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May 23, 2000

Dwayne Moore, Ph.D.
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Re: Hudson River Ecological Risk Assessment

Dear Dr. Moore:

In addition to the previously submitted correspondence concerning the Hudson River Baseline Ecological Risk Assessment (BERA) peer review in which you are participating, I enclose for your consideration a brief report concerning Charge Question 8. Dr. Lawrence Barnthouse prepared the report, on behalf of the General Electric Company (GE), which addresses the availability and interpretation of data concerning the fish populations of the Hudson River estuary.

I am sending you this report because the objective assessment of all available data is fundamental to a technically sound and defensible ecological risk assessment. As summarized in the enclosed report, 24 years of continuous sampling data concerning the fish populations of the Hudson River estuary are available for evaluation by EPA. This data set is, by far, the most complete data set available for any estuarine fish community in the United States, and probably the world. These data are highly relevant to EPA's reassessment for the Hudson River and the BERA because they directly address the condition of the exposed populations in the Lower Hudson River. In its Responsiveness Summary, EPA dismissed these data as being confounded by changes in water quality and fisheries management that may have masked adverse effects caused by PCBs. This argument is wholly unsupportable. In fact, the observed status and trends of the estuary ecological resources provided by the 24-year data set are a better representation of potential ecological risks than are the results of highly uncertain predictive modeling exercises such as the Toxicity Quotients relied upon in EPA's ecological risk assessments for the Upper and Lower Hudson River.

I hope that you will find the enclosed report informative as you complete the peer review process. If you have any questions, please contact Dr. Barnthouse (865-483-0100) or myself (518-862-2730).

Yours truly,

John Haggard/bg

John G. Haggard

JGH/bg
Enclosure

cc: Alison Hess, U.S. EPA
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Douglas Tomchuk, U.S. EPA
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The Hudson River DEIS: An Interpretive Summary

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Executive Summary

In December, 1999 the Hudson River utility companies issued a Draft Environmental Impact Statement (DEIS) that synthesizes 24 years of data concerning the fish populations of the Hudson River estuary. The entire estuary from the Battery to the Federal Dam at Troy was sampled, using methods that effectively collect all fish life stages. The DEIS includes data from monitoring programs conducted both by the utilities and by the New York State Department of Environmental Conservation (NYSDEC). The resulting data set is, by far, the most complete data set available for any estuarine fish community anywhere in the United States and probably in the world.

The data presented in the DEIS are highly relevant to EPA's reassessment for the Hudson River because they directly address the condition of the exposed populations. This report provides 1) a brief account of the history of the Hudson River fish population surveys, 2) an overview of the DEIS, 3) a summary of the principal conclusions drawn from the DEIS concerning the health of individual populations and of the fish community as a whole, and 4) preliminary tests of hypotheses concerning the effects of PCBs on reproductive success in striped bass.

The DEIS provides strong evidence that the fish community of the Lower Hudson River is healthy and is unaffected by past or present exposures to PCBs. Evidence is particularly strong in the case of striped bass, for which both direct measures of PCB exposure and multiple, independent estimates of abundance and reproductive success are available. This study should be given a high weight-of-evidence in ecological risk assessments performed to support remedial action decisions for the Hudson River.

I. Introduction

Fish populations of the Hudson River estuary have been studied intensively for nearly 30 years, to support assessments of the impacts of Hudson River power plants on striped bass and other fish species. These data were recently synthesized in a Draft Environmental Impact Statement (DEIS) prepared by the Hudson River utility companies (Central Hudson Gas & Electric Corp, et al. 1999). The data summarized in the DEIS reflect 24 years of continuous sampling, covering the entire estuary from the Battery (River Mile [RM] 0) to the Federal Dam at Troy (RM 153.9), using methods that effectively sample all fish life stages. In addition to data collected by the utility companies, the DEIS synthesizes information obtained from several monitoring programs conducted by the New York State Department of Environmental Conservation (NYSDEC). The resulting data set is, by far, the most complete data set available for any estuarine fish community anywhere in the United States and probably in the world.

Although only recently published in summary form, most of the data have been previously published in annual reports. Abundance indices for juvenile striped bass are provided annually to the National Marine Fisheries Service (NMFS), and are included in NMFS' annual striped bass stock assessments. The General Electric Company (GE) brought the existence of these data to the attention of EPA in comments on the Baseline Ecological Risk Assessment for the Upper Hudson River (September 1999). Unfortunately, in its Responsiveness Summary (March 2000), EPA dismissed the data synthesized in the DEIS as being "confounded" by changes in water quality and fisheries management that may have masked adverse effects caused by PCBs. Even with respect to ordinary data sets, this argument is weak and indicates only that other lines of evidence in addition to population/community trends are needed to support a defensible risk assessment. With respect to the Hudson River data set, EPA's argument is wholly unsupportable.

The data presented in the DEIS are highly relevant to EPA's reassessment because they directly address the condition of the exposed populations. The observed status and trends of the ecological resources of the estuary are a better guide to the need for remediation than are results of predictive modeling exercises such as the Toxicity Quotients (TQs) developed in EPA's ecological risk assessments for the upper and lower Hudson.

This report provides:

1. A brief account of the history of the Hudson River fish population surveys;
2. An overview of the DEIS;
3. A summary of the principal conclusions drawn in the DEIS concerning the health of individual populations and of the fish community as a whole; and
4. Preliminary tests of hypotheses concerning the effects of PCBs on reproductive success in striped bass, performed by combining data provided in the DEIS with data on past and present PCB concentrations in adult female striped bass.

II. Historical background

The Hudson River fish population studies have been performed to address the issue of whether mortality to young fish caused by cooling water withdrawals could be significantly reducing the abundance or productivity of these populations. To address this issue, riverwide data on the abundance and spatial distribution of representative fish species has been collected annually since 1974. In addition, in-depth studies of striped bass and several other species have been performed using supplemental data sets (e.g., mark-recapture population estimates) and mathematical models.

Data collected during the 1970s were used in licensing proceedings related to the Indian Point plant and in consolidated National Pollution Discharge Elimination System (NPDES) permit proceedings related to the Indian Point, Bowline Point, and Roseton plants. These proceedings ended with the establishment of a settlement agreement that (1) awarded 10-year NPDES permits to all three plants, and (2) imposed continued riverwide monitoring throughout the permit period. State Pollution Discharge Elimination System (SPDES) permits with five-year durations were issued by the NYSDEC in 1987.

In 1992, the owners of the Indian Point, Bowline Point, and Roseton plants applied for renewal of the SPDES permits. After reviewing the applications, NYSDEC directed the utilities to prepare an environmental impact statement (EIS) pursuant to the State Environmental Quality Review Act (SEQRA). The draft EIS (DEIS) was to provide quantitative assessments of the impacts of the three plants on five representative fish taxa (striped bass, white perch, Atlantic tomcod, bay anchovy, and river herring), to identify mitigating measures that the utilities would implement to minimize those impacts, and to demonstrate that operation of the plants according to the permit conditions would not adversely affect species diversity or species abundance within the fish communities of the Hudson River.

A preliminary version of the DEIS was submitted to NYSDEC for comment in 1994, but the document was not released to the public at that time. After revision, the DEIS was formally issued in December 1999. The DEIS synthesizes all data collected through 1997. In addition to providing the quantitative impact assessments described above, the DEIS evaluates population trends in 16 fish species and interprets those trends in the context of (1) changes in environmental quality that have affected the lower Hudson since the 1970s and (2) ecological processes at the population and community level that may have affected certain species.

III. Overview of the DEIS

The DEIS consists of two volumes. The first volume contains the main text, divided into 13 sections, and formatted according to the requirements of the SEQRA. The second volume contains the Appendices. The principal section of interest with respect to PCB is Section V, Environmental Setting. This section contains a general overview of the lower Hudson, summaries of physical and chemical characteristics of the lower Hudson, and data on the aquatic resources of the lower Hudson. Time trends for various life stages of 16 fish species are discussed in this section. Appendix VI contains results of population modeling for striped bass, Atlantic tomcod, American shad, and bay anchovy. Of these, the striped bass modeling (Appendix VI-4-A) is the most relevant to PCB effects since both direct measures of PCB exposure and multiple independent estimates of abundance and reproductive success are available. Section VI, Environmental Impacts of the Proposed Action, summarizes results of both the empirical trends analyses and the modeling.

> **Life Stage and Age Designators Used in the DEIS**
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> **Eggs:** fertilized eggs, collected after deposition but prior to hatching.
>
> **Yolk-sac larvae (YSL):** first larval stage, prior to yolk-sac absorption and initiation of feeding.
>
> **Post yolk-sac larvae (PYSL):** second larval stage, beginning with yolk-sac absorption and initiation of feeding, and ending with transformation to juvenile form.
>
> **Juveniles (young-of-the-year, or YOY):** young fish with fully developed fins and scales, from transformation through the end of the first year of life.
>
> **Age 1+:** fish between 1 and 2 years of age.
>
> **Adults:** fish that have become sexually mature.

The data utilized in the DEIS come from a variety of utility and non-utility sponsored data collection programs. The principal species of interest with regard to power plant impacts has always been striped bass; therefore, most of the sampling programs are directed at collecting information about striped bass. Data are available concerning every striped bass life stage, throughout the entire geographic range utilized by the Hudson River population. Many of the sampling programs also provide information concerning other species with similar life histories or distributional patterns. A few special sampling programs are targeted at other species such as white perch and Atlantic tomcod that are also highly vulnerable to power plant impacts.

A. Data available from utility-sponsored programs

Although utility-sponsored sampling of the Hudson River estuary began in the 1960s, sampling according to the current design began in 1974. Earlier data are not comparable and are not discussed in the DEIS.

Longitudinal River Ichthyoplankton Survey (LRS). This program samples eggs, larvae, and juvenile fish, weekly from April through July. The entire tidal estuary from the Battery to the Federal Dam at Troy is sampled[1]. Sampling is conducted using a stratified random design. The river is subdivided into 13 regions (Figure 1), and each reach is further divided into three depth strata: channel, bottom, and shoal. Two gear types are used: a 1-m^2 Tucker trawl is used to sample the water column; an epibenthic sled with a 1-m^2 net is used to sample near the bottom. The two gear types enable sampling of nearly the entire river from shore to shore. The LRS has been conducted annually since 1974.

Beach Seine Survey (BSS). This program samples juvenile fish, also called "young-of-the-year" fish (YOY) on alternate weeks from June through October. Sampling is conducted from the George Washington Bridge to the Federal Dam. Sampling is conducted in the shore zone (from the shoreline to a depth of 10 ft.) using a 100-ft. beach seine. The BSS has been conducted annually since 1974.

Fall Shoals Survey (FSS). This program samples YOY and older fish in offshore habitats, on alternate weeks from the Beach Seine Survey. Approximately 200 samples are collected per week, from Manhattan to the Federal Dam, using a stratified random design. Like the LRS, the FSS uses two different gears in order to sample as much as possible of the river: a 1-m^2 Tucker trawl and a 3-m beam trawl. This program was also initiated in 1974, however, the beam trawl was not used until 1985. From 1974 through 1984 an epibenthic sled was used to sample near the river bottom.

