IPRenewal NPEmails

From: Logan, Dennis
Sent: Friday, October 26, 2012 2:51 PM
To: Gray, Dara F
Cc: IPRenewal NPEmails; Wong, Melanie; Wentzel, Michael; Turk, Sherwin
Subject: FW: Draft Indian Point Biological Opinion
Attachments: IP draft Opinion 10_26_12 to NRC.pdf

Dara,

Here is the complete draft biological opinion for IP2 and IP3 from NMFS. We look forward to receiving your comments.

Dennis

From: Julie Crocker [mailto:julie.crocker@noaa.gov]
Sent: Friday, October 26, 2012 2:21 PM
To: Logan, Dennis; Balsam, Briana; EndangeredSpecies Resource
Cc: Julie Williams
Subject: Re: Draft Indian Point Biological Opinion

Dennis -

Attached is the complete draft of our Biological Opinion. Please note that there are several questions for NRC and/or Entergy embedded as "comment bubbles" in the document.

Some of the literature cited are still missing - but I didn't want to hold up getting this to you in order to finish that. I will email you a complete literature cited on Monday.

Julie

On Thu, Oct 25, 2012 at 10:53 AM, Julie Crocker <julie.crocker@noaa.gov> wrote:
Dennis and Briana -

Please find attached the first half of our draft Biological Opinion for the effects of the continued operation of IP2 and IP3 on shortnose and Atlantic sturgeon. We are incorporating some revisions to the remainder of the Opinion and will get that to you as soon as possible but in the interest of your time, we wanted to provide you something so you could begin your review today. It is our understanding that you intend to share the draft with the applicant, Entergy. Please let us know if and when you do.

The agreed upon "due date" for the final Biological Opinion is November 28. In order to meet that deadline we are requesting that we receive comments back from you (and Entergy) by close of business Friday November 9. During that following week, we will review your comments and will be able to determine if additional time is necessary to respond to the comments. Of course, if you or Entergy need more time to complete your review, please let us know and we can discuss extending the "due date" past November 28. If you would like to schedule a time to discuss comments, please let me know. I will be in the office every day over the next 2 weeks.

Thank you,

Julie

--
Julie Crocker
Protected Resources Division
Northeast Regional Office
National Marine Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

--
Julie Crocker
Protected Resources Division
Northeast Regional Office
National Marine Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

Hearing Identifier: IndianPointUnits2and3NonPublic_EX
Email Number: 3891

Mail Envelope Properties (A56E37EC1CBC8045910287CEF5E7AE6C011FBA4B4DCF)

Subject: FW: Draft Indian Point Biological Opinion
Sent Date: 10/26/2012 2:51:07 PM
Received Date: 10/26/2012 2:51:14 PM
From: Logan, Dennis

Created By: Dennis.Logan@nrc.gov

Recipients:
"IPRenewal NPEmails" <IPRenewal.NPEmails@nrc.gov>
Tracking Status: None
"Wong, Melanie" <Melanie.Wong@nrc.gov>
Tracking Status: None
"Wentzel, Michael" <Michael.Wentzel@nrc.gov>
Tracking Status: None
"Turk, Sherwin" <Sherwin.Turk@nrc.gov>
Tracking Status: None
"Gray, Dara F" <DGray@entergy.com>
Tracking Status: None

Post Office: HQCLSTR01.nrc.gov

Files	**Size**	**Date & Time**
MESSAGE	2530	10/26/2012 2:51:14 PM
IP draft Opinion 10_26_12 to NRC.pdf	1973656	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

ENDANGERED SPECIES ACT SECTION 7 CONSULTATION
DRAFT
BIOLOGICAL OPINION

Agency: Nuclear Regulatory Commission

Activity: **Continued Operations of the Indian Point Nuclear Generating Station F/NER/2012/02252**

Conducted by: NOAA's National Marine Fisheries Service
Northeast Regional Office

Date Issued: ________DRAFT____________________

Approved by: _________DRAFT_________________

Table of Contents

1.0 INTRODUCTION 3
2.0 BACKGROUND AND CONSULTATION HISTORY 3
2.1 Endangered Species Act Consultation 4
3.0 DESCRIPTION OF THE PROPOSED ACTION 6
3.1 NPDES/SPDES Permits 8
3.2 401 Water Quality Certificate 11
3.3 Description of Water Withdrawals 12
3.4 Action Area 14
4.0 STATUS OF THE SPECIES 14
4.1 Shortnose Sturgeon 15
4.2 Atlantic Sturgeon 22
4.2 Gulf of Maine DPS of Atlantic sturgeon 29
4.3 New York Bight DPS of Atlantic sturgeon 33
4.4 Chesapeake Bay DPS of Atlantic sturgeon 35
4.5 Shortnose Sturgeon in the Hudson River and the action area 37
4.6 Atlantic sturgeon in the Hudson River and the action area 40
4.7 Factors Affecting the Survival and Recovery of Shortnose and Atlantic sturgeon in the Hudson River 42
5.0 ENVIRONMENTAL BASELINE 47

6.0 CLIMATE CHANGE 49
6.1 Background Information on predicted climate change 49
6.2 Species Specific Information Related to Predicted Impacts of Climate Change 51
6.3 Potential Effects of Climate Change in the Action Area 53
6.4 Effects of Climate Change in the Action Area to Atlantic and shortnose sturgeon 54
7.0 EFFECTS OF THE ACTION **56**
7.1 Effects of Water Withdrawal 56
7.1.1 Entrainment 57
7.1.2 Impingement 60
7.1.3 Effects of Impingement and Entrainment on Shortnose and Atlantic sturgeon prey……. 89
7.1.4 Summary of Effects of Water Withdrawal 89
7.2 Effects of Discharges to the Hudson River 89
7.2.1 Heated Effluent 90
7.2.2 Potential Discharge of Radionuclides to the Hudson River 100
7.3 Non-Routine and Accidental Events 105
7.4 Effects of Operation in light of Anticipated Future Climate Change 106
8.0 CUMULATIVE EFFECTS 106
9.0 INTEGRATION AND SYNTHESIS OF EFFECTS **107**
9.1 Shortnose Sturgeon 108
9.2 Atlantic sturgeon 113
9.2.1 New York Bight DPS of Atlantic sturgeon 113
11.0 CONCLUSION **117**
12.0 INCIDENTAL TAKE STATEMENT **118**
12.1 Amount or Extent of Take 118
12.2 Reasonable and Prudent Measures 120
12.3 Terms and Conditions 121
13.0 CONSERVATION RECOMMENDATIONS **125**
14.0 REINITIATION OF CONSULTATION **125**
15.0 LITERATURE CITED **127**
APPENDIX I 136
APPENDIX II 139
APPENDIX III 141
APPENDIX IV 143
APPENDIX V 144

1.0 INTRODUCTION

This constitutes NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Opinion) issued in accordance with section 7 of the Endangered Species Act of 1973, as amended, on the effects of the continued operation of the Indian Point Nuclear Generating Station (Indian Point) pursuant to an existing operating license issued by the Nuclear Regulatory Commission (NRC) in accordance with the Atomic Energy Act of 1954 as amended (68 Stat. 919) and Title II of the Energy Reorganization Act of 1974 (88 Stat. 1242) as well as proposed extended operating licenses.

This Opinion is based on information provided in a Biological Assessment (BA) dated December 2010, the *Final Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38 Regarding Indian Point Nuclear Generating Unit 2 and 3* dated December 2010, a draft Supplement to that EIS dated June 2012, information submitted to us by the NRC via letter dated May 16, 2012, permits issued by the State of New York, information submitted to NMFS by Entergy and other sources of information. We will keep a complete administrative record of this consultation at the NMFS Northeast Regional Office, Gloucester, Massachusetts.

2.0 BACKGROUND AND CONSULTATION HISTORY

Indian Point Nuclear Generating Units 2 and 3 (IP2 and IP3) are located on approximately 239 acres (97 hectares (ha)) of land in the Village of Buchanan in upper Westchester County, New York (project location is illustrated in Appendix I, Figures 1 and 2). The facility is on the eastern bank of the Hudson River at river mile (RM) 43 (river kilometer (RKM) 69) about 2.5 miles (mi) (4.0 kilometers (km)) southwest of Peekskill, the closest city, and about 43 mi (69 km) north of the southern tip of Manhattan. Both IP2 and IP3 use Westinghouse pressurized-water reactors and nuclear steam supply systems (NSSSs). Primary and secondary plant cooling is provided by a once-through cooling water intake system that supplies cooling water from the Hudson River. Indian Point Nuclear Generating Station Unit 1 (IP1, now permanently shut down[1]) shares the site with IP2 and IP3. IP1 is located between IP2 and IP3. In 1963, IP1 began operations. IP1 was shut down on October 31, 1974, and is in a safe storage condition (SAFSTOR) awaiting final decommissioning. Construction began on IP2 in 1966 and on IP3 in 1969.

The Atomic Energy Commission (AEC), the predecessor to the NRC, initially licensed IP2 on September 28, 1973. The AEC issued a 40-year license for IP2 that will expire on September 29, 2013. IP2 was originally licensed to the Consolidated Edison Company, which sold that facility to Entergy in September 2001. IP3 was initially licensed on December 12, 1975, for a 40-year period that will expire in December 2015. While the Consolidated Edison Company of New York originally owned and operated IP3, it was later conveyed to the Power Authority of the State of New York (PASNY – the predecessor to the New York Power Authority [NYPA]). PASNY/NYPA operated IP3 until November 2000 when it was sold to Entergy.

[1] The intake for IP1 is used for service water for IP2; however, IP1 no longer is used for generating electricity and no cooling water is withdrawn from the IP1 intake. This use is discussed fully below.

2.1 Endangered Species Act Consultation

The Endangered Species Act was enacted in 1973. However, there was no requirement in the 1973 Act for the Secretary to produce a written statement setting forth his biological opinion on the effects of the action and whether the action will jeopardize the continued existence of listed species and/or destroy or adversely modify critical habitat. It was not until Congress amended the Act in 1978 that the Secretary was required to produce a Biological Opinion. The 1973 Act, including as amended in 1978, prohibited the "take" of endangered species. NMFS could issue a Section 10 incidental take permit to those who applied for incidental take authorization. In 1982, Congress amended the Act to provide for an "Incidental Take Statement" (ITS) in a Biological Opinion that specifies the level of incidental "take," identifies measures to minimize the level of incidental "take," and exempts any incidental "take" that occurs in compliance with those measures. Until we issued a Biological Opinion with ITS for shortnose sturgeon in 2011, we had not exempted any incidental take at IP1, IP2 and IP3 from the Section 9 prohibitions against take, either through a Section 10 permit or an ITS. The ITS issued with the 2011 Opinion was only prospective, that is, it covered the period from September 28, 2013-September 28, 2033 (IP1 & 2) and December 12, 2015-December 12, 2035 (IP3)..

As explained below, beginning in 1977, EPA held a series of hearings (Adjudicatory Hearing Docket No. C/II-WP-77-01) regarding the once through cooling systems at Indian Point, Roseton, Danskammer and Bowline Point, all of which are power facilities located along the Hudson River. During the course of these hearings, Dr. Mike Dadswell testified on the effects of the Indian Point facility on shortnose sturgeon. In a filing dated May 14, 1979, NOAA submitted this testimony to the U.S. EPA as constituting NMFS "Biological Opinion on the impacts of the utilities' once through cooling system on the shortnose sturgeon." The filing notes that this opinion is required by section 7 of the ESA of 1973, as amended.

In this testimony, Dr. Dadswell provides information on the life history of shortnose sturgeon and summarizes what was known at the time about the population in the Hudson River. Dr. Dadswell indicates that at the time it was estimated that there were approximately 6,000 adult and sub-adult shortnose sturgeon in the Hudson River population (Dadswell 1979) and that the population had been stable at this number between the 1930s and 1970s. Dr. Dadswell determined that there is no known entrainment of shortnose sturgeon at these facilities and little, if any, could be anticipated. Based on available information regarding impingement at IP2 and IP3, Dadswell estimated a worst case scenario of 35 shortnose sturgeon impingements per year, including 21 mortalities (assuming 60% impingement mortality). Dadswell estimated that this resulted in a loss of 0.3-0.4% of the shortnose sturgeon population in the Hudson each year and that this additional source of mortality will not "appreciably reduce the likelihood of the survival and recovery of the shortnose sturgeon." In conclusion Dadswell stated that the once through cooling systems being considered in the case were "not likely to jeopardize the continued existence of the shortnose sturgeon because, even assuming 100% mortality of impinged fish, its contribution to the natural annual mortality is negligible." Dr. Dadswell did note that as there is no positive benefit to impingement, any reductions in the level of impingement would aid in the conservation of the species. Incidental take of shortnose sturgeon at IP2 and IP3 was not exempted from the prohibitions on take by this testimony or "biological opinion." No additional ESA consultation occurred between NRC and NMFS on the operation of IP2 and IP3 until consultation was initiated in 2010 on the effects to shortnose sturgeon of operations during the proposed extended operating period.

In advance of relicensing proceedings, NRC began coordination with us in 2007. In a letter dated August 16, 2007, NRC requested information from us on federally listed endangered or threatened species, as well as on proposed or candidate species, and on any designated critical habitats that may occur in the vicinity of IP2 and IP3. In our response, dated October 4, 2007, we expressed concern that the continued operation of IP2 and IP3 could have an impact on the shortnose sturgeon *(Acipenser brevirostrum*). In a letter dated December 22, 2008, NRC requested formal consultation with us to consider effects of the proposed relicensing on shortnose sturgeon. With this letter, NRC transmitted a BA. In a letter dated February 24, 2009, we requested additional information on effects of the proposed relicensing on shortnose sturgeon. In a letter dated December 10, 2010, NRC provided the information that was available and transmitted a revised BA. In the original BA, NRC staff relied on data originally supplied by the applicant, Entergy Nuclear Operations, Inc. (Entergy). NRC sought and Entergy later submitted revised impingement data, which was incorporated into the final BA. Mathematical errors in the original data submitted to the NRC resulted in overestimates of the impingement of shortnose sturgeon that the NRC staff presented in the 2008 BA. Consultation on the effects of the proposed relicensing on shortnose sturgeon was initiated on December 10, 2010.

On June 16, 2011, we received information regarding Entergy's triaxial thermal plume study and NMFS staff obtained a copy of the study and supporting documentation from NYDEC's webpage on that date. Additional information regarding the intakes was provided by Entergy via conference call on June 20, June 22, and June 29, 2011. Supplemental information responding to specific questions raised by us regarding the thermal plume was submitted by Entergy via e-mail on July 8, July 25, and August 5, 2011. NRC provided us with a supplement to the December 2010 BA considering the new thermal plume information, on July 27, 2011. We transmitted a draft Opinion to NRC on August 26, 2011. The draft Opinion was subsequently transmitted by NRC to Entergy. Comments on the draft Opinion were received by us from NRC on September 6, 2011 and September 20, 2011. Comments were received by us from Entergy on September 6, 2011. Additionally, we received letters regarding the draft Opinion from New York State (dated September 6, 2011) and Hudson Riverkeeper (dated September 15, 2011). Additional clarifying information on the proposed action was received from NRC and Entergy throughout September 2011. We issued a Biological Opinion on October 14, 2011. In this Opinion we concluded that operation of IP2 and IP3 during the extended operating period was likely to adversely affect but not likely to jeopardize the continued existence of shortnose sturgeon.

As explained in the "Effects of the Action" section of the 2011 Opinion, we determined an average of 5 shortnose sturgeon per year are likely to be impinged at Unit 2 during the extended operating period, with a total of no more than 104 shortnose sturgeon over the 20 year period (dead or alive). Additionally, over the 20 year operating period, we estimated that an additional 6 shortnose sturgeon (dead or alive) were likely to be impinged at the Unit 1 intakes which will provide service water for the operation of Unit 2. We estimated that at Unit 3, an average of 3 shortnose sturgeon are likely to be impinged per year during the extended operating period, with a total of no more than 58 shortnose sturgeon (dead or alive) taken as a result of the operation of Unit 3 over the 20 year period. This level of take was exempted through an Incidental Take Statement that applies only to the period when the facility operates under a new operating license

(September 28, 2013 through September 28, 2033 for Units 1 and 2; December 12, 2015 through December 12, 2035 for Unit 3). The 2011 Opinion was to become effective once new operating licenses were issued by NRC. The Nuclear Regulatory Commission (NRC) has not yet made a decision on whether to issue the extended operating licenses.

As described in 50 CFR§ 402.16, reinitiation of formal consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal involvement or control over the action has been retained or is authorized by law and: (a) the amount or extent of taking specified in the ITS is exceeded; (b) new information reveals effects of these actions that may affect listed species or critical habitat in a manner or to an extent not previously considered; (c) any of the identified actions are subsequently modified in a manner that causes an effect to the listed species that was not considered in the Opinion; or (d) a new species is listed or critical habitat designated that may be affected by the identified actions. Based on prior communications with NRC, it is our understanding that for Indian Point facilities, NRC retains discretionary involvement or control to benefit listed species, or such involvement or control is authorized by law, and that NRC will reinitiate consultation if any of the criteria above are satisfied.
On February 6, 2012, we listed five distinct population segments (DPS) of Atlantic sturgeon as threatened (Gulf of Maine DPS) or endangered (New York Bight, Chesapeake Bay, Carolina and South Atlantic DPSs) (see 77 FR 5880 and 77 FR 5914). Atlantic sturgeon occur in the Hudson River and are known to be affected by operations of IP2 and IP3.

In a letter dated May 17, 2012, NRC requested reinitiation of the 2011 consultation to consider effects of operations of IP2 and IP3 during the extended operating period on Atlantic sturgeon. As described by NRC staff in a telephone call on July 3, 2012, NRC also requests that the consultation consider effects to shortnose sturgeon and five DPSs of Atlantic sturgeon of operations of IP2 and IP3 pursuant to the existing operating licenses up until such time as extended operating licenses are issued or operations cease. Therefore, the federal actions under consideration are authorization of operations of IP2 and IP3 by the NRC pursuant to licenses issued in 1973 and 1975, respectively, and operations pursuant to proposed new licenses, which NRC may issue at any time and would extend operations for 20 years beyond the expiration of the original licenses. Consultation was initiated on May 17, 2012. On July 23, 2012, Entergy submitted additional information to us and NRC regarding impingement of shortnose and Atlantic sturgeon (Entergy 2012). Subsequently, by mutual agreement of NRC and NMFS, we extended the consultation period by 60 days to allow time for review and incorporation of this new information, as appropriate. By issuing this Opinion, we withdraw the Opinion issued by us on October 14, 2011.

3.0 DESCRIPTION OF THE PROPOSED ACTION

As noted above, the proposed Federal action is the continued operation of Indian Point Units 2 and 3 pursuant to licenses issued by NRC in 1973 and 1975, respectively, as well as continued operation of IP2 and IP3 pursuant to NRC's proposed renewed operating licenses. The current 40-year licenses expire in 2013 (IP2) and 2015 (IP3). According to NRC, NRC's "timely renewal" provision (in 10 CFR 2.109(b)) provides that if a license renewal application is timely filed, which NRC asserts the Entergy application was, the current license is not deemed to have expired until the application has been finally determined (i.e., until a licensing decision is made). Thus, pursuant to this provision, the current operating licenses will not expire until the license renewal proceeding has concluded. NRC's proposed relicensing would authorize the extended operation of IP2 and IP3 for an additional 20 years (i.e., through September 28, 2033 and December 12, 2035, respectively). In this Opinion, we consider the potential impacts of the continued operation of the facility from now through the proposed extended operation period on shortnose and Atlantic sturgeon.

Details on the operation of the facilities under the terms of the existing license and over the extended operating period, as proposed by Entergy in the license application and as described by NRC in the FEIS, DSEIS and BA, and are summarized below. Both units withdraw water from and discharge water to, the Hudson River. As described by NRC in the Final SEIS (NRC 2010), in 1972, Congress assigned authority to administer the Clean Water Act (CWA) to the US Environmental Protection Agency (EPA). The CWA further allowed EPA to delegate portions of its CWA authority to states. On October 28, 1975, EPA authorized the State of New York to issue National Pollutant Discharge Elimination System (NPDES) permits. New York's NPDES, or State Pollutant Discharge Elimination System (SPDES), program is administered by the NY Department of Environmental Conservation (NYDEC). NYDEC issues and enforces SPDES permits for IP2 and IP3.

Section 316(b) of the Clean Water Act of 1977 requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impacts (33 USC 1326). EPA regulates impingement and entrainment under Section 316(b) of the CWA through the NPDES permit process. Administration of Section 316(b) has also been delegated to NYDEC, and that provision is implemented through the SPDES program.

Neither IP2 or IP3 can operate without cooling water, and NRC is responsible for authorizing the operation of nuclear facilities, as well as approving any extension of an initial operating license through the license renewal process. Intake and discharge of water through the cooling water system would not occur but for the operation of the facility pursuant to a renewed license; therefore, the effects of the cooling water system on shortnose sturgeon are a direct effect of the proposed action. NRC staff state that the authority to regulate cooling water intakes and discharges under the CWA lies with EPA, or in this case, NYDEC, as the state has been delegated NPDES authority by EPA. Pursuant to NRC's regulations, operating licenses are conditioned upon compliance with all applicable law, including but not limited to CWA Section 401 Certifications and NPDES/SPDES permits. Therefore, the effects of the proposed Federal action-- the continued operation of IP2 and IP3 as proposed to be approved by NRC, which necessarily involves the removal and discharge of water from the Hudson River-- are shaped not only by the terms of the renewed operating license but also by the NYDEC 401 Water Quality Certification and any conditions it may contain that would be incorporated into its SPDES permits. This Opinion will consider the effects of the operation of IP2 and IP3 pursuant to the extended Operating License to be issued by the NRC and the SPDES permits issued by NYDEC that are already in effect. NRC requested consultation on the operation of the facilities under the existing NRC license terms and the existing SPDES permits, even though a new SPDES permit might be issued in the future. A complete history of NYDEC permits is included in NRC's FSEIS at Section 2.2.5.3 (Regulatory Framework and Monitoring Programs) and is summarized below.

3.1 NPDES/SPDES Permits

Section 316(b) of the CWA requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impacts (33 USC 1326). In July 2004, the EPA published the Phase II Rule implementing Section 316(b) of the CWA for Existing Facilities (69 FR 41576), which applied to large power producers that withdraw large amounts of surface water for cooling (50 MGD or more) (189,000 m3/day or more). The rule became effective on September 7, 2004 and included numeric performance standards for reductions in impingement mortality and entrainment that would demonstrate that the cooling water intake system constitutes BTA for minimizing impingement and entrainment impacts. Existing facilities subject to the rule were required to demonstrate compliance with the rule's performance standards during the renewal process for their NPDES permit through development of a Comprehensive Demonstration Study (CDS). As a result of a Federal court decision, EPA officially suspended the Phase II rule on July 9, 2007 (72 FR 37107) pending further rulemaking. EPA instructed permitting authorities to utilize best professional judgment in establishing permit requirements on a case by-case basis for cooling water intake structures at Phase II facilities until it has resolved the issues raised by the court's ruling.

The licenses issued by the AEC for IP2 and IP3 initially allowed for the operation of those facilities with once-through cooling systems. However, the licenses required the future installation of closed-cycle cooling systems at both facilities, by certain dates, because of the potential for long term environmental impact from the once-through cooling systems on aquatic life in the Hudson River, particularly striped bass. A closed cycle cooling system is expected to withdraw approximately 90-95% less water than a once through cooling system. The license for IP2 was amended by the NRC in 1975, and the license for IP3 was amended by the NRC in 1976, to include requirements for the installation and operation of wet closed-cycle cooling systems at the facilities.

NRC eventually concluded that the operating licenses for the facilities should be amended to authorize construction of natural draft cooling towers at each Unit. Prior to the respective deadlines for installation of closed-cycle cooling at the Indian Point facilities, however, the NRC's authority to require the retrofit due to water quality impacts under federal nuclear licenses was superseded by comprehensive amendments to the federal Water Pollution Prevention and Control Act (the CWA) and creation of the NPDES program.

In 1975, the EPA issued separate NPDES permits for Units 2 and 3, pursuant to provisions of the CWA, chiefly § 316 (33 U.S.C. § 1326), that required both facilities to discontinue discharging heated effluent from the main condensers. The NPDES permits provided that "heat may be discharged in blowdown from a re-circulated cooling water system." The intent of these conditions was to require the facilities to install closed-cycle cooling systems in order to reduce the thermal and other adverse environmental impacts from the operation of Indian Point's CWISs upon aquatic organisms in the Hudson River. In 1977, the facilities' owners, Consolidated Edison Company of New York and PASNY/NYPA, requested administrative hearings with the EPA to overturn these conditions.

In October 1975, NYDEC received approval from the EPA to administer and conduct a State permit program pursuant to the provisions of the federal NPDES program under CWA § 402. Since then, NYDEC has administered that program under the SPDES permit program. As a result, NYDEC has the authority, under the CWA and state law, to issue SPDES permits for the withdrawal of cooling water for operations at the Indian Point facilities and for the resulting discharge of waste heat and other pollutants into the Hudson River. Compliance with the SPDES permit would be required under the Federal action given that the operating license shall be subject to the conditions imposed under the CWA.

As previously noted, in 1977 the then-owners of the Indian Point nuclear facilities sought an adjudicatory proceeding to overturn the EPA-issued NPDES permit determinations that limited the scope of the facilities' cooling water intake operations. The EPA's adjudicatory process lasted for several years before culminating in a multi-party settlement known as the Hudson River Settlement Agreement[2] (HRSA). The HRSA was initially a ten-year agreement whereby the owners of certain once-through cooled electric generating plants on the Hudson River, including IP2 and IP3, would collect biological data and complete analytical assessments to determine the scope of adverse environmental impact caused by those facilities. According to the NYDEC, the intent of the HRSA was that, based upon the data and analyses provided by the facilities, the Department could determine, and parties could agree upon, the best technology available to minimize adverse environmental impact on aquatic organisms in the Hudson River from these facilities in accordance with 6 NYCRR § 704.5. The Settlement obligated the utilities to undertake a series of operational steps to reduce fish kills, including partial outages during the key spawning months. In addition, the utilities agreed to fund and operate a striped bass hatchery, conduct biological monitoring, and set up a $12 million endowment for a new foundation for independent research on mitigating fish impacts by power plants. The agreement became effective upon Public Service Commission approval on May 8, 1981. The terms of the 1980 HRSA were extended through a series of four separate stipulations of settlement and judicial consent orders that were entered in Albany County Supreme Court [Index No. 0191-ST3251]. The last of these stipulations of settlement and judicial consent orders, executed by the parties in 1997, expired on February 1, 1998.

In 1982, NYDEC issued a SPDES permit for IP2 and IP3, and other Hudson River electric generating facilities, as well as a CWA § 401 WQC for the facilities. The 1982 SPDES permit for IP2 and IP3 contained special conditions for reducing some of the environmental impact from the facilities' cooling water intakes but, based upon provisions of the HRSA, the permit did not require the installation of any technology for minimizing the number of organisms entrained by the facilities each year. Similarly, based upon provisions of the HRSA, the 1982 § 401 WQC did not make an independent determination that the facilities complied with certain applicable State water quality standards at that time, including 6 NYCRR Part 704 – Criteria Governing Thermal Discharges.

[2] The signatory parties to the HRSA were USEPA, the Department, the New York State Attorney General, the Hudson River Fishermen's Association, Scenic Hudson, the Natural Resources Defense Council, Central Hudson Gas & Electric Co., Consolidated Edison Co., Orange & Rockland Utilities, Niagara Mohawk Power Corp., and PASNY. Entergy was not a party to the HRSA because it did not own the Indian Point facilities at any time during the period covered by the HRSA. NOAA was not a party to the HRSA.

In accordance with the provisions of the HRSA, NYDEC renewed the SPDES permit for IP2 and IP3 in 1987 for another 5-year period. As with the 1982 SPDES permit, the 1987 SPDES permit for IP2 and IP3 contained certain measures from the HRSA that were intended to mitigate, but not minimize, the adverse environmental impact caused by the operation of the facilities' cooling water intakes. The 1987 SPDES permit expired on October 1, 1992. Prior to the expiration date, however, the owners of the facilities at that time, Consolidated Edison and NYPA, both submitted timely SPDES permit renewal applications to the Department and, by operation of the State Administrative Procedure Act (SAPA), the 1987 SPDES permit for Units 2 and 3 is still in effect today. Entergy purchased Units 2 and 3 in 2001 and 2000, respectively, and the 1987 SAPA-extended SPDES permit for the facilities was subsequently transferred to Entergy.

In November 2003, NYDEC issued a draft SPDES permit for IP2 and IP3 that required Entergy, among other things, to retrofit the Indian Point facilities with closed-cycle cooling or an equivalent technology in order to minimize the adverse environmental impact caused by the CWISs in accordance with 6 NYCRR § 704.5 and CWA § 316(b). The draft permit contains conditions which address three aspects of operations at Indian Point: conventional industrial-wastewater pollutant discharges, thermal discharge, and cooling water intake. Limits on the conventional industrial discharges are not proposed to be changed significantly from the previous permit. The draft permit does, however, contain new conditions addressing the thermal discharge and additional new conditions to implement the measures NYDEC has determined to be the best technology available for minimizing impacts to aquatic resources from the cooling water intake, including the installation of a closed cycle cooling system at IP2 and IP3. With respect to thermal discharges, the draft SPDES permit would require Entergy to conduct a tri-axial (three-dimensional) thermal study to document whether the thermal discharges from IP2 and IP3 comply with state water quality criteria. The draft permit states that if IP2 and IP3 do not meet state standards, Entergy may apply for a modification of those criteria in an effort to demonstrate to NYDEC that such criteria are unnecessarily restrictive and that the requested modification would not inhibit the existence and propagation of a balanced indigenous population of shellfish, fish and wildlife in the Hudson River, which is an applicable CWA water quality-related standard. The draft permit also states that Entergy may propose, within a year of the permit's becoming effective, an alternative technology or technologies that can minimize adverse environmental impacts to a level equivalent to that achieved by a closed-cycle cooling system at IP2 and IP3. In order to implement closed-cycle cooling, the draft permit would require Entergy to submit a pre-design engineering report within one year of the permit's effective date. Within one year after the submission of the report, Entergy must submit complete design plans that address all construction issues for conversion to closed-cycle cooling. In addition, the draft permit requires Entergy to obtain approvals for the system's construction from other government agencies, including modification of the operating licenses for IP2 and IP3 from the NRC. While steps are being taken to implement BTA, Entergy would be required to schedule and take annual generation outages of no fewer than 42 unit-days during the peak entrainment season among other measures. In 2004, Entergy requested an adjudicatory hearing with NYDEC on the draft SPDES permit. That SPDES permit adjudicatory process is presently ongoing, and its outcome is uncertain at this time.

There is significant uncertainty associated with the conditions of any new SPDES permit. In the 2003 draft, NYDEC determined that cooling towers were the BTA to minimize adverse environmental effects. In a 2010 filing with NYDEC, Entergy proposed to use a system of cylindrical wedgewire screens, which Entergy states would reduce impingement and entrainment mortality to an extent comparable to the reductions in impingement and entrainment loss expected to result from operation with cooling towers. As no determination has been made regarding a revised draft SPDES permit or a final permit, it is unknown what new technology, if any, will be required to modify the operation of the facility's cooling water intakes. The 1987 SPDES permit is still in effect and will remain in effect until a new permit is issued and becomes effective. No schedule is available for the issuance of a revised draft or new final SPDES permit and the content of any SPDES permit will be decided as a result of the adjudication process. Therefore, in this consultation, we have considered effects of the continued operation of the Indian Point facility through the end of extended operating period with the 1987 SPDES permit in effect. This scenario is the one defined by NRC as its proposed action in the BA provided to NMFS in which NRC considered effects of the operation of the facility during the extended operating period on shortnose and Atlantic sturgeon. Therefore, it is the subject of this consultation. However, if a new SPDES permit is issued, NRC and NMFS would have to determine if reinitiation of this consultation is necessary to consider any effects of the operation of the facility on sturgeon that were not considered in this Opinion, including operation of the facility with cylindrical wedge wire screens. It is possible the effects of the construction, layout, and use of an intake system using cylindrical wedge wire screens will affect shortnose and/or Atlantic sturgeon in a manner and to a degree that is very different from the effects considered in this Opinion, and as a result, necessitate reinitiation of this consultation.

3.2 401 Water Quality Certificate

On December 7, 1970, NYSDEC issued a certification for IP1 and IP2, pursuant to §21(b) of the Water Quality Improvement Act 1 -the precursor to §401. On April 24, 1973, NYSDEC issued a WQC for the operational testing period for IPI and IP2. On September 24, 1973, NYSDEC issued a WQC for full operation of IP1 and IP2. On May 2, 1975, NYSDEC issued a WQC for operation of Indian Point 3 ("IP3"). On April 24, 1981, NYSDEC issued a subsequent WQC for operation of IP1, IP2 and IP3. IP2 and IP3 currently operate pursuant to the 1981 WQC.

On April 6, 2009, NYDEC received a Joint Application for a federal CWA § 401 WQC on behalf of Entergy Indian Point Unit 2, LLC, Entergy Indian Point Unit 3, LLC, and Entergy Nuclear Northeast (collectively Entergy). The Joint Application for § 401 WQC was submitted to NYDEC as part of Entergy's NRC license renewal. Pursuant to the CWA, a state must issue a certification verifying that an activity which results in a discharge into navigable waters, such as operation of the Indian Point facilities, meets state water quality standards before a federal license or permit for such activity can be issued. Entergy has requested NYDEC to issue a § 401 WQC to run concurrently with any renewed nuclear licenses for the Indian Point facilities.

In a decision dated April 2, 2010, NYDEC determined that the facilities, whether operated as they are currently or operated with the addition of a cylindrical wedge-wire screen system (NYDEC notes that this proposal was made by Entergy in a February 12, 2010, submission), "do not and will not comply with existing New York State water quality standards." Accordingly, pursuant to 6 NYCRR Part 621 (Uniform Procedures), NYDEC denied Entergy's request for a

§401 WQC (NYDEC 2010). The reasons for denial, as stated by NYDEC were related to impingement and entrainment of aquatic organisms, the discharge of heated effluent, and failure to implement what NYDEC had determined to be the Best Technology Available (closed cycle cooling towers), to minimize adverse environmental impacts. Entergy has appealed the denial. The matter is currently under adjudication in the state administrative system, and the results are uncertain. If New York State ultimately issues a WQC, it may contain conditions that alter the operation of the facility and its cooling water system. If this occurs, NMFS and NRC would need to review the modifications to operations to determine if consultation would need to be reinitiated.

3.3 Description of Water Withdrawals

IP2 and IP3 have once-through condenser cooling systems that withdraw water from, and discharge water to, the Hudson River. The maximum design flow rate for each cooling system is approximately 1,870 cubic feet per second (cfs), 840,000 gallons per minute (gpm), or 53.0 cubic meters per second (m^3/s). Two shoreline intake structures, one for each unit, are located along the eastern shore of the Hudson River on the northwestern edge of the site and provide cooling water to IP2 and IP3. Each structure consists of seven bays, six for circulating water and one for service water. IP2 also uses service water withdrawn from the former IP1 intake, located along the shoreline between the IP2 and IP3 intakes. The IP2 intake structure has seven independent bays, while the IP3 intake structure has seven bays that are served by a common plenum. In each structure, six of the seven bays contain cooling water pumps, and the seventh bay contains service/auxiliary water pumps. Before it is pumped to the condensers, river water passes through traveling screens in the intake structure bays to remove debris, fish and other aquatic life.

The six IP2 circulating water intake pumps are dual-speed pumps. When operated at high speed (254 revolutions per minute (rpm)), each pump provides 312 cfs (140,000 gpm; 8.83 m3/s) and a dynamic head of 21 ft (6.4 m). At low speed (187 rpm), each pump provides 38 cfs (84,000 gpm; 5.30 m^3/s) and a dynamic head of 15 ft (4.6 m). The six IP3 circulating water intake pumps are variable-speed pumps. When operated at high speed (360 rpm), each pump provides 312 cfs (140,000 gpm; 8.83 m^3/s); at low speed, it provides a dynamic head of 29 ft (8.8 m) and 143 cfs (64,000 gpm; 4.05 m^3/s).

As described in the FSEIS, Entergy adjusts the speed of the intake pumps to mitigate impacts to the Hudson River. Each coolant pump bay is about 15 ft (4.6 m) wide at the entrance, and the bottom is located 27 ft (8.2 m) below mean sea level. Before entering the intake structure bays, water flows under a floating debris skimmer wall, or ice curtain, into the screen wells. This initial screen keeps floating debris and ice from entering the bay. At the entrance to each bay, water also passes through a subsurface bar screen (consisting of metal bars with 3 inch clear spacing) to prevent additional large debris from becoming entrained in the cooling system. At full speed, the approach velocity in front of the screens is 1 foot per second (fps); at reduced speed, the approach velocity is 0.6 fps (Entergy 2007a). As this area is behind a bulkhead it is outside the influence of river currents. Next, smaller debris and fish that pass through the trash bars are screened out using modified Ristroph traveling screens.

Comment [A1]: Questions to NRC and Entergy – What enforceable instrument, if any, requires such speed adjustments? For example, is this speed adjustment a condition of the NRC license and/or a requirement of the NYPDES permit? What factors determine whether a pump is run at full speed versus reduced speed?

The modified Ristroph traveling screens consist of a series of panels that rotate continuously. The traveling screens employed by IP2 and IP3 are modified vertical Ristroph-type traveling screens installed in 1990 and 1991 at IP3 and IP2, respectively. The screens were designed in concert with the Hudson River Fishermen's Association, with screen basket lip troughs to retain water and minimize vortex stress (CHGEC 1999). As each screen panel rotates out of the intake bay, impinged fish are retained in water-filled baskets at the bottom of each panel and are carried over the headshaft, where they are washed out onto a mesh using low-pressure sprays from the rear side of the machine. The 0.25-by-0.5-inch (in.) (0.635-by-1.27 centimeters (cm)) mesh is smooth to minimize fish abrasion by the mesh. Two high-pressure sprays remove debris from the front side of the machine after fish removal. From the mesh, fish return to the river via a 12-in. (30-cm) diameter pipe. For IP2, the pipe extends 200 ft (61.0 m) into the river north of the IP2 intake structure and discharges at a depth of 35 ft (11 m). The sluice system is a 12-in.-diameter (30.5-cm-diameter) pipe that discharges fish into the river at a depth of 35 ft (10.7 m), 200 ft (61 m) from shore (CHGEC 1999). The IP3 fish return system discharges to the river by the northwest corner of the discharge canal.

Comment [A2]: Question to NRC and/or Entergy – Where does material that is removed by the high pressure spray go? Down the sluice?

Studies indicated that, assuming the screens continued to operate as they had during laboratory and field testing, the screens were "the screening device most likely to impose the least mortalities in the rescue of entrapped fish by mechanical means" (Fletcher 1990). The same study concluded that refinements to the screens would be unlikely to greatly reduce fish kills. No monitoring is currently ongoing at IP2 or IP3 for impingement or entrainment or to ensure that the screens are operating per design standards, and no monitoring took place after the screens were installed. Additionally, there is no monitoring ongoing to quantify any actual incidental take of shortnose sturgeon or their prey. The proposed action under consultation, as currently defined by NRC, does not provide for any monitoring of direct or indirect effects to shortnose sturgeon.

After moving through the condensers, cooling water is discharged to the discharge canal via a total of six 96-in. (240-cm) diameter pipes. The cooling water enters below the surface of the 40-ft (12-m) wide canal. The canal discharges to the Hudson River through an outfall structure located south of IP3 at about 4.5 feet per second (fps) (1.4 meters per second (mps)) at full flow. As the discharged water enters the river, it passes through 12 discharge ports (4-ft by 12-ft each (1-m by 3.7-m)) across a length of 252 ft (76.8 m) about 12 ft (3.7 m) below the surface of the river. The increased discharge velocity, about 10 fps (3.0 mps), is designed to enhance mixing to minimize thermal impact.

The discharged cooling water is at an elevated temperature, and therefore, some water is lost because of evaporation. Based on conservative estimates, NRC estimates that this induced evaporation resulting from the elevated discharge temperature would be less than 60 cfs (27,000 gpm or 1.7 m^3/s). This loss is about 0.5 percent of the annual average downstream flow of the Hudson River, which is more than 9000 cfs (4 million gpm or 255 m^3/s). The average cooling water transient time ranges from 5.6 minutes for the IP3 cooling water system to 9.7 minutes for the IP2 system. Auxiliary water systems for service water are also provided from the Hudson River via the dedicated bays in the IP2 and IP3 intake structures. The primary role of service water is to cool components (e.g., pumps) that generate heat during operation. Secondary functions of the service water include the following:

- protect equipment from potential contamination from river water by providing cooling to intermediate freshwater systems;

- provide water for washing the modified Ristroph traveling screens; and,
- provide seal water for the main circulating water pumps.

As noted above, additional service water is provided to the nonessential service water header for IP2 through the IP1 river water intake structure. The IP1 intake includes four intake bays each with a coarse bar screen and a single 0.125-in. (0.318-cm) mesh screen. The intake structure contains two 36-cfs^2 (16,000-gpm; 1.0-m^3/s) spray wash pumps. The screens are washed automatically and materials are sluiced to the Hudson River.

Comment [A3]: Question to NRC/Entergy – is this screen a Ristroph screen, modified Ristroph screen, or other type of screen? If the latter, please describe it.

Based on the description of the action provided in the FEIS, no major construction is proposed by Entergy during the relicensing period. Entergy may undertake some refurbishment activities. In the FEIS, NRC indicates that Entergy may replace the reactor vessel heads and control rod drive mechanisms (CRDMs) for IP2 and IP3 during the term of the renewed license. Ground-disturbing activities associated with this project would involve the construction of a storage building to house the retired components. The replacement components would arrive by barge and be transported over an existing service road by an all-terrain vehicle (Entergy 2008b). There would be no in-water work and there is no indication that effects of this refurbishment activity would extend to the Hudson River. As such, no shortnose or Atlantic sturgeon would be exposed to effects of this refurbishment activity; therefore, effects of this activity are not considered further in this Opinion.

3.4 Action Area

The action area is defined in 50 CFR 402.02 as “all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.” IP2 and IP3 are located on a 239-acre (97-hectare) site on the eastern bank of the Hudson River in the village of Buchanan, Westchester County, New York, about 43 miles (mi) (69 kilometers [km) north of the southern tip of Manhattan, New York (Figures 1 and 2). The direct and indirect effects of the Indian Point facility are related to the intake of water from the Hudson River and the discharge of heated effluent back into the Hudson River. The proposed action has the potential to affect shortnose and Atlantic sturgeon in several ways: impingement or entrainment of individual sturgeon at the intakes; altering the abundance or availability of potential prey items; and, altering the riverine environment through the discharge of heated effluent and other pollutants. Therefore, the action area for this consultation includes the intake areas of IP1 (for service water), IP2 and IP3 and the region where the thermal plume extends into the Hudson River from IP2 and IP3 as described in the Effects of the Action section below.

4.0 STATUS OF THE SPECIES

We have determined that the actions considered in the Opinion may adversely affect the following listed species:

Common name	Scientific name	ESA Status
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
GOM DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Threatened
New York Bight DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered
Chesapeake Bay DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered

This section presents biological and ecological information relevant to formulating the Biological Opinion. Information on the species' life history, its habitat and distribution, and other factors necessary for its survival are included to provide background for analyses in later sections of this opinion. This section reviews the status of the species rangewide as well as the status of the species in the Hudson River where the action takes place.

4.1 Shortnose Sturgeon

Shortnose sturgeon are benthic fish that mainly occupy the deep channel sections of large rivers. They feed on a variety of benthic and epibenthic invertebrates including mollusks, crustaceans (amphipods, isopods), insects, and oligochaete worms (Vladykov and Greeley 1963; Dadswell 1979 *in* NMFS 1998). Shortnose sturgeon have similar lengths at maturity (45-55 cm fork length) throughout their range, but, because sturgeon in southern rivers grow faster than those in northern rivers, southern sturgeon mature at younger ages (Dadswell et al. 1984). Shortnose sturgeon are long-lived (30-40 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at 5 to 10 years, while females mature between 7 and 13 years. Based on limited data, females spawn every three to five years while males spawn approximately every two years. The spawning period is estimated to last from a few days to several weeks. Spawning begins from late winter/early spring (southern rivers) to mid to late spring (northern rivers)[3] when the freshwater temperatures increase to 8-9ºC. Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse et al. 1987; Crowder et al. 1994; Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual survival as juveniles through adults to ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

Total instantaneous mortality rates (Z) are available for the Saint John River (0.12 - 0.15; ages 14-55; Dadswell 1979), Upper Connecticut River (0.12; Taubert 1980b), and Pee Dee-Winyah River (0.08-0.12; Dadswell et al. 1984). Total instantaneous natural mortality (M) for shortnose sturgeon in the lower Connecticut River was estimated to be 0.13 (T. Savoy, Connecticut Department of Environmental Protection, personal communication). There is no recruitment information available for shortnose sturgeon because there are no commercial fisheries for the species. Estimates of annual egg production for this species are difficult to calculate because females do not spawn every year (Dadswell et al. 1984). Further, females may abort spawning attempts, possibly due to interrupted migrations or unsuitable environmental conditions (NMFS 1998). Thus, annual egg production is likely to vary greatly in this species. Fecundity estimates have been made and range from 27,000 to 208,000 eggs/female and a mean of 11,568 eggs/kg body weight (Dadswell et al. 1984).

At hatching, shortnose sturgeon are blackish-colored, 7-11mm long and resemble tadpoles (Buckley and Kynard 1981). In 9-12 days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15mm total length (TL; Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20mm TL. Dispersal rates differ at least regionally, laboratory studies on Connecticut River larvae indicated dispersal peaked 7-12 days

[3] For purposes of this consultation, Northern rivers are considered to include tributaries of the Chesapeake Bay northward to the St. John River in Canada. Southern rivers are those south of the Chesapeake Bay.

after hatching in comparison to Savannah River larvae that had longer dispersal rates with multiple, prolonged peaks, and a low level of downstream movement that continued throughout the entire larval and early juvenile period (Parker 2007). Synder (1988) and Parker (2007) considered individuals to be juvenile when they reached 57mm TL. Laboratory studies demonstrated that larvae from the Connecticut River made this transformation on day 40 while Savannah River fish made this transition on day 41 and 42 (Parker 2007).

The juvenile phase can be subdivided in to young of the year (YOY) and immature/ sub-adults. YOY and sub-adult habitat use differs and is believed to be a function of differences in salinity tolerances. Little is known about YOY behavior and habitat use, though it is believed that they are typically found in channel areas within freshwater habitats upstream of the salt wedge for about one year (Dadswell et al. 1984, Kynard 1997). One study on the stomach contents of YOY revealed that the prey items found corresponded to organisms that would be found in the channel environment (amphipods) (Carlson and Simpson 1987). Sub-adults are typically described as age one or older and occupy similar spatio-temporal patterns and habitat-use as adults (Kynard 1997). Though there is evidence from the Delaware River that sub-adults may overwinter in different areas than adults and do not form dense aggregations like adults (ERC Inc. 2007). Sub-adults feed indiscriminately; typical prey items found in stomach contents include aquatic insects, isopods, and amphipods along with large amounts of mud, stones, and plant material (Dadswell 1979, Carlson and Simpson 1987, Bain 1997).

In populations that have free access to the total length of a river (e.g., no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah, Delaware and Merrimack Rivers), spawning areas are located at the farthest upstream reach of the river (NMFS 1998). In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding, and overwintering activities. In spring, as water temperatures reach between 7-9.7ºC (44.6-49.5°F), pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas. Spawning occurs from mid/late March to mid/late May depending upon location and water temperature. Sturgeon spawn in upper, freshwater areas and feed and overwinter in both fresh and saline habitats. Shortnose sturgeon spawning migrations are characterized by rapid, directed and often extensive upstream movement (NMFS 1998).

