Section 7
Status of the Hudson River, New York American Shad Stock

Contributors:

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7.1 INTRODUCTION

While it is possible that European fishermen were fishing in North America and the Hudson Valley long before Columbus, the earliest known fishery in the Hudson River valley extends back to the 1600s when the Dutch first colonized the area. French Jesuits and Dutch and English explorers noted in their diaries and reports the fish that they saw. The Dutch recognized that ten commercially important fish were the same as those in Europe, including herring, eel, salmon, and cod. A few species that they didn't recognize were named the elft (American shad), twalift (striped bass), and dirtienen (either lipsfisk, wrasse, or tautog).

Archaeological digs along the Hudson in Native American middens indicates that the fishery resources in the river provided an important food source to native peoples. As the colonists took up residence in the valley, the Europeans learned about fish and fishing from the Native Americans. The Europeans brought their fishing skills and tools with them, using the same techniques as in Europe to fish for both diadromous and riverine species. Native Americans and Europeans used nets, weirs, and hooks to harvest fish (R. Daniels, pers. comm.).

Written records of the Hudson's shad fishing history only begin in the late 1800s. This record traces man's use of the stock and outlines cyclic episodes of overfishing. Overfishing, compounded by huge habitat losses, contributed to the long history of decline of the Hudson stock. Harvest in the late 1880s was high, followed by a 20-year period of either low landings, or no fishing (records are missing; Figure 7.1). This assumed low fishing period allowed the stock to rebuild to the high levels that sustained the fishery at high landings during WWII. In the years following WWII, the Hudson River American shad stock experienced a second collapse, faulted primarily to overfishing during the war and in the seven to ten year period that followed (Talbot 1954). Habitat destruction—continued filling of shallow water spawning habitat—and water quality problems associated with pollution—creating low oxygen blocks in major portions of the river (Albany and New York City)—further contributed to the decline.

In this section, we summarize the history and characteristics of the Hudson River stock of American shad, provide abundance trends, develop estimates of current Z, and make recommendations for stock recovery.

7.2 MANAGEMENT UNIT DEFINITION

The management unit of the Hudson River American shad stock consists of the Hudson River Estuary and the stock's range along the Atlantic coast. The in-river management area is defined as the area from the Verrazano Narrows in New York City to the Federal Dam at Troy, New York. The Hudson River Estuary is tidal its entire length of 246 km from the Battery (tip of Manhattan Island) in New York City to the Federal Dam at Troy (Figure 7.2). The Hudson stock of American shad ranges along the Atlantic coast from the Bay of Fundy, Canada and Gulf of Maine south to waters off Virginia and North Carolina (Dadswell *et al*. 1987).

7.3 REGULATORY HISTORY

During the 19th century, regulating the shad fishery within New York waters was the sole responsibility of the state. An anecdotal article in Harper's Weekly (1872) suggested a serious decline of the Hudson River American shad had occurred in the 1860s. Following this "collapse" (referred to parenthetically as no written records exist to document this event), the 1868 New York State legislature implemented fishing net restrictions, an escapement period, and a season to control fishing on the Hudson. However, according to U.S. Fish Commission Reports (1898), the prevailing intent of the state was not to interfere in any business, including fishing. These restrictions generally reflected the established fishing practices, setting the season to coincide with the period that shad were in the river. It is clear, that although "restrictions" were implemented, fishing largely continued unabated. Some variant of these 19th century rules still exist to the present.

After the mid-1800s "collapse," the New York Board of Fish Commissioners "engaged the services of Seth Green and set him to work to restock the Hudson River with shad, and save to the people, a food source which bade fair to be presently exhausted" in about 1872. So began New York's legacy of shad hatchery production in an attempt to restore stocks that were perceived to be exhausted. This "exhausted" condition is questionable. From 1880 through 1890, the Hudson stock produced the largest harvest in its recorded history. Anecdotal information suggests that harvest may have been even higher 20 to 30 years earlier. This suggests the spawning stock was large enough to quickly recover to produce two successive, historically high peaks in harvest within 30 years. The suggested "need" for hatchery supplementation was a reflection of the times. Most other East Coast shad stocks, primarily the Susquehanna and other Chesapeake stocks, were being severely depleted. Leaders of the U.S. Fish Commission used hatchery production rather than fishing curtailment as a solution. Shad stocking continued in New York for nearly 50 years, decreasing steadily as the focus of fish culture shifted to other warm-water and coldwater species. After 1920, mention of shad hatchery production no longer appeared in New York State Commission Reports.

Several gaps occur in the fishing record from the early 1900s until 1915—few references to active fisheries were found. Landing records from 1915 through the mid-1930s indicate shad fishing on the Hudson occurred at low levels. Studies conducted by the U.S. Bureau of Fisheries (U.S. Fish Commission 1939) indicated that:

> "although pollution and obstruction of river have doubtless contributed to the failure of reproduction…of many Atlantic coast shad streams, the decline in yield has not been limited to polluted or obstructed streams…some unpolluted rivers (Edisto) have been severely depleted yet a fine recovery has been observed in the polluted Hudson. This recovery is attributed to regulations limiting fishing to four nights a week and closing spawning areas to fishing."

This recovery did not last very long. During the years leading up to, during, and after WWII, regulations were greatly relaxed or abolished altogether. After nearly ten years of continuous, nearly unabated fishing, at near record levels, the Hudson stock experienced a collapse in the early 1950s from which it never recovered. Some fishing restrictions were put in place after this event but they had little effect on reducing fishing effort. The high fishing rate continued to remove fish faster than the stock could replace itself. In hindsight, the greatest downfall of management of the fishery was the disconnect that occurred between fishing and understanding the biology of the stock.

This disconnect between understanding fish stock dynamics and the long prevailing attitude of not interfering in, or restricting, the fishing industry has held firm since the 1800s for American shad. Perceived declines created the hatchery industry that employed commercial fishers to get their eggs. Yet most reports of fishery agencies from the late 1880s though the 1920s and 1930s stated that overfishing was a continuing problem greatly interfering with natural and artificial propagation.

It was late in this period that the Atlantic States Marine Fisheries Commission was created. In 1943, however, its objective was to assist in continued harvest of U.S. fishery resources to supply troops during WWII; its motto was “food will win the war” (ASMFC 1944). Regulatory management of the Atlantic coast shad stocks through ASMFC would wait 42 years until the adoption of an Interstate Fishery Management Plan for Shad and River Herring (FMP) in 1985. Although the FMP contained many strong recommendations, following the plan was a voluntary “gentlemen’s agreement.” This changed in 1993 with the passage of the Atlantic Coastal Fisheries Cooperative Management Act that mandated compliance by federal law. In 1998, Amendment 1 to the FMP included the first interstate regulation to close the mixed stock ocean fisheries for shad by 2005 (ASMFC 1999). The closure took a stepped approach over five years that allowed further erosion of remaining shad stocks. This slow action proved to be too little too late for the Hudson River American shad stock.

Regulations pertaining to the commercial and recreational take of American shad in New York waters are listed in Appendix I.

7.4 ASSESSMENT HISTORY

During the 1930s, the U.S. Bureau of Fisheries conducted a variety of studies on Atlantic shad stocks, primarily tracking landings to assess stock condition (U.S. Fish Commission 1939); however, few study details can be found in Commission reports. The reports recognized that exploitation rates were very high in systems experiencing declines (Maryland, Virginia, and South Carolina stocks); overfishing was the primary reason for decline and not pollution or major obstructions. The Hudson stock was lightly fished during this period of other stock declines, “contrary to the general trend” (Talbot 1954). Annual harvest from the Hudson exceeded 1,100,000 kg between 1936 until 1948, peaking at 1,758,000 kg in 1944 (Figure 7.1). Fishing continued to erode the stock following WWII.

In 1949, the Anadromous Fish Act supported initiation of the Shad Project, a program funded to determine the underlying causes of shad stock declines along the Atlantic coast. Talbot (1954) conducted the sampling program in the Hudson in 1950 and 1951. He determined that the primary cause of the decline was overfishing due to the lack of and lapse of fishing restrictions during World War II and the years following. Mark-recapture studies showed exploitation to be 0.66 and 0.46.

The first ASMFC assessment of the Hudson stock occurred in 1988 (Gibson *et al*. 1988). This assessment used a Shepherd stock recruitment model to estimate maximum sustained yield (MSY) and maximum sustainable fishing rates (F_{msy}) with inputs of long-term commercial catch-effort, age composition, and mortality data. It is not clear what natural mortality rate was used. Model fit was poor (r^2=0.35), faulted to primarily significant measurement errors of the stock and recruitment estimates or other unknown or poorly understood factors (Gibson *et al*. 1988). Exploitation rate (µ) was estimated at 0.31 (F=0.37), which was below the value of µMSY of 0.45, recommended in the 1988 report. For a historical perspective, Gibson *et al*. (1988) adjusted Talbot’s rates in the 1950s because of catchability issues associated with Talbot’s use of Peterson disc tags in his mark-recapture study. The adjusted rates were µ of 0.38 and 0.27 for 1950 and 1951, well below the recommended 1988 level. Although the adjusted 1950 µ of 0.38, the adjusted 1951 µ of 0.27, and 1988 µ of 0.31 were well below the recommended µMSY of 0.45, stock levels in the Hudson continued to decline. These changes suggest that the recommended µ values were too high for stock stability.

Walters (1995) used growth parameters, natural survival rate, and proportion of variation in relative abundance indices due to measurement error to compute maximum likelihood estimates of the recruitment anomaly sequence for several stocks, including American shad of the Hudson River. He concluded that the American shad stock had been subject to massive recruitment overfishing.

In 1997, the Hudson River electric generating companies hired consultants to assess the Hudson's American shad stock status as part of their environmental impact statement on power plant operation effects on fishes of the Hudson River (CGH&E 1999). The initial assessment looked at 17 years of data from 1980 to 1997. During an intensive review, this time series was expanded to encompass all available data for the Hudson since 1915. Deriso *et al*. (2000) estimated fishing morality and calculated equilibrium yield exploring several hypotheses regarding the spawner-recruit (S-R) relationship. Natural mortality of 0.3 was used, based on maximum age (13) observed in the Hudson stock. A Beverton-Holt S-R was used with assumptions of low, mid, and high levels of density dependence occurring in the stock. Equilibrium calculation showed that the stock was fully to over-exploited, unless one assumed high density dependence. Given that the Hudson shad stock was approaching an all-time historic low stock size, the high density dependence hypothesis was rejected.

ASMFC (1998a) completed the most recent assessment, focusing only on the period 1980 to 1997, a time window encompassing a period of depressed stock conditions when stock abundance was at historically low levels (see Figure 7.1). This assessment generated debate on data inputs, methods, and model assumptions. At the forefront of the debate was the appropriate level of natural mortality (M) to use for American shad. The approach used a Thompson-Bell yield-per-recruit to calculate a $F_{30,}$ which was defined as the overfishing rate. This was compared to an estimate of "current" F.

Although stock-specific data were available for the Hudson, all Hudson yield model inputs in Gibson *et al*. (1988) were based on a variant of the Connecticut River shad stock, which exhibit different biological stock (growth) characteristics than the Hudson shad stock (see Section 7.10). The greatest debate over inputs occurred on the value of M. For the Hudson stock, M was 0.3 for ages one to three and 0.6 for ages four to ten, although the observed maximum age for Hudson shad was 13. These were "best estimates" based on what was observed in the Connecticut River shad stock. Current F was estimated from an exploitation rate calculated from harvest estimates (combination of in-river plus estimated ocean harvest, both adjusted for underreporting) divided by an estimated population size (scaled from the estimated population size of the Connecticut River shad stock using data from the 1950s). Current F was calculated at 0.33, the overfishing definition of F_{30} was 0.39. The conclusion was that the Hudson shad stock was not over-fished, but fully exploited.

The New York State Department of Environmental Conservation (NYSDEC) disagreed with the methods used and we (Hattala and Kahnle) wrote a minority opinion objecting to the ASMFC conclusions because we felt that data inputs and methodology over-estimated the overfishing definition and underestimated the current fishing rate. To illustrate our response, we used the same methods but with inputs that were based on Hudson River data. The major difference was reliance on a value of M based on maximum observed age. We also performed a sensitivity analyses on selection of a natural mortality rate (M). Model results were very sensitive to M. For age invariant M, F_{30} increased with increasing M. F_{30} was higher where M increased with age than when M declined with age. We recommend use of either an age invariant M of 0.3 or an age specific M that decreased with age. Our F_{30} estimates equaled 0.27 based on a constant M of 0.3 and 0.25 based on age specific M. We based current F estimates on F=Z-M, where Z resulted form catch curve analysis of annual age structure minus M of 0.3. Using these definitions of overfishing compared to current F, the Hudson shad stock has been over-fished since the mid-1980s.

The issues of discord between these assessment approaches were never resolved. The cause of decline in the Hudson American shad stock, as well as other stocks, remains in debate.

7.5 STOCK-SPECIFIC LIFE HISTORY

General life history characteristics of American shad are summarized in Section 1. Hudson River American shad are spring spawners, entering the estuary early April through the end of May. Adult shad are present in the river for a period of approximately six to ten weeks over the entire spawning season, dependent on water temperature (Hattala *et al*. 1998b). Once spawning ends, most shad quickly return to ocean waters. Tracking of radio and sonic tagged shad in 1995 and 1996 indicated that post-spawning mortality for Hudson shad was low (Whalon 1999). Once back in ocean waters, Hudson shad continue their annual migration north along the coast with the rest of the mixed stock assemblage (see Section 1).

One interesting observation is that over the course of the past 130 years, the spawning period for Hudson River American shad has greatly shortened. In the 1870s, fish first appeared in March, spawning peaked in early June, and continued into July (Harpers Weekly 1872). In the 1950s, Talbot (1954) remarked that spawning continued until the end of June. Over the past 20 years, spawning has occurred a few weeks in May (ASA 2006).

7.5.1 Growth

New York State DEC has collected data on length, weight, and age annually since 1980 from the commercial catch, and annually since 1985 from a fishery-independent survey (see Sections 7.9 and 7.10). The fishery focuses on pre-spawn mature fish. The fishery-independent survey samples fish that have escaped the fishery.

Length and weight-at-age are generally greater for females than males. Fish of both sexes tend to be larger in fishery-dependent samples than in fishery-independent samples (post commercial harvest). Von Bertalanffy curves for total length-at-age and Gompertz curves for weight-at-age were calculated for all fish (Table 7.1; Figure 7.3).

7.5.2 Reproduction

Spawning begins in the Hudson Estuary in late April when water temperatures reach 15°C. It continues through the month of May and generally ceases by early June. Shad spawn in fresh water, over shallow-water shoals that occur in the upper half of the Hudson (rkm 142 to 240).

Post-spawning mortality for Hudson shad appears to be low (Whalon 1999). Extensive radio and sonic tracking of American shad was conducted in the Hudson River Estuary in 1995 and 1996 (Whalon 1999). Over the two years of the study, 110 marked fish, captured during immigration to the Hudson, were released over several weeks during the spawning period. Shad were tracked over periods of 15 to 40 days after release through the entire spawning season. Field efforts ceased when no more fish could be located. Five fish apparently died (repeatedly found in one location) within 12 to 18 hours of release. Mortalities were assumed to be related to tagging stress from the sonic or radio-gullet applied tag. In 1995, approximately 49 percent of the 55 radio-marked shad released were found and followed throughout the spawning season. Results in 1996 improved when 77% of radio-marked fish (30 released) and 84 % of sonic-marked fish (23 released) were found and tracked throughout the spawning period. The improved 1996 detection rate resulted from more intensive air and boat surveys. The percent of fish listed above for fish tracked during spawning season does not include suspected dead fish. For the live, tracked fish, all left the river after spawning, suggesting a very low rate of in-river post-spawn mortality for the Hudson stock. Residence time for adult shad in the Hudson following tagging was found to be approximately 19.8 days.

Percent of repeat spawning in the Hudson River stock varies among years. Female shad exhibited repeat spawning rates as high as 73% with up to eight spawning marks for commercially caught fish and 69% with seven spawning marks observed in fishery-independent samples. Values as low as 42% and 28% were observed for females in commercial data and the fishery-independent samples in recent years (see Sections 7.8 and 7.9).

7.5.3 Maturity Schedule

Deriso *et al*. (2000) estimated the maturity schedule using a likelihood function on age and repeat spawn data of Hudson River shad (Table 7.1). This approximates the same results of calculating age-at-first spawn (age minus the number of repeat marks) from all age data, to arrive at an approximation of percent at age-at-first spawn.

7.5.4 Fecundity

The first estimate of fecundity for Hudson River shad was from samples taken in the 1950s (Lehman 1953) after the stock had collapsed following WWII (Table 7.1). Lehman recognized that “shad have a multi-spawning or continuous period of spawn, rather than a single spawning act.” He concluded that the fecundity estimates measured only a portion of the total egg production of a female in any given year (sample size was small, 22 fish; Figure 7.4).

Recently, Piper (2003) completed a study of fecundity of Hudson River American shad. Samples collected in 2000 and 2001 showed a wide range of variability at age within year and differences among years (Figure 7.4). Overall, the fish collected in 2000 and 2001 had higher fecundity estimates than those collected in 1951. It is not clear why the results of these studies are so different. Sample size may have contributed to the differences. Few samples were collected in 1951, yet fecundity was found to be directly proportional to age (r^2=0.96), length and weight of the fish. The more recent sample of 105 fish taken in 2000 and 2001 was larger. The relationship between fecundity and age was positive, but not as highly correlated to age (r^2=0.54), as the 1951 data. Since the studies had different results, we felt it was prudent to use both sets of estimates in the biomass-per-recruit model and then to compare the results (see Section 1).

7.6 HABITAT DESCRIPTION

7.6.1 Spawning and Nursery Habitat

The sandy, gravelly shoals and shallow water areas in the upper half of the Hudson River Estuary, from Kingston (km 144) to Troy (km 256; Figure 7.2) are used as spawning habitat. The nursery area extends south from here to Newburgh Bay (km 90), encompassing the freshwater portion of the Estuary. The estuary is tidal to Troy.

7.6.2 Habitat Water Quality

The Hudson has a very long history of abuse by pollution. New York City Department of Environmental Protection recognized pollution, primarily sewage, as a growing problem as early as 1909. By the 1930s, over one billion gallons of untreated sewage were dumped in the harbor every day. (NYCDEP home2.nyc.gov).

New York City was not the only source of sewage; most major towns and cities along the Hudson added their share. It was so prevalent that the Hudson was often referred to as an open sewer. Biological demand created by the sewage created oxygen blocks that occurred seasonally (generally mid to late summer) in some sections of the river. One of the best-known blocks occurred near Albany in the northern section of shad spawning and nursery habitat from 1960 through the 1970s. This block often developed in late spring and remained through the summer months, essentially cutting off the upper 25 miles of the Hudson for use as spawning and nursery habitat. A second oxygen block occurred in the lower river in the vicinity of New York City in late summer. This block could potentially have affected emigrating age-0 shad. This summer oxygen-restricted area occurred for decades until 1989 when a major improvement to a sewage treatment plant in upper Manhattan came online. It took decades, but water quality in general has greatly improved in both areas following the implementation of the Clean Water Act in the 1970s reduced sewage loading to the river.

There are other persistent chemical pollutants in the Hudson River. The best-known and most pervasive chemical contamination is from polychlorinated biphenyl (PCB). The major source of the chemical is approximately 40 miles north of the Troy Dam, where General Electric discharged up to 1.3 million pounds of PCB's into the river for over 25 years beginning in the 1940s. The EPA declared 200 miles of the Hudson below Hudson Falls and Fort Edward, New York, a Superfund site in the 1970s. The removal of the contaminated sediments via a controversial dredging clean-up project has yet to begin.

Because of the PCB contamination of fish flesh, the NYSDEC, under recommendation from the New York Department of Health, closed many of the Hudson's fisheries in 1976. American shad remain one of the few species that are allowed to be taken commercially as they do not accumulate the contaminant while in the river.

A whole host of other environmental contaminants have been found in the Hudson and its fish (PAHs, some metals, etc.), but are minor in comparison to the level of PCBs. Research is ongoing to try to determine effects of chemicals on fish.

7.6.3 Habitat Loss

Much spawning and nursery habitat was lost in the upper half of the tidal Hudson because of dredge and fill operations to maintain the river's shipping channel. Most of this loss occurred between the turn of the 19th century (NYDOS 1990) and the first half of the 20th century. Preliminary estimates are that approximately 57 percent of the shallow water habitat (1,821 hectares or 4,500 acres) north of Hudson (km 190) was lost to filling (Miller and Ladd 2004). Work is in progress to map the entire bottom of the Hudson River. Data from this project will be used to quantify existing spawning and nursery habitat.

Very little or no habitat has been lost due to dam construction. The first major dam was constructed in 1826 at rkm 256 in Troy, New York. Prior to the dam, the first natural barrier occurred at Glens Falls, 32 km above the Troy Dam. The construction of both dams is not believed to have reduced spawning or nursery habitat.

7.6.4 Habitat Alteration

The introduction of zebra mussels in the Hudson in 1991, and their subsequent explosive growth in the river, quickly caused pervasive changes in the phytoplankton (80% drop) and micro and macrozooplankton (76% and 50% drop, respectively) communities (Caraco *et al*. 1997). Water clarity improved dramatically (up by

45%) and shallow water zoobenthos increased by 10%. Given the massive changes, Strayer *et al*. (2004) explored potential effects of zebra mussel impact on young-of-year (YOY) American shad and other species. Most telling was a decrease in observed growth rate and abundance of YOY fishes, including American shad. It is not yet clear how this constraint affects annual survival and subsequent recruitment.

7.7 RESTORATION PROGRAMS

No restoration program (e.g., hatchery program) exists for the Hudson River shad stock.

7.8 AGE

Hudson River American shad are aged from scale impressions. Scale samples are removed from an area approximately one inch below the dorsal fin and placed in an individually identified envelope. In the laboratory, scale impressions are made on cellulose acetate slides and impressions examined with a microfiche reader. For each fish, two independent age determinations are made by different investigators and agreement on age and placement of annuli is sought. Readers use the age determination method developed by Cating (1954) on Hudson River shad. A third independent reader resolved differences. If differences could not be resolved the sample was not used. Where age samples were incomplete, age structure was estimated using an age-length key developed from age and length data obtained from previous sampling years.

The oldest age of Hudson River American shad (13 years) from the mid-1980s is much older than fish from most other shad stocks on the East Coast. Because of this, the ageing of these fish has been questioned (ASMFC 1998b). We feel that ageing of Hudson River American shad has been accurate for four reasons. First, the same people using the same techniques have aged our scales throughout the time series. Scales readers for Hudson shad are highly experienced compared to other agers in Atlantic coast states. Strict quality assurance procedures are followed before scales are read. The quality assurance procedure includes an annual review of Cating's method and ageing of a "test" set to assure consistency among years and readers. The variation in observed maximum age over the last 25 years in the Hudson shad was a function of change in observed number of annuli among years and not a change in methodology or of personnel. Second, several independent sources have corroborated the age estimates. NYSDEC contracted Normandeau Associates, Inc. (NAI) to age several years of Hudson River American shad scales. NAI has many years of experience of ageing shad scales for the Susquehanna River Restoration Project. They agreed with our estimates. Third, variation in annual mean age among years mirrored changes in mean length among years suggesting consistency in ageing techniques among years (See Section 1). Finally, reduced levels of Z corresponded to periods of high mean and maximum age. Conversely, periods of increased mortality corresponded with periods of low mean age suggesting that impacts of high mortality were apparent in the age data.

American shad of the Hudson River Estuary grew to age 10 in the years following WWII after the stock had experienced a major collapse (Talbot 1954). Recent data from the Hudson River stock indicate that female American shad can reach age 13, and males reach age 10. The maximum age that American shad stock from the Hudson River can attain is unknown because age data are not available from times when the stock was not fished.

7.9 FISHERY DESCRIPTIONS

7.9.1 Introduction

Recorded landings and anecdotal reports indicate a cyclical history of collapse and rebuilding for the Hudson

River's American shad stock. The first apparent fishery collapse occurred in the 1860s (Harper's Weekly 1872) and the stock rebounded by the 1880s when landings reached the highest level ever recorded. At the turn of the century, recorded landings became sporadic. It is doubtful that fishing stopped, given the landings spike in 1904 (Figure 7.1). From WWI to just before WWII, landings were fairly low for reasons that are unclear; however, if fishing occurred at low levels for this time period, this abatement would have allowed the stock to grow to the substantial size necessary to sustain the huge harvest that occurred from the late 1930s to the early 1950s.

The high levels of harvest from 1936 through the mid-1950s came in two waves. Each subsequent peak (those in 1944 and 1956) was lower than the previous and both were lower than highest peak in 1890. This suggests to us that each overfishing event removed a large portion of the stock, lessening its recovery resiliency. All declines are attributed to overfishing. Effects of pollution and habitat loss were of concern, but were secondary to overfishing. Walters (1995) suggested that the population never fully recovered from the second event following WWII. Recent landings indicate yet another decline since the mid-1980s. This last decline has brought reported American shad landings to an all time low for the Hudson River stock. Concern about the status of the stock by the few remaining Hudson River Valley commercial fishermen is high.

The present Hudson River commercial fishery exploits the spawning migration of American shad in the Hudson River Estuary, though at a much reduced level compared to previous decades. Fishing begins in late March or early April and continues approximately eight weeks until mid-May when fish come into full spawning condition. Monofilament gill nets, mostly of 5.5 inch stretch mesh, are the primary gear (both for fixed and drifted nets). The fixed gill-net fishery occurs from km 40 to km 70 (Piermont to Peekskill, Figure 7.2). In this stretch, the river is fairly wide (up to 5.5 km) with wide, deepwater (~ six to eight m) shoals bordering the channel. Fishers set their fixed gill nets in the same areas that were fished in the 1930s when fishers followed the U.S. Army Corps of Engineers' (USACOE) "designated" area program; this program was intended to avoid conflicts with commercial shipping traffic and fishing and was later used to prevent conflicts in the fishery (T. DeGroat and R. Gabrielson, pers. comm.). Currently, less than 10 active fishers participate in the fixed gear fishery. Fishers are restricted to "fish trap" areas designated to avoid conflicts with navigation; these are relatively the same areas assigned by the USACOE years ago. Nets deployed range in size from 61 to 275 m. Within the last five years this portion of the fishery has virtually disappeared due to interference and bycatch of striped bass, which are not allowed to be retained in the Hudson River commercial fishery because of contamination.

The drift gill-net fishery occurs from km 98 to km 182 (Newburgh Bay to Catskill) where the river is much narrower (1.6 to 2 km wide). At present, about 23 to 25 fishers participate in the drift gill-net fishery. Drift nets range in size from 152 to 304 m.

Two other gears were used in the recent Hudson fishery. One fisher used a haul seine near Catskill until 1997 and a small stake gill-net operation occurred in the New Jersey portion of the Hudson River near km 19 (George Washington Bridge) from after WWII until 1998.

The Hudson River Fisheries Unit (HRFU) of the NYSDEC conducts annual programs to assess the status of the Hudson River American shad stock. Fishery-dependent and independent programs sample biological characteristics of mature fish returning to spawn in the Estuary. Relative abundance of shad is tracked among years by observed catch-effort (CPUE) statistics of fish taken during the commercial fixed gear gill-net fishery in the Estuary. The spawning stock (mature fish) that escapes this fishery is sampled for age, length, weight, and sex composition. Mortality rates are calculated for this portion of the stock. The relative success of the spawn is measured by relative abundance data for age-0 fish. Pre-juvenile life stage abundance is measured by consultants to Hudson Valley power generating companies for estimates of annual mortality of each year class due to entrainment at once-through cooling facilities.

7.9.2 Commercial Fishery

Commercial fisheries for American shad in New York State waters occur in the Hudson River Estuary and in marine waters around Long Island. The shad taken in ocean fisheries are bycatch of unknown mixed stock origin. Commercial fishing restrictions for New York waters are listed in Appendix I.

Directed mixed stock fisheries, or ocean-intercept fisheries, occurred along the Atlantic coast from Virginia to New Jersey, including Delaware Bay, and were within the known migratory range of the Hudson stock, as well as other known bycatch fisheries that occur from New York to the Bay of Fundy. Undocumented bycatch in other fisheries may still occur along the entire Virginia to Nova Scotia range. A fishery that catches American shad in the ocean has the potential to harvest Hudson River American shad. The ocean-intercept fishery for American shad in the near shore Atlantic was closed in 2005. The directed mixed stock fishery in lower Delaware Bay remains open, as it was not included in the ocean closure.

Commercial Landings and License Reporting

National Marine Fisheries Service (NMFS) reported landings annually for the inland portion of the Hudson River (areas north of the George Washington Bridge) until 1993. From 1994 to the present, NYSDEC has summarized in-river landings from mandatory state catch reports for Hudson River commercial fishing licensees and sends the data to NMFS. Recording of effort data on reporting forms was phased in beginning in 1995. Full compliance for reporting of fishing effort was implemented in 2000. Commercial monitoring data (see Catch Rates below) are used to verify and adjust reporting rate for the mandatory reports. A reporting rate of 74 percent is used to adjust the landings (Hattala *et al*.1998a). Commercial landings of American shad are in Table 7.B1.

Commercial Discards

Discard rate of female shad in the Hudson River gill-net fishery is relatively low. The fishery uses mesh sizes that optimize catches of females for their roe; few (~1%) are discarded (Table 7.2). For males, discard rate has varied over time depending upon by gear and market demand. Males are sold as bait or kept for fillets or smoking. Male discard rate in the fixed gear fishery averaged about 58 percent for the period 1980 to 1990, then fell to near zero from 1991 to 1997 as males became scarce in the catch. Discards from fixed gear since 1998 have been extremely variable. In the drift fishery, male discards averaged 22 percent prior to 1990. Discards from 1992 to the present have increased to an average of 72 percent. Although the discard rate of males appears high, males make up a small proportion, approximately 23 percent, of the total catch of both gears combined.

Discard rates for the ocean-intercept fishery and ocean bycatch fisheries are unknown.

Commercial Catch Rates

Relative abundance of shad is tracked through CPUE statistics of the commercial gill-net fishery in the Hudson River Estuary. We have monitored the in-river commercial fishery annually since 1980. Information is obtained by direct observation onboard fishing boats. Technicians attempt to be onboard fishing vessels on all fishery days and when aboard, they record data on numbers of fish caught, gear type and size, and fishing time and location. Scale samples, and lengths and weights are taken from a sub-sample of the catch. CPUE is calculated as the number of fish collected per square yards multiplied by hours fished times 10^{-3}. Data within week are summarized as total catch divided by total effort for each gear type (fixed or drift gill nets). CPUE data are summarized as an annual sum of weekly CPUE because run size is determined by number (density) of spawners each week as well as duration (number of weeks) of the run. This approach mimics area under the curve calculations where sampling occurs in succeeding time periods.

We use the CPUE of the fixed gear fishery for estimating relative abundance as it provides a more accurate picture of shad moving into the river to spawn. Fixed gear is always fished in approximately the same locations in the lower Hudson each year, is passive in nature, and intercepts fish that move through the area. The CPUE in the drift fishery is more variable because it is an active gear that can be set directly into a school of fish.

Male American shad CPUE dropped quickly from 1986 to 1990 and has since remained extremely low. A linear regression of male CPUE on years was significant for the years 1986 through 1999 ($r^2 = 0.70$, slope = -2.96, $P = <0.01$) and for the years 1986 through 2001 ($r^2 = 0.43$, slope = -1.0, $P = <0.01$). CPUE for female American shad was low in the early 1980s increased to a high in 1986, declined through 1993, then varied at a low level through the present (Table 7.3; Figure 7.5). Small peaks occurred in the 1994 and 1996. It is unclear if catchability increased as stock size declined as suggested by Crecco and Savoy (1985). A linear regression of female CPUE on years was significant for the years 1986 through 1999 ($r^2 = 0.59$, slope = -1.43, $P = <0.01$) and for the years 1986 through 2001 ($r^2 = 0.36$, slope = -1.70, $P = <0.01$). Landings data do not indicate a trend.

The increase in female CPUE in 2000 and 2001 was unexpected. However, changes in ocean fishing gear regulations may have contributed to the return of more fish, or fish of a particular size range, to the Hudson. In January 2000, the Marine Mammal Protection Act required fishers using gill-nets with 5.0 inch stretch mesh or larger to switch from using monofilament twine to multifilament twine and increase the twine diameter size or they would have to use smaller mesh. Most coastal shad fishers (R. Allen, pers. comm.) chose smaller mesh to continue using the fine monofilament twine that is more effective at catching shad. How this regulation will affect future returns to the river remains to be seen

Sample sizes of CPUE data collections for 2002 through 2005 were very small and the data were not used because we did not feel that they represented annual abundance of shad immigrating into the river. Reduced sample size in the fixed gear fishery occurred because fishers changed fishing patterns as shad became more difficult to catch (fewer fish) and to avoid catching striped bass, which were more abundant, because striped bass from the Hudson River are not allowed to be retained or sold due to PCB contamination.

There was concern that striped bass abundance might have affected catch rates for American shad; however, examination of the data indicated that catch rates of female American shad and striped bass in fixed gill nets were positively correlated (Figure 7.6). We evaluated the correlations during two time periods. The first time period was from 1980 to 1990 when American shad and striped bass were present in both very low and then very high levels of abundance. During this time, striped bass abundance began to increase due to increased fishing restrictions implemented along the Atlantic coast (ASMFC 1989, 1995). The correlation of shad CPUE and striped bass CPUE was positive ($r^2 = 0.49$). In the second time period (1991-2001), shad and striped bass had similar catch rates ($r^2 = 0.44$). Gear saturation by striped bass did not appear to affect shad catch rates.

The interference of striped bass, although not a factor in catchability of shad, is problematic for fishers. Continuous catches of striped bass often result in gear damage (ripped meshes, large holes) and additional labor to remove the bass. To avoid these problems, many fishers no longer fish or greatly reduced their time fishing.

A few other long-term estimates of fishing effort in the Hudson River exist; however, the data present some challenges. Record keeping has not been consistent over time and there is little information on whether it is actual or presumed use of gear. Available effort data are listed on Table 7.B2. Early records from 1915 to 1951 were summaries of number of licenses sold or nets licensed (data were compiled by the U.S. Bureau of Commercial Fisheries, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service). Klauda *et al*. (1976) summarized these effort statistics from 1931 to 1975 as total square yards of net licensed obtained by the NMFS during their annual survey of Hudson River shad fishers (Figure 7.7 A). He further adjusted them by allowable fishing time. Various escapement closures of 60 to 36 hour per week occurred during this time period. Concurrent with Klauda's effort series, NYSDEC records were available for linear feet of licensed net for the period 1931 to 1964 (Figure 7.7 A). Since 1976, NYSDEC-HRFU license summaries include the number of licenses sold along with the amount of net licensed (Figure 7.7 A). Starting in 1995, NYSDEC required daily catch and effort statistics on annual mandatory report forms.

Using his long-term effort series, Klauda *et al*. (1976) attempted to calculate a CPUE index to track abundance of Hudson River shad for the period 1931 to 1975. Landings were divided by effort; effort defined as net area (square yards) multiplied by total allowable fishing hours per week (Figure 7.7 B). We attempted to continue the time series of Klauda *et al*. (1976) through the present by using the same method by converting licensed linear feet to square yards by multiplying the linear feet by fourteen (average depth of net; HRFU, unpub. data) then dividing by nine (Figure 7.7 B). Often, increases in effort followed peaks in catch. The resulting CPUE series presents an interesting scenario of similar repeating peaks that occurred in the 1940s and the mid-1950s, followed by slightly lower peaks in the late 1970s and mid-1980s (Figure 7.7 C).

We also examined the relationship between observed CPUE collected since 1980 (see Catch Rates above) with the Klauda *et al*. CPUE series described above. No correlation existed between the two data series leaving little faith in the long-term reported CPUE estimates (Figure 7.8). Reported versus observed CPUE periodically varied in opposite directions. Reported catch and effort records, from 1980 to the present, indicate that 20 to 60 percent of the licenses sold annually are actually used (Figure 7.9) thus the total amount of effort fished has been less than the number of licenses indicate. Over the past ten years, increasing numbers of fishers purchased shad and herring net licenses to catch river herring. This further confounds use of licensed gear as an effort index for shad. Our monitoring supports reported effort for the last two decades. Adjusting for the percent actually used would have considerably increased the CPUE for the period 1980 to the present when landings were actually quite low. No adjustment can be made for the earlier time period because we do not know what proportion of the licensed gear was actually fished.

Catch-per-unit-effort data must be interpreted with great caution. Hilborn and Walters (1992) warned that CPUE indices could actually remain stable, or even increase, during periods of stock decline. Crecco and Savoy (1985) also found that catchability of American shad could increase when stock size decreases.

Hudson shad were caught in the mixed stock fisheries on the coast and Delaware Bay. No catch rates were calculated due to a lack of effort data. See Section 1.

Hudson River Size and Age Structure

An increase in size and weight of both sexes of American shad sampled in the Hudson River commercial fishery occurred for the period 1980 to 1990. This was followed by a decline to a smaller size for the years 1992 through 2001 (Table 7.4; Figure 7.10). A slight increase in size occurred in 2002 to 2005. The same general trend occurred for both sexes.

We also examined mean total length and weight-at-age and noted a decline in both since the mid 1980s from both fishery-dependent and fishery-independent samples (Figure 7.11). The decline is likely caused by a concomitant increase in rate of fishing mortality as older, larger fish disappeared through the 1990s. Observed changes were not caused by changes in recruitment (see Section 7.10.1). Mean length and weight-at-age are summarized for the entire time series by sex and sexes combined for the fishery-dependent and fishery-independent data (Tables 7.B3).

The fishery-dependent data indicated a wide range of ages of shad (both sexes) occurred through the late 1980s. This changed in the 1990s with a consistent move toward younger fish (Table 7.5). In all years, the majority of fish caught are ages five through seven; however, over the period 1990 to 1998, few fish older than age seven were caught. Estimated ages indicate that from 1999 through 2005 some older (larger) fish reappeared in the catch. The percent of repeat spawners was fairly stable at greater than 60% for males and between 42 to 73% for females (Tables 7.5 and 7.6). These high percentages are expected as the fishery uses large mesh gill nets that catch the larger fish of each age group, which tend to be the repeat spawners. The highest value of mean repeat spawn for females occurred in 1987 at 1.85 and dropped to a low of 0.71 in 1992 (Table 7.6). For males, the high value also occurred in 1987 at 2.78 and also dropped to a low of 1.2 in 1992. Ages for 1996 through 2005 were estimated by age-length keys developed from length and age data from 1980 to 1995. Data on incidence of repeat spawning are not available after 1995; ageing is in progress.

7.9.3 Recreational Fishery

The magnitude of the recreational fishery is unknown for most years. NYSDEC contracted with Normandeau Associates, Inc. to conduct creel surveys on the Hudson in 2001 and 2005. Most recreational fishing for American shad occurs in the upper half of the Hudson River Estuary above Kingston (rkm 152) to the Federal Dam at Troy (rkm 243). Catch in 2001 was 19,766 fish with a 6.5 percent retention rate (Table 7.7). Catch dropped in 2005 to 6,582, although the retention rate was higher at 7.7 percent. Catch rates were dramatically different in the two years. In 2001, boat CPUE was 1.498 and shore CPUE was 1.534. In 2005, the rates were much lower at 0.586 for boats and 0.584 for shore fishers.

No known recreational data for American shad exist in New York ocean waters. Recreational catches of American shad reported from ocean waters along Long Island are suspect because hickory shad are frequently caught in the fall and misidentification is likely.

7.10 FISHERY-INDEPENDENT SURVEYS

7.10.1 Spawning Stock Survey

The fish sampled in this program represents the spawning stock, or production, portion of the population that has escaped from ocean and in-river commercial fisheries. Sampling occurs within the spawning reach (km 145-232) from late April through early June, concentrated from km 146 to km 182. Fish are collected by a 154-m or 305-m haul seine at beaches located throughout this area. The haul seine exhibits relatively low size selectivity in sampling fish (Kahnle *et al*. 1988) when compared to other gear types. Since we calculate mortality rates for this portion of the stock, we used chi-square analyses of weekly age structure within each year to see if age structure changed among weeks. This let us evaluate if variation in sample timing within year affected annual age structure. Age structure did not differ significantly among weeks in half of the years (1985, 1987, 1989, 1990, 1999-2001, and 2004; Table 7.B4). Years in which a significant difference in age structure occurred tended to be years in which most of the fish were taken in a single week. Since the sample week that collected the most fish was probably also the week with highest spawner abundance, we surmised that the age structure from that week also reflected the age structure of the spawning stock. Although the program began in 1983, sampling effort through 1984 was very limited. The most useful data are from 1985 to the present.

Size and Age Distribution

All shad collected are identified by sex, and most all are weighed, measured, and sampled for scales. Male shad ranged from 360 to 660 mm TL (Table 7.8). Females were generally larger and ranged from 400 to over 680 mm TL. Both sexes were largest during the period 1984 to 1989 (Table 7.8). Mean total length and weight for both sexes were fairly consistent from 1984 through 1988 (Figure 7.12). Size declined from 1989 through 1993, increased slightly until 1994, and then remained relatively stable through 2001. Size of both sexes increased in 2003 through 2005. The decline in TL and weight-at-age in spawning stock samples was more pronounced than in fishery-dependent (gill net) samples (Figure 7.11). A general downward trend occurred from 1988 through 1993 with some improvement through 2005. It is not clear what caused these changes, but since the change occurred fairly quickly it suggests a change in fishing.

Age structure of the spawning stock comprised a wide range of ages during the period 1984 through 1989 (Table 7.9). Ages were estimated by age-length keys in 2003 and 2005. From 1990 to 2001, a noticeable shift to younger fish occurred. Incidence (percent) of repeat spawning, along with mean average repeat, dropped with the absence of older fish (Tables 7.9 and 7.10). For the 1985 to1995 time period, a high of 58% female repeat spawners occurred in 1988, and a high of 52% for males occurred in 1989. Virgin fish dominated the samples from 1991 to 1997. Mean repeats began to climb after 1997 and then reached a record high of 2.18 in 2004 (Table 7.10). This increase occurred because of fewer virgin fish.

