 9	Above	22,735	97.2	21,320	91.2	19,911	85.1	9,242	39.5	9,183	39.3
	Within	650	2.8	1,938	8.3	3,218	13.8	695	3.0	718	3.1
	Below	0	0.0	128	0.5	255	1.1	13,448	57.5	13,483	57.7

Table C-18

Estimated Standing Crops (in Thousands) of White Perch Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION												
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
2/21-2/25	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/ 7-3/11	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21-3/26	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/ 4-4/ 7	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/18-4/20	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
4/25-4/28	SC	0	0	0	98	0	0	0	0	0	0	0	0	98
	SE	0	0	0	71	0	0	0	0	0	0	0	0	71
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3	156
5/ 2-5/ 5	SC	0	0	0	59	47	141	0	50	51	0	0	0	347
	SE	0	0	0	59	38	72	0	50	51	0	0	0	123
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
5/ 9-5/12	SC	235	8861	65	178	603	309	2537	317	594	2296	956	715	17665
	SE	235	3938	46	73	134	146	480	121	255	1025	588	407	4181
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3	157
5/16-5/19	SC	135	1823	430	756	2081	4408	8509	10067	15707	18977	13593	3141	79627
	SE	135	759	364	174	266	639	1733	2427	1945	3965	1524	154	5655
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3	157
5/23-5/26	SC	0	34341	13330	4528	18956	14379	57590	47771	22364	39016	39593	8866	300735
	SE	0	18475	2704	777	3552	1997	8839	8769	6794	9296	3883	4029	26168
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3	157
5/31-6/ 2	SC	0	5412	3616	19468	39738	2946	4464	2209	4403	2904	4948	26100	116207
	SE	0	3202	908	7106	12419	602	647	553	1609	1025	622	8322	17035
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3	155
6/ 6-6/ 9	SC	0	466	1364	3487	2387	2332	2411	3936	6540	5762	936	23427	53050
	SE	0	253	658	916	358	514	861	1654	3005	977	702	11815	12461
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/13-6/16	SC	0	0	85	119	578	584	321	235	50	407	354	573	3307
	SE	0	0	62	84	171	219	140	157	50	245	200	445	658
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/20-6/24	SC	0	142	77	232	377	69	0	29	28	95	0	212	1261
	SE	0	142	47	103	114	36	0	29	28	95	0	106	263
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/27-7/ 1	SC	0	0	0	0	36	44	40	0	0	0	0	4414	4534
	SE	0	0	0	0	26	31	40	0	0	0	0	2805	2806
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3	157
7/ 5-7/ 8	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/11-7/15	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/25-7/29	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
8/ 8-8/12	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157

Table C-19

Estimated Standing Crops (in Thousands) of White Perch Post Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION												
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
2/21-2/25	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/7-3/11	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21-3/26	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/4-4/7	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/18-4/20	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
4/25-4/28	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3	156
5/2-5/5	SC	0	0	0	80	0	0	0	0	0	0	0	0	80
	SE	0	0	0	80	0	0	0	0	0	0	0	0	80
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
5/9-5/12	SC	0	0	0	0	0	0	0	0	0	86	84	0	170
	SE	0	0	0	0	0	0	0	0	0	86	84	0	120
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3	157
5/16-5/19	SC	0	1166	120	237	210	782	534	0	0	0	105	0	3154
	SE	0	571	120	102	137	315	502	0	0	0	105	0	855
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3	157
5/23-5/26	SC	0	2152	2370	1670	8143	18795	58935	67472	47939	17723	7719	75	232995
	SE	0	977	961	788	4810	5757	12337	32964	16367	15211	2808	75	42482
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3	157
5/31-6/2	SC	78	3855	2113	59288	61386	31233	219864	375765	281457	360171	93105	2431	1490746
	SE	78	1858	619	9663	18188	6481	49930	72995	76712	103159	12595	582	158040
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3	155
6/6-6/9	SC	0	8058	34992	83094	62068	133512	355851	340093	472637	246565	100161	9595	1846626
	SE	0	5679	10564	16526	14518	29680	62421	77230	87022	38758	31732	1298	146468
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/13-6/16	SC	27	587	1630	42596	120055	125976	410707	369434	153105	123401	62612	3216	1413347
	SE	27	376	646	14095	16787	18454	100934	155813	25733	26657	15956	1362	192136
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/20-6/24	SC	194	651	5238	45156	133019	54146	44094	63606	33166	50662	30074	3058	463065
	SE	194	481	1341	11236	35563	21365	8601	12729	5262	9291	2822	2740	47063
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/27-7/1	SC	0	116	905	14259	48246	28331	55619	18037	39147	10496	14739	467	230362
	SE	0	116	224	3247	5045	3598	8186	5458	14789	5034	3247	123	20010
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3	157
7/5-7/8	SC	55	1788	3076	11173	5675	8731	9538	3098	2431	1163	2774	643	50146
	SE	28	1553	531	1600	884	1847	2795	1051	654	345	1058	185	4479
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/11-7/15	SC	0	0	132	1592	1480	2995	3214	1775	5022	2147	1933	691	20981
	SE	0	0	95	324	236	699	722	574	2477	973	590	691	3069
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/25-7/29	SC	0	0	0	75	15	159	279	117	90	0	64	0	798
	SE	0	0	0	44	15	60	120	68	59	0	64	0	180
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
8/8-8/12	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157

Table C-20

Estimated Density (No./1000 m^3) of White Perch Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION											
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/4-4/7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
4/25-4/28	DEN	0.0	0.0	0.0	0.4717	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.3389	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3
5/2-5/5	DEN	0.0	0.0	0.0	0.2822	0.2271	1.0072	0.0	0.3001	0.3586	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.2822	0.1818	0.5172	0.0	0.3001	0.3586	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
5/9-5/12	DEN	1.0228	27.5360	0.4375	0.8549	2.9095	2.2106	8.5070	1.9132	4.1967	13.0237	5.9467	10.0557
	SE	1.0228	12.2365	0.3142	0.3509	0.6480	1.0410	1.6110	0.7296	1.8007	5.8125	3.6588	5.7301
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3
5/16-5/19	DEN	0.5870	5.6655	2.9138	3.6294	10.0340	31.5285	28.5358	60.8270	111.0003	107.6430	84.5847	44.1795
	SE	0.5870	2.3571	2.4670	0.8337	1.2802	4.5729	5.8109	14.6667	13.7481	22.4895	9.4814	2.1628
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3
5/23-5/26	DEN	0.0	106.7156	90.2524	21.7374	91.4005	102.8568	193.1241	288.6454	158.0498	221.3043	246.3811	124.7002
	SE	0.0	57.4119	18.3097	3.7310	17.1286	14.2833	29.6425	52.9832	48.0139	52.7270	24.1652	56.6599
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3
5/31-6/2	DEN	0.0	16.8183	24.4852	93.4603	191.6002	21.0700	14.9707	13.3460	31.1133	16.4691	30.7902	367.0851
	SE	0.0	9.9507	6.1492	34.1165	59.8795	4.3050	2.1702	3.3430	11.3676	5.8148	3.8705	117.0463
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3
6/6-6/9	DEN	0.0	1.4489	9.2371	16.7426	11.5112	16.6786	8.0852	23.7851	46.2182	32.6837	5.8223	329.4995
	SE	0.0	0.7852	4.4552	4.3987	1.7255	3.6739	2.8860	9.9966	21.2334	5.5394	4.3587	166.1759
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/13-6/16	DEN	0.0	0.0	0.5729	0.5736	2.7889	4.1799	1.0767	1.4209	0.3564	2.3090	2.2046	8.0530
	SE	0.0	0.0	0.4172	0.4056	0.8263	1.5658	0.4703	0.9490	0.3564	1.3920	1.2458	6.2537
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/20-6/24	DEN	0.0	0.4422	0.5206	1.1124	1.8199	0.4901	0.0	0.1752	0.1985	0.5367	0.0	2.9821
	SE	0.0	0.4422	0.3190	0.4938	0.5491	0.2542	0.0	0.1752	0.1985	0.5367	0.0	1.4911
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/27-7/1	DEN	0.0	0.0	0.0	0.0	0.1752	0.3114	0.1338	0.0	0.0	0.0	0.0	62.0797
	SE	0.0	0.0	0.0	0.0	0.1277	0.2250	0.1338	0.0	0.0	0.0	0.0	39.4523
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3
7/5-7/8	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
8/8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3

Table C-21

Estimated Density (No./1000 m^3) of White Perch Post Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION YK	TZ	CH	IP	WP	CW	FK	HP	KG	SG	CS	AL
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/4-4/7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3
5/2-5/5	DEN	0.0	0.0	0.0	0.3857	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.3857	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
5/9-5/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4858	0.5232	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4858	0.5232	0.0
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3
5/16-5/19	DEN	0.0	3.6243	0.8135	1.1358	1.0123	5.5920	1.7894	0.0	0.0	0.0	0.6557	0.0
	SE	0.0	1.7732	0.8135	0.4899	0.6628	2.2518	1.6820	0.0	0.0	0.0	0.6557	0.0
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3
5/23-5/26	DEN	0.0	6.6877	16.0494	8.0165	39.2614	134.4453	197.6349	407.6888	338.7938	100.5277	48.0356	1.0604
	SE	0.0	3.0355	6.5041	3.7809	23.1912	41.1798	41.3732	199.1765	115.6697	86.2786	17.4734	1.0604
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3
5/31-6/2	DEN	0.3401	11.9804	14.3031	284.6269	295.9798	223.4095	737.3047	2270.4857	1989.0960	2042.9441	579.3718	34.1926
	SE	0.3401	5.7727	4.1937	46.3397	87.6942	46.3565	167.4383	441.0559	542.1376	585.1306	78.3743	8.1917
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3
6/6-6/9	DEN	0.0	25.0390	236.9119	398.9144	299.2663	955.0199	1193.3319	2054.9447	3340.1927	1398.5539	623.2821	134.9440
	SE	0.0	17.6480	71.5239	79.3362	70.0001	212.3039	209.3249	466.6441	614.9968	219.8391	197.4630	18.2618
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/13-6/16	DEN	0.1159	1.8240	11.0378	204.4938	578.8560	901.1170	1377.2878	2232.2322	1082.0163	699.9481	389.6220	45.2333
	SE	0.1159	1.1691	4.3706	67.6665	80.9402	132.0019	338.4787	941.4706	181.8595	151.2015	99.2893	19.1590
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/20-6/24	DEN	0.8473	2.0239	35.4637	216.7811	641.3660	387.3115	147.8679	384.3280	234.3892	287.3617	187.1416	43.0092
	SE	0.8473	1.4961	9.0822	53.9413	171.4692	152.8257	28.8426	76.9100	37.1875	52.6981	17.5584	38.5360
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/27-7/1	DEN	0.0	0.3612	6.1279	68.4533	232.6229	202.6531	186.5152	108.9874	276.6543	59.5372	91.7192	6.5654
	SE	0.0	0.3612	1.5161	15.5901	24.3233	25.7359	27.4505	32.9759	104.5138	28.5553	20.2032	1.7240
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3
7/5-7/8	DEN	0.2411	5.5576	20.8243	53.6389	27.3611	62.4524	31.9853	18.7192	17.1830	6.5971	17.2640	9.0443
	SE	0.1210	4.8249	3.5983	7.6795	4.2622	13.2107	9.3740	6.3482	4.6232	1.9561	6.5842	2.6015
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/11-7/15	DEN	0.0	0.0	0.8969	7.6430	7.1358	21.4233	10.7784	10.7225	35.4921	12.1773	12.0278	9.7235
	SE	0.0	0.0	0.6458	1.5571	1.1394	5.0011	2.4204	3.4693	17.5067	5.5194	3.6744	9.7235
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/25-7/29	DEN	0.0	0.0	0.0	0.3600	0.0704	1.1345	0.9356	0.7043	0.6362	0.0	0.4008	0.0
	SE	0.0	0.0	0.0	0.2101	0.0704	0.4317	0.4028	0.4117	0.4171	0.0	0.4008	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
8/8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3

Table C-22

Mean Regional Water Temperature (°C), Dissolved Oxygen (mg/ℓ), Conductivity (mS/cm), and White Perch Yolk-Sac Larvae Density (No./1000 m^3) during Periods of White Perch Yolk-Sac Larvae Abundance, 1974-77

		REGION											
1974		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
May 19-May 25	Temp.	16.9	17.6	17.7	16.8	16.8	16.4	16.0	16.4	16.8	16.5	16.7	16.8
	D.O.	6.9	10.8	10.4	9.6	9.6	9.4	8.8	8.6	8.3	8.7	8.5	9.3
	Cond.	10085	948	179	175	172	171	168	148	147	144	144	144
	Dens.	0.0	70.7	103.7	9.0	15.7	24.0	47.5	84.6	153.9	50.8	10.8	9.0
1975													
May 18-May 24	Temp.	17.6	17.7	18.5	17.5	18.0	18.2	18.6	18.1	19.8	19.6	19.4	19.0
	D.O.	8.1	9.8	10.0	9.1	9.0	8.7	9.8	9.9	9.3	9.4	8.7	8.0
	Cond.	5475	350	188	155	142	149	136	131	134	166	175	151
	Dens.	3.3	126.2	34.2	25.4	32.8	95.5	108.2	189.1	102.5	123.6	72.1	48.4
May 25-May 31	Temp.	18.7	19.8	20.7	19.5	19.6	20.2	20.7	21.2	21.2	21.0	20.9	20.5
	D.O.	7.8	9.8	11.1	9.4	9.1	9.0	9.2	8.3	8.4	9.3	8.9	8.2
	Cond.	6287	1166	171	149	148	166	146	150	152	150	154	153
	Dens.	0.0	186.8	117.8	53.4	31.1	28.7	29.3	51.5	49.1	84.4	102.8	106.4
1976													
May 16-May 22	Temp.	16.9	15.5	15.4	14.7	15.0	15.2	14.3	14.1	14.0	15.0	14.8	15.2
	D.O.	9.3	10.9	10.3	9.6	9.8	9.9	9.7	9.5	9.9	9.8	10.3	9.6
	Cond.	3011	207	165	157	145	159	142	139	144	147	156	156
	Dens.	0.3	96.2	56.9	31.6	89.2	234.9	185.9	351.1	188.0	108.9	175.7	112.1
Jun 6-Jun 12	Temp.	19.0	20.2	19.8	17.9	17.1	17.7	18.1	19.0	20.5	20.1	20.8	21.0
	D.O.	5.1	10.3	10.8	9.4	9.3	9.2	8.3	8.2	9.2	9.7	9.8	9.6
	Cond.	12505	2453	284	169	158	164	147	152	155	157	187	208
	Dens.	0.0	7.7	16.9	2.4	3.8	9.4	8.7	8.8	45.5	116.1	324.3	365.7
Jun 13-Jun 19	Temp.	20.2	21.2	20.6	19.6	19.3	20.4	20.2	21.4	21.6	21.7	22.3	22.4
	D.O.	6.5	10.3	10.3	9.2	8.4	8.5	8.7	8.8	8.8	8.8	8.7	9.0
	Cond.	7122	795	314	168	151	152	150	160	165	183	200	186
	Dens.	0.2	25.5	9.3	5.8	6.3	24.4	30.5	87.7	250.8	139.3	273.4	96.2
1977													
May 22-May 28	Temp.	19.1	18.6	20.7	19.1	18.0	18.9	14.7	18.9	19.7	20.4	21.7	21.9
	D.O.	8.3	9.3	10.8	9.4	9.4	9.6	9.2	10.0	9.6	10.4	9.3	8.3
	Cond.	7524	2048	285	441	158	175	192	179	173	164	169	160
	Dens.	0.0	106.7	90.3	21.7	91.4	102.9	193.1	288.6	158.1	221.3	246.4	124.7
May 29-Jun 4	Temp.	18.5	19.3	20.0	20.0	19.2	18.5	19.8	20.5	20.3	20.6	21.3	21.9
	D.O.	7.1	9.0	9.6	9.0	9.6	10.0	8.9	8.7	8.7	8.6	7.9	7.0
	Cond.	17515	9367	5910	3255	382	173	170	166	162	157	158	158
	Dens.	0.0	16.8	24.5	93.5	191.6	21.7	15.0	13.3	31.1	16.5	30.8	367.1

* =

Table C-23

Mean Regional Water Temperature (°C), Dissolved Oxygen (mg/ℓ), Conductivity (mS/cm), and White Perch Post Yolk-Sac Larvae Density (No./1000 m^3) during Periods of Peak White Perch Post Yolk-Sac Larvae Abundance, 1974-77

		REGION											
1974		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
Jun 9-Jun 15	Temp.	21.1	20.8	21.4	20.5	20.2	20.8	20.3	21.0	21.5	22.9	21.9	22.2
	D.O.	9.0	9.2	8.8	8.1	7.7	8.2	7.6	8.9	9.5	6.9	8.4	6.7
	Cond.	6618	2997	1196	858	226	147	156	153	164	166	168	162
	Dens.	0.5	0.2	38.7	93.0	318.6	193.8	333.2	241.6	842.5	153.0	64.1	6.3
Jun 16-Jun 22	Temp.	22.1	22.2	22.7	21.5	21.6	21.4	21.0	21.0	21.4	21.9	22.5	22.7
	D.O.	5.1	6.8	7.1	6.9	7.8	8.2	8.0	8.1	8.1	8.2	8.0	5.9
	Cond.	14417	7911	4957	2269	394	166	176	159	161	166	175	193
	Dens.	0.2	3.9	17.7	354.6	347.9	98.6	223.3	254.3	167.9	50.7	74.2	13.1
1975													
May 25-May 31	Temp.	18.7	19.8	20.7	19.5	19.6	20.2	20.7	21.2	21.2	21.0	20.9	20.5
	D.O.	7.8	9.8	11.1	9.4	9.1	9.0	9.2	8.3	8.4	9.3	8.9	8.2
	Cond.	6287	1166	171	149	148	166	146	150	152	150	154	153
	Dens.	10.1	387.6	242.3	127.1	221.4	664.2	456.5	1219.3	455.0	369.3	227.6	8.1
Jun 1-Jun 7	Temp.	20.5	20.5	21.0	20.5	20.2	20.2	20.7	21.5	21.7	22.6	21.9	22.5
	D.O.	9.4	8.3	9.3	9.0	9.2	8.8	8.6	8.7	8.5	9.0	7.3	7.4
	Cond.	5798	4754	1627	1052	210	166	154	140	148	151	157	158
	Dens.	2.1	26.0	393.7	460.5	683.4	787.2	863.6	862.1	1062.6	1580.7	813.0	49.3
Jun 8-Jun 14	Temp.	20.2	20.0	20.5	21.0	20.9	21.3	21.2	20.4	19.9	20.0	18.1	17.6
	D.O.	6.1	6.7	7.7	7.2	8.0	8.1	7.5	8.4	8.7	9.3	-	-
	Cond.	12019	7554	4462	2246	394	186	157	161	177	173	206	215
	Dens.	1.2	1.4	416.3	1690.0	729.5	210.9	160.6	249.6	366.3	317.6	31.9	0.8
1976													
Jun 13-Jun 19	Temp.	20.2	21.2	20.6	19.6	19.3	20.4	20.2	21.4	21.6	21.7	22.3	22.4
	D.O.	6.5	10.3	10.3	9.2	8.4	8.5	8.7	8.8	8.8	8.8	8.7	9.0
	Cond.	7122	795	314	168	151	152	150	160	165	183	200	186
	Dens.	0.0	61.2	49.9	43.8	54.1	133.7	438.8	2611.5	2556.6	2037.9	2007.7	291.0
Jun 20-Jun 26	Temp.	23.5	23.0	23.4	22.3	21.4	22.7	23.4	23.3	24.3	23.7	23.8	24.0
	D.O.	9.9	9.4	9.5	8.8	8.5	8.5	8.0	7.7	7.7	7.8	6.5	6.3
	Cond.	6357	2272	605	247	149	161	170	188	201	197	201	207
	Dens.	0.0	21.8	141.3	163.5	315.0	904.6	1783.2	1914.5	3924.9	1319.4	1051.5	294.7
1977													
May 29-Jun 4	Temp.	18.5	19.3	20.0	20.0	19.2	18.5	19.8	20.5	20.3	20.6	21.3	21.9
	D.O.	7.1	9.0	9.6	9.0	9.6	10.0	8.9	8.7	8.7	8.6	7.9	7.0
	Cond.	17515	9367	5910	3255	382	173	170	166	162	157	158	158
	Dens.	0.3	12.0	14.3	284.6	296.0	223.4	737.3	2270.5	1989.1	2043.0	579.4	34.2
Jun 5-Jun 11	Temp.	17.7	18.6	19.3	19.6	19.1	19.2	18.9	19.0	19.3	19.3	19.5	19.6
	D.O.	7.2	8.0	8.3	7.8	9.2	9.6	8.1	8.0	7.8	8.2	7.5	7.0
	Cond.	13256	7814	4633	2562	329	192	177	197	166	168	179	191
	Dens.	0.0	25.0	236.9	398.9	299.3	955.0	1193.3	2055.0	3340.2	1398.6	623.9	134.9
Jun 12-Jun 18	Temp.	20.6	20.8	21.2	20.6	19.7	21.0	20.9	20.2	20.0	19.7	20.0	19.3
	D.O.	7.7	8.2	9.2	7.4	9.0	10.0	7.7	7.6	8.1	7.7	8.2	7.6
	Cond.	13283	8071	6251	4703	851	269	200	180	183	184	198	208
	Dens.	0.1	1.8	11.0	204.5	578.9	901.1	1377.3	2232.2	1082.0	699.9	389.6	45.2

