IPRenewal NPEmails

From: Gray, Dara F [DGray@entergy.com]
Sent: Monday, July 23, 2012 4:00 PM
To: 'Julie.Crocker@Noaa.Gov'
Cc: Wentzel, Michael
Subject: Atlantic Sturgeon Information
Attachments: Sturgeon Impingement at IPEC.PDF

Hi Julie
Attached on behalf of Entergy, please find a report developed by scientists at AKRF, Inc., with the input of LWB Environmental Services, Inc., Normandeau Associates, Inc. and Applied Science Associates, Inc., to provide additional insight on the potential future impingement (mortality) of Atlantic sturgeon at Indian Point. The report establishes the absence of a correlation between potential impingement at Indian Point and Hudson River-wide abundance of Atlantic sturgeon, employing multiple abundance indices and accounting for current population dynamics. Further underscoring this point, based upon additional investigation of sturgeon swimming speeds and capabilities, the report establishes that the vast majority to Atlantic sturgeon impinged at Indian Point are moribund or dead upon arrival. This conclusion is supported by additional investigation of the American shad commercial fishery by-catch mortality, which is in fact correlated to Indian Point impingement; thus and with the closure of the in-river shad commercial fishery, by-catch mortality and impingement at Indian Point are expected to decline. In sum, the information provided in the report confirms the existing data and information provided to date that establishes that Indian Point's continued operation will not have any effect of Atlantic sturgeon population recovery efforts, even at current levels. At Entergy, we are particularly heartened that the authors of the report were able to take into account the substantial body of peer-reviewed, published data supporting and confirming the report's conclusions.

While NMFS already has issued a new biological opinion for Indian Point's future operations (following NRC license renewal) for shortnose sturgeon, we have included comparable data for this species in the report, consistent with our request that NMFS define impingement differently from impingement mortality, consistent with the Service's approach in recently issued Hudson River authorizations, e.g., for the Tappen Zee project. This information in the report establishes the potential impingement and impingement mortality numbers for both species to facilitate NMFS's efforts here to maintain consistency among its issued authorizations. To that end, we appreciate NMFS' prior indications during our discussions of shortnose sturgeon that they would consider specified impingement mortality limits and hereby request that they do so for Atlantic and shortnose sturgeon.

We look forward to receiving the BiOp and ITS for shortnose and Atlantic sturgeon. Please do not hesitate to contact me if you have any questions or would like additional supporting data.

Thanks

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Atlantic Sturgeon and Shortnose Sturgeon Impingement at IPEC Units 2 and 3:

Review of Historical Data,
Projections of Impingement, and
Assessment of the Condition of Impinged Sturgeon Upon Arrival at IPEC

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Table of Contents

I. Introduction and Summary

This report presents: 1) summaries of historical data on impingement of Atlantic sturgeon (*Acipenser oxyrinchus*) and shortnose sturgeon (*Acipenser brevirostrum*) at Indian Point Energy Center ("IPEC") 2) projections of impingement, and 3) an assessment of the condition of impinged sturgeon upon arrival at IPEC. The summaries include temporal patterns and trends as well as length frequency distributions of impinged sturgeons. The projections of impingement were based on the historical impingement data, published estimates of changes in sturgeon abundance in the Hudson River, and recent plant operating conditions. The assessment of the condition of impinged sturgeons included comparisons of patterns in sturgeon impingement to trends in riverwide abundance of sturgeon in the Hudson River and to estimates of sturgeon discards from the shad gillnet fishery. In addition, swimming speeds of sturgeons, as a function of fish length, were compared to through-screen velocities at the IPEC intake screens.

Briefly and as detailed below, annual estimates of impingement density at IPEC are not significantly correlated with either relevant indices of abundance, for either Atlantic sturgeon or shortnose sturgeon, which indicates that factors other than population abundance played a key role in determining patterns of sturgeon impingement at IPEC. Furthermore, based upon expected swimming speeds and length frequency distributions of sturgeons historically impinged at IPEC (pursuant to the incidental take authorization established for shortnose sturgeon), the vast majority of sturgeons impinged at IPEC would have had the ability to avoid impingement if healthy. This suggests many sturgeon arrived at the intake screens dead or moribund. Consistent with these facts, it appears discards of sturgeons from the commercial gillnet fisheries contributed to sturgeon impingement at IPEC. Finally, any healthy sturgeons that were impinged after modified Ristroph screens with fish return systems were installed at IPEC in the early 1990s likely would have been returned to the river unharmed. Thus, IPEC's ability to affect Atlantic or shortnose sturgeon abundance is negligible.

A. Historical Data Reviewed

Data reviewed for this report include: (1) impingement data collected at IPEC, (2) data collected by Hudson River Utilities on the riverwide abundances of Atlantic and shortnose sturgeon in the Hudson River, (3) data reported by the Atlantic States Marine Fisheries Commission ("ASMFC") on the bycatch of Atlantic sturgeon in the shad gillnet fishery, (4) published estimates of the population abundance of Atlantic sturgeon and shortnose sturgeon, and (5) published estimates of the swimming speed of shortnose sturgeon.

Impingement data at IPEC for Units 2 and 3 together with data on IPEC water withdrawals were available for the years 1976 to 1990. Data on riverwide abundance from the Utilities' Long River Survey ("LRS") and Fall Shoals Survey ("FSS") have been collected since 1974. The ASMFC reported estimates of fishing effort for the Hudson River shad gillnet fishery for the years 1976 to 2005, and reported estimates of catch per unit effort ("CPUE") of Atlantic sturgeon by the Hudson River shad gillnet fishery for the years 1980 to 1996.

Published estimates of riverwide abundance of Atlantic sturgeon, based on mark-recapture studies, were reported by Dovel and Berggren (1983) for 1976-77 and by Peterson et al. (2000) for 1995. Estimates of absolute abundance of shortnose sturgeon, based on mark-recapture studies, were reported by Bain et al. (2007) for the mid-1990s, and by Dovel et al. (1992) for 1979-80. Deslauriers and Kieller (2012) reported on the swimming speeds of shortnose sturgeon as a function of water temperature and fish length.

B. Report Organization

Basic data summaries are presented in Sections II and III along with brief descriptions of data analysis methods. Section II addresses impingement and Section III addresses riverwide abundance. Section II also includes the projections of impingement. Atlantic sturgeon and shortnose sturgeon are addressed in Sections II and III. Correlations between impingement densities and riverwide abundances are presented in Section III.

Background information on shortnose sturgeon swimming ability is presented in Sections IV, and background information on Atlantic sturgeon discards from the shad gillnet fishery is presented in Section V. Implications of sturgeon swimming ability and shad fishery discards on the condition of impinged sturgeon upon arrival at IPEC are also discussed in Sections IV and V.

Section VI contains a discussion of results and the report's conclusions.

II. Historical Impingement Patterns

Estimates of historical impingement densities (1976-1990) were based on collection efficiency adjusted impingement estimates listed in Tables 2a through 2d in Enclosure 1 to NL-09-091, *Sturgeon Impingement at Indian Point 1974-1990,* from Entergy to NRC, dated 7/1/09. Monthly average impingement densities were estimated by dividing the total number impinged by the actual average withdrawal rate (gpm x 10^6) for the month.

Historical flows (1976-1990) were from the SAS dataset CIRCFLOW.SSD dated 8/8/91 ("Indian Point Plant Operations Datasets for 1973-1990 last update 8/8/90 - john hamilton"). Flow data for 1975 were not included in the dataset. For projections, recent

(2001-2008) actual average monthly flows (cooling plus service water) are from Tables 3-1 and 3-2 in Enercon (2010).

A. Atlantic Sturgeon

1. Trends in Impingement Density

Impingement densities of Atlantic sturgeon at IPEC were highest in the late 1970s and declined to near zero by the late 1980s (Figure 1).

2. Within Year Impingement

a. Actual 1976-1990

For the period 1976-1990, the average number of Atlantic sturgeon impinged per year at IPEC was 49.7. On average, the highest impingement occurred in April (approximately 15 per month), with the lowest impingement (less than 2 per month) occurring in late fall (Figure 2).

b. Projected 2001-2008

Atlantic sturgeon impingement for the period 2001-2008 was projected from historical (1976-1990) impingement densities and actual IPEC flows from 2001-2008. To account for changes in riverwide abundance of Atlantic sturgeon, recent (2001-2008) impingement densities were assumed to be 20% of the historical (1976-1990) densities. That assumed reduction is based on the finding of Peterson et al. (2000) that the abundance of age-1 Atlantic sturgeon in the Hudson River declined 80% from 1977 to 1995.

The projected average number of Atlantic sturgeon impinged per year at IPEC from 2001 through 2008, based on the method described above, was 11.5 (Figure 3).

3. Impingement Length Frequency

From 1985 through 1990, lengths (mm total length, "mmTL") and weights (wet weight in grams) of impinged Atlantic sturgeon were reported; however, from 1974-1984, weights were reported but lengths were not. Therefore, for 1974-1984, lengths of impinged Atlantic sturgeon predicted based on reported weights of impinged Atlantic sturgeon. The prediction equation (R^2=0.85) was developed from length and weight measurements obtained from 36 Atlantic sturgeon collected during impingement sampling from 1985-1990 (Figure 4).

In addition, measurements on greatest body width (mm) and depth (mm) from Atlantic sturgeon collected in FSS and striped bass mark-recapture sampling programs from July through December 2011 were used to predict the longest Atlantic sturgeon

that would fit through the 3” wide opening of the bar racks, and could be impinged at IPEC. Applying this conservative approach, the longest Atlantic sturgeon that would not be excluded by the bar racks, i.e., that could fit between the bars regardless of orientation, would be approximately 600 mmTL.

The length frequency distributions for impinged Atlantic sturgeon (Figure 5) show a median length of approximately 330 mmTL, with a 10th percentile of approximately 200 mmTL and a 90th percentile of approximately 500 mmTL. Although the median length of Atlantic sturgeon collected by 35 foot otter trawls in the Hudson River in 1978 was almost 600mm (Dovel and Berggren, 1980), only 2.5% of impinged Atlantic sturgeon were greater than 600 mmTL, which supports the conclusion that Atlantic sturgeon larger than 600 mmTL are excluded from impingement by the bar racks at IPEC.

The length frequency distributions for impinged Atlantic sturgeon were very similar for Unit 2 and Unit 3. However, the estimated number impinged at Unit 2 was approximately double the number impinged at Unit 3 (Figure 6).

B. Shortnose Sturgeon

1. Trends in Impingement Density

Impingement densities of shortnose sturgeon at IPEC showed no clear trend, although they were somewhat higher in the late 1970s. During the 1980s, impingement was zero in 5 of 10 years (Figure 7).

2. Within Year Impingement

a. Actual 1976-1990

For the period 1976-1990, the average number of shortnose sturgeon impinged per year at IPEC was 3.8. On average, the highest impingement occurred in April (approximately 1 per month), with the lowest impingement (none) occurring in summer (Figure 8).

b. Projected 2001-2008

Shortnose sturgeon impingement for the period 2001-2008 was projected from historical (1976-1990) impingement densities and actual IPEC flows from 2001-2008. To account for changes in riverwide abundance of shortnose sturgeon, recent (2001-2008) impingement densities are assumed to be 4-times the historical (1976-1990) densities (from NMFS 2011 Biological Opinion).

The projected average number of shortnose sturgeon impinged per year at IPEC from 2001 through 2008, based on the method described above, was 20.1 (Figure 9).

3. Impingement Length Frequency

Because weights (wet weight in grams) of impinged shortnose sturgeon were recorded in all years of impingement sampling, while lengths of impinged shortnose sturgeon were recorded only in the latter years as described above for Atlantic sturgeon, shortnose sturgeon lengths were predicted based on the reported weights. The prediction equation (R^2=0.88) was developed from length and weight measurements obtained from 48 shortnose sturgeon collected during FSS and striped bass mark-recapture sampling from July through December 2011 (Figure 10).

In addition, measurements on greatest body width (mm) and depth (mm) from shortnose sturgeon collected in the 2011 field programs were used to predict the longest shortnose sturgeon that would fit through the 3" wide opening of the bar racks at IPEC. Applying this conservative approach, the longest shortnose sturgeon that would not be excluded by the bar racks, i.e., that would fit between the bars regardless of orientation, would be approximately 600 mmTL.

The length frequency distributions for impinged shortnose sturgeon (Figure 11) show a median length of approximately 500 mmTL, with 10th percentile of approximately 300 mmTL and a 90th percentile of approximately 600 mmTL. However, due to the low number of shortnose sturgeon impinged, the percentiles are inexact.

The estimated length frequency distributions for impinged shortnose sturgeon were somewhat different for Unit 2 or Unit 3, with larger shortnose sturgeon over 500 mmTL only impinged at Unit 2. As was the case for Atlantic sturgeon, the estimated number impinged at Unit 2 was approximately double the number impinged at Unit 3 (Figure 12).

III. Trends in Riverwide Abundance

Estimates of annual riverwide abundance of sturgeon were computed as the average weekly standing crop within a standard set of weeks. Separate estimates were computed using data from the LRS and the FSS. LRS Abundance estimates were based on average riverwide standing crop estimates for weeks 18-26. FSS Abundance estimates were based on average riverwide standing crop estimates for weeks 31-42.