Mean age of fish over the entire time series showed a similar declining trend in the late 1980s, followed by a steady period of younger mean age through 2000, then a sharp increase in 2003 and 2004 (Figure 7.13). We investigated the influence of year-class strength and its effect on mean age since the decline in mean age could have been caused by appearance of strong year classes of young fish in recent years as well as by a loss of older fish. We divided catch-at-age in the spawning stock samples by a juvenile (age-0) abundance index (JAI) for the same year class. We used an index of post-yolksac larvae (PYSL) as the age-0 measure because it includes all year-classes present in the adult samples. The PYSL is highly correlated with the juvenile abundance index (see Section 7.10.3) and is the longer data series, extending back to 1974. The JAI began in 1980. Adjusted mean age followed the same decline as that of unadjusted mean age (Figure 7.13). This suggests that the change to younger fish resulted from a loss of older fish from the spawning stock rather than an influx of younger fish. The dramatic increase in 2003 and 2004 indicates just the opposite. Younger, smaller virgin fish are missing, confirmed by the jump in the mean repeats. These changes are rather abrupt and the underlying cause is not clear.

Mortality Estimates

We calculated total instantaneous mortality (Z) within year as the negative slope of natural log of catch-at-age (A) on age and natural log of number of repeat spawners-at-age (RS) on repeats (Crecco and Gibson 1988). From 1984 to 1989, estimates of total instantaneous mortality (Z) were relatively stable with Z_A and Z_{RS} averaging about 0.6 for females (Table 7.11; Figure 7.14). For the same time period, estimates for males were generally higher although annual estimates ranged between 0.4 and 0.8 (Figure 7.14). Z-estimates were extremely variable from 1990 through 1999, but levels were generally much higher than in the 1980s. Z-estimates increased to a high of 1.42 (Z_A) for females in 1995 and a high of 1.41 (Z_A) for males in 1993. Z-estimates remain high through the present, dropping below 1.0 in 2004 and 2005 for both sexes (Table 7.11).

7.10.2 American Shad Tagging Program

Survival Estimates

In 1995, New York initiated a three-year, large-scale (greater than 1500 shad tagged per year) tagging program within the Hudson River in an attempt to estimate population size and exploitation rate on the Hudson shad stock. Estimates of population size and exploitation rate were never achieved because of the failure to meet many population estimate modeling assumptions in such an open system as the Hudson. A complete description of methods and results is found in Hattala *et al*. 1998b. Abundance estimates ranged from several hundred thousand to over one million fish, depending on the model used.

After 1997, we continued to tag shad annually in the Hudson River during the annual spawning stock survey (see Section 7.10.1). The consistent annual data on released and recaptured tagged fish allowed the calculation of annual survival rates using the software program MARK (White 2004).

The initial three-year tag-recapture periods covered 1995 through 1997. The model of constant S among years best fit the data and produced an estimate of S at 0.22, or a Z of 1.53 (Table 7.12). Similar results were obtained with the addition of the 1998 through 2001 tag-recapture data, where S estimates ranged from 0.23 (Z = 1.47) to 0.35 (Z = 1.06). All of the estimates are within the range of the Z-estimates obtained from catch curve analysis of the age and repeat spawn data for the same time period in all analyses. After 2001, models using a constant S no longer fit the data well. We added a model with two time periods (before and after 2001) to see if the changes in ocean fishing rules (implementation of the Harbor Porpoise Take Reduction Act in 2000) affected survival of shad. Model fit improved, and indicated to us that a change in survival occurred. The S-values in the latter period were dramatically lower (Z = 0.13) and were much lower than the Z-estimates from age. The model output data suggests that some change is beginning to occur in the stock.

Tag Return Distribution

During the three year intensive study, most tag returns came from within river during the same release year (Figure 7.15); however, 13 percent of the Hudson returns were recaptured in ocean waters from Nova Scotia to Virginia. In a similar tagging program, 19 percent of shad tagged and released in lower Delaware Bay were recaptured in the Hudson (see Section 8).

7.10.3 Juvenile Abundance

Since 1980, the NYSDEC has obtained an annual measure of relative abundance of juvenile (age-0) American shad in the Hudson River Estuary. In the first four years of the program, juvenile shad were sampled river-wide (rkm 0-252), bi-weekly from August through October, after the peak in abundance occurred. The sampling program was altered in 1984 to concentrate in the freshwater middle and upper portions of the Estuary (km 88-225), the major nursery area for juvenile shad (Figure 7.2). Timing of sampling was also changed—the survey begins in late June or early July and is conducted biweekly through late October each year. The sampling gear is a 30.5 m by 3.1 m beach seine of 0.64 cm stretch mesh. Sites are sampled during the day at approximately 28 standard sites in preferred juvenile shad habitat. Catch-effort is expressed as annual geometric and arithmetic means of number of fish per seine haul for annual weeks 26 through 42 (July through October), the period encompassing the major peak of juvenile presence in the middle and upper estuary.

The geometric mean JAI for the NYSDEC YOY program averaged around 16 in the first five years, then increased and varied at a higher level from 1986 to 1990 (Table 7.13; Figure 7.16). Since then, annual measures have been extremely variable, bouncing between high and low values over a period of ten years until 2001. The JAI dropped very low in 2002 and has remained at depressed levels since then.

In addition to the JAI, additional data on year class abundance in the Hudson Estuary are available. These data are abundance measures of all early life stages: egg (EGG), yolk-sac larvae (YSL), post-yolk-sac larval shad (PYSL), and age-0 fish (beach seine survey, BSS). Data are collected and summarized by contractors for the Hudson River Generating (HRG) companies (Table 7.14a). The Long River Survey (LRS) samples ichthyoplankton river-wide from the George Washington Bridge (km 19) to Troy (km 246) following a stratified random design (ASA 2006). The survey began in 1974 and runs through the present. Ichthyoplankton are sampled from all strata (shore, shoals, bottom, and channel). Sampling gears are either a 1-m epibenthic sled or a 1-m Tucker trawl. Each larval index is the density of eggs or fish collected per 1000 cubic meters of water sampled river-wide. The HRG beach seine survey (BSS) randomly samples beaches in thirteen river segments spread out the entire 246 km of river from July through October. It was designed to sample for YOY striped bass. The seine used is similar to the NYSDEC YOY program, except that the stretch mesh size is slightly larger (0.95 cm rather than 0.63 cm).

All abundance measures (EGG, YSL, PYSL, BSS and YOY) contain some degree of uncertainty in measurement accuracy due to life stage habitat preference, sample gear, and sample timing. The EGG index may only measure a portion of the total production because the sampling gear can only sample along the spawning shoals and not over them (most areas are too shallow for the sampling vessel). The YSL index has similar problems; fish are still small enough to be on the shoals that are inaccessible to sampling gear. Existing flow conditions also influence YSL and egg catchability. By the PYSL stage, larvae are able to move and may be more evenly distributed as they begin to choose a preferred location. Young-of-year have the greatest mobility choice. The two young-of-year sampling programs are different from each other. The NYSDEC YOY program samples beaches within the freshwater nursery area (Newburgh, km 88 and north) whereas the BSS has random site design, sampling a variety of habitats not necessarily where shad could be found, and it samples the entire estuary from New York City to Troy, although sampling is more highly concentrated in the brackish water portion of the Hudson. The BSS began in August for most years of the survey (1974 through 1997), but is now similar in timing to NYSDEC YOY survey (CHGE 1999).

We examined the relationship between all JAIs. Most were poorly correlated ($r^2 < 0.50$; Table 7.14b). The best relationship was between the PYSL and the NYSDEC YOY. Since 1980, trends in the two indices (YOY and PYSL) track well for all years (Fig 7.16). For the time period of 1980 through 2005, the two indices were correlated ($r^2 = 0.56$; Table 7.14b)

The PYSL index sampling began in 1974. Initial values for the period 1974 through 1979 were low. This index showed a variable but increasing trend from 1979 until 1990, followed by a drop to low levels from 1991 to the present (Figure 7.16).

Validation of Juvenile Abundance Index

Many state agencies collect data on young-of-year abundance but few have attempted to validate whether they actually measure year class strength. Validation requires a long time series of abundance indices at age-0 and at some later adult age. Fortunately, in New York we have both. We attempted to validate the NYSDEC YOY index by comparing relative abundance at age-0 to relative abundance of fish of the same year-class returning as mature adults to spawn. As described in the section above, several long time series of year-class abundance measures exist for the Hudson stock. We feel the best measures for age-0 fish are the YOY and PYSL indices described above. We also have calculated a third abundance measure, for adult fish by year-class, from CPUE data from the commercial fishery (see Commercial catch rate in Section 7.9.2 above).

Since shad mature and return to the river between ages four and eight (sometimes older), we developed an index of each returning year-class as they appeared in the fishery over several years. Segregated by sex, we multiplied percent-at-age within year by the annual CPUE to create individual year-class abundance indices for each year of available data. The adult year-class index is the sum of the segregated indices by year-class for ages five through seven, which are the most abundant ages in the commercial catch. The resulting adult year-class indices include year-classes from 1975 through 1996 (Table 7.15). Since the adult indices include the year-classes back to 1975 and given the degree of concurrence between the YOY and PYSL indices, we used the PYSL index as the measure at age-0 for the validation procedure. A simple correlation was made between the age-0 (PYSL) and adult index for year-classes 1975 to 1996. For all years, no significant relationship was evident ($r^2 = 0.03$ for females, $r^2 = 0.00$ for males and $r^2 = 0.02$ for sexes combined; Figure 7.17). However, we expected a poor correlation given the changes in mortality observed in catch-curve analysis of the adult stock age structure beginning in 1990, when the 1985 year-class would return. We therefore confined our analyses to year-classes produced from 1975 to 1984. These year-classes avoided the change in mortality that occurred in the period 1985 to 1992. The relationship dramatically changes to a nearly one-to one relationship ($r^2 = 0.84$ for females, $r^2 = 0.73$ for males and $r^2 = 0.83$ for sexes combined; Figure 7.17). This suggests that the PYSL and YOY indices are actual measures of year-class strength and, after the 1984 year-class left the Hudson, a dramatic drop in ocean survival occurred for the Hudson stock.

Entrainment Estimates

A river-wide ichthyoplankton survey occurs annually in the Hudson River Estuary, conducted by consultants under contract with the Hudson River Generating companies, see section 7.10.3 above. In order better define impacts of the once-through cooling systems on fish, estimates of mortality on various ichthyoplankton life stages were calculated using two models, the Empirical Transport Model and the Conditional Entrainment Mortality Rate (CEMR) model. Detailed methodology for both models can be found in CHG&E (1999).

Estimates of mortality are expressed as conditional entrainment mortality rates, or the percent reduction in a year-class that would be due to mortality from entrainment through once-through cooling water systems if no other causes of mortality operated. Losses for the Hudson River Estuary can occur at one major office complex air conditioning unit, two nuclear power plants, one waste-fuel power plant, and five fossil-fuel power plants located throughout the Hudson Valley above New York City. CEMR at these facilities combined has ranged from 16 to 52 percent during the period 1974 to 1997 (Table 7.14a). An estimated average of 20% was assumed for the period 1952 to 1973 when major power plant once-through cooling systems came on line (CHG&E 1999). Total losses have declined over the past few years as one fossil fuel plant located within the spawning area was retrofitted with closed cycle cooling.

7.11 ASSESSMENT APPROACHES AND RESULTS

7.11.1 Empirical Spawning Stock Abundance and Biomass Indices

We calculated empirical spawning stock abundance (SSA) and biomass (SSB) indices for the Hudson River shad stock using the relative abundance index of female shad in the fixed gear commercial gill-net fishery, age structure of females in the commercial fishery and the spawning stock (see Sections 7.9 and 7.10), and observed annual mean weight-at-age. These indices allowed us to evaluate the usefulness of various early life stage indices as surrogates of adult abundance.

We used age structure from the haul seine collections for age structure of the spawning stock. We did not use catch rates from this gear as abundance indices because the survey objective was to catch as many fish as possible in the short spring sample period The sample design for this survey was not randomized and we sampled at locations and during environmental conditions when we expected to catch fish

Empirical Index Method

We assumed that catch rates (CPUE) of age five through seven American shad in the gill-net fishery were proportional to relative annual abundance of these age classes in the spawning population because the modal age in the catch varied between five and seven throughout the time series. Total annual CPUE in the fishery was apportioned to ages five, six, and seven from the proportion of observed catch-at-age (ages five to seven) in the commercial catch (Table 7.16). Relative CPUE for other ages in the spawning population were estimated by year as:

$$CPUE_{agex} = (CPUE5{+}6{+}7) * ((p_{pop\text{-}agex} / (p_{pop\text{-}ages5+6+7})),$$

where:
$CPUE_{agex}$ = catch per unit effort of a given age in the population;
CPUE5+6+7 = CPUE for ages five, six and seven combined in observed catch;
$p_{pop\ agex}$ = percent of age x observed in spawning stock collections;
$p_{pop\ ages5+6+7}$ = percent of ages five, six, and seven combined observed in spawning stock collections.

We calculated the index of spawning stock abundance as the sum of CPUE-at-age for ages three through ten. To calculate a biomass index, CPUE-at-age is multiplied by observed annual weight-at-age (WAA, kilograms) before summation. We could only calculate these indices through 2001 because of small sample sizes in the commercial monitoring program after that year rendered CPUE5+6+7 unreliable.

We evaluated potential use of early life stage indices (EGG, YSL, PYSL, YOY) as surrogate adult indices with a simple linear regression of the early life stage index on the spawning stock index for the period 1985 through 2001. We assumed that a positive and strong correlation would be indicative of a causal relationship.

Empirical SSA and SSB Results

The empirical estimate of spawning stock abundance index (ESSA) peaked in 1986, declined through 1993, fluctuated without trend through 1999, and then increased (Table 7.16; Figure 7.18). The jump in 2000 and

2001 was unexpected, but it may have been related to changes in gill-net restrictions in ocean waters related to the Harbor Porpoise Take Reduction Plan as these restrictions required smaller mesh gill nets, allowing larger fish to escape the fishery and return to the Hudson (see Section 7.9). A linear regression of ESSA on years was significant for the years 1986 through 1999 (r^2 = 0.62, slope = -2.75, P = <0.01) and for the years 1986 through 2001 (r^2 = 0.24, slope = -1.46, P = 0.05)

The ESSA correlated best with the EGG index (R^2 = 0.59, Figure 7.18) indicating that a positive relationship existed between the observed spawning stock and the resulting egg production measured in the river. Some variation between the two indices (ESSA and EGG) occurred throughout the time series (Figure 7.18); however, this may be the result of the short duration of the egg phase, environmental influences of temperature and flow on the EGG index, or both. Relationships between the ESSA with other age-0 abundance indices were poor (r^2 = 0.06, YSL index; r^2 = 0.16, PYSL index; and r^2 = 0.21, YOY index).

The empirical spawning stock biomass index (ESSB; Figure 7.18) displayed a similar pattern as the ESSA with the exception of 1986 through 1989 when the biomass index was much higher relative to the rest of the biomass time series. In these years of the biomass time series, there were more large, older fish present in the spawning stock (see Section 7.10). A linear regression of ESSB on years was significant for the years 1986 through 1999 (r^2 = 0.64, slope = -6.2, P = <0.01) and for the years 1986 through 2001 (r^2 = 0.35, slope = -3.76, P = 0.02).

The EGG index correlated better with the biomass index (r^2 = 0.66; Figure 7.18) than with the abundance index since egg production is more a function of fish biomass than of fish length. The relationships between the ESSB and the other age-0 indices were poor (r^2 = 0.04,YSL index; R^2 = 0.21, PYSL index; and R^2 = 0.20, YOY index). We used the relationship between the EGG index and the ESSB to project the ESSB from 1999 through 2005 (Figure 7.18). The projected index increased slightly in 2000, but not as much as the ESSB, suggesting that the high values in 2000 and 2001 were a function of commercial sampling error rather than an actual rise in abundance.

7.12 BENCHMARK

A benchmark was calculated from a Thompson-Bell biomass-per-recruit model using Hudson River inputs for weight, maturity, and vulnerability-at-age, and M = 0.3, based on maximum age of 13 observed in the stock (see Section 1). The benchmark of Z_{30} is 0.54. Current Z-values are well above this reference point. The EGG index is at its lowest level in 20 years.

7.13 CONCLUSIONS AND RECOMMENDATIONS

Over the last 20 years, the Hudson River stock of American shad has shown consistent signs of excessive mortality on mature fish. As mortality rose above acceptable levels during the late 1980s, mean size, mean age, and abundance fell. Recruitment dropped to and remained at its lowest levels of the time series during the last four years. We contend that the high adult mortality was caused by fishing (see Section 1.5) and that this excessive fishing has now affected recruitment.

The excessive mortality of the last 20 years perpetuates almost a century of successive periods of overfishing on the Hudson River stock of American shad. Results of this fishing pressure have left the stock in a historically depressed condition with high uncertainty regarding its recovery. Few year-classes currently remain at high enough abundance to rebuild the spawning stock.

The Hudson River American shad stock is a shared resource along its entire migratory range, from North Carolina to Maine and Canada. As long as fisheries continue to operate in coastal waters, decisions on the fishery and the direction it will take are also a shared process.

We recommend that fisheries suspected of affecting the Hudson River stock of American shad be restricted to curtail any further damage to this stock. These fisheries include those in the Hudson, both commercial and recreational take, as well as known remaining mixed stock fisheries outside of the Hudson system such as those in lower Delaware Bay. A concerted effort needs to be made to identify bycatch in the other numerous fisheries that may harvest Hudson River American shad (e.g., Atlantic herring fishery) and identified bycatch fisheries need to be restricted to minimize catch of American shad. Even if fishing proves not to be the principle cause of the shad stock decline, it is the only cause that managers can control.

We also recommend that a fishery-independent CPUE survey be developed to track spawning stock abundance.

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Table 7.1 Hudson River American shad growth and life history data.

von Bertalanffy Growth - Length-at-age				Gompertz Growth - Weight-at-age						
Parameters	TL (mm) - all fish			Parameters	Weight (g)					
L_∞	587.4	642.0	641.3	W_o	19.4	31.6	24.0			
K	0.4	0.3	0.3	G	4.9	4.6	4.9			
t_0	-0.1	-0.1	-0.1	sg	0.4	0.4	0.4	Maturity*		Fecundity**
Age	Male	Females	All		Male	Female	All	Male	Female	
1	190.5	200.2	190.7		87.7	141.9	109.6	0%	0%	
2	308.8	329.6	312.7		248.3	390.6	312.1	0%	0%	
3	391.8	421.0	401.7		508.9	773.8	640.7	4%	0%	95491
4	450.1	485.7	466.6		834.4	1227.5	1050.6	48%	15%	157637
5	491.0	531.5	513.9		1173.4	1676.0	1476.2	86%	63%	219783
6	519.7	563.8	548.4		1484.3	2068.1	1865.2	97%	91%	281929
7	539.9	586.7	573.6		1745.4	2383.4	2190.6	99%	98%	344075
8	554.1	602.9	591.9		1951.6	2622.9	2446.8	100%	100%	406221
9	564.0	614.4	605.3		2107.8	2798.1	2640.1	100%	100%	468367
10	571.0	622.4	615.0		2222.7	2922.9	2781.8	100%	100%	530513
11	575.9	628.2	622.1		2305.5	3010.2	2883.7	100%	100%	592659
12	579.3	632.2	627.3		2364.4	3070.7	2955.9	100%	100%	654805
13	581.7	635.1	631.1		2405.9	3112.1	3006.5	100%	100%	716952
14	583.4	637.1	633.9		2434.9	3140.4	3041.9	100%	100%	779098

Table 7.2 Observed discard of American shad in the (a) fixed gear and (b) drift gear commercial gill-net fisheries in the Hudson River Estuary, 1980-2005.

(a)

Year	Fixed Gear fishery						
	Observed Catch Composition			% Discarded Within Sex		% Discard of Total Catch	
	Total Catch	% Male	% Female	% Male	% Female	% Male	% Female
1980	2848	17.7	82.3	45.7	2.6	8.1	2.1
1981	2316	22.9	77.1	50.9	1.8	11.7	1.4
1982	3633	26.7	73.3	55.4	1.8	14.8	1.3
1983	2962	40.0	60.0	65.3	0.0	26.1	0.0
1984	3349	27.9	72.1	60.9	0.0	15.6	0.0
1985	5619	30.4	69.6	60.4	2.9	17.4	1.9
1986	6591	31.5	68.5	75.9	1.2	23.4	0.8
1987	8409	19.5	80.5	55.6	2.2	10.8	1.7
1988	8248	29.4	70.6	78.5	0.5	23.0	0.3
1989	4547	25.2	74.8	35.2	1.0	8.4	0.7
1990	2773	19.1	80.9	49.8	0.0	9.4	0.0
1991	2331	10.9	89.1	0.8	0.2	0.1	0.2
1992	2808	7.0	93.0	0.0	0.0	0.0	0.0
1993	1078	6.4	93.6	0.0	0.0	0.0	0.0
1994	1358	9.4	90.6	0.0	0.0	0.0	0.0
1995	1188	11.4	88.6	0.0	0.0	0.0	0.0
1996	1624	8.9	91.1	0.0	0.1	0.0	0.1
1997	1117	11.8	88.2	0.0	0.1	0.0	0.1
1998	1306	24.5	75.5	65.0	0.0	15.9	0.0
1999	1362	8.6	91.4	0.9	1.0	0.1	1.0
2000	1257	12.4	87.6	23.1	0.4	2.9	0.3
2001	1575	10.0	90.0	32.7	0.2	3.2	0.2
2002	333	57.4	42.6	79.9	0.0	41.7	0.0
2003	69	14.5	85.5	0.0	0.0	0.0	0.0
2004	52	7.7	92.3	75.0	0.0	5.8	0.0
2005	0	0.0	0.0		0.0	0.0	0.0

Table 7.2 (cont.) Observed discard of American shad in the (a) fixed gear and (b) drift gear commercial gill-net fisheries in the Hudson River Estuary, 1980-2005.

(b)

Year	Drift Gear fishery						
	Observed Catch Composition			% Discarded Within Sex		% Discard of Total Catch	
	Total Catch	**% Male**	**% Female**	**% Male**	**% Female**	**% Male**	**% Female**
1980	593	36.6	63.4	5.5	0.3	2.0	0.2
1981	2539	38.5	61.5	42.5	0.5	16.4	0.3
1982	2038	47.4	52.6	1.0	0.0	0.5	0.0
1983	1698	67.9	32.1	11.1	5.0	7.5	1.6
1984	1063	53.2	46.8	58.1	0.0	31.0	0.0
1985	517	41.0	59.0	25.0	1.0	10.3	0.6
1986	1712	37.3	62.7	6.3	0.3	2.3	0.2
1987	943	37.5	62.5	20.1	5.1	7.5	3.2
1988	1911	24.5	75.5	20.3	0.0	5.0	0.0
1989	439	29.2	70.8	36.7	0.0	10.7	0.0
1990							
1991							
1992	878	18.5	81.5	41.4	0.0	7.6	0.0
1993	168	25.0	75.0	100.0	0.0	25.0	0.0
1994							
1995	638	14.7	85.3	100.0	0.0	14.7	0.0
1996	632	28.3	71.7	17.3	0.0	4.9	0.0
1997	593	30.9	69.1	74.3	0.5	22.9	0.3
1998	1821	35.9	64.1	97.7	0.0	35.1	0.0
1999	2353	18.7	81.3	52.4	0.0	9.7	0.0
2000	2350	36.5	63.5	53.8	0.0	19.6	0.0
2001	2616	42.5	57.5	77.9	0.1	33.1	0.0
2002	2119	60.2	39.8	89.3	4.3	53.7	1.7
2003	785	51.5	48.5	62.1	0.0	32.0	0.0
2004	1515	51.3	48.7	68.3	0.0	35.0	0.0
2005	2694	53.0	47.0	67.3	0.2	35.7	0.1

Table 7.3 Annual summary of observed catch-per-unit-effort (CPUE) of American shad in the commercial gill fishery in the Hudson River Estuary, 1980-2005. (a) Fixed gear - males; (b) fixed gear - females; (c) drift gear - males; and (d) fixed gear - females.

(a)

Year	**Number of Trips**	**Annual Weekly CPUE: Fixed Gear - Males**									**SUM**
		Week of Year									
		13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
1980	26			1.20	2.13	0.35	0.13	0.07	0.14	0.10	4.12
1981	24		0.64	3.62	0.67	0.56	0.07	0.08	0.47	0.06	6.17
1982	37			0.26	1.45	0.85	0.41		0.07		3.04
1983	38			1.79	0.48	2.21	0.69	0.48			5.65
1984	57				0.24	1.40	1.64	0.08	0.06		3.42
1985	54		2.14	5.35	1.44	0.77		0.17	0.79		10.66
1986	49	9.19	5.30	7.37	1.73	0.41	0.05	0.57	0.23		24.85
1987	49		4.62	3.98	3.42	0.55	0.27	0.33			13.17
1988	38		3.23	8.14	4.11	2.57	0.80	0.55			19.40
1989	30		1.05	1.25	3.39	2.51	1.10				9.30
1990	23		1.37	1.50	0.26	0.40					3.53
1991	22		0.90	0.77	0.50	0.06	0.09				2.32
1992	33		0.13	0.41	0.27	0.39	0.12				1.32
1993	8				0.73	0.18					0.91
1994	9				0.66	0.13	0.07				0.86
1995	10			0.61	0.66	0.13					1.40
1996	19			0.28	1.02	0.56	0.18	0.15			2.19
1997	26			0.20	0.31	0.30	0.10				0.91
1998	17			0.54	1.22	1.83					3.59
1999	27				0.26	0.36	0.18				0.80
2000	16		1.01	2.46	1.41	0.76	0.85				6.49
2001	21			2.55	0.78	0.28					3.61
2002*	4			7.31							*
2003*	1				1.04						*
2004*	2				2.25	0.36					*
2005*											*

*Total catch and CPUE are not representative of entire season due to low sample size.

Table 7.3 (cont.) Annual summary of observed catch-per-unit-effort (CPUE) of American shad in the commercial gill fishery in the Hudson River Estuary, 1980-2005. (a) Fixed gear - males; (b) fixed gear - females; (c) drift gear - males; and (d) fixed gear - females.

(b)

Year	Number of Trips	Annual Weekly CPUE: Fixed Gear - Females									SUM
		Week of Year									
		13	14	15	16	17	18	19	20	21	
1980	26			3.38	8.98	4.68	1.27	0.35	0.93		19.59
1981	24		0.62	3.58	2.09	5.45	0.99	1.03	0.71		14.47
1982	37			0.41	2.04	2.37	3.04		0.16		8.02
1983	38			1.18	0.81	2.67	1.93	2.57			9.16
1984	57			0.02	0.52	3.19	4.85	0.72	0.19		9.49
1985	54		2.28	6.91	4.82	6.39		1.22	4.97	0.06	26.65
1986	49	7.82	7.61	8.83	7.69	7.65	2.56	8.50	1.61		52.27
1987	49		11.81	6.90	14.85	6.06	3.92	3.83			47.37
1988	38		3.74	11.59	6.77	10.36	5.77	3.99			42.22
1989	30		0.83	1.39	7.51	11.84	12.22				33.79
1990	23		2.88	4.86	3.98	4.89					16.61
1991	22		6.86	4.14	4.61	1.53	1.17				18.31
1992	33		1.10	2.79	2.69	6.53	1.50				14.61
1993	8				8.55	4.47					13.02
1994	9				10.44	3.88	9.04	0.88			24.24
1995	10			4.95	4.19	2.35					11.49
1996	19			2.19	5.21	5.38	4.43	3.04			20.25
1997	26			1.99	2.43	1.91	0.78				7.11
1998	17			2.00	6.41	3.82					12.23
1999	27				2.29	3.76	4.76				10.81
2000	16		2.77	5.96	8.51	4.21	10.16				31.61
2001	21		0.12	12.54	5.90	7.18					25.74
2002*	4			5.35							*
2003*	1				6.13						*
2004*	2				24.75	3.96					*
2005*											*

*Total catch and CPUE are not representative of entire season due to low sample size.

Table 7.3 (cont.) Annual summary of observed catch-per-unit-effort (CPUE) of American shad in the commercial gill fishery in the Hudson River Estuary, 1980-2005. (a) Fixed gear - males; (b) fixed gear - females; (c) drift gear - males; and (d) fixed gear - females.

(c)

Year	**Number of Trips**	**Annual Weekly CPUE: Drift Gear - Males**									**SUM**
		Week of Year									
		13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
1980	10			5.14	11.53	12.14	24.38	2.38	1.61		57.18
1981	29			6.77	7.27	4.15	5.88	20.07	8.17	6.28	58.59
1982	29				9.24	20.10	3.40	1.47	0.48	1.07	35.76
1983	17				24.86	23.69	10.78	3.57	1.89	18.43	83.22
1984	7				9.52	7.18	87.74				104.44
1985	7		7.00	31.50	24.63	7.54					70.67
1986	8		34.60	11.02	24.46	28.57	5.85	28.16			132.66
1987	6			28.20	12.86	4.08	6.29	6.66			58.09
1988	15		11.67	8.39	4.74	6.35	1.92				33.07
1989	7		0.40		14.29	7.03	3.11				24.83
1990*	0										*
1991*	0										*
1992	11				3.31	8.74	1.80				13.85
1993*	1					15.12					*
1994*	0										*
1995*	5								8.60		*
1996*	5						8.41	5.18			*
1997*	3						7.34				*
1998	6				16.03	19.85					35.88
1999	11				4.99	8.08	5.32				18.39
2000	19			2.51	14.06	7.73	9.15				33.45
2001	14			8.42	27.43	10.87					46.72
2002	9		5.07	28.96	63.55	18.45					116.03
2003	7			5.54	15.04	17.89	11.10				49.57
2004	13		2.05	5.08	11.52	20.27					38.92
2005	20			8.06	17.94	10.26	11.09				47.35

*Total catch and CPUE are not representative of entire season due to low sample size.

Table 7.3 (cont.) Annual summary of observed catch-per-unit-effort (CPUE) of American shad in the commercial gill fishery in the Hudson River Estuary, 1980-2005. (a) Fixed gear - males; (b) fixed gear - females; (c) drift gear - males; and (d) fixed gear - females.

(d)

Year	**Number of Trips**	**Annual Weekly CPUE: Drift Gear - Females**									**SUM**
		Week of Year									
		13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
1980	10			15.43	13.33	12.14	71.21	6.69	3.21		122.01
1981	29			7.64	12.06	13.87	12.40	20.14	13.28	5.97	85.36
1982	29				2.82	13.83	9.21	13.50	3.11	6.42	48.89
1983	17				7.32	7.73	13.87	7.86	17.71	0.55	55.04
1984	7				4.76	4.81	112.07				121.64
1985	7		10.50	16.50	27.65	13.46					68.11
1986	8		18.09	13.43	66.25	36.73	42.21	81.43			258.14
1987	6			22.60	19.29	10.32	19.60	14.72			86.53
1988	15		13.67	11.30	14.40	31.74	11.14				82.25
1989	7		0.40		18.84	14.17	21.40				54.81
1990*	0										*
1991*	0										*
1992	11				10.57	41.54	15.60				67.71
1993*	1					45.36					*
1994*	0										*
1995*	5								49.76		*
1996*	5						38.15	7.19			*
1997*	3						16.45				*
1998	6				27.97	36.22					64.19
1999	11				12.72	34.47	29.70				76.89
2000	19			2.7	20.11	11.87	32.68				67.36
2001	14			8.94	34.03	25.75					68.72
2002	9		5.07	13.5	34.75	16.15		6.23			75.70
2003	7			2.46	13.73	15.13	21.6				52.92
2004	13		2.05	2.32	12.08	18.15					34.60
2005	20			3.19	11.77	12.63	19.29				46.88

*Total catch and CPUE are not representative of entire season due to low sample size.

Table 7.4 Mean total length (TL, mm) and weight (g) of (a) male (b) female and (c) both sexes of American shad collected in the Hudson River Estuary.

(a)

Year	Commercial Fishery						Spawning Stock					
	TL			Weight			TL			Weight		
	N	Mean	STD	N	Mean	STD	N	Mean	STD	N	Mean	STD
						Males						
1980	110	516.6	27.7	110	1572.5	265.8						
1981	225	527.2	26.0	225	1512.8	254.4						
1982	173	534.3	31.6	172	1778.3	295.7						
1983	153	533.9	34.1	152	1754.7	345.1	20	523.4	34.1	20	1493.0	290.4
1984	138	533.0	37.0	139	1831.9	408.2	86	513.9	44.8	85	1429.7	398.1
1985	117	534.9	31.7	115	1835.8	335.8	182	489.3	48.4	147	1170.9	420.2
1986	154	541.5	34.8	153	1919.0	413.4	416	491.4	46.5	393	1299.1	386.7
1987	71	564.7	27.8	71	2124.5	332.5	279	501.4	46.6	276	1286.9	396.4
1988	118	539.4	26.8	118	1909.2	365.8	227	505.9	38.7	219	1370.6	369.6
1989	192	549.4	28.5	174	2042.5	373.7	162	500.7	49.7	162	1246.9	410.9
1990	40	543.7	39.8	40	1909.3	492.1	39	481.4	49.9	38	1047.1	387.6
1991	29	547.0	40.8	27	1792.2	402.0	119	461.3	36.7	117	894.8	221.5
1992	143	512.5	38.5	138	1459.6	385.9	995	460.1	29.4	848	884.8	235.6
1993	35	522.3	30.3	35	1601.1	296.3	318	459.4	27.2	316	799.0	189.2
1994	15	514.2	19.2	8	1572.5	213.3	93	461.7	26.7	87	890.1	202.7
1995	113	516.6	21.9	78	1670.6	189.0	286	471.5	34.9	280	989.0	249.1
1996	63	521.4	22.9	63	1627.1	274.6	295	460.1	37.5	292	890.8	438.5
1997	124	514.7	31.8	124	1520.5	293.5	77	454.9	38.8	76	915.2	285.6
1998	84	504.6	28.7	84	1533.5	282.1	164	457.1	32.0	160	946.4	223.2
1999	157	515.6	30.4	157	1470.0	276.8	183	469.4	34.5	180	912.7	213.6
2000	202	510.7	30.6	192	1531.3	300.6	216	476.4	35.4	207	1058.3	260.4
2001	194	520.5	26.2	194	1469.9	241.3	570	477.1	35.1	538	969.3	241.8
2002	72	527.7	41.0	72	1734.3	316.6						
2003	57	526.6	35.5	57	1732.1	381.9	274	495.4	35.6	271	1201.8	301.2
2004	124	524.4	30.4	128	1676.3	280.7	282	502.4	42.5	283	1250.6	335.2
2005	195	526.7	28.8	195	1678.2	306.1	224	491.3	48.5	223	1168.4	350.8

Table 7.4 (cont.) Mean total length (TL, mm) and weight (g) of (a) male (b) female and (c) both sexes of American shad collected in the Hudson River Estuary.

(b)

Year	Commercial Fishery						Spawning Stock					
	TL			Weight			TL			Weight		
	N	Mean	STD	N	Mean	STD	N	Mean	STD	N	Mean	STD
Females												
1980	272	550.3	26.0	272	2101.5	337.6						
1981	579	563.0	29.8	579	2086.8	398.7						
1982	426	569.9	32.8	420	2307.4	454.1						
1983	389	566.9	37.2	388	2300.1	506.1						
1984	399	579.1	36.3	411	2507.0	513.9	61	587.0	42.3	61	2361.4	541.0
1985	474	572.4	40.3	473	2489.2	598.0	105	572.6	45.7	78	2024.6	629.1
1986	480	586.6	38.1	476	2635.2	572.0	287	568.5	44.0	277	2040.1	542.4
1987	470	595.1	39.4	469	2647.8	550.7	283	571.4	45.5	277	1946.4	504.8
1988	254	582.2	40.3	253	2571.2	575.0	316	572.3	39.1	309	2006.4	525.0
1989	332	577.9	31.6	300	2502.6	469.7	189	566.8	40.5	187	1891.2	541.8
1990	223	584.9	40.1	223	2530.7	552.6	48	555.4	46.2	49	1656.7	440.8
1991	223	568.7	39.4	220	2265.6	469.1	101	536.5	35.7	100	1483.1	335.3
1992	364	545.5	32.4	361	1957.1	402.1	444	525.9	33.3	439	1429.7	370.1
1993	73	555.4	34.1	73	1962.5	396.9	144	514.8	31.0	139	1173.5	261.0
1994	114	542.5	24.6	104	1798.5	307.2	89	513.7	23.2	83	1248.0	240.7
1995	149	544.2	21.4	107	1993.9	275.8	459	528.0	26.8	451	1476.2	308.7
1996	355	540.2	29.1	355	1959.2	347.5	131	533.2	43.5	126	1547.1	505.1
1997	242	536.5	34.9	242	1908.8	400.0	64	522.0	47.2	63	1440.2	438.0
1998	275	530.5	36.7	275	1904.2	442.0	145	529.8	36.8	143	1532.5	404.2
1999	306	542.5	33.0	305	1868.0	379.6	193	518.9	35.0	191	1312.6	315.6
2000	305	542.6	27.9	293	2033.4	386.4	217	534.5	30.0	213	1502.9	300.8
2001	355	547.4	32.8	356	1898.5	360.3	486	541.7	35.0	462	1498.6	349.1
2002	137	562.1	31.6	137	2265.0	467.6						
2003	65	565.0	34.1	63	2254.8	518.4	342	559.7	38.8	339	1830.4	453.2
2004	166	557.5	40.0	169	2132.7	502.0	545	569.2	43.6	540	1919.6	528.5
2005	205	558.6	38.0	206	2193.7	521.5	382	564.3	41.9	380	1840.8	479.4

Table 7.4 (cont.) Mean total length (TL, mm) and weight (g) of (a) male (b) female and (c) both sexes of American shad collected in the Hudson River Estuary.

(c)

Year	Commercial Fishery						Spawning Stock					
	TL			Weight			TL			Weight		
	N	Mean	STD	N	Mean	STD	N	Mean	STD	N	Mean	STD
Both Sexes												
1980	382	540.6	30.6	382	1949.1	398.5						
1981	804	553.0	33.0	804	1926.2	446.1						
1982	611	559.5	36.5	604	2154.0	479.8						
1983	543	557.6	39.3	541	2146.2	526.4	20	523.4	34.1	20	1493.0	290.4
1984	540	567.4	41.8	554	2336.3	573.0	150	543.0	57.9	149	1806.0	656.7
1985	597	564.6	41.6	594	2359.7	611.8	287	519.7	62.1	225	1466.8	645.7
1986	642	575.0	42.3	637	2451.9	621.1	703	522.9	59.2	670	1605.5	585.1
1987	541	591.1	39.5	540	2579.0	555.9	564	536.5	57.9	555	1615.4	560.8
1988	372	568.6	41.6	371	2360.6	602.3	543	544.6	50.9	528	1742.7	562.1
1989	525	567.3	33.8	475	2331.2	492.3	373	536.3	55.0	370	1581.9	571.4
1990	263	578.6	42.6	263	2436.2	587.2	88	522.0	60.0	88	1388.3	512.8
1991	252	566.2	40.1	247	2213.9	484.6	225	495.7	51.9	222	1164.6	402.7
1992	509	536.2	37.3	501	1819.4	454.5	1443	480.5	43.2	1290	1070.7	386.9
1993	108	544.7	36.3	108	1845.4	403.4	467	476.7	38.1	460	913.9	273.7
1994	129	539.2	25.6	112	1782.3	306.3	184	487.2	35.9	172	1064.2	283.5
1995	267	532.4	25.6	186	1857.1	289.8	763	506.5	40.7	749	1287.2	369.8
1996	418	537.4	29.0	418	1909.2	357.6	433	482.6	51.8	425	1085.7	547.0
1997	366	529.1	35.4	366	1777.2	410.5	143	485.5	54.0	141	1151.2	443.6
1998	359	524.5	36.6	359	1817.4	439.0	313	491.8	50.4	307	1227.5	438.1
1999	463	533.4	34.6	462	1732.8	395.7	383	494.5	42.6	377	1117.9	336.7
2000	508	529.9	32.9	486	1835.8	431.7	439	505.3	43.7	426	1281.0	357.5
2001	549	537.9	33.2	550	1747.3	382.7	1061	506.8	47.5	1002	1213.2	396.6
2002	209	550.2	38.7	209	2082.2	491.0						
2003	122	547.0	39.5	120	2006.5	526.6	621	531.0	49.1	614	1549.8	501.3
2004	290	543.4	39.7	297	1936.0	477.6	835	546.4	53.4	831	1687.0	566.6
2005	400	543.0	37.4	401	1943.0	501.4	613	537.2	56.7	609	1590.0	542.6

Table 7.5 Age structure and repeat spawn data of (a) male and (b) female American shad from fishery-dependent sampling (commercial gill net) in the Hudson River Estuary, 1980-2005.

Year	Age											Total	Mean Age	Mean Repeat Spawn	Virgin (%)	Repeat (%)
	3	4	5	6	7	8	9	10	11	12	13					
Male																
1980		9	26	29	28	10						102	6.0	1.42	0.23	0.77
1981		12	23	45	57	23	1					161	6.4	1.74	0.19	0.81
1982	1	11	24	29	33	20	17	3				138	6.6	2.03	0.22	0.78
1983		9	37	23	16	19	9	5	2			120	6.5	1.87	0.29	0.71
1984		1	28	24	11	16	6	3	1			90	6.5	1.99	0.23	0.77
1985		5	20	27	21	10	4	2				89	6.3	1.84	0.29	0.71
1986		7	28	25	18	10	4	1	2			95	6.2	1.87	0.17	0.83
1987			4	16	11	12	10	2	3			58	7.4	2.78	0.05	0.95
1988	1	3	19	44	25	12	7	3				114	6.5	1.96	0.15	0.85
1989		1	21	64	43	38	11	2				180	6.8	2.19	0.13	0.87
1990		1	8	8	6	5	1					29	6.3	1.69	0.31	0.69
1991	2	2	1	5	9	6						25	6.4	2.32	0.16	0.84
1992	2	20	28	39	30	9	1					129	5.8	1.20	0.33	0.67
1993		3	3	13	11	2	0					32	6.2	1.66	0.16	0.84
1994			2	6	5	0	1					14	6.4	1.79	0.07	0.93
1995		4	22	44	26	9	1					106	6.2	1.47	0.25	0.75
1996*	0.2	7.9	22.7	20.6	8.9	2.3	0.4	0.1	0.0			63	5.6			
1997*	1.2	15.6	32.6	37.6	24.7	9.5	2.3	0.4	0.0			124	5.9			
1998*	0.3	11.1	29.2	26.5	11.8	3.9	0.9	0.2	0.0			84	5.7			
1999*	0.8	17.0	47.9	48.5	28.3	11.0	2.9	0.6	0.1			157	5.9			
2000*	0.7	25.9	69.5	62.2	30.2	10.0	2.1	0.4	0.0			201	5.7			
2001*	0.5	14.6	51.1	67.5	41.1	14.4	3.8	0.7	0.2			194	6.0			
2002*	0.0	3.8	9.5	13.4	9.4	4.4	1.3	0.2	0.0			42	6.1			
2003*	0.3	5.3	11.7	15.0	13.6	8.0	2.5	0.5	0.1			57	6.3			
2004*	0.3	8.7	32.2	38.2	24.9	11.3	3.4	0.8	0.1			120	6.1			
2005*	0.4	12.0	46.1	62.0	44.4	21.9	6.6	1.4	0.1			195	6.2			

*1996 through 2005 ages estimated with a length-age key, ageing in progress.