Table C-24

Estimated Density (No./1000 m^3) of White Perch Yolk-Sac Larvae in Shoal, Bottom, and Channel Strata of Five Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

		REGION AND STRATUM*														
DATE		YK S	YK B	YK C	TZ S	TZ B	TZ C	CH S	CH B	CH C	IP S	IP B	IP C	CW S	CW B	CW C
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	0	0	1	6	6	9	7	10	11	3	5	7	3	4	5
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	0	3	8	7	11	6	13	6	4	5	9	3	4	4
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	6	18	9	3	5	3	3	4	3	3	3	3
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	5	18	10	3	5	3	3	4	3	3	3	3
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.61	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.43	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	6	10	17	3	8	6
5/ 2-5/ 5	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36	0.0	2.20	0.63
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36	0.0	1.10	0.63
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
5/ 9-5/12	DEN	0.0	0.0	1.16	23.47	7.68	40.06	0.49	1.17	0.0	0.62	0.55	0.94	2.55	6.48	0.53
	SE	0.0	0.0	1.16	8.08	7.68	27.41	0.49	1.17	0.0	0.62	0.37	0.44	2.55	3.67	0.53
	TOWS	3	0	3	3	4	3	6	5	4	5	12	16	3	7	6
5/16-5/19	DEN	5.05	0.0	0.0	6.41	16.79	0.0	6.69	0.64	0.80	8.91	4.15	3.11	75.16	87.29	6.18
	SE	5.05	0.0	0.0	3.00	10.71	0.0	6.69	0.64	0.80	3.98	1.76	0.96	5.12	16.17	2.42
	TOWS	3	0	3	2	4	3	6	5	4	5	11	17	3	8	6
5/23-5/26	DEN	0.0	0.0	0.0	128.76	17.44	127.45	74.55	85.20	106.74	25.06	37.66	18.20	80.20	108.00	102.79
	SE	0.0	0.0	0.0	84.75	17.44	110.79	34.93	29.86	27.43	9.23	14.85	3.62	0.0	25.77	18.52
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	2	11	11
5/31-6/ 2	DEN	0.0	0.0	0.0	34.98	0.0	8.37	21.71	68.06	3.82	0.0	80.20	103.44	29.55	11.04	24.24
	SE	0.0	0.0	0.0	24.96	0.0	7.35	13.84	15.23	2.49	0.0	39.53	43.02	6.57	4.45	6.08
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	3	10	11
6/ 6-6/ 9	DEN	0.0	0.0	0.0	3.35	0.94	0.0	10.46	24.63	0.0	44.75	10.40	15.87	66.33	5.52	16.77
	SE	0.0	0.0	0.0	2.02	0.94	0.0	5.06	18.43	0.0	24.64	6.88	5.12	22.19	2.97	4.94
	TOWS	3	0	3	3	3	3	4	3	5	4	5	16	3	6	10
6/13-6/16	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.59	1.62	0.0	0.83	0.0	0.67	10.01	1.69	4.65
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.59	1.62	0.0	0.83	0.0	0.52	8.27	0.76	2.18
	TOWS	3	0	3	3	3	3	6	2	4	3	5	17	3	6	10
6/20-6/24	DEN	0.0	0.0	0.0	0.0	0.0	1.03	0.0	0.0	1.25	0.0	2.03	1.01	0.0	0.0	0.72
	SE	0.0	0.0	0.0	0.0	0.0	1.03	0.0	0.0	0.77	0.0	1.35	0.57	0.0	0.0	0.37
	TOWS	3	0	3	3	3	3	4	3	5	3	7	15	3	5	11
6/27-7/ 1	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.47	0.28
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.47	0.28
	TOWS	2	0	3	4	3	3	4	2	5	3	6	17	3	6	10
7/ 5-7/ 8	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	5	3	4	3	5	17	3	6	10
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	2	4	3	5	3	5	17	3	7	9
8/ 8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10

*S = shoal strata
B = bottom stratum
C = channel stratum

Table C-25

Estimated Density (No./1000 m^3) of White Perch Yolk-Sac Larvae in Bottom and Channel Strata in Seven Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

		REGION AND STRATUM*													
		WP		PK		HP		KG		SG		CS		AL	
DATE		B	C	B	C	B	C	B	C	B	C	B	C	B	C
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	6	3	4	0	0	0	0	0	0	0	0	0	0
3/7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	7	0	0	0	0	0	0	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	3	3	3	0	0	0	0	0	0	0	0	0	0
4/4-4/7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	2	3	3	0	0	0	0	0	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	4	3	3	3	3	0
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	17	17	6	6	3	4	3	3	3	4	3	3	3	0
5/2-5/5	DEN	0.35	0.21	0.0	0.0	1.45	0.0	1.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.24	0.21	0.0	0.0	1.45	0.0	1.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	3	4	3	3	3	0
5/9-5/12	DEN	4.27	2.69	11.58	7.58	5.98	0.85	7.62	2.45	14.68	12.10	5.47	6.38	10.06	0.0
	SE	0.82	0.74	5.99	1.06	1.36	0.85	2.32	2.45	7.40	8.06	5.47	4.90	5.73	0.0
	TOWS	18	17	7	6	3	4	3	3	3	4	3	3	3	0
5/16-5/19	DEN	12.07	9.71	53.15	21.10	163.73	33.93	209.42	60.79	187.80	62.85	70.99	97.03	44.18	0.0
	SE	2.78	1.42	14.28	6.22	48.99	13.35	35.41	10.23	22.52	32.72	18.07	7.49	2.16	0.0
	TOWS	19	17	6	6	3	4	3	3	3	4	3	3	3	0
5/23-5/26	DEN	19.08	102.97	141.12	208.84	330.30	277.75	371.86	48.98	527.95	49.95	234.04	257.68	124.70	0.0
	SE	8.01	19.83	28.81	37.61	121.07	58.86	129.15	30.27	119.04	48.28	49.47	9.58	56.66	0.0
	TOWS	5	11	8	20	6	8	5	3	4	3	3	3	3	0
5/31-6/2	DEN	42.81	215.40	8.88	16.81	35.11	7.66	21.45	36.04	16.42	16.50	25.08	36.01	367.09	0.0
	SE	13.24	69.43	1.90	2.77	13.24	2.41	13.72	15.67	6.68	8.26	7.62	2.52	117.05	0.0
	TOWS	6	10	8	19	6	7	4	4	4	3	3	3	3	0
6/6-6/9	DEN	10.80	11.63	4.12	9.28	5.13	28.66	30.52	54.23	27.78	35.42	3.45	8.00	329.50	0.0
	SE	5.71	1.78	1.57	3.73	3.14	12.58	13.50	31.32	10.55	6.31	2.69	8.00	166.18	0.0
	TOWS	7	16	12	14	5	5	5	5	4	3	5	2	3	0
6/13-6/16	DEN	2.60	2.82	1.47	0.96	0.0	1.79	0.0	0.54	0.0	3.60	2.52	1.92	8.05	0.0
	SE	2.60	0.86	0.78	0.56	0.0	1.20	0.0	0.54	0.0	2.17	1.55	1.92	6.25	0.0
	TOWS	6	17	11	15	5	5	5	5	3	4	4	3	3	0
6/20-6/24	DEN	1.27	1.91	0.0	0.0	0.85	0.0	0.59	0.0	0.0	0.84	0.0	0.0	2.98	0.0
	SE	1.27	0.60	0.0	0.0	0.85	0.0	0.59	0.0	0.0	0.84	0.0	0.0	1.49	0.0
	TOWS	5	18	11	15	4	6	5	5	3	4	4	3	3	0
6/27-7/1	DEN	0.48	0.13	0.0	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.08	0.0
	SE	0.48	0.13	0.0	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.45	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/5-7/8	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	13	13	4	6	5	5	2	5	4	3	3	0
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
8/8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0

* B = bottom stratum
C = channel stratum

Table C-26

Estimated Density (No./1000 m^3) of White Perch Post Yolk-Sac Larvae in Shoal, Bottom, and Channel Strata of Five Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

DATE		YK S*	YK B	YK C	TZ S	TZ B	TZ C	CH S	CH B	CH C	IP S	IP B	IP C	CW S	CW B	CW C
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	0	0	1	6	6	9	7	10	11	3	5	7	3	4	5
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	0	3	8	7	11	6	13	6	4	5	9	3	4	4
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	6	18	9	3	5	3	3	4	3	3	3	3
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	5	18	10	3	5	3	3	4	3	3	3	3
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	6	10	17	3	8	6
5/ 2-5/ 5	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.49	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.49	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
5/ 9-5/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	12	16	3	7	6
5/16-5/19	DEN	0.0	0.0	0.0	1.71	4.27	5.03	2.23	0.0	0.0	0.68	1.35	1.13	0.0	0.76	7.94
	SE	0.0	0.0	0.0	1.71	2.50	3.68	2.23	0.0	0.0	0.68	0.60	0.61	0.0	0.76	3.30
	TOWS	3	0	3	2	4	3	6	5	4	5	11	17	3	8	6
5/23-5/26	DEN	0.0	0.0	0.0	6.27	1.74	9.28	10.24	3.25	27.94	31.81	5.35	6.72	3.15	10.48	193.72
	SE	0.0	0.0	0.0	3.77	1.74	6.20	1.37	1.07	15.61	1.63	4.08	4.78	0.06	3.58	60.65
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	2	11	11
5/31-6/ 2	DEN	2.92	0.0	0.0	13.31	1.55	15.50	16.49	15.38	11.81	52.20	600.83	237.60	179.08	104.77	273.20
	SE	2.92	0.0	0.0	11.34	0.90	9.00	7.15	6.27	7.18	36.18	191.63	44.52	6.81	26.83	67.49
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	3	10	11
6/ 6-6/ 9	DEN	0.0	0.0	0.0	11.39	8.20	44.65	197.57	143.12	321.23	650.49	215.42	417.14	370.15	858.93	1042.20
	SE	0.0	0.0	0.0	3.29	1.28	41.05	70.60	60.27	157.56	398.91	91.03	95.17	145.99	323.20	286.27
	TOWS	3	0	3	3	3	3	4	3	5	4	5	16	3	6	10
6/13-6/16	DEN	1.00	0.0	0.0	2.03	1.02	2.00	14.44	22.89	1.76	24.10	157.66	228.14	576.73	1132.78	838.97
	SE	1.00	0.0	0.0	2.03	1.02	2.00	9.08	12.81	1.02	10.34	61.65	85.91	175.91	378.35	126.74
	TOWS	3	0	3	3	3	3	6	2	4	3	5	17	3	6	10
6/20-6/24	DEN	0.0	0.0	0.96	1.86	0.0	3.08	17.76	39.01	49.16	38.30	114.53	251.68	15.88	784.43	265.02
	SE	0.0	0.0	0.96	1.86	0.0	3.08	8.55	8.76	20.02	10.82	29.59	68.96	10.41	507.48	109.35
	TOWS	3	0	3	3	3	3	4	3	5	3	7	15	3	5	11
6/27-7/ 1	DEN	0.0	0.0	0.0	0.0	0.0	0.84	8.30	0.0	7.47	18.78	129.92	59.66	121.02	135.36	235.71
	SE	0.0	0.0	0.0	0.0	0.0	0.84	2.44	0.0	2.96	2.22	43.72	17.87	27.96	38.15	34.83
	TOWS	2	0	3	4	3	3	4	2	5	3	6	17	3	6	10
7/ 5-7/ 8	DEN	2.07	0.0	0.0	1.98	0.0	11.22	9.47	41.86	19.66	108.22	60.57	47.97	77.06	52.78	64.96
	SE	1.04	0.0	0.0	0.99	0.0	11.22	6.41	9.85	4.02	44.85	26.08	7.50	6.32	15.27	18.53
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	2.46	0.0	0.0	9.29	5.83	7.89	4.62	8.65	27.81
	SE	0.0	0.0	0.0	0.0	0.0	0.0	1.77	0.0	0.0	7.06	2.69	1.84	3.55	3.99	7.20
	TOWS	3	0	3	3	3	3	5	3	4	3	5	17	3	6	10
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.19	0.0	0.37	7.54	0.43	0.86
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.19	0.0	0.25	1.22	0.43	0.60
	TOWS	3	0	3	3	4	2	4	3	5	3	5	17	3	7	9
8/ 8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10

* REGION AND STRATUM

S = shoal strata
B = bottom stratum
C = channel stratum

Table C-27

Estimated Density (No./1000 m^3) of White Perch Post Yolk-Sac Larvae in Bottom and Channel Strata in Seven Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

DATE		WP B	WP C	PK B	PK C	HP B	HP C	KG B	KG C	SG B	SG C	CS B	CS C	AL B	AL C
		REGION AND STRATUM*													
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	6	3	4	0	0	0	0	0	0	0	0	0	0
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	7	0	0	0	0	0	0	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	3	3	3	0	0	0	0	0	0	0	0	0	0
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	2	3	3	0	0	0	0	0	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	4	3	3	3	3	0
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	17	17	6	6	3	4	3	3	3	4	3	3	3	0
5/ 2-5/ 5	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	3	4	3	3	3	0
5/ 9-5/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.36	0.0	1.09	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.36	0.0	1.09	0.0	0.0	0.0
	TOWS	18	17	7	6	3	4	3	3	3	4	3	3	3	0
5/16-5/19	DEN	0.33	1.12	0.48	2.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.26	0.0	0.0
	SE	0.23	0.77	0.48	2.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.26	0.0	0.0
	TOWS	19	17	6	6	3	4	3	3	3	4	3	3	3	0
5/23-5/26	DEN	0.0	45.54	119.95	221.11	171.93	469.32	390.89	312.22	272.48	4.44	28.13	66.26	1.06	0.0
	SE	0.0	26.90	37.05	52.70	58.36	250.78	132.97	160.97	240.55	4.44	26.62	22.94	1.06	0.0
	TOWS	5	11	8	20	6	8	5	3	4	3	3	3	3	0
5/31-6/ 2	DEN	129.65	322.59	405.95	837.43	1119.25	2571.46	670.37	2661.83	1622.53	2277.87	492.65	658.76	34.19	0.0
	SE	45.59	101.46	144.39	213.62	205.25	553.77	155.30	814.86	304.42	896.10	113.94	107.97	8.19	0.0
	TOWS	6	10	8	19	6	7	4	4	4	3	3	3	3	0
6/ 6-6/ 9	DEN	148.77	323.34	804.49	1310.83	2164.47	2026.31	2078.46	3983.85	1406.70	1394.00	625.22	621.50	134.94	0.0
	SE	54.15	80.73	122.19	270.07	1048.63	520.90	275.54	918.03	443.89	236.45	113.42	363.69	18.26	0.0
	TOWS	7	16	12	14	5	5	5	5	4	3	5	2	3	0
6/13-6/16	DEN	873.28	531.76	648.83	1597.42	1187.48	2505.37	1137.29	1053.82	417.57	857.74	245.11	521.90	45.23	0.0
	SE	247.61	85.12	185.60	437.18	379.02	1183.46	254.80	241.92	126.82	224.79	112.96	159.61	19.16	0.0
	TOWS	6	17	11	15	5	5	5	5	3	4	4	3	3	0
6/20-6/24	DEN	191.02	713.40	248.55	117.44	202.63	431.83	243.77	229.60	152.82	362.54	66.26	297.79	43.01	0.0
	SE	55.97	198.69	50.97	34.26	52.07	96.06	90.12	32.26	123.18	44.83	25.50	24.21	38.54	0.0
	TOWS	5	18	11	15	4	6	5	5	3	4	4	3	3	0
6/27-7/ 1	DEN	192.51	239.04	171.69	190.99	66.50	120.10	127.83	352.58	36.82	72.23	111.84	73.31	6.57	0.0
	SE	49.44	27.08	46.49	32.87	18.50	41.31	48.48	155.88	8.88	44.23	29.23	27.95	1.72	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/ 5-7/ 8	DEN	23.94	27.91	19.78	35.67	35.46	14.34	26.81	12.27	7.20	6.26	31.06	4.63	9.04	0.0
	SE	11.42	4.59	3.52	12.16	7.95	7.73	6.29	6.20	3.13	2.50	13.37	3.05	2.60	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/11-7/15	DEN	10.17	6.65	12.23	10.34	4.64	12.31	17.14	44.85	26.81	4.00	7.90	15.81	9.72	0.0
	SE	2.68	1.25	3.42	2.98	1.34	4.36	2.93	26.40	15.14	1.57	2.99	6.48	9.72	0.0
	TOWS	6	17	13	13	4	6	5	5	2	5	4	3	3	0
7/25-7/29	DEN	0.51	0.0	1.23	0.85	1.66	0.46	1.88	0.0	0.0	0.0	0.84	0.0	0.0	0.0
	SE	0.51	0.0	0.52	0.50	0.96	0.46	1.23	0.0	0.0	0.0	0.84	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
8/ 8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0

* B = bottom stratum
C = channel stratum

Table C-28

Estimated Standing Crops (in Thousands) and Percent Standing Crops of White Perch Yolk-Sac Larvae Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of White Perch Yolk-Sac Larvae Abundance, 1977

Date		Bowline	Percent	Lovett	Percent	Indian Point	Percent	Roseton	Percent	Danskammer	Percent
5/16-5/19	Above	76767	96.4	76252	95.8	76021	95.5	64318	80.8	63757	80.1
	Within	1449	1.8	1331	1.7	1476	1.9	7880	9.9	7705	9.7
	Below	1411	1.8	2044	2.6	2130	2.7	7429	9.3	8165	10.3
5/23-5/26	Above	250233	83.2	246431	81.9	244327	81.2	176788	58.8	172987	57.5
	Within	26462	8.8	17296	5.8	16734	5.6	45602	15.2	47002	15.6
	Below	24039	8.0	37007	12.3	39673	13.2	78344	26.1	80746	26.8
5/31-6/2	Above	95012	81.8	83301	71.7	78890	67.9	42050	36.2	41756	35.9
	Within	17407	15.0	26772	23.0	30459	26.2	4450	3.8	4253	3.7
	Below	3788	3.3	6135	5.3	6858	5.9	69707	60.0	70199	60.4
6/6-6/9	Above	49039	92.4	47466	89.5	47201	89.0	41404	78.0	41245	77.7
	Within	3683	6.9	4843	9.1	4835	9.1	2774	5.2	2544	4.8
	Below	326	0.6	739	1.4	1012	1.9	8870	16.7	9259	17.5

Table C-29

Estimated Standing Crops (in Thousands) and Percent Standing Crops of White Perch Post Yolk-Sac Larvae Above, Within, and Below Five Power Plant Regions Determined from Ichthyoplankton Survey during Periods of Post Yolk-Sac Larvae Abundance, 1977

Date		Bowline	Percent	Lovett	Percent	Indian Point	Percent	Roseton	Percent	Danskammer	Percent
5/31-6/2	Above	1447645	97.1	1418598	95.2	1411784	94.7	1186144	79.6	1171633	78.6
	Within	40324	2.7	67792	4.5	74184	5.0	162266	10.9	171561	11.5
	Below	2776	0.2	4356	0.3	4778	0.3	142336	9.5	147552	9.9
6/6-6/9	Above	1751642	94.9	1713592	92.8	1706703	92.4	1287549	69.7	1264063	68.5
	Within	89343	4.8	117977	6.4	117868	6.4	304109	16.5	305298	16.5
	Below	5641	0.3	15056	0.8	22055	1.2	254968	13.8	277264	15.0
6/13-6/16	Above	1384480	98.0	1355180	95.9	1341854	94.9	848533	60.0	821427	58.1
	Within	28429	2.0	57226	4.0	70226	5.0	336930	23.8	342998	24.3
	Below	438	0.0	940	0.0	1266	0.0	227883	16.1	249121	17.6
6/20-6/24	Above	428758	92.6	397060	85.7	382295	82.6	195249	42.2	192339	41.5
	Within	33656	7.3	64112	13.8	77829	16.8	56484	12.2	50352	10.9
	Below	650	0.1	1893	0.4	2940	0.6	211331	45.6	220373	47.6

Table C-30

Estimated Standing Crops (in Thousands) of White Perch Juveniles in 12 Geographic Regions of Hudson River Estuary (RM 12-152; KM 19-243) Determined from 100-ft (30.5-m) Beach Seine during Daytime, 1977

