RAS 14981

Docket No. 50-247/286-LR

EXHIBITS A - N

To

ENTERGY NUCLEAR OPERATIONS, INC.'S ANSWERS TO PETITIONERS' REQUESTS FOR HEARING AND PETITIONS FOR LEAVE TO INTERVENE, AND GOVERNMENT ENTITIES' NOTICE OF INTENTION TO PARTICIPATE, SUBMITTED ON JANUARY 22, 2008

STATE OF NEW YORK
OFFICE OF THE ATTORNEY GENERAL

ELIOT SPITZER
Attorney General

DIVISION OF PUBLIC ADVOCACY
ENVIRONMENTAL PROTECTION BUREAU

January 20, 2004

HAND DELIVERY

Hon Charles E. Diamond
Clerk of the Court
Supreme Court Albany County
16 Eagle Street
Albany, New York 12207

Attn: Maureen Hartman
Special Term Clerk
Fax: (518) 487-5020

Re: Entergy Nuclear Indian Point 2 LLC, et al., v. NYSDEC, et al., Index No. 6747-03; Mirant Bowline LLC v. NYSDEC, et al, Index No. 6749-03

Dear Ms. Hartman:

Enclosed for filing please find State respondents' Notice of Motion to Consolidate and Dismiss the above-referenced petitions, supporting affidavits of William G. Little and Betty Ann Hughes, and a Memorandum of Law in Support.

As explained in the papers, State respondents seek to consolidate the petitions because they involve the same factual and legal issues, the same parties and challenge the same FEIS. We also request that the cases be heard by Justice Thomas Keegan, as they are related to the Brodsky v. Crotty Artice 78 proceeding pending before him, and challenge the FEIS issued pursuant to his May 14, 2003 Order in that case.

While the Notice of Motion indicates that the motion is returnable on January 30, 2004, I understand that counsel for petitioners in both cases will be seeking an additional 2 weeks to respond to the State respondents' motion. In addition, I understand that Riverkeeper and Mr. Brodsky may seek to intervene in the proceedings as well.

Please contact the undersigned should the Court has any questions regarding this motion.

Respectfully submitted,

Lisa M. Burianek

LISA M. BURIANEK by Angela Fiore

Assistant Attorney General

(518) 486-7398

SUPREME COURT OF THE STATE OF NEW YORK
COUNTY OF ALBANY

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In the Matter of the Application of
ENTERGY NUCLEAR INDIAN POINT 2, LLC, and
ENTERGY NUCLEAR INDIAN POINT 3, LLC, as
respective owners of Indian Point 2 and Indian Point 3, and
joint applicants for the Indian Point SPDES permit renewal,

Petitioner-Plaintiffs,

For a judgment pursuant to Article 78 of the Civil Practice
Law and Rules,

- against -

THE NEW YORK STATE DEPARTMENT OF
ENVIRONMENTAL CONSERVATION and ERIN CROTTY,
as Commissioner, New York State Department of
Environmental Conservation,

Respondent-Defendants,

MIRANT BOWLINE, LLC, as owner of Bowline Point 1 and
2 and applicant for the Bowline SPDES permit renewal,
DYNEGY ROSETON, LLC, as operator of Roseton 1 and 2,
and DYNEGY NORTHEAST GENERATION, INC., as
applicant for the Roseton SPDES permit renewal,

Respondent-Defendants.

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NOTICE OF MOTION TO
CONSOLIDATE AND
<u>DISMISS THE PETITIONS</u>

Index No. 6747/03

SUPREME COURT OF THE STATE OF NEW YORK
COUNTY OF ALBANY

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In the Matter of the Application of
MIRANT BOWLINE, LLC

Petitioner-Plaintiffs,

For a judgment pursuant to Article 78 of the Civil Practice
Law and Rules,

- against -

THE NEW YORK STATE DEPARTMENT OF
ENVIRONMENTAL CONSERVATION and ERIN CROTTY,
as Commissioner, New York State Department of
Environmental Conservation,

Respondent-Defendants,

ENTERGY NUCLEAR INDIAN POINT 2, LLC; ENTERGY
NUCLEAR INDIAN POINT 3, LLC; DYNEGY ROSETON,
LLC, and DYNEGY NORTHEAST GENERATION, INC.,

Respondent-Defendants.

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Index No. 6749-03

PLEASE TAKE NOTICE that upon the Verified Petitions in the above referenced proceedings (with exhibits), upon the affidavits of New York State Department of Environmental Conservation Associate Attorney William G. Little (with exhibits) and Environmental Analyst 3 Betty Ann Hughes, and the accompanying Memorandum of Law in Support of Motion to Consolidate and Dismiss, Respondent-defendants New York State Department of Environmental Conservation and Erin Crotty, Commissioner ("State respondents" or "DEC") will make a motion returnable at the Albany County Courthouse, Albany, New York on January 30, 2004 at 9:30 A.M. or as soon thereafter as Counsel may be heard, for an order consolidating the petitions, relating the matter to another currently pending before the Honorable Thomas J. Keegan, J.S.C., Brodsky v. Crotty, Index No. 7136-02, and dismissing the petitions in each case with prejudice for lack of subject matter jurisdiction under CPLR § 7801(1), as the DEC has taken no final agency action regarding the Entergy or Mirant permit applications.

In the event that the Court denies State respondent's motion, we respectfully request that the Court allow respondents 30 days after Notice of Entry of such decision to submit an answer, return and appropriate supportive documents.

Dated: Albany, New York
January 19, 2004

ELIOT SPITZER
Attorney General
Counsel for State Respondents
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By: LISA M. BURIANEK
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SUPREME COURT OF THE STATE OF NEW YORK
COUNTY OF ALBANY

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In the Matter of the Application of

ENTERGY NUCLEAR INDIAN POINT 2, LLC, and
ENTERGY NUCLEAR INDIAN POINT 3, LLC, as
respective owners of Indian Point 2 and Indian Point 3, and
joint applicants for the Indian Point SPDES permit renewal,

Petitioner-Plaintiffs,

For a judgment pursuant to Article 78 of the Civil Practice
Law and Rules,

- against -

AFFIRMATION

Index No. 6747/03

THE NEW YORK STATE DEPARTMENT OF
ENVIRONMENTAL CONSERVATION and ERIN CROTTY,
as Commissioner, New York State Department of
Environmental Conservation,

Respondent-Defendants,

MIRANT BOWLINE, LLC, as owner of Bowline Point 1 and
2 and applicant for the Bowline SPDES permit renewal,
DYNEGY ROSETON, LLC, as operator of Roseton 1 and 2,
and DYNEGY NORTHEAST GENERATION, INC., as
applicant for the Roseton SPDES permit renewal,

Respondent-Defendants.

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STATE OF NEW YORK)
SS:
COUNTY OF ALBANY)

WILLIAM G. LITTLE, an attorney duly admitted to practice in the State of New York hereby affirms:

1. I am employed as an Associate Attorney by the New York State Department of Environmental Conservation (Department or DEC). Since May 1998 I have assisted and

provided legal counsel to Department Staff in the matter of the renewal of the State Pollutant Discharge Elimination System (SPDES) permits for electric power generating facilities on the Hudson River known as Indian Point Units 1, 2 and 3, Roseton, and Bowline Units 1 and 2. Accordingly, I am familiar with the Department's case and the record in this case. I make this Affidavit in support of the State's Motion to Consolidate and Dismiss the Petitions because the administrative process with respect to the Indian Point Units 2 and 3 SPDES permit application is ongoing. The Department has taken no final agency action on the Indian Point application which would provide Article 78 jurisdiction. At best, the Entergy petition is premature, and should be dismissed. Any and all of the issues raised in the petition are, in the first instance, issues to be resolved in the Department's administrative hearing process.

2. It is apparent from face of this petition, as well as the text, and comparison with companion petitions entitled Mirant Bowline LLC v. NYSDEC, Index No. 6749-03, and Dynegy v. NYSDEC, Index No. 6738-03, that the named Hudson River electric generation facility owners are attempting to disrupt the SPDES permit processes to which they are subject. A simple review of the three petitions discloses a concerted effort by the facilities to complicate the administrative process and to introduce further delay with regard to the imposition of SPDES permits with more restrictive permit conditions for their use of Hudson River water for facility cooling. In the case of Entergy's Indian Point Units 2 and 3, the draft permit proposed on November 12, 2003 would impose substantial regulatory and operational impacts on that facility in order to mitigate impacts to the Hudson River ecosystem that have been under scrutiny for the past 30 years.

Background.

3. As this Court is aware, the Department's June 25, 2003 Final Environmental Impact Statement ("FEIS") was issued in response to and in compliance with this Court's May 14, 2003, Order, which required that DEC issue the FEIS by July 1, 2003, and to issue a draft SPDES permit for the Entergy Indian Point Units 2 and 3 by November 14, 2003. See Exhibit 1, May 14, 2003 Order; Exhibit 2, July 1, 2003 letter from Lisa M. Burianek to Hon. Thomas Keegan.

4. The Draft SPDES permit for Entergy Indian Point Units 2 and 3 was issued on November 12, 2003. See Exhibit 3, November 12, 2003 Letter from Lisa M. Burianek to Honorable Thomas Keegan (including the draft SPDES permit and supporting materials).

5. Since the draft SPDES permit was issued on November 12, 2003, DEC has been managing the public comment and administrative process which will lead to DEC issuing a final SPDES permit for Indian Point Units 2 and 3. As provided in the November 12, 2003 Environmental Notice Bulletin publication of the draft permit, DEC is presently conducting a 90-day public comment period, which ends on February 6, 2004. See Exhibit 3, NYSDEC Environmental Notice Bulletin. DEC has set public legislative hearings for 2 p.m. and 7 p.m. on both January 28 and 29, 2004, at the Esplanade Hotel at 95 South Broadway, in the city of White Plains, Westchester County, New York. In anticipation of a probable adjudicatory hearing, DEC has scheduled an issues conference at the same location at 10 a.m. on March 3, 4 and 5, 2003. After the issues conference the presiding administrative law judge (ALJ) will issue a decision regarding whether adjudicable issues have been raised by parties to the proceeding. In my experience as a staff attorney in similar proceedings, I submit that it is likely that the Entergy Indian Point draft permit will change as a result of the administrative process, which could

necessitate further environmental review. Depending on issues raised by parties to the administrative hearing, it is possible that a supplemental environmental review could be required.

6. Piecemeal review of components of the DEC permit application review process, such as the FEIS, does not present either a fully-formed record or reflect an administrative decision which causes actual injury to petitioners. As discussed below, DEC is at a pivotal mid-point its administrative process for Indian Point, and poised to begin public involvement in that process. Allowing this type of strategic litigation on issues, akin to "cherry-picking," eliminates DEC's ability to review applications in an orderly and consistent manner. This creates uncertainty for the Department, an applicant, and those who would oppose a particular project. It also guarantees delays in an already detailed and time-consuming administrative process. From the Court's perspective, it is apparent that litigation prior to a final agency action on a permit application ensures multiple cases involving a single matter which will needlessly clog the already burgeoning court dockets.

The Draft SPDES Permit for Indian Point Units 2 and 3

7. As explained in the draft SPDES permit, DEC staff determined that closed-cycle cooling is the "best technology available" (BTA) to minimize the environmental impacts of the Indian Point facility to the Hudson River and the fish species in the River. See Exhibit 3, Indian Point Draft SPDES Permit. The draft permit acknowledges that implementation of a permit requiring a closed cycle cooling system at the Indian Point facility will require certain additional pre-design and engineering design steps to be taken by the applicant before the construction may commence. Accordingly, the draft permit incorporates a schedule for implementation, the terms

of which will likely be the subject of an involved administrative hearing and adjudicatory process before a DEC ALJ.

8. Currently, the terms of the draft permit provide that within one year of the issuance of the final permit, Entergy must submit a pre-design engineering report, followed in twelve months by a more detailed engineering report addressing all construction issues for conversion of Units 2 and 3 to closed-cycle cooling. See Exhibit 3, Indian Point Draft SPDES Permit, Special Condition 28. Of equal importance, Entergy must also conduct studies within the first two years of the permit term to determine whether thermal discharges from the Indian Point facility comply with State water quality criteria. See Exhibit 3, Indian Point Draft SPDES Permit, Special Condition 7.

9. Interim mitigation measures proposed in the draft SPDES permit to address environmental impacts pending Entergy's implementation of a closed cycle cooling system require immediate reductions of environmental impacts when the permit is issued. These interim measures include: 42 unit outage days (unit shutdowns) between February 23 and August 23 of each calendar year to reduce entrainment and impingement of fish and aquatic organisms, seasonal reduction of cooling water intake flows, continued operation of fish impingement mitigation equipment, a fish monitoring program, and payment of $24 million annually to a Hudson River Estuary Restoration escrow fund, with projects to be directed by DEC. See, Exhibit 3, Indian Point Draft SPDES Permit, Special Condition 28.

10. As this Court is aware, Indian Point Units 2 and 3 each hold United States Nuclear Regulatory Commission (NRC) operating licenses that expire in 2013 and 2015, respectively. The Department's draft permit recognizes that physical or operational changes proposed to the

Indian Point facility as a result of the permit will be subject to separate review by the NRC, to determine whether the proposed facility changes meet NRC safety requirements. The BTA conditions of the final permit may also generate a need for independent review by the Federal Energy Regulatory Commission ("FERC"), which has separate jurisdiction over a natural gas pipeline having a right of way across the Indian Point property. The draft permit also stipulates that construction of a closed cycle cooling system is contingent upon Entergy receiving a license extension from the NRC. Accordingly, the draft permit requires that Entergy submit a schedule to DEC outlining its plans to obtain additional approvals from other government agencies such as the NRC and FERC to proceed with closed-cycle cooling. See Exhibit 3, Indian Point Draft SPDES permit, Special Condition 28(a).

11. There is no final DEC action on the Indian Point permit application, therefore, there is no Article 78 jurisdiction to review the FEIS, which is a necessary and important component of DEC's permit review. The remaining portion of this affidavit addresses various claims raised in the Entergy petition, none of which negate or overcome this fundamental jurisdictional defect. To that end, I address specific elements of DEC's ongoing administrative review process.

DEC Appropriately Applied SEQRA in Making Its Positive Declaration.

12. The Entergy petition alleges that "[t]he HRSA did not require installation of cooling towers at any of the Stations and did not contemplate their future construction." Petition, p. 7. Taken out of context, this appears to assert that cooling towers were antithetical to operating these Stations and always would be so. However, a simple review of the HRSA facilities' regulatory history demonstrates that cooling towers, or closed-cycle cooling, were intended as

mitigative technology since the EPA's 1975 NPDES permit.[1] The generation facilities opposed imposition of the changes to their plants, and instead litigated to block them. By executing the HRSA and subsequent Consent Orders, the Department endorsed and participated in a process designed to bring about enhanced protection of aquatic organisms and reduce or eliminate fish mortalities due to impingement and entrainment, while employing interim mitigation measures acceptable to other participating parties.

13. In light of the above history, the Department's 1992 review of the SPDES permit renewal applications for Units 2 and 3 appropriately resulted in a positive determination of significance pursuant to § 8-0109 of the Environmental Conservation Law ("ECL"), also known as the State Environmental Quality Review Act (SEQRA), and 6 NYCRR §617.7. The "positive declaration" for Indian Pints Units 2 and 3 means that an environmental impact statement would be required to further identify and assess measures and alternatives to avoid, minimize or mitigate environmental impacts from Indian Point and the other HRSA plants (Roseton and Bowline). Regarding Indian Point, the goal of the Department was to consistently work toward more stringent mitigation of operational impacts, rather than merely acquiesce to measures maintaining status quo levels of mitigation. See Petition, p. 7.

14. Permit renewals are not automatic, and if a facility's renewal application proposes a material change to operations, DEC has the broad discretion to subject the permit application to review as a "new" application under the Department's Uniform Procedures Act (UPA) regulations. ECL §70-0115(b); 6 NYCRR §621.13(e). While simple permit renewals for

[1] As the Petition notes, the USEPA's 1975 permit required that each Station install cooling towers to mitigate impingement and entrainment impacts. Petition, p. 6.

unchanged operations are generally Type II actions, which often do not warrant further review of potential environmental impacts, substantive changes can provide grounds for DEC to subject the permit application to a full SEQRA review. 6 NYCRR §617.7(c) (criteria for determining significance).

15. The Petitioners are simply wrong to claim that SEQRA was not properly applied to the Indian Point Units 2 and 3 1992 permit renewal application. Contrary to their claims, the 1992 renewal application was not a straightforward renewal. Specifically, the 1992 application, submitted by petitioners' predecessors in interest, did not provide continued assurances that HRSA-imposed flow reductions would be maintained for the duration of the SPDES permit term.[2] With respect to thermal discharges to the Hudson River, the application did not reflect that a more thorough analysis was needed to determine whether thermal discharges were in compliance with State water quality criteria now that provisions controlling thermal discharges in the HRSA had expired. Upon information and belief, these significant changes served as the basis for the 1992 positive declaration of significance. See 6 NYCRR §621.14(a). Therefore, Department acted appropriately and within its discretion to treat the renewal application as a modification of the permit.

[2] The 1992 SPDES Permit Renewal Application did not provide for seasonal intake flow limitations in the manner provided by the HRSA (Petition, Exhibit 1, p. 6). Whereas the 1982 and 1987 permit renewals incorporated the HRSA flow limitations, by 1992 the HRSA had expired. The 1992 Consent Order, at Table A of Attachment D, provides for flow limitations approximating those in the HRSA but only until a SPDES renewal permit is issued (which did not happen) or September 1, 1994, whichever came first.

16. Notably, definitive language in the HRSA governed the Department's issuance of renewal permits to the HRSA generators during the ten-year effective period of that agreement (1981 - 1991):

> Promptly after the effective date of this agreement:
> (i) DEC, in accordance with applicable law, shall issue to each of the Utilities SPDES permits for their respective Hudson River Plants which will permit, during the entire ten-year term of this Agreement, continued operation with the existing once-through cooling systems unaltered by thermal or intake requirements, subject only to the performance by the Utilities of their respective covenants as set forth in this Agreement. This Agreement shall be annexed to the SPDES permits and shall be incorporated therein as a condition of said permits.

See Petition, Exhibit 1, Hudson River Settlement Agreement, p. 17. The Department deferred a determination of significance of the adverse environmental impacts from the three plants until after the HRSA expired, substantive information had been gathered, and the facilities had submitted specific permit renewal applications.

17. The Petition observes that the Department's 1992 permit renewal application form requested certain information from the owners regarding "any changes to the location, design, operation, construction, or capacity of the cooling water intake" and whether any changes to the cooling water intake were anticipated during the ensuing permit term. As the Petition also observes, on April 3, 1992, Consolidated Edison Company (Con Ed), then-owner of Indian Point Unit 2, wrote to the Department to object to this request and reserved its right to contest DEC's authority to make such a request. The Petition implies that this information request amounted to exclusive or unique treatment of the renewal application, to allow the Department to reopen the issue of closed-cycle cooling. However, that information request was merely a standard question on the Department's "Form 2C Application Supplement" form that any applicant seeking to

renew a SPDES permit for a steam generating electricity facility would have to answer. See Petition, Exhibit 4, pp. 40 and 43. Upon information and belief, that question, or one very similar to it, has been a component of an electric generation facility SPDES permit renewal application form for approximately the past two decades. Accordingly, there is no basis for petitioners' claim of selective application of SEQRA.

18. Moreover, it is questionable whether Con Ed's April 3, 1992 reservation of rights nearly 12 years ago inures to the benefit of the Entergy petitioners, particularly after Con Ed's and petitioners' participation in the lengthy EIS process. However, petitioners' claim regarding the "reservation" underscores the importance of DEC's primary jurisdiction and technical expertise, and the need for petitioners to exhaust their administrative remedies regarding all of these complex issues. With all due respect to the Court, any issues involving the Department's discretion in applying SEQRA to the subject permit renewal, the positive declaration and subsequent production of the two draft EISs (DEIS), in 1993 and 1999, and the FEIS, should first be resolved by the DEC. The administrative process, outlined above, will address such issues and form a decisional record for issuance of a SPDES permit and, if appropriate, timely judicial review in the future.

19. Petitioners' attempt to make a "selective enforcement" argument regarding DEC's treatment of this 1992 SPDES permit application with the Newburgh, New York Danskammer station 1992 SPDES renewal application. After the Department conducted an appropriate SEQRA assessment of significance for the Danskammer station,[3] it reached a different

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[3] For all SEQRA Type I or unlisted actions a lead agency must make a determination of significance. 6 NYCRR §617.7.

conclusion for that plant, a negative declaration, based upon substantial differences in facility circumstances, including the efficacy of available technology to address Danskammer's impacts (BTA was determined to be implementation of restricted operational flows, seasonal use of a sonic deterrent and, if flow restrictions fail to produce a specific measure of mitigation, the installation of a screening system known as a Gunderboom). See 6 NYCRR §617.7(c). Like the HRSA plants, the Danskammer facility also has once-through cooling, but the Department found that its 1992 proposal of intake flow reductions and sonic deterrence technology would sufficiently reduce entrainment and impingement mortalities at the Danskammer station.

In stark contrast, the Indian Point Units 2 and 3 draft permit application proposes operations that DEC believes would not result in sufficient reductions. Balancing the weight of and differences between facilities is plainly within DEC's discretion, and is based upon review of application materials, including site-specific information for each facility, and the record.

Petitioners Place Incorrect Emphasis on the Timing of the Findings Statement

20. At the direction of the Court, the Department issued the HRSA FEIS on June 25, 2003. Also in compliance with the Court's order, DEC issued a draft SPDES permit for Indian Point Units 2 and 3 on November 14, 2003. But for the Court's directive to issue the FEIS by July 1, 2003, DEC would have issued the FEIS at the point of finality in the ongoing administrative proceeding. Ordinarily, the FEIS would be packaged with the Commissioner's Decision, the hearing record, and the findings statement. The Commissioner's Decision would indicate that the findings are effective not less than ten days after the date of the Decision, affording agencies and the public a reasonable time period to consider the FEIS and comment

accordingly. 6 NYCRR §617.11(a). The Decision would also direct DEC staff to issue a final permit after expiration of that time period, taking agency and public comment into account. Issuance of the draft SPDES permit is an initial but significant step in advancing DEC's administrative process and, as noted, it is likely to generate issues for an administrative hearing. DEC determined that it would be premature to issue a findings statement until after the hearing process was completed. Related to that, SEQRA time frames are considered to be directory in nature, not mandatory, so that the identification and assessment of environmental impacts, as well as alternative actions, is considered a paramount function, and time limitations that would constrain that function are viewed as secondary. Matter of Sun Beach Real Estate v. Anderson, 98 A.D. 2d 367, 375-376 (2d Dept.), aff'd 62 NY2d 965 (1984) ("We have no difficulty according priority to SEQRA because the legislative declaration of purpose in that statute makes it obvious that protection of 'the environment for the use and enjoyment of this and all future generations' (ECL §8-0103) far overshadows the rights of developers to obtain prompt reaction on their proposals."). DEC appropriately exercised discretion in coordinating a findings statement with its final decision on the permit application. A final decision on the permit application will be issued upon completion of the administrative hearing process, for which the issues conference is scheduled to commence on March 3, 2004. A meaningful findings statement incorporates the appropriate elements of the fully-developed record: the application, public comments, responses to comments compiled by the Department staff, additional information submitted in response to Department information requests, the EIS, applicable regulations and guidance, and any hearing record to articulate the reasoning underlying specific permit conditions. In this case, the anticipated adjudicatory hearing on the draft permit may well result in a change to the action, which could necessitate additional administrative process, including SEQRA review. Appropriately, the Department will issue a findings statement after the conclusion of the hearing and closure of the record, including any final decision regarding the permit by the Commissioner.

Entergy Petitioners' Direct Challenge to DEC's Regulatory Authority Must be Raised in the Administrative Process.

21. Entergy's third cause of action claims that the Department does not have appropriate authority delegated by the USEPA to make a BTA decision as provided for in §316(b) of the Clean Water Act (CWA). 33 U.S.C. §1326(b). It also claims that the applicable state regulation, 6 NYCRR §704.5, which mimics CWA §316(b), was promulgated improperly in 1974, rendering the regulation ineffective. Neither claim has anything to do with SEQRA or the FEIS. Moreover, such claims challenging DEC's substantive regulatory authority must first be raised in the administrative hearing context.

22. As a substantive matter, both CWA §316(b) and 6 NYCRR §704.5 clearly apply to this permit proceeding. The Department's regulations require that SPDES permit holders comply with applicable federal and state laws, which brings within the ambit of SPDES the §316(b) requirement to employ BTA for cooling water intake structures. 6 NYCRR §750-1.11(a)(5)(iii). The Petition also claims that, even if §316(b) is effective, it does not apply to facilities with existing cooling water intake structures. That statement flies in the face of a plain reading of the statute. Section 316(b) does not make any distinction between existing or future/new intake structures. Entergy conveniently ignores the fact that the USEPA has recently promulgated BTA

regulations for new cooling water intake structures and is in the process of promulgating such regulations for existing cooling water intake structures. See, 66 Fed. Reg. 65,256 (December 18, 2001) (USEPA BTA regulations promulgated for new facilities), as amended, 68 Fed. Reg. 36,749 (June 19, 2003); 67 Fed. Reg. 17,122 (April 9, 2002) (USEPA proposed regulations for BTA at existing facilities).

23. Entergy claims that 6 NYCRR §704.5 was improperly promulgated in September 1974 because prior public notice and a hearing were not provided. The time for raising such an infirmity is long past the four-month limitation period. See CPLR § 217(1).

24. The petition erroneously claims that 6 NYCRR §704.5 only applies to "new or modified" structures and, therefore, does not apply to Indian Point. The petition argues that §704.5 is somehow limited to "new or modified facilities" due to the context of a Department request for additional information contained in the 1992 renewal application form. A plain reading shows that the regulation makes no reference to or distinction between new or existing intake structures. The 1992 renewal application form, discussed above, asks if the facility has changed or anticipates making any "changes to the location, design, operation, construction or capacity of the cooling water intake." Petition, p. 19. Despite petitioners' assertion, basic, generic questions on a 1992 permit renewal application do not change the provisions of a State regulation promulgated in 1974. Petitioners' *non sequitur* is compounded by the fact that the question in the 1992 renewal application form requested information concerning "changes to the location, design, operation, construction or capacity of the cooling water intake," which clearly contemplates an existing facility and its cooling water intake. (Emphasis supplied.) See Petition, Exhibit 4.

25. Petitioners attempt to fashion a preemptory cumulative impact argument claiming the FEIS does not consider the potential impacts of other power generating facilities along the Hudson River. The Roseton, Indian Point and Bowline plants are linked together by the original decade-long HRSA and the Consent Orders that followed from 1992 - 1998. Due to the extensive history of the HRSA, the FEIS is appropriately broad in scope, and DEC has acknowledged that it is likely that additional details will be needed to generate or implement SPDES permit conditions for each of the three specific facilities and their operations. See Petition, Exhibit 14, p. 4.

26. As discussed above, while not a true "generic EIS," see 6 NYCRR §617.10, this FEIS reflects the extraordinary size of the resource affected, the Hudson River estuary, and the significant impacts of three electric generating facilities in separate locations on the Hudson River. The FEIS expressly contemplates additional information gathering specific to each of the plants to augment the record to support specific draft SPDES permit renewal conditions, including information related to site-specific mitigative actions. As noted previously, this process provides that if the action changes, or there is newly discovered information, or circumstances change, the Department can direct preparation of a supplemental EIS to develop further information on potential impacts, whether direct, indirect or cumulative in nature, in order to respond to each of the three renewal applications. See 6 NYCRR §617.9(a)(7).

27. In preparing the FEIS DEC was cognizant not only of Danskammer impacts but also of the impacts of the Lovett station, in Stony Point, New York, across the River from Indian

Point. DEC issued the Lovett SPDES permit in March 2003.[4] The extensive HRSA data base concerning the resources of and impacts to the Hudson River estuary fishery incorporates impacts from each of the HRSA plants, as well as Danskammer and Lovett, and was incorporated into the FEIS record. That same data base informs the BTA permit conditions for DEC's draft permits for the Danskammer and Indian Point plants now in the administrative review process, and the final permit for Lovett.

28. The most revealing element of the petition claims, remarkably, that rather than complying with its regulations for issuing SPDES permits the Department was requiring additional administrative review of the Entergy Indian Point facility only because of public comments opposed to continued operation of the plant. DEC has regulatory responsibilities regarding permitting the Indian Point facility, and is required by law to solicit and respond to public comments in conjunction with its permit and environmental impact analysis proceedings. 6 NYCRR §§617.9(a)(2) and 621.6. The fact that the Indian Point facility is the subject of intense interest and public scrutiny may be a complicating factor for petitioners, however, DEC submits that public involvement is required and desirable. The weight to be accorded the public comment will be addressed by DEC in the administrative hearing process.

29. The Petition suggests that the Department failed to take a "hard look" at impacts from the renewal of SPDES permits for Indian Point Units 2 and 3, and seeks additional review of operational impacts of more stringent regulation under SPDES. As discussed previously, the FEIS addresses the broader Hudson River estuary impacts of the three HRSA facilities, and

[4] Note that the FEIS alternatives assessment also incorporates a review of the mitigative technologies to be employed at new and re-powered electric generation facilities on the Hudson River. See, Petition, Exhibit 14, pp. 30 - 36.

individual draft SPDES permits have proposed and/or will propose facility-specific mitigative conditions and a BTA determination for each plant. The administrative process could change the draft SPDES permit, including the facility-specific BTA determination and selection of mitigative technology, which may necessitate supplemental environmental impact review. SEQRA contemplates such a sequence of events by allowing a lead agency to call for or prepare a supplemental EIS that augments the record of environmental review, for instance where the BTA decision results in a change to the project or in the circumstances related to the project. 6 NYCRR §§617.9(a)(7)(i)('a') and ('c'). The Department can, at any time during its review, ask for additional information which is reasonably necessary to make any findings or determinations required by law pertaining to a new or renewal permit application or modification proposal. 6 NYCRR §621.15(b).

Other Issues

30. Petitioners fault the Department for its alleged "failure" to include two industry documents in the public record supporting the FEIS, the "Electricity System Impacts of Certain DEC Utility Choice Alternatives" ("NERA Report") (Petition Exhibit 11) and "Status and Trends of Hudson River Fish Populations and Communities Since the 1970s: Evaluation of Evidence Concerning Impacts of Cooling Water Withdrawals" ("Fisheries Review") (Petition Exhibit 12). My search of Department records shows that the Fisheries Review was given to the Department in June 2003, the same month the Department issued the FEIS. Upon information and belief, the 1999 DEIS already contained substantially similar arguments on fish populations in the Hudson River.

31. Additionally, my records also show that Entergy gave the Department a set of paper copies of a "Power Point" computer presentation of slides summarizing the Fisheries Review in June 2002. The paper copies of the Fisheries Review Power Point slides and the NERA Report were marked by Entergy and its consultants as "Privileged and Confidential" documents provided solely for negotiations regarding draft SPDES permit conditions.[5] The Department conscientiously adhered to the direction of the facilities and their counsel regarding the confidentiality of these documents and, therefore, did not make them part of the public record. Had Petitioners desired that these documents be made part of the public FEIS record, they were obligated to advise the Department that hey waived the document's confidentiality so that they could be included in the FEIS record.

CONCLUSION.

32. DEC has taken no final agency action with respect to the Entergy Indian Point application and is in the midst of what promises to be a complex and lengthy permit review proceeding. Every aspect of this matter supports dismissal of the petition to allow the Department to develop a full record and a final decision regarding the Entergy Indian Point draft permit. The July 25, 2003 FEIS, issued pursuant to SEQRA, does not constitute "final agency action" upon which a party may sue pursuant to CPLR §7801(1), and SEQRA provides no right of action outside the scope of Article 78. At this formative stage of the administrative process, the unwarranted and preemptory SEQRA review sought by petitioners would thoroughly disrupt

[5] The Fisheries power point copies carry the additional note that they are "Attorney-Client Work Product".

that process, which itself allows for petitioners' claims to be considered by the ALJ and, ultimately, the Commissioner. For purposes of primary jurisdiction and judicial economy, petitioners' claims should only be considered upon a fully developed record and after a final permit determination by the Department.

Dated: Albany, New York
January 20, 2004

William G. Little
Associate Attorney

Tab 1

SUPREME COURT OF THE STATE OF NEW YORK
COUNTY OF ALBANY

---X

In the Matter of the Application of

RICHARD L. BRODSKY, ASSEMBLYMAN, from the 86th Assembly District in his individual capacity, HUDSON RIVER SLOOP CLEARWATER, INC., PETER AND TOSHI ALINE SEEGER, ADAM CLAYTON POWELL, IV., ASSEMBLYMAN from the 68th Assembly District, WILLIAM BUSH, SUSANNE T. CASAL, MARK R. JACOBS, ROBERT JONES, MARY LOU REYNOLDS,

Petitioners,

For a judgment pursuant to Article 78 of the Civil Practice Laws and Rules,

- against -

THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, ERIN CROTTY, as Commissioner, New York State Department of Environmental Conservation,

Respondent,

ENTERGY INDIAN POINT 2, LLC, ENTERGY INDIAN POINT 3, LLC, as applicant for the Indian Point SPDES permit renewal,

Respondents

---X

ORDER

Index No. 7136-02
(Keegan, J.)

Petitioners having commenced this Article 78 proceeding to mandate action by respondent New York State Department of Environmental Conservation ("DEC") regarding the pending SPDES permit renewal for respondent Entergy Indian Point 2, LLC, and Entergy Indian Point 3 LLC ("Entergy); and

The Court having dismissed the three causes of action in the petition in its January 27, 2003 Decision and Judgment; and,

Petitioners having amended their petition to add two additional causes of action; and

The Court, having heard oral arguments on April 9, 2003 from Richard Brodsky, <u>pro se</u> petitioner, David Gordon, counsel for potential intervenor Riverkeeper, Inc., Lisa M. Burianek, Assistant Attorney General, attorney for respondent DEC, and James C. Rehnquist, counsel for respondent Entergy; and

The Court having granted Riverkeeper, Inc.'s motion to intervene; and

The parties having reached agreement regarding a time frame for DEC to issue a draft SPDES permit renewal or other decision regarding the Entergy application;

Now, it is hereby ORDERED, ADJUDGED AND DECREED that the parties shall perform the actions specified in the following schedule:

June 9, 2003	Entergy Response to DEC's April 8, 2003 Request for Information
July 1, 2003	DEC to Complete Final Environmental Impact Statement ("FEIS") for HRSA facilities
November 14, 2003	DEC to Issue a Decision on Entergy SPDES permit renewal application, which ~~may~~ SHALL include a draft SPDES permit. [illegible]

It is FURTHER ORDERED, ADJUDGED AND DECREED that counsel for DEC shall notify the Court and the parties within five (5) days of completion of each of the above-referenced milestones; and

Finally, it is FURTHER ORDERED, ADJUDGED AND DECREED that the matter, including the amended petition and respondents' pending motions to dismiss, for remand and for leave to appeal, is stayed and held in abeyance until issuance of the DEC decision regarding the Entergy SPDES renewal permit application on or before November 14, 2003, at which time the parties will consult in order to determine the status of the matter and notify the Court.

Dated: Albany, New York
May 14 2003

THOMAS W. KEEGAN
Justice of the Supreme Court

5/20/03

STATE OF NEW YORK
COUNTY OF ALBANY CLERK'S OFFICE } ss.:

I, *THOMAS G. CLINGAN*, Clerk of the said County, and also Clerk of the Supreme and County Courts, being Courts of Record held therein, DO HEREBY CERTIFY that I have compared the annexed copy ...Order... with the original thereof filed in this office on the ...[illegible]... day of May... 2003 and that the same is a correct transcript therefrom, and of the whole of said original.

IN TESTIMONY WHEREOF, I have hereunto set my name and affixed my official seal, this 20th day of May 2003

....Clerk

Sir/Madam:

Take notice that the within is a copy of the [name of document] duly Filed and entered in the office of the Clerk of [Court] County on the [day of month] of [month/year].

ELIOT SPITZER
Attorney for Respondents

Office and Post Office Address
The Capitol
Albany, New York 12224

TO:

STATE OF NEW YORK - SUPREME COURT
COUNTY OF ALBANY, Index No. 7136-02

In the Matter of the Application of
RICHARD L. BRODSKY, ASSEMBLYMAN, from the 86th Assembly District in his official and individual capacities, et al.,

Petitioners,

For a Judgment Pursuant to Article 78 of the Civil Practice Law and Rules

- against -

THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, ERIN CROTTY, as Commissioner, etc.

Respondent,

ENTERGY INDIAN POINT 2, LLC
ENTERGY INDIAN POINT 3, LLC., etc.

Respondents.

NOTICE OF ENTRY

ELIOT SPITZER
Attorney General
By: Lisa Burianek
Assistant Attorney General
Attorney for State Respondents

OFFICE AND POST OFFICE ADDRESS
New York State Dept. Of Law
The Capitol
Albany, New York 12224
Telephone: (518) 486-7398

Tab 2

File

STATE OF NEW YORK
OFFICE OF THE ATTORNEY GENERAL

ELIOT SPITZER
Attorney General

DIVISION OF PUBLIC ADVOCACY
ENVIRONMENTAL PROTECTION BUREAU

July 2, 2003

Hon Thomas W. Keegan
New York State Supreme Court
Supreme Court Albany County
16 Eagle Street
Albany, New York 12207

Re: Brodsky v. Crotty, Index No. 7136-02

Dear Justice Keegan:

This Court's May 14, 2003 Order requires counsel for the respondent Department of Environmental Conservation ("DEC") to notify the Court and the parties within five (5) days of completion of the milestones contained in the Order.

The Order required respondent DEC complete the Final Environmental Impact Statement for the Hudson River Settlement Agreement facilities' SPDES permits (including Indian Point Units 2 and 3), on or before July 1, 2003. Please be advised that DEC issued its FEIS on July 1, 2003.

Respectfully submitted,

LISA M. BURIANEK
Assistant Attorney General
(518) 486-7398

James C. Rehnquist, Esq.
Elise N. Zoli, Esq.
Robert L. Brennan, Jr. Esq.
Counsel for Respondent Entergy
Goodwin Procter LLP
Exchange Place
53 State Street
Boston, Massachusetts 02109

Richard Brodsky, Esq.
John L. Parker, Esq
Susan H. Shapiro, Esq.
Counsel for Petitioners
5 West Main Street
Suite 205
Elmsford, New York 10523

David K. Gordon, Esq.
Attorney for Riverkeeper
25 Wing and Wing
Garrison, New York 10524

William G. Little, Esq.
Division of Legal Affairs
NYSDEC
625 Broadway
Albany, New York 12233

File

STATE OF NEW YORK
OFFICE OF THE ATTORNEY GENERAL

ELIOT SPITZER
Attorney General

DIVISION OF PUBLIC ADVOCACY
ENVIRONMENTAL PROTECTION BUREAU

November 12, 2003

HAND DELIVERY

Hon Thomas W. Keegan
New York State Supreme Court
Supreme Court Albany County
16 Eagle Street
Albany, New York 12207

Re: Brodsky v. Crotty, Index No. 7136-02

Dear Justice Keegan:

This Court's May 14, 2003 Order requires counsel for the respondent Department of Environmental Conservation ("DEC") to notify the Court and the parties within five (5) days of completion of the milestones contained in the Order.

The Order required respondent DEC to issue and publish a draft SPDES permit for the subject Indian Point Units 2 and 3 power production facilities on or before November 14, 2003. Please be advised that DEC issued the draft permit today, November 12, 2003, and notice of the permit and its availability for public comment was also published in the Environmental Notice Bulletin today. I have attached the notice, draft permit and a DEC fact sheet for the Court's information.

The issuance of the draft SPDES permit provides the relief sought in the amended petition. Accordingly, the matter is now moot and should be dismissed in all respects.

Respectfully submitted,

LISA M. BURIANEK
Assistant Attorney General
(518) 486-7398

Enc.

cc (w/ enc.)
James C. Rehnquist, Esq.
Elise N. Zoli, Esq.
Robert L. Brennan, Jr. Esq.
Counsel for Respondent Entergy
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Exchange Place
53 State Street
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David K. Gordon, Esq.
Attorney for Riverkeeper
25 Wing and Wing
Garrison, New York 10524

Tab 3

ENB - REGION 3 NOTICES

Completed Applications
Consolidated SPDES Renewals

Notice of Availability of Draft Permit, Legislative Hearing & Issues Conference

The NYS Department of Environmental Conservation (Department) proposes to issue a modified SPDES permit for Units 1, 2 & 3 at the Indian Point nuclear steam electric generating station in Buchanan, New York. The draft permit contains conditions which address three aspects of operations at Indian Point: conventional industrial-wastewater pollutant discharges, the thermal discharge, and the cooling water intake. Limits on the conventional industrial discharges are not proposed to be changed significantly from the previous permit. This draft permit does, however, contain new conditions addressing the thermal discharge and additional new conditions to implement the measures the Department has determined to be the "best technology available" (BTA) for minimizing impacts to aquatic resources from the cooling water intake, pursuant to the federal Clean Water Act (CWA).

Department Staff has reviewed information submitted by the applicants and information in numerous reports and studies conducted over more than 25 years related to entrainment and impingement at once through cooling facilities. Department Staff has also reviewed the application materials and supporting documentation. A tentative determination has been made to approve this application and a draft permit has been prepared. The background documentation supporting this determination is available in the "fact sheets" and the administrative record for the project.

The application materials, fact sheet, Draft and Final EIS, and the draft SPDES permit are available for review at the following locations during normal business hours between 9:00 AM and 4:00 PM, Monday through Friday:

1) NYSDEC Office of Hearings and Mediation Services, 625 Broadway, First Floor, Albany, NY 12233-1550. Contact: Administrative Law Judge Maria E. Villa or Administrative Law Judge Daniel P. O'Connell at (518) 402-9003.

2) NYSDEC Division of Environmental Permits, 625 Broadway, Albany, New York 12233-1750. Contact: Betty Ann Hughes, Project Manager, at (518) 402-9158; and

3) NYSDEC Region 3 Office, 21 South Putt Corners Road, New Paltz, NY 12561 Contact: Michael Merriman or Margaret Duke at (845) 256-3054.

These materials will also be available at the following repositories:

1) Adriance Memorial Library, 93 Market Street, Poughkeepsie, New York 12601

2) Village of Buchanan Hall, 236 Tate Avenue, Buchanan, New York 10511

3) Newburgh Town Hall, Union Avenue Extension, Newburgh, New York 12550

4) Haverstraw Town Hall, 1 Rosman Road, Garnerville, New York 10923

5) Mid-Manhattan Library, 455 Fifth Avenue, New York, New York 10016

6) Columbia-Greene Community College Library, 4400 Route 23, Hudson, New York 12534

7) Nyack Library, 59 South Broadway, Nyack, New York 10960

Copies of the draft SPDES permit/fact sheets and the Final EIS can also be obtained from the DEC Website.

Legislative Public Hearing: Legislative Hearing sessions to receive unsworn statements from the public on the applications and the draft permits, described above, will be held at 2:00 p.m. and 7:00 p.m. on Wednesday, January 28, 2004 and at 2:00 p.m. and 7:00 p.m. on Thursday, January 29, 2004 at the Esplanade Hotel, 95 South Broadway, White Plains, NY, telephone number 914-761-5721. An Issues Conference will be held at 10:00 A.M. on Wednesday, March 3, 2004 and Thursday, March 4, 2004, and as necessary on March 5, 2004, at the Esplanade Hotel, 95 South Broadway, White Plains, NY, telephone number 914-761-5721.

For more information about the Legislative Hearing and the Issues Conference please see the Hearing Notice.

Written Comments: All written comments concerning the draft SPDES permit must be postmarked by Friday, February 6, 2004, and sent to Administrative Law Judge Maria E. Villa, NYSDEC Office of Hearings and Mediation Services, 625 Broadway, First Floor, Albany, New York 12233-1550.

Contact Person:
Betty Ann Hughes
NYSDEC, Division of Environmental Permits
625 Broadway, 4th Floor
Albany, NY 12233-1750
Phone: 518-402-9158
Fax: 518-402-9168
bahughes@gw.dec.state.ny.us

Notice Of Cancellation Of Public Hearing

Westchester County - The NYC Department of Environmental Protection has

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DRAFT State Pollutant Discharge Elimination System (SPDES) DISCHARGE PERMIT

Special Conditions

First3.90

Industrial Code:	**4911**	SPDES Number:	**NY- 0004472**
Discharge Class (CL):	**03**	DEC Number:	
Toxic Class (TX):	**T**	Effective Date (EDP):	
Major Drainage Basin:	**13**	Expiration Date (ExDP):	
Sub Drainage Basin:	**01**	Modification Dates:	
Water Index Number:	**H**		
Compact Area:	**IEC**		

This SPDES permit is issued in compliance with Title 8 of Article 17 of the Environmental Conservation Law of New York State and in compliance with the Clean Water Act, as amended, (33 U.S.C. §1251 et.seq.)(hereinafter referred to as "the Act").

PERMITTEE NAME AND ADDRESS

Name: **Entergy Nuclear Indian Point Units #2 and #3 LLC** Attention: **Thomas Teague**
Street: **440 H American Avenue**
City: **White Plains** State: **NY** Zip Code: **10601**

is authorized to discharge from the facility described below:

FACILITY NAME AND ADDRESS

Name: **Entergy Nuclear Indian Point Units #2 and #3 LLC**
Location (C,T,V): **Buchanan (V)** County: **Westchester**
Facility Address: **Broadway and Bleakley Avenue**
City: **Buchanan** State: **NY** Zip Code: **10511**
NYTM -E: NYTM - N:
From Outfall No.: **001** at Latitude: **41** ° **16** ′ **7** ″ & Longitude: **73** ° **57** ′ **19** ″
into receiving waters known as: **Hudson River** Class: **SB**

and; (list other Outfalls, Receiving Waters & Water Classifications)

001	**Hudson River SB**	**005**	**Hudson River SB**	**01B**	**01P (01B-01P and 008) via 001**
002	**Hudson River SB**	**006**	**Hudson River SB**	**01C**	**01J**
003	**Hudson River SB**	**007**	**Hudson River SB**	**01D**	**01I**
004	**Hudson River SB**	**008**	**HR via 001 SB**	**01E**	**01L**
		009	**Hudson River SB**	**01G**	**01N, 01M**

in accordance with the effluent limitations, monitoring requirements and other conditions set forth in this permit and 6 NYCRR Part 750.

DISCHARGE MONITORING REPORT (DMR) MAILING ADDRESS

Mailing Name: **Entergy Nuclear Indian Point Units #2 and 3 LLC**
Street: **295 Broadway**
City: **Buchanan** State: **NY** Zip Code: **10511**
Responsible Official or Agent: **Thomas Teague** Phone: **914-734-6247**

This permit and the authorization to discharge shall expire on midnight of the expiration date shown above and the permittee shall not discharge after the expiration date unless this permit has been renewed, or extended pursuant to law. To be authorized to discharge beyond the expiration date, the permittee shall apply for permit renewal not less than 180 days prior to the expiration date shown above.

DISTRIBUTION: Bureau of Water Permits

Permit Administrator:	
Address:	
Signature:	Date: / /

PERMIT LIMITS, LEVELS AND MONITORING DEFINITIONS

C:\MyFiles\MyFiles\pp\APDFs\IndianPoint\SPDES.wpd

OUTFALL	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
	This cell describes the type of wastewater authorized for discharge. Examples include process or sanitary wastewater, storm water, non-contact cooling water.	This cell lists classified waters of the state to which the listed outfall discharges.	The date this page starts in effect. (e.g. EDP or EDPM)	The date this page is no longer in effect. (e.g. ExDP)

PARAMETER	MINIMUM	MAXIMUM	UNITS	SAMPLE FREQ.	SAMPLE TYPE
e.g. pH, TRC, Temperature, D.O.	The minimum level that must be maintained at all instants in time.	The maximum level that may not be exceeded at any instant in time.	SU, °F, mg/l, etc.		

PARAMETER	EFFLUENT LIMIT	PRACTICAL QUANTITATION LIMIT (PQL)	ACTION LEVEL	UNITS	SAMPLE FREQUENCY	SAMPLE TYPE
	Limit types are defined below in Note 1. The effluent limit is developed based on the more stringent of technology-based limits, required under the Clean Water Act, or New York State water quality standards. The limit has been derived based on existing assumptions and rules. These assumptions include receiving water hardness, pH and temperature; rates of this and other discharges to the receiving stream; etc. If assumptions or rules change the limit may, after due process and modification of this permit, change.	For the purposes of compliance assessment, the analytical method specified in the permit shall be used to monitor the amount of the pollutant in the outfall to this level, provided that the laboratory analyst has complied with the specified quality assurance/quality control procedures in the relevant method. Monitoring results that are lower than this level must be reported, but shall not be used to determine compliance with the calculated limit. This PQL can be neither lowered nor raised without a modification of this permit.	Type I or Type II Action Levels are monitoring requirements, as defined below in Note 2, that trigger additional monitoring and permit review when exceeded.	This can include units of flow, pH, mass, Temperature, concentration. Examples include µg/l, lbs/d, etc.	Examples include Daily, 3/week, weekly, 2/month, monthly, quarterly, 2/yr and yearly.	Examples include grab, 24 hour composite and 3 grab samples collected over a 6 hour period.

Note 1: DAILY DISCHARGE.: The discharge of a pollutant measured during a calendar day or any 24-hour period that reasonably represents the calendar day for the purposes of sampling. For pollutants expressed in units of mass, the 'daily discharge' is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the 'daily discharge' is calculated as the average measurement of the pollutant over the day.

DAILY MAX.: The highest allowable daily discharge. DAILY MIN.: The lowest allowable daily discharge.

MONTHLY AVG: The highest allowable average of daily discharges over a calendar month, calculated as the sum of each of the daily discharges measured during a calendar month divided by the number of daily discharges measured during that month.

7 DAY ARITHMETIC MEAN (7 day average): The highest allowable average of daily discharges over a calendar week.

30 DAY GEOMETRIC MEAN: The highest allowable geometric mean of daily discharges over a calendar month, calculated as the antilog of: the sum of the log of each of the daily discharges measured during a calendar month divided by the number of daily discharges measured during that month.

7 DAY GEOMETRIC MEAN: The highest allowable geometric mean of daily discharges over a calendar week.
RANGE: The minimum and maximum instantaneous measurements for the reporting period must remain between the two values shown.
Note 2: ACTION LEVELS: Routine Action Level monitoring results, if not provided for on the Discharge Monitoring Report (DMR) form, shall be appended to the DMR for the period during which the sampling was conducted. If the additional monitoring requirement is triggered as noted below, the permittee shall undertake a short-term, high-intensity monitoring program for the parameter(s). Samples identical to those required for routine monitoring purposes shall be taken on each of at least three consecutive operating and discharging days and analyzed. Results shall be expressed in terms of both concentration and mass, and shall be submitted no later than the end of the third month following the month when the additional monitoring requirement was triggered. Results may be appended to the DMR or transmitted under separate cover to the same address. If levels higher than the Action Levels are confirmed, the permit may be reopened by the Department for consideration of revised Action Levels or effluent limits. The permittee is not authorized to discharge any of the listed parameters at levels which may cause or contribute to a violation of water quality standards. TYPE I: The additional monitoring requirement is triggered upon receipt by the permittee of any monitoring results in excess of the stated Action Level. TYPE II: The additional monitoring requirement is triggered upon receipt by the permittee of any monitoring results that show the stated action level exceeded for four of six consecutive samples, or for two of six consecutive samples by 20 % or more, or for any one sample by 50 % or more.

PERMIT LIMITS, LEVELS AND MONITORING

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	SPECIAL CON. (SC)	EFFECTIVE	EXPIRING
001	Discharge Canal	Hudson River	1-11		

PARAMETER	MINIMUM	MAXIMUM	UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SPECIAL CONDITIONS (SC)
pH	6.0	9.0	SU	Weekly	Grab	

PARAMETER	COMPLIANCE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Total Residual Chlorine	NA	0.2			mg/l	Continuous	Recorder	9,10,11
Lithium Hydroxide	NA	0.01			mg/l	Monthly	Grab	12
Boron	NA	1.0			mg/l	Monthly	Grab	15
Boron	NA	525			lb/day	Monthly	Grab	15
Flow	MONITOR	MONITOR			MGD	Continuous	Recorder	6,8
Temperature	NA	110			degrees F	Continuous	Recorder	3,4,5,7

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
Sum of 01C & 01D	Combined Low volume Wastewater	Hudson River via Discharge Canal 001		

PARAMETER	ENFORCEABLE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Lithium Hydroxide	Monitor	Monitor			mg/l	Monthly	Grab	

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
Sum of 01B, 01C, 01D, 01J & 01L	Combined Low volume Wastewater	Hudson River via Discharge Canal 001		

PARAMETER	ENFORCEABLE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Flow	Monitoring				MGD	Weekly	Instantaneous	14
Total Suspended Solids	30	50			mg/l	Weekly	Grab	14, 16

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
01C	Unit 2 Primary Waste Disposal System	Hudson River via Discharge Canal 001		

PARAMETER	ENFORCEABLE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Flow	Monitoring				MGD	Weekly	Instantaneous	

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
01E	Water Treatment Filter and GAC Backwash	Hudson River via Discharge Canal 001		

PARAMETER	ENFORCEABLE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Flow	Monitoring				MGD	Weekly	Instantaneous	

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
01G	Units 2 & 3 Service Boiler Blowdown	Hudson River via Discharge Canal 001		

PARAMETER	ENFORCEABLE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Flow	Monitoring				MGD	Weekly	Instantaneous	
Phosphates as P	16	38			lb/day	Monthly	Grab	13

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
01I	Units 2 & 3 Condenser and Service Waters	Hudson River via Discharge Canal 001		

PARAMETER	ENFORCEABLE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Flow	Monitoring				MGD	Continuous	Recorder	8

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
01J	Floor Drains from Units 1, 2, 3 Buildings	Hudson River via Discharge Canal 001		

PARAMETER	ENFORCEABLE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Flow	Monitoring				MGD	Weekly	Estimate Visual Observation	
Oil & Grease		15			mg/l	Weekly	Grab	14

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
Sum of 01C, 01D and 01L	Combined Discharge	Hudson River via Discharge Canal 001		

PARAMETER	ENFORCEABLE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Boron	Monitor	Monitor			mg/l	Weekly	Grab	18
Oil & Grease		15			mg/l	Monthly	Grab	17

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
01L	Unit 3 Condenser Polisher/makeup Demineralizer and Ion Exchange Regeneration	Hudson River via Discharge Canal 001		

PARAMETER	COMPLIANCE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Flow	Monitor	Monitor			GPD	Weekly	Instantaneous	
pH	Range 6.0 - 9.0				SU	Monthly	Grab	
Chlorine, Total Residual	NA	Monitor			mg/l	Monthly	Grab	
Florides			5		lbs/day	Semi-Annual	Grab	
Iron			4		mg/l	Semi-Annual	Grab	
Copper			1.0		mg/l	Semi-Annual	Grab	

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
01N	Reverse Osmosis Reject	Hudson River via Discharge Canal 001		

PARAMETER	COMPLIANCE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Flow	Monitor	Monitor			GPD	Weekly	Instantaneous	
Oil & Grease	NA	15			mg/l	Weekly	Grab	
Total Suspended Solids	30	50			mg/l	Weekly	Grab	

OUTFALL No.	WASTEWATER TYPE	RECEIVING WATER	EFFECTIVE	EXPIRING
01P	Eductor Pit	Hudson River via Outfall 001		

PARAMETER	COMPLIANCE LIMIT		MONITORING ACTION LEVEL		UNITS	SAMPLE FREQUENCY	SAMPLE TYPE	SC
	Monthly Avg.	Daily Max.	TYPE I	TYPE II				
Flow	Monitor	Monitor			GPD	Weekly	Instantaneous	
Oil & Grease	NA	15			mg/l	Weekly	Grab	
Total Suspended Solids	30	50			mg/l	Weekly	Grab	

OUTFALL No. 01M, 002-009 - Uncontaminated Stormwater Discharge

No monitoring required.

SPECIAL CONDITIONS

CONDITIONS FOR OUTFALL 001

1. Discharge through Outfall 001 shall occur only through the subsurface ports of the outfall structure.

2. Sampling location for Outfall 001 is to be located upstream of the discharge from the common discharge canal into the Hudson River.

3. At no time shall the maximum discharge temperature at Outfall 001 exceed 43.3 degrees C (110°F).

4. The maximum discharge temperature at Outfall 001 shall not exceed 34°C (93.2°F) for an average of more than ten days per year; provided that the daily average discharge temperature at Outfall 001 shall not exceed 34°C (93.2°F) on more than 15 days between April 15 and June 30 in any year.

5. When the temperature in the discharge canal exceeds 90°F or the site gross electric output equals or exceeds 600MW, the head differential across the outfall structure shall be maintained at a minimum of 1.75 feet. When required, adjustment of the ports shall be made within four hours of any change in the flow rate of the circulating water pumps. If compliance is not achieved, further adjustments of the ports shall be made to achieve compliance. Flow schedules in Special Condition 6, below, shall take priority over this condition.

6. The permittee must not exceed the maximum flows listed in the table below during the specified periods, unless it is necessary to ensure the safe operation of the facility or to comply with the thermal standards contained in this permit.

Period	Flow in MGD/Unit	Flow in GPM/Unit
January 1 - May 15	726	504,000
May 16 - May 22	806	560,000
May 23 - May 31	968	672,000
June 1 - June 8	1053	731,000
June 9 - September 30	1210	840,000
October 1 - October 31	1053	731,000
November 1 - December 31	726	504,000

If these mitigative flows are exceeded, permittee must send written notification of that exceedance within 5 business days to NYSDEC; Division of Fish, Wildlife and Marine Resources; Leader, Steam Electric Unit; 625 Broadway; Albany, NY 12233-4756.

7. a. The thermal discharge from Outfall 001 is subject to 6 NYCRR Part 704.

b. Within six months of the effective date of the permit, the permittee shall submit to the NYSDEC, Division of Water, for review and approval, a protocol approvable as defined in 6 NYCRR Part 750-1.2(a)(8) for conducting a tri-axial (3-Dimensional) thermal study. The purpose of the thermal study will be to delineate the 90-degrees Fahrenheit isopleths at various depths and stages of tide to define the size of the mixing zone for the discharge from Outfall 001. The thermal study must be conducted under critical tidal current conditions when all units are operating under summer conditions. Temperatures must be recorded to the nearest degree Fahrenheit. The thermal study shall be conducted within one year after the NYSDEC approves the thermal study protocol. The results of the thermal study shall be submitted to the NYSDEC within three months of the completion of the study. The final report should also include the technical material necessary to satisfy the requirements of 6 NYCRR Part 704.3-Mixing zone criteria. Upon reviewing the results of the thermal study, the Division of Water will determine whether the requirements of 6 NYCRR Part 704.2 have been met. The protocol and final report (3 copies of each) shall be submitted to: NYSDEC, Division of Water, Director of the Bureau of Water Permits, 4th Floor, 625 Broadway, Albany, New York 12233-3505.

8. The flow of condenser cooling water discharges shall be monitored and recorded every eight hours by recording the operating mode of the circulating water pumps. Any changes in the flow rate of each circulating water pump shall be recorded, including the date and time, and reported monthly together with the Discharge Reporting Form. The permittee shall indicate whether any circulating pumps were not in operation due to pump breakdown or required pump maintenance and the period(s) (dates and times) the discharge temperature limitation was exceeded, if at all. Methods, equipment, installation, and procedures shall conform to those prescribed in the Water Measurement Manual, U.S. Department of the Interior, Bureau of Reclamation, Washington D.C.: 1967 or equivalent approved by the NYSDEC.

9. a The service water system may be chlorinated continuously.

b. Should the condenser cooling water system be chlorinated, the maximum frequency of chlorination for the condensers of each unit shall be limited to two hours per day. The total time for chlorination of the three units for which this permit is issued shall not exceed nine hours per week. Chlorination shall take place during daylight hours and shall not occur at more than one unit at a time.

10. Continuous monitoring of Total Residual Chlorine (TRC) during condenser chlorination is required. If the continuous monitor fails, is inaccurate, or is unreliable, TRC shall be monitored during condenser chlorination by analyzing grab samples taken at least once every 30 minutes during each chlorination period.

11. Grab samples shall be taken at least once daily during low level service water chlorination and at least once every 30 minutes during high level service water chlorination. During service water chlorination, Outfall 001 TRC concentrations may be determined by either direct measurement at Outfall 001 or by multiplying a measured TRC concentration in the service water system by the ratio of chlorinated service water flow to the total site flow.

<u>CONDITIONS FOR SUB-OUTFALLS</u>

12. The calculated quantity of lithium hydroxide in the discharge shall be determined by using the analytical results obtained from sampling that is to be performed on internal waste streams 01C and 01D.

13. Phosphate limit applies to only those internal streams at Indian Point 2 and 3 which comprise outfall 01G.

14. Because Outfall 01J cannot be monitored, the following shall apply:

    a. All oil spills shall be handled under the Spill Prevention Control and Countermeasure (SPCC) plan.

    b. Flow into the floor drains shall not contain more than 15 mg/l of oil and grease nor any visible sheen.

    c. Treated wastewater from the desilting operation within the intake structure and forebays shall be monitored once per 12 hour shift on the sand filter effluent. Grab samples shall be analyzed for total suspended solids and oil and grease. An estimate of discharge flow rate and a visual observation for the presence of any visible sheen shall be made on the sand filter effluent. The limitations for this discharge event are: 15 mg/l (oil & grease), 50 mg/l (total suspended solids) and no visible sheen.

15. The calculated quantity of boron in the discharge shall be determined by using the analytical results obtained from sampling that is to be performed on internal waste streams 01B, 01C, 01D and 01L.

16. One flow proportioned composite sample of total suspended solids (TSS) shall be obtained from one grab sample taken from each of the internal waste streams 01B, 01C, 01D, 01J and 01L.

17. One grab sample of oil and grease shall be obtained from each of the internal waste streams 01C, 01D, and 01L and the samples shall be analyzed separately. The results shall be reported by computing the flow-weighted average.

18. One flow proportioned composite sample of boron shall be obtained from one grab sample taken from each of the internal waste streams 01B, 01C, 01D, 01L.

WATER QUALITY REPORTING REQUIREMENTS:

19. The permittee shall submit on an annual basis to the NYSDEC at its offices in Tarrytown and Albany (see addresses below) a month-by-month report of daily operating data in EXCEL© format, by the 28th of January of the following year, that includes the following:

    a. Daily minimum, maximum and average station electrical output shall be determined and logged.

    b. Daily minimum, maximum and average water use shall be directly or indirectly measured or calculated and logged.

    c. Temperature of the intake and discharges shall be measured and recorded continuously. Daily minimum, maximum and average intake and discharge temperatures shall be logged.

    d. One copy of each annual report must be sent to the NYSDEC; Division of Water, Bureau of Watershed Compliance Programs; 625 Broadway; Albany, New York 12233-3506; and a second copy must be sent to NYSDEC; Regional Water Engineer, Region 3; 200 White Plains Road; Tarrytown, New York 10591.

20. Beginning upon the effective date of this permit, the permittee shall submit to the NYSDEC Offices in Albany and Tarrytown (see addresses in condition 19.d., above), a copy of their Semi-Annual Effluent and Waste Disposal Reports submitted to the Nuclear Regulatory Commission (NRC).

OTHER WATER QUALITY REQUIREMENTS

21. Notwithstanding any other requirements in this permit, the permittee shall also comply with all applicable Water Quality Regulations promulgated by the Interstate Environmental Commission (IEC), including Sections 1.01 and 2.05 (f) as they relate to oil and grease.

22. It is recognized that, despite the exercise of appropriate care and maintenance measures, and corrective measures by the permittee, influent quality changes, equipment malfunction, acts of God, or other circumstances beyond the control of the Permittee may, at times, result in effluent concentrations exceeding the permit limitations. The permittee may come forward to demonstrate to the NYSDEC that such circumstances exist in any case where effluent concentrations exceed those set forth in this permit. The NYSDEC, however, is not obligated to wait for, or solicit, such demonstrations prior to the initiation of any enforcement proceedings, nor must it accept as valid on its face the statement made in any such demonstration.

23. All chemicals listed and/or referenced in the permit application are approved for use. If use of new biocides, corrosion control chemicals or water treatment chemicals is intended, application must be made prior to use. No use will be approved that would cause exceedance of state water quality standards.

24. There shall be no net addition of PCBs by this facility's discharges to the Hudson River.

BIOLOGICAL REQUIREMENTS:

25. The permittee must continue to conduct the following long term Hudson River Monitoring programs during each calendar year:

a. Long River Ichthyoplankton, Fall Shoals Trawls, and Beach Seine Survey
All data recording, analysis of samples, and Quality Control and Assurance must be conducted in accordance with the 2002 Standard Operating Procedures (Normandeau Associates Inc., 2002) or in accordance with modified procedures approved in advance by the NYSDEC. The permittee must produce an annual year class report that presents the results of the above studies. Each annual report must be submitted to: NYSDEC; Division of Fish, Wildlife and Marine Resources; Leader, Steam Electric Unit, 625 Broadway, Albany, NY 12233-4756, no later than December 31 of the next calendar year.

b. Striped Bass/Atlantic Tomcod Mark-Recapture Survey
All data recording, analysis of samples, and Quality Control and Assurance must be conducted in accordance with the 2001-2002 Standard Operating Procedures (Normandeau Associates Inc., 2001) or in accordance with modified procedures approved in advance by the NYSDEC. The permittee must produce an annual report that presents the results of the above study. Each annual report must be submitted to the NYSDEC's Steam Electric Unit Leader within 12 months of the completion of each year's field operations.

26. The permittee must schedule and take annual outages of no fewer than 42 unit-days between 23 February and 23 August of each calendar year. A unit-day outage is defined as a period of 24 consecutive hours during which cooling water circulation pumps are off at either Indian Point Unit 2 or Unit 3. During these outages, cooling water circulation pumps may temporarily run for maintenance and testing activities, and service water pumps may be in operation. The permittee must give the NYSDEC's Steam Electric Unit Leader an annual report that provides a list of unit-day outages for each calendar year. Annual reports must be provided to the Steam Electric Unit before 31 January of the next calendar year.

27. The Ristroph modified traveling screens number 21 through 26 and 31 through 36 must continue to be operated on continuous wash when the corresponding cooling water circulation pump is running. The low pressure wash nozzles installed at each of these screens must be operated at 4 to 15 PSI so that the fish and invertebrates are removed from the traveling screens, washed into the existing fish return sluiceway, and returned to the Hudson River. The operation of the screens and fish return system must be inspected daily and the screen wash pressures recorded in the wash operator's log. The traveling screens and the fish return and handling system must minimize the mortality of fish to the maximum extent practicable.

28. The permittee must take the following steps to construct closed-cycle cooling:

   a. Within six months of the effective date of this permit, the permittee must submit to the NYSDEC, Division of Environmental Permits, Chief Permit Administrator, 625 Broadway, Albany, New York 12233-1750: (i) its schedule for seeking and obtaining, during this permit term, all necessary approvals from the NRC, Federal Energy Regulatory Commission (FERC), and other governmental agencies to enable construction and operation of closed-cycle cooling at Indian Point; and (ii) a report on the progress to date of the Pre-Design Engineering Report required in special condition 28. b., below.

   b. Within one year of the effective date of this permit, the permittee must submit to: NYSDEC, Division of Environmental Permits, Chief Permit Administrator, 625 Broadway, Albany, NY 12233-1750, a Pre-Design Engineering Report addressing regulatory and engineering issues, including but not limited to federal, state and local approvals, associated with installing closed-cycle cooling at Indian Point Units 1, 2, and 3. At a minimum, this report must address: (i) the potential relocation of a segment of the Algonquin Gas Company's (Algonquin) gas pipeline to construct closed-cycle cooling; (ii) the potential need for blasting to construct closed-cycle cooling and its potential impacts; (iii) particulate emissions from cooling towers; (iv) sequential construction outages at Units 2 and 3, as opposed to simultaneous construction outages; (v) the potential impacts to energy reliability and capacity associated with anticipated construction outages as well as the 42 day annual operating outages; and (vi) additional measures to reduce potential impacts to energy reliability or capacity.

   c. Within one year of the effective date of this permit, the permittee may also submit a Pre-Design Engineering Report to the Chief Permit Administrator for an alternative technology(s) that will minimize adverse environmental impact to a level equivalent to that which can be achieved by closed-cycle cooling.

   d. If the permittee submits a Pre-Design Engineering Report to the NYSDEC for an alternative technology(s), as provided for in special condition number 28. c., above, the NYSDEC will evaluate the capability of the proposed alternative to minimize adverse environmental impacts to a level equivalent to that which can be achieved by closed-cycle cooling. If the NYSDEC determines that the proposed alternative may be substituted for closed-cycle cooling, it will notify the permittee and, if appropriate, will commence a proceeding to modify this permit accordingly.

e. Within one year after submission of the Pre-Design Engineering Report, the permittee must submit design plans that address all construction issues for the conversion of the cooling water systems for Units 1, 2, and 3 to a closed-cycle system, or for an alternative technology(s) if approved by the NYSDEC pursuant to special condition number 28. c. and d., above. All plans must be stamped and signed by a Professional Engineer licensed by the State of New York. The design plans must be submitted to NYSDEC, Division of Environmental Permits, Chief Permit Administrator. NYSDEC will review to determine if the design plans are consistent with this permit and its requirements.

f. The permittee must inform the NYSDEC, Division of Environmental Permits, Chief, Energy and Management Bureau, in writing within 5 business days of any application submitted to the Nuclear Regulatory Commission (NRC) for modification or extension of the current operating licenses for Units 2 and 3, which expire on September 28, 2013 and December 12, 2015, respectively.

g. Within 30 days after receipt of the NRC's approval of the proposed design plans for closed-cycle cooling for Units 1, 2 and 3, the permittee must submit for approval to the NYSDEC, Division of Environmental Permits, Chief Permit Administrator, an update of its June 2003 construction schedule (Enercon Services, Inc. 2003) reflecting any design and schedule changes resulting from the NRC approval.

h. The NYSDEC reserves the authority to unilaterally modify this permit pursuant to 6 NYCRR Part 621, or take other appropriate action in the event that: (i) the NRC modifies or denies the permittee's design plans for closed-cycle cooling for Units 1, 2 and 3, (ii) any necessary proposal to a state or federal agency for relocating a segment of the Algonquin pipeline is modified or denied, or (iii) the permittee determines that it will not seek extension of its NRC licenses, and it so advises the NYSDEC, Division of Environmental Permits, Chief, Energy and Management Bureau, in writing,

29. Within six months after the effective date of this permit, and annually thereafter on January 1 of each year, the permittee must pay $24 million into an escrow account that it creates at a financial institution approved by the NYSDEC. The escrow account must be entitled the Hudson River Estuary Restoration Fund (HRERF). All of the monies in the HRERF shall be held for the benefit of the HRERF and made available to the NYSDEC to administer for projects or programs within the Hudson River Estuary (including tributaries to the estuary below the federal dam at Troy) designed to restore, enhance or protect aquatic habitats, fish species, or the quality of Hudson River Estuary waters. These funds will not be used to support any of the permittee's obligations under this permit. Payments to the HRERF are non-refundable. Partial year payments shall be prorated at $65,750 per day.

SCHEDULE OF COMPLIANCE:

30. a. The permittee shall comply with the Schedule of Compliance (following page), including the reporting requirements set forth below.

b. The permittee shall submit a written notice of compliance or non-compliance with each of the above schedule dates no later than 14 days following each elapsed date, unless conditions require more immediate notice under terms of 6 NYCRR Part 750. All such compliance or non-compliance notification shall be sent to the locations listed under the section of this permit entitled RECORDING, REPORTING AND ADDITIONAL MONITORING REQUIREMENTS. Each notice of non-compliance shall include the following information:

1. A short description of the non-compliance;
2. A description of any actions taken or proposed by the permittee to comply with the elapsed schedule requirements without further delay and to limit environmental impact associated with the non-compliance;
3. A description of any factors which tend to explain or mitigate the non-compliance; and
4. An estimate of the date the permittee will comply with the elapsed schedule requirement and an assessment of the probability that the permittee will meet the next scheduled requirement on time.

c. Unless otherwise specified in this permit or in writing by the Department, the permittee shall submit copies of any document required by the above schedule of compliance to NYSDEC Regional Water Engineer, Region 3,200 White Plains Road, Tarrytown, New York 10591 and to the NYSDEC, Division of Water, Bureau of Water Permits, 625 Broadway, Albany, N.Y. 12233-3505.

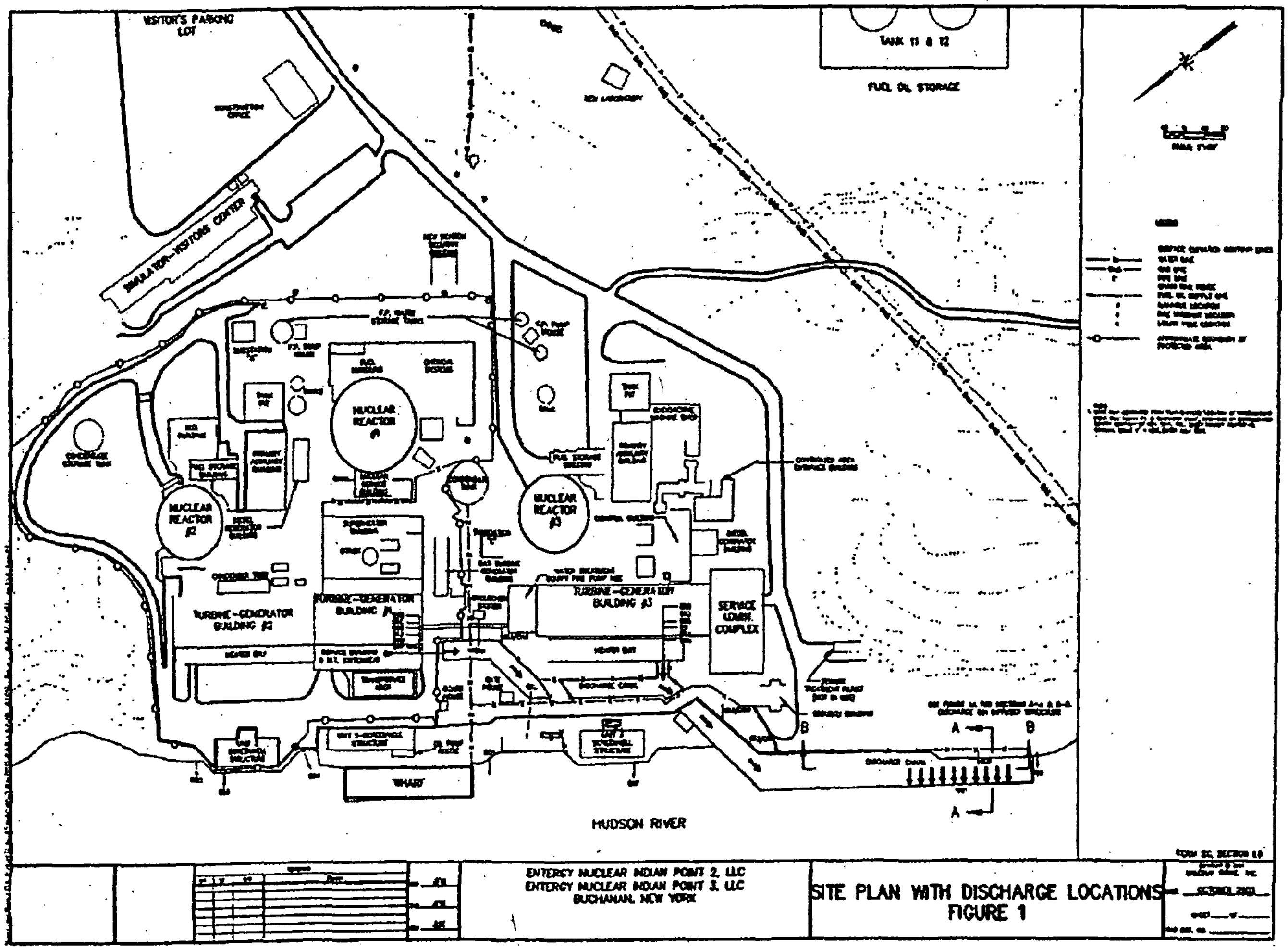
SCHEDULE OF COMPLIANCE

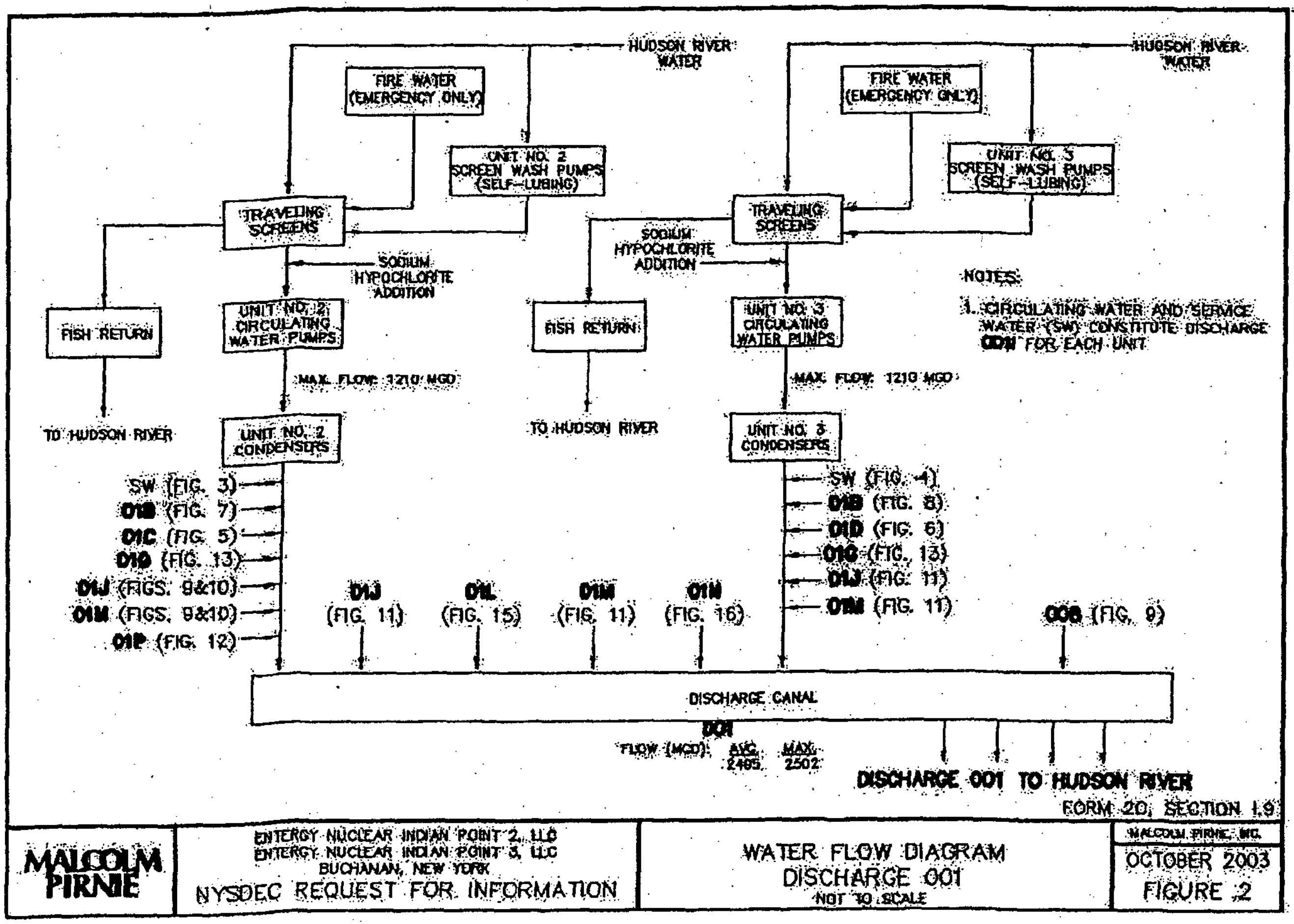
Action Code	Outfall Number(s)	Compliance Action	Due Date
	001	Submit approvable Protocol for Tri-Axial Thermal Study. (Special condition 7)	EDP + 6 months
	001	Submit a report on the progress to date of the Pre-Design Engineering Report (Special Condition 28. a)	EDP + 6 months
	001	Submit a schedule for obtaining all necessary approvals during the permit term from the Federal Energy Regulatory Commission (FERC), Nuclear Regulatory Commission (NRC), and other governmental agencies for the construction of closed cycle cooling at Indian Point during the next permit term. (Special condition 28. a)	EDP + 6 months
	001	Submit a Pre-Design Engineering Report addressing regulatory and engineering issues associated with installing closed cycle cooling at Units 1, 2, and 3 (Special condition 28.b)	EDP + 1 Year
	N/A	Permittee may submit Pre-Design Engineering Report for alternative technology(s) that achieves minimization of adverse environmental impact equivalent to closed-cycle cooling Special Condition 28.c).	EDP + 1 Year
	N/A	Annually, continue to ensure that biological monitoring projects [Longitudinal River Survey, Beach Seine Survey, Fall Shoals Trawls and Striped Bass/Atlantic Tomcod Mark Recapture Survey] are conducted according to the approved Standard Operation Procedures. Annual results from the Longitudinal River Survey, Beach Seine Survey, and Fall Shoals Trawls must be provided to the Department by 31 December of the next calendar year, while results from the Striped Bass/Atlantic Tomcod Mark Recapture Survey must be provided to the Department within 12 months of the completion of field operations. (Special condition 25)	EDP
	N/A	Schedule and take outages of no fewer than 42 unit-days between 23 February and 23 August in each calendar year over the permit term. Submit annual reports on outages prior to 31 January of each calendar year. (Special condition 26)	EDP
	N/A	Annually, the permittee must pay $24 million into an Hudson River Estuary Restoration Fund. These funds will be used to restore or enhance the Hudson River Estuary (Special condition 29).	Annually
	001	Conduct Tri-Axial Thermal Study as Outlined in Special Condition 7.	EDP + 1.5 years
	001	Submit results of Tri-Axial Thermal Study as outlined in Special Condition 7.	EDP + 1.75 years
	N/A	Submit design plans that address all construction issues for the conversion of the cooling water systems for units 1, 2, and 3 to a closed cycle system or for construction of DEC-approved alternative technology(s) (Special condition 28.e.).	EDP+ 2 Years
	001	Month-by-month report of daily operating data on electrical output, water use, and intake and discharge temperature (Special Condition #19).	Annual
	N/A	Submit Semi-annual Effluent and Waste Disposal Reports prepared for NRC (Special Condition 20).	Semi-Annual
	N/A	Submit revised construction schedule reflecting NRC approval process (Special Condition 28.g.)	NRC App + 30 Days
	N/A	Advise NYSDEC of extension of NRC licenses (Special Condition 28.f.)	October 3, 2008

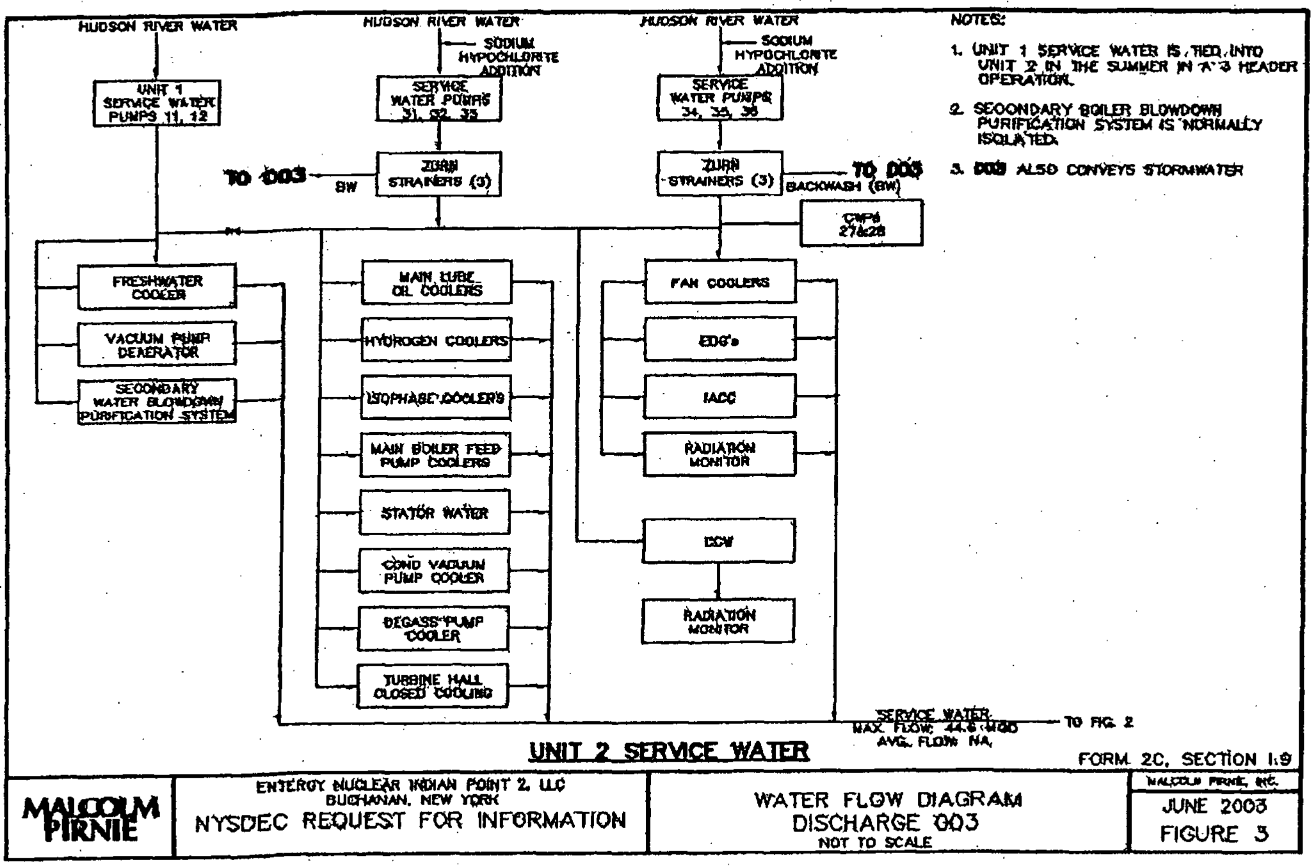
STANDARD CONDITIONS

MONITORING LOCATIONS

The permittee shall take samples and measurements, to comply with the monitoring requirements specified in this permit, at the location(s) shown in the three figures below:




HUDSON RIVER WATER
FIRE WATER (EMERGENCY ONLY)
UNIT NO. 2 SCREEN WASH PUMPS (SELF-LUBING)
TRAVELING SCREENS
SODIUM HYPOCHLORITE ADDITION
FISH RETURN
UNIT NO. 2 CIRCULATING WATER PUMPS
MAX. FLOW: 1210 MGD
TO HUDSON RIVER
UNIT NO. 2 CONDENSERS
SW (FIG. 3)
01B (FIG. 7)
01C (FIG. 5)
(FIG. 13)
01J (FIGS. 9&10)
01M (FIGS. 9&10)
01P (FIG. 12)
01J (FIG. 11)
01L (FIG. 15)
01M (FIG. 11)
01N (FIG. 16)
HUDSON RIVER WATER
FIRE WATER (EMERGENCY ONLY)
UNIT NO. 3 SCREEN WASH PUMPS (SELF-LUBING)
TRAVELING SCREENS
SODIUM HYPOCHLORITE ADDITION
FISH RETURN
UNIT NO. 3 CIRCULATING WATER PUMPS
MAX. FLOW: 1210 MGD
TO HUDSON RIVER
UNIT NO. 3 CONDENSERS
SW (FIG. 4)
01B (FIG. 8)
01D (FIG. 6)
(FIG. 13)
01J (FIG. 11)
01M (FIG. 11)
008 (FIG. 9)
NOTES:
1. CIRCULATING WATER AND SERVICE WATER (SW) CONSTITUTE DISCHARGE 001 FOR EACH UNIT
DISCHARGE CANAL
001
FLOW (MGD): AVG. 2495 MAX. 2502
DISCHARGE 001 TO HUDSON RIVER
FORM 20, SECTION 1.9
MALCOLM PIRNIE
ENTERGY NUCLEAR INDIAN POINT 2, LLC
ENTERGY NUCLEAR INDIAN POINT 3, LLC
BUCHANAN, NEW YORK
NYSDEC REQUEST FOR INFORMATION
WATER FLOW DIAGRAM
DISCHARGE 001
NOT TO SCALE
MALCOLM PIRNIE, INC.
OCTOBER 2003
FIGURE 2


HUDSON RIVER WATER
UNIT 1 SERVICE WATER PUMPS 11, 12
HUDSON RIVER WATER
SODIUM HYPOCHLORITE ADDITION
SERVICE WATER PUMPS 31, 32, 33
TO 003
BW
ZURN STRAINERS (3)
HUDSON RIVER WATER
SODIUM HYPOCHLORITE ADDITION
SERVICE WATER PUMPS 34, 35, 36
ZURN STRAINERS (3)
TO 003
BACKWASH (BW)
CWPS 27&28
FRESHWATER COOLER
VACUUM PUMP DEAERATOR
SECONDARY WATER BLOWDOWN PURIFICATION SYSTEM
MAIN LUBE OIL COOLERS
HYDROGEN COOLERS
ISOPHASE COOLERS
MAIN BOILER FEED PUMP COOLERS
STATOR WATER
COND VACUUM PUMP COOLER
DEGASS PUMP COOLER
TURBINE HALL CLOSED COOLING
FAN COOLERS
EDG's
IACC
RADIATION MONITOR
CCW
RADIATION MONITOR
SERVICE WATER
MAX. FLOW: 44.6 MGD
AVG. FLOW: NA
TO FIG. 2
NOTES:
1. UNIT 1 SERVICE WATER IS TIED INTO UNIT 2 IN THE SUMMER IN 'A' 3 HEADER OPERATION.
2. SECONDARY BOILER BLOWDOWN PURIFICATION SYSTEM IS NORMALLY ISOLATED.
3. 003 ALSO CONVEYS STORMWATER
UNIT 2 SERVICE WATER
FORM 2C, SECTION 1.9
MALCOLM PIRNIE
ENTERGY NUCLEAR INDIAN POINT 2, LLC
BUCHANAN, NEW YORK
NYSDEC REQUEST FOR INFORMATION
WATER FLOW DIAGRAM
DISCHARGE 003
NOT TO SCALE
MALCOLM PIRNIE, INC.
JUNE 2003
FIGURE 3

BEST MANAGEMENT PRACTICES

1. The permittee shall maintain and implement a Best Management Practices (BMP) plan to prevent, or minimize the potential for, release of significant amounts of toxic or hazardous pollutants to the waters of the State through plant site runoff; spillage and leaks; sludge or waste disposal; and storm water discharges including, but not limited to, drainage from raw material storage.