Table 7.5 (cont.) Age structure and repeat spawn data of (a) male and (b) female American shad from fishery-dependent sampling (commercial gill net) in the Hudson River Estuary, 1980-2005.

(b)

Year	Age											Total	Mean Age	Mean Repeat Spawn	Virgin (%)	Repeat (%)
	3	4	5	6	7	8	9	10	11	12	13					
Female																
1980		6	100	101	36	11	3					257	5.8	0.72	0.50	0.50
1981		7	104	160	87	56	12	4				430	6.3	1.10	0.41	0.59
1982		11	101	105	79	48	17	8	1			370	6.4	1.23	0.39	0.61
1983	1	9	104	97	31	28	14	16	1			301	6.2	0.97	0.58	0.42
1984		6	57	99	48	20	23	9	2	2		266	6.5	1.30	0.48	0.52
1985		18	91	107	68	26	20	11	6	2		349	6.4	1.25	0.44	0.56
1986		8	87	91	49	27	16	6	1	2		287	6.3	1.33	0.41	0.59
1987		2	63	104	74	46	27	30	12	3	2	363	7.1	1.85	0.27	0.73
1988	1	7	52	74	60	32	13	4				243	6.5	1.52	0.28	0.72
1989		2	69	113	82	36	7	3				312	6.4	1.29	0.41	0.59
1990		3	42	61	48	28	9	4	1	1		197	6.6	1.61	0.33	0.67
1991		17	59	62	45	12	8	1	1			205	6.0	1.18	0.46	0.54
1992		11	148	115	51	13	6	2				346	5.8	0.71	0.55	0.45
1993		5	16	23	11	6	1					62	6.0	1.16	0.35	0.65
1994			28	46	24	5	2					105	6.1	0.96	0.42	0.58
1995		3	53	54	23	4	2	1				140	5.9	0.73	0.54	0.46
1996*	2.5	22.2	154.2	122.0	41.8	9.3	1.9	0.8	0.1			355	5.6			
1997*	0.5	18.6	111.7	69.7	29.6	8.6	2.2	0.8	0.2	0.0	0.0	242	5.6			
1998*	5.0	26.6	129.2	72.0	29.0	8.8	3.0	1.1	0.2	0.0	0.0	275	5.5			
1999*	1.5	19.2	135.1	97.4	36.2	10.8	3.7	1.7	0.3	0.1	0.0	306	5.7			
2000*	1.5	18.0	137.9	100.3	32.8	9.6	3.2	1.3	0.2	0.0	0.0	305	5.6			
2001*	1.5	19.9	137.5	124.2	52.7	13.8	3.5	1.6	0.3	0.1	0.0	355	5.8			
2002*		2.1	23.5	27.6	15.2	6.0	1.7	0.6	0.1	0.0	0.0	77	6.1			
2003*	0.5	2.5	19.4	22.5	11.9	5.0	2.0	0.9	0.1	0.1	0.0	65	6.1			
2004*		7.6	60.6	46.0	22.9	11.3	5.4	2.5	0.4	0.2	0.0	157	6.0			
2005*	0.5	8.6	70.5	68.4	33.0	14.6	6.4	3.1	0.6	0.3	0.1	206	6.0			

*1996 through 2005 ages estimated with a length-age key, ageing in progress.

Table 7.6 Number, mean and percent repeat spawn data for (a) male and (b) female American shad from fishery dependent (commercial gill net) sampling in the Hudson River Estuary. RS = repeat spawn.

Year	**Number of Repeat Spawning Marks at Age**									**Total**	**Mean RS**	**Virgin (%)**	**Repeat (%)**
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**				
					Male Repeat Spawners								
1980	23	32	30	15	2					102	1.42	0.23	0.77
1981	31	28	61	34	7					161	1.74	0.19	0.81
1982	31	23	26	32	21	5				138	2.03	0.22	0.78
1983	35	22	23	16	15	6	3			120	1.87	0.29	0.71
1984	21	20	14	17	12	5		1		90	1.99	0.23	0.77
1985	26	12	20	15	13	3				89	1.84	0.29	0.71
1986	32	52	52	28	16	8	2			190	1.87	0.17	0.83
1987	3	12	15	6	13	5	4			58	2.78	0.05	0.95
1988	17	24	39	18	12	4				114	1.96	0.15	0.85
1989	24	26	56	46	22	6				180	2.19	0.13	0.87
1990	9	5	5	6	4					29	1.69	0.31	0.69
1991	4	3	4	9	5					25	2.32	0.16	0.84
1992	42	36	35	15	1					129	1.20	0.33	0.67
1993	5	6	16	5	0	0				32	1.66	0.16	0.84
1994	1	4	6	3	0					14	1.79	0.07	0.93
1995	26	25	36	17	2					106	1.47	0.25	0.75
1996- 2005			Analysis incomplete, ageing in progress										
					Female Repeat Spawners								
1980	129	83	35	7	3					257	0.72	0.50	0.50
1981	175	117	79	41	14	4				430	1.10	0.41	0.59
1982	145	95	68	32	23	7				370	1.23	0.39	0.61
1983	175	44	31	28	14	9				301	0.97	0.58	0.42
1984	127	46	36	21	22	10	2	2		266	1.30	0.48	0.52
1985	152	84	48	23	25	14	3			349	1.25	0.44	0.56
1986	118	57	56	28	16	10		2		287	1.33	0.41	0.59
1987	98	97	51	54	26	21	11	4	1	363	1.85	0.27	0.73
1988	68	63	59	29	19	5				243	1.52	0.28	0.72
1989	128	43	82	44	13	2				312	1.29	0.41	0.59
1990	65	39	29	43	16	3	1	1		197	1.61	0.33	0.67
1991	94	40	35	17	16	2	1			205	1.18	0.46	0.54
1992	189	100	35	15	6	1				346	0.71	0.55	0.45
1993	22	17	17	4	1	1				62	1.16	0.35	0.65
1994	44	26	32	1	2					105	0.96	0.42	0.58
1995	76	37	20	4	2	1				140	0.73	0.54	0.46
1996- 2005			Analysis incomplete, ageing in progress										

Table 7.7 Creel survey data for American shad caught in the recreational fishery in the Hudson River Estuary, 2001 and 2005.

Year	Boat	Shore	Total	Retention Rate	Directed Fishing Rates (catch/hour) Time Period	Boat	Shore	Mean Size (TL -mm)
2001 (Mar 16- Jun 30)								
Catch	13034	6732	**19766**			1.498	1.534	511.7
Harvest	1047	242	**1289**	6.5%				
2005 (Mar 16 - Jun 17)								
Catch	2899	3683	**6582**		Early Spring*	-	0.123	541.3
Harvest	485	23	**508**	7.7%	Late Spring*	0.586	0.584	

*Early spring: Mar 16 - Apr 30; late spring May 1- Jun 17.

Table 7.8 Length frequency of (a) male and (b) female Hudson River American shad collected during the spawning stock survey.

(a)

TL (mm)	Year																						
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
300-319																							
320-339																							
340-359													1										
360-379			2	4	3	1		1		5					1		1	1	1				
380-399			2	9	1	1	3	1	4	5	3		9	6	3	1	1		6		1	2	5
400-419		1	5	15	4	3	5		11	37	17	3	14	27	15	11	5	7	14			9	13
420-439		4	16	25	7	1	12	3	23	195	51	13	30	71	8	34	33	28	54		14	9	21
440-459	1	8	27	32	33	19	15	9	19	291	90	32	39	64	12	52	32	38	100		30	21	28
460-479	2	6	30	73	51	22	18	8	26	233	85	25	64	41	16	35	41	43	136		48	41	20
480-499	1	8	29	93	45	61	17	5	19	128	50	12	64	36	16	12	41	38	111		58	52	27
500-519	3	16	22	65	36	43	35	2	12	66	14	6	46	23	1	7	14	35	84		51	42	41
520-539	7	18	19	37	47	33	20	2	2	23	7	1	16	18	4	10	8	19	35		42	46	30
540-559	3	17	16	27	19	20	16	6	2	4		1	2	6	1	1	5	6	22		18	34	21
560-579	3	3	6	19	11	14	12	1	1	6	1		1	2		1	2		7		11	19	11
580-599		3	5	13	17	7	8	1		2				1				1				6	6
600-619		1	3	4	3	2	1														1	1	1
620-639		1			1																		
640-659					1																		
660-679																							
>680																							
TOTAL	**20**	**86**	**182**	**416**	**279**	**227**	**162**	**39**	**119**	**995**	**318**	**93**	**286**	**295**	**77**	**164**	**183**	**216**	**570**	**0**	**274**	**282**	**224**

Table 7.8 (cont.) Length frequency of (a) male and (b) female Hudson River American shad collected during the spawning stock survey.

(b)

TL (mm)	Year																						
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
300-319																							
320-339																							
340-359																							
360-379																							
380-399																							
400-419										1	1												
420-439			1										1		1				1		1	1	
440-459		1			2	1	1		1	3	2		4	5	4	1	2	3	5		1	2	1
460-479				1	2	2		2	1	24	10	6	20	9	5	11	13	4	11		7	6	6
480-499			4	10	5	5	4	5	10	76	33	19	36	18	14	13	49	13	37		14	20	17
500-519		2	8	22	16	9	9	6	20	88	43	27	92	22	13	29	48	43	70		28	46	35
520-539		6	14	43	30	41	35	6	32	105	24	27	164	19	9	41	31	55	94		42	81	47
540-559		4	15	68	71	62	42	5	12	88	16	9	86	20	5	23	22	60	110		72	72	76
560-579		12	15	40	57	65	38	7	9	39	11		44	20	3	9	14	25	105		64	86	65
580-599		12	18	33	32	66	21	8	11	9	4	1	9	9	4	13	9	12	33		66	93	56
600-619		9	15	24	22	29	20	4	3	5			3	6	4	3	3	1	10		25	69	36
620-639		8	9	20	18	17	12	5	1	4				1	2	1	2		8		18	52	31
640-659		6	3	17	12	10	2		1	1				1		1		1	2		3	22	9
660-679		1	3	9	13	7	3			1				1							1	3	3
>680					3	2	2																
TOTAL		**61**	**105**	**287**	**283**	**316**	**189**	**48**	**101**	**444**	**144**	**89**	**459**	**131**	**64**	**145**	**193**	**217**	**486**	**0**	**342**	**553**	**382**

Table 7.9 Age structure and repeat spawn percent of American shad from spawning stock sampling in the Hudson River Estuary, 1983-2005. RS = repeat spawn.

Year	Age											Total	Mean Age	Mean RS	Virgin (%)	Repeat (%)
	3	4	5	6	7	8	9	10	11	12	13					
Male																
1983		2	5	5	4	2	2					20	6.25	1.75	0.20	0.80
1984	3	18	23	22	9	7	1	1				84	5.55	1.10	0.45	0.55
1985	13	54	53	24	12	8	2	1				167	5.03	0.78	0.59	0.41
1986	9	77	72	39	15	6	3		1			222	5.05	0.74	0.61	0.39
1987	5	51	59	31	17	6	6	2	2			179	5.38	0.97	0.55	0.45
1988	2	42	97	42	26	7	4	2				222	5.43	0.83	0.58	0.42
1989	2	33	46	36	23	17	5	1				163	5.74	1.19	0.48	0.52
1990		7	16	7	7	1						38	5.45	0.74	0.63	0.37
1991	12	46	33	16	4	1						112	4.62	0.29	0.79	0.21
1992	13	172	232	68	7	1	2					495	4.79	0.27	0.78	0.22
1993	5	92	156	47	17	2						319	4.95	0.44	0.68	0.32
1994	2	32	36	7	3							80	4.71	0.53	0.69	0.31
1995	23	96	82	31	9							241	4.61	0.46	0.68	0.32
1996	23	162	64	15	4	1						269	4.32	0.49	0.62	0.38
1997	4	24	30	10	1			1				70	4.79	0.47	0.69	0.31
1998	7	78	48	12	4							149	4.52	0.69	0.52	0.48
1999	2	64	80	19	2	2						169	4.77	0.87	0.43	0.57
2000	22	79	67	15	1	1						185	4.44	0.63	0.56	0.44
2001	41	209	146	71	24	4						495	4.68	0.86	0.44	0.56
2002							No sampling									
2003*	5.2	63.4	107.7	62.0	25.8	7.9	1.4	0.4	0.2			274	5.26			
2004	7	39	86	60	35	32	4	2	1			266	5.77	1.60	0.29	0.71
2005*	11.2	58.0	69.7	46.9	23.6	9.5	3.6	1.1	0.4			224	5.29			
Female																
1983												0				
1984		1	7	15	14	8	5	3	1			54	6.98	1.85	0.31	0.69
1985	1	10	16	27	17	11	5	4	3			94	6.49	1.51	0.34	0.66
1986		17	56	65	26	17	10	2	4			197	6.14	1.07	0.53	0.47
1987		13	61	46	25	20	14	6	1	2	1	186	6.46	0.87	0.55	0.45
1988		16	90	104	56	14	11	6	5	2		302	6.23	1.14	0.42	0.58
1989		8	57	52	45	19	7	6	3			197	6.36	1.20	0.49	0.51
1990		2	16	11	13	5	1	1				49	6.20	0.96	0.55	0.45
1991	1	10	31	34	14	3	1	1				95	5.72	0.51	0.72	0.28
1992		21	169	161	67	8	6	2				434	5.76	0.54	0.62	0.38
1993		9	59	53	18	9						148	5.72	0.60	0.60	0.40
1994			49	19	7	2						77	5.51	0.62	0.60	0.40
1995	3	64	215	132	34	3						451	5.31	0.51	0.63	0.37
1996		30	50	20	8	4	2	1				115	5.27	0.94	0.47	0.53
1997		13	32	13	6	5	6					75	5.68	0.79	0.63	0.37
1998		28	65	24	7	5	1					130	5.22	1.01	0.41	0.59
1999		35	108	28	13		1					185	5.12	0.85	0.41	0.59
2000		46	113	25	5	2	1					192	4.99	0.78	0.47	0.53
2001	7	76	175	122	40	6	3	1				430	5.34	1.11	0.37	0.63
2002							No sampling									
2003*	0.9	23.7	103.0	108.2	66.5	23.4	11.5	3.4	1.4	0.1		342	6.05			
2004	1	21	97	117	128	63	48	24	3	1	1	502	6.78	2.18	0.23	0.77
2005*	0.6	25.6	113.1	111.5	71.9	30.5	19.0	6.4	3.2	0.2		382	6.18			

* Ages estimated using an age-length key, ageing in progress.

Table 7.10 Number, mean, and percent repeat spawn of American shad from spawning stock sampling in the Hudson River Estuary.

Year	Repeat Spawning at Age									Total	Mean RS	Virgin (%)	Repeat (%)
	0	1	2	3	4	5	6	7	8				
Male Repeat Spawners													
1983	4	6	3	5	2					20	1.75	0.20	0.80
1984	38	17	16	10	2	1				84	1.10	0.45	0.55
1985	99	33	17	11	4	3				167	0.78	0.59	0.41
1986	135	41	25	10	11					222	0.74	0.61	0.39
1987	98	33	26	8	8	4	2			179	0.97	0.55	0.45
1988	128	40	30	14	8	2	0			222	0.83	0.58	0.42
1989	78	31	18	19	15	2				163	1.19	0.48	0.52
1990	24	4	7	2	1	0				38	0.74	0.63	0.37
1991	89	17	4	1	1					112	0.29	0.79	0.21
1992	387	84	22		2					495	0.27	0.78	0.22
1993	217	72	23	7						319	0.44	0.68	0.32
1994	55	12	10	2	1					80	0.53	0.69	0.31
1995	164	48	25	4						241	0.46	0.68	0.32
1996	168	76	19	5	1					269	0.49	0.62	0.38
1997	48	16	3	2		1				70	0.47	0.69	0.31
1998	78	44	22	5						149	0.69	0.52	0.48
1999	73	53	37	4	2					169	0.87	0.43	0.57
2000	103	52	27	2	1					185	0.63	0.56	0.44
2001	216	172	71	32	4					495	0.86	0.44	0.56
2002						No sampling							
2003*													
2004	76	63	53	46	22	5	1			266	1.60	0.29	0.71
2005*													
Female Repeat Spawners													
1983										0			
1984	17	10	8	6	9	4				54	1.85	0.31	0.69
1985	32	24	15	11	5	7				94	1.51	0.34	0.66
1986	104	42	18	11	14	6	1	1		197	1.07	0.53	0.47
1987	96	36	23	9	5	2	2			173	0.87	0.55	0.45
1988	127	86	45	26	11	5	4			304	1.14	0.42	0.58
1989	97	27	34	25	6	5	3			197	1.20	0.49	0.51
1990	27	6	10	4	1	1				49	0.96	0.55	0.45
1991	68	14	8	3	1	1				95	0.51	0.72	0.28
1992	268	118	35	6	5	2				434	0.54	0.62	0.38
1993	89	35	18	6						148	0.60	0.60	0.40
1994	46	19	8	3	1					77	0.62	0.60	0.40
1995	284	113	47	7						451	0.51	0.63	0.37
1996	54	30	20	7	3	1				115	0.94	0.47	0.53
1997	47	11	6	8	3					75	0.79	0.63	0.37
1998	53	36	31	7	3					130	1.01	0.41	0.59
1999	76	71	30	7		1				185	0.85	0.41	0.59
2000	91	63	29	7	2					192	0.78	0.47	0.53
2001	157	125	103	37	6	2				430	1.11	0.37	0.63
2002						No sampling							
2003*													
2004	115	83	86	99	73	35	11	0	2	504	2.18	0.23	0.77
2005*													

*Ageing in progress.

Table 7.11 Estimates of total instantaneous mortality (Z), annual survival (S), and fishing mortality (F, assume M=0.3) of American shad collected in the spawning stock survey in the Hudson River Estuary.

Year	Catch Curve - Age					Catch Curve - Spawning Marks				
	Ages	Z	SE	S	F	Spawning Marks	Z	S	SE	F
Spawning Stock - Males										
1984	5-10	0.72	0.12	0.49	0.42	1-5	0.77	0.15	0.46	0.47
1985	4-10	0.70	0.07	0.50	0.40	1-5	0.62	0.05	0.54	0.32
1986	4-9	0.68	0.05	0.51	0.38	1-4	0.49	0.14	0.61	0.19
1987	5-11	0.60	0.05	0.55	0.30	1-6	0.54	0.15	0.58	0.24
1988	5-10	0.79	0.05	0.45	0.49	1-5	0.73	0.11	0.48	0.43
1989	5-10	0.72	0.14	0.48	0.42	1-5	0.57	0.21	0.57	0.27
1990	5-8	0.83	0.26	0.44	0.53	2-5	0.97	0.16	0.38	0.67
1991	4-8	0.98	0.14	0.38	0.68	1-4	0.99	0.25	0.37	0.69
1992	5-9	1.37	0.30	0.25	1.07	1-4	1.24	0.03	0.29	0.94
1993	5-8	1.41	0.18	0.24	1.11	1-3	1.17	0.01	0.31	0.87
1994	5-7	1.24	0.23	0.29	0.94	1-4	0.91	0.18	0.40	0.61
1995	4-7	0.81	0.18	0.45	0.51	1-3	1.24	0.34	0.29	0.94
1996	4-8	1.29	0.05	0.27	0.99	1-4	1.43	0.04	0.24	1.13
1997	5-10	0.65	0.32	0.52	0.35	1-5	0.63	0.20	0.53	0.33
1998	4-7	1.03	0.13	0.36	0.73	1-3	1.09	0.23	0.34	0.79
1999	5-8	1.33	0.31	0.26	1.03	1-4	1.21	0.25	0.30	0.91
2000	4-8	1.29	0.25	0.27	0.99	1-4	1.45	0.27	0.24	1.15
2001	4-8	0.97	0.16	0.38	0.67	1-4	1.21	0.21	0.30	0.91
2002										
2003	5-11	1.13	0.07	0.32	0.83					
2004	5-11	0.80	0.10	0.45	0.50	1-6	0.82	0.17	0.44	0.52
2005	5-11	0.90	0.06	0.41	0.60					
Spawning Stock - Females										
1984	7-11	0.53	0.07	0.59	0.23	1-5	0.17	0.09	0.84	-0.13
1985	6-11	0.46	0.04	0.63	0.16	1-5	0.36	0.09	0.70	0.06
1986	6-11	0.63	0.12	0.53	0.33	1-7	0.63	0.10	0.53	0.33
1987	5-13	0.56	0.06	0.57	0.26	1-6	0.64	0.06	0.53	0.34
1988	6-12	0.63	0.06	0.53	0.33	1-6	0.65	0.04	0.52	0.35
1989	5-11	0.54	0.06	0.58	0.24	2-6	0.65	0.11	0.52	0.35
1990	5-10	0.63	0.13	0.53	0.33	1-5	0.59	0.18	0.56	0.29
1991	6-10	0.97	0.15	0.38	0.67	1-5	0.74	0.10	0.48	0.44
1992	5-10	0.98	0.13	0.38	0.68	1-5	1.01	0.14	0.36	0.71
1993	5-8	0.67	0.13	0.51	0.37	1-3	0.88	0.13	0.41	0.58
1994	5-8	1.06	0.05	0.35	0.76	1-4	0.98	0.04	0.37	0.68
1995	5-8	1.42	0.31	0.24	1.12	1-3	1.39	0.30	0.25	1.09
1996	5-10	0.78	0.03	0.46	0.48	1-5	0.87	0.07	0.42	0.57
1997	5-9	0.43	0.14	0.65	0.13	1-4	0.36	0.16	0.70	0.06
1998	5-9	0.99	0.10	0.37	0.69	1-4	0.89	0.18	0.41	0.59
1999	5-9	1.15	0.07	0.32	0.85	1-5	1.09	0.06	0.34	0.79
2000	5-9	1.20	0.12	0.30	0.90	1-4	1.18	0.09	0.31	0.88
2001	5-10	1.11	0.09	0.33	0.81	1-5	1.11	0.16	0.33	0.81
2002										
2003	6-12	1.13	0.14	0.32	0.83					
2004	7-13	0.91	0.11	0.40	0.61	3-8	0.82	0.07	0.44	0.52
2005	5-12	0.83	0.12	0.44	0.53					

Table 7.12 Tag-recapture matrix and model summary for American shad tagged in the Hudson River. For outputs from MARK software, S-survival, r-recovery, t-vary with time, .-constant, p-period 1=before 1995-1999, 2=after 1999.

Year	Releases	Recaptures											
		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
1995	2516	51	12	2	1	0	0	0	0	0	0	0	**66**
1996	1500		23	4	0	0	0	0	0	0	0	0	**27**
1997	1944			34	10	2	0	0	0	0	0	0	**46**
1998	237				0	0	0	0	0	0	0	0	**0**
1999	392					2	0	1	0	0	0	0	**3**
2000	468						0	2	1	0	0	0	**3**
2001	515							1	2	3	1	1	**8**
2002	63								0	0	0	0	**0**
2003	574									1	3	1	**5**
2004	728										3	3	**6**
2005	493											2	**2**
Totals	**9429**	**51**	**35**	**40**	**11**	**4**	**0**	**4**	**3**	**4**	**7**	**7**	**166**

Survival Estimate Output from MARK Software				
Years	**Model**	**S(I)**	**SE**	**Z**
1995-1997	S(.)r(.)	0.22	0.05	1.53
	S(.)r(t)	0.23	0.05	1.46
1995-1998	S(.)r(.)	0.23	0.04	1.47
1995-1999	S(.)r(.)	0.23	0.03	1.48
	S(.)r(t)	0.27	0.05	1.30
1995-2001	S(.)r(t)	0.35	0.05	1.06
1995-2002	S(p)r(.) 1	0.25	0.03	1.38
	S(p)r(.) 2	0.88	0.05	0.12
1995-2003	S(p)r(.) 1	0.22	0.03	1.50
	S(p)r(.) 2	0.88	0.04	0.13
1995-2004	S(p)r(.) 1	0.22	0.03	1.50
	S(p)r(.) 2	0.88	0.04	0.13

Table 7.13 NYSDEC young-of-year indices for American shad collected in the Hudson River Estuary.

Year	Number of Hauls	Number Collected	Number of Zero Hauls	Geometric Mean	LCI	UCI	Arithmetic Mean	SE
1980	20	1071	0	23.9	12.9	43.5	53.6	18.1
1981	21	1098	3	19.1	8.7	40.1	52.3	14.2
1982	23	583	3	12.2	6.3	22.8	25.4	5.1
1983	133	5289	4	18.1	14.2	22.9	39.6	4.8
1984	124	2039	13	7.8	6.1	9.9	16.4	2.0
1985	177	10652	10	26.7	21.6	32.8	59.8	7.0
1986	186	14273	4	46.3	39.0	55.0	77.2	5.5
1987	95	3622	7	20.2	15.5	26.3	38.1	5.9
1988	192	14099	10	27.6	22.1	34.5	73.4	10.2
1989	212	19601	4	46.5	39.1	55.3	92.6	9.1
1990	202	16501	7	41.2	34.6	49.2	81.7	9.6
1991	240	15051	17	24.1	19.5	29.6	62.7	5.5
1992	245	18408	14	35.2	29.3	42.2	75.1	8.0
1993	205	5107	21	11.6	9.5	14.2	24.9	2.2
1994	217	9363	1	26.1	22.5	30.3	43.2	2.9
1995	238	3884	56	5.7	4.6	7.1	16.3	2.2
1996	187	14589	8	42.0	34.7	50.8	78.0	6.5
1997	210	6717	8	13.7	11.3	16.6	32.0	3.7
1998	219	1954	51	3.7	3.0	4.5	8.9	1.1
1999	239	15926	16	20.9	16.9	25.8	66.6	8.7
2000	241	7580	39	12.3	10.0	15.0	31.5	3.4
2001	227	15692	5	38.0	32.2	44.7	69.1	4.9
2002	219	2591	95	2.9	2.2	3.8	11.8	1.7
2003	244	4004	49	6.7	5.5	8.2	16.4	1.7
2004	229	3223	41	5.3	4.3	6.5	14.1	1.6
2005	237	4783	37	8.3	6.6	10.1	20.4	2.1

* YOY mean: number per haul, weeks 26-42.

Table 7.14 (a) Ichthyoplankton density (Number/1000 cubic meters) of various life stages of American shad collected in the Long River Survey for the Hudson River Generating companies (ASA 2006) and annual estimates of American shad conditional entrainment mortality rates (CHGE *et al.* 1999). Indices expressed as density (number per 1000^3) and CEMR expressed as percent. (b) R^2 Values comparing age-0 indices for Hudson River American shad.

(a)

Year	**EGG Index**	**SE (eggs)**	**YSL Index**	**SE (YSL)**	**PYSL Index**	**SE (PYSL)**	**BSS Index**	**SE (BSS)**	**CEMR**
1974	0.10	0.03	0.00	0.00	0.17	0.07	11.50	0.83	3.1
1975	0.06	0.02	0.03	0.00	0.28	0.18	10.63	1.43	36.5
1976	0.04	0.01	0.02	0.00	0.16	0.05	13.33	0.87	35.6
1977	0.04	0.00	0.02	0.00	0.17	0.03	13.70	1.39	7.1
1978	0.04	0.01	0.03	0.00	0.09	0.03	23.67	2.66	18.9
1979	0.05	0.01	0.05	0.01	0.49	0.07	11.65	1.74	29.5
1980	0.05	0.01	0.11	0.01	0.48	0.22	10.75	2.46	37.7
1981	0.16	0.08	0.11	0.01	0.78	0.31	17.62	2.17	15.5
1982	0.12	0.04	0.15	0.02	0.59	0.12	16.31	1.92	11.4
1983	0.36	0.11	0.13	0.02	0.57	0.09	19.68	3.89	18.9
1984	0.47	0.11	0.24	0.02	0.38	0.17	8.69	1.84	21.0
1985	0.26	0.04	0.25	0.04	0.67	0.17	8.08	1.30	19.6
1986	0.77	0.33	0.12	0.02	1.05	0.15	19.06	3.74	10.7
1987	0.35	0.08	0.06	0.01	0.18	0.08	13.47	2.28	30.0
1988	0.26	0.05	0.09	0.03	0.73	0.34	7.72	1.01	38.8
1989	0.33	0.06	0.08	0.01	1.04	0.79	22.05	2.41	39.2
1990	0.27	0.06	0.40	0.05	1.17	0.73	18.67	1.74	47.7
1991	0.09	0.02	0.04	0.01	0.32	0.12	11.97	3.16	32.9
1992	0.08	0.02	0.08	0.01	0.62	0.21	13.92	1.05	52.0
1993	0.12	0.03	0.01	0.00	0.23	0.12	7.07	0.87	9.6
1994	0.23	0.04	0.04	0.01	0.37	0.13	17.56	3.28	21.5
1995	0.12	0.03	0.02	0.00	0.19	0.06	3.79	0.43	12.3
1996	0.26	0.04	0.01	0.00	0.26	0.06	11.77	1.93	6.5
1997	0.04	0.01	0.01	0.00	0.15	0.03	12.54	2.04	16.9
1998	0.09	0.01	0.01	0.00	0.09	0.03	2.36	0.42	
1999	0.09	0.02	0.00	0.00	0.18	0.07	8.81	2.44	
2000	0.12	0.02	0.01	0.00	0.09	0.03	5.93	0.93	
2001	0.04	0.01	0.01	0.00	0.46	0.18	24.40	1.83	
2002	0.03	0.00	0.02	0.00	0.10	0.04	4.79	0.47	
2003	0.07	0.02	0.01	0.00	0.09	0.03	8.69	1.20	
2004	0.03	0.01	0.01	0.00	0.14	0.06	3.40	0.61	
2005	0.04	0.01	0.00	0.00	0.03	0.02	3.21	0.60	

(b)

Index	**EGG**	**YSL**	**PYSL**	**BSS**
NYSDEC YOY	0.23	0.11	0.56	0.53
EGG		0.25	0.35	0.08
YSL			0.51	0.07
PSYL				0.29

Table 7.15 Abundance indices for spawning adult (ages 5-7) American shad in the Hudson River.

Year-class	Ages 5-7		
	Female	**Male**	**Both**
1975	14.72	3.50	18.22
1976	6.72	2.27	8.99
1977	6.85	2.03	8.88
1978	11.89	5.17	17.06
1979	19.13	9.01	28.13
1980	33.18	11.43	44.61
1981	39.84	15.21	55.05
1982	29.96	10.62	40.58
1983	25.32	7.27	32.59
1984	16.64	2.89	19.53
1985	11.23	1.74	12.98
1986	12.44	0.80	13.24
1987	16.62	0.96	17.58
1988	15.87	0.80	16.66
1989	13.28	1.01	14.30
1990	12.18	1.19	13.37
1991	12.13	1.57	13.70
1992	7.77	1.52	9.28
1993	12.59	2.47	15.06
1994	18.99	3.02	22.00
1995	24.35	5.13	29.48
1996	13.01	3.53	16.54

Table 7.16 Various relative indices of spawning stock abundance for American shad of the Hudson River Estuary.

Year	Sum of Weekly CPUE	CPUE			Spawning Stock Abundance						
		Age-5	**Age-6**	**Age-7**	**Age-5**	**Age-6**	**Age-7**	**Ages 5 & 6**	**ESSA Age (5-7)**	**ESSB Age (5-7)**	**ESSB Estimate***
1980	19.59	7.62	7.70	2.74							
1981	14.47	3.50	5.38	2.93							
1982	8.02	2.19	2.28	1.71							
1983	9.16	3.16	2.95	0.94							
1984	9.49	2.03	3.53	1.71							
1985	26.65	6.95	8.17	5.19	40.82	28.45	28.71	33.05	31.82	64.3	
1986	52.27	15.84	16.57	8.92	55.74	50.23	67.62	52.78	55.40	112.9	
1987	47.37	8.22	13.57	9.66	25.47	55.76	73.01	38.49	45.03	89.3	
1988	42.22	9.03	12.86	10.42	30.52	37.58	56.59	34.30	39.30	80.2	
1989	33.79	7.47	12.24	8.88	25.83	46.36	38.88	35.62	36.57	69.2	
1990	16.61	3.54	5.14	4.05	10.84	22.91	15.25	15.76	15.60	25.9	
1991	18.31	5.27	5.54	4.02	16.15	15.47	27.27	15.80	17.83	26.6	
1992	14.61	6.25	4.86	2.15	16.05	13.09	13.95	14.61	14.49	20.9	
1993	13.02	3.36	4.83	2.31	8.43	13.49	18.99	10.82	11.95	14.2	
1994	24.24	6.46	10.62	5.54	10.16	43.04	60.95	19.34	23.23	30.1	
1995	11.49	4.35	4.43	1.89	9.12	15.14	25.04	11.41	12.63	19.1	
1996	20.25	8.80	6.96	2.39	20.23	40.02	34.30	25.89	26.75	41.5	
1997	7.11	3.28	2.05	0.87	7.69	11.82	10.88	8.88	9.12	13.6	
1998	12.23	5.75	3.20	1.29	11.50	17.36	23.93	13.08	13.87	21.5	
1999	10.81	4.77	3.44	1.28	8.17	22.74	18.21	11.17	11.79	16.6	18.5
2000	31.61	14.29	10.40	3.40	24.28	79.84	130.57	34.35	37.71	58.0	25.3
2001	25.74	9.97	9.01	3.82	24.49	31.74	41.06	27.47	29.08	43.7	9.3
2002*											8.3
2003*											15.9
2004*											8.1
2005*											9.9

*Data from 2002-2005 insufficient to generate CPUE and spawning stock indices, see text for methods.

Figure 7.1 Historic commercial fishery landings of American shad in the Hudson River Estuary, 1880-2005.

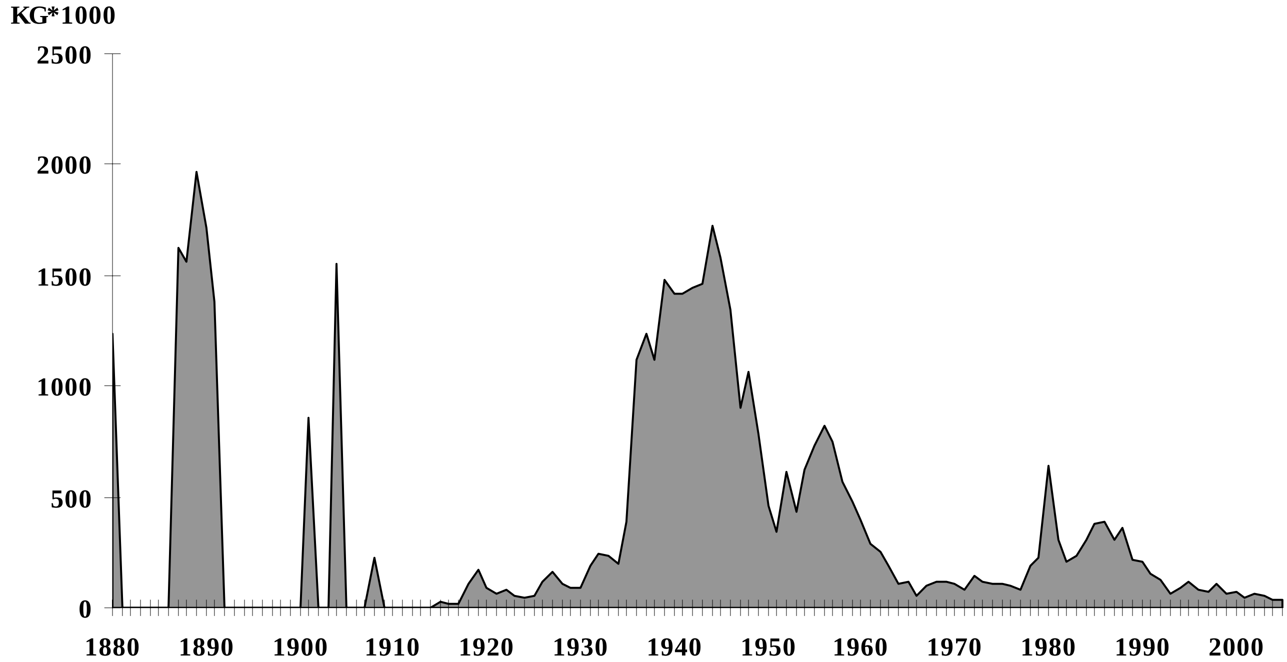


Figure 7.2 Hudson River Estuary with spawning, nursery and fishery areas for American shad.

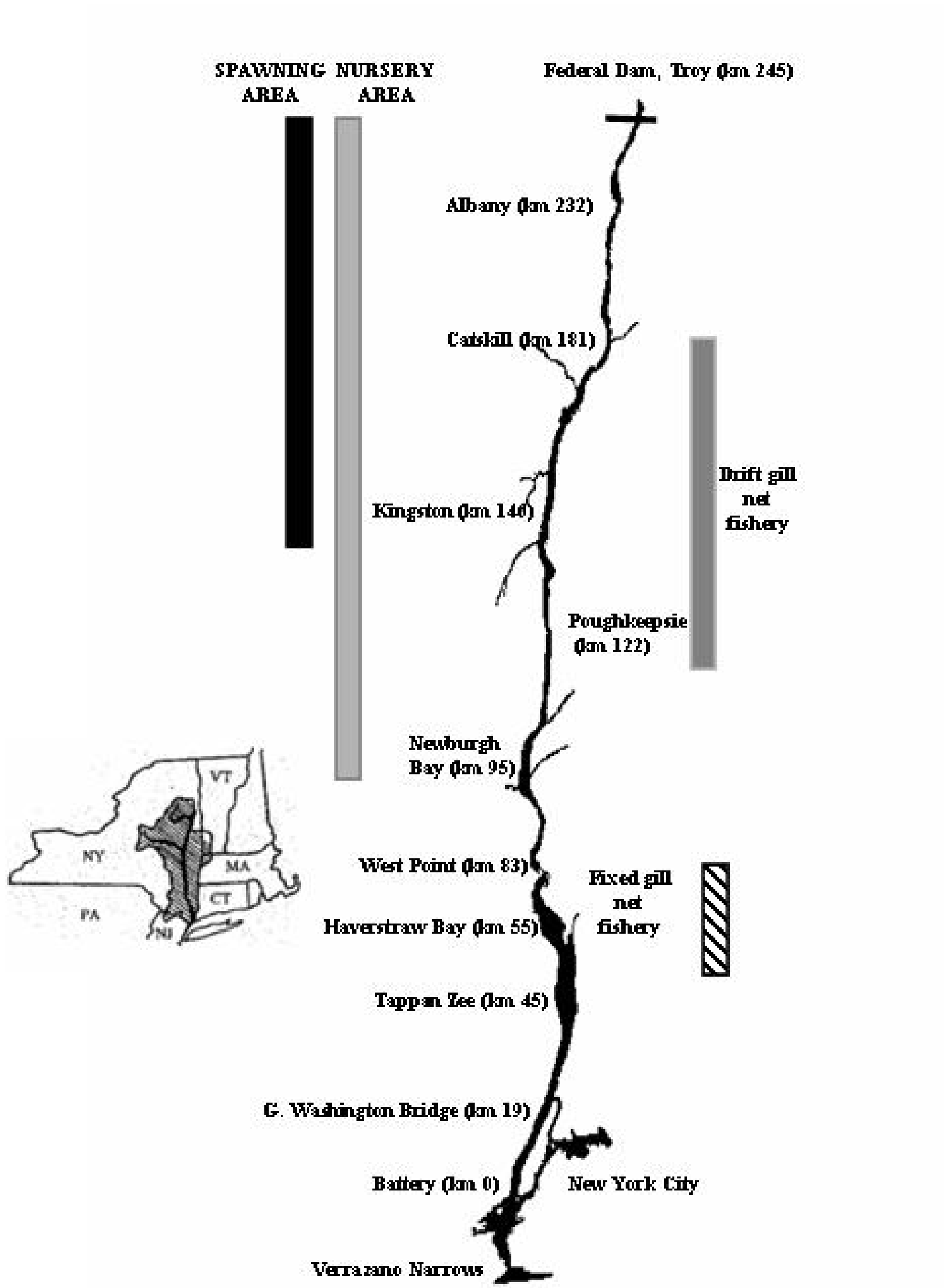


Figure 7.3 Von Bertalanffy and Gompertz growth functions for Hudson River American shad.