	REGIONS												
DATES	YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
6/12- 6/25													
SC	0	0	0	0	0	0	0	2480	0	4389	0	1235	8104
SE	0	0	0	0	0	0	0	1894	0	4389	0	1235	4937
TOWS	38	22	15	57	24	28	3	3	3	4	7	11	215
6/26- 7/ 9													
SC	290	5679	11952	13165	16540	43048	120624	36373	116220	421333	475024	131338	1391586
SE	290	3880	5842	4074	8547	16932	101146	30182	12913	178169	306123	104124	384748
TOWS	26	16	18	63	29	24	6	3	2	4	7	12	210
7/10- 7/23													
SC	2510	35870	47455	70578	49323	31953	35478	60967	146351	155806	193729	944597	1774614
SE	1082	12323	26546	21110	12946	8620	14002	28141	91162	53541	45376	571079	584723
TOWS	21	19	17	41	21	19	12	6	6	8	13	21	204
7/24- 8/ 6													
SC	8186	127220	80673	93538	43780	93863	25157	22320	114785	109722	398430	593490	1711163
SE	2216	78597	36411	24619	9457	31957	13270	10157	72494	41802	200391	289588	374866
TOWS	23	15	16	40	18	16	11	5	6	8	12	22	192
8/ 7- 8/20													
SC	2690	146043	42578	55513	32557	60179	49669	39680	94698	118500	92756	76579	811440
SE	795	64287	23042	16674	11268	19735	13389	16548	43897	31779	33793	28850	104034
TOWS	28	14	12	42	17	20	12	5	5	8	14	22	199
8/21- 9/ 3													
SC	1255	87626	80673	47358	49724	100425	14901	9713	37879	182139	271242	237767	1120700
SE	979	36418	26611	12709	14339	33621	5230	5255	24136	115689	111839	132184	218025
TOWS	24	14	30	36	15	14	10	6	5	8	14	22	198
9/ 4- 9/17													
SC	4142	57288	209900	107605	34465	146985	33704	4960	77480	310148	106810	50641	1144128
SE	2218	22532	104900	32858	9254	49088	22694	4960	29822	81297	100405	26044	184089
TOWS	20	23	36	34	39	25	4	2	3	3	7	11	207
9/18-10/ 1													
SC	0	95002	126772	89391	41805	59567	35478	6200	48784	0	229548	21135	753681
SE	0	33983	44521	27879	11452	15258	21985	4960	40175	0	147121	15040	168140
TOWS	30	33	14	30	29	27	5	2	3	3	6	9	191
10/ 2-10/15													
SC	0	33319	49445	192442	18139	6872	13009	3720	0	122889	127891	42119	609844
SE	0	12876	17684	59050	4627	2345	5622	3720	0	89803	59841	34816	129981
TOWS	12	30	31	17	34	31	6	2	2	4	6	10	185
10/16-10/29													
SC	38492	45436	29964	26541	14268	21302	27200	827	0	8778	8432	5435	226674
SE	12599	17024	6685	10183	5940	8469	13137	827	0	5068	3975	3004	30459
TOWS	27	29	35	25	29	28	6	3	3	4	7	10	206
10/30-11/12													
SC	67403	221038	17927	58255	31931	9941	1774	413	8609	58519	2459	49252	527521
SE	32385	133331	6616	19272	7519	3307	1774	413	8609	58519	2459	49252	158878
TOWS	20	37	30	28	26	30	4	3	2	3	8	8	199
11/13-11/26													
SC	15779	80932	34476	4608	879	1775	0	0	0	0	0	0	138449
SE	4760	20065	22417	1805	420	1385	0	0	0	0	0	0	30548
TOWS	21	32	39	28	21	24	6	3	3	4	8	8	197
11/27-12/10													
SC	14666	13363	3164	559	310	0	0	0	0	0	0	0	32061
SE	8686	8504	1888	389	310	0	0	0	0	0	0	0	12312
TOWS	19	17	34	33	17	10	0	0	0	0	0	0	139

Table C-31

Young-of-the-Year White Perch Catch per Tow in 12 Geographic Regions of Hudson River Estuary (RM 12-152; KM 19-243) Determined from 100-ft (30.5-m) Beach Seine during Daytime, 1977

		Region												
DATE		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTAL
APR 3-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
APR 16	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	30	27	35	24	20	6	3	3	5	7	11	199
APR 17-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
APR 30	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	34	37	27	20	22	5	2	2	4	5	4	190
MAY 1-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAY 14	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	21	41	35	49	15	12	2	3	1	4	7	9	199
MAY 15-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAY 28	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	21	26	33	51	21	29	3	3	2	5	8	12	214
MAY 29-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JUN 11	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	25	24	51	13	24	4	2	2	4	7	10	184
JUN 12-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.00	0.0	0.25	0.0	0.09	0.04
JUN 25	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.53	0.0	0.25	0.0	0.09	0.02
	TOWS	38	22	15	57	24	28	3	3	3	4	7	11	215
JUN 26-	CPUE	0.04	0.13	0.44	1.43	6.28	4.04	17.00	29.33	13.50	24.00	24.14	9.67	4.66
JUL 9	SE	0.04	0.09	0.22	0.44	3.24	1.59	14.25	24.34	1.50	10.15	15.56	7.66	1.05
	TOWS	26	16	18	63	29	24	6	3	2	4	7	12	210
JUL 10-	CPUE	0.33	0.79	1.76	7.66	18.71	3.00	5.00	49.17	17.00	8.88	9.85	69.52	14.37
JUL 23	SE	0.14	0.27	0.99	2.29	4.91	0.81	1.97	22.69	10.59	3.05	2.31	42.03	4.58
	TOWS	21	19	17	41	21	19	12	6	6	8	13	21	204
JUL 24-	CPUE	1.09	2.80	3.00	10.15	16.61	8.81	3.55	18.00	13.33	6.25	20.25	43.68	12.63
AUG 6	SE	0.29	1.73	1.35	2.67	3.59	3.00	1.87	8.19	8.42	2.38	10.18	21.31	2.74
	TOWS	23	15	16	40	18	16	11	5	6	8	12	22	192
AUG 7-	CPUE	0.36	3.21	1.58	6.02	12.35	5.65	7.00	32.00	11.00	6.75	4.71	5.64	5.99
AUG 20	SE	0.11	1.41	0.86	1.81	4.28	1.85	1.89	13.35	5.10	1.81	1.72	2.12	0.80
	TOWS	28	14	12	42	17	20	12	5	5	8	14	22	199
AUG 21-	CPUE	0.17	1.93	3.00	5.14	18.87	9.43	2.10	7.83	4.40	10.38	13.79	17.50	7.43
SEP 3	SE	0.13	0.80	0.99	1.38	5.44	3.16	0.74	4.24	2.80	6.59	5.68	9.73	1.36
	TOWS	24	14	30	36	15	14	10	6	5	8	14	22	198
SEP 4-	CPUE	0.55	1.26	7.81	11.68	13.08	13.80	4.75	4.00	9.00	17.67	5.43	3.73	8.50
SEP 17	SE	0.29	0.50	3.90	3.57	3.51	4.61	3.20	4.00	3.46	4.63	5.10	1.92	1.29
	TOWS	20	23	36	34	39	25	4	2	3	3	7	11	207
SEP 18-	CPUE	0.0	2.09	4.71	9.70	15.86	5.59	5.00	5.00	5.67	0.0	11.67	1.56	6.14
OCT 1	SE	0.0	0.75	1.66	3.03	4.35	1.43	3.10	4.00	4.67	0.0	7.48	1.11	0.96
	TOWS	30	33	14	30	29	27	5	2	3	3	6	9	191
OCT 2-	CPUE	0.0	0.73	1.84	20.88	6.88	0.65	1.83	3.00	0.0	7.00	6.50	3.10	4.34
OCT 15	SE	0.0	0.28	0.66	6.41	1.76	0.22	0.79	3.00	0.0	5.12	3.04	2.56	0.82
	TOWS	12	30	31	17	34	31	6	2	2	4	6	10	185
OCT 16-	CPUE	5.11	1.00	1.11	2.88	5.41	2.00	3.83	0.67	0.0	0.50	0.43	0.40	2.55
OCT 29	SE	1.67	0.37	0.25	1.11	2.25	0.80	1.85	0.67	0.0	0.29	0.20	0.22	0.44
	TOWS	27	29	35	25	29	28	6	3	3	4	7	10	206
OCT 30-	CPUE	8.95	4.86	0.67	6.32	12.12	0.93	0.25	0.33	1.00	3.33	0.13	3.63	4.74
NOV 12	SE	4.30	2.93	0.25	2.09	2.85	0.31	0.25	0.33	1.00	3.33	0.13	3.63	0.89
	TOWS	20	37	30	28	26	30	4	3	2	3	8	8	199
NOV 13-	CPUE	2.10	1.78	1.28	0.50	0.33	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.89
NOV 26	SE	0.63	0.44	0.83	0.20	0.16	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.20
	TOWS	21	32	39	28	21	24	6	3	3	4	8	8	197
NOV 27-	CPUE	1.95	0.29	0.12	0.06	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.38
DEC 10	SE	1.15	0.19	0.07	0.04	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.18
	TOWS	19	17	34	33	17	10	0	0	0	0	0	0	130
DEC 11-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEC 24	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	2	13	16	17	13	0	0	0	0	0	0	0	61

Table C-32

Young-of-the-Year White Perch Adjusted Catch per Unit Effort by Bottom Trawl in Hudson River Estuary, 1977

DATE		Region TZ	CH	IP	WP	CW	TOTAL
APR 3-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0
APR 16	SE	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	8	3	11	5	5	32
APR 17-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0
APR 30	SE	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	8	3	11	5	5	32
MAY 1-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0
MAY 14	SE	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	8	3	11	5	5	32
MAY 15-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0
MAY 28	SE	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	8	3	11	5	5	32
MAY 29-	CPUE	0.0	0.51	0.70	0.0	0.0	0.29
JUN 11	SE	0.0	0.51	0.70	0.0	0.0	0.24
	TOWS	8	3	11	5	5	32
JUN 12-	CPUE	0.0	0.0	0.14	1.85	0.0	0.72
JUN 25	SE	0.0	0.0	0.14	0.58	0.0	0.29
	TOWS	7	2	11	5	5	30
JUN 26-	CPUE	0.38	0.0	0.84	0.31	0.0	2.07
JUL 9	SE	0.25	0.0	0.43	0.31	0.0	1.23
	TOWS	8	3	11	5	5	32
JUL 10-	CPUE	0.0	0.0	0.42	0.31	0.0	0.34
JUL 23	SE	0.0	0.0	0.30	0.31	0.0	0.15
	TOWS	8	3	11	5	5	32
JUL 24-	CPUE	0.0	0.0	1.82	0.31	0.0	0.79
AUG 6	SE	0.0	0.0	1.67	0.31	0.0	0.60
	TOWS	7	3	11	5	5	31
AUG 7-	CPUE	0.0	0.0	0.0	0.0	0.62	0.0
AUG 20	SE	0.0	0.0	0.0	0.0	0.62	0.0
	TOWS	8	3	11	5	5	32
AUG 21-	CPUE	0.0	0.0	0.15	0.62	1.54	0.15
SEP 3	SE	0.0	0.0	0.15	0.62	0.84	0.11
	TOWS	8	3	10	5	5	31
SEP 4-	CPUE	0.0	0.0	0.0	0.0	0.92	0.0
SEP 17	SE	0.0	0.0	0.0	0.0	0.92	0.0
	TOWS	8	3	11	5	5	32
SEP 18-	CPUE	0.38	0.0	0.77	0.26	0.0	0.53
OCT 1	SE	0.25	0.0	0.34	0.26	0.0	0.19
	TOWS	8	3	10	6	5	32
OCT 2-	CPUE	0.38	0.0	6.85	7.38	0.0	4.18
OCT 15	SE	0.38	0.0	3.44	2.55	0.0	1.35
	TOWS	8	3	11	5	5	32
OCT 16-	CPUE	0.0	0.0	2.80	5.54	0.0	3.70
OCT 29	SE	0.0	0.0	1.21	3.32	0.0	1.24
	TOWS	8	3	11	5	5	32
OCT 30-	CPUE	1.54	1.54	15.80	10.77	0.0	8.46
NOV 12	SE	1.16	0.89	4.32	4.10	0.0	1.96
	TOWS	8	3	11	5	5	32
NOV 13-	CPUE	14.62	7.69	24.76	4.92	0.31	14.28
NOV 26	SE	4.24	6.94	15.60	2.25	0.31	5.55
	TOWS	8	3	11	5	5	32
NOV 27-	CPUE	134.04	0.0	0.0	9.54	0.0	58.95
DEC 10	SE	61.90	0.0	0.0	5.11	0.0	29.28
	TOWS	8	1	0	5	5	19

Table C-33

Estimated Standing Crop (in Thousands) of White Perch Juveniles in Seven Geographic Regions of Hudson River Estuary (RM 14-76; KM 22-122) Determined from Fall Shoals Survey, 1977

DATE		YK	TZ	CH	IP	WP	CW	PK	TOTL
8/15-	SC	11	0	21	40	0	197	271	539
8/19	SE	11	0	11	16	0	115	181	215
	TOWS	6	35	28	12	6	11	4	102
8/29-	SC	0	0	0	0	0	52	82	134
9/ 2	SE	0	0	0	0	0	40	48	63
	TOWS	6	36	28	12	4	10	4	100
9/12-	SC	0	109	0	5	0	0	66	180
9/16	SE	0	58	0	5	0	0	38	69
	TOWS	6	36	28	12	4	10	4	100
9/26-	SC	0	11	176	35	15	33	35	304
9/30	SE	0	11	86	15	15	19	35	97
	TOWS	6	36	28	12	4	10	4	100
10/10-	SC	10	33	111	78	14	171	295	711
10/13	SE	10	24	35	35	14	108	121	167
	TOWS	6	36	28	12	4	9	5	100
10/24-	SC	407	60	28	45	14	115	225	894
10/29	SE	122	34	22	18	14	66	102	179
	TOWS	6	36	28	12	4	10	4	100
11/ 7-	SC	1305	3943	625	316	13	234	0	6435
11/11	SE	592	939	158	163	13	36	0	1134
	TOWS	6	36	30	12	4	10	3	101
11/20-	SC	433	3268	1733	626	0	160	70	6290
11/22	SE	190	522	209	175	0	70	41	624
	TOWS	5	36	28	12	4	10	4	99
12/ 5-	SC	0	0	406	81	0	0	0	487
12/ 6	SE	0	0	98	43	0	0	0	107
	TOWS	0	0	14	9	0	0	0	23

Table C-34

Estimated Standing Crop (in Thousands) of White Perch Yearlings in 12 Geographic Regions of Hudson River Estuary (RM 12-152; KM 19-243) Determined from 100-ft (30.5-m) Beach Seine during Daytime, 1978

DATES		REGIONS												
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
3/26- 4/ 8														
	SC	0	2840	1034	0	126	0	0	0	0	0	0	0	3999
	SE	0	2840	1034	0	126	0	0	0	0	0	0	0	3025
	TOWS	11	16	26	12	21	10	8	0	0	0	0	0	104
4/ 9- 4/22														
	SC	685	3786	768	0	0	0	0	0	0	0	0	0	5239
	SE	685	2618	768	0	0	0	0	0	0	0	0	0	2813
	TOWS	22	24	35	31	30	25	19	3	4	4	3	10	210
4/23- 5/ 6														
	SC	1027	53337	1034	4800	304	0	0	0	0	0	0	0	60502
	SE	751	41163	1034	3327	168	0	0	0	0	0	0	0	41317
	TOWS	22	23	26	48	26	15	15	3	3	5	6	11	203
5/ 7- 5/20														
	SC	5422	69901	2758	1229	2086	1452	11826	413	0	0	7378	0	102466
	SE	1820	32397	1323	731	1218	1062	11826	413	0	0	5176	0	34994
	TOWS	25	26	39	30	24	22	9	3	2	5	8	8	201
5/21- 6/ 3														
	SC	12288	2726132	31093	15080	7298	2130	16162	1240	0	96556	32793	2717	2943484
	SE	4579	1557283	11269	3482	2828	1657	6950	0	0	36895	10975	1812	1557828
	TOWS	19	18	32	44	26	20	18	1	0	4	6	10	198
6/ 4- 6/17														
	SC	8134	611757	497486	72640	8200	3195	76277	2067	66001	280889	45910	37363	1709914
	SE	2256	194606	231055	35704	4070	1745	43766	2067	40481	112410	32793	23835	332258
	TOWS	25	28	32	34	18	20	16	3	3	4	6	12	201
6/18- 7/ 1														
	SC	0	994882	303387	98631	4612	22984	30747	620	94698	17556	0	140395	1708508
	SE	0	255826	56490	66745	1776	6529	9303	620	94698	10136	0	47929	290849
	TOWS	19	29	39	37	16	19	18	2	2	4	3	9	197

Table C-35

Yearling White Perch Catch per Tow in 12 Geographic Regions of Hudson River Estuary (RM 12-152, KM 19-243) Determined from 100-ft (30.5m) Beach Seine during Daytime, 1978

DATE		Region YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTAL
MAR 26-	CPUE	0.0	0.06	0.04	0.0	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03
APR 8	SE	0.0	0.06	0.04	0.0	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02
	TOWS	11	16	26	12	21	10	8	0	0	0	0	0	104
APR 9-	CPUE	0.09	0.08	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02
APR 22	SE	0.09	0.06	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
	TOWS	22	24	35	31	30	25	19	3	4	4	3	10	210
APR 23-	CPUE	0.14	1.17	0.04	0.52	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.29
MAY 6	SE	0.10	0.91	0.04	0.36	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.13
	TOWS	22	23	26	48	26	15	15	3	3	5	6	11	203
MAY 7-	CPUE	0.72	1.54	0.10	0.13	0.79	0.14	1.67	0.33	0.0	0.0	0.38	0.0	0.53
MAY 20	SE	0.24	0.71	0.05	0.08	0.46	0.10	1.67	0.33	0.0	0.0	0.26	0.0	0.14
	TOWS	25	26	39	30	24	22	9	3	2	5	8	8	201
MAY 21-	CPUE	1.63	60.00	1.16	1.64	2.77	0.20	2.28	1.00	0.0	5.50	1.67	0.20	6.93
JUN 3	SE	0.61	34.27	0.42	0.38	1.07	0.16	0.98	0.0	0.0	2.10	0.56	0.13	3.27
	TOWS	19	18	32	44	26	20	18	1	0	4	6	10	198
JUN 4-	CPUE	1.08	13.46	18.50	7.88	3.11	0.30	10.75	1.67	7.67	16.00	2.33	2.75	8.14
JUN 17	SE	0.30	4.28	8.59	3.87	1.54	0.16	6.17	1.67	4.70	6.40	1.67	1.75	1.75
	TOWS	25	28	32	34	18	20	16	3	3	4	6	12	201
JUN 18-	CPUE	0.0	21.90	11.28	10.70	1.75	2.16	4.33	0.50	11.00	1.00	0.0	10.33	8.82
JUL 1	SE	0.0	5.63	2.10	7.24	0.67	0.61	1.31	0.50	11.00	0.58	0.0	3.53	1.71
	TOWS	19	29	39	37	16	19	18	2	2	4	3	9	197

Table C-36

Yearling White Perch Adjusted Catch per Unit Effort by Bottom Trawl in Hudson River Estuary, 1978

DATE		Region TZ	CH	IP	WP	CW	PK	TOTAL
APR 9-	CPUE	6.15	6.67	9.93	6.15	0.31	0.0	5.49
APR 22	SE	1.69	5.91	6.77	4.38	0.31	0.0	2.29
	TOWS	5	3	11	5	5	6	35
APR 23-	CPUE	0.96	10.77	11.19	16.62	6.46	7.69	8.54
MAY 6	SE	0.50	10.01	3.48	6.37	3.17	3.13	1.72
	TOWS	8	3	11	5	5	6	38
MAY 7-	CPUE	4.81	1.03	4.90	4.00	3.38	11.54	5.30
MAY 20	SE	2.78	1.03	1.48	1.79	1.78	7.62	1.43
	TOWS	8	3	11	5	5	6	38
MAY 21-	CPUE	6.15	0.0	0.84	4.31	0.0	6.67	3.16
JUN 3	SE	5.31	0.0	0.48	3.21	0.0	4.06	1.36
	TOWS	8	3	11	5	5	6	38
JUN 4-	CPUE	0.77	0.0	0.14	0.31	1.54	0.0	0.45
JUN 17	SE	0.58	0.0	0.14	0.31	1.19	0.0	0.21
	TOWS	8	3	11	5	5	6	38
JUN 18-	CPUE	0.19	0.51	2.24	0.0	0.0	0.26	0.77
JUL 1	SE	0.19	0.51	2.09	0.0	0.0	0.26	0.61
	TOWS	8	3	11	5	5	6	38

Table C-37

Numbers of Juvenile White Perch Finclipped and Released September-November 1977 and April-June 1978 in Hudson River Estuary