Striped Bass Mark-Recapture Program. This program was initiated in 1984, to estimate the contribution of the Hudson River striped bass hatchery (established as a settlement condition) to the Hudson River population. The program targets 1-year-old and 2-year-old striped bass, and is conducted from November through March. During this

[1] When the LRS was established in 1974, sampling extended from the George Washington Bridge (RM 12) to RM 140. This region encompasses the habitat utilized by early life stages of striped bass. Sampling was extended upriver in 1986 and downriver in 1988 to provide better data concerning other species.

period, young striped bass are concentrated in the Battery region of the lower Hudson and in upper New York Harbor. Collections are made using a 9-m trawl. All collected striped bass are measured and examined for tags; all previously untagged striped bass that are larger than 150 mm and in "good condition" are tagged and released. Data from this program are used to estimate the numbers of striped bass >150 mm in length overwintering in the lower estuary. Growth and survival rate estimates are also obtained from this program.

Atlantic Tomcod Mark-Recapture Program. This program has been conducted in most years since 1974 to generate estimates of the number of tomcod in the winter spawning population. Box traps and bottom trawls are used to collect fish for marking and recapture.

B. NYSDEC Surveys

The NYSDEC established its own striped bass sampling program in 1976. Initially focused on juvenile striped bass in the lower Hudson, the state program has gradually expanded to include studies of older life stages both within the Hudson and throughout marine waters within the state's jurisdiction.

Juvenile Striped Bass Beach Seine Survey. Since 1976, the NYSDEC Division of Marine Resources (DMR) has conducted a beach seine survey in the Lower Hudson River estuary. The program focuses on the Tappan Zee and Haverstraw Bay (see Figure 1), the primary nursery area for YOY striped bass. Sampling is conducted biweekly in the shore zone using a 200-ft. seine. The primary objective of the program is to generate an annual index of relative abundance of YOY striped bass.

Bottom Trawl Survey. From 1981 through 1990, the NYSDEC Division of Fish and Wildlife (DFW) sampled the lower estuary using a 26-ft. bottom trawl. Sampling was conducted from July through early November. This program also focused on Haverstraw Bay and the Tappan Zee. Sampling was conducted in off-shore shoal areas. The objective of the program was to develop an annual abundance index for YOY striped bass and other juvenile fish.

Juvenile Alosid Survey. The NYSDEC-DFW conducts a beach seine survey in the middle and upper regions of the estuary (above RM 55) to estimate the relative abundance of YOY American shad and other juvenile fishes. Sampling is conducted biweekly using a 100-ft. seine, from mid-June through late October and early November. Approximately 30 standard sites are sampled, concentrating on two primary areas: RM 55-77 and RM 121-140. This program was initiated in 1980 and continues to the present.

Western Long Island Survey. The NYSDEC-DMR conducts a survey for subadult striped bass in the bays around western Long Island Sound. Sampling is conducted using a 200-ft. beach seine. The survey was initiated to provide an index of relative abundance for age 1 striped bass. The resulting index was used to validate the Hudson River YOY striped bass indices. The program was initiated in 1984 and is continuing, although it has been modified. The objective of the program is now to tag young striped bass for subsequent determination of migration patterns and mortality rates.

Spawning Stock Assessment. The NYSDEC-DFW conducts a haul seine survey in the Hudson River to provide information on length, age and sex distribution, and mortality rates for adult American shad and striped bass. The program was initiated in 1982 and continues to the present.

Commercial Fishery Monitoring. The NYSDEC-DFW monitors the commercial gill net fishery for American shad. This fishery is conducted in the lower estuary during the spring spawning run. Because the striped bass spawning run occurs at approximately the same time, substantial numbers of striped bass are caught as bycatch in the American shad fishery. The objective of the program is to determine the relative abundance and age structure of the commercial catch of American shad and of the striped bass bycatch. On-board observers record the catch per unit effort (CPUE), examine a subsample for length, weight, and sex, and collect scales for subsequent age determination.

IV. Results presented in the DEIS

Much of the DEIS focuses on using the data to assess impacts of the Indian Point, Bowline Point, and Roseton stations on fish populations and communities. This summary focuses on the status and trends data summarized in Section V (Environmental Setting).

A. Striped Bass

Section V of the DEIS contains an extensive summary of information on the Hudson River striped bass population. The most relevant of this information for ecological risk assessment are first, the abundance trends, and second, the interpretations of causes for changes in the abundance of the various striped bass life stages. Annual indices for 9 separate surveys are summarized in Table V-15 of the DEIS (attached). Figures V-34 through V-43 of the DEIS (attached) depict intercomparisons of the various indices, in order to document the change in abundance through time and to explain trends in the relative abundance of the different life stages.

Trends in YOY from 1976 through 1997 as measured by the NYSDEC survey, are depicted in Figure V-35 of the DEIS (attached). This index shows that there has been little or no trend in the abundance of YOY striped bass over the past 20 years. Indices of the abundance of YOY striped bass are used by the Atlantic States Marine Fisheries Commission (ASMFC) to estimate the number of striped bass that will contribute to the fishery in the future. The beach seine indices compiled by the utilities and by the NYSDEC are both accepted as valid indicators of year-class strength in striped bass and are used as inputs to the ASMFC's annual striped bass stock assessment. According to the NYSDEC index, large year classes were produced in 1977, 1978, 1982, 1983, 1987, 1988, 1989, 1990, and 1997. Weak year classes were produced in 1979, 1985, 1986, 1991, and 1996.

The general validity of the NYSDEC index as a measure of year-class strength has been evaluated by comparing this index to results of the striped bass mark-recapture surveys. The winter striped bass mark recapture survey estimates the abundance of one-year-old and two-year-old striped bass overwintering in the Lower Hudson River and upper New York Harbor. Figure V-36 of the DEIS (attached) compares abundance estimates for the 1984 through 1995 year classes, as measured both by the NYSDEC YOY striped bass index and by the mark-recapture survey. The two indices track each other very closely through 1990. After 1990, the YOY indices are consistently lower than the corresponding mark-recapture indices. These latter appear to show nearly constant abundance of age 1+ striped bass since the late 1980s. The difference is interpreted by the utilities as being due to increased dispersal of larval and juvenile striped bass after 1990 (so that they would not be sampled by the beach seine survey), related to improved water quality in the vicinity of New York City. This interpretation is supported by observation of an increasing trend in abundance of YOY striped bass in Western Long Island Sound since the late 1980s. Regardless of whether this interpretation is correct, it seems clear that the production of YOY striped bass has been fluctuating but relatively stable since the beginning of the surveys.

Abundance of the adult stock, as measured by the catch of striped bass as bycatch in the American shad fishery, has shown a distinctly increasing trend. This strong increase in the abundance of the adult stock is generally credited to reduced fishing effort following the 1975 consumption advisory, the commercial fishing ban, and the stringent striped bass conservation measures imposed in the mid-1980s (Young-Dubovsky et al. 1996). The increase in abundance of adults, coupled with stable production of young, has been interpreted in the DEIS as evidence for strong density-dependent population regulation in Hudson River striped bass.

Data on the abundance of eggs, yolk-sac larvae (YSL), and post yolk-sac larvae (PYSL) appear to support this interpretation. The abundance of YSL and PYSL (Figure V-34 of the DEIS) increased greatly after 1986 because the relatively large year classes spawned in the late 1970s and early 1980s were not heavily fished, resulting in a large increase in the size of the spawning stock. This large spawning stock, in turn, produced large numbers of eggs and larvae. However, as shown by the lack of trend in YOY indices, these high densities of early life stages produced virtually the same number of YOY as did the low density of larvae observed in 1977 and 1978.

The above data were used in Appendix VI-4 of the DEIS to develop a stock-recruitment model of the Hudson River striped bass population. Analysis of the model indicates that reproductive success in striped bass is highly density-dependent. According to the model, the recent increase in abundance of adult striped bass has resulted in a reduction in the number of surviving offspring (consistent with the observed data).

B. White Perch

Data on trends in the abundance of white perch in the lower Hudson estuary are available from many of the same programs that provide data on striped bass. Eggs and yolk-sac larvae of white perch have very short durations, and because white perch eggs are demersal and adhesive (i.e., they are deposited near the bottom of the river rather than being dispersed throughout the water column, as in striped bass) these life stages are not collected effectively by the utilities' sampling gear. The DEIS presents indices of annual abundance of post yolk-sac larvae, juveniles, and age 1+ fish from the LRS and the utilities' beach seine survey .

The abundance of PYSL, according to Figure V-48 of the DEIS (attached), increased gradually from 1974 through 1986 and then stabilized. No apparent trend is discernable from 1987 through 1997.

The abundance of YOY white perch, in contrast, increased from 1974 to 1979, and since then has declined steadily (Figure V-49). Several causes for this decline are discussed in the DEIS, including zebra mussels, entrainment at power plants, improved water quality, competition with and predation by young striped bass, and regrowth of water chestnut beds in the freshwater region of the estuary. Qualitative comparison of time trends, according to the DEIS, suggest that both water chestnuts and striped bass contributed to the decline in abundance of YOY and age 1+ white perch.

The abundance of age 1+ white perch has declined precipitously in the lower estuary, the area most heavily utilized by striped bass. The decline has been much more gradual in the upper estuary. Whatever the cause, the decline affects only juvenile and older white perch.

C. Shortnose sturgeon

Shortnose sturgeon have never been a major issue for Hudson River power plants, however, shortnose sturgeon are collected in the LRS and the FSS. Both data sets show increased abundance since the 1970s. The beam trawl used in the FSS has provided the greatest catches (Figure V-86) and shows no trend in the 1980s, followed by a dramatic increase in 1992 and a decline thereafter. The DEIS endorses the conclusion of Bain et al. (1995) that the Hudson River shortnose sturgeon population is "in excellent condition."

D. Fish Community Analysis

In addition to addressing trends in the abundance of individual species, the DEIS includes a description of the fish community as a whole, including:

- Species richness – the total number of unique species comprising the community at any point in space or time;
- Species diversity – a quantitative measure of the distribution of abundance cross the individual species comprising the community;
- Dominance succession – changes in the abundance of individual species that comprise the vast majority of individuals collected and exert a major controlling influence on the community character; and

- Target species succession – changes in the relative abundance if species that are the focus of the impact assessment.

Spatial and temporal patterns are addressed separately for the brackish water zone (Regions 1-5, RM 12-55), and the freshwater zone (Regions 6-12, RM 56-152). Separate analyses are provided for three life stages/age groups: larvae, YOY, and age 1+.

Data for analyzing the larval fish community were derived from the utilities' Longitudinal River Survey for the years 1974-1997. Not all larvae could be identified to the species level, so the larval fish community analysis refers to "taxa" – meaning either species or genus – rather than to "species." A total of 67 taxa of larval fish were collected over this period. Of these, 29 were marine taxa, 20 were freshwater, and 20 were estuarine or diadromous[2]. The peak abundance of larval fish in the estuary occurs in May and June. Over the entire period of study, seven taxa accounted for more than 99% of the mean catch in May and June: river herring (alewife and blueback herring, which are indistinguishable as larvae), white perch, striped bass, bay anchovy, American shad, rainbow smelt, and tessellated darter. River herring are the most abundant larvae in the freshwater zone and bay anchovy are the most abundant in the brackish water zone. White perch and striped bass larvae are abundant in both zones.

Analyses of temporal trends, depicted in Figures V-118 and V-119 of the DEIS (attached), show that taxonomic richness has increased slightly over time in both the brackish and the freshwater zones. The increases are attributed to an increase in the number of marine taxa present, probably related to a general increase in the mean salinity of the lower estuary since 1984. The total abundance of larvae has also increased slightly, primarily due to increased abundance of striped bass and bay anchovy.