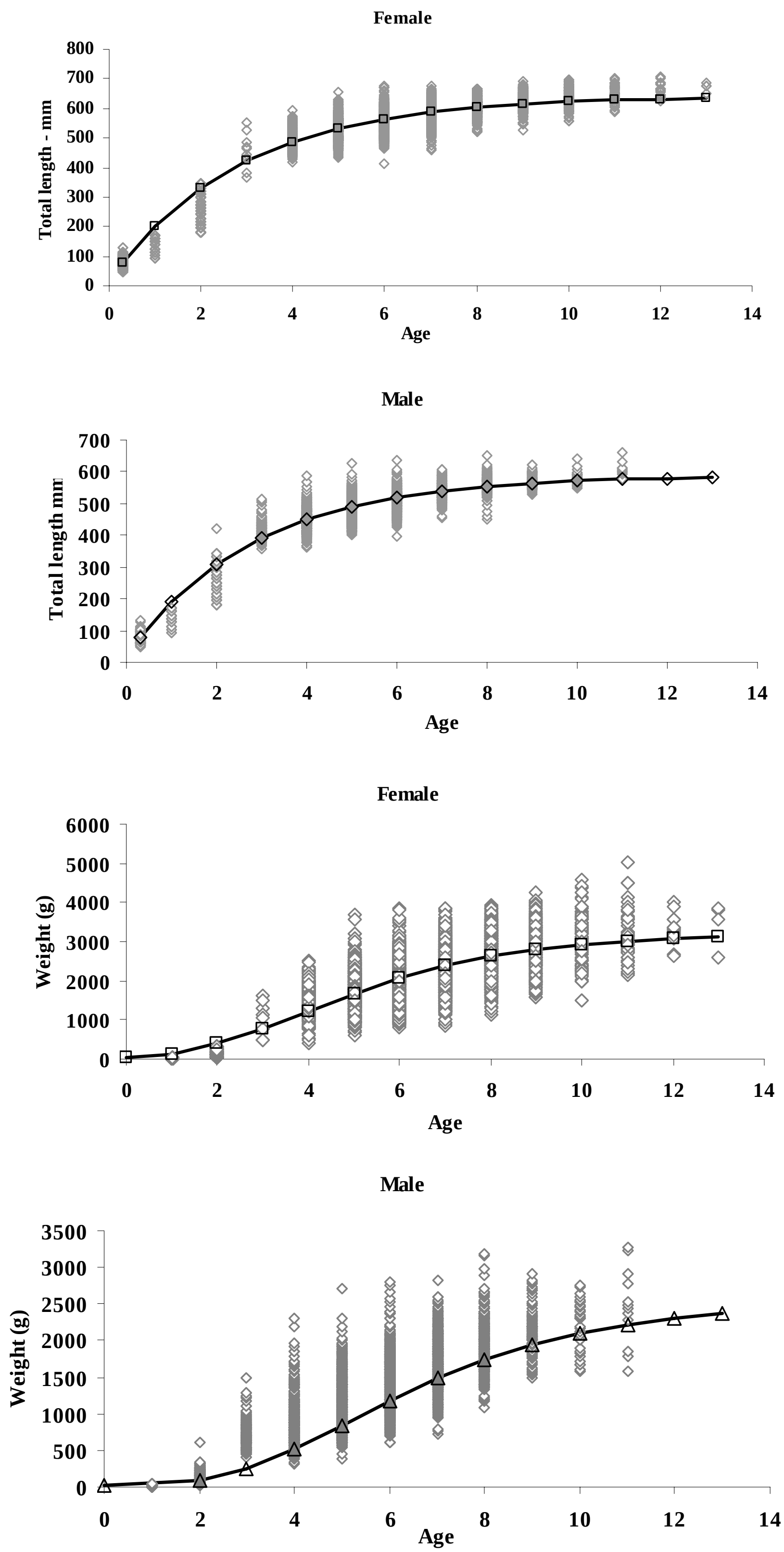


Figure 7.4 Fecundity estimates of Hudson River American shad.

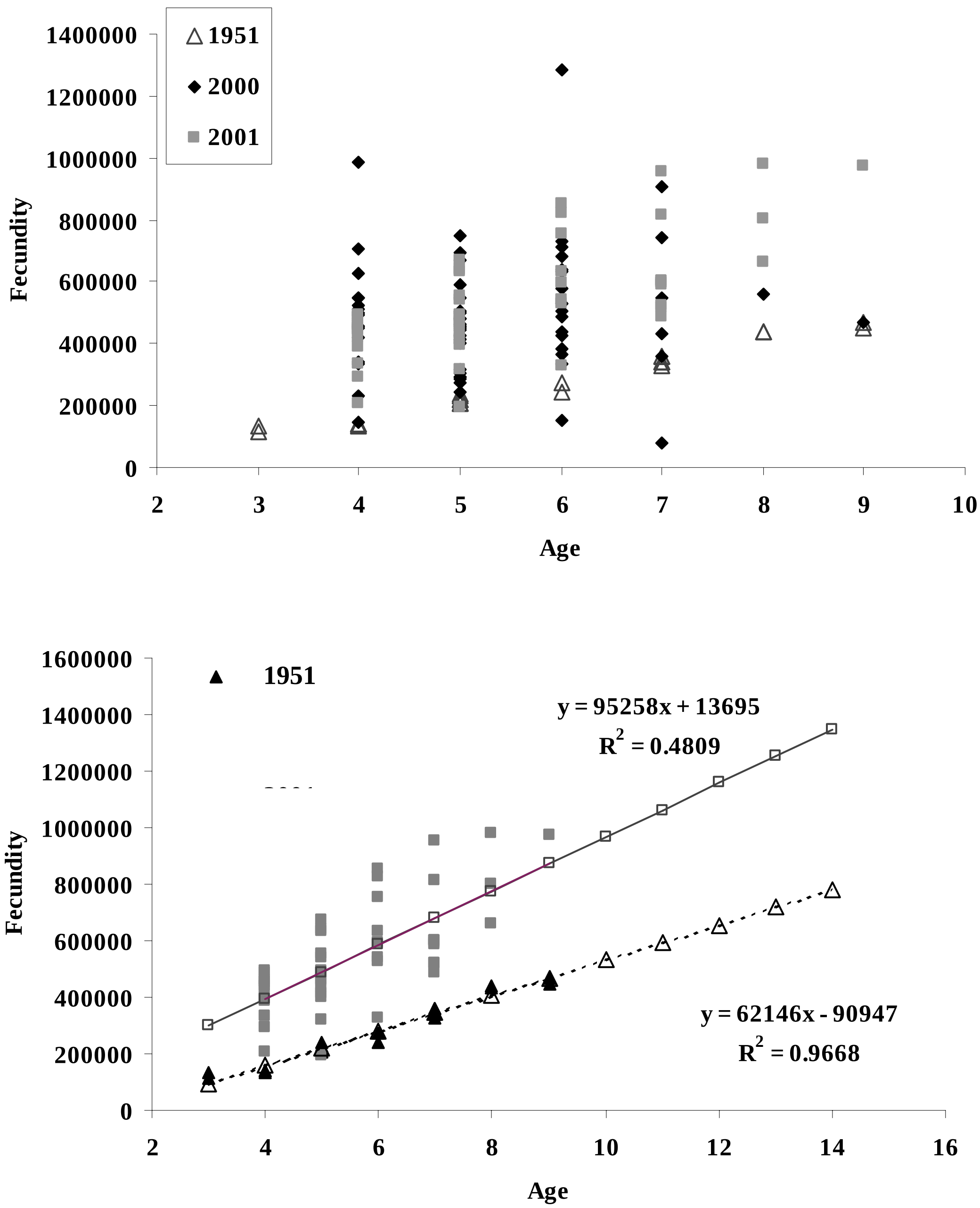
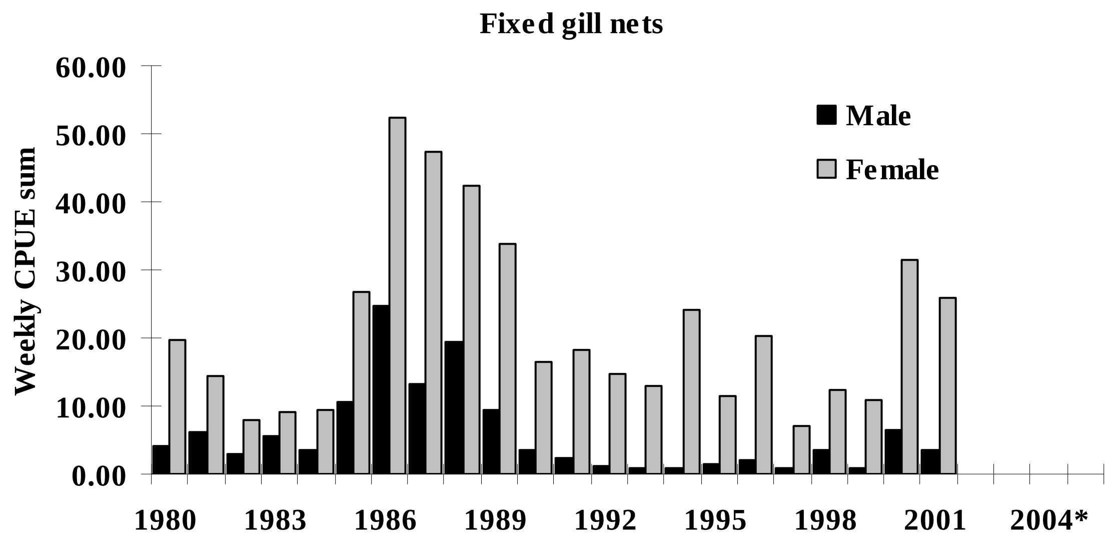


Figure 7.5 Weekly sum of CPUE of American shad caught in the commercial gill-net fishery in the Hudson River Estuary, 1980-2005. (Data not reported for fixed gear 2002-2005; drift gear 1990-1991,1993-1997; small sample size). Trend statistics in table below.

Years	Fixed gill nets	R2	Slope	*P*
1986-2001	Male	0.43	-1.00	0.005
	Female	0.36	-1.70	0.01
1986-1999	Male	0.70	-2.96	0.0001
	Female	0.59	-1.43	0.001



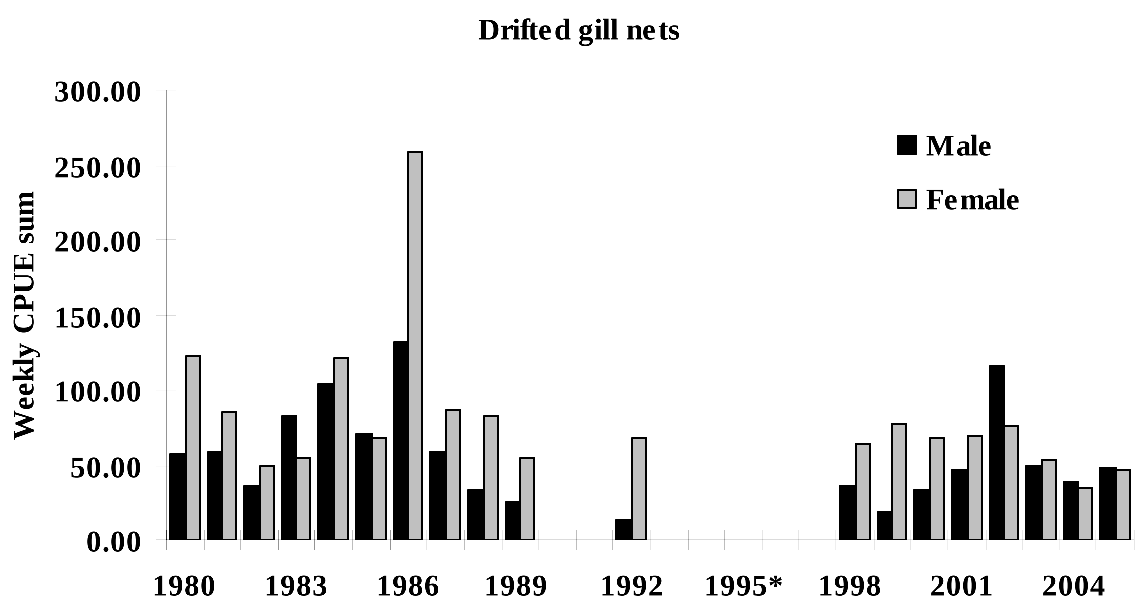


Figure 7.6 Relationship of catch per unit effort (square yard x hour x 10^{-3}) of American shad and striped bass in the American shad gill-net fishery in the Hudson River Estuary.

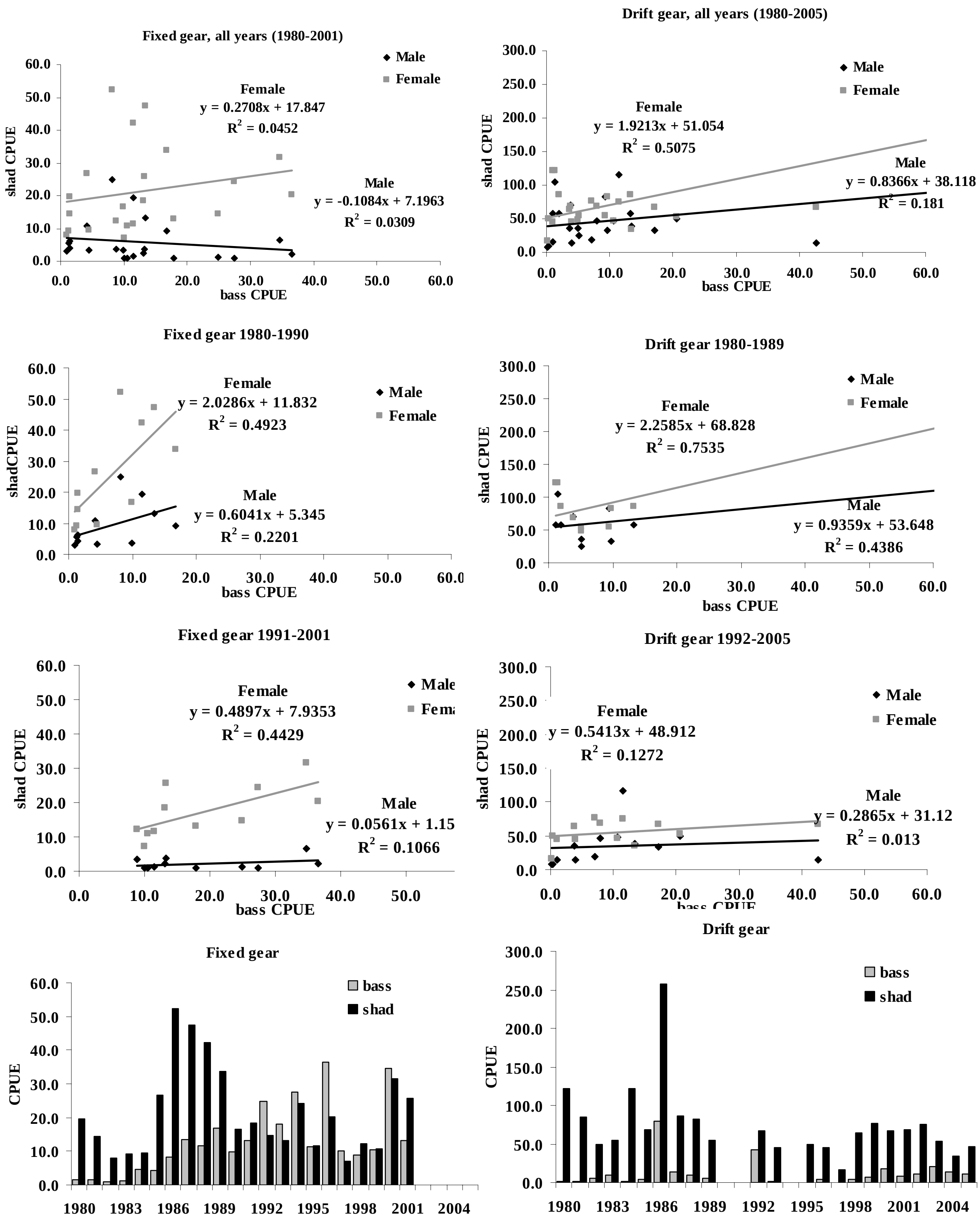


Figure 7.7 Long-term effort, landings, and conversion to CPUE data from the American shad commercial fishery in the Hudson River Estuary, 1931-2005.

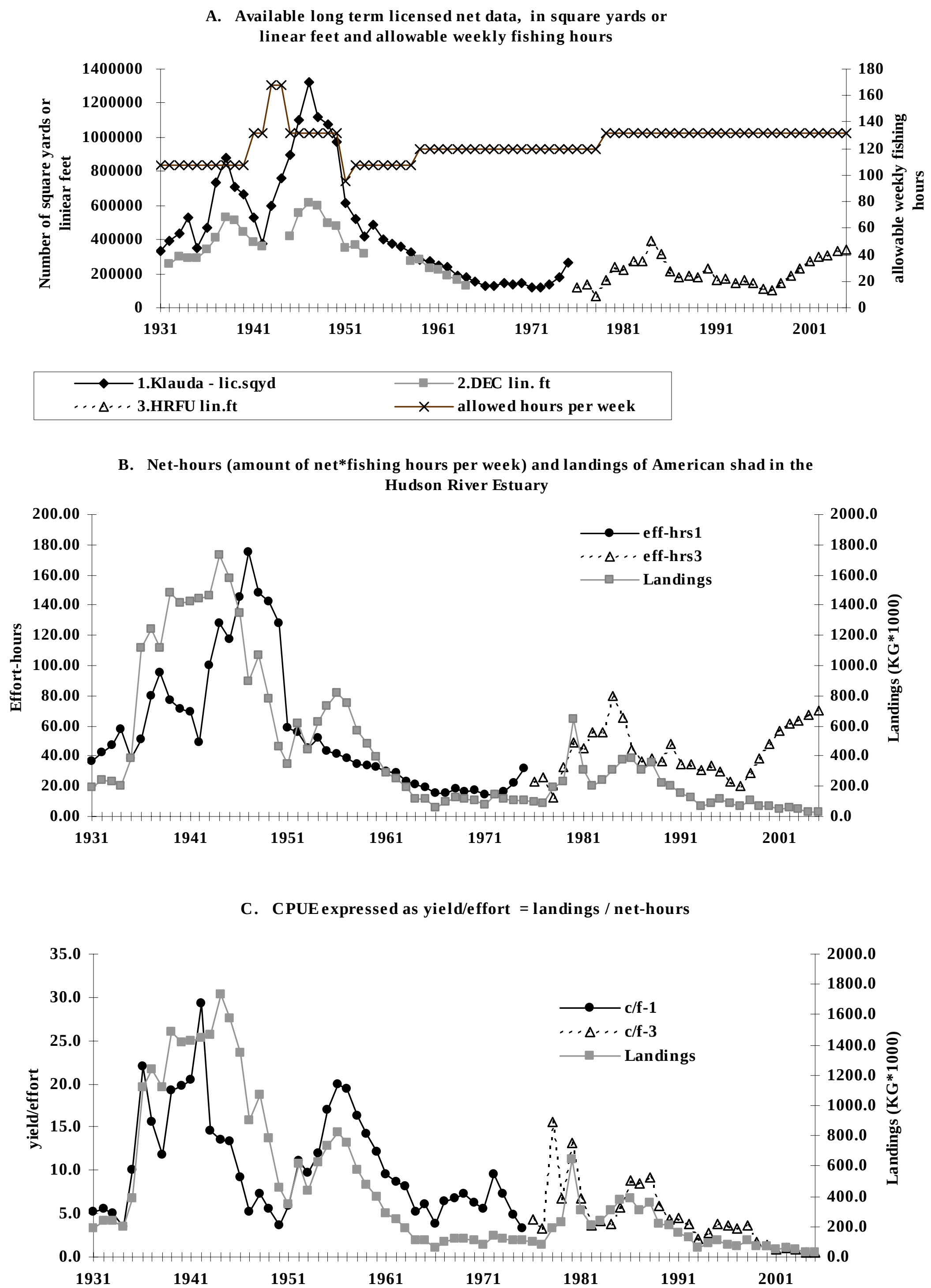


Figure 7.8 Comparison of CPUE data for American shad in the Hudson River Estuary: observed CPUE (number of shad/qyd*hours*10^{-3}) vs. catch/licensed effort = (landings/avg. annual weight)/(sqyd of licensed net *allowable hrs fished* 10^{-6}), 1980-2001. (2002-2005 excluded small sample size).

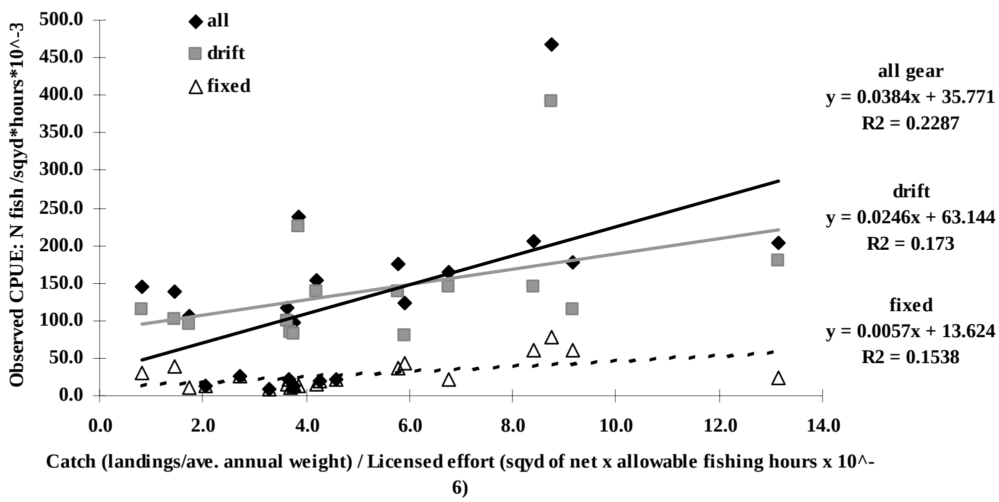


Figure 7.9 Total number of shad & herring gill net licenses sold for use in the Hudson River Estuary, with information on actual reporting of use.

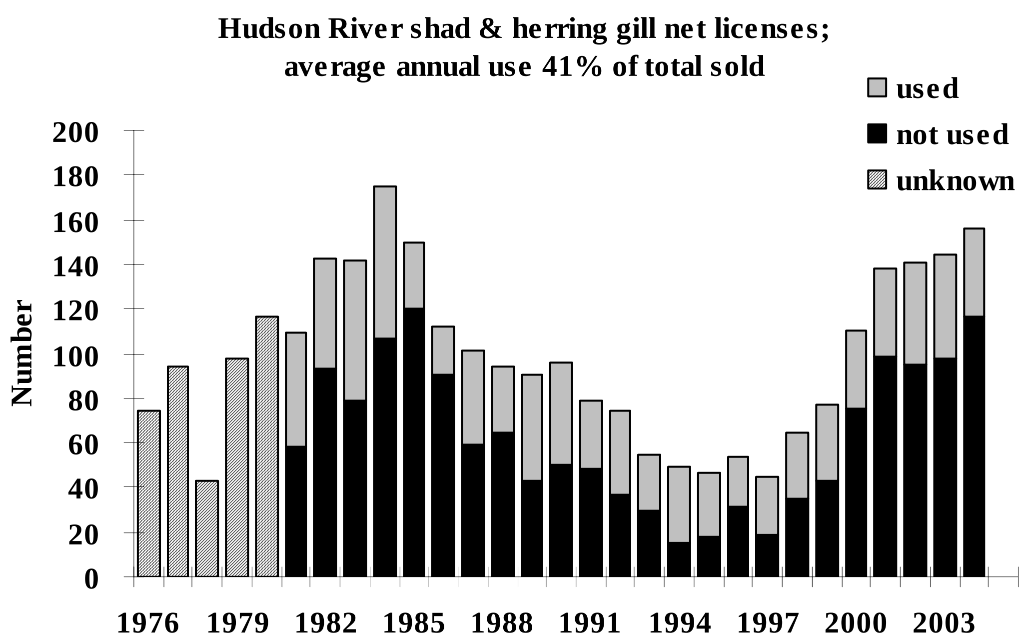


Figure 7.10 Mean total length and weight of American shad caught in the commercial gill-net fishery in the Hudson River Estuary, 1980-2005.

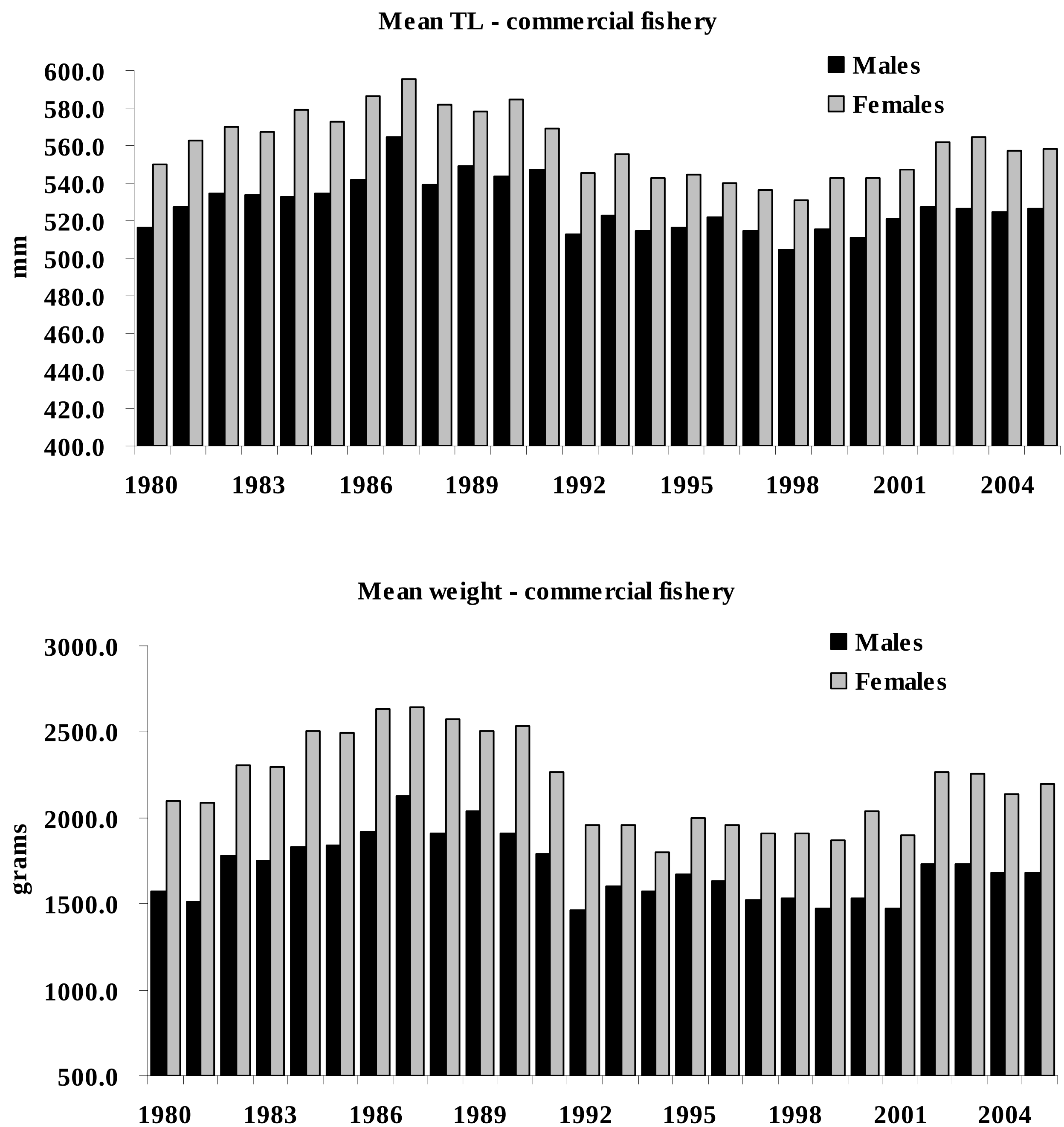


Figure 7.11 Mean total length (mm) and weight (g)-at-age for American shad, ages five through seven, collected in fishery-dependent (commercial fishery gill net) and fishery-independent (spawning stock) survey in the Hudson River Estuary.

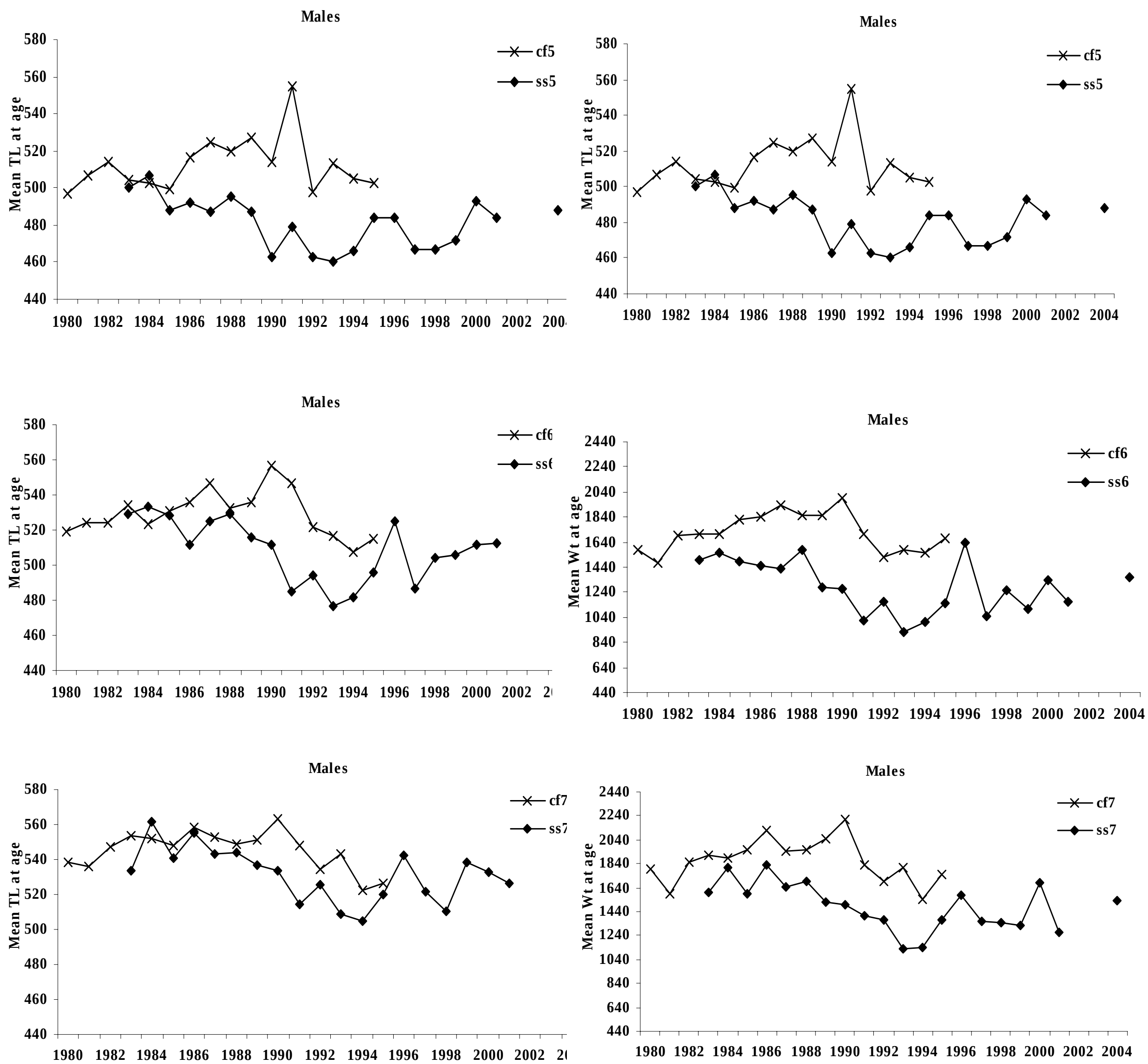


Figure 7.11 cont. Mean total length (mm) and weight (g)-at-age for American shad, ages five through seven, collected in fishery-dependent (commercial fishery gill net) and fishery-independent (spawning stock) survey in the Hudson River Estuary.

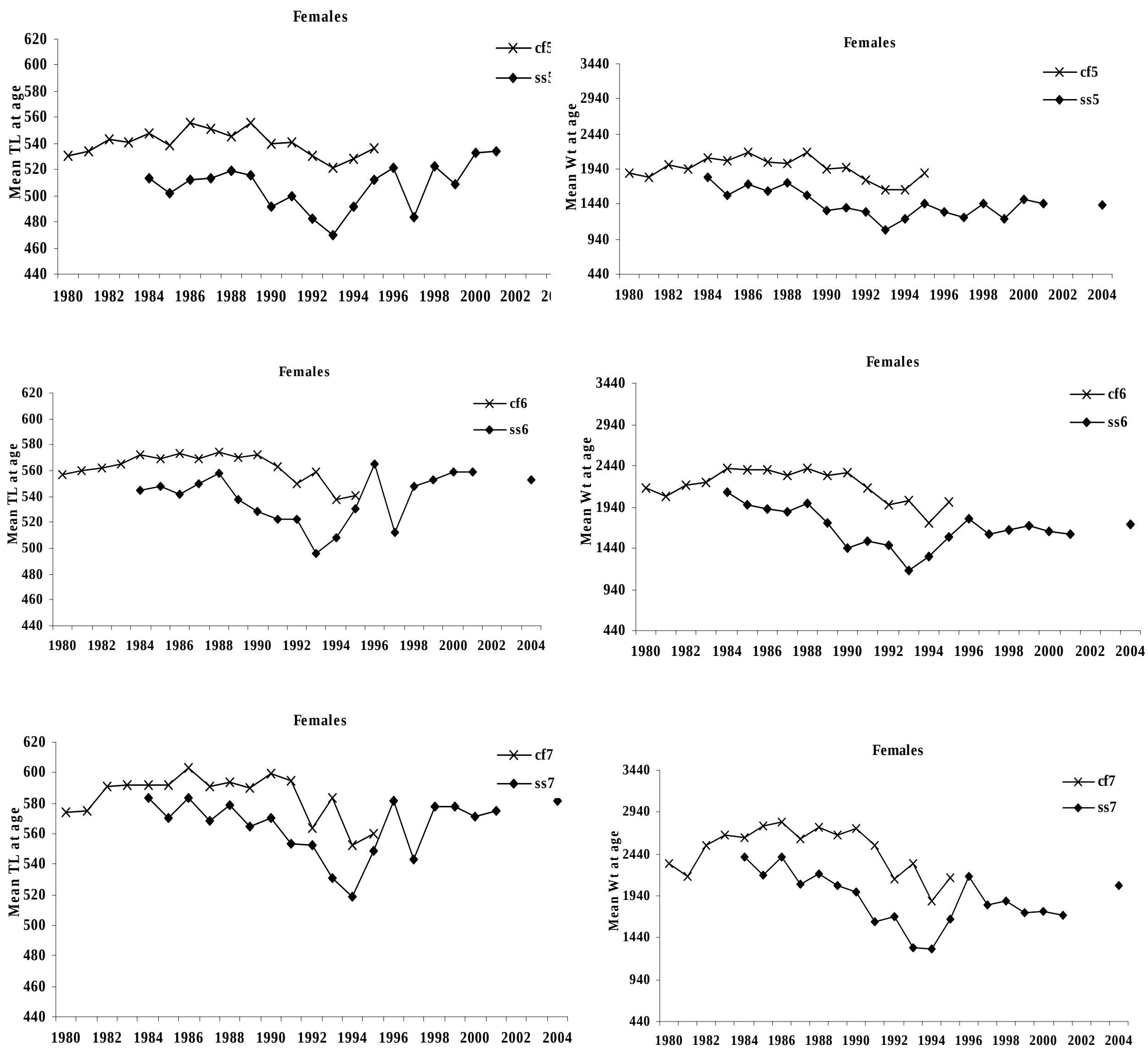
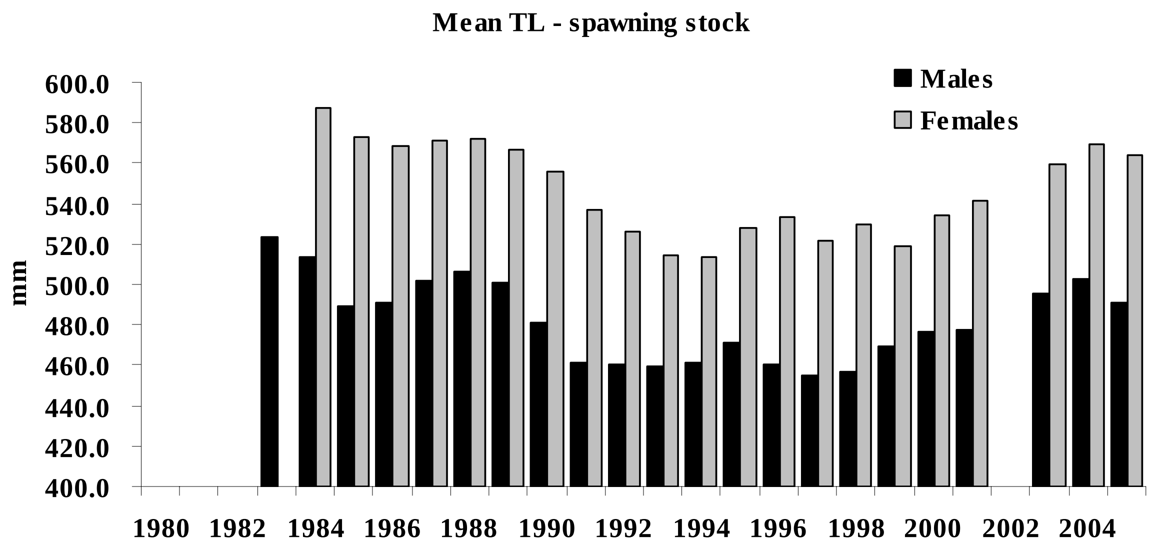


Figure 7.12 Mean total length and weight of American shad collected in the spawning stock survey in the Hudson River Estuary, 1983-2005.



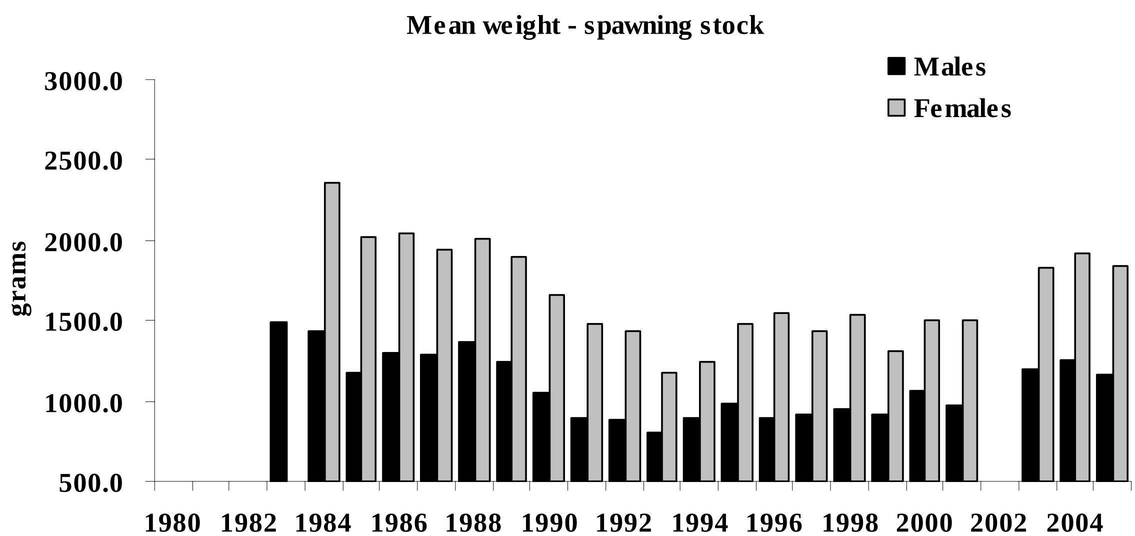
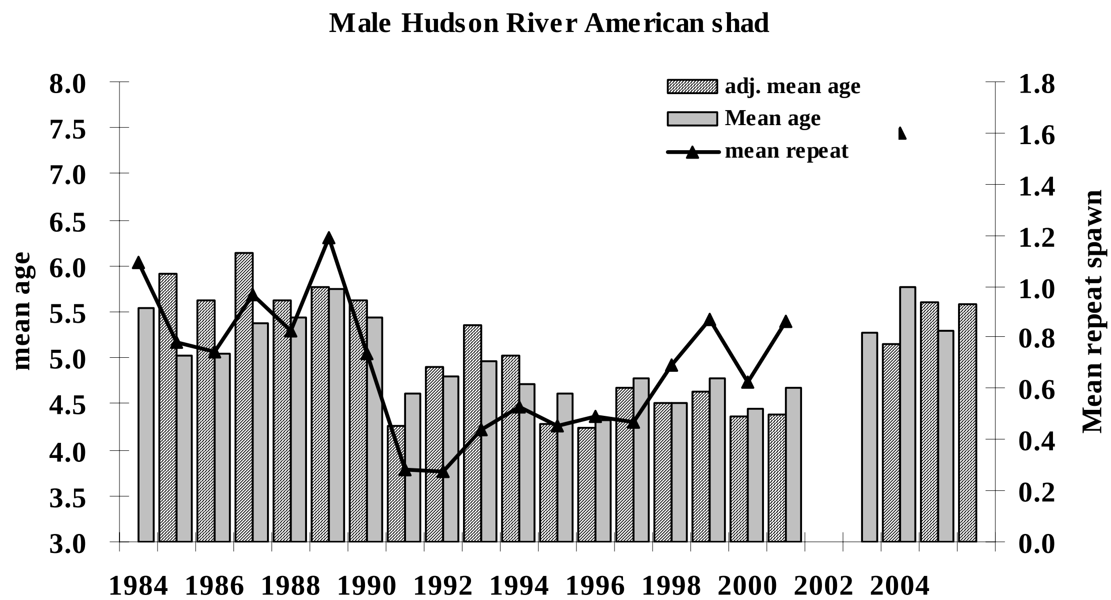


Figure 7.13 Mean age, mean adjusted age, and mean repeat spawn of American shad collected in the spawning stock survey in the Hudson River Estuary, 1984-2004. (No data in 2002, estimated age in 2003 &2005).