The FSS did not sample regions 8-12 from 1974 through 1978. For those years, the abundance in regions 8-12 was predicted based on the reported abundance in regions 1-7 and the results from a regression analysis (R^2=0.68). The regression analysis was conducted using data from 1979-2007 when regions 8-12 and regions 1-7 were sampled.

A. Atlantic Sturgeon

1. Population Abundance Estimates

Dovel and Berggren (1983) reported mark-recapture estimates of approximately 100,000 fish in 1976 and 1977, representing up to six year classes of juvenile fish excluding young-of-the-year which were not adequately sampled. The median length of Atlantic sturgeon was 580 mmTL (based on sampling in 1978), with the 10th percentile of 440 mmTL and the 90th percentile of 720 mmTL (from Figure 8 in Dovel and Berggren, 1983). Sampling was conducted with a 35 foot otter trawl.

Peterson et al. (2000) reported a mark-recapture estimate of 4,300 age-1 Atlantic sturgeon in 1995. The median length of Atlantic sturgeon collected by that study was 450 mmTL, with the 10th percentile of 330 mmTL and the 90th percentile of 590 mmTL. Sampling was conducted with gillnets with 3 sizes of mesh.

2. FSS and LRS

The median length of Atlantic sturgeon collected by the LRS (epibenthic sleds) was 483 mmTL (based on 298 fish measured between 1985 and 2005), with the 10th percentile of 158 mmTL and the 90th percentile of 680 mmTL. LRS sampling was conducted with a 1-meter square epibenthic sled. The median length of Atlantic sturgeon collected by the FSS (beam trawls) was 475 mmTL (based on 897 fish measured between 1985 and 2005), with the 10th percentile of 172 mmTL and the 90th percentile of 673 mmTL. FSS sampling was conducted with a 3-meter beam trawl.

The similarities in the length frequency distributions from the LRS and FSS indicate that the two sampling programs collected the same age classes of Atlantic sturgeon. The LRS and FSS appeared to have collected smaller Atlantic sturgeon than those reported by Dovel and Berggren (1983). Whereas Dovel and Berggren reported collecting mostly age-1 through age-4 Atlantic sturgeon, it appears the LRS and FSS collected mostly age-0 through age-2 Atlantic sturgeon (see Figure 9 in Dovel and Berggren, 1983).

The FSS abundance time series was adjusted to account for the FSS change in sampling gear (from epibenthic sled to beam trawl) that occurred in 1985. For years prior to 1985 (epibenthic sled sampling), the FSS abundance time series was adjusted so that the estimated 4-year average abundance from 1975-1978 was equal to the reported average combined abundance of 100,000 for 4 year classes of juvenile Atlantic sturgeon (Dovel and Berggren, 1983). This adjustment implied the average gear efficiency of the FSS epibenthic sled for Atlantic sturgeon was 0.12.

For 1985 and later years (beam trawl sampling), the abundance time series was adjusted so that the estimated average abundance in 1995 was consistent with the

reported abundance of 4,300 age-1 Atlantic sturgeon from Peterson et al. (2000). The abundance of all juvenile Atlantic sturgeon was assumed to be four times the age-1 abundance, as reported by Dovel and Berggren (1983). Accordingly, the beam trawl abundance time series was adjusted so the 1995 abundance was 17,200 (i.e., 4 x 4,300). This adjustment implied the average gear efficiency of the FSS beam trawl for Atlantic sturgeon was 0.28.

The FSS and LRS estimates of Atlantic sturgeon abundance display the same overall trends (Figure 13), with a sharp population decline occurring around 1990. The two time series are significantly correlated ($r=0.55$, $p<0.001$). Since the two programs operate independently using different sampling gears (since 1985), the significant correlation is evidence that both programs are accurately representing the riverwide abundance of Atlantic sturgeon.

3. Correlations with Impingement

Impingement data and data on riverwide Atlantic sturgeon abundance from the FSS and LRS programs overlap for the years 1976 through 1990. Therefore, correlations between impingement densities and riverwide abundance were conducted for those years only.

a. FSS

Impingement density of Atlantic sturgeon at IPEC was not significantly correlated with riverwide abundance as measured by the FSS (Figure 14). This result indicates that, for the years 1976-1990, changes in Atlantic sturgeon impingement density at IPEC were not attributable to changes in riverwide abundance.

b. LRS

Similarly, impingement density of Atlantic sturgeon at IPEC was not significantly correlated with riverwide abundance as measured by the LRS (Figure 15). This result supports the conclusion that, for the years 1976-1990, changes in Atlantic sturgeon impingement density at IPEC were not attributable to changes in riverwide abundance.

B. Shortnose Sturgeon

1. Population Abundance Estimates

Bain et al. (2007) compared mark-recapture estimates of abundance of adult (> 500 mmTL) shortnose sturgeon for 1979 and 1980 (from Dovel et al. (1992) and for the period 1994-1997. The estimates for 1979 and 1980 were approximately 13,000 each year , and the estimate for the mid-1990s was 57,000. The mean length of shortnose

sturgeon collected in 1979-1980 was 645 mmTL, and the mean length of shortnose sturgeon collected in the mid-1990s was 663 mmTL (Bain et al. 2007).

2. FSS and LRS

The median length of shortnose sturgeon collected by the LRS using 1-meter square epibenthic sleds was 730 mmTL (based on 75 fish measured between 1985 and 2005), with the 10th percentile of 597 mmTL and the 90th percentile of 837 mmTL. The median length of shortnose sturgeon collected by the FSS using 3-meter beam trawls was 684 mmTL (based on 646 fish measured between 1985 and 2005), with the 10th percentile of 385 mmTL and the 90th percentile of 794 mmTL.

The LRS collections were almost entirely adult shortnose sturgeon (i.e., fish > 500 mmTL), however, the FSS collected immature shortnose sturgeon as well, as evidenced by the 10^{th} percentile lengths.

The FSS abundance time series was adjusted to account for the FSS change in sampling gear (from epibenthic sled to beam trawl) that occurred in 1985. For years prior to 1985 (epibenthic sled sampling), the FSS abundance time series was adjusted so that the estimated 10-year average abundance from 1975-1984 was equal to the reported abundance of all adult year classes of 13,000 (Dovel et al., 1992). This adjustment implied the average gear efficiency of the FSS epibenthic sled for shortnose sturgeon was 0.21.

For 1985 and later years (beam trawl sampling), the abundance time series was adjusted so that the estimated 10-year average abundance for the years 1991-2000 was equal to the reported abundance of all adult year classes of 57,000 (Bain et al., 2007). This adjustment implied the average gear efficiency of the FSS beam trawl for shortnose sturgeon was 0.27.

The FSS and LRS estimates of shortnose sturgeon abundance display the same overall trends (Figure 16), with a sharp population increase occurring after 1990. The two time series are significantly correlated (r=0.50, p=0.003). Since the two programs operate independently using different sampling gears (since 1985), the significant correlation is evidence that both programs are accurately representing the riverwide abundance of Atlantic sturgeon.

3. Correlations with Impingement

As noted above, impingement data and data on riverwide shortnose sturgeon abundance from the FSS and LRS programs overlap for the years 1976 through 1990. Therefore, correlations between impingement densities and riverwide abundance were conducted for those years only.

a. FSS

Impingement density of shortnose sturgeon at IPEC was not significantly correlated with riverwide abundance as measured by the FSS (Figure 17). This result indicates that, for the years 1976-1990, changes in shortnose sturgeon impingement density at IPEC were not attributable to changes in riverwide abundance.

b. LRS

Similarly, impingement density of shortnose sturgeon at IPEC was not significantly correlated with riverwide abundance as measured by the LRS (Figure 18). This result supports the conclusion that, for the years 1976-1990, changes in shortnose sturgeon impingement density at IPEC were not attributable to changes in riverwide abundance.

IV. Sturgeon Swimming Ability

The swimming speed that causes juvenile shortnose sturgeon to experience fatigue was investigated by Deslauriers and Kieffer (2012). Juvenile shortnose sturgeon (19.5 cm average total length) were exposed to increasing current velocities in a flume to determine the velocity that caused fatigue. Fish were acclimated for 30 minutes to a current velocity of 5 cm/sec. Current velocities in the flume then were increased by 5 cm/sec increments for 30 minutes per increment until fish exhibited fatigue.

> "Fish were considered fatigued when they were impinged on the down-stream plastic screen for a period of 5 s." (Deslauriers and Kieffer (2012), page 177).

The current velocity that induced fatigue was reported as the critical swimming speed ("U_{crit}") under the assumption that the fish swam at the same speed as the current.

The effect of water temperature on U_{crit} for juvenile shortnose sturgeon was determined by repeating the experiment at five water temperatures: 5°C, 10°C, 15°C, 20°C and 25°C. The authors developed a prediction equation to describe the relationship between U_{crit} and water temperature.

Deslauriers and Kieffer (2012) compared the results of their experiment to the results of similar experiments conducted with other species of sturgeon: lake sturgeon (*Acipenser fluvescens*), green sturgeon (*Acipenser medirostris*), pallid sturgeon (*Scaphirhynchus albus*), and shovelnose sturgeon (*Scaphirhynchus platorynchus*). For that comparison, the authors expressed critical swimming speed in terms of body length per second (BL/sec), rather than cm/sec, to allow for comparisons across different sized fish. The results for all five sturgeon species were similar.

The prediction equation for U_{crit} as a function of water temperature was applied to the range of monthly water temperatures in the vicinity of IPEC to estimate the minimum size of sturgeon that would have a U_{crit} swimming speed greater than the through-screen velocity and therefore should be able to avoid impingement at IPEC. The through-screen intake velocity was assumed to be 1.0 ft/sec for full flow conditions and 0.6 ft/sec for reduced flow conditions (Enercon 2010). Based on the average historical flows at IPEC (Figures 2 and 3), it was assumed that full flow conditions might exist from May through October, and reduced flow conditions would exist from November through April.

The results indicate that healthy sturgeons over 19.5 cmTL should be capable of sustained avoidance of impingement at IPEC throughout the year (Table 1). However, all shortnose sturgeon impinged at IPEC from 1794-1990 were larger than 19.5 cmTL (Figure 11), and approximately 90% of impinged Atlantic sturgeon were larger than 19.5 cmTL (Figure 5).

These results may be conservative. In an earlier study, Kieffer et al. (2009) measured U_{crit} values for juvenile shortnose sturgeon ranging in length from 14 to 18 cmTL at a temperature of 15°C. These authors estimated U_{crit} at this temperature to be 2.18 BL/sec. Assuming this value, any shortnose sturgeon longer than 14.0 cmTL would be able to avoid impingement during the months of May through September, when the average water temperature at Indian Point is equal to or greater than 15°C. All shortnose sturgeon impinged at IPEC were larger than 14.0 cmTL (Figure 9), and approximately 95% (Unit 2) to 98% (Unit 3) of impinged Atlantic sturgeon were larger than 14.0 cmTL.

Table 1. Predicted swimming speed that would cause fatigue (U_{crit}) in shortnose sturgeon as a function of water temperature (from Deslauriers and Kieffer 2012), and derived lengths of sturgeon that would be capable of avoiding the IPEC intake screens.

Month	**Average Water Temperature (°C)** [from 2008 Year Class Report Figure 3-3]	**U_{crit} (BL/sec)**	**Minimum Length (cmTL) of Sturgeon Capable of Avoiding Intake Velocity**	
			Full Flow (1.0 ft/sec through-screen velocity)	**Reduced Flow (0.6 ft/sec through-screen velocity)**
1	2	1.22		15.0
2	2	1.22		15.0
3	5	1.33		13.7
4	8	1.43		12.8
5	15	1.58	19.3	
6	22	1.63	18.7	
7	26	1.62	18.9	
8	24	1.63	18.7	
9	22	1.63	18.7	
10	14	1.57	19.5	
11	5	1.33		13.7
12	2	1.22		15.0

V. Hudson River Commercial Gillnet Fisheries

A. Overview

NYSDEC issued two types of commercial gillnet licenses for the Hudson River from 1976 to 2010 – a combined shad/herring license and a regular gillnet license (NYSDEC, 2009). The shad/herring gillnet license allowed fishers to deploy gillnets from 15 March to 15 June, and the regular gillnet license was for the period 15 March through 30 November.

The commercial fishery for American shad was restricted to using a minimum stretch mesh size of 5 ½ inches (13.9 cm) and the commercial fishery for river herring was restricted to stretch mesh sizes of between 1 ½ inches (3.8 cm) and 3 ½ inches (8.8 cm) (NYSDEC, 2009). The regular gillnet license allowed stretch mesh greater than 5 ½ inches or less than 3 ½ inches.

The majority of holders of shad/herring gillnet licenses used their licenses to catch river herring, not American shad:

> "For the Hudson River shad fishery, a total of 172 shad & herring gill net licenses (valid March 15 through June 15) and 118 gill net licenses (valid March 15 through November 30) were sold in 2008 (Table 8). However, most shad and herring gill net licenses reflect purchases by individuals fishing for bait, primarily river herring." (NYSDEC, 2009)

From 1981 (the first year reported by NYSDEC) through 1990 (the last year of impingement data at IPEC), between 19% and 53% of the holders of shad/herring gillnet licenses in each year reported fishing for American shad (NYSDEC, 2009). This may be partly due to the fact that recreational fishers purchased commercial licenses in order to collect bait:

> "Recreational fishers often use commercial net gears because permit fees remain at 1911 levels. … In the last ten years, about 250 fishers annually purchased commercial gill net permits and approximately 240 purchased commercial scap net permits. However only 84 gill net and 93 scap/lift fishers reported using the gear licensed. Fishers using commercial gears are required to report landings annually. Most river herring taken in the Hudson and tributaries are used as bait in the recreational striped bass fishery." (NYSDEC, 2011)

In recent years, the shad/herring gillnet license cost $10.00 for residents of New York State, and the regular gillnet license cost $0.05 per linear foot of gillnet, with a maximum length of 600 feet per net.