2. The permittee shall review all facility components or systems (including material storage areas; in-plant transfer, process and material handling areas; loading and unloading operations; storm water, erosion, and sediment control measures; process emergency control systems; and sludge and waste disposal areas) where toxic or hazardous pollutants are used, manufactured, stored or handled to evaluate the potential for the release of significant amounts of such pollutants to the waters of the State. In performing such an evaluation, the permittee shall consider such factors as the probability of equipment failure or improper operation, cross-contamination of storm water by process materials, settlement of facility air emissions, the effects of natural phenomena such as freezing temperatures and precipitation, fires, and the facility's history of spills and leaks. For hazardous pollutants, the list of reportable quantities as defined in 40 CFR, Part 117 may be used as a guide in determining significant amounts of releases. For toxic pollutants, the relative toxicity of the pollutant shall be considered in determining the significance of potential releases.

   The review shall address all substances present at the facility that are listed as toxic pollutants under Section 307(a)(1) of the Clean Water Act or as hazardous pollutants under Section 311 of the Act or that are required to be reported on the Industrial Chemical Survey.

3. Whenever the potential for a significant release of toxic or hazardous pollutants to State waters is determined to be present, the permittee shall identify BMPs that have been established to minimize such potential releases. Where BMPs are inadequate or absent, appropriate BMPs shall be established. In selecting appropriate BMPs, the permittee shall consider typical industry practices such as spill reporting procedures, risk identification and assessment, employee training, inspections and records, preventive maintenance, good housekeeping, materials compatibility and security. In addition, the permittee may consider structural measures (such as secondary containment and erosion/sediment control devices and practices) where appropriate.

4. Development of the BMP plan shall include sampling of waste stream segments for the purpose of toxic "hot spot" identification. The economic achievability of effluent limits will not be considered until plant site "hot spot" sources have been identified, contained, removed or minimized through the imposition of site specific BMPs or application of internal facility treatment technology. For the purposes of this permit condition a "hot spot" is a segment of an industrial facility; including but not limited to soil, equipment, material storage areas, sewer lines etc.; which contributes elevated levels of problem pollutants to the wastewater and/or storm water collection system of that facility. For the purposes of this definition, problem pollutants are substances for which treatment to meet a water quality or technology requirement may, considering the results of waste stream segment sampling, be deemed unreasonable. For the purposes of this definition, an elevated level is a concentration or mass loading of the pollutant in question which is sufficiently higher than the concentration of that same pollutant at the compliance monitoring location so as to allow for an economically justifiable removal and/or isolation of the segment and/or B.A.T. treatment of wastewaters emanating from the segment.

5. The BMP plan shall be documented in narrative form and shall include any necessary plot plans, drawings or maps. Other documents already prepared for the facility such as a Safety Manual or a Spill Prevention,

Control and Countermeasure (SPCC) plan may be used as part of the plan and may be incorporated by reference. USEPA guidance for development of storm water elements of the BMP is available in the September 1992 manual "Storm Water Management for Industrial Activities," USEPA Office of Water Publication EPA 832-R-92-006 (available from NTIS, (703)487-4650, order number PB 92235969). A copy of the BMP plan shall be maintained at the facility and shall be available to authorized Department representatives upon request. As a minimum, the plan shall include the following BMP's:

a. BMP Committee	e. Inspections and Records	i. Security
b. Reporting of BMP Incidents	f. Preventive Maintenance	j. Spill prevention & response
c. Risk Identification & Assessment	g. Good Housekeeping	k. Erosion & sediment control
d. Employee Training	h. Materials Compatibility	l. Management of runoff

6. The BMP plan shall be reviewed annually and shall be modified whenever: (a) changes at the facility materially increase the potential for significant releases of toxic or hazardous pollutants, (b) actual releases indicate the plan is inadequate, or (c) a letter from the Regional Water Engineer highlights inadequacies in the plan.

7. <u>Facilities with Petroleum and/or Chemical Bulk Storage (PBS and CBS) Areas:</u>
Compliance must be maintained with all applicable regulations including those involving releases, registration, handling and storage (6NYCRR 595-599) and (6NYCRR 612-614). Stormwater discharges from handling and storage areas should be eliminated where practical.

A. <u>Spill Cleanup</u> - All spilled or leaked substances must be removed from secondary containment systems as quickly as practical and in all cases within 24 hours. The containment system must be thoroughly cleaned to remove any residual contamination which could cause contamination of stormwater and the resulting discharge of pollutants to waters of the State. Following spill cleanup the affected area must be completely flushed with clean water three times and the water removed after each flushing for proper disposal in an on-site or off-site wastewater treatment plant designed to treat such water and permitted to discharge such wastewater. Alternatively, the permittee may test the first batch of stormwater following the spill cleanup to determine discharge acceptability. If the water contains no pollutants it may be discharged. Otherwise it must be disposed of as noted above. See *Discharge Monitoring* below for the list of parameters to be sampled for.

B. <u>Discharge Operation</u> - Stormwater must be removed before it compromises the required containment system capacity. Each discharge may only proceed with the prior approval of the permittee staff person responsible for ensuring SPDES permit compliance. Bulk storage secondary containment drainage systems must be locked in a closed position except when the operator is in the process of draining accumulated stormwater. Transfer area secondary containment drainage systems must be locked in a closed position during all transfers and must not be reopened unless the transfer area is clean of contaminants. Stormwater discharges from secondary containment systems should be avoided during periods of precipitation. A logbook shall be maintained on-site noting the date, time and personnel supervising each discharge.

C. <u>Discharge Screening</u> - Prior to each discharge from a secondary containment system the stormwater must be screened for contamination. All stormwater must be inspected for visible evidence of contamination. Additional screening methods shall be developed by the permittee as part of the overall BMP Plan, e.g. the use of volatile gas meters to detect the presence of gross levels of gasoline or volatile organic compounds. If the screening indicates contamination, the permittee must collect and analyze a representative sample of the stormwater. If the water contains no pollutants it may be discharged. Otherwise it must either be disposed of in an on-site or off-site wastewater treatment plant designed to treat and permitted to discharge such wastewater or the Regional Water Engineer can be contacted to determine if it may be discharged without treatment.

D. Discharge Monitoring - Unless the discharge from any bulk storage containment system outlet is identified in the SPDES permit as an outfall with explicit effluent and monitoring requirements, the permittee shall monitor the outlet as follows:

(i) *Bulk Storage Secondary Containment Systems:*

(a) The volume of each discharge from each outlet must be monitored. A representative sample shall be collected of the first discharge[1] following any cleaned up spill or leak. The sample must be analyzed for pH, the substance(s) stored within the containment area and any other pollutants the permittee knows or has reason to believe are present[2].

(b) Every fourth discharge[1] from each outlet must be sampled for pH, the substance(s) stored within the containment area and any other pollutants the permittee knows or has reason to believe are present[2].

(ii) *Transfer Area Secondary Containment Systems:*

The first discharge[1] following any spill or leak must be sampled for flow, pH, the substance(s) transferred in that area and any other pollutants the permittee knows or has reason to believe are present[2].

E. Discharge Reporting - Any results of monitoring required above must be submitted to the Department by appending them to the corresponding discharge monitoring report (DMR). Failure to perform the required discharge monitoring and reporting shall constitute a violation of the terms of the SPDES permit.

F. Prohibited Discharges - **In all cases, any discharge which contains a visible sheen, foam, or odor, or may cause or contribute to a violation of water quality is prohibited.** The following discharges are prohibited unless specifically authorized elsewhere in this SPDES permit: spills or leaks, tank bottoms, maintenance wastewaters, wash waters where detergents or other chemicals have been used, tank hydrotest and ballast waters, contained fire fighting runoff, fire training water contaminated by contact with pollutants or containing foam or fire retardant additives, and, unnecessary discharges of water or wastewater into secondary containment systems. An example of a necessary discharge could be the addition of steam to prevent bulk storage containment area sump pumps from freezing during cold weather.

DISCHARGE NOTIFICATION REQUIREMENTS:

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[1]Discharge includes stormwater discharges and snow and ice removal. If applicable, a representative sample of snow and/or ice should be collected and allowed to melt prior to assessment.

[2]If the stored substance is gasoline or aviation fuel then sampled for oil & grease, benzene, ethylbenzene, naphthalene, toluene and total xylenes (EPA method 602). If the stored substance is kerosene, diesel fuel, fuel oil or lubricating oil gasoline or aviation fuel then sampled for oil & grease and polynuclear aromatic hydrocarbons (EPA method 610). If the substance(s) are listed in Tables 6-8 of application form NY-2C sampling is required. If the substance(s) are listed in NY-2C Tables 9-10 sampling for appropriate indicator parameters may be required, e.g., substituting BOD5 for methanol, substituting toxicity testing for demeton. Discharge volume may be calculated by measuring the depth of water within the containment area times the wetted area converted to gallons or by other suitable methods. *Form NY-2C is available on the NYSDEC web site. Contact the facility inspector for further guidance.* In all cases flow and pH monitoring is required.

1. The permittee shall, except as set forth in (c) below, maintain the existing identification signs at all outfalls to surface waters, which have not been waived by the Department in accordance with 17-0815-a. The sign(s) shall be conspicuous, legible and in as close proximity to the point of discharge as is reasonably possible while ensuring the maximum visibility from the surface water and shore. The signs shall be installed in such a manner to pose minimal hazard to navigation, bathing or other water related activities. If the public has access to the water from the land in the vicinity of the outfall, an identical sign shall be posted to be visible from the direction approaching the surface water.

The signs shall have **minimum** dimensions of eighteen inches by twenty four inches (18" x 24") and shall have white letters on a green background and contain the following information:

N.Y.S. PERMITTED DISCHARGE POINT

SPDES PERMIT No.: NY__________

OUTFALL No. :____

For information about this permitted discharge contact:

Permittee Name: ____

Permittee Contact: ____

Permittee Phone: (   ) - ### - ####

OR:

NYSDEC Division of Water Regional Office Address :

NYSDEC Division of Water Regional Phone: (   ) - ### -####

2. For each discharge required to have a sign in accordance with a), above, the permittee shall provide for public review at a repository accessible to the public, copies of the Discharge Monitoring Reports (DMRs) as required by the **RECORDING, REPORTING AND ADDITIONAL MONITORING REQUIREMENTS** page of this permit. This repository shall be open to the public, at a minimum, during normal daytime business hours. The repository may be at the business office repository of the permittee or at an off-premises location of its choice (such location shall be the village, town, city or county clerk's office, the local library or other location as approved by the Department). In accordance with the **RECORDING, REPORTING AND ADDITIONAL MONITORING REQUIREMENTS** page of your permit, each DMR shall be maintained on record for a period of three years.

3. The permittee shall periodically inspect the outfall identification signs in order to ensure that they are maintained, are still visible and contain information that is current and factually correct.

RECORDING, REPORTING AND ADDITIONAL MONITORING REQUIREMENTS:

1. The permittee shall also refer to 6 NYCRR Part 750 (http://www.dec.state.ny.us/website/regs/750.htm) for additional information concerning monitoring and reporting requirements and conditions.
2. The monitoring information required by this permit shall be summarized, signed and retained for a period of three years from the date of the sampling for subsequent inspection by the Department or its designated agent.

Also, monitoring information required by this permit shall be summarized and reported by submitting:

[x] (if box is checked) completed and signed Discharge Monitoring Report (DMR) forms for each 1 month reporting period to the locations specified below. Blank forms are available at the Department's Albany office listed below. The first reporting period begins on the effective date of this permit and the reports will be due no later than the 28th day of the month following the end of each reporting period.

[ ] (if box is checked) an annual report to the Regional Water Engineer at the address specified below. The annual report is due by February 1 and must summarize information for January to December of the previous year in a format acceptable to the Department.

[ ] (if box is checked) a monthly "Wastewater Facility Operation Report..." (form 92-15-7) to the:
[ ] Regional Water Engineer and/or [ ] County Health Department or Environmental Control Agency specified below

Send the <u>original</u> (top sheet) of each DMR page to:

Department of Environmental Conservation
Division of Water
Bureau of Watershed Compliance Programs
625 Broadway
Albany, New York 12233-3506

Phone: (518) 402-8177

Send the **first** <u>copy</u> (second sheet) of each DMR page to:

Department of Environmental Conservation
Regional Water Engineer, Region 3
200 White Plains Road
Tarrytown, New York 10591

Phone: 914-332-1835

3. Noncompliance with the provisions of this permit shall be reported to the Department as prescribed in the attached General Conditions (Part II).

4. Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit.

5. If the permittee monitors any pollutant more frequently than required by the permit, using test procedures approved under 40 CFR Part 136 or as specified in this permit, the results of this monitoring shall be included in the calculations and recording of the data on the Discharge Monitoring Reports.

6. Calculation for all limitations which require averaging of measurements shall utilize an arithmetic mean unless otherwise specified in this permit.

7. Unless otherwise specified, all information recorded on the Discharge Monitoring Report shall be based upon measurements and sampling carried out during the most recently completed reporting period.

8. Any laboratory test or sample analysis required by this permit for which the State Commissioner of Health issues

certificates of approval pursuant to section five hundred two of the Public Health Law shall be conducted by a laboratory which has been issued a certificate of approval. Inquiries regarding laboratory certification should be sent to the Environmental Laboratory Accreditation Program, New York State Health Department Center for Laboratories and Research, Division of Environmental Sciences, The Nelson A. Rockefeller Empire State Plaza, Albany, New York 12201.

New York State Department of Environmental Conservation
Erin M. Crotty, Commissioner

FACT SHEET

NEW YORK STATE POLLUTANT DISCHARGE ELIMINATION SYSTEM (SPDES) DRAFT PERMIT RENEWAL WITH MODIFICATION
INDIAN POINT ELECTRIC GENERATING STATION
Buchanan, NY - November 2003

Facility Name: Indian Point Units 1, 2 and 3
SPDES #: NY-0004472

DEC Application #s: 3-5522-00011/00004

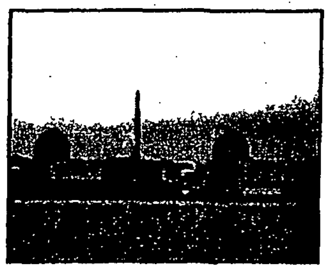

Fig. 1: Indian Point Nuclear Generating Station, Hudson River, New York State

I. Introduction:

These fact sheets generally describe the environmental and facility operational issues and draft permit conditions of a modified SPDES permit which the Department of Environmental Conservation (Department) proposes to issue for the Indian Point Electric Generating Station in Buchanan, New York. The draft permit will be the subject of a public review and comment period, as well as an administrative hearing process (including adjudication, if determined to be appropriate), before the Department issues a final permit.

The draft permit contains conditions which address three aspects of operations at Indian Point regulated under the United States' Clean Water Act (CWA; 33 USC §1251, *et seq.*) and parallel New York State law and regulations: conventional industrial pollutant discharges, thermal discharge, and cooling water intake structure. Limits on the conventional industrial discharges are not significantly changed from the previous permit. New conditions are included to address the thermal discharge and to implement the "best technology available" (BTA) for minimizing adverse impacts to aquatic resources from the cooling water intake.

Detailed discussions of water quality and biological components of the permit follow at Attachments A and B.

II. Facility Description:

The Indian Point facility is located on the east shore of the Hudson River at about River Mile 42, in Buchanan, New York (NY), south of Peekskill, in Westchester County, NY (figure 2, below). Indian Point Units 2 and 3 are nuclear powered steam electric generating plants owned and operated by Entergy Nuclear Indian Point 2 LLC and Entergy Nuclear Indian Point 3 LLC (Entergy - the permittee), respectively. Units 2 and 3 have a combined generating capacity of 1910MW. Indian Point Unit 1, also owned and managed by Entergy Nuclear, is no longer generating and is awaiting decommissioning; however, cooling and service water is still drawn through the Unit 1 intake.

Indian Point Power Plant

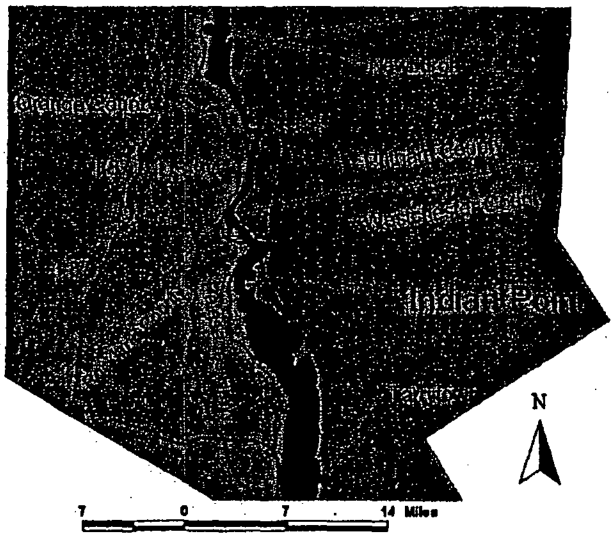

Fig. 2: General Location of Indian Point Nuclear Generating Station on the Hudson River, New York State

The Indian Point facility uses once-through cooling systems that withdraw up to 2.5 billion gallons of water per day from the Hudson River. This cooling water is drawn in through three intake structures located on the shoreline of the Hudson River. Heated non-contact cooling water is discharged back into the Hudson through sub-surface diffuser ports located along the seaward wall of the discharge canal which is located down-river (south) of the intake structures. Some residual industrial chemicals are discharged with the thermal discharge.

The facility currently operates Ristroph modified traveling screens, a fish handling and return system, two-speed pumps in Unit 2, and variable-speed pumps in Unit 3 as measures to reduce mortality of fish and aquatic invertebrates due to operation of the cooling water intake system.

III. Hudson River Settlement Agreement:

Prior SPDES permits for the Indian Point facility (along with the Roseton and Bowline Point steam electric generating units) reflected the terms of the 1981 - 1991 "Hudson River Settlement

Agreement" (HRSA) and four subsequent Consent Orders (effective 1992 - 1998) that generally extended HRSA conditions. The HRSA and Consent Order terms included specific provisions to partially address thermal discharges, some aquatic organism protection measures and a series of long-term studies of Hudson River fish species. The last SPDES permit for the Indian Point facility expired in 1992, but its terms have been continued under provisions of the NY State Administrative Procedure Act (SAPA).

IV. Overview of the Permit

This draft permit continues the discharge limits on certain metals, solvents and other industrial pollutants contained in the current permit. In addition, it requires compliance with thermal discharge standards and includes measures to protect aquatic organisms. The thermal discharge conditions will generate data that the Department can use to determine whether the thermal discharges from Units 2 and 3, together or separately, meet New York State thermal criteria. The conditions related to the protection of aquatic organisms will reduce impingement and entrainment of fish and other small aquatic organisms. (Large fish are impinged against the cooling water intake screens. Smaller organisms are entrained when they are drawn into and through the plant's cooling water system.) Finally, the draft permit also mandates the continuation of certain aquatic resource protection measures and Hudson River monitoring studies currently in use at the facility.

A. Conventional Industrial Discharges: Discharges related to the former on-site sewage treatment plant have been discontinued because sanitary waste from Indian Point is now routed to the community wastewater treatment plant. No other significant changes are proposed to existing effluent limits.

B. Thermal Discharges: The permittee must satisfy the provisions of Section 316(a) of the CWA and related requirements in 6 NYCRR Section 704.2 which provide that the thermal discharges from Indian Point to the Hudson River should meet regulatory temperature criteria for estuaries, and must meet the NYS standard of ensuring the propagation and survival of a balanced, indigenous population of shellfish, fish and other aquatic species.

- Within the first two years of the SPDES permit term, the permittee must conduct a tri-axial (3-dimensional) thermal study to document whether the thermal discharges from Units 2 and 3 comply with NYS water quality criteria.

- In the event that the Indian Point cooling water discharge does not meet the NYS thermal criteria, the permittee may apply for a modification of one or more of the criteria as provided for under 6 NYCRR Part 704.4. In applying for a modification, the permittee must establish to the satisfaction of the Department that one or more of the criteria are unnecessarily restrictive and that the modification would not inhibit the existence and propagation of a balanced indigenous population of shellfish, fish and wildlife in the Hudson River.

- Closed-cycle cooling is an available technology which can substantially reduce the amount of heat discharged into the Hudson River by reducing intake flow.

C. Cooling Water Intake Structure: Pursuant to Section 316(b) of the CWA, and 6 NYCRR Section 704.5, the Department has determined that the site-specific best technology available (BTA) to minimize adverse environmental impact of the Indian Point Units 1, 2 and 3 cooling water intake structures is closed-cycle cooling. However, the Department will give the permittee the opportunity to propose, within a year of the permit becoming effective, an alternative technology(s) that can minimize adverse environmental impact to a level equivalent to that which can be achieved by closed-cycle cooling at this site. The Department will evaluate any proposal submitted by the permittee. If the proposed technology(s) is accepted, the Department may modify the permit accordingly.

1. Immediate Fish Protection Measures:
In addition to the steps above, upon the effective date of the SPDES permit, the permittee must take the following steps to reduce or mitigate adverse environmental impacts from the continued operation of the existing once-through cooling water intake system while steps are being taken to implement BTA.

- To reduce the number of fish and other aquatic organisms entrained by reducing water withdrawals at Indian Point, the permittee must schedule and take annual generation outages of no fewer than 42 unit-days between 23 February and 23 August of each calendar year (the entrainment season). These outages must continue until the permittee has commenced operation of a closed-cycle cooling system at the Indian Point facility.

- To minimize injury and mortality to adult and juvenile fish due to impingement on the intake screens, the permittee must continue operating the existing, Department-approved fish impingement mitigation measures (*e.g.*, Ristroph screens, fish return sluiceway).

- To reduce entrainment when the facility is operating, the permittee must reduce flows throughout the year according to a prescribed schedule specified in the permit.

- The permittee must also, during each calendar year, continue to conduct long-term Hudson River fish monitoring programs: Long River Ichthyoplankton, Fall Shoals Trawls, Beach Seine, and Striped Bass/Atlantic Tomcod Mark-Recapture Survey.

2. Additional Compliance Measure:
Upon the effective date of the SPDES permit, the permittee must pay $24 million annually into an escrow account entitled the Hudson River Estuary Restoration Fund (HRERF), to be made available to the Department. All of the HRERF funds shall be held for the benefit of the HRERF, from which the Department will draw funds for programs or projects that are designed to restore, protect, or enhance Hudson River Estuary resources. These resources include but are not limited to aquatic habitat, fish, shellfish and other aquatic species (all life stages), and Hudson River water quality. This amount represents: a) the difference between the cost of operating and maintaining the existing facility and the cost of operating and maintaining a facility using closed-cycle cooling, and b) the expected return on unspent capital (i.e. the cost to construct cooling towers) that is instead available for investment. These annual payments will continue until the permittee has commenced construction of cooling towers for the closed-cycle cooling system at the Indian Point facility.

D. Pending Issues: Actual construction of a closed-cycle system cannot occur until certain initial investigations and proceedings have been completed. The permittee must, therefore, undertake specific steps to implement closed-cycle cooling:

1. Pre-Design Engineering Report
The permittee must complete certain site-related inquiries, including but not limited to assessing: potential need for blasting as well as any potential impacts from blasting; cooling tower particulate emissions; potential need to relocate the Algonquin Gas Company's natural gas pipeline; whether construction outages for Units 2 and 3 must occur simultaneously, can be done sequentially, or under an alternative schedule; and whether the construction outages, 42 day annual operating outages, or other measures can be undertaken so as to reduce potential impacts to energy reliability or capacity. Thus, the Department is requiring the permittee to submit for approval a Pre-Design Engineering Report that addresses and resolves all regulatory and engineering issues associated with installing closed-cycle cooling for Units 1, 2, and 3. This submission must occur within one year of the effective date of the SPDES permit.

2. Detailed Engineering Plans
Within one year after submission of the Pre-Design Engineering Report, the permittee must submit complete design plans that address all construction issues for conversion of Units 1, 2 and 3 to closed-cycle cooling.

3. License Modification and Other Approvals
The permittee must obtain approvals for closed-cycle cooling system construction from other government agencies having authority over the nuclear power generation facilities or aspects of the construction site. This includes, but is not limited to, the permittee's obtaining modifications of its operating licenses from the Nuclear Regulatory Commission (NRC) to authorize conversion to closed-

cycle cooling. The NRC will review operational safety and hazard issues that arise as a consequence of the permittee's proposal to convert to closed-cycle cooling. It also includes obtaining the approval of the Federal Energy Regulatory Commission (FERC) to relocate the Algonquin Gas Company's natural gas pipeline, if such relocation is determined to be necessary. Other state and local agency approvals may also be required. To address these issues, the Department is requiring the permittee to submit, within 6 months of the effective date of the SPDES permit, a schedule showing the permittee's plan for seeking other necessary government approvals for the construction of closed-cycle cooling for the Indian Point facility. If the NRC denies or requires changes to Entergy's application to modify its licenses, or if FERC does not approve relocation of the Algonquin pipeline, the Department may initiate a modification of the permit, or take other appropriate action.

4. NRC License Extension

An important unsettled issue relates to the potential for Entergy to seek an extension of its NRC operating licenses. The Department cannot require the permittee to seek NRC license extensions. If the permittee determines that it will not extend its NRC licenses, or the NRC denies the license extensions, the Department will not require the construction of a closed-cycle cooling system. In that case the Department may also initiate a proceeding to modify the permit, including revision of the Department's BTA determination.

This permit does not require the construction of cooling towers unless: (1) the applicant seeks to renew its NRC operating licenses, (2) the NRC approves extension of the licenses, and determines that the installation and operation of closed-cycle cooling is feasible and safe, and (3) all other necessary Federal approvals are obtained. If the NRC grants extensions of the permittee's licenses, the permittee must submit for Department approval a revised construction schedule to reflect any construction design or schedule changes resulting from the NRC approval process or other approvals. Entergy has estimated that once construction begins, the conversion to closed-cycle cooling will take 4 years and 9 months to complete. In order to ensure reliability of the State electric system, the Department will require that the permittee, in the process of producing the revised compliance schedule, investigate avoiding construction outages during the summer months of peak electricity consumption. Implementation of closed-cycle cooling will be subject to the specific preliminary requirements described above.

V. Attachments:

A: SPDES Permit Fact Sheet and summary of proposed permit changes for Wastewater Data, Receiving Water Data, and Permit Limit Derivation.

B: SPDES Permit Biological Fact Sheet and summary of proposed permit changes for Aquatic Resources and Best Technology Available (BTA) Determination.

Attachment A

SPDES PERMIT FACT SHEET and summary of proposed permit changes: Wastewater Data, Receiving Water Data, and Permit Limit Derivation.

SPDES PERMIT FACT SHEET: Wastewater Data, Receiving Water Data, and, Permit Limit Derivation.

(see last pages of fact sheet for explanatory notes).

(1) General Permittee Data:

Permit Number	Permittee Name	Facility Name	Location (C, T, V)	County	Industrial Code	Major/Sub Basin
0004472	Entergy Nuclear, Indian Point	Indian Point Nuclear Generation Facility	Buchanan	Westchester	4911	13-01

(2) Summary of Final Outfall Flow Rate(s) and Receiving Water Data:

Outfall Information					Receiving Water Information									
	Latitude	Longitude	Flow Rate (MGD)					*For use by WQ Engineer* - Critical Data						
Outfall #	°, ', "	°, ', "	Average	Maximum or Design	Name	Class	Water Index Number	7Q10 (MGD)	30Q10 (MGD)	Dilution/ Mixing	pH (SU)	Temp (°F)	Hardness (mg/l)
001	41 16 07	73 57 19		2500	Once-Through Cooling Water & LVW	SB	H						
002-009	"	"		Variable	Uncontaminated Stormwater Runoff	"	H						
01P	"	"		TBD	Eductor Pit Discharge	"	"						

(3) Individual Outfall Data Summaries and Permit Limit Development:

Outfall	001

Source(s) of Wastewater	Once-through Cooling Water, contributory treated wastewater streams (low volume wastewater)
Existing Wastewater Treatment Facilities	
EPA Point Source Category & Production Rate	Steam Electric Power Generation 40 CFR 423

Effluent Parameter (Units)	Existing Effluent Quality				Technology Based Effluent Limit					Water Quality Based Effluent Limit				Permit Basis (T or WQ)
(concentration units - mg/l, ug/l or ng/l; mass units - lbs/d or g/d)	concentration		mass					PQL		AWQC	Effluent			
	Avg/Max	95%/99%	Avg/Max	95%/99%	conc.	mass	Type	conc.	Basis	conc.	conc.	mass	Type	
WET TESTING								NA		Recommended?	NO			
Flow Rate, units = MGD	Average		Maximum	2500				NA	NA					
pH (su)	Minimum	6.0	Maximum	9.0			Range		40CFR423					
Total Residual Chlorine mg/l	0.2				0.2				40CFR423	0.0075				T
Lithium Hydroxide mg/l	0.01				0.01				BAT/BPJ	NA				T
Boron - Acid Soluable mg/l	0.7				1.0	525			BAT/BPJ	1.0				T
Temperature Degrees F*	110				110				6NYCRR Part 704					
* See (4) Additional Issues Page 4 of this document														
SUM OF 01B,01C, 01D, 01J& 01L														
Total Suspended Solids mg/l					50				BCT					T
SUM OF 01C & 01D														
Hexavalent Chromium mg/l					.1				BAT/BPJ	0.054				T
OUTFALL 01G														
Phosphates as P mg/l					38				BPJ	NA				T

(3) Individual Outfall Data Summaries and Permit Limit Development:

Outfalls	01M, 002-009

Source(s) of Wastewater	Uncontaminated Stormwater Runoff
Existing Wastewater Treatment Facilities	
EPA Point Source Category & Production Rate	40CFR423

Uncontaminated Stormwater Runoff - NO MONITORING REQUIRED

OUTFALLS 01L, 01P and 01N

Effluent Parameter (Units)	Existing Effluent Quality				Technology Based Effluent Limit					Water Quality Based Effluent Limit				Permit Basis (T or WQ)
(concentration units - mg/l, ug/l or ng/l; mass units - lbs/d or g/d)	concentration		mass					PQL		AWQC	Effluent			
	Avg/Max	95%/99%	Avg/Max	95%/99%	conc.	mass	Type	conc.	Basis	conc.	conc.	mass	Type	
01L								NA		Recommended?		NO		
Flow Rate, units =	Average		Maximum					NA						
pH (su)	Minimum	6.0	Maximum	9.0	6.0-9.0		Range		BCT					T
Florides						5.0 lb/day			AL					AL
Iron					4mg/l				AL					AL
Copper					1.0mg/l				AL					AL
CONTRIBUTORY WASTEWATER TO 001 01P EDUCTOR PIT DISCHARGE														
Oil & Grease mg/l					15				BCT					T
Total Suspended Solids mg/l					50				BCT					T
01N														
Oil & Grease mg/l					15				BCT					T
Total Suspended Solids mg/l					50				BCT					T

4) Additional Issues (see next page)

(4) Additional Issues

Water Quality Based Effluent Limits (WQBELs):
New York State water quality regulations (for surface waters) are implemented by applying the Total Maximum Daily Load (TMDL) process to watersheds, drainage basins or waterbody segments on a pollutant specific basis. The analysis determines if there is a "reasonable potential" that the discharge of a pollutant will result in exceedance of ambient water quality criteria (AWQC). If there is a reasonable potential for an exceedance of AWQC, the TMDL is used to establish waste load allocations for point sources and load allocations for nonpoint sources of the pollutant. For point sources, the waste load allocations are translated to WQBELs for inclusion in SPDES permits.

Reference - TOGS 1.3.1; USEPA Guidance for Water Quality - Based Decisions: The TMDL Process; 40 CFR 130; and the Clean Water Act 303(d).

See also thermal discharge discussion, below.

Statistics:
The statistical methods utilized are consistent with TOGS 1.2.1 and the USEPA, Office of Water, Technical Support Document For Water Quality-based Toxics Control, March 1991, Appendix E. They are generally based on log normal analysis. If other data distributions such as normal or delta-lognormal are utilized, it is noted below. Statistical calculations were not performed for parameters with insufficient data. Generally, ten or more data points are needed to calculate percentiles. Two or more data points are necessary to calculate an average and a maximum. Non-detects were included in the statistical calculations at the reported detection limit unless otherwise noted.

Monitoring data collected during the following time period was used to calculate statistics: N/A

This data was taken from the following source(s): N/A

Internal Waste Stream Monitoring:
40 CFR 122.45(h)(1) allows the permit authority to monitor and limit parameters at internal locations when controlling them solely at the final outfall is impractical or infeasible. Dilution of a process wastewater with large volumes of cooling water and/or storm water is one example of when the use of an internal monitoring point is justified. Monitoring at the following internal outfalls is necessary: 01B, 01C, 01D, 01G, 01L, & 01P.

WET Testing:
Testing is required, in accordance with TOGS 1.3.2, for the following reasons: NOT REQUIRED

Indicator Parameters:
In accordance with 40 CFR 122.44(e)(2), The permit writer has determined that effective treatment and/or acceptable performance for specific parameters is indicated by one or more other parameters which are limited and therefore a decision has been made to not limit or monitor these specific parameters. This judgement is based on the similarity between this and the regulated parameter(s) and historical data where available. The use of indicator parameters is not appropriate for WQBELs. Following is a list of the affected parameters: N/A

Thermal:
Under Section 316(a) of the Clean Water Act (CWA), a permittee may submit a demonstration that its thermal discharge does not threaten the survival of indigenous aquatic populations even if it does not meet state water quality criteria. Such a study was prepared in 1978 by the prior owners of the Indian Point units, but it was superseded by provisions of the 1981 - 1991 Hudson River Settlement Agreement and subsequent Consent Orders effective 1992 - 1998. Based on that older "316(a) demonstration", the former operators of the Indian Point units asserted that the facility complied with the NYS thermal standard (6 NYCRR Part 704).

Based on modeling submitted with the 1999 DEIS by the prior owners of Indian Point (along with owners of two other Hudson River generating stations), the thermal criteria outlined in 6 NYCRR Part 704.2 are not being consistently maintained under the present operation of the facility. Appendix VI Chapter 6 of the 1999 DEIS, "Near-field Temperature Modeling", concludes that newer analyses of the discharge from Indian Point "... indicate that it is highly likely that the exceedance of the top-width criterion, and possible the cross-sectional area criterion, would occur under slack conditions. Top-width exceedances occur under all flood scenarios . . . ." In more general terms, this means that temperatures measured at the water surface along a line running from the outfall across the river to the far shore, and measured at varying depths along the cross-section below that line from outfall to far shore, likely exceed the thermal criteria in the Department's regulations during periods with lowest river flow velocities, that is, during the transition between tidal cycles. Furthermore, temperatures at the water surface along that same line from outfall to far shore appear to exceed the thermal criteria at all flow levels classified as "flood", that is, during high tides.

The permit therefore requires the permittee to conduct additional thermal studies to verify actual in-stream conditions of the thermal component of the discharge. The in-stream tri-axial study mandated by Special Condition 7 will require actual measurement of river and outfall temperatures at multiple points on the surface and at depth, along the surface and in cross-section running from the outfall and across the river to the far shore, as well as temperature measurements on the surface and at various depths at specified points running parallel to the course of the river. Using this additional data plus existing sources, the Department will be able to determine if the Indian Point facility complies with the thermal standard and whether to grant Indian Point a variance from NYS thermal criteria.

Schedule of Compliance:

A schedule of compliance items and submissions has been developed and summarizes all required submissions for the term of the permit.

5) Summary of Proposed Permit Changes:

Compared to the issued permit this draft is intended to replace, the following significant changes are proposed:

Deleted outfalls: 01A and 01F

Added outfall 01P - Eductor Pit Discharge.

Added Thermal studies.

Removed all references to the now-expired Hudson River Settlement Agreement.

Includes a schedule of compliance.

(6) Explanatory Notes:

Please note that some of these terms are not applicable to every fact sheet.

AL -	Action level calculated in accordance with TOGS 1.2.1 (non POTWs) and TOGS 1.3.3 (POTWs). See the permit for a complete definition.
AVG or Av -	Average. The arithmetic mean.
AWQC -	Ambient water quality criteria for the receiving water. The applicable standard, guidance value or estimated value in accordance with TOGS 1.1.1, TOGS 1.3.1 and 6NYCRR 700-705.
Basis -	The technical analysis, internal guidance, regulation and/or law upon which an effluent limit or monitoring requirement is proposed.
BAT -	Best Available Technology Economically Achievable in accordance with TOGS 1.2.1 (non POTWs) and TOGS 1.3.3 (POTWs), 40 CFR 125, 6NYCRR 754, ECL 17-0811 and the Clean Water Act.
BCT -	Best Conventional Control Technology in accordance with TOGS 1.3.4, 40 CFR 125, 6NYCRR 754, ECL 17-0811 and the Clean Water Act.
BPJ -	Best Professional Judgement in accordance with TOGS 1.2.1 (non POTWs) and TOGS 1.3.3 (POTWs), 40 CFR 122 and 125, 6NYCRR 754.1, ECL 17-0811 and the Clean Water Act.
BPT -	Best Practicable Control Technology in accordance with TOGS 1.2.1, 40 CFR 125, 6NYCRR 754, ECL 17-0811 and the Clean Water Act.
BTA-	Best Technology Available
Conc. -	Concentration in units of mg/l, ug/l or ng/l.
Design Flow -	Treatment system design capacity as noted in an approved engineering report.
EDP	Effective date of permit.
Final -	Final permit period requirements. A level of performance that must be achieved according to a schedule specified in either the permit or a consent order.
FERC-	Federal Energy Regulatory Commission
g/d -	Grams per day discharged.
GW -	Groundwater effluent limitation developed in accordance with TOGS 1.2.1 (nonPOTWs), TOGS 1.3.3 (POTWs), TOGS 1.1.2 and 6NYCRR 703.
Ind -	Indicated parameter. See definition in section (4).
Interim -	Interim permit period requirements. A level of performance that must be achieved while improvements are being implemented in order to achieve final permit period requirements.
lbs/d or #/d -	Pounds per day discharged.
LVW	Low volume wastes/wastewater
Mass -	Mass discharge in units of #/d or g/d discharge.
Max or Mx -	The maximum value.
MGD -	Million gallons per day.
mg/l -	Milligrams per liter.
Dilution/Mixing -	Used to determine dilution available in receiving waters. For lakes, estuaries and slowly flowing rivers and streams, mixing zone dilution is generally assumed to be 10:1 unless data is available to indicate otherwise.
Model -	Calibrated water quality model applied in accordance with TOGS 1.3.1.
Mon -	Monitor only.
NA or N/A -	The characteristics of this parameter and the reported discharge levels do not justify routine monitoring or a limit. Also indicates "not applicable".
ng/l -	Nanograms per liter. 1000 ng/l = 1 ug/l = 0.001 mg/l.
NRC-	Nuclear Regulatory Commission
POTW -	Publicly owned treatment works (i.e., sewage treatment plants)
PQL -	The DEC published or site specific practical quantitation limit; the concentration in wastewater at which analytical results are thought to be accurate to within approximately plus or minus thirty percent.
R -	"Rolled Over", i.e. the specific requirement in this permit is equivalent to the previous permit. R(T) is roll over of a technology based requirement and R(WQ) is roll over of a WQBEL.
Range -	The discharge is limited to a range of effluent values, e.g. a pH limit of (6.0-9.0) SU.
RREL -	EPA's Risk Reduction Engineering Laboratory treatability database.
T -	Technology based effluent limit or requirement.
TOGS -	Technical and Operational Guidance Series. Internal guidance to permit drafters used by the NYSDEC Division of Water to aid in permit drafting. Copies of these guidance documents may be obtained from the internet at http://www.dec.state.ny.us/website/dow/togs/index.htm.
ug/l -	Micrograms per liter. 1000 ug/l = 1 mg/l.
WET-	Whole Effluent Toxicity (testing). See TOGS 1.3.2.
WQ -	Water quality.
WQBEL -	Water quality-based effluent limit. See information in section (4).
7Q10 -	The minimum average 7 consecutive day flow at a recurrence interval of 10 years. Applicable to evaluations involving aquatic health based AWQC.
30Q10 -	The minimum average 30 consecutive day flow at a recurrence interval of 10 years. Applicable to evaluations involving human health based AWQC.
95% -	The 95th percent confidence interval for the historical effluent data used to draft the permit.
99% -	The 99th percent confidence interval for the historical effluent data used to draft the permit.
133 -	Secondary treatment requirements in accordance with TOGS 1.3.3, 40 CFR 133, 6NYCRR 754, ECL 17-0509 and the Clean Water Act.
* -	These parameters represent scans. Detections vary among the compounds which are included in the scans. The listed value represents the maximum detected level of any compound in the scan.

Attachment B

SPDES PERMIT BIOLOGICAL FACT SHEET and summary of proposed permit changes: Aquatic Resources and Best Technology Available (BTA) Determination

1. Biological Effects

Each year Indian Point Units 2 and 3 (collectively "Indian Point") cause the mortality of more than a billion fish from entrainment of various life stages of fishes through the plant and impingement of fishes on intake screens. Entrainment occurs when small fish larvae and eggs (with other aquatic organisms) are carried into and through the plant with cooling water, causing mortality from physical contact with structures and thermal stresses. Impingement occurs when larger fish are caught against racks and screens at the cooling water intakes, where these organisms may be trapped by the force of the water, suffocate, or otherwise be injured. Losses at Indian Point are distributed primarily among 7 species of fish, including bay anchovy, striped bass, white perch, blueback herring, Atlantic tomcod, alewife, and American shad. Of these, Atlantic tomcod, American shad, and white perch numbers are known to be declining in the Hudson River (ASA Analysis and Communications 2002). Thus, current losses of various life stages of fishes are substantial.

2. Alternatives Evaluated

The following technologies were evaluated to determine whether they would effectively minimize adverse environmental impact from this facility:

- Relocation of intake structure
- Technologies currently in use at Indian Point:
  - Fish Handling and Return Systems
  - Ristroph Modified Traveling Screens
  - Variable-Speed Pumps
- Aquatic Microfiltration Barriers
- Flow Reductions
- Closed-cycle Cooling
- Generation Outages

Other available technologies, like wedgewire screens, were not evaluated as alternatives because they were determined not to be feasible for Indian Point's site and operation.

3. Discussion of Best Technology Available

According to Section 316(b) of the federal Clean Water Act and 6 NYCRR Part 704.5, the location (A), design (B), construction (C), and capacity (D) of cooling water intake structures must reflect the "best technology available" (BTA) for minimizing adverse environmental impact. In addition, the costs of these technologies should not be "wholly disproportionate" to the environmental benefits derived. The application of BTA is site-specific.

A. Location

The existing intake structure is located on the shoreline of the Hudson River adjacent to the power plant. Relocation of the intake structure to another shoreline location or an offshore location would not decrease the mortality of aquatic organisms because fish eggs and larvae in this area of the Hudson River are equally abundant in all alternate locations.

B. Design

Technologies currently in use at Indian Point

The current design of the intake structure includes Ristroph modified traveling screens, a fish handling and return system, two-speed pumps serving Unit 2, and variable-speed pumps serving Unit 3.

Traveling Screens: The Ristroph modified traveling screens are designed to reduce the mortality of fishes associated with traditional traveling screens. The screens at Indian Point also include a low pressure spray system that washes impinged fish and other larger aquatic organisms off the screens separately from debris that is removed using a high pressure spray.

Fish Handling Systems: The fish handling and return systems convey the fish and other organisms washed off the screens back into the Hudson River.

Multiple-Speed Pumps: The two-speed and variable-speed pumps allow Entergy to more precisely adjust the volume of water drawn into the plant compared to single-speed pumps. This more precise adjustment allows for a reduction in the volume of cooling water drawn into the plant, thereby reducing the numbers of aquatic organisms entrained and impinged.

According to Entergy, this current design, along with seasonal flow reductions and generation outages (see below), attains an estimated 77% reduction in impingement mortality but only 35% reduction in entrainment mortality over full flow conditions (ASA Analysis & Communication 2003).

Aquatic Microfiltration Barriers (Gunderboom® Marine Life Exclusion System™ or similar technology)

Aquatic microfiltration barriers are designed to prevent entrainment of organisms by excluding them from the water near the intake structure. These barriers are made of fabric with a limited porosity and a large surface area of this fabric is required to pass large volumes of water. This limited porosity combined with the large flow of cooling water at this facility (up to 2.5 billion gallons of water daily) would require an aquatic microfiltration barrier many thousands of feet in length. An aquatic microfiltration barrier of this size would be orders of magnitude larger than any previous deployment. The physical dimensions combined with logistical constraints of anchoring would make seasonal deployment difficult, at best. In addition, use of an aquatic microfiltration barrier would require an offshore location for the intake structure to avoid hydraulic impacts from the intake on barrier performance (ASA Analysis & Communication 2003). Any offshore location at Indian Point would likely create a hazard to navigation. Based on all the above factors, installing an aquatic microfiltration barrier at Indian Point would not be feasible.

C. Construction

There will be no impacts on aquatic organisms from construction activities for any feasible alternative because these alternatives do not require physical work in the river. In addition, erosion and sediment control plans are required for upland construction activities under the Environmental Protection Agency's Phase II stormwater regulations. The requirements contained in these regulations should prevent incidental impacts to aquatic resources.

D. Capacity

Flow Reductions
Minimizing cooling water intake flow volume by varying or reducing intake pump speeds is not a feasible alternative for substantially reducing fish mortality at Indian Point. In order to operate safely, the Plants must run their cooling water pumps at 60% capacity or greater. Although it is possible to reduce flow by 40%, this can only be done when River water temperatures are low, primarily during winter months. Since few fish are susceptible to entrainment during those months, this presents only a minimal opportunity for reducing fish mortality.

Closed-Cycle Cooling
Closed-cycle cooling recirculates cooling water in a closed system that substantially reduces the need for taking cooling water from the River. Entergy's analysis (Enercon Services 2003) showed that the construction of hybrid cooling towers is generally feasible but will require prior review and approval from the Nuclear Regulatory Commission (NRC), which issues Entergy's operating licenses. The benefit of hybrid cooling towers for minimizing adverse environmental impacts is substantial, with greater than a 98% reduction in fish mortality (ASA Analysis and Communication 2003) that is primarily a result of reducing intake flow volumes. Although the projected capital cost to construct hybrid cooling towers is approximately $740 million, with additional operational and maintenance costs of $145 million (Enercon Services, Inc. 2003), these costs, projected over the life of the plant (assuming twenty year license extensions after the 2013 and 2015 license expirations for Units 2 and 3, respectively), represent approximately 5-6% of Indian Point's annual gross revenue. The Department considers that these costs are not wholly disproportionate to the environmental benefits of the near

elimination of fish mortality due to entrainment and impingement from Indian Point.

Generation Outages

Generation outages are another way to reduce cooling water flow that could result in substantial decreases in fish mortality. Annual outages lasting 32 weeks would result in reductions in fish mortality similar to closed-cycle cooling. Since these generation outages would be necessary each year, the economic costs to the operator over a possible 30 year life of the plant (assuming twenty year license extensions after the 2013 and 2015 license expirations for Units 2 and 3, respectively) would represent approximately 62% of Indian Point's annual gross revenue. The Department considers these costs to be wholly disproportionate to the environmental benefits derived.

4. Determination of Best Technology Available

After evaluating all of the known and available alternatives, the Department has determined that in this case closed-cycle cooling represents the best technology available for minimizing adverse environmental impacts from the cooling water intake structure at Indian Point. As noted above, the costs of hybrid cooling towers are not wholly disproportionate to the benefits derived, assuming 20-year license extensions for both units.

Although the Department has determined that closed-cycle cooling represents the best technology available for this site, several points need to be addressed prior to the construction of cooling towers. First, a detailed Pre-Design Engineering Report and design plans that identify and address all regulatory and engineering issues must be developed. Second, the NRC must review and approve any proposed change to a nuclear power plant. The NRC review will address safety and hazard considerations related to construction impacts to the reactor systems and is understood to involve license modification proceedings that would take approximately one year to complete. Third, construction of closed-cycle cooling, as described in Entergy's June 2003 submission of a preliminary design to the Department, would likely require the Algonquin Gas Company (Algonquin) to relocate its gas pipeline, currently located in the vicinity of Indian Point Unit 3 (Enercon Services, Inc. 2003). Such a relocation would require the approval of the Federal Energy Regulatory Commission (FERC), a separate process which may take approximately a year or more. The actual length of time required to complete all of these necessary steps is currently unknown and is not regulated by any State permit. Consequently, this SPDES permit requires Entergy to do the following:

1) Within one year of the effective date of the permit, submit for the Department's approval, a Pre-Design Engineering Report addressing regulatory and engineering issues. A detailed schedule for regulatory approvals and an interim progress report are also required (see Special Condition 28. b. of permit);

2) Within one year after submission of the Pre-Design Engineering Report, submit for the Department's review and approval detailed engineering drawings for the construction of closed-cycle cooling towers (see Special Condition 28. e. of permit);

3) Upon the effective date of the permit, continue the use of Ristroph modified traveling screens in continuous wash mode (see Special Condition 27 of permit);

4) Upon the effective date of the permit, continue the use of the existing fish handling and return system (see Special Condition 27 of permit);

5) Upon the effective date of the permit, reduce cooling water flow between October and June of each calendar year (see Special Condition 6 of permit);

6) Upon the effective date of the permit, take an annual 42 unit-day outage during entrainment season (23 February and 23 August). This requirement is only an interim measure and Entergy would not be required to take an outage during the entrainment season following the conversion of Indian Point's operations to closed-cycle cooling (see Special Condition 26 of permit);

7) Upon the effective date of the permit, continue to conduct the annual Longitudinal River Survey, Beach Seine Survey, Fall Shoals Trawls and Striped Bass/Atlantic Tomcod Mark Recapture Survey. These long term studies monitor the abundance of fishes in the Hudson River (see Special Condition 25 of permit); and

8) Provide $24 million per year to an escrow account entitled the Hudson River Estuary Restoration Fund (HRERF) that will provide a mechanism to fund restoration, enhancement and protection programs and projects benefiting the Hudson River Estuary (see Special Condition 29 of permit). HRERF monies are intended to benefit the Hudson River Estuary and eliminate Entergy's potential financial savings from the delayed implementation of closed-cycle cooling. The annual amount for this fund represents:

> (a) the difference between the cost of operating and maintaining the existing facility and the cost of operating and maintaining a facility using closed-cycle cooling; and
>
> (b) the expected return on unspent capital (i.e., the cost to construct hybrid cooling towers, approximately $740 million) that is instead available for investment.

Entergy would not be required to contribute additional money to the HRERF in the event that it commences construction of cooling towers.

5. Legal Requirements

The requirements for the cooling water intake structure in this SPDES permit are consistent with the policies and requirements embodied in the New York State Environmental Conservation Law, in particular Sections 1-0101.1.; 1-0101.2.; 1-0101.3.b., c.; 1-0303.19.; 3-0301.1.b., c., i., s.

and t.; 11-0303.; 11-0535.2; 17-0105.17.; 17-0303.2., 4.g.; 17-0701.2. and the rules thereunder, specifically 6 NYCRR Section 704.5. Additionally, the requirements are consistent with the Clean Water Act, in particular Section 316(b).

6. References

ASA Analysis and Communications, Inc. 2003. Response to New York State Department of Environmental Conservation Request for Information on Indian Point Unit 2 and Unit 3, Items 3 & 4. June 2003.

ASA Analysis and Communications, Inc. 2002. 1999 Year Class Report for the Hudson River Estuary Monitoring Program. August 2002.

Central Hudson Gas & Electric Corp., Consolidated Edison Company of New York, Inc, New York Power Authority, Southern Energy New York. 1999. Draft Environmental Impact Statement for State Pollutant Discharge Elimination System Permits for Bowline 1 & 2, Indian Point 2 & 3, and Roseton 1 & 2. December 1999.

Enercon Services, Inc. 2003. Economic and Environmental Impacts Associated with Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration. June 2003.

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 & 2, Bowline 1 & 2, and Indian Point 2 & 3 Steam Electric Generating Stations, Orange, Rockland, and Westchester Counties. June 25, 2003.

7. Summary of Proposed Permit Changes

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Condition 3 of the previous permit allowed the permittee to exceed the maximum cooling water flows stipulated in the Hudson River Settlement Agreement (HRSA) in order to meet thermal limits required in conditions 1 and 2. As HRSA has expired this condition is no longer relevant.

Condition 4 of the previous permit provided for increased cooling water flows above stipulated HRSA limits in order to meet thermal limits contained in the permit. As HRSA has expired this condition is no longer relevant.

Condition 5 of the previous permit referenced the HRSA and is no longer relevant.

Condition 6 of the previous permit stated that no thermal effluent limitations (other than existing conditions 1 through 4) would be imposed at the Indian Point facility. This condition relates to the agreement that the terms of the HRSA would satisfy the New York State Criteria Governing Thermal Discharges. As HRSA has expired, this condition is no longer relevant.

Additional Conditions

Condition 2 of the previous permit pertaining to the handling of solid waste and aquatic organisms has been deleted. The requirement to return organisms to the Hudson River through the sluices has been incorporated into the draft permit as condition 27.

Condition 4 of the previous permit referencing biological monitoring at Indian Point, which was a requirement of HRSA has been deleted, as no impingement or entrainment monitoring at the facility are required during this permit period.

Conditions 7 and 11 of the previous permit referencing the expired HRSA have been deleted. Relevant requirements contained in the HRSA are incorporated in this permit as conditions 25, 26, and 27.

New conditions:

Condition 25 requires the continuation of Hudson River Monitoring programs (which were previously embodied in HRSA).

Condition 26 requires a minimum of 42 unit-days of outages between February 23 and August 23 for each calendar year of the permit term. These outages must continue until complete conversion of Indian Point's operations to closed-cycle cooling. This is a continuation of the same level of outages required by HRSA.

Condition 27 requires that the modified Ristroph modified traveling screens number 21 through 26 and 31 through 36 must be operated on continuous wash when the corresponding cooling water circulation pump is on at the correct pressure in order to maximize the survival of fish impinged on the traveling screens.

Condition 28 requires the following submissions:

1) a schedule for obtaining all necessary approvals during this permit term from the Nuclear Regulatory Commission (NRC), Federal Energy Regulatory Commission (FERC), and other governmental agencies to enable the construction of closed-cycle cooling at Indian Point;

2) a report on the progress to date of the Pre-Design Engineering Report;

3) a Pre-Design Engineering Report addressing regulatory and engineering issues associated with installing closed cycle cooling at Units 1, 2, and 3;

4) engineering design plans that address all construction issues for the conversion of the cooling water systems for Units 1, 2, and 3 to a closed-cycle system;

5) within 30 days after receipt of license extensions from the NRC, the permittee must submit a revised or updated construction schedule for the Department's approval reflecting any changes resulting from the NRC license extension process; and

6) notification to the Department's Division of Environmental Permits, in writing, within 5 business days of the submission of an application for license modification or extension to the NRC.

Condition 29 requires the permittee to pay $24 million dollars annually into a Hudson River Estuary Restoration Fund escrow account.

SUPREME COURT OF THE STATE OF NEW YORK
COUNTY OF ALBANY

In the Matter of the Application of

MIRANT BOWLINE, LLC

Petitioner-Plaintiffs,

For a judgment pursuant to Article 78 of the Civil Practice Law and Rules,

against

AFFIDAVIT

THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION and ERIN CROTTY, as Commissioner, New York State Department of Environmental Conservation,

Index No. 6749-03

Respondent-Defendants,

ENTERGY NUCLEAR INDIAN POINT 2, LLC; ENTERGY NUCLEAR INDIAN POINT 3, LLC; DYNEGY ROSETON, LLC; and DYNEGY NORTHEAST GENERATION, INC.

Respondent-Defendants.

STATE OF NEW YORK)
ss:
COUNTY OF ALBANY)

BETTY ANN HUGHES, being duly sworn, deposes and states:

1. I am a Environmental Analyst 3 with the New York State Department of Environmental Conservation (Department or DEC), employed in the Division of Environmental Permits. Included in my assigned responsibilities are matters and proceedings concerning

permitting electric generating facilities which involves the review of applications made to DEC for State Pollutant Discharge Elimination System (SPDES) permits.

2. I make this affirmation in support of DEC's Motion to Consolidate and Dismiss and in opposition to the petition of Mirant Bowline, LLC ("Petitioner"or "Mirant") herein. As the Department's project manager assigned to the Bowline facility in the licensing of Petitioner's electric generation facility, known as Bowline Units 1 and 2, I am personally familiar with the Department's recent actions and the record available in this case. It is clear from the facts and circumstances enumerated below that no final action has been taken by DEC with respect to the Department's ongoing review of a renewal of Petitioner's SPDES permit. In fact, DEC does not yet have a sufficient record to issue a draft permit for administrative review. In light of the fact that Mirant has raised issues that should be addressed in the Department's administrative hearing process, a process that will commence upon issuance of a draft permit, there has not been an opportunity for DEC to take final action with respect to the Petitioner. Thus, Petitioner's claims are premature and should be dismissed.

3. Similar petitions titled Entergy Nuclear Indian Point 2 and Entergy Nuclear Indian Point 3 v. NYSDEC, Index No. 6747-03 and Dynegy v. NYSDEC, Index No. 6738-03, were filed in connection with DEC's ongoing administrative review of the SPDES permits for Indian Point, owned by Entergy, and Roseton and Danskammer, owned by Dynegy. I

note that the Entergy and Mirant petitions are nearly identical, but for three additional causes of action in the Entergy papers.

4. It is clear from a reading of the Entergy, Mirant and Dynegy petitions that the three SPDES permit applicants are attempting to hinder or delay the Department's efforts to impose stricter permitting standards that would benefit aquatic resources of the Hudson River. Although these facilities, to some degree, have a shared history with respect to their collective impacts to the Hudson River, Mirant Bowline and Dynegy Roseton have not made the same progress in the administrative process as Entergy Indian Point or Dynegy Danskammer. While all three petitions are premature, a distinguishing factor between Mirant Bowline and Dynegy Roseton and the other two potential permittees is that draft SPDES permits were issued for the Indian Point and Danskammer facilities. DEC has not been able to issue a draft permit for the Mirant Bowline and Dynegy Roseton plants, therefore the administrative proceeding for those permit applications has not commenced and the Mirant Bowline and Dynegy Roseton petitions are even "less ripe" than the Entergy and Dynegy Danskammer petitions.

Background

5. The Bowline facility, located in the Town of Haverstraw, Rockland County, New York presently consists of Units 1 and 2 on a 257 acre site on the Hudson River. Units 1 and 2 have been in operation since the 1970s and have a combined generating capacity of 1200 MW. Prior to acquisition by Mirant, the Bowline facility was jointly owned by Orange

and Rockland Utilities (O&R) and Consolidated Edison, Inc. In 2002, Mirant Bowline was granted approval by the New York State Board on Electric Generation Siting and the Environment to construct an additional unit, identified as Unit 3, adjacent to Units 1 and 2 at Bowline.

6. In February 2003, DEC issued a Request for Information (RFI) to Petitioner in connection with the application for SPDES permit renewal, seeking additional information necessary for the DEC Staff to evaluate potential impacts and draft site-specific permit conditions. A response from Petitioner was due April 4, 2003. Following a meeting between DEC and Petitioner, an additional list of questions was sent to Petitioner by letter dated April 16, 2003. A draft response to the amended RFI was due to DEC May 28, 2003.

7. The Department's June 25, 2003 Final Environmental Impact Statement ("FEIS") for the HRSA facilities was issued in response to and in compliance with Justice Keegan's May 14, 2002, Order in Brodsky v. Crotty, Index No. 7136-02, requiring DEC to issue the FEIS addressing the combined impacts of the Hudson River plants by July 1, 2002 and to issue a draft SPDES permit for the Entergy Indian Point Units 2 and 3 by November 14, 2003. See Exhibit 1, May 14, 2002 Order; Exhibit 2, July 1, 2003 letter from Lisa M. Burianek to the Hon. Thomas Keegan.

8. Petitioner sought two extensions on May 29, 2003 and July 9, 2003 for submission of their response to the April 16, 2003 RFI.

9. On November 7, 2003, DEC received Mirant's response to the April 16, 2003 request for information, more than six months after the original May 28, 2003 due date. If sufficient information has been provided to DEC, staff will prepare a draft SPDES permit for Mirant Bowline. After a draft SPDES permit is prepared, DEC will initiate the public phase of the administrative process including public comment, and, if appropriate, a legislative hearing and an administrative adjudicatory hearing.

DEC Appropriately Issued a Positive Declaration

10. Petitioner alleges the 1992 application for renewal of their SPDES permit did not request any material changes in permit conditions or in the scope of permitted activities. Thus, petitioner argues its "renewal" was entitled to a determination that its continued operational activities would not require further environmental review as a Type II action.

11. The Department's 1992 review of the SPDES application for Bowline Units 1 and 2 appropriately resulted in a positive declaration of significance pursuant to Section 8-0109 of the Environmental Conservation Law ("ECL"), which embodies SEQRA, and 6 NYCRR §617.7. Petitioner's 1992 SPDES application proposed material changes from previously issued permits in that the 1992 application did not include the full range of aquatic resource protection measures provided for in the two previous SPDES permits (1982 and 1987) which included conditions incorporating the Hudson River Settlement Agreement ("HRSA"). Accordingly, the positive declaration was within the

Department's broad discretion to subject the permit application to review as a "new" application under the Department's Uniform Procedures Act (UPA). ECL §70-0115(b); 6 NYCRR §621.13(e). While simple permit renewals for unchanged operations are generally Type II actions, which often do not warrant further review of potential environmental impacts, substantive changes can provide grounds for DEC to subject the permit application to a full SEQRA review. 6 NYCRR §617.7(c) (criteria for determining significance).

12. The 1992 Bowline Units 1 and 2 application was not a straightforward renewal. The 1992 permit application submitted by petitioner's predecessors in interest did not provide continued assurances that HRSA-imposed mitigative flow reductions would be maintained for the duration of the SPDES permit term. Moreover, the 1992 application made substantial changes in the seasonal thermal discharge limitations included in previous Bowline permits. Upon information and belief, these substantive changes served as the basis for the 1992 Positive Declaration of Significance. See 6 NYCRR §621.14(a). I note that the central focus of the HRSA was to build a sufficient information base to: (a) address the need for additional mitigative measures and alternatives, (b) avoid and minimize continued impacts to the Hudson River from the three generating facilities, Bowline, Indian Point and Roseton, and (c) provide certain aquatic resource protective measures in the interim. As such, it was never the purpose of the HRSA process to maintain the status quo of the Hudson River plants *ad infinitum*. Thus, following the termination of the HRSA, it should have come as no surprise to

Petitioner's predecessors, O&R and Consolidated Edison, that DEC would issue a positive declaration.

13. The HRSA was intended to cover plant operations during the ten year period during which substantive information was gathered regarding ways to enhance protection of aquatic organisms and reduce or eliminate fish mortalities due to impingement and entrainment in the cooling water intake structures of the Hudson River plants. Upon the expiration of the HRSA, and upon review of the 1992 Bowline SPDES permit application, it was no longer necessary for the Department to defer a SEQRA significance determination.

14. Petitioner must raise questions about SEQRA compliance in the DEC administrative process. With all due respect to the Court, any issues involving the Department's discretion in applying SEQRA to the subject permit renewal, the positive declaration, the subsequent production of two draft EISs in 1993 and 1999, and the FEIS, should first be resolved by the DEC. The administrative process which follows DEC's issuance of a draft permit will allow petitioner to address such issues and DEC to develop a decisional record.

SEQRA Findings Are Appropriately Made After Draft Permit is Available

15. As noted, DEC issued the HRSA FEIS pursuant to the direction of the Court on June 25, 2003. Issuance of a draft SPDES permit is the next step that DEC will take regarding the

Mirant Bowline application to advance DEC's administrative process. Due to the outstanding informational issues, DEC has not yet issued a draft SPDES permit for the Mirant Bowline plant; when issued, the draft permit must be made subject to a public comment period. There is a strong likelihood that the public comment opportunity will include a public legislative hearing, and may generate issues requiring an administrative adjudicatory hearing. When the permit is final, either after the public comment period or, if necessary, after an adjudicatory hearing, it will be accompanied by DEC's findings statement. Under the circumstances, it would be premature to issue a findings statement until after the hearing process has been completed. The Department has the discretion to coordinate a findings statement with the Department's final decision on the permit application. 6 NYCRR §617.11(c). That meaningful findings statement will incorporate the appropriate elements compiled by Department Staff throughout the application review process including the application, information supplied in response to an RFI, public comments, responses to comments compiled by the Department staff, the EIS, applicable regulations and guidance, and any hearing record that articulates the reasoning underlying specific permit conditions. Since information on Petitioner's application is still being reviewed and analyzed, and the administrative process has yet to begin, a findings statement at this time would be incomplete.

16. The heart of an FEIS is the exploration of the appropriate range of mitigation measures and reasonable alternatives to the action (6 NYCRR §617.9(b)(5)(iv) and (v)). The FEIS was jointly completed for Indian Point, Roseton and Bowline, in conjunction with their concurrent SPDES permit renewal applications. The multiple facilities necessitated that

the EIS be more generic in nature than an EIS specific to a single facility's permit application.

17. As discussed above, while not a true "generic EIS," see 6 NYCRR §617.10, this FEIS reflects the extraordinary size of the resource affected, the Hudson River estuary, and the significant impacts of the electric generating facilities. The FEIS expressly contemplates additional information gathering specific to each of the three plants to augment the record to support facility-specific draft SPDES permit renewal conditions, including information related to site-specific mitigative actions to implement the requirement that the permit holder employ the "best technology available" (BTA) to minimize adverse environmental impact at the facility's cooling water intake structure. 33 U.S.C. §13246(b). The SEQRA process provides that if the action changes, or there is newly discovered information, or circumstances change, the Department can direct preparation of a supplemental EIS to develop further information on potential impacts, whether direct, indirect or cumulative in nature, in order to respond to each of the three renewal applications. See 6 NYCRR §617.9(a)(7).

The Department's SEQRA Review is Ongoing and Review of Site Specific Environmental Impacts Will Take Place Commensurate with Drafting of a SPDES Permit.

18. The Department is reviewing petitioner's recent submissions made in response to the April 16, 2003 RFI. Petitioner knew its RFI response would serve a basis for DEC's decision making in preparing a draft permit. Therefore, despite Petitioner's complaint

that a permit has not been drafted, it was well understood that a draft permit could not be prepared prior to receipt of the RFI response. As noted, that response was late by more than six months. Any delays in Mirant's administrative proceedings were caused by Mirant itself, not DEC.

19. Moreover, the RFI served on Petitioner on April 16, 2003 specifically requested cost information on the facility's BTA compliance alternatives, to update information received in the facilities' 1999 DEIS. Since Petitioner failed to respond to the RFI in a timely manner, DEC could not reasonably be expected to consider the site specific economic impacts of various FEIS alternatives.

20. The Petition faults the FEIS for depending on future "additional analysis" and the Department's failure to identify the "when," "how," and "what" of performing such an analysis. The Department can, at any time during its review, ask for additional information which is reasonably necessary to make any findings or determinations required by law pertaining to a new or renewal permit application or modification proposal. 6 NYCRR §621.15(b). If warranted by developments in the permit review process, such as the applicant's identification of a specific technology designed to achieve measures required in the draft permit and submittal of a proposed design, new impacts may be identified and need to be evaluated. 6 NYCRR §§617.9(a)(7)(i)('a') and ('c').

21. Petitioner faults the Department for its alleged "failure" to include an industry document in the public record supporting the FEIS, the "Electricity System Impacts of Certain DEC Utility Choice Alternatives" ("NERA Report") (Petition Exhibit 11).

22. DEC records show that the NERA Report was marked by Entergy and its consultants as "Privileged and Confidential," as a document provided solely for negotiations regarding draft SPDES permit conditions. The Department conscientiously adhered to the direction of the facilities and their counsel regarding the confidentiality of these documents and, therefore, did not make them part of the public record.

Conclusion

23. DEC has taken no final action with respect to the Mirant Bowline Units 1 and 2 permit application. In fact, due to Mirant's delay in submitting information, DEC has not yet issued a draft permit. As discussed above, every aspect of this matter supports dismissal of the petition to allow the Department to develop a full record for this permit application, starting with the development of a draft SPDES permit. Once DEC has issued a draft permit, the DEC's public administrative process will commence in earnest. Clearly, the June 25, 2003 FEIS, issued pursuant to SEQRA, does not constitute final agency action regarding the Mirant Bowline SPDES permit application. At this formative stage of the DEC's administrative process, the unwarranted and preemptory SEQRA review sought by petitioners would thoroughly disrupt that process, which itself allows for petitioners' claims to be considered by an ALJ and, ultimately, the Commissioner.

For purposes of primary jurisdiction and judicial economy, petitioners' claims should only be considered upon a fully developed record and after a final permit determination by the Department.

Dated: Albany, New York
January 20, 2004

Betty Ann Hughes
Environmental Analyst 3

Sworn to before me this 20th
day of January, 2004

Notary Public

MARK D. SANZA
Notary Public, State of New York
No. 02SA6010701
Qualified in Albany County
Commission Expires July 20, 2006

Sir/Madam:

Take notice that the within is a copy of the [name of document] duly Filed and entered in the office of the Clerk of [Court] County on the [day of month] of [month/year].

ELIOT SPITZER
Attorney for Defendant

Office and Post Office Address
The Capitol
Albany, New York 12224

TO:

STATE OF NEW YORK - SUPREME COURT
COUNTY OF ALBANY, Index No. 6747/03

In the Matter of the Application of
ENTERGY NUCLEAR INDIAN POINT 2, LLC, et al.

Petitioner-Plaintiffs,

v.

THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, ERIN CROTTY as Commissioner, et al.

Respondent-Defendants.

MIRANT BOWLINE, LLC.

Petitioner-Plaintiffs,

THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, ERIN CROTTY as Commissioner, et al.

Respondent-Defendants.

NOTICE OF MOTION IN SUPPORT AND AFFIDAVITS

ELIOT SPITZER
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By: Lisa Burianek
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AFFIRMATION OF WILLIAM G. LITTLE, DATED JUNE 2, 2004 [3020-3041]

SUPREME COURT OF THE STATE OF NEW YORK
COUNTY OF ALBANY

In the Matter of the Application of

ENTERGY NUCLEAR INDIAN POINT 2, LLC, and ENTERGY NUCLEAR INDIAN POINT 3, LLC, as respective owners of Indian Point 2 and Indian Point 3, and joint applicants for the renewal of the Indian Point SPDES permit,

Petitioner - Plaintiffs,

For a judgment pursuant to Article 78 of the Civil Practice Law and Rules,

against

THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION and ERIN CROTTY, as Commissioner, New York State Department of Environmental Conservation,

Respondent - Defendants,

MIRANT BOWLINE, LLC, as owner of Bowline 1 and 2 and applicant for renewal of the Bowline SPDES permit, and DYNEGY ROSETON, LLC, as operator of Roseton 1 and 2, and DYNEGY NORTHEAST GENERATION, INC., as the applicant for renewal of the Roseton SPDES permit,

Respondent - Defendants,

RIVERKEEPER, INC.; SCENIC HUDSON, INC.; NATURAL RESOURCES DEFENSE COUNCIL, INC.; and RICHARD L. BRODSKY, in his individual capacity,

Respondent - Intervenors.

AFFIRMATION OF WILLIAM G. LITTLE

Index Nos. 6747-03

RJI No.: 0103ST3971

STATE OF NEW YORK)
ss:
COUNTY OF ALBANY)

William G. Little, an attorney duly admitted to practice in the State of New York hereby affirms:

1. I am an Associate Attorney with the New York State Department of Environmental Conservation "(Department" or "DEC"). Since May 1998 I have assisted and provided legal counsel to Department Staff in the matter of the renewal of the State Pollutant Discharge Elimination System ("SPDES") permits for electric power generating facilities on the Hudson River known as Indian Point Units 2 and 3, Roseton, and Bowline Units 1 and 2. Accordingly, I am familiar with the record in this case.

2. I am fully familiar with the facts and circumstances of this and prior, related proceedings as a result of my experience and involvement with proceedings related to the Hudson River Settlement Agreement ("HRSA") since 1998, and as counsel to Department Staff in the Department's administrative proceeding concerning the renewal of the Indian Point SPDES permit, as well as my review of documents and records relating to HRSA, and the Department's promulgation of regulations relevant to this proceeding. I submit this Affirmation in opposition to Entergy's allegation that the Department failed to make findings pursuant to the State Environmental Quality Review Act ("SEQRA")(Article 8 of the Environmental Conservation Law ("ECL") and Part 617 of Title 6 of the New York Official Codes, Rules and Regulations ("6 NYCRR")), and in support of State respondent's cross motion for summary judgment on Petitioners' Third Cause of Action challenging the legal sufficiency of the Department's 1974 promulgation of 6 NYCRR §704.5.

DEC PROPERLY POSTPONED ISSUANCE
OF A FINDINGS STATEMENT UNTIL
THE COMPLETION OF THE ADMINISTRATIVE PROCESS

3. Justice Thomas W. Keegan, in his March 3, 2004 Decision and Order, dismissed Petitioners' causes of action in this proceeding as they related to SEQRA. Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Indian Point 3, LLC v. Crotty, 1 Misc.3d 690 (Sup. Ct. Albany Co. 2004). However, the Court's March 3, 2004 Decision and Order did not resolve the Second Cause of Action raised in the original Petition, and reiterated in the Amended Petition herein, of whether the Department had appropriately deferred issuing a "findings statement" until after the record is closed in the underlying permit renewal proceeding. Under SEQRA, a lead agency reviewing a permit application that is subject to SEQRA, such as Petitioners' permit renewal, is required to make a findings statement pursuant to the SEQRA statute (ECL §8-0109(8)), and the underlying regulations (6 NYCRR §617.11). The relevant provision of §617.11 states:

> b. ". . . [i]n the case of an action involving an applicant, the lead agency's filing of a written findings statement and decision on whether or not to fund or approve an action must be made within 30 calendar days after the filing of the Final EIS." (Emphasis supplied.)

4. As the Court is aware, in prior litigation, following agreement by the parties to a schedule for the administrative milestones, Justice Keegan directed the Department to issue a final environmental impact statement ("FEIS") regarding the renewal application for the Indian Point SPDES permit no later than July 1, 2003. See, Matter of Brodsky, et al., v. Crotty, et al., Index No. 7136-02, May 14, 2003 Order, Appendix of Exhibits Referenced in the Verified Petition ("Verified Petition"), October 24, 2003, Exhibit 16. The Department issued that FEIS on June 25, 2003. Verified Petition, Exhibit 14. Because of the ongoing

adjudicatory proceeding of the Indian Point permit renewal application, the Department did not issue a findings statement within 30 days after the filing of the FEIS.

5. Petitioners allege that the Department's decision not to issue the findings statement within the 30 day time period set forth in 6 NYCRR §617.11(b) was an abuse of its discretion, and was arbitrary, capricious and a violation of SEQRA. Amended Petition, ¶104. In doing so, petitioners fail to comprehend how SEQRA must be applied, particularly under these unique circumstances.

6. Section 617.11(b) clearly links the findings statement with the lead agency's final decision on whether to grant a permit. In further compliance with Justice Keegan's Brodsky order, the Department issued a draft permit for Indian Point Units 2 and 3 on November 12, 2003, which the Department prepared in response to Entergy's application to renew its SPDES permit. Issuance of the draft permit became one of the preliminary milestones in the Department's administrative proceeding regarding the Petitioners' pending permit application. As illustrated by the papers supporting the Amended Petition, as well as the Affidavit of Mark D. Sanza, coinciding with this Affirmation, the Department is still in the midst of administrative proceedings concerning adjudication of the draft permit.[1] Affidavit of Mark D. Sanza ("Sanza Aff."), June 2, 2004, ¶¶ 39 - 43. Affidavit of Elise N. Zoli, Esq., in support of Entergy's Motion for Determination on its Amended Verified Petition or, Alternatively, for Summary Judgment ("Zoli Aff."), May

[1] An issues conference has been held pursuant to 6 NYCRR §624.4(b); however, an issues determination has not been rendered by the presiding administrative law judge. Upon information and belief, this is because she awaits this Court's ruling on the validity of 6 NYCRR §704.5 before proceeding with hearings involving that regulation.

4, 2004, ¶¶ 10, 12, 13, 14. Because of the ongoing administrative process, it is inappropriate for the Department to issue a findings statement until the permit proceeding is concluded, the record is complete, and the Department is poised to take final agency action on the Petitioners' application. In short, if the Department had issued a findings statement within 30 days after the FEIS was issued, it could not have been accompanied by the Department's final permit decision, as contemplated by §617.11(b). Note that 6 NYCRR §617.11(c) of the SEQRA regulations provides "[f]indings and a decision may be made simultaneously." Thus the Department should not be penalized for its logical interpretation of the regulation and exercise of discretion as to the timing of the findings statement.

7. But for the Court's directive that the Department issue the FEIS by July 1, 2003, the Department would have issued the FEIS at the close of the administrative proceeding, packaged with the complete adjudicatory hearing record and the Department Commissioner's Hearing Decision. Having issued the FEIS on June 25, 2003, the remaining procedural steps are for the DEC Commissioner to make a final permit determination for Indian Point Units 2 and 3, and to indicate that the Department's findings are effective not less than ten days after the date of the Decision. 6 NYCRR §617.11(a).

8. Under the present circumstances, there has been no prejudice or harm to any parties due to the delayed findings statement. The schedule agreed upon by the parties and codified in the Court's May 14, 2003 Decision and Order provided for three linked steps:

(1) Entergy was to provide information to DEC by April 8, 2003,

(2) the Department was to issue the FEIS by July 1, 2003, and
(3) the Department was to issue a decision on Entergy's permit application, including a draft permit, by November 14, 2003.

As was discussed with Justice Keegan prior to his May 14, 2003 Order, each step would facilitate the next. See, Verified Petition, Exh. 16. Having agreed to this sequence of events in the development of the environmental impact review and the production of a draft permit and waived any objection, Petitioners cannot now be heard to complain that the Department erred by not issuing a findings statement, nor should Petitioners be allowed to use the necessarily delayed findings statement against the Department. The justification for this procedure is clearly that:

(1) the Department issued the FEIS pursuant to agreement of the parties,
(2) the Department issued the FEIS pursuant to Court Order, and
(3) the Department opted to issue its findings statement when it could be paired with its final decision in the adjudicatory proceeding and closure of the hearing record.

Petitioners' claim that this was an abuse of discretion, and arbitrary and capricious and a violation of SEQRA is therefore clearly inconsistent with SEQRA regulations.

9. Moreover, The Court's May 14 Brodsky Order did not reference the need to issue a findings statement in concert with issuing the FEIS.[2] Plainly, 6 NYCRR §617.11(b) contemplates that both the findings statement and the final permit determination would

[2] Note that the March 3, 2003 Decision and Order observes that "[t]he FEIS appears to be final in name only, as many issues have been left for future review." March 3, 2003 Decision and Order, p. 3. Further, the Court states that "[t]he FEIS on its face indicates that considerably more environmental review is necessary and is specifically contemplated." *Id.*, p. 6. The potential for further development of the environmental review during the pending administrative proceeding is an additional guarantee that Petitioners' opportunities for substantive participation in creating a record on which the Department can make a findings statement and final permit decision will not be prematurely foreclosed under the unique circumstances in this case.

follow the FEIS by 30 days. Here that sequence of events was altered by informed agreement of the parties and codified by Court order, and the Department reasonably delayed issuing a findings statement so that when issued it would accurately reflect the complete record of the administrative proceedings.

10. In fact, had the Department issued a findings statement in July 2003 after issuing the FEIS it would not have incorporated any of the results of the administrative proceeding after July 25, 2003. Separation of the findings statement from the final action would not only be inconvenient for the parties to the administrative proceeding, it would be prejudicial in that the findings statement would be the subject of adjudication during that proceeding, something clearly not provided for in the Department's hearing regulations. See, 6 NYCRR Part 624. Petitioners apparently do not understand the consequences of their claim, in that it would inappropriately include within the administrative proceedings a Department action that necessarily follows closure of the administrative record.

11. In support of the Department's reasoning, note that SEQRA time frames are considered to be directory in nature, not absolutely mandatory, in order not to frustrate the statute's underlying purpose to ensure a thorough environmental review and a record representing that review. Matter of Sun Beach Real Estate v. Anderson, 98 A.D. 2d 367, 375-376 (2d Dep't), aff'd 62 N.Y.2d 965 (1984) ("We have no difficulty according priority to SEQRA because the legislative declaration of purpose in that statute makes it obvious that protection of 'the environment for the use and enjoyment of this and all future generations (ECL §8-0103) far overshadows the rights of developers to obtain prompt reaction on their proposals."). The Department's delay in issuing a findings statement is

not arbitrary or capricious and is supported by the statute, regulations and facts in this case.

THE EXTENSIVE REGULATORY AND CASE HISTORY OF THIS MATTER ESTABLISH THAT INDIAN POINT UNITS 2 AND 3 HAVE BEEN AND CONTINUE TO BE SUBJECT TO BTA PURSUANT TO 6 NYCRR §704.5 AND 316(b).

12. The nearly 30 year history pertaining to New York State's regulation of cooling water intake structures is directly relevant to this proceeding. The Verified Petition, by claiming that the Department only first applied 6 NYCRR §704.5 to the Indian Point facility when it issued the FEIS on June 25, 2003, promotes a selective, revisionist version of that history. See, Amended Verified Petition, ¶4.

13. Because many of the historical milestones have been described in detail in other papers in this proceeding, or other related proceedings before this Court (See Matter of Riverkeeper, et al., v. Crotty and Dynegy Northeast Generation, Inc., and Dynegy v. Crotty, Albany County Supreme Court, Index No. 7540-02)[3], I will briefly relate the history of regulating cooling water intake structures in New York.

[3] Petitioner Entergy has appended to its Amended Verified Petition two affidavits by Department Staff that were submitted in the Dynegy Danskammer Article 78 proceeding. These are the affidavits of Department technical Staff members Joseph F. Kelleher and Edward W. Radle. These affidavits were submitted by the Department in the pending administrative proceeding (Matter of Renewal and Modification of SPDES permit by Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC, DEC No.: 3-5522-00011/00004, SPDES No.: NY-0004472), in support of Staff's motion to dismiss the applicant's (Entergy's) claim that 6 NYCRR §704.5 was improperly promulgated. See, Appendix of Exhibits referenced in Affidavit of Elise N. Zoli, Esq., in Support of Entergy's Motion for a Determination on its Amended Verified Petition or, Alternatively, Motion for Summary Judgment dated May 4, 2004, Exhibits 10, W and X. Each of these affidavits explains the development and employment of BTA conditions in the Department's draft SPDES permit for the Danskammer electric generating facility, located on the west side of the Hudson River in Newburgh, New York.

14. Petitioners' claim that the Department first applied 6 NYCRR §704.5 to its facilities in the June 25, 2003 FEIS, requiring that the "best technology available" ("BTA") be employed for the cooling water intake structures at Indian Point Units 2 and 3. See, State Respondent's Memorandum of Law and Zoli Aff., ¶8. Petitioners are wrong. As illustrated below, the USEPA and the Department have sought to impose BTA throughout this and other Hudson River SPDES permit proceedings since the advent of its regulatory program in 1972.

15. Section 316(b) of the Clean Water Act ("CWA"), enacted in 1972[4], contains the federal BTA requirement for cooling water intake structures which served as the model for §704.5. See, Sanza Aff., ¶6. Both CWA §316(b) and §704.5 require BTA technology that will "minimiz[e] adverse environmental impact" with respect to the "location, design, construction and capacity of cooling water intake structures." Section 316(b) is an integral part of a greater regulatory scheme that provides the USEPA with the authority to issue National Pollutant Discharge Elimination System ("NPDES") permits to qualifying operators having discharging pollutants from point sources. 33 USC §1251 et seq.

16. Upon information and belief, in approximately 1973, the Department sought USEPA approval to implement a SPDES program. The SPDES program is the State's equivalent of the federal NPDES program and, upon receiving USEPA approval, takes the place of the federal NPDES program to regulate pollutant discharges from point sources and cooling water intake structures. See, Sanza Aff., ¶¶21 - 25.

[4] 33 USC §1326(b), Pub. L. 92-500, §2, Stat 876.

17. In 1974, as part of its effort to qualify the SPDES program for USEPA approval and take over the NPDES program for New York State, the Department promulgated 6 NYCRR Part 704, including §704.5, which provides BTA requirements that are at least equivalent to the BTA requirements required for NPDES permits. Part 704 was promulgated and duly filed with the Secretary of State on September 20, 1974 after extensive public hearings in 1973 and a lengthy period for public comment. The USEPA approved the Department's SPDES program on October 28, 1975. Sanza Aff., ¶23.

18. In 1975, the Administrator of the USEPA issued draft NPDES permits to Consolidated Edison Company of New York, Inc. ("Con Ed"), predecessor in interest to Entergy, for Indian Point Units 2 and 3. Under the authority of CWA §316(b), the NPDES permits for Indian Point required, in effect, that cooling towers be retrofitted to Units 2 and 3 to drastically reduce the volume of cooling water intake, thereby minimizing adverse impacts to fish species that would otherwise be impinged or entrained within the facility's cooling water intake system. See, Verified Petition, Exh. 1, Hudson River Settlement Agreement, pp. 1 - 2. At approximately the same time, the USEPA issued NPDES permits to Orange & Rockland Utilities, Inc. ("O&R"), operator of Bowline Point Units 1 and 2 ("Bowline") generating facility, and to Central Hudson Gas and Electric, Inc. ("Central Hudson"), operator of the Roseton generating facility. Like Indian Point, both Bowline and Roseton are also located on the shore of the Hudson River and dependent on Hudson River water for cooling purposes. These 1975 NPDES permit also had the affect of making Bowline and Roseton subject to cooling tower retrofits.