Shortnose sturgeon are believed to spawn at discrete sites within their natal river (Kieffer and Kynard 1996). In the Merrimack River, males returned to only one reach during a four year telemetry study (Kieffer and Kynard 1996). Squires (1982) found that during the three years of the study in the Androscoggin River, adults returned to a 1-km reach below the Brunswick Dam and Kieffer and Kynard (1996) found that adults spawned within a 2-km reach in the Connecticut River for three consecutive years. Spawning occurs over channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell et al. 1984; NMFS 1998). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 8 - 15º (46.4-59°F), and bottom water velocities of 0.4 to 0.8 m/sec (Dadswell et al. 1984; Hall et al. 1991, Kieffer and Kynard 1996, NMFS 1998). For northern shortnose sturgeon, the temperature range for spawning is 6.5-18.0ºC (Kieffer and Kynard in press). Eggs are separate when spawned but become adhesive within approximately 20 minutes of fertilization (Dadswell et al. 1984).

Between 8° (46.4°F) and 12°C (53.6°F), eggs generally hatch after approximately 13 days. The larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment.

Adult shortnose sturgeon typically leave the spawning grounds soon after spawning. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell et al. 1984; Buckley and Kynard 1985; O'Herron et al. 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Young-of-the-year shortnose sturgeon are believed to move downstream after hatching (Dovel 1981) but remain within freshwater habitats. Older juveniles or sub-adults tend to move downstream in fall and winter as water temperatures decline and the salt wedge recedes and move upstream in spring and feed mostly in freshwater reaches during summer.

Juvenile shortnose sturgeon generally move upstream in spring and summer and move back downstream in fall and winter; however, these movements usually occur in the region above the saltwater/freshwater interface (Dadswell et al. 1984; Hall et al. 1991). Non-spawning movements include wandering movements in summer and winter (Dadswell et al. 1984; Buckley and Kynard 1985; O'Herron et al. 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Adult sturgeon occurring in freshwater or freshwater/tidal reaches of rivers in summer and winter often occupy only a few short reaches of the total length (Buckley and Kynard 1985). Summer concentration areas in southern rivers are cool, deep, thermal refugia, where adult and juvenile shortnose sturgeon congregate (Flourney et al. 1992; Rogers et al. 1994; Rogers and Weber 1995; Weber 1996).

While shortnose sturgeon do not undertake the significant marine migrations seen in Atlantic sturgeon, telemetry data indicates that shortnose sturgeon do make localized coastal migrations. This is particularly true within certain areas such as the Gulf of Maine (GOM) and among rivers in the Southeast. Interbasin movements have been documented among rivers within the GOM and between the GOM and the Merrimack, between the Connecticut and Hudson rivers, the Delaware River and Chesapeake Bay, and among the rivers in the Southeast.

The temperature preference for shortnose sturgeon is not known (Dadswell et al. 1984) but shortnose sturgeon have been found in waters with temperatures as low as 2 to 3ºC (35.6-37.4°F) (Dadswell et al. 1984) and as high as 34ºC (93.2°F) (Heidt and Gilbert 1978). However, water temperatures above 28ºC (82.4°F) are thought to adversely affect shortnose sturgeon. In the Altamaha River, water temperatures of 28-30ºC (82.4-86°F) during summer months create unsuitable conditions and shortnose sturgeon are found in deep cool water refuges. Dissolved oxygen (DO) also seems to play a role in temperature tolerance, with increased stress levels at higher temperatures with low DO versus the ability to withstand higher temperatures with elevated DO (Niklitchek 2001).

Shortnose sturgeon are known to occur at a wide range of depths. A minimum depth of 0.6m (approximately 2 feet) is necessary for the unimpeded swimming by adults. Shortnose sturgeon are known to occur at depths of up to 30m (98.4 ft) but are generally found in waters less than 20m (65.5 ft) (Dadswell et al. 1984; Dadswell 1979). Shortnose sturgeon have also demonstrated tolerance to a wide range of salinities. Shortnose sturgeon have been documented in freshwater (Taubert 1980; Taubert and Dadswell 1980) and in waters with salinity of 30 parts-per-thousand (ppt) (Holland and Yeverton 1973; Saunders and Smith 1978). Mcleave et al. (1977) reported adults moving freely through a wide range of salinities, crossing waters with differences of up to 10ppt within a two hour period. The tolerance of shortnose sturgeon to increasing salinity is thought to increase with age (Kynard 1996). Shortnose sturgeon typically occur in the deepest parts of rivers or estuaries where suitable oxygen and salinity values are present (Gilbert 1989); however, shortnose sturgeon forage on vegetated mudflats and over shellfish beds in shallower waters when suitable forage is present.

Status and Trends of Shortnose Sturgeon Rangewide
Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Although the original listing notice did not cite reasons for listing the species, a 1973 Resource Publication, issued by the US Department of the Interior, stated that shortnose sturgeon were “in peril…gone in most of the rivers of its former range [but] probably not as yet extinct” (USDOI 1973). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species’ decline. In the late nineteenth and early twentieth centuries, shortnose sturgeon commonly were taken in a commercial fishery for the closely related and commercially valuable Atlantic sturgeon (*Acipenser oxyrinchus*). More than a century of extensive fishing for sturgeon contributed to the decline of shortnose sturgeon along the east coast. Heavy industrial development during the twentieth century in rivers inhabited by sturgeon impaired water quality and impeded these species’ recovery; possibly resulting in substantially reduced abundance of shortnose sturgeon populations within portions of the species’ ranges (e.g., southernmost rivers of the species range: Santilla, St. Marys and St. Johns Rivers). A shortnose sturgeon recovery plan was published in December 1998 to promote the conservation and recovery of the species (see NMFS 1998). Shortnose sturgeon are listed as “vulnerable” on the IUCN Red List.

Although shortnose sturgeon are listed as endangered range-wide, in the final recovery plan NMFS recognized 19 separate populations occurring throughout the range of the species. These populations are in New Brunswick Canada (1); Maine (2); Massachusetts (1); Connecticut (1); New York (1); New Jersey/Delaware (1); Maryland and Virginia (1); North Carolina (1); South Carolina (4); Georgia (4); and Florida (2). NMFS has not formally recognized distinct population segments (DPS)[4] of shortnose sturgeon under the ESA. Although genetic information within and among shortnose sturgeon occurring in different river systems is largely unknown, life history studies indicate that shortnose sturgeon populations from different river systems are substantially reproductively isolated (Kynard 1997) and, therefore, should be considered discrete. The 1998 Recovery Plan indicates that while genetic information may reveal that interbreeding does not occur between rivers that drain into a common estuary, at this time, such

4 The definition of species under the ESA includes any subspecies of fish, wildlife, or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature. To be considered a DPS, a population segment must meet two criteria under NMFS policy. First, it must be discrete, or separated, from other populations of its species or subspecies. Second, it must be significant, or essential, to the long-term conservation status of its species or subspecies. This formal legal procedure to designate DPSs for shortnose sturgeon has not been undertaken.

river systems are considered a single population compromised of breeding subpopulations (NMFS 1998).

Studies conducted since the issuance of the Recovery Plan have provided evidence that suggests that years of isolation between populations of shortnose sturgeon have led to morphological and genetic variation. Walsh et al. (2001) examined morphological and genetic variation of shortnose sturgeon in three rivers (Kennebec, Androscoggin, and Hudson). The study found that the Hudson River shortnose sturgeon population differed markedly from the other two rivers for most morphological features (total length, fork length, head and snout length, mouth width, interorbital width and dorsal scute count, left lateral scute count, right ventral scute count). Significant differences were found between fish from Androscoggin and Kennebec rivers for interorbital width and lateral scute counts which suggests that even though the Androscoggin and Kennebec rivers drain into a common estuary, these rivers support largely discrete populations of shortnose sturgeon. The study also found significant genetic differences among all three populations indicating substantial reproductive isolation among them and that the observed morphological differences may be partly or wholly genetic.

Grunwald et al. (2002) examined mitochondrial DNA (mtDNA) from shortnose sturgeon in eleven river populations. The analysis demonstrated that all shortnose sturgeon populations examined showed moderate to high levels of genetic diversity as measured by haplotypic diversity indices. The limited sharing of haplotypes and the high number of private haplotypes are indicative of high homing fidelity and low gene flow. The researchers determined that glaciation in the Pleistocene Era was likely the most significant factor in shaping the phylogeographic pattern of mtDNA diversity and population structure of shortnose sturgeon. The Northern glaciated region extended south to the Hudson River while the southern non-glaciated region begins with the Delaware River. There is a high prevalence of haplotypes restricted to either of these two regions and relatively few are shared; this represents a historical subdivision that is tied to an important geological phenomenon that reflects historical isolation. Analyses of haplotype frequencies at the level of individual rivers showed significant differences among all systems in which reproduction is known to occur. This implies that although higher level genetic stock relationships exist (i.e., southern vs. northern and other regional subdivisions), shortnose sturgeon appear to be discrete stocks, and low gene flow exists between the majority of populations.

Waldman et al. (2002) also conducted mtDNA analysis on shortnose sturgeon from 11 river systems and identified 29 haplotypes. Of these haplotypes, 11 were unique to northern, glaciated systems and 13 were unique to the southern non-glaciated systems. Only 5 were shared between them. This analysis suggests that shortnose sturgeon show high structuring and discreteness and that low gene flow rates indicated strong homing fidelity.

Wirgin et al. (2005) also conducted mtDNA analysis on shortnose sturgeon from 12 rivers (St. John, Kennebec, Androscoggin, Upper Connecticut, Lower Connecticut, Hudson, Delaware, Chesapeake Bay, Cooper, Peedee, Savannah, Ogeechee and Altamaha). This analysis suggested that most population segments are independent and that genetic variation among groups was high.

The best available information demonstrates differences in life history and habitat preferences between northern and southern river systems and given the species' anadromous breeding habits, the rare occurrence of migration between river systems, and the documented genetic differences between river populations, it is unlikely that populations in adjacent river systems interbreed with any regularity. This likely accounts for the failure of shortnose sturgeon to repopulate river systems from which they have been extirpated, despite the geographic closeness of persisting populations. This characteristic of shortnose sturgeon also complicates recovery and persistence of this species in the future because, if a river population is extirpated in the future, it is unlikely that this river will be recolonized. Consequently, this Opinion will treat the nineteen separate populations of shortnose sturgeon as subpopulations (one of which occurs in the action area) for the purposes of this analysis.

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. The range extended from the St John River in New Brunswick, Canada to the Indian River in Florida. Today, only 19 populations remain ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Saint John River in New Brunswick, Canada. Shortnose sturgeon are large, long lived fish species. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes vary across the species' range. From available estimates, the smallest populations occur in the Cape Fear (~8 adults; Moser and Ross 1995) in the south and Merrimack and Penobscot rivers in the north (~ several hundred to several thousand adults depending on population estimates used; M. Kieffer, United States Geological Survey, personal communication; Dionne 2010), while the largest populations are found in the Saint John (~18, 000; Dadswell 1979) and Hudson Rivers (~61,000; Bain et al. 1998). As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1000 adults for 5 of 11 surveyed northern populations and all natural southern populations. Kynard 1996 indicates that all aspects of the species' life history indicate that shortnose sturgeon should be abundant in most rivers. As such, the expected abundance of adults in northern and north-central populations should be thousands to tens of thousands of adults. Expected abundance in southern rivers is uncertain, but large rivers should likely have thousands of adults. The only river systems likely supporting populations of these sizes are the St John, Hudson and possibly the Delaware and the Kennebec, making the continued success of shortnose sturgeon in these rivers critical to the species as a whole. While no reliable estimate of the size of either the total species population rangewide, or the shortnose sturgeon population in the Northeastern United States exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed.

Threats to shortnose sturgeon recovery rangewide

The Shortnose Sturgeon Recovery Plan (NMFS 1998) identifies habitat degradation or loss (resulting, for example, from dams, bridge construction, channel dredging, and pollutant discharges) and mortality (resulting, for example, from impingement on cooling water intake screens, dredging and incidental capture in other fisheries) as principal threats to the species' survival.

Several natural and anthropogenic factors continue to threaten the recovery of shortnose sturgeon. Shortnose sturgeon continue to be taken incidentally in fisheries along the east coast and are probably targeted by poachers throughout their range (Dadswell 1979; Dovel et al. 1992; Collins et al. 1996). In-water or nearshore construction and demolition projects may interfere with normal shortnose sturgeon migratory movements and disturb sturgeon concentration areas. Unless appropriate precautions are made, internal damage and/or death may result from blasting projects with powerful explosives. Hydroelectric dams may affect shortnose sturgeon by restricting habitat, altering river flows or temperatures necessary for successful spawning and/or migration and causing mortalities to fish that become entrained in turbines. Maintenance dredging of Federal navigation channels and other areas can adversely affect or jeopardize shortnose sturgeon populations. Hydraulic dredges can lethally take sturgeon by entraining sturgeon in dredge dragarms and impeller pumps. Mechanical dredges have also been documented to lethally take shortnose sturgeon. In addition to direct effects, dredging operations may also impact shortnose sturgeon by destroying benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with resuspended fine sediments. Shortnose sturgeon are susceptible to impingement on cooling water intake screens at power plants. Electric power and nuclear power generating plants can affect sturgeon by impinging larger fish on cooling water intake screens and entraining larval fish. The operation of power plants can have unforeseen and extremely detrimental impacts to riverine habitat which can affect shortnose sturgeon. For example, the St. Stephen Power Plant near Lake Moultrie, South Carolina was shut down for several days in June 1991 when large mats of aquatic plants entered the plant's intake canal and clogged the cooling water intake gates. Decomposing plant material in the tailrace canal coupled with the turbine shut down (allowing no flow of water) triggered a low dissolved oxygen water condition downstream and a subsequent fish kill. The South Carolina Wildlife and Marine Resources Department reported that twenty shortnose sturgeon were killed during this low dissolved oxygen event.

Contaminants, including toxic metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs) can have substantial deleterious effects on aquatic life including production of acute lesions, growth retardation, and reproductive impairment (Cooper 1989; Sinderman 1994). Ultimately, toxins introduced to the water column become associated with the benthos and can be particularly harmful to benthic organisms (Varanasi 1992) like sturgeon. Heavy metals and organochlorine compounds are known to accumulate in fat tissues of sturgeon, but their long term effects are not yet known (Ruelle and Henry 1992; Ruelle and Kennlyne 1993). Available data suggests that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976).

Although there is scant information available on the levels of contaminants in shortnose sturgeon tissues, some research on other related species indicates that concern about the effects of contaminants on the health of sturgeon populations is warranted. Detectible levels of chlordane, DDE (1,1-dichloro-2, 2-bis(p-chlorophenyl)ethylene), DDT (dichlorodiphenyl-trichloroethane), and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were found in pallid sturgeon tissue from the Missouri River (Ruelle and Henry 1994). These compounds were found in high enough levels to suggest they may be causing reproductive failure and/or increased physiological stress (Ruelle and Henry 1994). In addition to compiling data on contaminant levels, Ruelle and Henry also determined that heavy metals and organochlorine compounds (i.e. PCBs) accumulate in fat tissues. Although the long term effects of the accumulation of contaminants in fat tissues is not yet known, some speculate that lipophilic toxins could be transferred to eggs and potentially inhibit egg viability. In other fish species, reproductive impairment, reduced egg viability, and reduced survival of larval fish are associated with elevated levels of environmental contaminants including chlorinated hydrocarbons. A strong correlation that has been made between fish weight, fish fork length, and DDE concentration in pallid sturgeon livers indicates that DDE increases proportionally with fish size (NMFS 1998).

Contaminant analysis was conducted on two shortnose sturgeon from the Delaware River in the fall of 2002. Muscle, liver, and gonad tissue were analyzed for contaminants (ERC 2002). Sixteen metals, two semivolatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs, DDE (an organochlorine pesticide) were detected in the "adverse affect" range. It is of particular concern that of the above chemicals, PCDDs, DDE, PCBs and cadmium, were detected as these have been identified as endocrine disrupting chemicals. Contaminant analysis conducted in 2003 on tissues from a shortnose sturgeon from the Kennebec River revealed the presence of fourteen metals, one semivolatile compound, one PCB Aroclor, Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in one or more of the tissue samples. Of these chemicals, cadmium and zinc were detected at concentrations above an adverse effect concentration reported for fish in the literature (ERC 2003). While no directed studies of chemical contamination in shortnose sturgeon have been undertaken, it is evident that the heavy industrialization of the rivers where shortnose sturgeon are found is likely adversely affecting this species.

During summer months, especially in southern areas, shortnose sturgeon must cope with the physiological stress of water temperatures that may exceed 28ºC. Flourney et al.(1992) suspected that, during these periods, shortnose sturgeon congregate in river regions which support conditions that relieve physiological stress (i.e., in cool deep thermal refuges). In southern rivers where sturgeon movements have been tracked, sturgeon refrain from moving during warm water conditions and are often captured at release locations during these periods (Flourney et al.1992; Rogers and Weber 1994; Weber 1996). The loss and/or manipulation of these discrete refuge habitats may limit or be limiting population survival, especially in southern river systems.

Pulp mill, silvicultural, agricultural, and sewer discharges, as well as a combination of non-point source discharges, which contain elevated temperatures or high biological demand, can reduce dissolved oxygen levels. Shortnose sturgeon are known to be adversely affected by dissolved oxygen levels below 5 mg/L. Shortnose sturgeon may be less tolerant of low dissolved oxygen levels in high ambient water temperatures and show signs of stress in water temperatures higher than 28ºC (82.4°F) (Flourney et al. 1992). At these temperatures, concomitant low levels of dissolved oxygen may be lethal.

4.2 Atlantic Sturgeon

The section below describes the Atlantic sturgeon listing, provides life history information that is relevant to all DPSs of Atlantic sturgeon and then provides information specific to the status of each DPS of Atlantic sturgeon. Below, we also provide a description of which Atlantic sturgeon

DPSs likely occur in the action area and provide information on the use of the action area by Atlantic sturgeon.

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a subspecies of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA (Scott and Scott, 1988; ASSRT, 2007; T. Savoy, CT DEP, pers. comm.). NMFS has delineated U.S. populations of Atlantic sturgeon into five DPSs (77 FR 5880 and 77 FR 5914). These are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs (see Figure 1). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King, 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada occur throughout the full range of the subspecies. Therefore, sturgeon originating from any of the five DPSs can be affected by threats in the marine, estuarine and riverine environment that occur far from natal spawning rivers.

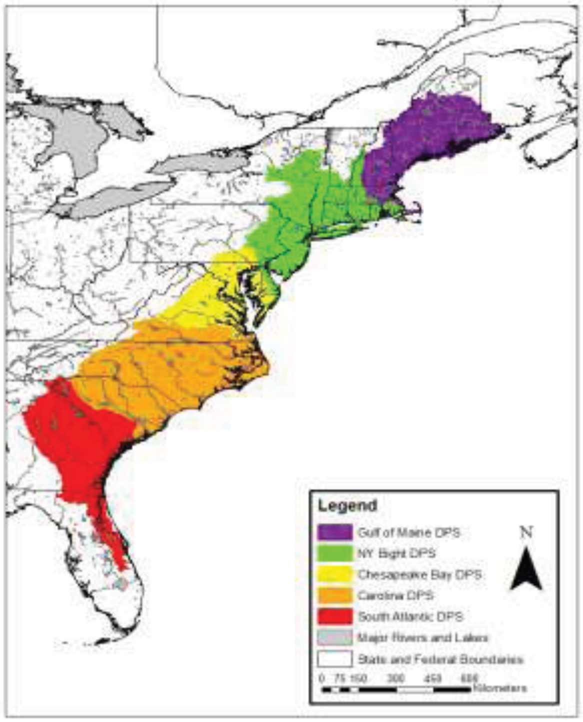
On February 6, 2012, we published notice in the *Federal Register* that we were listing the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs as endangered, and the Gulf of Maine DPS as threatened (77 FR 5880 and 77 FR 5914). The effective date of the listings was April 6, 2012. The DPSs do not include Atlantic sturgeon that are spawned in Canadian rivers. Therefore, Canadian spawned fish are not included in the listings.

As described below, individuals originating from three of the five listed DPSs may occur in the action area. Information general to all Atlantic sturgeon as well as information specific to each of the relevant DPSs, is provided below.

4.2.1 Determination of DPS Composition in the Action Area

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. We have determined that Atlantic sturgeon in the action area likely originate from three of the five DPSs at the following frequencies: Gulf of Maine 6%; NYB 92%; and, Chesapeake Bay 2%. These percentages are based on genetic sampling of individuals (n=39) captured within the Hudson River and therefore, represent the best available information on the likely genetic makeup of individuals occurring in the action area. The genetic assignments have a plus/minus 5% confidence interval; however, for purposes of section 7 consultation we have selected the reported values above, which approximate the mid-point of the range, as a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. These assignments and the data from which they are derived are described in detail in Damon-Randall *et al.* (2012a).

Figure 1. Map Depicting the Boundaries of the five Atlantic sturgeon DPSs



4.2.2 Atlantic sturgeon life history

Atlantic sturgeon are long lived (approximately 60 years), late maturing, estuarine dependent, anadromous[5] fish (Bigelow and Schroeder, 1953; Vladykov and Greeley 1963; Mangin, 1964; Pikitch *et al.*, 2005; Dadswell, 2006; ASSRT, 2007).

The life history of Atlantic sturgeon can be divided up into five general categories as described in the table below (adapted from ASSRT 2007).

[5] Anadromous refers to a fish that is born in freshwater, spends most of its life in the sea, and returns to freshwater to spawn (NEFSC FAQ's, available at http://www.nefsc.noaa.gov/faq/fishfaq1a.html, modified June 16, 2011)

Age Class	Size	Description
Egg		Fertilized or unfertilized
Larvae		Negative photo-taxic, nourished by yolk sac
Young of Year (YOY)	**0.3 grams <41 cm TL**	Fish that are > 3 months and < one year; capable of capturing and consuming live food
Non-migrant subadults or juveniles	**>41 cm and <76 cm TL**	Fish that are at least age 1 and are not sexually mature and do not make coastal migrations.
Subadults	**>76cm and <150cm TL**	Fish that are not sexually mature but make coastal migrations
Adults	**>150 cm TL**	Sexually mature fish

Table 1. Descriptions of Atlantic sturgeon life history stages.

Atlantic sturgeon are a relatively large fish, even amongst sturgeon species (Pikitch *et al.*, 2005). Atlantic sturgeons are bottom feeders that suck food into a ventrally-located protruding mouth (Bigelow and Schroeder, 1953). Four barbels in front of the mouth assist the sturgeon in locating prey (Bigelow and Schroeder, 1953). Diets of adult and migrant subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007; Savoy, 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007).

Rate of maturation is affected by water temperature and gender. In general: (1) Atlantic sturgeon that originate from southern systems grow faster and mature sooner than Atlantic sturgeon that originate from more northern systems; (2) males grow faster than females; (3) fully mature females attain a larger size (i.e. length) than fully mature males; and (4) the length of Atlantic sturgeon caught since the mid-late 20th century have typically been less than 3 meters (m) (Smith *et al.*, 1982; Smith *et al.*, 1984; Smith, 1985; Scott and Scott, 1988; Young *et al.*, 1998; Collins *et al.*, 2000; Caron *et al.*, 2002; Dadswell, 2006; ASSRT, 2007; Kahnle *et al.*, 2007; DFO, 2011).

The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 m (Vladykov and Greeley, 1963). Dadswell (2006) reported seeing seven fish of comparable size in the St. John River estuary from 1973 to 1995. Observations of large-sized sturgeon are particularly important given that egg production is correlated with age and body size (Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Dadswell, 2006). However, while females are prolific with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of 2-5 years (Vladykov and Greeley, 1963; Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Stevenson and Secor, 1999; Dadswell, 2006). Given spawning periodicity and a female's relatively late age to maturity, the age at which 50 percent of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman, 1997). Males exhibit spawning periodicity of 1-5 years (Smith, 1985; Collins *et al.*, 2000; Caron *et al.*, 2002). While long-lived, Atlantic sturgeon are exposed to a multitude of threats prior to achieving maturation and have a limited number of spawning opportunities once mature.

Water temperature plays a primary role in triggering the timing of spawning migrations (ASMFC, 2009). Spawning migrations generally occur during February-March in southern systems, April-May in Mid-Atlantic systems, and May-July in Canadian systems (Murawski and Pacheco, 1977; Smith, 1985; Bain, 1997; Smith and Clugston, 1997; Caron *et al.*, 2002). Male sturgeon begin upstream spawning migrations when waters reach approximately 6° C (43° F) (Smith *et al.*, 1982; Dovel and Berggren, 1983; Smith, 1985; ASMFC, 2009), and remain on the spawning grounds throughout the spawning season (Bain, 1997). Females begin spawning migrations when temperatures are closer to 12° C to 13° C (54° to 55° F) (Dovel and Berggren, 1983; Smith, 1985; Collins *et al.*, 2000), make rapid spawning migrations upstream, and quickly depart following spawning (Bain, 1997).

The spawning areas in most U.S. rivers have not been well defined. However, the habitat characteristics of spawning areas have been identified based on historical accounts of where fisheries occurred, tracking and tagging studies of spawning sturgeon, and physiological needs of early life stages. Spawning is believed to occur in flowing water between the salt front of estuaries and the fall line of large rivers, when and where optimal flows are 46-76 cm/s and depths are 3-27 m (Borodin, 1925; Dees, 1961; Leland, 1968; Scott and Crossman, 1973; Crance, 1987; Shirey *et al.* 1999; Bain *et al.*, 2000; Collins *et al.*, 2000; Caron *et al.* 2002; Hatin *et al.* 2002; ASMFC, 2009). Sturgeon eggs are deposited on hard bottom substrate such as cobble, coarse sand, and bedrock (Dees, 1961; Scott and Crossman, 1973; Gilbert, 1989; Smith and Clugston, 1997; Bain *et al.* 2000; Collins *et al.*, 2000; Caron *et al.*, 2002; Hatin *et al.*, 2002; Mohler, 2003; ASMFC, 2009), and become adhesive shortly after fertilization (Murawski and Pacheco, 1977; Van den Avyle, 1983; Mohler, 2003). Incubation time for the eggs increases as water temperature decreases (Mohler, 2003). At temperatures of 20° and 18° C, hatching occurs approximately 94 and 140 hours, respectively, after egg deposition (ASSRT, 2007).

Larval Atlantic sturgeon (i.e. less than 4 weeks old, with total lengths (TL) less than 30 mm; Van Eenennaam *et al.* 1996) are assumed to undertake a demersal existence and inhabit the same riverine or estuarine areas where they were spawned (Smith *et al.*, 1980; Bain *et al.*, 2000; Kynard and Horgan, 2002; ASMFC, 2009). Studies suggest that age-0 (i.e., young-of-year), age-1, and age-2 juvenile Atlantic sturgeon occur in low salinity waters of the natal estuary (Haley, 1999; Hatin *et al.*, 2007; McCord *et al.*, 2007; Munro *et al.*, 2007) while older fish are more salt tolerant and occur in higher salinity waters as well as low salinity waters (Collins *et al.*, 2000). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (Holland and Yelverton, 1973; Dovel and Berggen, 1983; Waldman *et al.*, 1996; Dadswell, 2006; ASSRT, 2007).

After emigration from the natal estuary, subadults and adults travel within the marine environment, typically in waters less than 50 m in depth, using coastal bays, sounds, and ocean waters (Vladykov and Greeley, 1963; Murawski and Pacheco, 1977; Dovel and Berggren, 1983; Smith, 1985; Collins and Smith, 1997; Welsh *et al.*, 2002; Savoy and Pacileo, 2003; Stein *et al.*, 2004; USFWS, 2004; Laney *et al.*, 2007; Dunton *et al.*, 2010; Erickson *et al.*, 2011; Wirgin and King, 2011). Tracking and tagging studies reveal seasonal movements of Atlantic sturgeon along the coast. Satellite-tagged adult sturgeon from the Hudson River concentrated in the southern part of the Mid-Atlantic Bight at depths greater than 20 m during winter and spring, and in the northern portion of the Mid-Atlantic Bight at depths less than 20 m in summer and fall (Erickson *et al.*, 2011). Shirey (Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC, 2009) found a similar movement pattern for juvenile Atlantic sturgeon based on recaptures of fish originally tagged in the Delaware River. After leaving the Delaware River estuary during the fall, juvenile Atlantic sturgeon were recaptured by commercial fishermen in nearshore waters along the Atlantic coast as far south as Cape Hatteras, North Carolina from November through early March. In the spring, a portion of the tagged fish re-entered the Delaware River estuary. However, many fish continued a northerly coastal migration through the Mid-Atlantic as well as into southern New England waters where they were recovered throughout the summer months. Movements as far north as Maine were documented. A southerly coastal migration was apparent from tag returns reported in the fall. The majority of these tag returns were reported from relatively shallow near shore fisheries with few fish reported from waters in excess of 25 m (C. Shirey, Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC, 2009). Areas where migratory Atlantic sturgeon commonly aggregate include the Bay of Fundy (e.g., Minas and Cumberland Basins), Massachusetts Bay, Connecticut River estuary, Long Island Sound, New York Bight, Delaware Bay, Chesapeake Bay, and waters off of North Carolina from the Virginia/North Carolina border to Cape Hatteras at depths up to 24 m (Dovel and Berggren, 1983; Dadswell *et al.*, 1984; Johnson *et al.*, 1997; Rochard *et al.*, 1997; Kynard *et al.*, 2000; Eyler *et al.*, 2004; Stein *et al.*, 2004; Wehrell, 2005; Dadswell, 2006; ASSRT, 2007; Laney *et al.*, 2007). These sites may be used as foraging sites and/or thermal refuge.

4.1.2 Distribution and Abundance

Atlantic sturgeon underwent significant range-wide declines from historical abundance levels due to overfishing in the mid to late 19th century when a caviar market was established (Scott and Crossman, 1973; Taub, 1990; Kennebec River Resource Management Plan, 1993; Smith and Clugston, 1997; Dadswell, 2006; ASSRT, 2007). Abundance of spawning-aged females prior to this period of exploitation was predicted to be greater than 100,000 for the Delaware, and at least 10,000 females for other spawning stocks (Secor and Waldman, 1999; Secor, 2002). Historical records suggest that Atlantic sturgeon spawned in at least 35 rivers prior to this period. Currently, only 16 U.S. rivers are known to support spawning based on available evidence (i.e., presence of young-of-year or gravid Atlantic sturgeon documented within the past 15 years)

(ASSRT, 2007). While there may be other rivers supporting spawning for which definitive evidence has not been obtained (e.g., in the Penobscot and York Rivers), the number of rivers supporting spawning of Atlantic sturgeon are approximately half of what they were historically. In addition, only four rivers (Kennebec, Hudson, Delaware, James) are known to currently support spawning from Maine through Virginia where historical records support there used to be fifteen spawning rivers (ASSRT, 2007). Thus, there are substantial gaps in the range between Atlantic sturgeon spawning rivers amongst northern and mid-Atlantic states which could make recolonization of extirpated populations more difficult.

There are no current, published population abundance estimates for any spawning stock or for any of the five DPSs of Atlantic sturgeon. An annual mean estimate of 863 mature adults (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.*, 2007). An estimate of 343 spawning adults per year is available for the Altamaha River, GA, based on fishery-independent data collected in 2004 and 2005 (Schueller and Peterson, 2006). Using the data collected from the Hudson River and Altamaha River to estimate the total number of Atlantic sturgeon in either subpopulation is not possible, since mature Atlantic sturgeon may not spawn every year (Vladykov and Greeley, 1963; Smith, 1985; Van Eenennaam *et al.*, 1996; Stevenson and Secor, 1999; Collins *et al.* 2000; Caron *et al.*, 2002), the age structure of these populations is not well understood, and stage to stage survival is unknown. In other words, the information that would allow us to take an estimate of annual spawning adults and expand that estimate to an estimate of the total number of individuals (e.g., yearlings, subadults, and adults) in a population is lacking. The ASSRT presumed that the Hudson and Altamaha rivers had the most robust of the remaining U.S. Atlantic sturgeon spawning populations and concluded that the other U.S. spawning populations were likely less than 300 spawning adults per year (ASSRT, 2007).

4.1.3 Threats faced by Atlantic sturgeon throughout their range

Atlantic sturgeon are susceptible to over exploitation given their life history characteristics (e.g., late maturity, dependence on a wide-variety of habitats). Similar to other sturgeon species (Vladykov and Greeley, 1963; Pikitch *et al.*, 2005), Atlantic sturgeon experienced range-wide declines from historical abundance levels due to overfishing (for caviar and meat) and impacts to habitat in the 19th and 20th centuries (Taub, 1990; Smith and Clugston, 1997; Secor and Waldman, 1999).

Based on the best available information, NMFS has concluded that unintended catch of Atlantic sturgeon in fisheries, vessel strikes, poor water quality, water availability, dams, lack of regulatory mechanisms for protecting the fish, and dredging are the most significant threats to Atlantic sturgeon (77 FR 5880 and 77 FR 5914; February 6, 2012). While all of the threats are not necessarily present in the same area at the same time, given that Atlantic sturgeon subadults and adults use ocean waters from the Labrador, Canada to Cape Canaveral, FL, as well as estuaries of large rivers along the U.S. East Coast, activities affecting these water bodies are likely to impact more than one Atlantic sturgeon DPS. In addition, given that Atlantic sturgeon depend on a variety of habitats, every life stage is likely affected by one or more of the identified threats.

An ASMFC interstate fishery management plan for sturgeon (Sturgeon FMP) was developed and implemented in 1990 (Taub, 1990). In 1998, the remaining Atlantic sturgeon fisheries in U.S. state waters were closed per Amendment 1 to the Sturgeon FMP. Complementary regulations were implemented by NMFS in 1999 that prohibit fishing for, harvesting, possessing or retaining Atlantic sturgeon or its parts in or from the Exclusive Economic Zone in the course of a commercial fishing activity.

Commercial fisheries for Atlantic sturgeon still exist in Canadian waters (DFO, 2011). Sturgeon belonging to one or more of the DPSs may be harvested in the Canadian fisheries. In particular, the Bay of Fundy fishery in the Saint John estuary may capture sturgeon of U.S. origin given that sturgeon from the Gulf of Maine and the New York Bight DPSs have been incidentally captured in other Bay of Fundy fisheries (DFO, 2010; Wirgin and King, 2011). Because Atlantic sturgeon are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), the U.S. and Canada are currently working on a conservation strategy to address the potential for captures of U.S. fish in Canadian directed Atlantic sturgeon fisheries and of Canadian fish incidentally in U.S. commercial fisheries. At this time, there are no estimates of the number of individuals from any of the DPSs that are captured or killed in Canadian fisheries each year.

Based on geographic distribution, most U.S. Atlantic sturgeon that are intercepted in Canadian fisheries are likely to originate from the Gulf of Maine DPS, with a smaller percentage from the New York Bight DPS.

Individuals from all 5 DPSs are caught as bycatch in fisheries operating in U.S. waters. At this time, we have an estimate of the number of Atlantic sturgeon captured and killed in sink gillnet and otter trawl fisheries authorized by Federal FMPs (NMFS NEFSC 2011) in the Northeast Region but do not have a similar estimate for Southeast fisheries. We also do not have an estimate of the number of Atlantic sturgeon captured or killed in state fisheries. At this time, we are not able to quantify the effects of other significant threats (e.g., vessel strikes, poor water quality, water availability, dams, and dredging) in terms of habitat impacts or loss of individuals. While we have some information on the number of mortalities that have occurred in the past in association with certain activities (e.g., mortalities in the Delaware and James rivers that are thought to be due to vessel strikes), we are not able to use those numbers to extrapolate effects throughout one or more DPS. This is because of (1) the small number of data points and, (2) lack of information on the percent of incidences that the observed mortalities represent.

As noted above, the NEFSC prepared an estimate of the number of encounters of Atlantic sturgeon in fisheries authorized by Northeast FMPs (NEFSC 2011). The analysis prepared by the NEFSC estimates that from 2006 through 2010 there were 2,250 to 3,862 encounters per year in observed gillnet and trawl fisheries, with an average of 3,118 encounters. Mortality rates in gillnet gear are approximately 20%. Mortality rates in otter trawl gear are believed to be lower at approximately 5%.

4.2 Gulf of Maine DPS of Atlantic sturgeon

The Gulf of Maine DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, MA. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT, 2007). Spawning still occurs in the Kennebec River, and it is possible that it still occurs in the Penobscot River as well. Spawning in the Androscoggin River was just recently confirmed by the Maine Department of Marine Resources when they captured a larval Atlantic sturgeon during the 2011 spawning season below the Brunswick Dam. There is no evidence of recent spawning in the remaining rivers. In the 1800s, construction of the Essex Dam on the Merrimack River at river kilometer (rkm) 49 blocked access to 58 percent of Atlantic sturgeon habitat in the river (Oakley, 2003; ASSRT, 2007). However, the accessible portions of the Merrimack seem to be suitable habitat for Atlantic sturgeon spawning and rearing (i.e., nursery habitat) (Keiffer and Kynard, 1993). Therefore, the availability of spawning habitat does not appear to be the reason for the lack of observed spawning in the Merrimack River. Studies are on-going to determine whether Atlantic sturgeon are spawning in these rivers. Atlantic sturgeons that are spawned elsewhere continue to use habitats within all of these rivers as part of their overall marine range (ASSRT, 2007). The movement of subadult and adult sturgeon between rivers, including to and from the Kennebec River and the Penobscot River, demonstrates that coastal and marine migrations are key elements of Atlantic sturgeon life history for the Gulf of Maine DPS as well as likely throughout the entire range (ASSRT, 2007; Fernandes, *et al.*, 2010).

Bigelow and Schroeder (1953) surmised that Atlantic sturgeon likely spawned in Gulf of Maine Rivers in May-July. More recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning more likely occurs in June-July (Squiers *et al.*, 1981; ASMFC, 1998; NMFS and USFWS, 1998). Evidence for the timing and location of Atlantic sturgeon spawning in the Kennebec River includes: (1) the capture of five adult male Atlantic sturgeon in spawning condition (i.e., expressing milt) in July 1994 below the (former) Edwards Dam; (2) capture of 31 adult Atlantic sturgeon from June 15,1980, through July 26,1980, in a small commercial fishery directed at Atlantic sturgeon from the South Gardiner area (above Merrymeeting Bay) that included at least 4 ripe males and 1 ripe female captured on July 26,1980; and, (3) capture of nine adults during a gillnet survey conducted from 1977-1981, the majority of which were captured in July in the area from Merrymeeting Bay and upriver as far as Gardiner, ME (NMFS and USFWS, 1998; ASMFC 2007). The low salinity values for waters above Merrymeeting Bay are consistent with values found in other rivers where successful Atlantic sturgeon spawning is known to occur.

Several threats play a role in shaping the current status of Gulf of Maine DPS Atlantic sturgeon. Historical records provide evidence of commercial fisheries for Atlantic sturgeon in the Kennebec and Androscoggin Rivers dating back to the 17th century (Squiers *et al.*, 1979). In 1849, 160 tons of sturgeon was caught in the Kennebec River by local fishermen (Squiers *et al.*, 1979). Following the 1880's, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon by-catch has been prohibited since 1998. Nevertheless, mortalities associated with bycatch in fisheries occurring in state and federal waters still occurs. In the marine range, Gulf of Maine DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.*, 2004; ASMFC 2007). As explained above, we have estimates of the number of subadults and adults that are killed as a result of bycatch in fisheries authorized under Northeast FMPs. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats. Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Many rivers in the Gulf of Maine DPS have navigation channels that are maintained by dredging. Dredging outside of Federal channels and in-water construction occurs throughout the Gulf of Maine DPS. While some dredging projects operate with observers present to document fish mortalities, many do not. To date we have not received any reports of Atlantic sturgeon killed during dredging projects in the Gulf of Maine region; however, as noted above, not all projects are monitored for interactions with fish. At this time, we do not have any information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects. We are also not able to quantify any effects to habitat.

Connectivity is disrupted by the presence of dams on several rivers in the Gulf of Maine region, including the Penobscot and Merrimack Rivers. While there are also dams on the Kennebec, Androscoggin and Saco Rivers, these dams are near the site of natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon are known to occur upstream of any hydroelectric projects in the Gulf of Maine region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. While not expected to be killed or injured during passage at a dam, the extent that Atlantic sturgeon are affected by the existence of dams and their operations in the Gulf of Maine region is currently unknown. The extent that Atlantic sturgeon are affected by operations of dams in the Gulf of Maine region is currently unknown; however, the documentation of an Atlantic sturgeon larvae downstream of the Brunswick Dam in the Androscoggin River suggests that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. The range of Atlantic sturgeon in the Penobscot River is limited by the presence of the Veazie and Great Works Dams. Together these dams prevent Atlantic sturgeon from accessing approximately 29 km of habitat, including the presumed historical spawning habitat located downstream of Milford Falls, the site of the Milford Dam. While removal of the Veazie and Great Works Dams is anticipated to occur in the near future, the presence of these dams is currently preventing access to significant habitats within the Penobscot River. While Atlantic sturgeon are known to occur in the Penobscot River, it is unknown if spawning is currently occurring or whether the presence of the Veazie and Great Works Dams affects the likelihood of spawning occurring in this river. The Essex Dam on the Merrimack River blocks access to approximately 58% of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented. Like the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning occurring in this river.

Gulf of Maine DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Gulf of Maine over the past decades (Lichter *et al.* 2006; EPA, 2008). Many rivers in Maine, including the Androscoggin River, were heavily polluted in the past from industrial discharges from pulp and paper mills. While water quality has improved and most discharges are limited through regulations, many pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds as developing eggs and larvae are particularly susceptible to exposure to contaminants.

There are no empirical abundance estimates for the Gulf of Maine DPS. The Atlantic sturgeon SRT (2007) presumed that the Gulf of Maine DPS was comprised of less than 300 spawning adults per year, based on abundance estimates for the Hudson and Altamaha River riverine populations of Atlantic sturgeon. Surveys of the Kennebec River over two time periods, 1977-1981 and 1998-2000, resulted in the capture of nine adult Atlantic sturgeon (Squiers, 2004). However, since the surveys were primarily directed at capture of shortnose sturgeon, the capture gear used may not have been selective for the larger-sized, adult Atlantic sturgeon; several hundred subadult Atlantic sturgeon were caught in the Kennebec River during these studies.

Summary of the Gulf of Maine DPS
Spawning for the Gulf of Maine DPS is known to occur in two rivers (Kennebec and Androscoggin) and possibly in a third. Spawning may be occurring in other rivers, such as the Sheepscot or Penobscot, but has not been confirmed. There are indications of increasing abundance of Atlantic sturgeon belonging to the Gulf of Maine DPS. Atlantic sturgeon continue to be present in the Kennebec River; in addition, they are captured in directed research projects in the Penobscot River, and are observed in rivers where they were unknown to occur or had not been observed to occur for many years (e.g., the Saco, Presumpscot, and Charles rivers). These observations suggest that abundance of the Gulf of Maine DPS of Atlantic sturgeon is sufficient such that recolonization to rivers historically suitable for spawning may be occurring. However, despite some positive signs, there is not enough information to establish a trend for this DPS.

Some of the impacts from the threats that contributed to the decline of the Gulf of Maine DPS have been removed (e.g., directed fishing), or reduced as a result of improvements in water quality and removal of dams (e.g., the Edwards Dam on the Kennebec River in 1999). There are strict regulations on the use of fishing gear in Maine state waters that incidentally catch sturgeon. In addition, there have been reductions in fishing effort in state and federal waters, which most likely would result in a reduction in bycatch mortality of Atlantic sturgeon. A significant amount of fishing in the Gulf of Maine is conducted using trawl gear, which is known to have a much lower mortality rate for Atlantic sturgeon caught in the gear compared to sink gillnet gear (ASMFC, 2007). Atlantic sturgeon from the GOM DPS are not commonly taken as bycatch in areas south of Chatham, MA, with only 8 percent (e.g., 7 of the 84 fish) of interactions observed in the Mid Atlantic/Carolina region being assigned to the Gulf of Maine DPS (Wirgin and King, 2011). Tagging results also indicate that Gulf of Maine DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south. However, data on Atlantic sturgeon incidentally caught in trawls and intertidal fish weirs fished in the Minas Basin area of the Bay of Fundy.(Canada) indicate that approximately 35 percent originated from the Gulf of Maine DPS (Wirgin *et al.*, in draft).

As noted previously, studies have shown that in order to rebuild, Atlantic sturgeon can only sustain low levels of bycatch and other anthropogenic mortality (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007; Brown and Murphy, 2010). NMFS has determined that the Gulf of Maine DPS is at risk of becoming endangered in the foreseeable future throughout all of its range (i.e., is a threatened species) based on the following: (1) significant declines in population sizes and the protracted period during which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect recovery.

4.3 New York Bight DPS of Atlantic sturgeon

The New York Bight DPS includes the following: all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, MA to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (Murawski and Pacheco, 1977; Secor, 2002; ASSRT, 2007). Spawning still occurs in the Delaware and Hudson Rivers, but there is no recent evidence (within the last 15 years) of spawning in the Connecticut and Taunton Rivers (ASSRT, 2007). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT, 2007; Savoy, 2007; Wirgin and King, 2011).

The abundance of the Hudson River Atlantic sturgeon riverine population prior to the onset of expanded exploitation in the 1800's is unknown but, has been conservatively estimated at 10,000 adult females (Secor, 2002). Current abundance is likely at least one order of magnitude smaller than historical levels (Secor, 2002; ASSRT, 2007; Kahnle *et al.*, 2007). As described above, an estimate of the mean annual number of mature adults (863 total; 596 males and 267 females) was calculated for the Hudson River riverine population based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.*, 2007). Kahnle *et al.* (1998; 2007) also showed that the level of fishing mortality from the Hudson River Atlantic sturgeon fishery during the period of 1985-1995 exceeded the estimated sustainable level of fishing mortality for the riverine population and may have led to reduced recruitment. All available data on abundance of juvenile Atlantic sturgeon in the Hudson River Estuary indicate a substantial drop in production of young since the mid 1970s (Kahnle *et al.*, 1998). A decline appeared to occur in the mid to late 1970s followed by a secondary drop in the late 1980s (Kahnle *et al.*, 1998; Sweka *et al.*, 2007; ASMFC, 2010). Catch-per-unit-effort data suggests that recruitment has remained depressed relative to catches of juvenile Atlantic sturgeon in the estuary during the mid-late 1980's (Sweka *et al.*, 2007; ASMFC, 2010). In examining the CPUE data from 1985-2007, there are significant fluctuations during this time. There appears to be a decline in the number of juveniles between the late 1980s and early 1990s and while the CPUE is generally higher in the 2000s as compared to the 1990s. Given the significant annual fluctuation, it is difficult to discern any trend. Despite the CPUEs from 2000-2007 being generally higher than those from 1990-1999, they are low compared to the late 1980s. There is currently not enough information regarding any life stage to establish a trend for the Hudson River population.

There is no abundance estimate for the Delaware River population of Atlantic sturgeon. Harvest records from the 1800s indicate that this was historically a large population with an estimated 180,000 adult females prior to 1890 (Secor and Waldman, 1999; Secor, 2002). Sampling in 2009 to target young-of- the year (YOY) Atlantic sturgeon in the Delaware River (i.e., natal sturgeon) resulted in the capture of 34 YOY, ranging in size from 178 to 349 mm TL (Fisher, 2009) and the collection of 32 YOY Atlantic sturgeon in a separate study (Brundage and O'Herron in Calvo *et al.*, 2010). Genetics information collected from 33 of the 2009 year class YOY indicates that at least 3 females successfully contributed to the 2009 year class (Fisher, 2011). Therefore, while the capture of YOY in 2009 provides evidence that successful spawning is still occurring in the Delaware River, the relatively low numbers suggest the existing riverine population is limited in size.

Several threats play a role in shaping the current status and trends observed in the Delaware River and Estuary. In-river threats include habitat disturbance from dredging, and impacts from historical pollution and impaired water quality. A dredged navigation channel extends from Trenton seaward through the tidal river (Brundage and O'Herron, 2009), and the river receives significant shipping traffic. Vessel strikes have been identified as a threat in the Delaware River; however, at this time we do not have information to quantify this threat or its impact to the population or the New York Bight DPS. Similar to the Hudson River, there is currently not enough information to determine a trend for the Delaware River population.