The commercial shad gillnet fishery on the Hudson River (Figure 19) historically operated in the vicinity of IPEC (river km 67) for an eight-week period in the spring of each year:

> "[Shad] 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)" (ASMFC 2007)

The commercial river herring gillnet fishery operates in the same general stretch of river (Figure 20) during the spring:

> "The present commercial fishery in the Hudson River and tributaries exploits the spawning migration of both alewife and blueback herring. The primary use of commercially caught herring is for bait in the recreational striped bass fishery. The herring fishery occurs from March into early June annually, although some fishers report catching herring as late as July."
>
> "The fixed gill net fishery occurs in the mainstem river from km 40 to km 75 (Piermont to Bear Mountain Bridge, Figure 1)" (NYSDEC, 2011)

A. Sturgeon Bycatch in the Gillnet Fisheries

Gillnets are size selective at catching fish. The shad gillnets (stretched mesh of 5 ½ inches) and herring gillnets (stretched mesh of 1 ½ to 3 ½ inches) likely would be able to catch different size classes of sturgeon:

> "… length frequencies from studies using gillnets having different mesh sizes indicate that there is considerable overlap between size distributions of sturgeon collected with different mesh sizes. Sub-yearling sturgeon (200-300 mm FL) have been captured using 5 cm (2") stretched mesh nets in the Hudson, Cape Fear, Edisto, and Savannah rivers but in all cases the catch rates were low. This was probably due to low abundance of small size classes in these rivers, rather than gear selectivity. For post-yearlings, all mesh sizes greater than 6.4 cm (2.5") stretched mesh result in similar length frequencies." (NMFS, 2010)

Atlantic sturgeon were historically caught as unintended bycatch by the commercial shad gillnet fishery. The NYSDEC conducted a sampling program that recorded the Atlantic sturgeon bycatch in the commercial shad gillnet fishery and reported the results of that sampling through the ASMFC (ASMFC 1998):

> "Commercial Fishery Bycatch Monitoring: The commercial gillnet fishery in the Hudson River Estuary exploits the spawning migration of American shad. Young (<1000 mm) Atlantic sturgeon are caught as bycatch. Shad fishing usually begins in early April and continues until May. Most Atlantic sturgeon are caught in fixed gillnets fished from km 40 to km 70 (Piermont to Peekskill). Few are caught in the drifted gillnet fishery for shad that occurs from km 98 to km 182 (Newburgh Bay to Catskill)."

Given the mesh size of the shad gillnets, Atlantic sturgeon bycatch in the shad gillnet fishery would be expected to be post-yearlings (e.g., larger than 400 mm).

Because river herring was not a focus of NYSDEC's commercial fishery monitoring program until 1996, NYSDEC did not have observers with gillnet operators who were fishing for river herring:

> "Up until the mid-1990s, the Department's commercial fishery monitoring program was directed at the American shad gill net fishery, a culturally historic and economically important fishery. We expanded monitoring to the river herring fishery in 1996, but were limited by available manpower and the ability to connect with the fishers." (NYSDEC, 2011)

Therefore, data on possible bycatch in the river herring gillnet fishery of sub-yearling Atlantic sturgeon (which may have been caught in the smaller mesh gillnets of the herring fishery) are not available.

Prior to 1993 (i.e., during the period of the IPEC impingement record), the legal size limit of Atlantic sturgeon caught in New York waters was 4 ft (1219 mmTL) (ASMFC 1998). Accordingly, Atlantic sturgeon caught by the commercial shad/herring gillnet fishery could not have been legally kept and would have been discarded. Observed immediate discard mortality of sturgeons caught in gillnets have been reported to range from 2.3% (Bahn et al. 2012) to 22% (Stein et al. 2004). In addition to immediate mortality, one study reported that 20% of sturgeon released live from gillnets were released with injuries (Collins et al. 1996).

To examine the possibility that Atlantic sturgeon discards from the commercial shad gillnet fishery contributed to Atlantic sturgeon impingement at IPEC, an annual index of Atlantic sturgeon discards was computed. The annual (relative) abundance of Atlantic sturgeon caught as bycatch in shad gillnets was computed as the product of (1) the CPUE of Atlantic sturgeon in the shad fixed gillnet fishery (ASMFC 1998, Table 3.3.6), (2) the number of feet of licensed

gillnet[1] and (3) the number of legal fishing hours per week (ASMFC 2007, Table 7B2). The ASMFC's reported CPUE was calculated as the number of fish collected per square yard-hour of net fished (ASMFC 1998).

The annual relative abundance of Atlantic sturgeon bycatch in the commercial shad gillnet fishery for the years 1980 through 1990 (the years with both ASMFC CPUE data and IPEC impingement data) was significantly correlated ($R = 0.65$, $p = 0.03$, $n=11$) with impingement densities at IPEC (Figure 21). This result suggests that discards of dead and injured post-yearling Atlantic sturgeon from the commercial gillnet fishery may have contributed to Atlantic sturgeon impingement at IPEC.

Because historical data on bycatch of sub-yearling Atlantic sturgeon in the river herring gillnet fishery are not available, the relative abundance of sub-yearling Atlantic sturgeon bycatch could not be estimated. Also, shortnose sturgeon which has been on the endangered species list is not a species that has been actively managed by the ASMFC. Therefore, the required ASMFC inputs for estimating bycatch were not available for shortnose sturgeon either. Furthermore, data on bycatch of neither sturgeon species was available for the regular gillnet fishery which was open from March through November.

VI. Modified Ristroph Traveling Screens at IPEC

Modified Ristroph traveling screens with fish return systems were installed at IPEC during the early 1990s. The IPEC modified Ristroph traveling screens and fish return systems were evaluated for optimum impingement mitigation from 1985 through 1994, under the oversight, direction and approval of USEPA, NYSDEC and Dr. Ian Fletcher (Fletcher 1990). The goal of these studies was to customize the construction, installation, and operation of the modified Ristroph screens and fish return system for the optimum survival of impinged fish at IPEC Unit 2 and Unit 3. Each fish return sluice system was tested to determine the best configuration of pipes and sluice flow to minimize the mortality of impinged fish during transfer from the modified Ristroph screens to the river.

After the installation of modified Ristroph modified traveling screens at Unit 3 in 1991 and at Unit 2 in 1992, testing of the installed full scale sluice system continued through 1993 to determine the best configuration to minimize the recirculation and re-impingement of surviving fish that were released back into the Hudson River. Following the completion of these studies, NYSDEC, and USEPA accepted the modified Ristroph screens and fish return system as Best Technology Available (i.e., "BTA") for minimizing impingement at IPEC units 2 and 3, and USEPA recently (20 April 2011) reaffirmed that decision in its proposed rule under Section 316(b) of the Clean Water Act (76 Fed. Reg. 22206).

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[1] The licensed feet of gillnet was not reported separately for different gillnet license types.

The Ristroph screens and fish return systems installed and operated at IPEC Units 2 and 3 since the early 1990s are generally consistent with NOAA's handling recommendations for sturgeon. NOAA's protocol (NMFS, 2010) for collecting and handling Atlantic, shortnose, gulf, and green sturgeons notes that sturgeon are hardy, so that sampling methods that are inappropriate for collecting and handling many fish species can be successfully used with sturgeon. NOAA (NMFS, 2010) recommends that handling after capture should be limited to 15 minutes, and that fish should be kept in water to the maximum extent possible during handling. The modified Ristroph screens at IPEC are continuously rotating traveling screens fitted with troughs that remain filled with water while they are rotating, so that impinged fish remain submerged in water until they are washed into a return sluice, that is also filled with water, and returned to the river. The modified Ristroph screens at IPEC were designed a modification to reduce turbulence in the fish buckets which substantially increases impingement survival.

Because they were impinged so infrequently, sturgeon were not among the species observed in the tests of impingement survival for the modified Ristroph screens at IPEC. However, impingement survival rates of other hardy species that were tested provide guidance on the impingement survival rate that can be expected for sturgeon. Fletcher (1990) documented impingement survival studies performed at one full scale Ristroph screen installed and operated at IPEC Unit 2 in 1986. Measured survival rates for white perch and striped bass were 86% and 91% respectively. Given the general hardiness of Atlantic and shortnose sturgeon and the general consistency of the Ristroph screen and fish return system with NOAA's 2010 protocols for safe sturgeon handling, survival of impinged live sturgeon at Indian Point should be at least within the range of survival observed there for white perch and striped bass.

VII. Discussion and Conclusions

Between 1976 and 1990, average annual impingement of Atlantic and shortnose sturgeon at IPEC was 49.7 and 3.8 per year respectively. All of the Atlantic sturgeon and most of the shortnose sturgeon would have been immature juvenile fish. Since 1990, two riverwide sampling programs, the LRS and the FSS, and other available information on sturgeon abundance in the Hudson River (Peterson et al. 2007, Bain et al. 2007) indicate that Atlantic sturgeon have declined in abundance and shortnose sturgeon have increased.

For Atlantic sturgeon the average abundance, as measured by the LRS, for the years 1991-2007 was 20% of the average abundance for the years 1974-1990. This is the same percentage reduction reported by Peterson et al. (2000) based on two mark-recapture studies, one from the late 1970s and the other from the mid-1990s. For shortnose sturgeon, the abundance reported in the published literature for the 1990s was 400% of the abundance from the 1970s (Bain et al. 2007). The average shortnose

sturgeon abundance, as measured by the LRS, for the years 1991-2007 was 237% of the average abundance for the years 1974-1990.

The consistency of the changes in sturgeon abundance as measured by the LRS with estimates from the published literature, and the significant correlation between the LRS and FSS indices of sturgeon abundance provide validation of these indices of abundance (Figure 13).

However, annual estimates of impingement density at IPEC are not significantly correlated with either the LRS or FSS indices of abundance during the period of concurrent data (1976-1990), for either Atlantic sturgeon (Figures 14 and 15) or shortnose sturgeon (Figures 17 and 18), which indicates that factors other than population abundance played a key role in determining patterns of sturgeon impingement at IPEC. If impingement data subsequent to 1990 were available, the large changes in riverwide abundances of Atlantic sturgeon (Figure 13) and shortnose sturgeon (Figure 16) that occurred around 1990 might have been reflected in impingement densities.

Results from published studies on the swimming ability of sturgeon indicate that healthy sturgeon larger than about 195 mmTL would have the ability to swim away from the intake screens. All shortnose sturgeon impinged at IPEC were larger than 195 mmTL (Figure 11), and 90% of Atlantic sturgeon impinged at IPEC were larger than 195 mmTL (Figure 5). This is evidence that many of the sturgeon impinged at IPEC arrived at the intake screens dead or moribund.

The historical gillnet fisheries on the Hudson River are a likely source of those dead and injured sturgeon. The commercial shad gillnet fishery operated between km 40 and km 70 (Figure 19), in the vicinity of IPEC (km 67) from late March though mid-May. The commercial herring gillnet fishery operated in the same general stretch of the river during the spring as well. Sturgeon caught in the commercial shad and herring gillnets had to be released - the Atlantic sturgeon because they were sublegal sizes, and the shortnose sturgeon because they were on the endangered species list. A substantial fraction of the discarded sturgeon likely were dead or injured. Published studies found up to 20% of sturgeon caught in gillnets were collected dead, and an additional 20% were released live but injured.

The size range of sturgeon that would have been susceptible to capture by the shad and herring gillnet fisheries is consistent with the length frequency distributions of impinged sturgeon. Post-yearling sturgeon (e.g., greater than 400 mm) would have been susceptible to the shad gillnet fishery with 5 ½" mesh nets, and sub-yearling sturgeon (e.g., 200mm to 400mm) would have been susceptible to the herring fishery with 1 ½" to 3 ½" nets. Furthermore, the seasonal pattern of sturgeon impingement at IPEC, with highest impingement in April (Figures 2 and 8) is consistent with the fact that the shad and herring gillnet fisheries targeted adult fish during their spring spawning runs.

The significant correlation between impingement densities of Atlantic sturgeon and estimates of Atlantic sturgeon bycatch in the commercial shad gillnet fishery (Figure 20) is additional evidence that discards of Atlantic sturgeon from the commercial shad gillnet fishery may have contributed to Atlantic sturgeon impingement at IPEC. Although ASMFC data on shortnose sturgeon bycatch in the shad gillnet fishery were not available, it is likely that the shad gillnet fishery contributed to shortnose impingement at IPEC as well, which also peaked in April. Although data are not available on bycatch of sturgeon in the regular gillnet fishery that operated from March through November, it is likely sturgeon were also caught and discarded by that fishery.

Since the installation of modified Ristroph traveling screens and fish return systems at IPEC in the early 1990s, any sturgeon impinged on the intake screens at IPEC have been returned to the Hudson River. As discussed in Barnthouse et al. (2011), given the high efficacy of modified Ristroph screens at reducing impingement mortality, and given the robust nature of sturgeon, it is likely the vast majority of healthy impinged sturgeon were returned to the river unharmed.