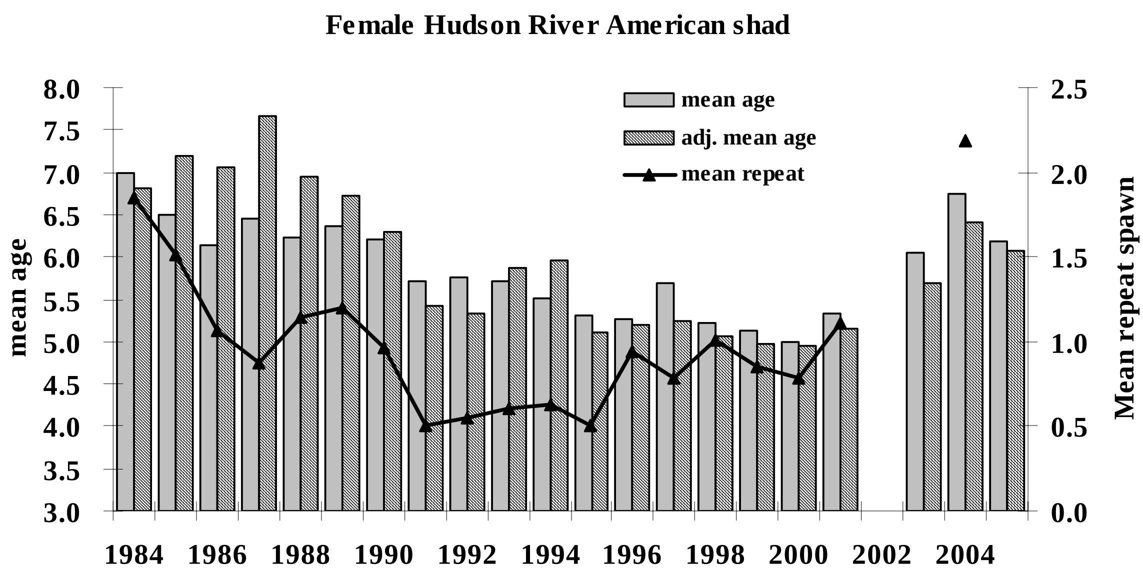
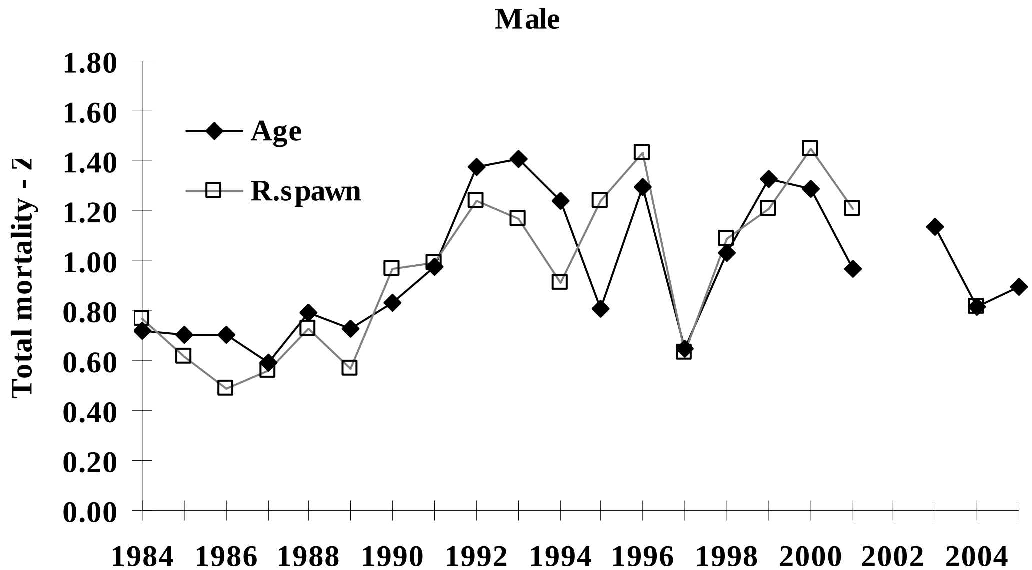


Figure 7.14 Total mortality rates, calculated using catch curves for age and repeat spawn data for Hudson River American shad, 1984-2005.



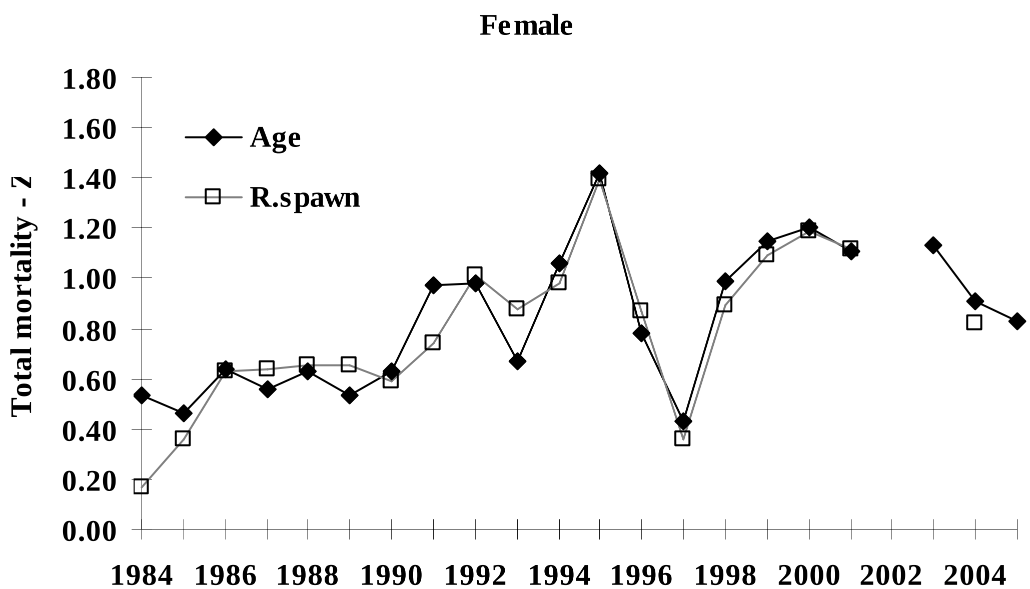


Figure 7.15 The number and location of recaptured American shad tagged and released in the Hudson River, 1995-2005.

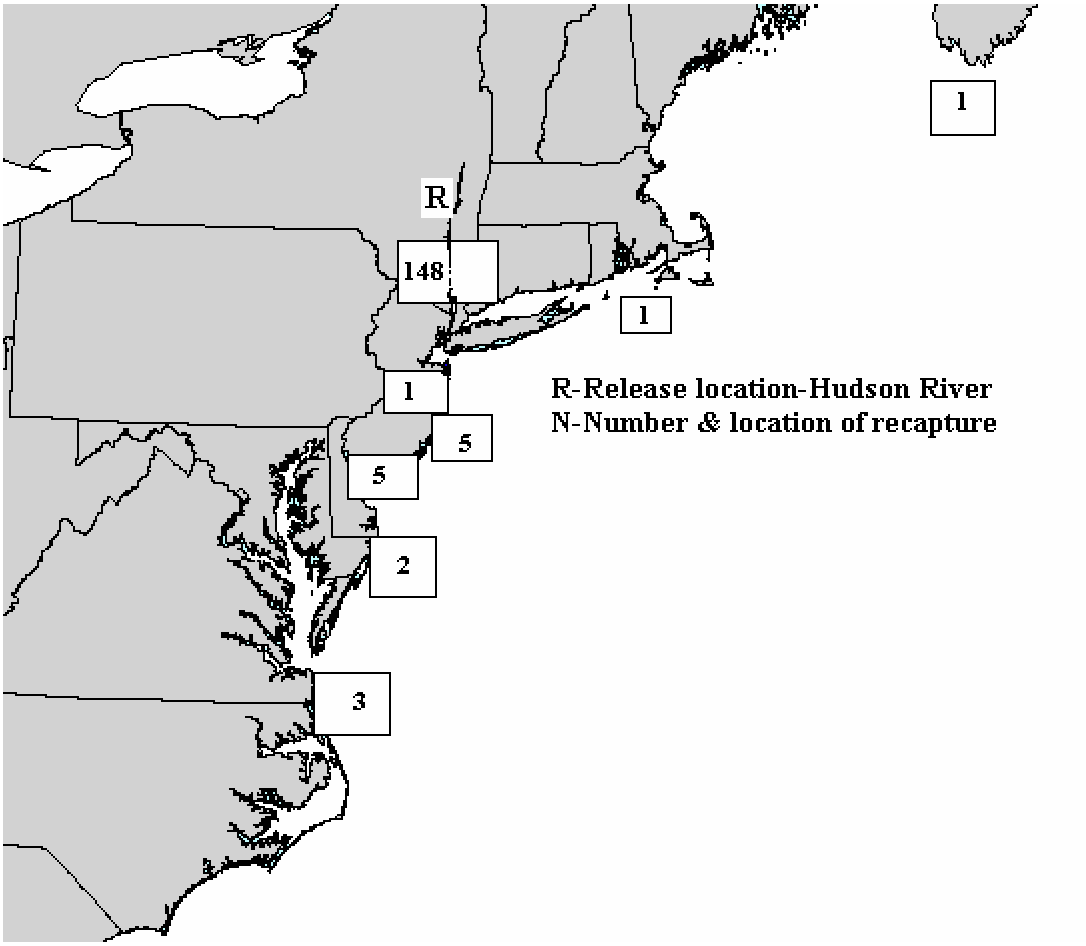


Figure 7.16 Young-of-year indices for American shad collected in the Hudson River Estuary, 1980-2005.

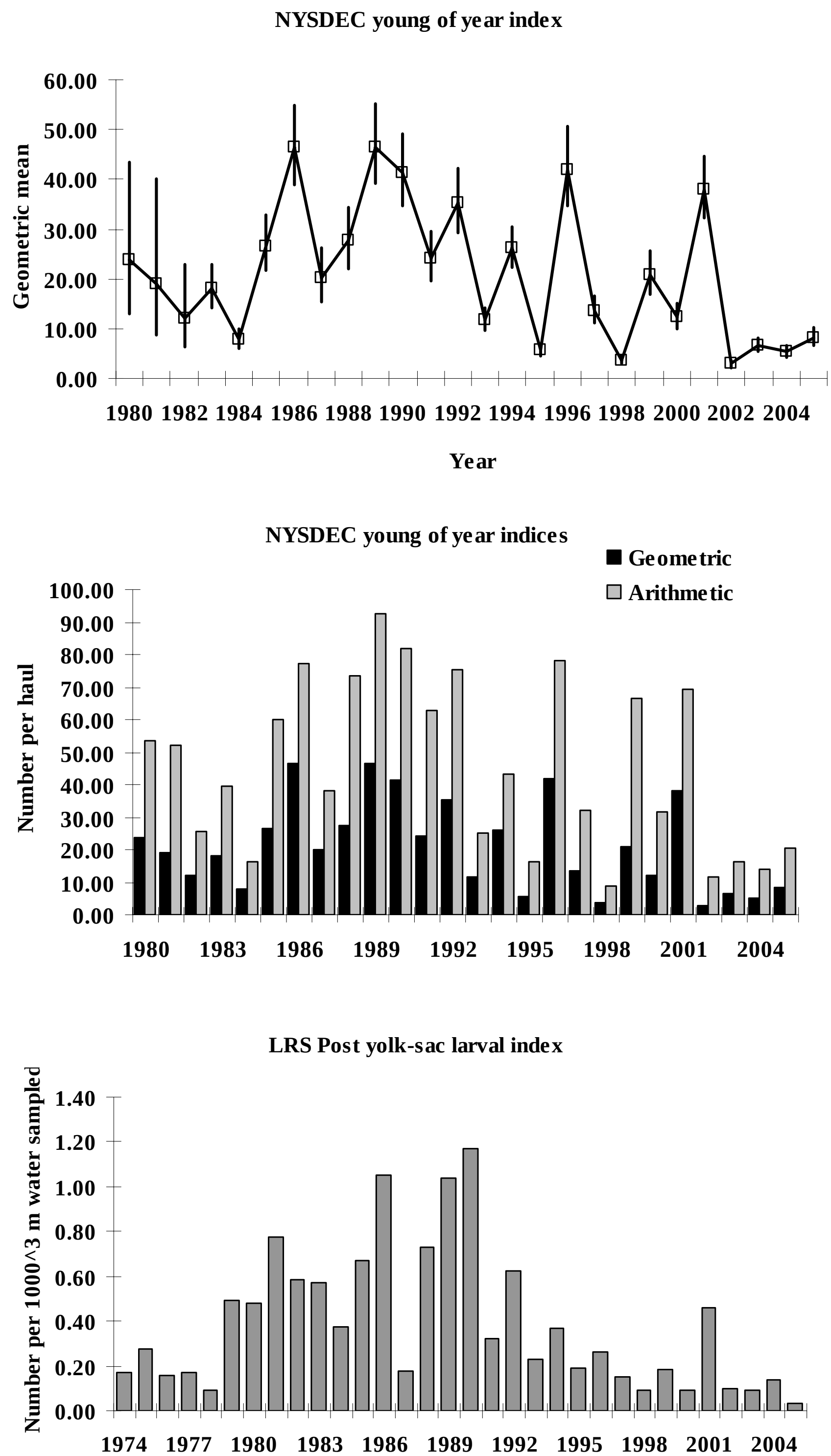


Figure 7.17 Comparison of the post-yolk-sac larval (PYSL) age-0 index with the spawning adult age 5-7 index (females, males and all fish) of the same cohort. Left panel – all year-classes, right panel – year-classes to 1984.

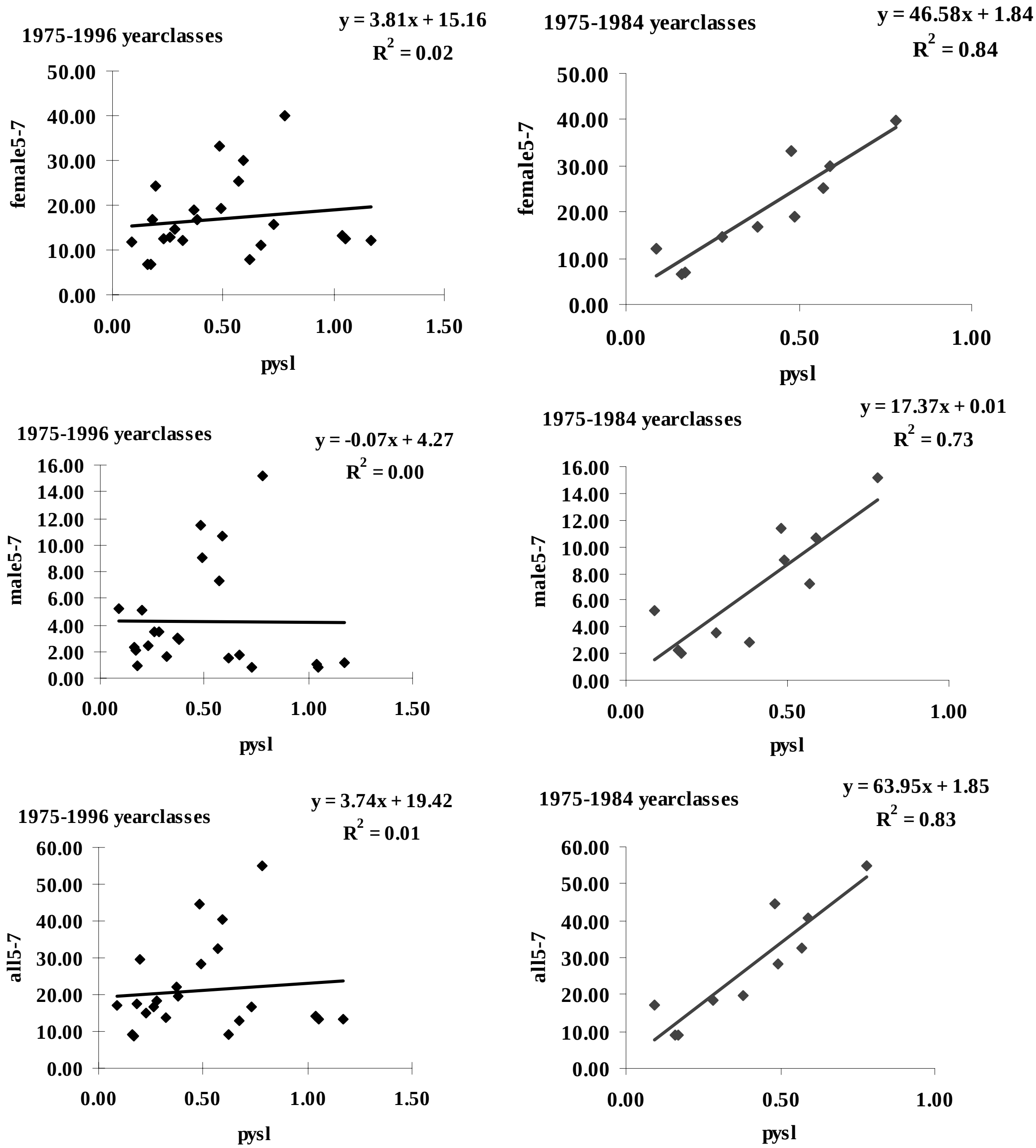
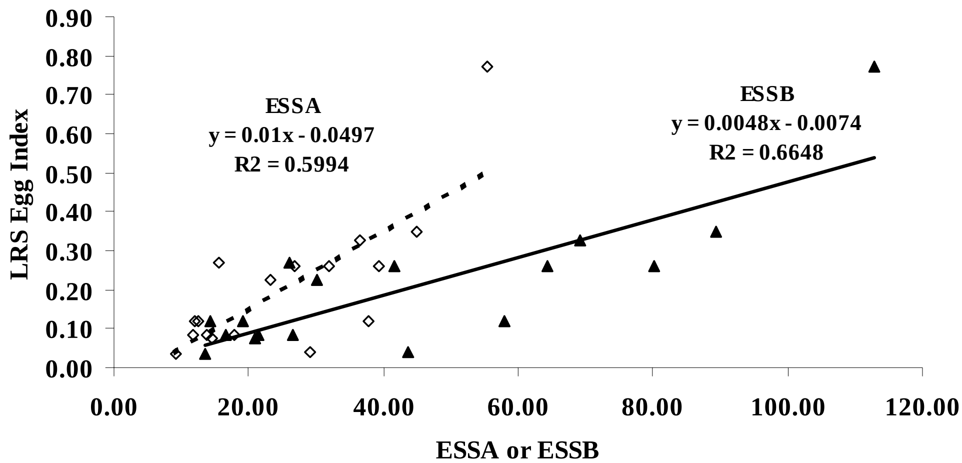


Figure 7.18 Comparison of the Hudson River American shad Empirical spawning stock abundance (ESSA) and biomass (ESSB) indices with LRS egg abundance index (density n/1000^{3}m): correlation and trend. ESSB* - estimated for 2002-2005. Trend statistics in table below.

Years	Index	R2	Slope	*P*
1986-2001	ESSA	0.24	-1.46	0.05
1986-1999		0.62	-2.75	0.0008
1986-2001	ESSB	0.35	-3.76	0.02
1986-1999		0.64	-6.20	0.0006



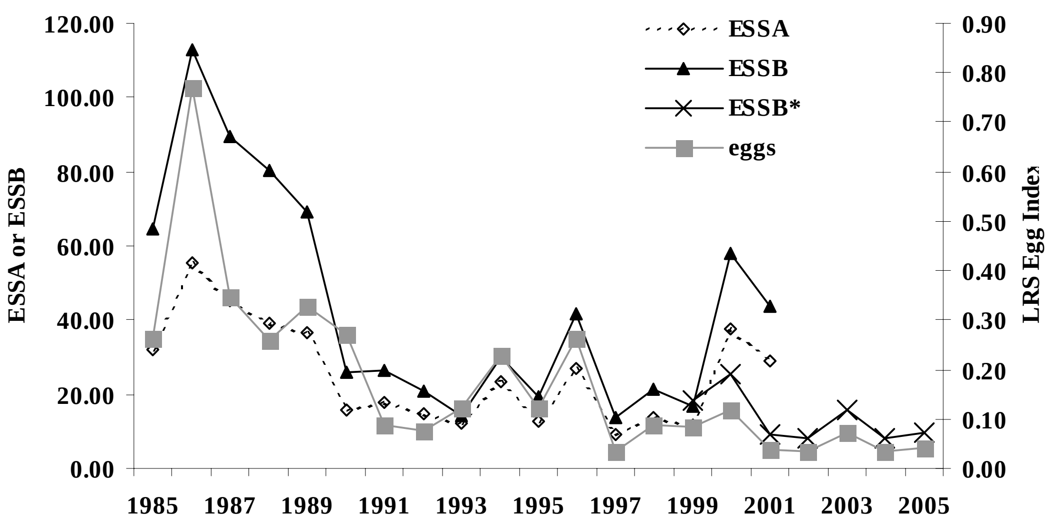


Table 7B.1 Historic commercial fishery landings (kg) of American shad in the Hudson River Estuary, 1880-2005. 1915-1949: Talbot, G.A. Factors associated with fluctuations in abundance of Hudson River Shad. Fish. Bull. 101(56):373-413. (data from USFWS). 1950-1993: annual report from NMFS. 1994-present: NY landings: NYSDEC State reports & NJ landings from NMFS.

Year	Total	Year	Total	Year	Total
1880	1240142.4	1922	79464	1965	113854
1881		1923	55216	1966	58514
1882		1924	42806	1967	96753
1883		1925	56398	1968	121111
1884		1926	120395	1969	116484
1885		1927	162414	1970	109499
1886		1928	111690	1971	78881
1887	1626609.6	1929	89244	1972	141432
1888	1563105.6	1930	93670	1973	115668
1889	1964995.2	1932	240296	1974	105190
1890	1713247.2	1933	235273	1975	105961
1891	1381212	1934	198677	1976	97479
1892		1935	384381	1977	84097
1893		1936	1119439	1978	190240
1894		1937	1239326	1979	225984
1895		1938	1119031	1980	644475
1896		1939	1483590	1981	305545
1897		1940	1412692	1982	205118
1898		1941	1421356	1983	236144
1899		1942	1445124	1984	307677
1900		1943	1463019	1985	375247
1901	854582	1944	1727944	1986	385183
1902		1945	1577258	1987	309438
1903		1946	1348164	1988	356589
1904	1556755	1947	898941	1989	219225
1905		1948	1067956	1990	203820
1906		1949	783535	1991	156641
1907		1950	457637	1992	129078
1908	225893	1951	346596	1993	62692
1909		1952	618166	1994	90072
1910		1953	437679	1995	112885
1911		1954	622067	1996	83690
1912		1955	735558	1997	67799
1913		1956	818793	1998	105484
1914		1957	750935	1999	66501
1915	31148	1958	570084	2000	69555
1916	18222	1959	476688	2001	45997
1917	19679	1960	393362	2002	59241
1918	106415	1961	284952	2003	49998
1919	170088	1962	250387	2004	33040
1920	90649	1963	187972	2005	32172
1921	59332	1964	110996		

Table 7B2 Historical records of type of commercial gill nets and licenses sold for the New York and New Jersey portions of the Hudson River Estuary.

	Talbot 1954 (a)				Fishery Statistics (b)	NYSDEC-HRFU Summary (c)				NYSDEC Spec. Lic. (d)
							Number of licenses by type			
YEAR	NY-T5 Number of nets *	NY-T3 Number of shad lic.	NJ-T5 Number of nets *	Standard Fishing Units	Number of nets *	Number licensed fishermen	shad/herr	gill	total	Number of nets *
1915	79		7	3840						
1916	76		3	2910						
1917	213		2	6810						
1918	272		1	7554						
1919	359		14	12633						
1920	190		10	7230						
1921	159		8	5973						
1922	133		8	5271						
1923	110		5	4020						
1924	97	97	4	3459						
1925	98	98	4	3486						
1926	99	99	4	3513						
1927	136	136	7	5142						
1928	129	129	7	4953						
1929	122	122	5	4344						
1930	121	121	7	4737						
1931	120	120	4	4080						
1932	123	123	6	4581						
1933	146	146	13	6672						
1934	144	144	14	6828						
1935	140	140	15	6930						
1936	162	162	36	11934						
1937	200	200	36	12960						
1938	261	261	52	17967						
1939	254	254	43	15888						
1940	216	216	46	14718						
1941	231	231	46	15213						
1942	220	220	48	15180	478					
1943	230	230	32	16380	233					
1944	263	263	38	19026	445					
1945	242	242	35	13761	295					
1946	357	357	52	20361	344					
1947	366	366	52	20658	379					
1948	357	357	44	19041	378					
1949	315	315	46	17985						
1950	295	295	40	16335	241					
1951	215	215	25	8160	174					
1952					162					
1953					158					
1954					181					
1955					158					
1956					152					
1957					142					
1958					135					
1959					130					

	Talbot 1954 (a)				Fishery Statistics (b)	NYSDEC-HRFU Summary (c)				NYSDEC Spec. Lic. (d)
							Number of licenses by type			
YEAR	NY-T5 Number of nets *	NY-T3 Number of shad lic.	NJ-T5 Number of nets *	Standard Fishing Units	Number of nets *	Number licensed fishermen	shad/herr	gill	total	Number of nets *
1960										
1961					100					
1962										
1963										
1964					58					
1965					55					
1966										
1967					41					
1968					50					
1969					53					
1970					55					87
1971					42					74
1972					50					64
1973										116
1974										141
1975										120
1976						48	74	34	108	106
1977						54	94	39	133	127
1978						27	43	11	54	107
1979						60	98	62	160	163
1980						86	117	70	187	155
1981						81	109	63	172	
1982						106	143	88	231	
1983						98	142	85	227	
1984						112	175	86	261	
1985						95	150	63	213	
1986						79	112	56	168	
1987						72	101	31	132	
1988						65	94	28	122	
1989						72	91	31	122	
1990						83	96	64	160	
1991						90	79	68	147	
1992						101	74	96	170	
1993						123	55	79	134	
1994						121	49	79	128	
1995						112	47	75	122	
1996						134	54	88	142	
1997						112	45	74	119	
1998						140	65	119	184	
1999						145	77	68	181	
2000						231	110	123	233	
2001						222	138	112	250	
2002						261	141	120	261	
2003						248	144	104	248	
2004						210	156	118	274	
2005						287	161	109	270	

Table 7B2 Continued

	AMOUNT OF LICENSED NET							
						Escapement (g)		
	Klauda (e)			**DEC Annual State Rpts (f)**	**NYSDEC HRFU (c)**	NY		NJ
	Licensed Square Yards			Licensed	Licensed	Closed	Fishing	Closed
YEAR	fixed	drift	total	feet	feet	Hours/wk	Hours/wk	Hours/wk
1915						48	120	0
1916						48	120	0
1917						48	120	0
1918						60	108	0
1919						60	108	0
1920						60	108	0
1921						60	108	0
1922						60	108	0
1923						60	108	0
1924						60	108	0
1925						60	108	0
1926						60	108	0
1927						60	108	0
1928						60	108	0
1929						60	108	0
1930						60	108	0
1931	19167	315298	334465			60	108	0
1932	18748	376884	395632	253142		60	108	0
1933	28760	406871	435631	298949		60	108	0
1934	27330	505050	532380	292790		60	108	0
1935	65255	288480	353735	286459		60	108	0
1936	103180	368490	471670	338018		60	108	0
1937	137375	597529	734904	413501		60	108	0
1938	151472	729111	880583	531780		60	108	0
1939	159210	552804	712014	509156		60	108	0
1940	232808	430379	663187	444873		60	108	60
1941	94511	432106	526617	385717		36	132	36
1942	183381	191103	374484	355118		36	132	36
1943	132859	462970	595829			0	168	0
1944	284601	475835	760436			0	168	0
1945	214400	677700	892100	419029		36	132	36
1946	422800	680500	1103300	554924		36	132	36
1947	519360	806000	1325360	617844		36	132	36
1948	322160	800360	1122520	599830		36	132	36
1949	425686	653500	1079186	499280		36	132	36
1950	387828	583080	970908	479135		36	132	36
1951	224915	390400	615315	351280		72	96	72
1952	180217	339910	520127	363580		60	108	60
1953	99600	316225	415825	314110		60	108	60
1954	104267	379889	484156			60	108	60
1955	150008	252777	402785			60	108	60
1956	168826	210151	378977			60	108	60
1957	158495	199913	358408			60	108	60
1958	140793	182768	323561	274865		60	108	60
1959	132225	146022	278247	277720		48	120	48

	AMOUNT OF LICENSED NET								
	Klauda (e)			**DEC Annual State Rpts (f)**	**NYSDEC HRFU (c)**	**Escapement (g)**			
						NY		NJ	
	Licensed Square Yards			Licensed	Licensed	Closed	Fishing	Closed	
YEAR	fixed	drift	total	feet	feet	Hours/wk	Hours/wk	Hours/wk	
1960	125463	145109	270572	231745		48	120	48	
1961	122661	125873	248534	219886		48	120	48	
1962	127281	113059	240340	189990		48	120	48	
1963	85677	105338	191015	158720		48	120	48	
1964	74555	103484	178039	131450		48	120	48	
1965	62203	94822	157025			48	120	48	
1966	55791	74480	130271			48	120	48	
1967	52893	73748	126641			48	120	48	
1968	61555	87720	149275			48	120	48	
1969	61209	71390	132599			48	120	48	
1970	62474	83965	146439			48	120	48	
1971	41911	76315	118226			48	120	48	
1972	46994	76316	123310			48	120	48	
1973	41703	92024	133727			48	120	48	
1974	115913	66348	182261			48	120	48	
1975	132574	132696	265270			48	120	48	
1976					121700	48	120		
1977					138300	48	120		
1978					65350	48	120		
1979					160933	36	132		
1980					238479	36	132		
1981					219840	36	132		
1982					270740	36	132		
1983					272990	36	132		
1984					389960	36	132		
1985					316800	36	132		
1986					214120	36	132		
1987					179000	36	132		
1988					189400	36	132		
1989					180280	36	132		
1990					232200	36	132		
1991					166290	36	132		
1992					166988	36	132		
1993					149150	36	132		
1994					161900	36	132		
1995					146695	36	132		
1996					111000	36	132		
1997					100047	36	132		
1998					141369	36	132		
1999					185405	36	132		
2000					233637	36	132		
2001					276000	36	132		
2002					301942	36	132		
2003					307196	36	132		
2004					329194	36	132		
2005					340028	36	132		

Table 7B2 Continued

NEW YORK GILL NET LICENSES
Two types of gill net licenses are available in New York State:
1) shad gill net license - valid for the spring shad season (Mar 15-Jun 15)
2) gill net licenses - valid for most of the year.

* Please note that "Number of nets" with "*" above and reference below are NOT KNOWN by net type i.e shad gill net license vs. gill net license or a total of both.

REFERENCES

(a) TALBOT, G.B. 1954. Factors associated with fluctuations in abundance of Hudson River shad. Fishery Bulletin 101. U.S. Dept of Interior. Standard Fishing Units = no. nets * allowed fishing hours * adjustment factor (NJ)

(b) FISHERY STATISTICS OF THE UNITED STATES
1956-1967: U.S. Dept. of Interior, U.S. Fish & Wildlife Service
1968-1972: U.S. Dept. of Commerce, National Marine Fisheries Service

(c) NYSDEC-HRFU SUMMARY: Hudson River Fisheries Unit summary of available Special Licenses Unit (SLU) receipts of number and type of licenses sold. HRFU copies of yearly records mostly complete, but cannot be verified as all records held by SLU were destroyed. Amount of net is summary of what appeared on licenses in HRFU files.

(d) NYSDEC-SPECIAL LICENSES: Summary of number of licenses sold by SLU, previous to file purging, cannot be verified.

(e) KLAUDA, R.J., M. NITTEL, K.P. CAMPBELL. 1976. Commercial fishery for American shad in the Hudson River: fish abundance and stock trends. Proceedings of a workshop on American shad. USFWS/NMFS. Amherst MA. Cited source as NYSDEC: NO records of this type exist, Sq. yards may have been be estimated from linear feet.

(f) DEC ANNUAL STATE REPORTS: Annual Conservation Dept. Reports to the Senate and Assembly. Bureau of Fisheries Library. Albany NY. Annual reports are from 1885 to 1964. References are incomplete. Discontinued printing reports in 1964.

(g) 1915-1951: Talbot 1954, 1951-1975: Klauda 1976, 1976-present: NYSDEC

Table 7B3 Mean total length and weight at age for American shad collected in fishery dependent (commercial gill net) and fishery independent surveys in the Hudson River Estuary.

Mean TL_FD	1980			1981			1982			1983			1984			1985			1986		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes combined																					
3							1	403.0		1	462.0										
4	15	491.8	34.6	19	481.5	29.7	23	499.1	34.3	18	497.8	27.6	6	508.2	26.4	24	513.2	15.6	15	516.5	29.0
5	126	523.8	18.8	127	529.4	20.6	128	537.5	21.9	142	531.1	25.8	85	532.6	27.6	113	531.7	27.9	117	545.0	30.2
6	130	548.5	23.8	205	552.5	21.8	137	554.0	26.5	120	559.2	22.0	121	562.3	27.8	136	561.7	31.4	117	564.8	27.9
7	64	558.4	24.5	144	559.6	27.4	114	578.5	26.5	47	578.6	25.1	57	584.4	30.5	88	581.3	33.2	67	591.4	32.0
8	21	572.8	26.1	79	583.7	27.8	69	584.6	29.4	47	592.6	28.4	34	596.3	29.9	36	594.5	32.0	37	614.5	31.5
9	3	613.3	14.3	13	610.1	19.9	35	591.7	33.9	23	602.9	31.9	29	618.6	35.8	24	603.3	33.5	20	631.2	31.6
10				4	621.0	47.6	11	613.8	37.7	21	616.8	40.9	13	632.9	42.0	13	619.5	31.6	7	639.7	30.8
11							1	604.0		3	625.0	40.9	3	610.7	33.5	6	658.0	38.4	3	636.3	26.8
12													2	653.5	14.9	2	631.5	12.0	2	671.0	19.8
13																					
Males																					
3							1	403.0													
4	9	472.3	24.5	12	467.1	21.0	11	479.6	28.4	9	479.1	17.5	1	480.0		5	503.0	6.5	7	500.4	33.0
5	26	497.3	12.3	23	506.4	11.1	24	513.7	16.6	37	504.6	19.5	28	502.4	15.7	20	499.1	24.0	28	516.1	24.8
6	29	518.8	17.8	45	524.4	16.5	29	524.5	19.2	23	534.2	15.2	24	523.0	24.5	27	530.5	21.9	25	535.5	23.1
7	28	538.6	11.4	57	535.6	14.4	33	547.3	19.2	16	553.4	13.2	11	551.8	12.6	21	548.1	23.1	18	558.4	24.0
8	10	551.4	11.3	23	550.0	12.8	20	555.4	19.3	19	564.5	17.2	15	574.5	28.7	10	570.1	19.8	10	579.2	18.8
9				1	575.0		17	563.7	19.3	9	570.7	14.7	6	575.8	18.2	4	577.3	12.0	4	590.0	22.1
10							3	577.0	2.0	5	569.0	15.9	3	576.7	12.1	2	589.0	5.7	1	594.0	
11										2	620.0	56.6	1	596.0					2	622.0	14.1
Females																					
3										1	462.0										
4	6	521.0	26.1	7	506.1	26.8	11	523.3	21.4	9	516.4	22.8	5	513.8	25.2	18	515.6	16.7	8	530.6	16.3
5	100	530.7	13.3	104	534.4	18.7	101	543.3	19.3	104	540.4	20.9	56	547.3	18.7	91	539.1	23.5	87	555.4	24.6
6	101	557.0	17.7	160	560.4	15.8	105	562.5	22.3	97	565.1	19.1	97	572.0	18.4	107	569.6	28.6	91	573.4	22.8
7	36	573.8	20.6	87	575.3	21.9	79	591.4	16.9	31	591.6	19.2	46	592.2	28.3	67	591.7	28.7	49	603.5	25.5
8	11	592.2	19.3	56	597.6	18.9	48	597.3	23.6	28	611.6	15.6	19	613.5	17.0	26	603.9	31.1	27	627.5	24.4
9	3	613.3	14.3	12	613.0	17.6	17	616.3	20.0	14	623.6	20.3	23	629.8	30.5	20	608.5	34.1	16	641.4	24.6
10				4	621.0	47.6	8	627.6	35.0	16	631.7	34.1	9	648.1	32.2	11	625.1	31.2	6	647.3	25.5
11							1	604.0	.	1	635.0		2	618.0	43.8	6	658.0	38.4	1	665.0	
12													2	653.5	14.9	2	631.5	12.0	2	671.0	19.8
13																					

Table 7B3 Continued

Mean TL_FD	1987			1988			1989			1990			1991			1992			1993		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes combined																					
3				2	416.0	73.5	1	458.0					2	473.5	44.6	2	438.5	9.2			
4	2	538.0	41.0	10	528.9	25.5	3	560.7	9.9	4	516.8	20.7	19	519.8	34.0	31	475.6	37.8	8	499.0	38.0
5	67	549.7	18.4	71	538.3	26.0	90	548.9	26.2	50	535.2	29.7	60	540.8	22.5	176	525.3	26.6	19	520.0	20.4
6	120	566.2	25.2	118	558.3	28.4	177	557.8	29.7	69	570.0	22.3	67	561.7	25.8	150	542.5	25.1	36	543.9	30.8
7	85	586.4	22.3	85	580.8	31.7	125	576.6	30.4	54	595.4	28.1	54	586.9	30.3	81	552.3	29.4	22	563.3	26.2
8	58	609.0	30.1	44	602.9	35.0	74	588.7	29.4	33	610.6	23.6	18	603.2	27.2	22	583.4	26.0	8	578.6	41.5
9	37	621.8	32.9	20	613.5	45.1	18	600.6	31.4	10	626.4	24.4	8	632.0	26.8	7	596.6	31.5	1	645.0	
10	32	644.2	26.3	7	632.4	37.9	5	630.6	42.2	4	625.5	10.9	1	664.0		2	666.0	5.7			
11	15	646.3	33.0							1	684.0		1	674.0							
12	3	661.3	24.3							1	662.0										
13	2	663.0	15.6																		
Males																					
3				1	468.0								2	473.5	44.6	2	438.5	9.2			
4				3	504.3	26.8	1	554.0		1	505.0		2	464.5	44.6	20	461.4	30.5			
5	4	524.8	24.7	19	519.6	19.8	21	527.2	30.6	8	514.3	33.1	1	555.0		28	497.6	25.9	3	513.0	28.6
6	16	546.3	18.8	44	532.4	19.2	64	535.8	22.1	8	556.5	31.5	5	546.8	15.7	38	521.6	23.4	13	517.0	23.6
7	11	552.8	17.2	25	548.8	19.0	43	551.4	21.0	6	562.8	18.6	9	547.8	18.4	30	534.1	23.1	11	543.5	19.9
8	12	566.0	18.7	12	564.4	22.9	38	569.6	18.1	5	577.8	25.2	6	585.8	24.4	9	564.3	8.9	2	525.0	9.9
9	10	581.4	19.1	7	561.0	14.2	11	582.0	23.6	1	571.0					1	584.0				
10	2	601.0	25.5	3	595.0	13.8	2	595.5	2.1												
11	3	605.7	5.5																		
Females																					
3				1	364.0																
4	2	538.0	41.0	7	539.4	17.6	2	564.0	11.3	3	520.7	23.5	17	526.3	27.3	11	501.5	37.0	5	518.4	22.1
5	63	551.3	17.0	52	545.1	24.7	69	555.5	20.8	42	539.2	27.7	59	540.5	22.7	147	530.4	23.4	16	521.3	19.5
6	104	569.3	24.7	74	573.8	20.6	113	570.2	26.1	61	571.8	20.6	62	562.9	26.1	112	549.7	21.5	23	559.0	23.2
7	74	591.4	18.3	60	594.2	25.8	82	589.8	26.0	48	599.5	26.5	45	594.8	25.9	50	563.7	27.4	11	583.2	13.5
8	46	620.2	21.0	32	617.3	26.9	36	608.9	25.3	28	616.5	18.2	12	611.8	25.1	13	596.6	25.8	6	596.5	29.3
9	27	636.8	22.6	13	641.7	25.5	7	629.9	15.4	9	632.6	15.7	8	632.0	26.8	6	598.7	34.0	1	645.0	
10	30	647.1	24.0	4	660.5	17.0	3	654.0	38.7	4	625.5	10.9	1	664.0		2	666.0	5.7			
11	12	656.5	28.6							1	684.0		1	674.0							
12	3	661.3	24.3							1	662.0										
13	2	663.0	15.6																		

Table 7B3 Continued

Mean TL_FD	1994			1995			Mean weight (g)>>	1980			1981			1982			1983		
AGE	N	MEAN	STD	N	MEAN	STD		N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes combined																			
3														1	640.0		1	1300.0	
4				7	512.0	30.6		15	1424.0	377.6	19	1276.3	412.2	23	1512.2	313.0	18	1497.8	335.3
5	30	527.1	16.1	78	527.1	25.7		126	1782.5	274.4	127	1725.4	311.4	125	1915.7	267.1	142	1821.3	303.4
6	52	534.3	22.5	98	528.9	19.7		130	2033.5	353.1	205	1938.7	358.4	135	2092.6	363.6	119	2134.9	314.6
7	29	547.1	21.7	51	542.1	24.3		64	2098.6	353.3	144	1939.1	418.5	113	2345.5	430.2	47	2410.6	479.8
8	5	591.8	22.9	13	534.9	27.9		21	2257.6	497.4	79	2217.2	521.3	69	2449.5	495.0	47	2628.1	547.4
9	3	584.7	32.8	3	587.0	30.8		3	2910.0	441.9	13	2545.4	521.2	34	2474.8	592.9	23	2645.2	639.2
10				1	630.0						4	2580.0	852.0	11	2838.2	594.1	21	2830.5	653.0
11														1	2900.0	.	3	2803.3	492.2
12																			
13																			
Males																			
3														1	640.0				
4								9	1176.7	175.1	12	1048.3	212.3	11	1338.2	277.3	9	1237.8	152.8
5	2	505.0	7.1	22	502.9	25.5		26	1400.4	134.4	23	1283.9	178.4	23	1588.6	175.7	37	1502.2	160.9
6	6	507.3	23.4	44	515.1	14.4		29	1574.5	209.5	45	1472.7	154.5	28	1695.4	221.3	23	1702.6	164.8
7	5	522.4	8.7	26	526.5	18.4		28	1795.7	123.8	57	1585.4	169.7	32	1858.0	172.9	16	1910.0	178.6
8				9	525.2	26.2		10	1845.0	209.5	23	1703.5	153.0	20	1976.0	154.2	19	2105.8	244.4
9	1	547.0		1	553.0						1	1610.0		17	2034.1	192.5	9	1966.7	250.9
10														3	2240.0	197.0	5	2012.0	257.2
11																	2	2755.0	685.9
Females																			
3																	1	1300.0	
4				3	532.0	6.2		6	1795.0	273.6	7	1667.1	380.6	11	1720.0	209.7	9	1757.8	251.9
5	28	528.7	15.4	53	536.6	17.6		100	1881.9	205.4	104	1823.0	242.2	99	1989.7	226.0	104	1933.6	259.8
6	46	537.9	20.1	54	540.2	16.0		101	2165.4	264.4	160	2069.8	281.9	104	2199.9	322.8	96	2238.4	246.1
7	24	552.3	19.9	23	559.8	17.9		36	2334.2	287.1	87	2170.8	367.8	79	2544.1	339.6	31	2669.0	366.5
8	5	591.8	22.9	4	556.5	19.5		11	2632.7	361.0	56	2428.2	469.3	48	2655.1	450.5	28	2982.5	385.2
9	2	603.5	5.0	2	604.0	12.7		3	2910.0	441.9	12	2623.3	458.4	16	2883.9	525.1	14	3081.4	359.3
10				1	630.0						4	2580.0	852.0	8	3062.5	531.3	16	3086.3	507.8
11														1	2900.0		1	2900.0	
12																			
13																			