Summary of the New York Bight DPS
Atlantic sturgeon originating from the New York Bight DPS spawn in the Hudson and Delaware rivers. While genetic testing can differentiate between individuals originating from the Hudson or Delaware river the available information suggests that the straying rate is high between these rivers. There are no indications of increasing abundance for the New York Bight DPS (ASSRT, 2009; 2010). Some of the impact from the threats that contributed to the decline of the New York Bight DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act (CWA). In addition, there have been reductions in fishing effort in state and federal waters, which may result in a reduction in bycatch mortality of Atlantic sturgeon. Nevertheless, areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in state and federally-managed fisheries, and vessel strikes remain significant threats to the New York Bight DPS.

In the marine range, New York Bight DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.*, 2004; ASMFC 2007). As explained above, currently available estimates indicate that at least 4% of adults may be killed as a result of bycatch in fisheries authorized under Northeast FMPs. Based on mixed stock analysis results presented by Wirgin and King (2011), over 40 percent of the Atlantic sturgeon bycatch interactions in the Mid Atlantic Bight region were sturgeon from the New York Bight DPS. Individual-based assignment and mixed stock analysis of samples collected from sturgeon captured in Canadian fisheries in the Bay of Fundy indicated that approximately 1-2% were from the New York Bight DPS. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Both the Hudson and Delaware rivers have navigation channels that are maintained by dredging. Dredging is also used to maintain channels in the nearshore marine environment. Dredging outside of Federal channels and in-water construction occurs throughout the New York Bight region. While some dredging projects operate with observers present to document fish mortalities many do not. We have reports of one Atlantic sturgeon entrained during hopper dredging operations in Ambrose Channel, New Jersey. At this time, we do not have any information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects are also not able to quantify any effects to habitat.

In the Hudson and Delaware Rivers, dams do not block access to historical habitat. The Holyoke Dam on the Connecticut River blocks further upstream passage; however, the extent that Atlantic sturgeon would historically have used habitat upstream of Holyoke is unknown. Connectivity may be disrupted by the presence of dams on several smaller rivers in the New York Bight region. Because no Atlantic sturgeon occur upstream of any hydroelectric projects in the New York Bight region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. The extent that Atlantic sturgeon are affected by operations of dams in the New York Bight region is currently unknown.

New York Bight DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Hudson and Delaware over the past decades (Lichter *et al.* 2006; EPA, 2008). Both the Hudson and Delaware rivers, as well as other rivers in the New York Bight region, were heavily polluted in the past from industrial and sanitary sewer discharges. While water quality has improved and most discharges are limited through regulations, many pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds as developing eggs and larvae are particularly susceptible to exposure to contaminants.

Vessel strikes occur in the Delaware River. Twenty-nine mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2004 to 2008, and at least 13 of these fish were large adults. Given the time of year in which the fish were observed (predominantly May through July, with two in August), it is likely that many of the adults were migrating through the river to the spawning grounds. Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the New York Bight DPS.

Studies have shown that to rebuild, Atlantic sturgeon can only sustain low levels of anthropogenic mortality (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007; Brown and Murphy, 2010). There are no empirical abundance estimates of the number of Atlantic sturgeon in the New York Bight DPS. NMFS has determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

4.4 Chesapeake Bay DPS of Atlantic sturgeon

The Chesapeake Bay DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, VA. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT, 2007). Based on the review by Oakley (2003), 100 percent of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e. dams) are located upriver of where spawning is expected to have historically occurred (ASSRT, 2007). Spawning still occurs in the James River, and the presence of juvenile and adult sturgeon in the York River suggests that spawning may occur there as well (Musick *et* *al.*, 1994; ASSRT, 2007; Greene, 2009). However, conclusive evidence of current spawning is only available for the James River. Atlantic sturgeon that are spawned elsewhere are known to use the Chesapeake Bay for other life functions, such as foraging and as juvenile nursery habitat prior to entering the marine system as subadults (Vladykov and Greeley, 1963; ASSRT, 2007; Wirgin *et al.*, 2007; Grunwald *et al.*, 2008).

Age to maturity for Chesapeake Bay DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit clinal variation with faster growth and earlier age to maturity for those that originate from southern waters, and slower growth and later age to maturity for those that originate from northern waters (75 FR 61872; October 6, 2010). Age at maturity is 5 to 19 years for Atlantic sturgeon originating from South Carolina rivers (Smith *et al.*, 1982) and 11 to 21 years for Atlantic sturgeon originating from the Hudson River (Young *et al.*, 1998). Therefore, age at maturity for Atlantic sturgeon of the Chesapeake Bay DPS likely falls within these values.

Several threats play a role in shaping the current status of Chesapeake Bay DPS Atlantic sturgeon. Historical records provide evidence of the large-scale commercial exploitation of Atlantic sturgeon from the James River and Chesapeake Bay in the 19th century (Hildebrand and Schroeder, 1928; Vladykov and Greeley, 1963; ASMFC, 1998; Secor, 2002; Bushnoe *et al.*, 2005; ASSRT, 2007) as well as subsistence fishing and attempts at commercial fisheries as early as the 17th century (Secor, 2002; Bushnoe *et al.*, 2005; ASSRT, 2007; Balazik *et al.*, 2010). Habitat disturbance caused by in-river work such as dredging for navigational purposes is thought to have reduced available spawning habitat in the James River (Holton and Walsh, 1995; Bushnoe *et al.*, 2005; ASSRT, 2007). At this time, we do not have information to quantify this loss of spawning habitat.

Decreased water quality also threatens Atlantic sturgeon of the Chesapeake Bay DPS, especially since the Chesapeake Bay system is vulnerable to the effects of nutrient enrichment due to a relatively low tidal exchange and flushing rate, large surface to volume ratio, and strong stratification during the spring and summer months (Pyzik *et al.*, 2004; ASMFC, 1998; ASSRT, 2007; EPA, 2008). These conditions contribute to reductions in dissolved oxygen levels throughout the Bay. The availability of nursery habitat, in particular, may be limited given the recurrent hypoxia (low dissolved oxygen) conditions within the Bay (Niklitschek and Secor, 2005; 2010). At this time we do not have sufficient information to quantify the extent that degraded water quality effects habitat or individuals in the James River or throughout the Chesapeake Bay.

Vessel strikes have been observed in the James River (ASSRT, 2007). Eleven Atlantic sturgeon were reported to have been struck by vessels from 2005 through 2007. Several of these were mature individuals. Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the New York Bight DPS.

In the marine and coastal range of the Chesapeake Bay DPS from Canada to Florida, fisheries bycatch in federally and state managed fisheries pose a threat to the DPS, reducing survivorship of subadults and adults and potentially causing an overall reduction in the spawning population

(Stein *et al.*, 2004; ASMFC, 2007; ASSRT, 2007).

Summary of the Chesapeake Bay DPS
Spawning for the Chesapeake Bay DPS is known to occur in only the James River. Spawning may be occurring in other rivers, such as the York, but has not been confirmed. There are anecdotal reports of increased sightings and captures of Atlantic sturgeon in the James River. However, this information has not been comprehensive enough to develop a population estimate for the James River or to provide sufficient evidence to confirm increased abundance. Some of the impact from the threats that facilitated the decline of the Chesapeake Bay DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act (CWA). We do not currently have enough information about any life stage to establish a trend for this DPS.

Areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in U.S. state and federally-managed fisheries, Canadian fisheries and vessel strikes remain significant threats to the Chesapeake Bay DPS of Atlantic sturgeon. Studies have shown that Atlantic sturgeon can only sustain low levels of bycatch mortality (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007). The Chesapeake Bay DPS is currently at risk of extinction given (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect the potential for population recovery.

4.5 Shortnose Sturgeon in the Hudson River and the action area
The action area is limited to the reach of the Hudson River affected by the operations of IP2 and IP3, including IP1 to the extent its water intake services IP2, as described in the “Action Area” section above. As such, this section will discuss the available information related to the presence and status of shortnose sturgeon in the Hudson River and in the action area.

Shortnose sturgeon were first observed in the Hudson River by early settlers who captured them as a source of food and documented their abundance (Bain et al. 1998). Shortnose sturgeon in the Hudson River were documented as abundant in the late 1880s (Ryder 1888 in Hoff 1988). Prior to 1937, a few fishermen were still commercially harvesting shortnose sturgeon in the Hudson River; however, fishing pressure declined as the population decreased. During the late 1800s and early 1900s, the Hudson River served as a dumping ground for pollutants that lead to major oxygen depletions and resulted in fish kills and population reductions. During this same time there was a high demand for shortnose sturgeon eggs (caviar), leading to overharvesting. Water pollution, overfishing, and the commercial Atlantic sturgeon fishery are all factors that may have contributed to the decline of shortnose sturgeon in the Hudson River (Hoff 1988).

In the 1930s, the New York State Biological Survey launched the first scientific analysis that documented the distribution, age, and size of mature shortnose sturgeon in the Hudson River (see Bain et al. 1998). In the 1970s, scientific sampling resumed precipitated by the lack of biological data and concerns about the impact of electric generation facilities on fishery resources (see Bain et al. 1998). The current population of shortnose sturgeon has been documented by studies conducted throughout the entire range of shortnose sturgeon in the Hudson River (see: Dovel 1979, Hoff et al. 1988, Geoghegan et al. 1992, Bain et al. 1998, Bain et al. 2000, Dovel et al. 1992).

Several population estimates were conducted throughout the 1970s and 1980s (Dovel 1979; Dovel 1981; Dovel et al. 1992). Most recently, Bain et al. (1998) conducted a mark recapture study from 1994 through 1997 focusing on the shortnose sturgeon active spawning stock. Utilizing targeted and dispersed sampling methods, 6,430 adult shortnose sturgeon were captured and 5,959 were marked; several different abundance estimates were generated from this sampling data using different population models. Abundance estimates generated ranged from a low of 25, 255 to a high of 80,026; though 61,057 is the abundance estimate from this dataset and modeling exercise that is typically used. This estimate includes spawning adults estimated to comprise 93% of the entire population or 56,708, non-spawning adults accounting for 3% of the population and juveniles 4% (Bain et al. 2000). Bain et al. (2000) compared the spawning population estimate with estimates by Dovel et al. (1992) concluding an increase of approximately 400% between 1979 and 1997. Although fish populations dominated by adults are not common for most species, there is no evidence that this is atypical for shortnose sturgeon (Bain et al. 1998).

Woodland and Secor (2007) examined the Bain et al. (1998, 2000, 2007) estimates to try and identify the cause of the major change in abundance. Woodland and Secor (2007) concluded that the dramatic increase in abundance was likely due to improved water quality in the Hudson River which allowed for high recruitment during years when environmental conditions were right, particularly between 1986-1991. These studies provide the best information available on the current status of the Hudson River population and suggests that the population is relatively healthy, large, and particular in habitat use and migratory behavior (Bain et al. 1998).

Shortnose sturgeon have been documented in the Hudson River from upper Staten Island (RM -3 (rkm -4.8)) to the Troy Dam (RM 155 (rkm 249.5); for reference, Indian Point is located at RM 43 (rkm 69))[6] (Bain et al. 2000, ASA 1980-2002). Prior to the construction of the Troy Dam in 1825, shortnose sturgeon are thought to have used the entire freshwater portion of the Hudson River (NYHS 1809). Spawning fish congregated at the base of Cohoes Falls where the Mohawk River emptied into the Hudson. In recent years (since 1999), shortnose sturgeon have been documented below the Tappan Zee Bridge from June through December (ASA 1999-2002; Dynegy 2003). While shortnose sturgeon presence below the Tappan Zee Bridge had previously been thought to be rare (Bain et al. 2000), increasing numbers of shortnose sturgeon have been documented in this area over the last several years (ASA 1999-2002; Dynegy 2003) suggesting that the range of shortnose sturgeon is extending downstream. Shortnose sturgeon were documented as far south as the Manhattan/Staten Island area in June, November and December 2003 (Dynegy 2003).

From late fall to early spring, adult shortnose sturgeon concentrate in a few overwintering areas. Reproductive activity the following spring determines overwintering behavior. The largest overwintering area is just south of Kingston, NY, near Esopus Meadows (RM 86-94, rkm 139-152) (Dovel et al. 1992). The fish overwintering at Esopus Meadows are mainly spawning adults. Recent capture data suggests that these areas may be expanding (Hudson River 1999-

6 See Figure 3 for a map of the Hudson River with these areas highlighted.

2002, Dynegy 2003). Captures of shortnose sturgeon during the fall and winter from Saugerties to Hyde Park (greater Kingston reach), indicate that additional smaller overwintering areas may be present (Geoghegan et al. 1992). Both Geoghegan et al. (1992) and Dovel et al. (1992) also confirmed an overwintering site in the Croton-Haverstraw Bay area (RM 33.5 – 38,rkm 54-61). The Indian Point facility is located approximately 8km (5 miles) north of the northern extent of this overwintering area, which is near rkm 61 (RM 38). Fish overwintering in areas below Esopus Meadows are mainly thought to be pre-spawning adults. Typically, movements during overwintering periods are localized and fairly sedentary.

In the Hudson River, males usually spawn at approximately 3-5 years of age while females spawn at approximately 6-10 years of age (Dadswell et al. 1984; Bain et al. 1998). Males may spawn annually once mature and females typically spawn every 3 years (Dovel et al. 1992). Mature males feed only sporadically prior to the spawning migration, while females do not feed at all in the months prior to spawning.

In approximately late March through mid-April, when water temperatures are sustained at 8º-9° C (46.4-48.2°F) for several days[7], reproductively active adults begin their migration upstream to the spawning grounds that extend from below the Federal Dam at Troy to about Coeymans, NY (rkm 245-212 (RM 152-131); located more than 150km (93 miles) upstream from the Indian Point facility) (Dovel et al. 1992). Spawning typically occurs at water temperatures between 10-18°C (50-64.4°F) (generally late April-May) after which adults disperse quickly down river into their summer range. Dovel et al. (1992) reported that spawning fish tagged at Troy were recaptured in Haverstraw Bay in early June. The broad summer range occupied by adult shortnose sturgeon extends from approximately rkm 38 to rkm 177 (RM 23.5-110). The Indian Point facility (at rkm 69) is located within the broad summer range.

There is scant data on actual collection of early life stages of shortnose sturgeon in the Hudson River. During a mark recapture study conducted from 1976-1978, Dovel et al. (1979) captured larvae near Hudson, NY (rkm 188, RM 117) and young of the year were captured further south near Germantown (RM 106, rkm 171). Between 1996 and 2004, approximately 10 small shortnose sturgeon were collected each year as part of the Falls Shoals Survey (FSS) (ASA 2007). Based upon basic life history information for shortnose sturgeon it is known that eggs adhere to solid objects on the river bottom (Buckley and Kynard 1981; Taubert 1980) and that eggs and larvae are expected to be present within the vicinity of the spawning grounds (rkm 245-212, RM 152-131) for approximately four weeks post spawning (i.e., at latest through mid-June). Shortnose sturgeon larvae in the Hudson River generally range in size from 15 to 18 mm (0.6-0.7 inches) TL at hatching (Pekovitch 1979). Larvae gradually disperse downstream after hatching, entering the tidal river (Hoff et al. 1988). Larvae or fry are free swimming and typically concentrate in deep channel habitat (Taubert and Dadswell 1980; Bath et al. 1981; Kieffer ad Kynard 1993). Given that fry are free swimming and foraging, they typically disperse downstream of spawning/rearing areas. Larvae can be found upstream of the salt wedge in the Hudson River estuary and are most commonly found in deep waters with strong currents,

[7] Based on information from the USGS gage in Albany (gage no. 01359139), in 2002 mean water temperatures reached 8ºC on April 10 and 15ºC on April 20; 2003 - 8ºC on April 14 and 15ºC on May 19; 2004 - 8ºC on April 17 and 15ºC on May 11. In 2011, water temperatures reached 8°C on April 11 and reached 15°C on May 19. In 2012, water temperatures reached 8°C on March 20 and reached 15°C on May 13.

typically in the channel (Hoff et al. 1988; Dovel et al. 1992). Larvae are not tolerant of saltwater and their occurrence within the estuary is limited to freshwater areas. The transition from the larval to juvenile stage generally occurs in the first summer of life when the fish grows to approximately 2 cm (0.8 in) TL and is marked by fully developed external characteristics (Pekovitch 1979).

Similar to non-spawning adults, most juveniles occupy the broad region of Haverstraw Bay (rkm 55-64.4) RM 34-40; Indian Point is located near the northern edge of the bay) (Dovel et al. 1992; Geoghegan et al. 1992) by late fall and early winter. Migrations from the summer foraging areas to the overwintering grounds are triggered when water temperatures fall to 8°C (46.4°F) (NMFS 1998), typically in late November[8]. Juveniles are distributed throughout the mid-river region during the summer and move back into the Haverstraw Bay region during the late fall (Bain et al. 1998; Geoghegan et al. 1992; Haley 1998).

Shortnose sturgeon are bottom feeders and juveniles may use the protuberant snout to “vacuum” the river bottom. Curran & Ries (1937) described juvenile shortnose sturgeon from the Hudson River as having stomach contents of 85-95% mud intermingled with plant and animal material. Other studies found stomach contents of adults were solely food items, implying that feeding is more precisely oriented. The ventral protrusable mouth and barbells are adaptations for a diet of small live benthic animals. Juveniles feed on smaller and somewhat different organisms than adults. Common prey items are aquatic insects (chironomids), isopods, and amphipods. Unlike adults, mollusks do not appear to be an important part of the diet of juveniles (Bain 1997). As adults, their diet shifts strongly to mollusks (Curran & Ries 1937).

Telemetry data has been instrumental in informing the extent of shortnose sturgeon coastal migrations. Recent telemetry data from the Gulf of Maine indicate shortnose sturgeon in this region undertake significant coastal migrations between larger river systems and utilize smaller coastal river systems during these interbasin movements (Fernandes 2008; UMaine unpublished data). Some outmigration has been documented in the Hudson River, albeit at low levels in comparison to coastal movement documented in the Gulf of Maine and Southeast rivers. Two individuals tagged in 1995 in the overwintering area near Kingston, NY were later recaptured in the Connecticut River. One of these fish was at large for over two years and the other 8 years prior to recapture. As such, it is reasonable to expect some level of movement out of the Hudson into adjacent river systems; however, based on available information it is not possible to predict what percentage of adult shortnose sturgeon originating from the Hudson River may participate in coastal migrations.

4.6 Atlantic sturgeon in the Hudson River and the action area

Use of the river by Atlantic sturgeon has been described by several authors. The area around Hyde Park (approximately rkm134) has consistently been identified as a spawning area through scientific studies and historical records of the Hudson River sturgeon fishery (Dovel and

---

[8] In 2002, water temperatures at the USGS gage at Hastings-on-Hudson (No. 01376304; the farthest downstream gage on the river) fell to 8°C on November 23. In 2003, water temperatures at this gage fell to 8°C on November 29. In 2010, water temperatures at the USGS gage at West Point, NY (No. 01374019; currently the farthest downstream gage on the river) fell to 8°C on November 23. In 2011, water temperatures at the USGS gage at West Point, NY (No. 01374019) fell to 8°C on November 24. This gage ceased operations on March 1, 2012.

Berggren, 1983; Van Eenennaam *et al.*, 1996; Kahnle *et al.*, 1998; Bain *et al.*, 2000). Habitat conditions at the Hyde Park site are described as freshwater year round with bedrock, silt and clay substrates and waters depths of 12-24 m (Bain *et al.*, 2000). Bain *et al.* (2000) also identified a spawning site at rkm 112 based on tracking data. The rkm 112 site, located to one side of the river, has clay, silt and sand substrates, and is approximately 21-27 m deep (Bain *et al.*, 2000).

Young-of-year (YOY) have been recorded in the Hudson River between rkm 60 and rkm 148, which includes some brackish waters; however, larvae must remain upstream of the salt wedge because of their low salinity tolerance (Dovel and Berggren, 1983; Kahnle *et al.*, 1998; Bain *et al.*, 2000). Catches of immature sturgeon (age 1 and older) suggest that juveniles utilize the estuary from the Tappan Zee Bridge through Kingston (rkm 43- rkm 148) (Dovel and Berggren, 1983; Bain *et al.*, 2000). Seasonal movements are apparent with juveniles occupying waters from rkm 60 to rkm 107 during summer months and then moving downstream as water temperatures decline in the fall, primarily occupying waters from rkm 19 to rkm 74 (Dovel and Berggren, 1983; Bain *et al.*, 2000). Based on river-bottom sediment maps (Coch, 1986) most juvenile sturgeon habitats in the Hudson River have clay, sand, and silt substrates (Bain *et al.*, 2000). Newburgh and Haverstraw Bays in the Hudson River are areas of known juvenile sturgeon concentrations (Sweka *et al.*, 2007). Sampling in spring and fall revealed that highest catches of juvenile Atlantic sturgeon occurred during spring in soft-deep areas of Haverstraw Bay even though this habitat type comprised only 25% of the available habitat in the Bay (Sweka *et al.*, 2007). Overall, 90% of the total 562 individual juvenile Atlantic sturgeon captured during the course of this study (14 were captured more than once) came from Haverstraw Bay (Sweka *et al.*, 2007). At around 3 years of age, Hudson River juveniles exceeding 70 cm total length begin to migrate to marine waters (Bain *et al.*, 2000).

Atlantic sturgeon adults are likely to migrate through the action area in the spring as they move from oceanic overwintering sites to upstream spawning sites and then migrate back through the area as they move to lower reaches of the estuary or oceanic areas in the late spring and early summer. Atlantic sturgeon adults are most likely to occur in the action area from May – September. Tracking data from tagged juvenile Atlantic sturgeon indicates that during the spring and summer individuals are most likely to occur within rkm 60-170. During the winter months, juvenile Atlantic sturgeon are most likely to occur between rkm 19 and 74. This seasonal change in distribution may be associated with seasonal movements of the saltwedge and differential seasonal use of habitats.

Based on the available data, Atlantic sturgeon may be present in the action area year round. As explained above, Atlantic sturgeon in the action area are likely to have originated from the New York Bight DPS, Chesapeake Bay DPS and Gulf of Maine DPS, with the majority of individuals originating from the New York Bight DPS, and the majority of those individuals originating from the Hudson River.

4.7 Factors Affecting the Survival and Recovery of Shortnose and Atlantic sturgeon in the Hudson River

There are several activities that occur in the Hudson River that affect individual shortnose and Atlantic sturgeon. Impacts of activities that occur within the action area are considered in the "Environmental Baseline" section (Section 5.0, below). Activities that impact sturgeon in the Hudson River but do not necessarily overlap with the action area are discussed below.

4.7.1 Hudson River Power Plants

The mid-Hudson River provides cooling water to four large power plants: Indian Point Nuclear Generating Station, Roseton Generating Station (RM 66, rkm 107), Danskammer Point Generating Station (RM 66, rkm 107), and Bowline Point Generating Station (RM 33, rkm 52.8). All of these stations use once-through cooling. The Lovett Generating Station (RM 42, rkm 67) is no longer operating.

In 1998, Central Hudson Gas and Electric Corporation (CHGEC), the operator of the Roseton and Danskammer Point power plants initiated an application with us for an incidental take (ITP) permit under section 10(a)(1)(B) of the ESA.[9] As part of this process CHGEC submitted a Conservation Plan and application for a 10(a)(1)(B) incidental take permit that proposed to minimize the potential for entrainment and impingement of shortnose sturgeon at the Roseton and Danskammer Point power plants. These measures ensure that the operation of these plants will not appreciably reduce the likelihood of the survival and recovery of shortnose sturgeon in the wild. In addition to the minimization measures, a proposed monitoring program was implemented to assess the periodic take of shortnose sturgeon, the status of the species in the project area, and the progress on the fulfillment of mitigation requirements. In December 2000, Dynegy Roseton L.L.C. and Dynegy Danskammer Point L.L.C. were issued incidental take permit no. 1269 (ITP 1269). At the time the ITP was issued, Atlantic sturgeon were not listed under the ESA; therefore, the ITP does not address Atlantic sturgeon.

The ITP exempts the incidental take of two shortnose sturgeon at Roseton and four at Danskammer Point annually. This incidental take level is based upon impingement data collected from 1972-1998. NMFS determined that this level of take was not likely to reduce the numbers, distribution, or reproduction of the Hudson River population of shortnose sturgeon in a way that appreciably reduces the likelihood of shortnose sturgeon to survive and recover in the wild. Since the ITP was issued, the number of shortnose sturgeon impinged has been very low. Dynegy has indicated that this may be due in part to reduced operations at the facilities which results in significantly less water withdrawal and therefore, less opportunity for impingement. While historical monitoring reports indicate that a small number of sturgeon larvae were entrained at Danskammer, no sturgeon larvae have been observed in entrainment samples collected since the ITP was issued. While the ITP does not currently address Atlantic sturgeon, the number of interactions with Atlantic sturgeon at Roseton and Danskammer that have been reported to NMFS since the ITP became effective has been very low.

[9] CHGEC has since been acquired by Dynegy Danskammer L.L.C. and Dynegy Roseton L.L.C. (Dynegy), thus the current incidental take permit is held by Dynegy. ESA Section 9 prohibits take, among other things, without express authorization through a Section 10 permit or exemption through a Section 7 Incidental Take Statement.

4.7.2 Scientific Studies permitted under Section 10 of the ESA

The Hudson River population of shortnose and Atlantic sturgeon have been the focus of a prolonged history of scientific research. In the 1930s, the New York State Biological Survey launched the first scientific sampling study and documented the distribution, age, and size of mature shortnose sturgeon (Bain *et al.* 1998). In the early 1970s, research resumed in response to a lack of biological data and concerns about the impact of electric generation facilities on fishery resources (Hoff 1988). In an effort to monitor relative abundance, population status, and distribution, intensive sampling of shortnose sturgeon in this region has continued throughout the past forty years. Sampling studies targeting other species, including Atlantic sturgeon, also incidentally capture shortnose sturgeon.

There are currently three scientific research permits issued pursuant to Section 10(a)(1)(A) of the ESA that authorize research on sturgeon in the Hudson River. The activities authorized under these permits are presented below.

NYDEC holds a scientific research permit (#16439, which replaces their previously held permit #1547) authorizing the assessment of habitat use, population abundance, reproduction, recruitment, age and growth, temporal and spatial distribution, diet selectivity, and contaminant load of shortnose sturgeon in the Hudson River Estuary from New York Harbor (RKM 0) to Troy Dam (RKM 245). NYDEC is authorized to use gillnets and trawls to capture up to 240 and 2,340 shortnose sturgeon in year one through years three and four and five, respectively. Research activities include: capture; measure, weigh; tag with passive integrated transponder (PIT) tags and Floy tags, if untagged; and sample genetic fin clips. A first subset of fish will also be anesthetized and tagged with acoustic transmitters; a second subset will have fin rays sampled for age and growth analysis; and a third subset will have gastric contents lavaged for diet analysis, as well as blood samples taken for contaminants. The unintentional mortality of nine shortnose sturgeon is anticipated over the five year life of the permit. This permit expires on November 24, 2016.

In April 2012, NYDEC was issued a scientific research permit (#16436) which authorizes the capture, handling and tagging of Atlantic sturgeon in the Hudson River. NYDEC is authorized to capture 1,350 juveniles and 200 adults. The unintentional mortality of two juveniles is anticipated annually over the five year life of the permit. This permit expires on April 5, 2017.

A permit was issued to Dynegy[10] in 2007 (#1580, originally issued as #1254) to evaluate the life history, population trends, and spacio-temporal and size distribution of shortnose sturgeon collected during the annual Hudson River Biological Monitoring Program. This permit was recently reissued to Entergy in August 2012 as permit #17095; the permit will expire in 2017. The permit holders are authorized to capture up to 82 shortnose sturgeon adults/juveniles and 82 Atlantic sturgeon annually to measure, weigh, tag, photograph, and collect tissue samples for genetic analyses. Dynegy is also authorized to lethally take up to 40 larvae of each species annually. No lethal take of any juvenile, subadult or adult sturgeon is authorized.

[10] Permit 1580 was issued by NMFS to Dynegy on behalf of "other Hudson River Generators including Entergy Nuclear Indian Point 2, L.L.C., Entergy Nuclear Indian Point 3, L.L.C. and Mirant (now GenOn) Bowline, L.L.C."

4.7.3 Hudson River Navigation Project
The Hudson River navigation project authorizes a channel 600 feet wide, New York City to Kingston narrowing to 400 feet wide to 2,200 feet south of the Mall Bridge (Dunn Memorial Bridge) at Albany with a turning basin at Albany and anchorages near Hudson and Stuyvesant, all with depths of 32 feet in soft material and 34 feet in rock; then 27 feet deep and 400 feet wide to 900 feet south of the Mall Bridge (Dunn Memorial Bridge); then 14 feet deep and generally 400 feet wide, to the Federal Lock at Troy; and then 14 feet deep and 200 feet wide, to the southern limit of the State Barge Canal at Waterford; with widening at bends and widening in front of the cities of Troy and Albany to form harbors 12 feet deep. The total length of the existing navigation project (NYC to Waterford) is about 155 miles. The only portion of the channel that is regularly dredged is the North Germantown and Albany reaches. Dredging is scheduled at times of year when sturgeon are least likely to be in the dredged reaches; no interactions with sturgeon have been observed.

4.7.4 Tappan Zee Bridge Replacement Project
The U.S. Federal Highway Authority (FHWA), the New York Department of Transportation (DOT), the New York State Thruway Authority (NYSTA) are planning to replace the existing Tappan Zee Bridge. A Record of Decision was signed in September 2012 and construction may start as soon as Fall 2012. Construction is expected to take 5 years. We issued a Biological Opinion to FHWA, as the lead Federal agency, in June 2012. This Opinion concluded that the proposed bridge replacement project may adversely affect but was not likely to jeopardize the continued existence of shortnose sturgeon or any DPS of Atlantic sturgeon. The ITS included with the Opinion exempts the lethal take of 2 shortnose sturgeon and 2 Atlantic sturgeon (from the Gulf of Maine, New York Bight or Chesapeake Bay DPS), as well as the capture and injury of shortnose and Atlantic sturgeon from the Gulf of Maine, New York Bight and Chesapeake Bay DPS. Injury and mortality may occur as a result of exposure to underwater noise from pile driving or capture in the dredge bucket. FHWA carried out a pile installation demonstration project in spring 2012 and no injured or dead sturgeon were observed.

4.7.5 Other Federally Authorized Actions
We have completed several informal consultations on effects of in-water construction activities in the Hudson River and New York Harbor permitted by the U.S. Army Corps of Engineers (USACE). This includes several dock and pier projects. No interactions with shortnose or Atlantic sturgeon have been reported in association with any of these projects.

We have also completed several informal consultations on effects of private dredging projects permitted by the USACE. All of the dredging was with a mechanical dredge. No interactions with shortnose or Atlantic sturgeon have been reported in association with any of these projects.

4.7.6 State Authorized Fisheries
Atlantic and shortnose sturgeon may be vulnerable to capture, injury and mortality in fisheries occurring in state waters. Information on the number of sturgeon captured or killed in state fisheries is extremely limited and as such, efforts are currently underway to obtain more information on the numbers of sturgeon captured and killed in state water fisheries. We are currently working with the Atlantic States Marine Fisheries Commission (ASMFC) and the

coastal states to assess the impacts of state authorized fisheries on sturgeon. We anticipate that some states are likely to apply for ESA section 10(a)(1)(B) Incidental Take Permits to cover their fisheries; however, to date, no applications have been submitted. Below, we discuss the different fisheries authorized by the states and any available information on interactions between these fisheries and sturgeon.

American Eel
American eel (*Anguilla rostrata*) is exploited in fresh, brackish and coastal waters from the southern tip of Greenland to northeastern South America. American eel fisheries are conducted primarily in tidal and inland waters. In the Hudson River, eels between 6 and 14 inches long may be kept for bait; no eels may be kept for food (due to potential PCB contamination). Eels are typically caught with hook and line or with eel traps and may also be caught with fyke nets. Sturgeon are not known to interact with the eel fishery.

Shad and River herring
Shad and river herring (blueback herring (*Alosa aestivalis*) and alewives (*Alosa pseudoharengus*)) are managed under an ASMFC Interstate Fishery Management Plan. In 2005, the ASMFC approved a coastwide moratorium on commercial and recreational fishing for shad. In May 2009, ASMFC adopted Amendment 2 to the ISFMP for Shad and River Herring, which closes all recreational and commercial fisheries unless each state can show its fisheries are sustainable. New York has submitted a Sustainable Fishing Plan that is currently under review. The plan prohibits the taking of river herring in any state waters, except for Hudson River stocks, for which it proposes partial closure in the tributaries and a five-year commercial gillnet fishery in the lower river. Although now closed, in the past this fishery was known to capture Atlantic and shortnose sturgeon.

Striped bass
Fishing for striped bass occurs within the Hudson River. Striped bass are managed by ASMFC through Amendment 6 to the Interstate FMP, which requires minimum sizes for the commercial and recreational fisheries, possession limits for the recreational fishery, and state quotas for the commercial fishery (ASMFC 2003). Under Addendum 2, the coastwide striped bass quota remains the same, at 70% of historical levels. Data from the Atlantic Coast Sturgeon Tagging Database (2000-2004) shows that the striped bass fishery accounted for 43% of Atlantic sturgeon recaptures; however, no information on the total number of Atlantic sturgeon caught by fishermen targeting striped bass is available. No information on interactions between shortnose sturgeon and the striped bass fishery is available; however, because shortnose sturgeon can be caught in hook and line fisheries as well as in otter trawls, if this gear is used in areas of the river and estuary where shortnose sturgeon are present, there could be some capture of shortnose and Atlantic sturgeon in this fishery.

4.7.7 Other Impacts of Human Activities in the Action Area

Impacts of Contaminants and Water Quality
Historically, shortnose sturgeon were rare in the lower Hudson River, likely as a result of poor water quality precluding migration further downstream. However, in the past several years, the water quality has improved and sturgeon have been found as far downstream as the

Manhattan/Staten Island area. It is likely that contaminants remain in the water and in the action area, albeit to reduced levels. Sewage, industrial pollutants and waterfront development has likely decreased the water quality in the action area. Contaminants introduced into the water column or through the food chain, eventually become associated with the benthos where bottom dwelling species like sturgeon are particularly vulnerable. Several characteristics of shortnose sturgeon life history including long life span, extended residence in estuarine habitats, and being a benthic omnivore, predispose this species to long term repeated exposure to environmental contaminants and bioaccumulation of toxicants (Dadswell 1979).

Principal toxic chemicals in the Hudson River include pesticides and herbicides, heavy metals, and other organic contaminants such as PAHs and PCBs. Concentrations of many heavy metals also appear to be in decline and remaining areas of concern are largely limited to those near urban or industrialized areas. With the exception of areas near New York City, there currently does not appear to be a major concern with respect to heavy metals in the Hudson River, however metals could have previously affected sturgeon.

PAHs, which are products of incomplete combustion, most commonly enter the Hudson River as a result of urban runoff. As a result, areas of greatest concern are limited to urbanized areas, principally near New York City. The majority of individual PAHs of concern have declined during the past decade in the lower Hudson River and New York Harbor.

PCBs are the principal toxic chemicals of concern in the Hudson River. Primary inputs of PCBs in freshwater areas of the Hudson River are from the upper Hudson River near Fort Edward and Hudson Falls, New York. In the lower Hudson River, PCB concentrations observed are a result of both transport from upstream as well as direct inputs from adjacent urban areas. PCBs tend to be bound to sediments and also bioaccumulate and biomagnify once they enter the food chain. This tendency to bioaccumulate and biomagnify results in the concentration of PCBs in the tissue concentrations in aquatic-dependent organisms. These tissue levels can be many orders of magnitude higher than those observed in sediments and can approach or even exceed levels that pose concern over risks to the environment and to humans who might consume these organisms. PCBs can have serious deleterious effects on aquatic life and are associated with the production of acute lesions, growth retardation, and reproductive impairment (Ruelle and Keenlyne 1993). PCB's may also contribute to a decreased immunity to fin rot (Dovel *et al.* 1992). Large areas of the upper Hudson River are known to be contaminated by PCBs, and this is thought to account for the high percentage of shortnose sturgeon in the Hudson River exhibiting fin rot. Under a statewide toxics monitoring program, the NYSDEC analyzed tissues from four shortnose sturgeon to determine PCB concentrations. In gonadal tissues, where lipid percentages are highest, the average PCB concentration was 29.55 parts per million (ppm; Sloan 1981) and in all tissues ranged from 22.1 to 997.0 ppm. Dovel (1992) reported that more than 75% of the shortnose sturgeon captured in his study had severe incidence of fin rot. Given that Atlantic sturgeon have similar sensitivities to toxins as shortnose sturgeon it is reasonable to anticipate that Atlantic sturgeon have been similarly affected. In the Connecticut River, coal tar leachate was suspected of impairing sturgeon reproductive success. Kocan (1993) conducted a laboratory study to investigate the survival of sturgeon eggs and larvae exposed to PAHs, a by-product of coal distillation. Only approximately 5% of sturgeon embryos and larvae survived after 18 days of exposure to Connecticut River coal-tar (i.e., PAH) demonstrating that contaminated sediment is toxic to shortnose sturgeon embryos and larvae under laboratory exposure conditions (NMFS 1998). Manufactured Gas Product (MGP) waste, which is chemically similar to the coal tar deposits found in the Connecticut River, is known to occur at several sites within the Hudson River and this waste may have had similar effects on any sturgeon present in the action area over the years.

Point source discharge (i.e., municipal wastewater, paper mill effluent, industrial or power plant cooling water or waste water) and compounds associated with discharges (i.e., metals, dioxins, dissolved solids, phenols, and hydrocarbons) contribute to poor water quality and may also impact the health of sturgeon populations. The compounds associated with discharges can alter the pH of receiving waters, which may lead to mortality, changes in fish behavior, deformations, and reduced egg production and survival.

Heavy usage of the Hudson River and development along the waterfront could have affected shortnose sturgeon throughout the action area. Coastal development and/or construction sites often result in excessive water turbidity, which could influence sturgeon spawning and/or foraging ability.

The Hudson River is used as a source of potable water, for waste disposal, transportation and cooling by industry and municipalities. Rohman *et al.* (1987) identified 183 separate industrial and municipal discharges to the Hudson and Mohawk Rivers. The greatest number of users were in the chemical industry, followed by the oil industry, paper and textile manufactures, sand, gravel, and rock processors, power plants, and cement companies. Approximately 20 publicly owned treatment works discharge sewage and wastewater into the Hudson River. Most of the municipal wastes receive primary and secondary treatment. A relatively small amount of sewage is attributed to discharges from recreational boats.

Water quality conditions in the Hudson River have dramatically improved since the mid-1970s. It is thought that this improvement may be a contributing factor to the improvement in the status of shortnose sturgeon in the river. However, as evidenced above, there are still concerns regarding the impacts of water quality on sturgeon in the river; particularly related to legacy contaminants for which no new discharges may be occurring, but environmental impacts are long lasting (e.g., PCBs, dioxins, coal tar, etc.)

5.0 ENVIRONMENTAL BASELINE

Environmental baselines for biological opinions include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this Opinion includes the effects of several activities that may affect the survival and recovery of the listed species in the action area.

As described above, the action area is limited to the area where direct and indirect effects of the Indian Point facility are experienced and by definition is limited in the Hudson River to the intake areas of IP1 (for service water), IP2 and IP3 and the region where the thermal plume extends into the Hudson River from IP2 and IP3. The discussion below focuses on effects of state, federal or private actions, other than the action under consideration, that occur in the action area.

5.1 Federal Actions that have Undergone Formal or Early Section 7 Consultation
The only Federal actions that occur within the action area are the operations of the Indian Point facility and research activities authorized pursuant to Section 10 of the ESA (discussed above). No Federal actions that have undergone formal or early section 7 consultation occur in the action area.

Impacts of the Historical Operation of the Indian Point Facility
IP1 operated from 1962 through October 1974. IP2 and IP3 have been operational since 1973 and 1975, respectively. Since 1963, shortnose and Atlantic sturgeon in the Hudson River have been exposed to effects of this facility. Eggs and early larvae would be the only life stages of sturgeon small enough to be vulnerable to entrainment at the Indian Point intakes (openings in the wedge wire screens are 6mm x 12.5 mm (0.25 inches by 0.5 inches); eggs are small enough to pass through these openings but are not expected to occur in the immediate vicinity of the Indian Point site.

Studies to evaluate the effects of entrainment at IP2 and IP3 occurred from the early 1970s through 1987, with intense daily sampling during the spring of 1981-1987. As reported by the NRC in its FSEIS considering the proposed relicensing of IP2 and IP3 (NRC 2011), entrainment monitoring reports list no shortnose or Atlantic sturgeon eggs or larvae at IP2 or IP3. Given what is known about these life stages (i.e., no eggs expected to be present in the action area; larvae only expected to be found in the deep channel area away from the intakes) and the intensity of the past monitoring, it is reasonable to assume that this past monitoring provides an accurate assessment of past entrainment of sturgeon early life stages. Based on this, it is unlikely that any entrainment of sturgeon eggs and larvae occurred historically.

We have no information on any monitoring for impingement that may have occurred at the IP1 intakes. Therefore, we are unable to determine whether any monitoring did occur at the IP1 intakes and whether shortnose or Atlantic sturgeon were recorded as impinged at IP1 intakes. Despite this lack of data, given that the IP1 intake is located between the IP2 and IP3 intakes and operates in a similar manner, it is reasonable to assume that some number of shortnose and Atlantic sturgeon were impinged at the IP1 intakes during the time that IP1 was operational. However, based on the information available to us, we are unable to make a quantitative assessment of the likely number of shortnose and Atlantic sturgeon impinged at IP1 during the period in which it was operational.

The impingement of shortnose and Atlantic sturgeon at IP2 and IP3 has been documented (NRC 2011). Impingement monitoring occurred from 1974-1990, and during this time period, 21 shortnose sturgeon were observed impinged at IP2. For Unit 3, 11 impinged shortnose sturgeon were recorded. At Unit 2, 251 Atlantic sturgeon were observed as impinged during this time period, with an annual range of 0-118 individuals (peak number in 1975); at Unit 3, 266 Atlantic sturgeon were observed as impinged, with an annual range of 0-153 individuals (peak in 1976). No monitoring of the intakes for impingement has occurred since 1990.

While models of the current thermal plume are available, it is not clear whether this model accurately represents past conditions associated with the thermal plume. As no information on past thermal conditions are available and no monitoring was done historically to determine if the thermal plume was affecting shortnose or Atlantic sturgeon or their prey, it is not possible to estimate past effects associated with the discharge of heated effluent from the Indian Point facility. No information is available on any past impacts to shortnose sturgeon prey due to impingement or entrainment or exposure to the thermal plume. This is because no monitoring of sturgeon prey in the action area has occurred.

6.0 CLIMATE CHANGE

The discussion below presents background information on global climate change and information on past and predicted future effects of global climate change throughout the range of the listed species considered here. Additionally, we present the available information on predicted effects of climate change in the action area and how listed sturgeon may be affected by those predicted environmental changes over the life of the proposed action. Climate change is relevant to the Status of the Species, Environmental Baseline and Cumulative Effects sections of this Opinion; rather than include partial discussion in several sections of this Opinion, we are synthesizing this information into one discussion. Effects of the proposed action that are relevant to climate change are included in the Effects of the Action section below (section 7.0 below).

6.1 Background Information on predicted climate change

The global mean temperature has risen 0.76ºC (1.36°F) over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007a). Precipitation has increased nationally by 5%-10%, mostly due to an increase in heavy downpours (NAST 2000). There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Ocean acidification resulting from massive amounts of carbon dioxide and other pollutants released into the air can have major adverse impacts on the calcium balance in the oceans. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007b); these trends have been most apparent over the past few decades.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next century. Both of the principal climate models used by the National Assessment Synthesis Team (NAST) project warming in the southeast by the 2090s, but at different rates (NAST 2000): the Canadian model scenario shows the southeast U.S. experiencing a high degree of warming, which translates into lower soil moisture as higher temperatures increase evaporation; the Hadley model scenario projects less warming and a significant increase in precipitation (about 20%). The scenarios examined, which assume no major interventions to reduce continued growth of world greenhouse gases (GHG), indicate that temperatures in the U.S. will rise by about 3^{o}-5^{o}C (5^{o}-9^{o}F) on average in the next 100 years which is more than the projected global increase (NAST 2000). A warming of about 0.2^{o}C (0.4°F) per decade is projected for the next two decades over a range of emission scenarios (IPCC 2007). This temperature increase will very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Climate warming has resulted in increased precipitation, river discharge, and glacial and sea-ice melting (Greene *et al.* 2008).

The past three decades have witnessed major changes in ocean circulation patterns in the Arctic, and these were accompanied by climate associated changes as well (Greene *et al.* 2008). Shifts in atmospheric conditions have altered Arctic Ocean circulation patterns and the export of freshwater to the North Atlantic (Greene *et al.* 2008, IPCC 2006). With respect specifically to the North Atlantic Oscillation (NAO), changes in salinity and temperature are thought to be the result of changes in the earth's atmosphere caused by anthropogenic forces (IPCC 2006). The NAO impacts climate variability throughout the northern hemisphere (IPCC 2006). Data from the 1960s through the present show that the NAO index has increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC 2006). This warming extends over 1000m (0.62 miles) deep and is deeper than anywhere in the world oceans and is particularly evident under the Gulf Stream/ North Atlantic Current system (IPCC 2006). On a global scale, large discharges of freshwater into the North Atlantic subarctic seas can lead to intense stratification of the upper water column and a disruption of North Atlantic Deepwater (NADW) formation (Greene *et al.* 2008, IPCC 2006). There is evidence that the NADW has already freshened significantly (IPCC 2006). This in turn can lead to a slowing down of the global ocean thermohaline (large-scale circulation in the ocean that transforms low-density upper ocean waters to higher density intermediate and deep waters and returns those waters back to the upper ocean), which can have climatic ramifications for the whole earth system (Greene *et al.* 2008).

While predictions are available regarding potential effects of climate change globally, it is more difficult to assess the potential effects of climate change over the next few decades on coastal and marine resources on smaller geographic scales, such as the Hudson River, especially as climate variability is a dominant factor in shaping coastal and marine systems. The effects of future change will vary greatly in diverse coastal regions for the U.S. Additional information on potential effects of climate change specific to the action area is discussed below. Warming is very likely to continue in the U.S. over the next 25 to 50 years regardless of reduction in GHGs, due to emissions that have already occurred (NAST 2000). It is very likely that the magnitude and frequency of ecosystem changes will continue to increase in the next 25 to 50 years, and it is possible that rate of change will accelerate. Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC 2007).

A warmer and drier climate is expected to result in reductions in stream flows and increases in water temperatures. Expected consequences could be a decrease in the amount of dissolved oxygen in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch *et al.* 2000). Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development, and this stress may be exacerbated by changes in climate, anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants other than heat currently degrade water quality (Murdoch *et al.* 2000). Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands. Surface water resources in the southeast are intensively managed with dams and channels and almost all are affected by human activities; in some systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer *et al.* 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change. Within 50 years, river basins that are impacted by dams or by extensive development may experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer *et al.* 2008).

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2^{o}C (0.4°F) per decade; and 3) a rise in sea level (NAST 2000). A warmer and drier climate will reduce stream flows and increase water temperature resulting in a decrease of DO and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing. Sea level is expected to continue rising: during the 20th century global sea level has increased 15 to 20 cm (6-8 inches).

6.2 Species Specific Information Related to Predicted Impacts of Climate Change

6.2.1 Shortnose sturgeon

Global climate change may affect shortnose sturgeon in the future. Rising sea level may result in the salt wedge moving upstream in affected rivers. Shortnose sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile shortnose sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, shortnose sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the saltwedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, for most spawning rivers there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the saltwedge. It is unlikely that shifts in the location of the saltwedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas and flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with DO and temperature. While this occurs primarily in rivers in the southeast U.S. and the Chesapeake Bay, it may start to occur more commonly in the northern rivers. Shortnose sturgeon are tolerant to water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats.

Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all shortnose sturgeon life stages, including adults, may become susceptible to strandings. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing shortnose sturgeon in rearing habitat; however, this would be mitigated if prey species also had a shift in distribution or if developing sturgeon were able to shift their diets to other species.