With the decline in recruitment of Atlantic sturgeon, and closure of the commercial shad gillnet fishery in March 2010, impingement densities of Atlantic sturgeon at IPEC currently, and for the forseeable future, are likely less than they were prior to 1990. For shortnose sturgeon, densities in the river have increased substantially, which could counteract the effect of the shad fishery closure. Despite the lack of correlation observed between abundance and impingement densities prior to 1990, it is likely that the higher densities of shortnose sturgeon today would produce higher impingement than the historical values. However, due to the Ristroph screens and fish return systems, the actual loss of healthy fish from the population will continue to be insignificant

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Figure 1. Among-year pattern of Atlantic sturgeon impingement density at IPEC. Annual density is the average of monthly estimates of impingement density based on number impinged and the average monthly flow rate (million gpm).

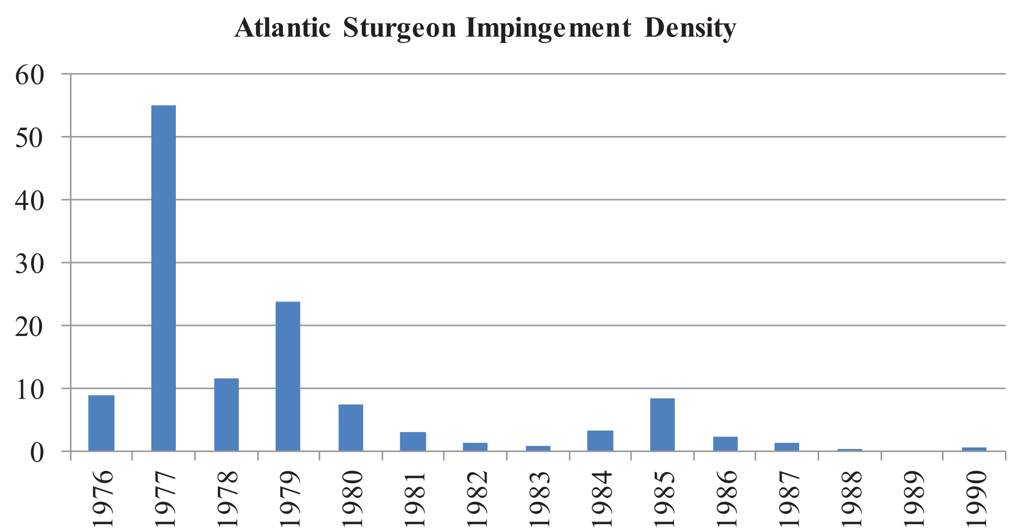

Figure 2. Among-month pattern of average Atlantic sturgeon impingement at IPEC, and average IPEC flows (cooling water plus service water) for the years 1976-1990.

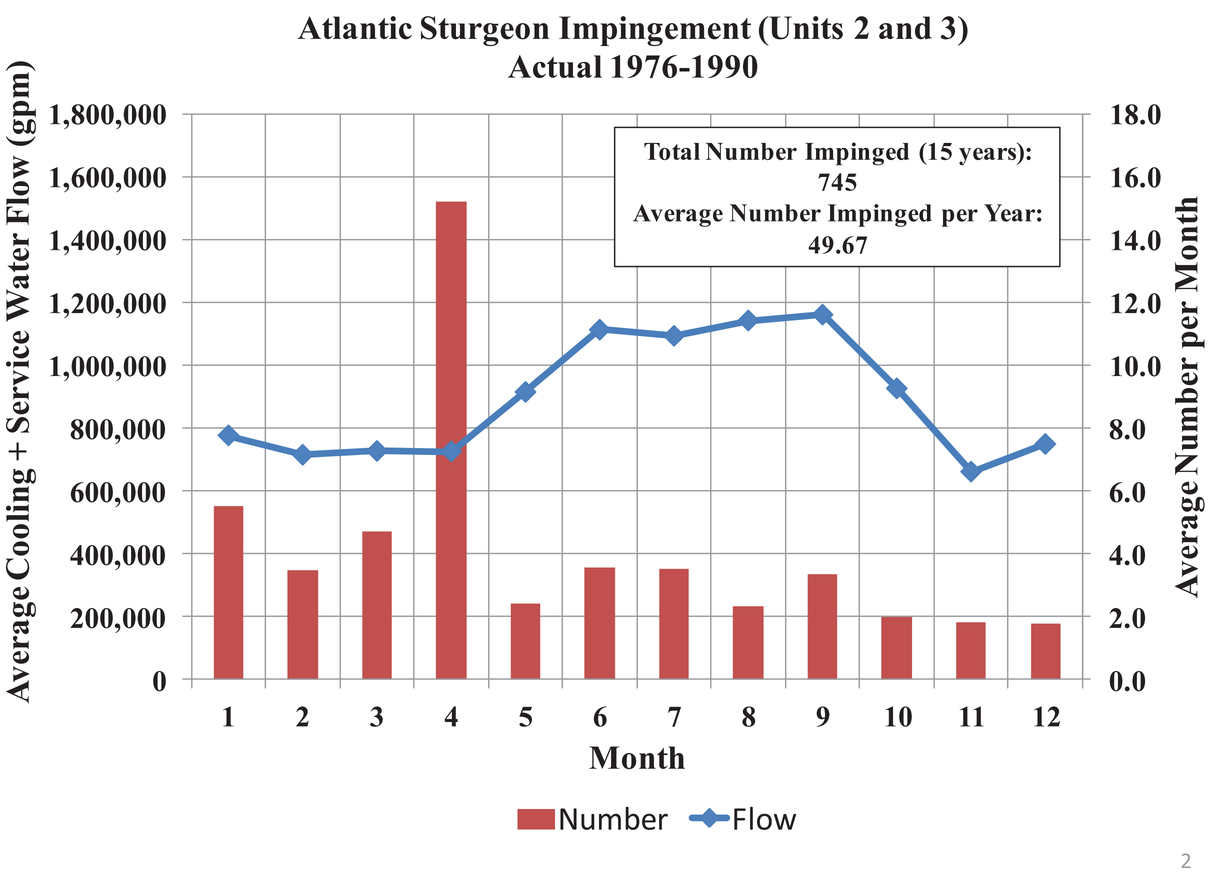

Figure 3. Among-month pattern of projected average Atlantic sturgeon impingement at IPEC, and average IPEC flows (cooling water plus service water) for the years 2001-2008.

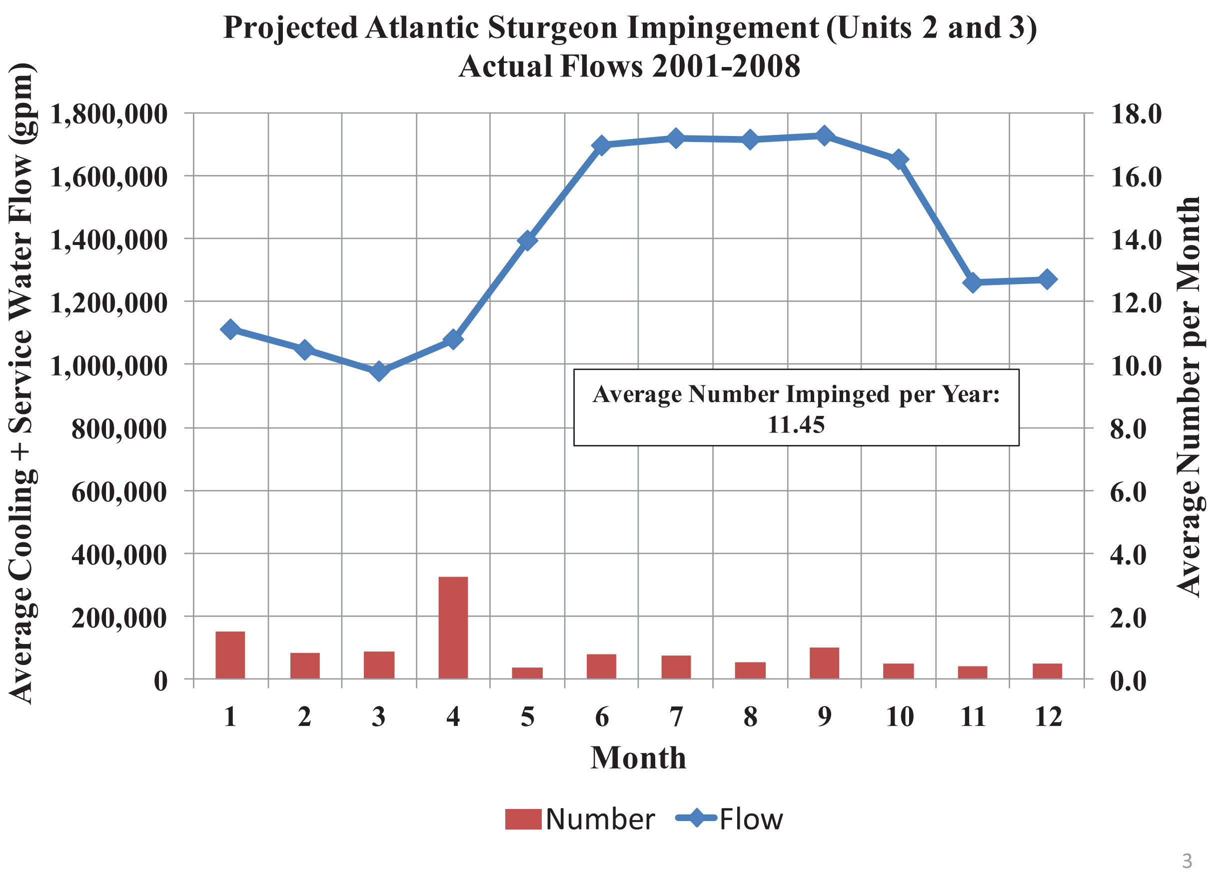

Figure 4. Atlantic sturgeon length-weight relationship based on length (mmTL) and weight measurements (green dots) recorded on 36 Atlantic sturgeon collected during IPEC impingement sampling from 1985-1990.

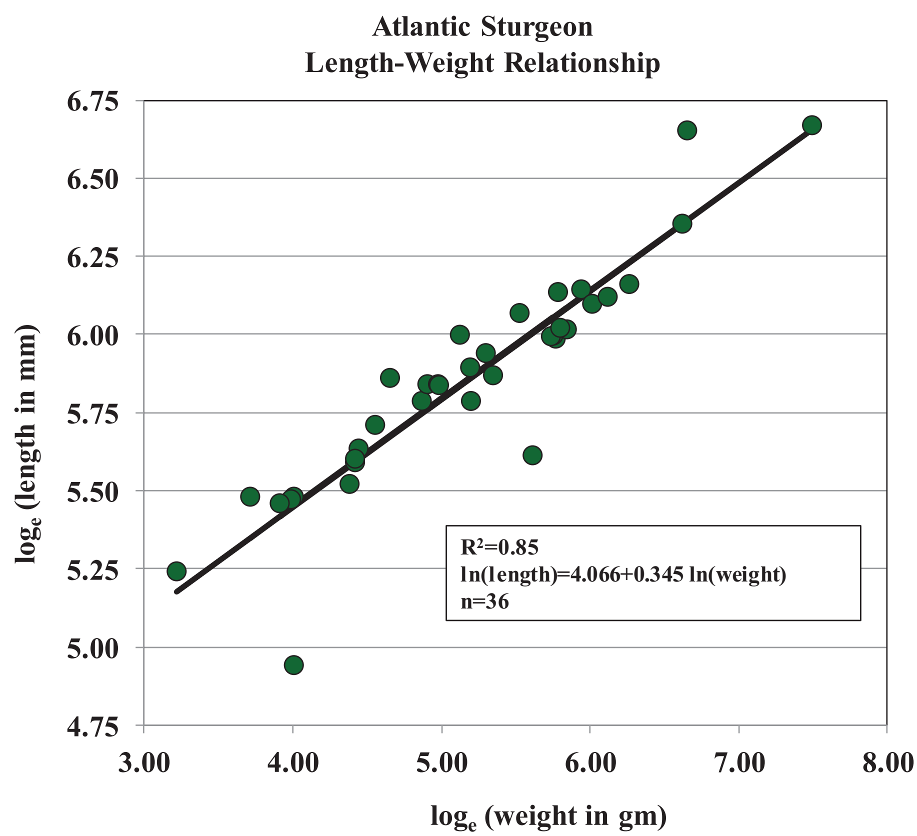

Figure 5. Estimated length (mmTL) frequency distribution of impinged Atlantic sturgeon collected at Unit 2 and Unit 3 at IPEC during the years 1974-1990.