[2] The term "diadromous" refers to species that migrate between marine and estuarine or freshwater ecosystems. There are two types of diadromous species. "Anadromous" species reproduce in fresh or brackish water (e.g., the Hudson River estuary) and then emigrate to the ocean. "Catadromous" species reside in fresh water and emigrate to the ocean to spawn. The American eel is the only catadromous species that inhabits the Hudson River. Striped bass, American shad, and river herrings are all anadromous species.

Data from the Beach Seine Survey were used to evaluate the YOY fish community. Peak abundance of YOY fish occurs in July and August. Over the years 1974 through 1997, 80 species of YOY fish were collected. Of these, 33 were freshwater species, 27 were marine species, and 20 were estuarine or diadromous. Over the entire study period, 10 species accounted for 98% of the total catch of YOY fish. Blueback herring, American shad, and white perch accounted for more than 75% of the catch. Blueback herring, American shad, and spottail shiner were the most abundant species in the freshwater zone, blueback herring, bay anchovy, and striped bass were the most abundant in the brackish water zone.

In contrast to the increasing temporal trend in species richness of larval fish, species richness of YOY fish declined slightly from 1974 through 1997 (Figures V-126 and V-127 of the DEIS, attached). The decline appears to be a result of a decrease in the number of freshwater species. The total abundance of YOY fish increased in the brackish water zone, primarily due to increased abundance of Atlantic silversides. The freshwater zone is dominated by a single species, blueback herring. This species has been relatively stable since the early 1980s, although it was more abundant prior to 1980 than in recent years.

Data from the Beach Seine Survey during July and August were also used to evaluate the age 1+ fish community. A total of 95 species were collected over the period 1974 through 1997. Of these, 46 were freshwater species, 28 were marine species, and 21 were estuarine or diadromous. The 10 most abundant species accounted for 87% of the total age 1+ fish, with white perch and spottail shiner accounting for approximately half of the total. White perch is the most abundant species in both the brackish water and freshwater areas. Unlike the larvae and YOY communities, which tend to be dominated by migratory species such as blueback herring and striped bass, the age 1+ fish community is dominated by resident fish species. As with the YOY fish, the species richness and abundance of freshwater fish appears to have decreased slightly.

The DEIS (pp. V-170 through V-172) states the following conclusions regarding the Lower Hudson River fish community:

- The estuary is species rich.

- The estuary's fish communities lack diversity at the species level.

- The fish community in brackish areas is dominated by marine species whereas in tidal freshwater areas the fish community is dominated by diadromous species as larvae and young of year and by freshwater and estuarine species as yearling and older.

- Species richness and overall abundance of the larval fish community increased since 1974.

- Species richness for the young-of-year fish community decreased whereas overall abundance has increased in brackish areas of the estuary since 1974.

- Species richness and overall abundance of the yearling and older fish community decreased in brackish areas of the estuary since 1974.

- Species richness in the yearling and older fish community decreased in freshwater areas of the estuary whereas overall abundance exhibits no long-term trend since 1974.

In short, although there have been some slight shifts in abundance of some species, there have been no major changes in the fish community of the Hudson River estuary between 1974 and 1997.

V. Relevance of the DEIS to EPA's Reassessment

The DEIS provides an important line of evidence indicating that PCB exposures have not adversely affected either specific receptor species evaluated by EPA or the fish community as a whole:

- Striped bass and shortnose sturgeon, both of which were declared to be "at risk" by EPA based on toxicity quotients, have increased in abundance since 1974 In the case of shortnose sturgeon, there have been no management changes that could confound the data – this species was listed as endangered in 1967.

- Fluctuations in the abundance of white perch since 1974 appear to be related to changes in habitat quality and striped bass predation, not with changes in PCB exposure.

- There have been few changes in the fish community as a whole.

In the case of striped bass, 20+ years of data on both contamination levels and reproductive success are available, permitting a direct test of the hypothesis that PCBs have reduced reproductive success.

Figure 2 compares time trends in PCB concentrations in adult female striped bass to the NYSDEC YOY index. The PCB concentrations were calculated using only female fish collected during the months of April and May. Adult females collected within the river during those months should be representative of the spawning stock. The measured PCB concentrations in fillets from those females should be a reasonable indicator of their exposure to PCBs. The NYSDEC YOY index has been correlated with other measures of striped bass abundance and is accepted by the ASMFC as a valid indicator of year class strength in Hudson River striped bass. If PCBs were adversely affecting striped bass reproduction, then the number of young striped bass produced each year should increase as PCB concentrations decline. Clearly, this has not happened. Whereas PCB concentrations in adult female striped bass have declined greatly since the mid-1970s, average year-class production, as measured by the NYSDEC index, has not changed. As noted above, the lack of correlation between adult abundance and YOY abundance has been interpreted in the DEIS as indicating that reproductive success in the Hudson River striped bass population is strongly density-dependent. Further evidence of density-dependence is provided by time trends in the abundance of eggs, yolk-sac larvae (YSL), and post yolk-sac larvae (PYSL) (Table V-15 of the DEIS, attached). Density estimates for all three of these early life stages show increasing trends that are correlated with each other and with the adult abundance index. These correlations suggest that as the size of the spawning population has increased, the total number of eggs and larvae produced annually has also increased. Early life stage densities, however, are not, correlated with YOY abundance. This pattern is interpreted as indicating that density-dependent mortality is occurring during the PYSL stage.

Other analyses using time trends derived from different data sets support the conclusion that PCBs have not adversely affected reproductive success in Hudson River striped bass. Table V-15 of the DEIS (attached) contains 9 different indices of the abundance of different striped bass life stages. The commercial fishing monitoring (CFM) index is a measure of adult striped bass abundance derived from counts of striped bass caught as bycatch in the American shad fishery. Because this fishery is conducted within the Hudson during the spring spawning run of both species, the CFM index is a measure of spawning stock size. The PYSL index is a measure of the riverwide abundance of striped bass post yolk-sac larvae. Figure 3 plots the ratio of the PYSL index to the CFM index for the years for which both indices are available. This ratio is a measure of the number of larvae produced by each spawning female. If high concentrations of PCBs have in the past adversely affected striped bass reproduction, then this ratio should be lower for early years in the time series, when concentrations were high, than for later years, when concentrations were low. Figure 3 shows exactly the opposite. More PYSL were produced per spawner in 1980-1982 than in later years.

Reproductive effects of PCBs are believed to involve maternal deposition of PCBs in eggs, leading to alteration of embryolarval development and often to death at the time of yolk-sac absorption (Monosson 1999). In striped bass, yolk-sac absorption is completed at the end of the YSL stage. If PCBs were adversely affecting the embryolarval survival of Hudson River striped bass, then the fraction of YSL surviving to the PYSL stage should have been lower in the past, when PCB concentrations in the spawning females were higher, than at present, when PCB concentrations in the spawners are lower. Figure 4 shows the ratio of PYSL to YSL density. This index is a measure of the survival rate of striped bass between the YSL and PYSL stages. If PCBs were adversely affecting embryolarval survival in Hudson River striped bass, then this index should be low early in the time series, when PCB levels where higher, than later in the time series, when PCB concentrations had decreased. Figure 4 shows no such increase.

These figures represent preliminary analyses. However, the hypothesis that reproductive success in Hudson River striped bass, however measured, is related to PCB exposure is clearly inconsistent with the data. Because recruitment to the adult population is strongly density-dependent and unrelated to egg and larval production, remedial actions intended to improve reproductive success by decreasing the exposure of striped bass to PCBs are likely to have negligible benefits.

V. Conclusion

The Hudson River DEIS provides strong evidence that the fish community of the Lower Hudson River is healthy and is unaffected by past or present exposures to PCBs. Evidence is particularly strong in the case of striped bass, for which both direct measures of PCB exposure and multiple, independent estimates of abundance and reproductive success are available. This study should be given a high weight of evidence in ecological risk assessments performed to support remedial action decisions for the Hudson River.

VII. References

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TABLE 15

ESTIMATES OF RELATIVE AND ABSOLUTE ABUNDANCE OF DIFFERENT LIFE STAGES OF STRIPED BASS (STANDARD ERRORS, WHERE AVAILABLE, ARE GIVEN AFTER "/".)

	ADULT	EGG	YSL	PYSL				Age 1+	Age 2+
YEAR	CFM[a]	LRS[b]	LRS[b]	LRS[b]	BSS[c]	NYSBS[d]	WLS	SBMR[e]	SBMR[f]
1974		0.006/0.04	0.08/0.02	0.42/0.03	5.65/0.87				
1975		0.08/0.01	0.49/0.03	0.69/0.04	4.56/0.30				
1976		0.10/0.01	0.25/0.01	0.26/0.02	3.45/0.39	16.3			
1977		0.19/0.02	0.57/0.03	0.60/0.04	5.92/0.41	39.7/7.80			
1978		0.08/0.01	0.31/0.02	0.54/0.04	9.11/1.88	41.8/9.70			
1979		0.08/0.01	0.36/0.02	0.47/0.03	3.76/0.76	5.0/0.74			
1980	1.25	0.07/0.01	0.32/0.02	0.83/0.06	5.60/0.83	24.1/4.70			
1981	1.45	0.14/0.02	0.49/0.06	2.48/0.12	6.61/0.91	21.6/3.72			
1982	0.93	0.07/0.01	0.74/0.08	0.82/0.06	3.83/0.54	30.5/4.01			
1983	1.38	0.28/0.19	0.39/0.03	0.59/0.03	6.58/1.25	48.1/9.10			
1984	4.78	0.15/0.02	0.36/0.03	0.87/0.10	5.06/1.01	37.1/7.44		821/152	213/46
1985	9.97	0.05/0.00	0.20/0.02	0.40/0.03	1.07/0.24	3.9/0.48	0.00	342/74	104/26
1986	7.82	0.06/0.01	0.42/0.03	0.72/0.04	1.62/0.39	6.1/0.74	0.00	282/64	108/26
1987	7.28	0.06/0.01	1.45/0.08	1.70/0.07	12.82/2.24	60.7/12.88	0.26	1336/194	611/96
1988	11.39	0.02/0.01	0.71/0.07	1.48/0.14	4.91/0.61	52.3/3.75	2.46	1128/89	560/55
1989	15.99	0.59/0.27	2.94/0.28	4.54/0.34	5.66/0.90	41.9/4.72	1.58	908/153	339/63
1990	13.95	1.22/0.18	3.27/0.29	5.64/0.54	6.41/0.70	38.0/3.65	0.76	817/109	344/53
1991	13.06	0.36/0.06	2.85/0.26	8.00/0.77	5.03/1.07	6.9/0.67	3.70	1017/139	512/87
1992	24.93	0.87/0.15	3.88/0.22	6.38/0.42	3.68/0.58	17.3/1.28	3.70	895/246	252/78
1993	31.05	0.63/0.12	4.81/0.97	8.25/0.73	7.50/1.63	26.5/2.80	14.07	996/497	191/105
1994	35.29	9.83/1.87	3.68/0.53	8.45/0.80	5.88/1.06	28.5/2.63	1.98	1140/276	351/124
1995	17.09	6.27/1.01	1.31/0.20	3.94/0.39	6.04/0.90	27.4/3.72	1.23	971/174	
1996	36.53	4.50/0.65	12.74/1.80	15.40/1.46	1.25/0.33	14.7/1.59	34.76		
1997	10.01	1.03/0.19	1.80/0.30	4.89/0.74	9.18/0.83	50.3/5.39	0.26		

a Catch per 1000 yd^2 hr in fixed nets. Data from NYSDEC data file CFBASSCF.WK1.
b Sum of weighted average number per m^3 for 7 consecutive sampling weeks over period of peak abundance.
c Average number per 100' seine haul for sampling from mid-August to early October (weeks 33-40).
d Geometric mean number per 200' seine haul for 6 week sampling period.
e. Estimated number of age 1+ fish during second winter of life, in 1000s.
f. Applied to the year in which the cohort was spawned.