Table 7B3 Continued

Mean Wt_FD	1984			1985			1986			1987			1988			1989			1990		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes combined																					
3													2	860.0	537.4	1	1130.0				
4	7	1742.9	294.7	24	1735.2	199.5	15	1794.0	444.8	2	1880.0	169.7	10	1915.0	341.9	2	2150.0	42.4	4	1635.0	198.2
5	86	1929.0	339.0	111	1951.4	407.0	114	2043.6	391.1	66	2024.2	226.9	71	1928.6	322.6	77	2123.4	428.9	50	1855.0	336.3
6	122	2262.4	389.0	133	2283.2	431.1	117	2269.2	420.0	120	2277.5	330.5	117	2197.4	391.6	160	2150.6	351.9	69	2318.3	381.5
7	59	2496.1	505.9	89	2582.0	534.7	67	2635.5	536.0	85	2538.1	342.9	85	2524.0	546.7	118	2457.1	459.1	54	2680.0	394.8
8	36	2672.2	503.8	36	2748.5	555.5	37	2985.1	550.1	58	2757.6	485.9	44	2871.1	544.5	67	2631.0	493.2	33	2851.5	400.4
9	29	2987.0	519.2	24	3009.6	816.1	20	3245.5	543.5	37	2900.3	566.9	20	2994.0	750.7	18	2829.4	605.5	10	2901.0	590.7
10	13	3270.0	764.0	13	3132.3	641.9	7	3467.1	574.0	32	3303.4	499.8	7	3137.1	566.9	5	3234.0	787.9	4	3030.0	147.2
11	3	2913.3	630.0	6	3789.2	947.5	3	3333.3	442.4	15	3252.0	590.8							1	3800.0	
12	2	3410.0	212.1	2	3350.0	42.4	2	2985.0	431.3	3	3593.3	411.0							1	3380.0	
13										2	3830.0	14.1									
Males																					
3													1	1240.0							
4	1	1360.0		5	1496.0	170.4	7	1652.9	609.4				3	1543.3	153.7	1	2180.0	.	1	1420.0	
5	28	1562.6	158.9	19	1455.3	157.1	27	1638.6	270.1	4	1782.5	399.0	19	1659.5	234.7	17	1936.5	786.0	8	1446.3	174.3
6	24	1706.3	190.9	26	1816.4	257.0	25	1840.8	280.5	16	1938.1	284.9	44	1857.5	211.7	58	1855.5	224.2	8	1990.0	406.4
7	11	1886.4	329.9	21	1957.1	238.1	18	2112.5	241.1	11	1943.6	186.5	25	1957.6	462.9	41	2054.9	208.9	6	2208.3	295.5
8	16	2318.1	514.5	10	2205.0	268.4	10	2309.8	272.6	12	2135.0	153.8	12	2246.7	395.6	35	2257.6	216.3	5	2302.0	522.1
9	6	2303.3	283.0	4	2305.0	110.0	4	2495.0	245.7	10	2234.0	306.5	7	2112.9	195.2	11	2412.7	309.3	1	1900.0	
10	3	2240.0	140.0	2	2310.0	212.1	1	2730.0		2	2560.0	56.6	3	2573.3	172.4	2	2550.0	127.3			
11	1	2520.0					2	3100.0	254.6	3	2566.7	185.8									
Females																					
3													1	480.0							
4	6	1806.7	264.6	18	1791.9	158.0	8	1917.5	199.9	2	1880.0	169.7	7	2074.3	262.2	1	2120.0		3	1706.7	167.7
5	57	2107.4	250.3	90	2057.1	368.2	85	2184.1	322.5	62	2039.8	207.3	52	2026.9	294.2	60	2176.3	237.6	42	1932.9	301.9
6	97	2407.4	279.2	106	2396.7	388.4	91	2393.5	368.2	104	2329.7	306.1	73	2402.3	327.3	102	2318.3	296.9	61	2361.3	359.8
7	48	2635.8	431.0	68	2774.9	445.4	49	2827.6	484.0	74	2626.5	263.4	60	2760.0	381.7	77	2671.2	409.5	48	2739.0	366.8
8	20	2955.5	261.7	26	2957.5	492.4	27	3235.2	391.0	46	2920.0	403.6	32	3105.3	384.9	32	3039.5	370.0	28	2949.6	289.4
9	23	3165.3	405.2	20	3150.5	824.0	16	3433.1	417.5	27	3147.0	422.4	13	3468.5	420.2	7	3484.3	246.3	9	3012.2	503.4
10	9	3556.7	589.8	11	3281.8	574.5	6	3590.0	518.3	30	3353.0	475.6	4	3560.0	258.2	3	3690.0	673.6	4	3030.0	147.2
11	2	3110.0	749.5	6	3789.2	947.5	1	3800.0		12	3423.3	527.1							1	3800.0	
12	2	3410.0	212.1	2	3350.0	42.4	2	2985.0	431.3	3	3593.3	411.0							1	3380.0	
13										2	3830.0	14.1									

Table 7B3 Continued

Mean Wt_FD	1991			1992			1993			1994			1995		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes combined															
3	2	1200.0	396.0	2	860.0	28.3									
4	19	1796.8	419.6	31	1189.7	405.8	8	1420.0	354.9				7	1694.3	363.8
5	59	1969.3	266.1	169	1711.8	326.5	19	1608.4	241.6	24	1641.7	169.5	56	1791.4	234.9
6	65	2134.8	340.1	149	1859.7	305.2	36	1857.8	359.2	45	1725.1	246.9	70	1850.3	238.8
7	54	2423.9	468.1	81	1966.2	361.4	22	2068.2	340.7	26	1843.5	273.3	31	1917.7	292.6
8	17	2529.4	452.5	21	2373.3	452.6	8	2180.0	629.2	5	2260.0	365.0	8	1823.8	257.9
9	8	3037.5	215.0	7	2640.0	498.0	1	2580.0		3	2373.3	514.7	2	2465.0	657.6
10	1	3480.0	.	2	4070.0	240.4							1	3340.0	
11	1	3784.0	.												
12															
13															
Males															
3	2	1200.0	396.0	2	860.0	28.3									
4	2	1080.0	339.4	20	998.0	263.4	3	1120.0	307.9				4	1515.0	403.8
5	1	1960.0		24	1276.3	348.7	3	1440.0	235.8	1	1480.0		15	1546.7	141.2
6	5	1710.0	152.6	36	1525.0	224.4	13	1573.9	267.9	3	1560.0	346.4	32	1671.3	131.5
7	9	1825.6	159.2	30	1687.7	232.2	11	1803.6	216.5	3	1546.7	110.2	17	1748.2	161.9
8	5	2242.0	422.2	9	1988.9	165.0	2	1530.0	240.4				5	1730.0	218.9
9				1	2160.0					1	1780.0		1	2000.0	
10															
11															
Females															
3															
4	17	1881.2	345.1	11	1538.2	393.8	5	1600.0	255.0				3	1933.3	50.3
5	58	1969.5	268.4	144	1784.0	261.8	16	1640.0	236.4	23	1648.7	169.7	41	1881.0	195.4
6	60	2170.2	327.6	113	1966.4	244.7	23	2018.3	302.5	42	1736.9	239.6	38	2001.1	202.0
7	45	2543.6	414.1	50	2136.6	321.9	11	2332.7	207.1	23	1882.2	264.9	13	2151.5	278.3
8	12	2649.2	424.1	12	2661.7	375.6	6	2396.7	563.3	5	2260.0	365.0	3	1980.0	280.0
9	8	3037.5	215.0	6	2720.0	493.8	1	2580.0		2	2670.0	42.4	1	2930.0	
10	1	3480.0		2	4070.0	240.4							1	3340.0	
11	1	3784.0													
12															
13															

Table 7B3 Continued (Fishery Independent data)

Mean TL_FI	1983			1984			1985			1986			1987			1988			1989		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																					
2																					
3				3	424.7	22.2	14	420.3	23.4	9	423.8	30.6	5	409.4	31.6	2	450.0	82.0	2	416.5	44.6
4	2	459.5	6.4	19	453.1	28.2	63	464.7	32.9	94	474.9	40.9	65	465.7	28.8	58	480.6	39.1	42	455.0	39.7
5	5	500.6	21.8	30	513.7	25.9	69	501.4	35.9	128	511.9	33.4	121	513.7	32.1	187	519.4	33.8	102	516.2	35.0
6	5	529.2	8.9	37	544.8	24.0	51	548.1	33.4	104	541.2	35.7	77	549.4	25.5	146	558.0	28.6	85	538.1	28.1
7	4	533.3	15.9	23	583.4	29.4	29	569.9	33.9	41	583.2	39.0	42	568.7	28.4	82	578.6	31.6	66	564.9	35.7
8	2	559.5	13.4	15	590.8	39.5	19	590.0	32.7	23	598.7	33.3	26	603.9	23.9	21	597.5	48.9	34	580.7	35.7
9	2	573.5	2.1	6	611.0	43.5	7	621.6	32.6	13	620.1	29.6	20	631.8	32.4	15	613.3	19.4	10	597.2	16.7
10				4	601.0	34.5	5	620.8	34.2	2	665.0	9.9	8	633.8	39.6	8	634.1	35.7	7	657.3	37.5
11				1	647.0	.	3	650.3	32.4	5	645.8	20.8	3	620.7	43.0	5	662.8	20.5	3	634.3	16.0
12													2	692.5	10.6	2	675.5	41.7			
13													1	685.0							
Males																					
2																					
3				3	424.7	22.2	13	419.8	24.3	9	423.8	30.6	5	409.4	31.6	2	450.0	82.0	2	416.5	44.6
4	2	459.5	6.4	17	458.1	20.8	53	455.8	26.9	77	464.1	35.3	52	458.3	22.1	42	466.1	32.0	32	440.4	27.6
5	5	500.6	21.8	23	507.0	22.3	53	488.2	25.9	72	491.7	25.4	59	487.3	19.9	97	495.7	19.5	43	487.4	28.7
6	5	529.2	8.9	22	533.5	17.6	24	528.3	27.3	39	511.9	30.8	31	525.4	17.9	42	529.3	25.1	35	515.7	21.3
7	4	533.3	15.9	9	561.8	27.5	12	541.2	12.8	15	555.0	22.0	17	543.1	18.6	26	544.0	19.5	22	536.9	22.8
8	2	559.5	13.4	7	555.0	20.4	8	571.8	29.4	6	570.3	15.2	6	569.5	15.0	7	549.9	49.1	17	555.8	29.8
9	2	573.5	2.1	1	548.0		2	578.0	24.0	3	596.0	8.9	6	589.2	8.7	4	593.0	7.0	5	588.6	13.1
10				1	559.0		1	590.0					2	595.0	63.6	2	591.0	1.4	1	593.0	
11										1	614.0		2	596.0	7.1						
Females																					
3				3	424.7	22.2	14	420.3	23.4	9	423.8	30.6	5	409.4	31.6	2	450.0	82.0	2	416.5	44.6
4				19	453.1	28.2	63	464.7	32.9	94	474.9	40.9	65	465.7	28.8	58	480.6	39.1	42	455.0	39.7
5				30	513.7	25.9	69	501.4	35.9	128	511.9	33.4	121	513.7	32.1	187	519.4	33.8	102	516.2	35.0
6				37	544.8	24.0	51	548.1	33.4	104	541.2	35.7	77	549.4	25.5	146	558.0	28.6	85	538.1	28.1
7				23	583.4	29.4	29	569.9	33.9	41	583.2	39.0	42	568.7	28.4	82	578.6	31.6	66	564.9	35.7
8				15	590.8	39.5	19	590.0	32.7	23	598.7	33.3	26	603.9	23.9	21	597.5	48.9	34	580.7	35.7
9				6	611.0	43.5	7	621.6	32.6	13	620.1	29.6	20	631.8	32.4	15	613.3	19.4	10	597.2	16.7
10				4	601.0	34.5	5	620.8	34.2	2	665.0	9.9	8	633.8	39.6	8	634.1	35.7	7	657.3	37.5
11				1	647.0	.	3	650.3	32.4	5	645.8	20.8	3	620.7	43.0	5	662.8	20.5	3	634.3	16.0
12													2	692.5	10.6	2	675.5	41.7			
13													1	685.0							

Table 7B3 Continued (Fishery Independent data)

Mean TL_FI	1990			1991			1992			1993			1994			1995			1996		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																					
2																					
3				14	426.9	31.4	13	419.5	22.0	5	419.6	12.9	2	435.5	13.4	25	426.2	38.5	24	424.9	16.6
4	9	451.7	49.6	57	452.8	32.9	188	446.2	26.1	90	443.1	24.6	32	447.6	20.4	149	474.0	35.1	194	451.2	29.9
5	32	491.9	45.1	66	499.1	30.4	383	482.1	31.8	206	470.0	25.8	85	491.7	30.2	255	512.4	29.2	115	500.5	34.5
6	18	528.8	38.4	51	521.9	35.3	215	522.2	29.5	100	495.8	30.8	27	508.2	28.3	135	530.8	30.3	36	548.0	30.0
7	19	570.0	38.9	18	553.4	37.3	63	552.9	27.4	34	530.7	31.1	11	518.7	18.6	39	548.8	24.9	11	567.1	26.4
8	7	579.0	41.3	4	592.3	15.1	5	575.6	32.1	9	553.0	26.8	2	555.5	36.1				5	607.6	40.5
9	1	627.0		1	651.0		8	603.5	26.7										2	635.0	21.2
10	1	635.0		1	612.0		2	653.5	19.1										1	526.0	
11																					
12																					
13																					
Males																					
2																					
3				12	417.5	22.0	13	419.5	22.0	5	419.6	12.9	2	435.5	13.4	23	418.5	28.8	23	424.5	16.9
4	7	434.0	39.8	46	443.8	26.6	168	441.5	21.4	83	439.6	21.4	32	447.6	20.4	92	455.7	26.6	162	443.9	24.4
5	16	462.8	25.6	33	479.2	25.1	224	463.1	21.9	152	460.0	18.6	36	466.1	22.2	77	484.2	25.8	64	484.3	29.0
6	7	512.0	52.1	16	485.1	27.2	66	494.4	24.5	47	476.3	20.6	7	481.4	18.5	31	496.2	27.5	15	525.4	24.5
7	7	533.3	35.8	4	514.8	43.3	7	525.7	28.3	16	508.8	25.3	3	505.0	27.2	8	520.4	12.4	4	542.5	21.0
8	1	547.0		1	574.0		1	560.0		2	518.0	14.1							1	564.0	
9							2	571.0	17.0												
10																					
11																					
Females																					
3				14	426.9	31.4	13	419.5	22.0	5	419.6	12.9	2	435.5	13.4	25	426.2	38.5			
4	9	451.7	49.6	57	452.8	32.9	188	446.2	26.1	90	443.1	24.6	32	447.6	20.4	149	474.0	35.1	30	491.4	25.4
5	32	491.9	45.1	66	499.1	30.4	383	482.1	31.8	206	470.0	25.8	85	491.7	30.2	255	512.4	29.2	50	521.0	30.2
6	18	528.8	38.4	51	521.9	35.3	215	522.2	29.5	100	495.8	30.8	27	508.2	28.3	135	530.8	30.3	20	564.9	22.7
7	19	570.0	38.9	18	553.4	37.3	63	552.9	27.4	34	530.7	31.1	11	518.7	18.6	39	548.8	24.9	7	581.1	17.6
8	7	579.0	41.3	4	592.3	15.1	5	575.6	32.1	9	553.0	26.8	2	555.5	36.1				4	618.5	37.4
9	1	627.0		1	651.0		8	603.5	26.7										2	635.0	21.2
10	1	635.0		1	612.0		2	653.5	19.1										1	526.0	
11																					
12																					
13																					

Table 7B3 Continued (Fishery Independent data)

Mean TL_FI	1997			1998			1999			2000			2001			2004		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																		
2																1	420	
3	4	416.5	10.2	7	419.6	21.6	3	430.3	6.4	22	431.7	14.9	48	443.4	38.9	8	430.8	24.6
4	38	448.9	42.4	108	459.9	38.6	100	467.5	34.3	128	479.6	35.2	287	471.3	31.3	60	470.0	39.5
5	63	484.6	28.5	114	499.1	37.5	191	492.6	29.6	181	518.0	29.1	323	511.1	36.1	188	506.0	28.1
6	23	513.1	35.1	36	533.4	37.0	49	533.3	33.1	40	540.9	32.8	193	541.9	31.0	178	540.0	32.7
7	7	549.4	47.0	12	559.4	51.3	15	572.9	22.9	6	564.8	17.5	64	556.7	32.2	164	572.8	29.1
8	5	594.4	18.2	5	579.2	24.9	2	543.5	30.4	3	580.3	21.4	10	558.8	38.0	95	582.7	34.6
9	6	607.0	18.5	1	632.0		1	602.0		1	610.0		3	622.7	40.0	51	613.1	26.2
10	1	556.0											1	650.0		25	623.4	26.9
11																4	623.0	35.2
12																1	637.0	
13																1	677.0	
Males																		
2																1	420	
3	4	416.5	10.3	7	419.6	21.6	2	428.0	7.1	22	431.7	14.9	41	434.1	29.8	7	428.6	25.7
4	24	425.6	31.6	78	443.3	23.4	64	454.0	32.4	79	461.6	24.6	209	459.3	23.2	39	450.2	29.3
5	29	466.6	22.0	48	466.8	24.5	79	471.4	23.6	67	493.0	22.4	146	483.6	24.5	86	487.8	23.8
6	10	486.6	28.9	12	504.3	19.0	19	505.7	29.6	15	511.6	23.3	71	512.8	24.8	59	514.7	27.8
7	1	522.0		4	510.3	54.7	2	538.5	23.3	1	533.0		24	526.4	21.7	35	540.1	19.9
8							2	543.5	30.4	1	556.0		4	553.3	12.4	32	548.1	23.0
9													79	486.7	37.6	4	556.8	20.5
10	1	556.0														2	568.5	13.4
11																1	572.0	
Females																		
3	4	416.5	10.3										7	498.0	43.0	1	446.0	
4	38	448.9	42.5	28	504.4	36.5	35	493.2	20.4	46	511.7	27.6	76	503.7	27.6	21	506.7	28.2
5	57	484.0	29.0	65	522.4	26.2	108	508.4	23.5	112	532.8	21.7	175	534.2	27.0	97	521.0	21.7
6	19	511.8	37.6	24	548.0	35.3	28	552.5	20.0	25	558.5	24.0	122	558.9	19.6	117	552.6	27.6
7	6	543.2	48.2	7	577.6	22.8	13	578.2	18.4	5	571.2	8.8	40	574.9	22.2	128	581.6	24.6
8	3	604.0	16.5	5	579.2	24.9				2	592.5	4.9	6	562.5	49.6	63	600.3	24.8
9	6	607.0	18.5	1	632.0		1	602.0		1	610.0		3	622.7	40.0	47	617.9	20.5
10	1	556.0											1	650.0		23	628.1	22.0
11																3	640.0	11.1
12																1	637.0	
13																1	677.0	

Table 7B3 Continued (Fishery Independent data)

Mean WT_FI	1983			1984			1985			1986			1987			1988			1989		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																					
2																					
3				3	744.0	124.9	13	705.5	97.3	9	862.2	186.6	5	744.0	192.6	2	860.0	339.4	2	590.0	141.4
4	2	1005.0	120.2	18	946.4	228.3	54	977.1	330.3	82	1182.2	339.7	62	1004.9	242.0	57	1137.5	322.9	42	922.1	272.9
5	5	1324.0	191.9	30	1455.4	327.0	49	1257.8	300.5	119	1470.9	369.2	120	1383.3	328.1	178	1494.5	394.8	101	1352.8	358.8
6	5	1498.0	72.9	37	1779.5	377.4	38	1739.3	504.5	98	1745.8	392.4	77	1700.7	374.6	142	1864.6	381.7	84	1541.4	373.0
7	4	1605.0	208.9	23	2167.2	459.6	23	1873.2	473.3	39	2180.0	476.9	42	1904.8	333.1	81	2049.3	481.6	65	1868.3	461.6
8	2	1795.0	289.9	15	2372.7	637.6	15	2268.5	584.4	21	2283.8	485.5	26	2268.5	404.9	21	2295.7	549.2	34	1984.1	433.9
9	2	1865.0	275.8	6	2370.8	698.7	5	2854.6	733.7	13	2643.1	378.2	20	2449.5	385.9	15	2475.3	503.8	11	2050.0	284.1
10				4	2547.5	646.7	3	2270.0	177.5	2	3620.0	311.1	8	2406.3	247.2	8	2630.0	642.5	7	3222.9	529.7
11				1	2780.0		3	2620.0	374.7	5	3004.0	491.8	3	2163.3	833.9	5	2868.0	444.0	3	2326.7	223.0
12													2	3210.0	155.6	2	3530.0	523.3			
13													1	2600.0							
Males																					
2																					
3				3	744.0	124.9	12	699.3	98.9	9	862.2	186.6	5	744.0	192.6	2	860.0	339.4	2	590.0	141.4
4	2	1005.0	120.2	16	985.9	192.4	45	872.7	210.0	66	1082.7	257.1	50	946.9	183.7	41	1036.6	277.4	32	821.6	163.5
5	5	1324.0	191.9	23	1341.8	196.9	37	1160.1	224.4	64	1246.7	223.6	59	1139.7	178.9	92	1264.7	220.4	43	1124.7	245.9
6	5	1498.0	72.9	22	1549.6	227.0	18	1489.5	279.2	37	1456.0	239.5	31	1425.5	193.9	41	1577.1	236.2	35	1278.0	212.1
7	4	1605.0	208.9	9	1804.4	308.2	12	1589.8	219.6	15	1834.0	324.3	17	1648.8	168.2	25	1694.0	287.3	22	1522.7	262.3
8	2	1795.0	289.9	7	1837.1	278.7	6	1859.2	269.9	5	1998.0	233.5	6	1976.7	275.5	7	1932.9	526.5	17	1755.3	283.0
9	2	1865.0	275.8	1	1635.0		2	2315.0	530.3	3	2383.3	332.5	6	2075.0	80.4	4	2142.5	132.8	5	2058.0	273.4
10				1	1780.0		1	2071.0					2	2205.0	502.1	2	2010.0	155.6	1	2480.0	
11										1	2380.0		2	1685.0	134.4						
Females																					
3							1	780.0													
4				1	860.0		9	1499.2	335.0	16	1592.5	336.8	12	1246.7	309.0	16	1396.3	291.2	8	1322.5	286.2
5				7	1828.6	403.3	12	1559.3	312.9	55	1731.8	332.5	60	1625.8	256.7	86	1740.4	392.6	50	1560.0	340.6
6				15	2116.7	289.9	20	1964.2	559.9	61	1921.6	362.2	46	1886.1	353.0	101	1981.3	368.0	44	1752.7	351.1
7				14	2400.4	386.5	11	2182.3	488.3	24	2396.3	429.9	25	2078.8	304.6	56	2207.9	467.3	41	2063.4	443.4
8				8	2841.3	456.8	9	2541.4	585.3	16	2373.1	513.8	20	2356.0	400.9	14	2477.1	479.4	15	2306.7	354.4
9				5	2518.0	669.2	3	3214.3	671.3	10	2721.0	370.0	14	2610.0	350.3	11	2596.4	538.2	6	2043.3	318.7
10				3	2803.3	484.4	2	2369.5	60.1	2	3620.0	311.1	6	2473.3	116.4	6	2836.7	606.7	6	3346.7	456.0
11				1	2780.0		3	2620.0	374.7	4	3160.0	400.3	1	3120.0		5	2868.0	444.0	3	2326.7	223.0
12													2	3210.0	155.6	2	3530.0	523.3			
13													1	2600.0							

Table 7B3 Continued (Fishery Independent data)

Mean WT_FI	1990			1991			1992			1993			1994			1995			1996		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																					
2																					
3	.	.	.	14	702.9	176.7	13	638.5	129.7	4	640.0	71.2	1	720.0		25	780.4	280.0	24	642.5	112.7
4	9	901.1	356.7	57	869.1	222.7	189	810.1	189.7	90	695.8	166.6	29	804.8	151.2	146	1039.3	322.6	191	818.4	230.7
5	31	1118.7	382.6	65	1181.2	283.2	380	1074.7	301.6	204	859.2	197.5	80	1091.5	270.8	250	1324.6	320.9	112	1161.1	405.9
6	18	1371.7	342.6	51	1360.6	350.5	212	1372.5	350.2	97	1046.6	221.8	26	1228.5	282.3	133	1471.2	331.2	36	1730.3	833.3
7	20	1811.0	391.0	16	1607.5	278.4	63	1655.2	396.5	33	1229.4	264.2	10	1234.0	180.6	38	1603.4	282.6	12	1977.8	411.5
8	7	1838.6	362.3	4	1750.0	233.5	5	1808.0	655.2	9	1572.2	366.9	2	1420.0	311.1				5	2312.0	667.3
9	1	2400.0		1	2260.0		8	2141.3	457.5										2	2820.0	28.3
10	1	2400.0		1	2160.0		2	2805.0	431.3										1	1140.0	
11																					
12																					
13																					
Males																					
2																					
3				12	652.5	121.1	13	638.5	129.7	4	640.0	71.2	1	720.0	.	23	725.2	203.7	23	645.2	114.5
4	7	741.4	180.2	46	803.7	170.4	169	773.0	130.1	83	669.2	136.8	29	804.8	151.2	89	882.6	219.2	162	759.8	158.3
5	15	864.0	165.2	33	987.9	173.3	222	902.3	168.4	151	789.6	138.2	34	911.8	216.8	75	1046.7	200.0	64	1039.7	412.8
6	7	1265.7	369.5	16	1010.6	194.2	65	1168.1	413.7	47	920.9	138.6	7	1002.9	54.7	31	1157.7	219.8	15	1638.0	1248.9
7	7	1492.9	405.5	2	1410.0	99.0	7	1375.7	199.4	16	1130.0	263.3	3	1146.7	161.7	8	1367.5	157.1	4	1580.0	268.8
8	1	1530.0		1	1440.0		1	1380.0		2	1230.0	14.1							1	2000.0	
9							2	1815.0	176.8												
10																					
11																					
Females																					
3				1	1130.0											1	1630.0				
4	2	1460.0	141.4	10	1175.0	192.7	20	1123.0	301.8	7	1011.4	172.8				56	1289.0	306.9	27	1177.8	276.5
5	16	1357.5	376.2	30	1391.3	228.4	157	1319.9	278.8	51	1066.7	206.2	46	1224.4	227.6	169	1450.8	288.5	47	1337.0	326.3
6	11	1439.1	323.7	34	1524.1	286.4	145	1466.3	274.4	47	1171.9	221.5	18	1332.2	280.9	98	1580.4	296.7	20	1801.0	343.5
7	13	1982.3	262.7	14	1635.7	286.0	56	1690.2	402.1	17	1322.9	235.3	6	1303.3	182.2	29	1667.9	281.4	8	2176.8	315.3
8	5	2028.0	162.2	3	1853.3	133.2	4	1915.0	704.3	7	1670.0	359.6	2	1420.0	311.1				4	2390.0	743.8
9	1	2400.0		1	2260.0		6	2250.0	479.6										2	2820.0	28.3
10	1	2400.0		1	2160.0		2	2805.0	431.3										1	1140.0	
11																					
12																					
13																					

Table 7B3 Continued (Fishery Independent data)

Mean WT_FI	1997			1998			1999			2000			2001			2004		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																		
2																1	600.0	
3	4	677.5	68.5	5	724.0	155.8	3	743.3	63.5	19	742.6	96.1	48	755.7	201.2	8	827.5	181.1
4	37	866.6	283.0	107	995.3	348.3	97	918.3	215.6	125	1080.8	276.0	265	965.6	264.7	60	996.8	271.7
5	56	1128.8	282.9	112	1260.8	354.0	190	1091.7	260.5	179	1376.0	298.7	307	1251.8	340.8	187	1286.4	282.9
6	19	1316.8	365.7	35	1524.9	337.1	48	1463.3	444.1	38	1534.0	298.5	181	1446.9	346.6	178	1606.5	385.4
7	6	1750.0	306.7	12	1731.7	441.0	15	1678.0	260.8	6	1747.7	158.5	57	1539.3	365.1	161	1953.3	439.4
8	3	2073.3	30.6	5	2040.0	476.0	2	1580.0	311.1	3	1913.3	355.7	10	1655.0	607.1	95	1998.3	442.7
9	6	2146.7	400.3	1	2400.0		1	2300.0		1	2260.0		3	2073.3	248.3	52	2320.2	430.1
10	1	1660.0											1	2760.0		26	2479.2	555.2
11																4	2390.0	438.9
12																1	2640.0	
13																1	3560.0	
Males																		
2																1	600.0	
3	4	677.5	68.5	5	724.0	155.8	2	725.0	77.8	19	742.6	96.1	41	701.9	149.0	7	794.3	167.2
4	24	723.5	220.5	77	854.6	157.2	62	809.5	154.6	77	937.8	183.3	193	867.1	175.6	39	856.9	180.4
5	28	1022.1	249.8	47	1000.0	192.8	79	906.5	157.7	67	1164.2	212.9	138	1009.4	211.2	86	1134.3	204.3
6	10	1050.0	197.4	12	1255.8	173.1	19	1101.1	191.6	14	1335.7	232.6	65	1163.1	243.8	60	1364.3	247.1
7	1	1360.0		4	1350.0	414.6	2	1320.0	113.1	1	1680.0		22	1269.1	169.8	35	1536.3	230.0
8							2	1580.0	311.1	1	1600.0		4	1395.0	123.7	32	1582.5	208.6
9																4	1715.0	245.7
10	1	1660.0														2	1590.0	14.1
11																1	1860.0	
Females																		
3													7	1070.9	182.8	1	1060.0	
4	12	1143.3	176.2	28	1355.7	427.3	34	1122.9	155.6	45	1332.1	233.9	72	1229.5	283.0	21	1256.7	216.4
5	27	1241.9	280.7	64	1451.7	325.4	108	1227.5	239.8	110	1506.6	270.4	168	1453.4	292.8	96	1422.4	279.4
6	9	1613.3	262.9	23	1665.2	317.1	27	1714.1	407.4	24	1649.6	273.7	116	1606.0	289.6	116	1734.5	386.5
7	5	1828.0	268.2	7	1877.1	325.1	13	1733.1	231.6	5	1761.2	173.3	35	1709.2	353.2	125	2069.7	414.6
8	3	2073.3	30.6	5	2040.0	476.0				2	2070.0	325.3	6	1828.3	751.1	63	2209.5	375.3
9	6	2146.7	400.3	1	2400.0		1	2300.0		1	2260.0		3	2073.3	248.3	48	2370.6	403.8
10													1	2760.0		24	2553.3	510.4
11																3	2566.7	319.0
12																1	2640.0	
13																1	3560.0	

Table 7B4 MARK model outputs for Hudson River American shad.

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Z Lower	Z Upper	Model	AICc	Delta AICc	AICc Weight	#Par	Dev.
1995-1997													
S(.)r(.)								S(.)r(.)	1324.96	0.00	0.63	2	2.51
S	0.216	0.047	0.138	0.322	1.53	1.98	1.13	S(.)r(t)	1327.85	2.90	0.15	4	1.40
r	0.023	0.002	0.019	0.028				S(t)r(t)	1328.46	3.50	0.11	5	0.00
S(.)r(t)								S(t)r(.)	1328.52	3.56	0.11	4	2.06
S	0.232	0.053	0.144	0.351	1.46	1.94	1.05						
r1	0.026	0.004	0.019	0.036									
r2	0.022	0.004	0.016	0.030									
r3	0.021	0.003	0.016	0.029									
S(t)r(.)													
S1	0.225	0.053	0.137	0.346									
S2	0.204	0.085	0.084	0.417									
S3	0.293	0.161	0.083	0.656									
r	0.024	0.003	0.019	0.030									
S(t)r(t)													
S1	0.309	0.101	0.150	0.531									
S2	0.151	0.069	0.058	0.337									
S3	0.974	0.000	0.974	0.974									
r1	0.029	0.006	0.020	0.043									
r2	0.018	0.004	0.012	0.028									
r3	0.661	0.000	0.661	0.661									
1995-1998													
S(.)r(.)								S(t)r(t)	1479.68	0.00	0.41	7	4.61
S	0.229	0.038	0.163	0.313	1.47	1.82	1.16	S(.)r(.)	1479.73	0.05	0.40	2	14.68
r	0.023	0.002	0.019	0.027				S(t)r(.)	1481.94	2.27	0.13	5	10.89
S(.)r(t)								S(.)r(t)	1483.32	3.64	0.07	5	12.26
S	0.263	0.050	0.177	0.371									
r1	0.028	0.004	0.020	0.037									
r2	0.022	0.004	0.016	0.030									
r3	0.022	0.003	0.016	0.029									
r4	0.017	0.005	0.009	0.031									
S(t)r(.)													
S1	0.237	0.054	0.148	0.357									
S2	0.220	0.079	0.102	0.411									
S3	0.393	0.107	0.212	0.610									
S4	0.630	0.162	0.304	0.869									
r	0.025	0.003	0.020	0.031									
S(t)r(t)													
S1	0.331	0.106	0.162	0.559									
S2	0.136	0.057	0.057	0.290									
S3	0.982	0.003	0.976	0.987									
S4	0.990	1.267	0.000	1.000									
r1	0.030	0.006	0.020	0.046									
r2	0.017	0.004	0.011	0.027									
r3	1.000	0.003	0.000	1.000									
r4	0.467	61.792	0.000	1.000									
1995-1999													
S(.)r(.)								S(t)r(t)	1541.22	0.00	0.50	9	5.62

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Z Lower	Z Upper	Model	AICc	Delta AICc	AICc Weight	#Par	Dev.
S	0.228	0.034	0.167	0.302	1.48	1.79	1.20	S(t)r(.)	1542.60	1.37	0.25	6	13.01
r	0.022	0.002	0.019	0.026				S(.)r(.)	1543.76	2.53	0.14	2	22.18
S(.)r(t)								S(.)r(t)	1544.37	3.14	0.10	6	14.78
S	0.272	0.047	0.189	0.372	1.30	1.67	0.99						
r1	0.027	0.004	0.021	0.037									
r2	0.022	0.004	0.016	0.030									
r3	0.022	0.003	0.016	0.030									
r4	0.016	0.005	0.009	0.030									
r5	0.009	0.004	0.003	0.023									
S(t)r(.)													
S1	0.234	0.053	0.146	0.353									
S2	0.205	0.073	0.097	0.382									
S3	0.377	0.098	0.210	0.589									
S4	0.595	0.167	0.274	0.851									
S5	0.848	0.093	0.575	0.959									
r	0.025	0.003	0.020	0.030									
S(t)r(t)													
S1	0.331	0.106	0.162	0.559									
S2	0.130	0.055	0.055	0.279									
S3	0.982	0.003	0.975	0.987									
S4	0.201	0.201	0.021	0.746									
S5	0.992	2.535	0.000	1.000									
r1	0.030	0.006	0.020	0.046									
r2	0.017	0.004	0.011	0.027									
r3	1.000	0.000	1.000	1.000									
r4	0.006	0.002	0.003	0.012									
r5	0.530	175.457	0.000	1.000									
1995-2000													
S(t)r(t)								S(t)r(t)	1576.41	0.00	0.57	10	10.19
S1	0.375	0.116	0.186	0.612				S(t)r(.)	1578.00	1.59	0.26	7	17.79
S2	0.160	0.061	0.073	0.318				S(.)r(t)	1578.83	2.42	0.17	7	18.62
S3	0.983	0.003	0.976	0.988				S(.)r(.)	1597.22	20.81	0.00	2	47.03
S4	0.155	0.155	0.018	0.650									
S5	0.076	104.065	0.000	1.000									
S6	0.747	0.000	0.747	0.747									
r1	0.032	0.007	0.021	0.051									
r2	0.017	0.004	0.011	0.027									
r3	1.000	0.001	0.999	1.001									
r4	0.006	0.002	0.003	0.012									
r5	0.006	0.622	0.000	1.000									
r6	0.000	0.000	0.000	0.000									
S(t)r(.)													
S1	0.259	0.054	0.168	0.379									
S2	0.254	0.079	0.131	0.434									
S3	0.413	0.100	0.238	0.612									
S4	0.583	0.167	0.266	0.843									
S5	0.861	0.087	0.597	0.963									
S6	1.000	0.000	1.000	1.000									
r	0.025	0.003	0.021	0.031									

Model/			95% CI		Z		
Parameter	S(I)	SE	Lower	Upper	S(I)	Lower	Upper
S(.)r(t)							
S	0.304	0.050	0.217	0.409	1.19	3.01	1.53
r1	0.029	0.005	0.021	0.039			
r2	0.022	0.004	0.016	0.031			
r3	0.022	0.003	0.016	0.030			
r4	0.018	0.005	0.010	0.032			
r5	0.008	0.004	0.003	0.022			
r6	0.000	0.000	0.000	0.000			
S(.)r(.)							
S	0.250	0.034	0.189	0.322	1.39	3.39	1.66
r	0.021	0.002	0.018	0.024			
1995-2001							
S(t)r(t)							
S1	0.375	0.116	0.186	0.612			
S2	0.157	0.060	0.071	0.312			
S3	0.983	0.003	0.976	0.988			
S4	0.147	0.108	0.031	0.484			
S5	0.995	0.003	0.983	0.998			
S6	1.000	0.000	1.000	1.000			
S7	0.001	8.334	0.000	1.000			
r1	0.032	0.007	0.021	0.051			
r2	0.017	0.004	0.011	0.027			
r3	1.000	0.000	1.000	1.000			
r4	0.006	0.002	0.003	0.011			
r5	1.000	0.000	1.000	1.000			
r6	0.053	313.610	0.000	1.000			
r7	0.003	0.024	0.000	1.000			
S(t)r(.)							
S1	0.257	0.054	0.166	0.375			
S2	0.240	0.073	0.127	0.408			
S3	0.392	0.090	0.235	0.575			
S4	0.540	0.166	0.241	0.813			
S5	0.844	0.094	0.572	0.956			
S6	1.000	0.000	1.000	1.000			
S7	0.893	0.054	0.732	0.962			
r	0.025	0.002	0.021	0.030			
S(.) r(t)							
S	0.345	0.050	0.255	0.449	1.06	3.00	1.37
r1	0.031	0.005	0.023	0.042			
r2	0.023	0.004	0.016	0.031			
r3	0.022	0.004	0.016	0.030			
r4	0.017	0.005	0.009	0.029			
r5	0.008	0.004	0.003	0.020			
r6	0.000	0.000	0.000	0.000			
r7	0.010	0.004	0.004	0.024			
S(.) r(.)							
S	0.276	0.034	0.215	0.346	1.29	3.39	1.54
R	0.020	0.002	0.017	0.024			

Model	AICc	Delta AICc	AICc Weight	#Par	Dev.
S(t)r(t)	1650.78	0	0.74152	11	11.222
S(t) r(.)	1652.99	2.21	0.24523	8	19.451
S(.)r(t)	1658.83	8.05	0.01325	8	25.288
S(.)r(.)	1681.06	30.28	0	2	59.539

Table 7B4 Continued

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Lower	Upper
1995-2002							
{S(t)r(t)}							
1:S	0.375	0.116	0.186	0.612			
2:S	0.160	0.061	0.073	0.318			
3:S	0.983	0.003	0.976	0.988			
4:S	0.103	0.094	0.015	0.458			
5:S	0.251	0.286	0.017	0.868			
6:S	1.000	0.000	1.000	1.000			
7:S	0.055	119.966	0.000	1.000			
8:S	0.468	241.609	0.000	1.000			
9:r	0.032	0.007	0.021	0.051			
10:r	0.017	0.004	0.011	0.027			
11:r	1.000	0.000	0.999	1.001			
12:r	0.006	0.002	0.003	0.010			
13:r	0.008	0.006	0.002	0.037			
14:r	0.002	48.045	0.000	1.000			
15:r	0.004	0.469	0.000	1.000			
16:r	0.089	191.018	0.000	1.000			
{S(p)r(.)} p=2 periods 1995-1999, 200-2003							
1:S	0.251	0.034	0.190	0.324	1.38	3.38	1.66
2:S	0.885	0.049	0.750	0.952	0.12	3.02	0.29
3:r	0.022	0.002	0.019	0.026			
{S(.)r(t)}							
1:S	0.317	0.047	0.233	0.414	1.15	3.06	1.46
2:r	0.030	0.005	0.022	0.040			
3:r	0.022	0.004	0.016	0.031			
4:r	0.022	0.003	0.016	0.030			
5:r	0.018	0.005	0.010	0.031			
6:r	0.008	0.004	0.003	0.021			
7:r	0.000	0.000	0.000	0.000			
8:r	0.008	0.004	0.003	0.021			
9:r	0.019	0.011	0.006	0.059			

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
{S(t)r(t)}	1680.3	0.000	0.317	1.000	13	13.312
{S(p)r(.)}	1680.5	0.270	0.276	0.872	3	33.632
{S(.)r(t)}	1683.1	2.860	0.076	0.239	9	24.199
{S(t)r(.)}	1683.1	2.860	0.076	0.239	9	24.201
{S(.)r(.)}	1703.4	23.110	0.000	0.000	2	58.471

p=2 periods 1995-1999, 2000-2002

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Lower	Upper	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
{S(t)r(.)}														
1:S	0.252	0.053	0.163	0.369										
2:S	0.218	0.065	0.116	0.371										
3:S	0.321	0.079	0.188	0.492										
4:S	0.356	0.205	0.088	0.761										
5:S	0.747	0.161	0.358	0.940										
6:S	1.000	0.000	1.000	1.000										
7:S	0.891	0.061	0.707	0.965										
8:S	0.908	0.059	0.713	0.975										
9:r	0.024	0.002	0.020	0.029										
{S(.)r(.)}														
1:S	0.262	0.032	0.204	0.330										
2:r	0.020	0.002	0.017	0.023										
1995-2003														
{S(p)r(.)}								{S(p)r(.)}	1704.0	0	0.894	1.000	3	34.160
1:S	0.224	0.033	0.166	0.294	1.50	3.42	1.80	{S(p)r(t)}	1709.1	5.11	0.070	0.078	11	23.239
2:S	0.880	0.043	0.769	0.941	0.13	3.16	0.26	{S(t)r(t)}	1711.6	7.59	0.020	0.022	17	13.681
3:r	0.022	0.002	0.019	0.026				{S(t)r(.)}	1712.0	8.08	0.016	0.018	11	26.209
{S(p)r(t)}								{S(.)r(t)}	1717.5	13.52	0.001	0.001	10	33.652
1:S	0.261	0.043	0.186	0.354	1.34	3.14	1.68	{S(.)r(.)}	1740.5	36.52	0.000	0.000	2	72.686
2:S	0.963	0.332	0.000	1.000	0.04	1.10	14.83							
3:r	0.027	0.004	0.020	0.037				p=2 periods 1995-1999, 2000-2003						
4:r	0.022	0.004	0.016	0.030										
5:r	0.022	0.003	0.016	0.029										
6:r	0.017	0.005	0.009	0.031										
7:r	0.009	0.004	0.003	0.023										
8:r	0.000	0.000	0.000	0.000										
9:r	0.095	0.831	0.000	1.000										
10:r	0.070	0.590	0.000	1.000										
11:r	0.064	0.533	0.000	1.000										
{S(t)r(t)}														
1:S	0.000	0.000	0.000	0.000										
2:S	0.331	0.106	0.162	0.559										
3:S	0.130	0.055	0.055	0.279										