Region	1	2	3	4	5	
River Mile	12-23	24-38	39-46	47-76	77-153	Total
Sep	24	1461	1852	1959	280	5576
Oct	266	2696	2867	1044	115	6988
Nov	[illegible]	2708	[illegible]	[illegible]	[illegible]	4874
Sep-Nov 1977	613	6865	5956	3566	438	17438
Apr-Jun 1978	78	2645	493	350	176	3742

Table C-38

Combined Standing Crop (in Thousands, Unadjusted for Catch Efficiency) of Juvenile White Perch in Shore, Shoal, Bottom, and Channel Strata of Hudson River, July to December 1977 (Page 1 of 12)

6/26/77 - 7/ 2/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	1	0	0*****	0	1
	SE	1	0	0	0	1
TAPPAN ZEE (24-33)	SC	14	0	0	0	14
	SE	10	0	0	0	10
CROTON-HAVER.(34-38)	SC	30	0	0	0	30
	SE	15	0	0	0	15
INDIAN POINT (39-46)	SC	33	0	0	0	33
	SE	11	0	0	0	11
WEST POINT(47-55)	SC	41	0***	0	0	41
	SE	22	0	0	0	22
CORNWALL (56-61)	SC	107	0	0	0	107
	SE	45	0	0	0	45
POUGHKEEPSIE (62-76)	SC	299	0***	0	0	299
	SE	254	0	0	0	254
HYDE PARK (77-85)	SC	90	0***	0	0	90
	SE	76	0	0	0	76
KINGSTON (86-93)	SC	288	6***	24	0	318
	SE	51	6	24	0	57
SAUGERTIES (94-106)	SC	1043	15***	42	0	1100
	SE	465	15	42	0	467
CATSKILL (107-124)	SC	1176	0***	0	0	1176
	SE	776	0	0	0	776
ALBANY (125-153)	SC	325	0***	0	0****	325
	SE	262	0	0	0	262
STRATUM TOTAL	SC	3447	21	66	0	3534
	SE	981	16	48	0	982

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

7/ 3/77 - 7/ 9/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	1	0	0*****	0	1
	SE	1	0	0	0	1
TAPPAN ZEE (24-33)	SC	14	0	0	0	14
	SE	10	0	0	0	10
CROTON-HAVER.(34-38)	SC	30	0	0	0	30
	SE	15	0	0	0	15
INDIAN POINT (39-46)	SC	33	26	22	26	107
	SE	11	26	22	26	44
WEST POINT(47-55)	SC	41	0***	0	0	41
	SE	22	0	0	0	22
CORNWALL (56-61)	SC	107	7	95	33	242
	SE	45	7	73	33	92
POUGHKEEPSIE (62-76)	SC	299	0***	0	43	342
	SE	254	0	0	43	258
HYDE PARK (77-85)	SC	90	2***	28	273	393
	SE	76	2	28	205	220
KINGSTON (86-93)	SC	288	27***	104	0	419
	SE	51	20	78	0	95
SAUGERTIES (94-106)	SC	1043	0***	0	0	1043
	SE	465	0	0	0	465
CATSKILL (107-124)	SC	1176	56***	91	0	1323
	SE	776	56	91	0	783
ALBANY (125-153)	SC	325	0***	0	0****	325
	SE	262	0	0	0	262
STRATUM TOTAL	SC	3447	118	340	375	4280
	SE	981	65	145	214	1017

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table C-38 (Page 2 of 12)

7/10/77 - 7/16/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	6	0	0*****	0	6
	SE	3	0	0	0	3
TAPPAN ZEE (24-33)	SC	89	0	0	157	246
	SE	33	0	0	157	160
CROTON-HAVER.(34-38)	SC	117	24	34	0	175
	SE	67	24	34	0	79
INDIAN POINT (39-46)	SC	175	27	0	0	202
	SE	58	27	0	0	64
WEST POINT(47-55)	SC	122	1***	15	29	167
	SE	36	1	15	29	49
CORNWALL (56-61)	SC	79	18	0	100	197
	SE	24	18	0	100	104
POUGHKEEPSIE (62-76)	SC	88	4***	58	97	247
	SE	37	2	25	97	107
HYDE PARK (77-85)	SC	151	1***	21	192	365
	SE	73	1	21	133	153
KINGSTON (86-93)	SC	362	10***	38	159	569
	SE	231	10	38	107	258
SAUGERTIES (94-106)	SC	386	22***	63	0	471
	SE	143	22	63	0	158
CATSKILL (107-124)	SC	479	0***	0	73	552
	SE	131	0	0	73	150
ALBANY (125-153)	SC	2338	63***	44	104****	2549
	SE	1451	63	44	104	1457
STRATUM TOTAL	SC	4392	170	273	911	5746
	SE	1488	79	99	300	1523

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

7/17/77 - 7/23/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	6	0**	0**	0**	6
	SE	3	0	0	0	3
TAPPAN ZEE (24-33)	SC	89	0**	0**	78**	167
	SE	33	0	0	78	85
CROTON-HAVER.(34-38)	SC	117	12**	33**	0**	162
	SE	67	12	33	0	76
INDIAN POINT (39-46)	SC	175	30**	0**	0**	205
	SE	58	30	0	0	65
WEST POINT(47-55)	SC	122	1**	15**	74**	212
	SE	36	1	15	41	57
CORNWALL (56-61)	SC	79	24**	0**	63**	166
	SE	24	24	0	63	72
POUGHKEEPSIE (62-76)	SC	88	5**	68**	96**	257
	SE	37	2	33	81	95
HYDE PARK (77-85)	SC	151	1**	23**	226**	401
	SE	73	1	23	197	211
KINGSTON (86-93)	SC	362	13**	51**	79**	505
	SE	231	8	32	53	239
SAUGERTIES (94-106)	SC	386	11**	31**	0**	428
	SE	143	11	31	0	147
CATSKILL (107-124)	SC	479	0**	0**	36**	515
	SE	131	0	0	36	136
ALBANY (125-153)	SC	2338	41**	29**	68**	2476
	SE	1451	41	29	68	1453
STRATUM TOTAL	SC	4392	138	250	720	5500
	SE	1488	59	76	257	1513

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

7/24/77 - 7/30/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	20	0	0*****	0	20
	SE	6	0	0	0	6
TAPPAN ZEE (24-33)	SC	315	0	0	0	315
	SE	200	0	0	0	200
CROTON-HAVER.(34-38)	SC	200	0	33	0	233
	SE	95	0	33	0	101
INDIAN POINT (39-46)	SC	232	34	0	0	266
	SE	69	34	0	0	77
WEST POINT(47-55)	SC	108	1***	16	120	245
	SE	28	1	16	54	63
CORNWALL (56-61)	SC	232	31	0	27	290
	SE	85	31	0	27	94
POUGHKEEPSIE (62-76)	SC	62	6***	79	96	243
	SE	34	3	41	65	84
HYDE PARK (77-85)	SC	55	1***	25	261	342
	SE	26	1	25	261	263
KINGSTON (86-93)	SC	284	17***	64	0	365
	SE	184	7	26	0	186
SAUGERTIES (94-106)	SC	272	0***	0	0	272
	SE	110	0	0	0	110
CATSKILL (107-124)	SC	986	0***	0	0	986
	SE	515	0	0	0	515
ALBANY (125-153)	SC	1469	20***	14	33****	1536
	SE	746	20	14	33	747
STRATUM TOTAL	SC	4235	110	231	537	5113
	SE	965	51	67	278	1008

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

7/31/77 - 8/ 6/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	20	0**	0**	0**	20
	SE	6	0	0	0	6
TAPPAN ZEE (24-33)	SC	315	0**	0**	0**	315
	SE	200	0	0	0	200
CROTON-HAVER.(34-38)	SC	200	0**	16**	0**	216
	SE	95	0	16	0	96
INDIAN POINT (39-46)	SC	232	17**	10**	14**	273
	SE	69	17	10	14	73
WEST POINT(47-55)	SC	108	0**	8**	60**	176
	SE	28	0	8	27	40
CORNWALL (56-61)	SC	232	15**	0**	30**	277
	SE	85	15	0	30	91
POUGHKEEPSIE (62-76)	SC	62	7**	95**	74**	238
	SE	34	3	49	58	83
HYDE PARK (77-85)	SC	55	0**	12**	130**	197
	SE	26	0	12	130	133
KINGSTON (86-93)	SC	284	8**	32**	0**	324
	SE	184	3	13	0	184
SAUGERTIES (94-106)	SC	272	7**	21**	0**	300
	SE	110	7	21	0	112
CATSKILL (107-124)	SC	986	0**	0**	0**	986
	SE	515	0	0	0	515
ALBANY (125-153)	SC	1469	10**	7**	16**	1502
	SE	746	10	7	16	746
STRATUM TOTAL	SC	4235	64	201	324	4824
	SE	965	26	60	149	979

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

8/ 7/77 - 8/13/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	7	0	0*****	0	7
	SE	2	0	0	0	2
TAPPAN ZEE (24-33)	SC	361	0	0	0	361
	SE	167	0	0	0	167
CROTON-HAVER.(34-38)	SC	105	0	0	0	105
	SE	59	0	0	0	59
INDIAN POINT (39-46)	SC	137	0	21	29	187
	SE	45	0	21	29	58
WEST POINT(47-55)	SC	81	0***	0	0	81
	SE	30	0	0	0	30
CORNWALL (56-61)	SC	149	0	0	33	182
	SE	53	0	0	33	62
POUGHKEEPSIE (62-76)	SC	123	8***	112	52	295
	SE	37	4	57	52	86
HYDE PARK (77-85)	SC	98	0***	0	0	98
	SE	43	0	0	0	43
KINGSTON (86-93)	SC	234	0***	0	0	234
	SE	113	0	0	0	113
SAUGERTIES (94-106)	SC	293	15***	42	0	350
	SE	89	15	42	0	100
CATSKILL (107-124)	SC	230	0***	0	0	230
	SE	90	0	0	0	90
ALBANY (125-153)	SC	190	0***	0	0****	190
	SE	76	0	0	0	76
STRATUM TOTAL	SC	2008	23	175	114	2320
	SE	274	16	74	68	292

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

8/14/77 - 8/20/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	7	8	24*****	0*	39
	SE	2	8	24	0	25
TAPPAN ZEE (24-33)	SC	361	0	0	0*	361
	SE	167	0	0	0	167
CROTON-HAVER.(34-38)	SC	105	16	0	0*	121
	SE	59	8	0	0	60
INDIAN POINT (39-46)	SC	137	15	20	0*	172
	SE	45	8	13	0	48
WEST POINT(47-55)	SC	81	0***	0	0*	81
	SE	30	0	0	0	30
CORNWALL (56-61)	SC	149	40	144	0*	333
	SE	53	28	108	0	124
POUGHKEEPSIE (62-76)	SC	123	18***	247	0*	388
	SE	37	12	165	0	170
HYDE PARK (77-85)	SC	98	0*	0*	0*	98
	SE	43	0	0	0	43
KINGSTON (86-93)	SC	234	0*	0*	0*	234
	SE	113	0	0	0	113
SAUGERTIES (94-106)	SC	293	0*	0*	0*	293
	SE	89	0	0	0	89
CATSKILL (107-124)	SC	230	0*	0*	0*	230
	SE	90	0	0	0	90
ALBANY (125-153)	SC	190	0*	0*	0*	190
	SE	76	0	0	0	76
STRATUM TOTAL	SC	2008	97	435	0	2540
	SE	274	33	199	0	340

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table C-38 (Page 5 of 12)

8/21/77 - 8/27/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	3	4**	12**	0*	19
	SE	2	4	12	0	13
TAPPAN ZEE (24-33)	SC	217	0**	0**	0*	217
	SE	95	0	0	0	95
CROTON-HAVER.(34-38)	SC	200	8**	0**	0*	208
	SE	72	4	0	0	72
INDIAN POINT (39-46)	SC	117	7**	10**	0*	134
	SE	35	4	6	0	36
WEST POINT(47-55)	SC	123	0**	0**	0*	123
	SE	39	0	0	0	39
CORNWALL (56-61)	SC	249	24**	91**	0*	364
	SE	90	17	73	0	117
POUGHKEEPSIE (62-76)	SC	37	11**	161**	0*	209
	SE	14	7	104	0	105
HYDE PARK (77-85)	SC	24	0*	0*	0*	24
	SE	13	0	0	0	13
KINGSTON (86-93)	SC	94	0*	0*	0*	94
	SE	61	0	0	0	61
SAUGERTIES (94-106)	SC	451	0*	0*	0*	451
	SE	293	0	0	0	293
CATSKILL (107-124)	SC	671	0*	0*	0*	671
	SE	292	0	0	0	292
ALBANY (125-153)	SC	588	0*	0*	0*	588
	SE	337	0	0	0	337
STRATUM TOTAL	SC	2774	54	274	0	3102
	SE	560	20	128	0	575

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

8/28/77 - 9/ 3/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	3	0	0*****	0*	3
	SE	2	0	0	0	2
TAPPAN ZEE (24-33)	SC	217	0	0	0*	217
	SE	95	0	0	0	95
CROTON-HAVER.(34-38)	SC	200	0	0	0*	200
	SE	72	0	0	0	72
INDIAN POINT (39-46)	SC	117	0	0	0*	117
	SE	35	0	0	0	35
WEST POINT(47-55)	SC	123	0***	0	0*	123
	SE	39	0	0	0	39
CORNWALL (56-61)	SC	249	9	39	0*	297
	SE	90	6	39	0	98
POUGHKEEPSIE (62-76)	SC	37	5***	75	0*	117
	SE	14	3	44	0	46
HYDE PARK (77-85)	SC	24	0*	0*	0*	24
	SE	13	0	0	0	13
KINGSTON (86-93)	SC	94	0*	0*	0*	94
	SE	61	0	0	0	61
SAUGERTIES (94-106)	SC	451	0*	0*	0*	451
	SE	293	0	0	0	293
CATSKILL (107-124)	SC	671	0*	0*	0*	671
	SE	292	0	0	0	292
ALBANY (125-153)	SC	588	0*	0*	0*	588
	SE	337	0	0	0	337
STRATUM TOTAL	SC	2774	14	114	0	2902
	SE	560	7	59	0	563

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table C-38 (Page 6 of 12)

9/ 4/77 - 9/10/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	10	0**	0**	0*	10
	SE	6	0	0	0	6
TAPPAN ZEE (24-33)	SC	142	36**	6**	0*	184
	SE	59	21	6	0	63
CROTON-HAVER.(34-38)	SC	520	0**	0**	0*	520
	SE	270	0	0	0	270
INDIAN POINT (39-46)	SC	266	1**	0**	0*	267
	SE	89	1	0	0	89
WEST POINT(47-55)	SC	85	0**	0**	0*	85
	SE	26	0	0	0	26
CORNWALL (56-61)	SC	364	4**	19**	0*	387
	SE	132	3	19	0	133
POUGHKEEPSIE (62-76)	SC	83	4**	67**	0*	154
	SE	57	2	39	0	69
HYDE PARK (77-85)	SC	12	0*	0*	0*	12
	SE	12	0	0	0	12
KINGSTON (86-93)	SC	192	0*	0*	0*	192
	SE	79	0	0	0	79
SAUGERTIES (94-106)	SC	768	0*	0*	0*	768
	SE	228	0	0	0	228
CATSKILL (107-124)	SC	264	0*	0*	0*	264
	SE	251	0	0	0	251
ALBANY (125-153)	SC	125	0*	0*	0*	125
	SE	67	0	0	0	67
STRATUM TOTAL	SC	2831	45	92	0	2968
	SE	481	21	44	0	483

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

9/11/77 - 9/17/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	10	0	0*****	0*	10
	SE	6	0	0	0	6
TAPPAN ZEE (24-33)	SC	142	72	13	0*	227
	SE	59	42	13	0	74
CROTON-HAVER.(34-38)	SC	520	0	0	0*	520
	SE	270	0	0	0	270
INDIAN POINT (39-46)	SC	266	3	0	0*	269
	SE	89	3	0	0	89
WEST POINT(47-55)	SC	85	0***	0	0*	85
	SE	26	0	0	0	26
CORNWALL (56-61)	SC	364	0	0	0*	364
	SE	132	0	0	0	132
POUGHKEEPSIE (62-76)	SC	83	4***	60	0*	147
	SE	57	2	35	0	67
HYDE PARK (77-85)	SC	12	0*	0*	0*	12
	SE	12	0	0	0	12
KINGSTON (86-93)	SC	192	0*	0*	0*	192
	SE	79	0	0	0	79
SAUGERTIES (94-106)	SC	768	0*	0*	0*	768
	SE	228	0	0	0	228
CATSKILL (107-124)	SC	264	0*	0*	0*	264
	SE	251	0	0	0	251
ALBANY (125-153)	SC	125	0*	0*	0*	125
	SE	67	0	0	0	67
STRATUM TOTAL	SC	2831	79	73	0	2983
	SE	481	42	37	0	484

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table C-38 (Page 7 of 12)

9/18/77 - 9/24/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	0	0**	0**	0*	0
	SE	0	0	0	0	0
TAPPAN ZEE (24-33)	SC	235	40**	6**	0*	281
	SE	90	25	6	0	94
CROTON-HAVER.(34-38)	SC	314	56**	13**	0*	383
	SE	119	32	5	0	123
INDIAN POINT (39-46)	SC	221	10**	6**	0*	237
	SE	76	4	6	0	76
WEST POINT(47-55)	SC	103	0**	7**	0*	110
	SE	32	0	7	0	33
CORNWALL (56-61)	SC	147	1**	15**	0*	163
	SE	43	1	9	0	44
POUGHKEEPSIE (62-76)	SC	88	3**	46**	0*	137
	SE	56	2	33	0	65
HYDE PARK (77-85)	SC	15	0*	0*	0*	15
	SE	12	0	0	0	12
KINGSTON (86-93)	SC	121	0*	0*	0*	121
	SE	101	0	0	0	101
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	568	0*	0*	0*	568
	SE	373	0	0	0	373
ALBANY (125-153)	SC	52	0*	0*	0*	52
	SE	38	0	0	0	38
STRATUM TOTAL	SC	1864	110	93	0	2067
	SE	430	41	36	0	433

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

9/25/77 - 10/ 1/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	0	0	0*****	0*	0
	SE	0	0	0	0	0
TAPPAN ZEE (24-33)	SC	235	8	0	0*	243
	SE	90	8	0	0	90
CROTON-HAVER.(34-38)	SC	314	112	27	0*	453
	SE	119	64	11	0	136
INDIAN POINT (39-46)	SC	221	17	13	0*	251
	SE	76	6	13	0	77
WEST POINT(47-55)	SC	103	1***	14	0*	118
	SE	32	1	14	0	35
CORNWALL (56-61)	SC	147	3	30	0*	180
	SE	43	3	19	0	47
POUGHKEEPSIE (62-76)	SC	88	2***	32	0*	122
	SE	56	2	32	0	65
HYDE PARK (77-85)	SC	15	0*	0*	0*	15
	SE	12	0	0	0	12
KINGSTON (86-93)	SC	121	0*	0*	0*	121
	SE	101	0	0	0	101
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	568	0*	0*	0*	568
	SE	373	0	0	0	373
ALBANY (125-153)	SC	52	0*	0*	0*	52
	SE	38	0	0	0	38
STRATUM TOTAL	SC	1864	143	116	0	2123
	SE	430	65	43	0	437

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table C-38 (Page 8 of 12)

10/ 2/77 - 10/ 8/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	0	3**	10**	0*	13
	SE	0	3	10	0	10
TAPPAN ZEE (24-33)	SC	82	16**	0**	0*	98
	SE	34	13	0	0	36
CROTON-HAVER.(34-38)	SC	122	66**	55**	0*	243
	SE	47	36	22	0	63
INDIAN POINT (39-46)	SC	476	19**	30**	0*	525
	SE	161	12	19	0	163
WEST POINT(47-55)	SC	45	1**	13**	0*	59
	SE	13	1	13	0	18
CORNWALL (56-61)	SC	17	58**	24**	0*	99
	SE	6	38	19	0	43
POUGHKEEPSIE (62-76)	SC	32	10**	150**	0*	192
	SE	15	5	71	0	73
HYDE PARK (77-85)	SC	9	0*	0*	0*	9
	SE	9	0	0	0	9
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	304	0*	0*	0*	304
	SE	226	0	0	0	226
CATSKILL (107-124)	SC	317	0*	0*	0*	317
	SE	155	0	0	0	155
ALBANY (125-153)	SC	104	0*	0*	0*	104
	SE	87	0	0	0	87
STRATUM TOTAL	SC	1508	173	282	0	1963
	SE	335	56	81	0	349