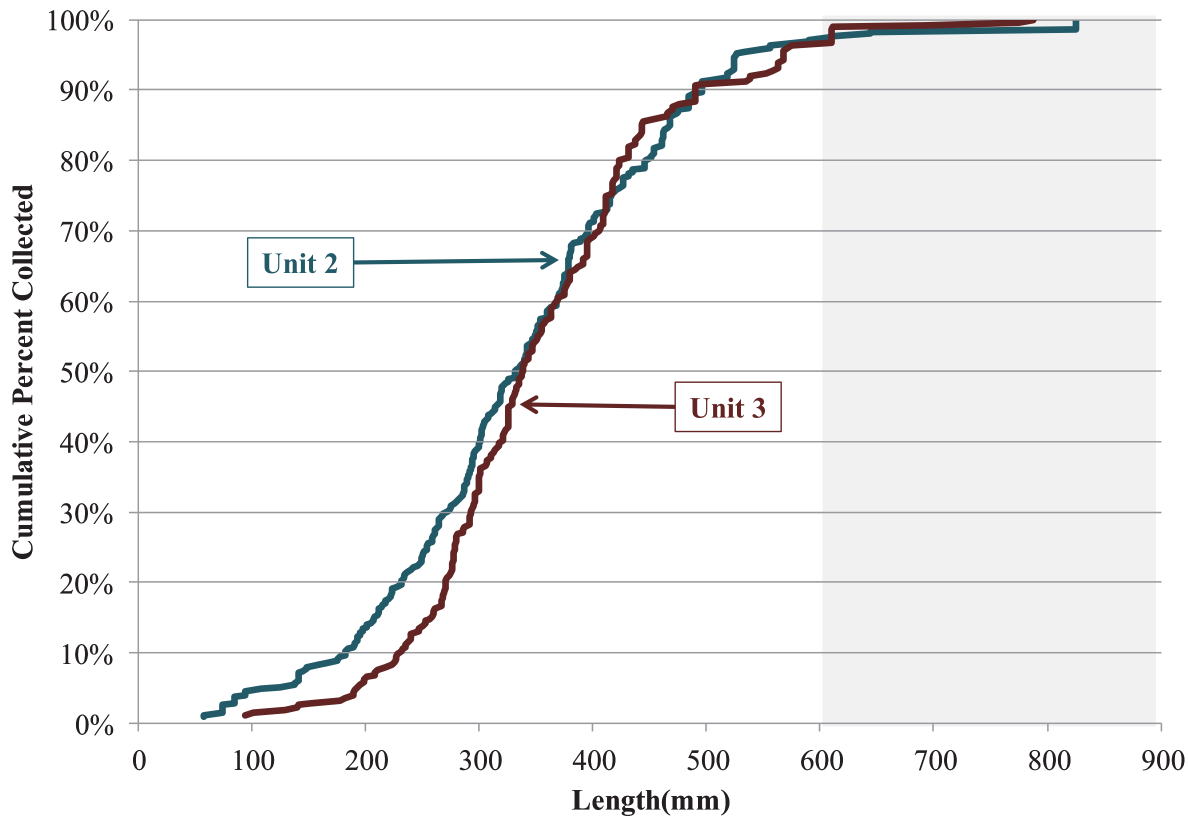

Figure 6. Cumulative number of Atlantic sturgeon impinged as a function of estimated length (mmTL). Based on impingement at IPEC for the years 1974-1990.

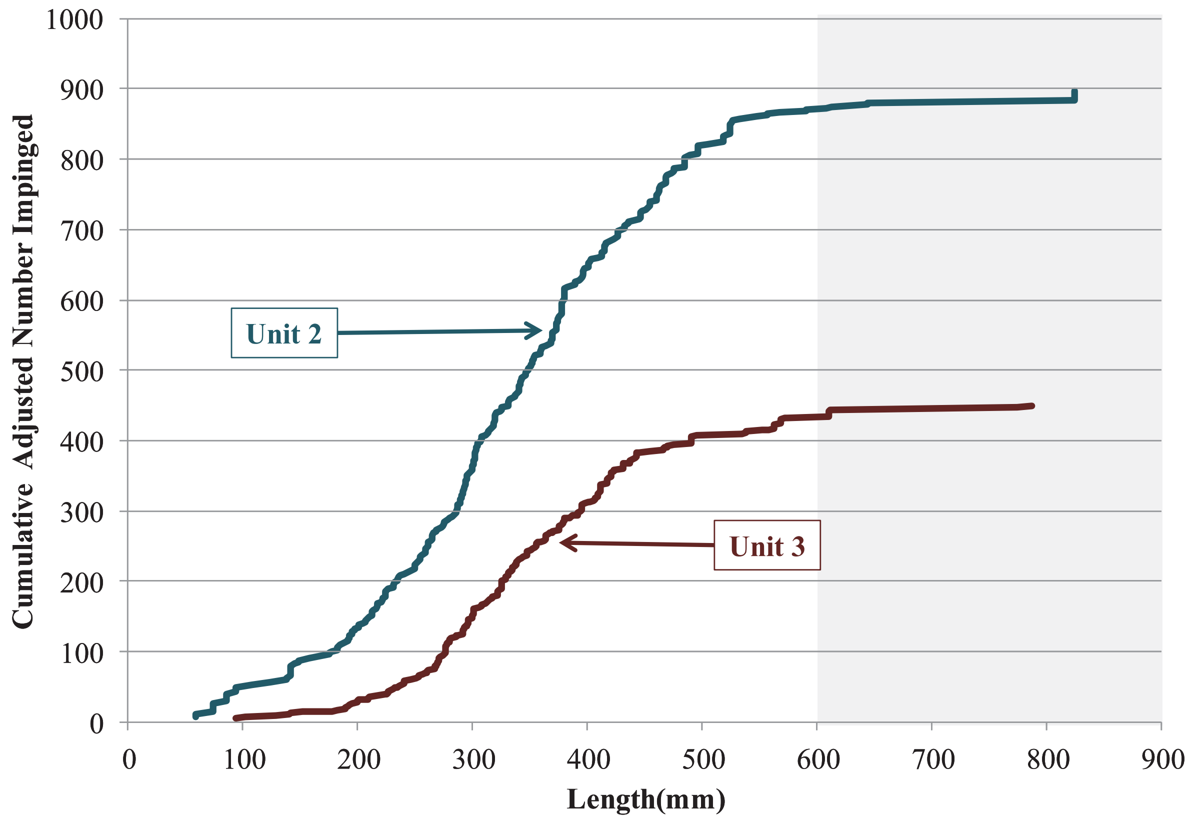

Figure 7. Among-year pattern of shortnose sturgeon impingement density at IPEC. Annual density is the average of monthly estimates of impingement density based on number impinged and the average monthly flow rate (million gpm).

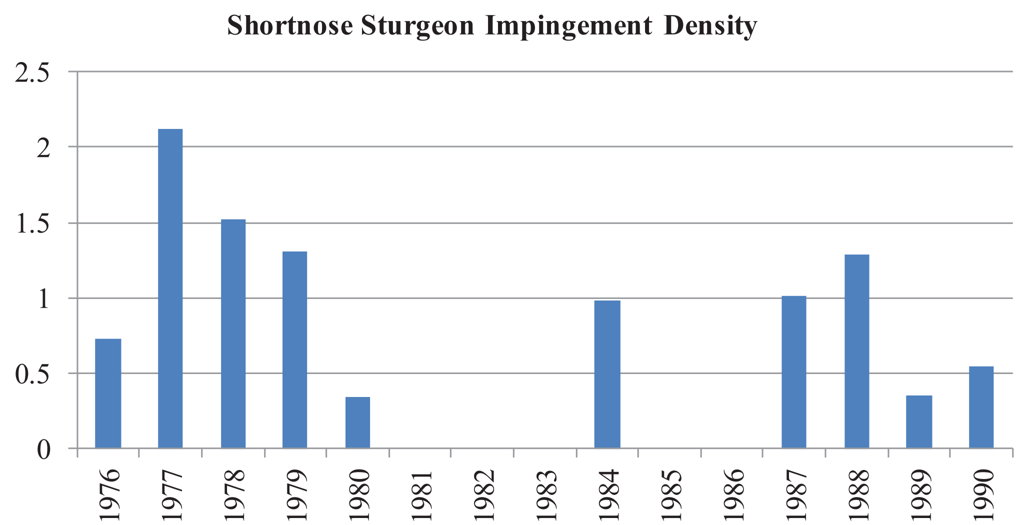

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Figure 8. Among-month pattern of average shortnose sturgeon impingement at IPEC, and average IPEC flows (cooling water plus service water) for the years 1976-1990.

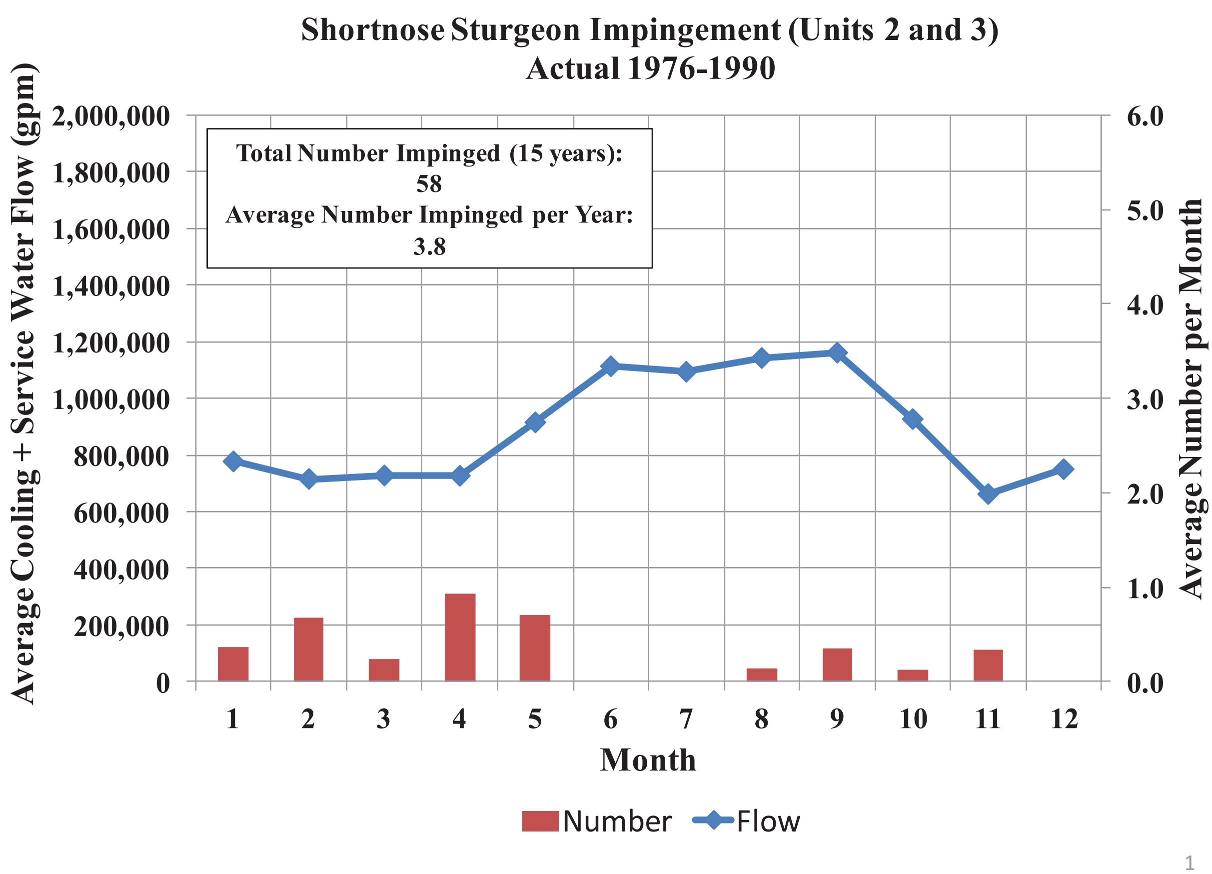


Figure 9. Among-month pattern of projected average shortnose sturgeon impingement at IPEC, and average IPEC flows (cooling water plus service water) for the years 2001-2008.