rpf/Network/HRDEIS/Edited-Sections/New-Tables-Sec-V/Tbl-15

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

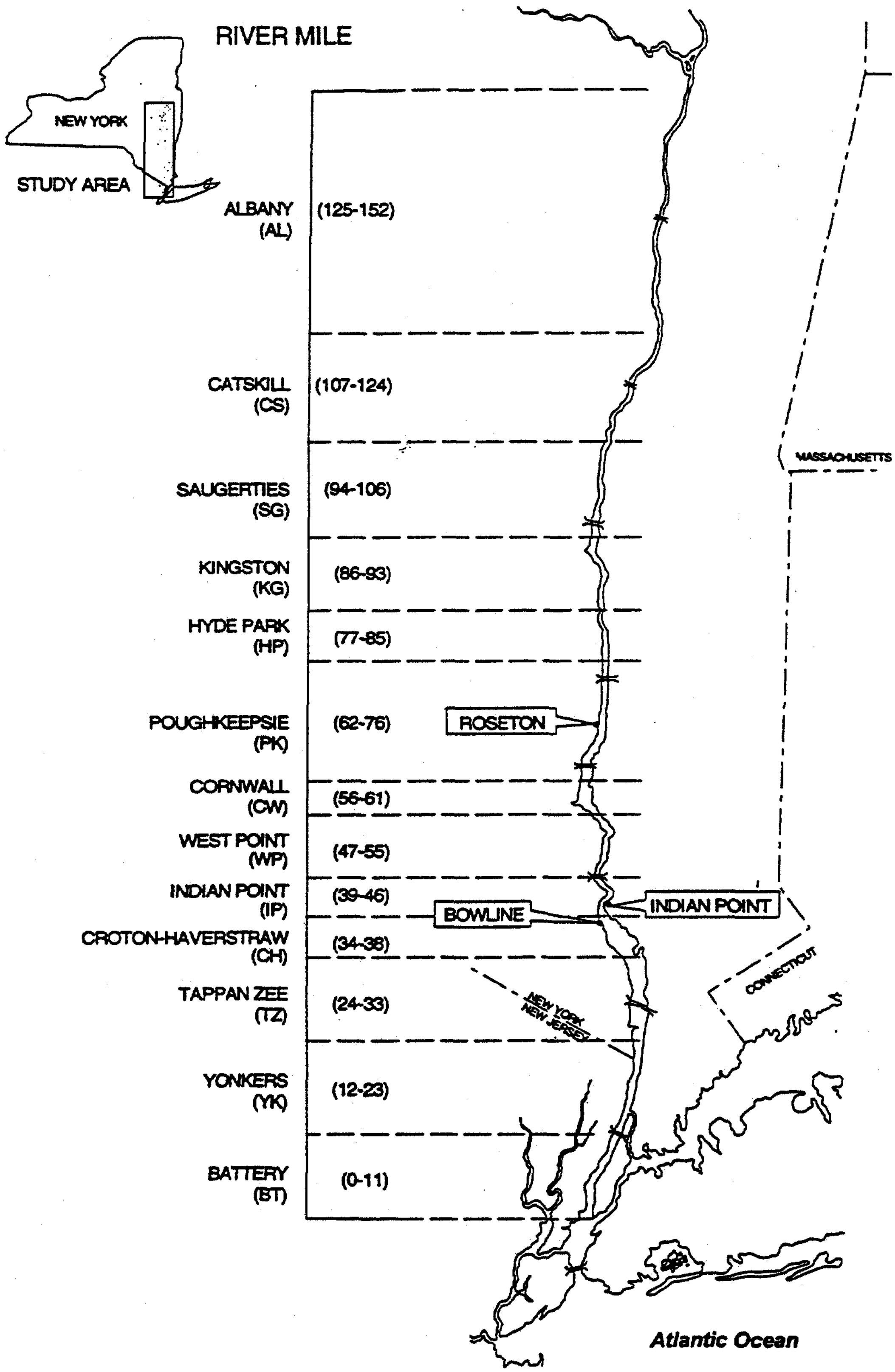

Figure 1. The lower Hudson River estuary.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

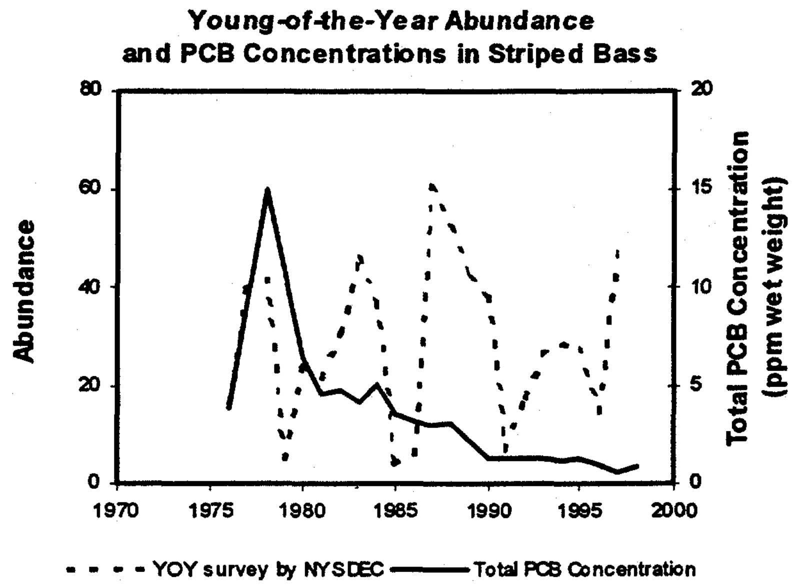

Figure 2. Relationship between the total PCB concentrations in adult female striped bass and the size of the year class produced by those females. PCB Concentrations are Average +/- 2SE for female striped bass (>1000g, April/May, fillet). Source: hudorg.dbf, NYSDEC database. Year-class abundance is estimated using the NYSDEC beach seine index, as reported in the DEIS. Figure prepared by QEA.

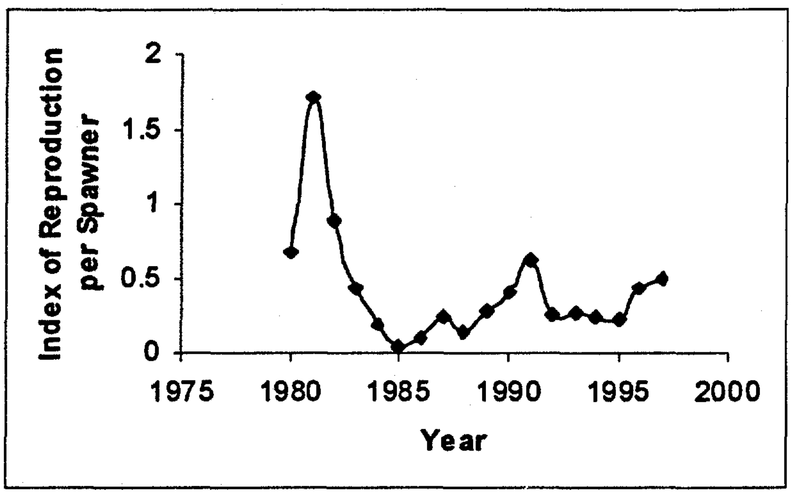

Figure 3. Index of striped bass reproduction per spawner. This index is calculated as the ratio of the density of post yolk-sac larvae measured in the utilities' Longitudinal River Survey Program (LRS) to the catch per haul of adult striped bass measured in the NYSDEC Commercial Fisheries Monitoring Program (CFM). Values from Table V-15 of the DEIS.

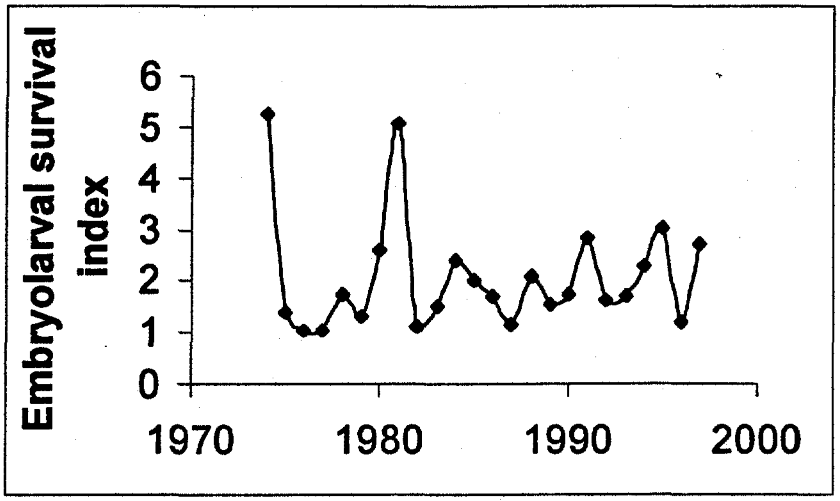

Figure 4. Index of embryolarval survival for Hudson River striped bass. This index is calculated as the ratio of the density of post yolk-sac larvae (PYSL) measured in the utilities' Longitudinal River Survey Program (LRS) to the density of yolk sac larvae (YSL) measured in the same survey. Values from Table V-15 of the DEIS.

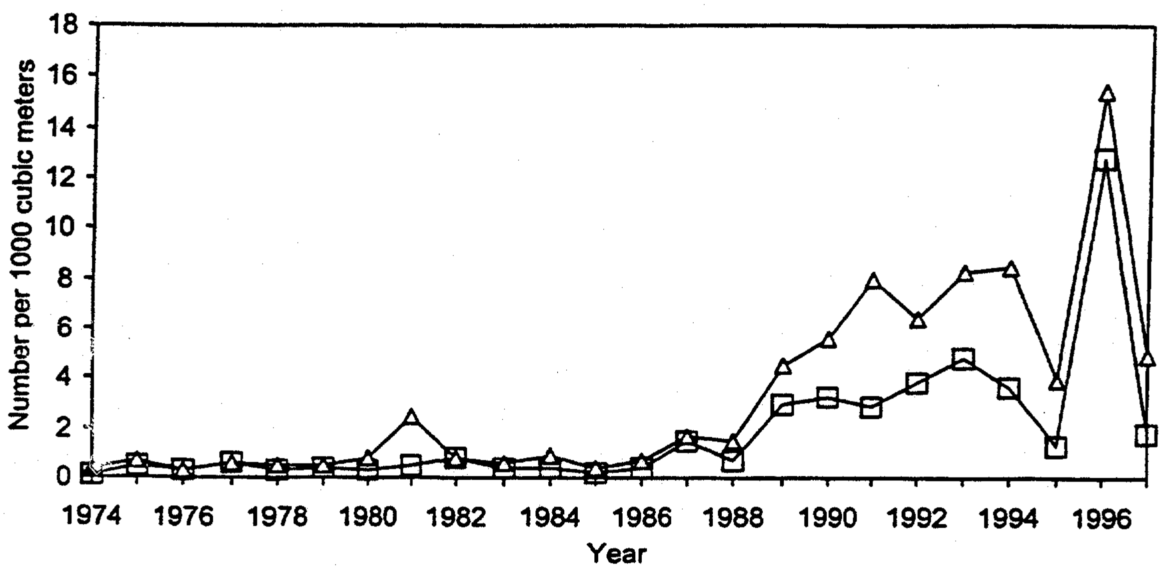

Figure V-34. Striped bass annual abundance indices for yolk-sac larvae (YSL) and post yolk-sac larvae (PYSL), 1974 - 1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