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

10/ 9/77 - 10/15/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	0	7	21*****	0*	28
	SE	0	7	21	0	22
TAPPAN ZEE (24-33)	SC	82	25	0	0*	107
	SE	34	18	0	0	38
CROTON-HAVER.(34-38)	SC	122	21	84	0*	227
	SE	47	9	33	0	58
INDIAN POINT (39-46)	SC	476	22	48	0*	546
	SE	161	18	25	0	164
WEST POINT(47-55)	SC	45	1***	13	0*	59
	SE	13	1	13	0	18
CORNWALL (56-61)	SC	17	114	19	0*	150
	SE	6	74	19	0	77
POUGHKEEPSIE (62-76)	SC	32	19***	269	0*	320
	SE	15	8	111	0	112
HYDE PARK (77-85)	SC	9	0*	0*	0*	9
	SE	9	0	0	0	9
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	304	0*	0*	0*	304
	SE	226	0	0	0	226
CATSKILL (107-124)	SC	317	0*	0*	0*	317
	SE	155	0	0	0	155
ALBANY (125-153)	SC	104	0*	0*	0*	104
	SE	87	0	0	0	87
STRATUM TOTAL	SC	1508	209	454	0	2171
	SE	335	79	122	0	365

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

10/16/77 - 10/22/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	95	155**	461**	0*	711
	SE	34	49	145	0	157
TAPPAN ZEE (24-33)	SC	112	20**	19**	0*	151
	SE	45	17	13	0	50
CROTON-HAVER.(34-38)	SC	74	18**	45**	0*	137
	SE	19	12	20	0	30
INDIAN POINT (39-46)	SC	66	21**	33**	0*	120
	SE	27	14	18	0	35
WEST POINT(47-55)	SC	35	1**	13**	0*	49
	SE	15	1	13	0	20
CORNWALL (56-61)	SC	53	69**	50**	0*	172
	SE	22	41	42	0	63
POUGHKEEPSIE (62-76)	SC	67	17**	237**	0*	321
	SE	34	7	102	0	108
HYDE PARK (77-85)	SC	2	0*	0*	0*	2
	SE	2	0	0	0	2
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	22	0*	0*	0*	22
	SE	13	0	0	0	13
CATSKILL (107-124)	SC	21	0*	0*	0*	21
	SE	10	0	0	0	10
ALBANY (125-153)	SC	13	0*	0*	0*	13
	SE	7	0	0	0	7
STRATUM TOTAL	SC	560	301	858	0	1719
	SE	80	69	185	0	213

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

10/23/77 - 10/29/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	95	304	902*****	0*	1301
	SE	34	91	270	0	287
TAPPAN ZEE (24-33)	SC	112	16	38	0*	166
	SE	45	16	27	0	55
CROTON-HAVER.(34-38)	SC	74	16	7	0*	97
	SE	19	16	7	0	26
INDIAN POINT (39-46)	SC	66	20	18	0*	104
	SE	27	10	12	0	31
WEST POINT(47-55)	SC	35	1***	13	0*	49
	SE	15	1	13	0	20
CORNWALL (56-61)	SC	53	25	82	0*	160
	SE	22	9	65	0	69
POUGHKEEPSIE (62-76)	SC	67	15***	205	0*	287
	SE	34	7	94	0	100
HYDE PARK (77-85)	SC	2	0*	0*	0*	2
	SE	2	0	0	0	2
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	22	0*	0*	0*	22
	SE	13	0	0	0	13
CATSKILL (107-124)	SC	21	0*	0*	0*	21
	SE	10	0	0	0	10
ALBANY (125-153)	SC	13	0*	0*	0*	13
	SE	7	0	0	0	7
STRATUM TOTAL	SC	560	397	1265	0	2222
	SE	80	95	295	0	320

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

10/30/77 - 11/ 5/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC SE	167 84	640** 267	1900** 792	0* 0	2707 840
TAPPAN ZEE (24-33)	SC SE	547 339	1428** 358	96** 54	0* 0	2071 496
CROTON-HAVER.(34-38)	SC SE	44 17	202** 67	56** 15	0* 0	302 71
INDIAN POINT (39-46)	SC SE	144 52	37** 15	130** 86	0* 0	311 102
WEST POINT(47-55)	SC SE	79 22	1** 1	12** 12	0* 0	92 25
CORNWALL (56-61)	SC SE	25 9	101** 18	41** 32	0* 0	167 38
POUGHKEEPSIE (62-76)	SC SE	4 4	7** 3	102** 47	0* 0	113 47
HYDE PARK (77-85)	SC SE	1 1	0* 0	0* 0	0* 0	1 1
KINGSTON (86-93)	SC SE	21 21	0* 0	0* 0	0* 0	21 21
SAUGERTIES (94-106)	SC SE	145 146	0* 0	0* 0	0* 0	145 146
CATSKILL (107-124)	SC SE	6 6	0* 0	0* 0	0* 0	6 6
ALBANY (125-153)	SC SE	122 123	0* 0	0* 0	0* 0	122 123
STRATUM TOTAL	SC SE	1305 403	2416 452	2337 801	0 0	6058 1004

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

11/ 6/77 - 11/12/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC SE	167 84	977 443	2899***** 1314	0* 0	4043 1389
TAPPAN ZEE (24-33)	SC SE	547 339	2840 701	155 81	0* 0	3542 783
CROTON-HAVER.(34-38)	SC SE	44 17	389 118	106 23	0* 0	539 121
INDIAN POINT (39-46)	SC SE	144 52	55 20	243 161	0* 0	442 170
WEST POINT(47-55)	SC SE	79 22	1*** 1	12 12	0* 0	92 25
CORNWALL (56-61)	SC SE	25 9	177 27	0 0	0* 0	202 28
POUGHKEEPSIE (62-76)	SC SE	4 4	0*** 0	0 0	0* 0	4 4
HYDE PARK (77-85)	SC SE	1 1	0* 0	0* 0	0* 0	1 1
KINGSTON (86-93)	SC SE	21 21	0* 0	0* 0	0* 0	21 21
SAUGERTIES (94-106)	SC SE	145 146	0* 0	0* 0	0* 0	145 146
CATSKILL (107-124)	SC SE	6 6	0* 0	0* 0	0* 0	6 6
ALBANY (125-153)	SC SE	122 123	0* 0	0* 0	0* 0	122 123
STRATUM TOTAL	SC SE	1305 403	4439 838	3415 1327	0 0	9159 1620

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table C-38 (Page 11 of 12)

11/13/77 - 11/19/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	39	650**	1930**	0*	2619
	SE	13	293	869	0	917
TAPPAN ZEE (24-33)	SC	200	2448**	341**	0*	2989
	SE	57	524	158	0	550
CROTON-HAVER.(34-38)	SC	85	660**	298**	0*	1043
	SE	57	122	74	0	154
INDIAN POINT (39-46)	SC	11	176**	237**	0*	424
	SE	5	60	136	0	149
WEST POINT(47-55)	SC	2	0**	6**	0*	8
	SE	1	0	6	0	6
CORNWALL (56-61)	SC	4	131**	23**	0*	158
	SE	3	33	23	0	40
POUGHKEEPSIE (62-76)	SC	0	2**	32**	0*	34
	SE	0	1	18	0	18
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
STRATUM TOTAL	SC	341	4067	2867	0	7275
	SE	82	616	897	0	1091

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

11/20/77 - 11/26/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	39	324	961*****	0*	1324
	SE	13	143	424	0	448
TAPPAN ZEE (24-33)	SC	200	2057	527	0*	2784
	SE	57	348	236	0	424
CROTON-HAVER.(34-38)	SC	85	932	491	0*	1508
	SE	57	126	126	0	187
INDIAN POINT (39-46)	SC	11	297	231	0*	539
	SE	5	101	111	0	150
WEST POINT(47-55)	SC	2	0***	0	0*	2
	SE	1	0	0	0	1
CORNWALL (56-61)	SC	4	85	47	0*	136
	SE	3	39	47	0	61
POUGHKEEPSIE (62-76)	SC	0	5***	64	0*	69
	SE	0	3	37	0	37
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
STRATUM TOTAL	SC	341	3700	2321	0	6362
	SE	82	411	517	0	666

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table C-38 (Page 12 of 12)

11/27/77 - 12/ 3/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	36	0*	0*	0*	36
	SE	22	0	0	0	22
TAPPAN ZEE (24-33)	SC	33	0*	0*	0*	33
	SE	22	0	0	0	22
CROTON-HAVER.(34-38)	SC	8	591**	281**	0*	880
	SE	5	97	81	0	126
INDIAN POINT (39-46)	SC	1	171**	126**	0*	298
	SE	1	65	66	0	93
WEST POINT(47-55)	SC	1	0*	0*	0*	1
	SE	1	0	0	0	1
CORNWALL (56-61)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
POUGHKEEPSIE (62-76)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
STRATUM TOTAL	SC	79	762	407	0	1248
	SE	32	117	104	0	160

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

12/ 4/77 - 12/10/77

REGION		SHORE ZONE	SHOAL (10'-20')	BOTTOM	CHANNEL	REGIONAL TOTALS
YONKERS (12-23)	SC	36	0*	0*	0*	36
	SE	22	0	0	0	22
TAPPAN ZEE (24-33)	SC	33	0*	0*	0*	33
	SE	22	0	0	0	22
CROTON-HAVER.(34-38)	SC	8	251	71	0*	330
	SE	5	68	37	0	78
INDIAN POINT (39-46)	SC	1	45	21	0*	67
	SE	1	29	21	0	36
WEST POINT(47-55)	SC	1	0*	0*	0*	1
	SE	1	0	0	0	1
CORNWALL (56-61)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
POUGHKEEPSIE (62-76)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
HYDE PARK (77-85)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
KINGSTON (86-93)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
SAUGERTIES (94-106)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
CATSKILL (107-124)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
ALBANY (125-153)	SC	0	0*	0*	0*	0
	SE	0	0	0	0	0
STRATUM TOTAL	SC	79	296	92	0	467
	SE	32	74	43	0	91

NIGHT/DAY CATCH RATIO =WPR= 2.4750 VAR(WPR) = 0.1200
BEACH SEINE EFFICIENCY =WPE= 1.0000 VAR(WPE) = 0.0
ICHTHOPLANKTON EFFICIENCY =WPS= 1.0000

* NO SAMPLE
** INTERPOLATED FROM ADJACENT WEEKS
*** SHOAL MISSING - SUB BOTTOM DENSITY
**** CHANNEL MISSING - SUB BOTTOM DENSITY
***** BOTTOM MISSING - SUB SHOAL DENSITY

Table C-39

Variables Entered into Analysis of Factors Affecting White Perch Abundance*

Observation	Juvenile White Perch Abundance Index	Juvenile Striped Bass Abundance Index	Mean Monthly Freshwater Flow (ft^3/sec)					Days to Span 18°-22°	Estimated Daily Water Withdrawal May-Jul ($m^3 \times 10^3$/d)	Jul Temperature
			Apr	May	Jun	Jul	Dec†			
1965	12.69	2.90	19284	8309	3573	3082	6096	27	3072	23.6
1966	18.95	13.17	15627	18406	8270	3674	10654	17	3663	25.6
1967	34.33	5.23	30937	17061	6197	5075	9118	16	3677	24.5
1968	11.91	2.34	18299	18487	15707	9795	16509	34	4382	23.6
1969	24.21	62.49	40730	20912	9995	5430	15597	19	4724	24.1
1970	22.19	29.86	39347	14546	6387	5997	11801	19	4580	23.5
1972	3.77	21.53	37963	40522	29630	18379	16998	48	4402	22.4
1973	19.82	51.42	30957	27603	13053	10390	27010	14	7390	23.7
1974	6.32	13.64	30167	22965	8791	11784	26419	24	10145	22.9
1975	17.70	17.81	25583	19999	12973	7464	19381	31	12351	24.9
1976	23.96	13.95	36757	31800	15223	15277	18784	10	10938	24.5
1977	22.09	19.66	40563	16023	7325	5735	14078	31	15137	24.4

†In addition, variables examined for striped bass were also used: bluefish abundance, yearling striped bass abundance, predator index, days to span 16° - 20°C, Dec temperature, Nov + Dec combined flow, Apr + May combined flow.
*From winter preceding that listed for year class indices.

Table C-40

Data Used To Calculate Mortality Rates for Young-of-the-Year White Perch in Hudson River Estuary during 1977

Period 2		Period 3	
Mid-Date of Sampling Interval	Standing Crop (millions)	Mid-Date of Sampling Interval	Standing Crop (thousands)
6/09	1,900	8/18	2,540
6/16	1,417	8/25	3,102
6/23	464	9/01	2,902
6/30	238	9/08	2,968
7/07	54	9/15	2.983
7/14	27	9/22	2,067
7/21	16	9/29	2,123
7/28	6	10/06	1,963
8/04	5	10/13	2,171
8/11	2	10/20	1,719
		10/27	2,222

Table C-41

Data Used in Analysis of Factors Affecting Larval Growth in White Perch

Year	Predicted Length Jul 15 (mm)	Est. No. of Days since Spawning	Mean Temp. since Spawning (°C)	Mean Monthly Freshwater Flows (ft^3/sec) Previous Nov/Dec	Mean Monthly Freshwater Flows (ft^3/sec) Previous Apr/May
1965	37.4	57	20.65	4706.4	12706.6
1966	29.4	47	20.53	10666.9	17039.2
1969	38.1	59	20.53	15008.3	30659.0
1970	35.9	64	20.01	13015.7	26743.3
1972	27.2	54	19.14	12223.9	39263.8
1973	25.6	47	20.64	26588.0	29252.5
1974	25.7	57	19.07	17498.0	26506.6
1975	33.2	59	21.04	18296.7	22745.2
1976	25.9	41	21.80	20609.8	34237.7
1977	29.4	57	20.35	15972.5	28091.8

Table C-42

Data Used in Analysis of Factors Affecting Juvenile Growth in White Perch

Year	Instantaneous Growth Rate	Mean Temp 15 Jul-15 Aug (°C)	Abundance Indices		Mean Monthly Freshwater Flows (ft^3/sec)		Predicted Length Jul 15 (mm)
			Juvenile Striped Bass	Juvenile White Perch	Previous Nov/Dec	Previous Apr/May	
1965	0.0154	24.29	2.90	12.69	4706.4	13706.6	37.4
1966	0.0153	25.49	13.17	18.95	10666.9	17039.2	29.4
1969	0.0119	24.44	62.49	24.21	15008.3	30659.0	38.5
1970	0.0129	24.95	29.86	22.19	13015.7	26743.3	35.9
1972	0.0174	24.66	21.53	3.77	12223.9	39263.8	27.2
1973	0.0222	24.66	51.42	19.82	26588.0	29252.5	25.6
1974	0.0204	23.89	13.64	6.32	17498.0	26506.6	25.7
1975	[illegible]77	25.74	17.81	17.70	18296.7	22745.2	33.2
1976	0.0181	23.86	13.95	23.96	20609.8	34237.7	25.9
1977	0.0174	25.41	19.66	22.09	15972.5	28091.8	29.4

Table D-1

Estimated Standing Crops (in Thousands) of Atlantic Tomcod Eggs in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey,1977

DATE		REGION YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
2/21-2/25	SC	0	49	0	63	6286	25	0	0	0	0	0	0	6424
	SE	0	49	0	63	6286	25	0	0	0	0	0	0	6287
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/ 7-3/11	SC	171	0	33	0	2051	507	0	0	0	0	0	0	2762
	SE	0	0	19	0	1011	286	0	0	0	0	0	0	1051
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21-3/26	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/ 4-4/ 7	SC	55	14	0	0	0	0	0	0	0	0	0	0	69
	SE	55	14	0	0	0	0	0	0	0	0	0	0	57
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103

*None collected after 4/7

Table D-2

Estimated Density (No./1000 m^3) of Atlantic Tomcod Eggs in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22--24) Determined from Ichthyoplankton Survey, 1977

DATE		REGION YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
2/21-2/25	DEN	0.0	0.1521	0.0	0.3045	30.3101	0.1807	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.1521	0.0	0.3045	30.3101	0.1807	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/ 7-3/11	DEN	0.7451	0.0	0.2233	0.0	9.8876	3.6262	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.1265	0.0	4.8759	2.0441	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/ 4-4/ 7	DEN	0.2403	0.0428	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.2403	0.0428	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0

*None collected after 4/7

Table D-3

Estimated Standing Crops (in Thousands) of Atlantic Tomcod Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
2/21-2/25	SC	1626	5018	2447	7853	13764	7379	14203	0	0	0	0	0	52290
	SE	0	926	547	2283	3447	1709	2397	0	0	0	0	0	5188
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/ 7-3/11	SC	12469	120943	109034	94800	337609	436140	0	0	0	0	0	0	1110993
	SE	5135	12262	20314	12136	40727	120973	0	0	0	0	0	0	130498
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21-3/26	SC	4384	4280	2247	5191	10771	4083	4392	0	0	0	0	0	35349
	SE	731	1016	711	1370	2929	860	1534	0	0	0	0	0	3952
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/ 4-4/ 7	SC	0	370	186	345	40	36	0	0	0	0	0	0	977
	SE	0	269	138	173	23	36	0	0	0	0	0	0	351
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103

*None collected after 4/7

Table D-4

Estimated Density (No./1000 m^3) of Atlantic Tomcod Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
2/21-2/25	DEN	7.0842	15.5938	16.5689	37.6989	66.3633	52.7828	47.6299	0.0	0.0	0.0	0.0	0.0
	SE	0.0	2.8777	3.7034	10.9601	16.6198	12.2221	8.0378	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/ 7-3/11	DEN	54.3298	375.8326	738.2099	455.1111	1627.8135	3119.7397	0.0	0.0	0.0	0.0	0.0	0.0
	SE	22.3739	38.1051	137.5348	58.2613	196.3680	865.3274	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21-3/26	DEN	19.1045	13.2991	15.2145	24.9217	51.9356	29.2063	14.7297	0.0	0.0	0.0	0.0	0.0
	SE	3.1845	3.1578	4.8167	6.5749	14.1213	6.1539	5.1430	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/ 4-4/ 7	DEN	0.0	1.1509	1.2604	1.6559	0.1917	0.2547	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.8347	0.9346	0.8317	0.1107	0.2547	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0

*None collected after 4/7

Table D-5

Estimated Standing Crops (in Thousands) of Atlantic Tomcod Post Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
2/21- 2/25	SC	0	3694	3597	3674	1060	299	236	0	0	0	0	0	12559
	SE	0	910	662	824	452	88	183	0	0	0	0	0	1480
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/ 7- 3/11	SC	86416	72889	1701	746	870	40	0	0	0	0	0	0	162661
	SE	27026	21665	540	254	778	32	0	0	0	0	0	0	34651
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21- 3/26	SC	838644	1103914	17899	14427	9791	1151	1106	0	0	0	0	0	1986933
	SE	220426	584547	1860	1846	1008	230	615	0	0	0	0	0	624733
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/ 4- 4/ 7	SC	578697	611	665	1162	42	0	0	0	0	0	0	0	581177
	SE	324311	162	134	676	24	0	0	0	0	0	0	0	324312
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/18- 4/20	SC	2261230	228106	19	0	4	0	0	0	0	0	0	0	2489361
	SE	2196635	135593	19	0	4	0	0	0	0	0	0	0	2200816
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
4/25- 4/28	SC	497600	458793	211	0	0	0	0	0	0	0	0	0	956603
	SE	292097	321246	158	0	0	0	0	0	0	0	0	0	434188
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3	156
5/ 2- 5/ 5	SC	31779	12817	0	0	0	0	0	0	0	0	0	0	44596
	SE	14074	7931	0	0	0	0	0	0	0	0	0	0	16155
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
5/ 9- 5/12	SC	12842	48	0	0	0	0	0	0	0	0	0	0	12890
	SE	6424	48	0	0	0	0	0	0	0	0	0	0	6424
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3	157
5/16- 5/19	SC	28	473	0	0	0	0	0	0	0	0	0	0	501
	SE	28	419	0	0	0	0	0	0	0	0	0	0	420
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3	157
5/23- 5/26	SC	0	123	0	35	0	0	0	0	0	0	0	0	157
	SE	0	123	0	35	0	0	0	0	0	0	0	0	127
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3	157
5/31- 6/ 2	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3	155
6/ 6- 6/ 9	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/13- 6/16	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/20- 6/24	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/27- 7/ 1	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3	157
7/ 5- 7/ 8	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/11- 7/15	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/25- 7/29	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
8/ 8- 8/12	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157