19. Con Ed, O & R and Central Hudson collectively objected strenuously to the USEPA's imposition of the cooling tower retrofit requirement in the 1975 NPDES permits. As a result, a lengthy adjudicatory proceeding ensued before a USEPA Administrative Law Judge. That proceeding was ultimately resolved by the parties entering into the Hudson River Settlement Agreement ("HRSA"), dated December 19, 1980, including the Department, Con Ed, O & R, Central Hudson, the USEPA, the New York State Attorney General, and several environmental groups, including the predecessor to the Riverkeeper. See, Verified Petition, Exh. 1. The HRSA provided, among other things, interim BTA measures under §704.5 and a ten year program of generator-funded biological studies pertaining to Hudson River fish species from the Troy Dam to the Battery. The biological studies provided for monitoring fish species and their life stages at different Hudson River locations during each season. This provision was designed to generate a broad data base to support the Department's determination of compliance with the BTA requirement in §704.5, by which the Department could ultimately determine whether the interim BTA measures provided elsewhere in the HRSA were adequate, or whether additional BTA measures were warranted at each facility.

20. The terms of the 1980 HRSA demonstrate that substantial elements of the §704.5 BTA provisions were included in the agreement, and accepted by the HRSA facilities to reduce adverse environmental impacts of the cooling water intake structures on fish species entrained in the cooling system or impinged on the intake screens.[5] Id., pp. 4 - 7. Thus,

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[5] The primary interim BTA conditions in the HRSA that sought to reduce adverse impacts from Indian Point's cooling water intake were, briefly: 42 unit-day outages per year taken between May 10 and August 10, and employing dual speed pumps to regulate intake flow

Entergy's predecessor in interest willingly participated in implementing interim §704.5 BTA measures at Indian Point as part of the HRSA process.

21. Pursuant to the HRSA, in 1981 the Department issued a SPDES permit for Indian Point Units 2 and 3 for a five year period. This SPDES permit incorporated the HRSA in its entirety to ensure consistency between the permit and the HRSA, so that the BTA measures provided in the HRSA (along with the aforesaid biological studies) would be carried out by the permittee to comply with §704.5 as enforceable permit conditions. See, 1981 DEC SPDES Permit, May 14, 1981, Exh. A, p. 9, ¶8. The 1981 SPDES permit expired according to its terms on May 13, 1986.

22. Interim BTA measures continued to be applied to Indian Point Units 2 and 3 in the Department's 1987 SPDES permit for Indian Point Units 2 and 3. This SPDES permit incorporated the HRSA in its entirety to ensure consistency between the permit and the HRSA, so that the interim BTA measures provided in the HRSA (along with the aforesaid biological studies) would be carried out by the permittee to comply with §704.5 as enforceable permit conditions. See 1987 DEC SPDES Permit, October 1, 1987, Exh. B, p. 11, ¶7. The 1987 SPDES permit expired according to its terms on October 1, 1992.

23. Subsequent to the expiration of the HRSA, on May 15, 1991, the Department and the utilities that owned and operated the respective HRSA electric generating facilities (Con Ed, the New York Power Authority("NYPA")(which had acquired Indian Point Unit 3

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at a minimum required for efficient plant operation. Indian Point was also required to install traveling screens to provide protection against impingement of fish against the intake screens.

from Con Ed), Central Hudson, and O &R) executed an agreement to carry out further interim §704.5 BTA measures that were the same or similar to interim BTA measures in the HRSA, in order to continue mitigating adverse environmental impacts to fish species through impingement and entrainment from their respective cooling water intake structures. This 1991 agreement was intended to be effective until September 30, 1992. See, Verified Petition, Exh. 2.

24. On September 13, 1991, shortly after the Department and the respective utilities entered into the 1991 Agreement, the Natural Resources Defense Council, Inc., the Hudson Riverkeeper Fund, Inc., and Scenic Hudson, Inc. brought an Article 78 proceeding against the Department and the utilities seeking to invalidate it. Matter of Natural Resources Defense Council, Inc., et al., v. NYSDEC, Consolidated Edison Company of New York, Inc., New York Power Authority, Orange & Rockland Utilities, Inc., and Central Hudson Gas & Electric, Inc., Supreme Ct., Albany Co., Index No. 6570-91.)[6] On March 23, 1992, all parties entered into a stipulation of settlement for that action in the form of a Consent Order ("1992 Consent Order"). The 1992 Consent Order was effective for one year but was extended on four separate occasions: August 5, 1993, May 25, 1995, February 27, 1996, and October 23, 1997. The fourth Consent Order expired on February 1, 1998. See, Verified Petition, Exh. 3. The 1992 Consent Order and its subsequent extensions provided for a biological monitoring program, essentially a continuation of the

[6] For the purpose of argument, note that neither Con Ed nor NYPA, Petitioners' predecessors in interest, thought it necessary to use this occasion as opportunity to challenge the applicability of the Department's authority to impose §704.5 on the cooling water intake structures at Indian Point.

studies conducted pursuant to the HRSA, "to estimate the effects of the operation of the Bowline, Roseton and Indian Point plants during said year on Hudson River fish populations . . . ." Id., p. 16. Like the Hudson River data base developed pursuant to the HRSA, regarding adverse environmental impacts to fish populations, this information would assist the Department in determining whether the facilities' continuing interim BTA measures would fully comply with §704.5.

25. The 1992 Consent Order and its subsequent extensions specified continuing BTA measures for each of the HRSA power plants. With respect to Indian Point Units 2 and 3, these interim BTA measures included continuing to manage the flow of water through variable speed pumps at the cooling water intake at the minimum required for efficient operation of the plant, as well as continuously operating traveling screens to remove fish impinged on the cooling water intake screens.[7] Id., p. 10, ¶ 6.

26. On April 3, 1992, Con Ed provided the Department with an application on its behalf and on behalf of NYPA, to renew the SPDES permit for Indian Point Units 2 and 3.[8] The application form was accompanied by a cover letter from Robert T. Keegan, Ph.D., Director, Water and Waste Management, Environmental Affairs. Id., Exh. 5. Notably, Mr. Keegan did not at that time raise any objection regarding the validity of §704.5 and,

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[7] The 1992 Consent Order, and subsequent Consent Orders, did not require Indian Point Units 2 and 3 to take any of the system outages (generation shutdowns) that were a feature of the HRSA. This is because Indian Point had, over time, accumulated enough outage days, banking them as it were, so that additional outages were not required during the years the Consent Orders were effective. See, Verified Petition, Exh. 3, p. 10, ¶ 5.

[8] O & R and Central Hudson also submitted SPDES permit renewal applications to the Department in 1992.

consequently, it is fair to conclude that Con Ed and the New York Power Authority did not question whether the Department had properly promulgated §704.5.

27. Department Staff reviewed the 1992 permit renewal application and, on May 26, 1992, issued a "positive declaration" of significance pursuant to SEQRA. See, ECL §8-0109, 6 NYCRR §617.7; See also, Verified Petition, Exh. 6; and Affirmation of William G. Little, January 20, 2004, ("Little Aff.,") p. 7, ¶ 13. The positive declaration represented the Department's determination that the future operations of Indian Point Units 2 and 3 proposed in the 1992 application would not provide for seasonal intake flow limitations in the manner provided by the HRSA. See, Verified Petition, Exh. 1, p. 6. The Department determined that an environmental impact statement would have to be prepared to identify and assess measures and alternatives to avoid, minimize, or mitigate the adverse environmental impacts from Indian Point. Little Aff., pp. 7 - 8, ¶¶ 13 -15.[9] The positive declaration constitutes a transition point, from the interim BTA measures that were characteristic of the HRSA and subsequent Consent Orders, to a thorough inquiry as to whether more stringent interim BTA measures should be employed pursuant to §704.5 to address adverse environmental impacts to aquatic organisms from the Indian Point cooling water intakes and thermal discharges. The Department's 1992 positive declaration is supported by the extensive HRSA data base, and the further contributions to that data base from additional biological monitoring required by the extended Consent

[9] In conjunction with the issuance of a positive declaration for Indian Point's SPDES permit renewal in 1992, the Department also issued positive declarations for two other Hudson River power plants, bowling and Roseton, whose respective SPDES permits were also up for renewal.

Orders. See, Verified Petition, Exh.14, Final Environmental Impact Statement ("FEIS"), pp. 7 - 10.

28. On July 16, 1992, Raymond R. Kimmel, Jr,. Assistant Vice President for Con Ed, wrote the Department with regard to the May 26, 1992 positive declaration. This letter characterizes Con Ed's position as an operator of Indian Point with respect to: (a) the Department's implementation of SEQRA as it applied to the 1992 renewal application, (b) the expiration of HRSA conditions pertaining to Indian Point, and (c) the status of the terms of the 1992 Consent Order. Id., Exh. 7. Mr. Kimmel indicates that Con Ed is willing to participate in the Department's environmental impact statement process with the understanding that Con Ed does not waive any rights with respect to its position on the operative conditions of the SPDES permits and as to the SEQRA process. Notably, Mr. Kimmel did not take this opportunity to identify any issue or concern regarding the validity of §704.5, although one would expect that, as a representative of Indian Point's operator, he would identify all existing concerns with the Department's regulatory authority arising in the context of the pending SPDES permit renewal application. Because Con Ed was an active participant in the process by which 6 NYCRR Part 704 was promulgated, it is reasonable to conclude that Con Ed did not have a concern regarding the validity of §704.5. See, Appendix of Exhibits Referenced in Affidavit of Elise N. Zoli, Esq., in support of Energy's Motion for a Determination of its Verified Amended Petition or, Alternatively, Motion for Summary Judgment ("Amended Verified Petition"), May 4, 2004, Exh. 10, Affidavit of Mark D. Sanza, April 19, 2004, ¶23.

29. In June 1993, in response to the Department's positive declarations, Con Ed, the New York Power Authority, Central Hudson, and O & R sent a joint Draft Environmental Impact Statement ("1993 DEIS") to the Department. The 1993 DEIS ostensibly examined the impacts to fish species attributed to the Indian Point, Bowline and Roseton cooling water intakes structures, and assessed alternative measures to avoid, minimize, or mitigate those impacts.

30. On September 3, 1993, the Department completed its evaluation of the 1993 DEIS and rejected it. The Department reviewed the 1993 DEIS to determine whether it had, among other things, appropriately identified adverse impacts, correctly employed the HRSA data base to specify how impacts had effected Hudson River fish species, and adequately assessed alternative actions to avoid, minimize or mitigate those impacts for purposes of applying §704.5 BTA requirements in their SPDES permits. The Department concluded that the 1993 DEIS did not supply sufficient support for the 1992 SPDES permit renewal applications submitted for each of the three HRSA generating facilities. See, September 3, 1993 Letter from John M. Cianci, DEC Project Manager, to Raymond R. Kimmel, Jr., Assistant Vice President, Consolidated Edison Company of New York, Inc., (Cianci Letter), Exhibit C.[10] As explained in the comments appended to the Cianci Letter, the 1993 DEIS failed to provide an adequate basis to make a §704.5 determination about the correct BTA technology to employ at Indian Point, Bowline or Roseton that would

[10] The Cianci Letter is also provided as an Exhibit to the Petitioners' Verified Petition, but did not include Department Staff's extensive substantive comments on deficiencies in the 1993 DEIS, appended to the Cianci letter. Verified Petition, Exh. 8. The version attached hereto as Exhibit A contains the Cianci letter in total, with Department Staff's substantive comments.

address adverse impacts to fish species from the respective cooling water intakes. As a consequence, the Department found that each of the renewal applications remained incomplete, and required further information to support the Department's permit review process.

31. Also in 1993, O & R was engaged in United States District Court litigation, brought by the Hudson Riverkeeper Fund, Inc. ("Riverkeeper"), concerning BTA conditions in O & R's SPDES permit for the Lovett electric generating facility at Tompkins Cove, New York. The Lovett plant is located on the west side of the Hudson River and, like the HRSA facilities, is also dependent on cooling water from the River to generate electric power. At issue in that proceeding was the Riverkeeper's claim that O & R did not comply with a BTA condition in its SPDES permit requiring it to protect against adverse impacts to fish species from Lovett's four separate cooling water intakes. Consistent with the impacts of concern in the HRSA, the impacts complained of at Lovett were mortalities to Hudson River fish from (1) impingement of fish on traveling screens behind the entrance of each intake, (2) entrainment of small fish, fish eggs and larvae within the cooling system itself, and (3) adverse impacts from waste heat discharged to the Hudson River as a result of the generation process. See, Hudson Riverkeeper Fund, Inc., v Orange & Rockland Utilities, Inc., 835 F. Supp. 160 (S.D.N.Y. 1993).

32. The Court in Hudson Riverkeeper was presented with a motion for summary judgement by O & R, and ruled that sufficient controversy existed regarding essential facts concerning BTA at Lovett that the motion would be denied. Hudson Riverkeeper, 835 F. Supp. at 167. In the course of doing so the Court observed that "[t]his case is somewhat

unusual in that the Permit Writer apparently chose to insert as a condition of the SPDES permit, a paraphrase of §704.5, as Condition 9 in the permit . . . ." And "[t]he permit language, by Condition 9, makes it clear that Best Technology Available must be employed and to ascertain whether or not this is being done it is not necessary to review legislative proceedings or congressional intent." Id., 166. (Citation omitted.) The Court clearly understood that the Department's SPDES authority included the authority to include BTA conditions within the terms of a SPDES permit. "EPA has issued no regulations for §316(b) of the Clean Water Act, although space has been reserved in the C.F.R. This leaves to the Permit Writer an opportunity to impose conditions on a case by case basis, consistent with the statute, and a view that best available does not mean perfect." Id., 165. The "statute" referenced by the Court is the Clean Water Act, 33 U.S.C. §1251 et seq., implemented in New York State ECL Article 17, and 6 NYCRR Parts 700 - 706 and Part 750 et seq. See Sanza Affidavit, ¶¶ 4 -5.

33. Thus, at approximately the same time that Con Ed, Central Hudson and O & R were engaged (with Central Hudson) in developing the 1993 DEIS as an information base to support a Department BTA determination for the HRSA generation facilities, O & R was battling with the Hudson Riverkeeper Fund, Inc., as to what constituted BTA at Lovett. By 1993, BTA determinations had been the primary focus of of regulatory activities involving the Department and Hudson River power plant operators for nearly two decades.

34. On December 15, 1999, the operators of the HRSA facilities sent the Department a revised DEIS ("1999 DEIS"). The 1999 DEIS was based in large part upon the Hudson

River data base built up of studies conducted in the River since the inception of the HRSA. On March 8, 2000, the Department published a Notice of Complete Application in the Environmental Notice Bulletin regarding the 1999 DEIS, approving it for purposes of further substantive review by Department Staff and for comment by the public. See, Verified Petition, Exh. 10, Notice of Complete Application, March 8, 2000. The Notice of Complete Application constitutes Department Staff's determination that, although the applicants may not have submitted enough information to write a draft permit, there was enough information on hand to begin reviewing the applications and to offer the record to the public for its scrutiny.

35. On November 12, 2003, after Petitioners responded by direction of Justice Keegan's May 14, 2003 Order to an additional information inquiry made by Department Staff, the Department issued the draft SPDES permit for Indian Point. See, Amended Verified Petition, Exh. 8.

36. It is notable that Petitioners purchased Con Ed's and NYPA's interests in Indian Point Units 2 and 3 in 2001 and 2000, respectively. Upon information and belief, it is reasonable to conclude that prior to making these acquisitions Petitioners conducted a full due diligence investigation for both Units 2 and 3. Such inquiries would have clearly disclosed to Petitioners all of the above circumstances that occurred prior to the acquisition dates, including, but not limited to, the USEPA's imposition of BTA requirements in the 1975 NPDES permit, the Department's imposition of interim BTA requirements in the 1982 and 1987 SPDES permits, and the Department's rejection of the 1993 DEIS for the inadequacies detailed in the extensive comments supplied by

Department Staff to Petitioners' predecessors.[11] Petitioners therefore acquired the Indian Point assets with full knowledge of the Departments SPDES program as it involved Units 2 and 3, and the consistent imposition of BTA requirements pursuant to federal and State authority, including §704.5.

37. The Department's treatment of BTA decision making has remained consistent with the BTA principles set forth in Hudson Riverkeeper. In the Department's final BTA determination for the Athens facility, a new gas-fired power plant in Athens, New York that proposed to withdraw cooling water from the Hudson River, then-Commissioner John Cahill reaffirmed that the Department's BTA determinations are made on a case by case basis in the course of issuing SPDES permits, pursuant to §704.5. The Commission observed that "a four step analysis determines whether [BTA] is being utilized by any particular facility:

(1) whether the facility's cooling water intake structure may result in adverse environmental impact;
(2) if so, whether the 'location, design, construction and capacity of the cooling water intake structure reflects best technology available for minimizing adverse environmental impact';
(3) whether practicable alternative technologies are available to minimize the adverse environmental effects; and
(4) whether the costs of practicable technologies are wholly disproportionate to the environmental benefits conferred by such measures."

[11] Interestingly, in 1975 the USEPA effectively determined that closed-cycle cooling (cooling tower retrofitting) was BTA under CWA §316(b) for Indian Point (as well as Bowline and Roseton) which precipitated legal challenges resulting in the HRSA and its extensive research base. In 2003, following issuance of the FEIS, Department Staff determined that closed-cycle cooling (cooling tower retrofitting) was BTA under §704.5 for Indian Point. Thus, for nearly 30 years, the owners/operators of Indian Point have been attempting to avoid imposition of BTA at its facility under federal and state laws.

Matter of an Application for a SPDES permit pursuant to ECL Article 17 and 6 NYCRR Parts 750 et seq., by Athens Generating Company, LP., Commissioner's Interim Decision, June 2, 2000, pp. 9 - 11; http://www.dec.state.ny.us/website/ohms/decis/athensid.htm. This aspect of the Commissioner's Interim Decision articulates the bedrock of the Department's BTA program as developed and applied pursuant to§704.5 over the years.

38. More recently, in Riverkeeper, Inc., et al. V. USEPA, 358 F.3d 174 ((2d Cir., 2004), the Court recognized that the USEPA has prescribed performance standards for categories of regulatory actions covering cooling water intake structures, yet there are still some instances where a case by case approach is allowed to impose technology against identified adverse impacts. Riverkeeper, 358 F.3d at 181.

39. Despite Petitioners' claims to the contrary, see, Zoli Aff., ¶ 8, at least since the HRSA was executed, and arguably earlier, the Department has exercised BTA authority in accord with §704.5 and its federally approved SPDES program. This longstanding SPDES program, and its implementation of BTA requirements pursuant to §704.5, clearly illustrates that the Department successfully fulfilled its obligations after the 1975 transfer of federal agency NPDES authority to the state.

40. Accordingly, the Court should dismiss Petitioners' Second and Third Causes of Action and grant summary judgment to State Respondents.

Dated: Albany, New York
June 2, 2004

William G. Little, Esq.
Associate Attorney

EXHIBIT A TO LITTLE AFFIRMATION - MAY 14, 1981 INDIAN POINT SPDES PERMIT [3042-3059]

COST OF BIOLOGICA MONITORING, SUMMARY OF MONITORING PROGRAM STUDIES, THE HUDSON RIVER SETTLEMENT AGREEMENT

Facility ID No. : Y-0004472

Effective Date (EDP) : May 14, 1981

Expiration Date (ExDP) : May 13, 1986

Copies: SPDES FILE, BWFD-ADAMCZYK, BWFD-PULASKI, EPA-BAKER, EPA-SPEAR, DEC REGION #3 SUBOFFICE, WESTCHESTER CO. H.D., ISC, NYCDCOE

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
STATE POLLUTANT DISCHARGE ELIMINATION SYSTEM (SPDES)
DISCHARGE PERMIT

Special Conditions
(Part I)

This SPDES permit is issued in compliance with Title 8 of Article 17 of the Environmental Conservation Law of New York State and in compliance with the Clean Water Act, as amended, (33 U.S.C. §1251 et. seq.) (hereinafter referred to as "the Act").

Permittee Name: CONSOLIDATED EDISON CO. OF NEW YORK, INC.
4 Irving Place
New York, New York 10003
Attn: Robert Keegan, Director
Room #1026

& POWER AUTHORITY OF THE STATE OF NEW YORK
10 Columbus Circle
New York, New York 10019
Attn: John W. Blake, Director

is authorized to discharge from the facility described below:

Facility Name: INDIAN POINT GENERATING STATION (UNITS 1 & 2 (ConEd) & 3 (PASNY))

Facility Location (C,T,V): Buchanan (V) County: Westchester

Facility Mailing Address (Street): Broadway and Bleakley Avenue

Facility Mailing Address (City): Buchanan State: New York Zip Code: 10511

into receiving waters known as:

Hudson River (Class SB)

in accordance with the effluent limitations, monitoring requirements and other conditions set forth in this permit.

This permit and the authorization to discharge shall expire on midnight of the expiration date shown above and the permittee shall not discharge after the expiration date unless this permit has been renewed, or extended pursuant to law. To be authorized to discharge beyond the expiration date, the permittee shall apply for permit renewal as prescribed by Sections 17-0803 and 17-0804 of the Environmental Conservation Law and Parts 621, 752, and 755 of the Departments' rules and regulations.

By Authority of William L. Garvey, P.E., Chief, Permit Administration Section
Designated Representative of Commissioner of the Department of Environmental Conservation

4/26/82
Date

William L. Garvey
Signature

INTERIM EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning May 14, 1981
and lasting until April 26, 1982
the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations Daily Avg.	Discharge Limitations Daily Max.	Units	Monitoring Reqmts. Measurement Frequency	Monitoring Reqmts. Sample Type

Except for the limits on condenser cooling water listed in paragraphs 10a and 10g of NPDES permits NY 002 7065 and NY 000 4472 all provisions of those permits shall apply to this facility.

FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning April 26, 1982
and lasting until May 13, 1986
the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations		Units	Monitoring Reqmts.	
	Daily Avg.	Daily Max.		Measurement Frequency	Sample Type
001* Discharge Canal (a, b)					

The Permittee shall discharge condenser cooling water so that the following conditions are satisfied:

1. At no time shall the maximum discharge temperature at Station DSN001 exceed 43.3°C (110°F).

2. Between April 15 and June 30, the daily average discharge temperature at Station DSN001 shall not exceed 34°C (93.2°F) for an average of more than ten days per year during the term of this permit beginning with 1981; provided that in no event shall the daily average discharge temperature at Station DSN 001 exceed 34°C (93.2°F) on more than 15 days between April 15 and June 30 in any year.

3. Whenever, due to forced outage or other technical problem, e.g. equipment failure, it is necessary to remove one or more circulating water pumps from service at an operating unit (or units), pumps at any non-operating unit (or units), including Unit 1, may be used to augment flow in the discharge canal as necessary to meet temperature limits, and will not be considered a violation of settlement outage requirements at the non-operating unit provided that in no event shall total Station flow, as so augmented, exceed the equivalent of full circulator flow at each unit which is then operating.

4. If the discharge temperature limits in clauses 1 and 2 above are exceeded as a result of reduced flow required by Section 2.D of the Settlement Agreement, corrective action, which may include increasing cooling water flow as necessary up to the equivalent of full circulator flow for each unit then operating, shall be taken as quickly as practical and will not be considered a violation of outage requirements at the non-operating unit. During the period required for corrective action (which shall not exceed 24 hours), the discharge will not be considered to be in excess of the foregoing temperature limits. To the extent practical the Permittee shall anticipate when the ambient river temperature will rise to such level that the prevailing reduced cooling water flow rate specified in the Settlement will fail to maintain discharge temperature below 34°C, and may, upon consultation with DEC, increase flow to the next rate scheduled in the Settlement prior to the discharge temperature exceeding 34°C.

5. Nothing contained herein shall be construed to change or otherwise affect the provisions of the Settlement Agreement.

6. Except as set forth above, there shall be no thermal effluent limitations which govern or otherwise affect the operation of the Station or discharges therefrom.

FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning April 26, 1982
and lasting until May 13, 1986
the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Internal Waste Stream Number & Effluent Parameter	Discharge Limitations Daily Avg.	Discharge Limitations Daily Max.	Units	Monitoring Reqmts. Measurement Frequency	Monitoring Reqmts. Sample Type
001* Discharge Canal [(a, b)]					
Total Residual Chlorine [(c)]		0.5	mg/l	Continuous during periods of chlorination	
Total Chromium		30[d]	lbs/dy	Weekly	Calculation
Total Chromium		200[d]	lbs/yr	Annual	Calculation
Lithium Hydroxide		0.01[d]	mg/l	Weekly	Calculation
Boron		1.0[e]	mg/l	Weekly	Calculation
Boron		525[e]	lbs/dy	Weekly	Calculation
pH (Range)		6.0 - 9.0	S.U.	Weekly	Grab
Biocides [f]					

* Outfall 001 is the point prior to confluence of the discharge from the common discharge canal and the Hudson River.

Internal Waste Streams Effluent Limitations

Parameter	Daily Avg.	Daily Max.	Units	Measurement Frequency	Sample Type
001A - Sewage Treatment Plant					
Flow		20,000	GPD	Continuous	Recorder
BOD_5	30[g]	45[h]	mg/l	Monthly	6-hr composit
Total Suspended Solids	30[g]	45[h]	mg/l	Monthly	6-hr composit
Settleable Solids		0.3	ml/l	Weekly	Grab
Fecal Coliform	200[i]	400[j]	MPN/100 ml	Weekly	Grab
pH (Range)	6.0 - 9.0		S.U.	Weekly	Grab
Free Available Chlorine	0.5	2.0	mg/l	Weekly	Grab
Sum of 001B, 001C, 001D, 001E, 001F,** 001G, & 001H					
Flow	Monitoring Only		MGD	Weekly	Instantaneous
Total Suspended Solids	30	50	mg/l	Weekly	Grab[k]
Sum of 001C & 001D					
Flow	Monitoring Only		MGD	Weekly	Instantaneous
Hexavalent Chromium	0.05	0.1	mg/l	Weekly	Grab[l]
Total Chromium	0.5	1.0	mg/l	Weekly	Grab[l]
Surfactants	3	6	lbs/dy	Weekly	Calculated [m]
Oil & Grease		15	mg/l	Weekly	Grab[n]
001F**					
Total Suspended Solids	30	50	mg/l	Weekly	Grab

**If river water is used in the Flash Evaporator, internal waste stream 001F must be sampled separately, and not included in the composite, the limits for 001F using river water are Net Limits.

FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning April 26, 1982
and lasting until May 13, 1986
the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Internal Wastes Streams Number & Effluent Parameter	Discharge Limitations Daily Avg.	Discharge Limitations Daily Max.	Units	Monitoring Reqmts. Measurement Frequency	Monitoring Reqmts. Sample Type
Sum of 001B, 001C, & 001D					
Flow	Monitoring Only		MGD	Weekly	Instantaneous
Boron	Monitoring Only		mg/l	Weekly	Grab°
001C					
Flow	Monitoring Only		MGD	Monthly	Instantaneous
001E					
Flow	Monitoring Only		MGD	Weekly	Instantaneous
pH (Range)	6.0 - 9.0		SU	Weekly	Grab
001F					
Flow	Monitoring Only		MGD	Monthly	Instantaneous
001G					
Flow	Monitoring Only		MGD	Weekly	Instantaneous
Phosphates as P	16	38	lbs/day	Weekly	Grab
001H					
Flow	Monitoring Only		MGD	Monthly	Instantaneous
001I					
Flow	Monitoring Only		MGD	P	P
001J ***					
Flow	Monitoring Only		MGD	Weekly	Estimate
Oil & Grease		No visible oil or sheen	mg/l	Weekly	Visual Observation.

***Because this outfall cannot be monitored, the following shall apply:

1. All oil spills shall be handled under the SPCC plan.
2. Flow tributary to the floor drains shall not contain more than 15 mg/l of oil and grease nor any visible sheen.

Footnotes

a. Discharge 001 shall occur only through the subsurface ports of the outfall structure.

b. When the temperature in the discharge canal exceeds 90°F or the site gross electric output equals or exceeds 600MW the head differential across the outfall structure shall be maintained at a minimum of 1.75 feet. When required adjustment of the ports shall be made within 4 (four) hours of any change in the flow rate of the circulating water pumps. If compliance is not achieved, further adjustments of the ports shall be made to achieve compliance. The requirements of the Settlement Agreement flow schedules shall take priority over the requirements of this footnote.

c. Condenser Chlorination

Total residual chlorine at DSN 001 shall not exceed 0.5 mg/l. Should the circulating water system be chlorinated, the maximum frequency of chlorination for the condensers of each unit shall be limited to 3 (three) times per week. The duration of any chlorination period shall not exceed one hour, with a maximum of 2 (two) chlorination periods occurring in a 24 hour period. The total time for chlorination of the three units for which this permit is issued shall not exceed 9 (nine) hours per week. Chlorination shall take place during daylight hours and shall not occur at more than one unit at a time.

d. The calculated quantity of these substances in the discharge shall be determined by using the analytical results obtained from sampling that is to be performed on interna waste streams 001C and 001D.

e. The calculated quantity of this substance in this discharge shall be determined by using the analytical results obtained from sampling that is to be performed on internal waste streams 001B, 001C and 001D.

f. No biocides, corrosion control chemicals, or other water treatment chemicals are authorized for use by the permittee except those listed below or limited as a parameter in the permit.

Morpholine
Cyclohexylamine
Hydrazine

Drewgard 100 may be added so the calculated concentration shall not exceed 11 mg/l the active ingredient E.D.T.A. shall not exceed .28 mg/l in the discharge canal.

g. Arithmetic mean of the values for effluent samples collected over a 30-day period.

h. Arithmetic mean of the values for effluent samples collected over a 7-day period.

i. 30 day geometric mean.

j. 7-day geometric mean.

k. One flow proportioned composite sample shall be obtained from one grab sample taken from each of the internal waste streams 001B, 001C, 001D, 001E, 001F, 001G, and 001H.

l. One flow proportioned composite sample shall be obtained from one grab sample taken from each of the internal waste streams 001C and 001D, during periods when chromium is being used.

m. The calculated quantity of these substances in the discharge shall be based on the quantity of the substances consumed at the facility.

n. One grab sample shall be obtained from each of the internal waste streams 001C and 001D and the samples shall be analyzed separately. The results of the two analyses shall be averaged and reported.

o. One flow proportioned composite sample shall be obtained from one grab sample taken from each of the internal waste streams 001B, 001C, and 001D.

p. The flow of condenser cooling water discharges shall be monitored and recorded by hourly recording of the operating mode of the circulating water pumps. Any changes in the flow rate of each circulating water pump shall be recorded, including the date and time, and reported monthly together with the Discharge Reporting Form. The permittee shall indicate whether any circulating pumps were not in operation due to pump breakdown or required pump maintenance and the period(s) (dates and times) the discharge temperature limitation was exceeded, if at all. For all other discharges or internal waste streams (only those which are limited), the flow shall be measured and recorded at a frequency coinciding with the most frequently sampled parameter. Methods, equipment, installation, and procedures shall conform to those prescribed in the Water Measurement Manual, U.S. Department of the Interior, Bureau of Reclamation, Washington, D.C.: 1967 or equivalent approved by the permit issuing authority.

Additional Requirements:

1. There shall be no discharge of PCB's from this facility.

2. All collected solids from the washing of intake screens shall be disposed of by a New York State licensed contractor or by the permittee at a NYSDEC approved landfill.

3. The permittee shall submit on a quarterly basis to the NYSDEC at its offices in White Plains and Albany a monthly report of daily operating data, by the 28th of the month following the end of the quarter, that includes the following:

   a. Daily minimum, maximum, and average station electrical output shall be determined and logged.

   b. Daily minimum, maximum and average water use shall be directly or indirectly measured or calculated and logged.

   c. Temperature of the intake and discharges shall be measured and recorded continuously. Daily minimum, maximum and average intake and discharge temperatures shall be logged.

4. The use of chlorine for condenser cleaning shall be kept to the minimum amount which will maintain plant operating efficiency. By issuance date + 6 months the applicant shall submit for NYSDEC approval, a plan of study for a chlorine minimization program. This program shall be conducted in accordance with the requirements of Appendix A of the proposed Steam Electric Effluent Limitations (Part 423) as shown on pages 68354 and 68355 of the Federal Register published on October 14, 1980.

   EPA has proposed draft limitations that would prohibit the discharge of chlorine from this facility. This permit contains water quality limitations on the discharge of chlorine. Following the promulgation of EPA BAT limitations on the discharge of chlorine, this permit may be revised to reflect these limitations.

5. Biological Monitoring and Reporting

   The permittee shall comply with biological monitoring requirements which shall be embodied in a Memorandum of Agreement (MOA) to be entered into between the NYSDEC and the Permittee for the permits issued to Indian Point Generating Station Unit 2 and Indian Point Generating Station Unit 3. Monitoring requirements shall be consistant with the Hudson River Settlement Agreement and Attachment V thereto.

   Live sturgeon collected during scheduled biological monitoring studies will be counted, measured, and examined for tags, then carefully returned to the river as quickly as possible. Dead sturgeon collected during scheduled biological monitoring studies shall be counted, weighed, measured, examined for tags and frozen for salvage for the Department of Environmental Conservation for up to one year, at which time the sturgeon will be disposed of in a sanitary landfill. Each sturgeon shall be individually labeled indicating date of capture and appropriate measurements.

6. Notwithstanding any other requirements in this permit, the permittee shall also comply with all of the Water Quality Regulations promulgated by the Interstate Sanitation Commission on October 15, 1977 including Sections 1.01 and 2.05 (f) as they relate to oil and grease.

7. It is recognized that influent quality changes, equipment malfunction, acts of God, or other circumstances beyond the control of the Permittees may, at times, result in effluent concentrations exceeding the permit limitations despite the exercise of appropriate care and maintenance measures, and corrective measures by the permittees. The permittees, either individually or jointly, may come forward to demonstrate to the DEC that such circumstances exist in any case where effluent concentrations exceed those set forth in this permit. The DEC, however, is not obligated to wait for, or solicit, such demonstrations prior to the initiation of any enforcement proceedings, nor must it accept as valid on its face the statements made in any such demonstration.

In the event of non-compliance attributable to only one facility, DEC will initiate enforcement proceedings against the permittee responsible for such facility.

DEC shall not initiate enforcement proceedings concurrently against both the Permittees, unless DEC has been unable to identify the non-complying facility. If DEC seeks to enforce in an administrative or judicial proceeding any provision of this permit, the Permittees may raise at that time the issue of whether, under the United States Constitution, statute, or decisional law, they are entitled to a defense that their conduct was caused by circumstances beyond their control.

8. The Hudson River Settlement Agreement, dated December 19, 1980, is annexed to this permit as Appendix 2 and is incorporated herein as a condition to this permit. The Settlement Agreement satisfies New York State Criteria Governing Thermal Discharges.

Definition of Daily Average and Daily Maximum

The daily average discharge is the total discharge by weight or in other appropriate units as specified herein, during a calendar month divided by the number of days in the month that the production or commercial facility was operating. Where less than daily sampling is required by this permit, the daily average discharge shall be determined by the summation of all the measured daily discharges in appropriate units as specified herein divided by the number of days during the calendar month the measurements were made.

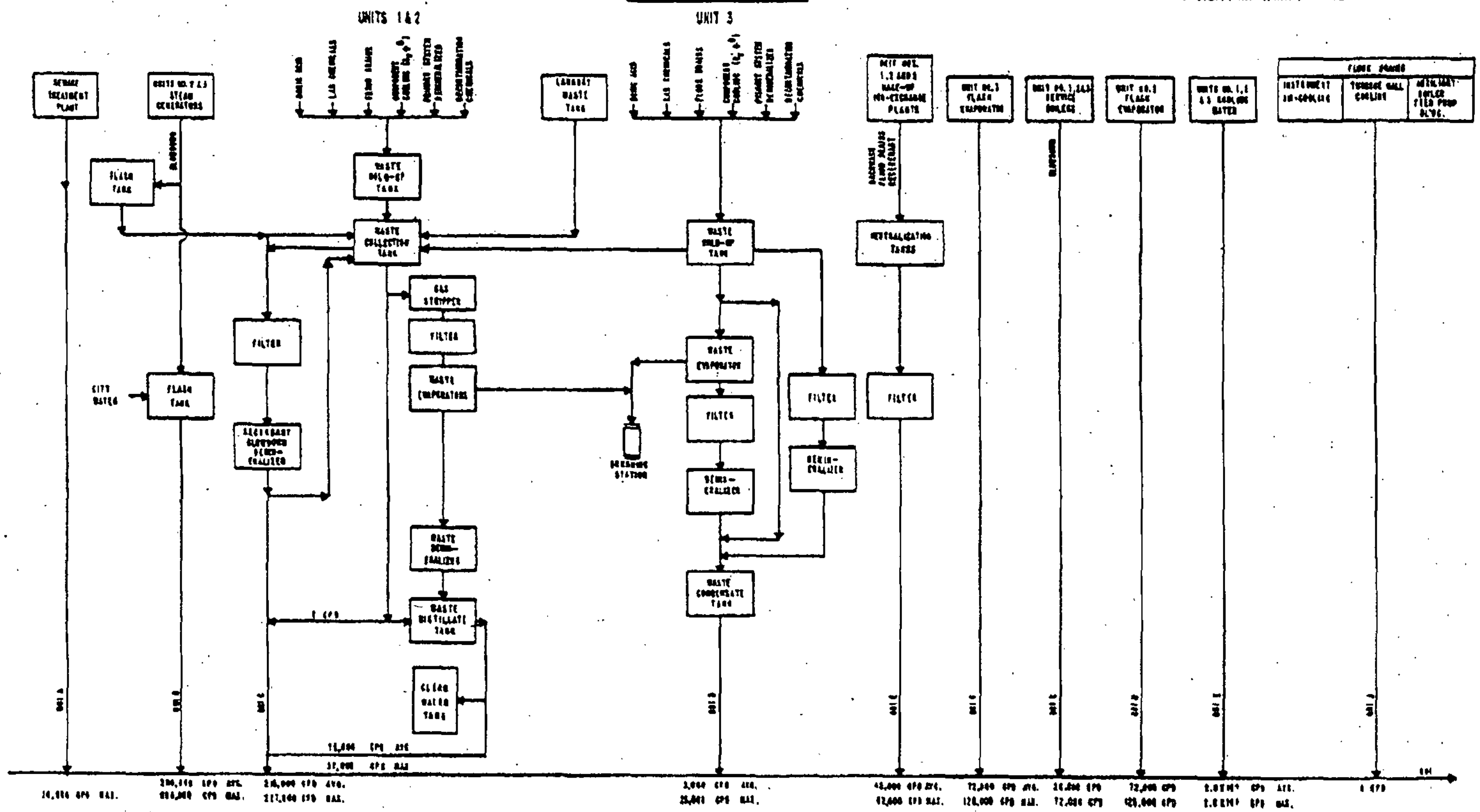
The daily maximum discharge means the total discharge by weight or in other appropriate units as specified herein, during any calendar day.

Monitoring Locations

Permittee shall take samples and measurements to meet the monitoring requirements at the location(s) indicated below: (Show locations of outfalls with sketch or flow diagram as appropriate). The sampling for the internal waste streams 001A thru 001J shall be taken in the internal waste streams before entering the river.

INDIAN POINT GENERATING STATION
CONTRIBUTIONS TO DIS. 001

FACILITY I.D. NO. N.Y. 0004472



AVERAGE AND MAXIMUM FLOWS
DISCHARGE 001 CANAL

3052

SCHEDULE OF COMPLIANCE FOR EFFLUENT LIMITATIONS

The permittee shall submit copies of the written notice of compliance or noncompliance required herein to the following offices:

Chief, Compliance Section
New York State Department of Environmental Conservation
50 Wolf Road
Albany, New York 12233

Regional Engineer
New York State Department of Environmental Conservation
Region 3
202 Mamaroneck Avenue
White Plains, New York 10601

Westchester County Health Department
150 Grand Street
White Plains, New York 10601

Dr. Richard Baker, Chief
Permits Administration Branch
Planning and Management Division
U.S. Environmental Protection Agency
Region II
26 Federal Plaza
New York, New York 10278

The permittee shall submit copies of any engineering reports, plans of study, final plans, as-built plans, infiltration-inflow studies, etc. required herein to the New York State Department of Environmental Conservation Regional Office specified above unless otherwise specified in this permit or in writing by the Department or its designated field office.

MONITORING, RECORDIN[illegible] ND REP[illegible]TING

a) The permittee shall also refer to the General Conditions (Part II) of this permit for additional information concerning monitoring and reporting requirements and conditions.

b) The monitoring information required by this permit shall be summarized and reported by submitting a completed and signed Discharge Monitoring Report form once every 1 month to the Department of Environmental Conservation and other appropriate regulatory agencies at the offices specified below. The first report will be due no later than April 28, 1982. Thereafter, reports shall be submitted no later than the 28th of the following month(s): Each Month

Water Division
New York State Department of Environmental Conservation
50 Wolf Road - Albany, New York 12233

New York State Department of Environmental Conservation
Regional Engineer - Region #3
202 Mamaroneck Avenue, White Plains, NY 10601

Westchester County Health Department, 150 Grand St., White Plains, NY 10601
Interstate Sanitation Commission, Attn:Mr. Thomas R. Glenn, Jr.
Director and Chief Engineer, 10 Columbus Circle, New York, NY 10019

[X] (Applicable only if checked):
Dr. Richard Baker, Chief - Permits Administration Branch
Planning & Management Division
USEPA Region II
26 Federal Plaza
New York, New York 10278

c) If so directed by this permit or by previous request, Monthly Wastewater Treatment Plant Operator's Reports shall be submitted to the DEC Regional Office and county health department or county environmental control agency specified above.

d) Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit.

e) If the permittee monitors any pollutant more frequently than required by the permit, using test procedures approved under 40 CFR 136 or as specified in the permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the Discharge Monitoring Reports.

f) Calculations for all limitations which require averaging of measurements shall utilize an arithmetic mean unless otherwise specified in the permit.

g) Unless otherwise specified, all information submitted on the Discharge Monitoring Form shall be based upon measurements and sampling carried out during the most recently completed reporting period.

h) Blank Discharge Monitoring Report Forms are available at the above addresses.

3055

Memorandum of Agreement
Between
New York State Department of Environmental Conservation
and
the Hudson River Utilities

1. This Memorandum of Agreement (MOA) is entered into by the New York State Department of Environmental Conservation (Department) with Consolidated Edison of New York, Inc. (Consolidated Edison), the Power Authority of the State of New York (Power Authority), Orange and Rockland Utilities, Inc. (O and R), and Central Hudson Gas and Electric Corp. (CH) in accordance with the Department's certification pursuant to Section 401 of the Clean Water Act and to supply the appropriate conditions "Biological Monitoring and Reporting" of the SPDES discharge permit numbers:

   NY 000 4472 Consolidated Edison's Indian Point Station Units 1 & 2

   NY 002 7065 The Power Authority's Indian Point Station Unit 3

   NY 000 8010 Orange and Rockland Utilities' Bowline Point Station

   NY 000 8231 Central Hudson's Roseton Station,

   and in accordance with the "Biological Monitoring Program" as provided for in Section 2.J and Attachment V to the Hudson River Settlement Agreement entered into December 19, 1980 (Settlement Agreement).

2. This MOA is to embody the agreement of the Utilities to conduct monitoring program studies as described in Attachment 1. The Department is of the view that the biological monitoring program described in Attachment 1 is consistent with program objectives and the funding level to which the Utilities have committed as identified in the Settlement Agreement. Nothing contained in this MOA shall cause the Utilities to perform activities or incur expenses in excess of or less than the amount specified in Attachment 2. Any further studies necessary to fulfill the dollar value of the Utilities' monitoring obligations will be conducted only with the prior written approval of DEC.

3. The Utilities agree to use their best efforts to conduct fully the biological monitoring program as specified in the Settlement Agreement and as identified in Attachment 1 hereto. The Department acknowledges that the Utilities will not be deemed to be in non-compliance with the Settlement Agreement or any Condition of any applicable discharge permit or Section 401 Certification if the full complement of all biomonitoring cannot be completed within the original calendar year for reasons beyond the reasonable control of the Utilities. However, should the full complement of biomonitoring not be completed within the original year, at the sole discretion of DEC, either the time to complete such studies shall be extended or the unexpended funds shall be used to supplement the biomonitoring program in the subsequent year.

4. The Department and the Utilities hereby agree that the study programs may be modified at any time by written agreement of the Department and the Utilities to fulfill the objectives of the study, provided that any cost savings which accrue through such modifications be redirected to other studies as appropriate.

5. Reports based on these studies and an accounting of funds expended will be submitted within six months of the completion of component studies and no later than June 30 of the subsequent year unless an extended schedule is mutually agreed upon by the Department and the Utilities.

6. The term of this MOA shall be from the date of the last signature hereto until December 31, 1985, after which time this MOA shall be of no further force or effect except for completion of reports, accountings, or studies identified in paragraphs 3 to 5.

7. The term of Attachment 1 shall be until December 31, 1981 and each subsequent Attachment 1 shall expire at the end of its calendar year.

Signatures ______________________/__________
Con Edison Date

______________________/__________
Orange & Rockland Date

______________________/__________
Central Hudson Date

______________________/__________
Power Authority Date

______________________/__________
Niagara Mohawk Date

______________________/__________
NYSDEC Date

Summary Description of Monitoring Program Studies Mutually Agreed Upon by New York State Department of Environmetal Conservation and the Hudson River Utilities

A. Impingement - Indian Point, Bowline Point, Roseton

Impingement collections will be made at each plant from January 1981 through December 1981. Sampling frequency at Indian Point Unit Nos. 2 and 3 will be daily at water intakes at which circulating water pumps are in operation until such time as relief from this requirement is granted. Thereafter, collections will be made as specified by DEC. Impingement collections will be made once per week at Bowline Point and Roseton over a continuous 24-hour sampling period. At each plant, fish will be identified and enumerated to determine total number, total weights and length/frequency distributions of the collected species, utilizing appropriate subsumpling methodologies. Water quality data and plant operating conditions will be recorded as appropriate.

B. Entrainment - Indian Point, Bowline Point, Roseton

Entrainment abundance sampling will be conducted approximately twice each week over a continuous 24-hour period weekly from mid-April at Roseton and early May at Bowline and Indian Point through August, 1981. Fish eggs and larvae will be identified and enumerated by species to the lowest taxonomic level practicable. Length of larvae will be determined from subsamples. Water quality data and plant operating conditions will be recorded as appropriate.

C. Fall Juvenile Survey

Beach seine, Tucker trawl and epibenthic sled samples will be collected between river miles 14 and 153 from August 1981 through October 1981. Approximately 100 randomly selected beaches will be seined biweekly. An aggregate of approximately 200 samples will be collected with the Tucker trawl and epibenthic sled during each biweekly sampling period.

Length and weight measurements of subsampled young-of-the-year and older striped bass, white perch and other selected fish species will be made. Striped bass and white perch will be examined for marks and suspected recaptures preserved for later verification. Appropriate water quality measurements will be taken with each sample.

D. River Ichthyoplankton

From early May through June 1981 approximately 200 samples will be collected weekly between river miles 14 and 140. At each sample site, water quality will be determined. From the samples collected, 157 will be analyzed for determination of the distribution and abundance of the eggs, larvae and juveniles of striped bass, white perch, Atlantic tomcod and other fish species within the Hudson River estuary.

E. BARRIER NET EVALUATION - BOWLINE POINT

Studies will be conducted at Bowline Point in the spring (periods of no river ice) of 1981 to further evaluate the efficiency of using a barrier net to reduce fish impingemment. Methodologies using hydroacoustics, gill nets and fish tags will be used to refine previous efficiency estimates derived solely from tagging studies.

F. IMPINGEMENT SURVIVAL - BOWLINE POINT

Impingement survival studies at Bowline Point will be continued through the spring of 1981 to refine previous estimates of survival and evaluate any potential effects of the new return system for impinged fish. Initial and latent mortality estimates will be compared for impinged and control fish. Water quality data will be recorded as appropriate.

G. ENVIRONMENTAL TECHNICAL SPECIFICATION REQUIREMENTS

Biological studies conducted by Consolidated Edison and the Power Authority in accordance with the Environmental Technical Specification Requirements for the Indian Point plants in effect during April 1981 shall constitute part of the monitoring program identified in the Settlement Agreement.

The settlement specifies that the biological monitoring program will be conducted "at a cost of at least $2 million per year, adjusted annually from the base year, which shall be the first year of the term of this Agreement, in accordance with the Implicit Price Deflator, GNP, published by the US Dept. of Commerce in the Survey of Current Business".

1981 represents the base year for which the biological monitoring expenditures will be $2,000,000.

3060

EXHIBIT B TO LITTLE AFFIRMATION - OCTOBER 1, 1987 INDIAN POINT SPDES PERMIT [3060-3082]

RECEIVED
SEP 02 1987
DIVISION OF WATER
BUREAU OF WASTEWATER FACILITIES DESIGN

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

State Pollutant Discharge Elimination System (SPDES) DISCHARGE PERMIT

Special Conditions (Part 1)

Industrial Code	4911	Facility ID Number:	NY- 000 4472
Discharge Class (CL)	03	UPA Tracking Number:	3086-0062
Toxic Class (TX)	T	Effective Date (EDP):	October 1, 1987
Major D.B.	13	Expiration Date (ExDP):	October 1, 1992
Sub D.B.	01	Modification Date(s):	
Water Index Number	H	Attachment(s):	General Conditions (Part II, 2/85) ~~"A" - Order on Consent, July 17, 1986~~ "B" - Order on Consent, August 20, 1987

This SPDES permit is issued in compliance with Title 8 of Article 17 of the Environmental Conservation Law of New York State and in compliance with the Clean Water Act, as amended, (33 U.S.C. §1251 et. seq.) (hereinafter referred to as "the Act").

Attn: Robert Keegan/John W. Blake

Permittee Name: Consolidated Edison Co. of New York/New York Power Authority

Street: 4 Irving Place, Room 300/123 Main Street

City: New York/White Plains State: NY/NY Zip Code: 10003/10601

is authorized to discharge from the facility described below:

Facility Name: Indian Point Generating Station (Units 1&2 Con Ed) & (Unit 3 PASNY)

Location (C,T,V): Buchanan (V) County: Westchester

Mailing Address (Street): Broadway and Bleakley Avenue

Mailing Address (City) Buchanan State: NY Zip Code: 10511

from Outfall No. 001 at: Latitude 41°16'7" & Longitude 73°57'19"

into receiving waters known as: Hudson River Class SB

and: (list other Outfalls, Receiving Waters & Water Classification)

001	Hudson River SB	005 Hudson River SB
002	Hudson River SB	006 Hudson River SB
003	Hudson River SB	007 Hudson River SB
004	Hudson River SB	008 Hudson River SB
		009 Hudson River SB

in accordance with the effluent limitations, monitoring requirements and other conditions set forth in this permit.

This permit and the authorization to discharge shall expire on midnight of the expiration date shown above and the permittee shall not discharge after the expiration date unless this permit has been renewed, or extended pursuant to law. To be authorized to discharge beyond the expiration date, the permittee shall apply for permit renewal as prescribed by Sections 17-0803 and 17-0804 of the Environmental Conservation Law and Parts 621, 752, and 755 of the Departments' rules and regulations.

PERMIT ADMINISTRATOR	DATE ISSUED	ADDRESS
Ralph Manna, Jr.	8/28/87	21 South Putt Corners Rd. New Paltz, NY 12561

Distribution: C. Manfredi/P. Doshna
R. Hannaford - BWFD ✓
Westchester Co. H.D.
EPA, NY - R. Baker
EPA, NJ - R. Spear
TSC
E. Reilly (pg. 1)
E. Radle, BEP - Albany
B. Brandt

Ralph L Manna Jr
SIGNATURE

91-20-2a (7/84)

Facility ID # NY 000 4472

Part 1, Page 2 of 19

FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the Period Beginning October 1, 1987

and lasting until October 1, 1992

the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations Daily Avg.	Discharge Limitations Daily Max.	Units	Minimum Monitoring Requirements: Measurement Frequency	Minimum Monitoring Requirements: Sample Type

001* Discharge Canal[a,b]

The permittee shall discharge condenser cooling water so that the following conditions are satisfied:

1. At no time shall the maximum discharge temperature at Station DSN 001 exceed 43.3°C (110°F).
2. Between April 15 and June 30, the daily average discharge temperature at Station DSN 001 shall not exceed 34°C (93.2°F) for an average of more than ten days per year during the term of this permit beginning with 1981; provided that in no event shall the daily average discharge temperature at Station DSN 001 exceed 34°C (93.2°F) on more than 15 days between April 15 and June 30 in any year.
3. Whenever, due to forced outage or other technical problem, e.g. equipment failure, it is necessary to remove one or more circulating water pumps from service at an operating unit (or units), pumps at any non-operating unit (or units), including Unit 1, may be used to augment flow in the discharge canal as necessary to meet temperature limits, and will not be considered a violation of settlement outage requirements at the non-operating unit provided that in no event shall total Station flow, as so augmented, exceed the equivalent of full circulator flow at each unit which is then operating.
4. If the discharge temperature limits in clauses 1 and 2 above are exceeded as a result of reduced flow required by Section 2.D of the Settlement Agreement, corrective action, which may include increasing cooling water flow as necessary up to the equivalent of full circulator flow for each unit then operating, shall be taken as quickly as practical and will not be considered a violation of outage requirements at the non-operating unit. During the period required for corrective action (which shall not exceed 24 hours), the discharge will not be considered to be in excess of the foregoing temperature limits. To the extent practical the permittee shall anticipate when the ambient river temperature will rise to such level that the prevailing reduced cooling water flow rate specified in the Settlement will fail to maintain discharge temperature below 34°C, and may, upon consultation with DEC, increase flow to the next rate scheduled in the Settlement prior to the discharge temperature exceeding 34°C.
5. Nothing contained herein shall be construed to change or otherwise affect the previsions of the Settlement Agreement.
6. Except as set forth above, there shall be no thermal effluent limitations which govern or otherwise affect the operation of the Station or discharges therefrom.

INTERIM EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the Period Beginning October 1, 1987

and lasting until January 1, 1989

the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations Daily Avg.	Discharge Limitations Daily Max.	Units	Minimum Monitoring Requirements Measurement Frequency	Minimum Monitoring Requirements Sample Type
001* Discharge Canal[a,b]					
Total Residual Chlorine[c]	NA	0.2	mg/l	(See footnotes q,r)	
Lithium Hydroxide	NA	0.01[d]	mg/l	Monthly	Calculation
Boron	NA	1.0[e]	mg/l	Weekly	Calculation
Boron	NA	525[e]	lbs/day	Weekly	Calculation
pH (Range) 6.0 - 9.0			SU	Weekly	Grab

*Outfall 001 is the point prior to confluence of the discharge from the common discharge canal and the Hudson River.

Internal Waste Streams Effluent Limitations

Outfall Number & Effluent Parameter	Daily Avg.	Daily Max.	Units	Measurement Frequency	Sample Type
001A - Sewage Treatment Plant					
Flow	Monitor	Monitor	GPD	Continuous	Recorder
BOD_5	30[g]	45[h]	mg/l	Monthly	6hr Composite
Total Suspended Solids	30[g]	45[h]	mg/l	Monthly	6hr Composite
Settleable Solids		0.3	ml/l	Weekly	Grab
Fecal Coliform	200[i]	400[j]	NO./100 ml	Weekly	Grab
Total Residual Chlorine[p]	0.5(min.)	3.0	mg/l	Weekly	Grab
pH (Range)	Monitor	Monitor	SU	Weekly	Grab
Sum of 001B, 001C, 001D, 001E, 001G & 001K, 001L					
Flow	Monitoring Only		MGD	Weekly	Instantaneo
Total Suspended Solids	30	50	mg/l	Weekly	Grab[k]
Sum of 001C & 001D					
Flow	Monitoring Only		MGD	Weekly	Instantai
Hexavalent Chromium	0.05	0.1	mg/l	Monthly	Grab[l]
Total Chromium	0.5	1.0	mg/l	Weekly	Grab[l]
Lithium Hydroxide	Monitoring Only		mg/l	Monthly	Grab[l]

91-20-2a (7/84)

Facility ID NY 000 4472
Part 1. Page 4 of 19

FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the Period Beginning January 1, 1989

and lasting until October 1, 1992

the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations Daily Avg.	Discharge Limitations Daily Max.	Units	Minimum Monitoring Requirements Measurement Frequency	Minimum Monitoring Requirements Sample Type
001* Discharge Canal[a,b]					
Total Residual Chlorine[c]	NA	0.2	mg/l	(See footnotes q,r)	
Lithium Hydroxide	NA	0.01[d]	mg/l	Monthly	Calculation
Boron	NA	1.0[e]	mg/l	Weekly	Calculation
Boron	NA	525[e]	lbs/day	Weekly	Calculation
pH (Range) 6.0 - 9.0			SU	Weekly	Grab

*Outfall 001 is the point prior to confluence of the discharge from the common discharge canal and the Hudson River.

Internal Waste Streams Effluent Limitations

001A - Sewage Treatment Plant

No Discharge Allowed

Outfall Number & Effluent Parameter	Daily Avg.	Daily Max.	Units	Measurement Frequency	Sample Type
Sum of 001B, 001C, 001D, 001E, 001G & 001K, 001L					
Flow	Monitoring Only		MGD	Weekly	Instantaneous
Total Suspended Solids	30	50	mg/l	Weekly	Grab[k]
Sum of 001C & 001D					
Flow	Monitoring Only		MGD	Weekly	Instantaneous
Hexavalent Chromium	0.05	0.1	mg/l	Monthly	Grab[l]
Total Chromium	0.5	1.0	mg/l	Weekly	Grab[l]
Lithium Hydroxide	Monitoring Only		mg/l	Monthly	Grab[l]

91-20-2s(1/89)

SPDES No.: NY 000 4472
Part Page 5 of 19
Modified: 09/30/99
Modified: 8/23/01
(WES)

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning October 1, 1987
and lasting until PERMIT EXPIRATION
the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations Daily Avg.	Discharge Limitations Daily Max.	Units	Minimum Monitoring Requirements Measurement Frequency	Minimum Monitoring Requirements Sample Type
Sum of 01B, 01C, 01D & 01J, 01L					
Flow	Monitoring	Only	MGD	Weekly	Instantaneous
Boron	Monitoring	Only	mg/l	Weekly	Grab[n]
001C					
Flow	Monitoring	Only	MGD	Monthly	Instantaneous
001E					
Flow	Monitoring	Only	MGD	Weekly	Instantaneous
001G					
Flow	Monitoring	Only	MGD	Weekly	Instantaneous
Phosphates as P**	16	38	lbs/day	Monthly	Grab
001I					
Flow	Monitoring	Only	MGD	Footnote o	Footnote o
001J***					
Flow	Monitoring	Only	MGD	Weekly	Estimate
Oil & Grease		No visible oil or sheen	mg/l	Weekly	Visual Observation
Sum of 01C, 01D, 01K and 01L					
Oil & Grease		15	mg/l	Monthly	Grab[m]

***This applies to only those internal streams at Indian Point 2, which comprise this outfall.*

***Because this outfall cannot be monitored, the following shall apply:

1. All oil spills shall be handled under the SPCC plan.
2. Flow tributary to the floor drains shall not contain more than 15 mg/l of oil and grease nor any visible sheen.
3. Treated wastewater from the desilting operation within the intake structure and forebays shall be monitored once per 12 hour shift on the sand filter effluent. Grab samples shall be analyzed for total suspended solids and oil & grease. An estimate of discharge flow rate and a visual observation for the presence of any visible sheen shall be made on the sand filter effluent. The limitations for this discharge event are: 15 mg/l (oil&grease), 50 mg/l (total suspended solids) and no visible sheen.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning November 20, 2000 and lasting until permit expiration the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations Daily Avg.	Daily Max.	Units	Minimum Monitoring Requirements Measurement Frequency	Sample Type
01K - Filter Backwash					
Flow	Monitor	Monitor	GPD	Weekly	Instantaneous
001C					
Flow	Monitoring	Only	MGD	Monthly	Instantaneous
001L - Condensate Polisher System Effluent and Stormwater Runoff from Chemical Bulk Storage Secondary Conainment					
Flow	Monitor	Monitor	GPD	Weekly	Instantaneous
pH	(Range 6.0-9.0)		SU	Monthly	Grab
Chlorine, Total Residual	NA	Monitor	mg/l	Monthly	Grab
01N - Reverse Osmosis Reject					
Flow	Monitor	Monitor	GPD	Weekly	Instantaneous
Oil & Grease	NA	15	mg/l	Weekly	Grab
Total Suspended Solids	30	50	mg/l	Weekly	Grab

002-009 - Uncontaminated Stormwater Discharge

No monitoring required

91-20-2g (9/85)

Facil. .D # NY 000 4472
Part 1, Page 7 of 19

ACTION LEVEL REQUIREMENTS

The parameters listed below have been reported present in the discharge but at levels that currently do not require water-quality or technology-based limits. Action levels have been established which if exceeded will result in reconsideration of Water Quality and Technology based limits.

Routine action level monitoring results, if not provided for on the Discharge Monitoring Report (DMR) form, shall be appended to the DMR for the period during which the sampling was conducted.

If any of the action levels is exceeded, the permittee shall undertake a short-term, high-intensity monitoring program for this parameter. Samples identical to those required for routine monitoring purposes shall be taken on each of at least three operating days and analyzed. Results shall be expressed in terms of both concentration and mass, and shall be submitted no later than the end of the third month following the month when the action level was first exceeded. Results may be appended to a DMR or transmitted under separate cover to the same addresses. If levels higher than the action levels are confirmed, the result shall constitute a revised application and the permit shall be reopened for consideration of revised action levels or effluent limits.

The permittee is not authorized to discharge any of the listed parameters at levels which may cause or contribute to a violation of water quality standards.

Outfall Number and Effluent Parameter	Action Level	Units	Minimum Monitoring Requirements: Measurement Frequency	Minimum Monitoring Requirements: Sample Type
001L - Condensate Polisher System Effluent				
Fluorides	5	lbs/day	Semi-Annual	Grab
Iron	4	mg/l	Semi-Annual	Grab
Copper	1.0	mg/l	Semi-Annual	Grab
001A - Sewage Treatment Plant (No discharge allowed after January 1, 1989)				
Copper	0.5	mg/l	Semi-Annual	Grab
Mercury	0.1	mg/l	Semi-Annual	Grab
Zinc	1.0	mg/l	Semi-Annual	Grab

Footnotes

a. Discharge 001 shall occur only through the subsurface ports of the outfall structure.

b. When the temperature in the discharge canal exceeds 90°F or the site gross electric output equals or exceeds 600MW the head differential across the outfall structure shall be maintained at a minimum of 1.75 feet. When required, adjustment of the ports shall be made within four hours of any change in the flow rate of the circulating water pumps. If compliance is not achieved, further adjustments of the ports shall be made to achieve compliance. The requirements of the Settlement Agreement flow schedules shall take priority over the requirements of this footnote.

c. The service water system may be chlorinated continuously. Should the condenser cooling water system be chlorinated, the maximum frequency of chlorination for the condensers of each unit shall be limited to two hours per day. The total time for chlorination of the three units for which this permit is issued shall not exceed nine hours per week. Chlorination shall take place during daylight hours and shall not occur at more than one unit at a time.

d. The calculated quantity of these substances in the discharge shall be determined by using the analytical results obtained from sampling that is to be performed on internal waste streams 01C and 01D.

e. The calculated quantity of this substance in this discharge shall be determined by using the analytical results obtained from sampling that is to be performed on internal waste streams 01B, 01C, 01D and 01L and releases from Unit 3's chemical batch tanks into 01J.

(Footnote f has been removed. Text has been placed in Additional Requirement #8.)

g. Arithmetic mean of the values for effluent samples collected over a 30 day period.

h. Arithmetic mean of the values for effluent samples collected over a 7 day period.

i. 30 day geometric mean.

j. 7 day geometric mean.

k. One flow proportioned composite sample shall be obtained from one grab sample taken from each of the internal waste streams 01B, 01C, 01D, 01E, 01G, and 01L.

l. One flow proportioned composite sample shall be obtained form one grab sample taken from each of the internal waste streams 001C and 001D. Sampling is not required if use of chromium is discontinued.

m. One grab sample shall be obtained from each of the internal waste streams 001C, 001D, 001K and 001L and the samples shall be analyzed separately. The results shall be reported by computing the flow-weighted average.

n. One flow proportioned composite sample shall be obtained from one grab sample taken from each of the internal waste streams 01B, 01C, 01D, 01L and each release from the chemical batch tanks at Unit 3 into 01J.

o. *The flow of condenser cooling water discharges shall be monitored and recorded every eight hours by recording the operating mode of the circulating water pumps.* Any changes in the flow rate of each circulating water pump shall be recorded, including the date and time, and reported monthly together with the Discharge Reporting Form. The permittee shall indicate whether any circulating pumps were not in operation due to pump breakdown or required pump maintenance and the period(s) (dates and times) the discharge temperature limitation was exceeded, if at all. Methods, equipment, installation, and procedures shall conform to those prescribed in the Water Measurement Manual, U.S. Department of the Interior, Bureau of Reclamation, Washington D.C.: 1967 or equivalent approved by the permit issuing authority.

p. Effluent disinfection is required all year. If chlorine is used for disinfection, a chlorine residual of 0.5 - 3.0 (Range) shall be maintained in the chlorine contact chamber effluent.

q. Continuous monitoring of TRC during condenser chlorination is required. A continuous TRC monitor shall be installed by October 1, 1987 or the date condenser chlorination begins, whichever is later. Prior to installation of the continuous monitor or when the continuous monitor fails, is inaccurate, or is unreliable, TRC shall be monitored during condenser chlorination by analyzing grab samples taken at least once every 30 minutes during each chlorination period.

r. Grab samples shall be taken at least once daily during low level service water chlorination and at least once every 30 minutes during high level service water chlorination. During service water chlorination, Outfall 001 TRC concentrations may be determined by either direct measurement at Outfall 001 or by multiplying a measured TRC concentration in the service water system by the ratio of chlorinated service water flow to the total site flow.

Additional Requirements:

1. There shall be no discharge of PCB's from this facility.

2. Collected screenings, sludges, and other solids and precipitates separated from the Permittee's discharges and/or intake water authorized by this permit shall be disposed of in such a manner as to prevent entry of such materials into navigable waters or the tributaries. Any fish, shellfish, or other organisms collected or trapped as a result of intake water screening or treatment may be returned to the water body habitat, together with associated solids.

3. The permittee shall submit on a quarterly basis to the NYSDEC at its offices in White Plains and Albany a monthly report of daily operating data, by the 28th of the month following the end of the quarter, that includes the following:

   a. Daily minimum, maximum and average station electrical output shall be determined and logged.

   b. Daily minimum, maximum and average water use shall be directly or indirectly measured or calculated and logged.

   c. Temperature of the intake and discharges shall be measured and recorded continuously. Daily minimum, maximum and average intake and discharge temperatures shall be logged.

4. Biological Monitoring and Reporting

   The permittee shall comply with biological monitoring requirements which shall be embodied in a Memorandum of Agreement (MOA) to be entered into between the NYSDEC and the Permittee for the permit issued to Indian Point Generating Station Unit 1-3. Monitoring requirements shall be consistent with the Hudson River Settlement Agreement and Attachment V thereto.

   Live sturgeon collected during biological monitoring studies will be counted, measured, and examined for tags, then carefully returned to the river as quickly as possible. Dead sturgeon collected during biological monitoring studies shall be counted, weighed, measured, examined for tags and frozen for salvage for the Department of Environmental Conservation for up to one year, at which time the sturgeon will be disposed of in a sanitary landfill. Each sturgeon shall be individually labeled indicating date of capture and appropriate measurements. The permittee shall provide written notice to the Chief, Bureau of Environmental Protection one (1) month prior to the disposal of any sturgeon.

5. Notwithstanding any other requirements in this permit, the permittee shall also comply with all applicable Water Quality Regulations promulgated by the Interstate Sanitation Commission including Sections 1.01 and 2.05 (f) as they relate to oil and grease.

6. It is recognized that influent quality changes, equipment malfunction, acts of God, or other circumstances beyond the control of the Permittees may, at times, result in effluent concentrations exceeding the permit limitations despite the exercise of appropriate care and maintenance measures, and corrective measures by the permittees. The permittees, either individually or jointly, may come forward to demonstrate to the DEC that such circumstances exist in any case where effluent concentrations exceed those set forth in this permit. The DEC, however, is not obligated to wait for, or solicit, such demonstrations prior to the initiation of any enforcement proceedings, nor must it accept as valid on its face the statements made in any such demonstration.

   In the event of non-compliance attributable to only one facility, DEC will initiate enforcement proceedings against the permittee responsible for such facility.

   DEC shall not initiate enforcement proceedings concurrently against both the Permittees, unless DEC has been unable to identify the non-complying facility. If DEC seeks to enforce in an administrative or judicial proceeding any provision of this permit, the Permittees may raise at that time the issue of whether, under the United States Constitution, statute, or decisional law, they are entitled to a defense that their conduct was caused by circumstances beyond their control.

7. The Hudson River Settlement Agreement, dated December 19, 1980, is annexed to this permit as Appendix 2 and is incorporated herein as a condition to this permit. The Settlement Agreement satisfies New York State Criteria Governing Thermal Discharges. The Agreement for Installation of Modified Ristroph Screens at Indian Point Units 2 & 3, dated October 31, 1988 is annexed to this permit as Appendix 3 and is incorporated herein as a condition to this permit. The Agreement for Installation of Modified Ristroph Screens at Indian Point Units 2 & 3 implements Section 2.F of the Hudson River Settlement Agreement and satisfies New York State Criteria Governing Thermal Discharges.

8. All chemicals listed and/or referenced in the January 17, 1986 permit application as well as Drewgard 315, Betz Corr-Shield 736 and Nalco 8325 are approved for use. Drewgard 100 may be added so the calculated concentration shall not exceed 11 mg/l and the active ingredient E.D.T.A. shall not exceed 0.28 mg/l in the discharge canal. If use of new biocides, corrosion control chemicals or water treatment chemicals is intended, application must be made prior to use. No use will be approved that would cause exceedance of state water quality standards.

9. Beginning upon the effective date of this permit, the permittees shall submit to the NYSDEC Offices in Albany and White Plains, a copy of their Semi-Annual Effluent and Waste Disposal Reports submitted to the Nuclear Regulatory Commission.

10. Permittee will (at Permittee's option) submit a report to analyze the suitability of continuous chlorine monitoring for compliance purposes. The report will compare results of continuous monitor to results of grab sampling program (for total residual chlorine). Within 60 days from receipt of the report, DEC shall either (a) approve the report's conclusions and recommendations and initiate any appropriate permit modification requested by the permittees or (b) provide the permittees with the detailed technical reasons for rejection. If DEC fails to meet this 60-day deadline, the Department shall initiate a permit modification to require grab samples at least once every 30 minutes during condenser chlorination.

11. The data, results and information being generated pursuant to aquatic studies and analyses and impact mitigation programs being conducted at this Facility under the terms of the Hudson River Settlement Agreement, dated December 19, 1980, shall constitute sufficient grounds for the applicant or the DEC to seek modification of this permit under 6 NYCRR 621.13.

W:\PERMITS\NY0004472.pk.wpd

SPECIAL CONDITIONS - BEST MANAGEMENT PRACTICES

1. The permittee shall develop a modification to the Best Management Practices (BMP) plan to prevent, or minimize the potential for, release of significant amounts of toxic or hazardous pollutants to the waters of the State through plant site runoff; spillage and leaks; sludge or waste disposal; and storm water discharges including, but not limited to, drainage from raw material storage. Completed BMP plans shall be submitted by **EDM + 6 Months** to the Regional Water Engineer at the address shown on the *Recording, Reporting and Additional Monitoring Requirements*. The BMP plan shall be implemented within 6 months of submission, unless a different time frame is approved by this Department.

2. Subsequent modifications to or renewal of this permit does not reset or revise the deadline set forth in (1) above, unless a new deadline is set explicitly by such permit modification or renewal.

3. The permittee shall review all facility components or systems (including material storage areas; in-plant transfer, process and material handling areas; loading and unloading operations; storm water, erosion, and sediment control measures; process emergency control systems; and sludge and waste disposal areas) where toxic or hazardous pollutants are used, manufactured, stored or handled to evaluate the potential for the release of significant amounts of such pollutants to the waters of the State. In performing such an evaluation, the permittee shall consider such factors as the probability of equipment failure or improper operation, cross-contamination of storm water by process materials, settlement of facility air emissions, the effects of natural phenomena such as freezing temperatures and precipitation, fires, and the facility's history of spills and leaks. For hazardous pollutants, the list of reportable quantities as defined in 40 CFR, Part 117 may be used as a guide in determining significant amounts of releases. For toxic pollutants, the relative toxicity of the pollutant shall be considered in determining the significance of potential releases.

   The review shall address all substances present at the facility that are listed as toxic pollutants under Section 307(a)(1) of the Clean Water Act or as hazardous pollutants under Section 311 of the Act or that are identified as Chemicals of Concern by the Industrial Chemical Survey.

4. Whenever the potential for a significant release of toxic or hazardous pollutants to State waters is determined to be present, the permittee shall identify Best Management Practices that have been established to minimize such potential releases. Where BMPs are inadequate or absent, appropriate BMPs shall be established. In selecting appropriate BMPs, the permittee shall consider typical industry practices such as spill reporting procedures, risk identification and assessment, employee training, inspections and records, preventive maintenance, good housekeeping, materials compatibility and security. In addition, the permittee may consider structural measures (such as secondary containment and erosion/sediment control devices and practices) where appropriate.

5. Development of the BMP plan shall include sampling of waste stream segments for the purpose of toxic "hot spot" identification. The economic achievability of effluent limits will not be considered until plant site "hot spot" sources have been identified, contained, removed or minimized through the imposition of site specific BMPs or application of internal facility treatment technology. For the purposes of this permit condition a "hot spot" is a segment of an industrial facility; including but not limited to soil, equipment, material storage areas, sewer lines etc.; which contributes elevated levels of problem pollutants to the wastewater and/or storm water collection system of that facility. For the purposes of this definition, problem pollutants are substances for which treatment to meet a water quality or technology requirement may, considering the results of waste stream segment sampling, be deemed unreasonable. For the purposes of this definition, an elevated level is a concentration or mass loading of the pollutant in question which is sufficiently higher than the concentration of that same pollutant at the compliance monitoring location so as to allow for an economically justifiable removal and/or isolation of the segment and/or B.A.T. treatment of wastewaters emanating from the segment.

6. The BMP plan shall be documented in narrative form and shall include any necessary plot plans, drawings or maps. Other documents already prepared for the facility such as a Safety Manual or a Spill Prevention, Control and Countermeasure (SPCC) plan may be used as part of the plan and may be incorporated by reference. USEPA guidance for development of storm water elements of the BMP is available in the September 1992 manual "Storm Water Management for Industrial Activities," USEPA Office of Water Publication EPA 832-R-92-006 (available from NTIS, (703)487-4650, order number PB 92235969). A copy of the BMP plan shall be maintained at the facility and shall be available to authorized Department representatives upon request. As a minimum, the plan shall include the following BMP's:

a. BMP Committee	e. Inspections and Records	i. Security
b. Reporting of BMP Incidents	f. Preventive Maintenance	j. Spill prevention & response
c. Risk Identification & Assessment	g. Good Housekeeping	k. *Erosion & sediment control*
d. Employee Training	h. Materials Compatibility	l. Management of runoff

7. The BMP plan shall be reviewed annually and shall be modified whenever: (a) changes at the facility materially increase the potential for significant releases of toxic or hazardous pollutants, (b) actual releases indicate the plan is inadequate or (c) a letter from the Regional Water Engineer highlights inadequacies in the plan..

8. Facilities with Petroleum and/or Chemical Bulk Storage (PBS and CBS) Areas:
Compliance must be maintained with all applicable regulations including those involving releases, registration, handling and storage (6NYCRR 595-599) and (6NYCRR 612-614). Stormwater discharges from handling and storage areas should be eliminated where practical.

a. Spill Cleanup - All spilled or leaked substances must be removed from secondary containment systems as quickly as practical and in all cases within 24 hours. The containment system must be thoroughly cleaned to remove any residual contamination which could cause contamination of stormwater and the resulting discharge of pollutants to waters of the State. Following spill cleanup the affected area must be completely flushed with clean water three times and the water removed after each flushing for proper disposal in an on-site or off-site wastewater treatment plant permitted to discharge such wastewater. Alternatively, the permittee may test the first batch of stormwater following the spill cleanup to determine discharge acceptability. If the water contains no pollutants it may be discharged. Otherwise it must be disposed of as noted above. See *Discharge Monitoring* below for the list of parameters to be sampled for.

b. Discharge Operation - Stormwater must be removed before it compromises the required containment system capacity. Each discharge may only proceed with the prior approval of the permittee staff person responsible for ensuring compliance with this permit. Bulk storage secondary containment drainage systems must be locked in a closed position except when the operator is in the process of draining accumulated stormwater. Transfer area secondary containment drainage systems must be locked in a closed position during all transfers and must not be reopened unless the transfer area is clean of contaminants. Stormwater discharges from secondary containment systems should be avoided during periods of precipitation. A logbook shall be maintained on-site noting the date, time and personnel supervising each discharge.

c. Discharge Monitoring of Bulk Storage Secondary Containment Systems and Tank Hydrotest Waters - *This paragraph only applies to those bulk storage containment system outlets which are not identified in the SPDES permit as an outfall with explicit effluent limitations.* Prior to each discharge of contained waters, such waters must be screened for contamination*. The method of screening shall be developed by the permittee as part of the overall Best Management Practices Plan. Examples of screening methods include inspection for any visible evidence of contamination for non-fuel petroleum secondary containment and volatile gas meters for petroleum fuel or volatile materials secondary containment. If the screening indicates contamination, the permittee must collect and analyze a representative sample** of the contained liquid and contact the regional water engineer (or the regional water engineer's authorized representative) to determine if the contained liquid may be discharged.

d. Discharge Monitoring of Transfer Area Secondary Containment Systems - *This paragraph only applies to those transfer area containment system outlets which are separate from bulk storage containment system outlets and are not identified in the SPDES permit as an outfall with explicit effluent limitations.* The first discharge* following any spill or leak must be sampled for flow, pH, the substance(s) transferred in that area and any other pollutants believed to be present**.

e. Discharge Reporting - Results of analytical monitoring required above must be submitted to the Department by appending them to the corresponding discharge monitoring report (DMR). Failure to perform the required discharge monitoring and reporting shall constitute a violation of the terms of the SPDES permit.

f. Prohibited Discharges - The following discharges are prohibited unless specifically authorized elsewhere in this SPDES permit or unless proper notification is provided to the department and the department determines such discharge may proceed without modification to this permit: spills or leaks, tank bottoms, maintenance wastewaters, wash waters where detergents or other chemicals have been used, contained fire fighting runoff, fire training water contaminated by contact with pollutants or containing foam or fire retardant additives, and, unnecessary discharges of water or wastewater into secondary containment systems. An example of a necessary discharge could be the addition of steam to prevent bulk storage containment area sump pumps from freezing during cold weather. In all cases, any discharges which contain a visible sheen, foam, or odor, or may cause or contribute to a violation of water quality are prohibited.

* Discharge includes stormwater discharges and snow and ice removal. If applicable, a representative sample of snow and/or ice should be collected and allowed to melt prior to assessment.

** If the stored substance is a petroleum fuel (i.e. fuel oil, gasoline, kerosene, etc.), then the discharge should be sampled for oil & grease, benzene, ethylbenzene, naphthalene, toluene and total xylenes. If the stored substance(s) are listed in Tables 6-8 of application form NY-2C sampling is required. If the substance(s) are listed in NY-2C Tables 9-10 sampling for appropriate indicator parameters may be required, e.g., substituting BOD5 for methanol, substituting toxicity testing for demeton. The volume of discharge may be calculated by measuring the depth of water within the containment area times the wetted area converted to gallons or by other suitable methods. Form NY-2C is available on the NYSDEC web site. Contact the facility inspector for further guidance.

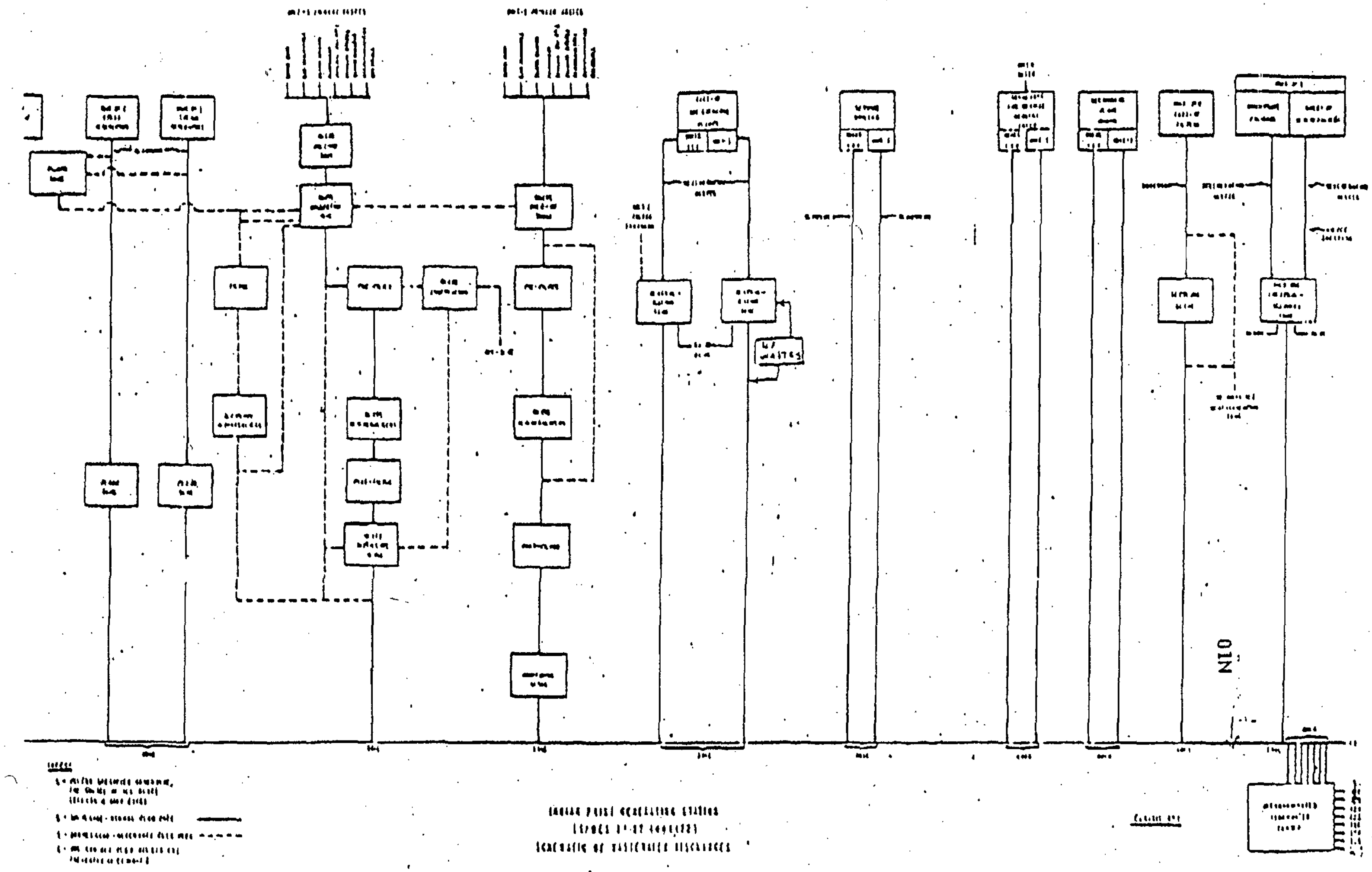
Definition of Daily Average and Daily Maximum

The daily average discharge is the total discharge by weight or in other appropriate units as specified herein, during a calendar month divided by the number of days in the month that the production or commercial facility was operating. Where less than daily sampling is required by this permit, the daily average discharge shall be determined by the summation of all the measured daily discharges in appropriate units as specified herein divided by the number of days during the calendar month when the measurements were made.

The daily maximum discharge means the total discharge by weight or in other appropriate units as specified herein, during any calendar day.

Monitoring Locations

Permittee shall take samples and measurements to meet the monitoring requirements at the location(s) indicated below: (Show locations of outfalls with sketch or flow diagram as appropriate). The sampling for the internal waste streams 001A thru 001L shall be taken in the internal waste streams before entering the circulating cooling water discharge canal.



SPT No: NY 000 4472
Part Page 14 of 19
Modified: 9-30-99

3076

91-20-2c (9/85)

Facility ID # NY 000 4472
Part 1, P 15 of 19

~~FINAL~~ SCHEDULE OF COMPLIANCE FOR EFFLUENT LIMITATIONS

(a) Permittee shall achieve compliance with the effluent limitations specified in this permit for the permitted discharge(s) in accordance with the following schedule:

Action Code	Outfall Number(s)	Compliance Action	Due Date
04	001A	Respondent shall begin construction of the "Sanitary Waste Pipeline Connection from the Indian Point Generating Facility to the Village of Buchanan.	4/1/88
08	001A	Respondent shall complete construction of the "Sanitary Waste Pipeline Connection from the Indian Point Generating Facility to the Village of Buchanan."	12/1/88
27	001A	Respondent shall cease discharges from the Sanitary Waste Treatment Plant, Outfall 001A, at the Indian Point Generating Facility.	1/1/89

The permittee shall comply with all terms and conditions of the orders on consent dated July 17, 1986 and August 20, 1987, described as attachments "A & B". Said terms and conditions are incorporated, herein, by reference.

(b) The permittee shall submit to the Department of Environmental Conservation the required document(s) where a specific action is required in (a) above to be taken by a certain date, and a written notice of compliance or noncompliance with each of the above schedule dates, postmarked no later than 14 days following each elapsed date. Each notice of noncompliance shall include the following information:

1. A short description of the noncompliance,
2. A description of any actions taken or proposed by the permittee to comply with the elapsed schedule requirement without further delay;
3. A description of any factors which tend to explain or mitigate the noncompliance; and
4. An estimate of the date permittee will comply with the elapsed schedule requirement and an assessment of the probability that permittee will meet the next scheduled requirement on time.

SCHEDULE OF COMPLIANCE FOR EFFLUENT LIMITATIONS (continued)

(c) The permittee shall submit copies of the written notice of compliance or noncompliance required herein to the following offices:

Chief, Compliance Section
New York State Department of Environmental Conservation
50 Wolf Road
Albany, New York 12233

Regional Water Engineer, Region 3
New York State Department of Environmental Conservation
202 Mamaroneck Avenue
White Plains, NY 10601

The permittee shall submit copies of any engineering reports, plans of study, final plans, as-built plans, infiltration-inflow studies, etc. required herein to the New York State Department of Environmental Conservation Regional Office specified above unless otherwise specified in this permit or in writing by the Department or its designated field office.

91-20-2: (9/85)

MONITORING, RECORDING AND REPORTING

a) The permittee shall also refer to the General Conditions (Part II) of this permit for additional information concerning monitoring and reporting requirements and conditions.

b) The monitoring information required by this permit shall be:

☒ Summarized, signed and retained for a period of three years from the date of sampling for subsequent inspection by the Department or its designated agent.

☒ Summarized and reported by submitting completed and signed Discharge Monitoring Report forms once every 1 month(s) to the locations specified below. Blank forms available at department offices listed below.

The first report will be due no later than November 28, 1987

Thereafter, reports shall be submitted no later than the 28th of the following month(s): each month

Department of Environmental Conservation
Regional Water Engineer, Region 3
202 Mamaroneck Avenue
White Plains, NY 10601

Westchester County Health Department
112 East Post Road
White Plains, NY 10601

Department of Environmental Conservation
Division of Water
50 Wolf Road,
Albany, New York 12233

Interstate Sanitation Commission
ATTN: Mr. Thomas R. Glenn, Jr.
Director and Chief Engineer
10 Columbus Circle
New York, NY 10019

☒ (Applicable only if checked)

Dr. Richard Baker, Chief
Permit Administration Branch
Planning & Management Division
USEPA Region II, 26 Federal Plaza
New York, New York 10278

c) XXXXXXXXX, Monthly Wastewater Treatment Plant Operator's Reports should be submitted to the Regional Engineer and County Health Department or County Environmental Control Agency specified above. (outfall 001A only)

d) Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit.

e) If the permittee monitors any pollutant more frequently than required by the permit, using test procedures approved under 40 CFR 136 or as specified in the permit, the results of this monitoring shall be included in the calculations and recording of the data on the Discharge Monitoring Reports.

f) Calculations for all limitations which require averaging of measurements shall utilize an arithmetic mean unless otherwise specified in this permit.

g) Unless otherwise specified, all information recorded on the Discharge Monitoring Report shall be based upon measurements and sampling carried out during the most recently completed reporting period.

h) On or after April 1, 1984, any laboratory test or sample analysis required by this permit for which the State Commissioner of Health issues certificates of approval pursuant to section five hundred two of the Public health Law shall be conducted by a laboratory which has been issued a certificate of approval. Inquires regarding laboratory certification should be sent to the Laboratory Certification/Quality Assurance Group, New York State Health Department Center for Laboratories and Research, Division of Environmental Sciences, The Nelson A. Rockefeller Empire State Plaza, Albany, New York 12201.