6.2.2 Atlantic sturgeon

Global climate change may affect all DPSs of Atlantic sturgeon in the future; however, effects of increased water temperature and decreased water availability are most likely to effect the South Atlantic and Carolina DPSs. Rising sea level may result in the salt wedge moving upstream in affected rivers. Atlantic sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile Atlantic sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, Atlantic sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the saltwedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, at this time there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the saltwedge. It is unlikely that shifts in the location of the saltwedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas and flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with DO and temperature. While this occurs primarily in rivers in the southeast U.S. and the Chesapeake Bay, it may start to occur more commonly in the northern rivers. Atlantic sturgeon prefer water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats.

Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all Atlantic sturgeon life stages, including adults, may become susceptible to strandings or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing sturgeon in rearing habitat.

6.3 Potential Effects of Climate Change in the Action Area

Information on how climate change will impact the action area is extremely limited. Available information on climate change related effects for the Hudson River largely focuses on effects that rising water levels may have on the human environment. The New York State Sea Level Rise Task Force (Spector in Bhutta 2010) predicts a state-wide sea level rise of 7-52 inches by the end of this century, with the conservative range being about 2 feet. This compares to an average sea level rise of about 1 foot in the Hudson Valley in the past 100 years. Sea level rise is expected to result in the northward movement of the salt wedge. The location of the salt wedge in the Hudson River is highly variable depending on season, river flow, and precipitation so it is unclear what effect this northward shift could have. Potential negative effects of a shift in the salt wedge include restricting the habitat available for early life stages and juvenile sturgeon which are intolerant to salinity and are present exclusively upstream of the salt wedge. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, at this time there are no predictions on the timing or extent of any shift that may occur.

Air temperatures in the Hudson Valley have risen approximately 0.5°C (0.9°F) since 1970. In the 2000s, the mean Hudson river water temperature, as measured at the Poughkeepsie Water Treatment Facility, was approximately 2°C (3.6°F) higher than averages recorded in the 1960s (Pisces 2008). However, while it is possible to examine past water temperature data and observe a warming trend, there are not currently any predictions on potential future increases in water temperature in the action area specifically or the Hudson River generally. The Pisces report (2008) also states that temperatures within the Hudson River may be becoming more extreme. For example, in 2005, water temperature on certain dates was close to the maximum ever recorded and also on other dates reached the lowest temperatures recorded over a 53-year period. Other conditions that may be related to climate change that have been reported in the Hudson Valley are warmer winter temperatures, earlier melt-out and more severe flooding. An average increase in precipitation of about 5% is expected; however, information on the effects of an increase in precipitation on conditions in the action area is not available.

Sea surface temperatures have fluctuated around a mean for much of the past century, as measured by continuous 100+ year records at Woods Hole (Mass.), and Boothbay Harbor (Maine) and shorter records from Boston Harbor and other bays. Periods of higher than average temperatures (in the 1950s) and cooler periods (1960s) have been associated with changes in the North Atlantic Oscillation (NAO), which affects current patterns. Over the past 30 years however, records indicate that ocean temperatures in the Northeast have been increasing; for example, Boothbay Harbor's temperature has increased by about 1°C since 1970. While we are not able to find predictive models for New York, given the geographic proximity of these waters to the Northeast, we assume that predictions would be similar. For marine waters, the model projections are for an increase of somewhere between 3-4°C by 2100 and a pH drop of 0.3-0.4 units by 2100 (Frumhoff *et al.* 2007). Assuming that these predictions also apply to the action area, one could anticipate similar conditions in the action area over that same time period; considering that the proposed action will occur until 2035, we could predict an increase in ambient water temperatures of 0.034-0.045 per year for an overall increase of 0.078-1.035°C .

6.4 Effects of Climate Change in the Action Area to Atlantic and shortnose sturgeon

As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on shortnose and Atlantic sturgeon. IP2 could operate until 2033 and IP3 could operate until 2035; thus, we consider here, likely effects of climate change over this time period.

Over time, the most likely effect to shortnose and Atlantic sturgeon would be if sea level rise was great enough to consistently shift the salt wedge far enough north which would restrict the range of juvenile sturgeon and may affect the development of these life stages. Upstream shifts in spawning or rearing habitat in the Hudson River are limited by the existence of the Troy Dam (RKM 250, RM 155), which is impassable by sturgeon. Currently, the saltwedge normally shifts seasonally from Yonkers to as far north as Poughkeepsie (RKM 120, RM 75). Given that sturgeon currently have over 75 miles of habitat upstream of the salt wedge before the Troy Dam, it is unlikely that the saltwedge would shift far enough upstream to result in a significant restriction of spawning or nursery habitat. The available habitat for juvenile sturgeon could decrease over time; however, even if the saltwedge shifted several miles upstream, it seems unlikely that the decrease in available habitat would have a significant effect on juvenile sturgeon because there would still be many miles of available low salinity habitat between the salt wedge and the Troy Dam.

In the action area, it is possible that changing seasonal temperature regimes could result in changes in the timing of seasonal migrations through the area as sturgeon move to spawning and overwintering grounds. There could be shifts in the timing of spawning; presumably, if water temperatures warm earlier in the spring, and water temperature is a primary spawning cue, spawning migrations and spawning events could occur earlier in the year. However, because spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change), it is not possible to predict how any change in water temperature or river flow alone will affect the seasonal movements of sturgeon through the action area.

Any forage species that are temperature dependent may also shift in distribution as water temperatures warm. However, because we do not know the adaptive capacity of these individuals or how much of a change in temperature would be necessary to cause a shift in distribution, it is not possible to predict how these changes may affect foraging sturgeon. If sturgeon distribution shifted along with prey distribution, it is likely that there would be minimal, if any, impact on the availability of food. Similarly, if sturgeon shifted to areas where different forage was available and sturgeon were able to obtain sufficient nutrition from that new source of forage, any effect would be minimal. The greatest potential for effect to forage resources would be if sturgeon shifted to an area or time where insufficient forage was available; however, the likelihood of this happening seems low because sturgeon feed on a wide variety of species and in a wide variety of habitats.

Limited information on the thermal tolerances of Atlantic and shortnose sturgeon is available. Atlantic sturgeon have been observed in water temperatures above 30°C in the south (see Damon-Randall *et al.* 2010); in the wild, shortnose sturgeon are typically found in waters less than 28°C. In the laboratory, juvenile Atlantic sturgeon showed negative behavioral and bioenergetics responses (related to food consumption and metabolism) after prolonged exposure to temperatures greater than 28°C (82.4°F) (Niklitschek 2001). Tolerance to temperatures is thought to increase with age and body size (Ziegweid *et al.* 2008 and Jenkins *et al.* 1993), however, no information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. Shortnose sturgeon, have been documented in the lab to experience mortality at temperatures of 33.7°C (92.66°F) or greater and are thought to experience stress at temperatures above 28°C. For purposes of considering thermal tolerances, we consider Atlantic sturgeon to be a reasonable surrogate for shortnose sturgeon given similar geographic distribution and known biological similarities.

Normal surface water temperatures in the Hudson River can be as high as 24-27°C at some times and in some areas during the summer months; temperatures in deeper waters and near the bottom are cooler. A predicted increase in water temperature of 3-4°C within 100 years is expected to result in temperatures approaching the preferred temperature of shortnose and Atlantic sturgeon (28°C) on more days and/or in larger areas. This could result in shifts in the distribution of sturgeon out of certain areas during the warmer months. Information from southern river systems suggests that during peak summer heat, sturgeon are most likely to be found in deep water areas where temperatures are coolest. Thus, we could expect that over time, sturgeon would shift out of shallow habitats on the warmest days. This could result in reduced foraging opportunities if sturgeon were foraging in shallow waters.

As described above, over the long term, global climate change may affect shortnose and Atlantic sturgeon by affecting the location of the salt wedge, distribution of prey, water temperature and water quality. However, there is significant uncertainty, due to a lack of scientific data, on the degree to which these effects may be experienced and the degree to which shortnose or Atlantic sturgeon will be able to successfully adapt to any such changes. Any activities occurring within and outside the action area that contribute to global climate change are also expected to affect shortnose and Atlantic sturgeon in the action area. While we can make some predictions on the likely effects of climate change on these species, without modeling and additional scientific data these predictions remain speculative. Additionally, these predictions do not take into account the adaptive capacity of these species which may allow them to deal with change better than predicted.

7.0 EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and occur later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). This Opinion examines the likely effects of the proposed action on listed species and their habitat in the action area within the context of the species current status, the environmental baseline and cumulative effects. The effects of the proposed action are the effects of the continued operation of IP2 and IP3 pursuant to the existing and proposed renewed licenses proposed to be issued by the NRC pursuant to the Atomic Energy Act. NRC has requested consultation on the proposed extended operation of the facilities under the same terms as in the existing licenses and existing SPDES permits.

The proposed action has the potential to affect shortnose and Atlantic sturgeon in several ways: impingement or entrainment of individual sturgeon at the intakes; altering the abundance or availability of potential prey items; and, altering the riverine environment through the discharge of heated effluent and other pollutants.

7.1 Effects of Water Withdrawal

Under the terms of the existing licenses and the proposed renewal licenses, IP2 and IP3 will continue to withdraw water from the Hudson River for cooling. Both units utilize once through cooling and will continue to use once through cooling during the extended operating period, assuming no changes are made to the proposed action. Section 316(b) of the CWA requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impacts. According to the draft SPDES permit for the facility, the NYDEC has determined for CWA purposes that the site-specific best technology available to minimize the adverse environmental impacts of the IP cooling water intake structures is closed-cycle cooling (NYDEC 2003b). IP2 and IP3 currently operate pursuant to the terms of the SPDES permits issued by NYDEC in 1987 but administratively extended since then. NYDEC issued a draft SPDES permit in 2003. Its final contents and timeframe for issuance are uncertain, given it is still under adjudication at this time. While it is also uncertain that the facility will be able to operate under the same terms as those in its existing license and SPDES permit, NRC sought consultation on its proposal to renew the license for the facility under the same terms as the existing license and SPDES permit, which authorize once through cooling. Here, we consider the impacts to shortnose and Atlantic sturgeon of the continued operation of IP2 and IP3 with the existing once through cooling system and existing SPDES permits from now through the duration of the proposed license renewal period for IP2 and IP3 (i.e., through September 2033 and December 2035, respectively). But, it is important to note that changes to the effects of the action, including but not limited to changes in the effects of the cooling water system, as well as changes in other factors, may trigger reinitiation of consultation (see 50 CFR 402.16).

7.1.1 Entrainment

Entrainment occurs when small aquatic life forms are carried into and through the cooling system during water withdrawals. Entrainment primarily affects small organisms with limited swimming ability that can pass through the screen mesh, used on the intake systems. Once entrained, organisms pass through the circulating pumps and are carried with the water flow through the intake conduits toward the condenser units. They are then drawn through one of the many condenser tubes used to cool the turbine exhaust steam (where cooling water absorbs heat) and then enter the discharge canal for return to the Hudson River. As entrained organisms pass through the intake they may be injured from abrasion or compression. Within the cooling system, they encounter physical impacts in the pumps and condenser tubing; pressure changes and shear stress throughout the system; thermal shock within the condenser; and exposure to chemicals, including chlorine and residual industrial chemicals discharged at the diffuser ports (Mayhew et al. 2000 in NRC 2011). Death can occur immediately or at a later time from the physiological effects of heat, or it can occur after organisms are discharged if stresses or injuries result in an inability to escape predators, a reduced ability to forage, or other impairments.

7.1.1.1 Entrainment of Shortnose Sturgeon

The southern extent of the shortnose sturgeon spawning area in the Hudson River is approximately RM 118 (rkm 190*),* approximately 75 miles (121 km) upstream of the Indian Point facility. The eggs of shortnose sturgeon are demersal, sinking and adhering to the bottom of the river, and, upon hatching the larvae in both yolk-sac and post-yolk-sac stages remain on the bottom of the river, primarily upstream of RM 110 (rkm 177) (NMFS 2000). Because eggs do not occur near the IP intakes, there is no probability of entrainment. Shortnose sturgeon larvae are 20mm (0.8 inches) in length at the time they begin downstream migrations (Buckley and Kynard 1995). Because of intolerance to salinity, larvae occur only in freshwater, above the salt wedge. The location of the salt wedge in the Hudson River varies both seasonally and annually, depending at least partially on freshwater input (e.g., rainfall, snow melt). In many years, the salt wedge is located upstream of the Indian Point intakes; in those years, larvae would not be expected to occur near the IP intakes as the salinity levels would be too high. However, at times when the salt wedge is downstream of the intakes, which is most likely to occur in the late summer, there is the potential for shortnose sturgeon larvae to be present in the action area. Larvae occur in the deepest water and in the Hudson River, they are found in the deep channel (Taubert and Dadswell 1980; Bath et al. 1981; Kieffer and Kynard 1993). Larvae grow rapidly and after a few weeks are too large to be entrained by the cooling water intake; thus, any potential for entrainment is limited to any period when individuals are small enough to pass through the openings in the mesh screens that coincide with a period when the salt wedge is located downstream of the intakes. Given the distance between the intake and the deep channel (2000 feet; 610 meters) where any larvae would be present if in the action area, larvae are unlikely to occur near the intake where they could be susceptible to entrainment.

Studies to evaluate the effects of entrainment at IP2 and IP3 conducted since the early 1970s employed a variety of methods to assess actual entrainment losses and to evaluate the survival of entrained organisms after they are released back into the environment by the once-through cooling system. IP2 and IP3 monitored entrainment from 1972 through 1987. Entrainment monitoring became more intensive at Indian Point from 1981 through 1987, and sampling was conducted for nearly 24 hours per day, four to seven days per week, during the spawning season in the spring. As reported by NRC, entrainment-monitoring reports list no shortnose sturgeon eggs or larvae at IP2 or IP3. During the development of the HCP for steam electric generators on the Hudson River, NMFS reviewed all available entrainment data. In the HCP, NMFS (2000) lists only eight sturgeon larvae collected at any of the mid-Hudson River power plants (all eight were collected at Danskammer (approximately 23 miles upstream of Indian Point), and four of the eight may have been Atlantic sturgeon). Entrainment sampling data supplied by the applicant (Entergy 2007b) include large numbers of larvae for which the species could not be determined; however, NRC has indicated that as sturgeon larvae are distinctive it is unlikely that sturgeon larvae would occur in the "unaccounted" category as it is expected that if there were any sturgeon larvae in these samples they would have been identifiable. Entergy currently is not required to conduct any monitoring program to record entrainment at IP2 and IP3; however, it is reasonable to use past entrainment results to predict future effects. This is because: (1) there have not been any operational changes that make entrainment more likely now than it was during the time when sampling took place and, (2)there have been no changes in the locations where sturgeon spawn which would increase the exposure of eggs or larvae to entrainment. Additionally, the years when intense entrainment sampling took place overlap with two of the years (1986 and 1987; Woodland and Secor 2007) when shortnose sturgeon recruitment is thought to have been the highest and therefore, the years when the greatest numbers of shortnose sturgeon larvae were available for entrainment. Reliance on the lack of observed entrainment of shortnose sturgeon during sampling at IP2 and IP3 is also reasonable given the known information on the location of shortnose sturgeon spawning and the distribution of eggs and larvae in the river.

NRC was not able to provide NMFS with any historical monitoring data from the IP1 intakes and it is not clear if any monitoring at IP1 ever occurred. However, given that the IP1 intake (used for service water for IP2) is located adjacent to the IP2 and IP3 intakes and that intake velocity and screen size is comparable to IP2 and IP3 it is reasonable to expect that the potential for entrainment of early life stages of shortnose sturgeon at the IP1 intake is comparable to the potential for entrainment of early life stages of shortnose sturgeon at the IP2 and IP3 intakes.

Based on the life history of the shortnose sturgeon, the location of spawning grounds within the Hudson River, and the patterns of movement for eggs and larvae, it is extremely unlikely that any shortnose sturgeon early life stages would be entrained at IP2 and/or IP3. This conclusion is supported by the lack of any eggs or larvae positively identified as sturgeon and documented during entrainment monitoring at IP2 or IP3. Provided that assumption is true, NMFS does not anticipate any entrainment of shortnose sturgeon eggs or larvae in the future when IP2 and IP3 are operating pursuant to their current licenses or when they are operating pursuant to their extended operating license (i.e., through September 2033 and December 2035, respectively). It is important to note that this determination is dependent on the validity of the assumption that none of the unidentified larvae were shortnose sturgeon. All other life stages of shortnose sturgeon are too big to pass through the screen mesh and could not be entrained at the facility. As NMFS expects that the potential for entrainment of shortnose sturgeon at the IP1 intake is comparable to IP2 and IP3, NMFS does not anticipate any entrainment of any life stage of shortnose sturgeon at the IP1 intake, as used for service water for IP2.

7.1.1.2 Entrainment of Atlantic sturgeon

In order to be entrained, Atlantic sturgeon would need to be small enough to pass through the mesh of the traveling screens (0.25-by-0.5-inch (in.) (0.635-by-1.27 centimeters (cm)). Eggs are adhesive and demersal and occur only on the spawning grounds. At hatching, Atlantic sturgeon larvae are approximately 7.8 mm TL (Smith 1980, 1981)). As described above, the location of spawning in a given year is likely dependent on the location of the salt wedge; the most recent reports of spawning have been upstream of river kilometer 112 (Van Eenennaam *et al.*, 1996; Kahnle *et al.*, 1998; Bain *et al.*, 2000). Young-of-year (YOY) have been recorded in the Hudson River between rkm 60 and rkm 148; which, because young of year are not likely to make extensive upstream movements, indicates that spawning likely occurs upstream of these areas. Larvae must remain upstream of the salt wedge because of their low salinity tolerance (Dovel and Berggren, 1983; Kahnle *et al.*, 1998; Bain *et al.*, 2000).

As noted above, the location of the salt wedge in the Hudson River varies both seasonally and annually, depending at least partially on freshwater input. In many years, the salt wedge is located upstream of the Indian Point intakes; in those years, larvae would not be expected to occur near the IP intakes as the salinity levels would be too high. However, at times when the salt wedge is downstream of the intakes, which is most likely to occur in the late summer, there is the potential for Atlantic sturgeon larvae to be present in the action area. Like shortnose sturgeon, Atlantic sturgeon larvae occur in the deepest water and in the Hudson River, they are found in the deep channel (Taubert and Dadswell 1980; Bath et al. 1981; Kieffer and Kynard 1993). Larvae grow rapidly; at hatching larvae are within 2 mm of the size of the opening of the mesh, in a short time they are too large to be entrained by the cooling water intake. Any potential for entrainment is limited to any period when individuals are small enough to pass through the openings in the mesh screens that coincide with a period when the salt wedge is located downstream of the intakes. Given the distance between the intake and the deep channel (2,000 feet; 610 meters) where any larvae would be present if in the action area, larvae are unlikely to occur near the intake where they could be susceptible to entrainment. No Atlantic sturgeon larvae have been documented as entrained at IP2 or IP3. The nearest documentation of Atlantic sturgeon larvae to IP2 and IP3 is at the Danskammer facility, approximately 23 miles upstream.

Based on the life history of Atlantic sturgeon, the location of spawning grounds within the Hudson River, and the patterns of movement for eggs and larvae, it is extremely unlikely that any Atlantic sturgeon early life stages would be entrained at IP2 and/or IP3. This conclusion is supported by the lack of any eggs or larvae positively identified as sturgeon and documented during entrainment monitoring at IP2 or IP3. Provided that assumption is true, we do not anticipate any entrainment of shortnose sturgeon eggs or larvae in the future when IP2 and IP3 are operating pursuant to their current licenses or when they are operating pursuant to their extended operating license (i.e., through September 2033 and December 2035, respectively). It is important to note that this determination is dependent on the validity of the assumption that none of the unidentified larvae were Atlantic sturgeon. All other life stages of Atlantic sturgeon are too big to pass through the screen mesh and could not be entrained at the facility. As we expect the potential for entrainment of Atlantic sturgeon at the IP1 intake is comparable to IP2 and IP3, we do not anticipate any entrainment of any life stage of Atlantic sturgeon at the IP1 intake, as used for service water for IP2.

7.1.2 Impingement

Impingement occurs when organisms are trapped against cooling water intake screens or racks by the force of moving water. Impingement can kill organisms immediately or contribute to death resulting from exhaustion, suffocation, injury, or exposure to air when screens are rotated for cleaning. The potential for injury or death is generally related to the amount of time an organism is impinged, its susceptibility to injury, and the physical characteristics of the screenwashing and fish return system that the plant operator uses. Below, NMFS considers the available data on the impingement of shortnose and Atlantic sturgeon at the facility and then considers the likely rates of mortality associated with this impingement.

Impingement only occurs when a fish cannot swim fast enough to escape the intake (e.g., the fish's swimming ability is overtaken by the velocity of water being sucked into the intake). A few studies have been carried out to examine the swimming ability of sturgeon and their vulnerability to impingement. Generally speaking, fish swimming ability, and therefore ability to avoid impingement and entrainment, are affected not just by the flow velocity into the intakes, but also fish size and age, water temperature, level of fatigue, ability to remain a head-first orientation into current, and whether the fish is sick or injured.

Kynard et al. (2005) conducted tests in an experimental flume of behavior, impingement, and entrainment of yearlings (minimum size tested 280mm FL, 324mm TL), juveniles (minimum size tested 516mm FL, 581mm TL) and adult shortnose sturgeon (minimum size tested 600mmFL, 700mm TL). Impingement and entrainment were tested in relation to a vertical bar rack with 2 inch clear spacing. The authors observed that after yearlings contacted the bar rack, they could control swimming at 1 and 2 feet/sec, but many could not control swimming at 3 feet/sec velocity. After juveniles or adults contacted the rack, they were able to control swimming and move along the rack at all three velocities. During these tests, no adults or juveniles were impinged or entrained at any approach velocity. No yearlings were impinged at velocities of 1 ft/sec, but 7.7-12.5% were impinged at 2 ft/sec, and 33.3-40.0% were impinged at 3 ft/sec. The range of entrainment of yearlings (measured as passage through the rack) during trials at 1, 2, and 3 ft/sec approach velocities follow: 4.3-9.1% at 1 ft/sec, 7.1-27.8% at 2 ft/sec, and 66.7-80.0% at 3 ft/sec. From this study, we can conclude that shortnose sturgeon that are yearlings and older (at least 280mm FL) would have sufficient swimming ability to avoid impingement at an intake with velocities of 1 fps or less.

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 (0.16 fps). 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 seconds (Deslauriers and Kieffer (2012).

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. Shortnose sturgeon in this study swam at a maximum of 2.7 body lengths/second (BL/s) at velocities of 45 cm/s (1.47 fps). In this study, the authors developed a prediction equation to describe the relationship between Ucrit and water temperature. The authors report that amongst North American sturgeon species, only the pallid and shovelnose sturgeon have higher documented U_{crit} values (in BL/s) than shortnose sturgeon at any given temperature .

Boysen and Hoover (2009) conducted swimming performance trials in a laboratory swim tunnel with hatchery-reared juvenile white sturgeon to evaluate entrainment risk in cutterhead dredges. The authors observed that 80% of individuals tested, regardless of size (80-100mm TL) were strongly rheotactic (i.e., they were oriented into the current), but that endurance was highly variable. Small juveniles (< 82 mm TL) had lower escape speeds (< 40 cm/s (1.31fps)) than medium (82–92 mm TL) and large (> 93 mm TL) fish (42–45 cm/s (1.47 fps)). The authors concluded that the probability of entrainment of juvenile white sturgeon could be minimized by maintaining dredge head flow fields at less than 45 cm/s (1.47 fps).

Hoover et al. (2011) used a Blazka-type swim tunnel, to quantify positive rheotaxis (head-first orientation into flowing water), endurance (time to fatigue), and behavior (method of movement) of juvenile sturgeon in water velocities ranging from 10 to 90 cm/s (0.3-3.0 fps). The authors tested lake and pallid sturgeon from two different populations in the U.S. Rheotaxis, endurance, and behavioral data were used to calculate an index of entrainment risk, ranging from 0 (unlikely) to 1.00 (inevitable), which was applied to hydraulic models of dredge flow fields. The authors concluded that at distances from the draghead where velocity had decreased to 40cm/s (1.31 fps) entrainment was unlikely.

7.1.2.1 Impingement of Shortnose Sturgeon at Indian Point

Impingement of most fish species at IP2 and IP3 was monitored daily until 1981. Impingement of sturgeon species was monitored daily from 1974-1990 (Entergy 2009). Collections were reduced to a randomly selected schedule of 110 days per year until 1991, and then monitoring ceased in 1991 with the installation of the modified Ristroph traveling screens.

After NRC submitted its 2008 BA, Entergy submitted revised impingement data to NRC to correct certain accounting errors related to sampling frequency. The corrected impingement data for shortnose sturgeon, presented in NRC's 2010 BA, is summarized below (Table 2). The actual observed number of impingements is recorded as "Observed Fish" below (called the Level 5 Count in NRC 2010 and 2012). This number was adjusted to account for collection efficiency to determine the "Estimated Fish" below (the "CE Adjusted Level 5 Count" in NRC 2010 and 2012).

A total of 32 shortnose sturgeon were observed during impingement monitoring at IP2 and IP3 from 1974-1990. Adjusting for collection efficiency, it is estimated that a total of 71 shortnose sturgeon were impinged at IP2 and IP3 during this period. For this period, the average number of shortnose sturgeon impinged per year at IP2 and IP3 was 4.2 shortnose sturgeon/year (see Table 2 below).

Table 2. Actual and Adjusted Level of Annual Impingement of Shortnose Sturgeon 1974-1990

	IP2		***IP3***		
Year	**Observed Fish**	**Estimated Fish**	**Observed Fish**	**Estimated Fish**	**Total IP2 and IP3 Annual Estimate**
1974	3	9	0	0	9
1975	1	3	NR	NR	3*
1976	1	2	0	0	2
1977	5	11	1	2	13
1978	2	5	3	5	10
1979	2	4	2	3	7
1980	0	0	1	2	2
1981	0	0	0	0	0
1982	0	0	0	0	0
1983	0	0	0	0	0
1984	1	3	1	2	5
1985	0	0	0	0	0
1986	0	0	0	0	0
1987	2	4	1	2	6
1988	3	7	1	2	9
1989	0	0	1	2	2
1990	1	3	0	0	3
Total	21	**51**	11	**20**	**71**

In addition to the withdrawal of water from the IP2 and IP3 intakes for cooling water and service water, additional service water for IP2 is withdrawn through the IP1 intakes. This intake is located between the IP2 and IP3 intakes, also along the eastern shore of the Hudson River. NRC was not able to provide NMFS with any monitoring data from IP1 and it is unclear if any monitoring at IP1 has ever occurred. As such, we have no reports of impingement at IP1 and none of the materials submitted by NRC or Entergy have contained an estimate of impingement at IP1.

Following the reinitiation of consultation in 2012, Entergy provided us with a report on shortnose and Atlantic sturgeon impingement at Indian Point (Entergy 2012). According to the report, Entergy has made the assumption that the likelihood of impingement is related to the amount of water withdrawn. This seems to be a reasonable assumption as the more water that is withdrawn through the intakes the greater the opportunity is for impingement. Entergy reports that the amount of water withdrawn varies seasonally and annually. They suspect that these differences could account for some of the interannual variability in impingement of sturgeon. To account for interannual variations in operations, Entergy calculated an “impingement density” of sturgeon; that is, the number of sturgeon/volume of water withdrawn (cooling plus service water). This value was calculated using the adjusted impingement values (Estimated Fish in the table above) from 1976-1990 and the actual water withdrawal rates from IP2 and IP3 during the same period. Monthly average impingement densities were estimated by dividing the total number of sturgeon impinged during that month by the actual average withdrawal rate (gpm x 106) for the month (Entergy 2012). Using this method, Entergy determined that on average during 1976-1990, the highest impingement occurred in April (approximately 1 per month), with the lowest impingement (none) occurring in the June, July or December. In other months, the average was less than one per month.

Impingement density values are shown for each year 1976 through 1990[11] for shortnose sturgeon in Figure 2. This figure presents year on the horizontal axis and the vertical axis shows the annual sturgeon impingement density (sturgeon per million gpm) for IP2 and IP3 combined. The annual sturgeon impingement density shown on the vertical axis of Figure 2 is calculated as the annual number (count) of sturgeon impinged and then scaled upward by monthly collection efficiency values for each Unit in each year and divided by the annual average cooling water withdrawal rate for that Unit and year in million gallons per minute. The impingement density values plotted on the vertical axis in Figure 3 represents the sum of each density value for IP2 and IP3 for each year.

Annual shortnose sturgeon impingement density (average of monthly estimates of impingement density based on number impinged and the average monthly flow rate) ranged from 0 (1981, 1982, 1983, 1985 and 1986) to 2.1 (1977). These are also the years with the lowest and highest estimated total impingement (see Table above).

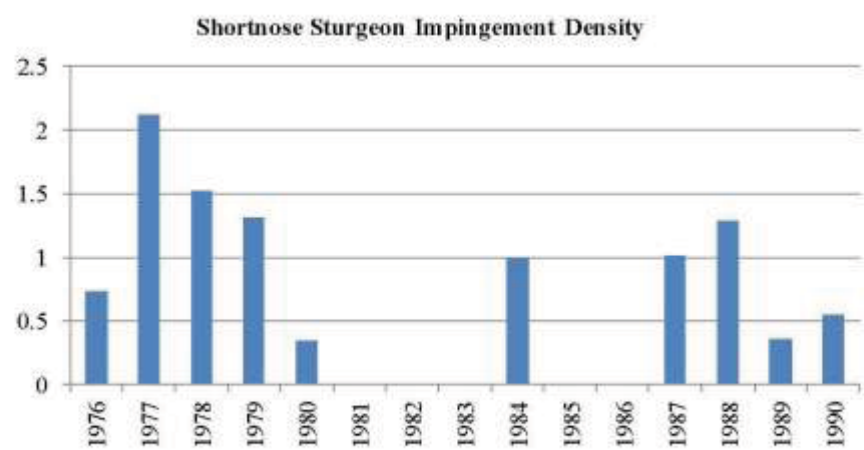


Figure 2. Among year pattern of shortnose sturgeon impingement density at IP2 and IP3 (combined). Annual density is the average of monthly estimates of impingement density based on number impinged and the average monthly flow rate (million gpm). From Entergy 2012.

[11] Entergy used the years 1976-1990 for this method because those were the years that flow data was available. Also, IP3 was not operational in 1975.

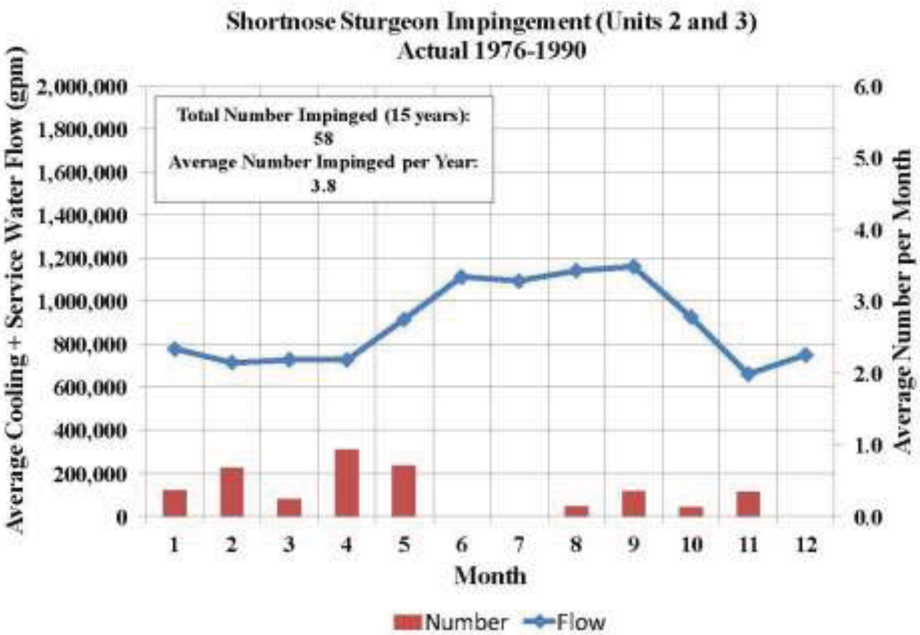


Figure 3. Among-month pattern of average shortnose sturgeon impingement at IP2 and IP3, and average IP flows (cooling water plus service water) for the years 1976-1990.

These calculations suggest that there may be factors other than water withdrawal volume that contributed to the number of sturgeon impinged at IP2 and IP3. For example, according to the information presented in Figure 3, June and July (months 6 and 7) are two of the months with the highest amount of water withdrawal, yet there is an average of zero impingements during these months. We would also expect that if the volume of water withdrawn was the only factor associated with impingement, there would be very little variability in impingement density from one year to the next. As demonstrated in Figure 2 there is substantial variability in impingement density from year to year.

Possible explanations for monthly and annual differences in impingement density include environmental conditions (i.e., water temperature, availability of forage, location of the salt wedge) that would influence the likelihood of shortnose sturgeon presence in the action area as well as changes in the number of sturgeon in the action area due to the strength of various year classes and overall size of the population. We do not have data on water temperature, availability of forage or location of the salt wedge for the time period that impingement monitoring occurred; therefore we are not able to explore any of these possible explanations. As discussed in more detail below, shortnose sturgeon in the Hudson River experienced an increasing trend over the time period that impingement monitoring occurred. We would expect that there would also be an increasing trend in impingement due to the presence of a greater number of shortnose sturgeon in the Hudson River, particularly after 1985; however, this is not seen.

Predicted Future Impingement of Shortnose Sturgeon
Shortnose sturgeon can be impinged at the IP1, IP2 or IP3 intakes. In front of all three intakes there are trash bars with 3-inch spacing between them. According to information provided by Entergy, approach velocities outside of the trash bars at IP2 and IP3 are approximately 1.0fps at full flow and 0.6fps at reduced flow (Enercon 2010; Entergy 2007). Fish that are narrower than 3-inches may pass through the trash bars. Fish wider than 3-inches could be vulnerable to impingement on the trash racks if they were not able to swim away. Once inside the trash racks, fish that do not swim back out through the racks into the river can be impinged at the screens in front of the intakes. At IP2 and IP3 there are modified Ristroph traveling screens. Fletcher (1990) reports that the mean water velocity in the area between the trash rack and the traveling screens was 30cm/second (0.98 feet/second) and varied with the tide during testing of the screens carried out in 1986. Fletcher (1990) does not report the range of velocities that are experienced in this area. The traveling screens continually move vertically through the water column as they rotate. The Ristroph screens have a screen basket equipped with a water-filled lifting bucket. Fish can be forcibly impinged on the screens or can be captured by the buckets. As each bucket passes over the top of the screen, fish are rinsed into a collection trough by a spraywash system.

Comment [A4]: Question to NRC – how far outside the trash bars is this velocity reported? The reports state "approximately" – what is the range of velocities that are experienced. What is the "through-rack" velocity? What is the range of water velocity between the trash rack and the Ristroph screens (Fletcher 1990 reports an average of 30cm/s)?

If through-rack velocity at the trash racks in front of IP1, IP2 and IP3 is 1.0 fps, as reported by Entergy, we would not anticipate any impingement of shortnose sturgeon at the trash racks. That is because sturgeon that are big enough to not be able to pass through the racks (i.e., those that have body widths greater than three inches) would be adults. These fish are able to avoid impingement at velocities of up to 3 feet per second and should be able to readily avoid getting stuck on the trash racks.

Entergy and Fletcher (1990) both report that velocities in front of the traveling screens are on average 1.0 fps or less. The laboratory studies on sturgeon swimming ability discussed in Section 7.1.2 indicate that shortnose sturgeon older than one year and larger than 28cm long should be able to avoid impingement. The Kynard study suggest that impingement rates for yearlings would be less than 10% at this intake velocity.

We examined the available data on shortnose sturgeon impinged at IP2 and IP3 to determine the length of impinged fish. Of the 32 shortnose sturgeon recorded at IP2 and IP3 from 1974-1990, length is available for only nine individuals. These fish ranged in size from 32-71 cm. This is consistent with our estimates of the size of fish that would be able to pass through the trash bars but is larger than the size of fish we would expect to be vulnerable to impingement if the flow velocity is 1 fps.

Entergy applied the prediction equation for U_{crit} as a function of water temperature (from Deslauriers and Kieffer 2012) to the range of monthly water temperatures in the vicinity of IP2 and IP3 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 IP2 and IP3 (Entergy 2012). In the equation, 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).

Comment [A5]: Question to NRC: What are these assumptions based on? What is the data that resulted in flow estimates of 1 ft/sec for full flow and 0.6 for reduced flow. To get those figures, was there a field study across a range of conditions or are these calculations based on pump specifications or something else?

Based on the average historical flows at IP2 and IP3 (Figures 2 and 3), Entergy assumed that full flow conditions might exist from May through October, and reduced flow conditions would exist from November through April.

The results of Entergy's analysis indicate that healthy sturgeons over 19.5 cm TL should be capable of sustained avoidance of impingement at IP2 and IP3 throughout the year. Entergy states that 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 cm TL 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 cm TL 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.

Based on the size of the shortnose sturgeon that have been impinged at IP2 and IP3 and the analysis completed by Entergy, it appears that there are other factors than the size of the fish that are contributing to the likelihood of impingement. It is possible that the configuration of the buckets on the traveling screen results in the capture of sturgeon prior to them getting "stuck" on the screens. This would explain why fish of a size that should be able to avoid impingement on the traveling screens have been documented during impingement sampling. It is interesting to note that Fletcher (1990) reports that striped bass are capable of sustained swimming at the flow speeds (mean 30cm/s) in front of the Ristroph screens yet during sampling at one intake bay in September and October 1986, 86 striped bass were documented as impinged (as determined by observation of individuals in the fish return sluice or the debris return sluice). Fletcher (1990) reports that the vast majority of these striped bass were not dead or dying upon collection. Of the 86 individuals, 2 were "damaged" and 5 were dead when collected. Fletcher suggests that freely swimming fish (which we would expect sturgeon to be) will still encounter the collection troughs with the likelihood of encounter increasing with the length of time that the fish spends in the collection area.

Another possible explanation for the impingement of shortnose sturgeon that are of sufficient size to avoid impingement at the reported intake velocities is that these fish are impaired prior to impingement. Fish that are sick or injured may have reduced swimming speed or endurance and may not be able to avoid impingement the way a healthy fish would. Unfortunately, the data that are available on the 32 impinged shortnose sturgeon only indicate condition (alive or dead) for nine individuals. We examined the available information to see if there was a relationship between the length of these nine fish and whether they were alive or dead, and there did not appear to be a relationship between size and condition.

It is also possible that fish that pass through the trash bars become tired or disoriented when trying to find an escape route. Even if through-rack velocity is not high enough to preclude fish from exiting the area, they may have difficulty finding a way out, especially if there is debris in front of the trash bars. Information presented by Fletcher (1990) on the length of time that fish spent in the area between the trash racks and the Ristroph screens supports this idea; for marked striped bass during a release-recapture study at Indian Point, the mean time spent in the area

between the trash racks and Ristroph screens prior to observation in the fish return sluice was 9.73 hours.
We have considered whether the thermal plume may affect shortnose sturgeon in a way that increases the potential for impingement (see 7.2.1, below) and have determined that based on the available information on the thermal plume, it is not likely that the thermal plume directly influences impingement of sturgeon. The impingement of sturgeon at IP2 and IP3 is probably due to a combination of the factors mentioned above, all of which explain how impingement can occur despite intake velocities at levels that are below those that most sturgeon should be able to readily escape from. The lack of information on the condition of the impinged shortnose sturgeon makes it difficult to draw any conclusions about other factors that may contribute to impingement, including the impact of the thermal plume on the swimming endurance of sturgeon near the intake. Despite the low intake velocity reported by Entergy, impingement of sturgeon occurred in the past and likely continues to occur. The lack of recent monitoring data makes predictions of future impingement more difficult. Estimating future impingement is made more difficult by the variability in annual impingement rates and not knowing the degree to which factors discussed above contribute to these differences. We have considered several ways to estimate likely future impingement including: (1) using the annual average number of impingements to predict future impingement; and (2) using Entergy's impingement density calculations.

Calculations based on Impingement data from 1974-1990
During the period that impingement sampling occurred, the number of shortnose sturgeon impinged ranged from zero to 13. The average annual impingement was 4.2 shortnose sturgeon/year. Excluding 1975, when only IP2 was operational, the average was 4 per year. As noted in the Status of the Species section of this Opinion, the shortnose sturgeon population has grown since the time impingement monitoring ceased. Therefore, we considered if the average impingement rate during 1974-1990 would underestimate future impingement.

We have made the basic assumption that the risk of impingement increases with the size of the population. That is, we expect that if there are more fish in the river there is more opportunity for individuals to be impinged. We expect if there are more sturgeon in the action area then the impingement rate would be higher. The shortnose sturgeon population in the Hudson River exhibited tremendous growth in the 20 year period between the late 1970s and late 1990s, with exceptionally strong year classes between 1986-1992 thought to have led to resulting increases in the subadult and adult populations sampled in the late 1990s (Woodland and Secor 2007). According to data presented by Bain (2000) and Woodland and Secor (2007), there were 4 times as many shortnose sturgeon in the Hudson River in the late 1990s as compared to the late 1970s. An increasing trend is also observed in the juvenile index of shortnose sturgeon (prepared by NYDEC) and the CPUE of the utilities Long River and Fall Shoals Survey (Mattson 2012). Woodland and Secor (2007) state that the population of shortnose sturgeon is currently stable at the high level described also by Bain (2000).

The period for which impingement sampling occurred (1974-1990) partially overlaps with the period of increased recruitment. During the portion of the sampling period that overlaps with the period of increased recruitment (1986-1990) the increases in the shortnose sturgeon population would have been fish less than 4 years old. Those are the year classes that would be most vulnerable to impingement. As such, we would expect a peak in impingement numbers from 1986-1990; however, such a peak is not seen in the data that is available to us. In fact, average impingement from 1986-1990 is just slightly higher (five fish per year, collectively at IP2 and IP3) as compared to the 17-year average, and is lower than the average from 1976-1980 (7.4 fish/year collectively at IP2 and IP3) and two of the years (1985 and 1986) had no impingement. One possible explanation is that the fish being impinged are not the small fish (yearlings) that we expect (see above), so even if there was an increase in the number of yearling shortnose sturgeon during this period that may not be reflected in the impingement numbers. It is also possible that while there was an increase in the number of yearlings from 1986-1990 as compared to earlier years, the size of the total population was not significantly different. This could be the case as shortnose sturgeon are long-lived fish, and there are expected to be at least 20-30 year classes in the river at one time. Another explanation is that the location of the salt wedge during 1986-1990 or a subset of those years precluded or minimized the use of the action area by juvenile shortnose sturgeon, which could also affect the impingement rate; however, we do not have the information necessary to investigate that hypothesis as salt wedge location data are only available since 1990.

Entergy conducted an analysis to determine if there was a statistically significant correlation between reported shortnose sturgeon population size and impingement density. It is expected that the more sturgeon there were in the river, the higher the impingement density would be because there would be more sturgeon that had the potential to be impinged. However, the analysis does not reveal a statistically significant correlation (Entergy 2012). It is likely that this lack of statistical correlation is not due to the fact that there is no relationship between population size and impingement but because impingement of sturgeon is a rare event which makes detection of a statistically significant correlation difficult.

As noted above, one factor that may affect the likelihood of impingement is the condition of fish prior to impingement, which may dilute the relationship between numbers of fish in the river and impingement rates. Factors that have changed over time that could be related to the condition of fish in the action area are water quality, and bycatch in the direct Atlantic sturgeon fishery and the American shad fishery. The directed fishery for Atlantic sturgeon occurred until 1996. Because impingement monitoring was discontinued after 1990, we are not able to make any comparisons of impingement rates during years when fishing was occurring and years it was not. We also do not have any information on the intensity of fishing effort over time or the bycatch rate of shortnose sturgeon that we could use to compare to the impingement rates at IP2 or IP3. Similarly, we do not have the necessary information on the shad fishery to compare to the impingement rates. We do know that, generally, water quality improved significantly in the Hudson River beginning in the mid-1970s. This improvement is considered by Woodland and Secor to be one of the primary factors contributing to the increase in the shortnose sturgeon population. It is possible that improvements in water quality resulted in an improvement of the general health of sturgeon in the action area which could have contributed to a reduction in impingement despite an increase in the number of shortnose sturgeon in the action area. Similarly, a reduction in fishing effort could lead to a reduction in bycatch and subsequent release of injured or stressed fish. However, all of this is speculative.

Other factors that may explain interannual variability in impingement numbers that are not related to absolute population size are environmental conditions in the river that are associated with the distribution of shortnose sturgeon. As established above, younger, smaller sturgeon are most likely to be vulnerable to impingement. These fish are restricted to the area of the river above the salt-freshwater interface. In some years, the saltwedge is located downstream of the Indian Point intakes and in some years it is above the Indian Point intakes. In years when the saltwedge is located further upstream, impingement would be expected to be low because, regardless of the total number of shortnose sturgeon in the river at that time, there would be few, if any, juveniles in the action area. The salt front (100 milligrams per liter of chloride) ranges from below Hastings-on-Hudson to New Hamburg during most years, but can move as far north as Poughkeepsie during periods of drought. As such, in drier periods, when the salt front is above Buchannan, we would anticipate that very few juvenile sturgeon would be present in the action area. Unfortunately, the available data on the location of the salt front in the Hudson River (October 1991 – March 2012; USGS 2012), do not overlap at all with the period of time for which impingement data is available. Therefore, we are unable to test this hypothesis regarding relationship between salt wedge location and impingement.

We considered reviewing impingement data for other Hudson River power plants to determine if this predicted correlation between increases in population size and increased impingement of individuals would be observed. Long term shortnose sturgeon impingement monitoring is only available for the Roseton and Danskammer facilities. However, since 2000, both facilities have operated at reduced rates and there has been minimal shortnose sturgeon impingement; in every year it has been less than the 2 and 4 impingements estimated respectively for these two facilities. As the Roseton and Danskammer facilities are not currently operating in the same capacity they were in the past, it is not possible to make an accurate comparison of past and present impingement which could serve to determine if it was reasonable to assume that an increase in impingement would occur in association with an increase in the number of shortnose sturgeon in the Hudson River. As noted above, the Lovett facility has been closed. The Bowline facility has always operated with extremely low levels of impingement, thought to be primarily due to the location of the intakes in a nearly enclosed embayment of the River where shortnose sturgeon are thought to be unlikely to occur (Bowline Pond) (NMFS 2000). Therefore, we are not able to use information from other power intakes to determine if there is an association between changes in population size and rates of impingement.

We also considered examining relationships between population trend and impingement rates at facilities outside the Hudson River. Monitoring of sturgeon impingement at the Salem Nuclear Generating Station, on the Delaware River, has been ongoing since 1978. However, the population of shortnose sturgeon in the Delaware River has been stable at approximately 12,000 adults since 1981. The impingement rate has similarly been stable at an average of less than one fish per year throughout this period. Because of the stable trend in the population and the impingement rate at this facility, it is not possible to use this information to determine if changes in population size are related to changes in impingement rates.

Despite the uncertainty in determining the factors that are related to impingement, the assumption that the more sturgeon there are in the river the higher the potential for impingement, is reasonable. If we adjust the average number of shortnose sturgeon impinged annually at IP2 and IP3 by 400% (the increase in the size of the population reported by Bain and Woodland and Secor), we would anticipate the impingement of an average of 16 shortnose sturgeon per year at IP2 and IP3 (combined) during the period that these facilities will continue to operate (i.e., 1974-1990 annual average was 4, times 4 = 16). From September 2033 – December 2035, only IP3 will be operational. During the period 1974-1990, approximately 28% of the impinged shortnose sturgeon were at IP3. Using that ratio and applying it to the estimate of 16 shortnose sturgeon when both facilities are operational, we expect an average of 4.5 shortnose sturgeon to be impinged annually when just IP3 is operational. Over the two year period we expect the impingement of nine shortnose sturgeon.