Table D-6

Estimated Density (No./1000 m^3) of Atlantic Tomcod Post Yolk-Sac Larvae in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
2/21-2/25	DEN	0.0	11.4793	24.3540	17.6378	5.1103	2.1354	0.7903	0.0	0.0	0.0	0.0	0.0
	SE	0.0	2.8265	4.4851	3.9552	2.1817	0.6289	0.6148	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/7-3/11	DEN	376.5385	226.5048	11.5141	3.5825	4.1944	0.2849	0.0	0.0	0.0	0.0	0.0	0.0
	SE	117.7586	67.3234	3.6594	1.2174	3.7507	0.2288	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21-3/26	DEN	3654.2233	3430.4359	121.1838	69.2625	47.2076	8.2333	3.7097	0.0	0.0	0.0	0.0	0.0
	SE	960.4615	1616.4922	12.5945	8.8604	4.8585	1.6419	2.0620	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/4-4/7	DEN	2521.5569	1.8987	4.4992	5.5785	0.2024	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	1413.1186	0.5022	0.9079	3.2453	0.1175	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/18-4/20	DEN	9852.8559	708.8450	0.1309	0.0	0.0215	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	9571.3937	421.3584	0.1309	0.0	0.0215	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
4/25-4/28	DEN	2168.1899	1425.7086	1.4265	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	1272.7517	998.2780	1.0715	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3
5/2-5/5	DEN	138.4694	39.8289	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	61.3238	24.6464	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
5/9-5/12	DEN	55.9570	0.1482	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	27.9395	0.1482	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3
5/16-5/19	DEN	0.1208	1.4705	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.1208	1.3032	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3
5/23-5/26	DEN	0.0	0.3811	0.0	0.1666	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.3811	0.0	0.1666	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3
5/31-6/2	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3
6/6-6/9	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/13-6/16	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/20-6/24	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/27-7/1	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3
7/5-7/8	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/11-7/15	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/25-7/29	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
8/8-8/12	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3

Table D-7

Mean Regional Water Temperature (°C), Dissolved Oxygen (mg/ℓ), Conductivity (mS/cm), and Atlantic Tomcod Yolk-Sac Larvae and Density (No./1000 m^3) during Periods of Atlantic Tomcod Yolk-Sac Larvae Abundance, 1975-1977

		REGION											
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
1975													
Mar 9-Mar.15	Temp.	4.8	4.0	3.9	3.1	4.6	4.8	3.0	NS	NS	NS	NS	NS
	D.O.	10.1	11.4	11.7	11.7	11.5	11.4	11.9	NS	NS	NS	NS	NS
	Cond.	17007	6733	3541	1248	240	184	169	NS	NS	NS	NS	NS
	Dens.	8.2	297.2	731.8	232.7	162.6	80.2	40.6	NS	NS	NS	NS	NS
1976													
Feb 29-Mar 6	Temp.	5.0	3.4	2.5	2.9	2.3	2.3	2.7	NS	NS	NS	NS	NS
	D.O.	12.0	12.6	12.6	12.7	13.0	12.9	12.8	NS	NS	NS	NS	NS
	Cond.	3130	260	188	185	177	173	170	NS	NS	NS	NS	NS
	Dens.	12.8	76.7	107.2	123.5	126.0	83.1	61.0	NS	NS	NS	NS	NS
Mar 7-Mar 13	Temp.	3.2	3.4	3.2	3.3	2.9	3.3	3.1	NS	NS	NS	NS	NS
	D.O.	12.0	11.4	12.3	12.3	12.4	12.3	13.4	NS	NS	NS	NS	NS
	Cond.	4672	5128	222	169	172	167	172	NS	NS	NS	NS	NS
	Dens.	113.3	349.2	619.5	308.1	190.7	99.8	34.0	NS	NS	NS	NS	NS
Mar 21-Mar 27	Temp.	6.1	6.6	5.8	4.0	4.0	5.6	5.1	NS	NS	NS	NS	NS
	D.O.	11.9	11.9	11.7	12.1	12.1	11.9	12.8	NS	NS	NS	NS	NS
	Cond.	1479	342	202	185	181	190	188	NS	NS	NS	NS	NS
	Dens.	157.6	199.7	151.3	120.3	21.1	8.7	4.4	NS	NS	NS	NS	NS
1977													
Mar 6-Mar 12	Temp.	5.1	4.7	3.5	3.0	2.6	1.9	0.9	NS	NS	NS	NS	NS
	D.O.	10.5	11.5	11.3	11.9	10.6	11.7	11.5	NS	NS	NS	NS	NS
	Cond.	8293	522	327	269	220	218	226	NS	NS	NS	NS	NS
	Dens.	54.3	375.8	738.2	455.1	1627.8	3119.7	NS	NS	NS	NS	NS	NS

NS = No Sampling

Table D-8

Mean Regional Water Temperature (°C), Dissolved Oxygen (mg/ℓ), Conductivity (mS/cm), and Atlantic Tomcod Post Yolk Sac Larvae Density (No./1000 m^3) during Periods of Atlantic Tomcod Post Yolk Sac Larvae Abundance, 1975-1977

		REGION											
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
1975													
Mar 23-Mar 29	Temp.	7.1	6.0	5.2	6.2	6.4	6.1	6.6	NS	NS	NS	NS	NS
	D.O.	11.1	11.5	11.7	11.9	11.5	11.0	11.0	NS	NS	NS	NS	NS
	Cond.	2912	542	211	225	174	175	178	NS	NS	NS	NS	NS
	Dens.	1727.8	371.7	20.2	10.6	8.1	4.1	0.5	NS	NS	NS	NS	NS
Apr 6-Apr 12	Temp.	6.4	5.5	5.7	4.7	4.7	4.7	5.0	NS	NS	NS	NS	NS
	D.O.	11.4	11.8	11.9	12.7	12.4	12.2	12.1	NS	NS	NS	NS	NS
	Cond.	6450	4214	2118	996	272	232	204	NS	NS	NS	NS	NS
	Dens.	2308.6	11063.3	63.3	0.3	0.0	0.1	0.0	NS	NS	NS	NS	NS
1976													
Mar 21-Mar 27	Temp.	6.1	6.6	5.8	4.0	4.0	5.6	5.1	NS	NS	NS	NS	NS
	D.O.	11.9	11.9	11.7	12.1	12.1	11.9	12.8	NS	NS	NS	NS	NS
	Cond.	1479	342	202	185	181	190	188	NS	NS	NS	NS	NS
	Dens.	231.2	36.4	2.9	0.5	0.9	0.0	0.0	NS	NS	NS	NS	NS
Apr 18-Apr 24	Temp.	12.1	12.0	12.0	11.5	10.6	10.9	10.4	11.1	11.3	11.9	13.3	14.1
	D.O.	11.3	11.1	11.2	11.4	11.3	10.9	11.3	11.3	11.3	11.1	10.5	10.5
	Cond.	3851	859	306	159	140	157	150	137	137	138	148	134
	Dens.	4.1	218.2	54.8	4.6	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Apr 25-May 1	Temp.	11.1	10.6	11.1	11.1	10.6	11.5	12.6	13.0	12.8	13.0	12.6	11.7
	D.O.	8.6	10.4	10.4	10.3	10.7	9.9	9.9	9.6	9.7	8.8	9.3	10.3
	Cond.	7713	2829	1121	277	138	171	127	126	117	117	118	115
	Dens.	0.1	168.1	208.8	98.8	0.1	0.6	0.1	0.0	0.0	0.0	0.0	0.0
1977													
Mar 20-Mar 26	Temp.	5.1	4.6	5.3	5.2	5.0	4.3	3.8	NS	NS	NS	NS	NS
	D.O.	11.9	12.4	12.6	12.5	13.2	12.8	13.2	NS	NS	NS	NS	NS
	Cond.	717	622	154	157	144	149	148	NS	NS	NS	NS	NS
	Dens.	3654.2	3430.4	121.2	69.3	47.2	8.2	3.7	NS	NS	NS	NS	NS
Apr 3-Apr 9	Temp	5.9	6.8	6.2	7.3	7.8	7.8	7.4	NS	NS	NS	NS	NS
	D.O.	11.8	12.1	12.2	12.3	11.6	12.1	12.1	NS	NS	NS	NS	NS
	Cond.	872	193	192	185	175	181	146	NS	NS	NS	NS	NS
	Dens.	2521.6	1.9	4.5	5.6	0.2	0.0	0.0	NS	NS	NS	NS	NS
Apr 17-Apr 23	Temp.	12.0	12.5	12.2	11.1	10.2	10.3	10.1	10.4	10.6	11.1	11.0	9.6
	D.O.	8.9	10.5	10.6	11.2	11.1	10.9	11.3	11.1	11.1	11.0	10.9	11.4
	Cond.	5147	255	158	158	155	174	192	164	163	171	149	130
	Dens.	9852.9	708.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Apr 24-Apr 30	Temp.	11.2	11.3	11.2	10.8	11.6	11.8	12.0	10.9	10.4	10.0	9.3	8.9
	D.O.	10.4	10.5	10.7	10.5	9.8	10.0	10.0	10.3	11.0	11.3	12.0	12.1
	Cond.	2348	739	156	143	145	134	149	158	163	149	148	144
	Dens.	2168.2	1425.7	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

NC = No Sampling

Table D-9

Estimated Standing Crops (in Thousands) of Atlantic Tomcod Juveniles in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	TOTL
2/21-2/25	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0	94
3/ 7-3/11	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0	95
3/21-3/26	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/ 4-4/ 7	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0	103
4/18-4/20	SC	0	0	0	0	0	0	0	0	0	0	0	0	0
	SE	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
4/25-4/28	SC	32037	49429	73	0	0	0	0	0	0	0	0	0	81539
	SE	27446	24797	52	0	0	0	0	0	0	0	0	0	36989
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3	156
5/ 2-5/ 5	SC	159403	101378	1168	1197	1526	231	142	0	0	0	0	0	265044
	SE	86768	51715	513	560	531	183	142	0	0	0	0	0	101015
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3	157
5/ 9-5/12	SC	855951	5087	318	1372	114	0	0	0	116	0	0	0	862958
	SE	622828	782	100	719	61	0	0	0	116	0	0	0	622829
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3	157
5/16-5/19	SC	1478	19480	410	4035	1855	42	41	89	0	0	0	0	27429
	SE	1022	11084	251	1801	675	42	41	47	0	0	0	0	11299
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3	157
5/23-5/26	SC	1029	57335	20	15064	3935	11	517	80	0	0	0	0	77991
	SE	964	54947	20	10853	1639	11	326	63	0	0	0	0	56041
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3	157
5/31-6/ 2	SC	19931	36781	516	14820	28226	1774	828	72	0	0	0	0	102948
	SE	18808	19234	264	8839	15997	540	402	72	0	0	0	0	32530
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3	155
6/ 6-6/ 9	SC	89	3453	2729	10487	1586	226	978	0	0	0	0	0	19548
	SE	49	2592	2537	4851	571	218	819	0	0	0	0	0	6142
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/13-6/16	SC	7454	64	164	6309	6263	0	325	197	157	0	0	0	20933
	SE	7454	64	164	2176	2735	0	155	162	157	0	0	0	8240
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/20-6/24	SC	1981	1761	7818	5107	7583	115	800	175	301	87	0	0	25728
	SE	1981	801	5184	1869	2583	115	755	149	237	87	0	0	6501
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
6/27-7/ 1	SC	78	3657	131	2772	13256	501	1019	136	589	130	146	0	22413
	SE	78	1290	131	808	2294	234	285	136	314	65	84	0	2805
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3	157
7/ 5-7/ 8	SC	4419	1613	623	10932	3088	1735	212	239	116	70	80	95	23220
	SE	3908	530	574	4315	1283	620	70	155	52	70	80	95	6048
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/11-7/15	SC	3488	4614	475	4301	4835	1958	144	171	71	0	107	0	20165
	SE	3429	4015	377	2117	1170	1056	53	171	53	0	62	0	5918
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
7/25-7/29	SC	375	6578	436	1133	10114	2140	418	167	0	0	0	0	21361
	SE	331	3645	86	392	3282	605	113	74	0	0	0	0	4971
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157
8/ 8-8/12	SC	0	783	42	1574	6110	1214	20	110	29	0	0	0	9832
	SE	0	196	42	689	1412	693	20	110	29	0	0	0	1735
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3	157

Table D-10

Estimated Density (No./1000 m^3) of Atlantic Tomcod Juveniles in 12 Geographical Regions of Hudson River Estuary (RM 14-140; KM 22-224) Determined from Ichthyoplankton Survey, 1977

DATE		REGION YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	21	28	15	10	12	7	0	0	0	0	0
3/7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	26	25	18	11	11	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/4-4/7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	28	33	11	10	6	9	6	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
4/25-4/28	DEN	139.5940	153.6001	0.4959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	119.5924	77.0584	0.3530	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	34	17	12	7	6	7	6	3
5/2-5/5	DEN	694.5647	315.0335	7.9058	5.7467	7.3590	1.6506	0.4772	0.0	0.0	0.0	0.0	0.0
	SE	378.0749	160.7042	3.4747	2.6869	2.5589	1.3065	0.4772	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	15	33	35	17	12	7	6	7	6	3
5/9-5/12	DEN	3729.6345	15.8083	2.1501	6.5876	0.5503	0.0	0.0	0.0	0.8164	0.0	0.0	0.0
	SE	2713.8479	2.4304	0.6754	3.4499	0.2946	0.0	0.0	0.0	0.8164	0.0	0.0	0.0
	TOWS	6	10	15	33	35	16	13	7	6	7	6	3
5/16-5/19	DEN	6.4382	60.5351	2.7741	19.3716	8.9429	0.3015	0.1383	0.5361	0.0	0.0	0.0	0.0
	SE	4.4511	34.4452	1.6962	8.6457	3.2527	0.3015	0.1383	0.2827	0.0	0.0	0.0	0.0
	TOWS	6	9	15	33	36	17	12	7	6	7	6	3
5/23-5/26	DEN	4.4831	178.1708	0.1375	72.3169	18.9738	0.0771	1.7337	0.4821	0.0	0.0	0.0	0.0
	SE	3.9377	170.7499	0.1375	52.1044	7.9006	0.0771	1.0918	0.3803	0.0	0.0	0.0	0.0
	TOWS	6	12	14	19	16	24	28	14	8	7	6	3
5/31-6/2	DEN	86.8454	114.2977	3.4937	71.1496	136.0943	12.6881	2.7760	0.4326	0.0	0.0	0.0	0.0
	SE	81.9514	59.7699	1.7889	42.4323	77.1295	3.8656	1.3471	0.4326	0.0	0.0	0.0	0.0
	TOWS	6	12	14	19	16	24	27	13	8	7	6	3
6/6-6/9	DEN	0.3897	10.7295	18.4761	50.3467	7.6467	1.6175	3.2782	0.0	0.0	0.0	0.0	0.0
	SE	0.2148	8.0533	17.1767	23.2869	2.7541	1.5571	2.7481	0.0	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/13-6/16	DEN	32.4793	0.1994	1.1099	30.2875	30.1965	0.0	1.0907	1.1910	1.1104	0.0	0.0	0.0
	SE	32.4793	0.1994	1.1099	10.4461	13.1873	0.0	0.6535	0.9791	1.1104	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/20-6/24	DEN	8.6304	5.4716	52.9300	24.5168	36.5618	0.8245	2.6822	1.0599	2.1297	0.4930	0.0	0.0
	SE	8.6304	2.4906	35.0959	8.9728	12.4520	0.8245	2.5324	0.9026	1.6779	0.4930	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
6/27-7/1	DEN	0.3378	11.3652	0.8845	13.3075	63.9148	3.5805	3.4175	0.8222	4.1590	0.7377	0.9066	0.0
	SE	0.3378	4.0094	0.8845	3.8787	11.0592	1.6726	0.9555	0.8222	2.2163	0.3696	0.5235	0.0
	TOWS	5	10	11	26	23	19	26	10	10	7	7	3
7/5-7/8	DEN	19.2533	5.0115	4.2200	52.4822	14.8868	12.4102	0.7100	1.4456	0.8165	0.3991	0.4959	1.3326
	SE	17.0271	1.6471	3.8582	20.7134	6.1843	4.4340	0.2357	0.9357	0.3681	0.3991	0.4959	1.3326
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/11-7/15	DEN	15.1998	14.3394	3.2135	20.6492	23.3124	14.0084	0.4834	1.0325	0.5036	0.0	0.6654	0.0
	SE	14.9409	12.4766	2.5527	10.1615	5.6426	7.5544	0.1792	1.0325	0.3719	0.0	0.3858	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
7/25-7/29	DEN	1.6335	20.4414	2.9496	5.4406	48.7672	15.3074	1.4014	1.0114	0.0	0.0	0.0	0.0
	SE	1.4412	11.3268	0.5852	1.8315	15.8227	4.3282	0.3787	0.4475	0.0	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3
8/8-8/12	DEN	0.0	2.4338	0.2821	7.5579	29.4586	8.6806	0.0679	0.6617	0.2069	0.0	0.0	0.0
	SE	0.0	0.6090	0.2821	3.3072	6.8087	4.9916	0.0579	0.6617	0.2069	0.0	0.0	0.0
	TOWS	6	9	12	25	23	19	26	10	10	7	7	3

Table D-11

Catch per Tow of Young-of-the-Year Atlantic Tomcod in 12 Geographic Regions of Hudson River Estuary (RM 12-152; KM 19-243) Determined from 100-ft (30.5-m) Beach Seine during Daytime, 1977

DATE		Region												TOTAL
		YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	
APR 3-	CPUE	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
APR 16	SE	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
	TOWS	28	30	27	35	24	20	6	3	3	5	7	11	199
APR 17-	CPUE	1.25	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.20
AFR 30	SE	0.67	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10
	TOWS	28	34	37	27	20	22	5	2	2	4	5	4	190
MAY 1-	CPUE	2.67	4.17	0.20	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.19
MAY 14	SE	0.86	0.91	0.09	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.24
	TOWS	21	41	35	49	15	12	2	3	1	4	7	9	199
MAY 15-	CPUE	17.29	1.88	0.36	0.67	0.05	0.10	0.0	0.0	0.0	0.0	0.0	0.0	2.16
MAY 28	SE	5.73	0.56	0.17	0.32	0.05	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.66
	TOWS	21	26	33	51	21	29	3	3	2	5	8	12	214
MAY 29-	CPUE	60.67	2.60	1.79	1.76	0.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.03
JUN 11	SE	23.61	0.89	1.08	0.48	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.61
	TOWS	18	25	24	51	13	24	4	2	2	4	7	10	184
JUN 12-	CPUE	19.18	0.77	1.53	0.72	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.79
JUN 25	SE	5.35	0.24	0.84	0.16	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.06
	TOWS	38	22	15	57	24	28	3	3	3	4	7	11	215
JUN 26-	CPUE	11.38	2.25	1.17	0.73	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.93
JUL 9	SE	3.53	1.04	0.85	0.24	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.51
	TOWS	26	16	18	63	29	24	6	3	2	4	7	12	210
JUL 10-	CPUE	0.38	0.05	0.0	0.12	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07
JUL 23	SE	0.23	0.05	0.0	0.06	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03
	TOWS	21	19	17	41	21	19	12	6	6	8	13	21	204
JUL 24-	CPUE	0.04	0.27	0.06	0.13	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06
AUG 6	SE	0.04	0.15	0.06	0.07	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02
	TOWS	23	15	16	40	18	16	11	5	6	8	12	22	192
AUG 7-	CPUE	0.0	0.07	0.0	0.0	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
AUG 20	SE	0.0	0.07	0.0	0.0	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
	TOWS	28	14	12	42	17	20	12	5	5	8	14	22	199
AUG 21-	CPUE	0.21	0.29	0.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08
SEP 3	SE	0.15	0.22	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03
	TOWS	24	14	30	36	15	14	10	6	5	8	14	22	198
SEP 4-	CPUE	0.05	0.39	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06
SEP 17	SE	0.05	0.22	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03
	TOWS	20	23	36	34	39	25	4	2	3	3	7	11	207
SEP 18-	CPUE	0.0	0.0	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
OCT 1	SE	0.0	0.0	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
	TOWS	30	33	14	30	29	27	5	2	3	3	6	9	191
OCT 2-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OCT 15	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	12	30	31	17	34	31	6	2	2	4	6	10	185
OCT 16-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OCT 29	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	27	29	35	25	29	28	6	3	3	4	7	10	206
OCT 30-	CPUE	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
NOV 12	SE	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
	TOWS	20	37	30	28	26	30	4	3	2	3	8	8	199
NOV 13-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NOV 26	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	21	32	39	28	21	24	6	3	3	4	8	8	197
NOV 27-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEC 10	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	19	17	34	33	17	10	0	0	0	0	0	0	130
DEC 11-	CPUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEC 24	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	2	13	16	17	13	0	0	0	0	0	0	0	61

Table D-12

Adjusted Catch per Unit Effort of Young-of-the-Year Atlantic Tomcod in Hudson River Estuary by Bottom Trawl, 1977