Memorandum of Agreement
Between
New York State Department of Environmental Conservation
and
the Hudson River Utilities

1. This Memorandum of Agreement (MOA) is entered into by the New York State Department of Environmental Conservation (Department) with Consolidated Edison of New York, Inc. (Consolidated Edison), and Power Authority of the State of New York (Power Authority), Orange and Rockland Utilities, Inc. (O and R), and Central Hudson Gas and Electric Corp. (CH) in accordance with the Department's certification pursuant to Section 401 of the Clean Water Act and to supply the appropriate conditions "Biological Monitoring and Reporting" of the SPDES discharge permit numbers:

NY 000 4472	Consolidated Edison's Indian Point Station Units 1 & 2
NY 002 7065	The Power Authority's Indian Point Station Unit 3
NY 000 8010	Orange and Rockland Utilities' Bowline Point Station
NY 000 8231	Central Hudson's Roseton Station,

and in accordance with the "Biological Monitoring Program" as provided for in Section 2.J and Attachment V to the Hudson River Settlement Agreement entered into December 19, 1980 (Settlement Agreement).

2. This MOA is to embody the agreement of the Utilities to conduct monitoring program studies as described in the Settlement Agreement. Specific studies will be carried out in accordance with work scopes approved by the Department. Nothing contained in this MOA shall cause the Utilities to perform activities or incur expenses in excess of or less than the amount specified in the settlement agreement. Any further studies necessary to fulfill the dollar value of the Utilities' monitoring obligations will be conducted only with the prior written approval of DEC.

3. The Utilities agree to use their best efforts to conduct fully the biological monitoring program as specified in the Settlement Agreement. The Department acknowledges that the Utilities will not be deemed to be in non-compliance with the Settlement Agreement or any Condition of any applicable discharge permit or Section 401 Certification if the full complement of all biomonitoring cannot be completed within the original calendar year for reasons beyond the reasonable control of the Utilities. However, should the full complement of biomonitoring not be completed within the original year, at the sole discretion of DEC, either the time to complete such studies shall be extended or the unexpended funds shall be used to supplement the biomonitoring program in the subsequent year.

4. The Department and the Utilities hereby agree that the study programs may be modified at any time by written agreement of the Department and the Utilities to fulfill the objectives of the study, provided that any cost savings which accrue through such modifications be redirected to other studies as appropriate.

5. Reports based on these studies and an accounting of funds expended will be submitted within six months of the completion of component studies and no later than June 30 of the subsequent year unless an extended schedule is mutually agreed upon by the Department and the Utilities.

6. The term of this MOA shall be from the expiration of the permit currently in force until the expiration date of this permit, after which time this MOA shall be of no further force or effect except for completion of reports, accountings, or studies identified in paragraphs 3 to 5.

Signatures

Con Edison	Date
Orange & Rockland	Date
Central Hudson	Date
Power Authority	Date
Niagara Mohawk	Date
NYSDEC	Date

Clam-Trol (7/91)

SPDES N NY 0004472

Part 1, Attachment #: C

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning May 15, 1992

and lasting until October 1, 1992

the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations Daily Avg.	Discharge Limitations Daily Max.	Units	Minimum Monitoring Requirements: Measurement Frequency	Minimum Monitoring Requirements: Sample Type
Outfall(s) 001					
Betz Clam-Trol CT-1 (whole product)	N/A	0.2	mg/l	Duration of chemical application & discharge	Multiple Grab*

* For purpose of this authorization, multiple grab is defined as individual grab samples collected at three hour intervals during the duration of chemical addition and discharge.

Special Conditions

The Betz Clam-Trol CT-1 program for zebra mussel control, application submitted by letter application dated 04/20/92 to NYSDEC Region 3 New Paltz Office, is approved with the following conditions:

1. The effluent concentrations at the discharge shall not exceed 10 ug/l (ppb) of quaternary ammonium compounds and 6 ug/l (ppb) of dodecylguanidine hydrochloride. For Betz Clam-Trol CT-1, these limitations will be achieved by limiting effluent whole product concentrations.
2. Clam-Trol CT-1 detoxification with bentonite clay or other Department approved adsorption medium is required for all affected discharge waste streams throughout the treatment period.
3. Each individual zebra mussel control treatment is limited to a maximum of 24 hours duration.
4. Treatments for zebra mussel control shall be limited to a maximum of four treatments annually. Treatments shall be separated by at least 45 days.
5. Caged fish studies are required to be conducted during the discharge of the molluscicide. Sample study protocols are available from the Department's Division of Fish and Wildlife. Specific caged fish study protocols must be approved by the Department prior to commencement of the zebra mussel control program.
6. Records of product dosage concentration, effluent flow and effluent concentration of product during addition and discharge must be maintained. The flow shall be measured at the frequency specified for flow elsewhere in this permit or at the frequency of the parameter specified above, whichever is more frequent.
7. The Regional Water Engineer shall be notified not less than 48 hours before initiation of a zebra mussel control program.
8. Reports describing caged fish studies shall be sent to New York State Department of Environmental Conservation, Division of Fish and Wildlife, Standards and Criteria Unit - Room 530, 50 Wolf Road, Albany, New York 12233-4756, within 60 days following each individual zebra mussel control treatment.
9. Reports describing the results of the effectiveness of the zebra mussel control program and the effluent analyses for Betz Clam-Trol CT-1 shall be submitted to the Regional Water Engineer, NYSDEC, within 60 days following each chemical treatment.
10. This permit modification is issued based on the best environmental and aquatic toxicity information available at this time. This authorization is subject to modification or revocation any time new information becomes available which justifies such modification or revocation.

3083

EXHIBIT C TO LITTLE AFFIRMATION - SEPTEMBER 3, 1993 DEC LETTER AND COMMENTS RE: DRAFT HUDSON RIVER EIS [3083-3121]

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233

Thomas C. Jorling
Commissioner

September 3, 1993

Mr. Raymond R. Kimmel, Jr.
Asst. Vice President
Consolidated Edison of N.Y., Inc.
4 Irving Place
N.Y., N.Y. 10003

Re: Hudson River Generation Stations SPDES Modifications
No. 3-5522-00011/00004-9
No. 3-3346-00095/00002-9
No. 3-3922-00003/00003-9

Dear Mr. Kimmel:

The Department of Environmental Conservation has reviewed the preliminary draft Environmental Impact Statement submitted by the Hudson River utilities in support of the above-referenced permit modifications. We have concluded that the applications remain incomplete pending receipt of additional information.

The Department has prepared the enclosed comments. These comments are not exhaustive, however, as the DEIS is very complex and requires a significant effort by staff in the areas of data use, modelling analysis, appropriate reference material, analysis of alternatives, etc., as well an impact analysis and compliance with rules and regulations. In addition, we expect the consultant will be available very soon to assist in further review of some of the topics mentioned above, as per the Scope of Work developed by DEC and the Utilities.

Staff will submit further comments as they are developed. We are available to discuss our comments with the Utilities and your consultants, either at a scheduled meeting or via telephone. It should be noted that the enclosed comments also reflect input from Scenic Hudson, the National Marine Fisheries Service and the U.S. Fish & Wildlife Service. Again, they are expected to provide additional comments in the near future.

The Department expects that responses to comments will be submitted in letter form, with attachments as appropriate. The format will be a copy of the comment followed by the response. New or revised tables or figures should be presented with the response. Upon acceptance of the response by the Department, the Applicants should consider if the response will result in modification of the DEIS. The next step would be preparation of a draft DEIS revision to show

how the response is incorporated into the document, and finally, revision of the DEIS. Only one revision of the DEIS will be necessary as that will be just prior to the document being Noticed for public review.

Please do not hesitate to contact me if you have any questions.

Sincerely,

John M. Cianci
Project Manager
Div. of Regulatory Affairs

att.
cc: see attached list

Distribution List-Sept. 3, 1993 letter to R. Kimmel, Con Edison

W. Elliot
A. Kahnle/K Hattala
B. Young/K. McKown
E. Radle
F. Dunwell
K. Silliman
W. Keller
L. Corin
M. Chang
M. Ludwig
T. Lyons
P. Isaacson
C. Lee
K. Kennedy
J. Cronin
W. Mancroni
D. Dunning
R. Kosior

New York State Department of Environmental Conservation

COMMENTS

Preliminaty Draft Environmental Impact Statement
for

SPDES Permit Modifications for Indian Point, Bowline Point and Roseton Electric Generation Stations

SECTION III

SECTION III - SUMMARY
A. THE ACTION

Page III-1
Par. 1. Permit conditions will "minimize, to the extent practicable, adverse environmental impact". Please track the wording in ECL 8-0109: "to the maximum extent practical.

Page III-2, Paragraph 2
What is the reason for the anticipated increase in conditional mortality rates due to entrainment for the years 1994-1998?

SECTION IV - PROPOSED ACTION
A. DESCRIPTION OF THE PROPOSED ACTION

Page IV-1
Par. 1. Same comment as Page III-1. Par. 1

Page IV-1a Table IV-1, (1)
The approximate flow rates should be presented as gallons per day (gpd). This terminology should subsequently be used consistently throughout the document. The important point is to use standard terminology adapted to flow rates. The documents has gps, gpm, gpd and cfs all related to flow rates.

Page IV-2, top
It is stated that if actual flows at Indian Point exceed those scheduled from May 3 through August 8, offsetting flow reductions providing equivalent credit points will be taken. Apparently the same approach is not planned at Roseton and Bowline. Please explain the rationale for the position.

Page IV-2
There are two sets of dates given for flow restriction goals and mitigation at Indian Point. Based on Table IV-3, it appears that one set of dates, May 10 through August 8 would accomplish the same goals and perhaps be less confusing.

Please consider using one set of dates.

Page IV-4
(ii) No mention is made of continued evaluation of fine mesh screens to mitigate entrainment at Indian Point. Please consider adding such a statement to this section.

Page IV-4, Para. 1
The 6th line down describes a low pressure debris wash on the front of the Ristroph screen. Please confirm that such a spray wash is installed.

Page IV-18
The fourth line indicates tidal flow at Bowline is 77,000 cfs, but on page 12, the flow at Indian Point is given as 140,000 cfs. It does not seem logical for a downstream location (Bowline) would have a lower flow then an upstream one. Also, please check the freshwater flow at Bowline (p18): it seems too large compared to the flow at Indian Point. See also Figure V-8, Hudson River tidal flow and current velocity.

Page IV-20, Table 10
The table and discussion of flow in the text indicate that the condenser can be throttled to provide flow flexibility. However, A VI-1, P45, Table 3 indicates that pumps can also be throttled to provide other flow options. Please modify the text and the tables as necessary to indicate the full potential variability with the existing plant configuration. For example, from Table 3, is operation with two pumps throlled and condenser valves closed an option? What would the resulting flow be?

SECTION V - ENVIRONMENTAL SETTING

General Comments

DEC beach seine survey was designed to estimate the relative abundance of YOY striped bass only. The DEC Indices (Beach Seine, Trawl, and combined) has been validated to the ASMFC (McKown, 1991). The catches of other species are reported in annual reports, but these do not necessarily reflect abundance indices. The DEC striped bass beach seine survey does not sample the Hudson adequately to produce abundance indices for species such as: white perch, American shad, river herring, and spottail shiner. In addition, species such as bay anchovy, hogchoker, weakfish and atlantic and shortnose sturgeon are distributed offshore so the beach seine does not adequately sample them. The DEC does conduct a shad and river herring survey. This data is used in the shad section, but it should also be incorporated into the river herring section. The DEC also conducts a Trawl survey in conjunction with the YOY Striped Bass Beach Seine Survey. This data would be more appropriate for the "offshore" species such as bay anchovy, hogchoker, weakfish and the sturgeons.

In tables providing information on estimates of relative and absolute abundance, the DEIS generally cites DEC-Division of Marine Resourses (DMR) catch data for the period mid-August thru mid-November. This DEC-DMR program was expanded temporally in 1985 to begin in mid-July. Please note that the Division of Fish & Wildlife also conducts a beach seing program in the upriver tidal portion of the Hudson, directed at Alosids, as well as a shoal trawling program, directed at striped bass. These programs should be referenced as DEC-DFW studies.

Your decision to report a subset of the DEC-DMR data available in 1985 and later is reasonable in order to maintain consistency.

In general, reporting c/f is preferred since annual effort varies.

The Department will supply summarized data for Division of Fish & Wildlife sampling programs upon request.

All tables with abundance data should cite the specific source.

Page V-8, Paragraph 5

a. The statement is made that some of the reduction of native plants are due to pollution. What type of pollution? Please elaborate.

b. The discussion should mention the importance of the estuary for rare and endangered plant species.

Page V-9

There is no discussion of the recent zebra mussel invation. As their influence is continually expanding, the DEIS should present information on potential impacts of these organisms on the overall ecology and what measures will be taken by utilities to control the populations at intake and discharge structures.

Page V-24 Par. 3

Please correct the error: the Hudson River's widest point is 3.5 miles wide not 2.5.

Page V-36, Paragraph 3

What evidence is available to demonstrate that the reason phytoplankton do not uptake phosphorus in harbor because they are over- whelmed by wastewater inputs of phosphorus?

Page V-37, Paragraph 3
The 9th line should be modified by changing [distributed] to disturbed and ending the sentence there. Current dredging practices causes very little resuspension of sediments.

Page V-38, Paragraph 3
State which water quality criteria are referenced in the last sentence.

Page V-39, Paragraph 2
The 3rd line should be modified to read ..... industrial discharges such as that in the Foundry Cove area. The original sentence reads as if Foundry Cove were the only source of cadmium.

The 4th line of this paragraph should be changed to read.....with suspended material that [sediments] settles to the river bottom.

Page V-40, 1st whole paragraph
a. Citation for Chase et al. (1989) not presented.

b. Ref: citation DEC 1990a. The information contained in the preceeding sentence is not included in the referenced report. This reference should be checked and verified.

Page V-40, Paragraph 3, (1)
Citation for FDA (1979) not presented.

Page V-42, Paragraph 1
Please be advised that recreational fishing advisories are issued with fresh-water fishing licenses.

Page V-44, 2nd line from top of page, (1)
No citation listed for Quirk, Lawler and Matusky Engineers surveys.

Page V-48a, Figure V-28
Please order the graphs by date, to allow easire reading.

Page V-50, 1st full paragraph
HREMP Quarterly Report update does not appear to be a proper citation. More appropriately Beebe and Savidge AFS Monograph 4: 25-36.

Section V.D.2.A. Striped bass

Life History and Distribution

Page V-53

Please provide support or reference for the statement that PYSL stage duration is 30 days. Recent analyses by the Technical Working Group suggest that life stage duration may be very difficult to estimate from field data. Members of the EPRI striped bass COMPMECH team feel that duration of the PYSL stage is longer than 30 days.

Page V-54, Paragraph 3, first sentence

"... (DEC 1992a)." If the reference for striped bass moving out to western Long Island is from the DEC western Long Island survey, then the citation should be the DEC Report: McKown, K.A. (1992). An Investigation of the Movements and Growth of the 1990 Hudson River Year Class, In: A Study of the Striped Bass in the Marine District of New York VI.

Page V-54a

Figure V-39. Clarification of data summarized in figure is required. Do these fractions represent proportion in three regions relative to entire river BSS data, proportion of YOY in BSS data relative to all data within region, fraction of YOY standing crop estimates in shore zone?

Temporal Changes in Abundance

Page V-55

1. "The haul seine ...may not be a good index of abundance." The haul seine program is not an abundance survey, but was designed to obtain an estimate of age structure.

2. Dew (1988) information on mesh size used and ages caught in the gill net fishery is out of date. Please indicate the rationale for using these data when current information is available. DEC monitoring data suggest that ages five through seven predominated in recent years. Dominant ages would be expected to vary among years with changes in year class production and survival prior to recruitment.

3. Par. 2. Discussion of usefulness of beach seine data to estimate relative abundance. Was any attempt made to combine onshore (BSS or DEC-DMR beach seine data) and offshore data (either from the FSS or DEC DFW trawl program) to avoid problem cited (Versar 1987) and why wasn't this done? Was any offshore data evaluated as to their usefulness as abundance indicators?

4. Par. 3. There is confusion when DEC beach seine programs are referenced throughout the life history section (text and tables) under the same or various names. Since there are two DEC beach seine programs, please rename each survey to refer to the correct program. The DEC-DMR beach seine survey is for striped bass in the lower river (Peekskill and south). The DEC-DFW beach seine survey is for American shad and river herring in the middle and upper river (Newburgh Bay and north). The DEC program mentioned here is DEC-DMR beach seine: please reference the source of the data (i.e. report).

Page V-55a Table 14

1. Table headings are misleading. Gill net c/f are not reported by year-class. No reference is made to DEC-DFW trawl data, why? Indicate which DEC beach seine program data was used.

2. Please indicate if the time period for the DEC-DMR index cited is late August thru November, and that an index based on expanded temporal sampling (beginning mid-July since 1985) produces a higher indes.

3. Provide variance estimates for DEC beach seine and age zero and age 1+ population estimates.

4. The citation for the DEC Beach seine should be the DEC Report: McKown, K.A. (1992). Investigation of the 1991 Hudson River Striped Bass Spawning Success. In: A Study of the Striped Bass in the Marine District of New York VI.

The DEC also produced a report for the Atlantic States Marine Fisheries Commission on the DEC-DMR Y-O-Y surveys. The conclusion was that the combined DEC Beach Seine and DEC-DFW Trawl survey gave a better estimate of abundance then either alone, since it incorporated differences in onshore/offshore distribution. I think it would be a good idea to include that index in Table V-14. The citation is McKown, K.A. (1991). Validation of the Hudson River Young-of-the-Year Striped Bass Indices. Report to the ASMFC (enclosed).

Also, the DEC is changing to a geometric mean index for the beach seine (the combined is already geometric mean) due to the results of the report to ASMFC mentioned above, and recommendation from the ASMFC Striped Bass Technical Committee. The DEC-DMR Beach Seine indices (which are reported in Table V-14 as arithmetic means) should be substituted with the geometric mean indices.

Page V-56

1. Par. 1. "The striped bass bycatch from the .. shad fishery indicates abundance of young striped bass". Clarification of ages sampled in the gill net fishery is necessary. See comment V-55 2 (above) about appropriateness of using Dew, 1988 data. Regarding the use of gill net c/f by catch to estimate egg abundance of spawners, where has this technique been used that would support this use of the data?

2. What sort of analyses were used to determine rate of change in the DEC gill net index, the PYSL index, the Utility BSS index, and in the DEC beach seine index?

Page V-56, Paragraph 1

The average rate of increase in DEC Gill Net By Catch is positively affected by regulatory changes which reduced mortality rates on adult and sub-adult stocks thus affect the number of eggs deposited, YSL, PYSL.

Page V-57

1. The correlation coefficient (r) between the Utilities' BSS index and yearling abundance estimates is listed as 0.95 here and 0.88 in the previous paragraph. Please investigate this discrepency.

2. Did the absolute abundance estimates for age zero fish correlate with any other index? Does the presence or absence of such correlation provide added insight on relative value of indices?

3. Was there a trend among years in age zero absolute abundance estimates?

4. Were attempts made to utilize juvenile abundance data from either the Utilities' fall shoals survey or the DEC-DFW bottom trawl survey?

Potential Influences on Abundance

Page V-58

1. A table of abiotic factors examined by Pace et al. (1993) and CES (1992) would be helpful. Which life stages were evaluated?

2. Par. 1. Reference for relationship between PYSL and juveniles. Should that be CES and not Pace et al.?

3. Density dependence is identified here as a possible explanation for increased abundance of adults and PYSL without a concomitant increase in abundance of juveniles or yearlings. This possibility is apparently embraced by

modelling used in Appendices to evaluate impacts of entrainment and impingement. Since the issue of density dependence sparked protracted debate prior to the Hudson River Settlement Agreement, the hypothesis needs a thorough discussion at some place in the document. The possibility of density dependence in striped bass could be made more believable if alternative explanations for stable recruitment were discounted and possible mechanisms of density dependence were suggested along with supporting data. The following two questions touch on alternative hypotheses.

4. Could the asymptotic relationship between the PYSL and BSS indices suggested in Figure V-40 be a result of larval misidentification? If half of the striped bass PYSL each year since 1989 were really white perch, a curve might not fit the data any better than a straight line.

5. The DEIS should address the possibility that the apparent upper limit to the juvenile index might be caused by emigration of juveniles from the estuary during years of high production. Emigrants would be missed form the age one populations estimates if they did not return to the estuary until they had matured.

6. Support the statement that Hudson fish mostly contribute to NY and New England fisheries.

Page V-58, 1st full paragraph
Is it possible that a multivariate analysis is more appropriate than this bivariate analysis. It seems appropriate to compare this value with water temp, DO and possibly salinity. If done please report results.

Page V-58a, Figure V-41
a. No citations for DEC data presented.
b.There is no citation for either the SBSSS or LIOHS mortality rates. Identify the source of these numbers.

Page V-59
1. Par. 2. "The 1986 restrictions" adding coast-wide would describe restrictions better.

2. Please provide a table showing harvest restrictions imposed on striped bass in coastal states where Hudson River striped bass are likely to be harvested. Increasingly restrictive regulations have been imposed on commercial and recreational harvest of striped bass since the early 1980's. Changes made in 1986 may not have been substantial relative to others made during the last ten years.

3. Again, the increase in PYSL abundance since 1989 shown

in Figure V-42 may have been caused by an concomitant increase in white perch larvae which were misidentified as striped bass.

4. The citation DEC 1990c is found in the References as NYSDEC. 1990. Striped Bass Management. Other references are cited as New York State Department of Environmental Conservation, and Department of Environmental Conservation. There is a need to have all the Department's citations consistent. For technical resports, please follow the format suggested in the comment on Page V-54, Paragraph 3 (above).

5. The discussion of the two fishing management options F.25 and F.50 are appropriate but it should be made clear that New York State is not contemplating increasing F from .25 to .50, at this time.

Page V-60

1. This section summarizes mean effect of withdrawal facilities as 18 % in 1981-1987 and 16.4 % in 1989-1991. Estimates for the early time frame were made with a combination of CEMR and ETM methods; those for the later time frame with ETM only. If the two estimators (CEMR and ETM) predict different impacts from the same data it might not be appropriate to compare impacts between the two time periods. If comparisons are important, then possible influence of using different estimators should be discussed. Such a discussion should be part of any inferences made about relative effects of withdrawal facilities on survival to the juvenile stage in 1981-1987 vs 1988-1991.

2. Statements concerning the mediating effects of density dependent processes need clarification and support. See earlier comments on density dependent hypothesis on page V-58.

3. The third line refers to IP 1 & 2; shouldn't this be 2 & 3?

Page V-60, 3rd full paragraph, last sentence

Is it possible that the juvenile striped bass have expanded their nursery area? DEC has captured YOY striped bass outside of the Hudson River in Little Neck Bay, Manhasset Bay and Jamaica Bay every year since 1987. This should be examined.

Page V-60a

Table V-15 (and for all species) The title of the table should be changed to reflect what the numbers are. All are Conditional Entrainment or Impingement Mortality Rates and not just "effects".

Page V-61, 1st partial paragraph
Estimation of F on fish > 28" TL. Calculations for the value of F=0.04 should be presented.

Page V-61, Paragraph 1, last sentence
The citation DEC 1990 is referring to the citation in the previous comment. There is a DEC 1990a listed in the references cited, but this citation should be NYSDEC (1990). Striped Bass Management.

Page V-61, Pollution
The correct citation (enclosed) for Hudson River PCB trends is Sloan, R. and K.A.Hattala, (1991). Temporal and Spatial Aspects of PCB Contamination in Hudson River Striped Bass. Technical Report 91-2 (Bureau of Environmental Protection), Division of Fish & Wildlife, New York State Dept. of Environmental Conservation.

Section V.D.2.b White perch

Life History and Distribution

Page V-62
a. Are fecundity data available from Hudson River studies? Please use/cite these data if possible.

b. Reference to "reduction on nutrient loading decreased fertility of the nursery area", how does this relate to the Hudson nursery area and decrease in recruitment level?

Temporal Changes in Abundance

Page V-63
1. Par. 4. Indicate which DEC beach seine program, reference report. For the standing crop estimates, where is the detailed methodology explained?

2. Discussion of sampling programs should include trawl survey used in the stock assessment program.

3. How were rates of change in PYSL index and YOY indices determined? Which years were included in each analyses? The BSS YOY index in Table V-16 appears to go through plateaus of abundance rather than a constant change.

4. Please provide error values associated with estimated number of YOY in Table V-16.

5. Why was total catch reported for the DEC beach seine data rather than some calculation of catch per haul?

Perhaps a catch per haul index from the DEC beach seine would correlate with the Utilities' BSS index.

6. Abundance data and a description of analysis supporting the increase in adult white perch from Wells et al. (1992). is necessary. Which year classes contributed to the correlation between egg and larval and adult abundance alluded to in Wells et al. (1992)? Do any other YOY indices correlate with the adult data?

7. Are data available for larval life stage duration?

Potential Influences on Abundance

Page V-64

1. Were any attempts made to evaluate effects of abiotic factors on abundance of early life stages as was described for striped bass?

2. Why were density dependent processes not discussed for white perch? Models described in Appendix used density dependence in the spawner-recruit relationship.

3. A plot of various YOY abundance indices on the PYSL index may be of value in discussing presence or absence of relationships.

Page V-63, White Perch

How has the problem of identification of young white perch and striped bass been resolved in these analyses? Recent analyses funded by the Hudson River Foundation suggest that striped bass and white perch larvae were misidentified in some years. In most cases, white perch were classified as striped bass. If such effors occurred at different rates among years, they might explain interannual trends reported for the striped bass larval indixes. In particular, could the relatively high values of striped bass PYSL since 1989 have been caused by misidentification? Please discuss these concerns and how they could impact calculations presented the these species.

Page V-63a, Table V-16

Provide citations for data presented in Table V-16.

Section V.D.2.C. Atlantic Tomcod

Temporal Changes in Abundance

Page V-66

1. Par. 5. YOY index (PYSL and Juvenile)
(a) how is this calculated
(b) where is the detailed methodology explained

(c) are the two life stages just added together?

2. Explain how were data on temporal abundance of eggs, YSL, and PYSL obtained in Fig V-47 if the LRS survey did not start until mid May?

Page V-67

1. Par. 1. Indicate the specific DEC beach seine program(s) and reference report(s). Were the data summarized as total catch or as some catch-per-unit-effort? These questions also apply to Table V-18.

2. Did these analyses include data from the Utility's beach seine surveys (Appendix VI-4C) and the DEC-DFW trawl survey.

3. Are data from any sample program affected by inter-annual variation in water temperature which might affect movement in or out of time and location sampled?

4. What analysis was used to determine the average annual rate of change in the LRS index?

<u>Potential Influences on Abundance</u>

Page V-67

Discussion is required on the influence of predation on tomcod abundance.

Page V-67a, Table V-18

1982 Tomcod catch should be 785 not 758.

Page V-68

1. Provide a reference supporting statements about effects of population size on fecundity.

2. Provide support for statements indicating that tomcod are not sought by recreational fishermen and that health advisories have reduced recreational interests in this species. A small but active recreational fishery exists in the river in late fall. A recent survey by the Hudson River Sloop Clearwater suggests that perhaps half of Hudson River anglers do not know about the consumption advisories.

Section V.D.2.D American shad

<u>Life History and Distribution</u>

Page V-69

Please state references for life history characteristics (age, repeat spawning, fecundity, etc.). (DEC data reports ages to 13, repeat spawning to 8, see Appendix VI-4D)

Page V-69 b&c

Present a description of which years of data were summarized in Figures V-51 and V-52.

Temporal Changes in Abundance

Page V-70

1. This section indicates that ages five and six dominate DEC sample data from the commercial fishery. I would expect that ages captured in the commercial fishery would be influenced by year class strength, mortality prior to recruitment, and gill net mesh size. Did ages five and six dominate the entire time series of data since 1980?

2. Par. 2. Reference for DEC 1992b is missing.

Page V-71

1. What analyses were used to determine the lack of trend in the DEC gill net data and the significant increase in the PYSL index? Do DEC gill net data refer to DEC data from the commercial fishery? Were there any changes among years in sampling methods for PYSL that might explain the trend observed?

2. Par. 1. Why correlate male/female catches in the gill net data?

3. Par. 2. Reference for changes in "DEC YOY program"? The BSS YOY index is stated as the preferred index due partly to the longer time series. Table V-20 indicates a time series from 1974-1992. Explain the different time series used here than in the annual year-class reports which indicates the useful time series for shad to be 1979-1992. (i.e. LMS 1990 Year-class Report, values are also slightly different.)

4. How was "trend" of BSS data calculated?

5. Since the BSS data is subsetted to the time period mid-August to mid-October (weeks 33-40):

a. Are the effects of emigration on abundance during this time period accounted for? How do the effects of inter-annual variation in emigration affect presence of American shad in the sampled time window?

b. This same time period (Aug-Oct) misses the peak abundance of juvenile shad. Since most years of the BSS survey (1974-79 and 1987-91) began earlier in the year (at least by mid June, Appendix V), could data be backfitted for the missing June-July period for 1980-86 to obtain a better abundance estimate for the entire time series?

6. Could predation by striped bass or bluefish have affected abundance of juvenile American shad as they emigrate from the estuary in summer and fall?

7. Par. 3. Where are methods outlining calculation of standing crop estimate of YOY shad, is this also the PYSL Forecast (reference report)? Since the PYSL data generated the YOY shad estimate, what was the purpose of running a correlation? They should be highly correlated. Was there any correlation between the PYSL forecast and the BSS data or the DEC beach seine data (DEC-DFW survey) among years?

8. Were weekly mortality rates used to translate PYSL densities to YOY standing crop affected by density or year specific migration rates?

Page 71a, Table V-20

a. The Table should distinguish that the DEC beach seine data is from the YOY Shad Survey (DEC-DFW), not the YOY Striped Bass survey. These are two very different sampling programs and literature citations are appropriate.

b. The "year-class or cohort" column heading is misleading. Gill net CPUE data is reported by year, not by year-class. Please indicate which DEC beach seine program data was used.

Page V-72

1. PCB sampling for American shad has occurred since the 1980's to the present. The last reported data is available for 1989.

2. Par. 2. Reference the source of current landings for American shad.

3. Provide a reference for the statement that the in-river fishery has been further hurt by declining catches and a saturated market.

4. Par. 4. "Because shad generally migrate north ... ocean harvests from Maryland to Florida likely did not seriously affect Hudson River shad". Please explain how this happens given that this southern harvest occurs in areas where Hudson shad overwinter before the spring spawning migration.

5. Par. 4. and Figure V-53. "The proportion of New York and New Jersey harvest, which would affect the Hudson...." Why are New York and New Jersey's harvests lumped together? How are in-river Delaware River (New Jersey portion) shad stock landings distinguished from the Hudson's? How are the effects of ocean harvest determined for each stock (Delaware River vs. Hudson)? What data sources were used to generate

this graph?

Section V.D.2.E Blueback herring

Life History and Distribution

Page V-74

1. Par. 3. Reference for fecundity? Are fecundity data available for the blueback herring population in the Hudson River estuary?

Page V-74 b&c Figures V-55 and V-56.

If egg and larval distributions are for "river herring" (a combination of blueback herring and alewife) please state so on the Figure.

Temporal Changes in Abundance

Page V-75

1. Par. 3. What criteria were used to determine the "best available index". Were BSS data and/or DEC-DFW beach seine data evaluated? Where is methodology for YOY standing crop estimate outlined? Which DEC beach seine program were numbers reported from? (same question for Table V-22)?

2. How was annual rate of change calculated? Which years were used? The text indicates 1975-92 but Table V-22 reports data from 1979-92.

3. Table V-22 - Suggest that the DEC beach seine catch be summarized as catch per haul. Need error estimates for estimated number of YOY.

Page V-75a and b, Tables V-22 and V-23

DEC YOY shad survey data should be used in this table, not the YOY striped bass survey data.

Potential Influences on Abundance

Page V-76

1. Need to address possible impact of predators on abundance of herring. Striped bass move in to the Hudson River estuary in late fall and winter and could feed on blueback herring emigrating from the estuary.

2. Par 1. How do the findings of Sutcliffe et al. or Dow apply to the Hudson stock?

3. Par. 3. Reference for current bycatch data?

Page V-77

1. Discussion is necessary regarding expansion of blueback

herring into the Mohawk River and possible impacts on population of the estuary. This should include a discussion of adding hydro capabilities to existing dams.

Section V.D.2.F Alewife

Life History and Distribution

Page V-78 b&c

Figures V-58 and V-59. If egg and larval distributions are for "river herring" (a combination of blueback herring and alewife) please state so on the Figure.

Temporal Changes in Abundance

Page V-79

1. Please discuss the effect of time of day on sample data used to produce an index of abundance. The observation about low abundance of alewives compared to blueback herring in DEC beach seine data may be a factor of differential inshore movement.

2. Par. 1. What criteria were used to determine the "best available index". Were BSS data and/or DEC-DFW beach seine data evaluated? Where is methodology for YOY standing crop estimate outlined? Which DEC beach seine program were numbers reported from? (same question for Table V-23)?

3. Par. 2. How was the annual rate of change calculated?

Page V-80

Par. 3. Reference for current bycatch data?

Section V.D.2.G Bay anchovy

Life History and Distribution

Page V-81

1. The conclusion that bay anchovies from estuaries north of Delaware Bay overwinter together along the coastal shelf has no supporting citation.

2. Do maturation and fecundity data exist for bay anchovy of the Hudson River?

Temporal Changes in Abundance

Page V-82

1. Provide an indication of sample years summarized in Figures V-61 and V-62.

2. No rational is given for selection of FSS channel data for use in a juvenile abundance index, what criteria were used to choose this over other data?. What about FSS data from shoal and bottom strata? Is the juvenile index meant to measure only age zero fish? If so, how were older ages excluded from the catch data?

3. Were there any other sources of abundance data which could have been used to corroborate FSS abundance estimates? Possibilities include FSS data from shoal or bottom strata, utility beach seine data, DEC bottom trawl data, River-wide DEC beach seine data. Were any of these program data evaluated?

4. Which DEC beach seine programs were used to generate total catch data? Why were data not summarized as some form of catch per effort to reduce variation caused by variation in number of seine hauls per year?

5. It is stated that "a juvenile index was developed using FSS" data. In the last part of the same paragraph "The utilities beach seine program .... was used in conjunction with the FSS sampling to develop an index of abundance." How was this second abundance index calculated? What was each index used for and how does the reader distinguish one index from the other?

Potential Influences on Abundance

Page V-83

1. Several issues weaken inferences made about the lack of correlation between abundance of adult anchovies in DEC beach seine and YOY anchovies in the FSS program.
   - No information is given on age of anchovies indexed by either program.
   - No explanation is given for possible influence of sample size variation among years on total catch in DEC beach seine.
   - No correlations are attempted with other possible abundance data above.

2. Was any attempt made to identify or correlate abundance of adult or juvenile bay anchovies with changes in physical or water quality parameters in the estuary or in the NY Bight?

3. Hypotheses about movement of adult or juvenile bay anchovies into or out of the estuary could be strengthened by supplementary seasonal data from NMFS trawl surveys in the NY Bight. See V-84 1. comments below.

4. Discussion of possible influence of predation on anchovy

abundance in the estuary is necessary. Anchovy appear to be a popular prey item, and, they go well on a Ritz.

5. The DEC beach seine program samples both adult and YOY bay anchovies, all sizes that recruited to the gear. That is a factor in the lack of correlation with the FSS program.

6. No trend among years was noted in the FSS index or in total DEC beach seine catches. Need a description of data and analysis used to reach this conclusion. What about other possible abundance data noted above?

7. Par. 1. How was annual rate of change calculated? Data from which "DEC Hudson River" beach seine program was used? Was any attempt made to combine onshore and offshore data to obtain a YOY index? Was an attempt made to examine DEC-DFW trawl data, in addition to the FSS data, to examine anchovy abundance? Where are standing crop methods outlined?

Page V-83a, Table V-27
There should be an "a" superscript by the 1984 value of the DEC LI beach seine catch of 7,063. Also CPUE instead of catch would be more appropriate, especially for the LI beach seine data.

Page V-84
1. The conclusion that Hudson or Hudson-Raritan estuary bay anchovy are part of a coastal population is not supported by any reference. These fish may constitute a discrete spawning population that never leaves the estuary complex. Vouglitois et al.(1987) provided data and suggestions about seasonal movement out of shallow estuaries behind NJ barrier islands. Their conclusions may not apply to large, deep rivers such as the Hudson. Fall trawl data in Vouglitois et al.(1987) for the NY Bight are intriguing. However, corresponding seasonal data are needed from the lower Hudson Estuary before statements can be made about offshore movement of Hudson River bay anchovies. Perhaps data from the Westway study would be helpful.

Page V-84 & 85
2. Par. 2, 4 & 5. Since anchovies are a common prey species, their abundance can potentially affect the abundance and or distribution of predators. With effects of water withdrawals reducing this available prey by 48%, even on a localized in-river population, what evidence is there for constant replenishment, and is there any evidence of effects on predator abundance and distribution?

Section V.D.2.H. Atlantic and shortnose sturgeon

Potential Influences on Abundance

Page V-89

1. Par. 2. Several questionable statements are made in this paragraph:

a. Please explain basis for statement "This recent increase has prompted regulatory agencies to formulate management plans to meet the potential increase in demand." Recent regulations were put in place in response to the coast-wide decline of Atlantic sturgeon, not to meet a potential demand.

b. "DEC hopes to restore...". The goal stated is that of the Atlantic States Marine Fisheries Commission (ASMFC-1990) Atlantic sturgeon Management Plan, not the DEC's. DEC shares in the goal as a participant in the Plan.

c. The proposed DEC regulations were for a 60 inches minimum size limit, not 72 inches.

d. Please explain the last sentence "New York currently imposes...". At the time the DEIS was produced New York had already implemented new regulations and completed the first fishing season under the new regulations.

2. Par. 3. Several errors and omissions occur in the description of the commercial fishing regulations for Atlantic sturgeon. Why are the regulations described in such detail for sturgeon and not for other species (i.e. striped bass) whose regulations are just as restrictive? The tagging, reporting and sale restrictions are intended to provide a tracking system to obtain an accurate number of fish harvested. An accurate detailed description of the Atlantic sturgeon regulations should be obtained if they are to be included in the DEIS.

3. 2nd to last sentence - NYS regulations are 60 inch (5 feet) minimum size limit (not 72"). The open seasons are May 15 to June 15 for the Hudson River and Marine District, and October 1 to November 30 in the Marine District only. In addition, possession of sturgeon with a dressed length of less than 36 inches is prohibited.

4. The statement is made that a record search failed to disclose a single record of shortnose sturgeon entrainment, while in SVI,P9,§1, it is noted that "During entrainment sampling programs, very few entrainable-size sturgeon have been collected." Suggest the latter sentence be revised to reflect that no shortnose sturgeon and few Atlantic sturgeon

were entrained.

Section V.D.2.I. Bluefish

Temporal changes in Abundance

Page V-90, Paragraph 2, 2nd to last sentence

"Two major spawning aggregate... summer spawning and winter ..." Bluefish spawning is generally referred to as spring spawners (spawn in March-April) and summer spawners (spawn in June-July). In the next paragraph "spring spawned" fish are referred to.

Page V-90a, Table V-30

Is any information on sturgeon impingement at other major water intakes of the Hudson River available? If so, it should be reported in this table.

Page V-92a, Table V-31

DEC Beach seine, a superscript "a" should be next to the 1982 catch of 427, and 1983 catch of 362. Also it might be appropriate to add DEC WLI Beach seine c/f for bluefish to the table. This would give a broader picture of the population, similar to what was reported for bay anchovy. Is it possible to calculate absolute abundance? If not, please revise the table heading.

Page V-92

1. Were DEC-DFW trawl data evaluated in selecting an abundance index? Was any attempt made in combining onshore and off-shore data (beach seine/trawl) to obtain an index? Which DEC beach seine program were numbers reported from (also Table V-31)? Shouldn't these numbers be converted to c/f to account for differences in the number of seine hauls made each year, to allow for inter-annual comparisons?

2. Par. 2. How was annual rate of change calculated?

Potential Influences on Abundance

Par. 3 & 4. Reference for the data and trends reported from NMFS inshore trawl surveys?

Page V-92a

Table title: "Absolute abundance"?

Section V.D.2.J. Hogchoker

Life History and Distribution

Page V-94

Please state references for: Par. 2. overwintering; Par.3. fecundity.

Page V-95

Please state references for: Par. 1. adult movement, ability to sex these fish, is this only during spawning season; Par. 2. maturity and food habits.

Temporal Changes in Abundance

Page V-94 b&c

Figures V-73 & 74. Temporal and spatial distribution for YOY hogchokers is shown using BSS data. Is this correct when the abundance index used FSS data?

Page V-95

1. Par. 3. Were DEC-DFW trawl data evaluated in selecting an abundance index?

2. Par. 4. Which DEC beach seine program were numbers reported from (also Table V-32)? If these are just catch (numbers), please convert them to c/f to provide a basis for annual comparison.

Page V-96

a. Par. 1. How was annual rate of change calculated?
b. Please state references for ecological influences.

Page V-96a

Table title: "Absolute abundance"?

Section V.D.2.J. Weakfish

Life History and Distribution

Pages V-96 & 97

What are the references for: Par. 5 migration /overwintering habits; Pg. V-96 Par. 1. spawning, evidence to support " duration of larval stage ..depends on prey density", juvenile weakfish food habits and migration; Par. 2. New York Bight spawning, "consist with other estuaries", which ones?; Par. 3. food habits, growth.

Temporal Changes in Abundance

Page V-98

1. Par. 1. Why was only channel data used for the FSS

survey, what criteria eliminated use of shoal or bottom data? Were DEC-DFW trawl data evaluated in selecting an abundance index?

2. Par. 2. Which DEC beach seine program were numbers reported from (also Table V-33)? If these are just catch (numbers), please convert them to c/f to provide a basis for annual comparison.

3. Par. 3. All the ecological influences are possible, are there references to support them?

Page V-98a
Table title: "Absolute abundance"?

Section V.D.2.L Rainbow smelt

Life History and Distribution

Page V-100
1. Par 1-3. What are the references for: growth, spawning/maturity, fecundity?

2. Par. 4. How do you explain the presence of eggs in the LRS data, when smelt are stated to spawn in the tributaries? Since eggs are collected in the LRS, wouldn't this suggest that perhaps smelt may be spawning in the main river, as well as the tributaries? The adhesive character of the eggs would support this or are they carried by the current out into the main river to be sampled by the LRS? What is the evidence that larval smelt are carried out of the tributaries, what sampling in the tributaries supports this?

Temporal Changes in Abundance

Page V-101
Par. 4. Why was only channel data used for the FSS survey, what criteria eliminated the use of shoal or bottom data?

Page V-102
Specify which DEC beach seine program? Rainbow smelt were captured by DEC-DMR beach seing in 1987 and 1988 in the extended sampling program.

Potential Influences on Abundance

Page V-102
1. Par. 1. All the ecological factors are possible influences, what are the references to support them? (i.e. interruption of spawning, egg exposure to brackish water,

parasites, etc.)

2. Par. 3. Please see comment V-100.2. above. If eggs are adhesive when spawned, then are the eggs collected upriver in the LRS also non-contributors to the larval population? Although the entrainable eggs are far downriver of the highest densities of YSL and PYSL, wouldn't this perhaps suggest that a small amount of spawning occurs in the lower river or tributaries near the vicinity of the plants?

Section V.D.2.M Gizzard shad

Life History and Distribution

Page V-103
What are the references for: Par. 2. spawning, fecundity; Par. 4. growth?

Temporal Changes in Abundance

Page V-102
Which DEC beach seine program were numbers reported from?

Potential Influences on Abundance

Page V-104
Par. 1,3 & 5. Please reference and explain the statement "gizzard shad primarily occur in the Mohawk", although it is stated that they apparently overwinter in the lower Hudson (impingement at Roseton and Indian Point plants). Which early life stages occur during sampling and where in the river? Could these data support the presence of a small spawning population? Supporting evidence of gizzard shad spawning in the Hudson can be provided through the DEC spring spawning stock sampling for American shad and striped bass. Ripe-running gizzard shad have been collected throughout the Kingston-Catskill area for the past two years.

There are other information which also do not support the theory that the Hudson's gizzard shad population is a result of emigration from the Mohawk River. See Dew, C.B. 1973. Comments on the recent incidence of the gizzard shad, *Dorosoma cepedianum*, in the lower Hudson River. Third Hudson River Symposium.

Note also the recent impingement of gizzard shad at the Lovett Generating Station. Gizzard shad were the second most abundant fish impinged in 1990 and the dominant (47%) fish impinged in 1991.

Section V.D.2.N Spottail shiner

Life History and Distribution

Page V-105

1. Par. 2. Please explain how upriver movement is hindered by strong currents at the Troy Dam during a flood tide, or is the reference to the current above the dam?

2. Par. 3. Reference for spawning habitat, fecundity?

Temporal Changes in Abundance

Pages V-105 & 106

How was annual rate of change calculated? Where are methods outlining calculation of standing crop estimates of YOY? Which DEC beach seine program were numbers reported from (also Table V-35)? If these are just catch (numbers), please convert them to c/f (catch per haul) to provide a basis for annual comparison. Were DEC-DFW beach seine data evaluated?

Potential Influences on Abundance

Page V-106

Par. 1. Reference for statement "spottails do not migrate far"?

Par. 4. Source of information documenting the increase in water chestnut?

Section V.D.2.O White catfish

Life History and Distribution

Page V-107

Par. 1-3. Please reference sources of life history information (movements, growth, spawning, etc.).

Temporal Changes in Abundance

Page V-108

1. Par. 1. If the best available abundance index comes from BSS data, please explain the use of the FSS data to describe distributions and abundance on Page V-107. What were the values for the FSS survey (indicate on Table V-37). Which DEC beach seine program were numbers reported from (also Table V-37)? If these are just catch (numbers), please convert them to c/f (catch per haul) to provide a basis for annual comparison.

2. Par. 2. How was annual rate of change calculated?

Potential Influences on Abundance

Page V-108

1. Par. 3. Please reference source of information concerning PCB levels in white catfish.

2. Par. 4. The paragraph is vague in indicating whether or not recreational fishing occurs, it does. The recent survey by Clearwater showed that fishermen were often unaware or did not believe in the advisories.

Page V-108b

Table V-37 title "absolute" abundance?

Section V.D.2.P Blue crab

Life History and Distribution

Page V-109

Please state references for information in Par. 3.

Potential Influences on Abundance

Page V-111

Par. 5. Please reference the source of the landings data.

Page V-117, Paragraph 1

Power plant entrainment/impingement should be included in the list of possible hypotheses to explain the apparent decline in some species in the River. The other hypotheses should be ranked in comparison to estimates of mortality induced by the power plants.

SECTION VI

VI-1, Figure 1

This figure provides the bases to determine satisfaction of thermal parameters for calculating flow management credit points. The Technical Working Group and the Utilities looked further at thermally induced entrainment mortality since the graph was first developed. Please confirm that this more recent work did not alter the graph.

Page VI-1A-1

Reference to Table 12 should be Table 13.

Page VI-1A-3

Roseton Intake and Discharge Temperatures and on the following page for Bowline Point: Please explain the derivation of the condenser temperature rise given in these paragraphs. Why are Roseton and Bowline delta T temperatures less than those provided in Table IV-4 and Table IV-9.

Page VI-2-1
The statement is made that no impingement data is available from Westchester RESCO. Enclosed are the impingement results from the May 1985 through April 1986 studies, the only such studies conducted to date at this facility.

Page VI-2-2
The statement is made that the coefficients of the regression model (Table 2) are estimates of reciprocals of the gear efficiencies. However, the reciprocals of the values in Table 2 seem too low to be estimates of gear efficiencies. Please explain.

VI-3, Figure 20
At Indian Point, using the heat rejection rate provided in the text, Table IV-7 ($6.96 \times 10^9 + 6.91 \times 10^9$/BTU/hr.) for a 24 hour period yields a heat load of 332.88×10^9 BTU/24 hours. Please explain the discrepancy with the values (about 200×10^9) provided in this figure. AVI-3, Table 23 also supports the higher heat load. Please explain.

Page VI-4
Please provide an expansion on the last sentence in this paragraph which indicates FMCP must be equal or greater than zero at the end of the permit period. Bringing the concept of the credits banked previously and the outages committed to elsewhere in the DEIS together with the FMCP system would be very helpful.

Page VI-8 Paragraph 4
The impacts of the conditional mortality rates identified in Table VI-5 should be assessed and explained, especially for bay anchovy. What are the ecological effects of this level of mortality for bay anchovy?

Page VI-8, Paragraph 5
If an error term or variance could be determined for the entrainment predictions it would be easier to compare those values to 81-87 entrainment values.

Page VI-13, Paragraph 4
a. Why is it predicted that the bay anchovy is the only species that might have a significant increase in combined

mortality rate from what occurred during the 1980s?

b. Again, if there was an error or variance term for the estimated (81-87) and predicted (94-98) moralities we could evaluate the differences better.

SECTION VIII

Page VIII-6

Please explain the derivation of the $400,000 per day cost of outages at Indian Point.

a. does the extimate include any costs associated with replacement capacity? If so, why has Con Ed recently purchased IPP contracts totalling 350 MW?

b. Is the extimate based upon current LRAC's? If so, for what years?

c. Specify where this power will come from. NYSDEC has either permitted or is reviewing 1726 MW of IPP power contracted to ConEd, plus Con Ed has contracted for over 1000 MW out-of-state. In addition, O&R has contracted for 213 MW in NY from IPP's.

d. Specify the costs associated with outages at Bowline and Roseton, as per (a) and (b) above.

e. For outages at Bowline and Roseton, compare the impacts from replacement power IPP's.

Cooling Towers-General Comment

Please provide an assessment of a cooling alternative that would include a single cooling tower at each generating station that could serve either unit, would be seasonally deployable (used only during periods of high entrainment) with the unit not using the cooling tower taking a maintenance or refueling outage during the high entrainment period.

Page VIII-8, Paragraph 1

Diel flow schedules are discussed at Roseton and Indian Point, but not at Bowline. Please include Bowline in discussing the following mitigative strategy:

a. Figure A-6 from the December 1, 1992 Central Hudson Annual Report on the Consent Order (attached) provides operational information at Roseton for the week of 14 June - 20 June 1992. Temperature Rise plots indicate the mitigation achieved through pump on-off cycling, represented by the area between projected and actual temperatures -

significant. The area above actual temperature, bounded by the 10^0 C permit limit, represents potential flow mitigation that was not achieved - an area at least as large as the achieved mitigation.

b. Develop a mitigative strategy that includes installation of some variable speed circulating water pumps to more fully take advantage of diel cycling as it occurs at Bowline and Roseton Generating Stations.

Page VIII-9, Paragraphs 1 & 2
The statements are made in §1 that "Warm water is distributed at the top of the tower and that recirculating water is "periodically" discharged. Please confirm these statements as staff's perception is that water is pumped only part way up the tower, and that it is continually discharged.

Page VIII-12
Table VIII-5 follows Table VIII-6. Request this order be revised.

Page VIII-13, Paragraph 2
Please develop and document any estimate of the evaporative loss of water from the Hudson River as a result of the current cooling system configuration at Roseton, Bowline, and Indian Point.

Page VIII-21, Paragraph 2
Please confirm the calculations that led to the conclusion that only 25% of the exposed larvae (12.8mm) would benefit. It seems that with a collection efficiency of 70.9% and an adjusted survival of 64% (=1-mortality of 36%), 45% of the larvae would survive.

Page VIII-21, Paragraph 3
The high retention and good survival of striped bass 15.9 mm in length on fine mesh screens raises the question of what size fish are experiencing mortality in the tables of weekly entrainment credit points. Please provide data on the length frequency distribution of entrained larvae for all species for which entrainment credit point values were calculated. This information will provide insight into the potential mitigative value of fine mesh screens. Please also provide a copy of the Envirex 1993 letter report referenced in VIII- 21, §4.

Page VIII-23, Paragraph 1
Please explain how you calculate it necessary to increase

the net cross-sectional area by a factor of 10 in order to decrease the through-flow velocity by 7.

APPENDIX IV-1

PAGE A-IV-4

The statement on page A-IV-4, paragraph 2; last sentence "At the end of the discharge permit period, the cumulative FMCP total must be equal to or greater than zero." If FMCP's are equal to zero doesn't that mean that no points are awarded? If that is so - then wouldn't that mean that no "equivalent outages" had occurred? The text does not explain the system for Indian Point well.

Page A-IV-5, Paragraph 2, bullet 2 - end of sentence

"..., they would meet the Roseten flow management objective and provide an additional 0.9 FMCP's..." - should be 0.7 FMCP's.

APPENDIX V

Page A-V-2, equation 3 and Page 4, equation 2

What is the variable "Mywi" in the denominator. It is not stated.

APPENDIX VI-1

Page 14, Paragraph 2

"Herring (American shad, blueback herring, and alewife) were treated as one species." In other cases American Shad is treated separately and bluebacks and alewifes are lumped. Why not in this case? Please explain this rationale.

Page 22, Paragraph 3, 1st sentence

Using BSS data to estimate weekly juvenile survival rates does not account for onshore/offshore shifts in distribution. This should be investigated using either the FSS data, or DEC Beach seine and trawl data to see how this might affect survival estimates.

Page 29, equation at bottom of page

Should Yy,w,k really be Cy,w,k? Yy,w,k is not defined below, while Cy,w,k is, and is not in the equation.

- General Question on Entrainment Mortality

How does the misidentification of Striped Bass and White Perch YSL and PYSL affect Entrainment Mortality estimates on those two species. A sensitivity analysis should be conducted to examine the effects of misidentification in the LRS, in plant sampling, Mechanical Mortality rates, and W estimates. See also comment V-63.

APPENDIX VI-1-34

Please explain the flow at Roseton with a 1 unit outage given here as 418,000 gpm while Table IV-5 on Text page 9 indicates that one unit flow with 2 pumps on is 376,000 gpm.

APPENDIX VI-2

Page 15, Table 1

How was survival for yearlings and age 2-3 (method b) estimated?

APPENDIX VI-3 Evaluation of the Impact of Thermal Discharges

a. The thermal analysis provided in this appendix was conducted under average flood and evv conditions. Please conduct a similar analysis, worst case scenario, under the following conditions for Roseton, Bowline Point and Indian Point Generating Stations:

-run CORMIX Model under "slack flood begins" (SFB) condition using lowest 10 percentile of velocity data;

-use the mean low water depth measured at the neap tide and at low flow summer conditions as an input parameter into the CORMIX Model;

-plot plan and elevation views of the thermal plume in near and far-fields along with the observed data for comparison;

-submit input and output files for this model run;

b. Please comment and compare the low river flow summer data, used in the CORMIX Model for the average ebb and flood conditions, with the MA7CD10 flow of 2560 CFS for the Hudson River measured at the Green Island gage station.

APPENDIX VI-4

Page 22, Table II.2

The data in this Table need to be verified as age 0 white perch in 1984 represent the lowest year class recorded, yet are the second largest age 3 cohort shown in the Table. How is this relationship explained. How is vulnerability over time explained. What changes in gear occurred that would affect vulnerability?

APPENDIX VI-4A

Page 3, last paragraph

Does factoring in larval Striped Bass misidentification have any effect on the PYSL - YOY relationship?

Page 4, Paragraph 4, 1st sentence
The citation Young et al. (1993) should be 1992.

Page 4, Paragraph 6
If the data is assumed to be log-normally distributed, what effect does violation of this assumption have on the output. Ichthyoplankton data is generally distributed as a delta distribution, while NYSDEC beach seine data has been examined and it is not log-normally distributed.

Page 5, Paragraph 1
What source was used to obtain the MRFS data? New York has produced a document referenced as Saltz, 1992. A Study of New York's Marine Recreational Fishery from 1979 to 1989. This document contains Marine Recreational fishing trips taken in New York State from 1979 to 1989. Also the number of trips from 1990 to 1992 can be obtained by calling NMFS in Silver Spring, Maryland. Several of the values reported in Table 4 are not in agreement with Saltz (1992).

Page 5, last paragraph
Estimates of Commercial Fishing Mortality on Table 4 are referenced by Coastal 1992. Coastal does not describe how these mortality rates are produced. Please describe how these values were estimated.

Page 5, Paragraph 2
What are the mean lengths at age used to estimate the vulnerability to fishing? Was this based on Chesapeake Bay data? If so, length at age data from either the Hudson River or Long Island would be more appropriate. Also, what size limits are used for each year. How are dual recreational size limits on the Hudson and coast taken into account, and different size limits for recreational and commercial fisheries?

Page 7, 2nd sentence
Annual entrainment rates are listed in Table 6 not Table 7.

Page 7, 1st full paragraph, last sentence
The citation (Francis 1992) is not in the Literature cited.

Page 9, Recruitment anomalies, last sentence
The citation Beddington and Cooke (1983) is not in the literature cited.

Page 10, 2nd sentence
It refers to an equation 9, there is no equation 9, this should read equation 8.

Page 10, Results, Paragraph 1

F in 1972 = 1.2. Is this calculated on the data from Wilson, Coastal Environmental Services, Inc.? If yes, then this reflects F on the Chesapeake stock not on the Hudson stock. Please reevaluate these values, if possible, on Hudson River stocks.

Page 10, Results, Paragraph 2
The PYSL - YOY relationship does not break down until 1989 and later. The 1985-1987 year classes appear to demonstrate that increased spawning does, in fact, have an impact on year class strength.

Page 13, last paragraph, last sentence
States that h=.8 less than h=.9, but Table 9 shows higher values for h=.8. Please explain this inconsistency.

Page 14, Paragraph 2, 2nd sentence
What is the reasoning (justification) for setting the vulnerability schedule to 1985 for 1993-2017 to estimate an F=.5. This assumes 1)F=.5 in 1985, and 2)that in the future states will decrease size limits to achieve F=.5 rather than increasing quotas or bag limits at the current size limits. How do other changes to achieve F=.5 (other than size limits) effect the model output.

Page 16, Literature cited
The references Anon., 1992 and Applied Biomathematics, 1992 are not mentioned in the text. Annon 1992 purportedly reports on maturity and fecundity of female Hudson striped bass, while the text says the maturity and fecundity data is from Coastal (1992). Coastal (1992) used Chesapeake Bay data from Dorazio and Rago (1988) for maturity and fecundity schedules.

Page 22, Table 5
These data are inconsistent with what historically occurred in New York. The data evaluated here are for the Chesapeake Bay. Specifically in the period 1972 to 1984 New York's minimum size limit was 16" FL, therefore the larger age 2 fish were vulnerable to capture, a majority of the age 3 fish, as well as nearly 100% of ages 4, 5, and 6. Because of changing management these input values need to be revisited and the model rerun. Please look at commercial monitoring data from New York when attempting to fill in missing values for this table.

Page 23, Table 6
Are these values Conditional Entrainment and Impingement Mortality Rates? If so, why are some of the values different than the ones reported in Table V-15 on page V-60a?

Page 24, Table 7

Kahnle, Hattala, and Liebig, 1993, is not in the Literature cited. The DEC document cited in the Literature citations - Young et al does not contain the striped bass by-catch data from the Hudson River Shad Fishery.

APPENDIX VI-4E.

THE EFFECTS OF POWER PLANT MORTALITY ON HUDSON RIVER BAY ANCHOVY.

Methods

Page 2

The source of data measuring relative abundance of spawn and recruits is not clear. The text implies that eggs spawned are measured by the PYSL index (density dependency after entrainment) perhaps from the LRS survey while recruitment is measured by the FSS channel survey. If this is the case, then the following two questions apply:

1. The LRS survey usually ended each year before the end of bay anchovy spawning. The FSS survey often started after the appearance of yoy anchovy. No explanation is provided on the impact of incomplete or inconsistent temporal sampling of life stages on selection of data as measures of spawning stock or recruitment. This may have been exacerbated by further subsetting of data for consistency among years.

2. No rational is given for the selection of FSS Channel data as a measure of recruitment in bay anchovy. What about FSS data from shoal and bottom strata? (See also Appendix V-3, pg 4)

Note that Appendix V-3 addressed, but did not answer these questions.

Page 3

1. No support is provided for the assumption that the data are log-normally distributed. Logging data may not make distributions normal if data are extremely skewed.

Results - Stock Assessment

Page 5

1. Privice a rational for fitting a S/R curve to data which shows no relationship between stock and recruitment.

2. Provide a discussion of alternative hypotheses for stable recruitment other than density dependence and immigration. Possibilities include measurement error or density dependent movement in or out of recruitment sample

area.

3. For each best fit h or cutoff value, density dependence scenario, and recommended level of immigration, we need a table showing parameters for the age structured and S/R models and plots of S/R lines against S/R data. This information would provide a quick overview and some feeling for whether parameters are reasonable.

4. Explanation how immigration levels were selected.

5. The S/R time series includes 13 years of data (1979-1991). Is this an adequate time series for the concurrent calculation of several model parameters?

6. Stable recruitment during the time series was explained by density dependency and immigration. The possibility of density dependency would be more believable if possible mechanisms were suggested along with supporting data. The possibility of immigration would be more acceptable if data were provided on the timing of seasonal abundance shifts in the NY bight along with information on age classes or sizes involved.

7. Was any attempt made to explain recruitment variation by variation in abiotic factors? Were any biotic factors added to S/R relationships?

APPENDIX VI-5

General Comment

There are several data input problems, identified above, in this section. Please verify all data used in the striped bass sections, rerun all models which used these inputs and provide the outputs and analysis of those efforts.

Page 3, Paragraph 1

Maturity data for Hudson stock is available from Specker, University of Rhode Island (enclosed).
Fecundity seems low for older fish. The modeling both Rhode Island and New York has done uses a fecundity - length relationship developed by Gibson (1990) on a data set by Westin and Rogers (1978). This relationship gives much higher fecundity at older ages.

Page 3, Paragraph 2

NYSDEC striped bass spawning stock survey produces mean length by age and sex. This data may be more appropriate to use than data based on Maryland winter gill net fishery. The gill net fishery is very size selective.

Page 3, Paragraph 3
What is the juvenile stage defined as? There is certainly a significant number of age 1 fish that do not migrate out of the Hudson.

Page 3, Paragraph 4
What is the basis for using F = 0.84 for 1954-84 and F = 0.31 after 1984. Please identify the sources of fishing mortality information for the Hudson. Please discuss the appropriateness of an F of .31 on the coastal stock under the changing management during the period after 1984. Please present in Tabular form by stock the F's used in the models.

Page 3
Length and Weight at Age - Is this the same data as reported in Table 5, Appendix VI-4a, Striped Bass Pg. 22? There are problems with that Table when applied to the Coastal and Hudson River fisheries. There is a need to discuss how the data chosen apply to the Hudson River. Is data available from New York's coastal commercial and recreational harvest data?

Immigration-Emigration Rates - What is the affect on the analysis if some fraction of the subadult and adult striped bass remain in the Hudson River estuary? There is evidence that not all subadult and adult striped bass leave the river.

Page 5, Paragraph 3, 1st sentence
It states that F = 0.45 used until 1966, but the superscript (1) reports fishing rates of 1963 = .57, 1964 = .63, 1965 = .66, and 1966 = .62. These reported values are much higher than the rate used. Why was that value selected?

Page 10, Paragraph 1
Fishing Mortality Rate (0.50) - This value should be 0.25. Under the current FMP all states are constrained at F 0.25. Coastal Recreational size limits are generally at 36" TL.

Page 20, Table 5
Commercial striped bass landings. Please verify these data with National Marine Fisheries Service to ensure the accuracy because the values shown in this document are consistently lower than the values reported to ASMFC. Please verify and rerun all models which reference these data with corrected values obtained from NMFS.

Page 21, Table 6

The data reported here are inconsistent with the data provided from MRFSS to the states (copy attached). Please verity these data and rerun all models which reference these data with the corrected values obtained from MRFSS. (Maury Osborn/Ronald Salz, 1993, Marine Recreational Fishery Statistics Survey, Striped Bass Catch Estimates). New York's coastal commercial striped bass harvest was 20,353 fish (Division of Marine Resources, Commercial Landings Reports).

General Comment

It would be helpful to see the model predictions of numbers of fish at each of the chosen size limits 18, 24, 30, 36" in order to assess the scenarios. Tables 7a-11d list a variety of combined options which are difficult to assess against current fishery conditions (Recreational and commercial). It would be useful to compare projected power plant impacts against current harvests of striped bass in numbers. In 1992, New York's coastal recreational fishery harvested an estimated 42,243 striped bass 36" or greater.

APPENDIX VIII

Appendix VIII-3 Page 18

Question the development of the value of replacement power for DHC. It seems that such cost are incurred only when the unit would be at maximum generating capacity but is unable to achieve full electrical output due to the DHC commitment. When a station is not limited by DHC output, no cost for replacement power is incurred.

Appendix VIII-3 Page 48

Reference to Units 1 and 2 should be to Units 2 and 3.

AFFIDAVIT OF MARK D. SANZA, DATED JUNE 1, 2004 [3122-3137]

STATE OF NEW YORK
SUPREME COURT COUNTY OF ALBANY

In the Matter of the Application of

ENTERGY NUCLEAR INDIAN POINT 2, LLC, and ENTERGY NUCLEAR INDIAN POINT 3, LLC, as respective owners of Indian Point 2 and Indian Point 3, and Joint Applicants for the Indian Point SPDES permit renewal,

Petitioner-Plaintiffs,

For a judgment pursuant to Article 78 of the Civil Practice Law and Rules,

-against-

THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION and ERIN CROTTY, as Commissioner, New York State Department of Environmental Conservation,

Respondent-Defendants,

MIRANT BOWLINE, LLC, as owner of Bowline Point 1 and 2, and Applicant for the Bowline SPDES permit renewal; DYNEGY ROSETON, LLC, as operator of Roseton 1 and 2; and DYNEGY NORTHEAST GENERATION, INC., as Applicant for the Roseton SPDES permit renewal,

Respondent-Defendants,

RIVERKEEPER, INC.; SCENIC HUDSON, INC., NATURAL RESOURCES DEFENSE COUNCIL, INC.; and RICHARD L. BRODSKY, in his individual capacity,

Respondent-Interveners.

Index Nos.: 6747-03
6749-03

RJI No.: 0103ST3971

Assigned Justice:
Hon. E. Michael Kavanagh

AFFIDAVIT OF
MARK D. SANZA

AFFIDAVIT OF MARK D. SANZA

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE SECRETARY

In the Matter of ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC, and ENTERGY NUCLEAR OPERATIONS, INC. (Indian Point Nuclear Power Station)	Docket Nos. 50-247, 50-286

**DECLARATION OF LAWRENCE W. BARNTHOUSE, PH.D.
IN OPPOSITION TO RIVERKEEPER CONTENTION EC-1 AND
NEW YORK ATTORNEY GENERAL CONTENTION 31**

I, Lawrence W. Barnthouse, Ph.D., declare as follows:

QUALIFICATIONS

1. I am President and Principal Scientist of LWB Environmental Services, Inc. I have 30 years of experience in research and assessment projects involving impacts of energy technologies in freshwater, estuarine, and marine environments. For the last decade, I have served as an expert scientific consultant to several corporations involved in assessments of the potential impacts of cooling water intake structures ("CWIS") and hazardous substance releases on biological resources. I have particular depth and expertise in assessing the potential aquatic impacts of power-plant operations under Clean Water Act ("CWA") §316(b) and equivalent state law. I have served as the senior technical advisor on numerous major ecological risk assessment projects, including in NPDES and SPDES permit proceedings.

2. I have substantial, first-hand experience assessing the Hudson River ecosystem. I have conducted extensive studies of Hudson River fish populations and communities, specifically with regard to the impacts of cooling water withdrawals on these populations and communities. I began this work in 1977, as part of my duties as a research staff member at the U.S. Department of Energy's ("DOE") Oak Ridge National Laboratory ("ORNL"). Along with other ORNL scientists, I supported the U.S. Environmental Protection Agency ("USEPA") in analyzing data collected by the Hudson River power companies concerning the potential impacts of CWIS on striped bass and other key fish populations of the Hudson. I was also a member of the technical team that supported USEPA, power company, and New York State Department of Environmental Conservation ("NYSDEC") negotiators during the development of the Hudson River Settlement Agreement ("HRSA").

3. I spent 19 years as a staff scientist at ORNL. At ORNL, I led or participated in dozens of environmental research and assessment projects involving development of new methods for predicting and measuring the potential environmental impacts of energy technologies. During my years at ORNL, I performed data quality assessments for all of the datasets used to support USEPA's assessments, analyzed data concerning the spatial distributions of entrainable life stages of fish in the vicinities of CWIS and developed quantitative assessments of potential impacts of impingement on white perch, striped bass, and other Hudson River fish species. Following the HRSA, I was the senior editor of a peer-reviewed scientific monograph documenting all of the key utility and agency-sponsored studies related to impacts of CWIS on Hudson River striped bass, white perch, Atlantic tomcod, bay anchovy, American shad, and river herring populations.

4. I am a Fellow of the American Association for the Advancement of Science, Hazard/Risk Assessment Editor of the journal *Environmental Toxicology and Chemistry*, and Founding Associate Editor of the journal *Integrated Environmental Assessment and Management*. I am a member of the Atlantic States Marine Fisheries Commission Cumulative Impacts Assessment Panel, and am Chair of the Society of Environmental Toxicology and Chemistry's Population-Level Ecological Risk Assessment Work Group. I hold a Ph.D. degree in Biology from the University of Chicago, and a Bachelor of Arts degree in Biology from Kenyon College. My current curriculum vitae, including a list of my peer reviewed scientific publications, is attached hereto as Attachment 1.

THIS PROCEEDING

5. I understand that this proceeding ("Proceeding") before the Nuclear Regulatory Commission ("NRC" or the "Commission") concerns the May 2007 application by Entergy Nuclear Operations, Inc. ("Entergy") to renew, for a period of 20 years, the operating licenses for Entergy Nuclear Indian Point 2, LLC ("IP2") and Entergy Nuclear Indian Point 3, LLC ("IP3"), nuclear power generating units located in Buchanan, New York. 72 Fed. Reg. 26,850 (May 11, 2007). I understand that Riverkeeper, Inc. ("Riverkeeper") and the New York Attorney General ("NYS") have filed petitions ("Petitions") to intervene in this license renewal proceeding, in which they specifically request a hearing before the NRC with respect to certain issues that they maintain are not adequately addressed in Entergy's license renewal application ("LRA").

6. I have reviewed the contentions related to the issues of entrainment and impingement – Riverkeeper Contention EC-1 and NYS Contention 31 (the "EI Contentions"). I have reviewed the declarations of Drs. Richard Seaby and Peter Henderson in support of Riverkeeper's Contention EC-1, and accompanying reports co-authored by Drs. Seaby and Henderson entitled *Status of Fish Populations and the Ecology of the Hudson River* ("Pisces Hudson Report") and *Analysis of Entrainment, Impingement, and Thermal Impacts at Indian Point Power Station* ("Pisces EI Report"). I have also reviewed the declaration of Roy A. Jacobson in support of NYS Contention 31.

7. This Declaration is submitted in support of Entergy's response to the EI Contentions.

AEI REPORT

8. Together with Drs. Douglas F. Heimbuch of AKRF, Inc., Webster Van Winkle of Van Winkle Environmental Consulting, and John Young of ASA Analysis & Communications, Inc., I have prepared a report, entitled *Entrainment and Impingement at IP2 and IP3: A Biological Impact Assessment* (Jan. 2008) ("AEI Report"). The AEI Report is attached hereto as Attachment 2 and is incorporated herein by reference. To the best of my knowledge, the factual statements in the AEI Report are true and accurate, and the opinions expressed therein are based on my best professional judgment.

9. As detailed therein, the AEI Report contains a comprehensive evaluation of whether entrainment and impingement by the respective CWIS at IP2 and IP3 have caused an adverse environmental impact ("AEI"), using biologically-based definitions of AEI that are consistent with established definitions and standards of ecological risk assessment and fisheries management.

10. The AEI Report confirms that, considering all of the fish species for which abundance trends can be evaluated, there is no relationship between long-term trends in fish abundance and susceptibility to IP2 and IP3's respective CWIS. Perceived negative trends in species abundance in the Hudson River can only be termed AEI, using a biologically-based definition of that term, if there is a reasonable degree of scientific certainty that such trends are the result of the operation of IP2 and IP3's respective CWIS. This has not been established. Rather, using data provided by nearly 30 years of intensive monitoring of key Hudson River fish populations, the AEI Report demonstrates that IP2 and IP3's respective CWIS have had no detectable impact on the abundance of any species. Instead, as the AEI Report also demonstrates, overharvesting (fishing) and predation by striped bass have been the most important influences on trends in species abundance.

RESPONSE TO PISCES HUDSON REPORT

11. Below, I respond to the Pisces Hudson Report. The Pisces Hudson Report addresses the larger and general Hudson River ecosystem without regard to IP2 and IP3 (or even any mention of it). Therefore, the Pisces Hudson Report does not permit any inferences to be made regarding the possible effects of Indian Point's operations on the ecosystem. Rather, the Pisces Hudson Report is a general assessment of the health of the Hudson River ecosystem, in that its focus is on whether certain fish species in the River have either increased or decreased in abundance over the past three decades. The Report, however, contains no mention of IP2 and IP3 or any allegation that the operation of IP2 and IP3's respective CWIS has had an influence on the abundance of any species. The Report therefore offers no scientific opinion on AEI, using the biologically-based definition of that term as described above in paragraph 11.

12. In fact, the Pisces Hudson Report offers alternative explanations for the declines in several species, none of which involve impingement or entrainment at Indian Point, and many of which have been confirmed by rigorous hypothesis testing in the AEI Report:

- *Bay Anchovy*: The Pisces Hudson Report asserts that declines in bay anchovy "may be linked to the increase in abundance of the predatory striped bass." Pisces Hudson Report, at 25. This hypothesis was tested in the AEI Report, which concludes that striped bass predation is the most likely explanation for these declines (AEI Report, §3.4.6.2).

- *Atlantic tomcod*: The Pisces Hudson Report states that Atlantic tomcod have declined due to climatic changes that have resulted in higher summer River temperatures. *See* Pisces Hudson Report, at 24-25. This hypothesis was tested in the AEI Report, which concluded that striped bass predation (primarily) and climatic temperature increases in summer river temperatures (secondarily) are strongly related to the declines in Atlantic tomcod (AEI Report, §3.4.4.3).

- *White perch*: With respect to white perch, the Pisces Hudson Report suggests that declines in this species are "much more clearly shown in the changing abundance of yearling and older age classes," Pisces Hudson Report, at 22, which are age classes older than those that are potentially susceptible to entrainment at Indian Point.[1] The AEI Report examines this question, and concludes that causes other than entrainment and impingement, including striped bass predation and zebra mussel activities, are responsible for any observed decline in white perch abundance (AEI Report, §3.4.2.3)

- *American shad*: The Pisces Hudson Report asserts that "American shad has been declining in the Hudson for many years because of overfishing, pollution and other anthropomorphic effects." Pisces Hudson Report, at 26. The AEI Report concludes that overfishing and, to a lesser degree, striped bass predation, are the likely causes of declines in American shad (AEI Report, §3.4.3.4).

In short, nothing in the Pisces Hudson Report offers an expert opinion that there has been any AEI or contradicts the principal conclusion of the AEI Report – that impingement and entrainment at IP2 and IP3 are not related to observed declines in key fish species in the Hudson River.

[1] The Pisces Hudson Report also observes that white perch has "staged a mild recovery" over the past 10 years. Pisces Hudson Report, at 22.

RESPONSE TO PISCES EI REPORT AND JACOBSON DECLARATION

13. I have reviewed the Pisces EI Report and Jacobson Declaration, which, unlike the Pisces Hudson Report, at least purport to offer opinions about IP2 and IP3. Below, I reply in part to these documents. I disagree with many of the opinions offered in these documents. The fact that I do not specifically address a particular opinion or contention in this Declaration does not mean that I agree with such opinions or contentions.

Entrainment and Impingement

14. The Pisces EI Report and Jacobson Declaration argue, generally, that entrainment and impingement losses at IP2 and IP3 are high, and therefore that the operation of IP2 and IP3's respective CWIS must be causing adverse effects on fish populations. *See, e.g.*, Pisces EI Report, at 1 ("Entrainment and impingement mortality each year is in the order of billions and hundreds of thousands of fish respectively."); *see also id.* at 3-5, 11; Jacobson Decl. ¶ 15 ("The impingement and entrainment impacts caused by IP2 and IP3 are well-documented. . . . The millions of fish that are killed each year from operations at Indian Point represent a significant mortality and stress on the River's fish community."); *see also id.* ¶¶ 17, 20.

15. The concerns expressed in the Pisces EI Report and Jacobson Declaration regarding entrainment and impingement mortality are unsupported by scientific evidence, and therefore invalid. Both the Pisces EI Report and the Jacobson Declaration simply assert, without any evidence, that if there is entrainment and impingement mortality, then that mortality must be a major cause of any negative trend in abundance. Such an assertion is not valid scientific technique, nor is it scientifically correct in this instance.

16. Specifically, as evidenced by the AEI Report, even assuming entrainment and impingement by IP2 and IP3's respective CWIS were "high" it is not reasonable, as a matter of science, to conclude that the operation of IP2 and IP3's respective CWIS is ***causing*** AEI. Rather, the AEI Report demonstrates that impingement and entrainment at IP2 and IP3 are ***not*** related to observed declines in key fish species in the Hudson River.

17. Moreover, the Pisces EI Report's general assertion that high levels of impingement and entrainment are harmful to fish species is directly contradicted by the Pisces Hudson Report. In the Pisces EI Report, for example, Pisces alleges that entrainment of striped bass has increased by over 750% during the period from 1987 and 2005. *See* Pisces EI Report, at 11. But in the Pisces Hudson Report, Pisces states that "[s]triped bass populations are known to be doing well in the north east coast of the USA, and the population has shown a steady increase from the early 1980s." Pisces Hudson Report, at 17. Thus, Pisces' own assessment does not support the argument that high levels of impingement and entrainment necessarily result in declines in abundance of fish species.

Use of Conditional Mortality Rates ("CMRs")

18. The Pisces EI Report reaches a number of mistaken conclusions based on the use of Conditional Mortality Rates or CMRs. CMRs are a measure of the mortality imposed on a population by a stressor such as a CWIS. In the Pisces EI Report, Pisces improperly relies on CMRs in order to conclude that mortalities caused by entrainment and impingement of certain species by the operation of IP2 and IP3's respective CWIS "are large." Pisces EI Report, at 11; *see also id.* at 1, 5, 7. These conclusions hinge on a flawed understanding of the appropriate use of CMRs and are incorrect.

19. Pisces attempts to use CMRs as measures of adverse impacts on populations. *See, e.g.*, Pisces EI Report, at 5-7. As discussed in the AEI Report, §2.3, however, CMRs cannot be validly used as measures of AEI, because CMRs are measures of short-term mortality caused by entrainment and impingement, not measures of the impacts of that mortality on the long-term abundance or sustainability of susceptible populations. The reason for this is that CMRs do not account for the density-dependent processes that can partially offset mortality due to entrainment and impingement (Barnthouse et al. 1984). Depending on the strength of density-dependence in a given population, a particular CMR value corresponds to either a negligible or a substantial impact on the sustainability of a population.[2]

20. As discussed in the AEI Report, and contrary to the assertions of the Pisces EI Report, analysis of long-term trends in the abundance of important Hudson River fish populations, available from 30 years of intensive data collection, is the best method available for assessing impacts of IP2 and IP3 on Hudson River fish populations.

21. Moreover, even if CMRs were appropriately used as measures of short-term mortality due to entrainment and impingement, the Pisces EI Report's statement that "[t]hese deaths will be contributing to the decline of these species," Pisces EI Report, at 7, is speculative, unsupported by scientific evidence, and directly contradicted by the AEI Report's analysis and conclusions, which show that mortality caused IP2 and IP3, as measured using CMRs, has had no measurable effect on the abundance of any of the fish species discussed in the Pisces EI Report.

22. Further, as the Pisces EI Report itself acknowledges, "[t]o analyze the relationships fully, data are needed on the density of the fish in the vicinity of the power plant." Pisces EI Report, at 11. The AEI Report provides precisely such an analysis, because the model used to calculate entrainment CMRs is based on weekly estimates of the distribution of eggs and larvae throughout the estuary. Moreover, the community-level trends analysis provided in the AEI Report, §5, is based on comparisons of average densities of larvae in the vicinity of IP2 and IP3 to Riverwide average densities.

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2 Although there can be substantial uncertainty concerning the strength of density-dependence in specific populations, there is strong theoretical and empirical evidence that the great majority of biological populations, including fish populations, are regulated in part by density-dependent mechanisms (Murdoch 1994, Turchin 1999, Rose et al. 2001, Brook and Bradshaw 2006).

Adjusting Entrainment Estimates With New Data

23. The Pisces EI Report suggests that the data used by Entergy to assess the impact of entrainment and impingement are "old," and implies that Entergy's conclusions are therefore less reliable. *See* Pisces EI Report, at 1, 7. Similarly, the Report asserts that "[m]odern data suggest that striped bass entrainment is likely to have increased by over 750% from the level at the time when the data was [sic] gathered." *Id.* at 1; *see also id.* at 11. These purported concerns regarding the dataset are misguided.

24. The assertions in the Pisces EI Report refer only to data on the numbers of organisms entrained and impinged. As discussed in the AEI Report, §2.2, counts of the numbers of organisms entrained and impinged are irrelevant for the purpose of determining AEI. Long-term data on the abundance and distribution of susceptible species are the best data for evaluating impacts of entrainment and impingement on fish populations. The Hudson River Biological Monitoring Program ("HRBMP") dataset on which Entergy's Environmental Report ("ER") and the AEI Report rely provides such data. These data are collected using state-of-the-science sampling methods and are validated under a strict Quality Assurance program that has since become the industry standard. *See* Declaration of Mark T. Mattson, Ph.D., ¶¶ 9-26 (Jan. 18, 2008); Declaration of John R. Young, Ph.D., ¶¶ 9-17 (Jan. 18, 2008).

25. The AEI Report utilized data for all available years through 2004. Although the 2005 data were not available at the time the AEI Report was finalized, *see* Young Decl. (Jan. 18, 2008), I have reviewed these data in connection with the opinions set forth in this Declaration. Specifically, I reviewed 2005 data (the most recent validated data), as set forth in the 2005 Year Class Report. The 2005 data show ***no*** significant departures from the trends observed through 2004, and no significant changes in the status of any of the species evaluated in the AEI Report. Hence, in my professional opinion, inclusion of the 2005 data would not change any of the conclusions in the AEI Report.

Misuse of Barnthouse et al. 2002 Report

26. The Pisces EI Report cites an unpublished report by Barnthouse et al. 2002. *See* Pisces EI Report, at 7. The paragraph from Barnthouse et al. 2002 quoted in the Pisces EI Report cites three characteristics of a healthy fish community: (1) relative stability of key populations; (2) relative constancy of species composition; and (3) maintenance of important functional relationships. The Pisces EI Report discusses only the first of these three characteristics, and inaccurately states that "many" key populations have declined in abundance. While some common species have declined in abundance, other species have increased in abundance (AEI Report, §5). As documented in the DEIS and in the ER, the species composition of the Hudson River fish community has been relatively constant, and there is no evidence that important functional relationships have been disrupted.

CONCLUSION

27. The AEI Report concludes that entrainment and impingement resulting from the operation of IP2 and IP3's respective CWIS have not caused AEI.

28. The Pisces Hudson Report addresses the larger and general Hudson River ecosystem without regard to IP2 and IP3 (or even any mention of it). Therefore, the Pisces Hudson Report does not permit any inferences to be made regarding the possible effects of Indian Point's operations on the ecosystem.

29. In my professional opinion, nothing in the Pisces EI Report or Jacobson Declaration undermines the ER, or alters the conclusion set forth in the AEI Report that entrainment and impingement associated with IP2 and IP3's respective CWIS does not adversely impact Hudson River fish populations. Therefore, as a matter of science, the Pisces EI Report and Jacobson Declaration do not alter the conclusion that the operation of IP2 and IP3's respective CWIS has not caused harm to the Hudson River ecosystem, and also therefore that closed-cycle cooling would not improve the Hudson River ecosystem.

Signed this 18th day of January, 2008.

Lawrence W. Barnthouse, Ph.D.
LWB Environmental Services, Inc.
President and Principal Scientist

ATTACHMENT 1

LAWRENCE W. BARNTHOUSE, Ph. D.

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Education

Ph.D., Biology, University of Chicago, Chicago, Illinois, 1976
A.B., Biology, Kenyon College, Gambier, Ohio, 1968

Experience Summary

Dr. Barnthouse is the President and Principal Scientist of LWB Environmental Services, Inc. His consulting activities include 316(b) demonstrations for nuclear and non-nuclear power plants, Superfund ecological risk assessments, Natural Resource Damage Assessments, risk-based environmental restoration planning, and a variety of other projects involving close interactions with regulatory and resource management agencies. He formerly spent 19 years as a research staff member and Group Leader at Oak Ridge National Laboratory, where he was involved in dozens of environmental research and assessment projects involving development of new methods for predicting and measuring environmental risks of energy technologies. After leaving Oak Ridge National Laboratory in 1995, he spent two and a half years with McLaren-Hart, Inc. prior to establishing LWB Environmental Services.

Dr. Barnthouse has authored or co-authored more than 90 publications relating to ecological risk assessment. He is a Fellow of the American Association for the Advancement of Science, Hazard/Risk Assessment Editor of the journal *Environmental Toxicology and Chemistry*, and Founding Editorial Board Member of the new journal *Integrated Environmental Assessment and Management*. He frequently serves on committees of the National Academy of Sciences and on peer review panels for major federal agency projects. He chairs the Society of Environmental Toxicology and Chemistry's Population-Level Ecological Risk Assessment Work Group. He recently chaired a SETAC-sponsored workshop on population-level ecological risk assessment in Roskilde, Denmark. The report from the workshop will be published in 2007.

Current Activities

- **Development of biologically-based methods for compliance with EPA's 316(b) Phase II Rule.** Funded by the Electric Power Research Institute (1) to develop and demonstrate methods for quantifying biological benefits of reducing entrainment and impingement losses at existing facilities, and (2) to review biological issues affecting the feasibility of using habitat restoration as a compliance approach.

- **Technical Team Leader, 316(b) assessment for the Salem Generating Station.** Responsible for developing methods for quantitative assessment of impacts of entrainment and impingement on estuarine fish species; directed the analysis of data relating to entrainment and impingement impacts to support the facility owner's 1999 and 2006 permit renewal applications.

- **Technical expert on effects of cooling water withdrawals on Hudson River fish populations.** Performing analysis of impacts of cooling water withdrawals on Hudson River fish populations and communities in support of ongoing permitting proceedings for the Indian Point Generating Station. Testified as an expert witness at permit hearings for the Danskammer Generating Station, November-December 2005.

- **Technical expert on entrainment impact assessment for Gulf of Mexico LNG terminals.** Providing advice to two major corporations concerning the validity of data and methods used to predict impacts of proposed offshore LNG terminals on Gulf of Mexico fishery resources, and on the design of baseline monitoring programs for these facilities.

- **Senior ecological risk assessor, restoration of the southeastern Tennessee Copper Basin.** The project involves development and implementation of an adaptive management-based watershed restoration plan for the North Potato Creek Watershed, Tennessee, which was seriously degraded by historic mining and smelting activities. This project was recently cited by the National Academy of Sciences as an example that should be followed at other large, complex sites.

- **Technical expert on ecological risk assessment and NRDA for General Electric Co. operations in New York and Massachusetts.** The project involves support of ongoing CERCLA risk assessment and Natural Resource Damage Assessment activities relating to historic discharges of PCBs to the Hudson and Housatonic Rivers.

- **Technical expert on ecological risk assessment and NRDA for pulp mill in eastern North Carolina.** Provided confidential comments to facility owner concerning validity of ecological risk assessments performed by consultants to the owner and by the U.S. Environmental Protection Agency; advised the owner concerning the types and magnitudes of potential natural resource damage liabilities due to contamination of sediment by dioxins and mercury.