In addition to the withdrawal of water from the IP2 and IP3 intakes for cooling water and service water, additional service water for IP2 will be withdrawn from the IP1 intakes. This intake is located between the IP2 and IP3 intakes, also along the eastern shore of the Hudson River. NRC was not able to provide us with any monitoring data from IP1, and it is unclear if any monitoring at IP1 has ever occurred. Given the lack of intake specific monitoring data, we have assessed the likelihood of impingement of shortnose sturgeon at the IP1 intakes as compared to the likelihood of impingement at the IP2 and IP3 intakes. As noted above, there is no geographic difference in intake location which would make impingement at IP1 more or less likely at IP2 or IP3. The intake velocity, trash bar spacing and screen mesh size are also comparable between IP1 and IP2 and IP3. The major difference between the IP1 intake and the IP2 and IP3 intakes is the volume of water removed. Together, IP2 and IP3 remove a maximum flow of approximately 1.746 million gallons per minute. According to information provided by Entergy[12], the IP1 intake structure has two redundant forebays, each with a maximum or design flow of 10,000 gpm; however, as currently configured in a redundant manner, the maximum flow of the intake is 10,000 gpm. Entergy further indicates that the typical peak operating flow for IP1 is 5,500 gpm with 6,000 gpm as the limit of the IP2 load.

Given the maximum 6,000 gpm operation of the IP1 intake, this represents approximately 0.34% of the total intake flow from IP2 and IP3 (6,000gpm/1,746,000gpm). Assuming, that all other parameters being equal, the potential for impingement is related to the volume of water withdrawn, we expect that the number of shortnose sturgeon impinged at the IP1 intakes would be 0.34% of the number of shortnose sturgeon impinged at IP2 and IP3. As explained above, adjusting the long term average by 400%, we expect 16 shortnose sturgeon to be impinged at IP2 and IP3 annually. Assuming that an additional 0.34% would be impinged at the IP1 intake, we would expect an average of 0.05 shortnose sturgeon to be impinged annually at IP1 intakes. Between now and 2033 when the IP2 license expires (a period of 21 years), we would expect one shortnose sturgeon to be impinged at IP1.

In summary, using the average annual impingement from 1974-1990 and adjusting it by 400% to account for increases in the shortnose sturgeon population and then adding 0.34% to account for the IP1 intakes, we would expect a total impingement of 337 shortnose sturgeon between now and September 2033 (the time period when IP2 and IP3 will be operational and water will be withdrawn through the IP1 intakes) and an additional 9 shortnose sturgeon from September 2033-December 2035 when just IP3 will be operational. This results in a total estimate of 346 shortnose sturgeon impinged at Indian Point.

[12] Email from Elise Zoli, representing Entergy, to NMFS and NRC on September 21, 2011.

Calculations based on Entergy's Impingement Density Calculations
Entergy states that some of the interannual variability in impingement is likely due to the variable operation of the facility (i.e., changes in the volume of water withdrawn due to outages). To account for this variable, Entergy developed the impingement density estimate which calculates the average number of sturgeon impinged per month per volume of water removed. Entergy has determined that operations of IP2 and IP3 from 2001-2008 are representative of future operations, including under the terms of the proposed new licenses. Entergy has indicated that there are no power uprates or other changes being proposed at the facility that would result in more water being withdrawn in the future. Therefore, Entergy applied an adjusted impingement density (to account for increases in the shortnose sturgeon population) to the predicted volume of water to be removed in the future (based on 2001-2008 operation), to predict future impingement of shortnose sturgeon.
Entergy predicted future impingement using the impingement density values. They consider the annual average water withdrawal rate for 2001-2008 to be representative of future operations of the Indian Point cooling water intake structures. Because operations vary monthly, with average water withdrawal lower in some months than others, they factored this variability in operations into the calculations. To account for the increase in shortnose sturgeon in the Hudson River, Entergy adjusted the monthly impingement density rates by 400%. They then applied this impingement density rate to the predicted water withdrawal for the future operating period. Using this method, they predict that impingement would vary monthly, with no impingement in June, July and December and a peak in April; in total, this method estimates the impingement of 20 shortnose sturgeon per year (see Figure 4 below).

Figure 4. Among-month pattern of projected average shortnose sturgeon impingement at IP2 and IP3, and average of IP2 and IP3 flows (cooling water plus service water) for the years 2001-2008. From Entergy 2012.

Comparison of results of the two calculation methods
Both of the methods considered above make adjustments to account for the greater number of shortnose sturgeon in the Hudson River now as compared to the number when impingement monitoring occurred. The Entergy method predicts greater numbers of future impingement than just using the average annual impingement rate from 1974-1990. Entergy predicts that future operations will be similar to operations from 2001-2008. During that time, average service and cooling water flows through the IP2 and IP3 intakes ranged from 1 million to 1.8 million gallons per minute depending on the month. From 1976-1990, average service and cooling water flows through the IP2 and IP3 intakes ranged from 0.6-1.2 million gallons per minute depending on the month suggesting an overall increase of 1.5-1.6 times the amount of water to be withdrawn in the future as compared to 1976-1990. If we assume that the risk of impingement increases with the volume of water removed through the intakes, then it becomes important to factor in increased water usage when considering future impingement. If we adjust the calculated impingement number (16; based on the annual average) by a factor of 1.6 to account for increased water usage we would estimate an annual average of 25.6 shortnose sturgeon impinged at IP2 and IP3.

Because of the uncertainty related to the factors associated with impingement rates, it is difficult to determine which estimate is a better predictor of future impingement. The Entergy methodology assumes there will be no impingement of shortnose sturgeon in June, July or

December. However, a review of the impingement data that are available suggests that this may not be a reasonable assumption. For example, two of the 32 impinged shortnose sturgeon were impinged in June (1974 and 1975), which suggests that impingement is likely to occur in June. Because of this, and because we believe that by making adjustments to our estimate to account for increased water usage we are removing the potential for underestimating due to lower water usage in the past, we have determined that the best estimate of future impingement at IP2 and IP3 is 26 shortnose sturgeon per year (rounding 25.6 fish up to whole fish). This estimate is based on the annual average estimate of 4 sturgeon per year during the period of 1974-1990 (exclusive of 1975 when only IP3 was operational) and adjustments made to account for a 400% increase in the number of shortnose sturgeon in the Hudson River now as compared to the time when impingement sampling occurred and a 160% increase to account for increases in the predicted amount of water to be withdrawn in the future as compared to 1976-1990. Using the calculation discussed previously for IP1, we expect the annual average impingement of 0.09 shortnose sturgeon at the IP1 intakes. Therefore, for the time period when IP2 and IP3 will be operational (now through September 2033), we expect the impingement of 548 shortnose sturgeon (26 sturgeon per year for 21 years plus two at IP1). During the time period when just IP3 will be operational (September 2033-December 2035), we expect the impingement of 7 shortnose sturgeon per year. This results in a total estimate of 562 shortnose sturgeon impinged at Indian Point.

Comparison of estimate of impingement of shortnose sturgeon in NMFS 2011 Opinion and this Opinion

In the 2011 Opinion, we estimated that over the 20 year extended operating period, 168 shortnose sturgeon would be impinged at IP1, IP2 and IP3, collectively. We calculated this estimate by first determining the average annual impingement rate at IP2 from 1974-1990 and the average annual impingement rate at IP3 from 1976-1990, which we stated was 1.3 and 0.73, respectively. To account for the 400% increase in the shortnose sturgeon population between the late 1970s and the late 1990s, we adjusted those annual impingement rates by a factor of 4 was 5.2 and 2.9 shortnose sturgeon per year, respectively. We then multiplied those annual estimates by the number of years each unit would be operational (20) to get a total estimate for IP2 of 104 and a total estimate for IP3 of 58. We then used the calculations noted above (6,000gpm/1,746,000gpm) to estimate the amount of impingement at IP1. We estimated the impingement of six additional shortnose sturgeon at IP1. However, it appears that we made a mathematical error (multiplying 162 by 0.034 instead of 0.0034)and that number should have been one, not six.

In reviewing the methodology used in 2011, we now recognize two ways that this resulted in an underestimate of future impingement. First, we relied on the actual observed number of impingements of shortnose sturgeon, not the estimated number of impingements based on collection efficiency. Collection efficiency takes into account the fraction of fish that enter the intake structure but do not make it into impingement collections. According to NRC, currents may sweep some fish around the traveling screens because screens do not form a perfectly water tight seal against the intake structure. NRC has stated that the CE adjusted estimates should be more accurate . We also have new information on the volume of water Entergy is likely to withdraw through the IP2 and IP3 intakes in the future (Entergy 2012). The information provided by Entergy indicates that water withdrawal will range from 1.2-1.6 mgd depending on the month. They report water usage from 1974-1990 as ranging from 0.6-1.2 mgd depending on the month. We expect a relationship between water usage and impingement; the more water that is withdrawn the higher the risk for impingement. Therefore, by not adjusting the historic impingement numbers to account for current and future increases in water use, our 2011 estimate likely underestimates future impingement of shortnose sturgeon. We believe the methodology described above, which avoids that underestimation, and results in a total estimate of 562 shortnose sturgeon impinged at Indian Point is a better approach.

Predicted Mortality of Impinged Shortnose Sturgeon
NRC has stated that the installation of the modified Ristroph screens following the 1987-1990 monitoring period is expected to have reduced impingement mortality for shortnose sturgeon. However, because no monitoring occurred after the installation of the Ristroph screens, more recent data are not available and, it is not possible to determine to what extent the modified Ristroph screens may have reduced impingement mortality as compared to pre-1991 levels.

Of the 32 shortnose sturgeon collected during impingement sampling at IP2 and IP3, condition (alive or dead) is reported for nine fish (NRC BA 2010); of these, seven are reported as dead (78% mortality rate). There is no information to indicate whether alive meant alive and not injured, or alive and injured. There is also no additional information to assess whether these fish reported as dead were likely killed prior to impingement and drifted into the intake or whether being in the intake bays and/or impingement was the sole cause of death or a contributing cause of death.

Before installation of modified Ristroph screen systems in 1991, impingement mortality at IP2 and IP3 was assumed to be 100 percent. Beginning in 1985, pilot studies were conducted to evaluate whether the addition of Ristroph screens would decrease impingement mortality for representative species. The final design of the screens, as reported in Fletcher (1990), appeared to reduce impingement mortality for some species based on a pilot study compared to the original system in place at IP2 and IP3. The Fletcher study reported mortality following an 8-hour holding period in an attempt to account for delayed mortality that may result from injuries suffered during impingement. Based on the information reported by Fletcher (1990), impingement mortality and injury are lowest for striped bass, weakfish, and hogchoker, and highest for alewife, white catfish, and American shad, with mortality rates ranging from 9-62%, depending on species. No evaluation of survival of shortnose sturgeon on the modified Ristroph screens at IP2 or IP3 was made and no monitoring has occurred since the screens were installed in 1991.

PSEG prepared estimates of impingement survival following interactions with Ristroph screens at their Salem Nuclear Generating Station located on the Delaware River (PSEG in Seabey and Henderson 2007); survival of shortnose sturgeon was estimated at 60% following impingement on a conventional screen and 80% following survival at a Ristroph Screen; survival for other species ranged from 0-100%. It is important to note that PSEG did not conduct field verifications with shortnose sturgeon to demonstrate whether these survival estimates are observed in the field. A review by NMFS of shortnose sturgeon impingement information at Salem indicates that all recorded impingements (20 total since 1978; NRC 2010) have been at the trash racks, not on the Ristroph screens. This is consistent with the expectation that all shortnose sturgeon in the vicinity of the Salem intakes would be too large to fit through the trash bars and potentially contact the Ristroph screens. Thus, while there is impingement data from Salem, there is no information on post-impingement survival for shortnose sturgeon impinged on the Ristroph screens. The majority of impinged shortnose sturgeon at Salem have been dead at the time of removal from the trash racks (17 out of 20; 85%),

In his 1979 testimony, Dadswell discussed a mortality rate of shortnose sturgeon at traditional screens of approximately 60%, although it is unclear what information this number is derived from as no references were provided and no explanation was given in the testimony. NRC states in their BA that this was based on the percent of shortnose sturgeon alive vs. dead during one year of impingement monitoring that was available at the time.

No further monitoring of the IP2 or IP3 intakes or impingement rates or impingement mortality estimates was conducted after the new Ristroph screens were installed at IP2 and IP3 in 1991, and any actual reduction in mortality or injury to shortnose sturgeon resulting from impingement after installation of these systems at IP2 and IP3 has not been established. As explained above, shortnose sturgeon with a body width of at least three inches would not be able to pass through the trash bars and would become impinged on the trash bars and not pass through to the Ristroph screens. Survival for shortnose sturgeon impinged on the trash bars would be dependent on the length of time the fish was impinged and whether it also interacted with debris that collects on the bars. The available data for shortnose sturgeon impingement at trash bars indicates that mortality is likely to be high (e.g., 85% at Salem nuclear facility) even when a monitoring program is in place designed to observe and remove impinged fish[13].

As noted above, healthy shortnose sturgeon (yearlings and older) are expected to be able to readily avoid an intake with an approach velocity of 1.0 fps or less. Some of the shortnose sturgeon impinged may already be dead or suffering from injury or illness. Some sturgeon caught in the buckets of the Ristroph screen may be healthy and free swimming and may experience injury or mortality while being transported to the sluice. Other sturgeon may become impinged on the traveling screens and suffer injury or mortality due to their impingement. Some sturgeon may become injured or die from being in the intake embayment between the trash bars and screens. Past monitoring at IP2 and IP3 indicates that mortality rates are approximately 78% (assuming the best case, that all shortnose sturgeon recorded as “alive” were not just alive but were uninjured), monitoring at the Salem nuclear facility indicates that mortality rates at the trash bars are approximately 85%. With no monitoring or inspection plan in place to detect and remove shortnose sturgeon that become impinged on the trash bars, mortality rates for shortnose sturgeon impinged on the trash bars are more likely to be as high as 100%, as there would be no opportunity for fish to be removed once stuck between or on the bars.

Based on the available information, it is difficult to predict the likely mortality rate for shortnose sturgeon following impingement on the Ristroph screens. Shortnose sturgeon passing through the trash bars and becoming impinged on the Ristroph screens are likely to be small juveniles with body widths less than three inches. Based on the 8-hour survival rates reported by Fletcher for other species, it is likely that some percentage of shortnose sturgeon impinged on the

[13] At Salem, trash racks infront of the intakes are cleaned at least three times per week and the trash bars are inspected every four hours from April through October.

Ristroph screens will survive. Shortnose sturgeon that become impinged on the Ristroph screens may be suffering from injuries, illnesses, or other stressors that have impaired their swimming ability and prevented them from being able to escape from the relatively low approach velocity (1.0 fps or less as measured within the intake bay in front of the Ristroph screens, which yearling and older shortnose sturgeon are expected to be able to avoid (Kynard et al. 2005)). Given the design of the Ristroph screens and the short passage time, it is unlikely that passage through the screen system would increase the likelihood of mortality or exacerbate injury or illness. However, because we do not know the condition of the fish prior to impingement, and we have no site-specific studies to base an estimate or even species-specific studies at different facilities, we will assume the worst case, that mortality is 100%.

Using the impingement rates calculated above, and the worst case mortality rate of 100% at both the modified Ristroph screens and the trash bars, an average of 24 shortnose sturgeon may die each year as a result of impingement at IP2 and IP3. We expect a total of 562 shortnose sturgeon to die as a result of impingement at IP2 and IP3 between now and the time that the extended operating licenses expire. For the reasons given above, we believe that the 100% mortality estimate is a conservative, yet reasonable, mortality rate for impinged shortnose sturgeon at the trash bars and Ristroph screens.

7.1.2.2 Impingement of Atlantic sturgeon at IP2 and IP3

Daily monitoring for sturgeon occurred at IP2 and IP3 from 1974-1990. The actual observed number of impingements is recorded as “Observed Fish” below (called the “Level 5 Count” in NRC 2010 and 2012). This number was adjusted to account for collection efficiency to determine the “Estimated Fish” below (the “CE Adjusted Level 5 Count” in NRC 2010 and 2012).

A total of 601 Atlantic sturgeon were observed during impingement monitoring at IP2 and IP3 from 1974-1990. Adjusting for collection efficiency, it is estimated that a total of 1,334 Atlantic sturgeon were impinged at IP2 and IP3 during this period. For this period, the average number of Atlantic sturgeon impinged per year at IP2 and IP3 was 78.5 Atlantic sturgeon/year (see Table 3 below).

	IP2		***IP3***		
Year	**Observed Fish**	**Estimated Fish**	**Observed Fish**	**Estimated Fish**	**Total IP2 and IP3 Annual Estimate**
1974	101	282	10	17	299
1975	118	302	NR	NR	302
1976	8	17	8	14	31
1977	44	105	153	252	357
1978	16	38	21	31	69
1979	32	75	38	51	126
1980	9	24	10	17	41

1981	3	8	5	7	15
1982	1	2	1	1	3
1983	3	6	0	0	6
1984	3	6	5	10	16
1985	9	19	17	25	44
1986	2	6	5	6	12
1987	2	6	1	2	8
1988	1	2	0	0	2
1989	0	0	0	0	0
1990	0	0	2	3	3
Total	352	**898**	276	**436**	**1334**

To account for interannual variations in operations, Entergy calculated an "impingement density" of sturgeon (see above). For Atlantic sturgeon, on average, the highest impingement occurred in April (approximately 15 per month), with the lowest impingement (less than two per month) occurring in late Fall.

The impingement density values calculated by Entergy are shown for each year 1976 through 1990[14] for Atlantic sturgeon in Figure 5. This figure presents year on the horizontal axis and the vertical axis shows the annual sturgeon impingement density (sturgeon per million gpm) for IP2 and IP3 combined. The annual sturgeon impingement density shown on the vertical axis of Figure 5 is calculated as the annual number (count) of sturgeon impinged and then scaled upward by monthly collection efficiency values for each Unit in each year and divided by the annual average cooling water withdrawal rate for that Unit and year in million gallons per minute. The impingement density values plotted on the vertical axis in Figure 6 represents the sum of each density value for IP2 and IP3 for each year.

Annual Atlantic sturgeon impingement density (average of monthly estimates of impingement density based on number impinged and the average monthly flow rate) ranged from 0 (1989) to 54 (1977).

[14] Entergy used the years 1976-1990 for this method because those were the years that flow data was available. Also, IP3 was not operational in 1975.

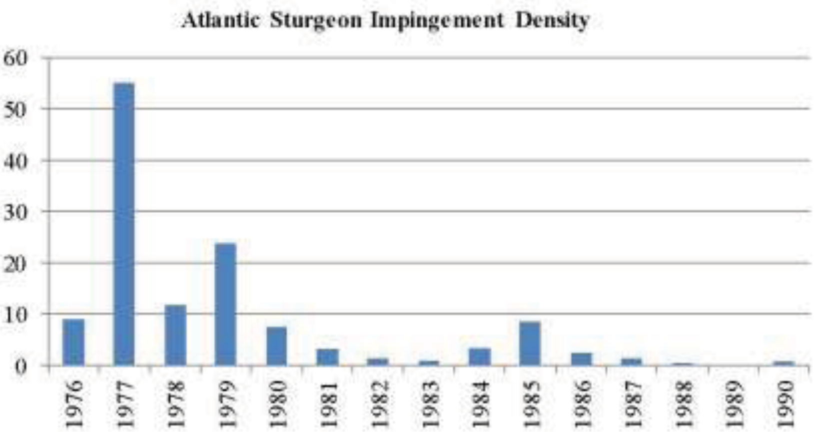


Figure 5. Among year pattern of Atlantic sturgeon impingement density at IP2 and IP3 (combined). Annual density is the average of monthly estimates of impingement density based on number impinged and the average monthly flow rate (million gpm). From Entergy 2012.

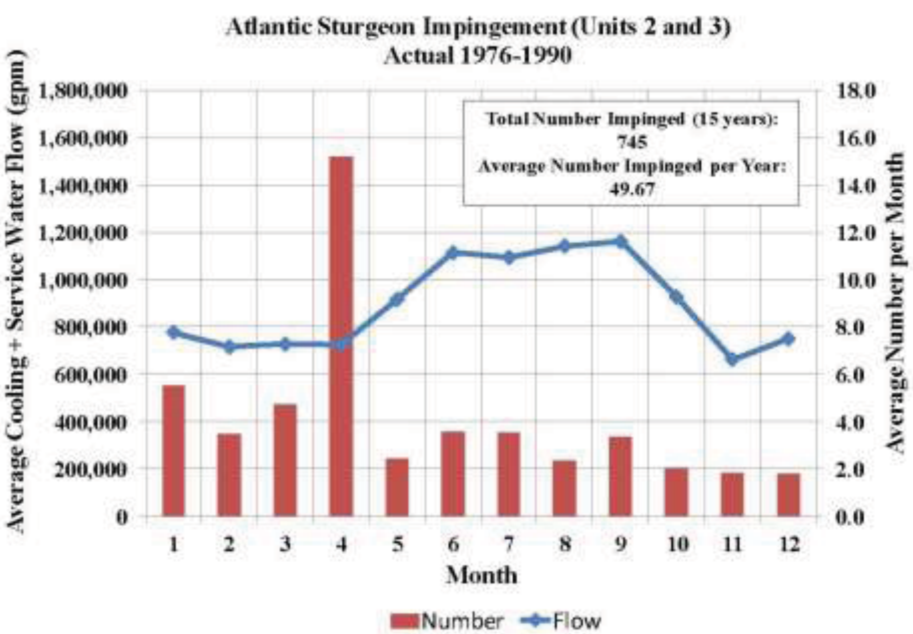


Figure 6. Among-month pattern of average Atlantic sturgeon impingement at IP2 and IP3, and average flows (cooling water plus service water) for the years 1976-1990.

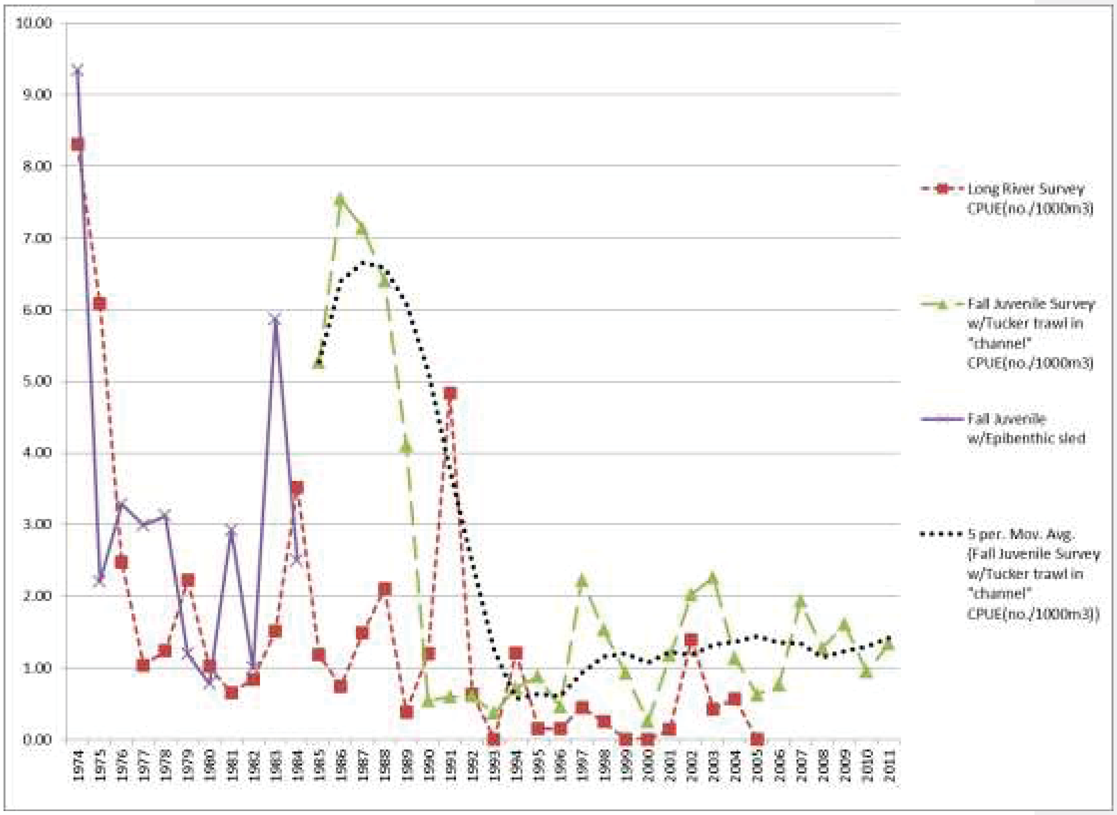
Predicted Future Impingement of Atlantic Sturgeon at IP2 and IP3
We examined the available data on Atlantic sturgeon impinged at IP2 and IP3 to determine the length of impinged fish. Of the 601 Atlantic sturgeon recorded at IP2 and IP3 from 1974-1990, length is available for 36 individuals. These fish ranged in size from 14-79 cm. Like shortnose sturgeon, this is consistent with our estimates of the size of fish that would be able to pass through the trash bars but is larger than the size of fish we would expect to be vulnerable to impingement.

We examined condition information to determine if there was an indication that these fish were sick or injured. We expect fish that are sick or injured to have reduced swimming speed or endurance and that they may not be able to avoid impingement the way a healthy fish would. Unfortunately, the data that is available on the 601 impinged Atlantic sturgeon only indicates condition (alive or dead) for 37 individuals (the same ones that had length recorded plus one additional). Of these 37 fish, 22 were dead; however, there does not appear to be a relationship between the length of the fish and whether they were alive or dead.
Like shortnose, based on the size of the Atlantic sturgeon that have been impinged at IP2 and IP3 and the analysis completed by Entergy, it appears that there are other factors than the size of the fish that are contributing to the likelihood of impingement. We expect that the factors discussed above for shortnose (i.e,. "active" capture of fish by the buckets on the Ristroph screens, possible impairment due to illness or injury, disorientation or exhaustion due to being "trapped" between the trash racks and Ristroph screens, conditions in the area including water temperature), also contribute to the likelihood that Atlantic sturgeon are impinged and would explain why fish that are of sufficient size to avoid impingement at the reported velocities would still be impinged.

The impingement of sturgeon at IP2 and IP3 is probably due to a combination of the factors mentioned above, all of which explain how impingement can occur despite reported intake velocities at levels that are below those that most sturgeon should be able to readily escape from. Despite the low intake velocity reported by Entergy, impingement of Atlantic sturgeon occurred in the past and likely continues to occur. The lack of recent monitoring data makes predictions of future impingement more difficult. Estimating future impingement is made more difficult by the variability in annual impingement rates and not knowing the degree to which factors discussed above contribute to these differences. Like we did for shortnose sturgeon, we have considered several ways to estimate likely future impingement of Atlantic sturgeon including: (1) using the annual average number of impingements to predict future impingement; and (2) using Entergy's impingement density calculations.

Calculations based on Impingement data from 1974-1990
During the period that impingement sampling occurred, the number of Atlantic sturgeon impinged ranged from zero to 357. The average annual impingement was 78.4 Atlantic sturgeon/year. Excluding 1975, when only IP2 was operational, the average was 60.8 per year. As noted in the Status of the Species section of this Opinion, the Atlantic sturgeon population in the Hudson River has had a decreasing trend over the time period that impingement monitoring occurred. Therefore, we considered if the average impingement rate during 1974-1990 would overestimate future impingement.

We have made the basic assumption that the risk of impingement increases with the size of the population. That is, we expect that if there are more fish in the river there is more opportunity for individuals to be impinged. We expect if there are more sturgeon in the action area then the impingement rate would be higher. As evidenced by estimates of juvenile abundance, the Atlantic sturgeon population in the Hudson River has declined over time. Peterson et al. (2000) found that the abundance of age-1 Atlantic sturgeon in the Hudson River declined 80% from 1977 to 1995. Similarly, longterm indices of juvenile abundance (the Hudson River Long River and Fall Shoals surveys) demonstrate a longterm declining trend in juvenile abundance. The figure below (Figure 7) illustrates the CPUE of Atlantic sturgeon in the two longterm surveys of the Hudson River. Please note that the Fall Shoals survey switched gear types in 1985. We do not have the CPUE data for the Long River Survey for 2006-2011.



As evidenced in the above table, impingement of Atlantic sturgeon declined over time. The annual average impingement from 1974-1978 was 211.6 Atlantic sturgeon; from 1986-1990 it was 5. Unlike for shortnose sturgeon where the impingement trend did not seem to match the trend of the population, the decline in Atlantic sturgeon in the river appears to be reflected in the declining trend in impingements of Atlantic sturgeon over time. This could be due to the time period of impingement monitoring better reflecting the time when changes were experienced in the Atlantic sturgeon population than changes in the shortnose sturgeon population.

CPUE for the Fall Juvenile Survey for the most recent five year period (2007-2011) is approximately 27% of the CPUE from 1985-1990 (1.41 compared to 5.17). The CPUE results suggest a sharp decline in juvenile Atlantic sturgeon in the Hudson River after 1989. While the CPUE results only indicate trends for juvenile Atlantic sturgeon, given the size of the Atlantic sturgeon impinged at Indian Point, they are a good representative of the year classes affected by operations of Indian Point. Therefore, while we do not have an index of the Hudson River population as a whole, that type of index may not be relevant for considering the number of Atlantic sturgeon available for impingement at Indian Point. Because of the change in gear type, we cannot directly compare CPUE from 1974-1990 (when impingement monitoring occurred) to CPUEs for more recent time periods. The only CPUEs that overlap with the impingement monitoring that can be directly compared to current CPUEs are those from 1985-1990. However, as evidenced in the figure above, there was an overall declining trend in the number of juvenile Atlantic sturgeon in the Hudson River since the mid-1970s. This declining trend is reflected in declines in impingement at Indian Point. CPUE data from 2007-2011 iss more than two times higher than the CPUE from 1991-1996 which may be suggestive of an increasing trend in juvenile abundance. However, the index suggests that numbers of juveniles are still significantly lower now than during the end of the impingement monitoring period. Given the high variability between years, it is difficult to use this data to assess short term trends, however, when looking at a five-year moving average, the index appears to be increasing from lows in the early 1990s, but is still much lower than the 1970s and 1980s.

Based on the CPUE, there appear to be approximately 27% of the number of Atlantic sturgeon juveniles in the Hudson River now as compared to the period 1985-1990. During that period, the average annual impingement rate was 6 Atlantic sturgeon per year. Using the CPUE to adjust that rate to predict current abundance, we would expect an annual average impingement rate of 1.62 Atlantic sturgeon per year. As noted above, there are some indications that the trend in juvenile abundance is increasing. The period 1985-1990 captures the period just prior to the sharp decline in Atlantic sturgeon juvenile abundance. Because there is some evidence of an increasing trend in juveniles in the Hudson River, it is possible that by reducing the average impingement rate from 1985-1990 we could underestimate future impingement.

Entergy conducted an analysis to determine if there was a statistically significant correlation between reported Atlantic sturgeon population size and impingement density. We would expect that the more sturgeon there were in the river, the higher the impingement density would be because there would be more sturgeon that had the potential to be impinged. However, the analysis does not reveal a statistically significant correlation (Entergy 2012). It is likely that this lack of statistical correlation is not due to the fact that there is no relationship between population size and impingement but because impingement of sturgeon is a rare event and because of the high interannual variability in impingement numbers which makes detection of a statistically significant correlation difficult.

We considered reviewing impingement data for other Hudson River power plants to determine if this predicted correlation between decreases in individuals and increased impingement of individuals would be observed. Long term sturgeon impingement monitoring is only available for the Roseton and Danskammer facilities. However, since 2000, both facilities have operated at reduced rates and there has been minimal sturgeon impingement; in every year it has been no more than one. As the Roseton and Danskammer facilities are not currently operating in the same capacity they were in the past, it is not possible to make an accurate comparison of past and present impingement which could serve to determine if it was reasonable to assume that an increase in impingement would occur in association with any change in the number of Atlantic sturgeon in the Hudson River. As noted above, the Lovett facility has been closed. The Bowline facility has always operated with extremely low levels of impingement, thought to be primarily due to the location of the intakes in a nearly enclosed embayment of the River where Atlantic sturgeon are thought to be unlikely to occur (Bowline Pond) (NMFS 2000). Therefore, we are not able to use information from other power intakes to determine if there is an association between changes in population size and rates of impingement.

We also considered examining relationships between population trend and impingement rates at facilities outside the Hudson River. Monitoring of shortnose sturgeon impingement at the Salem Nuclear Generating Station, on the Delaware River, has been ongoing since 1978. However, reporting of impinged Atlantic sturgeon only began in 2010, with one impingement recorded to date. Because of the lack of data, it is not possible to use this information to determine if changes in population size are related to changes in impingement rates.

Despite the uncertainty in determining the factors that are related to impingement, the assumption that the more sturgeon there are in the river the higher the potential for impingement, is reasonable. Because we expect fewer Atlantic sturgeon in the river now than during the period of impingement monitoring we considered adjusting the annual impingement value by 72% (the decrease in juveniles suggested by the CPUE from the Fall Shoals Survey). However, by doing this we may be underestimating future impingement if Atlantic sturgeon juvenile abundance is increasing in the way the Fall Shoals Survey CPUE suggests (i.e., an increase from the early 1990s, but still depressed from the 1970s). Based on what we know about Atlantic sturgeon in the river, the impingement rates from 1985-1990 appear to be the most reflective of future impingement rates. Using the annual average of Atlantic sturgeon impinged during this period, we would anticipate the impingement of an average of 6 Atlantic sturgeon per year at IP2 and IP3 (combined) during the period that these facilities will continue to operate. From September 2033 – December 2035, only IP3 will be operational. During the period 1974-1990, approximately 33% of the impinged Atlantic sturgeon were at IP3. Using that ratio and applying it to the estimate of 6 Atlantic sturgeon when both facilities are operational, we expect an average of 2 Atlantic sturgeon to be impinged annually when just IP3 is operational. Over the two year period we expect the impingement of 4 Atlantic sturgeon.

As described above for shortnose sturgeon, we also need to account for impingement of Atlantic sturgeon at IP1. Using the methodology discussed above, we assume that an additional 0.34% would be impinged at the IP1 intake; therefore, we would expect an average of 0.02 Atlantic sturgeon to be impinged annually at IP1 intakes. Between now and 2033 when the IP2 license expires (a period of 21 years), we would expect one Atlantic sturgeon to be impinged at IP1.

In summary, using the average annual impingement from 1985-1990 and then adding 0.34% to account for the IP1 intakes, we would expect a total impingement of 127 Atlantic sturgeon between now and September 2033 (the time period when IP2 and IP3 will be operational and water will be withdrawn through the IP1 intakes) and an additional 4 Atlantic sturgeon from September 2033-December 2035 when just IP3 will be operational. This results in a total estimate of 131 Atlantic sturgeon impinged at Indian Point.

Calculations based on Entergy's Impingement Density Calculations

Entergy applied an adjusted impingement density (to account for decreases in the Atlantic sturgeon population) to the predicted volume of water to be removed in the future (based on 2001-2008 operation), to predict future impingement of Atlantic sturgeon.

Entergy predicted future impingement using the impingement density values. They consider the annual average water withdrawal rate for 2001-2008 to be representative of future operations of the Indian Point cooling water intake structures. Because operations vary monthly, with average water withdrawal lower in some months than others, they factored this variability in operations into the calculations. To account for the decrease in Atlantic sturgeon in the Hudson River, Entergy adjusted the monthly impingement density rates by reducing them 80%. This was based on Peterson et al. (2000) finding that the abundance of age-1 Atlantic sturgeon in the Hudson River declined 80% from 1977 to 1995. They then applied this impingement density rate to the predicted water withdrawal for the future operating period. Using these rates to estimate future impingement, Entergy predicted an annual average impingement rate of 11.45 individuals per year.

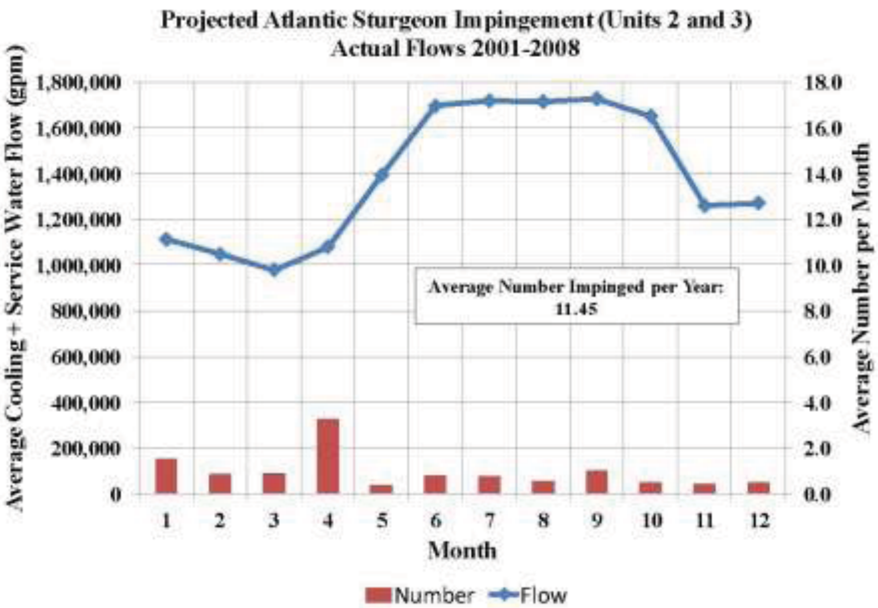


Figure 8. Among-month pattern of projected average Atlantic sturgeon impingement at IP2 and IP3, and average of IP2 and 3 flows (cooling water plus service water) for the years 2001-2008. From Entergy 2012.

Comparison of results of the two calculation methods
Both of the methods considered above make adjustments to account for the lesser number of Atlantic sturgeon in the Hudson River now as compared to the number when impingement monitoring occurred. The Entergy method predicts an annual average impingement rate of 11.4 Atlantic sturgeon per year. Our method, using the average impingement rate from 1985-1990, predicts an annual average rate of 6 Atlantic sturgeon per year. Entergy predicts that future operations will be similar to operations from 2001-2008. During that time, average service and cooling water flows through the IP2 and IP3 intakes ranged from 1 million to 1.8 million gallons per minute depending on the month. From 1976-1990, average service and cooling water flows through the IP2 and IP3 intakes ranged from 0.6-1.2 million gallons per minute depending on the month suggesting an overall increase of 1.5-1.6 times the amount of water to be withdrawn in the future as compared to 1976-1990. If we assume that the risk of impingement increases with the volume of water removed through the intakes, then it becomes important to factor in increased water usage when considering future impingement. If we adjust the calculated impingement number (6; based on the annual average from 1985-1990) by a factor of 1.6 to account for increased water usage we would estimate an annual average of 9.6 Atlantic sturgeon impinged at IP2 and IP3.

Because of the uncertainty related to the factors associated with impingement rates, it is difficult to determine which estimate is a better predictor of future impingement. The Entergy methodology assumes an 80% reduction in impingement in the future as compared to the time when monitoring took place. Based on comparisons of CPUE from 1985-1990 as compared to 2007-2011, it appears that at 72% reduction may be more reasonable. The two estimates result in very similar results, differing by an average of less than two Atlantic sturgeon per year. Entergy's estimate factors in impingement density from the 1970s when impingement rates were very high. That difference likely accounts for the differences in our predicted annual impingement. However, we believe that our estimate is a reasonable predictor of future Atlantic sturgeon impingement. This estimate is based on the annual average estimate of 6 Atlantic sturgeon per year during the period of 1985-1990 and a 160% increase to account for increases in the predicted amount of water to be withdrawn in the future as compared to 1976-1990. Using the calculation discussed previously for IP1, we expect the annual average impingement of 0.02 Atlantic sturgeon at the IP1 intakes. Therefore, for the time period when IP2 and IP3 will be operational (now through September 2033), we expect the impingement of an average of 10 Atlantic sturgeon per year (rounding up 9.6 to 10 to account for whole fish) plus one at IP1 for a total of 211 Atlantic sturgeon. During the time period when just IP3 will be operational (September 2033-December 2035), we expect the impingement of 4 Atlantic sturgeon per year. This results in a total estimate of 219 Atlantic sturgeon impinged at Indian Point.

As explained in section 4.2.2, we have determined that Atlantic sturgeon in the action area likely originate from three of the five DPSs at the following frequencies: NYB 92%; Gulf of Maine 6%; and, Chesapeake Bay 2%. However, it is important to note that only subadults and adults leave their natal rivers. Therefore, any young of the year or juveniles that are impinged would originate from the Hudson River and the New York Bight DPS. We can identify the life stage of Atlantic sturgeon by length. Subadults may move to coastal waters once reaching lengths of approximately76-92 cm (Murawski and Pacheco 1977; Smith 1985).

From 1985 through 1990, lengths (mm total length, "mmTL") and weights (wet weight in grams) of impinged Atlantic sturgeon were reported at IP2 and IP3; however, from 1974-1984, weights were reported but lengths were not. Therefore, for 1974-1984, Entergy predicted lengths of impinged Atlantic sturgeon 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 9 below).

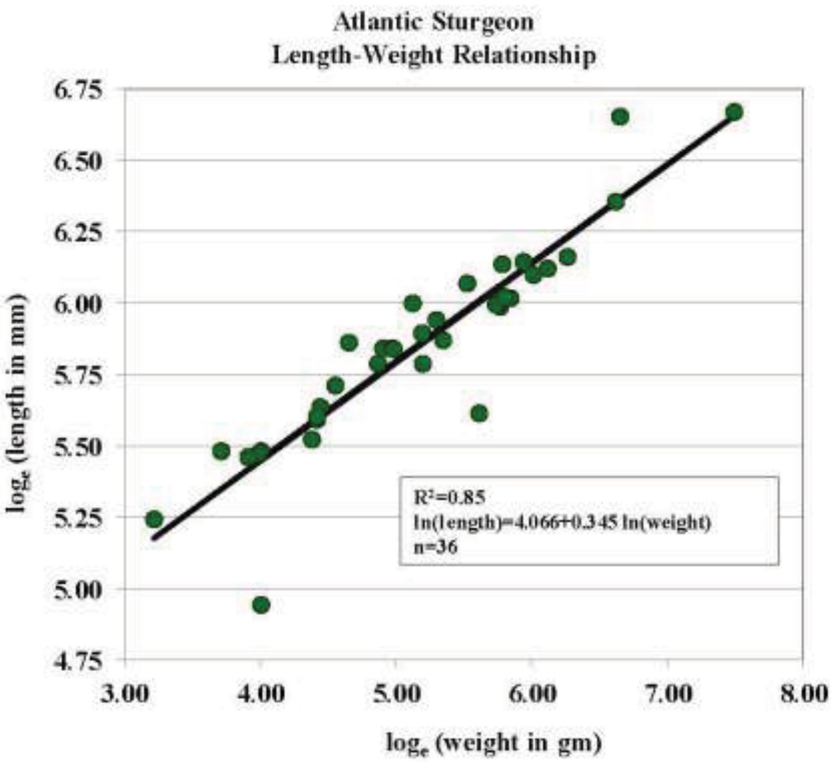


Figure 9. Atlantic sturgeon length-weight relationship based on length (mm TL) and weight measurements (dots) recorded on 36 Atlantic sturgeon collected during impingement sampling at IP2 and IP3 from 1985-1990.

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 IP2 or IP3. Applying this 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 9) 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 on the Ristroph screens by the bar racks.

Of the 36 impinged Atlantic sturgeon where length was recorded, only two were longer than 76cm and could have been migrants from outside the Hudson River. However, given their size (77 and 78 cm) at the low end of the range at which coastal migrations begin (76-92 cm) and the time of year that they were impinged (February 14 and March 13) it is likely that these two fish originated from the Hudson River.

Based on the available information on past impingements and the predicted size of individuals that will be impinged in the future, it is likely that all impingements will be of young of year, juveniles and subadults originating from the Hudson River. Therefore, we expect all individuals impinged to originate from the New York Bight DPS.

Predicted Mortality of Impinged Atlantic Sturgeon
NRC has stated that the installation of the modified Ristroph screens following the 1987-1990 monitoring period is expected to have reduced impingement mortality for sturgeon. However, because no monitoring occurred after the installation of the Ristroph screens, more recent data are not available and, it is not possible to determine to what extent the modified Ristroph screens may have reduced impingement mortality as compared to pre-1991 levels.

Of the 601 Atlantic sturgeon collected during impingement sampling at IP2 and IP3, condition (alive or dead) is reported for 37 fish (NRC BA 2012); of these, 22 are reported as dead (59% mortality rate). There is no information to indicate whether alive meant alive and not injured, or alive and injured. There is also no additional information to assess whether these fish reported as dead were likely killed prior to impingement and drifted into the intake or whether being in the intake bays and/or impingement was the sole cause of death or a contributing cause of death.

Before installation of modified Ristroph screen systems in 1991, 100 percent impingement mortality at IP2 and IP3 was assumed. Beginning in 1985, pilot studies were conducted to evaluate whether the addition of Ristroph screens would decrease impingement mortality for representative species. The final design of the screens, as reported in Fletcher (1990), appeared to reduce impingement mortality for some species based on a pilot study compared to the original system in place at IP2 and IP3. The Fletcher study reported mortality following an 8-hour holding period in an attempt to account for delayed mortality that may result from injuries suffered during impingement. Based on the information reported by Fletcher (1990), impingement mortality and injury are lowest for striped bass, weakfish, and hogchoker, and highest for alewife, white catfish, and American shad, with mortality rates ranging from 9-62%, depending on species. No evaluation of survival of Atlantic sturgeon on the modified Ristroph screens at IP2 or IP3 was made and no monitoring has occurred since the screens were installed in 1991.

No further monitoring of the IP2 or IP3 intakes or impingement rates or impingement mortality estimates was conducted after the new Ristroph screens were installed at IP2 and IP3 in 1991, and any actual reduction in mortality or injury to Atlantic sturgeon resulting from impingement after installation of these systems at IP2 and IP3 has not been established. As explained above, Atlantic sturgeon with a body width of at least three inches would not be able to pass through the trash bars and would become impinged on the trash bars and not pass through to the Ristroph screens. Survival for Atlantic sturgeon impinged on the trash bars would be dependent on the length of time the fish was impinged and whether it also interacted with debris that collects on the bars. Assuming that shortnose and Atlantic sturgeon mortality rates are similar, we expect that the mortality of Atlantic sturgeon at trash is likely to be high (e.g., 85% for shortnose sturgeon at Salem nuclear facility) even when a monitoring program is in place designed to observe and remove impinged fish.

As noted above, healthy Atlantic sturgeon (yearlings and older) are expected to be able to readily avoid an intake with an approach velocity of 1.0 fps or less. Therefore, any Atlantic sturgeon impinged at the trash bars, where the velocity is 1.0 fps or less depending on operating condition, are likely to already be suffering from injury or illness which has impaired their swimming ability. Past monitoring at IP2 and IP3 indicates that mortality rates for Atlantic sturgeon are approximately 60%, monitoring at the Salem nuclear facility indicates that mortality rates at the trash bars are approximately 85% for shortnose sturgeon. With no monitoring or inspection plan in place to detect and remove Atlantic sturgeon that become impinged on the trash bars, mortality rates for Atlantic sturgeon impinged on the trash bars are more likely to be as high as 100%, as there would be no opportunity for fish to be removed once stuck between or on the bars.

Based on the available information, it is difficult to predict the likely mortality rate for Atlantic sturgeon following impingement on the Ristroph screens. Atlantic sturgeon passing through the trash bars and becoming impinged on the Ristroph screens are likely to be small juveniles or subadults with body widths less than three inches. Based on the 8-hour survival rates reported by Fletcher for other species, it is likely that some percentage of Atlantic sturgeon impinged on the Ristroph screens will survive. Atlantic sturgeon that become impinged on the Ristroph screens may be suffering from injuries, illnesses, or other stressors that have impaired their swimming ability and prevented them from being able to escape from the relatively low approach velocity (1.0 fps or less as measured within the intake bay in front of the Ristroph screens, which yearling and older Atlantic sturgeon are expected to be able to avoid. Given the design of the Ristroph screens and the short passage time, it is unlikely that passage through the screen system would increase the likelihood of mortality or exacerbate injury or illness. However, because we do not know the condition of the fish prior to impingement, and we have no site-specific studies to base an estimate or even species-specific studies at different facilities, we will assume the worst case, that mortality is 100%.