DATE		Region TZ	CH	IP	WP	CW	TOTAL
APR 3-	CPUE	8.27	0.0	0.0	0.0	0.0	2.07
APR 16	SE	8.27	0.0	0.0	0.0	0.0	2.07
	TOWS	8	3	11	5	5	32
APR 17-	CPUE	398.08	0.0	0.0	0.0	0.0	99.52
APR 30	SE	219.27	0.0	0.0	0.0	0.0	60.60
	TOWS	8	3	11	5	5	32
MAY 1-	CPUE	169.42	32.31	3.08	0.0	0.0	46.44
MAY 14	SE	93.74	25.70	3.08	0.0	0.0	25.81
	TOWS	8	3	11	5	5	32
MAY 15-	CPUE	720.96	2.56	95.10	137.85	17.54	237.45
MAY 28	SE	633.40	2.56	56.88	81.63	17.54	160.37
	TOWS	8	3	11	5	5	32
MAY 29-	CPUE	21.35	178.46	849.93	104.00	74.77	342.16
JUN 11	SE	15.80	178.46	329.30	70.04	37.41	129.52
	TOWS	8	3	11	5	5	32
JUN 12-	CPUE	198.02	0.77	641.12	238.77	0.31	321.18
JUN 25	SE	110.85	0.77	246.56	87.67	0.31	103.63
	TOWS	7	2	11	5	5	30
JUN 26-	CPUE	301.15	17.95	253.85	317.54	1.54	214.09
JUL 9	SE	101.73	17.95	151.41	201.57	1.19	66.51
	TOWS	8	3	11	5	5	32
JUL 10-	CPUE	1.54	14.36	245.59	142.77	0.0	108.46
JUL 23	SE	1.33	14.36	138.77	113.07	0.0	52.79
	TOWS	8	3	11	5	5	32
JUL 24-	CPUE	0.0	0.0	51.61	221.85	3.08	54.59
AUG 6	SE	0.0	0.0	46.63	70.09	3.08	23.66
	TOWS	7	3	11	5	5	31
AUG 7-	CPUE	3.85	0.51	2.66	20.00	1.54	5.29
AUG 20	SE	1.79	0.51	1.47	10.14	1.19	1.96
	TOWS	8	3	11	5	5	32
AUG 21-	CPUE	0.0	0.0	13.23	48.00	0.0	12.01
SEP 3	SE	0.0	0.0	11.12	17.96	0.0	5.32
	TOWS	8	3	10	5	5	31
SEP 4-	CPUE	0.58	0.0	1.12	5.85	13.54	3.56
SEP 17	SE	0.58	0.0	0.98	2.50	12.77	2.06
	TOWS	8	3	11	5	5	32
SEP 18-	CPUE	7.31	0.0	3.69	2.31	0.92	3.56
OCT 1	SE	3.80	0.0	1.78	1.11	0.62	1.16
	TOWS	8	3	10	6	5	32
OCT 2-	CPUE	0.0	0.0	5.31	0.62	0.62	2.02
OCT 15	SE	0.0	0.0	3.24	0.62	0.38	1.17
	TOWS	8	3	11	5	5	32
OCT 16-	CPUE	0.0	0.0	2.66	0.31	1.23	1.15
OCT 29	SE	0.0	0.0	1.23	0.31	0.58	0.47
	TOWS	8	3	11	5	5	32
OCT 30-	CPUE	0.0	0.0	1.12	0.31	1.54	0.67
NOV 12	SE	0.0	0.0	0.59	0.31	1.19	0.28
	TOWS	8	3	11	5	5	32
NOV 13-	CPUE	2.50	0.51	0.84	0.92	0.0	1.11
NOV 26	SE	1.48	0.51	0.38	0.62	0.0	0.42
	TOWS	8	3	11	5	5	32
NOV 27-	CPUE	4.42	0.0	0.0	0.92	0.0	2.11
DEC 10	SE	1.49	0.0	0.0	0.38	0.0	0.77
	TOWS	8	1	0	5	5	19

Table D-13

Number of Samples Containing Atlantic Tomcod and Number of Juvenile Tomcod Collected during 1977 Ichthyoplankton Survey in Relation to Salt Front

Sampling Period	No. Samples Processed	No. Samples Containing Juvenile Atlantic Tomcod	No. Samples with Juvenile Atlantic Tomcod Below Salt Front No.	Percent	No. Juvenile Atlantic Tomcod Collected*	No. Juveniles Collected Below Salt Front No.	Percent
Apr 25-28	156	12	9	75	1,106	947	86
May 02-05	157	54	8	15	3,867	3,442	89
May 09-12	157	34	4	12	4,019	3,803	95
May 16-19	157	48	9	19	764	226	30
May 23-26	157	23	6	26	1,900	1,136	60
May 31-Jun 02	155	44	24	55	3,111	2,848	92
Jun 06-09	157	41	25	61	653	553	85
Jun 13-16	157	27	20	74	762	732	96
Jun 20-24	157	36	28	78	908	856	94
Jun 27-Jul 01	157	65	48	74	789	752	95
Jul 05-08	157	63	45	71	703	667	95
Jul 11-15	157	54	42	78	511	459	90
Jul 25-29	157	61	58	95	746	740	99
Aug 08-12	157	40	37	92	390	384	98
Total	2,195	602	363	60	20,229	17,545	87

*Number of tomcod caught in a sample was adjusted to a unit sampling effort of 300 m^3; e.g., a catch of 43 tomcod from a sample of 280 m^3 would become 46, 43 x 300/280 = 46; 68 tomcod with a volume of 370 m^3 would become 55, 68 x 300/370 = 55.

Table D-14

Results of Friedman Nonparametric 2-way Analysis of Variance and Multiple Comparison Test on 1977 Interregional and Bottom Trawl Catch per Effort of Juvenile Atlantic Tomcod

Friedman Statistic (S')†	Depth Intervals‡		
10.34*	0-30	31-50	51-80

† Adjusted for ties
‡ Underlining indicates no significant difference (α =0.05)
* Significant at α =0.05

Table D-15

Estimated Density (No./1000 m^3) of Atlantic Tomcod Juveniles in Shoal, Bottom, and Channel Strata of Five Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

		REGION AND STRATUM*														
		YK			TZ			CH			IP			CW		
DATE		S	B	C	S	B	C	S	B	C	S	B	C	S	B	C
2/21-	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2/25	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	0	0	1	6	6	9	7	10	11	3	5	7	3	4	5
3/ 7-	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3/11	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	1	0	3	8	7	11	6	13	6	4	5	9	3	4	4
3/21-	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3/26	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	6	18	9	3	5	3	3	4	3	3	3	3
4/ 4-	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4/ 7	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	25	5	18	10	3	5	3	3	4	3	3	3	3
4/18-	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4/20	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
4/25-	DEN	11.91	0.0	156.41	1.10	789.93	1.74	0.60	1.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4/28	SE	8.68	0.0	135.33	1.10	399.29	1.74	0.60	1.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	6	10	17	3	8	6
5/ 2-	DEN	1837.38	0.0	544.10	277.84	1085.60	1.08	18.36	5.47	0.0	0.60	4.91	6.32	0.0	1.39	1.89
5/ 5	SE	1519.54	0.0	378.20	272.18	639.50	1.08	9.20	4.04	0.0	0.60	2.06	3.42	0.0	0.92	1.89
	TOWS	3	0	3	3	4	3	6	5	4	5	11	17	3	8	6
5/ 9-	DEN	2.27	0.0	4220.37	0.0	81.92	0.0	1.35	7.53	0.0	0.68	16.38	5.03	0.0	0.0	0.0
5/12	SE	2.27	0.0	3071.14	0.0	12.59	0.0	1.35	2.10	0.0	0.68	9.63	3.96	0.0	0.0	0.0
	TOWS	3	0	3	3	4	3	6	5	4	5	12	16	3	7	6
5/16-	DEN	31.11	0.0	3.19	23.89	91.44	78.94	1.62	2.61	3.87	0.0	80.82	8.23	0.0	1.15	0.0
5/19	SE	29.61	0.0	3.19	23.89	59.37	72.76	1.13	1.60	3.87	0.0	49.66	4.32	0.0	1.15	0.0
	TOWS	3	0	3	2	4	3	6	5	4	5	11	17	3	8	6
5/23-	DEN	38.53	0.0	0.0	11.38	900.97	0.0	0.0	0.62	0.0	0.0	451.01	0.0	0.0	0.29	0.0
5/26	SE	33.85	0.0	0.0	6.58	884.73	0.0	0.0	0.62	0.0	0.0	324.95	0.0	0.0	0.29	0.0
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	2	11	11
5/31-	DEN	43.41	0.0	92.56	0.76	587.25	1.60	0.0	15.88	0.0	0.0	93.49	72.08	0.0	48.20	0.0
6/ 2	SE	43.41	0.0	92.56	0.76	309.70	1.60	0.0	8.13	0.0	0.0	55.62	53.24	0.0	14.68	0.0
	TOWS	3	0	3	4	4	4	4	5	5	3	4	12	3	10	11
6/ 6-	DEN	3.35	0.0	0.0	1.02	53.59	0.0	0.74	82.74	0.0	1.51	170.22	29.47	1.06	5.91	0.0
6/ 9	SE	1.65	0.0	0.0	1.02	41.68	0.0	0.74	78.05	0.0	0.87	109.25	19.69	1.06	5.91	0.0
	TOWS	3	0	3	3	3	3	4	3	5	4	5	16	3	6	10
6/13-	DEN	279.18	0.0	0.0	0.0	1.03	0.0	0.0	5.04	0.0	0.0	81.63	22.07	0.0	0.0	0.0
6/16	SE	279.18	0.0	0.0	0.0	1.03	0.0	0.0	5.04	0.0	0.0	51.36	8.25	0.0	0.0	0.0
	TOWS	3	0	3	3	3	3	6	2	4	3	5	17	3	6	10
6/20-	DEN	74.18	0.0	0.0	6.50	15.62	0.0	0.0	240.55	0.0	3.97	35.42	23.87	0.0	3.13	0.0
6/24	SE	74.18	0.0	0.0	5.18	7.96	0.0	0.0	159.50	0.0	3.97	19.31	10.80	0.0	3.13	0.0
	TOWS	3	0	3	3	3	3	4	3	5	3	7	15	3	5	11
6/27-	DEN	2.90	0.0	0.0	8.21	42.80	0.0	2.42	0.0	0.0	0.0	45.25	7.77	0.0	11.45	0.83
7/ 1	SE	2.90	0.0	0.0	4.74	18.58	0.0	2.42	0.0	0.0	0.0	16.28	3.68	0.0	6.18	0.57
	TOWS	2	0	3	4	3	3	4	2	5	3	6	17	3	6	10
7/ 5-	DEN	19.38	0.0	19.24	0.0	25.97	0.0	0.0	19.18	0.0	0.0	111.94	44.32	1.09	32.89	5.43
7/ 8	SE	8.49	0.0	19.24	0.0	8.54	0.0	0.0	17.67	0.0	0.0	90.27	19.02	1.09	14.14	3.55
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10
7/11-	DEN	2.25	0.0	16.91	0.0	6.04	30.72	0.0	12.84	0.93	0.0	21.43	22.09	2.14	24.78	10.85
7/15	SE	2.25	0.0	16.91	0.0	1.41	29.09	0.0	11.47	0.93	0.0	18.13	12.50	2.14	6.42	10.85
	TOWS	3	0	3	3	3	3	5	3	4	3	5	17	3	6	10
7/25-	DEN	14.04	0.0	0.0	36.33	25.07	4.35	0.0	13.40	0.0	5.97	13.84	3.67	13.33	41.16	5.45
7/29	SE	12.39	0.0	0.0	28.03	18.28	4.35	0.0	2.66	0.0	5.97	7.07	1.87	13.33	12.03	4.20
	TOWS	3	0	3	3	4	2	4	3	5	3	5	17	3	7	9
8/ 8-	DEN	0.0	0.0	0.0	2.10	8.49	0.0	0.0	1.28	0.0	0.0	20.44	5.49	0.0	31.20	0.69
8/12	SE	0.0	0.0	0.0	1.06	2.38	0.0	0.0	1.28	0.0	0.0	10.33	3.67	0.0	18.83	0.69
	TOWS	3	0	3	3	3	3	4	3	5	3	5	17	3	6	10

*S = shoal strata
B = bottom stratum
C = channel stratum

Table D-16

Estimated Density (No./1000 m^3) of Atlantic Tomcod Juveniles in Bottom and Channel Strata in Seven Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

		REGION AND STRATUM*													
		WP		PK		HP		KG		SG		CS		AL	
DATE		B	C	B	C	B	C	B	C	B	C	B	C	B	C
2/21-2/25	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	6	3	4	0	0	0	0	0	0	0	0	0	0
3/ 7-3/11	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	7	0	0	0	0	0	0	0	0	0	0	0	0
3/21-3/26	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	3	3	3	3	0	0	0	0	0	0	0	0	0	0
4/ 4-4/ 7	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	4	2	3	3	0	0	0	0	0	0	0	0	0	0
4/18-4/20	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	4	3	3	3	3	0
4/25-4/28	DEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	17	17	6	6	3	4	3	3	3	4	3	3	3	0
5/ 2-5/ 5	DEN	5.48	7.66	0.0	0.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	1.41	2.96	0.0	0.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	6	6	3	4	3	3	3	4	3	3	3	0
5/ 9-5/12	DEN	2.85	0.18	0.0	0.0	0.0	0.0	2.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	1.81	0.18	0.0	0.0	0.0	0.0	2.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	18	17	7	6	3	4	3	3	3	4	3	3	3	0
5/16-5/19	DEN	32.36	5.20	0.60	0.0	2.59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	11.15	3.33	0.60	0.0	1.36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	19	17	6	6	3	4	3	3	3	4	3	3	3	0
5/23-5/26	DEN	137.59	0.0	7.47	0.0	0.59	0.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	57.29	0.0	4.71	0.0	0.59	0.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	5	11	8	20	6	8	5	3	4	3	3	3	3	0
5/31-6/ 2	DEN	941.53	7.26	9.09	0.87	0.0	0.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	558.78	3.95	5.32	0.70	0.0	0.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	10	8	19	6	7	4	4	4	3	3	3	3	0
6/ 6-6/ 9	DEN	15.36	6.41	14.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	8.56	2.89	11.84	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	7	16	12	14	5	5	5	5	4	3	5	2	3	0
6/13-6/16	DEN	65.96	24.48	4.70	0.0	5.75	0.0	0.0	1.68	0.0	0.0	0.0	0.0	0.0	0.0
	SE	29.96	14.53	2.82	0.0	4.72	0.0	0.0	1.68	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	5	5	5	5	3	4	4	3	3	0
6/20-6/24	DEN	203.02	9.94	11.56	0.0	0.84	1.12	6.30	0.0	1.38	0.0	0.0	0.0	0.0	0.0
	SE	84.31	5.17	10.91	0.0	0.84	1.12	4.97	0.0	1.38	0.0	0.0	0.0	0.0	0.0
	TOWS	5	18	11	15	4	6	5	5	3	4	4	3	3	0
6/27-7/ 1	DEN	157.22	48.99	8.39	1.92	0.0	1.04	8.34	2.03	2.06	0.0	1.90	0.0	0.0	0.0
	SE	46.89	10.41	2.89	0.89	0.0	1.04	5.22	2.03	1.03	0.0	1.10	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/ 5-7/ 8	DEN	46.46	9.84	3.06	0.0	2.54	1.16	2.42	0.0	1.11	0.0	1.04	0.0	1.33	0.0
	SE	39.76	3.32	1.02	0.0	0.85	1.16	1.09	0.0	1.11	0.0	1.04	0.0	1.33	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
7/11-7/15	DEN	71.55	15.60	2.08	0.0	4.98	0.0	0.52	0.49	0.0	0.0	1.39	0.0	0.0	0.0
	SE	23.89	5.31	0.77	0.0	4.98	0.0	0.52	0.49	0.0	0.0	0.81	0.0	0.0	0.0
	TOWS	6	17	13	13	4	6	5	5	2	5	4	3	3	0
7/25-7/29	DEN	184.89	26.99	6.04	0.0	4.88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	104.07	7.73	1.63	0.0	2.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0
8/ 8-8/12	DEN	80.46	21.30	0.29	0.0	3.19	0.0	0.61	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	27.41	6.57	0.29	0.0	3.19	0.0	0.61	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOWS	6	17	11	15	4	6	5	5	3	4	4	3	3	0

*B = bottom stratum
C = channel stratum

Table D-17

Mean Monthly Conductivity (mS/cm) in Indian Point and Poughkeepsie Regions, 1974-77

Month	1974 IP	1974 PK	1975 IP	1975 PK	1976 IP	1976 PK	1977 IP	1977 PK
Jan	*	*	445	226	500	212	3012	219
Feb	*	*	838	211	375	210	1854	228
Mar	526	*	477	174	200	177	734	201
Apr	640	167	469	220	325	141	164	161
May	164	154	420	140	162	150	227	154
Jun	1083	173	936	171	188	159	3926	211
Jul	3093	212	3064	273	1481	188	5802	271
Aug	4760	318	3594	194	2942	194	7020	339
Sep	2695	254	2504	257	3361	221	6263	423
Oct	1781	252	226	201	1169	224	549	194
Nov	1492	242	201	197	317	190	1126	191
Dec	429	229	770	196	600	204	431	194

*No data available

Table D-18

Standing Crop (in Thousands) of Atlantic Tomcod Juveniles within Five Power Plant Regions of Hudson River Estuary during Ichthyoplankton Survey, 1977

Sampling Period	Plant Region: Bowline	Lovett	Indian Point	Roseton	Danskammer
Apr 25-28	14902	58	44	0	0
May 02-05	32330	2301	2237	210	181
May 09-12	2702	1639	1588	0	0
May 16-19	8776	4569	4693	48	44
May 23-26	26636	15517	15950	350	383
May 31-Jun 02	20813	18366	21396	1439	1198
Jun 06-09	10319	12846	12476	765	792
Jun 13-16	4126	7135	7798	217	238
Jun 20-24	11538	12203	11481	591	625
Jun 27-Jul 01	2961	4348	5793	930	914
Jul 05-08	7939	11773	11991	1009	733
Jul 11-15	4547	5218	5659	1075	758
Jul 25-29	3118	2604	3640	1349	1019
Aug 08-12	1261	2286	2956	620	419

Table D-19

Standing Crop (in Thousands) of Atlantic Tomcod Juveniles within Five Power Plant Regions, Fall Shoals Survey, Hudson River Estuary, 1977

	Plant Region				
Sampling Period	Bowline	Lovett	Indian Point	Roseton	Danskammer
Aug 15-19	1309	1235	1512	1025	683
Aug 29-Sep 2	654	528	656	61	560
Sep 12-16	108	80	69	125	103
Sep 26-30	367	256	226	24	16
Oct 10-13	140	136	121	37	25
Oct 24-29	79	98	91	24	26
Nov 7-11	98	60	59	16	11
Nov 20-22	218	195	180	12	67

Table D-20

Calculations of Average Monthly Ratios Used To Adjust 1972 and 1973 Juvenile Atlantic Tomcod Abundance Indices

Year	Month	Dates	Catch In Cod End	Catch In Cod-End Cover	Ratio*
1977	Jul	7/10- 7/23 7/24- 8/06	1725 803	531 297	1.33
	Aug	8/07- 8/20 8/21- 9/03	105 201	5 41	1.15
	Sep	9/04- 9/17 9/18-10/01	64 65	10 9	1.15

	1974**	1975	1976	1977	Average Ratio
Jul	2.29	8.36	1.04	1.33	3.26
Aug	2.25	3.72	1.03	1.15	2.04
Sep	2.71	1.84	1.05	1.15	1.69

*Monthly ratio = $\frac{\text{monthly catch in cod end \& cod-end cover}}{\text{monthly catch in cod end}}$

**Juvenile Atlantic tomcod catches in 1974-76 were presented in an earlier report (TI 1977, Table B-30)

Table D-21

Friedman Analysis of Juvenile Atlantic Tomcod Catch Per Tow, Bottom Trawl Gear, Hudson River Estuary, July-September

Biweekly Interval*	1969 c/f	1969 R	1970 c/f	1970 R	1972† c/f	1972† R	1973† c/f	1973† R	1974 c/f	1974 R	1975 c/f	1975 R	1976 c/f	1976 R	1977 c/f	1977 R
1	146.3	8**	137.8	7	16.7	3	95.7	5	13.9	2	66.2	4	12.4	1	127.4	6
2	110.3	7	128.0	8	24.8	2	4.6	1	30.5	5	30.2	4	89.0	6	26.4	3
3	135.6	7	105.8	6	44.3	4	30.1	3	9.5	2	93.5	5	168.0	8	1.4	1
4	11.6	4	162.1	8	3.1	1	29.1	5	4.9	2	48.2	6	110.3	7	6.6	3
5	11.2	4	102.0	8	67.5	6	0.2	1	0.3	2	12.7	5	68.6	7	0.6	3
6	14.4	5	119.9	8	2.2	4	1.4	1	1.7	2	16.0	6	61.2	7	1.8	3
Sum of Ranks		35		45		20		16		15		30		36		19
Statistical Group††		A, B		B		A, B		A		A		A, B		A, B		A

*Dates included in the July-September time periods:

1969	7/06-09/27
1970	7/05-09/26
1972	7/09-09/30
1973	7/15-10/06
1974	7/13-10/04
1975	7/13-10/04
1976	7/11-10/02
1977	7/10-10/01

**CPUE's were ranked across years
†CPUE's were adjusted for gear differences to be comparable with other years
††Years which were not significantly different are denoted by the same letter

Table D-22

Correlation Coefficient Matrix for Factors which May Affect Atlantic Tomcod Abundance