- **Technical advisor, remediation of contaminated sediment at Langley AFB, Virginia.** Provided advice to remediation team concerning (1) establishment of cleanup goals in lead-contaminated sediment, and (2) development of a post-remediation monitoring program involving measurement of lead concentrations in fish and mussels.

Significant Previous Projects

LWB Environmental Services

- **Member, National Academy of Sciences Committee on Superfund Site Assessment and Remediation of the Coeur d'Alene River Basin.** This committee independently evaluated the U.S. Environmental Protection Agency's scientific and technical practices in Superfund site characterization, human and ecological risk assessment, remedial planning, and decisionmaking with regard to the Coeur d'Alene Basin Superfund site. The committee's report was released in July, 2005.

- **Expert witness, NPDES Permit action in western Pennsylvania.** Engaged by corporate client to evaluate claims that discharges from the client's steel mills have caused ecological degradation of the Allegheny and Kiskiminetas Rivers. Led technical team performing quantitative ecological risk assessment. Testified at trial, February, 2001. Prepared supplemental report following successful appeal of initial decision by client; case was settled out-of-court in November, 2004.

- **Expert witness, NPDES Permit action in Ohio.** Engaged by corporate client to evaluate allegations by federal and state agencies that discharges from the client's metal plating plant caused fish kills in the Ohio River. Charges against the client were withdrawn prior to trial.

- **Technical expert on 316(a) and 316(b) issues at the Diablo Canyon Power Plant.** Reviewed historical predictive and retrospective thermal effects assessment studies; provided expert review of draft 316(b) Demonstration. Represented client at regional water board hearing, March 2001.

- **Peer Review Coordinator, Columbia Basin PATH Project.** Organized and chaired an external review committee for a multi-stakeholder project that developed and tested models of the impacts of hydropower operations, harvesting, hatcheries, habitat quality, and oceanic conditions on endangered Snake River Basin salmonid populations. Organized an expert briefing on salmon issues for senior executives of the Bonneville Power Administration.

McLaren-Hart, Inc.

- **Senior Technical Advisor for an assessment of ecological risks of chlorinated solvents, heavy metals, mercury, and PCBs at a chemical manufacturing facility in southwest Louisiana.** Responsible for selection of risk assessment methodologies used by team of risk assessors evaluating on-site and off-site risks to fish, wildlife, and sediment-dwelling biota. Developed a strategy for negotiating major elements of the project work plan with EPA Region VI. Responsible for defining strategy for integrating results of ecological risk assessment into corrective measures planning and potential NRDA defense activities.

Environmental Sciences Division, Oak Ridge National Laboratory

- **Co-principal investigator, 5-year EPA/DOE research program on ecological risk assessment methods.** This was the first federally funded research project explicitly identified as an "ecological risk assessment" project. Methods for uncertainty analysis of ecological models developed for this project were the forerunners of Monte Carlo food-chain exposure models that are widely used today. Much of the ecological risk assessment terminology now used by EPA and other agencies (e.g., "assessment endpoints" and "measurement endpoints") originated with this project. The final publication from this research was named the best scientific paper published at Oak Ridge National Laboratory in 1990.

- **Project manager for a basic research program on biological mechanisms underlying density-dependent population growth in fish.** The project pioneered the development and application of "individual-based population models" that are now widely used in biological research and in management of endangered species.

- **Technical advisor and expert witness for EPA Region II in NPDES permit hearings related to impacts of fossil and nuclear power plants on fish populations in the Hudson River.** Assisted EPA lawyers in preparation of case, performed independent data evaluations and model-based analyses, testified in administrative law hearings. Represented EPA on a technical team that assisted EPA, the State of New York, and the Consolidated Edison Co. in the negotiation of a widely publicized settlement agreement. Became senior editor for an American Fisheries Society monograph presenting scientific results from 10 years of monitoring and research on the Hudson. Assessment methods developed for the "Hudson River Power Case" are now used by utility companies and regulatory agencies throughout the United States.

- **Group leader for ecological risk assessment team performing CERCLA baseline ecological risk assessments for U.S. Department of Energy facilities in Oak Ridge, Tennessee, Portsmouth, Ohio, and Paducah, Kentucky (EPA Regions IV and V).** Major assessments included a five-year investigation and baseline risk assessment for the Clinch River, Tennessee; reservation-wide assessments for the Portsmouth Gaseous Diffusion Plant and the Oak Ridge National Laboratory; and operational-unit-level assessments for numerous burial grounds and waste ponds.

- **Expert advisor on ecological risk assessment for the DOE Office of Air, Water, and Radiation.** Surveyed ecological risk assessment capabilities at all major DOE facilities, initiated development of standard ecological screening benchmarks for all DOE sites, reviewed EPA draft Ecological Risk Assessment Guidance for Superfund for DOE, developed training course on Natural Resource Damage Assessment for DOE site managers, led NRDA case study project at the Savannah River Site, prepared white paper on the application of the EPA Data Quality Objectives Process at DOE sites.

Professional Society Activities

Member, Ecological Society of America, Society for Environmental Toxicology and Chemistry, Society for Risk Analysis

Hazard/Risk Assessment Editor, *Environmental Toxicology and Chemistry*, 1992 - present.

Founding Editorial Board Member, *Integrated Environmental Assessment and Management*, 2004-present

Chair, SETAC/ESA Workshop on Sustainable Environmental Management, Pellston, Michigan, August 1993.

Chair, SETAC Workshop on Population-Level Ecological Risk Assessment, Roskilde, Denmark, August, 2003.

Short Course Instructor, Annual SETAC meeting

- Ecological Risk Assessment (1992, 1994)
- Product Life Cycle Assessment (1996, 1997)

Chair, Applied Ecology Section, Ecological Society of America, 1995-1997

Ecological Risk Assessment Specialty Group Chair, Society for Risk Analysis, 1991-1993

Member, Advisory Panel, Society for Risk Analysis, 1996-1998

Other Professional Activities

Member, External Laboratory Review Panel, EPA Midwest Ecology Division, Duluth, MN, February, 2002.

Peer reviewer, EPA Drake Chemical Site Incinerator Risk Assessment, 1998.

Member, Ecological Committee on FIFRA Risk Assessment Methodologies (ECOFRAM), 1997-2000

Reviewer and issue paper author, EPA Risk Assessment Forum Ecological Risk Assessment Guidelines Program, 1991-present

- Member of Peer Review Panel for EPA Framework for Ecological Risk Assessment
- Author of issue paper on Conceptual Model Development
- Member of Peer Review Panel for EPA Ecological Risk Assessment Guidelines
- Member of Peer Review Panel for EPA Generic Endpoints for Ecological Risk Assessment

Chair, National Research Council Workshop on Ecological Risk Assessment, Warrenton, Virginia, February 1991.

Member, National Research Council Committee on Environmental Remediation at Naval Facilities, 1997-1998.

Member, National Research Council Committee to Review the DOI's Biomonitoring of Environmental Status and Trends Program, 1994

Member, National Research Council Committee on Risk Assessment Methodology (Chair, Ecological Risk Assessment Topic Group), 1989-1993

Member, National Research Council Board on Environmental Studies and Toxicology, 1989-1992

Member, National Research Council Committee on Pesticides and Ecological Risk Assessment, 1986-1987

International Activities:

Workshop on Population-Level Ecological Risk Assessment, 12th SETAC Europe Congress, Vienna, Austria, 2002

Ninth SETAC Europe Congress, Leipzig, Germany, 1999

XIIIth International Plant Protection Congress, The Hague, The Netherlands, 1995

Fifth SETAC Europe Congress, Copenhagen, Denmark, 1995

IPPC Special Workshop on Article 2 of the U.N. Framework Convention on Climate Change, Fortaleza, Brazil, 1994

SGOMSEC Workshop on Methods to Assess the Effects of Chemicals on Ecosystems, Montpellier, France, 1994

IAEA Validation of Assessment Models Project, Vienna, Austria, 1992

International Biospheric Model Validation Project, Vienna, Austria, 1992

Seventh International Congress of Pesticide Chemistry, Hamburg, Germany, 1990

Workshop on Ecological Risk Assessment for Chemicals, Schmallenburg, West Germany, 1987

NATO Conference on Safety Assurance for Environmental Introductions of Genetically-Engineered Organisms, Rome, 1987

Awards and Honors

- Martin Marietta Energy Systems Technical Achievement Award, 1991
- Martin Marietta Energy Systems Author of the Year, 1991
- Martin Marietta Energy Systems Technical Achievement Award, 1994
- Fellow, American Association for the Advancement of Science, 1994

Publications

Books and Monographs

Barnthouse, L. W., W. R. Munns, and M. T. Sorensen (eds.). *Population-Level Ecological Risk Assessment.* SETAC Press, Pensacola, Florida, U.S.A. (in press).

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Suter, G. W. II, S. B. Norton, and **L. W. Barnthouse**. 2003. The evolution of frameworks for ecological risk assessment from the Red Book ancestor. *Human and Ecological Risk Assessment* 9:1349-1360.

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ATTACHMENT 2

ENTRAINMENT AND IMPINGEMENT AT IP2 AND IP3: A BIOLOGICAL IMPACT ASSESSMENT

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January 2008

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Executive Summary

This report evaluates whether entrainment and impingement by the respective cooling water intake structures ("CWIS") at Indian Point Unit 2 ("IP2") and Indian Point Unit 3 ("IP3") have caused an adverse environmental impact ("AEI"), using biologically-based definitions of AEI that are consistent with established definitions and standards of ecological risk assessment and fisheries management.

The approach involves three elements. First, we use the extensive Hudson River fisheries datasets to determine (1) whether changes in the status of species of interest identified by the New York State Department of Environmental Conservation ("NYSDEC") have occurred since IP2 and IP3 began commercial operation, (2) whether cooling-water withdrawals by IP2 and IP3 during this period could have been responsible for any such changes, or (3) whether alternative stressors including striped bass predation, zebra mussels, and harvesting are the more probable cause of perceived changes.

Second, we use a widely-accepted method for quantifying the impacts of harvesting on the sustainability of fish populations, termed the Spawning Stock Biomass per Recruit ("SSBPR") model, to determine whether entrainment and impingement at IP2 and IP3 could have adversely affected the sustainability of the Hudson River striped bass and American shad populations.

Third, we examine long-term trends in the abundance of all Hudson River fish species for which adequate trends data sets can be developed to determine whether species with high susceptibility to entrainment at IP2 and IP3 are more likely to have declined in abundance over the past 30 years than are species with low susceptibility to entrainment.

All three elements of the assessment support a conclusion that IP2 and IP3 have not caused an AEI. Evaluation of alternative hypotheses concerning the causes of changes in abundance of Hudson River fish populations found no evidence supporting the hypothesis that IP2 and IP3 contributed to these changes. Instead, the evaluation shows that overharvesting is the most likely cause of recent declines in abundance of American shad, with striped bass predation being a potentially significant contributing factor. Increased predation by the rapidly growing Hudson River striped bass population is the most likely cause of recent declines in the abundance of Atlantic tomcod, river herring and bay anchovy. Striped bass predation probably contributed to the decline in abundance of white perch, although other unknown causes were also involved.

Two additional lines of evidence support a conclusion that entrainment and impingement at IP2 and IP3 have not resulted in AEI. Application of the SSBPR model to stock assessment data for striped bass and American shad shows that mortality caused by entrainment at IP2 and IP3 is negligible, particularly compared to fishing mortality, and does not impair the ability of these populations to sustain themselves. Analysis of community-level trends data show that species with relatively high susceptibility to entrainment at IP2 and IP3 are no more likely to have declined in abundance since 1974 than are species with relatively low susceptibility to entrainment.

Considered together, the evidence evaluated in this report shows that the operation of IP2 and IP3 has not caused effects on early life stages of fish that reasonably would be considered "adverse" by fisheries scientists and/or managers. The operation of IP2 and IP3 has not destabilized or noticeably altered any important attribute of the resource.

Glossary

Ichthyoplankton: Eggs and larvae of fish with limited swimming abilities that float in the water-column and are passively transported by currents

Entrainment: The drawing of ichthyoplankton and other small aquatic organisms through a cooling water intake structure into the cooling system of a power plant

Impingement: The trapping of fish and other aquatic organisms against intake screens by the force of the water being drawn through a cooling water intake structure

Individual: A single organism

Population: A group of plants, animals, or other organisms, all of the same species, that live together and reproduce

Community: An assemblage of species populations that occur together in space and time

Yolk-sac larvae (YSL): Fish larvae that have recently hatched and are still receiving nutrition from yolk deposited in the eggs before they were spawned

Post yolk-sac larvae (PYSL): Fish larvae that have absorbed the yolk and obtain nutrition by feeding

Young-of-the-year (YOY): Fish that have completed the transformation from the larval to the juvenile stage and have grown large enough to be captured by the gear used in the generators' Beach Seine Survey and Fall Shoals Survey

Longitudinal River Survey (LRS): The Hudson River generators' annual riverwide ichthyoplankton survey

Beach Seine Survey (BSS): The Hudson River generators' annual survey of YOY and older fish abundance in the shorezone

Fall Shoals Survey (FSS): The Hudson River generators' annual survey of YOY and older fish abundance in the shoal zone

Early life stage: The collective term for the egg, YSL, PYSL, and early juvenile (juveniles too small to be captured by the gear used in the BSS and FSS) life stages

Conditional mortality rate (CMR): A measure of the mortality imposed on a population by a stressor such as a cooling water intake structure

Recruit: A fish that has grown large enough to be caught in gears used by agencies performing stock assessments for harvested fish species; as used in the spawning stock biomass per recruit model, a one-year-old fish

Spawning stock biomass per recruit (SSBPR): The expected lifetime reproduction of a typical female recruit, measured in terms of the expected future egg production or biomass

Density-dependence: A relationship between the abundance of a population and the growth rates or mortality rates of individuals belonging to that population

Stressor: An anthropogenic or environmental factor that increases mortality or decreases growth of organisms belonging to a population exposed to that factor

Stressor metric: A measure of the intensity of a stressor

Response metric: A measure of the response of an exposed population to one or more stressors

1. Introduction

This report evaluates whether entrainment and impingement by the respective cooling water intake structures ("CWIS") at Indian Point Unit 2 ("IP2") and Indian Point Unit 3 ("IP3") has caused an adverse environmental impact ("AEI"), as that term is employed in §316(b) of the Clean Water Act ("CWA") and 6 NYCRR §704.5 and reasonably may be interpreted by the scientific community.[1] Our evaluation of whether entrainment and impingement by the respective CWIS at IP2 and IP3 has caused AEI is based on biologically-based definitions of "adverse environmental impact" consistent with established definitions and standards of ecological risk assessment (USEPA 1998) and fisheries management (Restrepo et al. 1998, Quinn and Deriso 1999). Our approach involves three elements.

First, we use the extensive Hudson River fisheries datasets (prepared under the direction and oversight of the New York State Department of Environmental Conservation ("Department" or "NYSDEC")) to determine (1) whether changes in the status of species of interest identified by NYSDEC have occurred since IP2 and IP3 began commercial operation, (2) whether cooling-water withdrawals by IP2 and IP3 during this period could have been responsible for any such changes, or (3) whether alternative stressors including striped bass predation, zebra mussels, and harvesting are the more probable cause of perceived changes.

Second, we use a widely-accepted method for quantifying the impacts of harvesting on the sustainability of fish populations, termed the Spawning Stock Biomass per Recruit ("SSBPR") model, to determine whether entrainment and impingement at IP2 and IP3 could have adversely affected the sustainability of the Hudson River striped bass and American shad populations.

Third, we examine long-term trends in the abundance of all Hudson River fish species for which adequate trends data sets can be developed to determine whether species with high

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[1] As applicable here, the CWIS for IP2 and IP3 extend from the point at which water is withdrawn from the Hudson River (the "River") up to, and including, the intake pumps. *See, e.g.*, In Re Matter of Bowline, LLC, 2001 WL 1587359 (N.Y. Dept. Env. Conserv.) (Nov. 30, 2001), at *6-7 (relying on USEPA definition, now codified at 40 C.F.R §125.93); 40 C.F.R. §125.93. The CWIS at IP2 and IP3 are shown schematically in Figures IV-12 through IV-15 of the Draft Environmental Impact Statement for State Pollutant Discharge Elimination System Permits for Bowline Point, Indian Point 2 & 3, and Roseton Steam Electric Generating Stations, dated December 1999 (the "DEIS"), subsequently incorporated into the Final Environmental Impact Statement by the New York State Department of Environmental Conservation, accepted June 25, 2003 (the "FEIS"). *See* FEIS, p. 12. These intake structures generally commence with bar racks and debris barriers at the point of entry, include modified Ristroph traveling screens and fish return systems upstream of the point of entry, and terminate with the circulating water pumps.

susceptibility to entrainment at IP2 and IP3 are more likely to have declined in abundance over the past 30 years than are species with low susceptibility to entrainment.

Although the technical analyses documented in this report emphasize entrainment, the conclusions reached apply to the combined impacts of entrainment and impingement. There are two reasons for this. First, the trends data that are the primary focus of this assessment reflect the combined effects of entrainment and impingement. Second, entrainment is the focus of the Department, as the existing retrofits (i.e., Ristroph screens and fish returns) have resolved the Department's concerns regarding impingement (Draft SPDES Permit, Special Condition 27).

2. Approach to Impact Assessment

Populations[2] and communities[3] are the proper focus for evaluating adverse impacts of cooling-water withdrawals on the Hudson River estuary. The fundamental reason for focusing on populations and communities is that, whereas all individual organisms have finite life spans, populations and communities can persist. Because populations and communities can persist in spite of the inevitable mortality of the individual organisms, populations and communities can be managed and restored. Most commonly, fisheries management agencies establish harvesting policies to manage populations of fish while allowing harvesting of individual fish to continue (Restrepo et al. 1998). The U.S. Environmental Protection Agency ("USEPA") develops biological assessment methods, based on measures of aquatic community composition, to help states, tribes, territories, and interstate commissions identify communities that are impaired and in need of restoration (USEPA 2002). Established principles of population and community ecology underly both fisheries management and biological assessment. These scientific disciplines also provide a sound foundation for assessing impacts of entrainment and impingement on the biological resources of the Hudson River.

Our evaluation is primarily based on an analysis of empirical data collected over the 30 years during which IP2 and IP3 have been operating, in a manner that appropriately accounts for other potential causes of changes in fish populations. This is because factors other than entrainment and impingement affect the abundance of fish populations, including short-term

2 A population is a group of plants, animals, or other organisms, all of the same species, that live together and reproduce (Gotelli 1995).

3 A community is an assemblage of species populations that occur together in space and time (Begon et al. 1996).

natural environmental fluctuations, long-term environmental change, introductions of exotic species, pollution, and over-harvesting (Pew Oceans Commission 2003). The preamble to USEPA's Phase II Rule, 69 Fed. Reg. 41588 (July 9, 2004), also acknowledges the potential influence of these factors on Hudson River fish populations. Where potentially adverse changes in Hudson River fish populations have occurred over the past 30 years, we attempt to determine whether those changes are reasonably attributable to entrainment and impingement, or whether they are more likely to have resulted from other factors.

This impact assessment focuses on eight of the ten species identified for quantitative assessment in NYSDEC's October 1, 1992 Scope of Work for the DEIS: (1) striped bass; (2) white perch; (3) American shad; (4) Atlantic tomcod; (5) alewife; (6) blueback herring; (7) bay anchovy; and (8) spottail shiner. All of these species have been included in §316(b) studies for Indian Point and other Hudson River power plants since the 1970s (TI 1980). Six of these species, striped bass, white perch, Atlantic tomcod, alewife, and bay anchovy, were listed by USEPA as Representative Important Species ("RIS") for the Hudson River (TI 1980). Although not officially listed as RIS, blueback herring was included in the list of species studied because of its abundance in impingement collections at Indian Point, and American shad was included because of its commercial importance (TI 1980).

NYSDEC finalized the Scope of Work for the DEIS following a public scoping meeting and the integration of comments received from the generators, state and federal agencies, and environmental organizations. Two of the species identified in the Scope of Work, blue crab and shortnose sturgeon, are not addressed in this report. These two species are not addressed here because there is broad consensus that the CWIS at IP2 and IP3 have no impact on these species. *See, e.g.*, DEIS, p. V-125, 126 (sturgeon); Technical Comments on the DEIS, Pisces Conservation, Ltd., June 2000 ("Pisces Comments"), p. 27 ("There seems no basis for suggesting that power plants are linked to [changes in Atlantic and shortnose sturgeon abundance]."); DEIS, p. V-157 (based on preferred habitat, blue crab eggs and larvae not entrained at IP2 and IP3; very high impingement survival); Pisces Comments, p. 28-29 (numbers of blue crab within the estuary have risen dramatically since 1980).

2.1 Definition of "adverse environmental impact"

Neither §316(b) of the CWA (including USEPA's Phase II Existing Facilities Rule), nor New York regulation provides a definition of the term "adverse environmental impact." *See, e.g.*, 6 NYCRR §704.5. However, both regulations governing fisheries management in the United States and other USEPA guidance provide a foundation for a scientifically appropriate definition of this term.

2.1.1 Definition of adverse environmental impact in the context of fishery management

In the context of fisheries management, mortality *per se* could not be considered an AEI, because the act of fishing necessarily causes mortality. To the contrary, fisheries management agencies, including NYSDEC, actively encourage the responsible harvesting of fish. For example, NYSDEC has issued a guide to saltwater fishing in the New York City area (http://www.dec.ny.gov/outdoor/8377.html) that discusses equipment, fish identification, and specific fishing locations in all five New York City boroughs.

Fishery policy in waters under the control of the U.S. federal government, including estuaries and rivers utilized by anadromous fish, is established in the Magnuson-Stevens Fishery Conservation and Management Act ("Magnuson-Stevens Act"). The amended Act states:

> Fishery resources are finite but renewable. If placed under sound management before over-fishing has caused irreversible effects, the fisheries can be conserved and maintained so as to provide optimal yields on a continuing basis.

16 U.S.C. §1801(a)(5).

Federal guidelines implementing the Magnuson-Stevens Act state that "[c]onservation and management measures shall prevent over-fishing while achieving on a continuing basis, the optimum yield ("OY") from each managed fishery for the U.S. fishing industry." 70 Fed. Reg. 36240, 36250 (June 22, 2005). Thus, a fish population is viewed by managers as a renewable resource for which mortality in the form of harvesting is permissible, provided that this mortality does not threaten the long-term productivity of the population. Over-fishing that threatens the long-term sustainability of harvests is considered to be adverse. The National Oceanic and Atmospheric Administration ("NOAA") guidelines and other related technical guidance documents (e.g., Restrepo et al. 1998) provide specific procedures for determining whether overfishing is occurring. Fishery management councils are required to take action to reduce harvest levels if over-fishing is found to exist. 70 Fed. Reg. 36240, 36257 (June 22, 2005).

The Magnuson-Stevens Act is often cited as the "Sustainable Fisheries Act." The term "sustainable" is often used in a wider environmental policy context to refer to an approach to economic development and resource utilization that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development 1987). Sustainable uses of resources preserve those resources for future use; non-sustainable uses degrade or destroy the resources so that they may be unavailable in the future (World Commission on Environment and Development 1987).

Applying the definition of sustainable use provided by the World Commission on Environment and Development, sustainable use in the context of a fish population refers to a resource-management approach that permits the population to persist indefinitely into the future, while continuing to perform its normal ecological function and support normal human use. Ecological function is included as part of the definition of sustainable use of fish populations because fish have a role in the maintenance of healthy aquatic systems that can be compromised by over-fishing (Dayton et al. 2002). Predatory fish, such as striped bass, control the abundance of other fish species upon which they prey, and forage fish, such as bay anchovy, serve as both food for other fish species and as controls on the abundance of smaller organisms at the base of the marine food chain (Dayton et al. 2002). Over-fishing has led to a wide variety of direct and indirect changes in the structure and function of fish communities throughout the world (Dayton et al. 2002).

The sustainability of a population is a function of the abundance and other characteristics of the population (e.g., age and size structure) and also of the ability of members of the population to reproduce and replace themselves. Thus, with respect to the harvest-related mortality imposed on a fish population, an adverse impact consists of harvest-related reductions in abundance, changes in age/size structure, increases in mortality rates, or reduction in reproduction rates that threaten the capacity of the population to persist, perform its normal ecological function, and support normal human uses.

2.1.2 Definition of AEI in the context of ecological risk assessment

USEPA's Guidelines for Ecological Risk Assessment (USEPA 1998) provide a general discussion of adverse ecological effects of environmental stressors, including criteria for evaluating whether or not observed or predicted changes should be considered adverse. These guidelines were expressly issued to "set forth current scientific thinking and approaches for conducting and evaluating ecological risk assessments" (USEPA 1998, p. 8). This guidance discusses adverse ecological effects of environmental stressors, including criteria for evaluating whether or not observed or predicted changes should be considered adverse. According to USEPA and the scientific community, adverse ecological effects are changes that "alter valued structural or functional attributes of the ecological entities under consideration" (USEPA 1998, p. 106). USEPA (1998, p. 106) further states that the following criteria should be considered when determining whether an observed or predicted effect is adverse:

- Nature and intensity of effects;
- Spatial and temporal scale; and
- Potential for recovery.

"Nature and intensity of effects" refers to the types of effects that have occurred (or are predicted to occur), and the magnitude of the measured or predicted effects, the statistical significance of measured effects, and the ecological significance of the effects. "Spatial and temporal scale" refers to the size and location of the area within which an effect occurs, and the duration of the period required for the effect to appear. "Potential for recovery" refers to the expected rate and extent of return of an affected population or community following elimination of the stressor responsible for an effect that has been determined to be ecologically significant.

USEPA's definition and criteria for determining ecological adversity are consistent both with accepted principles of fishery management and with the current scientific understanding of the potential effects of harvesting on fish populations and communities. As noted in the introduction to this Section, in the context of §316(b) and §704.5, the ecological entities of interest are the populations and communities potentially affected by entrainment at CWIS. A definition of AEI of CWIS consistent with the Guidelines for Ecological Risk Assessment (USEPA 1998) should be expressed in terms of undesirable alterations in the structural or functional attributes of these populations and communities. An assessment whether adverse impacts have occurred (or will occur) should address the three criteria provided in the Guidelines.

2.1.3 Definition of adverse environmental impact in the context of entrainment and impingement

The definition of sustainable use in the Magnuson-Stevens Act and the definition of ecological adversity in USEPA's Guidelines for Ecological Risk Assessment provide a reasoned basis for a definition of AEI applicable to entrainment and impingement at CWIS. A sustainable approach to managing a fishery would ensure the long-term persistence and productivity of the population being managed. A non-sustainable approach, in contrast, would cause harvest-related reductions in abundance, changes in age/size structure, increases in mortality, or reductions in reproduction that could threaten the capacity of a population to persist, perform its normal ecological function, and support normal human uses. Since the ecological function of a population is understood by scientists to include interactions with other populations, non-sustainable use of a population can affect an entire community.

Abundance, age/size structure, mortality, and reproduction are examples of the "structural and functional attributes" discussed in the USEPA Guidelines. Hence, non-sustainable management of a fishery would be an example of an AEI according to USEPA's definition. Entrainment mortality differs from mortality caused by harvesting only in that the mortality is imposed on early life stages of fish or shellfish rather than on adults. Excessive levels of entrainment mortality could potentially affect most of the same structural and functional attributes affected by harvesting.

In sum, the term AEI, as it relates to entrainment and impingement, is reasonably and appropriately defined as follows:

> An adverse environmental impact due to entrainment and impingement consists of adverse changes in important population or community characteristics sufficient to threaten the sustainability of susceptible populations or to cause significant or potentially irreversible changes in population or community structure and function.

Such a definition would be consistent with recognized principles of both natural resource management and ecological risk assessment, as discussed above.

2.2 Why entrainment losses alone are insufficient to demonstrate AEI

Context is essential to understanding what the term AEI reasonably may mean with respect to fisheries biology. As a matter of science and logic, losses, even large numbers of early life stage individuals do not necessarily equate to AEI. This is because fish species inhabiting the Hudson River exhibit either "periodic" or "opportunistic" life history traits (Winemiller and Rose 1992). From an ecological perspective, periodic fish species are characterized by high fecundity (i.e., they spawn a large number of eggs), large size, and long life spans during which a female fish may spawn many times (Winemiller and Rose 1992). Striped bass is an example of a periodic species (Winemiller and Rose 1992). Opportunistic species are characterized by small body size, short life spans, and the ability to disperse offspring widely throughout the environment (Winemiller and Rose 1992). Bay anchovy is an example of an opportunistic species. Periodic and opportunistic traits are advantageous to fish species that live in unstable or unpredictable environments, such as the Hudson River, which experiences significant within-year and between-year variation in environmental conditions (e.g., temperature, salinity, freshwater flow, etc.). In other words, the reproductive strategies of these fish in these unstable conditions, including the very large numbers of eggs produced, ensure that sufficient offspring will survive to sustain the populations, even in unstable environments characterized by the presence of multiple stressors.

Entrainment losses consist mainly of eggs and larvae. Only a small fraction of the entrained fish would survive to adulthood, even if IP2 and IP3 did not exist. For example, an 18-year-old Hudson River striped bass was found to contain more than 3 million eggs (Hoff et al. 1988). A 16-year-old female striped bass examined by Olsen and Rulifson (1992) was found to contain nearly 5 million eggs. Since striped bass can live for up to 30 years (Secor and Piccoli 1996), a single fish could potentially spawn tens of millions of eggs over her entire lifespan. According to early life stage survival estimates developed by Secor and Houde (1995), more than 99.99% of young striped bass eggs die from natural causes within 60 days following spawning. Less than one striped bass egg in 100,000 is likely to survive to become a one-year-old fish; and less than one in a million is likely to survive to reach six years of age, the median age at which female striped bass become sexually mature (EPRI 2005).

Because nearly all of the eggs and larvae entrained at IP2 and IP3 would have died in any case, counts of total numbers entrained reveal nothing meaningful about the potential impact of IP2 and IP3 on fish populations. What matters is whether or not entrainment significantly reduces the number of fish that survive the early period of high natural mortality. As discussed in the next sections, this fact was recognized more than 30 years ago by the scientists who performed the first entrainment impact assessments for IP2 and IP3, in conjunction with other Hudson River generating stations.

2.3 Role of the conditional mortality rate (CMR) in impact assessment

The first assessments of the effects of cooling-water withdrawals on Hudson River fish populations, conducted on behalf of the Consolidated Edison Company of New York and various federal regulatory agencies were based on mathematical models that predicted the potential effects of entrainment losses on the abundance and other characteristics of fish populations, especially striped bass (Barnthouse et al. 1984). Many of these models were developed to support U.S. Atomic Energy Commission licensing proceedings for IP2 and IP3, and were incorporated in environmental impact statements prepared to support these proceedings (Barnthouse et al. 1984). At the time they were first developed, in the early and mid-1970s, modeling was undertaken because no actual fisheries data were available to test whether cooling-water withdrawals would have adverse impacts on important fish populations. When data from riverwide ichthyoplankton sampling became available in the late 1970s, scientists studying entrainment impacts developed an empirical model, termed the Empirical Transport Model ("ETM", Boreman et al. 1981), and used it to estimate the impact of entrainment on the abundance of juvenile fish. The metric calculated using the ETM, which was termed the "conditional mortality rate" ("CMR"), provides an estimate of the fraction by which the abundance of young-of-the-year fish is reduced due to entrainment. A similar model, termed the Empirical Impingement Model ("EIM", Barnthouse and Van Winkle 1988), was used to estimate a CMR for impingement.

It was recognized at the time that the CMR could not be used to predict long-term impacts on populations, however, because neither the ETM, nor the EIM, accounts for the density-dependent processes that can partially offset mortality due to entrainment and impingement (Barnthouse et al. 1984). CMRs could, however, be used to compare the relative potential effectiveness of alternative technologies intended to reduce entrainment and impingement mortality. As discussed by Englert et al. (1988), CMRs calculated using the ETM also were used to develop the cross-plant outage credits that were included in the Hudson River Settlement Agreement ("HRSA"). CMRs were also used in the DEIS to compare alternative entrainment mitigation approaches. In all of these applications, CMRs were used usefully as measures of mortality caused by entrainment and impingement, not as measures of the impacts of that mortality on the long-term abundance or sustainability of susceptible populations.

Because it does not account for density-dependent effects, the CMR is not a valid measure of long-term entrainment impacts. Depending on the strength of density-dependence in a given population, a particular CMR value corresponds to either a negligible or a substantial impact on the sustainability of a population.[4] CMRs can, however, be used as a measure of the annual rate of mortality imposed by entrainment and as inputs to assessment models that estimate the combined impacts of entrainment mortality and fishing mortality on the sustainability of populations (Goodyear 1977, 1993). For this assessment, CMRs are used for both of these purposes. They are not, however, used as measures of AEI, because CMRs are not appropriately used in that fashion and superior methods for assessing adverse impacts are available. As discussed in the following sections, analysis of long-term trends in the abundance of important Hudson River fish populations, available from 30 years of intensive data collection, is the best method available for assessing impacts of IP2 and IP3 on Hudson River fish populations. The trends analysis is supplemented by an analysis of the impacts of IP2 and IP3 on the sustainability of the Hudson River striped bass and American shad populations, using the SSBPR model.

2.4 Role of long-term datasets in impact assessment

Today, nearly 30 years of data are available from both generator and agency-sponsored monitoring programs. Together, these overlapping datasets provide information concerning long-term trends in the abundance and distribution of eggs, larvae, and juveniles of all of the species addressed in this report. For some commercially harvested species, data on long-term

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4 Although there can be substantial uncertainty concerning the strength of density-dependence in specific populations, there is strong theoretical and empirical evidence that the great majority of biological populations, including fish populations, are regulated in part by density-dependent mechanisms (Murdoch 1994, Turchin 1999, Rose et al. 2001, Brook and Bradshaw 2006).

trends in the abundance, age distribution, and mortality of adult fish are available. These datasets can be used both to assess trends in the status of important fish populations and to test alternative hypotheses concerning potential causes of adverse changes.

In this report, information concerning long-term trends on key population characteristics and on the intensities of potential stressors is used to test specific hypotheses concerning the expected impacts of cooling-water withdrawals, termed "risk hypotheses" in USEPA's Guidelines for Ecological Risk Assessment (USEPA 1998). These hypothesis tests are used to distinguish changes that could have been caused by cooling-water withdrawals from changes that are most likely related to other causes.

The following generator-sponsored long-term datasets are the primary datasets used in assessing the effects of the CWIS at IP2 and IP3:

- *Longitudinal River Ichthyoplankton Survey ("LRS").* This program samples eggs, larvae, and juvenile fish, weekly from April through July. The region between the George Washington Bridge and the Federal Dam at Troy (Figure 1) has been sampled with only minor changes in methodology since 1974. In 1988, the LRS was extended to sample the region between the Battery and the George Washington Bridge.

- *Beach Seine Survey ("BSS").* This program samples juvenile fish, also called "young-of-the-year" fish ("YOY") (i.e., fish spawned earlier in the year) on alternate weeks from June through October. Sampling is conducted from the George Washington Bridge to the Federal Dam. The BSS has been conducted annually with only minor changes in methodology since 1974.

- *Fall Shoals Survey ("FSS").* This program samples YOY and older fish in offshore habitats, on alternate weeks from the BSS. Approximately 200 samples are collected per week, from Manhattan to the Federal Dam. The FSS uses two different gears in order to sample as much of the Hudson River as possible: a 1-m^2 Tucker trawl and a 3-m beam trawl. This program was also initiated in 1974, however, the beam trawl was not used until 1985. From 1974 through 1984 an epibenthic sled was used to sample near the river bottom. To ensure comparability between years, only the data collected from 1985 onward are used in this assessment.

- *Atlantic Tomcod Mark-Recapture Program.* This program has been conducted in most years since 1974 to generate estimates of the number of tomcod in the winter spawning population.[5] Box traps and bottom trawls are used to collect fish for marking and recapture.

The above datasets were selected as the primary datasets for this assessment because they have been conducted continuously since the mid-1970s. They cover nearly all of the period of commercial operation of IP2 (1973 startup) and all of the period of commercial operation of IP3 (1976 startup). These four datasets provide the most comprehensive and consistent estimates of long-term trends in the abundance of multiple life stages of important Hudson River fish populations. More detailed descriptions of these datasets are provided in ASA (2007).

A variety of other programs, conducted by the generators, NYSDEC, and federal resource management agencies provide information that can be used to test the validity of the primary trends data. These programs include:

- *Striped Bass Mark-Recapture Program.* This program was initiated in 1984, to estimate the contribution of the Hudson River striped bass hatchery (established as a condition of the HRSA) to the Hudson River population. The program targets 1-year-old and 2-year-old striped bass, and is conducted from November through March. Data from this program are used to estimate the numbers of striped bass greater than 150 mm in length overwintering in the lower estuary. Growth and survival rate estimates are also obtained from this program.

5 The program was not conducted in 1984 and 1986.

- *NYSDEC Beach Seine Survey.* Since 1976, the NYSDEC Division of Marine Resources has conducted a beach seine survey in the lower Hudson River estuary. The program focuses on the Tappan Zee and Haverstraw Bay. It samples juvenile fish using a method similar, but not identical to, the generators' BSS.

- *Juvenile Alosid Survey.* NYSDEC conducts a beach seine survey in the middle and upper regions of the estuary (above River Mile 55) to estimate the relative abundance of YOY American shad and other juvenile fishes. This program was initiated in 1980 and continues to the present.

- *Western Long Island Survey.* NYSDEC conducts a survey for subadult striped bass in the bays around western Long Island Sound. Sampling is conducted using a 200-ft. beach seine. The program was initiated in 1984 and is continuing, although it has been modified over time.

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

- *Commercial Fishery Monitoring.* NYSDEC monitors the commercial gill net fishery for American shad. The objective of the program is to determine the relative abundance and age structure of the commercial catch of American shad.

As shown in Appendix A, indices derived from these datasets are strongly correlated with indices derived from the primary datasets. These correlations support the use of the primary datasets in this assessment.

In addition to the Hudson River monitoring programs, information on population status and trends for important fish species is also available from the National Marine Fisheries Service

("NMFS") and the Atlantic States Marine Fisheries Commission ("ASMFC"). Quantitative stock assessments, which include estimates of age structure, natural mortality, and fishing mortality, are available for striped bass (ASMFC 2005) and American shad (ASMFC 2007a). These assessments provide additional information for determining whether these populations have been harmed by CWIS.

2.5 Indicators of adverse impacts potentially related to CWIS

As discussed above, an adverse impact of CWIS would consist of entrainment and impingement-related adverse changes in important population or community characteristics sufficient to threaten the sustainability of relevant populations, or to cause significant or potentially irreversible changes in community structure and function. Characteristics that influence the sustainability of a fish population include the total size of the population, the relative abundances of different life stages or age groups, the sizes and reproductive rates of the individual fish, and the rates of mortality of fish at different life stages or ages. Measures of any of these population characteristics could, at least in principle, be used as indicators of adverse impact. Some of these measures are not suitable as indicators of adverse impacts potentially caused by CWIS, however, because they measure changes that cannot be reasonably attributed to cooling-water withdrawals. For example, a reduction in fecundity could be an indicator of a potential impact caused by a toxic chemical but, because impingement and entrainment do not affect fecundity, this characteristic is not an appropriate indicator of impacts caused by CWIS. Similarly, some indicators of impact are not particularly useful in narrowing the potential causes of impacts. For example, a prolonged downward trend in the abundance of adult fish could be the result of any number of causes, including over-fishing or environmental factors.

CWIS may impose mortality on early life stages of fish (i.e., eggs, larvae, and YOY) in addition to the mortality that would have occurred naturally. Therefore, characteristics that are either directly or indirectly affected by increased mortality of these life stages are potentially useful as indicators of harm related to CWIS. Increased mortality imposed on a particular life stage would reduce the fraction of organisms in that stage that survive to the next stage. Accordingly, this assessment focuses on whether CWIS have had a measurable influence on the survival of early life stages of fish in the Hudson River.

As discussed in Section 2.1 of this report, however, mortality of early life stages as a result of CWIS is insufficient, of itself, to establish that an adverse impact has occurred. It is necessary, in addition, to evaluate whether the magnitude, spatial extent, and duration of this mortality are large enough to constitute an adverse impact (USEPA 1998). Fisheries scientists have developed metrics, termed "biological reference points," for determining whether harvested fish populations are being harmed by over-fishing (Restrepo et al. 1998). These reference points, expressed in terms of either the total spawning stock biomass ("SSB") or the SSBPR, are viewed as indicators of the risk that over-fishing will lead to future declines in abundance and harvest. The methods that fisheries scientists use to estimate effects of fishing mortality on SSB and SSBPR can also be used to estimate impacts of entrainment-related mortality on SSB and SSBPR (Goodyear 1993). Hence, the indicators used to determine whether fish populations are being adversely affected by fishing can also be used as indicators of whether these same populations are being adversely affected by cooling-water withdrawals. Accordingly, for species for which published agency stock assessment reports provide relevant information, this assessment addresses whether the magnitude of entrainment mortality (as measured using the CMR) is sufficient to produce an ecologically significant reduction in SSB or SSBPR.

Information needed to estimate SSBPR is available for both striped bass and American shad. A coastwide SSB estimate is available for striped bass.

The following indicators have been selected for this assessment:

1. Long-term declines in the abundance of YOY fish belonging to species with life stages susceptible to impingement and entrainment, *see, infra*, Section 3;
2. Reductions in the spawning potential of female fish below the sustainable level as estimated using the SSBPR approach, *see, infra*, Section 4; and
3. Long-term trends in the abundance of species with high susceptibility to entrainment at IP2 and IP3 as compared to species with low susceptibility to entrainment at IP2 and IP3, *see, infra*, Section 5.

The analyses documented in Sections 3, 4, and 5 of this report evaluate whether any such declines or reductions in spawning potential have occurred and, if so, whether they may reasonably be attributed to the CWIS of IP2 and IP3.

3. Evaluation of changes in abundance of fish populations with life stages susceptible to entrainment

In complex ecological systems, such as the Hudson River estuary, fish populations are influenced by many factors in addition to CWIS, including water quality impairment, introductions of non-native species, and overfishing (Pew Oceans Commission 2003). Many of these factors are discussed in the preamble to USEPA's Final Phase II Existing Facilities Rule. 69 Fed. Reg. 41575, 41588 (July 9, 2004). For this reason, investigations of the causes of changes in fish populations must consider multiple hypotheses, weighing the evidence for and against each hypothesis (Hilborn and Mangel 1997, Suter et al. 2007). This approach has been termed "ecological detection" by Hilborn and Mangel (1997) and "ecoepidemiology" by Suter et al. (2007).

Most environmental factors affecting Hudson River fish populations vary in intensity over time. Knowledge of these variations can be used to predict the change in each metric that should have occurred, if that stressor had been affecting a particular fish population. To test each hypothesis, this analysis utilizes rules for evaluating causal associations provided by Suter et al. (2007, p. 50). These authors identified five criteria that should guide analyses of potential causes of adverse environmental effects:

1. *Co-occurrence*: An effect occurs where and when its cause occurs and does not occur in the absence of its cause.
2. *Sufficiency*: The intensity or frequency of a cause should be adequate to produce the observed magnitude of effect.
3. *Temporality*: A cause must precede its effect.
4. *Manipulation*: Changing the cause must change its effect.
5. *Coherence*: The relationship between a cause and effect must be consistent with scientific knowledge and theory.

Evaluations of co-occurrence discussed in this sections rely on a commonly-used and relatively straightforward statistical method known as correlation analysis (Clarke and Kempson 1997). In simple terms, correlation is a measure of whether two different variables are related to one another and, if so, how strong that relationship is (Clarke and Kempson 1997). A positive correlation between two variables indicates that as the value of one variable increases, so does the other. For example, height and weight among people are positively correlated. Although some taller people weigh less than shorter people, on average the taller a person is, the more that person is likely to weigh. Conversely, a negative correlation indicates that, as the value of one variable increases, the other decreases (Clarke and Kempson 1997). For example, weight and fuel efficiency among automobiles are negatively correlated. Although some heavier cars get better gas mileage than some lighter cars, on average the heavier a car is, the lower its gas mileage will be.

The existence and strength of correlations between stressor metrics and response metrics provides evidence concerning the co-occurrence criterion. If, for example, entrainment mortality at IP2 and IP3 is reducing the survival of eggs and larvae of a particular fish species, then there should be a negative correlation between entrainment mortality and a measure of the fraction of eggs and larvae that survive to reach older life stages. This means that in years when mortality due to IP2 and IP3 is high, survival should be relatively low, and in years when mortality due to IP2 and IP3 is low, survival should be high. Data showing the presence of a negative correlation between early life stage survival and IP2 and IP3-related mortality would constitute evidence supporting this impact hypothesis; data showing the absence of a correlation would constitute evidence against this hypothesis.

Evaluations of sufficiency in this assessment rely on measures of the magnitude of the stressor, as compared to the magnitude required to cause the observed response. For example, the rate of fishing mortality imposed on the striped bass and American shad populations can be compared to overfishing thresholds established by the ASMFC.

Evaluations of temporality in this assessment rely on time trends of the various stressor and response metrics. For any stressor to be a potential cause of a decline in the survival or abundance of a fish population, the decline should be preceded by an increase in the intensity of the stressor. If the decline in survival or abundance precedes the increase in the stressor, then the stressor cannot have caused the decline.

Evaluations of manipulation in this assessment rely on observations of responses of populations to deliberate changes in the magnitudes of stressors, e.g., the harvesting restrictions imposed on the striped bass fishery in the 1980s.

Evaluations of coherence in this assessment rely on the consistency of the responses with all relevant scientific information.

Because the focus of the permit proceedings is on entrainment and impingement of age 0 fish, the analysis will focus primarily on age 0 response metrics. The steps in the analysis include:

1. Develop a conceptual model of each stressor, including (1) a description of the stressor itself, (2) the reasonably expected causal mechanisms through which fish populations would be affected, (3) the species that would likely be affected, (4) the life stages (e.g., juveniles) that would likely be affected, (5) the life history characteristics (e.g., survival and growth) that would likely be affected, and (6) the type of measurable effects that would likely occur (increase or decrease);
2. Identify appropriate sets of "stressor metrics" and "response metrics" that can be used to test the potential influence of the various stressors;
3. Summarize the expected effect of the stressor on each response metric;
4. Apply the five evaluation criteria discussed above to the available data for each fish species; and
5. Summarize conclusions regarding (1) whether changes in the response metrics could have been caused by entrainment by CWIS at IP2 or IP3, or (2) whether other stressors are more likely to be responsible for these changes.

3.1 Species addressed

The DEIS assessed entrainment and impingement impacts on striped bass (*Morone saxatilis*), white perch (*Morone Americana*), Atlantic tomcod (*Microgadus tomcod*), bay anchovy (*Anchoa mitchilli*), American shad (*Alosa sapidissima*), alewife (*Alosa *pseudoharengus*), blueback herring (*Alosa aestivalis*), and spottail shiner (*Notropis hudsonius*) (DEIS, Sections 5 and 6). This report assesses entrainment and impingement impacts on these same species, focusing on the most economically important species (striped bass) and on the three species (white perch, American shad, and Atlantic tomcod) identified in the draft permit fact sheet as being of potential concern with respect to IP2 and IP3. Fact Sheet, Draft SPDES Permit, Attachment B, at 1 of 8. The datasets used in these analyses are documented in the 2005 Year Class Report (ASA 2007). The stressor and response metrics are documented in Appendix B.

3.2 Impact hypotheses and stressor metrics

This section documents expected effects of CWIS and four other stressors that are widely regarded as potentially having affected Hudson River fish populations: fishing, invasion of the Hudson River by zebra mussels (*Dresseina polymorpha*), temperature (Atlantic tomcod only) and predation by striped bass.

3.2.1 CWIS

CWIS may cause mortality of fish due to entrainment and impingement. For most species, this mortality is largely limited to eggs, larvae, and YOY. Because most of the susceptible life stages are planktonic[6] and are widely dispersed throughout the estuary due to tidal and nontidal flows, cooling-water withdrawals would not be expected to alter the spatial distributions of the affected species. In addition, the CWIS would not be expected to reduce the survival of fish that have grown through the most susceptible life stages, or to reduce fish growth rates at any life stage.

As discussed in Section 2.3, the CMR is a direct estimate of the rate of mortality caused by entrainment and impingement, independent from natural mortality. Similar measures are used by fisheries scientists to estimate the rate of mortality imposed on adult fish by fishing. The CMR can have values ranging between 0.0 and 1.0. The higher the value of the CMR, the greater the mortality imposed on early life stages of fish.

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6 Planktonic organisms are small organisms such as fish larvae that have limited swimming capabilities and are passively transported up and downriver with tidal currents.

Expected effects of CWIS on the life stages potentially susceptible to entrainment and impingement (i.e., eggs, larvae, and YOY) are summarized in Figure 2. As shown in Figure 2, CWIS should affect the survival rates of the susceptible life stages, but should not affect the survival of stages that are not susceptible to entrainment or impingement. If entrainment or impingement were having a measurable impact on a fish population, then in years when the IP2 and IP3 CMR is high, the survival rates of susceptible life stages of that species should be lower than in years when the IP2 and IP3 CMR is low. As a consequence, long-term trends in IP2 and IP3 CMR values for that species should be negatively correlated with long-term trends in the survival rates of susceptible life stages.

Although entrainment would not affect the number of eggs spawned by females of susceptible species, it is still possible that entrainment could directly affect the abundance of early life stages. The reason for this is that the LRS is conducted during the period in which entrainment at IP2 and IP3 is occurring. Therefore, entrainment could affect the abundance estimates derived from LRS data. If entrainment at IP2 and IP3 is reducing early life stage abundance, then the IP2 and IP3 CMR values should also be negatively correlated with PYSL abundance estimates.

3.2.2 Fishing

Fishing imposes mortality primarily on harvestable-sized[7] fish.[8] For managed Hudson River fish species (i.e., striped bass and American shad), harvesting is largely limited to age 1 and older fish (ASMFC 1998, 2002). Fishing has predictable effects on the age distribution of adult fish and on the abundance (numbers and biomass) of the spawning stock (Dayton et al. 2002). Measures of age distribution and spawning stock abundance are used by fisheries managers as indicators of fishing (Restrepo et al. 1998). Fishing reduces the total reproductive output of a fish population (Goodyear 1993).

The most appropriate estimate of stress due to fishing is the annual rate of fishing mortality (F) imposed on the population. Estimates of F for two of the species addressed in this analysis, striped bass and American shad, are available from the ASMFC.

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7 Harvestable-size fish are fish that fall within the size range for which harvesting is permitted.

8 Fish outside the permitted range are frequently caught by trawls and other fishing gear. Although they are returned to the ocean, substantial mortality may still occur. This mortality is termed "bycatch" mortality.

Expected effects of fishing on age 0 life stages are summarized in Figure 3. Overharvesting reduces the size of the adult population and necessarily the total number of eggs produced per year. The reduction in egg production would be expected to reduce the number of eggs surviving to become one-year-old fish. Fishing should not reduce the survival or growth rate of any age 0 life stage, however, because early life stages of fish are not susceptible to harvesting.

3.2.3 Zebra mussels

Zebra mussels invaded the Hudson River in the early 1990s (Caraco et al. 1997). Zebra mussels form dense beds on the bottom of colonized water bodies. Because of their high filtering capacity, zebra mussels remove phytoplankton from the water column, thus reducing the food base that supports pelagic fish larvae, such as American shad, striped bass, and white perch (Strayer et al. 2004). Because less food is available to support fish species that feed in open water, the survival and growth of these species may decrease. The increased water clarity caused by zebra mussel filtration can result in improved growth of rooted vegetation. The survival and growth of species that inhabit vegetated areas may increase because of increased habitat availability (Strayer et al. 2004). Zebra mussels are limited to fresh water, and are not found in substantial numbers below approximately river kilometer ("RKM") 100 in the Hudson River. For this reason, zebra mussels could potentially alter the spatial distributions of some species, reducing their abundance above RKM 100 as compared to below RKM 100.

There is no readily available quantitative metric for zebra mussel abundance. Due to the discontinuous nature of the zebra mussel invasion (absent prior to 1992; highly abundant after 1992), however, the qualitative evaluation can use presence/absence to develop predicted effects, and the quantitative analysis can use a simple index to distinguish between these two periods (e.g., "0" for all years prior to 1993 and "1" for 1993 and later). Expected effects of zebra mussels on age 0 life stages are summarized in Figure 4. Zebra mussels would be expected to reduce the survival and growth rates of post yolk-sac larvae and YOY utilizing freshwater regions of the Hudson River. These changes in survival and growth could result in a shift in the relative abundance of YOY present in predominantly freshwater regions (Regions 6-12; Figure 1) as compared to marine and brackish regions (Regions 0-5; Figure 1). Specifically, if zebra mussel activity reduces the growth and survival of pelagic fish species in freshwater regions as compared to marine and brackish regions, then during the post-invasion period a greater fraction of the populations of pelagic species, such as striped bass, white perch, alewife, and river herring, should be found in marine and brackish regions than during the pre-invasion period.

3.2.4. Predation by striped bass

Increased abundance of yearling and older striped bass, which are piscivorous[9] (Gardinder and Hoff 1982, Walter et al. 2003), could lead to increased predation mortality. Savoy and Crecco (2004) have attributed a recent decline in American shad and blueback herring populations in the Connecticut River to predation by large adult striped bass on spawning adults of these species.

Because the abundance of striped bass early life stages has been found to be strongly correlated with the relative abundance of adults (Pace et al. 1993; Barnthouse et al. 2003), estimates of striped bass larval abundance from the LRS can be used as a surrogate for adult striped bass abundance.

Predation on adults would, like harvesting, reduce the number of spawning adults and, as a consequence, the number of eggs spawned. The reduction in egg production would be expected to reduce the number of eggs surviving to become one-year-old fish. Predation on YOY would directly reduce YOY abundance, over and above and reductions resulting from reduced egg production (Figure 5).

3.2.5 Temperature

Changes in temperature can cause either increases or decreases in the growth and survival of affected species, depending on species-specific temperature tolerances. Long-term trends in Riverwide temperatures could potentially lead to long-term changes in the abundance of sensitive species, such as Atlantic tomcod (FEIS, pp. 65-66). Expected effects of elevated summer temperatures on age 0 temperature sensitive species are summarized in Figure 6. Elevated summer temperatures would be expected to cause decreases in survival and growth of temperature-sensitive species during this period. Growth and survival of early life stages would

9 Piscivorous fish are fish that eat other fish.

not be depressed, however, because these life stages are present only during the winter and early spring, when temperatures would be well below adverse effects thresholds.

According to McLaren et al. (1988), the growth of juvenile Atlantic tomcod in the Hudson River ceases during the summer when river temperatures regularly exceed 25°C. The lethal temperature for juvenile Atlantic tomcod is 26.5°C (McLaren et al. 1988). Temperature records available from the Poughkeepsie Water Works (PWW) were used to develop a degree-day index for evaluating the potential effects of elevated summer temperatures on Atlantic tomcod. A degree-day is defined as the number of degrees by which the temperature measured at the PWW on that day exceeds 24°. If, for example, the temperature measured at the PWW on a given date was 27°C, then the degree-day value for that date would be 3. If the temperature on a date is 24° or less, then the degree-day value for that date is recorded as 0. The degree-day index for a years is calculated by summing the degree-days for all days during that year.

3.3 Response metrics

Because not all data sets are suitable for evaluating all species, the response metrics used in this assessment are not the same for all species.

3.3.1 Response metrics for striped bass, white perch, American shad, alewife, blueback herring, and bay anchovy

For species other than spottail shiner and Atlantic tomcod, the LRS and BSS provide the most reliable data concerning survival, growth, and spatial distribution. Because the durations of egg and YSL life stages are comparatively short, such that individuals can hatch and develop through one or both of these stages between survey dates, most of the fish captures in the LRS are PYSL. The PYSL stage is typically much longer, so that PYSL are susceptible to sampling for at least one and possibly two or more survey dates. For these reasons, estimates of total larval abundance from the LRS are best interpreted as estimates of the abundance of PYSL. Although the beach seine used in the BSS and the beam trawl used in the FSS do not capture larvae, they effectively sample YOY fish present in the sampled habitats (shore zone for the BSS and shoal zone for the FSS). The response variables that can be calculated from the generators' survey data are:

1. Abundance of PYSL, as measured in the LRS;
2. Survival from the PYSL to the YOY stage, as measured by the ratio of densities of larvae in the LRS dataset to densities of juveniles in the BSS or FSS,
3. Abundance of YOY, as measured in the BSS or FSS;
4. YOY growth, as measured by the average length of YOY fish from the BSS or FSS; and
5. Spatial distribution of PYSL and YOY relative to river regions with high zebra mussel densities, as measured by the per cent of the total population occurring downriver from RKM 100.

3.3.2 Response metrics for spottail shiner

Because the LRS does not adequately sample areas of the Hudson River inhabited by spottail shiner, for this species, no estimates of egg and larval abundance are available. However, the BSS provides estimates of both YOY abundance and adult abundance (age 1 and 2 adults) for this species. For the purpose of trends analysis, adult abundance is used as a surrogate for egg production.

3.3.3 Response metrics for Atlantic tomcod

Because a substantial fraction of Atlantic tomcod larvae and YOY occur downriver from the regions sampled by the generators' surveys, for Atlantic tomcod, the data provided by the Atlantic tomcod mark-recapture program should be more reliable than the LRS, BSS, or FSS data for estimating survival rates. The mark-recapture program provides annual estimates of age-1 abundance, spawning stock size, and total egg production that can be used to calculate the fraction of eggs produced during a given year that survive to become age-1 spawners the following year. The LRS data can be used to characterize both year-to-year variations in early life stage abundance and the distribution of Atlantic tomcod larvae and juveniles within the Hudson River.

For this species, the response variables include:

1. Abundance of PYSL and early juveniles, as estimated from the LRS;
2. Abundance of Age-1 and Age-2 fish, as estimated from the mark-recapture program;
3. Total age 0 survival, as measured by the ratio of total egg production each year to age 1 abundance during the following year;
4. Juvenile growth, as measured from growth rates of juveniles from the FSS; and
5. Spatial distribution of PYSL and early juveniles, as measured by the fraction of the total PYSL/juvenile population found in river regions 1-5 (LRS dataset).

3.4 Tests of impact hypotheses

The predicted impacts of the stressors on the response metrics are summarized below and in Tables 1 (striped bass, white perch, American shad, river herring, bay anchovy, and spottail shiner) and 2 (Atlantic tomcod):

- ***CWIS***: Entrainment at IP2 and IP3 would be expected to reduce survival from the PYSL to the YOY stage, and could also reduce the abundance of PYSL. Entrainment should have no effect on growth or spatial distribution.
- ***Fishing***: Fishing would be expected to reduce the abundance of eggs and early larvae because of reduced spawner abundance, but should not reduce the survival of any age 0 life stage.
- ***Zebra mussels***: Zebra mussel activity would be expected to decrease both PYSL survival and YOY growth, and also to shift the spatial distribution of juveniles toward the lower regions and away from the freshwater regions where zebra mussels are abundant.

- ***Temperature***: Since Atlantic tomcod are known to be sensitive to high summer water temperatures, increased summer temperatures would be expected to decrease the growth and survival rates of life stages of this species that are present in the Hudson during this season.
- ***Striped bass predation***: Predation by older striped bass would be expected to decrease juvenile abundance, if the juveniles are susceptible to predation, and early life stage abundance, if adults are susceptible to predation.

Appendix B documents the stressor and response metrics and statistical methods used in this analysis. The subsections below present the results of the analyses performed for each species, and evaluate the consistency of these results with the impact hypotheses.

3.4.1 Striped bass

Figure 7a depicts long-term trends in the abundance of striped bass PYSL and YOY in the Hudson. Figure 7b depicts long-term trends in striped bass PYSL to YOY survival. The abundance of juvenile striped bass in the Hudson has shown no trend, even though the abundance of striped bass early life stages has greatly increased. The increase in abundance of striped bass larvae has occurred concurrently with an increase in the abundance of the Hudson River spawning stock of striped bass (Barnthouse et al. 2003). The increase in spawning size has been attributed to coastwide restrictions on harvesting that were imposed to promote the recovery of the Chesapeake Bay striped bass stock (Young-Dubovsky et al. 1995). As first noted by Pace et al. (1993), and later confirmed by Barnthouse et al. (2003), there is no correlation between the abundance of striped bass PYSL and striped bass YOY (Figure 8a). There is a strong negative relationship between PYSL abundance and PYSL survival, however (Figure 8b). This negative correlation has been interpreted by both Pace et al. (1993) and Barnthouse et al. (2003) as evidence for density-dependent mortality of striped bass larvae. This density-dependent mortality is reflected in the long-term trend in PYSL to YOY survival (Figure 7b), which has declined through time as the size of the spawning population has increased.

3.4.1.1 CWIS

Co-occurrence

Appendix B (Tables B-11 and B-12) summarizes the results of the correlation analysis for striped bass. If entrainment at IP2 and IP3 were reducing the survival or abundance of early life stages of striped bass, then there should be a negative correlation between the CMR and striped bass PYSL survival, PYSL abundance, or both. However, as shown in Figure 9, there is no correlation between the IP2 and IP3 CMR and either PYSL survival (Figure 9a) or PYSL abundance (Figure 9b) for striped bass. Hence, the CWIS hypothesis fails the co-occurrence criterion for striped bass.

Sufficiency

There are no independent measures of sufficiency that can be applied to this hypothesis. The objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Hence, the sufficiency criterion is inapplicable to the CWIS hypothesis.

Temporality

If entrainment at IP2 and IP3 were reducing the survival or abundance of early life stages of striped bass, then a decline in PYSL survival, or PYSL abundance should have occurred after the startup of commercial operations of IP2 (1974) and IP3 (1976). However, as shown in Figure 7, no such declines occurred. PYSL abundance was relatively stable until 1985, and then rapidly increased. Striped bass PYSL survival has declined over time (Figure 7b), but the decline did not begin until several years after the startup of IP2 and IP3. Hence, the CWIS hypothesis fails the temporality criterion for striped bass.

Manipulation

No experimental manipulations of plant operations have been performed for the purpose of evaluating entrainment impacts on fish populations. However, outages, including refueling and maintenance outages mandated by the HRSA (Englert et al. 1988), have frequently occurred during the months when entrainable striped bass are present in the River. The peak abundance of striped bass eggs and larvae typically occurs during May and June (Boreman and Klauda, 1988). IP2 was offline during the entire months of May and June in 1976, 1989, 1991, 1997, 1998, and 2000. IP3 was offline during the entire months of May and June in 1975, 1982, 1993, and 1994. If entrainment at Indian Point were reducing the survival of striped bass PYSL, then PYSL survival should have been higher in years when one unit was offline than in years when both units were operating. As shown in Figure 10a, the measured PYSL survival values are inconsistent with this expectation. Figure 10a shows the time series of annual PYSL survival indices from 1975 through 2002. The horizontal line in Figure 10a shows the median survival index value for this time period. The median is defined as the midpoint of the entire distribution of survival index values, meaning that one-half of the survival indices are above the median and one-half are below the median. If striped bass PYSL survival were higher in years of one-unit operation than in years of 2-unit operation, then significantly more survival index values for years of one-year operation should be higher than the median than lower than the median. However, Figure 10a shows that the PYSL survival index was higher than the median for only 3 of the 11 years of one-unit operation. The PYSL index was lower than the median in 8 years of one-unit operation.

This result is confirmed by Figure 10b, which shows the relationship between the striped bass PYSL survival index and the May-June total water withdrawals by IP2 and IP3 for the years 1975-2002. There is no correlation between withdrawals by IP2 and IP3 and striped bass PYSL survival. Hence, the CWIS hypothesis fails the manipulation criterion for striped bass.

Coherence

As noted above, the objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Including "coherence" as an explicit evaluation criterion for CWIS would be redundant. Hence, the coherence criterion is inapplicable to the CWIS hypothesis.

3.4.1.2 Fishing

Co-occurrence

Fishing indirectly affects the abundance of early life stages of fish by reducing the abundance of spawning adults (Goodyear 1993). If a population is being overfished, then reducing the rate of fishing should cause the spawning population, and therefore the number of eggs spawned, to increase. As discussed by Young-Dubovsky et al. (1994), a coastwide ban on harvesting of striped bass was imposed in 1986. Estimates of fishing mortality and adult population abundance developed by the ASMFC (2005) show that the coastwide adult population has increased greatly since 1986. As shown in Figure 7a, the abundance of striped bass PYSL began increasing in 1988 and increased steadily throughout the 1990s. This is the same period during which the adult striped bass population was expanding. Hence, the overfishing hypothesis satisfies the co-occurrence criterion.

Sufficiency

Fishing mortality estimates for individual striped bass spawning stocks are not estimated by the ASMFC, because much of the fishing occurs along the Atlantic coast when fish from the individual spawning stocks are mixed (ASMFC 2003). Since the magnitude of fishing mortality imposed specifically on Hudson River striped bass has never been estimated, it is not possible to determine whether the fishing hypothesis satisfies the sufficiency criterion.

Temporality

The ban on striped bass harvesting preceded the increase in abundance of striped bass PYSL in the Hudson River by approximately 2 years. Hence, the fishing hypothesis satisfies the temporality criterion.

Manipulation

The 1986 ban on striped bass harvesting was described by Young-Dubovsky et al. (1996) as an "adaptive management experiment." In other words, fishing was deliberately reduced in order to observe the response of the striped bass population to reduced harvesting. The fact that the adult population of striped bass began to increase immediately following the ban was interpreted by Young-Dubovsky et al. (1994) as strong evidence that overfishing was, if not the only cause, at least the primary cause of the depressed abundance of Atlantic striped bass prior to the ban. Because the response of the population to this management was consistent with the expectations from the fishing hypothesis, the fishing hypothesis satisfies the manipulation criterion.

Coherence

Atlantic striped bass are managed as a single coastwide fishery because a large fraction of the harvest occurs when fish originating in Chesapeake Bay, the Delaware River, and the Hudson River are mixed and migrating along the Atlantic coast (ASMFC 2003, Waldman et al. 1990, Waldman and Fabrizio 1994). If reduced harvesting had been the cause of increases in the abundance of early life stages of striped bass in the Hudson River, then similar increases should have occurred in the Chesapeake Bay and the Delaware River as well. As shown in the ASMFC's 2003 stock assessment, the abundance of juvenile striped bass in both Chesapeake Bay and the Delaware River grew rapidly after the harvest ban. Hence, the overfishing hypothesis is consistent with the coherence criterion.

3.4.1.3 Zebra mussels

Co-occurrence

As documented in Appendix B (Table B-11), the zebra mussel index is negatively correlated with the striped bass PYSL survival index. This correlation is consistent with the zebra mussel hypothesis. Hence, the zebra mussel hypothesis satisfies the co-occurrence criterion.

Sufficiency

The potential effects of zebra mussel activity on early life stages of fish are indirect, and related to reductions in prey abundance and changes in habitat quality. No experiments have been performed that could quantify the relationship between zebra mussel activity and fish growth or survival, and no mathematical models that could be used to quantify the indirect effects of zebra mussel activity have been developed. Hence, whether or not the zebra mussel hypothesis satisfies the sufficiency criterion is unknown.

Temporality

Zebra mussels first became abundant in the Hudson River in 1992 (Caraco et al. 1997). However, as shown in Figure 7b, striped bass PYSL survival began declining in the 1980s and had already fallen to a very low level by 1990. Because the decline in striped bass PYSL survival preceded, rather than followed, the appearance of zebra mussels in the River, the zebra mussel hypothesis fails the temporality criterion.

Manipulation

No deliberate manipulations of zebra mussel populations in the Hudson River have been performed, therefore, this criterion is inapplicable to the zebra mussel hypothesis.

Coherence

Because the proposed mechanism through which zebra mussel activity could have affected striped bass in the Hudson River involves reducing food availability, the growth as well as the survival of striped bass PYSL and YOY should have been reduced. Although Strayer et al. (2004) found a negative relationship between the growth rate of YOY striped bass and the presence of zebra mussels, no significant correlation was found in the analyses performed to support this report (Appendix B, Table B-11). Zebra mussel activity should also have shifted the distribution of striped bass PYSL and YOY downriver, away from the freshwater zone in which zebra mussels are abundant. Strayer et al. (2004) found no downstream shift in the distribution of striped bass PYSL and YOY. In the analyses performed to support this report (Appendix B, Table B-11), no downstream shift in the distribution of PYSL was found, and an upstream shift (i.e., a shift in the opposite direction from the shift predicted by the zebra mussel hypothesis) in the distribution of YOY was found. The negative effect of zebra mussel activity on striped bass YOY growth that was reported by Strayer et al. (2004) conflicts with the findings in Appendix B, moreover, neither Strayer et al. (2004) nor the present analysis (Appendix B) found the predicted relationship between zebra mussel activity and striped bass PYSL and juvenile distribution. Hence, the zebra mussel hypothesis fails the coherence criterion for striped bass.

3.4.1.4 Summary evaluation of hypotheses

Table 3 summarizes the consistency of the striped bass trends data with the CWIS, overfishing, and zebra mussel hypotheses. Two of the five evaluation criteria – sufficiency and coherence – are inapplicable to the CWIS hypothesis. However, this hypothesis fails all three of the remaining criteria. Hence, the CWIS hypothesis can be rejected as an explanation for long-term trends in the abundance of age 0 striped bass in the Hudson River. The zebra mussel hypothesis passes the co-occurrence criterion, but fails the temporality and coherence criteria. Because striped bass PYSL survival declined several years prior to the invasion of the Hudson River by zebra mussels, and because predicted effects of zebra mussels on the growth and distribution of striped bass PYSL and YOY were not observed, the zebra mussel hypothesis also can be rejected as an explanation for long-term trends in the abundance of age 0 striped bass in the Hudson River.

The overfishing hypothesis, in contrast, passes four of the five evaluation criteria. The remaining criterion (sufficiency) is inapplicable to this hypothesis. The abundance of striped bass PYSL in the Hudson began increasing shortly following a reduction in striped bass harvesting. The reduction in harvest was specifically intended to promote striped bass reproduction, and was followed by simultaneous increases in striped bass reproductive success in all three of the major east coast spawning populations. It is reasonable to conclude, therefore, that elimination of overfishing is the most likely cause of trends in the abundance of early life stages of striped bass in the Hudson River.

3.4.2 White perch

Figure 11 depicts long-term trends in the abundance of white perch YOY and PYSL in the Hudson. As shown in Figure 11, the abundance of juvenile white perch declined steadily throughout the 1980s, but has increased since 1990. Despite the recent increase, over the entire time series, there is a statistically significant decline in YOY abundance (Appendix B, Table B-13 and Figure B-4). There is no long-term trend in the annual abundance of PYSL (Figure 11), however, which suggests that larval production is stable. There is no relationship between PYSL abundance and YOY abundance in white perch (Figure 12a). The survival rate of white perch from the PYSL to the juvenile stage has declined (Appendix B, Table B-13). Moreover, there is a strong positive relationship between PYSL survival and YOY abundance (Figure 12b, Appendix B, Table B-14). Because YOY abundance in white perch is closely related to PYSL survival but not to PYSL abundance, we can conclude that the decline in YOY abundance was due to a decline in PYSL survival rather than to a decline in white perch reproduction.

3.4.2.1 CWIS

Co-Occurrence

Appendix B, Table B-13 and B-14 summarize the results of the correlation analysis for white perch. If entrainment at Indian Point had caused the observed decline in white perch PYSL survival, there should be a negative relationship between the entrainment CMR for white perch and white perch PYSL survival. This means that in years when the CMR was high, white perch PYSL survival should have been low, and in years when the CMR was low, white perch PYSL survival should have been high. However, as shown in Figure 13a, the opposite relationship exists. The IP2 and IP3 CMR is *positively* correlated with PYSL to juvenile survival, meaning that the CMR was high in years when PYSL survival was high and the CMR was low in years when PYSL survival was low.

There is a negative relationship between the IP2 and IP3 CMR and white perch PYSL abundance (Figure 13b), but this correlation is significant only at the 10% level. Figure 14 plots time trends in both the CMR and in PYSL to juvenile survival for white perch. The two trend lines show similar patterns, with values decreasing from the mid-1970s to the mid-1980s, fluctuating until the mid-1990s, and then increasing. It is important to note that the recent increase in survival occurred during a period in which the capacity factors for IP2 and IP3 have been higher than in earlier years (Darla Gray, Entergy Corp., personal communication).

Although there is a weak negative relationship between the CMR for IP2 and IP3 and white perch PYSL abundance, the much stronger positive relationship between the CMR and PYSL to YOY survival must be accorded a higher weight. Because this positive correlation clearly conflicts with the CWIS hypothesis, the CWIS hypothesis fails the co-occurrence criterion for white perch.

Sufficiency

There are no independent measures of sufficiency that can be applied to this hypothesis. The objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Hence, the sufficiency criterion is inapplicable to the CWIS hypothesis.

Temporality

As shown in Figure 14, white perch PYSL survival began to decline in 1977, one year following the startup of commercial operation at IP3. Since the startup of 2-unit operation preceded the decline in white perch PYSL survival, the CWIS hypothesis satisfies the temporality criterion.

Manipulation

As discussed in Section 3.4.1.1, outages of IP2 or IP3 have frequently occurred during the entrainment season at Indian Point. The peak abundance of white perch eggs and larvae typically occurs during May and June (Klauda 1988). IP2 was offline during the entire months of May and June in 1976, 1989, 1991, 1997, 1998, and 2000. IP3 was offline during the entire months of May and June in 1975, 1982, 1993, and 1994. If entrainment at Indian Point were reducing the survival of white perch PYSL, then PYSL survival should have been higher in years when one unit was offline than in years when both units were operating. As shown in Figure 15a, the measured PYSL survival values are inconsistent with this expectation. Figure 15a shows the time series of annual PYSL survival indices from 1975 through 2002, which are the years for which cooling water flow data were available. The horizontal line in Figure 15 shows the median survival index value for this time period. The median is defined as the midpoint of the entire distribution of survival index values, meaning that one-half of the survival indices are above the median and one-half are below the median. If white perch PYSL survival were higher in years of one-unit operation than in years of 2-unit operation, then significantly more survival index values for years of one-year operation should be higher than the median than lower than the median. However, Figure 15a shows that the PYSL survival index was higher than the median for only 4 of the 11 years of one-unit operation. The PYSL index was equal to the median in one year (1989) of one-unit operation, and lower than the median in 6 years of one-unit operation.

This result is confirmed by Figure 15b, which shows the relationship between the white perch PYSL survival index and the May-June total water withdrawals by IP2 and IP3 for the years 1975-2002. There is no correlation between withdrawals by IP2 and IP3 and white perch PYSL survival. Hence, the CWIS hypothesis fails the manipulation criterion for white perch.

Coherence

As noted above, the objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Including "coherence" as an explicit evaluation criterion for CWIS would be redundant. Hence, the coherence criterion is inapplicable to the CWIS hypothesis.

3.4.2.2 Zebra mussels

Co-Occurrence

As shown in Appendix B, Table B-13, the zebra mussel index is negatively correlated with PYSL to YOY survival in white perch. Hence, the zebra mussel hypothesis satisfies the co-occurrence criterion.

Temporality

As shown in Figure 14, however, the decline in white perch PYSL to YOY survival occurred primarily between 1974 and 1986, prior to the zebra mussel invasion. PYSL to YOY survival has actually been increasing since 1993, the first year in which zebra mussels were abundant enough to potentially affect fish populations (Strayer et al. 2004). Hence, the zebra mussel hypothesis fails the temporality criterion.

Sufficiency

The potential effects of zebra mussel activity on early life stages of fish are indirect, and related to reductions in prey abundance and changes in habitat quality. No experiments have been performed that could quantify the relationship between zebra mussel activity and fish growth or survival, and no mathematical models that could be used to quantify the indirect effects of zebra mussel activity have been developed. Hence, whether or not the zebra mussel hypothesis satisfies the sufficiency criterion is unknown.

Manipulation

No deliberate manipulations of zebra mussel populations in the Hudson River have been performed, therefore, this criterion is inapplicable to the zebra mussel hypothesis.

Coherence

Because the proposed mechanism through which zebra mussel activity could have affected white perch in the Hudson River involves reducing food availability, the growth as well as the survival of white perch PYSL should have been reduced. Although Strayer et al. (2004) reported a negative relationship between zebra mussel activity and white perch growth, the analysis performed to support this assessment (Appendix B, Table B-13) found no significant relationship between zebra mussels and white perch growth. Moreover, the percent of white perch juveniles downriver from RKM 100 is negatively, instead of positively, correlated with the zebra mussel index (Appendix B, Table B-13). This negative correlation implies that over this same period of years, the percentage of the population present downriver from RKM 100 has declined, rather than increasing as predicted by the zebra mussel hypothesis. This result is also consistent with the findings of Strayer et al. (2004). Hence, the zebra mussel hypothesis partially, but not fully, satisfies the coherence criterion.

3.4.2.3 Striped bass predation

Co-occurrence

There is a weak negative correlation between the striped bass index and the white perch PYSL index (Appendix B, Table B-13). This relationship provides weak evidence supporting the hypothesis that striped bass are preying on adult white perch. There is much stronger negative correlation between the striped bass index and the YOY index (Figure 16a). This correlation is consistent with the hypothesis that striped bass are preying on juvenile white perch. There is also a strong negative correlation between the striped bass index and white perch PYSL to YOY survival, however, this relationship is difficult to interpret because striped bass would not be expected to prey on larval white perch. Overall, the striped bass hypothesis satisfies the co-occurrence criterion with respect to predation on YOY white perch.

Sufficiency

Striped bass larger than 200 mm in length have been shown to feed on white perch (Gardinier and Hoff 1982, Dunning et al. 1997). Appendix C to this report documents an analysis of prey consumption by Hudson River striped bass. This analysis compares the change in striped bass prey consumption requirements (August through October) between earlier (1983-1990) and more recent (1991-2004) periods to changes in abundance of YOY fish in the Hudson River between these same two periods. The analysis shows that the increase in prey consumption from the earlier to the later period would be sufficient to explain the decline in YOY white perch abundance between these two periods if 1% of the age 1 and age 2 striped bass seasonal predatory demand was satisfied by YOY white perch, or if 0.3% of the age 1 through age 13 striped bass seasonal predatory demand was satisfied by YOY white perch. Hence, the striped bass predation hypothesis satisfies the sufficiency criterion for white perch.

Temporality

A sustained decline in white perch YOY abundance began in 1989, at the same time the striped bass index began to increase (Figure 16b). However, the historic peak in YOY abundance occurred in 1980 (Figure 16b), and PYSL to YOY survival declined substantially between 1975 and 1985 (Figure 14). White perch PYSL to YOY survival and YOY abundance are strongly correlated (Figure 12b), implying that declining YOY abundance must have been at least in part caused by a decline in PYSL to YOY survival. The decline in PYSL to YOY survival that declined between 1975 and 1985 cannot be explained by striped bass predation. Hence, the striped bass predation hypothesis only partially satisfies the temporality criterion.

Manipulation

No deliberate manipulations of striped bass predation in the Hudson River have been performed, therefore, this criterion is inapplicable to the striped bass hypothesis.

Coherence

If predation by striped bass had caused the decline in abundance of YOY white perch in the Hudson River, then the YOY abundance of other known striped bass prey species, including river herring, American shad, bay anchovy, and Atlantic tomcod should also have declined. As shown in other Sections of this report, YOY abundance for all of these species has declined since the late 1980s, when striped bass abundance began to increase. Moreover, other published studies have concluded that striped bass predation is reducing the abundance of some prey species. Savoy and Crecco (2004) attributed recent declines in the abundance of both blueback herring and American shad in the Connecticut River to striped bass predation. Hartman (2003) estimated that the coastwide annual prey consumption by striped bass between 1 and 10 years of age increased by more than a factor of 8 between 1982 and 1995, from 17,900 metric tons (mt) to 147,900 mt. Uphoff (2003) calculated even larger estimates of striped bass consumption, and attributed a 90% decline in the abundance of Atlantic menhaden in upper Chesapeake Bay from 1980 through 1999 to predation by striped bass.

Because parallel declines in other susceptible species have occurred, and because the other published studies have documented the influence of striped bass predation on susceptible prey species, the striped bass predation hypothesis satisfies the coherence criterion.

3.4.2.4 Summary evaluation of hypotheses

Table 4 summarizes the consistency of the white perch trends data with the CWIS, zebra mussel, and striped bass predation hypotheses. Two of the five evaluation criteria – sufficiency and coherence – are inapplicable to the CWIS hypothesis. The CWIS hypothesis fails the co-occurrence and manipulation criteria. Although the CWIS hypothesis satisfies the temporality criterion because the observed decline in white perch PYSL survival followed the startup of IP2 and IP3, the inconsistency of this hypothesis with the co-occurrence and manipulation hypotheses means that the temporal correspondence between the beginning of the decline in survival and the startup of IP2 and IP3 is very likely a coincidence. Hence, the CWIS hypothesis can be rejected as an explanation for long-term trends in the abundance of age 0 white perch in the Hudson River.

The zebra mussel hypothesis passes the co-occurrence criterion and at least partially satisfies the coherence criterion. However, it fails the temporality criterion because the declines in white perch PYSL survival and YOY abundance began prior to the appearance of zebra mussels in the Hudson River. Although zebra mussel activity might have contributed to a decline in white perch PYSL to YOY survival and YOY abundance from 1993 to 2004, zebra mussels could not have been the primary explanation for long-term trends in white perch survival and abundance.

The striped bass predation hypothesis satisfies four of the five criteria. The fifth, manipulation, is inapplicable to this hypothesis. However, the strong relationship between white perch PYSL survival and YOY abundance over the entire period from 1974 to 2004 (Figure 12b) cannot be explained by the predation hypothesis, because striped bass abundance did not begin to increase until 1987. Hence, although striped bass predation likely contributed to the decline in white perch PYSL to YOY survival and YOY abundance, from 1987 onward, predation could not have been the primary cause of declines that took place between 1975 and 1985.

3.4.3 American shad

Figure 17 depicts long-term trends in the abundance of American shad YOY and PYSL in the Hudson. The abundance of both life stages has declined significantly since the initiation of the generators' monitoring program, with declines in the abundance of both life stages beginning in the late 1980s. As shown in Figure 18, there is a strong positive correlation between PYSL abundance and YOY abundance in American shad (Figure 18a), and no relationship between PYSL survival and YOY abundance (Figure 18b). Because YOY abundance is correlated with PYSL abundance but not with PYSL survival, we can conclude that the decline in YOY abundance is a consequence of reduced reproduction rather than reduced PYSL survival.

Four hypothetical causes for these changes are evaluated below: the Indian Point CWIS, overfishing, zebra mussels, and striped bass predation.

3.4.3.1 CWIS

Co-Occurrence

There is no correlation between PYSL survival and the entrainment CMR at IP2 and IP3 (Figure 19a). The IP2 and IP3 CMR is also uncorrelated with American shad PYSL abundance (Figure 19b). Hence, the CWIS hypothesis fails the co-occurrence criterion.

Sufficiency

There are no independent measures of sufficiency that can be applied to this hypothesis. The objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Hence the sufficiency criterion is inapplicable to the CWIS hypothesis.

Temporality

American shad PYSL abundance grew from the mid-1970s, when IP2 and IP3 began commercial operations, until 1986 (Figure 17). The highest values for both PYSL and YOY abundance occurred in 1986, 10 years after the startup of commercial operations at IP3 and 12 years after the startup of IP2 (Figure 17). Hence, the CWIS hypothesis fails the temporality criterion.

Manipulation

As discussed in Section 3.4.1.1, outages of IP2 or IP3 have frequently occurred during the entrainment season at Indian Point. Although American shad eggs and larvae occur only at very low densities in the vicinity of Indian Point (DEIS, Figure V-68), the peak abundance of American shad eggs and larvae typically occurs during May and June (DEIS, Figure V-67). IP2 was offline during the entire months of May and June in 1976, 1989, 1991, 1997, 1998, and 2000. IP3 was offline during the entire months of May and June in 1975, 1982, 1993, and 1994. If entrainment at Indian Point were reducing the survival of American shad PYSL, then PYSL survival should have been higher in years when one unit was offline than in years when both units were operating. As shown in Figure 20a, the measured PYSL survival values are inconsistent with this expectation. Figure 20a shows the time series of annual PYSL survival indices from 1985 through 2002. The horizontal line in Figure 20a shows the median survival index value for this time period. The median is defined as the midpoint of the entire distribution of survival index values, meaning that one-half of the survival indices are above the median and one-half are below the median. If American shad PYSL survival were higher in years of one-unit operation than in years of 2-unit operation, then significantly more survival index values for years of one-year operation should be higher than the median than lower than the median. However, Figure 20a shows that the PYSL survival index was higher than the median for 5 of the 8 years of one-unit operation. The PYSL index was lower than the median in 3 years of one-unit operation. This difference could easily have arisen by chance. Moreover, 3 of the 5 years with the highest survival rates (1996, 1999, and 2002) were years of 2-unit operation.

This result is confirmed by Figure 20b, which shows the relationship between the American shad PYSL survival index and the May-June total water withdrawals by IP2 and IP3 for the years 1975-2002. There is no correlation between withdrawals by IP2 and IP3 and American shad PYSL survival. Hence, the CWIS hypothesis fails the manipulation criterion for American shad.

Coherence

The objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Including "coherence" as an explicit evaluation criterion for CWIS would be redundant. Hence, the coherence criterion is inapplicable to the CWIS hypothesis.

3.4.3.2 Fishing

Co-Occurrence

If a population is being overfished to the point at which spawner abundance is reduced, then the number of eggs and larvae produced by those spawners should decline. Historically, American shad supported very large unregulated commercial fisheries along the east coast of both the United States and Canada (ASMFC 1999). These harvests have declined dramatically in recent years. In its most recent stock assessment for American shad (ASMFC 2007), the ASMFC found that the abundance of adult American shad in the Hudson River peaked in 1985 and 1986 and has since declined. This decline in adult abundance occurred during the same period in which the abundance of American shad PYSL and YOY in the Hudson River declined (Figure 17). Hence, the fishing hypothesis satisfies the co-occurrence criterion.

Sufficiency

There is conflicting information concerning whether the magnitude of fishing mortality imposed on Hudson River American shad has been sufficient to cause the declines in spawner abundance. According to the ASMFC (2007), many American shad stocks have declined in abundance in recent decades. Although the declines appear to be related to an increase in the mortality of adult shad, the contribution of fishing to the increase in mortality is unclear and probably differs between spawning populations. According to Hattala and Kahnle (2007), the Hudson River population of American shad is probably being overfished, however, other sources of mortality cannot be excluded as contributing causes. Although there is still substantial uncertainty concerning causes of decline in American shad population, this assessment accepts Hattala and Kahnle's (2007) results and concludes that the overfishing hypothesis satisfies the sufficiency criterion.

Temporality

The decline in American shad spawner abundance coincided with the decline in abundance of PYSL and YOY (Figure 17). Hence, the overfishing hypothesis satisfies the temporality criterion.

Manipulation

Amendment 1 to the Interstate Fisheries Management Plan for Shad and River Herring (ASMFC 1999) directed all states to phase out the coastal fishery for American shad over a five year period beginning in 2000. The phase-out should reduce fishing mortality on American shad. If the coastal fishery had been contributing to decreased abundance of Connecticut River American shad, then the abundance of this population should increase as a result of this action. Data on fishing mortality and population abundance from the post-closure period are not yet available, so it is not yet possible to evaluate whether the overfishing hypothesis satisfies the manipulation criterion.

Coherence

As noted above, there is still substantial uncertainty concerning the impact of fishing on the Hudson River American shad population. However, available data are consistent with a conclusion that fishing is at least a significant contributor to the recent decline in abundance of Hudson River American shad (Hattala and Kahnle 2007). Hence, the overfishing hypothesis satisfies the coherence criterion.

3.4.3.3 Zebra mussels

Co-occurrence

As shown in Appendix B, Table B-15, the American shad PYSL survival index is positively correlated with the zebra mussel index, rather than negatively correlated as predicted by the zebra mussel hypothesis. As can easily be seen from Figure 17, American shad PYSL to YOY survival has increased since the zebra mussel invasion. Hence, the zebra mussel hypothesis fails the co-occurrence criterion for American shad.

Sufficiency

The potential effects of zebra mussel activity on early life stages of fish are indirect, and related to reductions in prey abundance and changes in habitat quality. No experiments have been performed that could quantify the relationship between zebra mussel activity and fish growth or survival, and no mathematical models that could be used to quantify the indirect effects of zebra mussel activity have been developed. Hence, whether or not the zebra mussel hypothesis satisfies the sufficiency criterion is unknown.