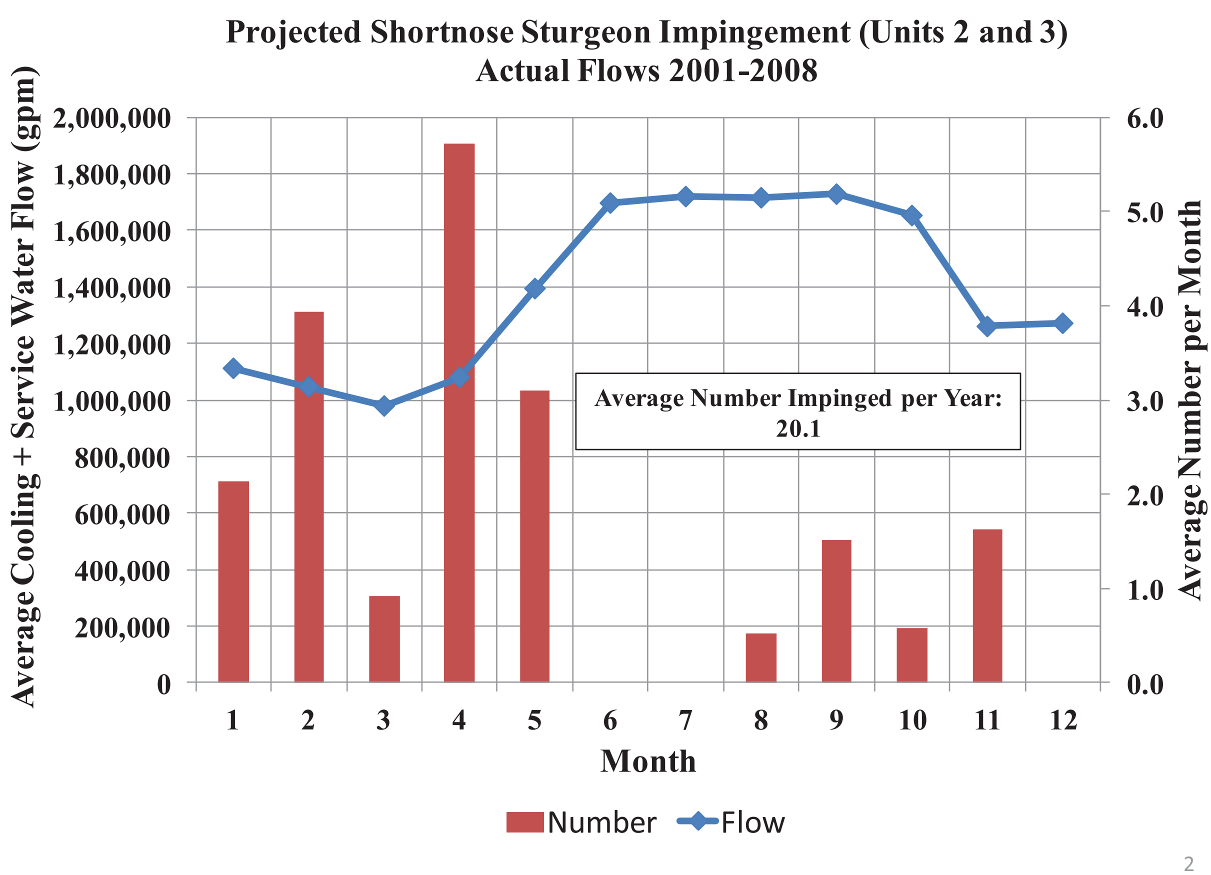


Figure 10. Shortnose sturgeon length-weight relationship based on length (mmTL) and weight measurements (green dots) recorded on 48 shortnose sturgeon collected during FSS and striped bass mark-recapture sampling from July to December 2011.

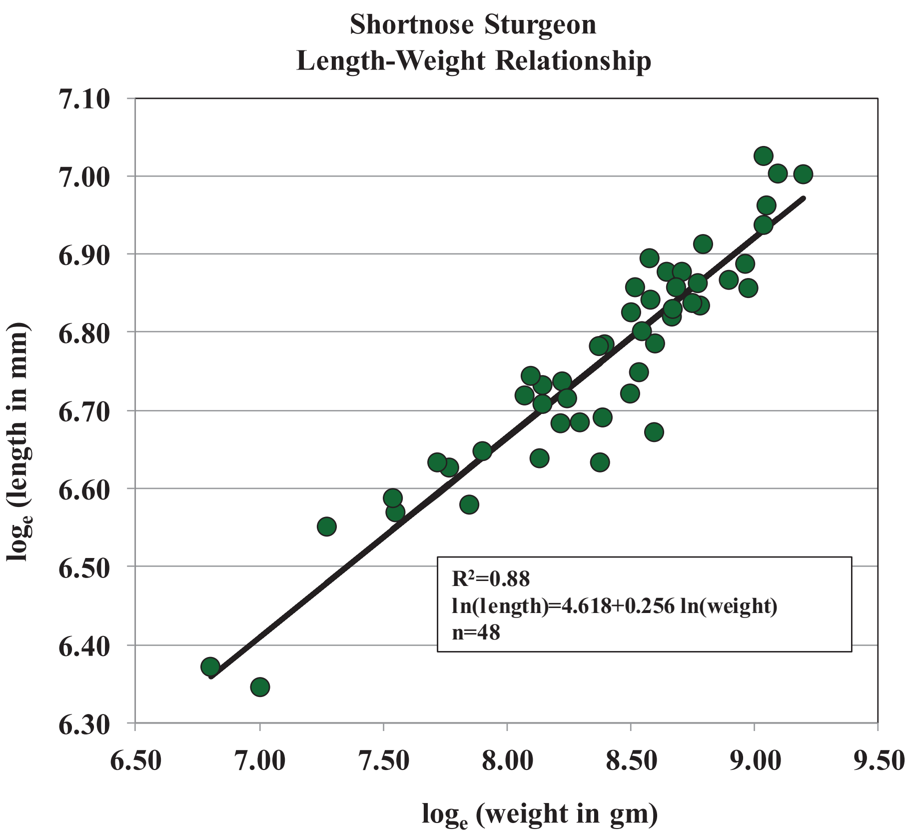


Figure 11. Estimated length (mmTL) frequency distribution of impinged shortnose sturgeon collected at Unit 2 and Unit 3 at IPEC during the years 1974-1990.

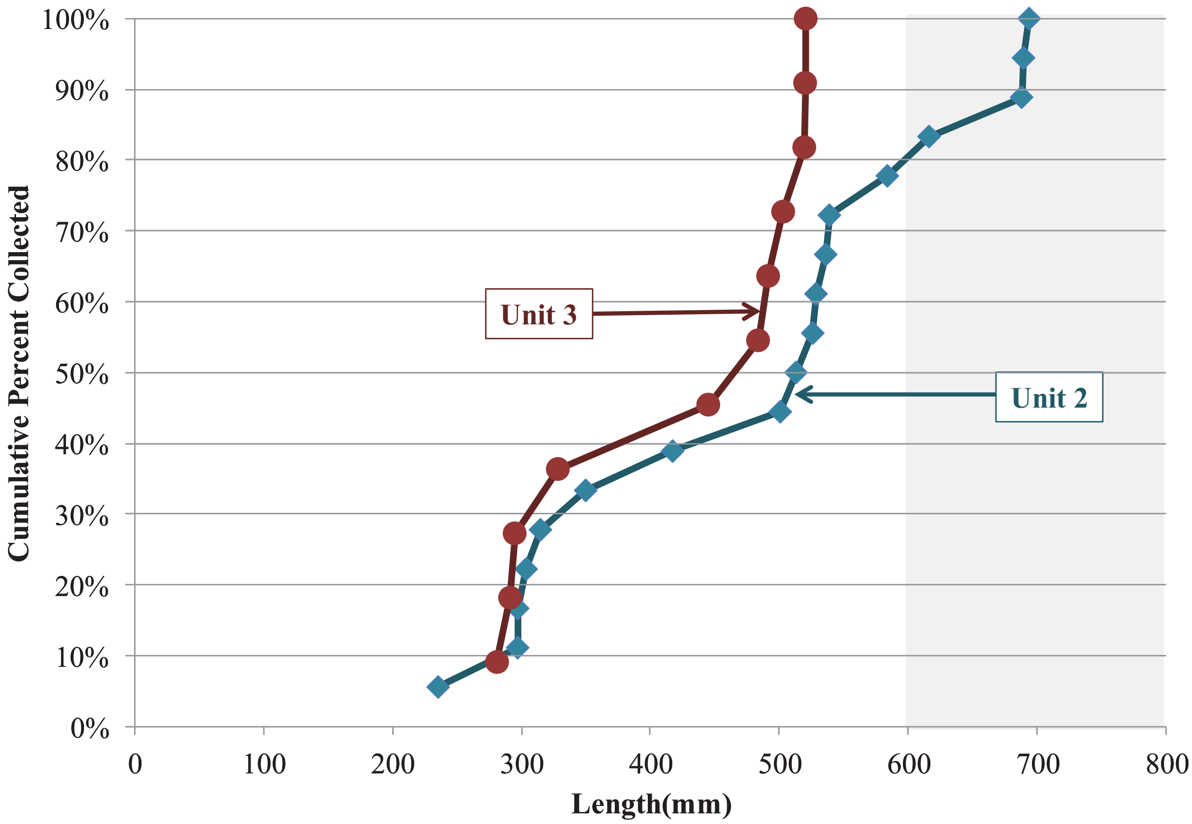


Figure 12. Cumulative number of shortnose sturgeon impinged as a function of estimated length (mmTL). Based on impingement at IPEC for the years 1974-1990.

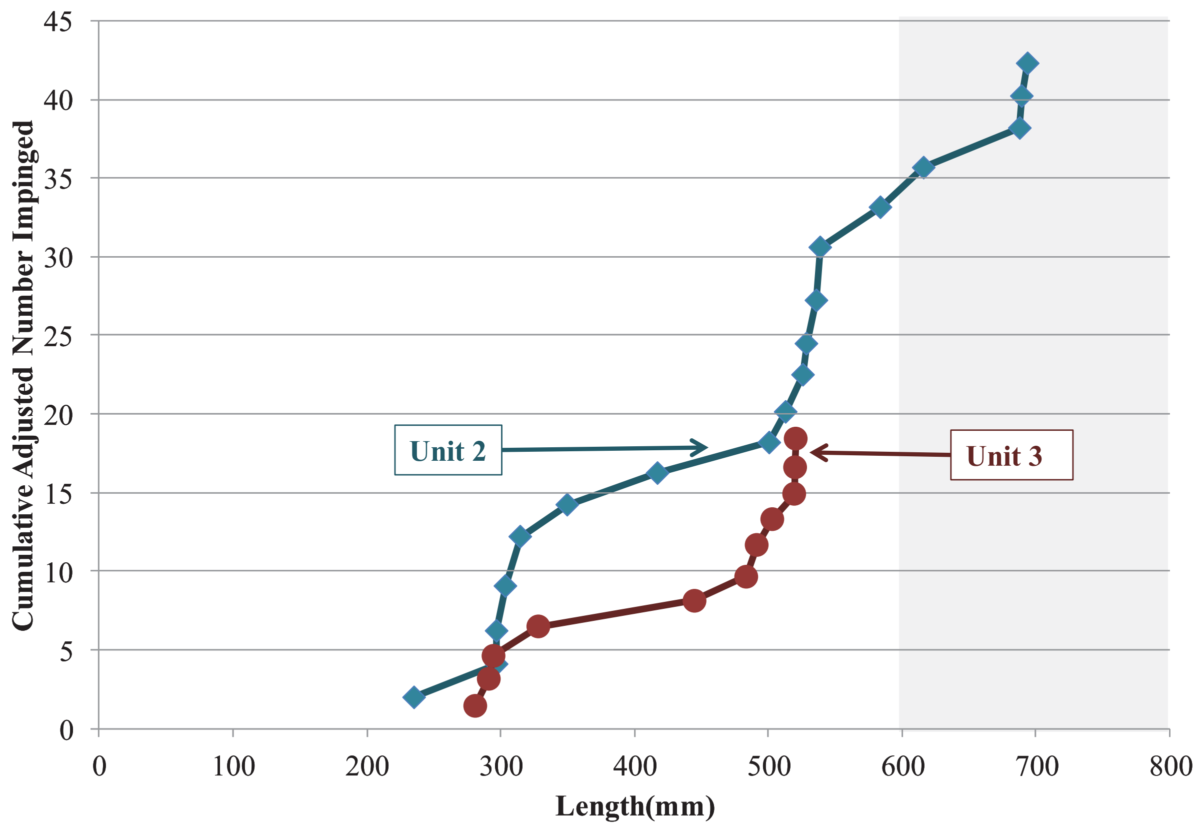


Figure 13. Annual estimates of Atlantic sturgeon abundance based on standing crop estimates from the LRS and FSS sampling programs and published population abundance estimates from mark-recapture studies.