Using the impingement rates calculated above, and the worst case mortality rate of 100% at both the modified Ristroph screens and the trash bars, an average of 10 Atlantic sturgeon may die each year as a result of impingement at IP2 and IP3. As such, we expect a total of 265Atlantic sturgeon to die as a result of impingement at IP2 and IP3 between now and the time that the extended operating licenses expire. For the reasons given above, we believe that the 100% mortality estimate is a conservative, yet reasonable, mortality rate for impinged Atlantic sturgeon at the trash bars and Ristroph screens. As noted above, we expect all impinged Atlantic sturgeon to originate from the Hudson River and the New York Bight DPS. Therefore, we expect the mortality of 219 New York Bight DPS Atlantic sturgeon between now and December 15, 2035.

7.1.3 Effects of Impingement and Entrainment on Shortnose and Atlantic sturgeon prey

Shortnose and Atlantic sturgeon feed primarily on benthic invertebrates. As these prey species are found on the bottom and are generally immobile or have limited mobility and are not within the water column, they are less vulnerable to impingement or entrainment. Impingement and entrainment studies have not included macroinvertebrates as focus species. No macroinvertebrates are represented in the Representative Important Species (RIS) species focused on by NRC in the FSEIS. However, given the life history characteristics (sessile, benthic, not suspended in or otherwise occupying the water column) of shortnose and Atlantic sturgeon forage items which make impingement and entrainment unlikely, any loss of sturgeon prey due to impingement or entrainment is likely to be minimal. Therefore, we have determined that the effect on shortnose and Atlantic sturgeon due to the potential loss of forage items caused by impingement or entrainment in the IP1, IP2 or IP3 intakes is insignificant and discountable.

7.1.4 Summary of Effects of Water Withdrawal

IP2 and IP3 currently operate pursuant to operating licenses issued by NRC; this will continue until a licensing decision is made. If new licenses are issued as proposed, IP2 and IP3 will continue to operate with once through cooling until September 29, 2033 and December 12, 2035 respectively. The extended operation of IP2 and IP3 would be authorized by the NRC through the issuance of renewed operating licenses. Compliance with the Clean Water Act provisions is a condition of the existing licenses and will be a condition of any new licenses issued.

In the analysis outlined above, we determined the impingement of shortnose sturgeon is likely to occur at IP2 and IP3 while IP2 and IP3 continue to operate as well as at the IP1 intake which will be used for withdrawing service water for the operation of IP2. We estimate, using the impingement and mortality rates calculated above, that each year an average of 24 shortnose sturgeon may die as a result of impingement at the Indian Point facility, for a total of 562 shortnose sturgeon mortalities between now and December 12, 2035. We also estimate that an average of 10 Atlantic sturgeon will be impinged and die each year, for a total of 219 Atlantic sturgeon mortalities between now and December 12, 2035. All of these Atlantic sturgeon are likely to originate from the Hudson River and the New York Bight DPS. We believe that the 100% mortality estimate is a conservative, yet reasonable estimate of the likely mortality rate for impinged shortnose sturgeon at the Ristroph screens. Due to the size of shortnose and Atlantic sturgeon that occur in the action area, no entrainment at any of the IP intakes is anticipated. Any effects to shortnose or Atlantic sturgeon prey from the continued operation of IP2 and IP3, as defined by the proposed action, would be insignificant and discountable.

7.2 Effects of Discharges to the Hudson River

The discharge of pollutants from the IP facility is regulated for CWA purposes through the New York SPDES program. The SDPES permit (NY-0004472) specifies the discharge standards and monitoring requirements for each discharge. Under this regulatory program, Entergy treats wastewater effluents, collects and disposes of potential contaminants, and undertakes pollution prevention activities. Compliance with the SPDES permit is a condition of the existing operating licenses and will be a condition of any new operating licenses issued for IP2 and IP3.

As explained above, Entergy's 1987 SPDES permit remains in effect while NYDEC administrative proceedings continue on a new draft permit. As such, pursuant to NRC's consultation request, the effects of the IP facility continuing to operate under the terms of the existing licenses and the proposed renewed licenses and under the terms of the 1987 SPDES permit will be discussed below.

7.2.1 Heated Effluent

As indicated above, the extended operation of IP2 and IP3 will be regulated by the NRC through the issuance of renewed operating licenses. Given the facilities with a once-through cooling water system cannot operate without the intake and discharge of water, and any limitations or requirements necessary to assure compliance with applicable Clean Water Act provisions would be conditions of the proposed renewed licenses, the effects of discharges are effects of the proposed action. This is also true for the existing licenses under which the facility will operate until NRC makes a licensing decision. The discharges would not occur but for the operation of the facilities.

Thermal discharges associated with the operation of the once through cooling water system for IP2 and IP3 are regulated for CWA purposes by the terms of the SPDES permit. Temperature limitations are established and imposed on a case-by-case basis for each facility subject to NYCRR Part 704. Specific conditions associated with the extent and magnitude of thermal plumes are addressed in 6 NYCRR Part 704 as follows:

(5) Estuaries or portions of estuaries.

i. The water temperature at the surface of an estuary shall not be raised to more than 90°F at any point.
ii. At least 50 percent of the cross sectional area and/or volume of the flow of the estuary including a minimum of one-third of the surface as measured from water edge to water edge at any stage of tide, shall not be raised to more than 4°F over the temperature that existed before the addition of heat of artificial origin or a maximum of 83°F, whichever is less.
iii. From July through September, if the water temperature at the surface of an estuary before the addition of heat of artificial origin is more than an 83°F increase in temperature not to exceed 1.5°F at any point of the estuarine passageway as delineated above, may be permitted.
iv. At least 50 percent of the cross sectional area and/or volume of the flow of the estuary including a minimum of one-third of the surface as measured from water edge to water edge at any stage of tide, shall not be lowered more than 4°F from the temperature that existed immediately prior to such lowering.

Specific conditions of permit NY-0004472 related to thermal discharges from IP2 and IP3 are specified by NYSDEC (2003b) and include the following:

- The maximum discharge temperature is not to exceed 110°F (43°C).
- The daily average discharge temperature between April 15 and June 30 is not to exceed 93.2°F (34°C) for an average of more than 10 days per year during the term of the permit, beginning in 1981, provided that it not exceed 93.2°F (34°C) on more than 15 days during that period in any year.

The discharge of heated water has the potential to cause lethal or sublethal effects on fish and other aquatic organisms and create barriers, preventing or delaying access to other areas within the river. Limited information is available on the characteristics of the thermal plume associated with discharges from IP2 and IP3. As water withdrawn through the IP1 intakes will be used for service water, not cooling water, the discharge of this water is not heated. Below, NMFS summarizes the available information on the thermal plume, discusses the thermal tolerances of shortnose sturgeon, and considers effects of the plume on shortnose sturgeon, Atlantic sturgeon and their prey.

7.2.1.1 Characteristics of Indian Point's Thermal Plume

Thermal studies at IP2 and IP3 were conducted in the 1970s. These studies included thermal modeling of near-field effects using the Cornell University Mixing Zone Model (CORMIX), and modeling of far-field effects using the Massachusetts Institute of Technology (MIT) dynamic network model (also called the far-field thermal model). For the purpose of modeling, near-field was defined as the region in the immediate vicinity of each station discharge where cooling water occupies a clearly distinguishable, three-dimensional temperature regime in the river that is not yet fully mixed; far-field was defined as the region farthest from the discharges where the plumes are no longer distinguishable from the river, but the influence of the discharge is still present (CHGEC et al. 1999). The MIT model was used to simulate the hydraulic and thermal processes present in the Hudson River at a scale deemed sufficient by the utilities and their contractor and was designed and configured to account for time-variable hydraulic and meteorological conditions and heat sources of artificial origins. Model output included a prediction of temperature distribution for the Hudson River from the Troy Dam to the island of Manhattan. Using an assumption of steady-state flow conditions, the permit applicants applied CORMIX modeling to develop a three-dimensional plume configuration of near-field thermal conditions that could be compared to applicable water quality criteria.

The former owners of IP2 and IP3 conducted thermal plume studies employing both models for time scenarios that encompassed the period of June–September. These months were chosen because river temperatures were expected to be at their maximum levels. The former owners used environmental data from 1981 to calibrate and verify the far-field MIT model and to evaluate temperature distributions in the Hudson River under a variety of power plant operating conditions. They chose the summer months of 1981 because data for all thermal discharges were available and because statistical analysis of the 1981 summer conditions indicated that this year represented a relatively low-flow, high-temperature summer that would represent a conservative (worst-case) scenario for examining thermal effects associated with power plant thermal discharges. Modeling was performed under the following two power plant operating scenarios to determine if New York State thermal criteria would be exceeded:

i. Individual station effects—full capacity operation of Roseton Units 1 and 2, IP2 and IP3, or Bowline Point Units 1 and 2, with no other sources of artificial heat.
ii. Extreme operating conditions—Roseton Units 1 and 2, IP2 and IP3, and Bowline Point Units 1 and 2, and all other sources of artificial heat operating at full capacity.

Modeling was initially conducted using MIT and CORMIX Version 2.0 under the conditions of maximum ebb and flood currents (CHGEC et al. 1999). These results were supplemented by later work using MIT and CORMIX Version 3.2 and were based on the hypothetical conditions represented by the 10th-percentile flood currents, mean low water depths in the vicinity of each station, and concurrent operation of all three generating stations at maximum permitted capacity

(CHGEC et al. 1999). The 10th percentile of flood currents was selected because it represents the lowest velocities that can be evaluated by CORMIX, and because modeling suggests that flood currents produce larger plumes than ebb currents. The results obtained from the CORMIX model runs were integrated with the riverwide temperature profiles developed by the MIT dynamic network model to evaluate far-field thermal impacts (e.g., river water temperature rises above ambient) for various operating scenarios, the surface width of the plume, the depth of the plume, the percentage of surface width relative to the river width at a given location, and the percentage of cross-sectional area bounded by the 4°F (2°C) isotherm. In addition, the decay in excess temperature was estimated from model runs under near slack water conditions (CHGEC et al. 1999). For IP2 and IP3, two-unit operation at full capacity resulted in a monthly average cross-sectional temperature increase of 2.13 to 2.86°F (1.18 to 1.59°C) for ebb tide events in June and August, respectively. The average percentage of river surface width bounded by the 4°F (2°C) temperature rise isotherm ranged from 54 percent (August ebb tide) to 100 percent (July and August flood tide). Average cross-sectional percentages bounded by the plume ranged from 14 percent (June and September) to approximately 20 percent (July and August). When the temperature rise contributions of IP2 and IP3, Bowline Point, and Roseton were considered collectively (with all three facilities operating a maximum permitted capacity and discharging the maximum possible heat load), the monthly cross-sectional temperature rise in the vicinity of IP2 and IP3 ranged from 3.24°F (1.80°C) during June ebb tides to 4.63°F (2.57°C) during flood tides in August. Temperature increases exceeded 4°F (2°C) on both tide stages in July and August. After model modifications were made to account for the variable river geometry near IP2 and IP3, predictions of surface width bounded by the plume ranged from 36 percent during September ebb tides to 100 percent during flood tides in all study months. On near-slack tide, the percentage of the surface width bounded by the 4°F (2°C) isotherm was 99 to 100 percent in all study months. The average percentage of the cross-sectional area bounded by the plume ranged from 27 percent (June ebb tide) to 83 percent (August flood tide) and was 24 percent in all study months during slack water events.

Exceedences generally occurred under scenarios that Entergy indicated may be considered quite conservative (maximum operation of three electrical generation facilities simultaneously for long periods of time, tidal conditions promoting maximum thermal impacts, atypical river flows). The steady-state assumptions of CORMIX are also important because, although the modeled flow conditions in the Hudson River would actually occur for only a short period of time when slack water conditions are replaced by tidal flooding, CORMIX assumes this condition has been continuous over a long period of time. CHGEC et al. (1999) found that this assumption can result in an overestimate of the cross-river extent of the plume centerline.

Information provided by Entergy during the consultation period indicates that the CORMIX model has significant limitations which limit its utility when considering the discharge of heated effluent into the Hudson River. Specifically, the CORMIX model results in an overestimate of the scope and extent of the thermal plume. As more recent information on the thermal plume is available (see below) and this new information has been reviewed by NYDEC and determined to be appropriate to use when considering the effects of the thermal discharge on the Hudson River, NMFS is not relying on the CORMIX model in our effects analysis, but rather is relying on the more recent triaxial thermal plume study described below.

More recently, a triaxial thermal plume study was completed. Swanson et al. (2011 b) conducted thermal sampling and modeling of the cooling water discharge at Indian Point and reported that the extent and shape of the thermal plume varied greatly, primarily in response to tidal currents. For example, the plume (illustrated as a 4°F temperature increase or LH isotherm, Figure 5-6 in Swanson et al. 2011 b) generally followed the eastern shore of the Hudson River and extended northward from Indian Point during flood tide and southward from Indian Point during ebb tide. Depending on tides, the plume can be well-defined and reach a portion of the near-shore bottom or be largely confined to the surface.

Temperature measurements reported by Swanson et al. (2011 b) generally show that the warmest water in the thermal plume is close to the surface and plume temperatures tend to decrease with depth. Occasionally, the thermal plume extends deeply rather than across the surface. A cross-river survey conducted in front of Indian Point captured one such incident during spring tide on July 13, 2010 (Figure 3-28 in Swanson et al. 2011b). Across most of the river, water temperatures were close to 82°F (28°C), often with warmer temperatures near the surface and cooler temperatures near the bottom. The Indian Point thermal plume at that point was clearly defined and extended about 1000 ft (300 m) from shore. Surface water temperatures reached about 85°F (29°C). At 23-ft to about 25-ft (7-m to 8-m) depths, observed plume temperatures were 83° to 84°F (28° to 29°C). Maximum river depth along the measured transect is approximately 50 ft (15 m).

A temperature contour plot of a cross-river transect at Indian Point prepared in response to a NYSDEC review illustrates a similar condition on July 11, 2010 during slack before flood tide (Swanson et al. 2011a, Figure 1-10). Here the thermal plume is evident to about 2000 ft (600 m) from the eastern shore (the location of the Indian Point discharge) and extends to a depth of about 35 ft (11 m) along the eastern shore. Bottom temperatures above 82°F (28°C), were confined to about the first 250 ft (76 m) from shore. The river here is over 4500 ft (1400 m) wide. In that small area, bottom water temperatures might also exceed 30°C (86°F); elsewhere, bottom water temperatures were about 80°F (27°C). These conditions would not last long, however, as they would change with the tidal cycle. Under no conditions did interpolated temperatures in Entergy's modeled results exceed the 28°C in the deep reaches of the river channel (Swanson 2011 a).

In response to the NYSDEC's review of the Indian Point thermal studies (Swanson et al. 2011 b), Mendelsohn et al. (2011) modeled the maximum area and width of the thermal plume (defined by the 4°F (2°C) ΔT isotherms) in the Hudson River. Mendelsohn, et al. reported that for four cross-river transects near IP2 and IP3, the maximum cross-river area of the plume would not exceed 12.3 percent and the maximum cross-river width of the plume would not exceed 28.6 percent of the river (Mendelsohn, et al.'s Table 3-1).

7.2.1.2 Thermal Tolerances – Shortnose sturgeon

Most organisms can acclimate (i.e. metabolically adjust) to temperatures above or below those to which they are normally subjected. Bull (1936) demonstrated, from a range of marine species, that fish could detect and respond to a temperature front of 0.03 to 0.07°C (0.05 – 0.13°F). Fish will therefore attempt to avoid stressful temperatures by actively seeking water at the preferred temperature.

The temperature preference for shortnose sturgeon is not known (Dadswell et al. 1984) but shortnose sturgeon have been found in waters with temperatures as low as 2 to 3ºC (35.6-37.4°F)(Dadswell et al. 1984) and as high as 27-30°C in the Connecticut River (Dadswell et al. 1984) and 34ºC in the Altamaha River, Georgia (93.2°F) (Heidt and Gilbert 1978). Foraging is known to occur at temperatures greater than 7°C (44.6°F) (Dadswell 1979). In the Altamaha River, temperatures of 28-30ºC (82.4-86°F) during summer months are correlated with movements to deep cool water refuges. Some information specific to the Hudson River is available. Smith (1985 in Gilbert 1989) reports that juvenile Atlantic sturgeon were most common in areas where water temperatures were 24.2-24.7°C. Haley (1999) conducted studies on the distribution of Atlantic and shortnose sturgeon in the Hudson River in 1995 and 1996. Water temperatures at capture locations were recorded. Atlantic sturgeon were found in warmer areas than shortnose sturgeon. The mean temperature of areas where Atlantic sturgeon were present was 25.6°C (s.d. +/- 2.0); the mean temperature for shortnose sturgeon was 24.34°C (s.d. +/- 2.8°C.

Ziegeweid et al. (2008a) conducted studies to determine critical and lethal thermal maxima for young-of-the-year (YOY) shortnose sturgeon acclimated to temperatures of 19.5 and 24.1°C (67.1 – 75.4°F). These studies were carried out in a lab with fish from the Warm Springs National Fish Hatchery (Warm Springs, Georgia). The fish held at this fish hatchery were reared from broodstock collected from the Altamaha and Ogeechee rivers in Georgia. Lethal thermal maxima were 34.8°C (±0.1) and 36.1°C (±0.1) (94.6°F and 97°F) for fish acclimated to 19.5 and 24.1°C (67.1°F and 75.4°F), respectively. The acclimation temperature of 24.1°C is similar to the temperature where shortnose and Atlantic sturgeon juveniles were most often found in the Hudson River (24.1°C) suggesting that this it is reasonable to rely on these results for assessing effects to Hudson River sturgeon. However, it is important to note that there may be physiological differences in sturgeon originating from different river systems. Fish originating from southern river systems may have different thermal tolerances than fish originating from northern river systems. However, the information presented in this study is currently the best available information on thermal maxima and critical temperatures for shortnose sturgeon. The study also used thermal maximum data to estimate upper limits of safe temperature, final thermal preferences, and optimum growth temperatures for YOY shortnose sturgeon. Visual observations suggest that fish exhibited similar behaviors with increasing temperature regardless of acclimation temperature. As temperatures increased, fish activity appeared to increase; approximately 5–6°C (9-11°F) prior to the lethal endpoint, fish began frantically swimming around the tank, presumably looking for an escape route. As fish began to lose equilibrium, their activity level decreased dramatically, and at about 0.3°C (0.54°F)before the lethal endpoint, most fish were completely incapacitated. Estimated upper limits of safe temperature (ULST) ranged from 28.7 to 31.1°C (83.7-88°F) and varied with acclimation temperature and measured endpoint. Upper limits of safe temperature (ULST) were determined by subtracting a safety factor of 5°C (9°F) from the lethal and critical thermal maxima data. Final thermal preference and thermal growth optima were nearly identical for fish at each acclimation temperature and ranged from 26.2 to 28.3°C (79.16-82.9°F). Critical thermal maxima (the point at which fish lost equilibrium) ranged from 33.7 (±0.3) to 36.1°C (±0.2) (92.7-97°F) and varied with acclimation temperature. Ziegeweid et al. (2008b) used data from laboratory experiments to examine the individual and interactive effects of salinity, temperature, and fish weight on the survival of young-of-year shortnose sturgeon. Survival in freshwater declined as temperature increased, but temperature tolerance increased with body size. The authors conclude that temperatures above 29°C (84.2°F) substantially reduce the probability of survival for young-of-year shortnose sturgeon. However, previous studies indicate that juvenile sturgeons achieve optimum growth at temperatures close to their upper thermal survival limits (Mayfield and Cech 2004; Allen et al. 2006; Ziegeweid et al. 2008a), suggesting that shortnose sturgeon may seek out a narrow temperature window to maximize somatic growth without substantially increasing maintenance metabolism. Ziegeweid (2006) examined thermal tolerances of young of the year shortnose sturgeon in the lab. The lowest temperatures at which mortality occurred ranged from 30.1 – 31.5°C (86.2-88.7°F) depending on fish size and test conditions. For shortnose sturgeon, dissolved oxygen (DO) also seems to play a role in temperature tolerance, with increased stress levels at higher temperatures with low DO versus the ability to withstand higher temperatures with elevated DO (Niklitchek 2001).

7.2.1.3 Thermal Tolerances – Atlantic sturgeon

Limited information on the thermal tolerances of Atlantic sturgeon is available. Atlantic sturgeon have been observed in water temperatures above 30°C in the south (see Damon-Randall *et al.* 2010). In the laboratory, juvenile Atlantic sturgeon showed negative behavioral and bioenergetics responses (related to food consumption and metabolism) after prolonged exposure to temperatures greater than 28°C (82.4°F) (Niklitschek 2001). These tests were carried out with fish reared at the US Fish and Wildlife Service's Northeast Fishery Center (Lamar, PA) and are progeny of Hudson River broodstock. Thus, it is reasonable to rely on results of this study when considering thermal tolerances of Atlantic sturgeon in the Hudson River.

Tolerance to temperatures is thought to increase with age and body size (Ziegweid *et al.*. 2008 and Jenkins *et al.*. 1993); however, no information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. For purposes of considering effects of thermal tolerances, shortnose sturgeon are a reasonable surrogate for Atlantic sturgeon given similar geographic distribution and known biological similarities.

7.2.1.4 Effect of Thermal Discharge on Shortnose and Atlantic Sturgeon

The lab studies discussed in Section 7.2.1.2 above, indicate that thermal preferences and thermal growth optima for shortnose sturgeon range from 26.2 to 28.3°C (79.2-83°F). This is consistent with field observations which correlate movements of shortnose sturgeon to thermal refuges when river temperatures are greater than 28°C (82.4°F) in the Altamaha River. Lab studies (see above; Ziegeweid et al. 2008a and 2008b) indicate that thermal maxima for shortnose sturgeon are 33.7 (±0.3) – 36.1(±0.1) (92.7-97°F), depending on endpoint (loss of equilibrium or death) and acclimation temperature (19.5 or 24.1°C). Upper limits of safe temperature were calculated to be 28.7 – 31.1°C (83.7-88°F). At temperatures 5-6°C (9-11°F) less than the lethal maximum, shortnose sturgeon are expected to begin demonstrating avoidance behavior and attempt to escape from heated waters; this behavior would be expected when the upper limits of safe temperature are exceeded. For purposes of this consultation, we will consider these threshold temperature values to also apply to Atlantic sturgeon.

We first consider the potential for sturgeon to be exposed to temperatures which would most likely result in mortality. To be conservative, we considered mortality to be likely at temperatures that are expected to result in loss of equilibrium (33.7±0.3 for fish acclimated to temperatures of 19.5°C and 36.1±0.2 for fish acclimated to temperatures of 24.1°C). As noted above, shortnose and Atlantic sturgeon in the Hudson River are most often found in areas where temperatures are approximately 24°C suggesting that use of temperatures for fish acclimated to temperatures of 24.1°C is reasonable.

The maximum observed temperature of the thermal discharge is approximately 35°C (95°F). Modeling has demonstrated that the surface area of the river affected by the Indian Point plume where water temperatures would exceed 32.22°C (90°F) would be limited to an area no greater than 75 acres. Information provided by Entergy and presented in the recent thermal model (Swanson et al. 2011) indicate that water temperatures will not exceed 32.2°C (90°F) in waters more than 5 meters (16.4 feet) from the surface. Because 32.22°C is below the temperature that would result in a loss of equilibrium, we do not expect loss of equilibrium or death to fish exposed to this temperature. Water depths in the area are approximately 18 meters (59 feet) meaning that there should be 13 meters of water column with water temperatures below 32.22°C. Given this information, it is unlikely that shortnose or Atlantic sturgeon remaining near the bottom of the river or even in the middle of the water column would be exposed to water temperatures of 33.7°C (92.7°F). Temperatures at or above 33.7°C (92.7°F) will occasionally be experienced at the surface of the river in areas closest to the discharge point. Shortnose and Atlantic sturgeon are known to move to deep cool water areas during the summer months in southern rivers. Laboratory studies using shortnose sturgeon (progeny from Savannah River broodstock) and Atlantic sturgeon (progeny from Hudson River broodstock) demonstrate that these species are able to identify and select between water quality conditions that significantly affect growth and metabolism, including temperature. Based on field observations and laboratory studies, we expect that sturgeon would actively avoid areas where temperatures are intolerable. Assuming that there is a gradient of temperatures decreasing with distance from the outfall (as illustrated in Swanson et al. 2011), we expect shortnose and Atlantic sturgeon to begin avoiding areas with temperatures greater than 28°C (82.4°F). We do not expect individuals to remain within the heated surface waters to swim towards the outfall and be exposed to temperatures which could result in mortality. As such, provided that conditions allow for sturgeon to detect changes in temperature (i.e., that there is a gradual gradient of temperatures decreasing with increasing distance from the outfall as reported in Swanson et al. 2011) and escape from the area prior to prolonged exposure to critical temperatures, it is extremely unlikely that any sturgeon would remain within the area where surface temperatures are elevated to 33.7°C (92.7°F) and be exposed to potentially lethal temperatures. This gradient of temperatures that decreases from the surface to the bottom is also expected to deter sturgeon from moving high enough up into the water column to encounter surface waters that have stressful or lethal temperatures. Tis risk is further reduced by the limited amount of time shortnose and Atlantic sturgeon spend near the surface, the small area where such high temperatures will be experienced and the gradient of warm temperatures extending from the outfall. Near the bottom where shortnose and Atlantic sturgeon most often occur, water temperatures are not likely to ever reach 33.7°C (92.7°F), creating no risk of exposure to temperatures likely to be lethal near the bottom of the river. It is important to note that this analysis is dependent on the assumption that exposure to increased temperatures will be gradual; that is, we do not anticipate that sturgeon would be exposed to rapid changes in water temperature. As noted in Ziegweid (2008a), heating rate is a factor in determining critical

Comment [A6]: Question to NRC/Entergy – in this context, please describe the characteristics of the discharge during (1) routine operations, (2)during times when a unit is shut down and restarted and (3) at times when generation is increasing. For example, is the discharge always at a steady flow and temperature or are there fluctuations? What is the time frame associated with these fluctuations (seconds, minutes, hours?) ? How quickly can temperatures change near the intakes? What documentation supports your answers?

maxima (loss of equilibrium and mortality). In order for there to be a loss of equilibrium or mortality a fish must be exposed to the heat source long enough for deep body temperatures to equal water temperatures. However, Ziegweid does not provide any indication of the length of time fish were exposed to critical temperatures before loss of equilibrium or mortality would occur. He does note, however, that larger fish will take longer to "heat up" than smaller fish.

We have also considered the potential for shortnose and Atlantic sturgeon to be exposed to water temperatures greater than 28°C (82.4°F). Available information from field observations (primarily in southern systems; however this may be related to the prevalence of temperatures greater than 28°C in those areas compared to the rarity of ambient temperatures greater than 28°C in northern rivers) and laboratory studies (using progeny of fish from southern and northern rivers) suggests that water temperatures of 28°C (82.4°F) or greater can be stressful for sturgeon and that shortnose and Atlantic sturgeon are likely to actively avoid areas with these temperatures. This temperature (28°C; (82.4°F)) is close to both the final thermal preference and thermal growth optimum temperatures that Ziegeweid et al. (2008) reported for juvenile shortnose sturgeon acclimated to 24.1 °C (75.4 °F), and thus is consistent with observations that optimum growth temperatures are often near the maximum temperatures fish can endure without experiencing physiological stress. Based on the available information, it is reasonable to anticipate that shortnose and Atlantic sturgeon will actively avoid areas with temperatures greater than 28°C.

In the summer months (June – September) ambient river temperatures can be high enough that temperature increases as small as 1-4°C (1.8-7.2°C) may cause water temperatures within the plume to be high enough to be avoided by shortnose and Atlantic sturgeon (greater than 28°C (82.4°F)). When ambient river temperatures are at or above 28°C (82.4°F), the area where temperatures are raised by more than 1.5°C (2.7°F) are expected to be limited to a surface area of up to 75 acres. Shortnose and Atlantic sturgeon exposure to the surface area where water temperature may be elevated above 28°C (82.4°F) due to the influence of the thermal plume is limited by their normal behavior as benthic-oriented fish, which results in limited occurrence near the water surface. Assuming that there is a gradient of water temperatures that decreases with increasing distance from the outfall and decreases with depth from the surface, any surfacing shortnose or Atlantic sturgeon are likely to detect the increase in water temperature and swim away from near surface waters with temperatures greater than 28°C (82.4°F). Reactions to this elevated temperature are expected to consist of swimming away from heated surface waters by traveling deeper in the water column or by swimming around bottom waters heated by the plume.

Under no conditions did interpolated temperatures in Entergy's modeled results exceed 28°C (82°F) in the deep reaches of the river channel (Swanson 2011 a) where shortnose sturgeon are most likely to occur. Swanson also examined other sources of available bottom water temperature data for the Indian Point area. Based upon examination of the 1997 through 2010 long river survey water temperature data from the near-bottom stations near Indian Point, 28°C (82.4°F) was exceeded for just 56 of 1,877 observations or 2.98% during this 14-year period (readings measured weekly from March through November). These already low incidences of observed near-bottom water temperatures above 28°C (82.4°F) would be even lower when viewed in the context of an entire year instead of the nine months sampled due to the cold water period not sampled from December through February (i.e., 2.24% for the Indian Point region).

Comment [A7]: Question for NRC – What is it about the model that results in findings that bottom waters never exceeded 28C while this information indicates that water temperatures at the bottom can be higher than 28C ?

The available information on the thermal plume indicates that water temperature at the bottom of the river will be elevated to above 28°C only rarely (approximately 2.24% of the time). We expect that sturgeon will avoid bottom waters where temperatures are greater than 28°C. Sturgeon in the action area are likely to be foraging, resting or migrating. Disruptions to these behaviors will be limited to moving away from the area with stressful temperatures. Given the small area that may have temperatures elevated above 28°C (82.4°F) it is extremely unlikely that these minor changes in behavior will preclude shortnose sturgeon from completing any essential behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected. Additionally, there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health.

Given that shortnose and Atlantic sturgeon are known to actively seek out cooler waters when temperatures rise to 28°C (82.4°F), any shortnose sturgeon encountering bottom waters with temperatures above 28°C (82.4°F) area are likely to avoid it. Reactions to this elevated temperature are expected to be limited to swimming away from the plume by swimming around it. Given the extremely small percentage of the estuary that may have temperatures elevated above 28°C (82.4°F) and the limited spatial and temporal extent of any elevations of bottom water temperatures above 28°C (82.4°F), it is extremely unlikely that these minor changes in behavior will preclude any shortnose or Atlantic sturgeon from completing any essential behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected. Additionally, there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health.

We have considered whether avoidance of the thermal plume would affect the likelihood of impingement at the intakes. The intakes are located upstream of the discharge canal. During ebb tides, the thermal plume is largely directed downstream; at flood tide the area of stressful temperatures may overlap the intake area. The thermal plume could influence the likelihood of impingement if sturgeon were more likely to be present near the intakes because of avoidance behavior related to the thermal plume or if sturgeon present near the intakes were suddenly overcome by discharges of warm water and lost equilibrium. Based on the available information, neither one of these scenarios seems likely. Based on illustrations of the thermal plume (see Swanson et al. 2011a and 2011b) there do not appear to be any conditions during which sturgeon would move to the intake area to seek refuge from heated waters. Sturgeon are most likely to be present in the deep channel. Considering the cross section of the river immediately adjacent to the intakes, there do not appear to be any conditions under which sturgeon would be displaced from the deepwater areas by thermal conditions and would move towards the eastern shoreline where the intakes are located. Therefore, it is not reasonable to anticipate that sturgeon that move to avoid the thermal plume would be more likely to be present near the intakes as there are adjacent deepwater areas near by as well as the area on the western side of the river that is largely unaffected by the plume. The available information on the thermal discharge indicates that there is a gradual gradient of warmed water originating from the discharge canal. Given the distance of the discharge canal from the intakes (over 200 meters (700 feet) to IP3 and over 400 meters (1,400 feet) to IP2), and our understanding of the discharge it is unlikely that water temperature changes in the river near the intake would be rapid enough to prevent sturgeon from avoiding water at temperatures that would result in impairment and a resulting increased likelihood of impingement. We also considered whether swimming to avoid the thermal plume would make sturgeon tired and less able to avoid impingement. However, because of the gradual gradient of water temperatures and the size of the plume, sturgeon will not need to swim long distances to avoid heated water. As noted above, we do not expect any energy expenditure to have any detectable effect on the physiology of any individuals. Therefore, it is unlikely that swimming to avoid the thermal plume would result in exhaustion and decreased ability to avoid the intakes.

Water temperature and dissolved oxygen levels are related, with warmer water generally holding less dissolved oxygen. As such, we considered the potential for the discharge of heated effluent to affect dissolved oxygen in the action area. Entergy provided an assessment of dissolved oxygen conditions in the vicinity of the thermal plume and nearby downstream areas. Swanson examined dissolved oxygen concentrations observed among 14 recent years (1997 through 2010) of water quality samples taken 0.3 m (1 ft) above the river bottom weekly during the Utilities Fall Shoals surveys in the Indian Point region of the Hudson River from March through November of each year. Only 17 (0.91%) dissolved oxygen concentrations below 5 mg/l were observed in the Indian Point region during this 14-year period consisting of 1,877 readings, and the lowest dissolved oxygen concentration of 3.4 mg/l occurred just once, while the remaining 16 values were between 4.4 mg/l and 4.9 mg/l. Although I/FS survey water quality sampling did not occur in the Indian Point region during the winter period from December through February of each year due to river ice conditions, it is unlikely that dissolved oxygen concentrations below 5 mg/l would be observed then due to the high oxygen saturation of the cold water in the winter. The Hudson River region south of the Indian Point region had 501 dissolved oxygen concentrations below 5 mg/l (6.33% of 7,918 total observations) in the near bottom waters, seven times more frequently than the Indian Point region. Based on this information the discharge of heated effluent appears to have no discernible effect on dissolved oxygen levels in the area. As the thermal plume is not contributing to reductions in dissolved oxygen levels, it will not cause changes in dissolved oxygen levels that could affect any shortnose or Atlantic sturgeon.

7.2.1.5 Effect on Shortnose and Atlantic Sturgeon Prey

Shortnose and Atlantic sturgeon feed primarily on benthic invertebrates; these prey species are found on the bottom. As explained above, the IP thermal plume is largely a surface plume with elevated temperatures near the bottom limited to short duration and a geographic area limited to the area close to the discharge point. No analysis specific to effects of the thermal plume on the macroinvertebrate community has been conducted. However, given what is known about the plume (i.e., that it is largely a surface plume and has limited effects on water temperatures at or near the bottom) and the areas where shortnose sturgeon forage items are found (i.e., on the bottom), it is unlikely that potential sturgeon forage items would be exposed to the effects of the thermal plume. If the thermal plume is affecting benthic invertebrates, the most likely effect would be to limit their distribution to areas where bottom water temperatures are not affected by the thermal plume. Considering that shortnose and Atlantic sturgeon are also likely to be excluded from areas where the thermal plume influences bottom water temperatures and given that those areas are small, foraging sturgeon are not likely to be affected by any limits on the distribution of benthic invertebrates caused by the thermal plume's limited influence on bottom waters. Thus, based on this analysis, it appears that the prey of shortnose or Atlantic sturgeon, would be impacted insignificantly, if at all, by the thermal discharge from IP.

7.2.2 Potential Discharge of Radionuclides to the Hudson River

Comment [A8]: Question to NRC and Entergy – It is our understanding you will be undertaking new fish sampling in Haverstraw Bay in 2013. Will you be applying for a modification to your ESA Section 10 permit for this work? If not, why not?

Environmental monitoring and surveillance for radionuclides have been conducted at IP2 and IP3 since 1958, four years before the startup of IP1. The preoperational program was designed and implemented to determine the background radioactivity and to measure the variations in activity levels from natural and other sources in the vicinity, as well as fallout from nuclear weapons tests. The preoperational radiological data include both natural and manmade sources of environmental radioactivity. These background environmental data permit the detection and assessment of current levels of environmental activity attributable to plant operations.

The annual REMP is carried out by Entergy to monitor and document radiological impacts to the environment and the public around the IP2 and IP3 site and compare these to NRC standards. Radionuclides monitored include tritium (^{3}H), strontium-90 (^{90}Sr), nickel-63, and cesium-137. Entergy summarizes the results of its REMP in an Annual Radiological Environmental Operating Report. The objectives of the IP2 and IP3 REMPs are the following: (1) to enable the identification and quantification of changes in the radioactivity of the area; and, (2) to measure radionuclide concentrations in the environment attributable to operations of the IP2 and IP3 site (NRC 2010).

The REMP at IP2 and IP3 directs Entergy to sample environmental media in the environs around the site to analyze and measure the radioactivity levels that may be present. The REMP designates sampling locations for the collection of environmental media for analysis. These sampling locations are divided into indicator and control locations. Indicator locations are established near the site, where the presence of radioactivity of plant origin is most likely to be detected. Control locations are established farther away (and upwind/upstream, where applicable) from the site, where the level would not generally be affected by plant discharges or effluents. The use of indicator and control locations enables the identification of potential sources of detected radioactivity as either background or from plant operations. The media samples are representative of the radiation exposure pathways to the public from all plant radioactive effluents. The REMP is used to measure the direct radiation and the airborne and waterborne pathway activity in the vicinity of the IP2 and IP3 site. Direct radiation pathways include radiation from buildings and plant structures, airborne material that may be released from the plant, or from cosmic radiation, fallout, and the naturally occurring radioactive materials in soil, air, and water. The liquid waste processing system at IP2 and IP3 collects, holds, treats, processes, and monitors all liquid radioactive wastes for reuse or disposal. During normal plant operations the system receives input from numerous sources, such as equipment drains and leak lines, chemical laboratory drains, decontamination drains, demineralizer regeneration, reactor coolant loops and reactor coolant pump secondary seals, valve and reactor vessel flange leak lines, and floor drains. After it is determined that the amount of radioactivity in the wastewater is diminished to acceptable levels, the water is released into the Hudson River.

Entergy has also identified the migration of tritium to the Hudson River through groundwater pathways. In 2005, Entergy discovered a spent fuel pool water leak to groundwater while installing a new crane to facilitate transfer of Unit 2 spent fuel to dry cask storage. This leak was determined to have generated a groundwater plume of tritium (^{3}H). During efforts to track the ^{3}H plume, ^{90}Sr was discovered in a downgradient portion of the plume and traced back to a leak in the Unit 1 spent fuel pool (Skinner and Sinnott 2009). Because site groundwater flows to the Hudson River, the 2006 Radiological Environmental Monitoring Program (REMP) conducted by Entergy was modified to include ^{90}Sr as an analyte in fish samples. ^{90}Sr was detected in 4 of 10 samples of fish taken from the river in the vicinity of the Indian Point facility, and in three of five samples from an upstream reference location near the Roseton Generating Station in Newburgh, NY. The tissues analyzed were composites of edible flesh from fish representing several species. Entergy concluded that the ^{90}Sr levels were low and may be indistinguishable from background levels from fallout from nuclear weapons testing in the 1950's and 1960's (Entergy 2007). The New York State Departments of Health (NYSDOH) and NYSDEC concurred with Entergy's assessment. However, the NYSDEC and NYSDOH were concerned that the home ranges of several sampled species, and all striped bass, may overlap at the two sampling sites (Skinner and Sinnott 2009). In order to assure independence of sampling sites, the NY agencies initiated a one-time enhanced radiological surveillance for 2007 (results presented in Skinner and Sinnott 2009). The objectives of the enhanced radiological monitoring effort were to: gain information about the levels, impacts, and possible ^{90}Sr sources at the reference locations and the indicator station; determine if significant spatial differences in ^{90}Sr concentrations were present; to assess whether or not ^{90}Sr concentrations in the bones and flesh of fish signify heightened risk either to aquatic life in the Hudson River; and, provide information for an independent assessment of potential public health impacts.

The one-time design modifications for the 2007 effort included: the addition of carp (*Cyprinus carpio*) – a benthic feeder – to the target species list; adding ^{90}Sr to the list of radionuclide analytes; analysis of fish bone or crab carapace; and , sampling fish at a third location, the Catskill Region between river miles 107 and 125. The NY agencies stated that this upstream location assures appropriate separation of fish populations that are resident to the river, and, consequently, assures isolation of resident fish populations from the potential influence of discharges from the Indian Point facility.

The study concluded that there were no apparent excursions above criteria for the protection of biota based on the radionuclide data available. The levels of radionuclides, including ^{90}Sr, were two to five orders of magnitude lower than criteria established by the US Department of Energy (USDOE 2002) for the protection of aquatic animals and freshwater ecosystems. Also, the study concluded that there were no spatial differences in concentrations of ^{90}Sr and ^{224}Ra in resident fish from the three locations sampled in the lower Hudson River (i.e., Indian Point facility, and the reference sites at the Roseton Generating Station and at Catskill). In contrast, ^{40}K levels were somewhat greater in the vicinity of Roseton Generating Station, but the differing concentrations have no known significance.

Detailed information on the radiological investigations, including groundwater, is available in the 2006-2009 REMPs. NRC indicates in the FSEIS that this multi-year period provides a representative data set that covers a broad range of activities that occur at IP2 and IP3 such as, refueling outages, non-refueling outage years, routine operation, and years where there may be significant maintenance activities, and that effects during an extended operating period would be consistent with these sampling periods. In the FSEIS, NRC reports that tritium releases in total (groundwater as well as routine liquid effluent) represent less than 0.001% of the Federal dose limits for radioactive effluents from the site. In addition to monitoring potential effects to human health from exposure to radiation, Entergy conducts inspections of radionuclides in the environment, including fish and river sediments.

NRC has reported to NMFS that NRC has reviewed all of the available information on radionuclides and has identified no unusual trends or significant radiological impacts to the environment, including Hudson River water, river sediments and fish tissues, due to operation of the Indian Point facility. In the FSEIS, NRC states that no radioactivity distinguishable from background was detected during the most recent sampling and analysis of fish and crabs taken from the affected portion of the Hudson River and designated control locations. NRC also summarizes a 2007 NYSDEC report which concludes that strontium-90 levels in fish near the site (18.8 pCi/kg (0.69 Bq/kg)) are no higher than in those fish collected from background locations across New York State.

As explained above, additional information on potential impacts of radionuclides potentially originating from the Indian Point facility on aquatic organisms in the Hudson River is available in a recent report prepared by NYDEC (Skinner and Sinnott 2009). Neither the Skinner and Sinnott report or any of the REMPs identified radionuclide levels attributable to operation of the Indian Point facility that are at levels that are thought to negatively impact fish. It is important to note that no shortnose or Atlantic sturgeon have been tested to determine levels of radionuclides; however, as other species that have been sampled that are similarly mobile through the Hudson River have not indicated that they have radionuclide levels of concern and because expert review (NRC and NYDEC) of environmental indicators (Hudson River water, sediments, aquatic organisms) also indicates that radionuclides originating from the Hudson River, are not at levels of concern. Based on this information, while shortnose and Atlantic sturgeon may be exposed to radionuclides originating from Indian Point, as well as other sources, any exposure is not likely to be at levels that would affect the health or fitness of any individual shortnose or Atlantic sturgeon. Thus, NMFS considers the effects to shortnose and Atlantic sturgeon from radionuclides to be insignificant and discountable.

7.2.3 Other Pollutants Discharged from IP2 and IP3

The 1987 SPDES permit contains effluent limits related to an on-site sewage treatment plant, as well as cooling water discharges. The on-site sewage treatment plant is no longer operational and sanitary waste from Indian Point is now routed to the community wastewater treatment plant. Therefore, no sanitary waste discharges at the Indian Point outfalls will occur during the extended operating period. Other than the pollutants associated with sanitary wastes, pollutants limited by the 1987 SPDES permit include: total residual chlorine (TRC), lithium hydroxide, boron, pH, total suspended solids (TSS), and, oil and grease.

NMFS has no information on the actual levels of these pollutants discharged in the past. NMFS assumes, for the purposes of this analysis, that discharges from Indian Point will be in compliance with the pollutant limits included in the 1987 SPDES permit. The effect of discharges in compliance with these limits on shortnose sturgeon is discussed below.

7.2.3.1 Total Residual Chlorine

TRC is limited at a maximum daily average of 0.2mg/l. This level of chlorine is measured in the plant, prior to dilution in the Hudson River. Once the waste stream mixes with the Hudson River, concentrations of TRC will be a maximum of 0.019 mg/l (for one hour) and 0.011mg/l (indefinitely).

To date, the effects of TRC on shortnose sturgeon have not been studied; however, there have been a number of studies that have examined the effects of levels of TRC on various fish species (Post 1987; Buckley 1976), including a recent study done on the white sturgeon (Campbell and Davidson 2007). Campbell and Davidson (2007) found that at concentrations of 0.034-0.042 mg/l of chlorine over four days, 50% of the test population, which consisted of 30 day old and 160 day old early life stage and juvenile sturgeon, died (i.e., 96 hour LC50). Similarly, adverse effects to rainbow trout (e.g., reductions of hemoglobin and hemocrit levels indicative of anemia) were found to occur at TRC levels of approximately 0.03 -0.04 mg/L (Buckley 1976; Black and McCarthy 1990). In a study conducted by Dwyer et al. (2000a), researchers compared toxicity test results for a range of species tested, including shortnose and Atlantic sturgeon. While TRC was not one of the compounds tested, the authors concluded that toxicity test results for rainbow trout were a good surrogate for effects to listed fish species, including shortnose sturgeon. As such, while recognizing that these conclusions are based on a limited number of chemical exposures, if rainbow trout can be considered a reasonable surrogate for toxicity testing for shortnose and Atlantic sturgeon, and TRC levels of 0.03-0.04mg/l have been shown to cause adverse affects to rainbow trout, it is reasonable to conclude that shortnose sturgeon would also experience adverse effects if exposed to TRC levels of 0.03-0.04mg/l. The concentration of TRC authorized by the SPDES permit (0.011mg/l in the river) is below the levels shown to adversely affect fish. As such, NMFS anticipates that any effects to shortnose and Atlantic sturgeon from exposure to TRC at concentrations authorized by the SPDES permit would be insignificant and discountable.

7.2.3.2 Lithium hydroxide

The 1987 SPDES permit authorizes the discharge of lithium hydroxide at a daily maximum concentration of 0.01mg/l. Limited information is available on the toxicity of lithium hydroxide to aquatic species. The no effect concentration level for fish is reported at 13mg/l as determined by exposure of fathead minnows; no effect concentration levels for Daphnia magna are reported at 11mg/l (Long et al. 1997). While no studies have examined the effects of lithium exposure to shortnose sturgeon, as the levels of lithium authorized by the SPDES permit are lower than the levels shown to have no effects to fathead minnows, which are typically used as a surrogate species for other fish in toxicity testing, we anticipate that any effects to shortnose or Atlantic sturgeon from exposure to boron at concentrations authorized by the SPDES permit would be insignificant and discountable.

7.2.3.3 Boron

The 1987 SPDES permit authorizes the discharge of boron at monthly average concentrations of 1.0mg/l. Chronic toxicity studies with *Daphnia magna* indicate no effect concentration (NOEC) levels ranging between 6 and 10 mg boron/litre (IPCS 1998). A 28-day laboratory study consisting of six trophic stages yielded a NOEC of 2.5 mg boron/litre. Acute tests with several fish species yielded toxicity values ranging from about 10 to nearly 300 mg boron/litre. Rainbow trout (*Oncorhynchus mykiss*) and zebra fish (*Brachydanio rerio*) were the most sensitive, providing values around 10 mg boron/liter (IPCS 1998). While no studies have examined the effects of boron exposure to shortnose or Atlantic sturgeon, as the levels of boron authorized by the SPDES permit are lower than the levels shown to have no effects to a variety of fish species, we anticipate that any effects to shortnose and Atlantic sturgeon from exposure to boron at concentrations authorized by the SPDES permit would be insignificant and discountable.

7.2.3.4 pH

The permit requires that the discharge maintain a pH of 6.0 – 9.0. This pH is within the normal range of pH for river water. As such, any change in the pH of the receiving water due to the discharge from Indian Point is not expected to deviate significantly from the receiving waters pH and will remain within the normal range for river water that is known to be harmless to aquatic life. Therefore, any effects to shortnose and Atlantic sturgeon will be discountable.