Temporality

The decline in abundance of American shad PYSL and YOY began in the late 1980s (Figure 17), several years prior to the zebra mussel invasion. Hence, the zebra mussel hypothesis fails the temporality criterion.

Manipulation

No deliberate manipulations of zebra mussel populations in the Hudson River have been performed, therefore, this criterion is inapplicable to the zebra mussel hypothesis.

Coherence

Because the proposed mechanism through which zebra mussel activity could have affected American shad in the Hudson River involves reducing food availability, the growth as well as the survival of American shad PYSL and YOY should have been reduced. Although Strayer et al. (2004) found a decline in growth rate of American shad PYSL and YOY following the zebra mussel invasion, this relationship was not significant even at the 20% level (Strayer et al. 2004, Fig. 7). No relationship between American shad YOY growth and zebra mussel activity was found in the analysis performed to support this assessment (Appendix B, Table B-15). Zebra mussel activity should also have shifted the distribution of American shad PYSL and YOY downriver, away from the freshwater zone in which zebra mussels are abundant. Strayer et al. (2004) found a net downriver shift in the distribution of American shad YOY, but a net upriver shift in the distribution of PYSL. In the analysis performed to support this assessment (Appendix B, Table B-15), no significant shifts in the distribution of either life stage was found. The observed changes in growth and distribution predicted by the zebra mussel hypothesis were not observed. Hence, the zebra mussel hypothesis fails the coherence criterion for American shad.

3.4.3.4 Striped bass predation

Co-occurrence

American shad PYSL abundance, which reflects spawner abundance and reproduction, is negatively correlated with the striped bass index (Figure 21a), although this relationship is significant only at the 10% level. This correlation provides weak support for the hypothesis that striped bass are preying on adult American shad. There is a negative relationship between the striped bass index and the American shad YOY index, (Figure 21b), however, this relationship is not statistically significant. Hence, the striped bass predation hypothesis appears to marginally satisfy the co-occurrence criterion for predation .

Sufficiency

Striped bass larger than 200 mm in length have been shown to feed on alosids such as American shad (Gardinier and Hoff 1982, Dunning et al. 1997). However, the prey consumption analysis documented in Appendix C to this report did not address predation on YOY American shad. Hence, with respect to YOY American shad, whether or not striped bass predation satisfies the sufficiency criterion is unknown. Kahnle and Hattala (2007) have argued that the great majority of adult striped bass in the Hudson are feeding on river herring rather than shad, and the striped bass predation is insufficient to significantly affect the abundance of adult Hudson River American shad. This assessment accepts the conclusions of Kahnle and Hattala (2007) that striped bass predation on adult Hudson River American shad is probably low.

Temporality

As can be seen from Figure 22, the increase in striped bass spawner abundance that began in the late 1980s closely coincides with the decline in American shad PYSL abundance. As shown in Figure 17, American shad YOY abundance has declined over this same period. Hence, the striped bass predation hypothesis satisfies the temporality criterion with respect to predation on both adults and YOY.

Manipulation

No deliberate manipulations of striped bass predation in the Hudson River have been performed, therefore, this criterion is inapplicable to the striped bass hypothesis.

Coherence

If predation by striped bass had caused the decline in abundance of American shad PYSL and YOY in the Hudson River, then the PYSL and YOY abundance of other known striped bass prey species, including white perch, river herring, bay anchovy, and Atlantic tomcod should also have declined. As discussed in other Sections of this report, no declines in white perch or bay anchovy PYSL abundance have occurred. However, PYSL abundance for river herring and Atlantic tomcod declined over the same period in which PYSL abundance for American shad declined. YOY abundance for all of the above species has declined since the late 1980s, when striped bass abundance began to increase. Moreover, other published studies have concluded that striped bass predation is reducing the abundance of some prey species. Savoy and Crecco (2004) attributed recent declines in the abundance of both blueback herring and American shad in the Connecticut River to striped bass predation on spawning adults, however, Kahnle and Hattala (2007) concluded that predation of striped bass on adult American shad in the Hudson River is relatively low. On the other hand, Hattala and Kahnle (2007) acknowledged that predation by striped bass on young American shad could be substantial and could be contributing to a decline in recruitment of young shad to the adult population.

Hartman (2003) estimated that the coastwide annual prey consumption by striped bass between 1 and 10 years of age increased by more than a factor of 8 between 1982 and 1995, from 17,900 mt to 147,900 mt. Uphoff (2003) calculated even larger estimates of striped bass consumption, and attributed a 90% decline in the abundance of Atlantic menhaden in upper Chesapeake Bay from 1980 through 1999 to predation by striped bass.

Because parallel declines in YOY abundance of other susceptible species have occurred, and because the other published studies have documented the influence of striped bass predation on susceptible prey species, the striped bass predation hypothesis satisfies the coherence criterion with respect to predation on YOY American shad, but not with respect to predation on adults.

3.4.3.5 Summary evaluation of hypotheses

Table 5 summarizes the consistency of the American shad data with the CWIS, overfishing, zebra mussel, and striped bass predation hypotheses. Two of the five evaluation criteria – sufficiency and coherence – are inapplicable to the CWIS hypothesis. The CWIS hypothesis fails the co-occurrence, temporality, and manipulation criteria. Hence, the CWIS hypothesis can be rejected as an explanation for long-term trends in the abundance of age 0 American shad in the Hudson River.

The overfishing hypothesis satisfies the co-occurrence, sufficiency, temporality, and coherence criteria for American shad. The manipulation criterion is inapplicable at present, although applicable data may become available once the response of the population to the phase-out of the ocean intercept fishery has been observed.

The zebra mussel hypothesis fails the co-occurrence, temporality, and coherence criteria for American shad. Whether the sufficiency criterion is satisfied is unknown, and the manipulation criterion is inapplicable. Hence, the zebra mussel hypothesis can be rejected as an explanation for long-term trends in the abundance of age 0 American shad in the Hudson River.

The striped bass predation hypothesis satisfies two and possibly three of the five criteria. Because no estimates of potential striped bass predation on YOY American shad have been developed, whether this hypothesis satisfies the sufficiency criterion is unknown. The manipulation criterion, is inapplicable to this hypothesis. The simultaneous declines in abundance of susceptible life stages of other prey species in the Hudson River and the published studies documenting impacts of striped bass predation on prey species support for the predation hypothesis. However, substantial uncertainty remains concerning the fraction of the American shad YOY population that might be consumed.

It appears reasonable to conclude that the recent decline in abundance of Hudson River American shad is most likely a result of overfishing, but striped bass predation may be a contributing cause.

3.4.4. Atlantic tomcod

Figure 23 depicts long-term trends in the abundance of Atlantic tomcod as measured by the LRS and the Atlantic Tomcod mark-recapture program. The LRS index reflects the abundance of late PYSL and early juvenile fish. The mark-recapture index reflects the combined abundance of age 1 and older (predominantly age 2) fish. The abundance of Atlantic tomcod has declined since the initiation of the generators' monitoring programs, with the abundance of age 1 and older fish abundance showing an abrupt decline beginning in 1990. The trend in abundance in the LRS time series is less clear, but the LRS index also has declined since 1990. Using Atlantic tomcod survival rates derived from annual mark-recapture surveys, for each year, the total egg to age 1 survival rate is estimated by comparing the total egg production during that year to the number of age 1 fish estimated to be present in the Hudson River during the following year. As shown in Figure 24, there is no relationship between egg deposition and resulting age 1 abundance (Figure 24a). There is a positive relationship between egg to age 1 survival and age 1 abundance (Figure 24b). Hence, the decline in Atlantic tomcod abundance is related to a decrease in survival rather than a decrease in egg production.

Atlantic tomcod are uncommon in freshwater reaches of the Hudson River, therefore, they should not be susceptible to the effects of zebra mussel activity. This potential stressor is not evaluated as a cause of changes in the abundance of this species. Three hypothetical causes for these changes are evaluated below: the Indian Point CWIS, elevated summer temperatures, and striped bass predation.

3.4.4.1 CWIS

Co-occurrence

As shown in Figure 25a, there is no correlation between the IP2 and IP3 CMR and egg-to-age 1 survival. There is a negative correlation between the IP2 and IP3 CMR and the Atlantic tomcod LRS index (Figure 25b), but this correlation is significant only at the 10% level (Appendix B, Table B-17). There is no correlation between the IP2 and IP3 CMR and the mark-recapture index (Figure 25c). Because the IP2 and IP3 CMR are negatively correlated with only one of the three response metrics, and only at the 10% level, the CWIS hypothesis only weakly satisfies the co-occurrence criterion.

Sufficiency

There are no independent measures of sufficiency that can be applied to this hypothesis. The objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Hence, the sufficiency criterion is inapplicable to the CWIS hypothesis.

Temporality

As shown in Figure 23, the decline in abundance of Atlantic tomcod in the mark-recapture survey did not begin until the mid-1980s and the decline in the LRS survey did not begin until 1990. Hence, the CWIS hypothesis fails the temporality criterion.

Manipulation

Although American tomcod spawn in December and January, entrainable larvae and juveniles are still abundant in the lower estuary during May and June (DEIS, Figure 5-56). IP2 was offline during the entire months of May and June in 1976, 1989, 1991, 1997, 1998, and 2000. IP3 was offline during the entire months of May and June in 1975, 1982, 1993, and 1994. If entrainment at Indian Point were reducing the survival of Age 0 Atlantic tomcod, then egg to age 1 survival should have been higher in years when one unit was offline than in years when both units were operating. As shown in Figure 26a, the measured PYSL survival values are inconsistent with this expectation. Figure 26a shows the time series of egg to age 1 indices from 1976 through 2001. The horizontal line in Figure 26a shows the median survival index value for this time period. The median is defined as the midpoint of the entire distribution of survival index values, meaning that one-half of the survival indices are above the median and one-half are below the median. If Atlantic tomcod survival were higher in years of one-unit operation than in years of 2-unit operation, then significantly more survival index values for years of one-year operation should be higher than the median than lower than the median. However, Figure 26a shows that the PYSL survival index was higher than the median for 3 of the 7 years of one-unit operation. The PYSL index was lower than the median in 4 years of one-unit operation.

This result is confirmed by Figure 26b, which shows the relationship between the Atlantic tomcod egg to age 1 survival index and the May-June total water withdrawals by IP2 and IP3 for the years 1975-2002. There is no correlation between withdrawals by IP2 and IP3 and Atlantic tomcod egg to age 1 survival. Hence, the CWIS hypothesis fails the manipulation criterion for Atlantic tomcod.

Coherence

The objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Including "coherence" as an explicit evaluation criterion for CWIS would be redundant. Hence, the coherence criterion is inapplicable to the CWIS hypothesis.

3.4.4.2 Elevated summer temperatures

Co-occurrence

As shown in Appendix B, Table B-17, egg to age 1 survival is negatively correlated with the PWW degree-day index. Egg to age 1 survival is not, however, correlated with the August cooling water flows at IP2 and IP3, which is an index of the thermal loading to the River from IP2 and IP3. Hence, the temperature hypothesis satisfies the co-occurrence criterion, although there is no evidence that IP2 and IP3 contribute to a temperature effect.

Sufficiency

As discussed by McLaren et al. (1988), summer temperatures in the Hudson River frequently exceed optimal levels for juvenile Atlantic tomcod, and occasionally can exceed the lethal tolerance temperature (26.5°C) for this species (McLaren et al. 1988). Although the temperature of the Hudson River is highly variable between locations, depth strata, and years, it can be concluded that the temperature hypothesis satisfies the sufficiency criterion.

Temporality

Figure 27 compares long-term trends in PWW degree-day index to long-term trends in the abundance of age 1 and age 2 Atlantic tomcod, for the period 1987-2001. For each year, the degree-day index is paired with the mark-recapture estimates generated during the following winter (e.g., the 1987 temperature value is paired with the mark-recapture value for the winter of 1987-1988). As shown in Figure 27, a decline in Atlantic tomcod occurred from 1990-2001. However, elevated temperatures that could have explained this decline did not occur. There is no long-term trend in the PWW degree-day index, and three of the four lowest values of the index have occurred since 1990. Hence, the temperature hypothesis fails the temporality criterion.

Manipulation

No deliberate manipulations of Hudson River water temperatures have been performed, therefore, this criterion is inapplicable to temperature hypothesis.

Coherence

If elevated temperatures were adversely affecting Atlantic tomcod in the Hudson River, then other temperature-sensitive species should also be declining. As noted in the FEIS (pp 66-67), the abundance of rainbow smelt in the Hudson River has also been declining. In addition, the temperature hypothesis is consistent with laboratory data on thermal tolerances in Atlantic tomcod and with the geographic distribution of this species. As noted by McLaren et al. (1988), the Hudson River is the southern-most reproducing Atlantic tomcod population. Hence, the temperature hypothesis satisfies the coherence criterion.

3.4.4.3 Striped bass predation

Co-occurrence

Both the Atlantic tomcod mark-recapture index and the LRS index are negatively correlated with the striped bass index (Figure 28). Hence, the striped bass predation hypothesis satisfies the co-occurrence criterion.

Sufficiency

Striped bass larger than 200 mm in length have been shown to feed on Atlantic tomcod (Gardinier and Hoff 1982, Dunning et al. 1997). Appendix C to this report documents an analysis of prey consumption by Hudson River striped bass. This analysis compares the change in striped bass prey consumption requirements (August through October) between earlier (1983-1990) and more recent (1991-2004) periods to changes in abundance of YOY fish in the Hudson River between these same two periods. The analysis shows that the increase in prey consumption from the earlier to the later period would be sufficient to explain the decline in YOY Atlantic tomcod abundance between these two periods if 1.4% of the age 1 and age 2 striped bass seasonal predatory demand was satisfied by YOY Atlantic tomcod, or if 0.4% of the age 1 through age 13 striped bass seasonal predatory demand was satisfied by YOY Atlantic tomcod. Hence, the striped bass predation hypothesis satisfies the sufficiency criterion.

Temporality

The increase in striped bass abundance coincides in time with the declines in both Atlantic tomcod abundance metrics (Figure 29). Hence, the striped bass predation hypothesis satisfies the temporality criterion.

Manipulation

No deliberate manipulations of striped bass predation in the Hudson River have been performed, therefore, this criterion is inapplicable to the striped bass hypothesis.

Coherence

If predation by striped bass had caused the decline in abundance of Atlantic tomcod in the Hudson River, then the YOY abundance of other known striped bass prey species, including white perch, river herring, American shad, and bay anchovy, should also have declined. As shown in other Sections of this report, YOY abundance for all of these species has declined since the late 1980s, when striped bass abundance began to increase. Moreover, other published studies have concluded that striped bass predation is reducing the abundance of some prey species. Savoy and Crecco (2004) attributed recent declines in the abundance of both blueback herring and American shad in the Connecticut River to striped bass predation. Hartman (2003) estimated that the coastwide annual prey consumption by striped bass between 1 and 10 years of age increased by more than a factor of 8 between 1982 and 1995, from 17,900 mt to 147,900 mt. Uphoff (2003) calculated even larger estimates of striped bass consumption, and attributed a 90% decline in the abundance of Atlantic menhaden in upper Chesapeake Bay from 1980 through 1999 to predation by striped bass.

Because parallel declines in other susceptible species have occurred, and because the other published studies have documented the influence of striped bass predation on susceptible prey species, the striped bass predation hypothesis satisfies the coherence criterion.

3.4.4.4 Summary evaluation of hypotheses

Table 6 summarizes the consistency of the Atlantic tomcod data with the CWIS, temperature, and striped bass predation hypotheses. Two of the five evaluation criteria –

sufficiency and coherence – are inapplicable to the CWIS hypothesis. The CWIS hypothesis weakly satisfies the co-occurrence criterion, but fails the temporality, and manipulation criteria. The CWIS hypothesis can be rejected as an explanation for long-term trends in the abundance of age 0 Atlantic tomcod in the Hudson River.

The temperature hypothesis satisfies the co-occurrence, sufficiency, and coherence criteria, but fails the temporality criterion. The manipulation criterion is inapplicable to this hypothesis. Hence, the temperature hypothesis cannot be rejected. However, failure to satisfy the temporality criterion indicates that factors other than temperature were responsible for the decline in abundance of Atlantic tomcod that occurred after 1990.

The striped bass predation hypothesis satisfies all of the applicable criteria. The correlations between striped bass abundance and Atlantic tomcod abundance, the temporal correspondence between the timing of the striped bass increase and the Atlantic tomcod decline, the estimates of striped bass prey consumption, the simultaneous declines in abundance of susceptible life stages of other prey species in the Hudson River, and the published studies documenting impacts of striped bass predation on prey species all provide relatively strong support for the predation hypothesis.

3.4.5 Alewife and blueback herring

Figure 30 depicts long-term trends in the abundance of alewife and blueback herring PYSL and YOY in the Hudson. These two species must be considered together for purposes of evaluating impacts of CWIS, because their larvae are indistinguishable. PYSL abundance for both species combined (Figure 30a) was stable until 1985, and has since declined. With respect to YOY abundance, these two species have tended to vary together (Figure 30b). YOY abundance in both species declined abruptly in the mid-1980s and has fluctuated without apparent trend since that time, but without returning to previous abundance levels.

3.4.5.1 CWIS

Co-occurrence

IP2 and IP3 entrainment CMR is uncorrelated with river herring PYSL survival (Figure 31a), river herring PYSL abundance (Figure 31b), alewife YOY abundance (Figure 32a), and blueback herring YOY abundance (Figure 32b). Hence, the CWIS hypothesis fails the co-occurrence criterion.

Sufficiency

There are no independent measures of sufficiency that can be applied to this hypothesis. The objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Hence the sufficiency criterion is inapplicable to the CWIS hypothesis.

Temporality

As shown in Figures 30a and 30b, alewife and blueback herring PYSL and YOY abundance did not decline until the mid-1980s, nearly a decade after the startup of commercial operations at IP2 and IP3. Hence, the CWIS hypothesis fails the temporality criterion.

Manipulation

The peak abundance of river herring eggs and larvae typically occurs during May and June (DEIS, Figures V-71 and V-74). IP2 was offline during the entire months of May and June in 1976, 1989, 1991, 1997, 1998, and 2000. IP3 was offline during the entire months of May and June in 1975, 1982, 1993, and 1994. If entrainment at Indian Point were reducing the survival of river herring PYSL, then PYSL survival should have been higher in years when one unit was offline than in years when both units were operating. As shown in Figure 33a, the measured PYSL survival values are inconsistent with this expectation. Figure 33a shows the time series of annual PYSL survival indices from 1974 through 2002. The horizontal line in Figure 33a shows the median survival index value for this time period. The median is defined as the midpoint of the entire distribution of survival index values, meaning that one-half of the survival indices are above the median and one-half are below the median. If river herring PYSL survival were higher in years of one-unit operation than in years of 2-unit operation, then significantly more survival index values for years of one-year operation should be higher than the median than lower than the median. However, Figure 33a shows that the PYSL survival index was higher than the median for 4 of the 11 years of one-unit operation. The PYSL was index lower than the median in 7 years of one-unit operation.

This result is confirmed by Figure 33b, which shows the relationship between the river herring PYSL survival index and the May-June total water withdrawals by IP2 and IP3 for the years 1975-2002. There is no correlation between withdrawals by IP2 and IP3 and river herring PYSL survival. Hence, the CWIS hypothesis fails the manipulation criterion for alewife and blueback herring.

Coherence

The objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Including "coherence" as an explicit evaluation criterion for CWIS would be redundant. Hence, the coherence criterion is inapplicable to the CWIS hypothesis.

3.4.5.2 Zebra mussels

Co-occurrence

As shown in Appendix B, Tables B-19 and B-21, there is no correlation between the zebra mussel index and any abundance index for either alewife or blueback herring. Hence, the zebra mussel hypothesis fails the co-occurrence criterion for both species.

Sufficiency

The potential effects of zebra mussel activity on early life stages of fish are indirect, and related to reductions in prey abundance and changes in habitat quality. No experiments have been performed that could quantify the relationship between zebra mussel activity and fish growth or survival, and no mathematical models that could be used to quantify the indirect effects of zebra mussel activity have been developed. Hence, whether or not the zebra mussel hypothesis satisfies the sufficiency criterion is unknown.

Temporality

The decline in abundance of alewife and blueback herring PYSL and YOY occurred during the mid-1980s, more than 5 years prior to the invasion of the river by zebra mussels (Figure 30). Hence, the zebra mussel hypothesis fails the temporality criterion.

Manipulation

No deliberate manipulations of zebra mussel populations in the Hudson River have been performed, therefore, this criterion is inapplicable to the zebra mussel hypothesis.

Coherence

Because the proposed mechanism through which zebra mussel activity could have affected river herring in the Hudson River involves reducing food availability, the growth as well as the survival of river herring PYSL and YOY should have been reduced. Strayer et al. (2004) found a decline in the growth rate of YOY alewife following the zebra mussel invasion using both the utility beach seine index and the NYSDEC beach seine index. Only the decline in the growth rate calculated from the NYSDEC index was statistically significant, and only at the 20% level. No relationship between alewife or blueback herring growth and zebra mussel activity was found in the analysis performed to support this assessment (Appendix B, Tables B-19 and B-21). Zebra mussel activity should also have shifted the distribution of river herring PYSL and YOY downriver, away from the freshwater zone in which zebra mussels are abundant. Strayer et al. (2004) found net downriver shifts in the distribution of alewife and blueback herring YOY, but a net upriver shift in the distribution of PYSL. None of these shifts was statistically significant, even at the 20% level. In the analysis performed to support this assessment (Appendix B, Tables B-19 and B-21), no significant shift in the distribution of blueback herring was found, but an upstream shift in the distribution of alewife YOY was found. Only one of the predicted effects of the zebra mussel invasion on river herring was observed, in only one out of three analyses, and at a significance level (20%) not usually accepted in scientific studies. Hence, the zebra mussel hypothesis fails the coherence criterion for alewife and blueback herring.

3.4.5.3 Striped bass predation

Co-occurrence

The river herring PYSL abundance index, which reflects spawner abundance and reproduction, is negatively correlated with the striped bass index (Figure 34a). The alewife YOY index, and the blueback herring YOY index are also negatively correlated with the striped bass index, although only at the 10% significance level (Appendix B, Tables B-19 and B-21). (Figures 34b and 34c). Hence, the striped bass predation hypothesis satisfies the co-occurrence criterion for predation, on both adults and YOY.

Sufficiency

Striped bass larger than 200 mm in length have been shown to feed on alosids, including alewife and blueback herring (Gardinier and Hoff 1982, Dunning et al. 1997). According to Savoy and Crecco (2004) and Davis et al. (2007), adult striped bass in the Connecticut River feed heavily on spawning blueback herring. Recently, Kahnle and Hattala (2007) reported that river herring were the most common prey item in the stomachs of adult striped bass captured in the Hudson River. Appendix C to this report documents an analysis of prey consumption by Hudson River striped bass. This analysis compares the change in striped bass prey consumption requirements (August through October) between earlier (1983-1990) and more recent (1991-2004) periods to changes in abundance of YOY fish in the Hudson River between these same two periods. The analysis shows that the increase in prey consumption from the earlier to the later period would be sufficient to explain the decline in YOY river herring abundance between these two periods if 3% of the age 1 and age 2 striped bass seasonal predatory demand was satisfied by YOY river herring, or if 0.9% of the age 1 through age 13 striped bass seasonal predatory demand was satisfied by YOY river herring. Hence, the striped bass predation hypothesis satisfies the sufficiency criterion with respect to predation on YOY river herring. No quantitative estimates of consumption of adult river herring by striped bass are available.

Temporality

The decline in river herring abundance coincides in time with the increase in the striped bass index (Figure 35). Hence, the trends analysis supports the hypothesis that predation by striped bass has contributed to the decline in alewife and blueback herring abundance. Alewife and blueback herring do not return to the Hudson as spawning adults until an age of at least four years (ASMFC 1998). Hence, if only juvenile river herring were susceptible to predation by striped bass, a four-year time lag would be expected between the increase in striped bass abundance and the decline in PYSL abundance. The fact that no such time lag is apparent over the substantial time series available (Figure 35a), is consistent with the hypothesis that spawning adults are also susceptible to predation. Hence, the predation hypothesis satisfies the temporality criterion for both predation on adults and predation on YOY.

Manipulation

No deliberate manipulations of striped bass predation in the Hudson River have been performed, therefore, this criterion is inapplicable to the striped bass hypothesis.

Coherence

If predation by striped bass had caused the decline in abundance of river herring in the Hudson River, then the YOY abundance of other known striped bass prey species, including white perch, American shad, Atlantic tomcod, and bay anchovy, should also have declined. As shown in other Sections of this report, YOY abundance for all of these species has declined since the late 1980s, when striped bass abundance began to increase. Moreover, other published studies have concluded that striped bass predation is reducing the abundance of some prey species. Savoy and Crecco (2004) attributed recent declines in the abundance of both blueback herring and American shad in the Connecticut River to striped bass predation. This conclusion is supported by a recent study of the diet composition of striped bass present in the Connecticut River during the spring shad and river herring spawning run (Davis et al. 2007). These authors found that striped bass between 600 and 800 mm in length feed predominantly on adult river herring. These results are consistent with the results published by Kahnle and Hattala (2007), who found that river herring were the most abundant of the identifiable prey items in the stomachs of adult striped bass captured in the Hudson River. Hartman (2003) estimated that the coastwide annual prey consumption by striped bass between 1 and 10 years of age increased by more than a factor of 8 between 1982 and 1995, from 17,900 metric tons (mt) to 147,900 mt. Uphoff (2003) calculated even larger estimates of striped bass consumption, and attributed a 90% decline in the abundance of Atlantic menhaden in upper Chesapeake Bay from 1980 through 1999 to predation by striped bass.

Because parallel declines in other susceptible species have occurred, because predation by striped bass on adult river herring has been demonstrated, and because the other published studies have documented the influence of striped bass predation on susceptible prey species, the striped bass predation hypothesis satisfies the coherence criterion.

3.4.5.4 Summary evaluation of hypotheses

Table 7 summarizes the consistency of the alewife and blueback herring data with the CWIS, temperature, and striped bass predation hypotheses. Two of the five evaluation criteria – sufficiency and coherence – are inapplicable to the CWIS hypothesis. The CWIS hypothesis fails the co-occurrence, temporality, and manipulation criteria. Hence, the CWIS hypothesis can be rejected as an explanation for long-term trends in the abundance of age 0 river herring in the Hudson River.

The zebra mussel hypothesis fails the co-occurrence, temporality, and coherence criteria for river herring. Whether the sufficiency criterion is satisfied is unknown, and the manipulation criterion is inapplicable. Hence, the zebra mussel hypothesis can be rejected as an explanation for long-term trends in the abundance of age 0 river herring in the Hudson River.

The striped bass predation hypothesis satisfies all of the applicable criteria. The correlations between striped bass abundance and river herring abundance, the temporal correspondence between the timing of the striped bass increase and the river herring decline, the estimates of striped bass prey consumption, the simultaneous declines in abundance of susceptible life stages of other prey species in the Hudson River, and the published studies documenting predation by striped bass on spawning adult river herring, and studies documenting impacts of striped bass predation on prey species all provide relatively strong support for the predation hypothesis.

3.4.6. Bay anchovy

Bay anchovy is a marine species and, because zebra mussels occur only in the freshwater zone of the Hudson River, bay anchovy should not be susceptible to the effects of zebra mussel activity. This potential stressor is not evaluated as a cause of changes in the abundance of this species. Two hypothetical causes for these changes are evaluated below: the Indian Point CWIS and striped bass predation.

Figure 36 depicts long-term trends in the abundance of bay anchovy YOY and PYSL in the Hudson. The abundance of juvenile bay anchovy, as measured by the FSS, has declined since 1985. There has been no trend in abundance of PYSL.

3.4.6.1 CWIS

Co-occurrence

As shown in Figure 37, the PYSL to YOY survival rate (Figure 37a) and the PYSL index (Figure 37b) are both uncorrelated with the IP2 and IP3 CMR. Hence, the CWIS hypothesis fails the co-occurrence criterion.

Sufficiency

There are no independent measures of sufficiency that can be applied to this hypothesis. The objective of this report is to determine, using all available and relevant evidence whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Hence, the sufficiency criterion is inapplicable to the CWIS hypothesis.

Temporality

There has been no decline in bay anchovy PYSL abundance, and bay anchovy YOY abundance did not decline until the late 1980s, more than 10 years following the startup of IP2 and IP3. Hence, the CWIS hypothesis fails the temporality criterion.

Manipulation

The peak abundance of bay anchovy eggs and larvae typically occurs during June and July (DEIS, Figures V-78). IP2 was offline during the entire months of June and July in 1976, 1998, and 2000. IP3 was offline during the entire months of June and July in 1975, 1982, 1987, 1993, 1994, and 1997. If entrainment at Indian Point were reducing the survival of bay anchovy PYSL, then PYSL survival should have been higher in years when one unit was offline than in years when both units were operating. As shown in Figure 38a, the measured PYSL survival values are inconsistent with this expectation. Figure 38a shows the time series of annual PYSL survival indices from 1985 through 2002. The horizontal line in Figure 38a shows the median survival index value for this time period. The median is defined as the midpoint of the entire distribution of survival index values, meaning that one-half of the survival indices are above the median and one-half are below the median. If bay anchovy PYSL survival were higher in years of one-unit operation than in years of 2-unit operation, then significantly more survival index values for years of one-year operation should be higher than the median than lower than the median. However, Figure 38a shows that the PYSL survival index was higher than the median for 4 of the 7 years of one-unit operation and lower than the median for the other 3 years. This difference could easily have arisen by chance.

This result is confirmed by Figure 38b, which shows the relationship between the bay anchovy PYSL survival index and the June-July total water withdrawals by IP2 and IP3 for the years 1975-2002. There is no correlation between withdrawals by IP2 and IP3 and bay anchovy PYSL survival. Hence, the CWIS hypothesis fails the manipulation criterion for bay anchovy.

Coherence

The objective of this report is to determine, using all available and relevant evidence, whether the magnitude of entrainment and impingement at Indian Point have been sufficient to cause a reduction in the abundance of important Hudson River fish species. Including "coherence" as an explicit evaluation criterion for CWIS would be redundant. Hence, the coherence criterion is inapplicable to the CWIS hypothesis.

3.4.6.2 Striped bass predation

Co-occurrence

Bay anchovy juvenile abundance is negatively correlated with the striped bass index (Figure 39a). Hence, the striped bass hypothesis satisfies the co-occurrence criterion.

Sufficiency

Striped bass larger than 200 mm in length have been shown to feed on clupeids such as bay anchovy (Gardinier and Hoff 1982, Dunning et al. 1997). However, the prey consumption analysis documented in Appendix C to this report did not address predation on bay anchovy. Hence, whether the striped bass predation hypothesis satisfies the sufficiency criterion for bay anchovy is unknown.

Temporality

The increase in striped bass abundance coincides in time with the decline in bay anchovy juvenile abundance (Figure 39b). Hence, the striped bass hypothesis satisfies the temporality criterion for bay anchovy.

Manipulation

No deliberate manipulations of striped bass predation in the Hudson River have been performed, therefore, this criterion is inapplicable to the striped bass hypothesis.

Coherence

If predation by striped bass had caused the decline in abundance of bay anchovy YOY in the Hudson River, then the YOY abundance of other known striped bass prey species, including white perch, American shad, river herring, and Atlantic tomcod should also have declined. As discussed in other Sections of this report, YOY abundance for all of the above species has declined since the late 1980s, when striped bass abundance began to increase. Moreover, other published studies have concluded that striped bass predation is reducing the abundance of some prey species.

Hartman (2003) estimated that the coastwide annual prey consumption by striped bass between 1 and 10 years of age increased by more than a factor of 8 between 1982 and 1995, from 17,900 mt to 147,900 mt. Uphoff (2003) calculated even larger estimates of striped bass consumption, and attributed a 90% decline in the abundance of Atlantic menhaden in upper Chesapeake Bay from 1980 through 1999 to predation by striped bass.

Because parallel declines in other susceptible species have occurred, and because the other published studies have documented the influence of striped bass predation on susceptible prey species, the striped bass predation hypothesis satisfies the coherence criterion with respect to predation on YOY bay anchovy.

3.4.6.3 Summary evaluation of hypotheses

Table 8 summarizes the consistency of the bay anchovy data with the CWIS and striped bass predation hypotheses. Two of the five evaluation criteria – sufficiency and coherence – are inapplicable to the CWIS hypothesis. The CWIS hypothesis fails the co-occurrence, temporality, and manipulation criteria. Hence, the CWIS hypothesis can be rejected as an explanation for long-term trends in the abundance of age 0 bay anchovy in the Hudson River.

The striped bass hypothesis satisfies three of the five criteria. The manipulation criterion is inapplicable to this hypothesis, and whether this hypothesis satisfies the sufficiency criterion is unknown. The simultaneous declines in abundance of susceptible life stages of other prey species in the Hudson River and the published studies documenting impacts of striped bass predation on prey species all provide relatively strong support for the predation hypothesis. However, substantial uncertainty remains concerning the fraction of the bay anchovy YOY population that might be consumed.

3.4.7. Spottail shiner

Figure 40 depicts long-term trends in the abundance of spottail shiners and YOY in the Hudson River. The abundance of shiners has significantly declined, while the abundance of YOY has significantly increased. The increase in abundance of YOY spottail shiner is inconsistent with all of the hypotheses evaluated in this report. Hence, there is no need to perform a formal evaluation using the criteria from Suter et al. (2007).

As shown in Figure 41, there is no correlation between the IP2 and IP3 CMR and either spottail shiner response metric. This result is not unexpected because, as discussed in the DEIS (Figure V-107), spottail shiner is a freshwater species that is uncommon in the vicinity of Indian Point. The causes of recent changes in the abundance of this species cannot be identified using the data available for this report; however, the CWIS hypothesis can be rejected.

3.5 Summary evaluation of trends analysis

The results of the trends analysis are inconsistent with the hypothesis that entrainment at IP2 and IP3 is reducing the survival or abundance of any of the eight Hudson River fish species considered in this assessment. Overfishing is the most likely cause of the recent decline in abundance of American shad, with striped bass predation being a potentially important contributing factor. For other species, the striped bass predation hypothesis is the most strongly supported hypothesis. This hypothesis satisfies the co-occurrence, sufficiency, temporality, and coherence criteria for many of the species evaluated. With respect to the co-occurrence criterion, the striped bass index is negatively correlated with abundance indices for white perch, American shad, Atlantic tomcod, river herring, and bay anchovy. With respect to sufficiency, the analyses documented in Appendix C show that the increase in prey consumption by Hudson River striped bass in recent years is sufficient to account for observed declines in the YOY abundance of white perch, Atlantic tomcod, and river herring. With respect to temporality, the increase in striped bass abundance that occurred following the imposition of harvest restrictions in the mid-1980s coincides in time with the declines in abundance of one or more life stages of all of these species. With respect to coherence, striped bass predation has been implicated in declines of susceptible species in other mid-Atlantic northeastern estuaries (Hartman 2003, Uphoff 2003, Savoy and Crecco 2004) and striped bass have been shown to prey on all of the species listed above (Gardinier and Hoff 1982, Dunning et al. 1997, Savoy and Crecco 2004, Kahnle and Hattala 2007).

The available evidence is sufficient to reject Indian Point CWIS as having a measurable effect on any of the species evaluated. Within the limits of the data available for this assessment, it can reasonably be concluded that striped bass predation is a far more likely cause of declines in the abundance of YOY white perch, American shad, Atlantic tomcod, river herring, and bay anchovy than are any of the other potential causes evaluated.

4. Evaluation of impacts of cooling-water withdrawals on spawning potential

Fisheries scientists have developed a variety of quantitative methods for determining whether the sustainability of a fish population is being harmed by excessive harvesting. From the perspective of population dynamics, entrainment and impingement have been characterized (somewhat over simplistically) as a type of "fishing," imposed on early life stages rather than on adult fish (Goodyear 1977). For this reason, these methods may be used to determine whether entrainment or impingement by IP2 and IP3's respective CWIS could have adversely affected Hudson River fish populations that support managed fisheries. The method to be used, the SSBPR model, has a long history of application both in power-plant impact assessment studies and in fisheries management (Goodyear 1993).

4.1 History of the SSBPR model

One of the critical questions in fisheries management is how much spawning stock (essentially, the number of adult fish) must be protected from harvesting to allow a population to replace itself and persist through time (i.e., a sustainable population) (Mace and Sissenwine 1993). The so-called spawning stock biomass per recruit or SSBPR model is the most widely used approach for answering this important question for fish populations subjected to commercial and recreational fishing (Sissenwine and Shepherd 1987, Gabriel et al. 1989, Goodyear 1993, Mace and Sissenwine 1993, Rosenberg et al. 1994). Further, since it was originally developed by Goodyear (1977) as a method for assessing whether entrainment and impingement of striped bass at Hudson River power plants could, in combination with fishing mortality, threaten the ability of the population to sustain itself, its application to entrainment and impingement is well-supported.

The SSBPR model uses information on age-specific mortality and fecundity (i.e., the number of eggs produced by a female fish of a given age) to calculate the expected lifetime reproduction of a one-year-old female fish (a "recruit," in fisheries terminology). Expected lifetime reproduction is a function both of the average fecundity of female fish at each age and the probability that the female will survive to reproduce at that age (Goodyear 1977). Mortality due to fishing, CWIS, or other causes reduces expected lifetime reproduction either by reducing the probability of survival (in the case of fishing), reducing the probability that spawned eggs will survive to become one-year-old recruits (in the case of CWIS), or reducing the fecundity of female fish (e.g., through adverse environmental conditions, such as toxic chemicals). For the population to persist, each one-year-old female fish must produce at least one female egg that survives to become a one-year-old female recruit (Mace and Sissenwine 1993, Goodyear 1993). An average female has the potential to produce far more eggs than are required to replace her (Mace and Sissenwine 1993). For example, a female striped bass can spawn 3 million or more eggs in a single year (Hoff et al. 1988; Olsen and Rulifson 1992) and can live for up to 30 years (Secor and Piccoli 1996). For the population to maintain itself at a stable level, only one of the female eggs produced by each fish over her lifetime must survive to adulthood. This massive surplus of eggs ensures that the population will be able to persist in spite of natural and potentially extreme fluctuations in environmental conditions. This massive surplus of eggs also ensures that even substantial harvesting by commercial and recreational fishermen will not adversely affect the population.

4.2 Explanation of the SSBPR concept

The use of SSBPR in fisheries management derives from recognition that the lifetime reproductive capacity of a typical recruit provides a useful measure of the replacement capability of a population (Goodyear 1977, 1993, Sissenwine and Shepherd 1987, Mace and Sissenwine 1993, Rosenberg et al. 1994). At low levels of fishing mortality, the lifetime reproductive capacity of a typical female recruit is far larger than is necessary to sustain the population. As fishing mortality increases, the expected life span of each fish decreases, resulting in a reduction in lifetime reproductive capacity. If fishing mortality exceeds a critical threshold, the number of eggs produced by a female over her lifetime will fall below the replacement level. Once egg production falls below this level, recruitment (the number of fish entering the population each year) will begin to decline, and will continue to decline unless fishing is reduced to a level that once again allows lifetime egg production to meet or exceed the replacement level (Sissenwine and Shepherd 1987, Mace and Sissenwine 1993).

In a review of over-fishing definitions used in the management of marine fish stocks, Rosenberg et al. (1994) found that most of these definitions were based on the SSBPR model, and used the SSBPR model to evaluate over-fishing definitions used to manage the marine fish stocks. NOAA guidelines (Restrepo et al. 1998) for implementing National Standard 1 of the Magnuson-Stevens Act identify the SSBPR model as one of the methods that can be used to establishing over-fishing reference points that comply with the Act.

SSBPR is estimated as:

$$SSBPR = \sum_i l_i m_i f_i$$

where

l_i = probability of survival from age 1 to age i

m_i = fraction of the population of age i which are mature females; and

f_i = average fecundity of a female fish at age i (average number of eggs/female of age i).

The probability of survival to age i is estimated by combining age-specific rates of natural mortality, fishing mortality, and entrainment/impingement mortality:

$$l_i = \prod_{a=1}^{a=i-1} e^{-(M_a + F_a + P_a)}$$

where

M_a = age-specific instantaneous natural mortality rate at age a;

F_a = instantaneous fishing mortality rate at age a; and

P_a = instantaneous power-plant mortality rate at age a.

The impact of fishing and power-plant mortality on expected lifetime egg production is expressed as the ratio of SSBPR including both sources of mortality to SSBPR without these sources of mortality. This ratio is often termed the "spawning potential ratio" ("SPR"):

$$SPR = \frac{SSBPR_{fished}}{SSBPR_{unfished}}$$

Rates of fishing mortality that would produce a given SPR value are used by fisheries management agencies to establish acceptable limits on fishing mortality. Historically, the two reference points most commonly used by fisheries managers are $F_{.35}$ and $F_{.20}$. $F_{.35}$ is the fishing mortality rate that will lead to an SPR value of 0.35. $F_{.35}$ has often been used as a default goal for achieving maximum sustained yield ("MSY"), i.e., the maximum amount of adult fish (in pounds or kilograms) that can be removed from the population each year by fishermen without affecting the sustainability of the population. Values of F greater than $F_{.35}$ would lead to harvests greater than could be sustained over time. $F_{.20}$ is the fishing mortality rate that will lead to SPR value of 0.2, a default value indicating over-fishing. If F consistently exceeds $F_{.20}$, then significant declines in the adult population may occur. Although some fish stocks may be able to maintain recruitment at $F_{.20}$, other stocks are more sensitive to fishing and cannot sustain exploitation at this level (Mace and Sissenwine 1993, Rosenberg et al. 1994).

4.3 Application to Hudson River fish populations

Quantitative stock assessments and biological reference points are available for two of the species addressed in this report: striped bass (ASMFC 2005) and American shad (ASMFC 2007). As long as mortality caused by entrainment and impingement is limited to fish that are younger than one year old (which is true for both striped bass and American shad), the CMR calculated using the generators' empirical entrainment and impingement models provides a direct measure of the reduction in SSBPR caused by IP2 and IP3 (Goodyear 1977). The likelihood that entrainment and impingement at IP2 and IP3 have adversely affected the sustainability of these two species is evaluated in two ways. First, estimates of reduction in SSBPR due IP2 and IP3 are compared to reductions caused by fishing mortality. Second, estimates of combined reductions in SSBPR due to both IP2 and IP3 and fishing are compared to the biological reference points that are currently used to manage these species.

4.3.1 Striped bass

As shown in Figure 42, the striped bass CMR for the 30 years for which data are available corresponds to an SPR of 0.92. In other words, IP2 and IP3 reduce the spawning potential of the Hudson River striped bass population to 92% of the value for an unfished population. Fishing for striped bass at the current target rate established by the ASMFC (F=0.30)[10] corresponds to an SPR of 0.13. This means that fishing for striped bass, under the current management approach, has reduced the reproductive potential of a typical 1-year-old female striped bass to only 13% of the value that would be expected in an unfished striped bass population. The threshold fishing rate for striped bass is currently set at F=0.41 (ASMFC 2003). This value corresponds to an SPR of 0.096. If the rate of fishing were to rise above F=0.41, the ASMFC would be required to declare the population to be over-fished and would take action to reduce harvesting.

As shown in Figure 42, even when effects of fishing are combined with effects of IP2 and IP3, the combined SPR is still above the threshold. Hence, either alone or in combination with fishing, entrainment and impingement at IP2 and IP3 have not jeopardized the sustainability of the Hudson River striped bass population as defined by ASMFC regulations. Further, as is clear from Figure 42, the impacts of fishing on the sustainability of the Hudson River striped bass population dwarf any impact of IP2 and IP3. Eliminating entrainment and impingement of striped bass at IP2 and IP3 would not have a measurable influence on the sustainability of the population.

4.3.2 American shad

The ASMFC (ASMFC 2007a, 2007b) recently used the SSBPR model to assess impacts of increased mortality on the sustainability of Atlantic coastal American shad populations, including the Hudson River American shad population. Because the relative contributions of fishing mortality and natural mortality to the increase are uncertain, the ASMFC expressed the maximum sustainable rate of mortality in terms of total mortality (Z) rather than fishing mortality. The ASMFC selected Z_{30}, the total mortality rate at which SSBPR would fall to 30%

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10 For assessment purposes, Atlantic striped bass are treated as a single mixed population, and the same fishing mortality rate is assumed to be applicable to all of the individual spawning populations that contribute to the mixed coastal fishery.

of an assumed baseline value, as an excess mortality threshold analogous to $F_{.30}$. Using alternative assumptions concerning the operation of the American shad fishery, the ASMFC developed a range of estimates of $Z_{.30}$ of Z=0.54 to Z=0.73 for the Hudson River American shad population.

Empirical estimates of total annual mortality in Hudson River American shad are available for the years 1984-2004 (ASMFC 2007a). Total mortality has exceeded $Z_{.30}$ in most years during this period. Hattala and Kahnle (2007) have contended that the excessive mortality imposed on Hudson River American shad is due primarily to overfishing. However, regardless of the actual cause, it is clear that entrainment at Indian Point is a negligible contributor to American shad mortality. Figure 43 compares reductions in spawning potential of American shad due to IP2 and IP3 to reductions due to other causes, including fishing. The calculations were performed using the Hudson-specific life history parameters from Tables 1.1.5.1-b (age-invariant natural mortality) and 1.1.5.2-b of ASMFC (2007a) and the revised Type 1 fishery model from ASMFC (2007b).

As shown in Figure 43, entrainment at IP2 and IP3 would reduce the spawning potential of Hudson River American shad by only 1% compared to the baseline value. According to the ASMFC (2007a), the current rate of total mortality on age 1 and older American shad (Z=0.87) corresponds to an SPR of 0.23, well below the threshold level. Because it was derived from an analysis of long-term trends in abundance and age structure of the Hudson River shad population, the total mortality rate estimate already includes the effects of entrainment at IP2 and IP3. If this contribution (as estimated using the CMR) is removed, the decrease in total mortality and increase in SPR level are negligibly small (Figure 43). Eliminating entrainment at IP2 and IP3 would result in less than a 1% increase in spawning potential, leaving the SPR still substantially below the threshold defined by the ASMFC.

5. Community-Level Trends Analysis

Cooling-water withdrawals impose some incremental additional mortality on species susceptible to entrainment. If entrainment at IP2 and IP3 were having an adverse impact on the Hudson River fish community, then species with high susceptibility to entrainment would be more likely to have declined in abundance over the past 30 years than would species with low susceptibility. Among those species that declined in abundance, the magnitude of the decline should have been greater for species with high susceptibility than for species with low susceptibility. Among species that increased in abundance, the magnitude of the increase should have been lower for species with high susceptibility than for species with low susceptibility.

This hypothesis can be tested using data available from the generators' riverwide survey programs, using data for all Hudson River fish species for which an adequate trends dataset could be developed. The method used to perform the test is analysis of correlations between indices of entrainment susceptibility, as calculated using distributional data obtained from the LRS, and indices of trends in age 0 abundance, obtained from the BSS and FSS.

Evaluating the correlation between entrainment susceptibility and change in YOY abundance requires selecting those species for which data are available for both variables. Entrainment susceptibility at IP2 and IP3 can be estimated by evaluating the distribution of entrainable life stages in the region from which IP2 and IP3 withdraws water in comparison to all the regions sampled. The generators' LRS program is designed to collect such data. The expected effect of continued annual entrainment losses of early life stages of a species, if losses are severe enough to reduce population size, is a decrease in YOY abundance. YOY is the best stage to look for the effect of entrainment losses because entrainment occurs prior to the YOY stage, and because most susceptible species are still in the river during the YOY stage and thus their abundance is measurable. The generators' BSS and FSS sampling programs are designed to monitor YOY abundance.

5.1 Methods

The evaluation involves three steps: (1) calculate a species-specific numeric index of entrainment susceptibility based on data from the LRS; (2) calculate a species-specific numeric index of change in YOY abundance based on data from the BSS and FSS; and (3) determine whether entrainment susceptibility is related to change in age 0 abundance.

Susceptibility to entrainment at IP2 and IP3 was evaluated using an index of standing crop estimated from the generators' LRS for the 31-year period 1974-2004 (Appendix D). Indian Point is located in Region 4 (Figure 1), but because of tidal and nontidal flows, can withdraw water originating in the two adjoining regions as well. Therefore, relative abundance of a species in Regions 3-5 (Figure 1), as compared to the riverwide abundance of that species, was used to define a susceptibility index termed *EntSus*. For each sampled year (and each seasonal period when possible), *EntSus* is estimated for each species as the ratio of standing crop in Regions 3-5 to standing crop in all sampled regions. For those species occurring in more than one of the three seasonal periods, annual *EntSus* values are calculated as an average across periods, *p*, weighted by abundance for each period:

$$EntSus_i = \frac{\sum_p SC_{ip} EntSus_{ip}}{\sum_p SC_{ip}}$$

where $EntSus_i$ = fraction of species in the Hudson River estuary in the IP2 and IP3 region in year *i*;

SC_{ip} = sum of abundance of the species within seasonal period *p* in year *i*; and

$EntSus_{ip}$ = value of *EntSus* for seasonal period *p* in year *i*.

Annual *EntSus* values for each species for each of 31 years (1974-2004) in which the yolk-sac or post yolk-sac stages appeared in the Hudson River are provided in Appendix D.

The BSS and FSS programs were selected as the best potential indicators of long-term relative abundance of fish in the estuary. These programs have sampled the estuary using similar gear and methodology since the early 1970s, although there have been variations in the regions sampled and in time of initiation and end of the sampling across the years. To maintain consistent sampling effort and maximize comparability of results, data are restricted to Regions 1-12, and weeks 31-42, approximately August through October.

As documented in Appendix D, abundance data by species are categorized into two salinity zones, three habitats, and two time periods. The two salinity zones are brackish (Regions 1-6; river miles 12-61) and freshwater (Regions 7-12; river miles 62-152). The three habitats sampled by these surveys are (a) shorezone (bottom area in water 10 ft or less in depth), (b) benthic (volume of water between river bottom and 3 ft above the bottom), and (c) water column (water volume not included in either the shorezone or benthic habitats). Time series of abundance data are divided into two equal periods: Period 1, covering the years 1974 through 1989, and Period 2, covering the years 1990-2005.

Because freshwater and marine species typically have strong salinity preferences, data from the non-preferred salinity zones (brackish zone for freshwater guild; freshwater zone for marine guild) were excluded when calculating overall relative change in abundance from Period 1 to Period 2 for species in these two guilds. So that species with greatly differing abundances could be compared in the same scale, the between-period changes were expressed as a relative change index (i.e., abundance in Period 2 divided by abundance in Period 1). Details concerning these calculations are provided in Appendix D.

The quantity and quality of abundance and distribution data vary greatly among species. The inclusion of species collected only rarely, or only in a small number of years, would weaken the analysis. Selection criteria are needed to eliminate species caught too infrequently to provide meaningful estimates of *EntSus* or meaningful abundance trends. However, any single choice of selection criteria can be questioned. For this reason, a sensitivity analysis was performed to evaluate influence of selection criteria on the outcome of the hypothesis test. The sensitivity analysis was performed by defining two cases, or sets of species, termed "Case A" and "Case B." Species included in both cases were selected based on the annual numbers of organisms collected in the LRS and BSS/FSS surveys. Species were included in the Case A analysis if (1) an average of at least 100 larvae per year of occurrence was collected in LRS samples during 1974-2005 and (2) at least 100 YOY were collected in BSS or FSS samples in at least one salinity zone-habitat combination in at least one of the two time periods. Species were included in the Case B analysis if (1) an average of at least 1000 larvae per year of occurrence was collected in LRS samples 1974-2005 and (2) at least 1000 YOY were collected in BSS or FSS samples in at least one salinity zone-habitat combination in at least one of the two time periods. The species included in Case B are a subset of the species included in Case A. The selection criteria and the species included in each case are more fully documented in Appendix D.

Three correlation metrics (Pearson, Spearman, and Kendall) were used to evaluate the association between entrainment susceptibility and YOY abundance change. There is no simple mathematical relation between any two of these three methods, and when the true correlation coefficient is not zero, it is likely that each coefficient is sensitive to different types of departures from independence (Sokal and Rohlf, 1995).

5.2 Results and Discussion

Table 9 shows the correlation coefficients and probability values, for both Case A and Case B, for all three correlation indices. None of the correlations are statistically significant. Figure 44 provide plots of mean entrainment susceptibility vs. the normalized index of relative change in YOY abundance from Period 1 to Period 2 for both Case A and Case B.

These figures illustrate the same two patterns. First, more species decreased in abundance than increased. For the 21 species in Case A, 71% decreased and 19% increased (Figure 44a). For the 11 species in Case B, 73% decreased and 17% increased (Figure 44b). Second, the regression of relative abundance change on E*ntSus* is not statistically significant for any case, even at the 20% level. This means that relative change from the earlier to the later period was the same for species with high susceptibility to entrainment (high E*ntSus*) as for species with low susceptibility to entrainment. This result is inconsistent with the hypothesis that the susceptibilities of species to entrainment at Indian Point influenced their rates of increase or decrease over the period 1974-2005. Although the number of taxa (19) included in this analysis is small compared to the total number of species present in the Hudson, these taxa represent approximately 94% (Case A) and 88% (Case B) of all age 0 fish captured in the BSS/FSS programs from 1974-2005.

The guild to which each of the 21 species in Case A belongs is indicated in Figure 44a. Although each guild is represented by only four to six species, at least one species in each guild increased in abundance. This pattern further reinforces the conclusion that the long-term trends in abundance of the fish species inhabiting the Hudson River estuary are similar across all guilds and are unrelated to entrainment at IP2 and IP3.

6. Conclusions

The FEIS and the Draft Permit for IP2 and IP3 stated that three fish species (Atlantic tomcod, American shad, and white perch) have declined in abundance in recent years, and attributed these declines to cooling-water withdrawals at IP2 and IP3. Analyses performed to test alternative hypotheses concerning the causes of these declines show that cooling water withdrawals by IP2 and IP3 did not cause these declines. Overharvesting is the most likely cause of recent declines in the abundance of American shad, with striped bass predation being a potentially significant contributing factor. Striped bass predation is the most likely cause of the decline in abundance of Atlantic tomcod (as well as river herring and bay anchovy). Striped bass predation probably contributed to the decline in abundance of YOY white perch, although other unknown causes were also involved. The striped bass hypothesis is supported not only by analysis of species abundance trends, but also by four recently-published studies of striped bass predation (Hartman 2003, Uphoff 2003, Savoy and Crecco 2004, Kahnle and Hattala 2007) and by an analysis of the increase in prey consumption needed to support the recent growth of the Hudson River striped bass population (Appendix C).

Two additional lines of evidence support a conclusion that entrainment and impingement at IP2 and IP3 have not resulted in AEI. Application of the SSBPR model to stock assessment data for striped bass and American shad (Section 4) shows that mortality caused by entrainment at IP2 and IP3 is negligible, particularly compared to fishing mortality, and does not impair the ability of these populations to sustain themselves. Analysis of community-level trends data (Section 5) shows that species with relatively high susceptibility to entrainment at IP2 and IP3 are no more likely to have declined in abundance since 1974 than are species with relatively low susceptibility to entrainment.

Considered together, the evidence evaluated in this report shows that the operation of IP2 and IP3 has not caused effects on early life stages of fish that reasonably would be considered "adverse" by fisheries scientists and/or managers. The effects of mortality at IP2 and IP3 on the survival and abundance of susceptible populations cannot be detected, even after 30 years of intensive monitoring. Those changes that have occurred are more likely attributable to predation by the Hudson River's rapidly growing striped bass population.

For all of the above reasons, from the perspective of a science-based definition of AEI, the available data demonstrate that entrainment and impingement associated with cooling-water withdrawals by IP2 and IP3 have not had an adverse impact on Hudson River fish populations and communities.

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Table 1. Expected effects of stressors on Hudson River fish populations (except Atlantic tomcod): age 0 growth, age 0 survival, and age 0 spatial distribution, and adult age structure.

Response metric	**CWIS**	**Fishing**	**Zebra mussels**	**Predation by striped bass**
PYSL Abundance	↓	↓	—	↓
PYSL→Juv survival	↓	—	↓	—
Juvenile abundance	—	—	—	↓
Juvenile growth	—	—	↓	—
Spatial distribution	—	—	↓	—

Table 2. Expected effects of stressors on Hudson River fish Atlantic tomcod population: Age 0 survival, age 1 survival, juvenile growth, and spatial distribution.

Response metric	**CWIS**	**Temperature**	**Striped bass predation**
PYSL/early juvenile abundance	↓	—	↓
Egg to age 1 survival	↓	↓	↓
Age 1 &2 abundance	—	—	↓
Age 1 to age 2 survival	—	↓	↓
Juvenile growth	—	↓	—
Spatial distribution	—	—	—

Table 3. Consistency of hypotheses with evaluation criteria: striped bass.

	CWIS	Fishing	Zebra Mussels
Co-occurrence	-	+	+
Sufficiency	N/A	unknown	unknown
Temporality	-	+	-
Manipulation	-	+	N/A
Coherence	N/A	+	-
Summary evaluation	CWIS and zebra mussel hypotheses rejected Most likely cause: fishing		

Table 4. Consistency of hypotheses with evaluation criteria: white perch.

	CWIS	Zebra mussels	Striped bass predation
Co-occurrence	-	+	+
Sufficiency	N/A	unknown	+
Temporality	+	-	+ (?)
Manipulation	-	N/A	N/A
Coherence	N/A	+(?)	+
Summary evaluation	CWIS hypothesis rejected. Zebra mussels and striped bass predation may have contributed declines occurring in later years, but other unknown causes were responsible for declines occurring between 1975 and 1985.		

Table 5. Consistency of hypotheses with evaluation criteria: American shad.

	CWIS	Overfishing	Zebra mussels	Striped bass predation
Co-occurrence	-	+	-	+ (?)
Sufficiency	N/A	+	unknown	unknown
Temporality	-	+	-	+
Manipulation	-	N/A	N/A	N/A
Coherence	N/A	+	-	+
Summary evaluation	CWIS and zebra mussel hypotheses rejected Most likely cause: fishing, with striped bass predation a potential contributing factor			

Table 6. Consistency of hypotheses with evaluation criteria: Atlantic tomcod.

	CWIS	Temperature	Striped bass predation
Co-occurrence	±	+	+
Sufficiency	N/A	+	+
Temporality	-	-	+
Manipulation	-	N/A	N/A
Coherence	N/A	+	+
Summary evaluation	CWIS hypothesis rejected Temperature a significant influence, but cannot explain post-1990 decline Most likely cause of decline: striped bass predation		

Table 7. Consistency of hypotheses with evaluation criteria: River herring.

	CWIS	Zebra mussels	Striped bass predation
Co-occurrence	-	-	+
Sufficiency	N/A	N/A	+
Temporality	-	-	+
Manipulation	-	N/A	N/A
Coherence	N/A	-	+
Summary evaluation	CWIS and zebra mussel hypotheses rejected Most likely cause: striped bass predation		

Table 8. Consistency of hypotheses with evaluation criteria: bay anchovy.

	CWIS	Striped bass predation
Co-occurrence	-	+
Sufficiency	N/A	Unknown
Temporality	-	+
Manipulation	-	N/A
Coherence	N/A	+
Summary evaluation	CWIS hypothesis rejected Striped bass predation most likely cause of change	

Table 9. Pearson, Spearman, and Kendall correlation coefficients for the association between $Log_{10}(R)$ and mean *EntSus*. A value of p represents the probability of a sample correlation coefficient larger than the observed sample correlation coefficient, if the true correlation coefficient is zero.

Case	N		Pearson	Spearman	Kendall
A	19	r	0.225	0.182	0.129
		p	0.355	0.457	0.442
B	12	r	0.157	-0.042	-0.046
		p	0.625	0.897	0.837

Figure 1. Hudson River map, with sample regions

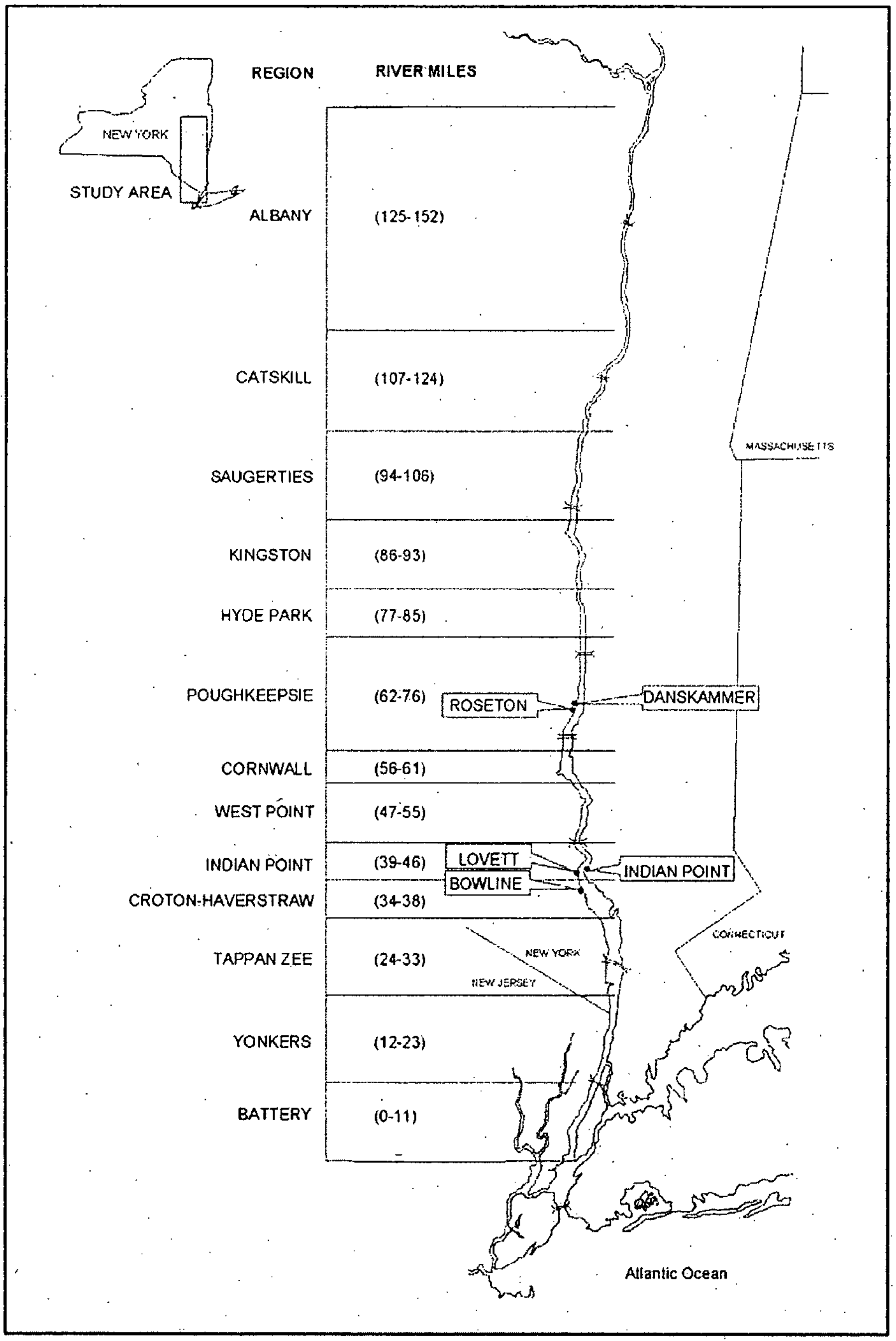


Figure 2. Impacts of CWIS on Age 0 life stages, partitioned between abundance of each life stage and survival between life stages.

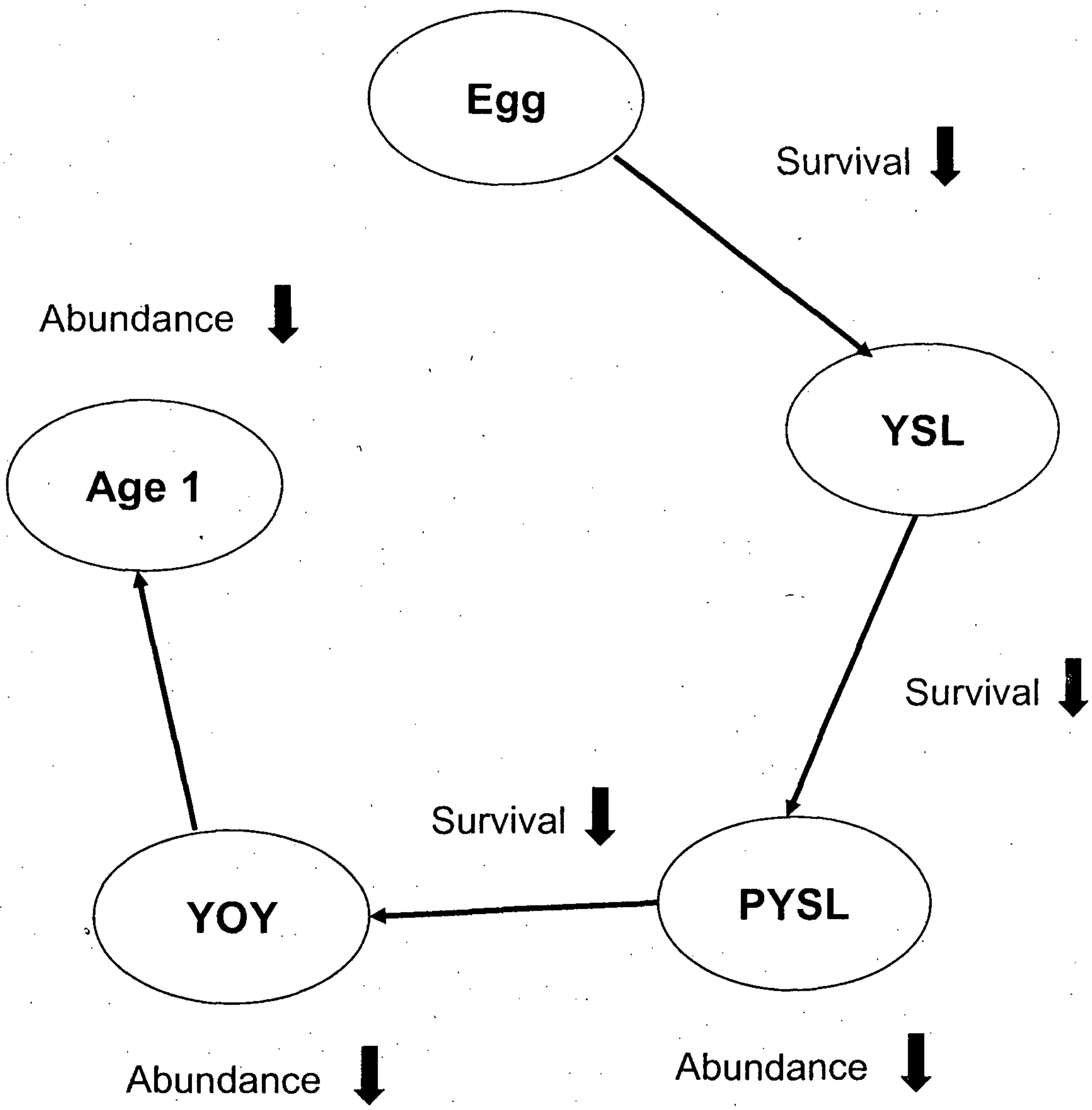


Figure 3. Impacts of fishing on Age 0 life stages.

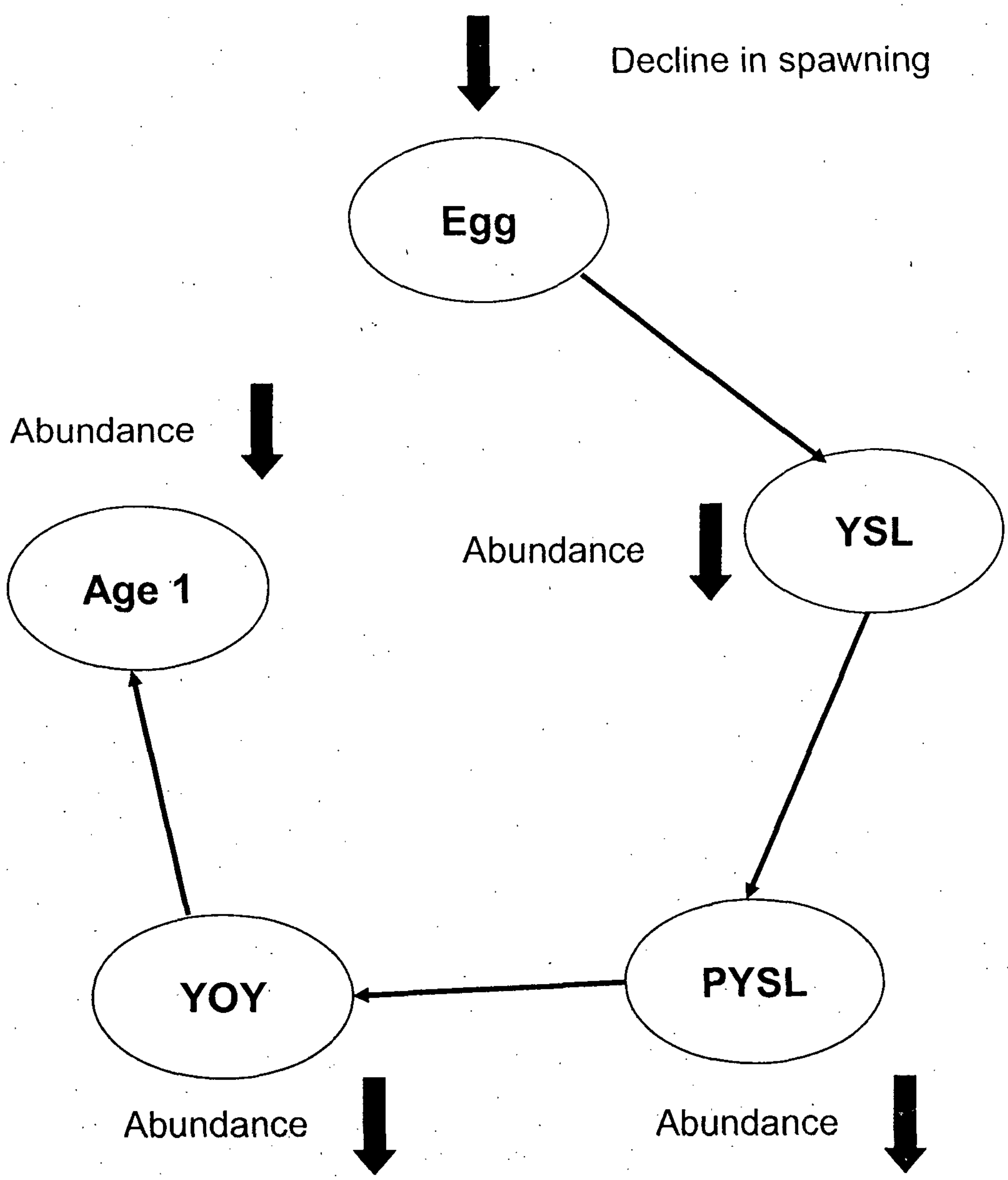


Figure 4. Impacts of zebra mussel activity on Age 0 life stages.

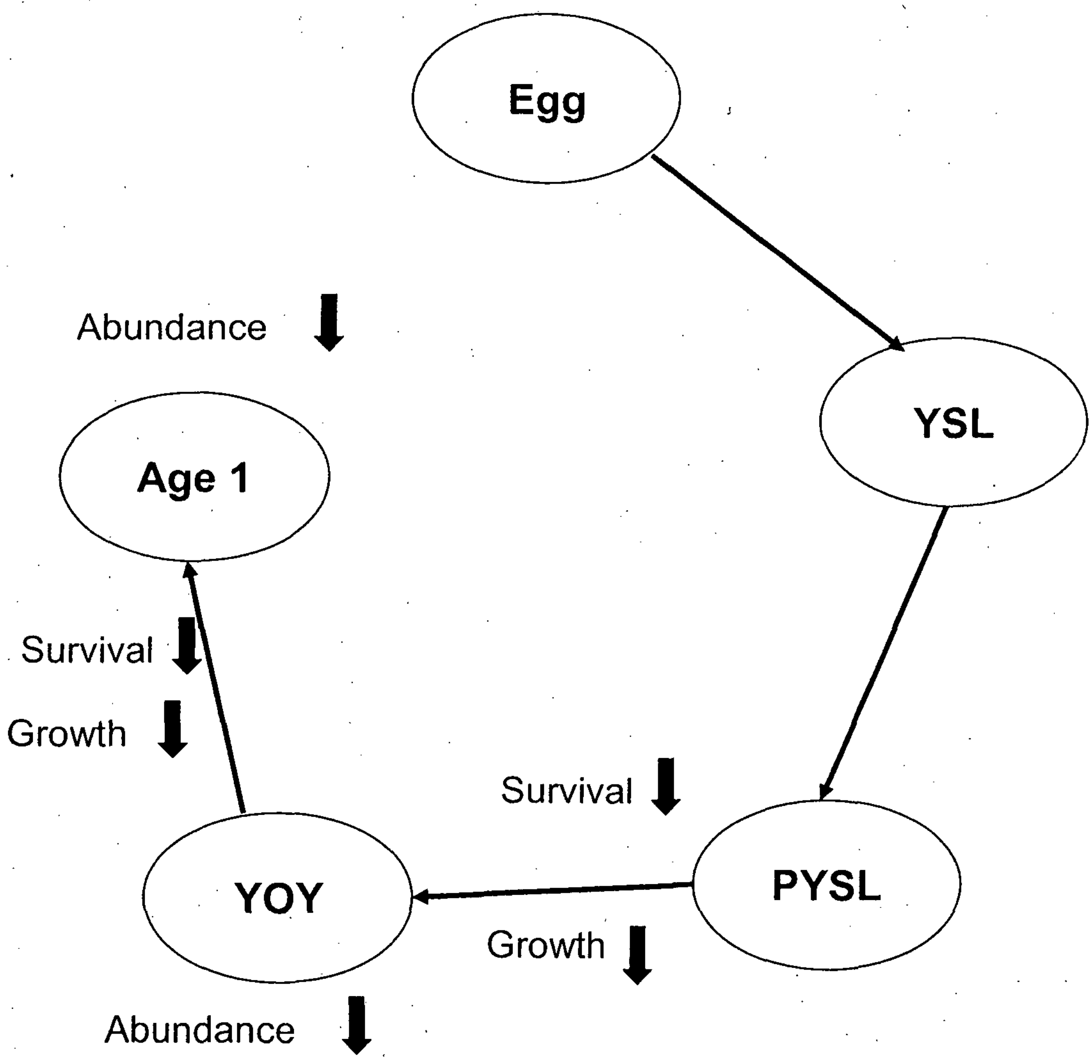


Figure 5. Impact of striped bass predation on Age 0 life stages.

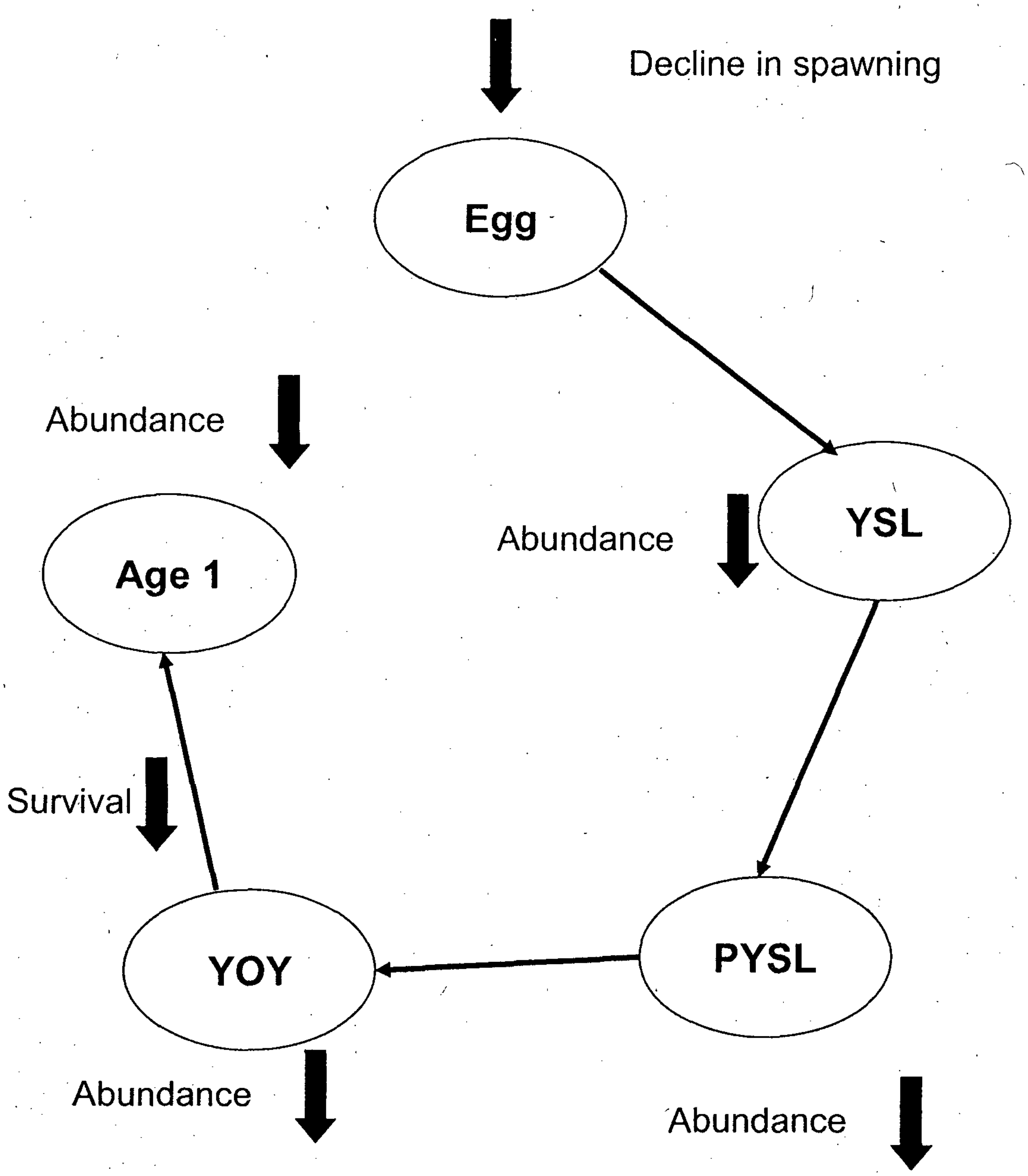


Figure 6. Impact of elevated summer temperatures on Age 0 Atlantic tomcod.

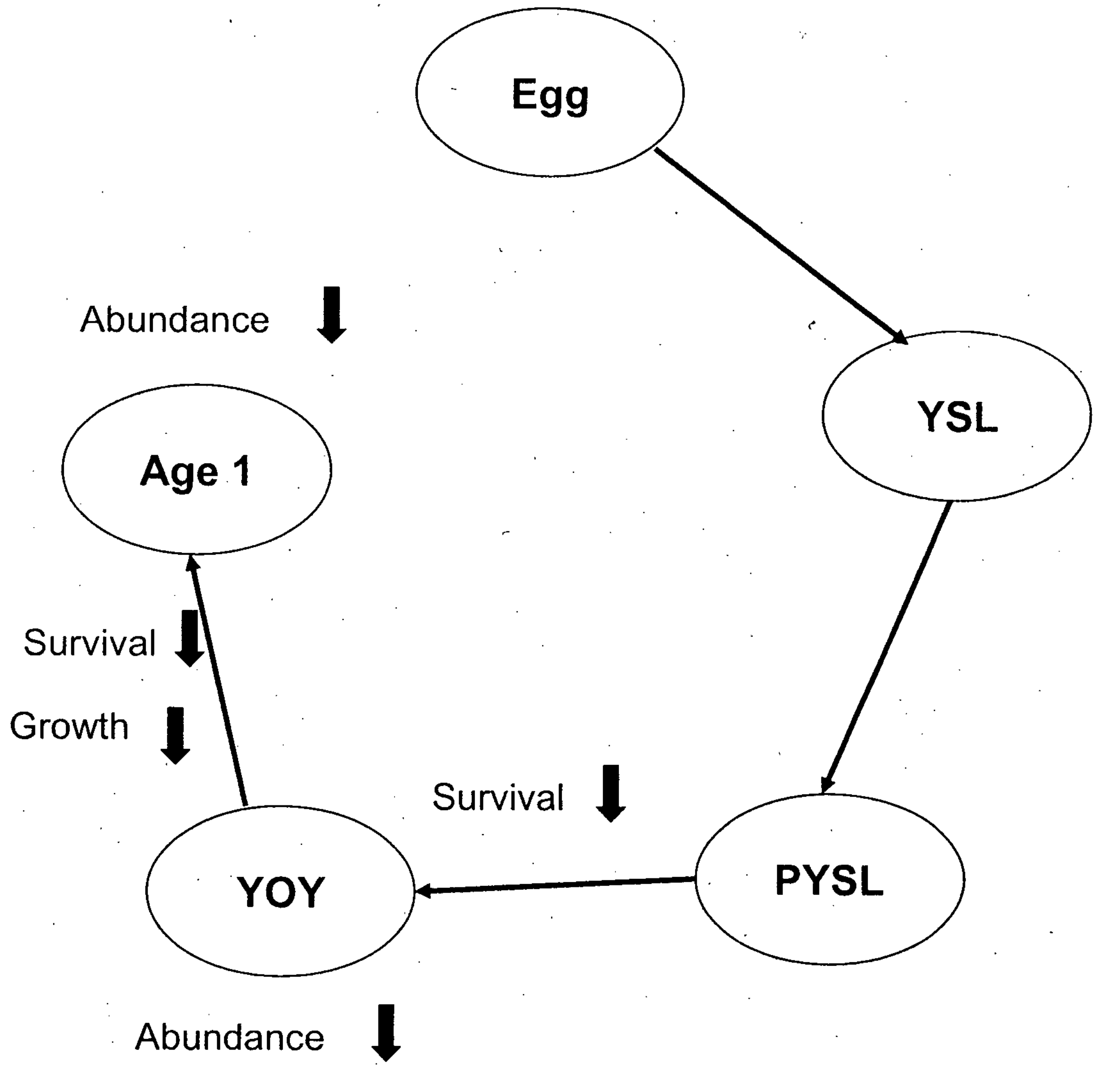


Figure 7a. Long-term trends in the abundance of striped bass PYSL and YOY.

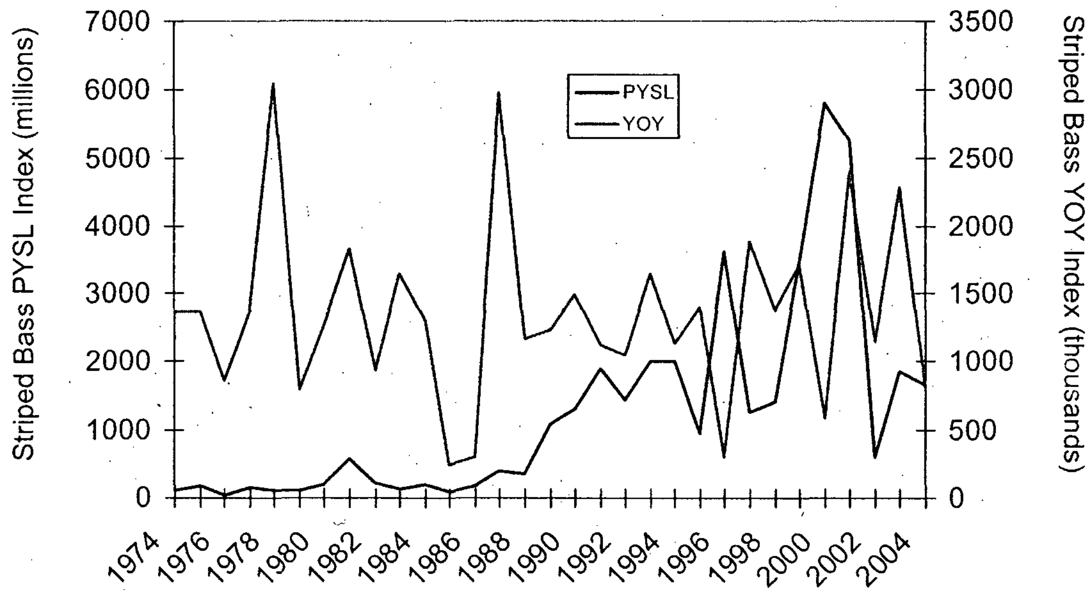


Figure 7b. Long-term trend in striped bass PYSL to YOY survival.

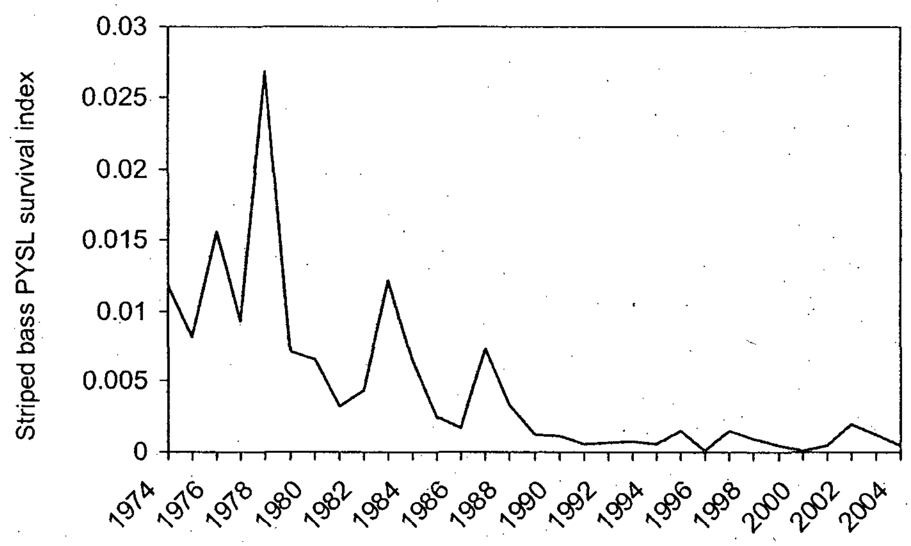


Figure 8a. Relationship between striped bass PYSL abundance and striped bass YOY abundance.

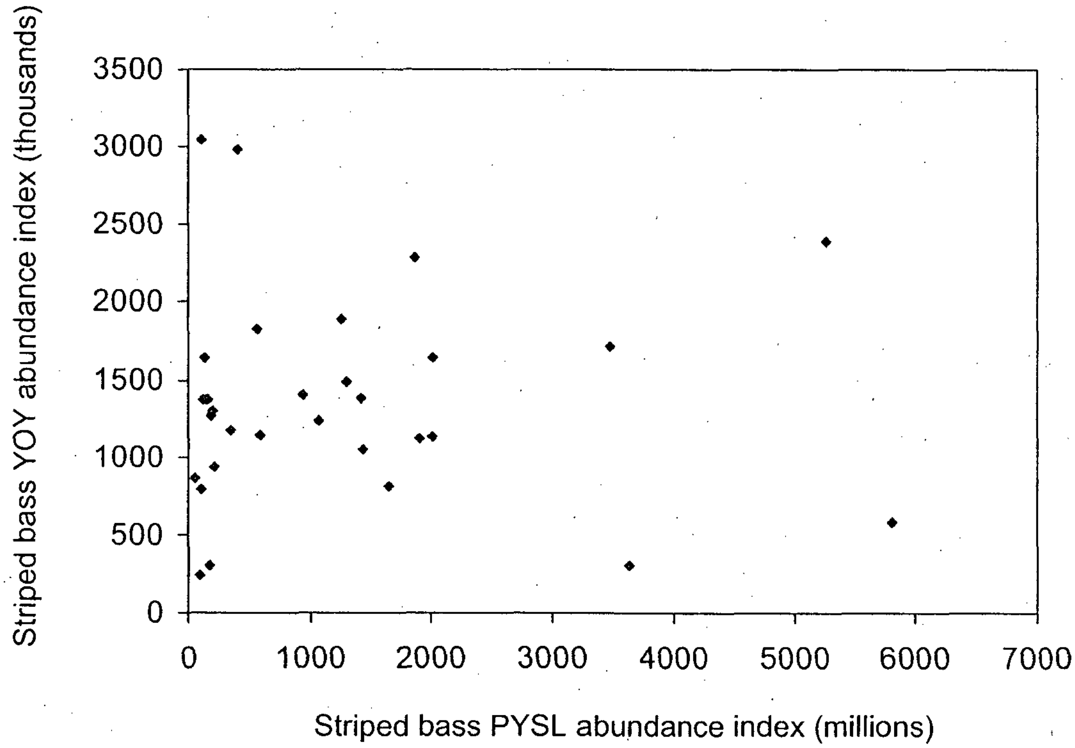


Figure 8b. Relationship between striped bass PYSL abundance and PYSL survival.