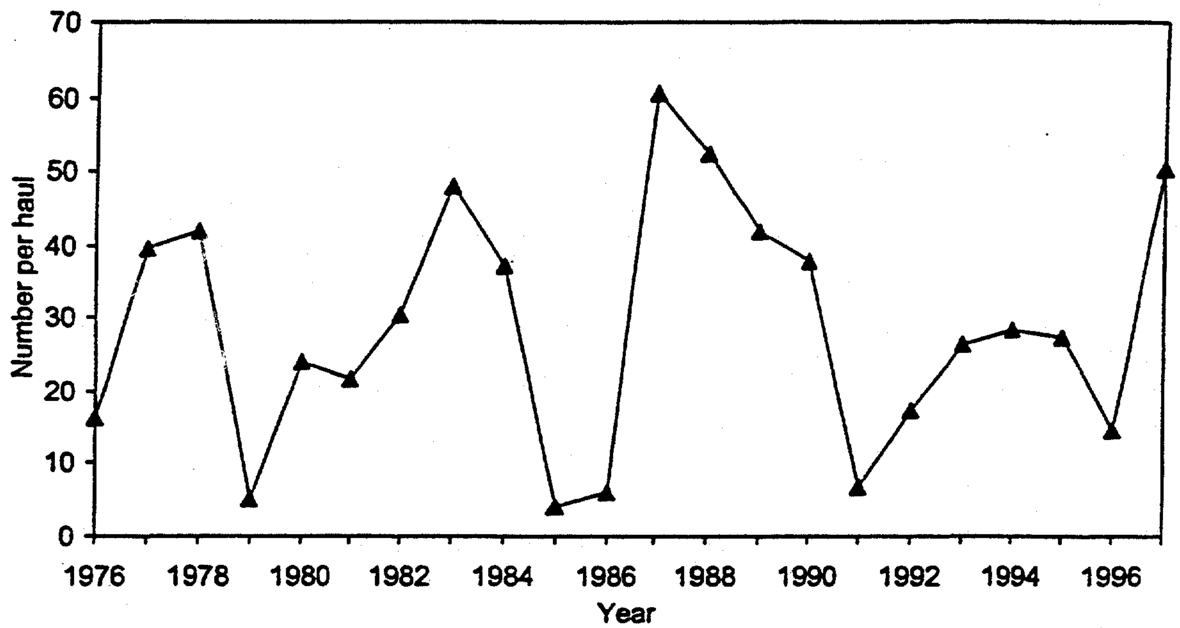

Figure V-35. Striped bass: annual abundance indices for young-of-the-year (YOY) generated from the NYSDEC Juvenile Striped Bass Survey (JSB), 1976-1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

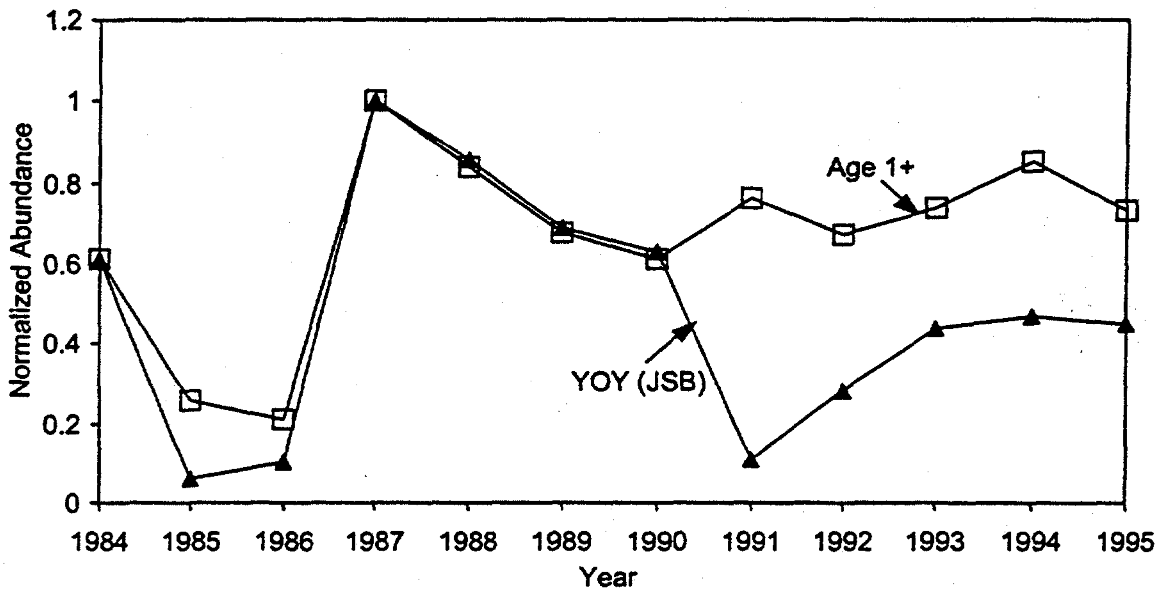

Figure V-36. Striped bass: normalized annual abundance indices for young-of-the-year (YOY) generated from the NYSDEC Juvenile Striped Bass Survey (JSB) and Age 1+, 1984-1995. The indices were normalized by dividing each annual index by the maximum value for that index.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

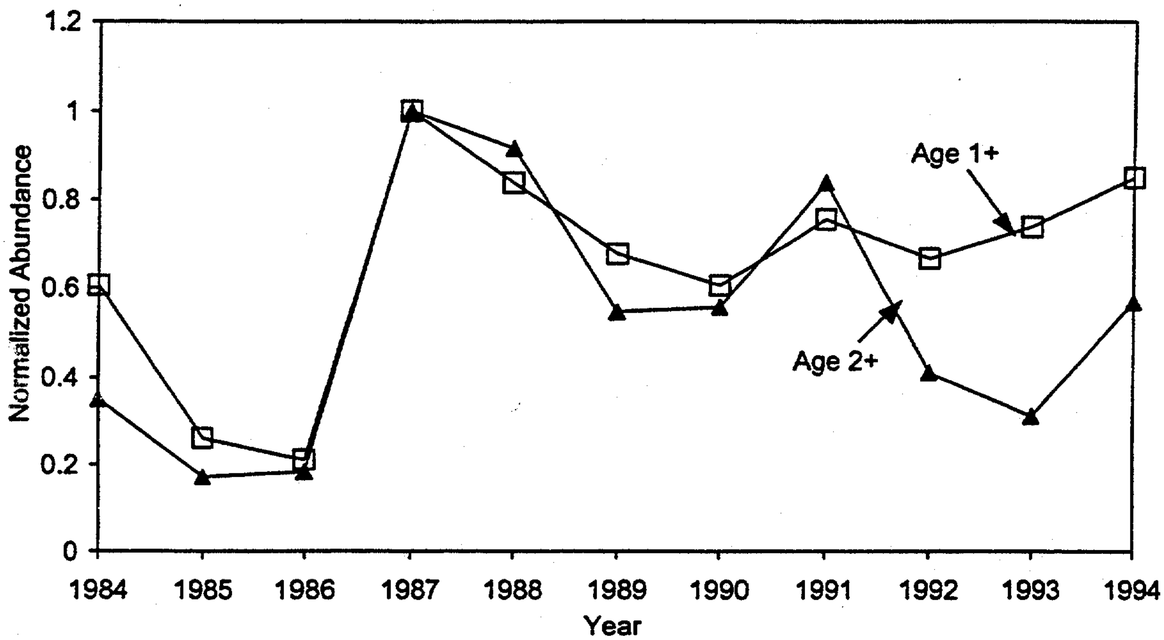

Figure V-37. Striped bass normalized annual abundance indices for ages 1+ and 2+, 1984 - 1995. The indices were normalized by dividing each annual index by the maximum value for that index.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

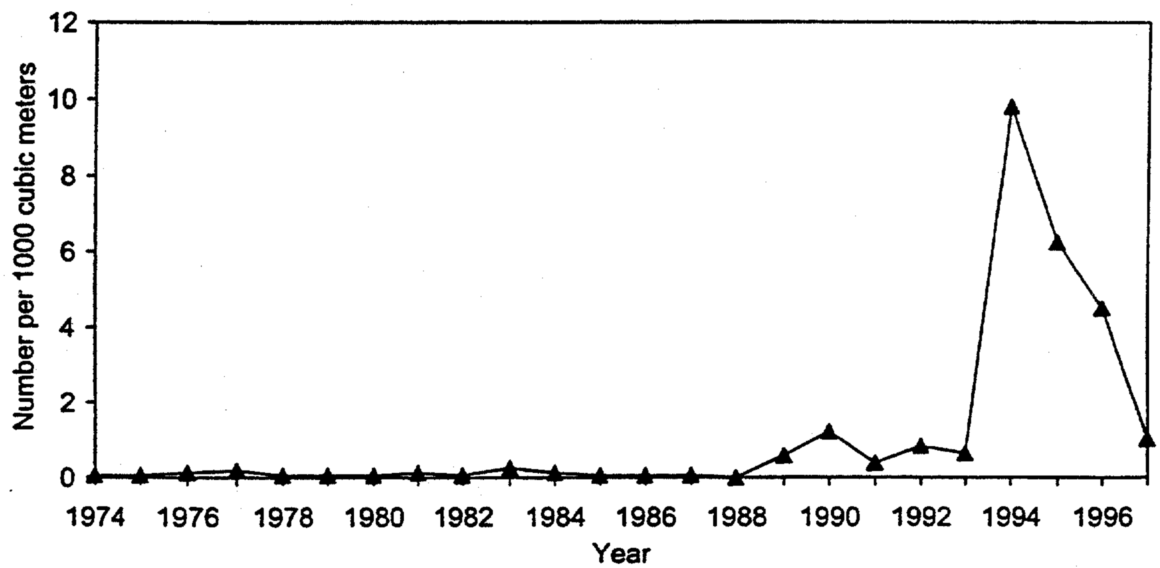

Figure V-38. Striped bass annual abundance indices for eggs, 1974 - 1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

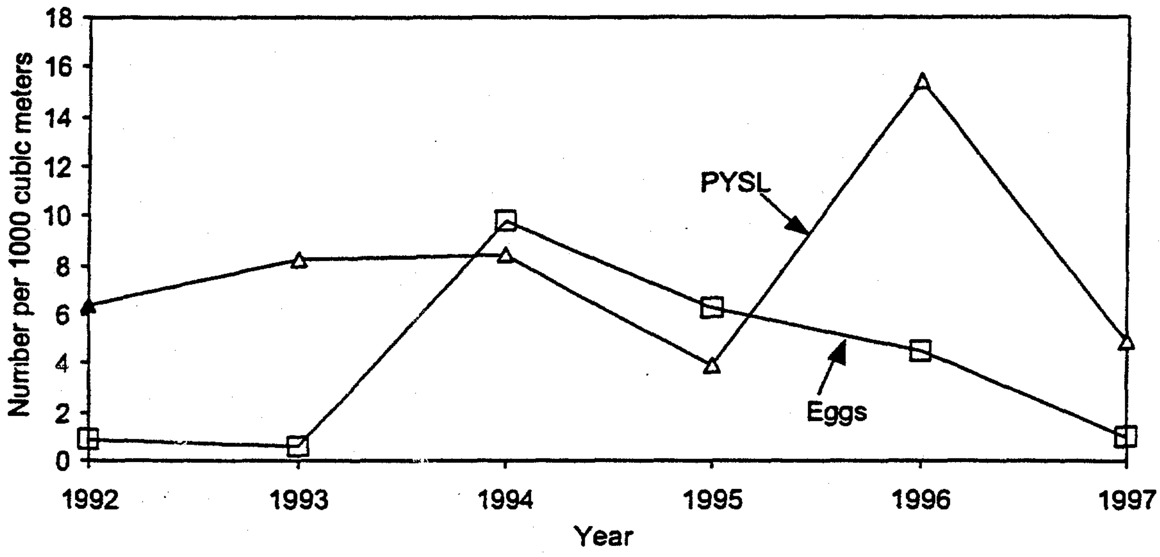

Figure V-39. Striped bass annual abundance indices for eggs and post yolk-sac larvae (PYSL), 1992 - 1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