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Lower	Upper	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
4:S	0.982	0.003	0.975	0.987										
5:S	0.109	0.100	0.016	0.477										
6:S	0.247	0.297	0.014	0.882										
7:S	0.640	0.445	0.039	0.987										
8:S	0.996	0.002	0.987	0.999										
9:S	0.997	0.002	0.989	0.999										
10:S	0.990	2.271	0.000	1.000										
11:r	0.030	0.006	0.020	0.046										
12:r	0.017	0.004	0.011	0.027										
13:r	1.000	0.002	0.000	1.000										
14:r	0.005	0.002	0.003	0.010										
15:r	0.008	0.006	0.002	0.037										
16:r	0.000	0.000	0.000	0.000										
17:r	1.000	0.029	0.000	1.000										
18:r	1.000	0.031	0.000	1.000										
19:r	0.269	63.639	0.000	1.000										
{S(t)r(.)}														
1:S	1.000	0.000	1.000	1.000										
2:S	0.228	0.052	0.143	0.345										
3:S	0.174	0.060	0.085	0.323										
4:S	0.277	0.071	0.161	0.433										
5:S	0.320	0.191	0.078	0.725										
6:S	0.683	0.189	0.280	0.923										
7:S	1.000	0.000	1.000	1.000										
8:S	0.882	0.063	0.694	0.961										
9:S	0.903	0.060	0.709	0.973										
10:S	0.902	0.053	0.741	0.968										
11:r	0.023	0.002	0.019	0.027										
{S(.)r(t)}														
1:S	0.329	0.046	0.245	0.425	1.11	3.07	1.41							
2:r	0.030	0.005	0.022	0.041										
3:r	0.022	0.004	0.016	0.031										
4:r	0.022	0.003	0.016	0.030										
5:r	0.015	0.005	0.008	0.027										

Model/ Parameter	S(I)	SE	95% CI Lower	Upper	Z S(I)	Lower	Upper	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
6:r	0.008	0.004	0.003	0.021										
7:r	0.000	0.000	0.000	0.000										
8:r	0.008	0.004	0.003	0.021										
9:r	0.014	0.008	0.005	0.045										
10:r	0.009	0.004	0.003	0.023										
{S(.)r(.)}														
1:S	0.265	0.032	0.207	0.333	1.33	3.44	1.57							
2:r	0.019	0.002	0.016	0.022										
1995-2004														
{S(p.)r(.)}								{S(p.)r(.)}	1775.3	0.000	0.880	1.000	3	38.382
1:S	0.222	0.033	0.165	0.292	1.50	3.43	1.80	{S(p_t)r(.)}	1780.0	4.700	0.084	0.095	7	35.074
2:S	0.879	0.037	0.785	0.935	0.13	3.29	0.24	{S(p.)r(t)}	1782.5	7.220	0.024	0.027	12	27.568
3:r	0.022	0.002	0.019	0.026				{S(t)r(.)}	1784.6	9.250	0.009	0.010	11	31.606
{S(p_t)r(.)}								{S(t)r(t)}	1786.5	11.150	0.003	0.004	19	17.448
1:S	0.223	0.033	0.165	0.293				{S(.)r(t)}	1794.9	19.570	0.000	0.000	11	41.929
2:S	1.000	0.000	1.000	1.000				{S(.)r(.)}	1823.4	48.030	0.000	0.000	2	88.415
3:S	0.837	0.081	0.614	0.943										
4:S	0.860	0.082	0.618	0.959										
5:S	0.875	0.064	0.690	0.957										
6:S	0.884	0.054	0.732	0.955										
7:r	0.022	0.002	0.019	0.026										
{S(p.)r(t)}														
1:S	0.260	0.043	0.185	0.353										
2:S	0.834	0.185	0.267	0.986										
3:r	0.027	0.004	0.020	0.037										
4:r	0.022	0.004	0.016	0.030										
5:r	0.022	0.003	0.016	0.029										
6:r	0.017	0.005	0.009	0.031										
7:r	0.009	0.004	0.003	0.023										
8:r	0.000	0.000	0.000	0.000										
9:r	0.023	0.026	0.002	0.184										
10:r	0.019	0.019	0.003	0.126										
11:r	0.018	0.017	0.003	0.108										
12:r	0.016	0.015	0.003	0.092										

Model/ Parameter	S(I)	SE	95% CI Lower	Upper	Z S(I)	Lower	Upper	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
{S(t)r(.)}														
1:S	0.228	0.052	0.142	0.344										
2:S	0.171	0.059	0.084	0.318										
3:S	0.265	0.065	0.157	0.410										
4:S	0.265	0.167	0.063	0.660										
5:S	0.616	0.218	0.209	0.907										
6:S	1.000	0.000	1.000	1.000										
7:S	0.868	0.070	0.666	0.956										
8:S	0.890	0.067	0.678	0.969										
9:S	0.897	0.055	0.732	0.965										
10:S	0.902	0.047	0.764	0.963										
11:r	0.023	0.002	0.019	0.027										
{S(t)r(t)}														
1:S	0.331	0.106	0.162	0.559										
2:S	0.130	0.055	0.055	0.279										
3:S	0.982	0.003	0.975	0.987										
4:S	0.107	0.098	0.016	0.470										
5:S	0.239	0.289	0.014	0.876										
6:S	0.508	0.349	0.063	0.941										
7:S	0.995	0.003	0.986	0.998										
8:S	0.807	0.579	0.003	1.000										
9:S	0.997	0.002	0.989	0.999										
10:S	0.995	0.000	0.995	0.995										
11:r	0.030	0.006	0.020	0.046										
12:r	0.017	0.004	0.011	0.027										
13:r	1.000	0.003	0.000	1.000										
14:r	0.005	0.002	0.003	0.010										
15:r	0.008	0.006	0.002	0.036										
16:r	0.000	0.000	0.000	0.000										
17:r	1.000	0.002	0.997	1.003										
18:r	0.017	0.054	0.000	0.901										
19:r	1.000	0.057	0.000	1.000										
20:r	0.480	0.000	0.480	0.480										
{S(.)r(t)}														

Model/ Parameter	S(I)	SE	95% CI Lower	Upper	Z S(I)	Lower	Upper	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
1:S	0.356	0.047	0.271	0.452										
2:r	0.031	0.005	0.023	0.043										
3:r	0.023	0.004	0.016	0.032										
4:r	0.022	0.004	0.016	0.030										
5:r	0.014	0.004	0.008	0.025										
6:r	0.007	0.004	0.003	0.020										
7:r	0.000	0.000	0.000	0.000										
8:r	0.008	0.004	0.003	0.021										
9:r	0.014	0.008	0.004	0.042										
10:r	0.009	0.004	0.003	0.024										
11:r	0.008	0.004	0.003	0.019										
{S(.)r(.)}														
1:S	0.286	0.032	0.228	0.353										
2:r	0.018	0.001	0.015	0.021										

Table 7B.5 Results of chi-square analyses on weekly age structure of annual spawning stock survey samples of American shad in the Hudson River, New York.

Year	Ages	Number of weeks sampled	Number of fish caught	DF	*X*^2	*P*
1985	3-9	4	246	18	25.21	0.119
1986	3-9	5	410	24	42.74	0.011
1987	3-10	5	400	28	20.93	0.828
1988	4-9	7	509	30	51.32	0.009
1989	4-9	5	361	20	24.38	0.226
1990	4-8	5	86	16	11.80	0.758
1991	3-7	4	211	12	31.26	0.002
1992	4-9	5	911	20	85.34	<0.001
1993	4-8	4	467	12	28.40	0.005
1994	4-7	5	157	12	88.40	<0.001
1995	3-7	6	705	20	125.09	<0.001
1996	3-7	4	380	12	26.47	0.009
1997	4-8	4	136	12	27.20	0.007
1998	3-8	3	282	10	13.09	0.219
1999	4-8	3	342	8	2.59	0.957
2000	3-7	4	378	12	11.87	0.456
2001	3-8	3	921	10	15.76	0.107
2002			No sampling			
2003			Age data not complete			
2004	3-11	3	776	16	20.05	0.218
2005			Age data not complete			

APPENDIX I

Summary of fishery regulation for American Shad in New York State

<u>Commercial Harvest</u>

Hudson River Estuary (George Washington Bridge north to Troy Dam, rkm 19-245):

- Season: March 15-June15
- 36-hour escapement period (Friday 0600-Saturday 1800, prevailing time)
- Net size restriction: limit of 1200 feet
- Mesh size restriction: mesh >5 inch stretch mesh
- Net deployment restriction: distance between fishing gear >1500 feet
- Area restrictions: drift gear allowed only in certain portions of the river
- Area closures: no fishing in a portion of the spawning area (Kingston Flats)

Marine Waters (Hudson River south of George Washington Bridge and waters including New York Harbor and around Long Island)

- Shad allowed to be landed as bycatch as long as landings are less than 5% of the total landings of all fish landed for the trip

Delaware River (New York portion, north of Port Jervis)

- No commercial fishery exists, but no rules prohibit it

<u>Recreational Harvest</u>

Statewide for inland waters:

- Bag limit of 6 fish per day
- No season

Table 7B1. Historic commercial fishery landings (kg) of American shad in the Hudson River Estuary, 1880-2005.

1915-1949: Talbot, G.A. Factors associated with fluctuations in abundance
of Hudson River Shad. Fish. Bull. 101(56):373-413. (data from USFWS)
1950-1993: annual report from NMFS
1994-present: NY landings: NYSDEC State reports & NJ landings from NMFS

Year	Total	Year	Total	Year	Total
1880	1240142	1931	188068	1982	205118
1881		1932	240296	1983	236144
1882		1933	235273	1984	307677
1883		1934	198677	1985	375247
1884		1935	384381	1986	385183
1885		1936	1119439	1987	309438
1886		1937	1239326	1988	356589
1887	1626610	1938	1119031	1989	219225
1888	1563106	1939	1483590	1990	203820
1889	1964995	1940	1412692	1991	156641
1890	1713247	1941	1421356	1992	129078
1891	1381212	1942	1445124	1993	62692
1892		1943	1463019	1994	90072
1893		1944	1727944	1995	112885
1894		1945	1577258	1996	83690
1895		1946	1348164	1997	67799
1896		1947	898941	1998	105484
1897		1948	1067956	1999	66501
1898		1949	783535	2000	69555
1899		1950	457637	2001	45997
1900		1951	346596	2002	59241
1901	854582	1952	618166	2003	49998
1902		1953	437679	2004	33040
1903		1954	622067	2005	32172
1904	1556755	1955	735558		
1905		1956	818793		
1906		1957	750935		
1907		1958	570084		
1908	225893	1959	476688		
1909		1960	393362		
1910		1961	284952		
1911		1962	250387		
1912		1963	187972		
1913		1964	110996		
1914		1965	113854		
1915	31148	1966	58514		
1916	18222	1967	96753		
1917	19679	1968	121111		
1918	106415	1969	116484		
1919	170088	1970	109499		

Table 7B2 Historical records of type of commercial gill nets and licenses sold for the New York and New Jersey portions of the Hudson River Estuary.

	Talbot 1954 (a)				Fishery Statistics (b)	NYSDEC-HRFU Summary (c)				NYSDEC Spec. Lic. (d)
							Number of licenses by type			
YEAR	**NY-T5 Number of nets ***	**NY-T3 Number of shad lic.**	**NJ-T5 Number of nets ***	**Standard Fishing Units**	**Number of nets ***	**Number licensed fishermen**	**shad/herr**	**gill**	**total**	**Number of nets ***
1915	79		7	3840						
1916	76		3	2910						
1917	213		2	6810						
1918	272		1	7554						
1919	359		14	12633						
1920	190		10	7230						
1921	159		8	5973						
1922	133		8	5271						
1923	110		5	4020						
1924	97	97	4	3459						
1925	98	98	4	3486						
1926	99	99	4	3513						
1927	136	136	7	5142						
1928	129	129	7	4953						
1929	122	122	5	4344						
1930	121	121	7	4737						
1931	120	120	4	4080						
1932	123	123	6	4581						
1933	146	146	13	6672						
1934	144	144	14	6828						
1935	140	140	15	6930						
1936	162	162	36	11934						
1937	200	200	36	12960						
1938	261	261	52	17967						
1939	254	254	43	15888						
1940	216	216	46	14718						
1941	231	231	46	15213						
1942	220	220	48	15180	478					
1943	230	230	32	16380	233					
1944	263	263	38	19026	445					
1945	242	242	35	13761	295					
1946	357	357	52	20361	344					
1947	366	366	52	20658	379					
1948	357	357	44	19041	378					
1949	315	315	46	17985						
1950	295	295	40	16335	241					
1951	215	215	25	8160	174					
1952					162					
1953					158					
1954					181					
1955					158					
1956					152					
1957					142					
1958					135					
1959					130					

YEAR	Talbot 1954 (a) NY-T5 Number of nets *	Talbot 1954 (a) NY-T3 Number of shad lic.	Talbot 1954 (a) NJ-T5 Number of nets *	Talbot 1954 (a) Standard Fishing Units	Fishery Statistics (b) Number of nets *	NYSDEC-HRFU Summary (c) Number licensed fishermen	NYSDEC-HRFU Summary (c) Number of licenses by type shad/herr	NYSDEC-HRFU Summary (c) Number of licenses by type gill	NYSDEC-HRFU Summary (c) Number of licenses by type total	NYSDEC Spec. Lic. (d) Number of nets *
1960										
1961					100					
1962										
1963										
1964					58					
1965					55					
1966										
1967					41					
1968					50					
1969					53					
1970					55					87
1971					42					74
1972					50					64
1973										116
1974										141
1975										120
1976						48	74	34	108	106
1977						54	94	39	133	127
1978						27	43	11	54	107
1979						60	98	62	160	163
1980						86	117	70	187	155
1981						81	109	63	172	
1982						106	143	88	231	
1983						98	142	85	227	
1984						112	175	86	261	
1985						95	150	63	213	
1986						79	112	56	168	
1987						72	101	31	132	
1988						65	94	28	122	
1989						72	91	31	122	
1990						83	96	64	160	
1991						90	79	68	147	
1992						101	74	96	170	
1993						123	55	79	134	
1994						121	49	79	128	
1995						112	47	75	122	
1996						134	54	88	142	
1997						112	45	74	119	
1998						140	65	119	184	
1999						145	77	68	181	
2000						231	110	123	233	
2001						222	138	112	250	
2002						261	141	120	261	
2003						248	144	104	248	
2004						210	156	118	274	
2005						287	161	109	270	

Table 7B2 Continued

	AMOUNT OF LICENSED NET							
	Klauda (e)			**DEC Annual State Rpts (f)**	**NYSDEC HRFU (c)**	**Escapement (g)**		
						NY		NJ
	Licensed Square Yards			Licensed	Licensed	Closed	Fishing	Closed
YEAR	fixed	drift	total	feet	feet	Hours/wk	Hours/wk	Hours/wk
1915						48	120	0
1916						48	120	0
1917						48	120	0
1918						60	108	0
1919						60	108	0
1920						60	108	0
1921						60	108	0
1922						60	108	0
1923						60	108	0
1924						60	108	0
1925						60	108	0
1926						60	108	0
1927						60	108	0
1928						60	108	0
1929						60	108	0
1930						60	108	0
1931	19167	315298	334465			60	108	0
1932	18748	376884	395632	253142		60	108	0
1933	28760	406871	435631	298949		60	108	0
1934	27330	505050	532380	292790		60	108	0
1935	65255	288480	353735	286459		60	108	0
1936	103180	368490	471670	338018		60	108	0
1937	137375	597529	734904	413501		60	108	0
1938	151472	729111	880583	531780		60	108	0
1939	159210	552804	712014	509156		60	108	0
1940	232808	430379	663187	444873		60	108	60
1941	94511	432106	526617	385717		36	132	36
1942	183381	191103	374484	355118		36	132	36
1943	132859	462970	595829			0	168	0
1944	284601	475835	760436			0	168	0
1945	214400	677700	892100	419029		36	132	36
1946	422800	680500	1103300	554924		36	132	36
1947	519360	806000	1325360	617844		36	132	36
1948	322160	800360	1122520	599830		36	132	36
1949	425686	653500	1079186	499280		36	132	36
1950	387828	583080	970908	479135		36	132	36
1951	224915	390400	615315	351280		72	96	72
1952	180217	339910	520127	363580		60	108	60
1953	99600	316225	415825	314110		60	108	60
1954	104267	379889	484156			60	108	60
1955	150008	252777	402785			60	108	60
1956	168826	210151	378977			60	108	60
1957	158495	199913	358408			60	108	60
1958	140793	182768	323561	274865		60	108	60
1959	132225	146022	278247	277720		48	120	48

	AMOUNT OF LICENSED NET								
	Klauda (e)			**DEC Annual State Rpts (f)**	**NYSDEC HRFU (c)**	**Escapement (g)**		
						NY		NJ
	Licensed Square Yards			Licensed	Licensed	Closed	Fishing	Closed
YEAR	fixed	drift	total	feet	feet	Hours/wk	Hours/wk	Hours/wk
1960	125463	145109	270572	231745		48	120	48
1961	122661	125873	248534	219886		48	120	48
1962	127281	113059	240340	189990		48	120	48
1963	85677	105338	191015	158720		48	120	48
1964	74555	103484	178039	131450		48	120	48
1965	62203	94822	157025			48	120	48
1966	55791	74480	130271			48	120	48
1967	52893	73748	126641			48	120	48
1968	61555	87720	149275			48	120	48
1969	61209	71390	132599			48	120	48
1970	62474	83965	146439			48	120	48
1971	41911	76315	118226			48	120	48
1972	46994	76316	123310			48	120	48
1973	41703	92024	133727			48	120	48
1974	115913	66348	182261			48	120	48
1975	132574	132696	265270			48	120	48
1976					121700	48	120	
1977					138300	48	120	
1978					65350	48	120	
1979					160933	36	132	
1980					238479	36	132	
1981					219840	36	132	
1982					270740	36	132	
1983					272990	36	132	
1984					389960	36	132	
1985					316800	36	132	
1986					214120	36	132	
1987					179000	36	132	
1988					189400	36	132	
1989					180280	36	132	
1990					232200	36	132	
1991					166290	36	132	
1992					166988	36	132	
1993					149150	36	132	
1994					161900	36	132	
1995					146695	36	132	
1996					111000	36	132	
1997					100047	36	132	
1998					141369	36	132	
1999					185405	36	132	
2000					233637	36	132	
2001					276000	36	132	
2002					301942	36	132	
2003					307196	36	132	
2004					329194	36	132	
2005					340028	36	132	

Table 7B2 Continued

NEW YORK GILL NET LICENSES
Two types of gill net licenses are available in New York State:
1) shad gill net license - valid for the spring shad season (Mar 15-Jun 15)
2) gill net licenses - valid for most of the year.

* Please note that "Number of nets" with "*" above and reference below are NOT KNOWN by net type i.e shad gill net license vs. gill net license or a total of both.

REFERENCES

(a) TALBOT, G.B. 1954. Factors associated with fluctuations in abundance of Hudson River shad. Fishery Bulletin 101. U.S. Dept of Interior. Standard Fishing Units = no. nets * allowed fishing hours * adjustment factor (NJ)

(b) FISHERY STATISTICS OF THE UNITED STATES
1956-1967: U.S. Dept. of Interior, U.S. Fish & Wildlife Service
1968-1972: U.S. Dept. of Commerce, National Marine Fisheries Service

(c) NYSDEC-HRFU SUMMARY: Hudson River Fisheries Unit summary of available Special Licenses Unit (SLU) receipts of number and type of licenses sold. HRFU copies of yearly records mostly complete, but cannot be verified as all records held by SLU were destroyed. Amount of net is summary of what appeared on licenses in HRFU files.

(d) NYSDEC-SPECIAL LICENSES: Summary of number of licenses sold by SLU, previous to file purging, cannot be verified.

(e) KLAUDA, R.J., M. NITTEL, K.P. CAMPBELL. 1976. Commercial fishery for American shad in the Hudson River: fish abundance and stock trends. Proceedings of a workshop on American shad. USFWS/NMFS. Amherst MA. Cited source as NYSDEC: NO records of this type exist, Sq. yards may have been be estimated from linear feet.

(f) DEC ANNUAL STATE REPORTS: Annual Conservation Dept. Reports to the Senate and Assembly. Bureau of Fisheries Library. Albany NY. Annual reports are from 1885 to 1964. References are incomplete. Discontinued printing reports in 1964.

(g) 1915-1951: Talbot 1954, 1951-1975: Klauda 1976, 1976-present: NYSDEC

Table 7B3 Mean total length and weight at age for American shad collected in fishery dependent (commercial gill net) and fishery independent surveys in the Hudson River Estuary.

Mean TL_FD	1980			1981			1982			1983			1984			1985			1986		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes combined																					
3							1	403.0		1	462.0										
4	15	491.8	34.6	19	481.5	29.7	23	499.1	34.3	18	497.8	27.6	6	508.2	26.4	24	513.2	15.6	15	516.5	29.0
5	126	523.8	18.8	127	529.4	20.6	128	537.5	21.9	142	531.1	25.8	85	532.6	27.6	113	531.7	27.9	117	545.0	30.2
6	130	548.5	23.8	205	552.5	21.8	137	554.0	26.5	120	559.2	22.0	121	562.3	27.8	136	561.7	31.4	117	564.8	27.9
7	64	558.4	24.5	144	559.6	27.4	114	578.5	26.5	47	578.6	25.1	57	584.4	30.5	88	581.3	33.2	67	591.4	32.0
8	21	572.8	26.1	79	583.7	27.8	69	584.6	29.4	47	592.6	28.4	34	596.3	29.9	36	594.5	32.0	37	614.5	31.5
9	3	613.3	14.3	13	610.1	19.9	35	591.7	33.9	23	602.9	31.9	29	618.6	35.8	24	603.3	33.5	20	631.2	31.6
10				4	621.0	47.6	11	613.8	37.7	21	616.8	40.9	13	632.9	42.0	13	619.5	31.6	7	639.7	30.8
11							1	604.0		3	625.0	40.9	3	610.7	33.5	6	658.0	38.4	3	636.3	26.8
12													2	653.5	14.9	2	631.5	12.0	2	671.0	19.8
13																					
Males																					
3							1	403.0													
4	9	472.3	24.5	12	467.1	21.0	11	479.6	28.4	9	479.1	17.5	1	480.0		5	503.0	6.5	7	500.4	33.0
5	26	497.3	12.3	23	506.4	11.1	24	513.7	16.6	37	504.6	19.5	28	502.4	15.7	20	499.1	24.0	28	516.1	24.8
6	29	518.8	17.8	45	524.4	16.5	29	524.5	19.2	23	534.2	15.2	24	523.0	24.5	27	530.5	21.9	25	535.5	23.1
7	28	538.6	11.4	57	535.6	14.4	33	547.3	19.2	16	553.4	13.2	11	551.8	12.6	21	548.1	23.1	18	558.4	24.0
8	10	551.4	11.3	23	550.0	12.8	20	555.4	19.3	19	564.5	17.2	15	574.5	28.7	10	570.1	19.8	10	579.2	18.8
9				1	575.0		17	563.7	19.3	9	570.7	14.7	6	575.8	18.2	4	577.3	12.0	4	590.0	22.1
10							3	577.0	2.0	5	569.0	15.9	3	576.7	12.1	2	589.0	5.7	1	594.0	
11										2	620.0	56.6	1	596.0					2	622.0	14.1
Females																					
3										1	462.0										
4	6	521.0	26.1	7	506.1	26.8	11	523.3	21.4	9	516.4	22.8	5	513.8	25.2	18	515.6	16.7	8	530.6	16.3
5	100	530.7	13.3	104	534.4	18.7	101	543.3	19.3	104	540.4	20.9	56	547.3	18.7	91	539.1	23.5	87	555.4	24.6
6	101	557.0	17.7	160	560.4	15.8	105	562.5	22.3	97	565.1	19.1	97	572.0	18.4	107	569.6	28.6	91	573.4	22.8
7	36	573.8	20.6	87	575.3	21.9	79	591.4	16.9	31	591.6	19.2	46	592.2	28.3	67	591.7	28.7	49	603.5	25.5
8	11	592.2	19.3	56	597.6	18.9	48	597.3	23.6	28	611.6	15.6	19	613.5	17.0	26	603.9	31.1	27	627.5	24.4
9	3	613.3	14.3	12	613.0	17.6	17	616.3	20.0	14	623.6	20.3	23	629.8	30.5	20	608.5	34.1	16	641.4	24.6
10				4	621.0	47.6	8	627.6	35.0	16	631.7	34.1	9	648.1	32.2	11	625.1	31.2	6	647.3	25.5
11							1	604.0	.	1	635.0		2	618.0	43.8	6	658.0	38.4	1	665.0	
12													2	653.5	14.9	2	631.5	12.0	2	671.0	19.8
13																					

Table 7B3 Continued

Mean TL_FD	1987			1988			1989			1990			1991			1992			1993		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes combined																					
3				2	416.0	73.5	1	458.0					2	473.5	44.6	2	438.5	9.2			
4	2	538.0	41.0	10	528.9	25.5	3	560.7	9.9	4	516.8	20.7	19	519.8	34.0	31	475.6	37.8	8	499.0	38.0
5	67	549.7	18.4	71	538.3	26.0	90	548.9	26.2	50	535.2	29.7	60	540.8	22.5	176	525.3	26.6	19	520.0	20.4
6	120	566.2	25.2	118	558.3	28.4	177	557.8	29.7	69	570.0	22.3	67	561.7	25.8	150	542.5	25.1	36	543.9	30.8
7	85	586.4	22.3	85	580.8	31.7	125	576.6	30.4	54	595.4	28.1	54	586.9	30.3	81	552.3	29.4	22	563.3	26.2
8	58	609.0	30.1	44	602.9	35.0	74	588.7	29.4	33	610.6	23.6	18	603.2	27.2	22	583.4	26.0	8	578.6	41.5
9	37	621.8	32.9	20	613.5	45.1	18	600.6	31.4	10	626.4	24.4	8	632.0	26.8	7	596.6	31.5	1	645.0	
10	32	644.2	26.3	7	632.4	37.9	5	630.6	42.2	4	625.5	10.9	1	664.0		2	666.0	5.7			
11	15	646.3	33.0							1	684.0		1	674.0							
12	3	661.3	24.3							1	662.0										
13	2	663.0	15.6																		
Males																					
3				1	468.0								2	473.5	44.6	2	438.5	9.2			
4				3	504.3	26.8	1	554.0		1	505.0		2	464.5	44.6	20	461.4	30.5			
5	4	524.8	24.7	19	519.6	19.8	21	527.2	30.6	8	514.3	33.1	1	555.0		28	497.6	25.9	3	513.0	28.6
6	16	546.3	18.8	44	532.4	19.2	64	535.8	22.1	8	556.5	31.5	5	546.8	15.7	38	521.6	23.4	13	517.0	23.6
7	11	552.8	17.2	25	548.8	19.0	43	551.4	21.0	6	562.8	18.6	9	547.8	18.4	30	534.1	23.1	11	543.5	19.9
8	12	566.0	18.7	12	564.4	22.9	38	569.6	18.1	5	577.8	25.2	6	585.8	24.4	9	564.3	8.9	2	525.0	9.9
9	10	581.4	19.1	7	561.0	14.2	11	582.0	23.6	1	571.0					1	584.0				
10	2	601.0	25.5	3	595.0	13.8	2	595.5	2.1												
11	3	605.7	5.5																		
Females																					
3				1	364.0																
4	2	538.0	41.0	7	539.4	17.6	2	564.0	11.3	3	520.7	23.5	17	526.3	27.3	11	501.5	37.0	5	518.4	22.1
5	63	551.3	17.0	52	545.1	24.7	69	555.5	20.8	42	539.2	27.7	59	540.5	22.7	147	530.4	23.4	16	521.3	19.5
6	104	569.3	24.7	74	573.8	20.6	113	570.2	26.1	61	571.8	20.6	62	562.9	26.1	112	549.7	21.5	23	559.0	23.2
7	74	591.4	18.3	60	594.2	25.8	82	589.8	26.0	48	599.5	26.5	45	594.8	25.9	50	563.7	27.4	11	583.2	13.5
8	46	620.2	21.0	32	617.3	26.9	36	608.9	25.3	28	616.5	18.2	12	611.8	25.1	13	596.6	25.8	6	596.5	29.3
9	27	636.8	22.6	13	641.7	25.5	7	629.9	15.4	9	632.6	15.7	8	632.0	26.8	6	598.7	34.0	1	645.0	
10	30	647.1	24.0	4	660.5	17.0	3	654.0	38.7	4	625.5	10.9	1	664.0		2	666.0	5.7			
11	12	656.5	28.6							1	684.0		1	674.0							
12	3	661.3	24.3							1	662.0										
13	2	663.0	15.6																		

Table 7B3 Continued

Mean TL_FD	1994			1995			Mean weight (g)>>	1980			1981			1982			1983		
AGE	N	MEAN	STD	N	MEAN	STD		N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes combined																			
3														1	640.0		1	1300.0	
4				7	512.0	30.6		15	1424.0	377.6	19	1276.3	412.2	23	1512.2	313.0	18	1497.8	335.3
5	30	527.1	16.1	78	527.1	25.7		126	1782.5	274.4	127	1725.4	311.4	125	1915.7	267.1	142	1821.3	303.4
6	52	534.3	22.5	98	528.9	19.7		130	2033.5	353.1	205	1938.7	358.4	135	2092.6	363.6	119	2134.9	314.6
7	29	547.1	21.7	51	542.1	24.3		64	2098.6	353.3	144	1939.1	418.5	113	2345.5	430.2	47	2410.6	479.8
8	5	591.8	22.9	13	534.9	27.9		21	2257.6	497.4	79	2217.2	521.3	69	2449.5	495.0	47	2628.1	547.4
9	3	584.7	32.8	3	587.0	30.8		3	2910.0	441.9	13	2545.4	521.2	34	2474.8	592.9	23	2645.2	639.2
10				1	630.0						4	2580.0	852.0	11	2838.2	594.1	21	2830.5	653.0
11														1	2900.0	.	3	2803.3	492.2
12																			
13																			
Males																			
3														1	640.0				
4								9	1176.7	175.1	12	1048.3	212.3	11	1338.2	277.3	9	1237.8	152.8
5	2	505.0	7.1	22	502.9	25.5		26	1400.4	134.4	23	1283.9	178.4	23	1588.6	175.7	37	1502.2	160.9
6	6	507.3	23.4	44	515.1	14.4		29	1574.5	209.5	45	1472.7	154.5	28	1695.4	221.3	23	1702.6	164.8
7	5	522.4	8.7	26	526.5	18.4		28	1795.7	123.8	57	1585.4	169.7	32	1858.0	172.9	16	1910.0	178.6
8				9	525.2	26.2		10	1845.0	209.5	23	1703.5	153.0	20	1976.0	154.2	19	2105.8	244.4
9	1	547.0		1	553.0						1	1610.0		17	2034.1	192.5	9	1966.7	250.9
10														3	2240.0	197.0	5	2012.0	257.2
11																	2	2755.0	685.9
Females																			
3																	1	1300.0	
4				3	532.0	6.2		6	1795.0	273.6	7	1667.1	380.6	11	1720.0	209.7	9	1757.8	251.9
5	28	528.7	15.4	53	536.6	17.6		100	1881.9	205.4	104	1823.0	242.2	99	1989.7	226.0	104	1933.6	259.8
6	46	537.9	20.1	54	540.2	16.0		101	2165.4	264.4	160	2069.8	281.9	104	2199.9	322.8	96	2238.4	246.1
7	24	552.3	19.9	23	559.8	17.9		36	2334.2	287.1	87	2170.8	367.8	79	2544.1	339.6	31	2669.0	366.5
8	5	591.8	22.9	4	556.5	19.5		11	2632.7	361.0	56	2428.2	469.3	48	2655.1	450.5	28	2982.5	385.2
9	2	603.5	5.0	2	604.0	12.7		3	2910.0	441.9	12	2623.3	458.4	16	2883.9	525.1	14	3081.4	359.3
10				1	630.0						4	2580.0	852.0	8	3062.5	531.3	16	3086.3	507.8
11														1	2900.0		1	2900.0	
12																			
13																			

Table 7B3 Continued

Mean Wt_FD	1984			1985			1986			1987			1988			1989			1990		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes combined																					
3													2	860.0	537.4	1	1130.0				
4	7	1742.9	294.7	24	1735.2	199.5	15	1794.0	444.8	2	1880.0	169.7	10	1915.0	341.9	2	2150.0	42.4	4	1635.0	198.2
5	86	1929.0	339.0	111	1951.4	407.0	114	2043.6	391.1	66	2024.2	226.9	71	1928.6	322.6	77	2123.4	428.9	50	1855.0	336.3
6	122	2262.4	389.0	133	2283.2	431.1	117	2269.2	420.0	120	2277.5	330.5	117	2197.4	391.6	160	2150.6	351.9	69	2318.3	381.5
7	59	2496.1	505.9	89	2582.0	534.7	67	2635.5	536.0	85	2538.1	342.9	85	2524.0	546.7	118	2457.1	459.1	54	2680.0	394.8
8	36	2672.2	503.8	36	2748.5	555.5	37	2985.1	550.1	58	2757.6	485.9	44	2871.1	544.5	67	2631.0	493.2	33	2851.5	400.4
9	29	2987.0	519.2	24	3009.6	816.1	20	3245.5	543.5	37	2900.3	566.9	20	2994.0	750.7	18	2829.4	605.5	10	2901.0	590.7
10	13	3270.0	764.0	13	3132.3	641.9	7	3467.1	574.0	32	3303.4	499.8	7	3137.1	566.9	5	3234.0	787.9	4	3030.0	147.2
11	3	2913.3	630.0	6	3789.2	947.5	3	3333.3	442.4	15	3252.0	590.8							1	3800.0	
12	2	3410.0	212.1	2	3350.0	42.4	2	2985.0	431.3	3	3593.3	411.0							1	3380.0	
13										2	3830.0	14.1									
Males																					
3													1	1240.0							
4	1	1360.0		5	1496.0	170.4	7	1652.9	609.4				3	1543.3	153.7	1	2180.0	.	1	1420.0	
5	28	1562.6	158.9	19	1455.3	157.1	27	1638.6	270.1	4	1782.5	399.0	19	1659.5	234.7	17	1936.5	786.0	8	1446.3	174.3
6	24	1706.3	190.9	26	1816.4	257.0	25	1840.8	280.5	16	1938.1	284.9	44	1857.5	211.7	58	1855.5	224.2	8	1990.0	406.4
7	11	1886.4	329.9	21	1957.1	238.1	18	2112.5	241.1	11	1943.6	186.5	25	1957.6	462.9	41	2054.9	208.9	6	2208.3	295.5
8	16	2318.1	514.5	10	2205.0	268.4	10	2309.8	272.6	12	2135.0	153.8	12	2246.7	395.6	35	2257.6	216.3	5	2302.0	522.1
9	6	2303.3	283.0	4	2305.0	110.0	4	2495.0	245.7	10	2234.0	306.5	7	2112.9	195.2	11	2412.7	309.3	1	1900.0	
10	3	2240.0	140.0	2	2310.0	212.1	1	2730.0		2	2560.0	56.6	3	2573.3	172.4	2	2550.0	127.3			
11	1	2520.0					2	3100.0	254.6	3	2566.7	185.8									
Females																					
3													1	480.0							
4	6	1806.7	264.6	18	1791.9	158.0	8	1917.5	199.9	2	1880.0	169.7	7	2074.3	262.2	1	2120.0		3	1706.7	167.7
5	57	2107.4	250.3	90	2057.1	368.2	85	2184.1	322.5	62	2039.8	207.3	52	2026.9	294.2	60	2176.3	237.6	42	1932.9	301.9
6	97	2407.4	279.2	106	2396.7	388.4	91	2393.5	368.2	104	2329.7	306.1	73	2402.3	327.3	102	2318.3	296.9	61	2361.3	359.8
7	48	2635.8	431.0	68	2774.9	445.4	49	2827.6	484.0	74	2626.5	263.4	60	2760.0	381.7	77	2671.2	409.5	48	2739.0	366.8
8	20	2955.5	261.7	26	2957.5	492.4	27	3235.2	391.0	46	2920.0	403.6	32	3105.3	384.9	32	3039.5	370.0	28	2949.6	289.4
9	23	3165.3	405.2	20	3150.5	824.0	16	3433.1	417.5	27	3147.0	422.4	13	3468.5	420.2	7	3484.3	246.3	9	3012.2	503.4
10	9	3556.7	589.8	11	3281.8	574.5	6	3590.0	518.3	30	3353.0	475.6	4	3560.0	258.2	3	3690.0	673.6	4	3030.0	147.2
11	2	3110.0	749.5	6	3789.2	947.5	1	3800.0		12	3423.3	527.1							1	3800.0	
12	2	3410.0	212.1	2	3350.0	42.4	2	2985.0	431.3	3	3593.3	411.0							1	3380.0	
13										2	3830.0	14.1									

Table 7B3 Continued

Mean Wt_FD	1991			1992			1993			1994			1995		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes combined															
3	2	1200.0	396.0	2	860.0	28.3									
4	19	1796.8	419.6	31	1189.7	405.8	8	1420.0	354.9				7	1694.3	363.8
5	59	1969.3	266.1	169	1711.8	326.5	19	1608.4	241.6	24	1641.7	169.5	56	1791.4	234.9
6	65	2134.8	340.1	149	1859.7	305.2	36	1857.8	359.2	45	1725.1	246.9	70	1850.3	238.8
7	54	2423.9	468.1	81	1966.2	361.4	22	2068.2	340.7	26	1843.5	273.3	31	1917.7	292.6
8	17	2529.4	452.5	21	2373.3	452.6	8	2180.0	629.2	5	2260.0	365.0	8	1823.8	257.9
9	8	3037.5	215.0	7	2640.0	498.0	1	2580.0		3	2373.3	514.7	2	2465.0	657.6
10	1	3480.0	.	2	4070.0	240.4							1	3340.0	
11	1	3784.0	.												
12															
13															
Males															
3	2	1200.0	396.0	2	860.0	28.3									
4	2	1080.0	339.4	20	998.0	263.4	3	1120.0	307.9				4	1515.0	403.8
5	1	1960.0		24	1276.3	348.7	3	1440.0	235.8	1	1480.0		15	1546.7	141.2
6	5	1710.0	152.6	36	1525.0	224.4	13	1573.9	267.9	3	1560.0	346.4	32	1671.3	131.5
7	9	1825.6	159.2	30	1687.7	232.2	11	1803.6	216.5	3	1546.7	110.2	17	1748.2	161.9
8	5	2242.0	422.2	9	1988.9	165.0	2	1530.0	240.4				5	1730.0	218.9
9				1	2160.0					1	1780.0		1	2000.0	
10															
11															
Females															
3															
4	17	1881.2	345.1	11	1538.2	393.8	5	1600.0	255.0				3	1933.3	50.3
5	58	1969.5	268.4	144	1784.0	261.8	16	1640.0	236.4	23	1648.7	169.7	41	1881.0	195.4
6	60	2170.2	327.6	113	1966.4	244.7	23	2018.3	302.5	42	1736.9	239.6	38	2001.1	202.0
7	45	2543.6	414.1	50	2136.6	321.9	11	2332.7	207.1	23	1882.2	264.9	13	2151.5	278.3
8	12	2649.2	424.1	12	2661.7	375.6	6	2396.7	563.3	5	2260.0	365.0	3	1980.0	280.0
9	8	3037.5	215.0	6	2720.0	493.8	1	2580.0		2	2670.0	42.4	1	2930.0	
10	1	3480.0		2	4070.0	240.4							1	3340.0	
11	1	3784.0													
12															
13															

Table 7B3 Continued (Fishery Independent data)