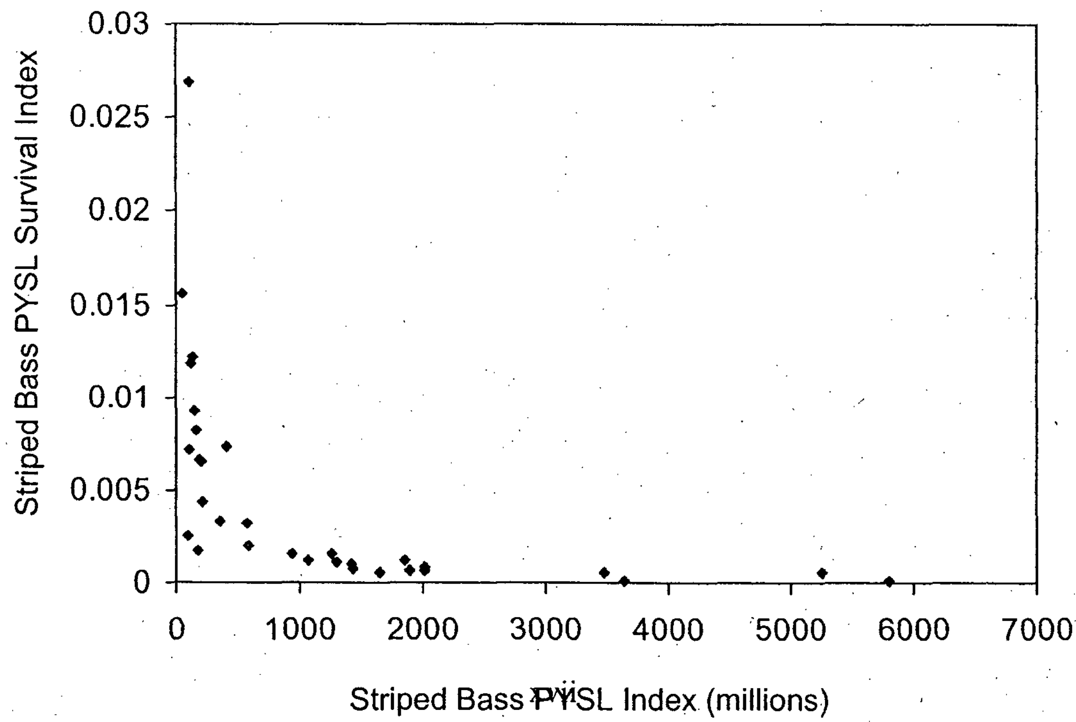


Figure 9a. Relationships between IP2 and IP3 CMR for striped bass and striped bass PYSL survival index.

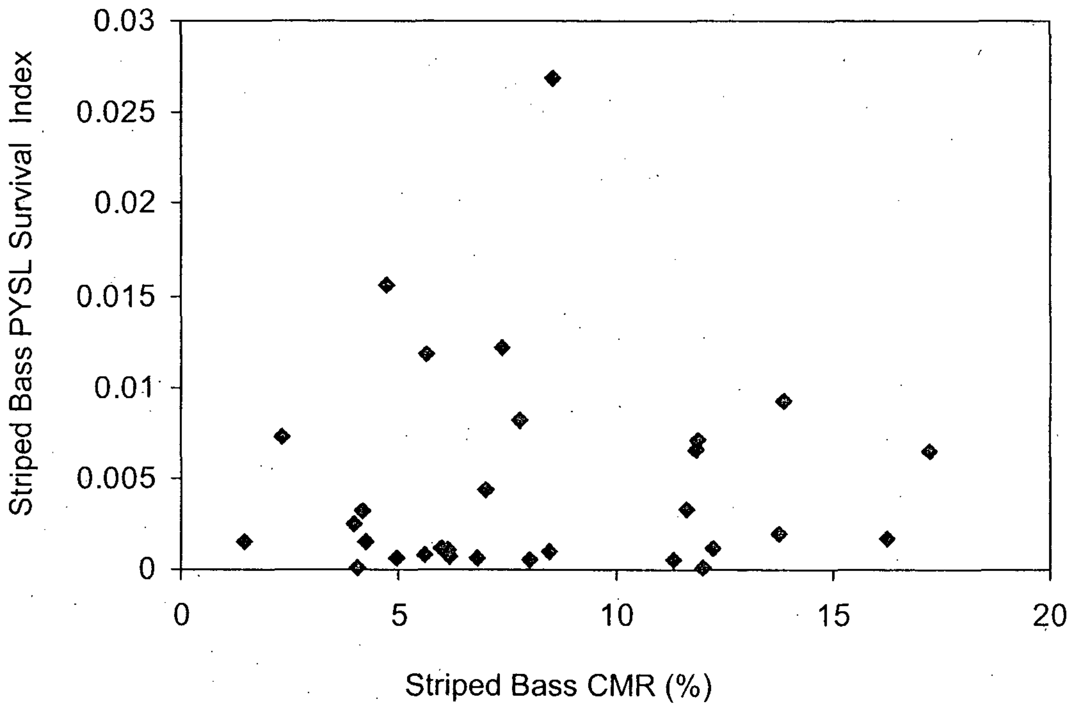


Figure 9b. Relationship between IP2 and IP3 CMR for striped bass and striped bass PYSL abundance index.

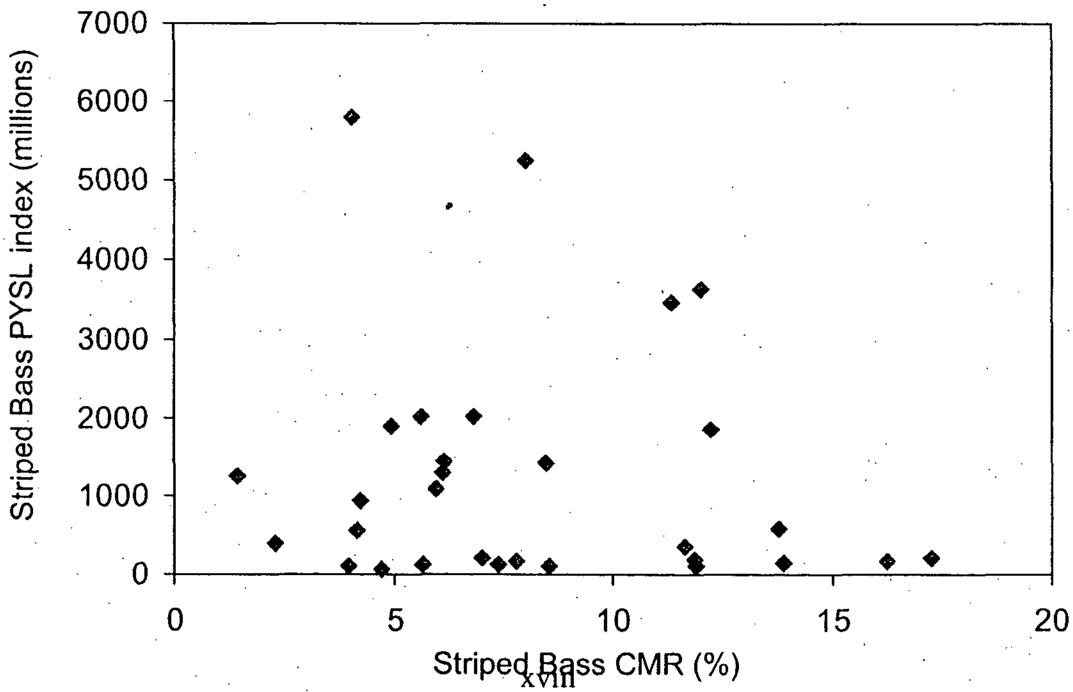


Figure 10. (a) Striped bass PYSL to YOY survival during years in which 1 unit (blue) and 2 units (red) at Indian Point were operating during May and June, the peak months during which entrainable life stages of striped bass are present in the Hudson River. The horizontal line shows the median survival index value for the time series. (b) Relationship between total May-June withdrawals by IP2 and IP3 and striped bass PYSL survival.

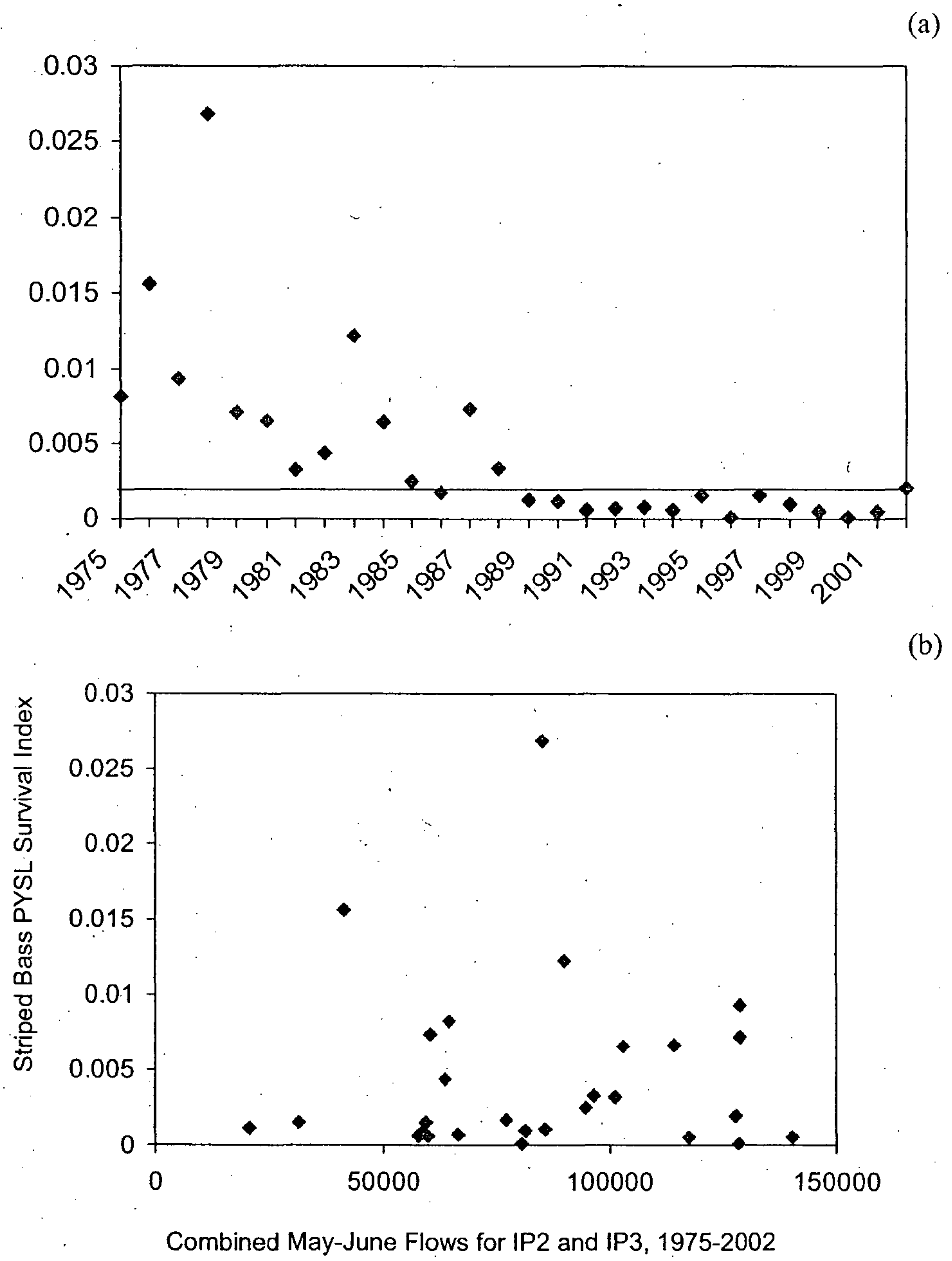


Figure 11. Long-term trends in the abundance of white perch PYSL and YOY in the Hudson River.

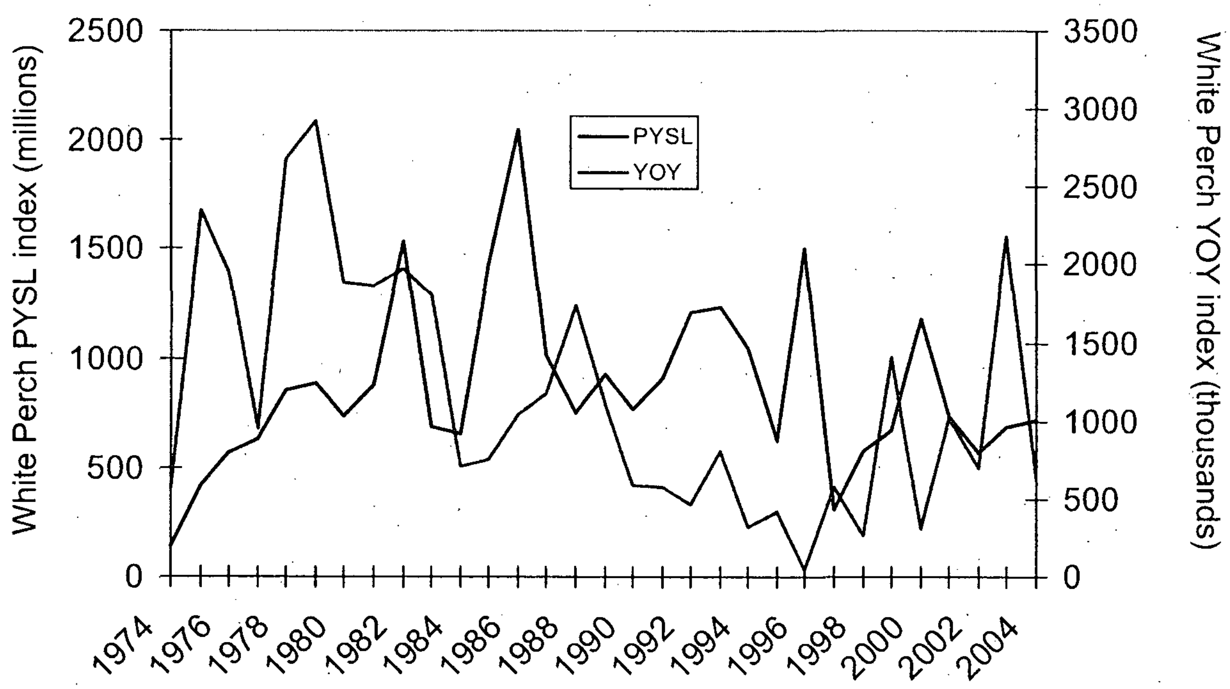


Figure 12a. Relationship between white perch PYSL abundance and YOY abundance.

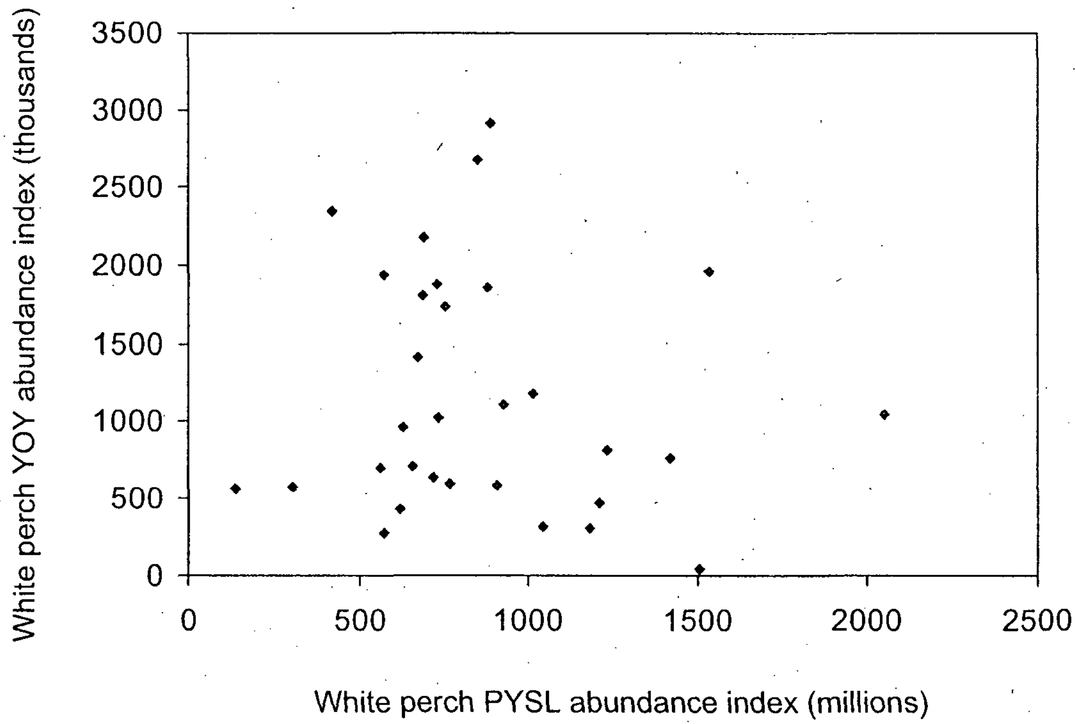


Figure 12b. Relationship between white perch PYSL survival and YOY abundance.

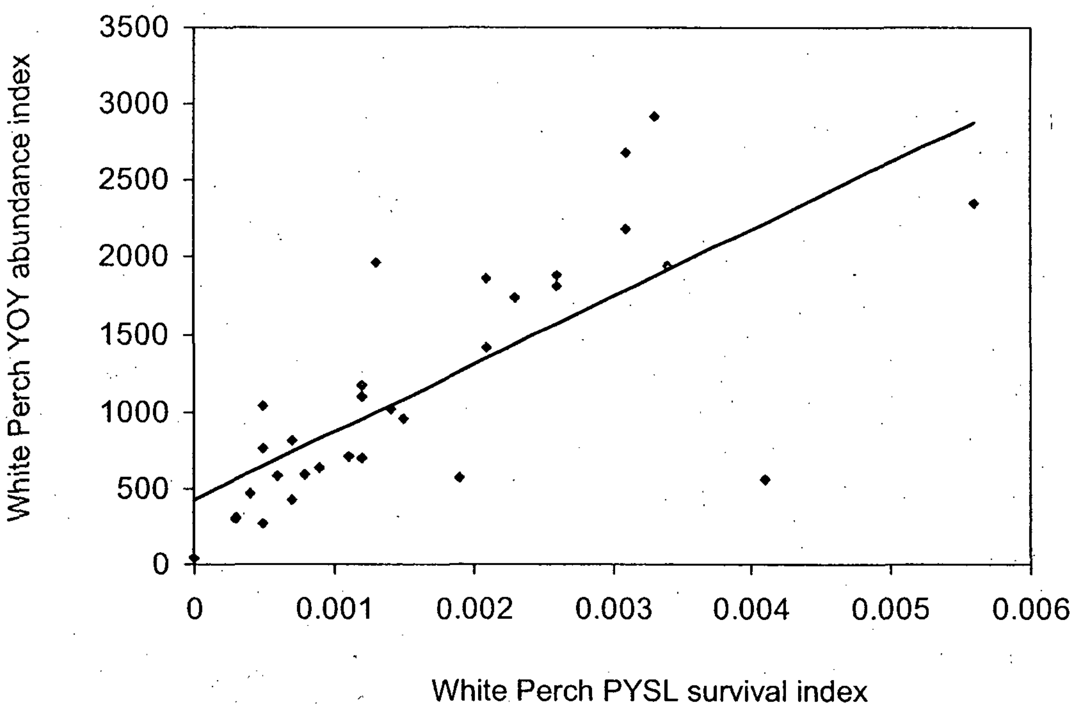


Figure 13a. Relationship between the IP2 and IP3 CMR for white perch and the white perch PYSL survival index.

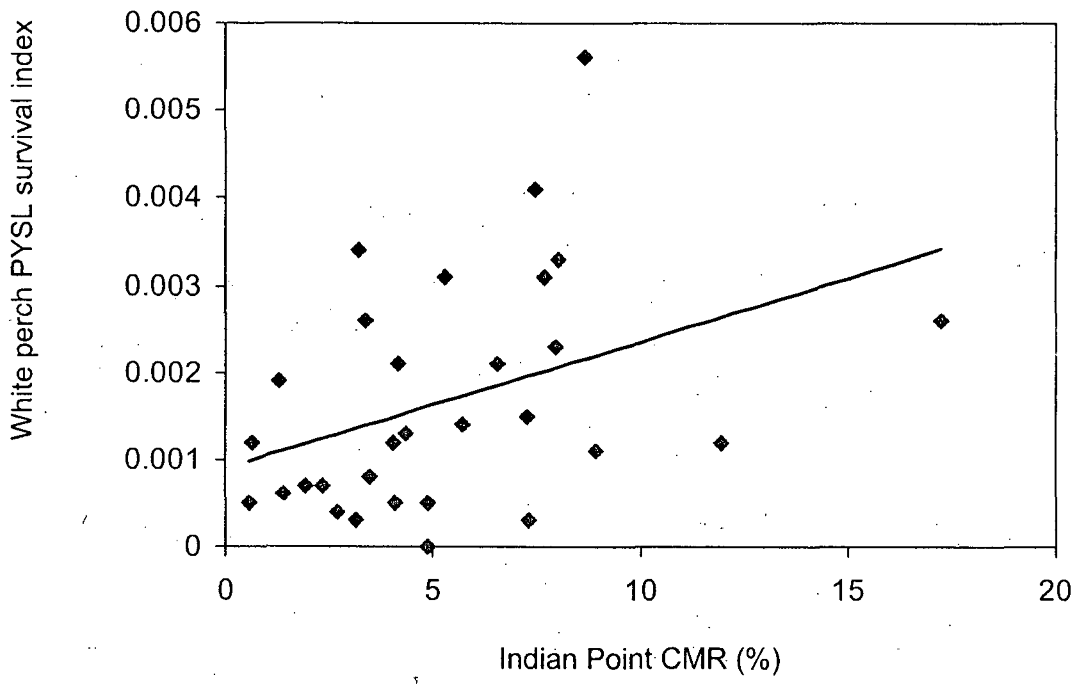


Figure 13b. Relationship between the IP2 and IP3 CMR for white perch and the white perch PYSL abundance index.

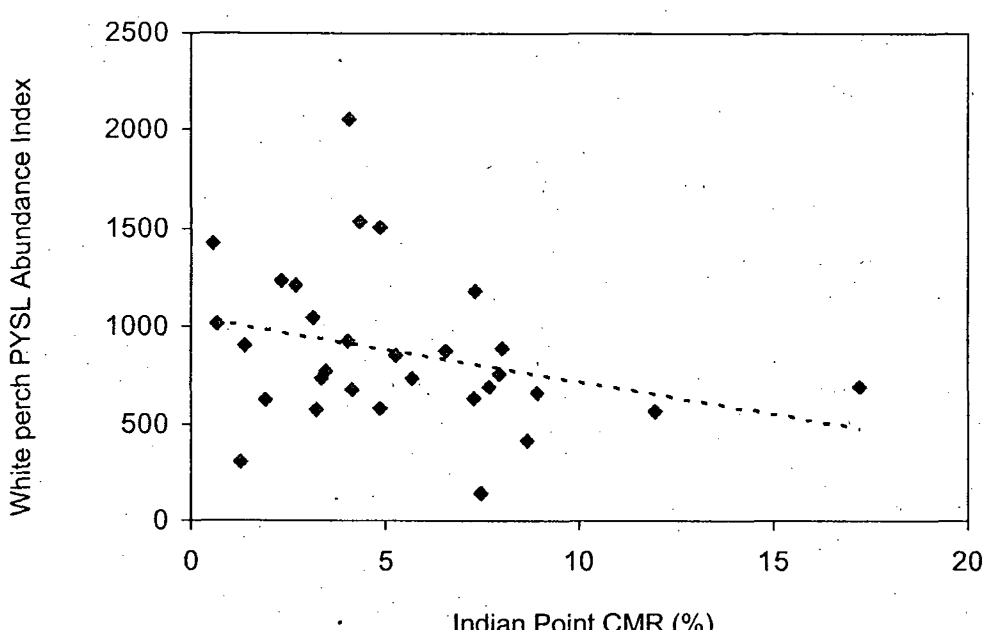


Figure 14. Long-term trends in IP2 and IP3 CMR for white perch and white perch PYSL survival.

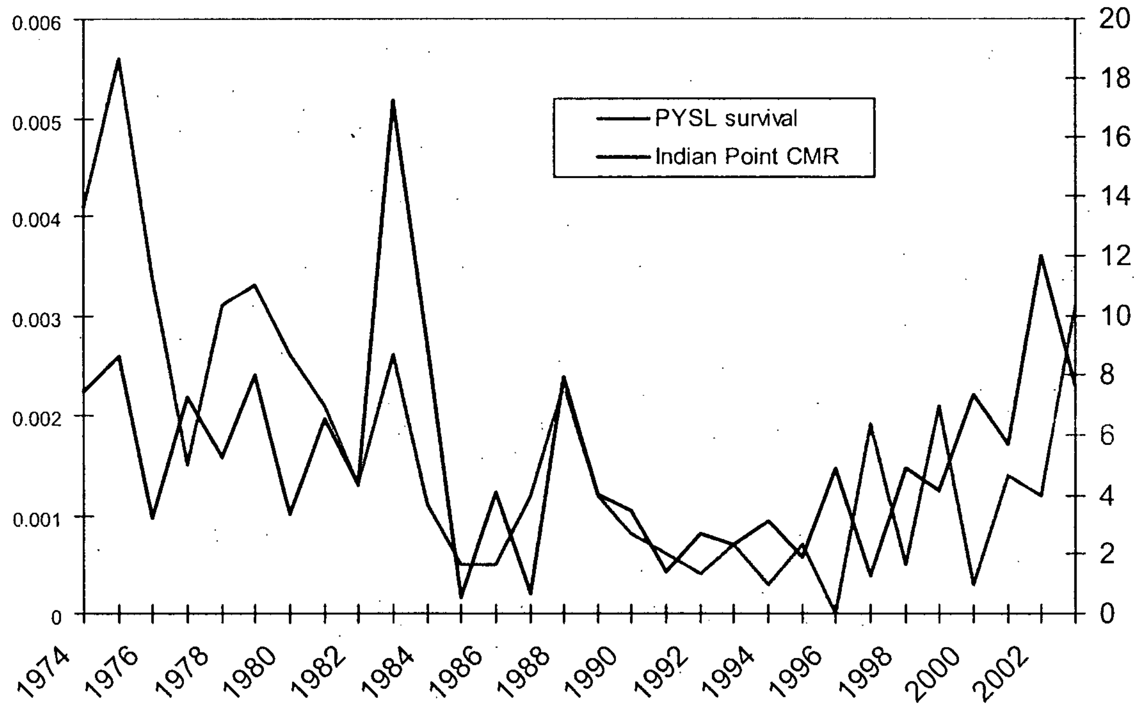
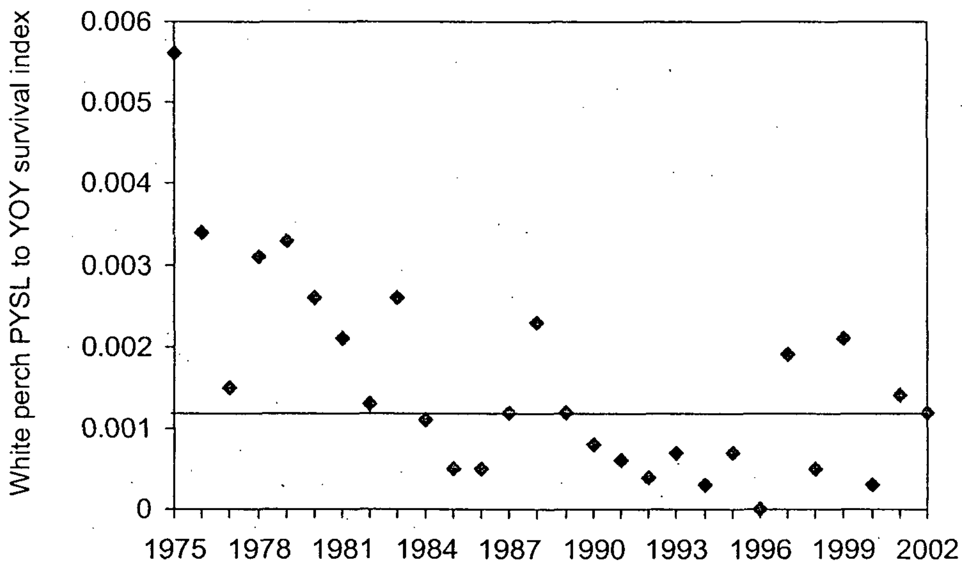


Figure 15. (a) White perch PYSL to YOY survival during years in which 1 unit (blue) and 2 units s(red) at Indian Point were operating during May and June, the peak months during which entrainable life stages of white perch are present in the Hudson River. The horizontal line shows the median survival index value for the time series. (b) Relationship between total May-June withdrawals by IP2 and IP3 and white perch PYSL survival.

(a)



(b)

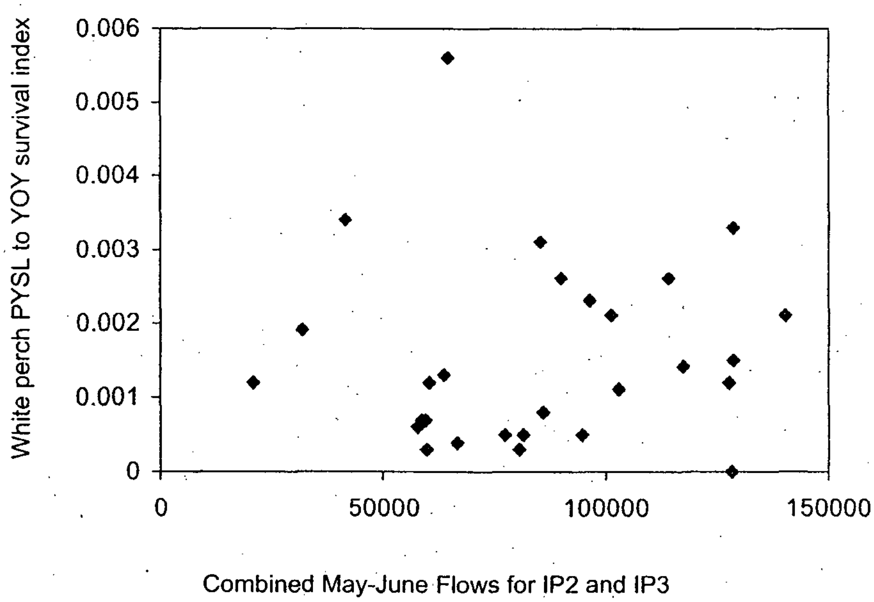


Figure 16a. Relationship between white perch YOY abundance and the striped bass predation index.

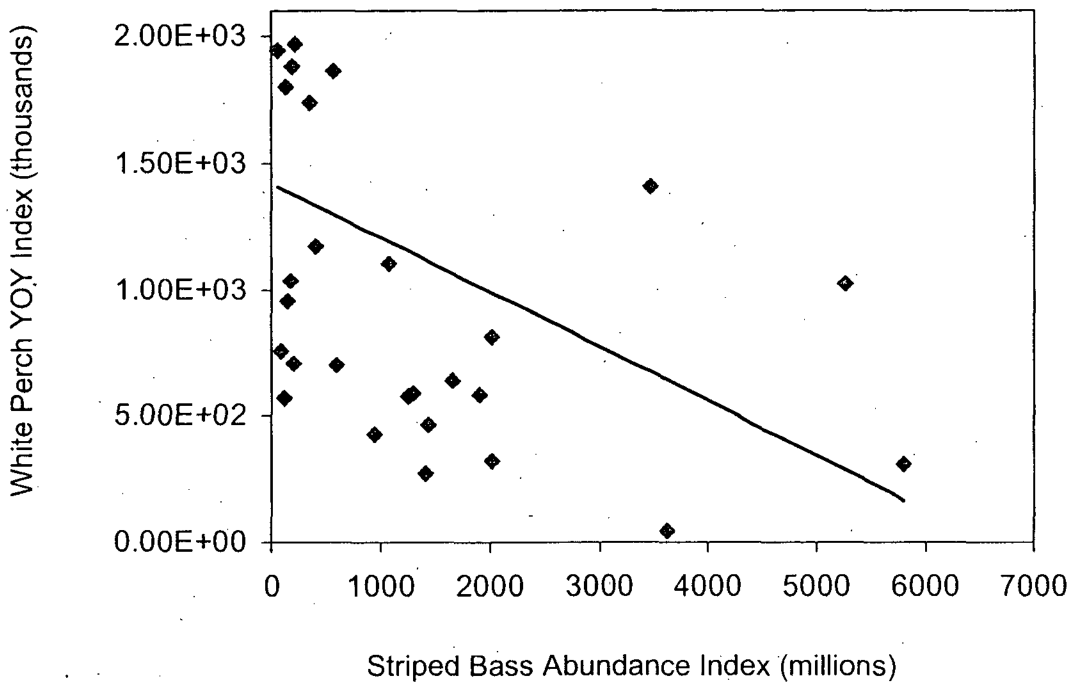


Figure 16b. Long-term trends in white perch YOY abundance and the striped bass predation index.

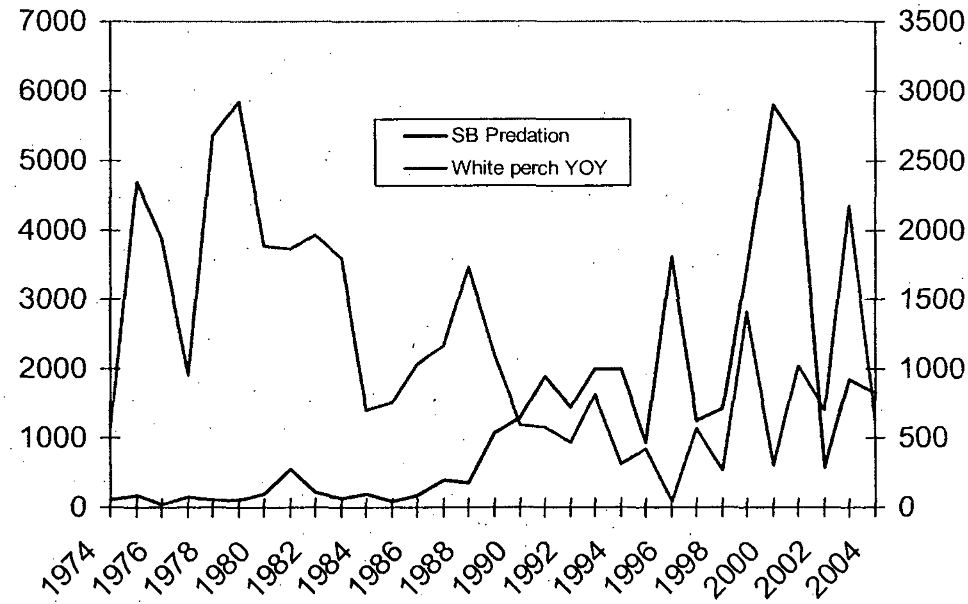


Figure 17. Long-term trends in abundance of American shad PYSL and YOY abundance in the Hudson River.

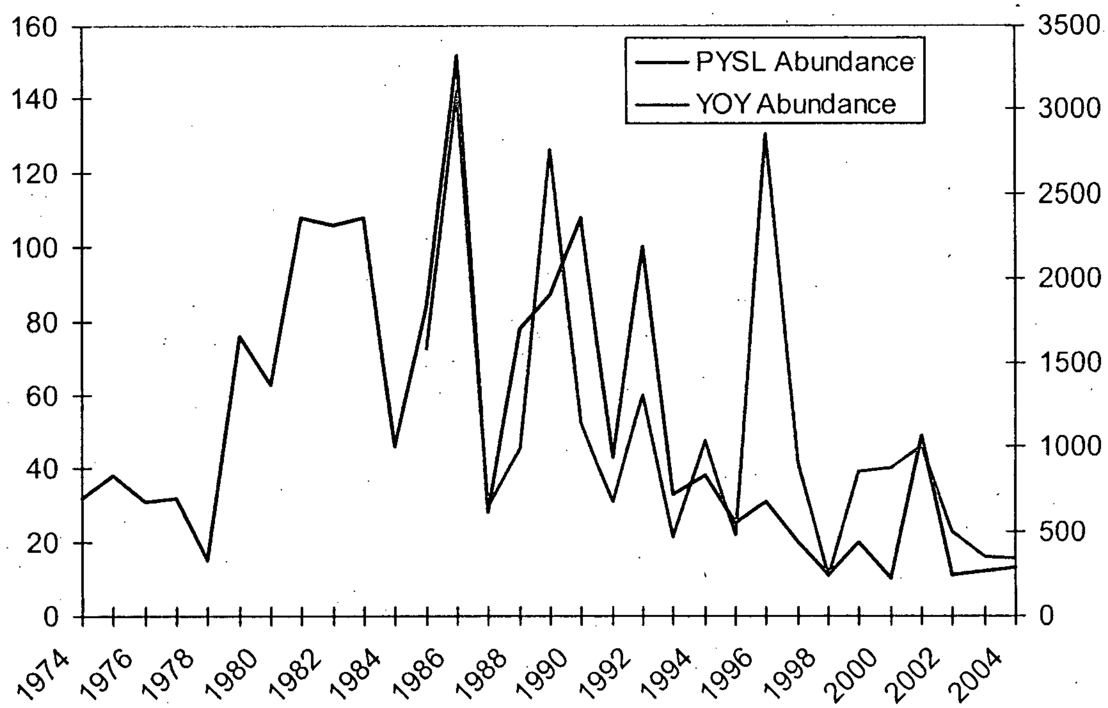


Figure 18a. Relationship between American shad PYSL abundance and YOY abundance in the Hudson River.

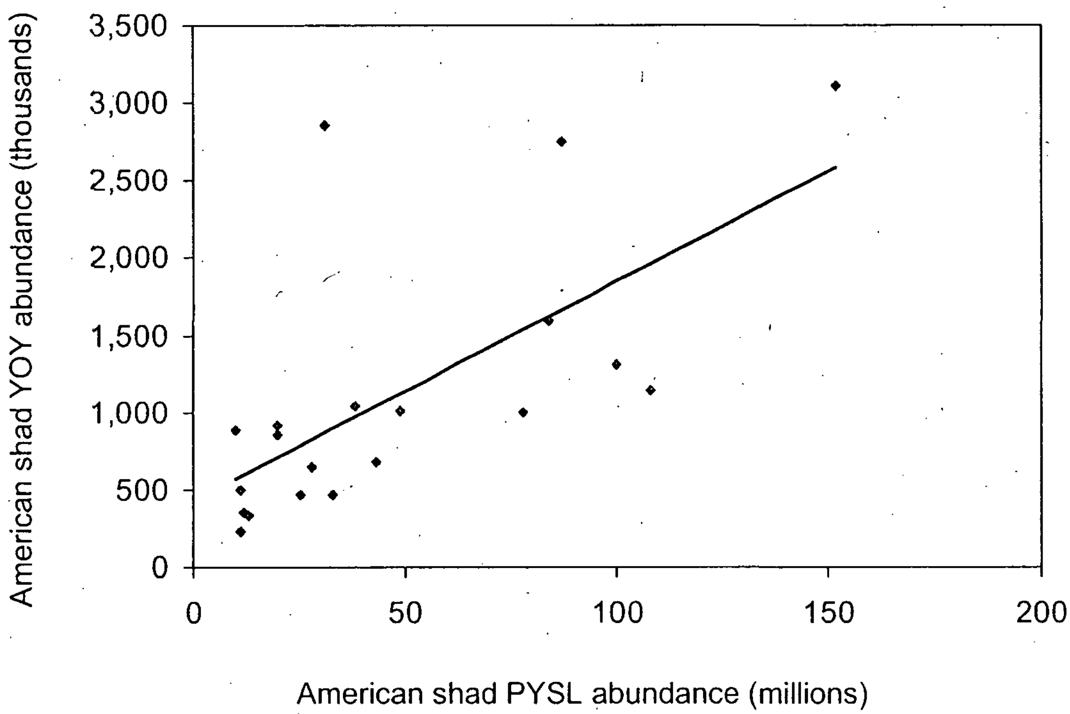


Figure 18b. Relationship between American shad PYSL survival and YOY abundance in the Hudson River.

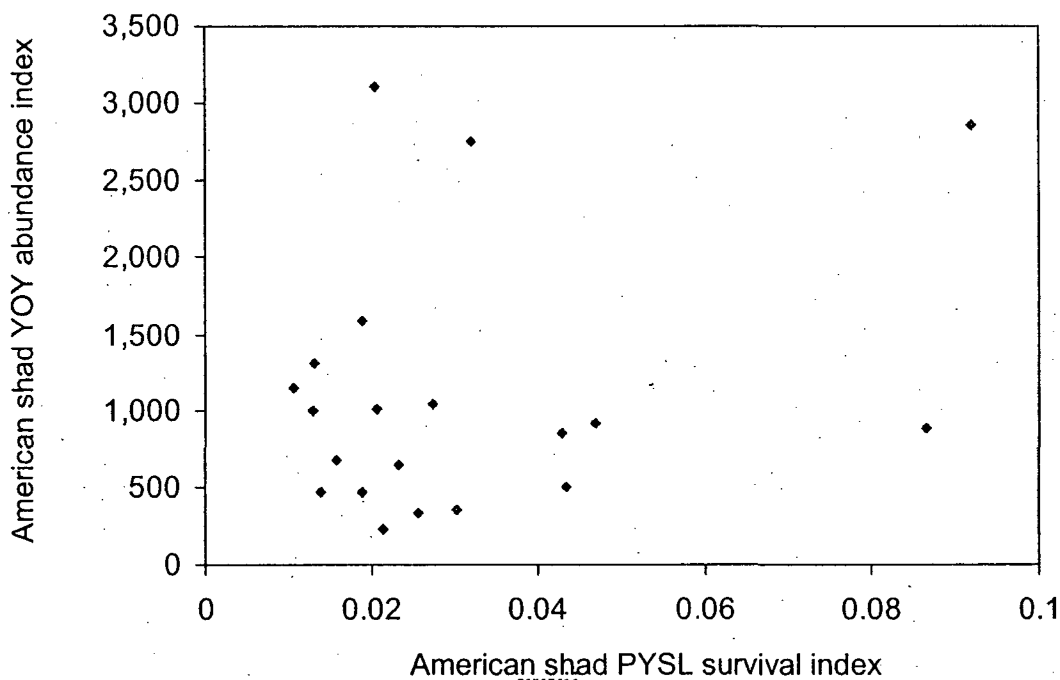


Figure 19a. Relationship between the IP2 and IP3 CMR for American shad and American shad PYSL survival.

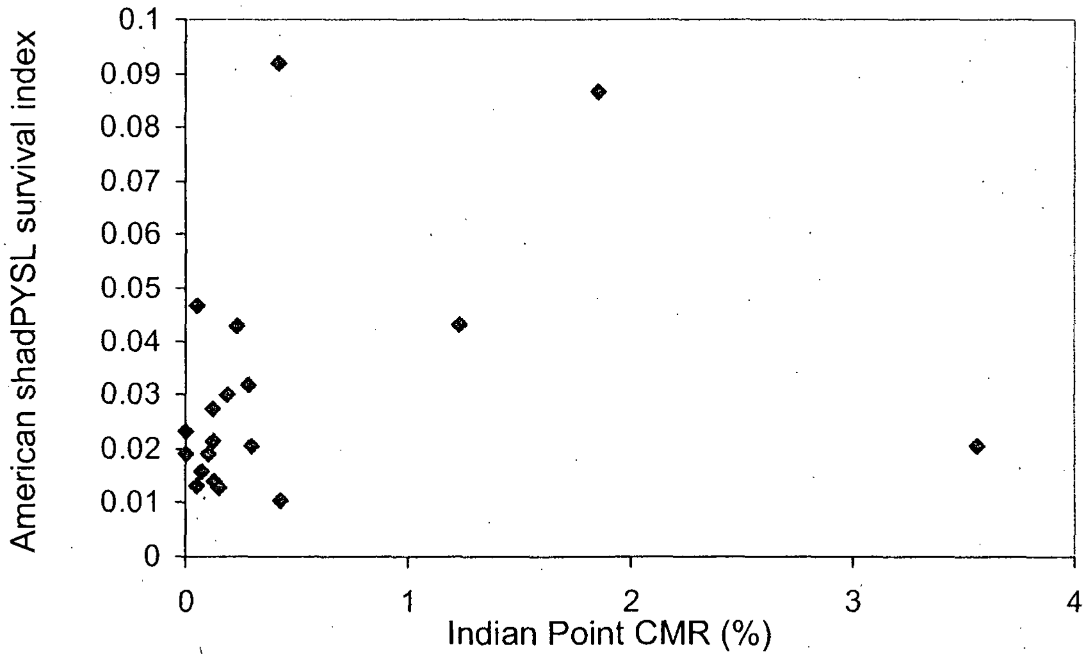


Figure 19b. Relationship between the IP2 and IP3 CMR for American shad and American shad PYSL abundance.

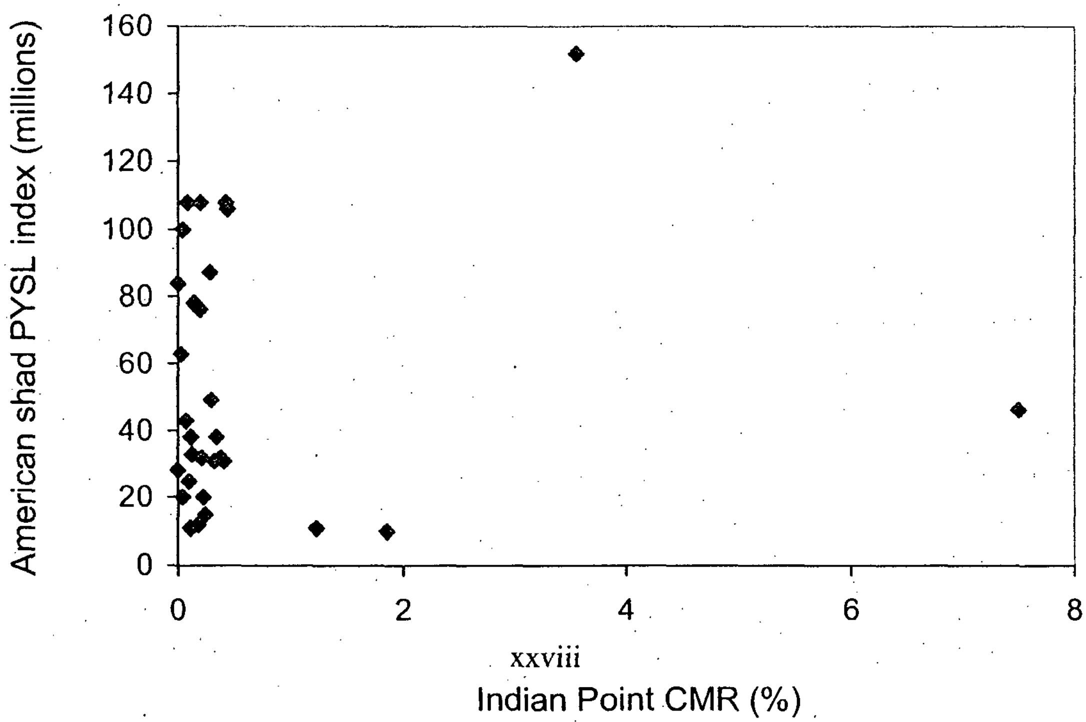
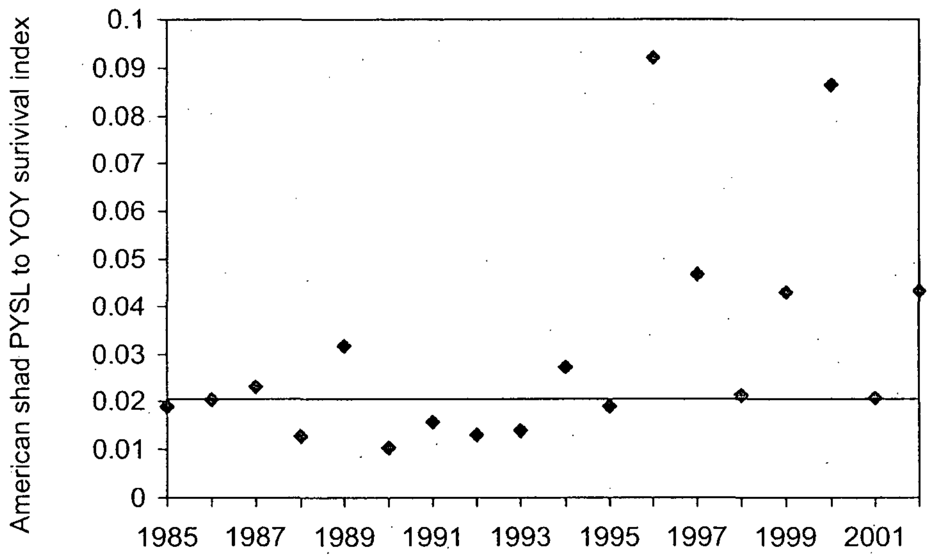


Figure 20. (a) American shad PYSL to YOY survival during years in which 1 unit (blue) and 2 units s(red) at Indian Point were operating during May and June, the peak months during which entrainable life stages of American shad are present in the Hudson River. The horizontal line shows the median survival index value for the time series. (b) Relationship between total May-June withdrawals by IP2 and IP3 and American shad PYSL survival.

(a)



(b)

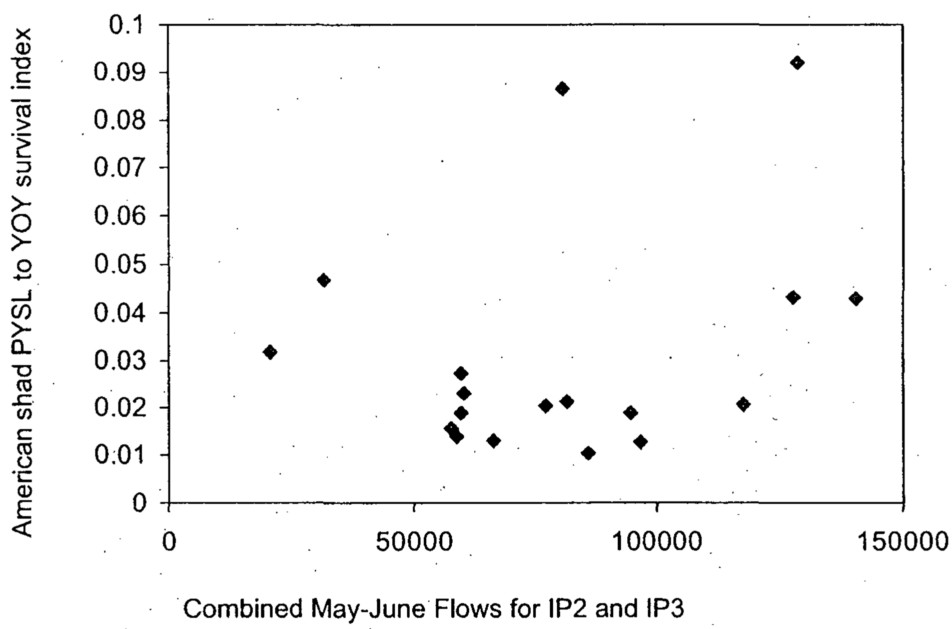


Figure 21a. Relationship between American shad PYSL abundance and the striped bass predation index.

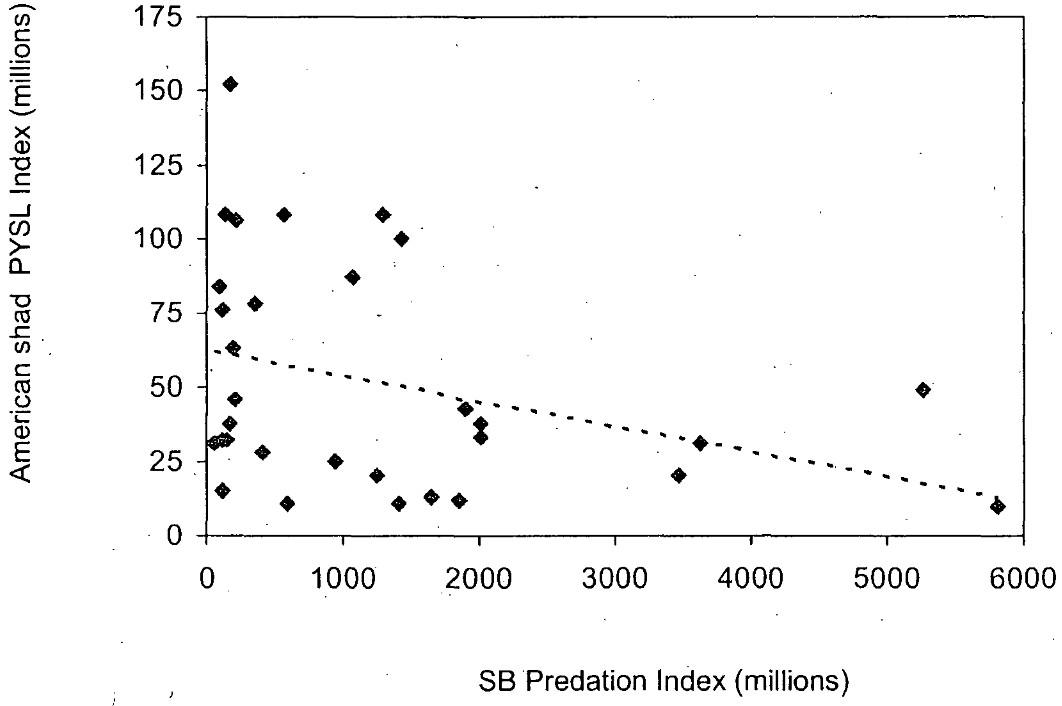


Figure 21b. Relationship between American shad YOY abundance and the striped bass predation index.

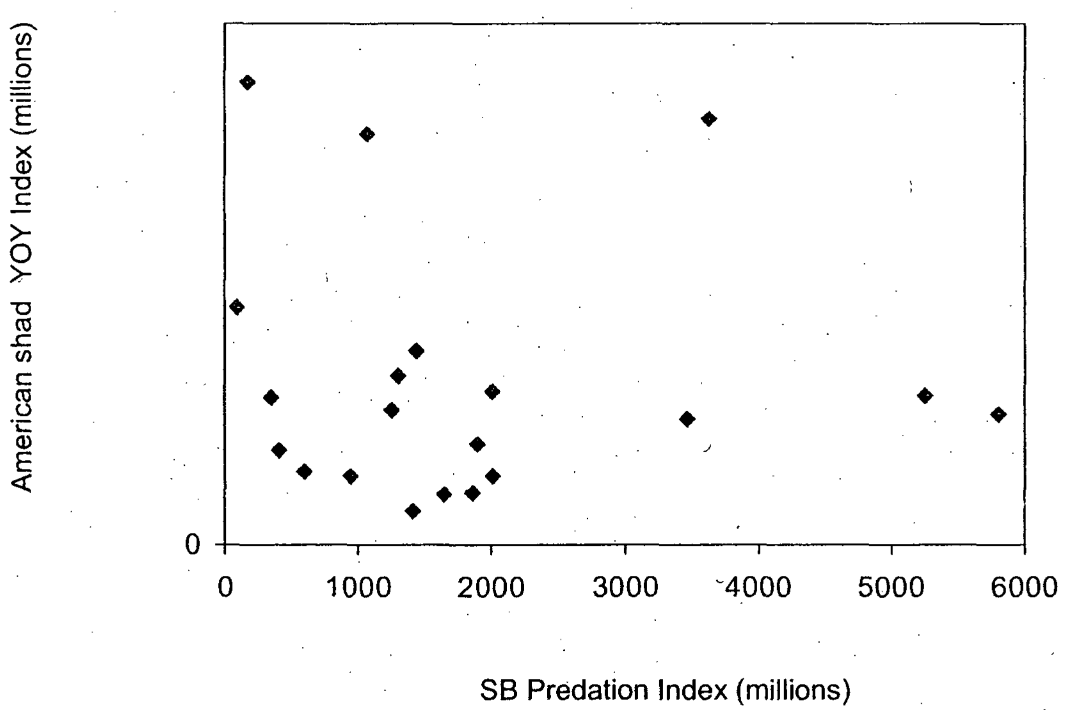


Figure 22. Long-term trends in American shad PYSL abundance and in the striped bass predation index.

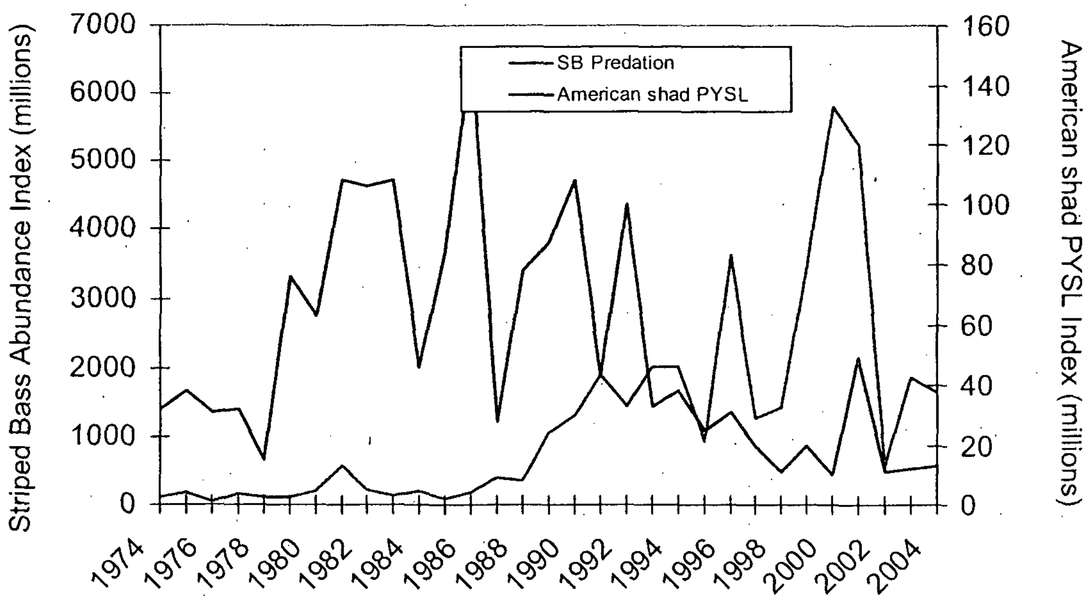


Figure 23. Long-term trends in the abundance of Atlantic tomcod in the Hudson River.

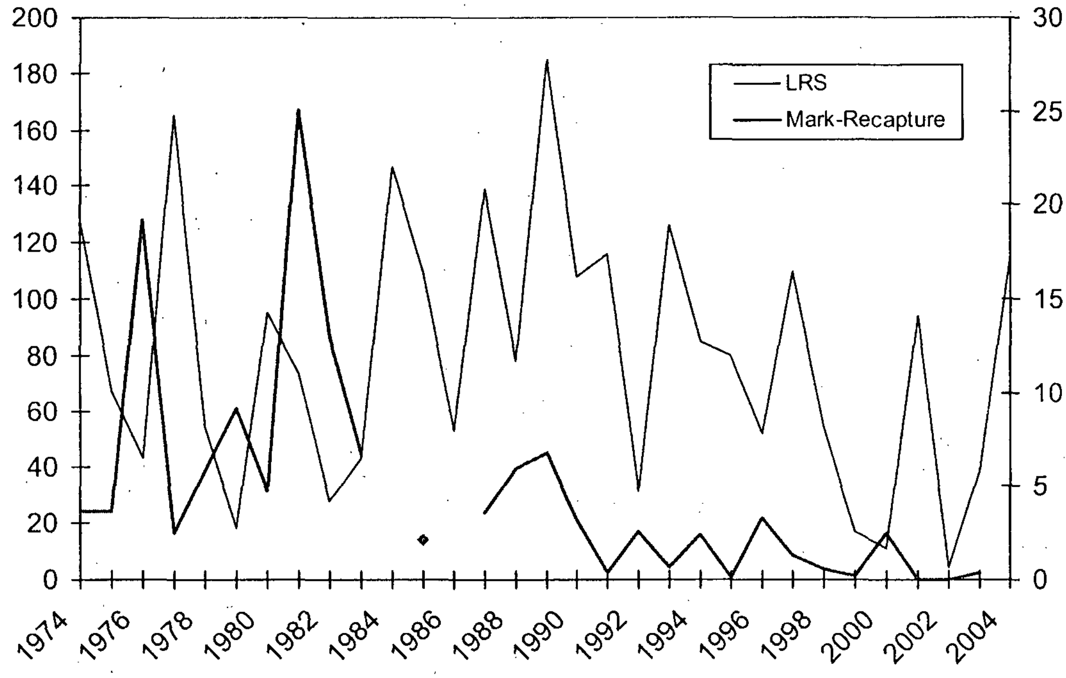


Figure 24a. Relationship between Atlantic tomcod egg deposition and resulting age 1 abundance.

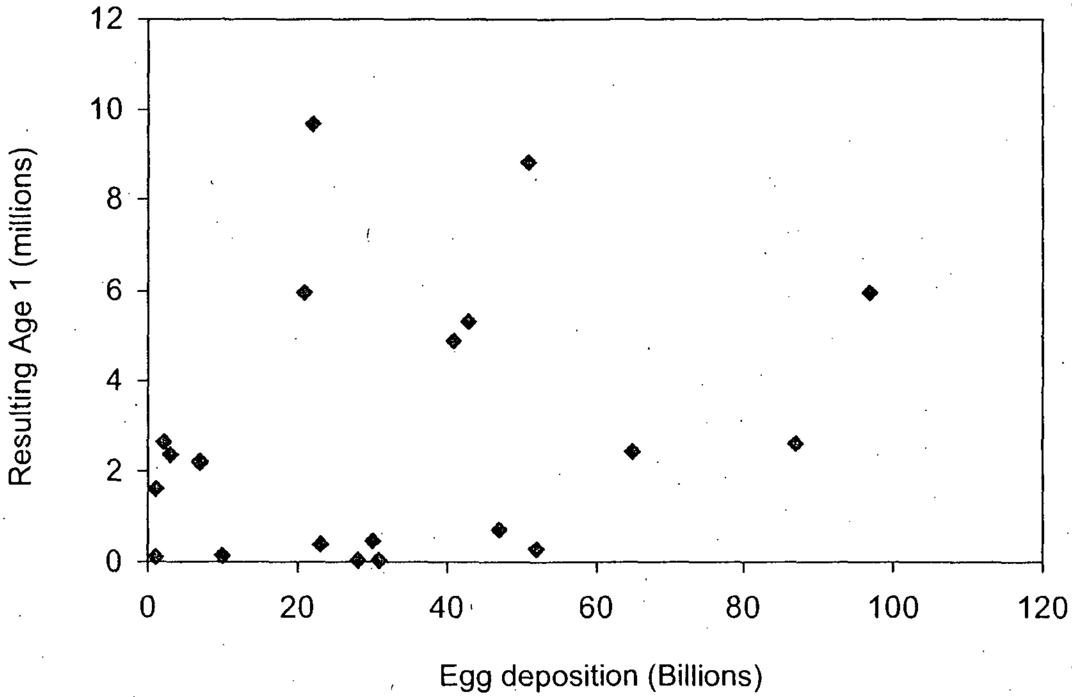


Figure 24b. Relationship between Atlantic tomcod egg to age 1 survival and age 1 abundance.

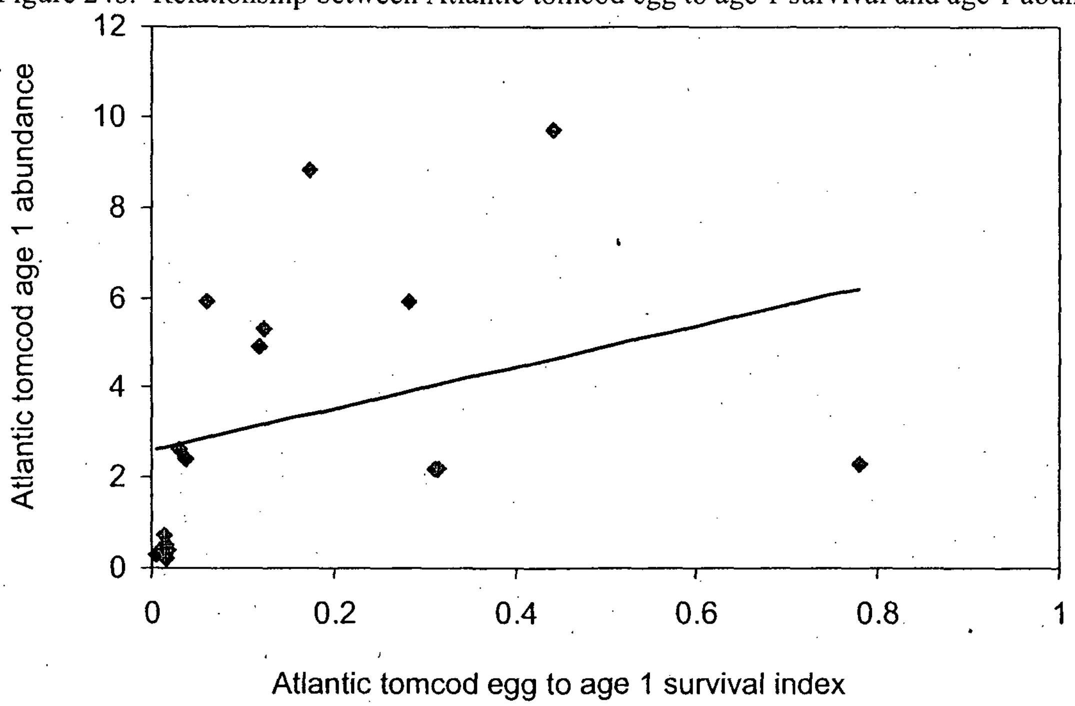


Figure 25a. Relationship between IP2 and IP3 CMR and Atlantic tomcod egg to age 1 survival.

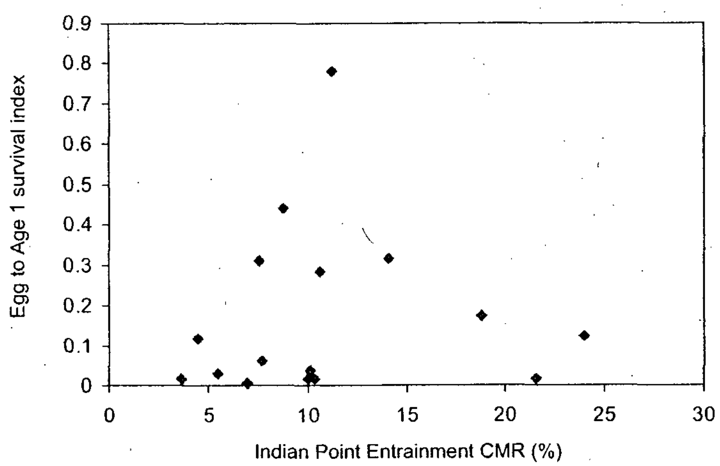


Figure 25b. Relationship between IP2 and IP3 CMR and Atlantic tomcod LRS index.

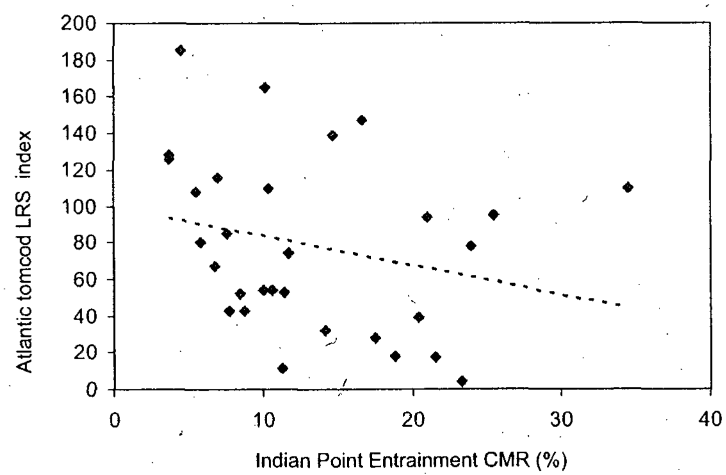


Figure 25c. Relationship between IP2 and IP3 CMR and Atlantic tomcod mark-recapture index

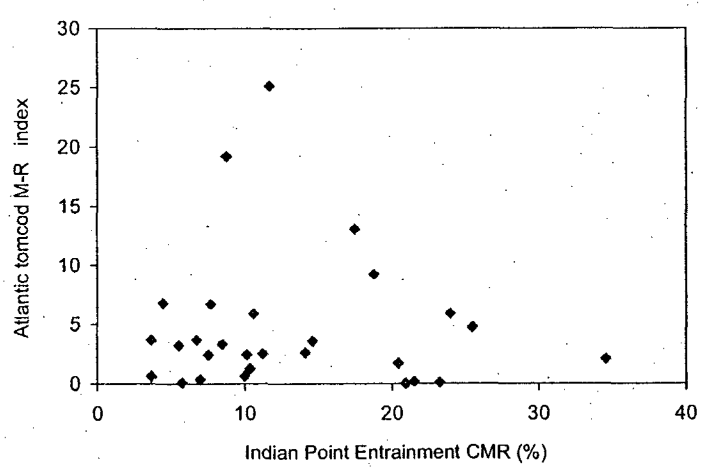
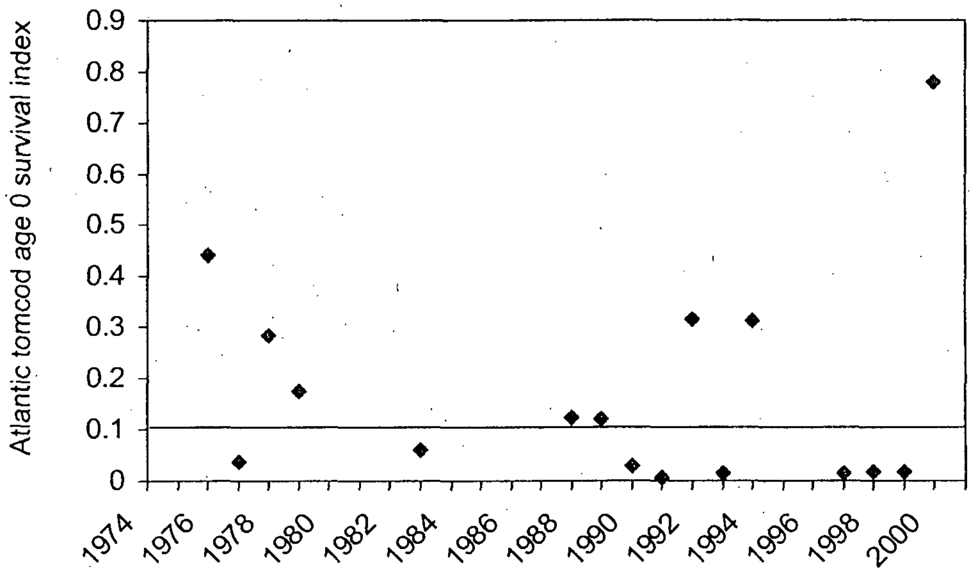


Figure 26. (a) Atlantic tomcod age 0 survival during years in which 1 unit (blue) and 2 units (red) at Indian Point were operating during May and June, the peak months during which entrainable life stages of Atlantic tomcod are present in the Hudson River. The horizontal line shows the median survival index value for the time series. (b) Relationship between combined IP2 and IP3 May-June withdrawals and Atlantic tomcod egg to age 1 survival.

(a)



(b)

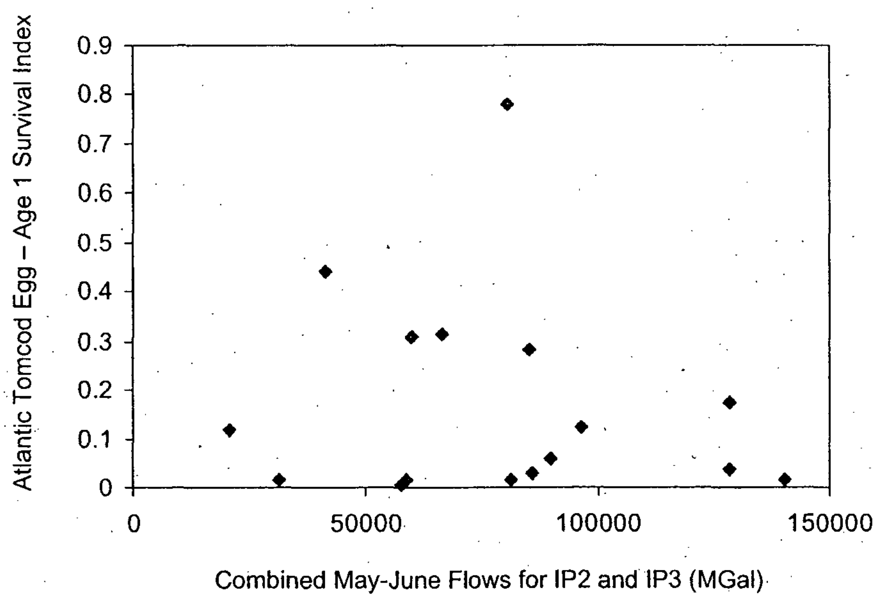


Figure 27. Comparison of long-term trends in the PWW degree-day index to long-term trends in the abundance of age 1 and age 2 Atlantic tomcod.

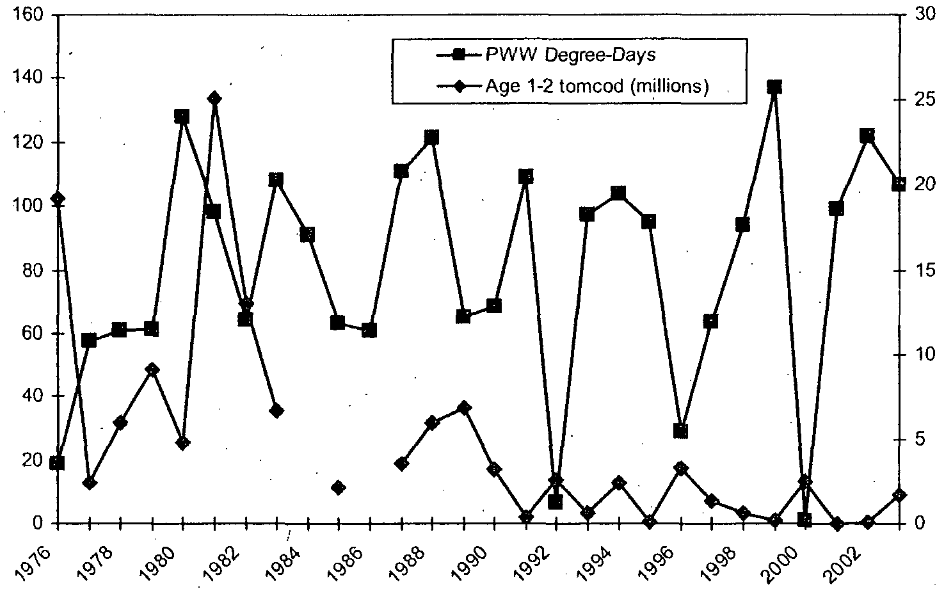


Figure 28a. Relationship between the striped bass predation index and the Atlantic tomcod LRS index.

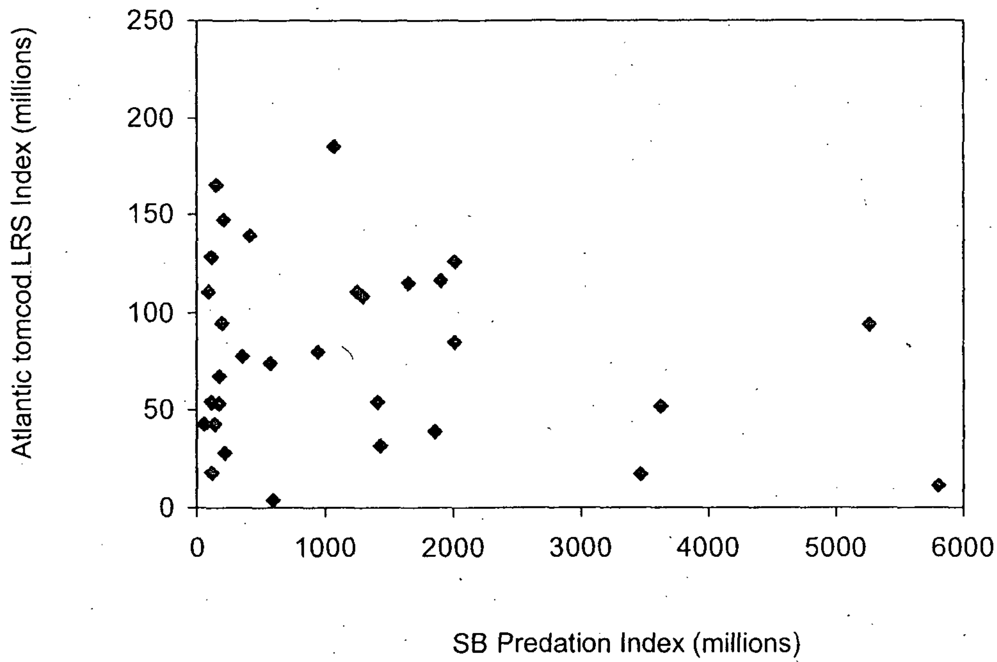


Figure 28b. Relationship between the striped bass predation index and the Atlantic tomcod mark-recapture index.

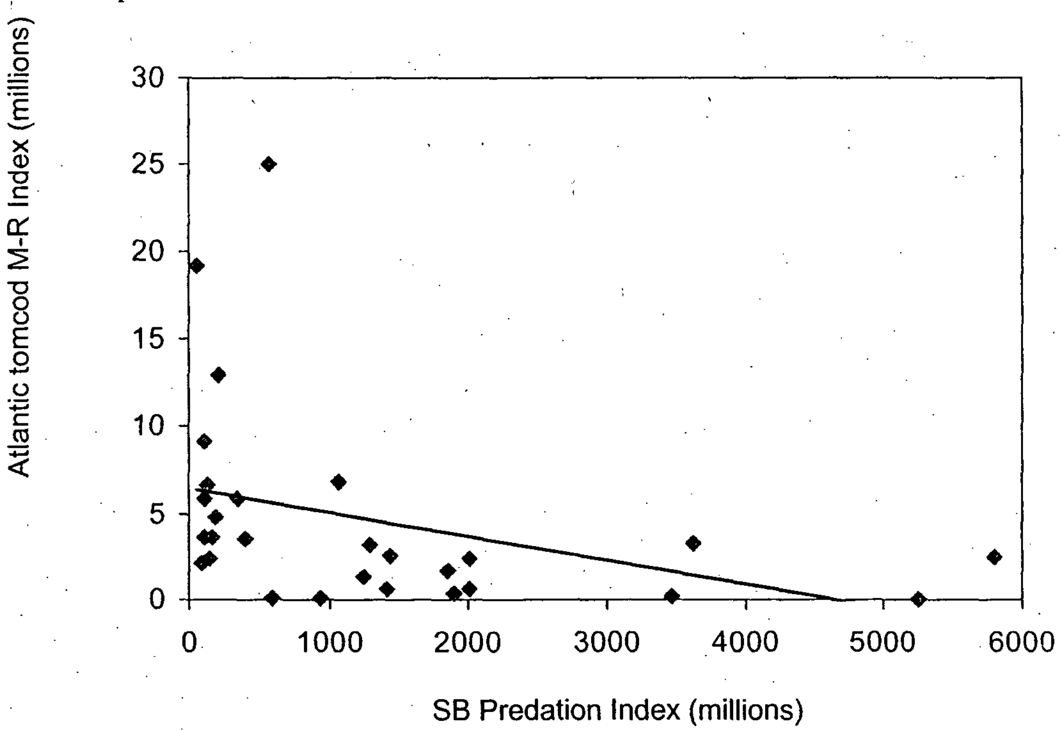


Figure 29a. Long-term trends in the Atlantic tomcod LRS index and the striped bass predation index.

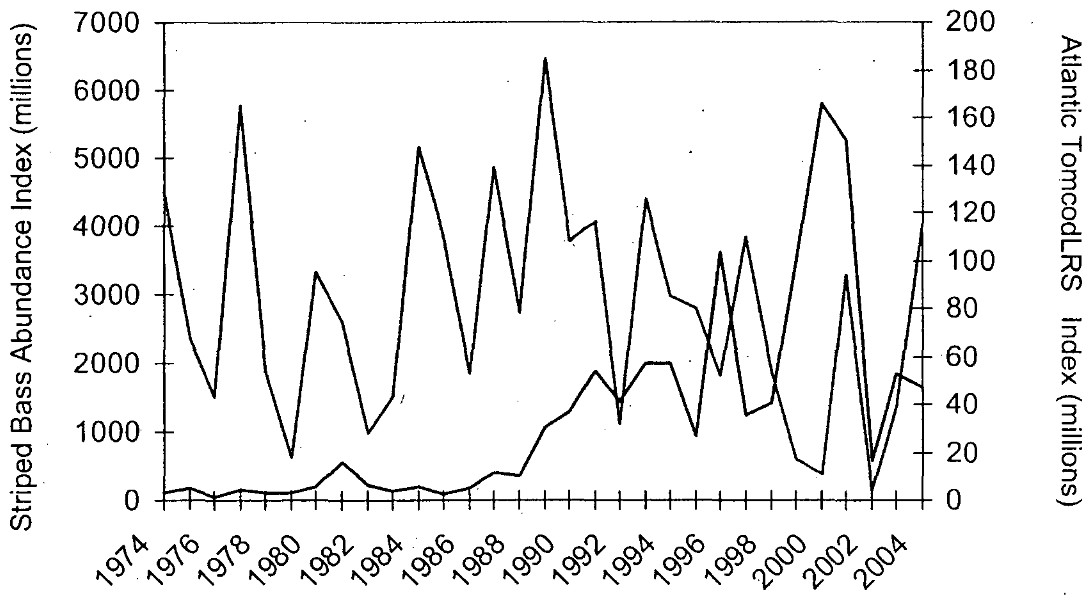


Figure 29b. Long-term trends in the Atlantic tomcod mark-recapture index and the striped bass predation index.

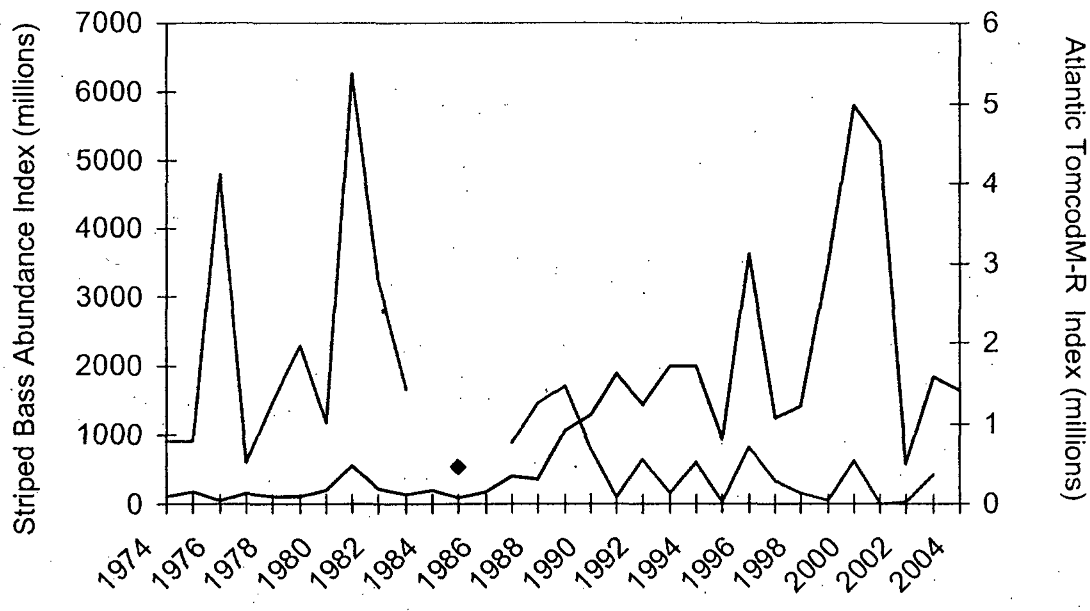


Figure 30a. Long-term trend in abundance of river herring PYSL in the Hudson River.

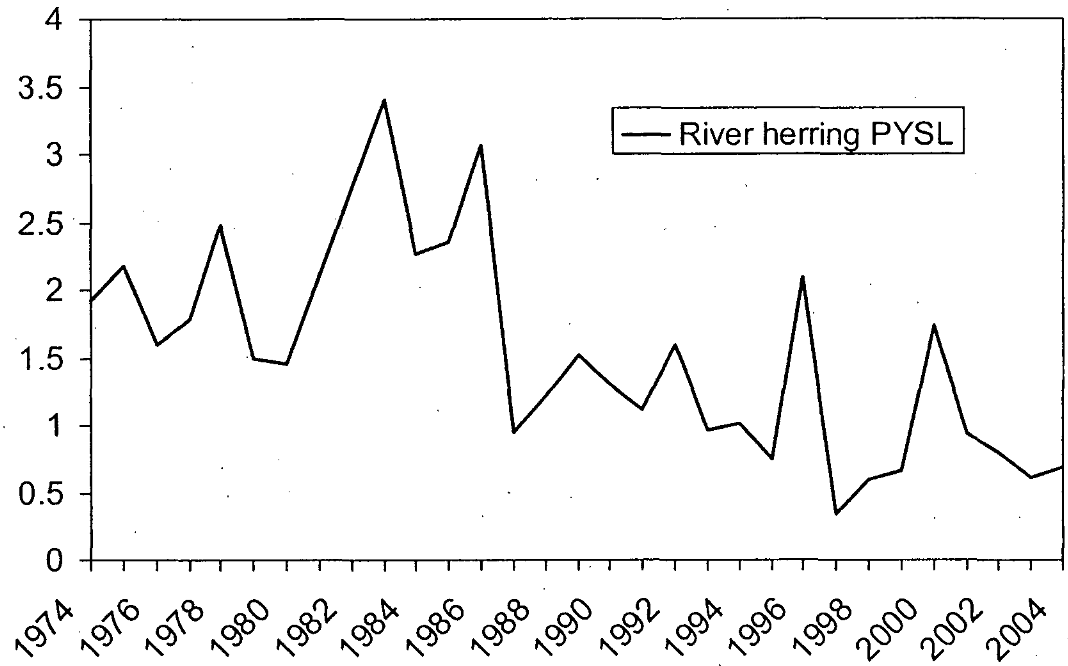


Figure 30b. Long-term trends in abundance of alewife and blueback herring YOY in the Hudson River.

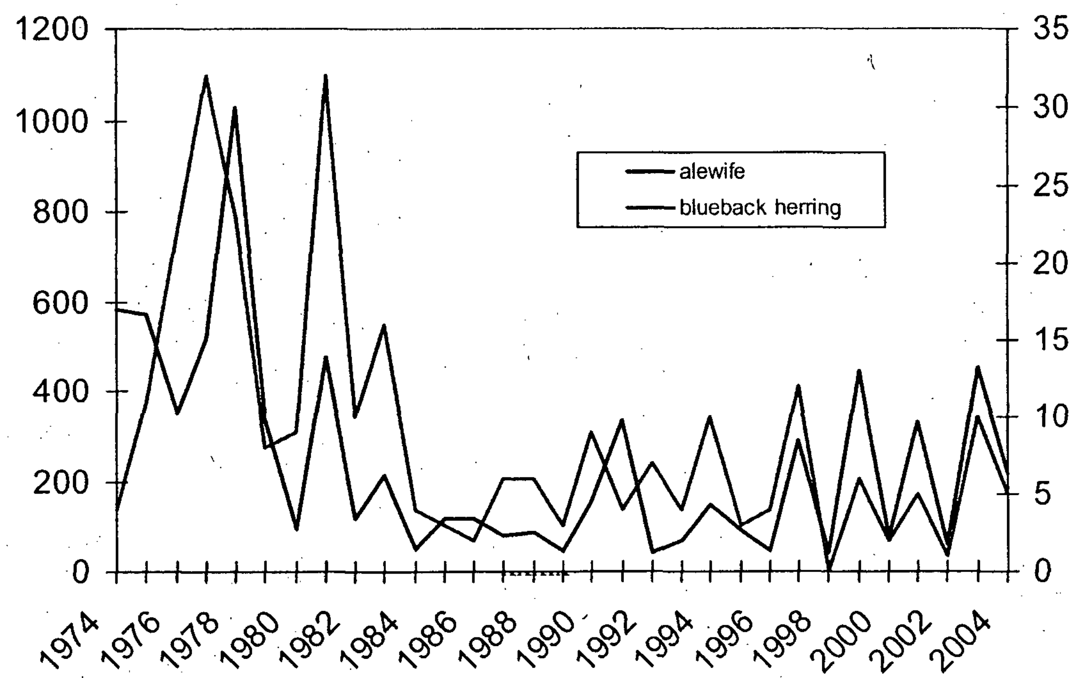


Figure 31a. Relationship between the IP2 and IP3 CMR and river herring PYSL survival.