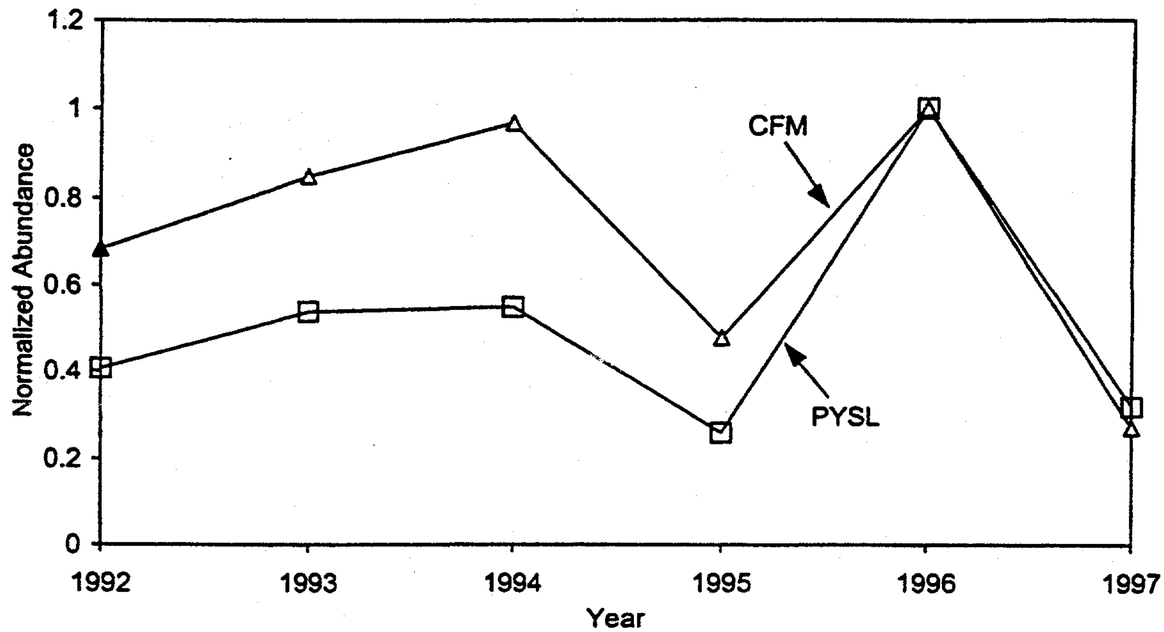

Figure V-40. Striped bass: normalized annual abundance indices for post yolk-sac larvae (PYSL) and the by-catch of striped bass in the commercial gill net fishery for American shad (CFM), 1992 - 1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

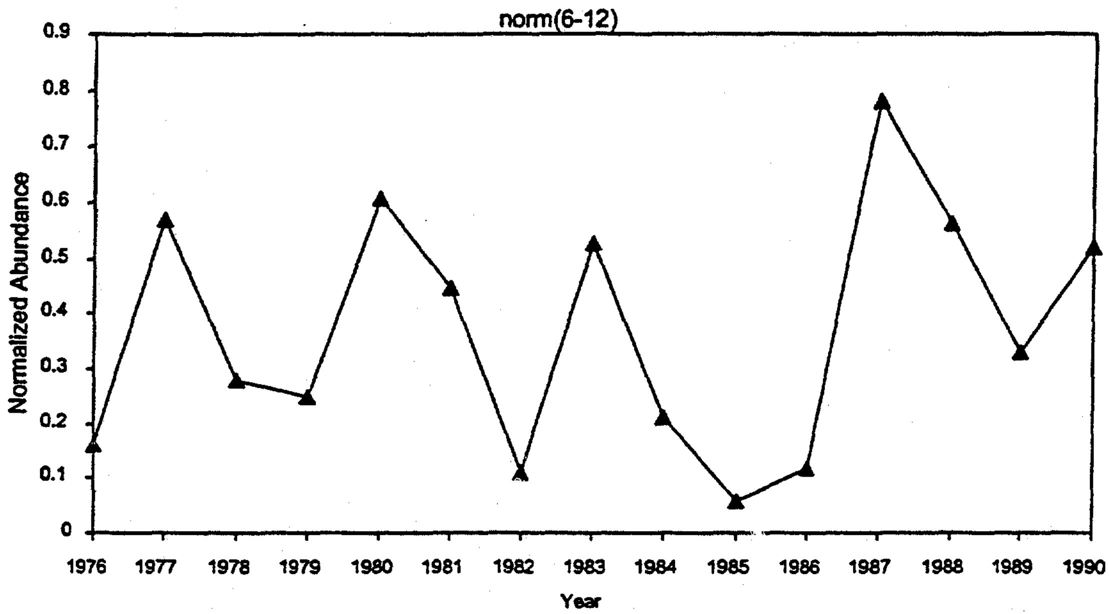

Figure V-41. Striped bass: annual abundance indices for young-of-the-year (YOY) from regions 6 through 12 in the Hudson River, 1974 through 1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

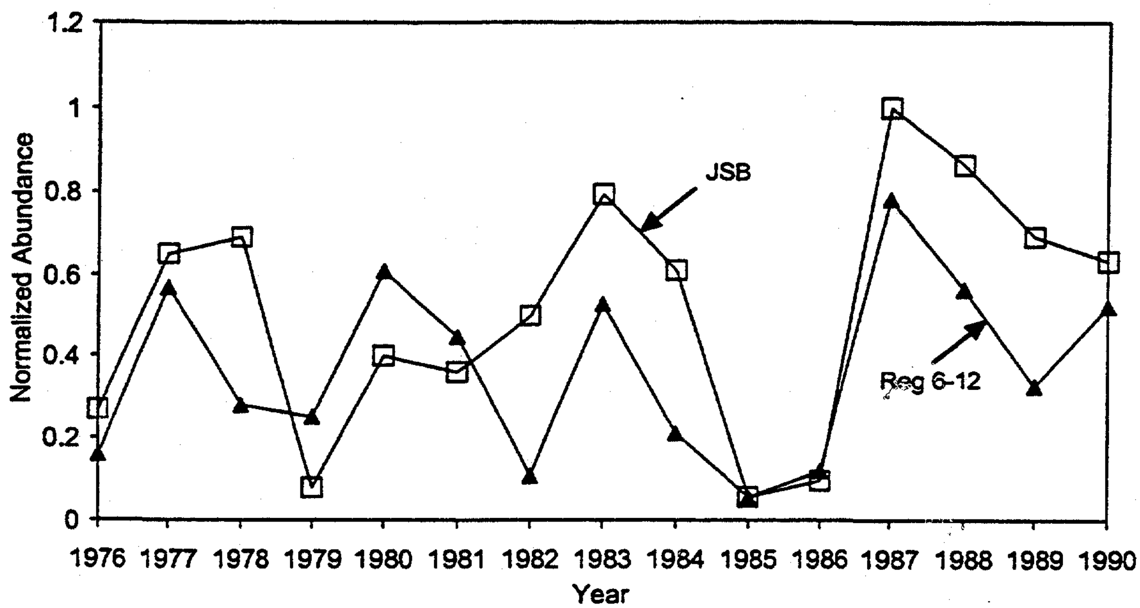

Figure V-42. Striped bass: normalized annual abundance indices for young-of-the-year (YOY) from the primary nursery area (JSB) and from outside of the primary nursing area (Reg. 6-12) during the period when emigration of PYSL and YOY from the river was low, 1976 - 1990. The indices were normalized by dividing each annual index by the maximum value for that index.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

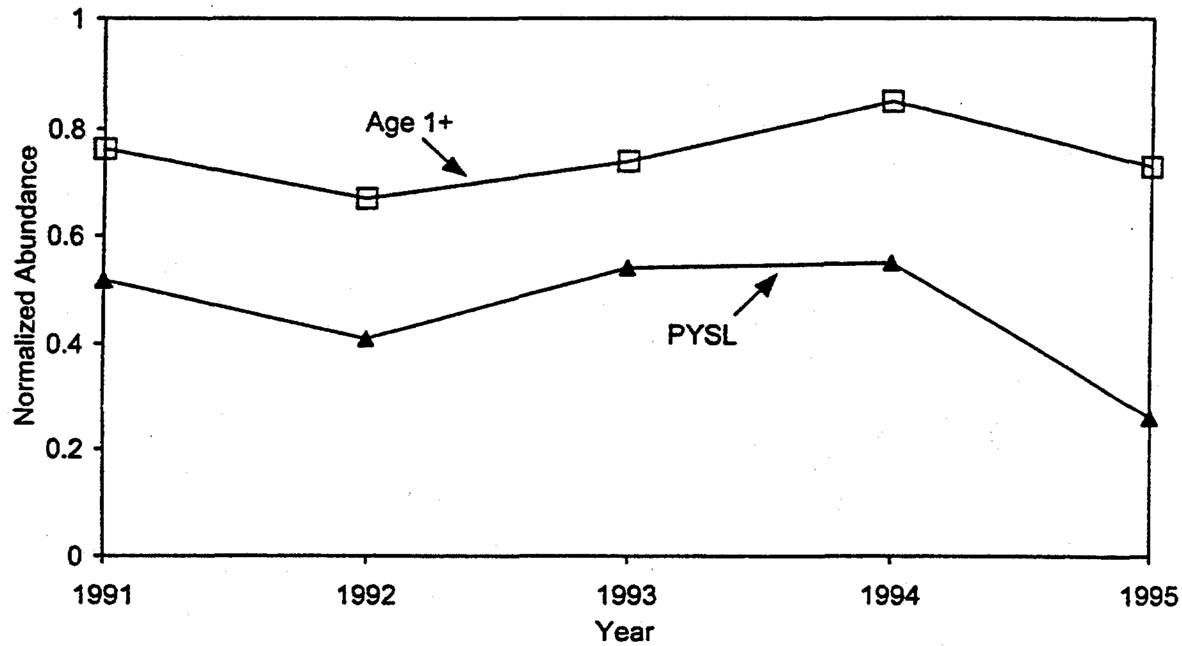

Figure V-43. Striped bass: normalized annual abundance indices for post yolk-sac larvae (PYSL) and age 1+ during the period when emigration of PYSL and YOY from the river was high, 1991 - 1995. The indices were normalized by dividing each annual index by the maximum value for that index.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