7.2.3.5 Total Suspended Solids

The 1987 SPDES permit limits the discharge of TSS to a daily maximum of 50mg/l and a monthly average of 30mg/L. TSS can affect aquatic life directly by killing them or reducing growth rate or resistance to disease, by preventing the successful development of fish eggs and larvae, by modifying natural movements and migration, and by reducing the abundance of available food (EPA 1976). These effects are caused by TSS decreasing light penetration and by burial of the benthos. Eggs and larvae are most vulnerable to increases in solids. Due to the distance from the spawning site, neither shortnose or Atlantic sturgeon eggs or larvae are likely to occur in the vicinity of the discharge.

Studies of the effects of turbid waters on fish suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton 1993). The studies reviewed by Burton demonstrated lethal effects to fish at concentrations of 580mg/L to 700,000mg/L depending on species. Sublethal effects have been observed at substantially lower turbidity levels. For example, prey consumption was significantly lower for striped bass larvae tested at concentrations of 200 and 500 mg/L compared to larvae exposed to 0 and 75 mg/L (Breitburg 1988 in Burton 1993). Studies with striped bass adults showed that pre-spawners did not avoid concentrations of 954 to 1,920 mg/L to reach spawning sites (Summerfelt and Moiser 1976 and Combs 1979 in Burton 1993). While there have been no directed studies on the effects of TSS on shortnose or Atlantic sturgeon, shortnose sturgeon juveniles and adults are often documented in turbid water and Dadswell (1984) reports that shortnose sturgeon are more active under lowered light conditions, such as those in turbid waters. As such, shortnose sturgeon are assumed to be as least as tolerant to suspended sediment as other estuarine fish such as striped bass. Given that Atlantic sturgeon occur in similar habitats to shortnose sturgeon, we expect Atlantic sturgeon to have similar tolerances to suspended sediments and turbidity as shortnose sturgeon.

No adverse effects to juvenile or adult fish have been documented at levels at or below 50mg/L (above the highest level authorized by this permit). Based on this information, it is likely that the discharge of TSS in the concentrations authorized by the permit will have an insignificant effect on shortnose and Atlantic sturgeon.

7.2.3.6 Oil and Grease

High concentrations of petroleum products such as oil and grease can be toxic to aquatic life, including shortnose sturgeon. EPA (1976) indicates that lethal levels of gasoline for finfish are 91mg/L and for waste oil are 1700mg/L. No information is available on the toxic levels of petroleum products on shortnose sturgeon specifically. The limits in the SPDES permit (15mg/L monthly average) is well below the limits demonstrated to cause effects to fish. In addition, as the permit prohibits the discharge of levels of oil and grease at levels that are visible, levels are not likely to reach those where there is a risk of coating. As such, the effect of any exposure of shortnose and Atlantic sturgeon to oil and grease discharged at levels in compliance with the SPDES permit will be insignificant and discountable.

7.2.3.7 Other Criteria and Requirements of the SPDES Permit

The permit also contains criteria for the thermal plume. Effects of the thermal discharge are considered above. The 1987 SPDES permit also directs Entergy to comply with the biological sampling requirements of the HRSA. These include sampling surveys conducted throughout the Hudson River. These surveys result in the capture of shortnose and Atlantic sturgeon; however, capture and handling of shortnose and Atlantic sturgeon during these studies is authorized by NMFS through the ESA Section 10 scientific research permit discussed above (currently permit #17095, available at: https://apps.nmfs.noaa.gov/preview/applicationpreview.cfm?ProjectID=17095&view=01000000000000). The permit authorizes the take of 82 shortnose sturgeon and 82 Atlantic sturgeon annually. These fish will be captured in trawls and will be tagged (PIT and dart), measured, weighed and have tissue samples taken. The permit also authorizes the lethal collection of 40 shortnose sturgeon eggs/larvae and 40 Atlantic sturgeon eggs/larvae annually. These early life stages will be collected during ichthyoplankton sampling. The permit is valid from January 20, 2012 until August 28, 2017. All sturgeon captured during the trawl surveys are expected to be returned to the river alive. No lethal or sublethal effects of trawling are anticipated. The only lethal take authorized by the Section 10 permit is for the 40 eggs or larvae captured during ichthyoplankton sampling. The ESA Section 7 consultation completed on the issuance of this permit determined that the action was not likely to jeopardize the continued existence of shortnose sturgeon or any DPS of Atlantic sturgeon (available at: http://www.nmfs.noaa.gov/pr/consultation/opinions.htm). Because effects to listed species from these studies have already been considered, these studies will not be considered further in this Opinion.

7.3 Non-Routine and Accidental Events

By their nature, non-routine and accidental events that may affect the marine environment are unpredictable and typically unexpected. In the FSEIS, NRC considers design-basis accidents (DBAs); these are those accidents that both the licensee and the NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients, and a broad spectrum of postulated accidents, without undue hazard to the health and safety of the public. NRC states that "a number of these postulated accidents are not expected to occur during the life of the plant, but are evaluated to establish the design basis for the preventive and mitigative safety systems of the facility" (NRC FSEIS 2011). NRC states that the environmental impacts of these DBAs will be “small” (i.e., insignificant), because the plant is designed to withstand these types of accidents including during the extended operating period.

NRC also states that the risk of severe accidents initiated by internal events, natural disasters or terrorist events is small. As noted by Thompson (2006) in a report regarding the risks of spent-fuel pool storage at nuclear power plants in the U.S., the available information does not allow a statistically valid estimate of the probability of an attack-induced spent-fuel-pool fire. However, Thompson states that “prudent judgment” indicates that a probability of at least one per century within the U.S. is a reasonable assumption. There have been very few instances of accidents or natural disasters that have affected nuclear facilities and none at IP2 or IP3 that have led to any impacts to the Hudson River. While the experience at Fukishima in Japan provides evidence that natural disaster induced problems at nuclear facilities can be severe and may have significant consequences to the environment, the risk of non-routine and accidental events at Indian Point that would affect the riverine environment, and subsequently affect shortnose and Atlantic sturgeon, is extremely low. Because of this, effects to listed species are discountable. We expect that in the unlikely event of any accident or disaster that affects the riverine environment, reinitiation of consultation, or an emergency consultation, would be necessary.

7.4 Effects of Operation in light of Anticipated Future Climate Change

In the future, global climate change is expected to continue and may impact listed species and their habitat in the action area. The period considered for the continued operation of IP2 is now through 2033 and for IP3 is now through 2035.

In section 6.0 above we considered effects of global climate change on shortnose and Atlantic sturgeon. It is possible that there will be effects to sturgeon from climate change over the time that IP2 and IP3 continue to operate. As explained above, based on currently available information and predicted habitat changes, these effects are most likely to be changes in distribution and timing of seasonal migrations of sturgeon throughout the Hudson River including the action area. However, because we expect only a small increase in water temperature (1°C) and a small change in the location of the salt wedge (shifting further upstream from the action area), there are not likely to be major shifts in abundance, distribution or seasonal use of the action area by Atlantic sturgeon or shortnose sturgeon.

The greatest potential for climate change to impact our assessment would be if (1) ambient water temperatures increased enough such that a larger portion of the thermal plume had temperatures that were stressful for listed species or their prey or if (2) the status, distribution and abundance of listed species or their prey changed significantly in the action area. Given the small predicted increase in ambient water temperatures in the action area during the time period considered (1°C), it is not likely that over the remainder of the operating period that any water temperature changes would be significant enough to affect the conclusions reached by us in this consultation. If new information on the effects of climate change becomes available then reinitiation of this consultation may be necessary.

8.0 CUMULATIVE EFFECTS

Cumulative effects, as defined in 50 CFR 402.02, are those effects of future State or private activities, not involving Federal activities, which are reasonably certain to occur within the action area. Future Federal actions are not considered in the definition of "cumulative effects." It is important to note that the definition of "cumulative effects" in the section 7 regulations is not the same as the NEPA definition of cumulative effects. However, the factors discussed in the Cumulative Effects section of NRC's FSEIS - continued withdrawal of water to support fossil fuel electrical generation or water for human use; the presence of invasive or nuisance species; fishing pressure; habitat loss; changes to water and sediment quality; and, climate change are largely consistent with the cumulative effects we consider here.

Activities reasonably certain to occur in the action area and that are carried out or regulated by the State of New York and that may affect shortnose and Atlantic sturgeon include the authorization of state fisheries and the regulation of point and non-point source pollution through the National Pollutant Discharge Elimination System. We are not aware of any local or private actions that are reasonably certain to occur in the action area that may affect listed species.

While there may be other in-water construction or coastal development within the action area, all of these activities are likely to need a permit or authorization from the US Army Corps of Engineers and would therefore, be subject to section 7 consultation.

State Water Fisheries - Future recreational and commercial fishing activities in state waters may take shortnose and Atlantic sturgeon. In the past, it was estimated that up to 100 shortnose sturgeon were captured in shad fisheries in the Hudson River each year, with an unknown mortality rate. Atlantic sturgeon were also incidentally captured in NY state shad fisheries. In 2009, NY State closed the shad fishery indefinitely. That state action is considered to benefit both sturgeon species. Should the shad fishery reopen, shortnose and Atlantic sturgeon would be exposed to the risk of interactions with this fishery. However, NMFS has no indication that reopening the fishery is reasonably certain to occur.

Information on interactions with shortnose and Atlantic sturgeon for other fisheries operating in the action area is not available, and it is not clear to what extent these future activities would affect listed species differently than the current state fishery activities described in the Status of the Species/Environmental Baseline section. However, this Opinion assumes effects in the future would be similar to those in the past and are, therefore, reflected in the anticipated trends described in the status of the species/environmental baseline section.

State PDES Permits – The State of New York has been delegated authority to issue NPDES permits by the EPA. These permits authorize the discharge of pollutants in the action area. Some of the facilities that operate pursuant to these permits are included in the Environmental Baseline. Other permitees include municipalities for sewage treatment plants and other industrial users. The states will continue to authorize the discharge of pollutants through the SPDES permits. However, this Opinion assumes effects in the future would be similar to those in the past and are therefore reflected in the anticipated trends described in the status of the species/environmental baseline section.

9.0 INTEGRATION AND SYNTHESIS OF EFFECTS

We have estimated that the continued operation of IP2 and IP3 and continued withdrawal of water through the IP1 intake, pursuant to the existing operating licenses and through the proposed extended license period (now through September 2033 and now through December 2035, respectively) will result in the impingement and mortality of 562 shortnose sturgeon and 219 juvenile New York Bight DPS Atlantic sturgeon. As explained in the "Effects of the Action" section, all other effects to shortnose and Atlantic sturgeon, including to their prey and from the discharge of heat, will be insignificant or discountable. No entrainment of shortnose or Atlantic sturgeon is anticipated.

In the discussion below, we consider whether the effects of the proposed action reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of any listed species. The purpose of this analysis is to determine whether the proposed action, in the context established by the status of the species, environmental baseline, and cumulative effects, would jeopardize the continued existence of any listed species. In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter." Recovery is defined as, "Improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act." Below, for the listed species that may be affected by the proposed action, NMFS summarizes the status of the species and considers whether the proposed action will result in reductions in reproduction, numbers or distribution of that species and then considers whether any reductions in reproduction, numbers or distribution resulting from the proposed action would reduce appreciably the likelihood of both the survival and recovery of that species, as those terms are defined for purposes of the federal Endangered Species Act.

9.1 Shortnose Sturgeon

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers. As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1,000 adults for 5 of 11 surveyed northern populations and all natural southern populations. The only river systems likely supporting populations close to expected abundance are the St John, Hudson and possibly the Delaware and the Kennebec (Kynard 1996), making the continued success of shortnose sturgeon in these rivers critical to the species as a whole.

The Hudson River population of shortnose sturgeon is the largest in the United States. Historical estimates of the size of the population are not available as historic records of sturgeon in the river did not discriminate between Atlantic and shortnose sturgeon. Population estimates made by

Dovel et al. (1992) based on studies from 1975-1980 indicated a population of 13,844 adults. Bain et al. (1998) studied shortnose sturgeon in the river from 1993-1997 and calculated an adult population size of 56,708 with a 95% confidence interval ranging from 50,862 to 64,072 adults. Bain determined that based on sampling effort and methodology his estimate is directly comparable to the population estimate made by Dovel et al. Bain concludes that the population of shortnose sturgeon in the Hudson River in the 1990s was 4 times larger than in the late 1970s. Bain states that as his estimate is directly comparable to the estimate made by Dovel, this increase is a "confident measure of the change in population size." Bain concludes that the Hudson River population is large, healthy and particular in habitat use and migratory behavior. Woodland and Secor (2007) conducted studies to determine the cause of the increase in population size. Woodland and Secor captured 554 shortnose sturgeon in the Hudson River and made age estimates of these fish. They then hindcast year class strengths and corrected for gear selectivity and cumulative mortality. The results of this study indicated that there was a period of high recruitment (31,000 – 52,000 yearlings) in the period 1986-1992 which was preceded and succeeded by 5 years of lower recruitment (6,000 – 17,500 yearlings/year). Woodland and Secor reports that there was a 10-fold recruitment variability (as measured by the number of yearlings produced) over the 20-year period from the late 1970s to late 1990s and that this pattern is expected in a species, such as shortnose sturgeon, with periodic life history characterized by delayed maturation, high fecundity and iteroparous spawning, as well as when there is variability in interannual hydrological conditions. Woodland and Secor examined environmental conditions throughout this 20-year period and determined that years in which water temperatures drop quickly in the fall and flow increases rapidly in the fall (particularly October), are followed by high levels of recruitment in the spring. This suggests that these environmental factors may index a suite of environmental cues that initiate the final stages of gonadal development in spawning adults.

The Hudson River population of shortnose sturgeon has exhibited tremendous growth in the 20-year period between the late 1970s and late 1990s. Woodland and Secor conclude that this is a robust population with no gaps in age structure. Lower recruitment that followed the 1986-1992 period is coincident with record high abundance suggesting that the population may be reaching carrying capacity. The population in the Hudson River exhibits substantial recruitment and is considered to be stable at high levels.

While no reliable estimate of the size of either the shortnose sturgeon population in the Northeastern US or of the species throughout its range exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed. Based on the number of adults in population for which estimates are available, there are at least 104,662 adult shortnose sturgeon, including 18,000 in the Saint John River in Canada. The lack of information on the status of some populations, such as that in the Chesapeake Bay, add uncertainty to any determination on the status of this species as a whole. Based on the best available information, NMFS believes that the status of shortnose sturgeon throughout their range is at best stable, with gains in populations such as the Hudson, Delaware and Kennebec offsetting the continued decline of southern river populations, and at worst declining.

As described in the Status of the Species/Environmental Baseline, and Cumulative Effects sections above, shortnose sturgeon in the action area are affected by impingement at water intakes, habitat alteration, bycatch in commercial and recreational fisheries, water quality and in-water construction activities. It is difficult to quantify the number of shortnose sturgeon that may be killed in the Hudson River each year due to anthropogenic sources. Through reporting requirements implemented under Section 7 and Section 10 of the ESA, for specific actions NMFS obtains some information on the number of incidental and directed takes of shortnose sturgeon each year. Typically, scientific research results in the capture and collection of less than 100 shortnose sturgeon in the Hudson River each year, with little if any mortality. NMFS has no reports of interactions or mortalities of shortnose sturgeon in the Hudson River resulting from dredging or other in-water construction activities. NMFS also has no quantifiable information on the effects of habitat alteration or water quality; in general, water quality has improved in the Hudson River since the 1970s when the CWA was implemented. NMFS also has anecdotal evidence that shortnose sturgeon are expanding their range in the Hudson River and fully utilizing the river from the Manhattan area upstream to the Troy Dam, which suggests that the movement and distribution of shortnose sturgeon in the river is not limited by habitat or water quality impairments. Impingement at the Roseton and Danskammer plants is regularly reported to NMFS. Since reporting requirements were implemented in 2000, less than the exempted number of takes (6 total for the two facilities) have occurred each year. We also anticipate the mortality of two shortnose sturgeon over the next five years as a result of impacts of the replacement of the Tappan Zee Bridge. Despite these ongoing threats, there is evidence that the Hudson River population of shortnose sturgeon experienced tremendous growth between the 1970s and 1990s and that the population is now stable at high numbers. Shortnose sturgeon in the Hudson River continue to experience anthropogenic and natural sources of mortality. However, NMFS is not aware of any future actions that are reasonably certain to occur that are individually or cumulatively likely to change this trend or reduce the stability of the Hudson River population. Also, as discussed above, NMFS does not expect shortnose sturgeon to experience any new effects associated with climate change during the 23-year duration of the proposed action. As such, NMFS expects that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the 23-year duration of the proposed action.

We have estimated that the proposed continued operation of IP2 and IP3 through the duration of the existing operating license and the proposed extended operating licenses (i.e., through September 29, 2033 for IP2 and December 12, 2035 for IP3) will result in the impingement of an average of 20 shortnose sturgeon per year, for a total of 444 shortnose sturgeon impinged, all of which may die as a result of their impingement. This number represents a very small percentage of the shortnose sturgeon population in the Hudson River, which is believed to be stable at high numbers, and an even smaller percentage of the total population of shortnose sturgeon rangewide. The best available population estimates indicate that there are approximately 56,708 (95% CI=50,862 to 64,072) adult shortnose sturgeon in the Hudson River and an unknown number of juveniles (Bain 2000). While the death of up to 444 shortnose sturgeon over the next 23 years will reduce the number of shortnose sturgeon in the population compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this population or its stable trend. This is because this loss represents a very small percentage of the population (less than 0.8%, just considering the number of adults). The impact of this loss is even less when considered on an annual basis. The annual loss represents approximately 0.2% of the Hudson River shortnose sturgeon population. Additionally, it is important to note that this is not a new source of mortality. The Hudson River population has exhibited tremendous growth during the period of time that IP2 and IP3 have been operational; we do not expect the rate of impingement to change in the future, therefore, it is reasonable to expect that the continued operation of IP2 and IP3 would not preclude maintenance of the population’s stable trend.

Reproductive potential of the Hudson population is not expected to be affected in any other way other than through a reduction in numbers of individuals. A reduction in the number of shortnose sturgeon in the Hudson River would have the effect of reducing the amount of potential reproduction in this system as the fish killed would have no potential for future reproduction. However, it is estimated that on average, approximately 1/3 of adult females spawn in a particular year and approximately ½ of males spawn in a particular year. Given that the best available estimates indicate that there are more than 56,000 adult shortnose sturgeon in the Hudson River, it is reasonable to expect that there are at least 20,000 adults spawning in a particular year. It is unlikely that the loss of 20 shortnose sturgeon per year over a 23-year period would affect the success of spawning in any year. Additionally, this small reduction in potential spawners is expected to result in a small reduction in the number of eggs laid or larvae produced in future years and similarly, a very small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be very small and would not change the stable trend of this population. Additionally, the proposed action will not affect spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds.

The proposed action is not likely to reduce distribution because the action will not impede shortnose sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Hudson River. Further, the action is not expected to reduce the river by river distribution of shortnose sturgeon. Additionally, as the number of shortnose sturgeon likely to be killed as a result of the proposed action is less than 0.80% of the Hudson River population, there is not likely to be a loss of any unique genetic haplotypes and therefore, it is unlikely to result in the loss of genetic diversity.

While generally speaking, the loss of a small number of individuals from a subpopulation or species can have an appreciable effect on the likelihood of survival and recovery of the species, this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range or the species has extremely low levels of genetic diversity. This situation is not likely in the case of shortnose sturgeon because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity (see status of the species/environmental baseline section above), and there are thousands of shortnose sturgeon spawning each year.

Based on the information provided above, the death of up to 562 shortnose sturgeon over a 23-year period (i.e., from now through December 2035) resulting from the proposed continued operation of IP2 and IP3 will not appreciably reduce the likelihood of survival of this species (i.e., the likelihood that the species will continue to exist in the future while retaining the potential for recovery) because, (1) it will not cause so many mortalities that the population will decrease; (2) the population trend of shortnose sturgeon in the Hudson River is stable at high levels; (3) the death of 24 shortnose sturgeon per year represents an extremely small percentage of the number of shortnose sturgeon in the Hudson River and an even smaller percentage of the species as a whole; (4) the loss of these shortnose sturgeon is likely to have such a small effect on reproductive output of the Hudson River population of shortnose sturgeon or the species as a whole that the loss of these shortnose sturgeon will not change the status or trends of the Hudson River population or the species as a whole; and, (5) the action will have only a minor and temporary effect on the distribution of shortnose sturgeon in the action area (related to movements around the thermal plume) and no effect on the distribution of the species throughout its range.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, NMFS has determined that the proposed action will not appreciably reduce the likelihood that shortnose sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where shortnose sturgeon are no longer in danger of extinction through all or a significant part of its range.

A Recovery Plan for shortnose sturgeon was published in 1998 pursuant to Section 4(f) of the ESA. The Recovery Plan outlines the steps necessary for recovery and indicates that each population may be a candidate for downlisting (i.e., to threatened) when it reaches a minimum population size that is large enough to prevent extinction and will make the loss of genetic diversity unlikely. However, the plan states that the minimum population size for each population has not yet been determined. The Recovery Outline contains three major tasks, (1) establish delisting criteria; (2) protect shortnose sturgeon populations and habitats; and, (3) rehabilitate habitats and population segments. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the Hudson River population of shortnose sturgeon in a way that would affect the species likelihood of recovery.

The Hudson River population of shortnose sturgeon has experienced an increasing trend and is currently stable at high levels. This action will not change the status or trend of the Hudson River population of shortnose sturgeon or the species as a whole. This is because the reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant and discountable, and the area of the river that sturgeon will be precluded from (due to high temperatures) is small. The proposed action will not affect shortnose sturgeon outside of the Hudson River. Therefore, because it will not reduce the likelihood that the Hudson River population can recover, it will not reduce the likelihood that the species as a whole can recover. Therefore, the proposed action will not appreciably reduce the likelihood that shortnose sturgeon can be brought to the point at which they are no longer listed as endangered. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.2 Atlantic sturgeon

As explained above, the proposed action is likely to result in the mortality of 219 New York Bight DPS Atlantic sturgeon. We do not anticipate the mortality of Atlantic sturgeon from any other DPS. Individuals from the Gulf of Maine and Chesapeake Bay DPSs may occur in the action area. These individuals would be exposed to effects of the action including the thermal plume, other pollutants and impacts to prey and habitats. However, all of the effects experienced by Gulf of Maine and Chesapeake Bay DPS Atlantic sturgeon will be insignificant and discountable. Based on the best available information, we do not expect that individuals from the Carolina or South Atlantic DPS will occur in the action area.

9.2.1 New York Bight DPS of Atlantic sturgeon

The NYB DPS has been listed as endangered. While Atlantic sturgeon occur in several rivers in the NYB DPS, recent spawning has only been documented in the Delaware and Hudson rivers. As noted above, we expect all Atlantic sturgeon impinged at Indian Point will originate from the Hudson River. There is limited information on the demographics of the Hudson River population of Atlantic sturgeon. An annual mean estimate of 863 mature adults (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.* 2007).

No data on abundance of juveniles are available prior to the 1970s; however, catch depletion analysis estimated conservatively that 6,000-6,800 females contributed to the spawning stock during the late 1800s (Secor 2002, Kahnle *et al*. 2005). Two estimates of immature Atlantic sturgeon have been calculated for the Hudson River population, one for the 1976 year class and one for the 1994 year class. Dovel and Berggren (1983) marked immature fish from 1976-1978. Estimates for the 1976 year class at age were approximately 25,000 individuals. Dovel and Berggren estimated that in 1976 there were approximately 100,000 juvenile (non-migrant) Atlantic sturgeon from approximately 6 year classes, excluding young of year.

In October of 1994, the NYDEC stocked 4,929 marked age-0 Atlantic sturgeon, provided by a USFWS hatchery, into the Hudson Estuary at Newburgh Bay. These fish were reared from Hudson River brood stock. In 1995, Cornell University sampling crews collected 15 stocked and 14 wild age-1 Atlantic sturgeon (Peterson *et al*. 2000). A Petersen mark-recapture population estimate from these data suggests that there were 9,529 (95% CI = 1,916 – 10,473) age-0

Atlantic sturgeon in the estuary in 1994. Since 4,929 were stocked, 4,600 fish were of wild origin, assuming equal survival for both hatchery and wild fish and that stocking mortality for hatchery fish was zero.

Information on trends for Atlantic sturgeon in the Hudson River are available from a number of long term surveys. From July to November during 1982-1990 and 1993, the NYSDEC sampled the abundance of juvenile fish in Haverstraw Bay and the Tappan Zee Bay. The CPUE of immature Atlantic sturgeon was 0.269 in 1982 and declined to zero by 1990. This study has not been carried out since this time.

The Long River Survey (LRS) samples ichthyoplankton river-wide from the George Washington Bridge (rkm 19) to Troy (rkm 246) using a stratified random design (CONED 1997). These data, which are collected from May-July, provide an annual index of juvenile Atlantic sturgeon in the Hudson River estuary since 1974. The Fall Juvenile Survey (FJS), conducted from July – October by the utilities, calculates an annual index of the number of fish captured per haul. Between 1974 and 1984, the shoals in the entire river (rkm 19-246) were sampled by epibenthic sled; in 1985 the gear was changed to a three-meter beam trawl. While neither of these studies were designed to catch sturgeon, given their consistent implementation over time they provide indications of trends in abundance, particularly over long time series. When examining CPUE, these studies suggest a sharp decline in the number of young Atlantic sturgeon in the early 1990s. While the amount of interannual variability makes it difficult to detect short term trends, a five year running average of CPUE from the FJS indicates a slowly increasing trend since about 1996. Interestingly, that is when the in-river fishery for Atlantic sturgeon closed. While that fishery was not targeting juveniles, a reduction in the number of adult mortalities would be expected to result in increased recruitment and increases in the number of young Atlantic sturgeon in the river. There also could have been bycatch of juveniles that would have suffered some mortality.

In 2000, the NYSDEC created a sturgeon juvenile survey program to supplement the utilities' survey; however, funds were cut in 2000, and the USFWS was contracted in 2003 to continue the program. In 2003 – 2005, 579 juveniles were collected (N = 122, 208, and 289, respectively) (Sweka et al. 2006). Pectoral spine analysis showed they ranged from 1 – 8 years of age, with the majority being ages 2 – 6. There has not been enough data collected to use this information to detect a trend, but at least during the 2003-2005 period, the number of juveniles collected increased each year which could be indicative of an increasing trend for juveniles.

NYB DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. The largest single source of mortality appears to be capture as bycatch in commercial fisheries operating in the marine environment. A bycatch estimate provided by NEFSC indicates that approximately 376 Atlantic sturgeon die as a result of bycatch each year. Mixed stock analysis from the NMFS NEFOP indicates that 49% of these individuals are likely to originate from the NYB and 91% of those likely originate from the Hudson River, for a total of approximately 167 adult and subadult mortalities annually. Because juveniles do not leave the river, they are not impacted by fisheries occurring in Federal waters. Bycatch and mortality also occur in state fisheries; however, the primary fishery that impacted juvenile sturgeon (shad), has now been closed and there is no indication that it will reopen soon. NYB DPS Atlantic sturgeon are killed as a result of anthropogenic activities in the Hudson River and other rivers; sources of potential mortality include vessel strikes and entrainment in dredges. As noted above, we expect the mortality of two Atlantic sturgeon as a result of the Tappan Zee Bridge replacement project; it is possible that these individuals could originate from the Hudson River. There could also be the loss of a small number of juveniles at other water intakes in the River including the Danskammer and Roseton plants.

The Atlantic sturgeon that will be killed at Indian Point are expected to be juveniles that originate from Hudson River. The most recent estimate of juveniles was 4,600 wild Hudson River juveniles in the 1994 year class. While we have no estimates of the number of juveniles since that time, the available information on trends indicates that there may be a slight increasing trend in juvenile abundance in the Hudson River since the mid-1990s. This suggests that there may be more juveniles in the river now than in 1994. Based on the size of fish impinged in the past, Atlantic sturgeon impinged at IP2 and IP3 are likely to be less than three years old. Even assuming that the three youngest year classes in the Hudson River only have 4,600 individuals each, we would estimate that there are at least 13,800 juvenile Atlantic sturgeon in the Hudson River. We are anticipating a loss of approximately 10 juvenile Atlantic sturgeon per year for 23 years. While there are likely other sources of mortality for juvenile Atlantic sturgeon in the Hudson River, there appears to be a recent increasing trend of juveniles in the river, as evidenced by the upward trend in the 5-year moving average for the FJS CPUE. The closure of the directed Atlantic sturgeon fishery in 1996 and the shad fishery in 2010 are expected to have led to reduced bycatch of juvenile Atlantic sturgeon and subsequently may contribute to increased survival of young sturgeon. It is also important to note that the mortality we are considering here is not a new source of mortality. Any increase in the juvenile population has occurred with the ongoing impingement of individuals at IP2 and IP3.

The mortality of 10 juvenile Atlantic sturgeon annually from the NYB DPS represents a very small percentage of our minimum estimated juvenile population (*i.e.*, approximately 0.09% of the population, just considering the minimum estimated number of Hudson River origin juveniles age 1-3; the percentage would be much less if we also considered the number of adults, subadults and young of year as well as any Delaware River origin sturgeon). While the death of these individuals will reduce the number of NYB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the Hudson River population of juveniles and an even smaller percentage of the overall Hudson River population or the DPS as a whole.

Because there will be no loss of adults, the reproductive potential of the NYB DPS will not be affected in any way other than through a reduction in numbers of individual future spawners as opposed to current spawners. The loss of 12 juveniles per year for 23 years would have the effect of reducing the amount of potential reproduction as any dead NYB DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The proposed action will also not affect the spawning grounds within the Hudson River or Delaware River where NYB DPS fish spawn. We do not anticipate the impingement of any spawning adults. All effects to spawning adults will be insignificant and discountable and there will be no reduction in individual fitness or any future reduction in spawning by these individuals.

The proposed action is not likely to reduce distribution because the action will not impede NYB DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Delaware or Hudson River or elsewhere. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the area of the thermal plume.

Based on the information provided above, the death of an average of 102 juvenile NYB DPS Atlantic sturgeon annually for 23 years , will not appreciably reduce the likelihood of survival of the New York Bight DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of these juvenile NYB DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these juvenile NYB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these NYB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these juvenile NYB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of NYB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of NYB DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging NYB DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, NMFS has determined that the proposed action will not appreciably reduce the likelihood that the NYB DPS of Atlantic sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where the NYB DPS of Atlantic sturgeon is no longer in danger or extinction through all or a significant part of its range.

No Recovery Plan for the NYB DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the Hudson River population of Atlantic sturgeon in a way that would affect the NYB DPS likelihood of recovery.

This action will not change the status or trend of the Hudson River population of Atlantic sturgeon or the status and trend of the NYB DPS as a whole. The proposed action will result in a small amount of mortality (an average of 10 juveniles annually from a population of at least 4,600 juveniles and likely at least 24,000 juveniles, just considering the Hudson River and not the DPS as a whole) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant and discountable and the area of the river that sturgeon will be precluded from (due to high temperatures) is small. The proposed action will not affect Atlantic sturgeon outside of the Hudson River or affect habitats outside of the Hudson River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. Because it will not reduce the likelihood that the Hudson River population can recover, it will not reduce the likelihood that the NYB DPS as a whole can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the NYB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered. . Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

11.0 CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under NMFS jurisdiction, the environmental baseline for the action area, the effects of the proposed action, interdependent and interrelated actions and the cumulative effects, it is NMFS' biological opinion that the proposed action may adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon or the New York Bight DPS of Atlantic sturgeon. We have determined that the proposed action is not likely to adversely affect the Gulf of Maine or Chesapeake Bay DPS of Atlantic sturgeon. No critical habitat is designated in the action area; therefore, none will be affected by the proposed action.

12.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. "Fish and wildlife" is defined in the ESA "as any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, nonmigratory, or endangered bird for which protection is also afforded by treaty or other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof." 16 U.S.C. 1532(8). "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR 19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA.]" 16 U.S.C. 1538(g). A "person" is defined in part as any entity subject to the jurisdiction of the United States, including an individual, corporation, officer, employee, department or instrument of the Federal government (see 16 U.S.C. 1532(13)). Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by NRC and the applicant, Entergy, for the exemption in section 7(o)(2) to apply. NRC has a continuing duty to regulate the activity covered by this Incidental Take Statement. If NRC (1) fails to assume and implement the terms and conditions consistent with its authority or (2) fails to require the applicant, Entergy, to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the renewed license consistent with its authority, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, NRC or the applicant must report the progress of the action and its impact on the species to the NMFS as specified in the Incidental Take Statement [50 CFR §402.14(i)(3)] (See U.S. Fish and Wildlife Service and National Marine Fisheries Service's Joint Endangered Species Act Section 7 Consultation Handbook (1998) at 4-49).

12.1 Amount or Extent of Take

This ITS serves two important functions: (1) it provides an exemption from the Section 9 prohibitions for any taking incidental to the proposed action that is in compliance with the terms and conditions; and (2) it provides the means to insure the action as it is carried out is not jeopardizing the continued existence of affected species by monitoring and reporting the progress of the action and its impact on the species such that consultation can be reinitiated if any of the criteria in 50 CFR 402.16 are met. This ITS applies to the remaining term of the existing operating licenses and any extended operating period through the expiration date of those licenses. As such, we anticipate that this amount of take will occur at IP2, from now through September 28, 2033 and at IP3 until December 12, 2035. Take will also occur at the IP1 intakes as long as they are used for service water for IP2 which will occur from now until the IP2 license expires on September 28, 2033. The continued operation of IP2 and IP3 will adversely affect shortnose and Atlantic sturgeon due to impingement at the IP1, IP2 and IP3 intakes. These interactions at the intakes constitute "capture" or "collect" in the definition of "take" and will cause injury and mortality to the affected individuals. All impinged sturgeon are expected to die, immediately or later, as a result of interactions with the facility. As explained in the "Effects of the Action" section, effects of the facility on shortnose and Atlantic sturgeon also include effects of the thermal plume on distribution and prey. However, based on the available information on the thermal plume and the assumptions regarding sturgeon behavior and thermal tolerances outlined in the Opinion, we do not anticipate or exempt any take of shortnose or Atlantic sturgeon due to effects to prey items or due to exposure to the thermal plume.

We recognize that some sturgeon impinged at Indian Point may be dead prior to impingement. While it is possible the cause of death is unrelated to the operation of Indian Point, we do not currently have any information to determine whether that is the case. The take level that is exempted is inclusive of "previously killed" fish; this ITS exempts the "collection" or "capture" of these previously killed fish. At this time, because there are no necropsy reports for any sturgeon collected at Indian Point and very little data on the condition of impinged shortnose and Atlantic sturgeon (other than "dead" or "alive" for a few fish), we are unable to predict what percent of the impinged sturgeon are likely to have been killed prior to impingement at Indian Point. Future monitoring, as required by the RPMs and Terms and Conditions, will enable the ITS to serve its function of supporting the reinitiation provision.

This ITS exempts the following take:

- A total of 562 shortnose sturgeon (dead or alive) impinged at the Unit 1[15], 2, or 3 intakes (trash bars or screens) from now until the IP3 proposed renewed operating license would expire on December 12, 2035; and,
- A total of 219 New York Bight DPS Atlantic sturgeon (dead or alive) impinged at Unit 1, 2 or 3 intakes (trash bars or Ristroph screens) from now until the IP3 proposed renewed operating license would expire on December 12, 2035.

The Section 9 prohibitions against take apply to live individuals as well as to dead specimens and their parts. The Section 9 prohibitions include "capture" and "collect" in the definition of take, as well as injury and mortality. NMFS recognizes that shortnose and Atlantic sturgeon that have been killed prior to impingement at the IP facility may become impinged on the intakes at IP1, IP2 and IP3. However, the capture or collection of previously dead animals is prohibited under Section 9 and will be exempted through this ITS. Additionally, NMFS recognizes the potential for some shortnose and Atlantic sturgeon to pass through the trash bars, contact the Ristroph screens and travel down the sluice back to the River without significant injury or mortality. The Section 9 prohibitions on take also apply to the capture or collection of live, uninjured animals

[15] As explained in the Opinion, water withdrawn through the Unit 1 intakes is used for service water for the operation of IP2.

even if these animals are released without injury. Thus, it is appropriate for this ITS to also address shortnose and Atlantic sturgeon that may be captured or collected at the Ristroph screens and returned to the river unharmed. As no monitoring has taken place at the intakes since 1990, we cannot predict what percentage of sturgeon would be collected at the Ristroph screens without injury or mortality and, therefore, we are not able to refine this estimate of take to separate out the number of fish that may be collected but not killed. Due to the difficulty in determining the cause of death of sturgeon found dead at the intakes and the lack of past necropsy results that would allow us to better assess the likely cause of death of impinged sturgeon, the aforementioned anticipated level of take includes shortnose and Atlantic sturgeon that may have been killed prior to impingement on the IP intakes. As explained in the Opinion, we do not have sufficient information to predict what percentage of impinged sturgeon were previously killed and merely captured or collected at the facility and sturgeon that died as a result of their impingement at the Indian Point intakes. Therefore, we are not able to further refine this estimate of take into a number of previously dead sturgeon captured or collected at the facility and a number of sturgeon whose death was caused by operation of the facility. In the accompanying Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to shortnose sturgeon or to any DPS of Atlantic sturgeon.

12.2 Reasonable and Prudent Measures

In order to effectively monitor the effects of this action, it is necessary to monitor the intakes to document the amount of incidental take (i.e., the number of shortnose and Atlantic sturgeon captured, collected, injured or killed) and to examine the shortnose and Atlantic sturgeon that are impinged at the facility. Monitoring minimizes take by providing information on the characteristics of the sturgeon encountered and factors related to interactions that is useful for judging the effectiveness of current measures and for developing more effective measures to avoid future interactions with listed species. Monitoring also serves to check the assumptions and conclusions in the Opinion's analysis, thereby enabling NRC and NMFS to know whether reinitiation of consultation is necessary. We do not anticipate any additional injury or mortality to be caused by removing the fish from the water and examining them as required in the RPMs. Any live sturgeon are to be released back into the river, away from the intakes and thermal plume. These RPMs and their implementing terms and conditions apply to operations of IP2 and IP3 under their existing licenses as well as the license to be issued for the continued operation of IP2 and the license to be issued for the continued operation of IP3. We expect that the NRC will amend the operating licenses to incorporate these RPMs and Terms and Conditions as appropriate.

We have determined the following reasonable and prudent measures are necessary or appropriate to minimize and monitor impacts of incidental take of endangered shortnose and Atlantic sturgeon:

1. A program to monitor the incidental take of shortnose and Atlantic sturgeon at the IP1, IP2 and IP3 intakes must be developed, approved by NMFS, and implemented within 120 days of the issuance of this Opinion. This program must be implemented throughout the remaining duration of the existing operating licenses and for the entire duration of any new operating licenses.

2. All live shortnose and Atlantic sturgeon must be released back into the Hudson River at an appropriate location away from the intakes and thermal plume that does not pose additional risk of take, including death, injury, harassment, collection/capture.

3. Any dead shortnose or Atlantic sturgeon must be transferred to NMFS or an appropriately permitted research facility NMFS will identify so that a necropsy can be undertaken to attempt to determine the cause of death.

4. A genetic sample must be taken of all Atlantic and shortnose sturgeon impinged at Indian Point.

5. All shortnose and Atlantic sturgeon impingements associated with the Indian Point facility and any shortnose or Atlantic sturgeon sightings in the action area must be reported to NMFS.

12.3 Terms and Conditions

In order to be exempt from prohibitions of section 9 of the ESA, Entergy must comply with, and NRC, consistent with its authorities, must ensure through enforceable terms of the existing and renewed licenses that Entergy does comply with, the following terms and conditions of the Incidental Take Statement, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary. Any taking that is in compliance with the terms and conditions specified in this Incidental Take Statement shall not be considered a prohibited taking of the species concerned (ESA Section 7(o)(2)). Within 60 days of issuance of this Opinion, NRC must add a condition(s) to the existing licenses and to the proposed renewed licenses that requires Entergy to adhere to the terms and conditions of this Opinion.

1. To implement RPM #1, Entergy must fully implement a NMFS-approved monitoring plan within 120 days of the issuance of this Opinion. A draft monitoring plan must be provided to NMFS within 30 days of the issuance of this Opinion for NMFS review and approval. The monitoring plan must be implemented throughout the remaining term of the existing operating licenses and any period beyond their expiration that the facilities continue to operate pursuant to those licenses. The monitoring plan must also be implemented through the duration of the operating period authorized by any new operating licenses. The monitoring plan must be designed and implemented to allow for the detection and observation of all shortnose and Atlantic sturgeon that are impinged anywhere at the intakes, including on the trash bars, or that contact the Ristroph screens or its fish buckets. All references to "Ristroph screens" below are inclusive of all parts of the Ristroph screen system including the screening itself, the fish buckets, and the fish return system. This monitoring plan must contain the following components:
    a. methods and procedure for monitoring the intake trash bars on a schedule that ensures detection and timely release of all shortnose and Atlantic sturgeon impinged on the trash bars;
    b. any method developed to monitor the intake trash bars for shortnose and Atlantic sturgeon must be able to detect all individuals impinged at the trash bars within 24 hours of impingement;

c. methods and procedures for monitoring the Ristroph screens on a schedule that ensures detection and timely release of all shortnose and Atlantic sturgeon that pass through the trash bars and contact or are impinged on the screens;
d. any method developed to monitor the Ristroph screens must ensure the detection and inspection of all shortnose and Atlantic sturgeon prior to their being discharged back into the River;
e. a handling and release plan that describes how all live shortnose and Atlantic sturgeon that are impinged at the trash bars or the Ristroph screens will be safely removed from the water, handled for examination, and returned to the River;
f. handling and disposal procedures for dead shortnose and Atlantic sturgeon or body parts of shortnose and Atlantic sturgeon;
g. procedures for obtaining genetic samples from all shortnose and Atlantic sturgeon;
h. reporting forms that contain all information to be reported for all incidental takes of shortnose and Atlantic sturgeon;
i. procedures for notifying NMFS of all incidental takes;
j. monitoring the water velocity at the trash bars (approach and through-rack velocity), between the trash bars and Ristroph screens and at the Ristroph screens (approach and through-screen velocity) at IP1, IP2 and IP3 so that this information can be reported any time a take occurs;
k. monitoring water temperature at the trash bars and at the Ristroph screens at IP1, IP2 and IP3 so that this information can be reported any time a take occurs (surface, mid-water and bottom water);
l. monitoring operating conditions so that this information can be reported any time a take occurs;
m. coordination procedures regarding personnel who will be carrying out this monitoring. Qualifications must be submitted to NMFS for review and approval. All monitors will need to demonstrate experience in identifying and handling sturgeon species.

and,

n. procedures for making any necessary updates or modifications to the monitoring plan.

2. To implement RPM #1, At least 60 days prior to the issuance of the renewed operating license(s), NMFS must receive a copy of a proposed renewed monitoring plan for our approval. At that time, NMFS, the licensee and NRC must determine if any improvements to the existing monitoring plan are necessary. This proposed renewed monitoring plan must be approved by NMFS prior to the effective date of any renewed license(s) and must be implemented beginning on the day that the new license(s) becomes effective and carried out throughout the duration of those licenses.

3. To implement RPM #2, Entergy must ensure that all live shortnose and Atlantic sturgeon are returned to the river away from the intakes and the thermal plume, following complete documentation of the event pursuant to the approved monitoring plans and forms provided with this ITS. Handling and release procedures must be a part of the monitoring plan outlined in Term and Condition #1.

4. To implement RPM #3, Entergy must ensure that all dead specimens or body parts of shortnose and Atlantic sturgeon or fish that might be sturgeon are photographed, measured, and preserved (refrigerate or freeze). No dead shortnose or Atlantic sturgeon or body parts of shortnose or Atlantic sturgeon may be disposed without discussing disposal procedures with NMFS. General disposal procedures must be included in the monitoring plan outlined in Term and Condition #1 above. NMFS may request that the specimen be transferred to NMFS or to an appropriately permitted researcher so that a necropsy may be conducted. The forms included as Appendix II and III must be completed and submitted to NMFS as noted in Term and Condition #7.

5. To implement RPM#4, Entergy must obtain genetic samples from all captured or impinged Atlantic and shortnose sturgeon. This must be done in accordance with the procedures provided in Appendix IV.

6. To implement RPM #5, if any live or dead shortnose or Atlantic sturgeon are taken at IP1, IP2 or IP3, Entergy must notify NMFS (978-281-9328 and incidental.take@noaa.gov) and NRC immediately. An incident report (Appendix I) must also be completed by plant personnel and sent to the NMFS Section 7 Coordinator via e-mail (incidental.take@noaa.gov) within 24 hours of the take. The form included as Appendix III must be filled out for any dead sturgeon and submitted via e-mail (incidental.take@noaa.gov) within 24 hours of the take. Every shortnose and Atlantic sturgeon, must be photographed and photographs must be submitted to NMFS within 24 hours. Information in Appendix V will assist in identification of shortnose and Atlantic sturgeon.

7. To implement RPM #5, Entergy must notify NMFS and NRC in writing when the facility reaches 50% of the annual estimated incidental take level for shortnose and Atlantic sturgeon (12 and 5 individuals, respectively). At that time, NMFS will determine if additional measures are necessary or appropriate to minimize impingement at the intake structures, or if additional monitoring is necessary, in order to avoid exceeding the incidental take levels specified in this Incidental Take Statement.

8. To implement RPM #5, Entergy must notify NMFS and NRC in writing any time the facility exceeds the annual estimated incidental take level for shortnose and Atlantic sturgeon (25 and 10 individuals, respectively). At that time, NMFS will determine if this annual exceedence represents new information that would necessitate reinitiation of consultation.

8. To implement RPM #5, Entergy must submit an annual report of incidental takes to NMFS and NRC by February 15 of each year. The report must include, as detailed in this Incidental Take Statement and the monitoring plan required by Term and Condition #1, any necropsy reports of specimens, incidental take reports, photographs , a record of all sightings of shortnose and Atlantic sturgeon in the vicinity of Indian Point, conditions at the time of the take (operations as well as environmental conditions including water velocity and water temperature) and a record of when inspections of the intake trash bars and Ristroph screens were conducted for the 48 hours prior to the take. The annual report must also identify any potential measures to reduce shortnose or Atlantic sturgeon

impingement, injury, and mortality at the intake structures. At the time the report is submitted, NMFS will supply NRC and Entergy with any information on changes to reporting requirements (i.e., staff changes, phone or fax numbers, e-mail addresses) for the coming year.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize and monitor the impact of incidental take that results from the proposed action. Specifically, these RPMs and Terms and Conditions will ensure that Entergy monitors the intakes in a way that allows for the detection of all impinged shortnose and Atlantic sturgeon and implements measures to reduce the potential of mortality for all shortnose and Atlantic sturgeon impinged at Indian Point, to report all interactions to NMFS and NRC and to provide information on the likely cause of death of any shortnose and Atlantic sturgeon impinged at the facility. The discussion below explains why each of these RPMs and Terms and Conditions are necessary or appropriate to minimize or monitor the level of incidental take associated with the proposed action. The RPMs and terms and conditions involve only a minor change to the proposed action.

RPM #1 and Term and Condition #1 and 2 are necessary and appropriate because they are specifically designed to ensure that all appropriate measures are carried out to monitor the incidental take of sturgeon at Indian Point, which by definition includes the capture or collection of live sturgeon as well as the injury or mortality of impinged sturgeon. An effective monitoring plan is essential to allow NRC and Entergy to fulfill the requirement to monitor the actual level of incidental take associated with the operation of Indian Point and to allow NMFS and NRC to determine if consultation must be reinitiated. These requirements are also essential for confirming the cause of death. These conditions ensure that the potential for detection of shortnose and Atlantic sturgeon at the intakes is maximized and that any sturgeon removed from the water are removed in a manner that minimizes the potential for further injury.

RPM#2 and Term and Condition #3 are necessary and appropriate to ensure that any shortnose or Atlantic sturgeon that survive impingement is given the maximum probability of remaining alive and not suffering additional injury or subsequent mortality through inappropriate handling or release near the intakes.

RPM #3 and Term and Condition #4 are necessary and appropriate to ensure the proper handling and documentation of any shortnose and Atlantic sturgeon removed from the intakes that are dead or die while in Entergy possession. This is essential for monitoring the level of incidental take associated with the proposed action, confirming cause of death and ensuring proper disposal.