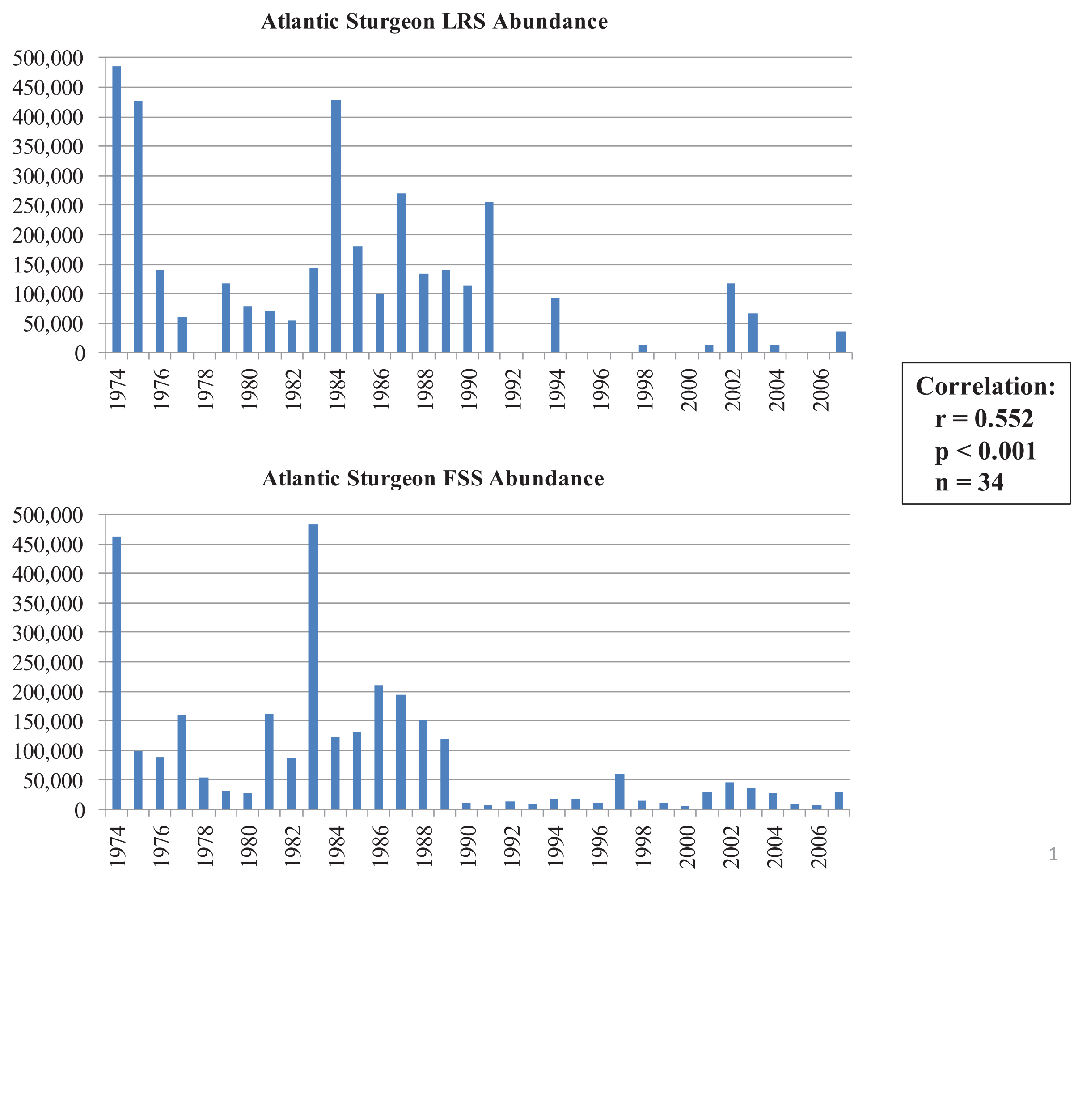
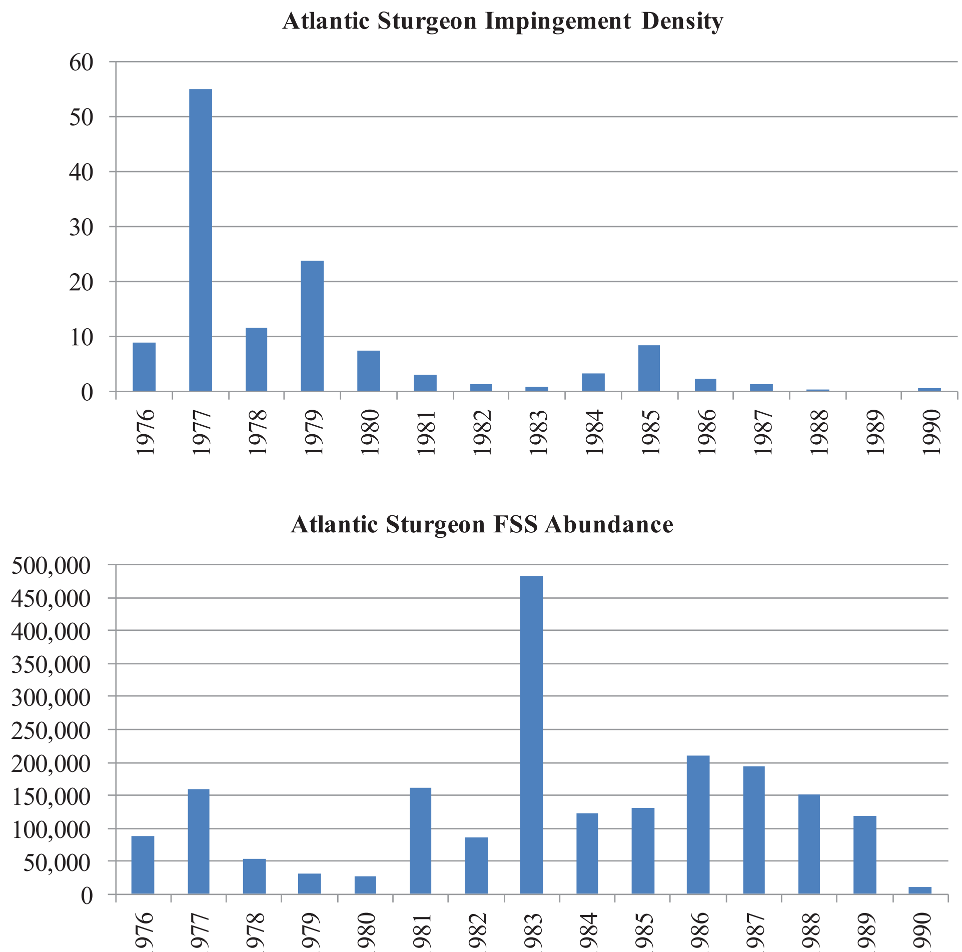


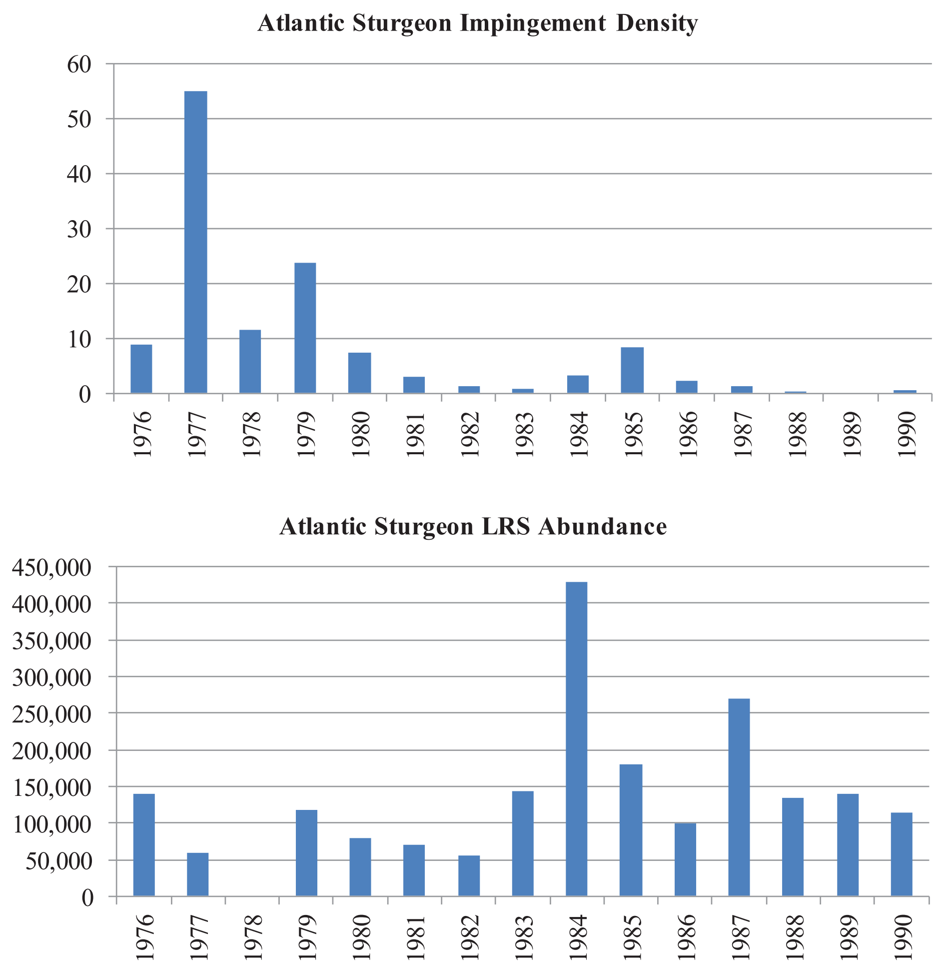
Figure 14. Correlation between annual estimates of Atlantic sturgeon impingement densities at IPEC and estimates of Atlantic sturgeon riverwide abundance from the FSS, 1976-1990.



Correlation:
r = -0.129
p = 0.647
n = 15

4

Figure 15. Correlation between annual estimates of Atlantic sturgeon impingement densities at IPEC and estimates of Atlantic sturgeon riverwide abundance from the LRS, 1976-1990.



Correlation:
r = -0.264
p = 0.341
n = 15

2

Figure 16. Annual estimates of shortnose sturgeon abundance based on standing crop estimates from the LRS and FSS sampling programs and published population abundance estimates from mark-recapture studies.

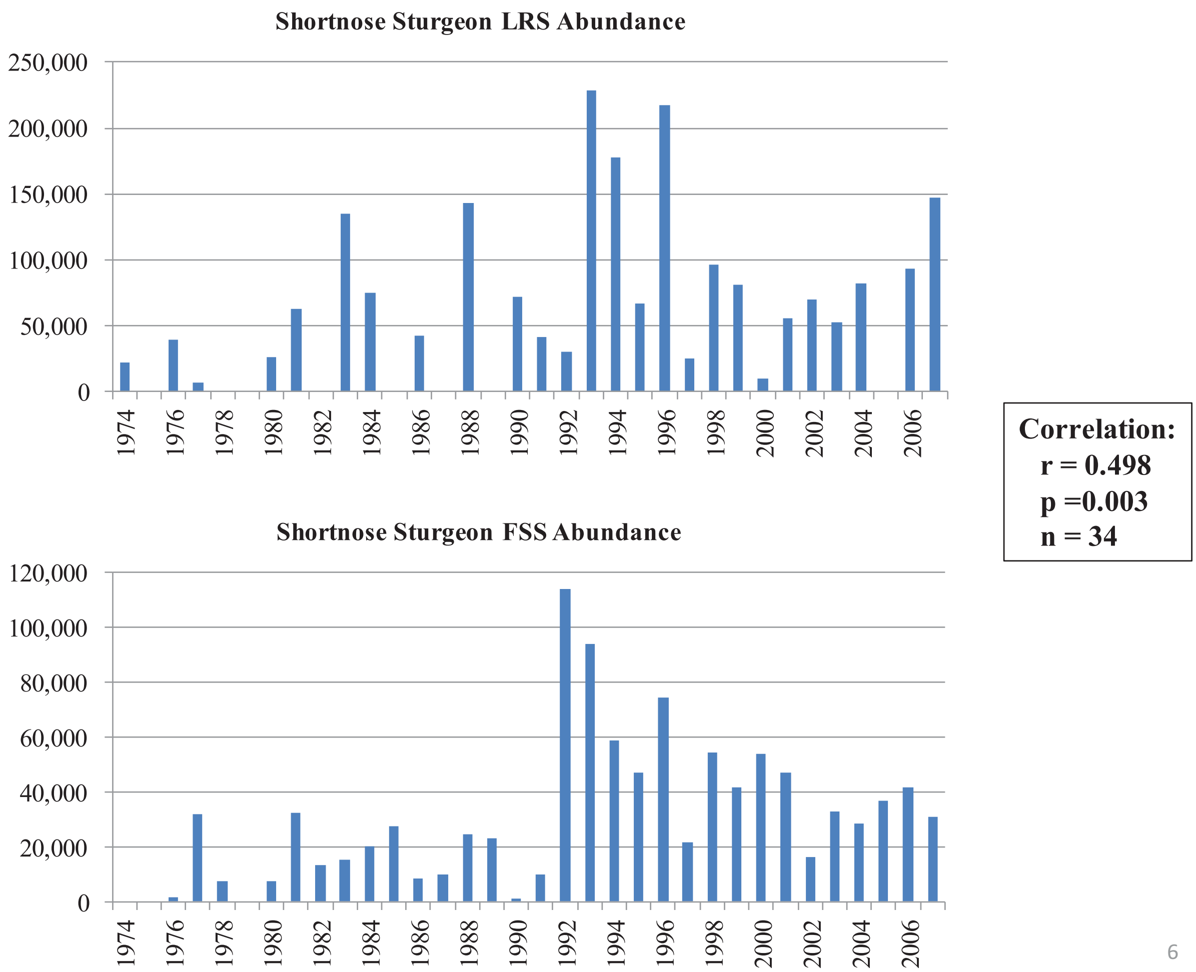


Figure 17. Correlation between annual estimates of shortnose sturgeon impingement densities at IPEC and estimates of shortnose sturgeon riverwide abundance from the FSS, 1976-1990.