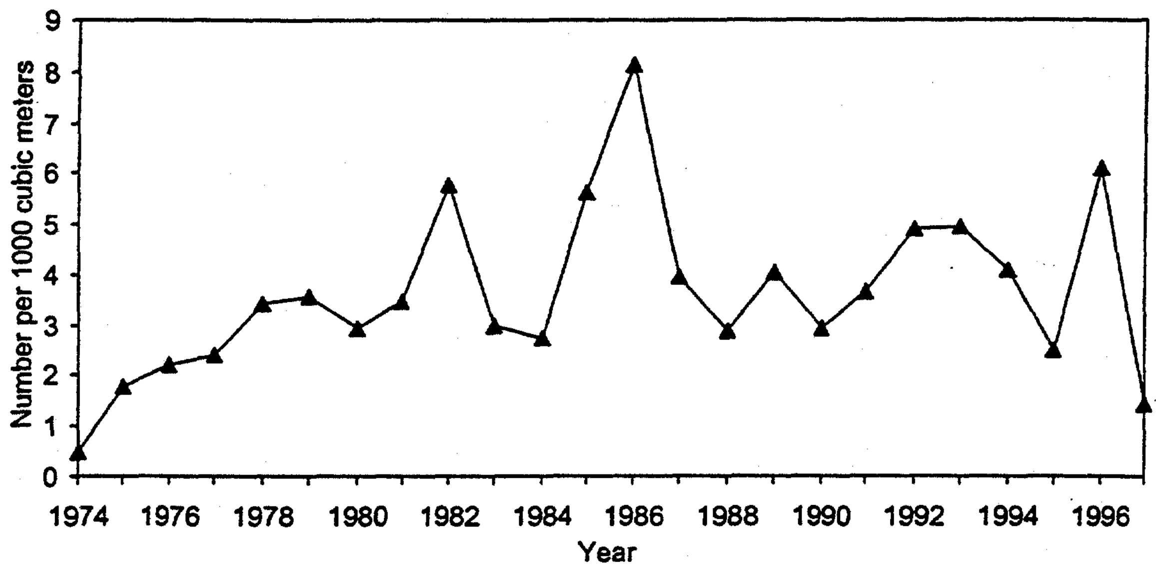

Figure V-48. White perch: annual abundance indices for post yolk-sac larvae (PYSL), 1974-1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

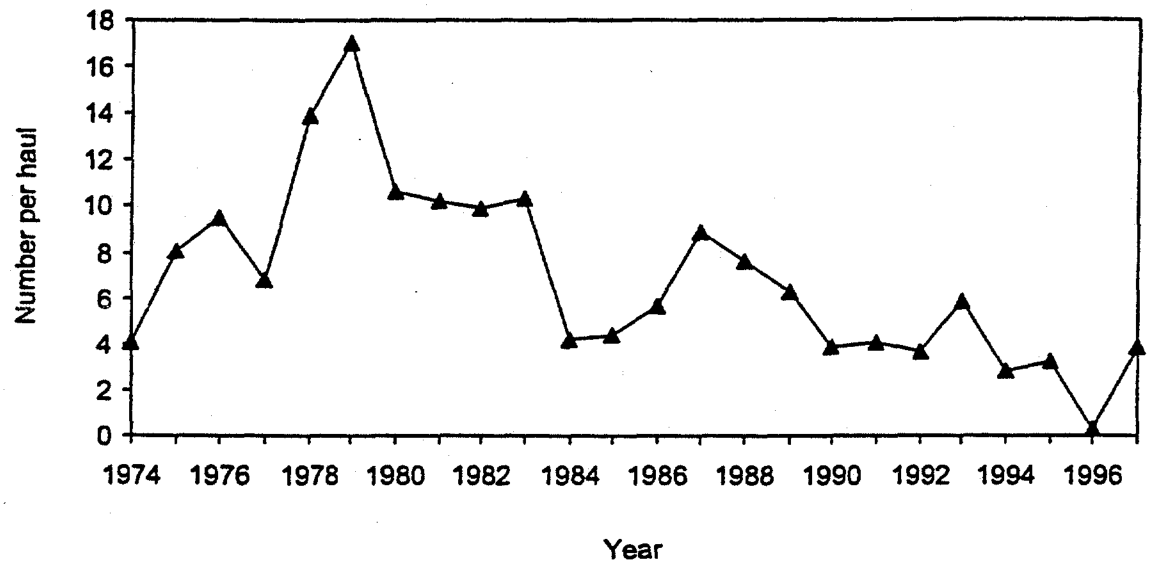

Figure V-49. White perch annual indices of abundance for young-of-the-year (YOY), 1974-1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

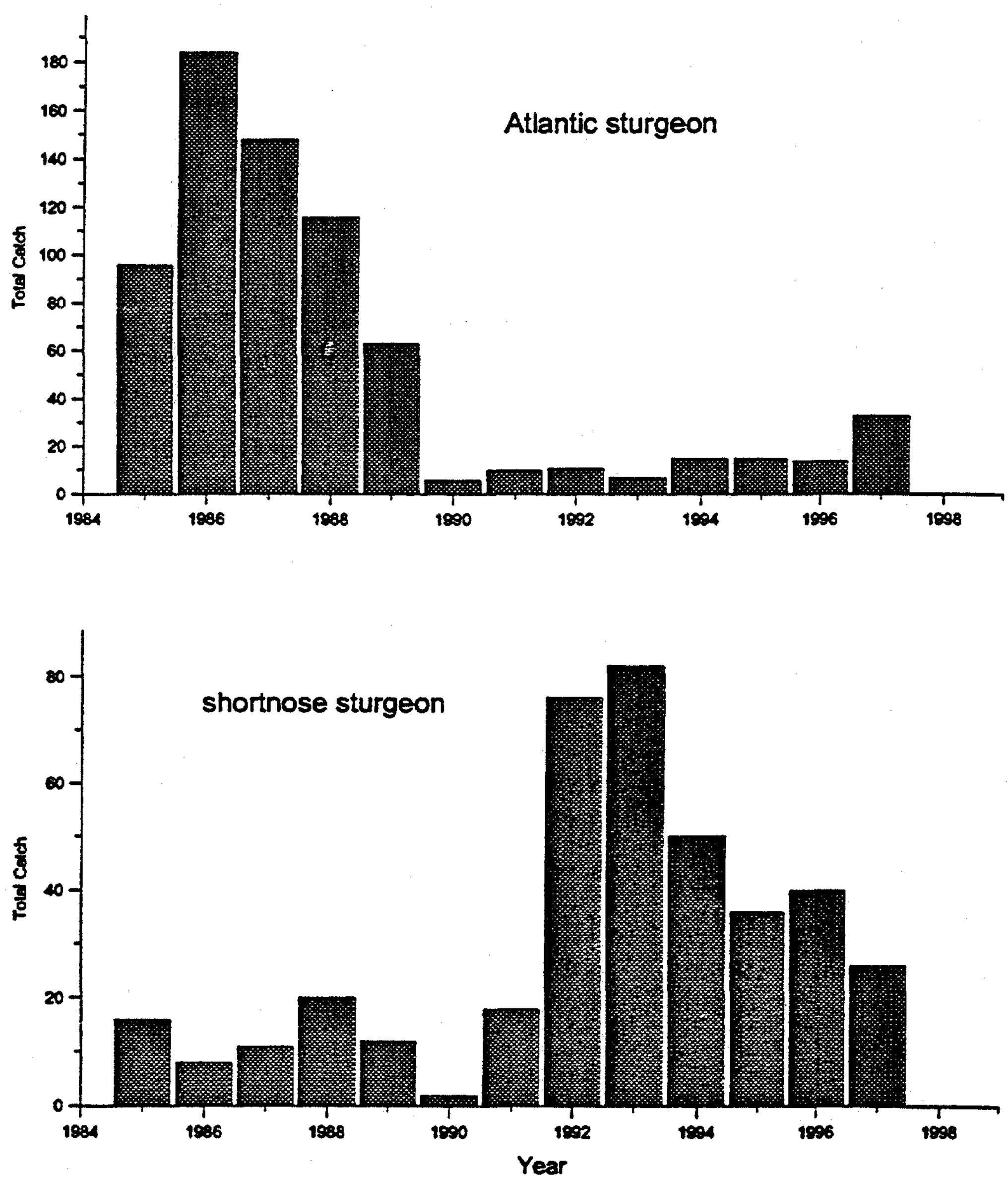

Figure V-86. Annual catch of Atlantic and Shortnose sturgeon yearling in beam trawls in the utilities' monitoring program.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

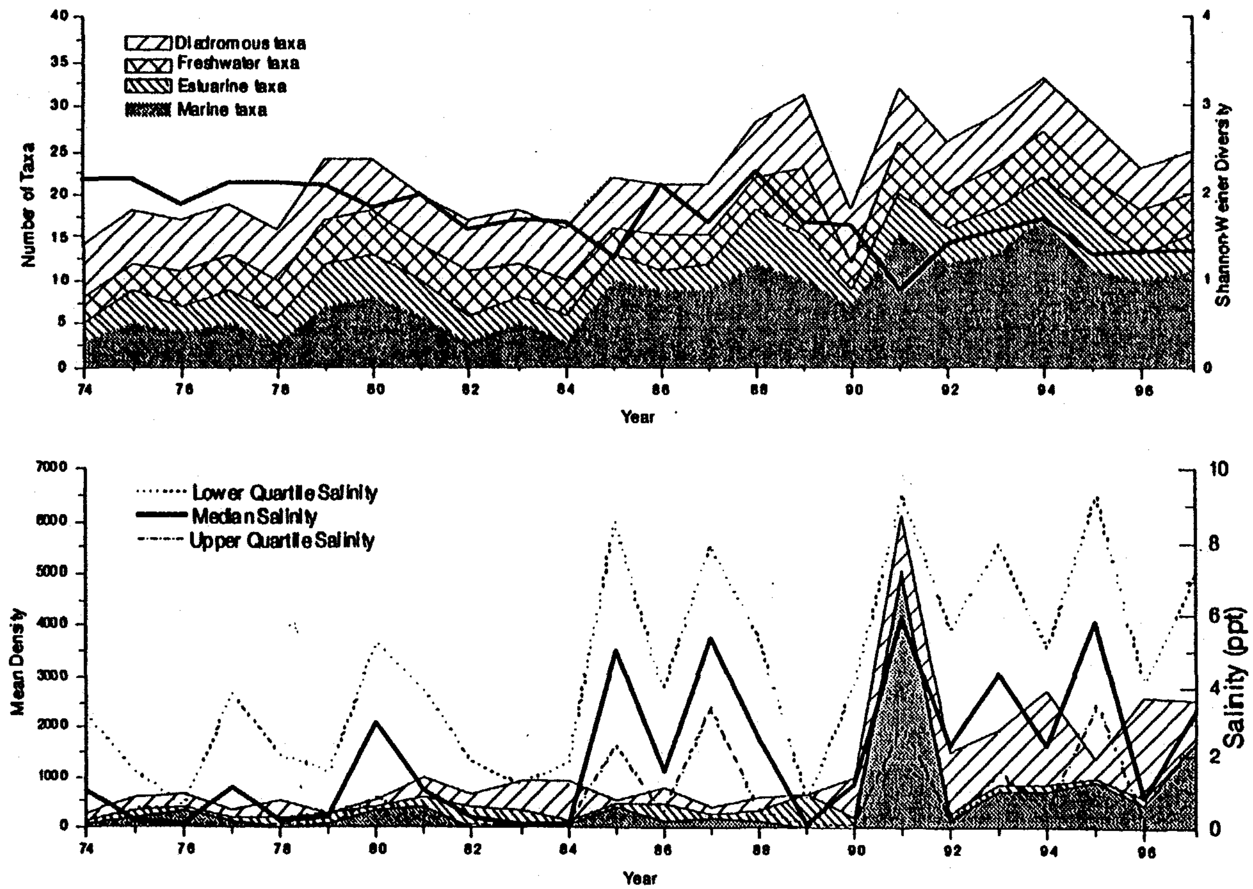

Figure V-118 Long-term trends in species richness and overall abundance of post yolk-sac larval fish in brackish areas of the Hudson River Estuary during May and June, 1974 – 1997.