	Dec Flow	Jan Flow	Feb Temperature	Bluefish Abundance	Power Plant Withdrawal Capacity
Dec Flow	1.0				
Jan Flow	0.96	1.0			
Feb Temperature	0.41	0.33	1.0		
Bluefish Abundance	0.57	0.42	0.48	1.0	
Power Plant Withdrawal Capacity	0.23	0.15	0.18	0.63	1.0
Atlantic Tomcod Abundance	0.72	0.64	0.64	0.67	0.27

Table D-23

Male and Female Atlantic Tomcod Catch per Hour in Tappan Zee, Croton-Haverstraw and West Point Regions of Hudson River Estuary during 1977-78 Spawning Season

	Tappan Zee RM 24-33		Croton-Haverstraw RM 34-38		West Point RM 47-55	
Week	Male	Female	Male	Female	Male	Female
11/20-11/26	-	-	-	-	-	-
11/27-12/03	-	-	-	-	-	-
12/04-12/10	-	-	-	-	-	-
12/11-12/17	0.39	0.02	-	-	0.31	0.04
12/18-12/24	1.43	0.26	0.28	0.17	1.00	0.62
12/25-12/31	1.87	0.79	0.86	0.53	2.02	1.33
01/02-01/08	1.90	0.80	0.20	0.20	0.84	0.57
01/07-01/15	0.66	0.16	0.10	0.08	1.49	0.36
01/16-01/22	0.14	0.09	-	-	0.06	0.06
01/23-01/29	0.21	0.02	0.17	0.07	0.05	0.02
01/30-02/05	0.12	0.03	0.02	<0.01	-	-
02/06-02/12	0.07	0.01	-	-	-	-
02/13-02/19	-	-	-	-	-	-
02/20-02/26	-	-	-	-	-	-
02/27-02/05	-	-	-	-	-	-

- Indicates weeks when no Atlantic tomcod caught or insufficient numbers of tomcod processed to provide sex ratio and therefore male and female catch-per-hour values

Table D-24

Number of Atlantic Tomcod Released with Carlin Tags and Finclips in Hudson River Estuary during November 1977-February 1978

		Carlin Tags					Finclips				
	Release Region	0-38	39-46	47-61	62-77	Total	0-38	39-46	47-61	62-77	Total
	Release Period										
1977	11/20-11/26	2				2					
	11/27-12/03	2		1		3					
	12/04-12/10	14		1		15					
	12/11-12/17	161	11	80	63	315					
	12/18-12/24	613	5	580	177	1375	137				137
	12/25-12/31	1191	7	1393	508	3099	495		506	59	1060
1978	01/01-01/07	885	64	929	488	2366	268			136	404
	01-08-01/14	237	64	836	476	1613					
	01/15-01/21	59	47	62	68	236					
	01/22-01/28	64	17	48	70	199					
	01/29-02/04	16	2	4	18	40					
	02/05-02/11										
	02/12-02/18										
	Total	3244	226	3934	1868	9272	900		506	195	1601

Total number of Carlin Tags and Finclips - 10,873

Table D-25

Release/Recapture Matrix for Finclipped Atlantic Tomcod Released and Recaptured during December 1977 in Hudson River Estuary

	River Miles	Recapture Region 12-38	39-46	47-61	62-152
Release Region	12-38	1			
	39-46				
	47-61			2	
	62-153				

Table D-26

Release/Recapture Matrix for Finclipped Atlantic Tomcod Released during December 1977 and January 1978 and Recaptured during January 1978 in Hudson River Estuary

	River Miles	Recapture Region 12-38	39-46	47-61	62-152
Release Region	12-38			1	
	39-46				
	47-61		2		
	62-153		1		1

Table D-27

Length Frequencies of Atlantic Tomcod Ages I and II Caught in Boxtraps in Hudson River Esutary during December 1975-February 1976

Length Intervals (mm)	December 1975				January 1976				February 1976				Combined 1975-76			
	Male		Female		Male		Female		Male		Female		Male		Female	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
91-150	852		49		1011		159		146		2		2009		210	
151-155	95		5		277		35		35				407		40	
156-160	282		8		308		147		29		1		619		156	
161-165	320		92		307		89		32		3		659		184	
166-170	78		20		203		47		23				304		67	
171-175	350		13		133		78		37				520		91	
176-180	63		10		107		61		6	1	2		176	1	73	
181-185	88		15	1	46	2	89		5				137	4	104	1
186-190	59		13		33		100		2	1	1		61	34	114	
191-195	14		23		20		64		3	2			17	22	87	
196-200	7		17		4		40		1				8	4	57	
201-205	2	1	4			5	30						2	6	34	
206-210	2	7	5			2	24		1	2			2	12	29	
211-215	1	3	4			5	14			1			1	9	18	
216-220		9	1			3	10			1				13	11	
221-225		4	1				3	3		1			1	5	4	3
226-230		6	1	1		4	3							10	4	1
231-235		3		1		1		1		1				5		2
236-240		2		2		3		2						5		4
241-245		1		2				4						1		6
246-250		2		2				3						2		5
251-255		2		1										2		1
256-260		2		3				2						2		5
261-265		1		1				1						1		2
266-270				2				1								3
271-275				5				2								7
276-280				2												2
281-285																
286-290																
291-295																
296-300																
301-305																
306-310																
Sample Size	2213	43	281	23	2450	25	993	19	320	10	9		4983	78	1283	42
Mean Length	157.8	226.0	169.9	254.3	154.9	215.0	171.6	246.7	154.4	205.5	164.7		156.2	219.9	171.2	250.9
Proportion	0.9809	0.0191	0.9243	0.0757	0.9899	0.0101	0.9812	0.0188	0.9697	0.0303	1.000		0.9846	0.0153	0.9683	0.0317

Table D-28

Length Frequencies of Atlantic Tomcod Ages I, II and III Caught in Boxtraps in Hudson River Estuary during December 1976-February 1977

Length Intervals (mm)	December 1976						January 1977				February 1977				Combined 1976-77					
	Male			Female			Male		Female		Male		Female		Male			Female		
	I	II	III	I	II	III	I	II	I	II	I	II	I	II	I	II	III	I	II	III
91-150	3555			380			2749		867		299		70		6583			1254		
151-155	362			63			173		144		13				548			207		
156-160	343			131			153		128		24				520			259		
161-165	281			111			139		174		11				431			285		
166-170	256			102			85		170		15		2		356			274		
171-175	190			94			72		101		9		2		271			197		
176-180	39			53			22	4	70		4	1			65	5		123		
181-185	37	18		58			16	1	105		2		2		55	19		165		
186-190	18	16		44	1			2	67		1		1		19	18		112	1	
191-195	10	27		44			1	7	30			2			11	36		74		
196-200	7	38		25				15	16			3			7	56		41		
201-205	2	31		12	1			8	1	4		6			2	45		13	5	
206-210	1	63		5	3		2	16	5	3		3			3	82		10	6	
211-215		47		6				15	2	1		2				64		8	1	
216-220		46		3	1			9	2	3						55		5	5	
221-225		69			3			8		6						77			9	
226-230		29			10			5		3		2				36			13	
231-235		49			6			2		8		2		1		53			14	
236-240		27			3			5		6				1		32			9	
241-245		13			14			3		6		1		1		17			22	
246-250		5			32					4						5			34	
251-255		2			10			1		5						3			16	
256-260		3			19					5						3			24	
261-265					13					4				1					18	
266-270		1			9					4						1			13	
271-275					9					1									10	
276-280					12					5									17	
281-285					10					2									12	
286-290					3					1									4	
291-295					3														3	
296-300			1		2	1											1		2	1
Sample Size	5101	484	1	1131	164	1	3412	101	1882	71	358	22	14	4	8871	607	1	3027	239	1
Mean Lengths	143.6	215.4	298.0	160.4	255.2	298.0	137.7	210.3	153.3	243.1	137.6	208.7	154.8	244.2	141.1	214.4	298.0	156.0	251.4	298.0
Proportion	0.9132	0.0866	0.0002	0.8727	0.1265	0.0008	0.9712	0.0288	0.9636	0.0364	0.9421	0.0597	0.7778	0.2222	0.9359	0.0640	0.0001	0.9265	0.0732	0.0003

Table D-29

Length Frequencies of Atlantic Tomcod Ages I and II Caught in Boxtraps in Hudson River Estuary during December 1977-February 1978

Length Intervals (mm)	December 1977				January 1977				February 1978				Combined 77-78			
	Male		Female		Male-		Female		Male		Female		Male		Female	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
91-150	365		46		471		66		11		4		847		116	
151-155	109		32		72		15		5				186		47	
156-160	70		14		99		33		2		1		171		48	
161-165	126		45		74		27		2				202		72	
166-170	104		21		83		32		1				188		53	
171-175	99		16		107		37		2				208		53	
176-180	75		27		51		22						126		49	
181-185	78		61		40		31						118		92	
186-190	49		52		26		38						75		90	
191-195	37		37		13		42						50		79	
196-200	7		54		6		22						13		76	
201-205	7		17				11						7		28	
206-210	1		19		2	2	10	2					3	2	29	2
211-215	3	3	12			1	4			1			3	5	16	
216-220		8	7	1		1	4							9	11	1
221-225		5	6				3	1						5	9	1
226-230		5	5											5	5	
231-235		2	2	3		2								4	2	3
236-240		1		4				2						1		6
241-245				4		1		1						1		5
246-250		2	1	7				1						2	1	8
251-255				11												11
256-260				8				1								9
261-265				6				2								8
266-270				8				2								10
271-275				4												4
276-280				4												4
281-285				2												2
286-290				4				1								5
291-295																
296-300																
301-305																
306-310								1								1
Sample Size	1130	26	474	66	1044	7	397	14	23	1	5		2197	34	876	80
Mean Length	160.3	224.5	180.4	258.6	154.8	222.3	172.8	251.6	148.2	213.0	145.0		157.6	223.7	176.8	257.4
Proportion	.9775	.0225	.8778	.1222	.9933	.0067	.9659	.0341	.9583	.0417	1.0000		.9848	.0152	.9163	.0837

Table D-30

Sample Size and Percent of Males Young-of-the-Year Tomcod, September 1974-77

	1974		1975		1976		1977	
	Sample Size	Percent Males	Sample Size	Percent Males	Sample Size	Percent Males	Sample Size	Percent Males
Jun 01-15	304	57.2	*	47.4	183	40.4	141	51.8
16-30	250	62.4	70	60	53	58.5	160	56.9
Jul 01-15	506	54.3	96	56.2	258	56.6	160	56.2
16-31	590	52.2	57	59.6	179	58.1	159	59.7
Aug 01-15	100	49.0	80	53.8	73	50.7	237	61.6
16-31	755	54.7	*	52.0	162	47.5	129	61.2
Sep 01-15	291	51.9	77	40.3	80	46.2	44	72.7
16-30	135	62.2	149	57.0	162	53.1	71	62.0

*Values calculated to fill in "missing data" necessary to run 2-factor ANOVA
Analysis used: Missing Data Estimation, Steel and Torrie. 1960. p. 139-141

Table D-31

Mortality Estimated by Sex for Ages I, II, and III Hudson River Atlantic Tomcod during 1975-77

Year Class		1974-75			1975-76			1976-77			1977-78		
		3.67x10^{6}*			3.68x10^{6}*			10.41x10^{6}*			1.32x10^{6}*		
		Male	Female	Combined	Male	Female	Combined	Male	Female	Combined	Male	Female	Combined
			Age I			Age II			Age III				
1974	Proportion	0.5493	0.4507	~0.95	0.6500	0.3500	0.0188	0.5000	0.5000	0.0002			
	Number	1,915,134	1,571,366	3,486,500	44,970	24,214	69,184	1,041	1,041	2,082			
	Mortality				0.9765	0.9846	0.9802	0.9769	0.9570	0.9699			
						Age I			Age II				
1975	Proportion				0.5463	0.4537	0.9812	0.7175	0.2825	0.0664			
	Number				1,972,589	1,638,227	3,610,816	495,953	195,271	691,224			
	Mortality							0.7486	0.8830	0.8086			
									Age I			Age II	
1976	Proportion							0.5148	0.4852	0.9335	0.2982	0.7018	0.0358
	Number							5,002,690	4,715,045	9,717,735	27,009	63,565	90,574
	Mortality										0.9946	0.9865	0.9907

*Spawning population estimate

Table D-32

Mark-Recapture Data for Schaefer Population Estimate of 1977-78 Spawning Stock of Atlantic Tomcod in Hudson River Estuary

Recovery Period	Release Period 12/11-12/24 (1)	12/25-1/7 (2)	1/8-1/21 (3)	1/22-2/4 (4)	R_j	C_j	C_j/R_j
12/11-12/24 (1)	0	-	-	-	0	3038	-
12/25-1/7 (2)	1	5	-	-	6	4240	707
1/8-1/21 (3)	4	11	1	-	16	2313	145
1/22-2/4 (4)	0	2	2	0	4	517	129
R_i	5	18	3	0	26		
M_i	900	4019	1442	140			
M_i/R_i	180	223	481	-			

Total catch = ΣCj = 10108
Total marked = ΣMi = 6501

APPENDIX E

GLOSSARY

Abiotic Factors: physical or chemical factors (e.g., water depth, temperature, spawning substrate) which may influence different aspects of animal populations.

AFS: American Fisheries Society

Anadromous: pertaining to migratory fish which spend most of their lives in a marine environment and migrate to fresh water to spawn.

Biomass: weight of a given species or life stage within a given area.

Biotic Factors: factors such as competition, predation, or disease related to the actions of living organisms.

Catch-per-Effort (C/f): number or weight of fish taken with a specified unit of effort, (e.g., catch-per-tow).

Compensation: the group of processes operating in populations which cause population densities to be maintained at pre-impact levels despite mortality from man's activities. Compensation stabilizes numbers, biomass, and/or energy content of populations because birth rates, survival rates, and/or growth rates are inverse (negative) functions of density. Thus, compensation reflects the principles of density-dependent population regulation.

Competition: inter- or intraspecific interaction resulting from individuals or populations sharing an environmental requisite in limited supply.

Conditional Mortality Rate: the fraction of the initial population that would die from any specified cause during a given interval if no other sources of mortality acted during that time interval (Ricker 1975).

Conductivity (specific conductance): a measure of the dissolved ion concentration of a solution determined from the capacity to conduct an electrical current; measured in mSiemens per centimeter (mS/cm) at a standard temperature of 25°C.

Catch Curve: a representation of population composition in which the number of fish caught is plotted against successive ages or sizes.

Demographic: relating to the dynamic balance of a population created by births and deaths, especially with regard to density and capacity of the population for expansion or decline.

Density-dependent: factors whose influence on populations varies with the increase or decrease of populations, i.e., competition, predation, and disease. Density-dependent factors are normally compensatory.

Density-independent: factors, usually abiotic forces, acting on populations in a manner independent of population density (e.g., pollution, floods, water temperature).

Diel: refers to events that recur at intervals of 24 hours (hr) or less.

Dissolved Oxygen (D.O.): oxygen dissolved in water and expressed in milligrams per liter (mg/ℓ) or parts per million (ppm).

EAI or EA: Ecological Analysts Incorporated.

Emigration: a form of population dispersal that involves a one-way outward movement of individuals.

Entrainment: passage of small organisms into power plant condenser systems with the cooling water.

Epibenthic: pertaining to the layer of water just above the river bottom.

Estuary: a semienclosed coastal body of water having free access to the sea and measurably diluted below the salinity of open ocean water by freshwater; for the Hudson River system, it is the tidal portion downstream from Troy Dam, Troy, New York.

Euryhaline: referring to tolerance for wide changes in salinity; characteristic of many estuarine species and certain stages in the life history of other species.

Exploitation Rate: the probability that a given fish will be killed.

Exposure (vulnerability): a measure of the potential susceptibility of the population to either entrainment or impingement by power plants and expressed as a percent of the population in proximity to power plants.

Fecundity: the number of ripe eggs produced by a female.

Finclip: a method of marking fish by excising (cutting a piece out of or completely removing) one or more of the fins.

Gear Avoidance: behavior of an organism that enables it to escape capture by fishing gear.

Gear Efficiency: ratio of the density of organisms caught by a particular sampling gear to the density of organisms actually present.

Gill Net: net that is held down by lead weights at the bottom and held upright by floats along the top and captures fish by entangling their gills.

Haul Seine: a long net, one end of which is usually held on shore while the other is extended so as to enclose the area to be sampled. Fish present in the enclosed area are captured as both ends are drawn ashore.

Ichthyoplankton: early life stages of fish (eggs, larvae, early juveniles), which have either weak swimming ability or drift passively with currents.

Impingement: entrapment of organisms upon intake screens of a power plant when cooling water is withdrawn from a water source.

Index: a ratio or numerical quantity (often dimensionless) derived from a series of observations that denotes the relative magnitude of a phenomenon, condition, or process.

Instantaneous Mortality Rate (Z): the rate of decline of the natural logarithm of the population size with respect to time.

Juvenile (young-of-the-year): the lifestage beginning when a fish acquires the full complement of adult fin characteristics and extending to age I (i.e., through 31 December of the year spawned).

Key Species: in this report, the following three fish species: striped bass (Morone saxatilis), white perch (Morone americana), and Atlantic tomcod (Microgadus tomcod).

LMS: Lawler, Matusky, Skelly Engineers

Mark-recapture: a method of estimating numbers of animals by initially releasing a known number of marked individuals and then sampling to determine what fraction of the population consists of marked individuals.

Natality: production of new individuals in the population.

Nearfield: areas of the Hudson river in the vicinity of a power generating station.

NYU: New York University

PASNY: Power Authority of the State of New York

Persistence: the ability of a population to continue to exist.

Petersen-type Estimate: a type of mark-recapture population estimate in which the marking period and recapture period do not overlap.

Plant Region (power plant region): region of the estuary including the area 6 river miles downstream and 6 river miles upstream of the river mile within which the power plant is located; a total of 13 miles of river approximately centered on the power plant.

Population: a group of organisms of the same species (within which individuals may exchange genetic information) occupying a particular space.

Population Characteristics: attributes (i.e., sex ratios, age composition, fecundity, age at maturity) of a population as a whole that are set by the interaction of genetic-based characteristics with a particular environment.

Population Dynamics: aggregate of processes that determine the size and composition of a population.

Post Yolk-Sac Larvae: the life stage of a fish, beginning with the presence of a complete and functional digestive system (regardless of the degree of yolk and/or oil retained) and ending with the juvenile life stage.

RAY: Raytheon Company

Recirculation: the portion of the organisms passed through a plant that will be reentrained at some future time.

Recruitment: the addition (usually through growth or immigration) of fish to that population under consideration.

R/C Ratio: the number of marked fish (R) in a sample divided by the total number of fish in that sample (C).

R/C Value: the number of fish recaptured (R) divided by the number of fish marked (M) during a particular marking period.

Salt Front: leading edge of the mass of intruding seawater into the estuary; defined for the Hudson River estuary as the point associated with conductivity of 200 mSiemens per centimeter (mS/cm) or salinity of approximately 0.1 parts per thousands (°/oo).

Schumacher-Eschmeyer Estimate: a type of mark-recapture population estimate in which marking and recapturing occur concurrently.

Spawning Stock: mature or maturing fish capable of contributing to the production of a specific year's spawn.

Standing Crop: number or biomass of organisms in an area at a given point in time.

Stratum (Strata pl.): section of a river cross-section based on depth and distance from the bottom; in this report, shoals, bottom, and channel are used.

Subpopulation: an identifiable fraction or subdivision of a population.

TI: Texas Instruments Incorporated

Total Length: straight-line distance from the most anterior part of the head to the tip of the tail.

Tucker Trawl: a rectangular midwater trawl having the towing bridles attached to the top of the trawl frame, leaving the mouth unobstructed; used to sample pelagic fish eggs and larvae at discrete depths.

Turbidity: cloudy appearance of a liquid caused by a suspension of colloidal liquid droplets or fine solids such as clay, silt, or microorganisms.

Type A Error: a systematic error in mark-recapture data that will bias the population estimate by a constant proportion.

Type B Error: a systematic error in mark-recapture data that will produce a temporarily increasing amount of bias in the population estimate.

Type C Error: a systematic error in mark-recapture data that will produce a temporarily decreasing amount of bias in the population estimate.

Unit Stock: a population in which the vital statistics of recruitment, growth, and mortality are homogeneous.

Withdrawal Factor: ratio of the density of ichthyoplankton in the intake cooling water of a power plant to the density of ichthyoplankton in the estuary in the vicinity of the power plant.

Year Class: cohort of fish spawned or hatched during a given calendar year.

Year Class Abundance (year class strength): the number (or relative number) of organisms of a given species resulting from spawning during a particular year.

Yearling: a fish age classification that extends from 1 January following the year in which the fish was spawned through 31 December.

Yolk: food reserve of embryonic and early larval stages, usually seen as a yellowish sphere diminishing in size during development.

Yolk-Sac Larvae: the life stage of a fish from hatching through development of a complete and functional digestive system, during which nourishment is derived from within the yolk-sac.

Zooplankton: microscopic animals that move passively in aquatic ecosystems.