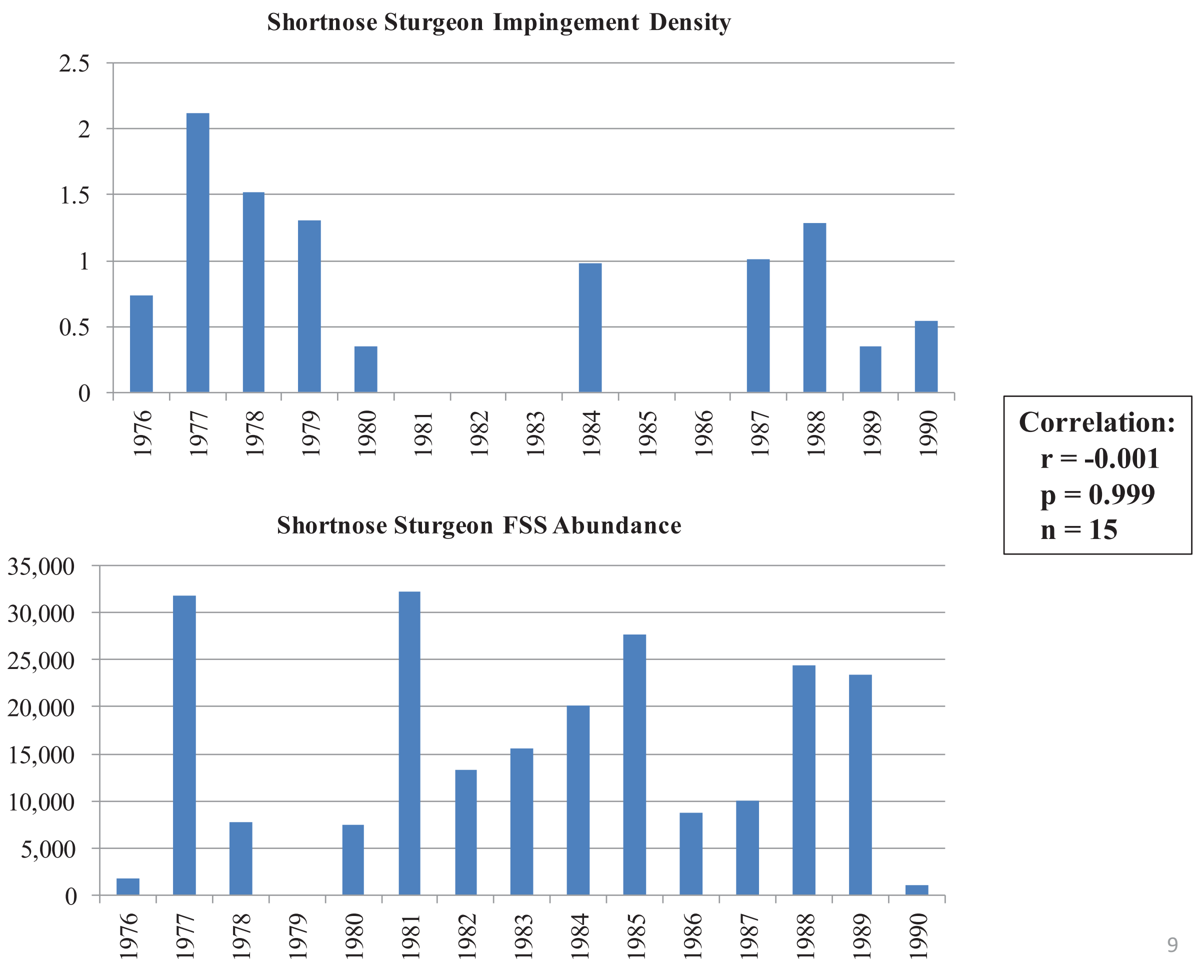


Figure 18. Correlation between annual estimates of shortnose sturgeon impingement densities at IPEC and estimates of shortnose sturgeon riverwide abundance from the LRS, 1976-1990.

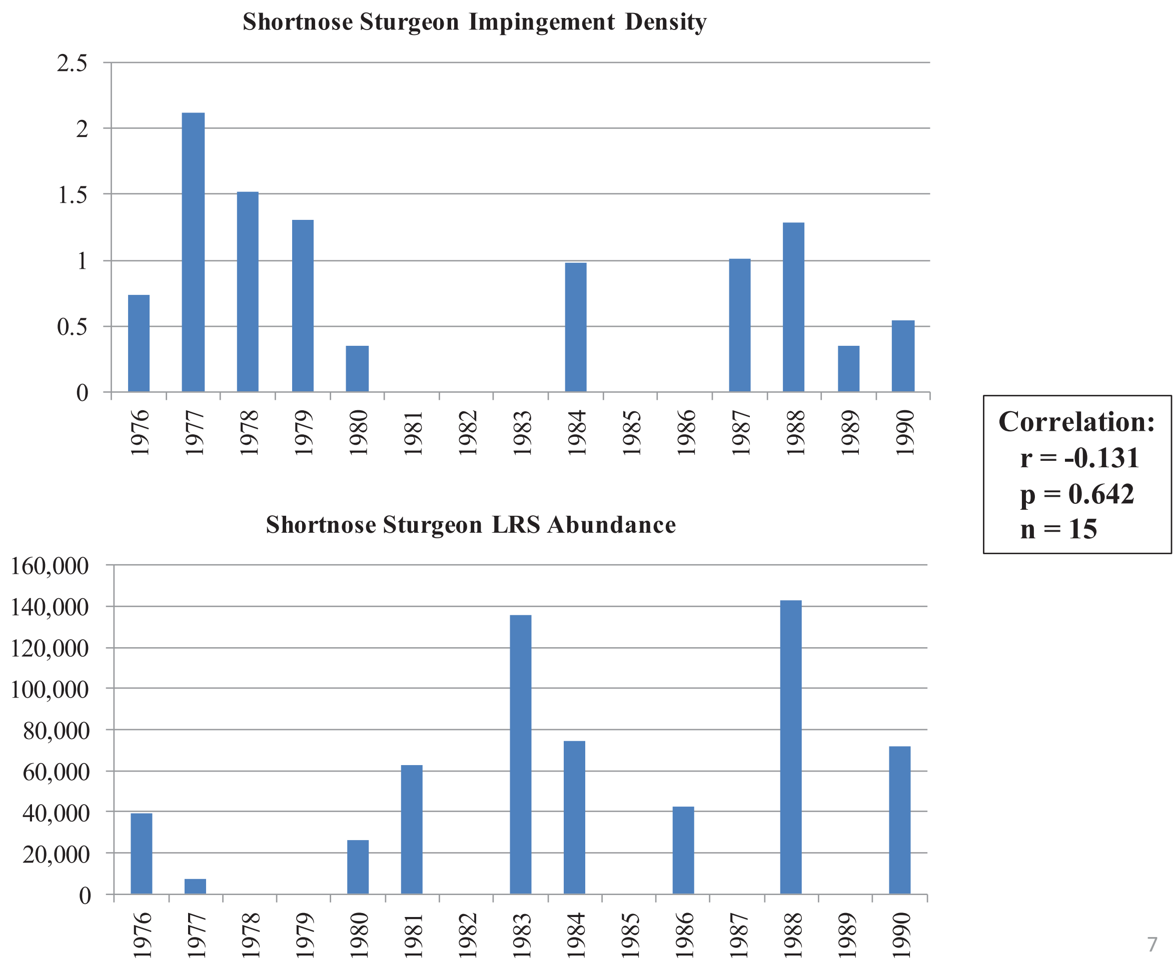


Figure 19. Locations of Hudson River commercial shad gillnet fishery (from ASMFC 2007).

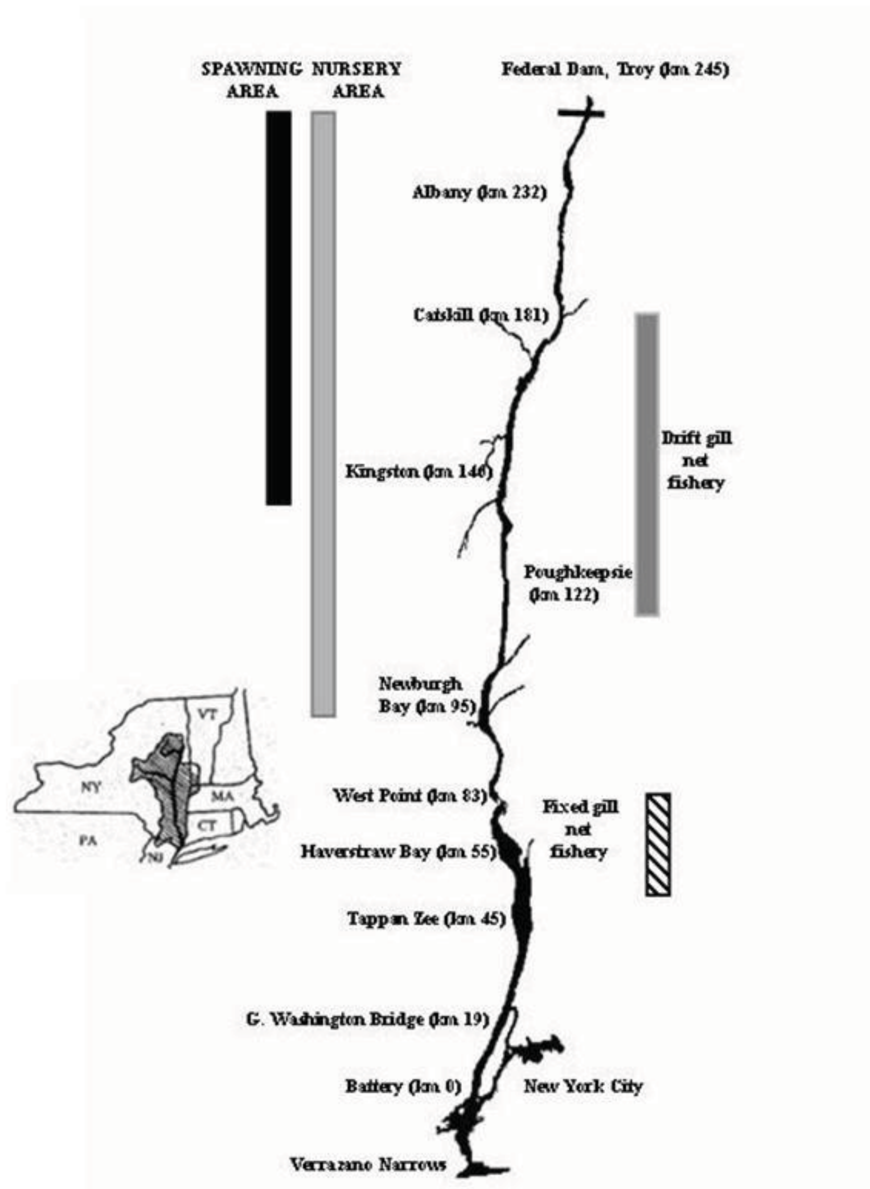


Figure 20. Hudson River estuary with major spawning tributaries for river herring (from NYSDEC 2011).

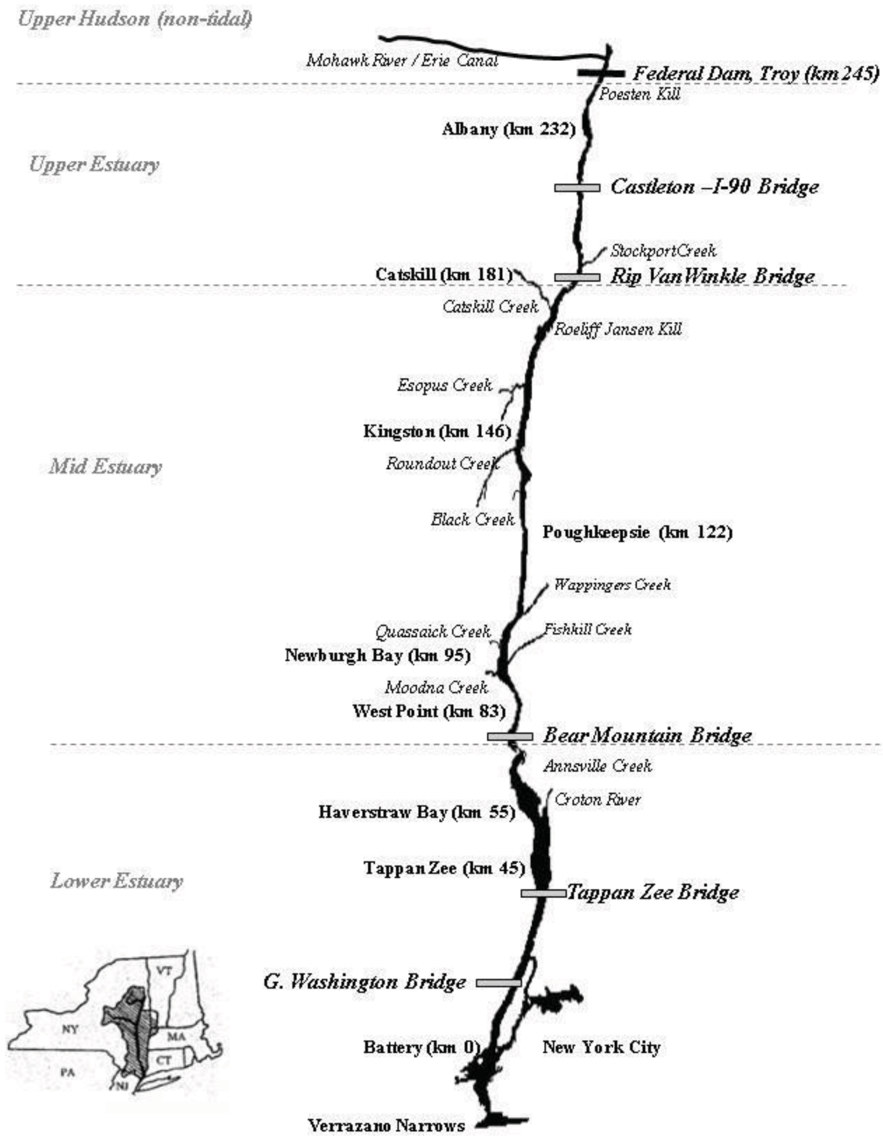


Figure 21. Correlation between annual estimates of Atlantic sturgeon impingement densities at IPEC and estimates of Atlantic sturgeon bycatch in the Hudson River commercial shad gillnet fishery, 1980-1990.