Mean TL_FI	1983			1984			1985			1986			1987			1988			1989		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																					
2																					
3				3	424.7	22.2	14	420.3	23.4	9	423.8	30.6	5	409.4	31.6	2	450.0	82.0	2	416.5	44.6
4	2	459.5	6.4	19	453.1	28.2	63	464.7	32.9	94	474.9	40.9	65	465.7	28.8	58	480.6	39.1	42	455.0	39.7
5	5	500.6	21.8	30	513.7	25.9	69	501.4	35.9	128	511.9	33.4	121	513.7	32.1	187	519.4	33.8	102	516.2	35.0
6	5	529.2	8.9	37	544.8	24.0	51	548.1	33.4	104	541.2	35.7	77	549.4	25.5	146	558.0	28.6	85	538.1	28.1
7	4	533.3	15.9	23	583.4	29.4	29	569.9	33.9	41	583.2	39.0	42	568.7	28.4	82	578.6	31.6	66	564.9	35.7
8	2	559.5	13.4	15	590.8	39.5	19	590.0	32.7	23	598.7	33.3	26	603.9	23.9	21	597.5	48.9	34	580.7	35.7
9	2	573.5	2.1	6	611.0	43.5	7	621.6	32.6	13	620.1	29.6	20	631.8	32.4	15	613.3	19.4	10	597.2	16.7
10				4	601.0	34.5	5	620.8	34.2	2	665.0	9.9	8	633.8	39.6	8	634.1	35.7	7	657.3	37.5
11				1	647.0	.	3	650.3	32.4	5	645.8	20.8	3	620.7	43.0	5	662.8	20.5	3	634.3	16.0
12													2	692.5	10.6	2	675.5	41.7			
13													1	685.0							
Males																					
2																					
3				3	424.7	22.2	13	419.8	24.3	9	423.8	30.6	5	409.4	31.6	2	450.0	82.0	2	416.5	44.6
4	2	459.5	6.4	17	458.1	20.8	53	455.8	26.9	77	464.1	35.3	52	458.3	22.1	42	466.1	32.0	32	440.4	27.6
5	5	500.6	21.8	23	507.0	22.3	53	488.2	25.9	72	491.7	25.4	59	487.3	19.9	97	495.7	19.5	43	487.4	28.7
6	5	529.2	8.9	22	533.5	17.6	24	528.3	27.3	39	511.9	30.8	31	525.4	17.9	42	529.3	25.1	35	515.7	21.3
7	4	533.3	15.9	9	561.8	27.5	12	541.2	12.8	15	555.0	22.0	17	543.1	18.6	26	544.0	19.5	22	536.9	22.8
8	2	559.5	13.4	7	555.0	20.4	8	571.8	29.4	6	570.3	15.2	6	569.5	15.0	7	549.9	49.1	17	555.8	29.8
9	2	573.5	2.1	1	548.0		2	578.0	24.0	3	596.0	8.9	6	589.2	8.7	4	593.0	7.0	5	588.6	13.1
10				1	559.0		1	590.0					2	595.0	63.6	2	591.0	1.4	1	593.0	
11										1	614.0		2	596.0	7.1						
Females																					
3				3	424.7	22.2	14	420.3	23.4	9	423.8	30.6	5	409.4	31.6	2	450.0	82.0	2	416.5	44.6
4				19	453.1	28.2	63	464.7	32.9	94	474.9	40.9	65	465.7	28.8	58	480.6	39.1	42	455.0	39.7
5				30	513.7	25.9	69	501.4	35.9	128	511.9	33.4	121	513.7	32.1	187	519.4	33.8	102	516.2	35.0
6				37	544.8	24.0	51	548.1	33.4	104	541.2	35.7	77	549.4	25.5	146	558.0	28.6	85	538.1	28.1
7				23	583.4	29.4	29	569.9	33.9	41	583.2	39.0	42	568.7	28.4	82	578.6	31.6	66	564.9	35.7
8				15	590.8	39.5	19	590.0	32.7	23	598.7	33.3	26	603.9	23.9	21	597.5	48.9	34	580.7	35.7
9				6	611.0	43.5	7	621.6	32.6	13	620.1	29.6	20	631.8	32.4	15	613.3	19.4	10	597.2	16.7
10				4	601.0	34.5	5	620.8	34.2	2	665.0	9.9	8	633.8	39.6	8	634.1	35.7	7	657.3	37.5
11				1	647.0	.	3	650.3	32.4	5	645.8	20.8	3	620.7	43.0	5	662.8	20.5	3	634.3	16.0
12													2	692.5	10.6	2	675.5	41.7			
13													1	685.0							

Table 7B3 Continued (Fishery Independent data)

Mean TL_FI	1990			1991			1992			1993			1994			1995			1996		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																					
2																					
3				14	426.9	31.4	13	419.5	22.0	5	419.6	12.9	2	435.5	13.4	25	426.2	38.5	24	424.9	16.6
4	9	451.7	49.6	57	452.8	32.9	188	446.2	26.1	90	443.1	24.6	32	447.6	20.4	149	474.0	35.1	194	451.2	29.9
5	32	491.9	45.1	66	499.1	30.4	383	482.1	31.8	206	470.0	25.8	85	491.7	30.2	255	512.4	29.2	115	500.5	34.5
6	18	528.8	38.4	51	521.9	35.3	215	522.2	29.5	100	495.8	30.8	27	508.2	28.3	135	530.8	30.3	36	548.0	30.0
7	19	570.0	38.9	18	553.4	37.3	63	552.9	27.4	34	530.7	31.1	11	518.7	18.6	39	548.8	24.9	11	567.1	26.4
8	7	579.0	41.3	4	592.3	15.1	5	575.6	32.1	9	553.0	26.8	2	555.5	36.1				5	607.6	40.5
9	1	627.0		1	651.0		8	603.5	26.7										2	635.0	21.2
10	1	635.0		1	612.0		2	653.5	19.1										1	526.0	
11																					
12																					
13																					
Males																					
2																					
3				12	417.5	22.0	13	419.5	22.0	5	419.6	12.9	2	435.5	13.4	23	418.5	28.8	23	424.5	16.9
4	7	434.0	39.8	46	443.8	26.6	168	441.5	21.4	83	439.6	21.4	32	447.6	20.4	92	455.7	26.6	162	443.9	24.4
5	16	462.8	25.6	33	479.2	25.1	224	463.1	21.9	152	460.0	18.6	36	466.1	22.2	77	484.2	25.8	64	484.3	29.0
6	7	512.0	52.1	16	485.1	27.2	66	494.4	24.5	47	476.3	20.6	7	481.4	18.5	31	496.2	27.5	15	525.4	24.5
7	7	533.3	35.8	4	514.8	43.3	7	525.7	28.3	16	508.8	25.3	3	505.0	27.2	8	520.4	12.4	4	542.5	21.0
8	1	547.0		1	574.0		1	560.0		2	518.0	14.1							1	564.0	
9							2	571.0	17.0												
10																					
11																					
Females																					
3				14	426.9	31.4	13	419.5	22.0	5	419.6	12.9	2	435.5	13.4	25	426.2	38.5			
4	9	451.7	49.6	57	452.8	32.9	188	446.2	26.1	90	443.1	24.6	32	447.6	20.4	149	474.0	35.1	30	491.4	25.4
5	32	491.9	45.1	66	499.1	30.4	383	482.1	31.8	206	470.0	25.8	85	491.7	30.2	255	512.4	29.2	50	521.0	30.2
6	18	528.8	38.4	51	521.9	35.3	215	522.2	29.5	100	495.8	30.8	27	508.2	28.3	135	530.8	30.3	20	564.9	22.7
7	19	570.0	38.9	18	553.4	37.3	63	552.9	27.4	34	530.7	31.1	11	518.7	18.6	39	548.8	24.9	7	581.1	17.6
8	7	579.0	41.3	4	592.3	15.1	5	575.6	32.1	9	553.0	26.8	2	555.5	36.1				4	618.5	37.4
9	1	627.0		1	651.0		8	603.5	26.7										2	635.0	21.2
10	1	635.0		1	612.0		2	653.5	19.1										1	526.0	
11																					
12																					
13																					

Table 7B3 Continued (Fishery Independent data)

Mean TL_FI	1997			1998			1999			2000			2001			2004		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																		
2																1	420	
3	4	416.5	10.2	7	419.6	21.6	3	430.3	6.4	22	431.7	14.9	48	443.4	38.9	8	430.8	24.6
4	38	448.9	42.4	108	459.9	38.6	100	467.5	34.3	128	479.6	35.2	287	471.3	31.3	60	470.0	39.5
5	63	484.6	28.5	114	499.1	37.5	191	492.6	29.6	181	518.0	29.1	323	511.1	36.1	188	506.0	28.1
6	23	513.1	35.1	36	533.4	37.0	49	533.3	33.1	40	540.9	32.8	193	541.9	31.0	178	540.0	32.7
7	7	549.4	47.0	12	559.4	51.3	15	572.9	22.9	6	564.8	17.5	64	556.7	32.2	164	572.8	29.1
8	5	594.4	18.2	5	579.2	24.9	2	543.5	30.4	3	580.3	21.4	10	558.8	38.0	95	582.7	34.6
9	6	607.0	18.5	1	632.0		1	602.0		1	610.0		3	622.7	40.0	51	613.1	26.2
10	1	556.0											1	650.0		25	623.4	26.9
11																4	623.0	35.2
12																1	637.0	
13																1	677.0	
Males																		
2																1	420	
3	4	416.5	10.3	7	419.6	21.6	2	428.0	7.1	22	431.7	14.9	41	434.1	29.8	7	428.6	25.7
4	24	425.6	31.6	78	443.3	23.4	64	454.0	32.4	79	461.6	24.6	209	459.3	23.2	39	450.2	29.3
5	29	466.6	22.0	48	466.8	24.5	79	471.4	23.6	67	493.0	22.4	146	483.6	24.5	86	487.8	23.8
6	10	486.6	28.9	12	504.3	19.0	19	505.7	29.6	15	511.6	23.3	71	512.8	24.8	59	514.7	27.8
7	1	522.0		4	510.3	54.7	2	538.5	23.3	1	533.0		24	526.4	21.7	35	540.1	19.9
8							2	543.5	30.4	1	556.0		4	553.3	12.4	32	548.1	23.0
9													79	486.7	37.6	4	556.8	20.5
10	1	556.0														2	568.5	13.4
11																1	572.0	
Females																		
3	4	416.5	10.3										7	498.0	43.0	1	446.0	
4	38	448.9	42.5	28	504.4	36.5	35	493.2	20.4	46	511.7	27.6	76	503.7	27.6	21	506.7	28.2
5	57	484.0	29.0	65	522.4	26.2	108	508.4	23.5	112	532.8	21.7	175	534.2	27.0	97	521.0	21.7
6	19	511.8	37.6	24	548.0	35.3	28	552.5	20.0	25	558.5	24.0	122	558.9	19.6	117	552.6	27.6
7	6	543.2	48.2	7	577.6	22.8	13	578.2	18.4	5	571.2	8.8	40	574.9	22.2	128	581.6	24.6
8	3	604.0	16.5	5	579.2	24.9				2	592.5	4.9	6	562.5	49.6	63	600.3	24.8
9	6	607.0	18.5	1	632.0		1	602.0		1	610.0		3	622.7	40.0	47	617.9	20.5
10	1	556.0											1	650.0		23	628.1	22.0
11																3	640.0	11.1
12																1	637.0	
13																1	677.0	

Table 7B3 Continued (Fishery Independent data)

Mean WT_FI	1983			1984			1985			1986			1987			1988			1989		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																					
2																					
3				3	744.0	124.9	13	705.5	97.3	9	862.2	186.6	5	744.0	192.6	2	860.0	339.4	2	590.0	141.4
4	2	1005.0	120.2	18	946.4	228.3	54	977.1	330.3	82	1182.2	339.7	62	1004.9	242.0	57	1137.5	322.9	42	922.1	272.9
5	5	1324.0	191.9	30	1455.4	327.0	49	1257.8	300.5	119	1470.9	369.2	120	1383.3	328.1	178	1494.5	394.8	101	1352.8	358.8
6	5	1498.0	72.9	37	1779.5	377.4	38	1739.3	504.5	98	1745.8	392.4	77	1700.7	374.6	142	1864.6	381.7	84	1541.4	373.0
7	4	1605.0	208.9	23	2167.2	459.6	23	1873.2	473.3	39	2180.0	476.9	42	1904.8	333.1	81	2049.3	481.6	65	1868.3	461.6
8	2	1795.0	289.9	15	2372.7	637.6	15	2268.5	584.4	21	2283.8	485.5	26	2268.5	404.9	21	2295.7	549.2	34	1984.1	433.9
9	2	1865.0	275.8	6	2370.8	698.7	5	2854.6	733.7	13	2643.1	378.2	20	2449.5	385.9	15	2475.3	503.8	11	2050.0	284.1
10				4	2547.5	646.7	3	2270.0	177.5	2	3620.0	311.1	8	2406.3	247.2	8	2630.0	642.5	7	3222.9	529.7
11				1	2780.0		3	2620.0	374.7	5	3004.0	491.8	3	2163.3	833.9	5	2868.0	444.0	3	2326.7	223.0
12													2	3210.0	155.6	2	3530.0	523.3			
13													1	2600.0							
Males																					
2																					
3				3	744.0	124.9	12	699.3	98.9	9	862.2	186.6	5	744.0	192.6	2	860.0	339.4	2	590.0	141.4
4	2	1005.0	120.2	16	985.9	192.4	45	872.7	210.0	66	1082.7	257.1	50	946.9	183.7	41	1036.6	277.4	32	821.6	163.5
5	5	1324.0	191.9	23	1341.8	196.9	37	1160.1	224.4	64	1246.7	223.6	59	1139.7	178.9	92	1264.7	220.4	43	1124.7	245.9
6	5	1498.0	72.9	22	1549.6	227.0	18	1489.5	279.2	37	1456.0	239.5	31	1425.5	193.9	41	1577.1	236.2	35	1278.0	212.1
7	4	1605.0	208.9	9	1804.4	308.2	12	1589.8	219.6	15	1834.0	324.3	17	1648.8	168.2	25	1694.0	287.3	22	1522.7	262.3
8	2	1795.0	289.9	7	1837.1	278.7	6	1859.2	269.9	5	1998.0	233.5	6	1976.7	275.5	7	1932.9	526.5	17	1755.3	283.0
9	2	1865.0	275.8	1	1635.0		2	2315.0	530.3	3	2383.3	332.5	6	2075.0	80.4	4	2142.5	132.8	5	2058.0	273.4
10				1	1780.0		1	2071.0					2	2205.0	502.1	2	2010.0	155.6	1	2480.0	
11										1	2380.0		2	1685.0	134.4						
Females																					
3							1	780.0													
4				1	860.0		9	1499.2	335.0	16	1592.5	336.8	12	1246.7	309.0	16	1396.3	291.2	8	1322.5	286.2
5				7	1828.6	403.3	12	1559.3	312.9	55	1731.8	332.5	60	1625.8	256.7	86	1740.4	392.6	50	1560.0	340.6
6				15	2116.7	289.9	20	1964.2	559.9	61	1921.6	362.2	46	1886.1	353.0	101	1981.3	368.0	44	1752.7	351.1
7				14	2400.4	386.5	11	2182.3	488.3	24	2396.3	429.9	25	2078.8	304.6	56	2207.9	467.3	41	2063.4	443.4
8				8	2841.3	456.8	9	2541.4	585.3	16	2373.1	513.8	20	2356.0	400.9	14	2477.1	479.4	15	2306.7	354.4
9				5	2518.0	669.2	3	3214.3	671.3	10	2721.0	370.0	14	2610.0	350.3	11	2596.4	538.2	6	2043.3	318.7
10				3	2803.3	484.4	2	2369.5	60.1	2	3620.0	311.1	6	2473.3	116.4	6	2836.7	606.7	6	3346.7	456.0
11				1	2780.0		3	2620.0	374.7	4	3160.0	400.3	1	3120.0		5	2868.0	444.0	3	2326.7	223.0
12													2	3210.0	155.6	2	3530.0	523.3			
13													1	2600.0							

Table 7B3 Continued (Fishery Independent data)

Mean WT_FI	1990			1991			1992			1993			1994			1995			1996		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																					
2																					
3	.	.	.	14	702.9	176.7	13	638.5	129.7	4	640.0	71.2	1	720.0		25	780.4	280.0	24	642.5	112.7
4	9	901.1	356.7	57	869.1	222.7	189	810.1	189.7	90	695.8	166.6	29	804.8	151.2	146	1039.3	322.6	191	818.4	230.7
5	31	1118.7	382.6	65	1181.2	283.2	380	1074.7	301.6	204	859.2	197.5	80	1091.5	270.8	250	1324.6	320.9	112	1161.1	405.9
6	18	1371.7	342.6	51	1360.6	350.5	212	1372.5	350.2	97	1046.6	221.8	26	1228.5	282.3	133	1471.2	331.2	36	1730.3	833.3
7	20	1811.0	391.0	16	1607.5	278.4	63	1655.2	396.5	33	1229.4	264.2	10	1234.0	180.6	38	1603.4	282.6	12	1977.8	411.5
8	7	1838.6	362.3	4	1750.0	233.5	5	1808.0	655.2	9	1572.2	366.9	2	1420.0	311.1				5	2312.0	667.3
9	1	2400.0		1	2260.0		8	2141.3	457.5										2	2820.0	28.3
10	1	2400.0		1	2160.0		2	2805.0	431.3										1	1140.0	
11																					
12																					
13																					
Males																					
2																					
3				12	652.5	121.1	13	638.5	129.7	4	640.0	71.2	1	720.0	.	23	725.2	203.7	23	645.2	114.5
4	7	741.4	180.2	46	803.7	170.4	169	773.0	130.1	83	669.2	136.8	29	804.8	151.2	89	882.6	219.2	162	759.8	158.3
5	15	864.0	165.2	33	987.9	173.3	222	902.3	168.4	151	789.6	138.2	34	911.8	216.8	75	1046.7	200.0	64	1039.7	412.8
6	7	1265.7	369.5	16	1010.6	194.2	65	1168.1	413.7	47	920.9	138.6	7	1002.9	54.7	31	1157.7	219.8	15	1638.0	1248.9
7	7	1492.9	405.5	2	1410.0	99.0	7	1375.7	199.4	16	1130.0	263.3	3	1146.7	161.7	8	1367.5	157.1	4	1580.0	268.8
8	1	1530.0		1	1440.0		1	1380.0		2	1230.0	14.1							1	2000.0	
9							2	1815.0	176.8												
10																					
11																					
Females																					
3				1	1130.0											1	1630.0				
4	2	1460.0	141.4	10	1175.0	192.7	20	1123.0	301.8	7	1011.4	172.8				56	1289.0	306.9	27	1177.8	276.5
5	16	1357.5	376.2	30	1391.3	228.4	157	1319.9	278.8	51	1066.7	206.2	46	1224.4	227.6	169	1450.8	288.5	47	1337.0	326.3
6	11	1439.1	323.7	34	1524.1	286.4	145	1466.3	274.4	47	1171.9	221.5	18	1332.2	280.9	98	1580.4	296.7	20	1801.0	343.5
7	13	1982.3	262.7	14	1635.7	286.0	56	1690.2	402.1	17	1322.9	235.3	6	1303.3	182.2	29	1667.9	281.4	8	2176.8	315.3
8	5	2028.0	162.2	3	1853.3	133.2	4	1915.0	704.3	7	1670.0	359.6	2	1420.0	311.1				4	2390.0	743.8
9	1	2400.0		1	2260.0		6	2250.0	479.6										2	2820.0	28.3
10	1	2400.0		1	2160.0		2	2805.0	431.3										1	1140.0	
11																					
12																					
13																					

Table 7B3 Continued (Fishery Independent data)

Mean WT_FI	1997			1998			1999			2000			2001			2004		
AGE	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD	N	MEAN	STD
Sexes Combined																		
2																1	600.0	
3	4	677.5	68.5	5	724.0	155.8	3	743.3	63.5	19	742.6	96.1	48	755.7	201.2	8	827.5	181.1
4	37	866.6	283.0	107	995.3	348.3	97	918.3	215.6	125	1080.8	276.0	265	965.6	264.7	60	996.8	271.7
5	56	1128.8	282.9	112	1260.8	354.0	190	1091.7	260.5	179	1376.0	298.7	307	1251.8	340.8	187	1286.4	282.9
6	19	1316.8	365.7	35	1524.9	337.1	48	1463.3	444.1	38	1534.0	298.5	181	1446.9	346.6	178	1606.5	385.4
7	6	1750.0	306.7	12	1731.7	441.0	15	1678.0	260.8	6	1747.7	158.5	57	1539.3	365.1	161	1953.3	439.4
8	3	2073.3	30.6	5	2040.0	476.0	2	1580.0	311.1	3	1913.3	355.7	10	1655.0	607.1	95	1998.3	442.7
9	6	2146.7	400.3	1	2400.0		1	2300.0		1	2260.0		3	2073.3	248.3	52	2320.2	430.1
10	1	1660.0											1	2760.0		26	2479.2	555.2
11																4	2390.0	438.9
12																1	2640.0	
13																1	3560.0	
Males																		
2																1	600.0	
3	4	677.5	68.5	5	724.0	155.8	2	725.0	77.8	19	742.6	96.1	41	701.9	149.0	7	794.3	167.2
4	24	723.5	220.5	77	854.6	157.2	62	809.5	154.6	77	937.8	183.3	193	867.1	175.6	39	856.9	180.4
5	28	1022.1	249.8	47	1000.0	192.8	79	906.5	157.7	67	1164.2	212.9	138	1009.4	211.2	86	1134.3	204.3
6	10	1050.0	197.4	12	1255.8	173.1	19	1101.1	191.6	14	1335.7	232.6	65	1163.1	243.8	60	1364.3	247.1
7	1	1360.0		4	1350.0	414.6	2	1320.0	113.1	1	1680.0		22	1269.1	169.8	35	1536.3	230.0
8							2	1580.0	311.1	1	1600.0		4	1395.0	123.7	32	1582.5	208.6
9																4	1715.0	245.7
10	1	1660.0														2	1590.0	14.1
11																1	1860.0	
Females																		
3													7	1070.9	182.8	1	1060.0	
4	12	1143.3	176.2	28	1355.7	427.3	34	1122.9	155.6	45	1332.1	233.9	72	1229.5	283.0	21	1256.7	216.4
5	27	1241.9	280.7	64	1451.7	325.4	108	1227.5	239.8	110	1506.6	270.4	168	1453.4	292.8	96	1422.4	279.4
6	9	1613.3	262.9	23	1665.2	317.1	27	1714.1	407.4	24	1649.6	273.7	116	1606.0	289.6	116	1734.5	386.5
7	5	1828.0	268.2	7	1877.1	325.1	13	1733.1	231.6	5	1761.2	173.3	35	1709.2	353.2	125	2069.7	414.6
8	3	2073.3	30.6	5	2040.0	476.0				2	2070.0	325.3	6	1828.3	751.1	63	2209.5	375.3
9	6	2146.7	400.3	1	2400.0		1	2300.0		1	2260.0		3	2073.3	248.3	48	2370.6	403.8
10													1	2760.0		24	2553.3	510.4
11																3	2566.7	319.0
12																1	2640.0	
13																1	3560.0	

Table 7B4 MARK model outputs for Hudson River American shad.

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Z Lower	Z Upper	Model	AICc	Delta AICc	AICc Weight	#Par	Dev.
1995-1997													
S(.)r(.)								S(.)r(.)	1324.96	0.00	0.63	2	2.51
S	0.216	0.047	0.138	0.322	1.53	1.98	1.13	S(.)r(t)	1327.85	2.90	0.15	4	1.40
r	0.023	0.002	0.019	0.028				S(t)r(t)	1328.46	3.50	0.11	5	0.00
S(.)r(t)								S(t)r(.)	1328.52	3.56	0.11	4	2.06
S	0.232	0.053	0.144	0.351	1.46	1.94	1.05						
r1	0.026	0.004	0.019	0.036									
r2	0.022	0.004	0.016	0.030									
r3	0.021	0.003	0.016	0.029									
S(t)r(.)													
S1	0.225	0.053	0.137	0.346									
S2	0.204	0.085	0.084	0.417									
S3	0.293	0.161	0.083	0.656									
r	0.024	0.003	0.019	0.030									
S(t)r(t)													
S1	0.309	0.101	0.150	0.531									
S2	0.151	0.069	0.058	0.337									
S3	0.974	0.000	0.974	0.974									
r1	0.029	0.006	0.020	0.043									
r2	0.018	0.004	0.012	0.028									
r3	0.661	0.000	0.661	0.661									
1995-1998													
S(.)r(.)								S(t)r(t)	1479.68	0.00	0.41	7	4.61
S	0.229	0.038	0.163	0.313	1.47	1.82	1.16	S(.)r(.)	1479.73	0.05	0.40	2	14.68
r	0.023	0.002	0.019	0.027				S(t)r(.)	1481.94	2.27	0.13	5	10.89
S(.)r(t)								S(.)r(t)	1483.32	3.64	0.07	5	12.26
S	0.263	0.050	0.177	0.371									
r1	0.028	0.004	0.020	0.037									
r2	0.022	0.004	0.016	0.030									
r3	0.022	0.003	0.016	0.029									
r4	0.017	0.005	0.009	0.031									
S(t)r(.)													
S1	0.237	0.054	0.148	0.357									
S2	0.220	0.079	0.102	0.411									
S3	0.393	0.107	0.212	0.610									
S4	0.630	0.162	0.304	0.869									
r	0.025	0.003	0.020	0.031									
S(t)r(t)													
S1	0.331	0.106	0.162	0.559									
S2	0.136	0.057	0.057	0.290									
S3	0.982	0.003	0.976	0.987									
S4	0.990	1.267	0.000	1.000									
r1	0.030	0.006	0.020	0.046									
r2	0.017	0.004	0.011	0.027									
r3	1.000	0.003	0.000	1.000									
r4	0.467	61.792	0.000	1.000									
1995-1999													
S(.)r(.)								S(t)r(t)	1541.22	0.00	0.50	9	5.62

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Z Lower	Z Upper	Model	AICc	Delta AICc	AICc Weight	#Par	Dev.
S	0.228	0.034	0.167	0.302	1.48	1.79	1.20	S(t)r(.)	1542.60	1.37	0.25	6	13.01
r	0.022	0.002	0.019	0.026				S(.)r(.)	1543.76	2.53	0.14	2	22.18
S(.)r(t)								S(.)r(t)	1544.37	3.14	0.10	6	14.78
S	0.272	0.047	0.189	0.372	1.30	1.67	0.99						
r1	0.027	0.004	0.021	0.037									
r2	0.022	0.004	0.016	0.030									
r3	0.022	0.003	0.016	0.030									
r4	0.016	0.005	0.009	0.030									
r5	0.009	0.004	0.003	0.023									
S(t)r(.)													
S1	0.234	0.053	0.146	0.353									
S2	0.205	0.073	0.097	0.382									
S3	0.377	0.098	0.210	0.589									
S4	0.595	0.167	0.274	0.851									
S5	0.848	0.093	0.575	0.959									
r	0.025	0.003	0.020	0.030									
S(t)r(t)													
S1	0.331	0.106	0.162	0.559									
S2	0.130	0.055	0.055	0.279									
S3	0.982	0.003	0.975	0.987									
S4	0.201	0.201	0.021	0.746									
S5	0.992	2.535	0.000	1.000									
r1	0.030	0.006	0.020	0.046									
r2	0.017	0.004	0.011	0.027									
r3	1.000	0.000	1.000	1.000									
r4	0.006	0.002	0.003	0.012									
r5	0.530	175.457	0.000	1.000									
1995-2000													
S(t)r(t)								S(t)r(t)	1576.41	0.00	0.57	10	10.19
S1	0.375	0.116	0.186	0.612				S(t)r(.)	1578.00	1.59	0.26	7	17.79
S2	0.160	0.061	0.073	0.318				S(.)r(t)	1578.83	2.42	0.17	7	18.62
S3	0.983	0.003	0.976	0.988				S(.)r(.)	1597.22	20.81	0.00	2	47.03
S4	0.155	0.155	0.018	0.650									
S5	0.076	104.065	0.000	1.000									
S6	0.747	0.000	0.747	0.747									
r1	0.032	0.007	0.021	0.051									
r2	0.017	0.004	0.011	0.027									
r3	1.000	0.001	0.999	1.001									
r4	0.006	0.002	0.003	0.012									
r5	0.006	0.622	0.000	1.000									
r6	0.000	0.000	0.000	0.000									
S(t)r(.)													
S1	0.259	0.054	0.168	0.379									
S2	0.254	0.079	0.131	0.434									
S3	0.413	0.100	0.238	0.612									
S4	0.583	0.167	0.266	0.843									
S5	0.861	0.087	0.597	0.963									
S6	1.000	0.000	1.000	1.000									
r	0.025	0.003	0.021	0.031									

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Z Lower	Z Upper	Model	AICc	Delta AICc	AICc Weight	#Par	Dev.
S(.)r(t)													
S	0.304	0.050	0.217	0.409	1.19	3.01	1.53						
r1	0.029	0.005	0.021	0.039									
r2	0.022	0.004	0.016	0.031									
r3	0.022	0.003	0.016	0.030									
r4	0.018	0.005	0.010	0.032									
r5	0.008	0.004	0.003	0.022									
r6	0.000	0.000	0.000	0.000									
S(.)r(.)													
S	0.250	0.034	0.189	0.322	1.39	3.39	1.66						
r	0.021	0.002	0.018	0.024									
1995-2001													
S(t)r(t)								S(t)r(t)	1650.78	0	0.74152	11	11.222
S1	0.375	0.116	0.186	0.612				S(t) r(.)	1652.99	2.21	0.24523	8	19.451
S2	0.157	0.060	0.071	0.312				S(.)r(t)	1658.83	8.05	0.01325	8	25.288
S3	0.983	0.003	0.976	0.988				S(.)r(.)	1681.06	30.28	0	2	59.539
S4	0.147	0.108	0.031	0.484									
S5	0.995	0.003	0.983	0.998									
S6	1.000	0.000	1.000	1.000									
S7	0.001	8.334	0.000	1.000									
r1	0.032	0.007	0.021	0.051									
r2	0.017	0.004	0.011	0.027									
r3	1.000	0.000	1.000	1.000									
r4	0.006	0.002	0.003	0.011									
r5	1.000	0.000	1.000	1.000									
r6	0.053	313.610	0.000	1.000									
r7	0.003	0.024	0.000	1.000									
S(t)r(.)													
S1	0.257	0.054	0.166	0.375									
S2	0.240	0.073	0.127	0.408									
S3	0.392	0.090	0.235	0.575									
S4	0.540	0.166	0.241	0.813									
S5	0.844	0.094	0.572	0.956									
S6	1.000	0.000	1.000	1.000									
S7	0.893	0.054	0.732	0.962									
r	0.025	0.002	0.021	0.030									
S(.) r(t)													
S	0.345	0.050	0.255	0.449	1.06	3.00	1.37						
r1	0.031	0.005	0.023	0.042									
r2	0.023	0.004	0.016	0.031									
r3	0.022	0.004	0.016	0.030									
r4	0.017	0.005	0.009	0.029									
r5	0.008	0.004	0.003	0.020									
r6	0.000	0.000	0.000	0.000									
r7	0.010	0.004	0.004	0.024									
S(.) r(.)													
S	0.276	0.034	0.215	0.346	1.29	3.39	1.54						
R	0.020	0.002	0.017	0.024									

Table 7B4 Continued

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Lower	Upper
1995-2002							
{S(t)r(t)}							
1:S	0.375	0.116	0.186	0.612			
2:S	0.160	0.061	0.073	0.318			
3:S	0.983	0.003	0.976	0.988			
4:S	0.103	0.094	0.015	0.458			
5:S	0.251	0.286	0.017	0.868			
6:S	1.000	0.000	1.000	1.000			
7:S	0.055	119.966	0.000	1.000			
8:S	0.468	241.609	0.000	1.000			
9:r	0.032	0.007	0.021	0.051			
10:r	0.017	0.004	0.011	0.027			
11:r	1.000	0.000	0.999	1.001			
12:r	0.006	0.002	0.003	0.010			
13:r	0.008	0.006	0.002	0.037			
14:r	0.002	48.045	0.000	1.000			
15:r	0.004	0.469	0.000	1.000			
16:r	0.089	191.018	0.000	1.000			
{S(p)r(.)} p=2 periods 1995-1999, 200-2003							
1:S	0.251	0.034	0.190	0.324	1.38	3.38	1.66
2:S	0.885	0.049	0.750	0.952	0.12	3.02	0.29
3:r	0.022	0.002	0.019	0.026			
{S(.)r(t)}							
1:S	0.317	0.047	0.233	0.414	1.15	3.06	1.46
2:r	0.030	0.005	0.022	0.040			
3:r	0.022	0.004	0.016	0.031			
4:r	0.022	0.003	0.016	0.030			
5:r	0.018	0.005	0.010	0.031			
6:r	0.008	0.004	0.003	0.021			
7:r	0.000	0.000	0.000	0.000			
8:r	0.008	0.004	0.003	0.021			
9:r	0.019	0.011	0.006	0.059			
{S(t)r(.)}							

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
{S(t)r(t)}	1680.3	0.000	0.317	1.000	13	13.312
{S(p)r(.)}	1680.5	0.270	0.276	0.872	3	33.632
{S(.)r(t)}	1683.1	2.860	0.076	0.239	9	24.199
{S(t)r(.)}	1683.1	2.860	0.076	0.239	9	24.201
{S(.)r(.)}	1703.4	23.110	0.000	0.000	2	58.471

p=2 periods 1995-1999, 2000-2002

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Lower	Upper
1:S	0.252	0.053	0.163	0.369			
2:S	0.218	0.065	0.116	0.371			
3:S	0.321	0.079	0.188	0.492			
4:S	0.356	0.205	0.088	0.761			
5:S	0.747	0.161	0.358	0.940			
6:S	1.000	0.000	1.000	1.000			
7:S	0.891	0.061	0.707	0.965			
8:S	0.908	0.059	0.713	0.975			
9:r	0.024	0.002	0.020	0.029			
{S(.)r(.)}							
1:S	0.262	0.032	0.204	0.330			
2:r	0.020	0.002	0.017	0.023			
1995-2003							
{S(p)r(.)}							
1:S	0.224	0.033	0.166	0.294	1.50	3.42	1.80
2:S	0.880	0.043	0.769	0.941	0.13	3.16	0.26
3:r	0.022	0.002	0.019	0.026			
{S(p)r(t)}							
1:S	0.261	0.043	0.186	0.354	1.34	3.14	1.68
2:S	0.963	0.332	0.000	1.000	0.04	1.10	14.83
3:r	0.027	0.004	0.020	0.037			
4:r	0.022	0.004	0.016	0.030			
5:r	0.022	0.003	0.016	0.029			
6:r	0.017	0.005	0.009	0.031			
7:r	0.009	0.004	0.003	0.023			
8:r	0.000	0.000	0.000	0.000			
9:r	0.095	0.831	0.000	1.000			
10:r	0.070	0.590	0.000	1.000			
11:r	0.064	0.533	0.000	1.000			
{S(t)r(t)}							
1:S	0.000	0.000	0.000	0.000			
2:S	0.331	0.106	0.162	0.559			
3:S	0.130	0.055	0.055	0.279			
4:S	0.982	0.003	0.975	0.987			

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
{S(p)r(.)}	1704.0	0	0.894	1.000	3	34.160
{S(p)r(t)}	1709.1	5.11	0.070	0.078	11	23.239
{S(t)r(t)}	1711.6	7.59	0.020	0.022	17	13.681
{S(t)r(.)}	1712.0	8.08	0.016	0.018	11	26.209
{S(.)r(t)}	1717.5	13.52	0.001	0.001	10	33.652
{S(.)r(.)}	1740.5	36.52	0.000	0.000	2	72.686

p=2 periods 1995-1999, 2000-2003

Model/ Parameter	S(I)	SE	95% CI Lower	Upper	Z S(I)	Lower	Upper	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
5:S	0.109	0.100	0.016	0.477										
6:S	0.247	0.297	0.014	0.882										
7:S	0.640	0.445	0.039	0.987										
8:S	0.996	0.002	0.987	0.999										
9:S	0.997	0.002	0.989	0.999										
10:S	0.990	2.271	0.000	1.000										
11:r	0.030	0.006	0.020	0.046										
12:r	0.017	0.004	0.011	0.027										
13:r	1.000	0.002	0.000	1.000										
14:r	0.005	0.002	0.003	0.010										
15:r	0.008	0.006	0.002	0.037										
16:r	0.000	0.000	0.000	0.000										
17:r	1.000	0.029	0.000	1.000										
18:r	1.000	0.031	0.000	1.000										
19:r	0.269	63.639	0.000	1.000										
{S(t)r(.)}														
1:S	1.000	0.000	1.000	1.000										
2:S	0.228	0.052	0.143	0.345										
3:S	0.174	0.060	0.085	0.323										
4:S	0.277	0.071	0.161	0.433										
5:S	0.320	0.191	0.078	0.725										
6:S	0.683	0.189	0.280	0.923										
7:S	1.000	0.000	1.000	1.000										
8:S	0.882	0.063	0.694	0.961										
9:S	0.903	0.060	0.709	0.973										
10:S	0.902	0.053	0.741	0.968										
11:r	0.023	0.002	0.019	0.027										
{S(.)r(t)}														
1:S	0.329	0.046	0.245	0.425	1.11	3.07	1.41							
2:r	0.030	0.005	0.022	0.041										
3:r	0.022	0.004	0.016	0.031										
4:r	0.022	0.003	0.016	0.030										
5:r	0.015	0.005	0.008	0.027										
6:r	0.008	0.004	0.003	0.021										
7:r	0.000	0.000	0.000	0.000										

Model/ Parameter	S(I)	SE	95% CI Lower	95% CI Upper	Z S(I)	Lower	Upper
8:r	0.008	0.004	0.003	0.021			
9:r	0.014	0.008	0.005	0.045			
10:r	0.009	0.004	0.003	0.023			
{S(.)r(.)}							
1:S	0.265	0.032	0.207	0.333	1.33	3.44	1.57
2:r	0.019	0.002	0.016	0.022			
1995-2004							
{S(p.)r(.)}							
1:S	0.222	0.033	0.165	0.292	1.50	3.43	1.80
2:S	0.879	0.037	0.785	0.935	0.13	3.29	0.24
3:r	0.022	0.002	0.019	0.026			
{S(p_t)r(.)}							
1:S	0.223	0.033	0.165	0.293			
2:S	1.000	0.000	1.000	1.000			
3:S	0.837	0.081	0.614	0.943			
4:S	0.860	0.082	0.618	0.959			
5:S	0.875	0.064	0.690	0.957			
6:S	0.884	0.054	0.732	0.955			
7:r	0.022	0.002	0.019	0.026			
{S(p.)r(t)}							
1:S	0.260	0.043	0.185	0.353			
2:S	0.834	0.185	0.267	0.986			
3:r	0.027	0.004	0.020	0.037			
4:r	0.022	0.004	0.016	0.030			
5:r	0.022	0.003	0.016	0.029			
6:r	0.017	0.005	0.009	0.031			
7:r	0.009	0.004	0.003	0.023			
8:r	0.000	0.000	0.000	0.000			
9:r	0.023	0.026	0.002	0.184			
10:r	0.019	0.019	0.003	0.126			
11:r	0.018	0.017	0.003	0.108			
12:r	0.016	0.015	0.003	0.092			
{S(t)r(.)}							
1:S	0.228	0.052	0.142	0.344			

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
{S(p.)r(.)}	1775.3	0.000	0.880	1.000	3	38.382
{S(p_t)r(.)}	1780.0	4.700	0.084	0.095	7	35.074
{S(p.)r(t)}	1782.5	7.220	0.024	0.027	12	27.568
{S(t)r(.)}	1784.6	9.250	0.009	0.010	11	31.606
{S(t)r(t)}	1786.5	11.150	0.003	0.004	19	17.448
{S(.)r(t)}	1794.9	19.570	0.000	0.000	11	41.929
{S(.)r(.)}	1823.4	48.030	0.000	0.000	2	88.415

Model/ Parameter	S(I)	SE	95% CI Lower	Upper	Z S(I)	Lower	Upper	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
2:S	0.171	0.059	0.084	0.318										
3:S	0.265	0.065	0.157	0.410										
4:S	0.265	0.167	0.063	0.660										
5:S	0.616	0.218	0.209	0.907										
6:S	1.000	0.000	1.000	1.000										
7:S	0.868	0.070	0.666	0.956										
8:S	0.890	0.067	0.678	0.969										
9:S	0.897	0.055	0.732	0.965										
10:S	0.902	0.047	0.764	0.963										
11:r	0.023	0.002	0.019	0.027										
{S(t)r(t)}														
1:S	0.331	0.106	0.162	0.559										
2:S	0.130	0.055	0.055	0.279										
3:S	0.982	0.003	0.975	0.987										
4:S	0.107	0.098	0.016	0.470										
5:S	0.239	0.289	0.014	0.876										
6:S	0.508	0.349	0.063	0.941										
7:S	0.995	0.003	0.986	0.998										
8:S	0.807	0.579	0.003	1.000										
9:S	0.997	0.002	0.989	0.999										
10:S	0.995	0.000	0.995	0.995										
11:r	0.030	0.006	0.020	0.046										
12:r	0.017	0.004	0.011	0.027										
13:r	1.000	0.003	0.000	1.000										
14:r	0.005	0.002	0.003	0.010										
15:r	0.008	0.006	0.002	0.036										
16:r	0.000	0.000	0.000	0.000										
17:r	1.000	0.002	0.997	1.003										
18:r	0.017	0.054	0.000	0.901										
19:r	1.000	0.057	0.000	1.000										
20:r	0.480	0.000	0.480	0.480										
{S(.)r(t)}														
1:S	0.356	0.047	0.271	0.452										
2:r	0.031	0.005	0.023	0.043										
3:r	0.023	0.004	0.016	0.032										

Model/ Parameter	S(I)	SE	95% CI Lower	Upper	Z S(I)	Lower	Upper	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
4:r	0.022	0.004	0.016	0.030										
5:r	0.014	0.004	0.008	0.025										
6:r	0.007	0.004	0.003	0.020										
7:r	0.000	0.000	0.000	0.000										
8:r	0.008	0.004	0.003	0.021										
9:r	0.014	0.008	0.004	0.042										
10:r	0.009	0.004	0.003	0.024										
11:r	0.008	0.004	0.003	0.019										
{S(.)r(.)}														
1:S	0.286	0.032	0.228	0.353										
2:r	0.018	0.001	0.015	0.021										

Table 7B5 Results of chi-square analyses on weekly age structure of annual spawning stock survey samples of American shad in the Hudson River, New York.

Year	Ages	Number of weeks sampled	Number of fish caught	DF	X^2	Prob
1985	3-9	4	246	18	25.21	0.119
1986	3-9	5	410	24	42.74	0.011
1987	3-10	5	400	28	20.93	0.828
1988	4-9	7	509	30	51.32	0.009
1989	4-9	5	361	20	24.38	0.226
1990	4-8	5	86	16	11.80	0.758
1991	3-7	4	211	12	31.26	0.002
1992	4-9	5	911	20	85.34	<0.001
1993	4-8	4	467	12	28.40	0.005
1994	4-7	5	157	12	88.40	<0.001
1995	3-7	6	705	20	125.09	<0.001
1996	3-7	4	380	12	26.47	0.009
1997	4-8	4	136	12	27.20	0.007
1998	3-8	3	282	10	13.09	0.219
1999	4-8	3	342	8	2.59	0.957
2000	3-7	4	378	12	11.87	0.456
2001	3-8	3	921	10	15.76	0.107
2002			No sampling			
2003			Age data not complete			
2004	3-11	3	776	16	20.05	0.218
2005			Age data not complete			