RPM #4 and Term and Condition #5 are necessary and appropriate to ensure the proper documentation of species and/or DPS of origin for any impinged sturgeon collected at Indian Point. Sampling of fin tissue is used for genetic sampling. This procedure does not harm shortnose or Atlantic sturgeon and is common practice in fisheries science. Tissue sampling does not appear to impair the sturgeon’s ability to swim and is not thought to have any long-term adverse impact. NMFS has received no reports of injury or mortality to any shortnose or Atlantic sturgeon sampled in this way.

RPM#5 and Term and Condition #6-8 are necessary and appropriate to ensure the proper handling and documentation of any interactions with listed species as well as the prompt reporting of these interactions to NMFS.

13.0 CONSERVATION RECOMMENDATIONS

In addition to Section 7(a)(2), which requires agencies to ensure that all projects will not jeopardize the continued existence of listed species, Section 7(a)(1) of the ESA places a responsibility on all federal agencies to "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species." Conservation Recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. As such, NMFS recommends that the NRC consider the following Conservation Recommendations:

1. The NRC should use its authorities to ensure tissue analysis of dead shortnose sturgeon removed from the Indian Point intakes is performed to determine contaminant loads, including radionuclides.

2. The NRC should use its authorities to ensure studies are performed that document impacts of impingement, entrainment and heat shock to benthic resources that may serve as forage for shortnose and Atlantic sturgeon.

3. The NRC should use its authorities to ensure studies are performed to ground truth the thermal plume model published in 2011 (Swanson et al. 2011) with field sampling across a range of environmental conditions (weather, tide, etc.).

4. The NRC should use its authorities to require that the REMP sample species that may serve as forage for shortnose and Atlantic sturgeon.

5. The NRC should use its authorities to ensure a scientific study on the mortality of sturgeon impinged on Ristroph Screens is performed.

6. The NRC should use its authorities to ensure in-water assessments, abundance, and distribution surveys for shortnose and Atlantic sturgeon in the Hudson River, and Haverstraw Bay specifically, are performed.

7. The NRC should use its authorities to ensure studies are performed that document the presence, if any, of shortnose sturgeon in the broadest area affected by the thermal plume in order to validate the assumption in this Opinion that shortnose sturgeon are likely to move away from the thermal plume.

14.0 REINITIATION OF CONSULTATION

This concludes formal consultation on the continued operation of IP2 and IP3 under the terms of the existing operating licenses and the proposed renewed operating licenses. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, Section 7 consultation must be reinitiated immediately.

If in the future, NY State issues a revised SPDES permit or 401 WQC that modifies the operations of IP2 or IP3, reinitiation of this consultation is likely to be necessary. Additionally, it is our understanding that revised CWA 316(b) regulations may be issued by EPA in 2013. If there are any modifications to the Indian Point facility resulting from the implementation of these regulations, reinitiation of this consultation is likely to be necessary.

15.0 LITERATURE CITED

Allen PJ, Nicholl M, Cole S, Vlazny A, Cech JJ Jr. 2006. Growth of larval to juvenile green sturgeon in elevated temperature regimes. Trans Am Fish Soc 135:89–96

ASA (Analysis and Communication). 2008. 2006 year class report for the Hudson River Estuary Program prepared for Dynegy Roseton LLC, on behalf of Dynegy Roseton LLC Entergy Nuclear Indian Point 2 LLC, Entergy Nuclear Indian Point 3 LLC, and Mirant Bowline LLC. Washingtonville NY.

Bain, M. B. 1997. Atlantic and shortnose sturgeons of the Hudson River: Common and Divergent Life History Attributes. Environmental Biology of Fishes 48: 347-358.

Bain, M., K. Arend, N. Haley, S. Hayes, J. Knight, S. Nack, D. Peterson, and M. Walsh. 1998a. Sturgeon of the Hudson River: Final Report on 1993-1996 Research. Prepared for The Hudson River Foundation by the Department of Natural Resources, Cornell University, Ithaca, New York.

Bain, Mark B., D.L. Peterson, K. K. Arend. 1998b. Population status of shortnose sturgeon in the Hudson River: Final Report. Prepared for Habitat and Protected Resources Division National Marine Fisheries Service by New York Cooperative Fish and Wildlife Research Unit, Department of Natural Resources, Cornell University, Ithaca, NY.

Bain, Mark B., N. Haley, D. L. Peterson, K. K. Arend, K. E. Mills, P. J. Sullivan. 2000. Annual meeting of American fisheries Society. EPRI-AFS Symposium: Biology, Management and Protection of Sturgeon. St. Louis, MO. 23-24 August 2000.

Bain, Mark B., N. Haley, D. L. Peterson, K. K Arend, K. E. Mills, P. J. Sulivan. 2007. Recovery of a US Endangered Fish. PLoS ONE 2(1): e168. doi:10.1371/journal.pone.0000168

Bath, D.W., J.M. O'Conner, J.B. Albert and L.G. Arvidson. 1981. Development and identification of larval Atlantic sturgeon (*Acipenser oxyrinchus*) and shortnose sturgeon (*A. brevirostrum*) from the Hudson River estuary, New York. Copeia 1981:711-717.

Beamesderfer, Raymond C.P. and Ruth A. Farr. 1997. Alternatives for the protection and restoration of sturgeons and their habitat. Environmental Biology of Fishes 48: 407-417.

Berlin, W.H., R.J. Hesselberg, and M.J. Mac. 1981. Chlorinated hydrocarbons as a factor in the reproduction and survival of lake trout (Salvelinus namaycush) in Lake Michigan. Technical Paper 105 of the U.S. Fish and Wildlife Service, 42 pages.

Buckley, J., and B. Kynard. 1981. Spawning and rearing of shortnose sturgeon from the Connecticut River. Progressive Fish Culturist 43:74-76.

Buckley, J. and B. Kynard. 1985. Habitat use and behavior of pre-spawing and spawning shortnose sturgeon, *Acipenser brevirostrum*, in the Connecticut River. North American Sturgeons: 111-117.

Carlson, D.M., and K.W. Simpson. 1987. Gut contents of juvenile shortnose sturgeon in the upper Hudson estuary. Copeia 1987:796-802

CHGE. Central Hudson Gas and Electric Corp., Consolidated Edison Company of New York, New York Power Authority, and Southern Energy New York. 1999. Draft environmental impact statement for State pollution discharge elimination system permits for Bowline Point1&2, Indian Point 1&2, and Roseton 1&2 Steam electric generating stations.

Collins, M. R., S. G. Rogers, and T. I. J. Smith. 1996. Bycatch of sturgeons along the Southern Atlantic Coast of the USA. North American Journal of Fisheries Management 16: 24-29.

Dadswell, M.J. 1979. Biology and population characteristics of the shortnose sturgeon, Acipenser brevirostrum LeSueur 1818 (Osteichthyes: Acipenseridae), in the Saint John River estuary, New Brunswick, Canada. Canadian Journal of Zoology 57:2186-2210.

Dadswell, M.J., B.D. Taubert, T.S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* Lesueur 1818. NOAA Technical Report, NMFS 14, National Marine Fisheries Service. October 1984 45 pp.

Dovel, W.J. 1978. The Biology and management of shortnose and Atlantic sturgeons of the Hudson River. Performance report for the period April 1, to September 30, 1978. Submitted to N.Y. State Department of Environmental Conservation.

Dovel, W.J. 1979. Biology and management of shortnose and Atlantic sturgeon of the Hudson River. New York State Department of Environmental Conservation, AFS9-R, Albany.

Dovel, W.L. 1981. The Endangered shortnose sturgeon of the Hudson Estuary: Its life history and vulnerability to the activities of man. The Oceanic Society. FERC Contract No. DE-AC 39-79 RC-10074.

Dovel, W.L., A.W. Pekovitch, and T.J. Berggren. 1992. Biology of the shortnose sturgeon (*Acipenser brevirostrum* Lesueur 1818) in the Hudson River estuary, New York. Pages 187-216 in C.L. Smith (editor). Estuarine research in the 1980s. State University of New York Press, Albany, New York.

Dwyer, F. James, Douglas K. Hardesty, Christopher G. Ingersoll, James L. Kunz, and David W. Whites. 2000. Assessing contaminant sensitivity of American shad, Atlantic sturgeon, and shortnose sturgeon. Final Report. U.S. Geological Survey. Columbia Environmental Research Center, 4200 New Have Road, Columbia, Missouri.

Entergy Nuclear Operations, Inc. (Entergy). 2007a. “Indian Point, Units 2 & 3, License Renewal Application.” April 23, 2007.

Entergy Nuclear Operations, Inc. (Entergy). 2007b. “Applicant’s Environment Report, Operating License Renewal Stage." (Appendix E to "Indian Point, Units 2 & 3, License Renewal Application".) April 23, 2007.

Entergy Nuclear Operations, Inc. (Entergy). 2007c. Letter from Fred Dacimo, Indian Point Energy Center Site Vice President, to the U.S. NRC regarding Indian Point Nuclear Generating Units Nos. 2 and 3. Docket Nos. 50-247, 50-286. May 3, 2007.

ERC, Inc. (Environmental Research and Consulting, Inc.). 2002. Contaminant analysis of tissues from two shortnose sturgeon (Acipenser brevirostrum) collected in the Delaware River. Prepared for National Marine Fisheries Service. 16 pp. + appendices.

ERC, Inc. (Environmental Research and Consulting, Inc.). 2007. Preliminary acoustic tracking study of juvenile shortnose sturgeon and Atlantic sturgeon in the Delaware River. May 2006 through March 2007. Prepared for NOAA Fisheries. 9 pp.

Eyler, Sheila M., Jorgen E. Skjeveland, Michael F. Mangold, and Stuart A. Welsh. 2000. Distribution of Sturgeons in Candidate Open Water Dredged Material Placement Sites in the Potomac River (1998-2000). U.S. Fish and Wildlife Service, Annapolis, MD. 26 pp.

Fernandes, S.J. 2008. Population demography, distribution, and movement patterns of Atlantic and shortnose sturgeons in the Penobscot River estuary, Maine. University of Maine. Masters thesis. 88 pp.

Fletcher, R. I. 1990. Flow dynamics and fish recovery experiments: water intake systems. Transactions of the American Fisheries Society. Vol. 119, No. 3, pp. 393-415.

Flournoy, P.H., S.G. Rogers, and P.S. Crawford. 1992. Restoration of shortnose sturgeon in the Altamaha River, Georgia. Final Report to the U.S. Fish and Wildlife Service, Atlanta, Georgia.

Geoghegan, P., M.T. Mattson and R.G Keppel. 1992. Distribution of shortnose sturgeon in the Hudson River, 1984-1988. IN Estuarine Research in the 1980s, C. Lavett Smith, Editor. Hudson River Environmental Society, Seventh symposium on Hudson River ecology. State University of New York Press, Albany NY, USA.

Giesy, J.P., J. Newsted, and D.L. Garling. 1986. Relationships between chlorinated hydrocarbon concentrations and rearing mortality of chinook salmon (Oncorhynchus tshawytscha) eggs from Lake Michigan. Journal of Great Lakes Research 12(1):82-98.

Gilbert, C.R. 1989. Atlantic and shortnose sturgeons. United States Department of Interior Biological Report 82, 28 pages.

Grunwald, C., J. Stabile, J.R. Waldman, R. Gross, and I. Wirgin. 2002. Population genetics of shortnose *sturgeon (Acipenser brevirostrum*) based on mitochondrial DNA control region sequences. Molecular Ecology 11: 000-000.

Hansen, P.D. 1985. Chlorinated hydrocarbons and hatching success in Baltic herring spring spawners. Marine Environmental Research 15:59-76.

Haley, N. 1996. Juvenile sturgeon use in the Hudson River Estuary. Master's thesis. University of Massachusetts, Amhearst, MA, USA.

Hall, W.J., T.I.J. Smith, and S.D. Lamprecht. 1991. Movements and habitats of shortnose sturgeon Acipenser brevirostrum in the Savannah River. Copeia (3):695-702.

Hastings, R.W. 1983. A study of the shortnose sturgeon (*Acipenser brevirostrum*) population in the upper tidal Delaware River: Assessment of impacts of maintenance dredging. Final Report to the U.S. Army Corps of Engineers, Philadelphia, Pennsylvania. 129 pp.

Heidt, A.R., and R.J. Gilbert. 1978. The shortnose sturgeon in the Altamaha River drainage, Georgia. Pages 54-60 in R.R. Odum and L. Landers, editors. Proceedings of the rare and endangered wildlife symposium. Georgia Department of Natural Resources, Game and Fish Division, Technical Bulletin WL 4, Athens, Georgia.

Holland, B.F., Jr. and G.F. Yelverton. 1973. Distribution and biological studies of anadromous fishes offshore North Carolina. North Carolina Department of Natural and Economic Resources, Division of Commercial and Sports Fisheries, Morehead City. Special Scientific Report 24:1-132.

Hulme, P.E. 2005. Adapting to climate change: is there scope for ecological management in the face of global threat? Journal of Applied Ecology 43: 617-627.IPCC (Intergovernmental Panel on Climate Change) 2007. Fourth Assessment Report. Valencia, Spain.

Jenkins, W.E., T.I.J. Smith, L.D. Heyward, and D.M. Knott. 1993. Tolerance of shortnose sturgeon, *Acipenser brevirostrum*, juveniles to different salinity and dissolved oxygen concentrations. Proceedings of the Southeast Association of Fish and Wildlife Agencies, Atlanta, Georgia.

Kieffer, M.C. and B. Kynard. 1993. Annual movements of shortnose and Atlantic sturgeons in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 1221: 1088-1103.

Kieffer, M., and B. Kynard. 1996. Spawning of shortnose sturgeon in the Merrimack River. Transactions of the American Fisheries Society 125:179-186.

Kieffer and Kynard in review [book to be published by AFS]. Kieffer, M. C., and B. Kynard. In review. Pre-spawning and non-spawning spring migrations, spawning, and effects of hydroelectric dam operation and river regulation on spawning of Connecticut River shortnose sturgeon.

Kocan, R.M., M.B. Matta, and S. Salazar. 1993. A laboratory evaluation of Connecticut River coal tar toxicity to shortnose sturgeon (*Acipenser brevirostrum)* embryos and larvae. Final

Report to the National Oceanic and Atmospheric Administration, Seattle, Washington.

Kynard, B. 1996. Twenty-one years of passing shortnose sturgeon in fish lifts on the Connecticut River: what has been learned? Draft report by National Biological Service, Conte Anadromous Fish Research Center, Turners Falls, MA. 19 pp.

Kynard, B. 1997. Life history, latitudinal patterns, and status of the shortnose sturgeon, Acipenser brevirostrum. Environmental Biology of Fishes 48:319–334.

Longwell, A.C., S. Chang, A. Hebert, J. Hughes and D. Perry. 1992. Pollution and developmental abnormalities of Atlantic fishes. Environmental Biology of Fishes 35:1- 21.

Mac, M.J., and C.C. Edsall. 1991. Environmental contaminants and the reproductive success of lake trout in the Great Lakes: An epidemiological approach. Journal of Toxicology and Environmental Health 33:375-394.

Mayfield RB, Cech JJ Jr. 2004. Temperature effects on green sturgeon bioenergetics. Trans Am Fish Soc 133:961–970

Morgan, R.P., V.J. Rasin and L.A. Noe. 1973. Effects of Suspended Sediments on the Development of Eggs and Larvae of Striped Bass and White Perch. Natural resources Institute, Chesapeake Biological Laboratory, U of Maryland, Center for Environmental and Estuarine Studies. 20 pp.

Moser, M.L. and S.W. Ross. 1995. Habitat use and movements of shortnose and Atlantic sturgeons in the lower Cape Fear River, North Carolina. Transactions of the American Fisheries Society 124:225-234.

NAST (National Assessment Synthesis Team). 2008. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, US Global Change Research Program, Washington DC, 2000 http://www.usgcrp.gov/usgcrp/Library/nationalassessment/1IntroA.pdf

NMFS, 1996. Status Review of shortnose sturgeon in the Androscoggin and Kennebec Rivers. Northeast Regional Office, National Marine Fisheries Service, unpublished report. 26 pp.

NMFS. 1998. Recovery plan for the shortnose sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland 104 pp.

NOAA. 1979. Testimony of Dr. Dadswell. May 14, 1979. Docket C/II-WP-77-01.

NRC 2010. Generic Environmental Impact Statement for License Renewal of Nuclear Plants. Supplement 38 – Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3. Final Report. NUREG-1437, Supplement 38

NRC 2009. Biological Assessment to NMFS for Indian Point relicensing. Unpublished report transmitted to NMFS.

NRC 2010b. Revised Biological Assessment to NMFS for Indian Point relicensing. December 2010.

NRC 2011. Supplement to Biological Assessment to NMFS for Indian Point relicensing.

NYHS (New York Historical Society as cited by Dovel as Mitchell. S. 1811). 1809. Volume1. Collections of the New-York Historical Society for the year 1809.

NYDEC. 1982. State Pollution Discharge Elimination System Final Permit for Indian Point Nuclear Generating Station.

NYSDEC (New York State Department of Environmental Conservation). 2003. "Final Environmental Impact Statement Concerning the Applications to Renew New York State Pollutant Discharge Elimination System (SPDES) Permits for the Roseton 1 and 2 Bowline 1 and 2 and IP2 and IP3 2 and 3 Steam Electric Generating Stations, Orange, Rockland and Westchester Counties" (Hudson River Power Plants FEIS). June 25, 2003.

NYDEC. 2010. Letter from W. Adriance to D. Grey, Entergy. Denial of 401 WQC. April 2, 2010.

Niklitschek, J. E. 2001. Bioenergetics modeling and assessment of suitable habitat for juvenile Atlantic and shortnose sturgeons (Acipenser oxyrinchus and A. brevirostrum) in the Chesapeake Bay. Dissertation. University of Maryland at College Park, College Park.

O'Herron, J.C., K.W. Able, and R.W. Hastings. 1993. Movements of shortnose sturgeon (*Acipenser brevirostrum)* in the Delaware River. Estuaries 16:235-240.

Parker E. 2007. Ontogeny and life history of shortnose sturgeon (*Acipenser brevirostrum* lesueur 1818): effects of latitudinal variation and water temperature. Ph.D. Dissertation. University of Massachusetts, Amherst. 62 pp.

Pekovitch, A.W. 1979. Distribution and some life history aspects of shortnose sturgeon (*Acipenser brevirostrum)* in the upper Hudson River Estuary. Hazleton Environmental Sciences Corporation. 67 pp.

Rogers, S. G., and W. Weber. 1994. Occurrence of shortnose sturgeon (Acipenser brevirostrum) in the Ogeechee-Canoochee river system, Georgia during the summer of 1993. Final Report of the United States Army to the Nature Conservancy of Georgia.

Rogers, S.G., and W. Weber. 1995a. Movements of shortnose sturgeon in the Altamaha River system, Georgia. Contributions Series #57. Coastal Resources Division, Georgia Department of Natural Resources, Brunswick, Georgia.

Rogers, S.G., and W. Weber. 1995b. Status and restoration of Atlantic and shortnose sturgeons in Georgia. Final Report to the National Marine Fisheries Service, Southeast Regional Office, St. Petersburg, Florida.

Ruelle, R., and K.D. Keenlyne. 1993. Contaminants in Missouri River pallid sturgeon. Bull. Environ. Contam. Toxicol. 50: 898-906.

Ruelle, R. and C. Henry. 1994. Life history observations and contaminant evaluation of pallid sturgeon. Final Report U.S. Fish and Wildlife Service, Fish and Wildlife Enhancement, South Dakota Field Office, 420 South Garfield Avenue, Suite 400, Pierre, South Dakota 57501-5408.

Sherk, J.A. J.M. O'Connor and D.A. Neumann. 1975. Effects of suspended and deposited sediments on estuarine environments. *In*: Estuarine Research Vol. II. Geology and Engineering. L.E. Cronin (editor). New York: Academic Press, Inc.

Skjeveland, Jorgen E., Stuart A. Welsh, Michael F. Mangold, Sheila M. Eyler, and Seaberry Nachbar. 2000. A Report of Investigations and Research on Atlantic and Shortnose Sturgeon in Maryland Waters of the Chesapeake bay (1996-2000). U.S. Fish and Wildlife Service, Annapolis, MD. 44 pp.

Smith, Hugh M. and Barton A. Bean. 1899. List of fishes known to inhabit the waters of the District of Columbia and vicinity. Prepared for the United States Fish Commission. Washington Government Printing Office, Washington, D.C.

Snyder, D.E. 1988. Description and identification of shortnose and Atlantic sturgeon larvae. American Fisheries Society Symposium 5:7-30.

Spells, A. 1998. Atlantic sturgeon population evaluation utilizing a fishery dependent reward program in Virginia's major western shore tributaries to the Chesapeake Bay. U.S. Fish and Wildlife Service, Charles City, Virginia.

Squiers, T., L. Flagg, and M. Smith. 1982. American shad enhancement and status of sturgeon stocks in selected Maine waters. Completion report, Project AFC-20.

Squiers, T. And M. Robillard. 1997. Preliminary report on the location of overwintering sites for shortnose sturgeon in the estuarial complex of the Kennebec River during the winter of 1996/1997. Unpublished report, submitted to the Maine Department of Transportation.

Swanson, C., D. Crowley, Y. Kim, N. Cohn, and D. Mendelsohn. 2011a. Part 2 of Response to the NYSDEC Staff Review of the 2010 Field Program and Modeling Analyis of the Cooling Water Discharge from the Indian Point Energy Center. Prepared for Indian Point Energy Center, Buchanan, New York. ADAMS Accession No. ML 11189A026. Available URL: http://www.dec.ny.gov/permits/57609.html.

Swanson, C., D. Mendelsohn, N. Cohn, D. Crowley, Y. Kim, L Decker, and L Miller. 2011 b. Final Report: 2010 Field Program and Modeling Analysis of the Cooling Water Discharge from the Indian Point Entergy Center. Prepared for Indian Point Energy Center, Buchanan, New York. ADAMS Accession No. **ML** 11189A026. Available URL: http://www.dec.ny.gov/permits/57609.html.

Taubert, B.D. 1980b. Biology of shortnose sturgeon (Acipenser brevirostrum) in the Holyoke Pool, Connecticut River, Massachusetts. Ph.D. Thesis, University of Massachusetts, Amherst, 136 p.

Taubert, B.D., and M.J. Dadswell. 1980. Description of some larval shortnose sturgeon (Acipenser brevirostrum) from the Holyoke Pool, Connecticut River, Massachusetts, USA, and the Saint John River, New Brunswick, Canada. Canadian Journal of Zoology 58:1125-1128.

Uhler, P.R. and O. Lugger. 1876. List of fishes of Maryland. Rept. Comm. Fish. MD. 1876: 67-176.

USDOI (United States Department of Interior). 1973. Threatened wildlife of the United States. Shortnose sturgeon. Office of Endangered Species and International Activities, Bureau of Sport Fisheries and Wildlife, Washington, D.C. Resource Publication 114 (Revised Resource Publication 34).

Varanasi, U. 1992. Chemical contaminants and their effects on living marine resources. pp. 59-71. in: R. H. Stroud (ed.) Stemming the Tide of Coastqal Fish Habitat Loss. Proceedings of the Symposium on Conservation of Fish Habitat, Baltimore, Maryland. Marine Recreational Fisheries Number 14. National Coalition for Marine Conservation, Inc., Savannah Georgia.

Vinyard, L. and W.J. O'Brien. 1976. Effects of light and turbidity on the reactive distance of bluegill (*Lepomis macrochirus*) J. Fish. Res. Board Can. 33: 2845-2849.

Vladykov, V.D. and J.R. Greeley. 1963. Order Acipenseroidea. Pages 24-60 in Fishes of the Western North Atlantic. Memoir Sears Foundation for Marine Research 1(Part III). xxi + 630 pp.

Von Westernhagen, H., H. Rosenthal, V. Dethlefsen, W. Ernst, U. Harms, and P.D. Hansen. 1981. Bioaccumulating substances and reproductive success in Baltic flounder Platichthys flesus. Aquatic Toxicology 1:85-99.

Wirgin, I., Grunwald, C., Carlson, E., Stabile, J., Peterson, D.L. and J. Waldman. 2005. Range-wide population structure of shortnose sturgeon Acipenser brevirostrum based on sequence analysis of mitochondrial DNA control region. Estuaries 28:406-21.

Waldman JR, Grunwald C, Stabile J, Wirgin I. 2002. Impacts of life history and biogeography on genetic stock structure in Atlantic Sturgeon, *Acipenser oxyrinchus oxyrinchus*, Gulf sturgeon *A. oxyrinchus desotoi*, and shortnose sturgeon, *A.brevirostrum.* J Appl Ichthyol 18:509-518

Walsh, M.G., M.B. Bain, T. Squires, J.R. Walman, and Isaac Wirgin. 2001. Morphological and genetic variation among shortnose sturgeon Acipenser brevirostrum from adjacent and distant rivers. Estuaries Vol. 24, No. 1, p. 41-48. February 2001.

Waters, Thomas F. 1995. Sediment in Streams. American Fisheries Society Monograph 7. American Fisheries Society, Bethesda, MD. Pages 95-96.

Weber, W. 1996. Population size and habitat use of shortnose sturgeon, Acipenser brevirostrum, in the Ogeechee River sytem, Georgia. Masters Thesis, University of Georgia, Athens, Georgia.

Welsh, Stuart A., Michael F. Mangold, Jorgen E. Skjeveland, and Albert J. Spells. 2002. Distribution and Movement of Shortnose Sturgeon (*Acipenser brevirostrum*) in the Chesapeake Bay. Estuaries Vol. 25 No. 1: 101-104.

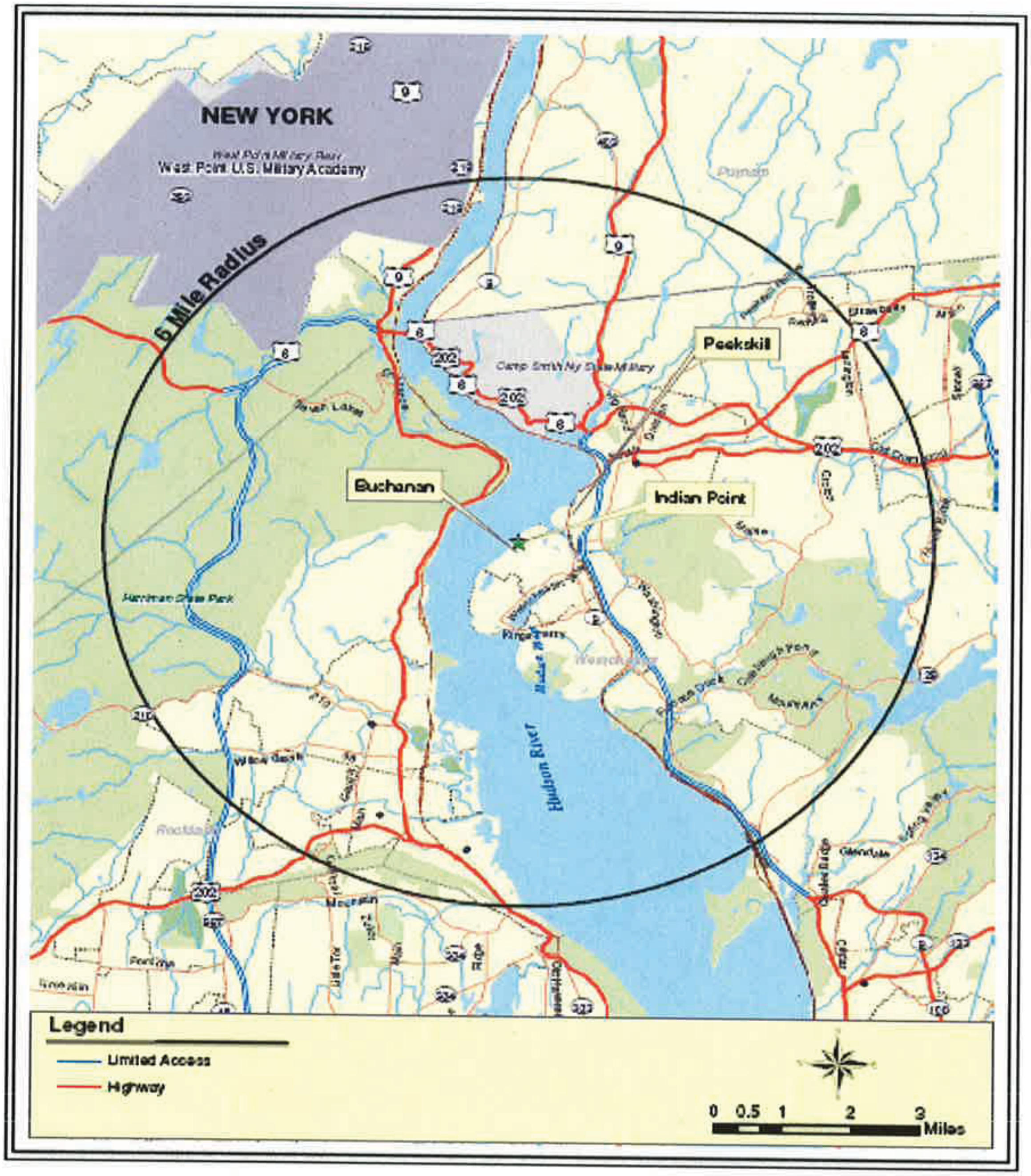
Wilber, Dara H. and Douglas C. Clarke. 2001. Biological Effects of Suspended Sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. North American Journal of Fisheries Woodland, R. J. 2005. Age, growth, and recruitment of Hudson River shortnose sturgeon (Acipenser brevirostrum). Master's thesis. University of Maryland, College Park.

Woodland, R.J. and D. H. Secor. 2007. Year-class strength and recovery of endangered shortnose sturgeon in the Hudson River, New York. Transaction of the American Fisheries Society 136:72-81.

Ziegeweid, J.R., C.A. Jennings, and D.L. Peterson. 2008a. Thermal maxima for juvenile shortnose sturgeon acclimated to different temperatures. Environmental Biology of Fish 3: 299-307.

Ziegeweid, J.R., C.A. Jennings, D.L. Peterson and M.C. Black. 2008b. Effects of salinity, temperature, and weight on the survival of young-of-year shortnose sturgeon. Transactions of the American Fisheries Society 137:1490-1499.

Figure 1

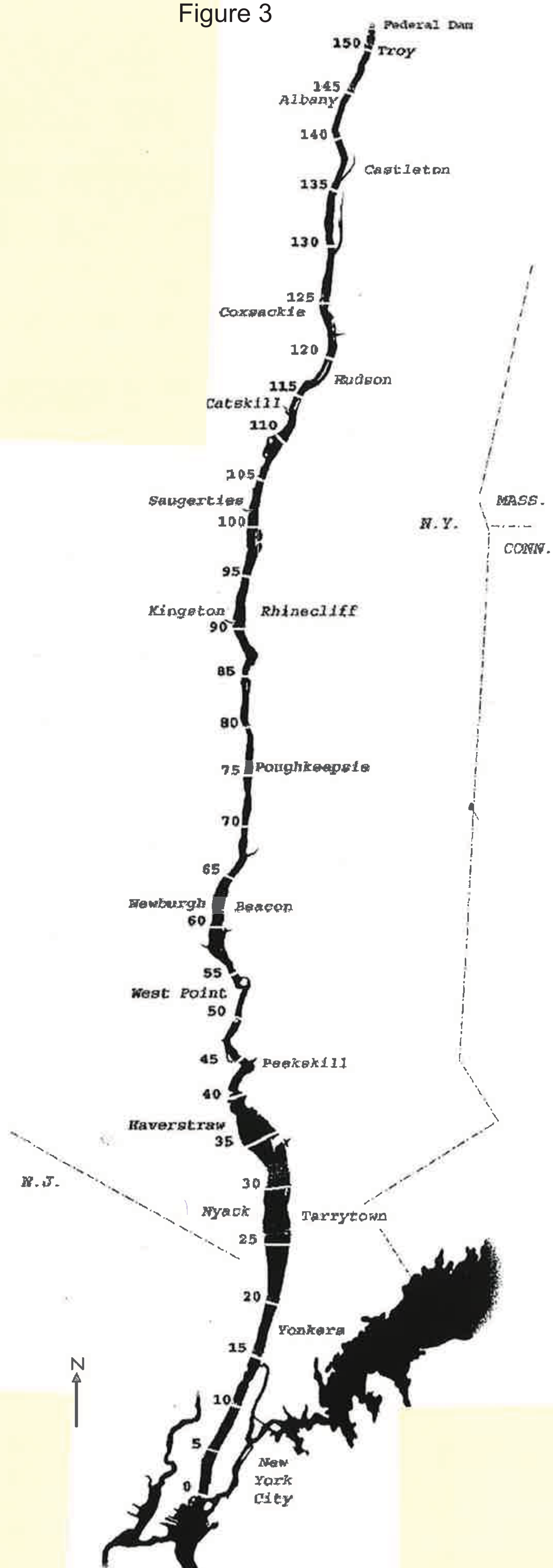


Location of Indian Point, View 1

Figure 2

Location of Indian Point, View 2
p. 79

Figure 3



Hudson River Miles
p. 80

APPENDIX II

Incident Report Sturgeon Take – Indian Point

Photographs should be taken and the following information should be collected from all sturgeon (alive and dead) found in association with the Indian Point intakes. Please submit all necropsy results (including sex and stomach contents) to NMFS upon receipt.

Observer's full name:____
Reporter’s full name:____

Species Identification :____

Site of Impingement (Unit 2 or 3, CWS or DWS, Bay #, etc.):_________________________________

Date animal observed:________________ Time animal observed: ________________________
Date animal collected:________________ Time animal collected:_________________________

Environmental conditions at time of observation (i.e., tidal stage, weather):
____
____

Date and time of last inspection of intakes:_____________________________________
Water temperature (°C) at site and time of observation:__________________________
Number of pumps operating at time of observation:____________________________________
Average percent of power generating capacity achieved per unit at time of observation:________
Average percent of power generating capacity achieved per unit over the 48 hours previous to observation:____

Sturgeon Information:
Species ____________________________________

Fork length (or total length) ______________________ Weight _______________________

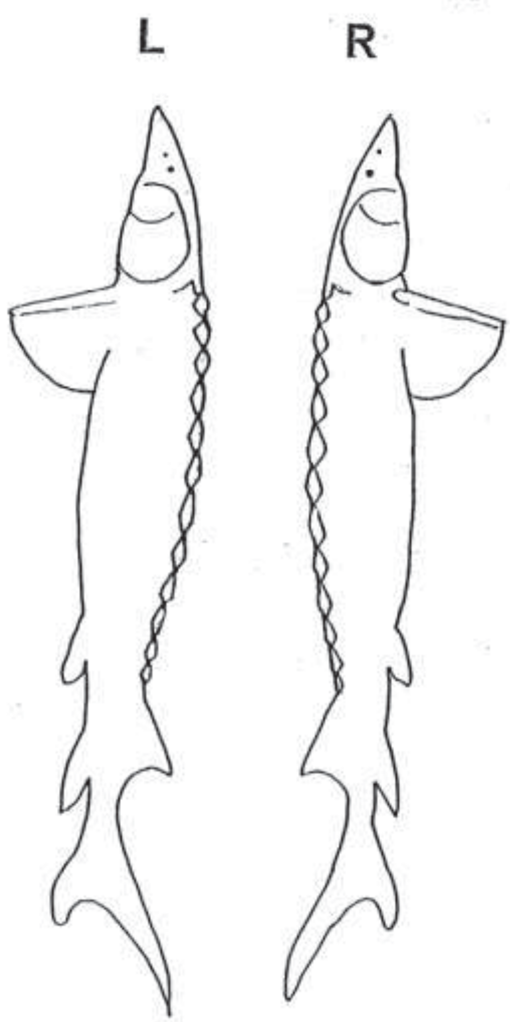
Condition of specimen/description of animal
____
____
____
____

Fish Decomposed: NO SLIGHTLY MODERATELY SEVERELY
Fish tagged: YES / NO *Please record all tag numbers.* Tag # ________________

Photograph attached: YES / NO
(please label *species, date, geographic site* and *vessel name* on back of photograph)

Appendix II, continued

Draw wounds, abnormalities, tag locations on diagram and briefly describe below



Description of fish condition:

STURGEON SALVAGE FORM

For use in documenting dead sturgeon in the wild under ESA permit no. 1614 (version 05-16-2012)

INVESTIGATORS'S CONTACT INFORMATION

Name: First ________________ Last ________________________

Agency Affiliation ________________ Email______________________

Address ____

____

Area code/Phone number ______________________________________

UNIQUE IDENTIFIER (Assigned by NMFS)

DATE REPORTED:

Month ☐☐ Day☐☐ Year 20☐☐

DATE EXAMINED:

Month ☐☐ Day☐☐ Year 20☐☐

SPECIES: (check one)

☐ shortnose sturgeon
☐ Atlantic sturgeon
☐ Unidentified *Acipenser* species

Check "Unidentified" if uncertain .
See reverse side of this form for aid in identification.

LOCATION FOUND: ☐Offshore (Atlantic or Gulf beach) ☐Inshore (bay, river, sound, inlet, etc)

River/Body of Water________________ City________________________ State ____

Descriptive location (be specific)____

____

____

Latitude ______________N (Dec. Degrees) Longitude ______________ W (Dec. Degrees)

CARCASS CONDITION at time examined: (check one)

☐ 1 = Fresh dead
☐ 2 = Moderately decomposed
☐ 3 = Severely decomposed
☐ 4 = Dried carcass
☐ 5 = Skeletal, scutes & cartilage

SEX:

☐ Undetermined
☐ Female ☐ Male

How was sex determined?

☐ Necropsy
☐ Eggs/milt present when pressed
☐ Borescope

MEASUREMENTS: **Circle unit**

Fork length _________ cm / in

Total length _________ cm / in

Length ☐ actual ☐ estimate

Mouth width (inside lips, see reverse side) _________ cm / in

Interorbital width (see reverse side) _________ cm / in

Weight ☐ actual ☐ estimate _________ kg / lb

TAGS PRESENT? Examined for external tags including fin clips? ☐ **Yes** ☐ **No** **Scanned for PIT tags?** ☐ **Yes** ☐ **No**

Tag #	**Tag Type**	**Location of tag on carcass**

CARCASS DISPOSITION: (check one or more)

☐1 = Left where found
☐2 = Buried
☐3 = Collected for necropsy/salvage
☐4 = Frozen for later examination
☐5 = Other (describe) __________________________

Carcass Necropsied?

☐Yes ☐No

Date Necropsied:_____________

Necropsy Lead:

____

PHOTODOCUMENTATION:

Photos/vide taken? ☐ Yes ☐ No

Disposition of Photos/Video:___________

____

____

SAMPLES COLLECTED? ☐ **Yes** ☐ **No**

Sample	**How preserved**	**Disposition (person, affiliation, use)**

Comments:

____

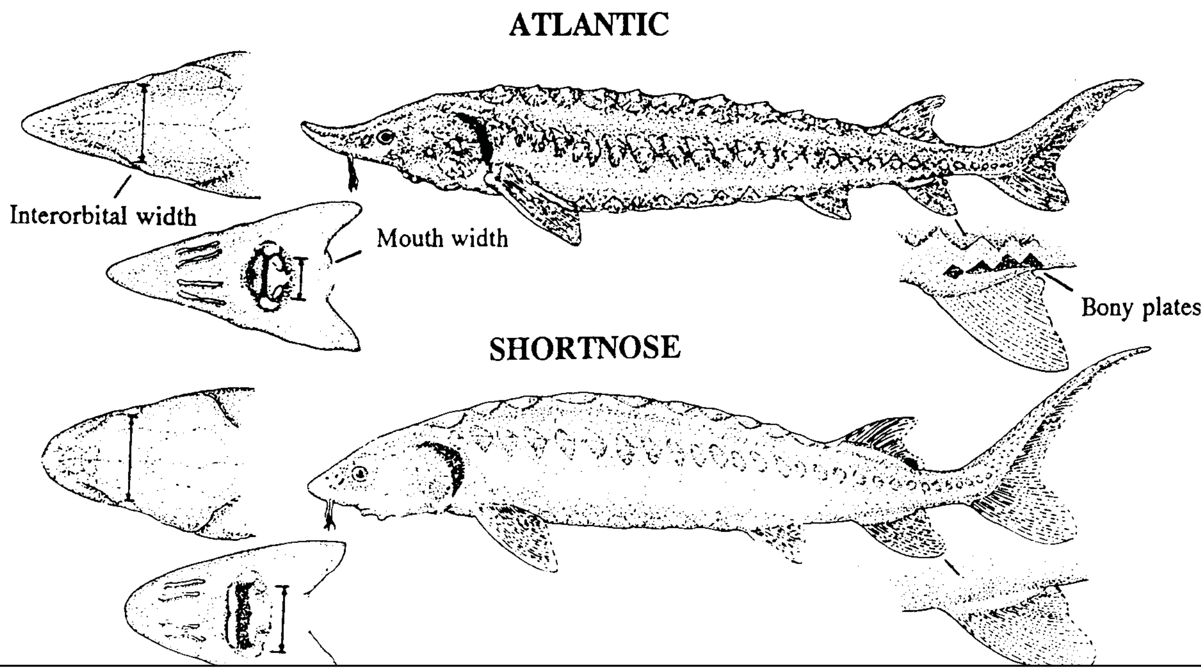
____

____

Distinguishing Characteristics of Atlantic and Shortnose Sturgeon (version 07-20-2009)

Characteristic	Atlantic Sturgeon, *Acipenser oxyrinchus*	Shortnose Sturgeon, *Acipenser brevirostrum*
Maximum length	> 9 feet/ 274 cm	4 feet/ 122 cm
Mouth	Football shaped and small. Width inside lips < 55% of bony interorbital width	Wide and oval in shape. Width inside lips > 62% of bony interorbital width
*Pre-anal plates	Paired plates posterior to the rectum & anterior to the anal fin.	1-3 pre-anal plates almost always occurring as median structures (occurring singly)
Plates along the anal fin	Rhombic, bony plates found along the lateral base of the anal fin (see diagram below)	No plates along the base of anal fin
Habitat/Range	Anadromous; spawn in freshwater but primarily lead a marine existence	Freshwater amphidromous; found primarily in fresh water but does make some coastal migrations

* From Vecsei and Peterson, 2004



Describe any wounds / abnormalities (note tar or oil, gear or debris entanglement, propeller damage, etc.). **Please note if no wounds / abnormalities are found.**

Data Access Policy: Upon written request, information submitted to National Marine Fisheries Service (NOAA Fisheries) on this form will be released to the requestor provided that the requestor credit the collector of the information and NOAA Fisheries. NOAA Fisheries will notify the collector that these data have been requested and the intent of their use.

Submit completed forms (within 30 days of date of investigation) to: **Northeast Region Contacts** – Shortnose Sturgeon Recovery Coordinator (Jessica Pruden, Jessica.Pruden@noaa.gov, 978-282-8482) or Atlantic Sturgeon Recovery Coordinator (Lynn Lankshear, Lynn.Lankshear@noaa.gov, 978-282-8473); **Southeast Region Contacts**- Shortnose Sturgeon Recovery Coordinator (Stephania Bolden, Stephania.Bolden@noaa.gov, 727-824-5312) or Atlantic Sturgeon Recovery Coordinator (Kelly Shotts, Kelly.Shotts@noaa.gov, 727-551-5603).

APPENDIX IV

Procedure for obtaining fin clips from sturgeon for genetic analysis

Obtaining Sample

1. Wash hands and use disposable gloves. Ensure that any knife, scalpel or scissors used for sampling has been thoroughly cleaned and wiped with alcohol to minimize the risk of contamination.

2. For any sturgeon, after the specimen has been measured and photographed, take a one-cm square clip from the pelvic fin.

3. Each fin clip should be placed into a vial of 95% non-denatured ethanol and the vial should be labeled with the species name, date, name of project and the fork length and total length of the fish along with a note identifying the fish to the appropriate observer report. All vials should be sealed with a lid and further secured with tape Please use permanent marker and cover any markings with tape to minimize the chance of smearing or erasure.

Storage of Sample

1. If possible, place the vial on ice for the first 24 hours. If ice is not available, please refrigerate the vial. Send as soon as possible as instructed below.

Sending of Sample

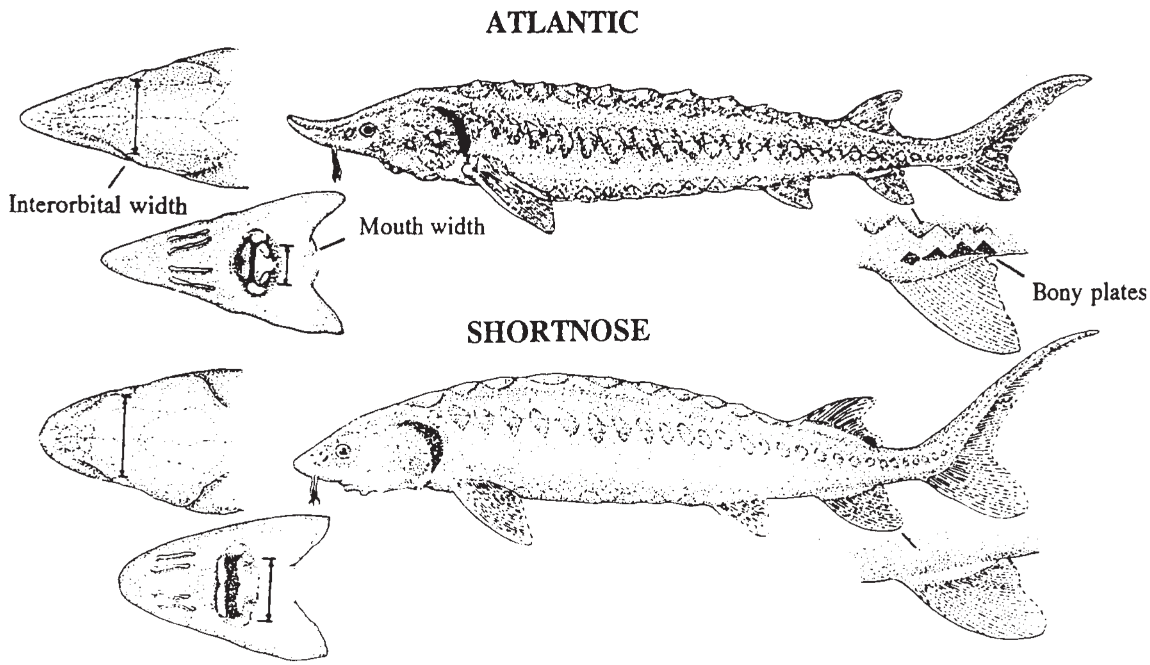
1. Vials should be placed into Ziploc or similar resealable plastic bags. Vials should be then wrapped in bubble wrap or newspaper (to prevent breakage) and sent to:

   Julie Carter
   NOAA/NOS – Marine Forensics
   219 Fort Johnson Road
   Charleston, SC 29412-9110
   Phone: 843-762-8547

   a. Prior to sending the sample, contact Russ Bohl at NMFS Northeast Regional Office (978-282-8493) to report that a sample is being sent and to discuss proper shipping procedures.

APPENDIX V

Identification Key for Sturgeon Found in Northeast U.S. Waters



Distinguishing Characteristics of Atlantic and Shortnose Sturgeon

Characteristic	Atlantic Sturgeon, *Acipenser oxyrinchus*	Shortnose Sturgeon, *Acipenser brevirostrum*
Maximum length	> 9 feet/ 274 cm	4 feet/ 122 cm
Mouth	Football shaped and small. Width inside lips < 55% of bony interorbital width	Wide and oval in shape. Width inside lips > 62% of bony interorbital width
*Pre-anal plates	Paired plates posterior to the rectum & anterior to the anal fin.	1-3 pre-anal plates almost always occurring as median structures (occurring singly)
Plates along the anal fin	Rhombic, bony plates found along the lateral base of the anal fin (see diagram below)	No plates along the base of anal fin
Habitat/Range	Anadromous; spawn in freshwater but primarily lead a marine existence	Freshwater amphidromous; found primarily in fresh water but does make some coastal migrations

* From Vecsei and Peterson, 2004