10.3186

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

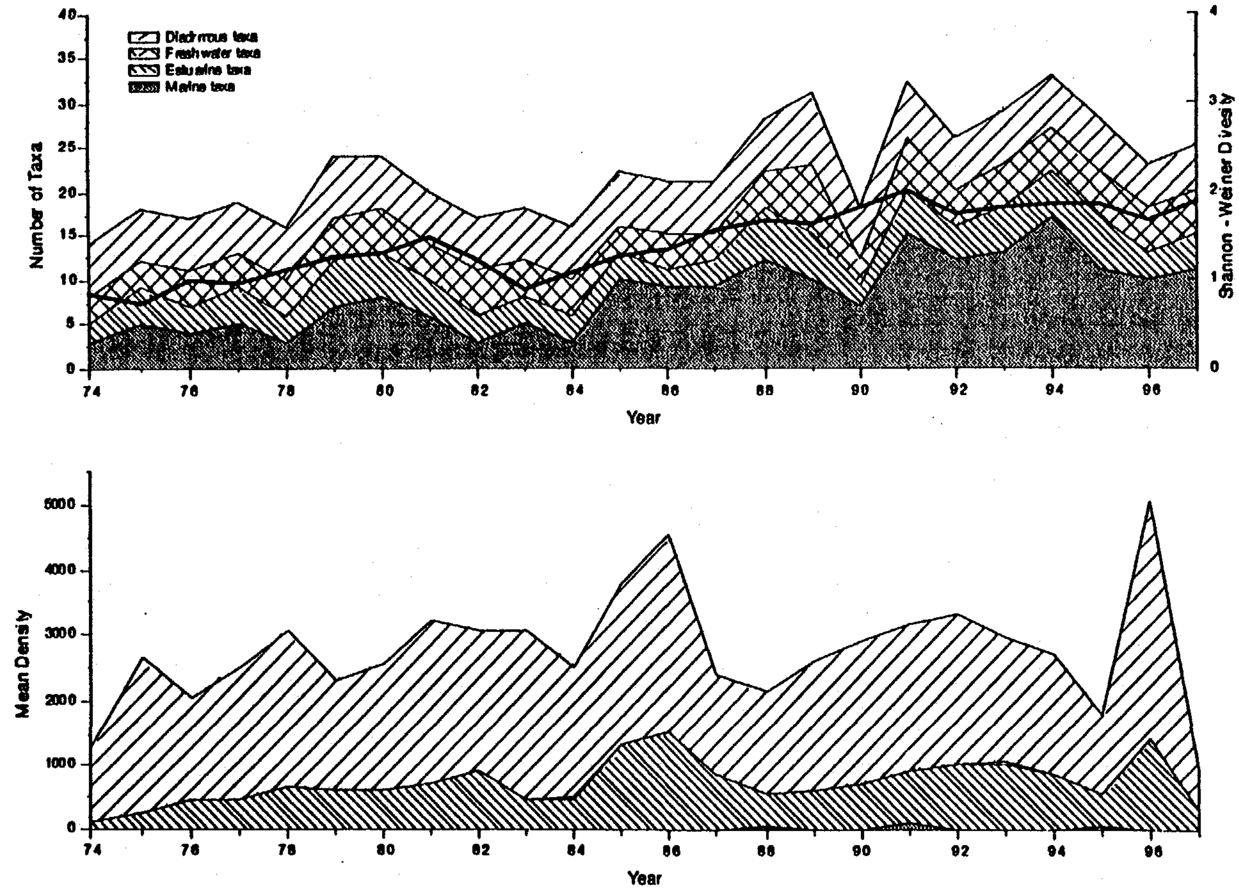

Figure V-119 Long-term trends in species richness and overall abundance of post yolk-sac larval fish in freshwater areas of the Hudson River Estuary during May and June, 1974 – 1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

10.3187

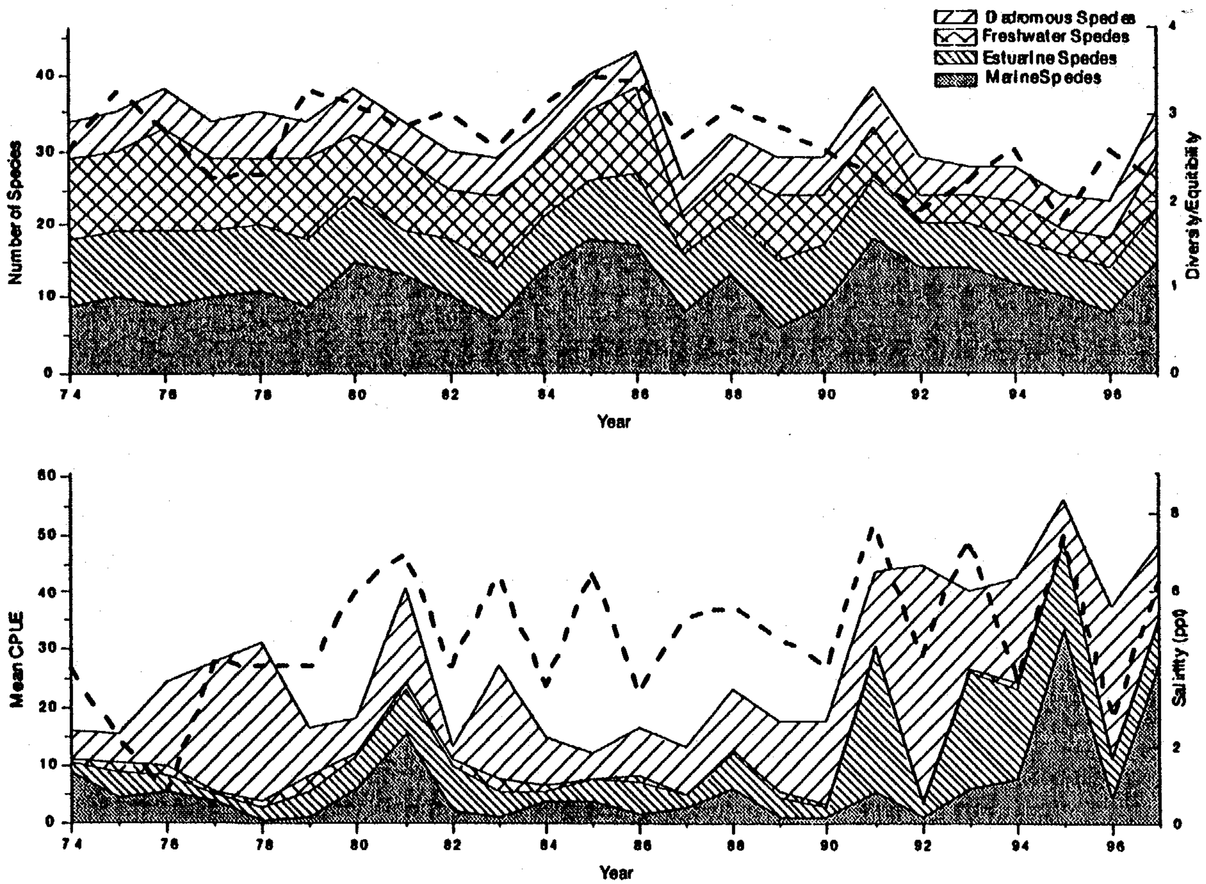

Figure V-126 Long-term trends in species richness and overall abundance of young-of-year fish in brackish littoral areas of the Hudson River Estuary during July and August, 1974 – 1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

10.3188

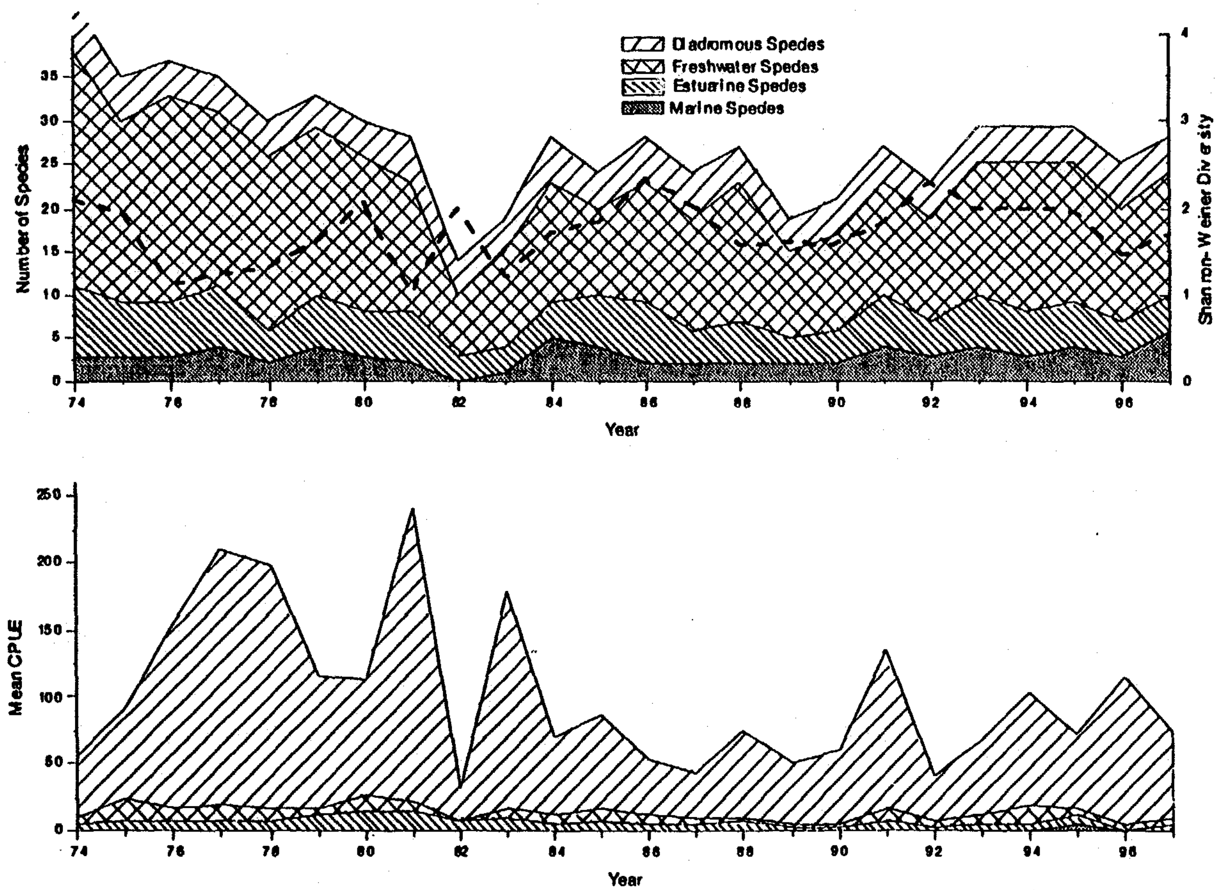

Figure V-127 Long-term trends in species richness and overall abundance of young-of-year fish in freshwater littoral areas of the Hudson River Estuary during July and August, 1974 – 1997.

Source: Central Hudson Gas & Electric Corp., Consolidated Edison Co. of New York, Inc., New York Power Authority, and Southern Energy New York. 1999.

10.3189