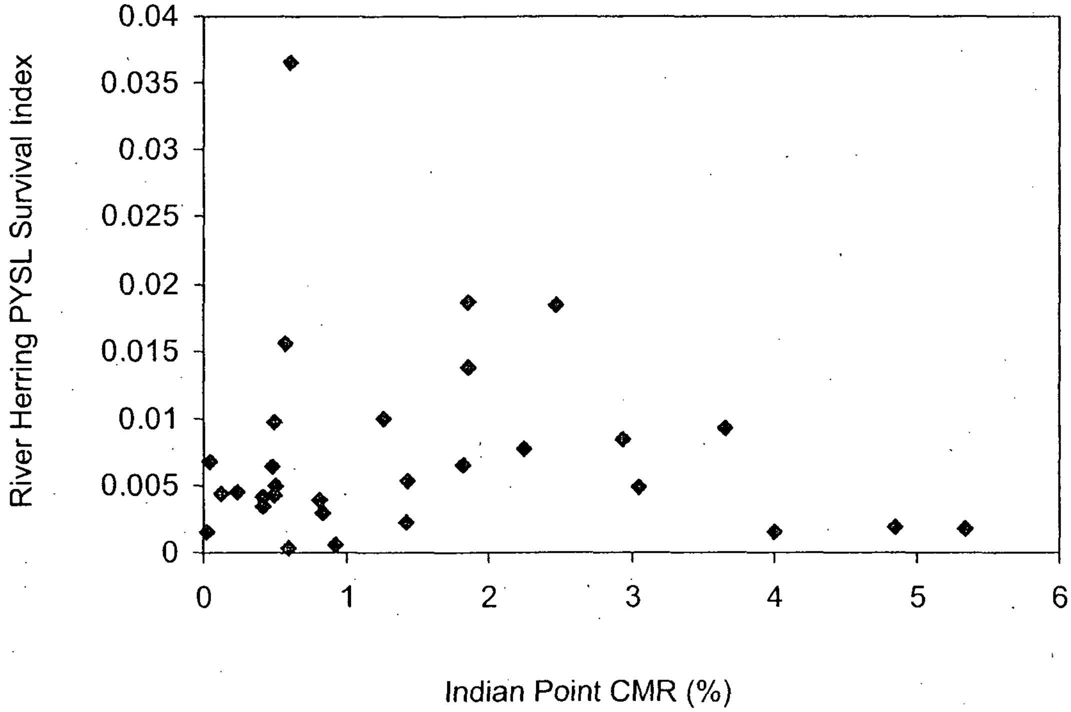


Figure 31b. Relationship between the IP2 and IP3 CMR and river herring PYSL abundance.

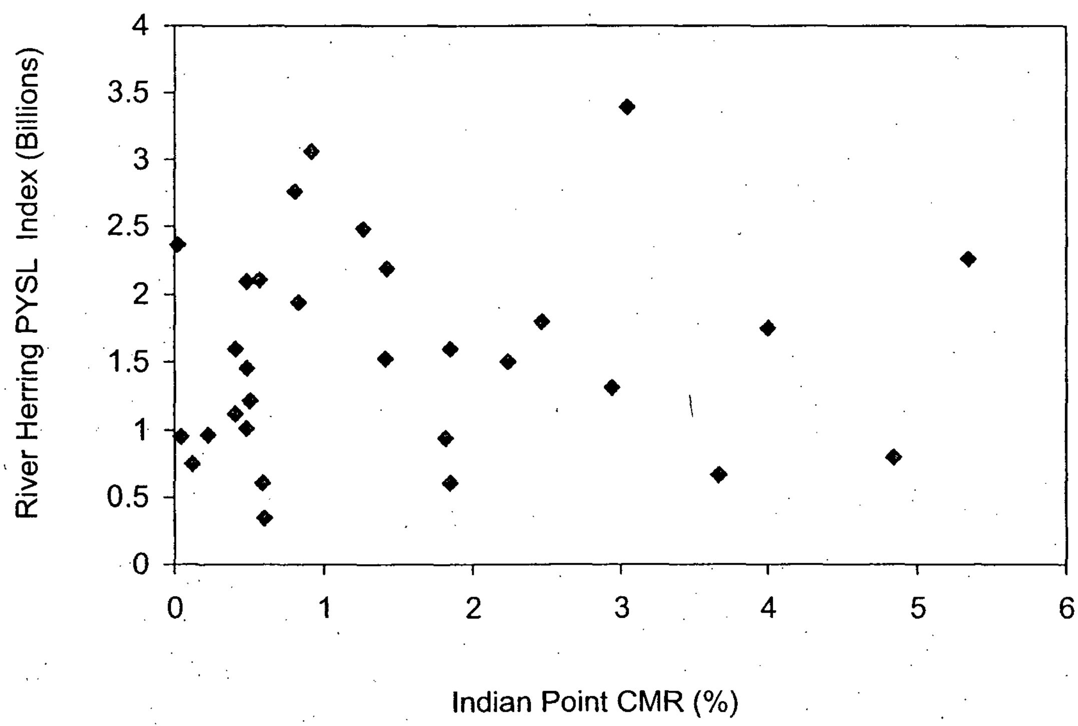


Figure 32a. Relationship between the IP2 and IP3 CMR and alewife YOY abundance.

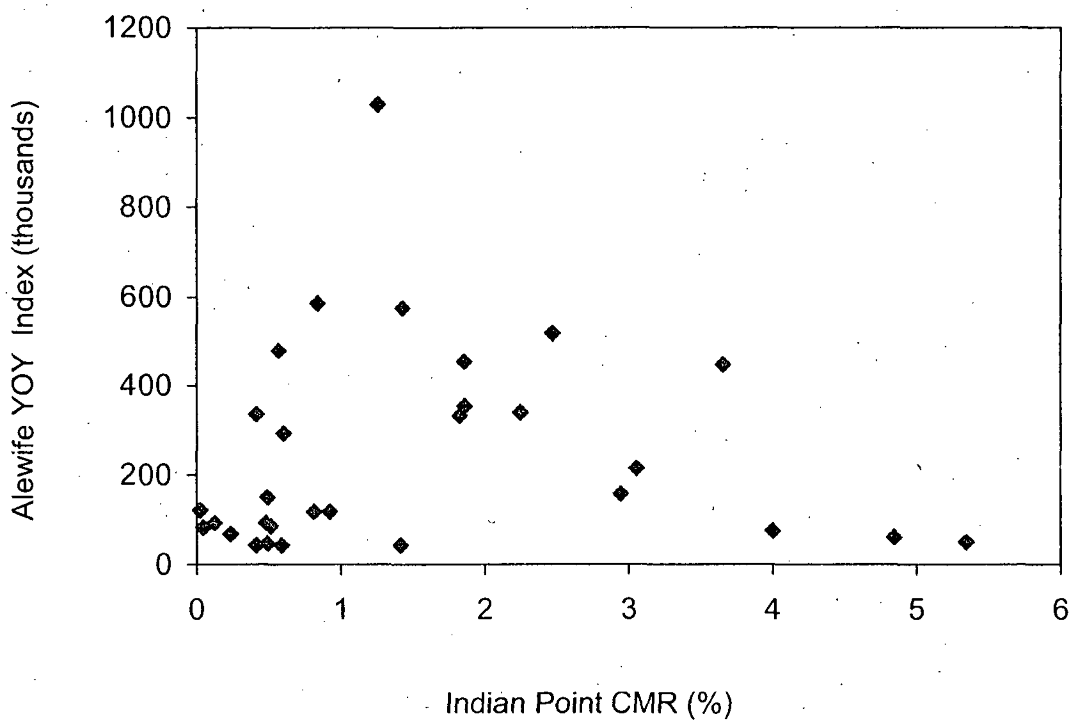


Figure32b. Relationship between the IP2 and IP3 CMR and blueback herring YOY abundance.

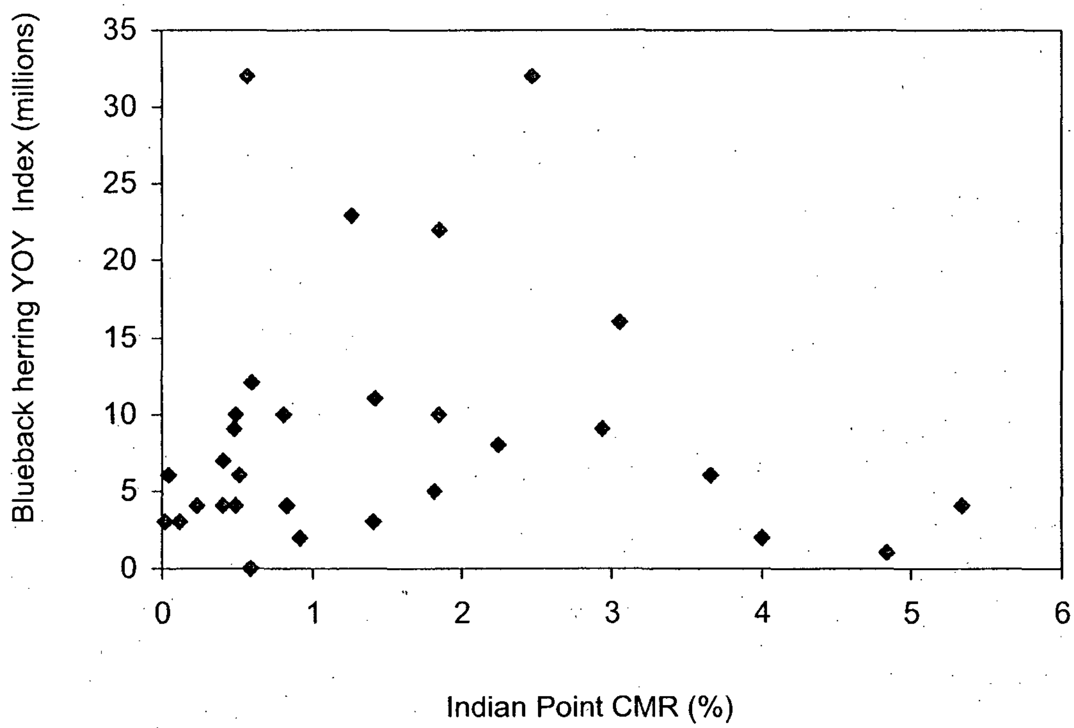
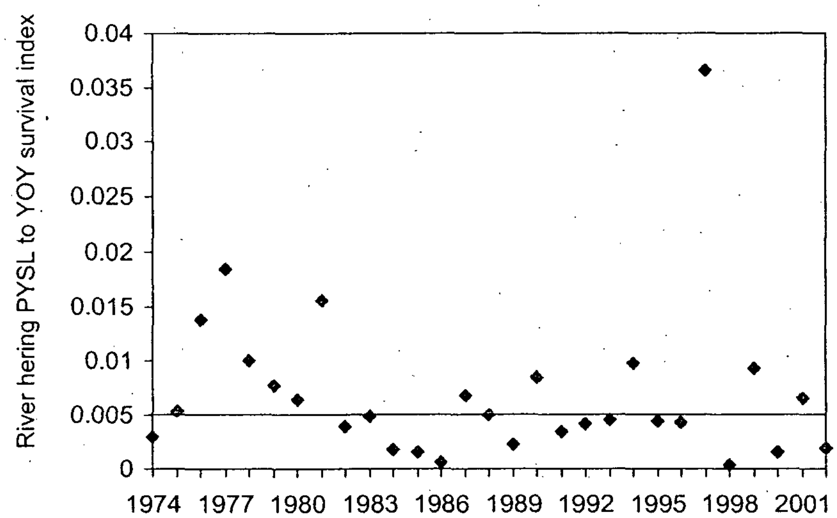


Figure 33. (a) River herring (alewife and blueback herring) PYSL to YOY survival during years in which 1 unit (blue) and 2 units (red) at Indian Point were operating during May and June, the peak months during which entrainable life stages of river herring are present in the Hudson River. The horizontal line shows the median survival index value for the time series. (b) Relationship between IP2 and IP3 May-June water withdrawals and river herring PYSL survival.

(a)



(b)

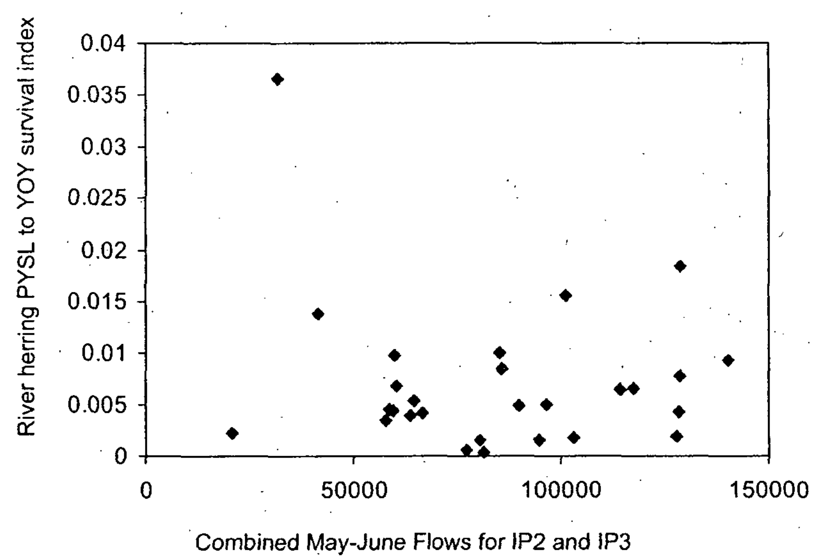


Figure 34a. Relationship between the striped bass predation index and river herring PYSL abundance.

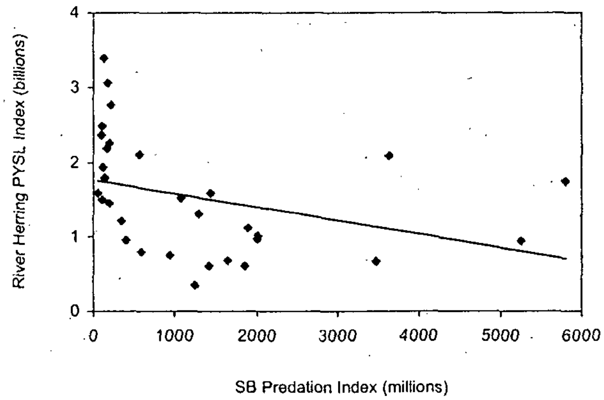


Figure 34b. Relationship between the striped bass predation index and alewife YOY abundance.

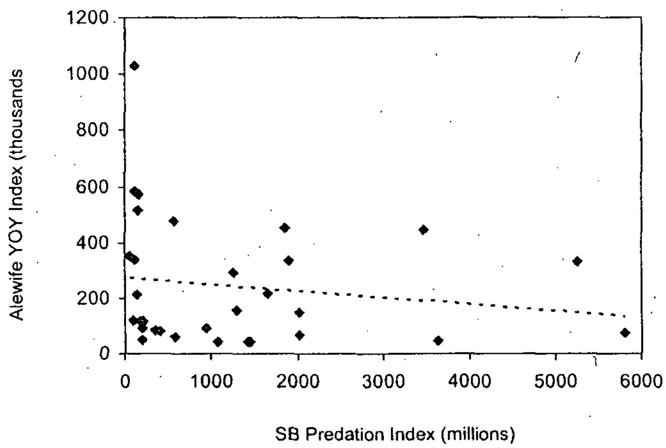


Figure 34c. Relationship between the striped bass predation index and blueback herring YOY abundance.

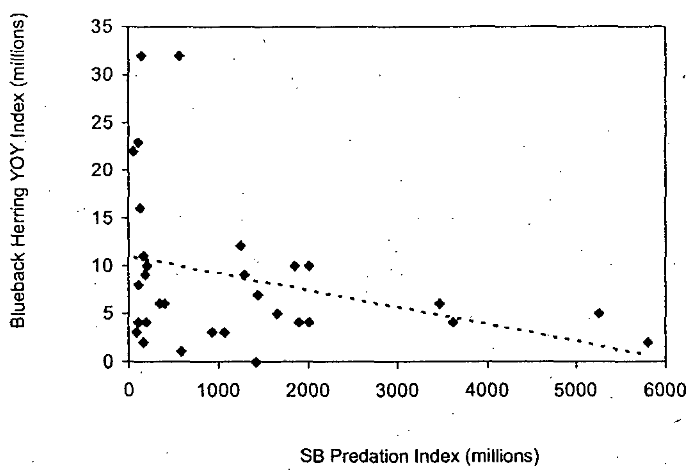


Figure 35a. Long-term trends in river herring PYSL abundance and in the striped bass predation index.

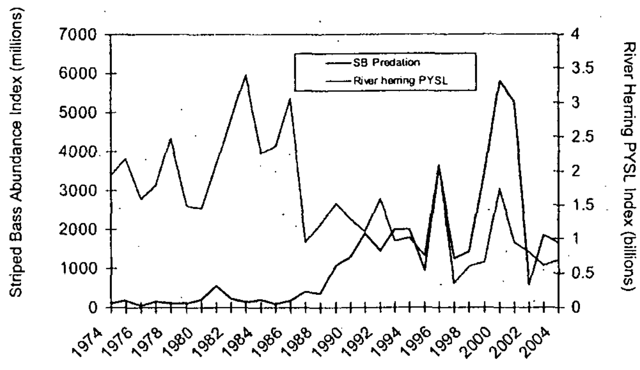


Figure 35b. Long-term trends in alewife YOY abundance and in the striped bass predation index.

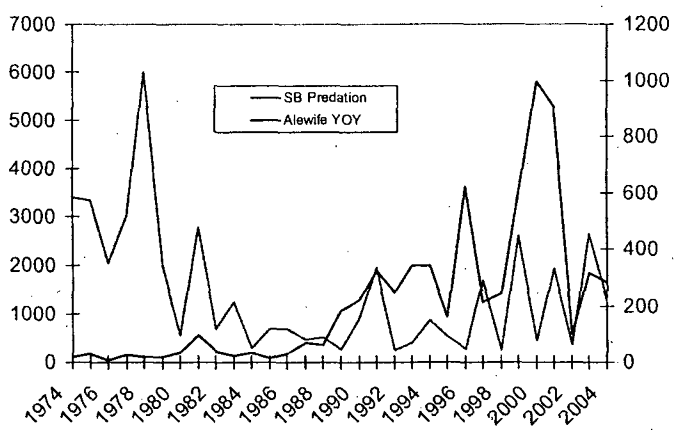


Figure 35c. Long-term trends in blueback herring YOY abundance and in the striped bass predation index.

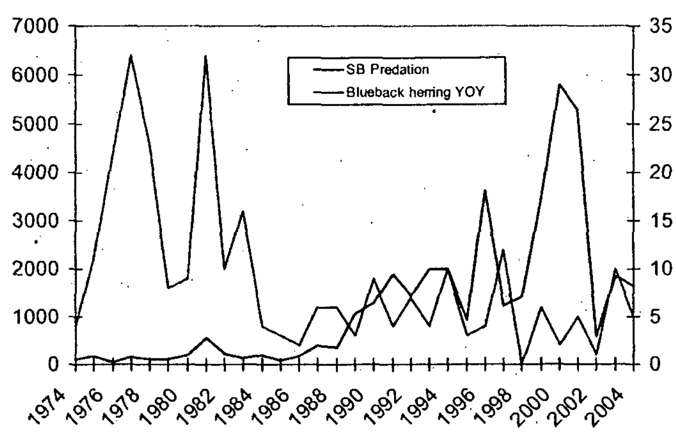


Figure 36. Long-term trends in abundance of bay anchovy PYSL and YOY.

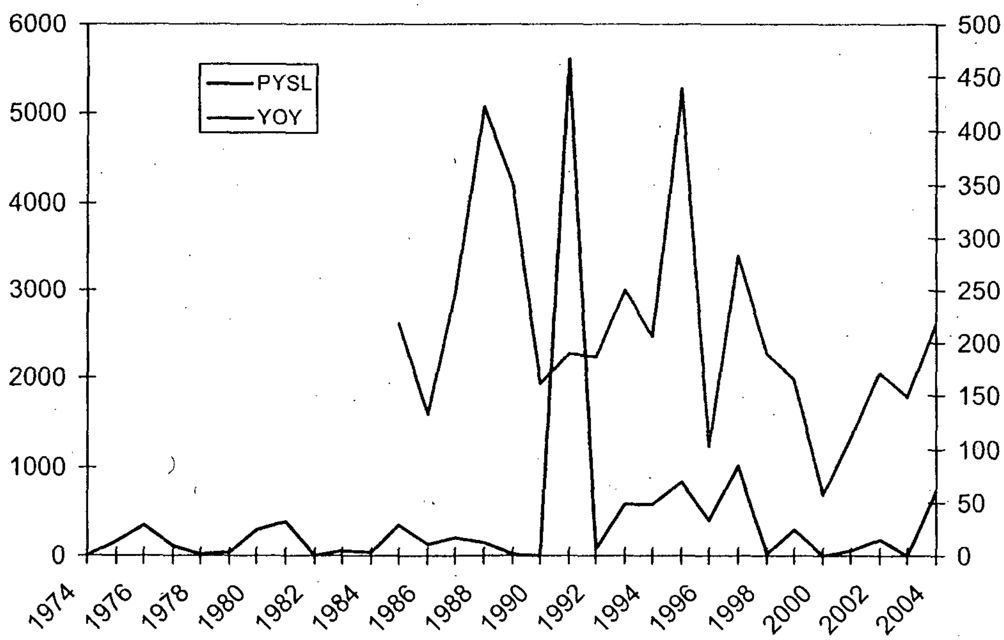


Figure 37a. Relationship between the IP2 and IP3 CMR and bay anchovy PYSL to YOY survival.

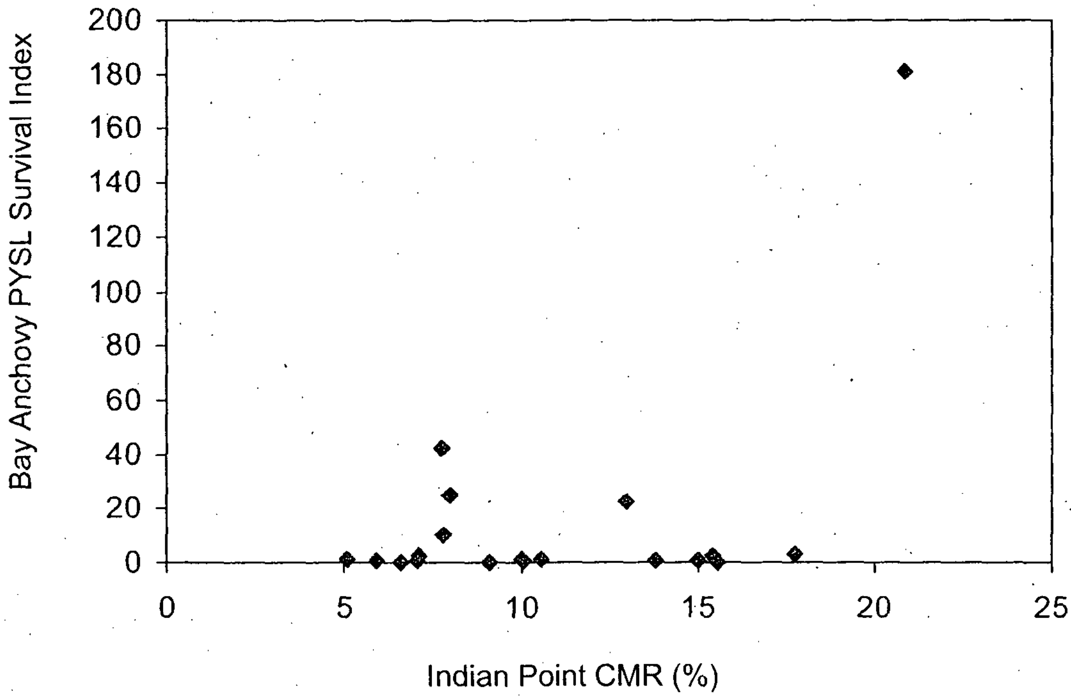


Figure 37b. Relationship between the IP2 and IP3 CMR and bay anchovy PYSL abundance.

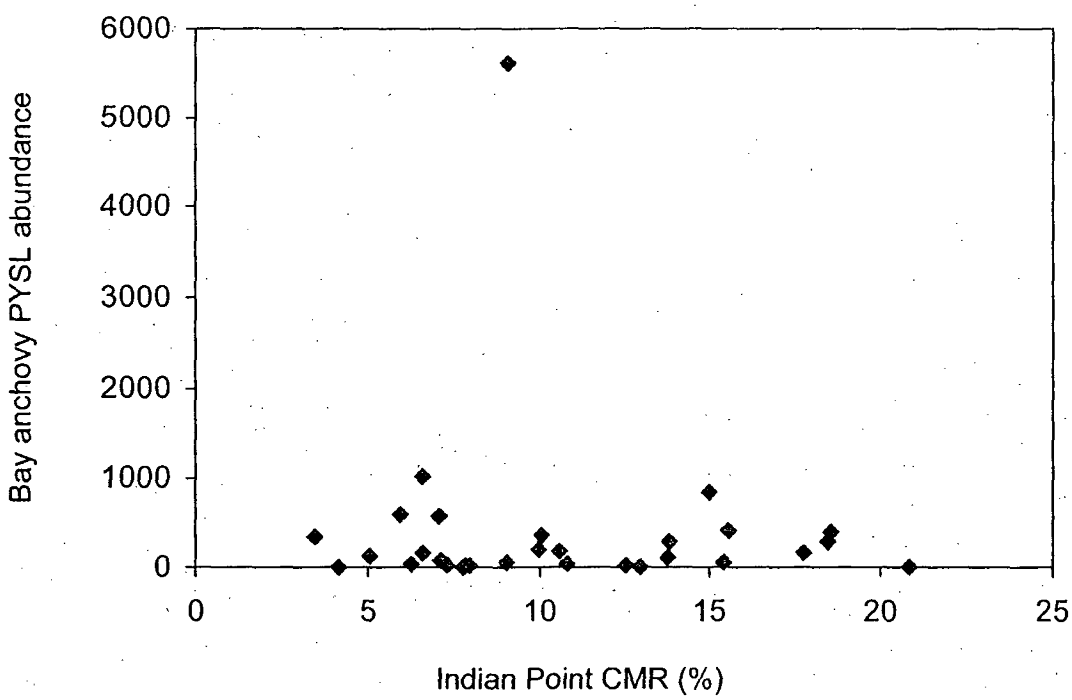
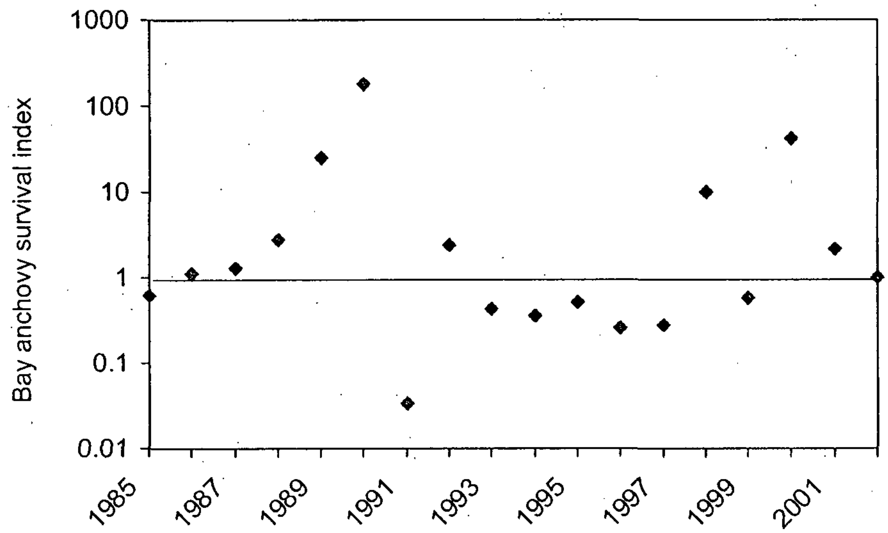


Figure 38. (a) Bay anchovy PYSL to YOY survival during years in which 1 unit (blue) and 2 units (red) at Indian Point were operating during May and June, the peak months during which entrainable life stages of river herring are present in the Hudson River. The horizontal line shows the median survival index value for the time series. (b) Relationship between total IP2 and IP3 June-July withdrawals and bay anchovy PYSL survival.

(a)



(b)

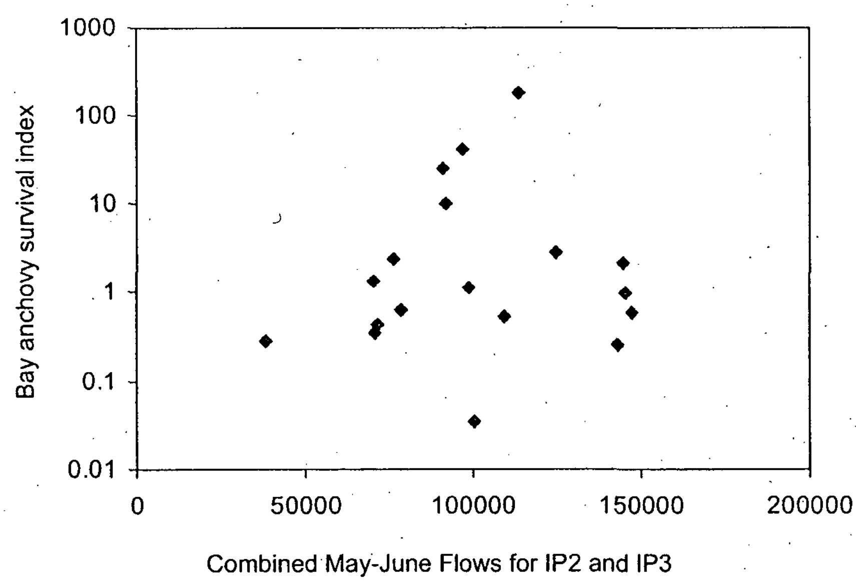


Figure 39a. Relationship between bay anchovy YOY abundance and the striped bass predation index.

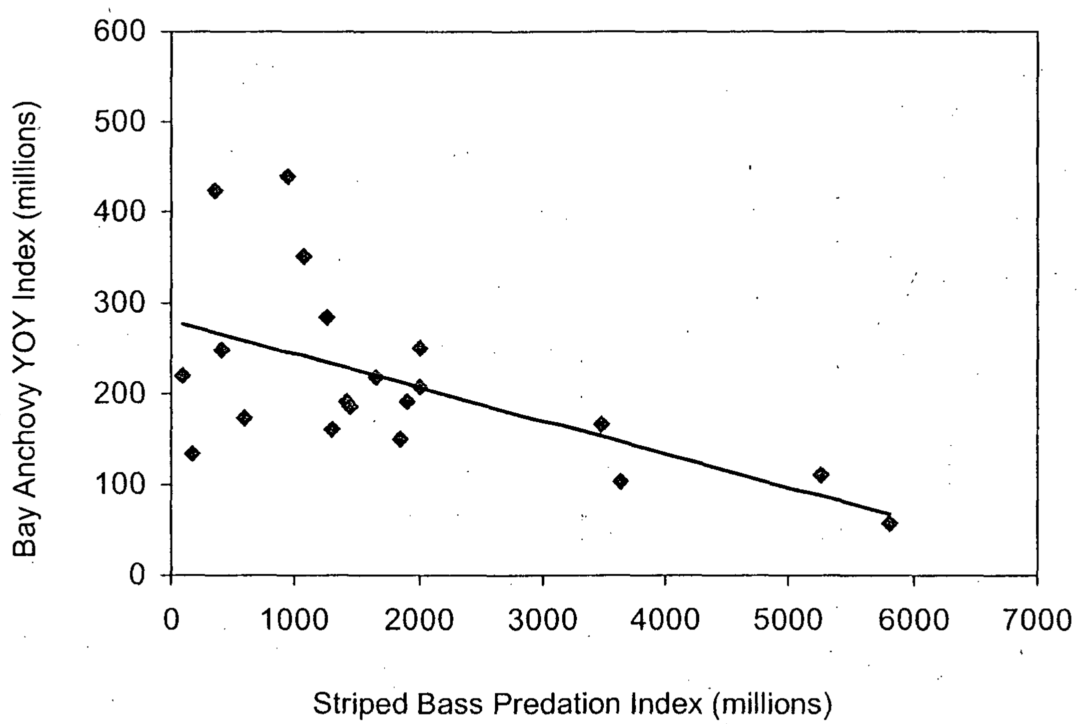


Figure 39b. Long-term trends in bay anchovy YOY abundance and the striped bass predation index.

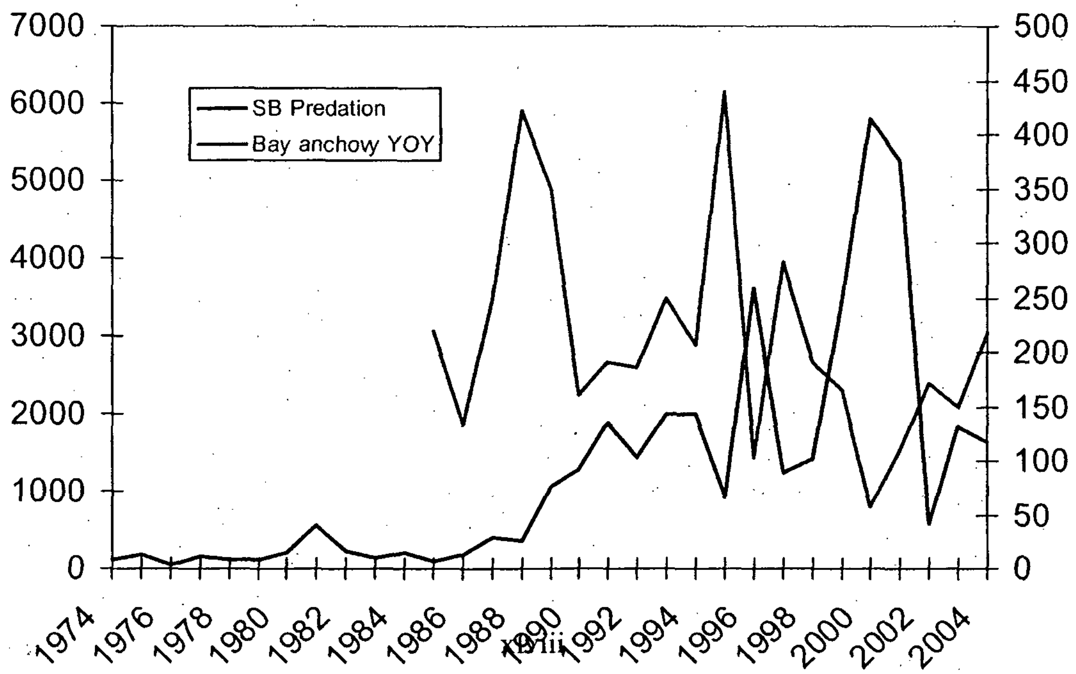


Figure 40. Long-term trends in the abundance of spottail shiner eggs and YOY.

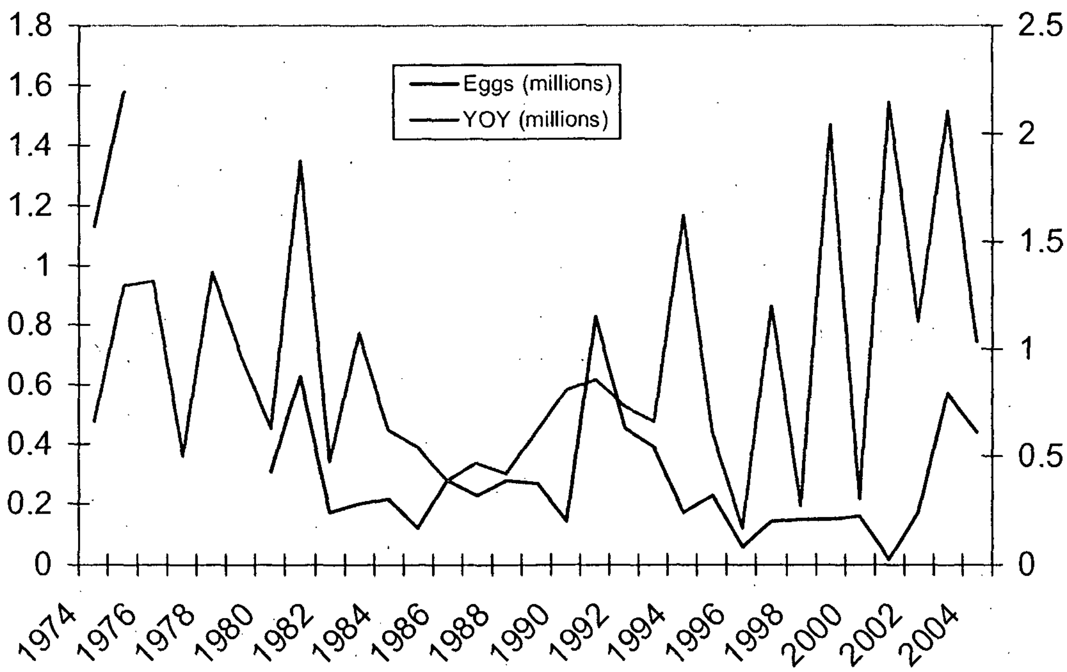


Figure 41a. Relationship between the IP2 and IP3 CMR and spottail shiner egg to YOY survival.

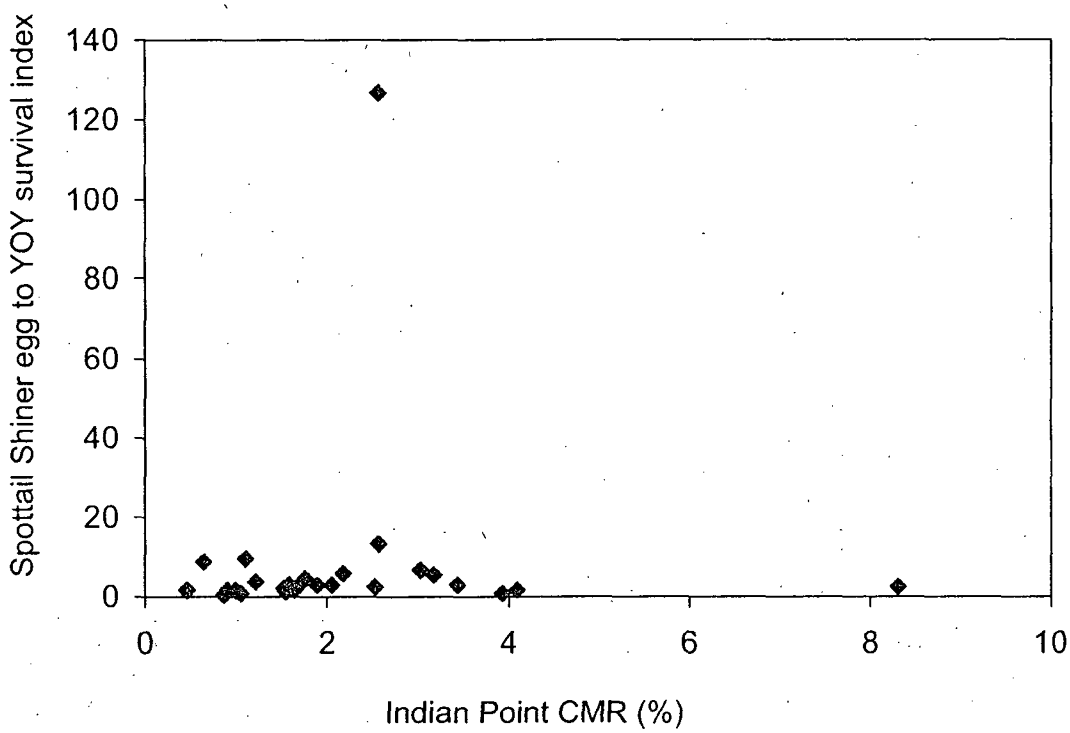


Figure 41b. Relationship between the IP2 and IP3 CMR and spottail shiner YOY abundance.

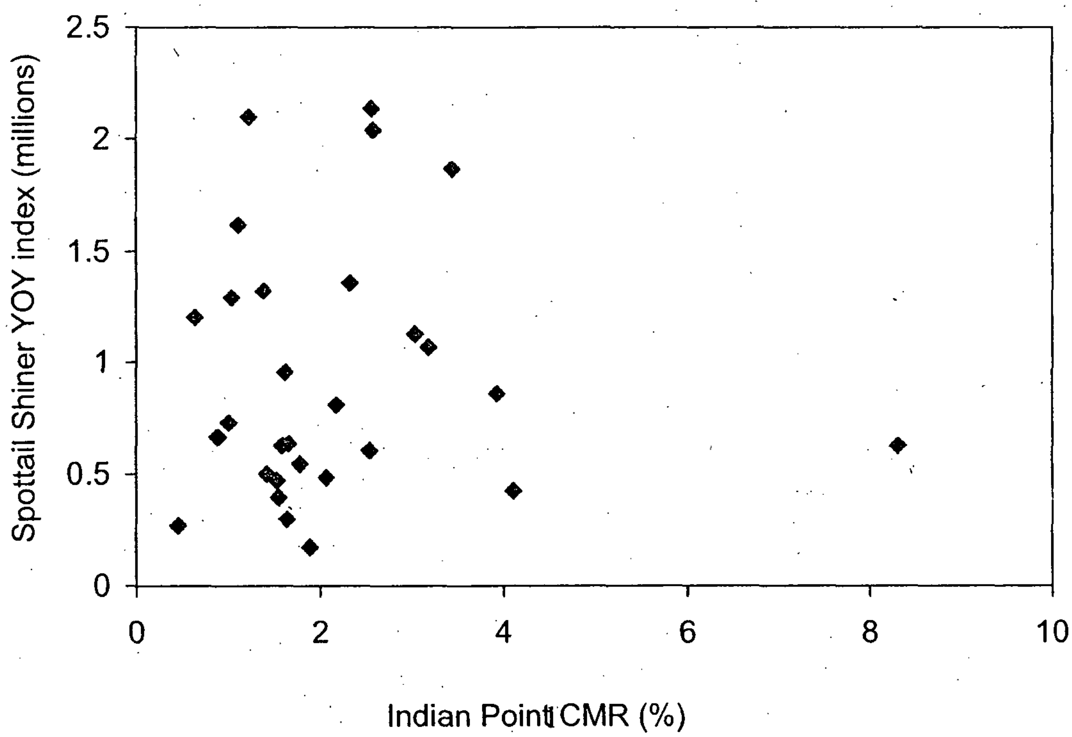


Figure 42. Relative influence of IP2 and IP3 vs. fishing on the spawning potential of Hudson River striped bass.

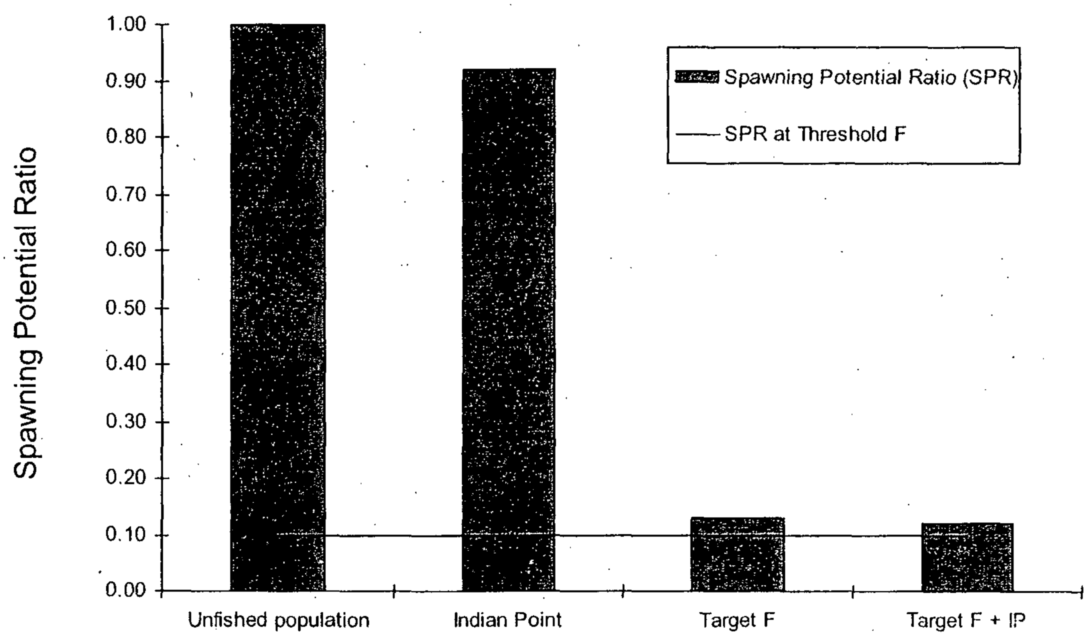


Figure 43. Comparative effects of Indian Point and fishing on Hudson River American shad SPR using data and modeling method from 2007 American shad stock assessment (ASMFC 2007a).

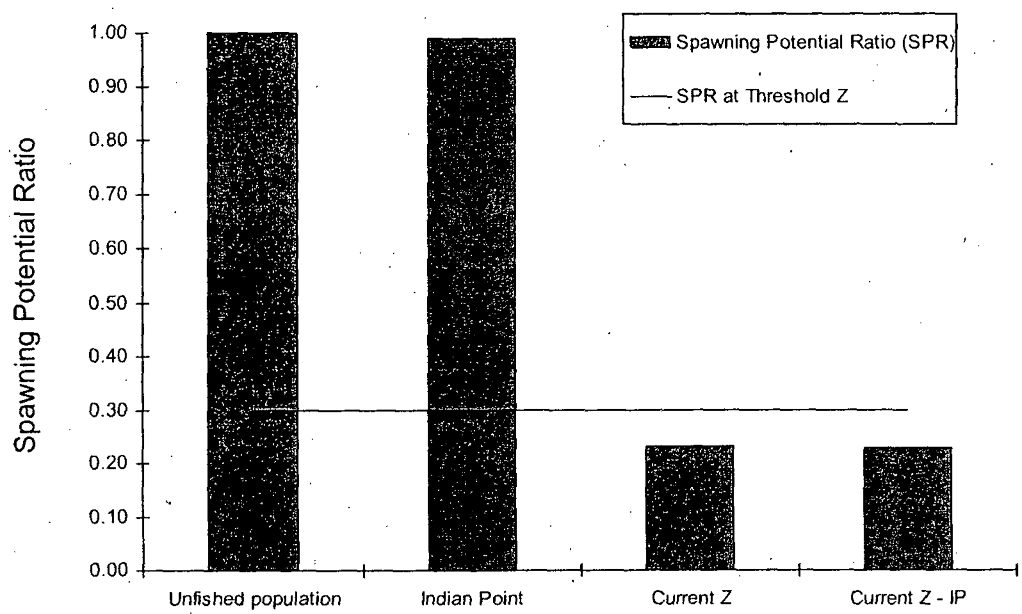


Figure 44a. Relationship between relative change in YOY abundance from Period 1 to Period 2 and entrainment susceptibility for the 21 fish species included in Case A. Zero on the logarithmic Y axis corresponds to no change in abundance from Period 1 to Period 2.

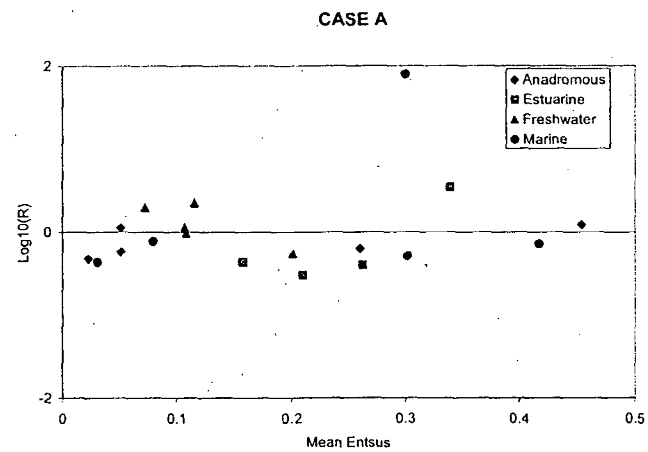
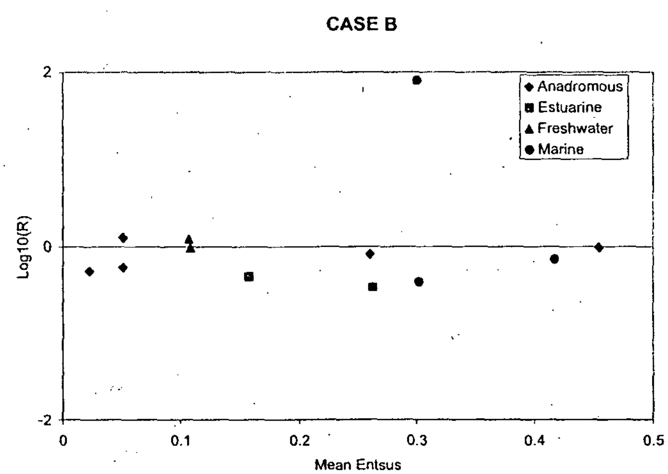


Figure 44b. Relationship between relative change in YOY abundance from Period 1 to Period 2 and entrainment susceptibility for the 11 fish species included in Case B. Zero on the logarithmic Y axis corresponds to no change in abundance from Period 1 to Period 2.



APPENDIX A

Prepared by:

AKRF, Inc.

TABLE OF CONTENTS

I. INTRODUCTION

Indices of relative abundance, derived from Hudson River Generator's Longitudinal River Ichthyoplankton Survey ("LRS"), Beach Seine Survey ("BSS"), and Fall Shoals Survey ("FSS") data, are used to analyze trends in abundance and to test the impact hypothesis for eight different species of finfish found in the Hudson River. These analyses are presented in Appendix B.

To confirm that the selection of relative abundance indices in Appendix B is valid, this document presents an examination of relationships that exist among LRS, BSS and FSS data. It also examines relationships that exist among LRS, BSS and FSS data and data from the Atlantic States Marine Fisheries Commission ("ASMFC"), as well as relationships that exist with the coast-wide striped bass abundance derived from its stock assessment (ASMFC 2005), the New York State Department of Environmental Conservation ("NYSDEC"), and the Hudson River Generators' mark-recapture studies of Atlantic tomcod ("ATMR") and striped bass. Correlation among these surveys validates the use of the LRS, BSS and FSS in Appendix B and demonstrates the robustness of the trends analysis and test of impact.

The strength of the correlation analysis can be evaluated using a power analysis. The power of a particular statistical test refers to the probability that the null hypothesis has been correctly rejected. In the case of a correlation analysis, the null hypothesis is defined as no significant correlation between surveys. The alternative hypothesis is defined as the presence of significant correlation between surveys. The power of a correlation analysis for different sample sizes is shown in Figure 1.

II. COMPARISON OF HUDSON RIVER GENERATORS' DATA

A correlation analysis was used to validate the use of the BSS and FSS surveys. The analysis demonstrates that the abundance index derived from the BSS follow the abundance index derived from the FSS.

A. Methods

Two datasets were compared in this analysis. Species-specific young-of-year indices based on the BSS were compared with species-specific FSS indices. See Appendix B for details on the development of these indices. The BSS and FSS indices are presented in Tables A-1 and A-2. The FSS indices were subset to the time period 1985 through 2004 to ensure that gear were comparable to the gear used in the BSS.

A Pearson correlation analysis was conducted, comparing the indices on a species-specific basis. A weighting factor based on the inverse of the variance was used, as described in the formula below:

$$WF = \frac{1}{(SE_{BSS})^2 + (SE_{FSS})^2}$$

where:

WF	=	weighting factor for Pearson Correlation Analysis
SE_{BSS}	=	standard error of BSS abundance estimate
SE_{FSS}	=	standard error of FSS abundance estimate

This analysis was conducted for white perch, striped bass, spottail shiner, bay anchovy, American shad, alewife, blueback herring, and Atlantic tomcod.

B. Results

The correlation analysis shows that that seven of the eight species of fish considered in this analysis are significantly and positively correlated (Table A-3). The correlation coefficients among the seven species range from 0.5 to 0.80. According to Figure A-1, the sample size of 20 in the present correlation analysis results in the power for the test ranging from about 60% to about 100%. Spottail shiner is the only species that does not show a significant correlation between the two indices. The lack of correlation is most likely attributable to large variation in the FSS data within individual years (Table A-2). The coefficient of variation for spottail shiner catch rates range between 0.17 and 1 in the FSS. Based on the overall results of the analysis, it can be concluded that species and life stages that share both habitats and are sampled by the two surveys exhibit the same interannual variation. This variation is reflected in the indices of the two surveys.

III. COMPARISON OF STRIPED BASS DATA WITH INDEPENDENT STUDIES

This analysis examines the relationship between the BSS striped bass data with independent studies conducted by the NYSDEC, the ASMFC and the Hudson River Generators.

Striped bass is sampled in a beach seine survey conducted by the NYSDEC. This survey is conducted in the Tappan Zee and Croton-Haverstraw region of the Hudson River. This is an area where a large proportion of the young-of-year ("YOY") striped bass found in the Hudson River are located in late summer and fall. The BSS and the NYSDEC beach seine survey overlap in this area, but the BSS samples a much larger area of the Hudson River, ranging from near the mouth of the river to Troy Dam. The two surveys have run concurrently since 1982. The size and the method of setting the beach seines vary between the two surveys. A correlation analysis was conducted to validate the use of the BSS in Appendix B.

The results from the NYSDEC beach seine survey are also used in the stock assessment of striped bass performed by the ASMFC (2005). An additional 61 age-specific and age-aggregated fishery-independent and fishery-dependent indices were used in the striped bass stock assessment (ASMFC 2005). A correlation analysis between the BSS and the coast-wide striped bass population abundance was conducted to show whether the Hudson River striped bass contribute significantly to the abundance of the coast-wide population.

Finally, the Hudson River Generators conducted a mark-recapture study of striped bass from 1984 through 1993. A correlation analysis was conducted to demonstrate the validity of the BSS when compared to these mark-recapture data.

A. Methods

Input data for this analysis included the ASMFC 2005 striped bass stock assessment – both total stock estimates as well as indices of abundance for different spawning regions, BSS YOY data, and striped bass mark-recapture data presented in the Draft Environmental Impact Statement ("DEIS") (Central Hudson Gas & Electric Corp. et al. 1999).

A linear regression was used to determine the fraction of the overall striped bass stock that could be attributed to the three major spawning stock regions: the Hudson River, the Delaware Estuary, and the Chesapeake Bay. The total estimated population of age-1 striped bass, as reported in the 2005 stock assessment (Table A-4), was compared with the indices of abundance for New York, New Jersey, Maryland, and Virginia (Table A-5) ("Model 1"). The index of New York abundance used by ASMFC was based on NYSDEC sampling data. A second linear regression was developed using BSS YOY data (Table A-1) to represent the New York component of the stock ("Model 2").

A correlation analysis using a Pearson model was used to compare the NYSDEC index, the BSS index, mark-recapture data collected by the Hudson River Generators (Table A-6), the estimate of the New York portion of the striped bass stock based on NYSDEC data (Table A-7), and the estimate of the New York portion of the striped bass stock based on BSS data (Table A-7).

B. Results

The correlation analysis between the BSS and the NYSDEC beach seine survey results in a significant positive correlation (Table A-8). This demonstrates that the two independent surveys of young-of-year striped bass in the Hudson River produce similar annual results. BSS and the coast-wide population abundance of striped bass are also significantly positively correlated. This positive correlation is not surprising, as the NYSDEC beach seine survey is one of many input parameters used in the coast-wide stock assessment of striped bass (ASMFC 2005). It has already been established that the NYSDEC beach seine survey and the BSS are positively correlated (See Section II.B). However, the results show that the many other input parameters in the striped bass stock assessment do not mask this relationship and confirm that striped bass associated with the Hudson River contribute significantly to the population dynamics of the coast-wide striped bass population. Another independent survey, a mark-recapture study, shows a significant linear relationship with the BSS. In summary, the BSS correlates significantly and positively with other existing independent surveys of striped bass YOY and older. This shows the robustness of the BSS in predicting young-of-year striped bass abundance.

IV. COMPARISON OF ATLANTIC TOMCOD DATASET WITH INDEPENDENT STUDIES

The ATMR study in the Hudson River has been conducted for 22 years, starting in 1974 (Normandeau Associates, Inc. 2006). Abundance indices of 1 and 2 year old Atlantic tomcod are calculated, using data from the ATMR program (Table A-9). Yearly egg production estimates are also provided in Normandeau (2006).

Atlantic tomcod data from the BSS, FSS, and the LRS were compared with data from the mark-recapture study conducted by the Hudson River Generators to validate the results of the ATMR program by determining if correlations among the datasets exist.

A. Methods

There were multiple inputs used to conduct further examinations of the Atlantic tomcod data used in earlier analyses. These data included the Atlantic tomcod index presented in Appendix A (based on mark-recapture surveys), BSS data, FSS data, and LRS data (Table A-10). Two different statistical methods were used to examine the Atlantic tomcod data.

- A correlation analysis, based on the Pearson model, was conducted comparing the mark-recapture data of age-1 Atlantic tomcod with young-of-year BSS and FSS data.
- A second correlation analysis, also based on the Pearson model, compared the estimated of eggs derived from the mark-recapture study with the post yolk-sac index based on LRS data.

B. Results

The relative abundance of Atlantic tomcod based on the FSS is significantly and positively correlated with their abundance based on the BSS (Table A-11). The mark-recapture program for Atlantic tomcod also correlates positively and significantly to the FSS and the BSS. The egg deposition is borderline positively correlated to the post yolk-sac larvae Atlantic tomcod estimated from the LRS (Table A-12).

V. LITERATURE CITED

Atlantic States Marine Fisheries Commission 2005. 2005 Stock Assessment Report for Atlantic striped bass: Catch-at-age VPA & tag release/recovery based survival estimation. A report prepared by the striped bass technical committee for the Atlantic striped bass management board. Atlantic States Marine Fisheries Center.

Central Hudson Gas & Electric Corp. et al. 1999. Draft Environmental Impact Statement for State Pollutant Discharge Elimination System Permits for Bowline Point, Indian Point 2 & 3, and Roseton Steam Electric Generating Stations.

Normandeau Associates, Inc. 2006. Abundance and stock characteristics of the Atlantic tomcod spawning population in the Hudson River, winter 2003-2004. Prepared for Entergy Nuclear Operations, Inc.

VI. TABLES

Table 1. Abundance indices and associated standard errors, based on BSS.

Year	WHITE PERCH Young-of-Year		STRIPED BASS Young-of-Year		SPOTTAIL SHINER Young-of-Year		BAY ANCHOVY Young-of-Year		AMERICAN SHAD Young-of-Year		ALEWIFE Young-of-Year	
	Index	SE	Index	SE	Index	SE	Index	SE	Index	SE	Index	SE
1974	566,346	61,280	1,373,138	264,598	658,945	87,448	2,999,066	973,844	2,123,265	232,509	583,238	74,805
1975	2,342,937	440,999	1,367,496	242,374	1,286,297	193,361	5,159,511	1,666,189	1,998,286	161,394	572,550	107,585
1976	1,944,220	255,910	864,743	70,734	1,324,434	203,989	5,234,482	2,595,405	2,354,807	125,450	352,263	96,375
1977	953,799	87,722	1,375,537	124,595	495,690	66,445	4,616,994	875,014	2,123,707	114,152	517,792	49,081
1978	2,675,700	402,374	3,042,920	614,048	1,363,313	148,541	329,478	57,321	4,021,203	251,047	1,027,891	174,698
1979	2,921,393	285,862	794,022	91,389	956,236	97,330	1,860,753	686,496	1,934,405	107,064	340,271	59,099
1980	1,884,895	231,650	1,265,254	147,121	633,323	72,196	3,445,878	818,900	1,632,041	117,820	93,783	17,894
1981	1,862,222	160,903	1,827,767	152,481	1,865,058	216,442	4,505,689	1,862,587	2,558,539	149,238	477,348	84,403
1982	1,967,754	287,490	934,550	97,768	477,090	62,605	2,740,240	1,735,314	1,768,839	150,312	116,606	24,817
1983	1,803,266	399,823	1,642,536	191,103	1,070,822	104,909	364,403	243,354	2,452,068	183,820	214,922	42,154
1984	703,959	145,133	1,300,754	173,872	616,182	128,367	1,887,240	963,767	1,060,902	74,374	49,776	10,864
1985	757,003	82,536	238,259	21,226	543,246	66,532	621,718	203,675	1,263,843	153,248	119,509	22,024
1986	1,036,321	97,303	298,745	31,415	388,736	69,297	975,435	779,300	2,207,907	125,447	119,468	48,899
1987	1,169,236	121,876	2,976,381	314,807	470,267	74,827	830,978	229,609	1,482,041	125,017	80,611	13,768
1988	1,738,310	255,364	1,172,303	68,239	419,874	49,588	546,894	225,975	997,414	59,920	87,080	15,727
1989	1,105,280	278,101	1,238,434	116,464	623,204	95,526	2,840,186	987,471	2,455,819	135,247	43,711	12,956
1990	588,162	75,727	1,486,911	89,409	808,662	101,694	208,541	65,810	2,004,620	162,122	157,159	25,580
1991	580,165	76,201	1,125,126	64,076	855,292	110,557	935,366	246,296	1,499,227	120,544	335,535	63,111
1992	463,555	53,444	1,046,654	53,265	726,888	124,009	1,629,973	1,184,246	1,886,715	101,469	40,507	9,371
1993	806,848	97,157	1,640,132	90,969	655,117	95,425	1,183,278	462,699	815,539	68,698	69,438	11,826
1994	315,662	39,618	1,136,106	63,179	1,624,997	289,784	2,255,731	478,603	1,963,731	124,116	148,030	30,079
1995	425,062	49,042	1,404,935	89,202	603,130	94,204	2,507,280	721,809	552,490	48,911	91,731	22,716
1996	44,925	10,283	299,997	30,506	174,026	39,053	720,000	151,968	1,743,007	125,007	47,371	14,912
1997	571,160	114,812	1,892,597	169,399	1,197,799	170,583	3,496,618	815,723	1,573,674	106,235	291,323	54,177
1998	270,835	51,992	1,384,364	85,327	273,165	53,055	2,675,549	670,172	319,702	47,834	40,865	30,194
1999	1,411,184	169,447	1,715,282	142,568	2,040,399	243,244	858,192	298,574	1,399,557	107,459	445,167	79,622
2000	304,950	52,787	580,006	52,449	303,081	52,956	769,133	427,827	941,909	105,935	76,445	37,606
2001	1,019,516	119,666	2,392,216	170,860	2,143,066	610,761	613,810	401,115	2,479,221	176,132	330,876	70,451
2002	699,145	80,612	1,145,686	60,295	1,132,479	146,862	3,826,181	1,061,795	721,680	72,203	60,954	13,491
2003	2,177,013	228,303	2,282,684	118,276	2,102,568	257,006	1,703,952	451,911	1,071,881	69,880	452,292	87,223
2004	632,961	89,075	807,661	70,743	1,031,399	152,802	404,497	145,762	444,880	31,585	218,118	35,902

Table A-1. Abundance indices and associated standard errors, based on BSS (continued).

Year	BLUEBACK HERRING Young-of-Year		ATLANTIC TOMCOD Young-of-Year	
	Index	SE	Index	SE
1974	3,647,758	502,857	18,536	4,046
1975	10,888,524	1,249,788	39,688	11,253
1976	21,621,271	3,075,761	41,196	12,039
1977	31,795,371	4,717,652	8,178	2,802
1978	22,993,451	4,200,939	37,401	11,147
1979	8,221,314	1,461,758	58,632	18,283
1980	8,892,467	2,207,337	17,337	6,016
1981	32,066,440	9,586,015	3,698	1,141
1982	10,164,307	1,750,817	70,051	14,120
1983	16,326,879	2,278,723	11,419	3,218
1984	3,577,323	786,742	50,486	12,104
1985	3,323,511	664,762	34,760	6,246
1986	1,555,182	357,032	28,125	5,369
1987	6,188,101	773,111	35,074	8,600
1988	5,887,963	1,008,925	21,020	5,249
1989	3,230,116	497,839	12,946	3,825
1990	9,436,487	1,274,900	16,941	5,709
1991	3,530,392	596,059	4,417	1,849
1992	6,642,282	1,599,250	43,740	10,403
1993	4,234,168	531,496	2,144	913
1994	9,584,696	1,308,960	1,198	579
1995	3,202,735	892,613	0	0
1996	4,044,353	890,186	9,182	5,836
1997	12,075,530	2,541,612	5,053	1,572
1998	155,761	32,365	1,384	616
1999	5,691,570	776,702	0	0
2000	2,342,499	572,561	9,823	3,892
2001	5,268,663	704,402	1,520	752
2002	1,438,577	299,230	0	0
2003	10,203,281	1,459,824	0	0
2004	5,091,421	620,888	5,928	1,647

Table A-2. Abundance indices and associated standard errors, based on FSS.

year	WHITE PERCH Young-of-Year		STRIPED BASS Young-of-Year		SPOTTAIL SHINER Young-of-Year		BAY ANCHOVY Young-of-Year		AMERICAN SHAD Young-of-Year		ALEWIFE Young-of-Year	
	Index	SE	Index	SE	Index	SE	Index	SE	Index	SE	Index	SE
1985	1,685,851	165,213	164,284	16,636	85,977	39,236	218,612,898	21,269,766	1,591,435	190,139	2,105,489	381,844
1986	1,759,522	207,644	651,049	49,859	49,745	11,399	132,925,173	13,133,411	3,104,605	640,844	595,155	115,129
1987	1,579,037	136,932	4,889,589	239,032	20,977	5,401	246,910,112	26,982,497	647,070	157,299	695,124	245,872
1988	3,777,521	297,018	9,569,544	497,548	83,429	20,121	422,678,791	38,213,532	997,871	144,252	624,702	142,344
1989	3,167,143	357,848	4,235,166	333,577	3,591	1,550	349,952,337	26,107,654	2,754,815	198,752	505,822	105,987
1990	548,583	167,722	2,883,805	200,426	17,347	5,614	161,039,442	14,450,450	1,139,272	235,276	807,620	138,564
1991	443,688	67,292	1,138,102	87,685	131,938	34,430	190,474,265	11,540,891	680,209	72,781	685,242	104,724
1992	1,064,922	136,793	1,186,233	113,756	23,041	8,964	185,902,303	13,738,226	1,306,732	147,744	746,514	158,432
1993	415,097	100,885	2,779,357	178,004	70,379	17,018	249,913,241	19,475,645	464,702	48,446	530,240	83,846
1994	566,404	53,440	3,439,449	209,768	34,772	5,983	206,642,043	14,141,476	1,036,782	88,932	571,174	82,018
1995	1,514,550	230,289	2,878,188	173,061	10,530	3,570	439,617,793	28,732,239	471,444	75,896	308,139	49,342
1996	414,924	60,068	2,396,874	172,968	73,863	15,117	102,941,191	5,959,974	2,859,373	451,439	1,076,096	124,312
1997	539,792	86,123	2,439,137	273,488	6,312	2,846	283,382,412	17,014,202	913,970	107,851	1,233,697	154,951
1998	357,696	35,390	580,977	65,746	2,367	2,367	189,541,611	9,166,785	232,260	56,459	112,261	28,629
1999	2,021,946	166,188	2,655,600	220,747	25,220	5,712	165,375,818	9,972,244	853,411	135,639	2,543,734	197,641
2000	433,794	60,439	1,634,254	228,331	2,010	1,496	57,208,944	3,577,181	878,405	100,807	913,399	108,152
2001	869,631	93,161	1,184,609	105,581	20,724	9,574	109,701,139	8,052,515	1,006,787	162,014	2,253,572	652,056
2002	401,209	46,026	982,555	156,264	14,619	4,774	171,692,430	10,652,063	497,537	57,524	255,519	37,190
2003	2,181,001	165,766	4,787,259	432,818	938	841	148,898,706	11,753,477	351,278	47,131	941,836	102,643
2004	543,243	159,067	991,181	119,540	40,935	8,459	218,178,981	17,899,774	336,973	63,105	249,944	43,269

Table A-2. Abundance indices and associated standard errors, based on FSS (continued).

year	BLUEBACK HERRING Young-of-Year		ATLANTIC TOMCOD Young-of-Year	
	Index	SE	Index	SE
1985	63,437,557	9,471,265	3,818,562	537,609
1986	15,577,561	2,395,825	6,935,212	588,195
1987	38,342,783	9,373,512	3,431,206	257,718
1988	61,946,416	6,136,684	3,731,674	370,666
1989	33,621,840	3,107,711	13,006,674	1,862,570
1990	63,121,526	6,836,956	1,377,747	247,070
1991	43,421,773	5,346,974	263,792	37,402
1992	46,987,241	6,744,931	3,846,993	297,928
1993	20,223,194	1,817,165	3,742,238	1,013,814
1994	17,568,127	1,521,183	604,300	55,493
1995	14,114,745	1,634,192	84,328	16,082
1996	67,981,601	8,013,906	3,543,737	380,726
1997	29,241,071	3,323,567	2,392,903	208,967
1998	927,634	153,551	507,900	73,503
1999	22,609,332	2,329,531	19,312	6,888
2000	11,400,882	1,150,959	2,262,871	196,166
2001	23,294,104	4,713,494	897,887	240,836
2002	10,219,873	969,053	80,565	17,597
2003	17,724,162	1,789,797	355,046	74,484
2004	6,347,406	606,675	2,100,531	318,419

Table A-3. Correlations between BSS and FSS data

Taxa	Number of Years	Inverse-Variance Weighted Correlation Factors	Significance Level
White Perch	20	0.69	0.0007
Striped Bass	20	0.69	0.0008
Spottail Shiner	20	-0.09	0.6969
Bay Anchovy	20	0.55	0.0122
American Shad	20	0.76	<0.0001
Alewife	20	0.50	0.0235
Blueback Herring	20	0.73	0.0002
Atlantic Tomcod	20	0.80	<0.0001

Table A-4. Estimated age-1 striped bass population.

Year	Striped Bass Age-1 Population (thousands)
1982	1,534
1983	3,181
1984	2,401
1985	3,579
1986	2,763
1987	3,944
1988	5,219
1989	5609
1990	8,419
1991	8,644
1992	8,706
1993	11,065
1994	16,562
1995	13,338
1996	12,932
1997	15,586
1998	10,625
1999	10,982
2000	8,261
2001	15,490
2002	18,024
2003	5,976
2004	22,275
2005	12,721

Source: ASMFC 2005

Table A-5. Indices of abundance for Atlantic striped bass adjusted to January 1st

Year	Young-of-Year New York Index	Young-of-Year New Jersey Index	Young-of-Year Maryland Index	Young-of-Year Virginia Index
1982	8.86		0.59	1.56
1983	14.17	0.12	3.57	2.71
1984	16.25	0.03	0.61	3.4
1985	15	0.29	1.64	4.47
1986	1.92	0.18	0.91	2.41
1987	2.92	0.28	1.34	4.74
1988	15.9	0.41	1.46	15.74
1989	33.46	0.35	0.73	7.64
1990	21.35	1.03	4.87	11.23
1991	19.08	1	1.03	7.34
1992	3.6	0.47	1.52	3.76
1993	11.43	1.19	2.34	7.35
1994	12.59	1.78	13.97	18.11
1995	17.64	0.96	6.4	10.48
1996	16.23	1.98	4.41	5.45
1997	8.93	1.7	17.61	23
1998	22.3	1.01	3.91	9.35
1999	13.39	1.31	5.5	13.25
2000	26.64	1.9	5.34	2.8
2001	3.16	1.77	7.42	16.18
2002	22.98	1.07	12.57	14.17
2003	12.32	0.51	2.2	3.98
2004	17.36	2.43	10.83	22.89
2005	8.81	1.13	4.85	12.7

Source: ASMFC 2005

Table A-6. Abundance estimate of Hudson River striped bass, based on mark-recapture data.

Year	Age-2+ Abundance
1984	213
1985	104
1986	108
1987	611
1988	560
1989	339
1990	344
1991	502
1992	238
1993	201

Source: Central Hudson Gas & Electric Corp. et al. 1999

Table A-7. Estimate of NY striped bass stock, based on NYSDEC and BSS data.

Year	Estimate of Hudson River age-1 striped bass	
	Based on NYSDEC Data	Based on BSS data
1974		1,510,636
1975		1,504,429
1976		951,333
1977		1,513,275
1978		3,347,621
1979		873,531
1980		1,391,949
1981	560,788	2,010,789
1982	896,882	1,028,131
1983	1,028,534	1,807,010
1984	949,416	1,431,004
1985	121,525	262,117
1986	184,820	328,660
1987	1,006,381	3,274,419
1988	2,117,831	1,289,691
1989	1,351,336	1,362,444
1990	1,207,657	1,635,802
1991	227,860	1,237,790
1992	723,455	1,151,460
1993	796,877	1,804,365
1994	1,116,513	1,249,869
1995	1,027,268	1,545,617
1996	565,219	330,037
1997	1,411,465	2,082,111
1998	847,512	1,522,986
1999	1,686,163	1,887,041
2000	200,010	638,085
2001	1,454,505	2,631,759
2002	779,787	1,260,408
2003	1,098,791	2,511,259
2004	557,624	888,536

Table A-8. Striped Bass correlation coefficients

	New York Index	BSS Index	Mark-recapture age-2 Abundance	New York Stock (based on NYDEC data)
New York Index		**0.53**	0.55	**1.00**
BSS Index	**0.53**		**0.68**	**0.53**
Mark-recapture age-2	0.55	**0.68**		0.55
New York Stock (based on NYDEC data)	**1.00**	**0.53**	0.55	

	New York Index	BSS Index	Mark-recapture age-2 Abundance	New York Stock (based on BSS data)
New York Index		**0.53**	0.55	**0.53**
BSS Index	**0.53**		**0.68**	**1.00**
Mark-recapture age-2	0.55	**0.68**		**0.68**
New York Stock (based on BSS data)	**0.53**	**1.00**	**0.68**	

Note: Correlation coefficients significant at the 10% level are shown.
Correlation coefficients significant at the 5% level are shown in bold.

Table A-9. Atlantic tomcod mark-recapture data

Year	Proportion Age-1	Proportion Age-2	Population Egg Deposition (billions)	Population Age-1 (millions)
1975				3.6
1976	0.98	0.02	22	9.7
1977	0.933	0.067	65	2.4
1978	0.965	0.035	21	5.9
1979	0.989	0.01	51	8.8
1980	0.97	0.03	57	
1981	0.943	0.056		
1982	0.968	0.032		10.5
1983	0.843	0.155	97	5.9
1984	0.887	0.113	75	
1985	.	.		2
1986	0.957	0.043	25	
1987	.	.		2.9
1988	0.837	0.163	43	5.3
1989	0.9	0.1	41	4.9
1990	0.715	0.285	87	2.6
1991	0.81	0.19	52	0.3
1992	0.715	0.285	7	2.2
1993	0.849	0.151	30	0.5
1994	0.662	0.338	7	2.2
1995	0.907	0.093	31	
1996	0.483	0.517		2.6
1997	0.8	0.2	47	0.7
1998	0.535	0.465	23	0.4
1999	0.664	0.336	10	0.2
2000	0.799	0.201	3	2.3
2001	0.935	0.065	28	
2002	0.827	0.173		
2003	0.95	0.05		1.6
2004	0.952	0.048	28	

Source: Normandeau Associates, Inc. 2006

Table A-10. Atlantic Tomcod abundance index and associated standard errors, based on LRS

year	ATLANTIC TOMCOD Post Yolk-Sac Larvae Index	SE
1974	128,306,743	19,426,263
1975	67,024,707	19,768,962
1976	42,777,042	13,470,065
1977	164,621,663	70,515,234
1978	54,313,088	10,307,482
1979	18,127,435	3,099,375
1980	95,402,234	13,128,146
1981	74,140,778	13,052,007
1982	28,419,800	7,665,326
1983	42,683,202	8,311,722
1984	147,133,069	25,916,525
1985	109,664,584	11,132,251
1986	53,404,268	4,770,519
1987	138,570,516	12,594,732
1988	78,376,300	10,680,903
1989	185,450,859	23,858,579
1990	107,915,374	25,158,013
1991	116,333,462	14,859,973
1992	32,021,214	4,889,565
1993	126,394,886	20,139,893
1994	85,456,373	22,227,930
1995	79,816,881	6,641,688
1996	51,571,386	5,696,759
1997	110,409,961	28,829,551
1998	53,594,909	8,409,591
1999	17,392,702	2,076,588
2000	11,120,807	1,442,773
2001	93,816,691	8,320,053
2002	4,382,650	649,979
2003	38,715,789	3,683,762
2004	115,401,578	16,005,570

Table A-11. Atlantic tomcod correlation coefficients

	Age-1 Mark-recapture data	Young-of-year: BSS data	Young-of-year: FSS data
Age-1: mark-recapture data		**0.77**	**0.65**
Young-of-year: BSS data	**0.77**		**0.45**
Young-of-year: FSS data	**0.65**	**0.45**	

Note: Only correlation coefficients significant at the 10% level are shown.
Correlation coefficients significant at the 5% level are shown in bold.

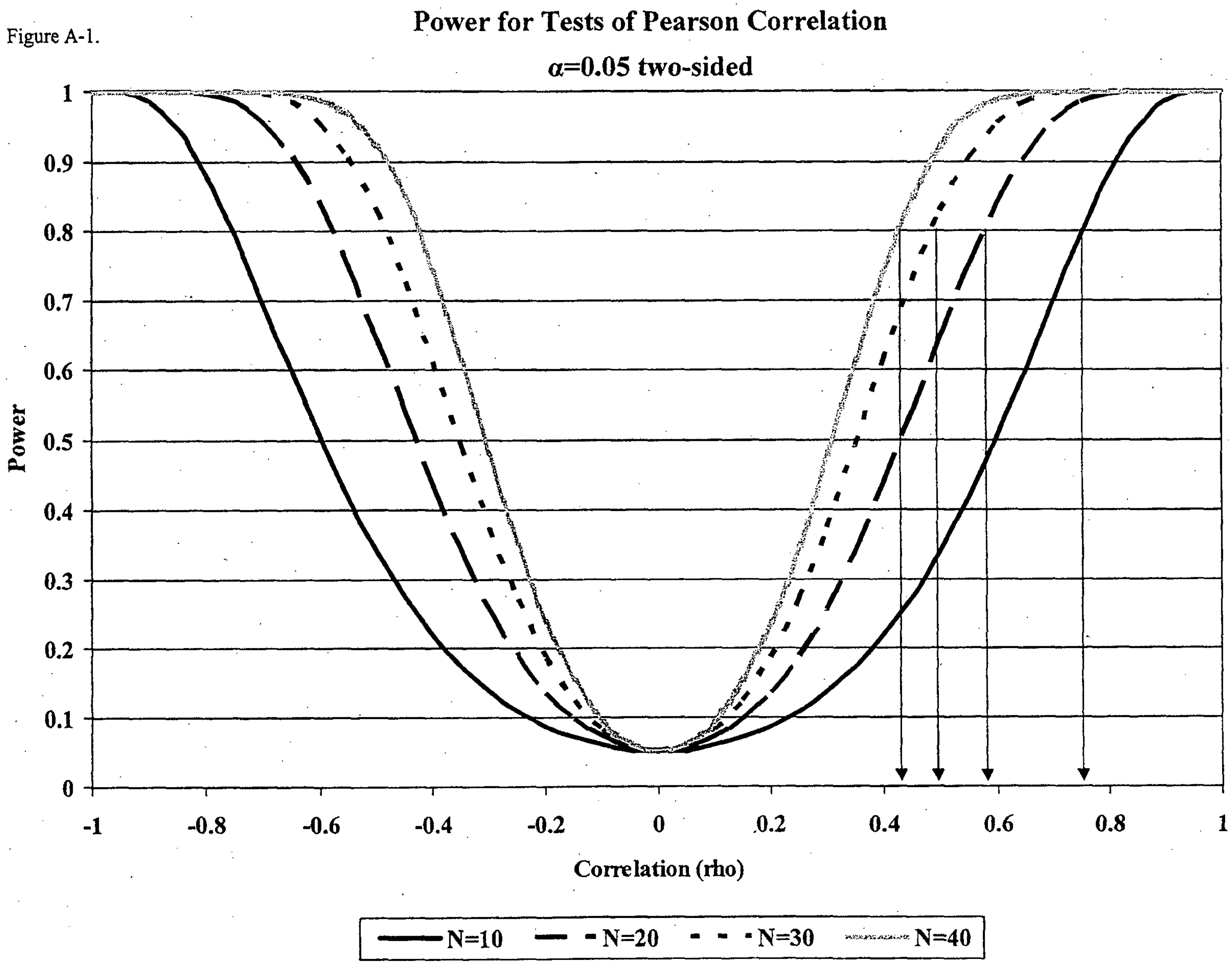
Table A-12. Atlantic tomcod correlation coefficients

	Eggs: Mark-recapture data	Post yolk-sac: LRS data
Eggs: mark-recapture data		0.41
Post yolk-sac: LRS data	0.41	

Note: Only correlation coefficients significant at the 10% level are shown.
Correlation coefficients significant at the 5% level are shown in bold.

VII. FIGURES

Figure A-1.



Power for Tests of Pearson Correlation
α=0.05 two-sided
Power
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Correlation (rho)
N=10
N=20
N=30
N=40

APPENDIX B

Prepared by:
AKRF, Inc.

TABLE OF CONTENTS

I. INTRODUCTION

This Appendix documents the methods and data used in: (1) analyses of trends in fish population abundance; and (2) correlation analyses to address impact hypotheses. The rationale for and the results from the analyses of trends and the correlation analyses are discussed in the report titled: "Entrainment and Impingement at IP2 and IP3: A Biological Impact Assessment."

The analyses of trends in fish population abundance and the correlation analyses were based on indices developed from data collected by the Hudson River Generators' Longitudinal River Ichthyoplankton Survey ("LRS"), Beach Seine Survey ("BSS"), Fall Shoals Survey ("FSS"), and Atlantic Tomcod Mark-Recapture ("ATMR") Program. Three types of indices were defined for these analyses:

- indices of fish population abundance;
- indices of stressors of fish populations; and
- indices of fish population response to stressors.

The remainder of this Appendix is organized in three Sections. The first Section documents the three types of indices; the second Section documents the trend analysis methods and results; and the third Section documents the correlation analysis methods and results.

II. INDICES

A. Fish Population Abundance

Annual indices of fish population abundance were computed as the average of the weekly standing crop estimates presented in the Year Class Report for the Multiplant Impact Study of the Hudson River Estuary for the years 1974 through 1979 and the Hudson River Estuary Monitoring Program for the years 1980 through 2004 (collectively, ("Year Class Report") (Applied Science Associates, Inc. 2000, 2001; ASA Analysis & Communication, Inc. 2001, 2002, 2003, 2004a, 2004b, 2005, 2006; Batelle New England Marine Research Laboratory 1983; Consolidated Edison Company of New York, Inc. 1996, 1997a, 1997b; EA Engineering, Science, and Technology 1990, 1991, 1996; Lawler, Matusky & Skelly Engineers 1989, 1992, 1996; Martin Marietta Environmental Systems 1986; Normandeau Associates, Inc. 1985a, 1985b; Texas Instruments, Inc. 1977, 1978, 1979, 1980a, 1980b, 1981; Versar, Inc. 1987). A separate annual index value was computed for each species and life stage. Indices of abundance for age-1 and age-2 Atlantic tomcod and abundance of Atlantic tomcod eggs were based on abundance estimates from the ATMR Program (Normandeau Associates, Inc. 2006).

Weekly standing crop estimates for post yolk-sac larvae ("PYSL") were based on data collected by the LRS. Weekly standing crop estimates for young-of-year[1] ("YOY") fish inhabiting the beach zone of the Hudson River were based on data collected by the BSS. Weekly standing crop estimates for YOY fish inhabiting the shoals, bottom, and channel of the Hudson River were based on data collected by the FSS. These standing crop estimates, with associated standard errors, were provided in electronic format by ASA Analysis & Communication, Inc.

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[1] Young-of-year fish are sometimes also referred to as juvenile fish.

("ASA"). Data collection methods for the LRS, BSS, and FSS, and methods for estimating weekly standing crops (and associated standard errors) are documented in the Year Class Reports. Annual estimates of the number of age-1 and age-2 Atlantic tomcod and the number of Atlantic tomcod eggs spawned were developed by the ATMR program, and were provided by Normandeau Associates, Inc. ("NAI"). Data collection methods for the ATMR program and methods for estimating Atlantic tomcod abundance are documented in annual ATMR Program Reports prepared by NAI for the Hudson River Generators. In addition, estimates of the variance of the estimate of the total number of age-1 and age-2 Atlantic tomcod were computed, as described below.

A set of regions and weeks that were consistently sampled among years was identified for each sampling program. Annual abundance indices based on LRS data were computed for 1974 through 2004, based on data from regions 1 through 12, and weeks 18 through 26. Annual abundance indices based on BSS data were computed for 1974 through 2004, based on data from regions 1 through 12, and weeks 31 through 42. Annual abundance indices based on FSS data were computed for 1979 through 2004, based on data from regions 1 through 12, and weeks 31 through 42. Data from the ATMR program were included for all years (1974 through 2004) in which the number of recaptured Atlantic tomcod exceeded one fish.

BSS data were used to develop YOY abundance indices for alewife, blueback herring, spottail shiner, striped bass, and white perch. FSS data were used to develop YOY abundance indices for American shad and bay anchovy. LRS data were used to develop the PYSL indices for striped bass, white perch, river herring (which included alewife, blueback herring and unidentified clupeids – three taxonomic groups that could not reliably be identified to species as PYSL), American shad, and bay anchovy. The LRS did not adequately sample areas of the river inhabited by spottail shiner larvae. To address the abundance of early life stages of spottail shiner, an index of egg abundance was developed based on spawning age spottail shiner (i.e., yearling and older) sampled by the BSS. The index of yearling and older spottail shiner was used as a surrogate index for spottail shiner egg abundance.

For each species, sampling program (LRS, BSS, and FSS), and year, the annual index of abundance ($\overline{A}_y$) was computed using the following formula:

$$\overline{A}_y = \left(\frac{1}{\sum_{W=W_{\min}}^{W_{\max}} \delta_{W,y}} \right) \sum_{W=W_{\min}}^{W_{\max}} SC_{W,y} \times \delta_{W,y}$$

where

$$SC_{W,y} = \sum_{R=1}^{12} SC_{R,W,y}$$

W_{min} = first week of the season,

W_{max} = last week of the season,

$SC_{R,W,y}$ = estimated standing crop in region *R*, week *W* and year *y*,

$\delta_{W,y}$ = 1 if all 12 standard regions were sampled in week *W* of year *y*, and

$\delta_{W,y}$ = 0 otherwise.

For Atlantic tomcod, approximately unbiased Peterson-type mark-recapture estimates of abundance were computed as (Seber 1982):

$$\tilde{A}_y = \frac{(C_y + 1)(M_y + 1)}{(m_y + 1)} - 1$$

and the variance of the estimated abundance was estimated as (Seber 1982):

$$v(\tilde{A}_y) = \frac{(C_y + 1)(M_y + 1)(C_y - m_y)(M_y - m_y)}{(m_y + 1)^2 (m_y + 2)}$$

where

C_y = number of fish (marked and unmarked) caught subsequent to marking,

M_y = number of fish marked, and

m_y = number of marked fish recaptured.

The abundance indices are presented in Tables B-1 through B-3.

B. Stressors of Fish Populations

Four potential stressors of fish populations in the Hudson River estuary were identified: (1) power plant mortality due to entrainment at Indian Point; (2) effects of the zebra mussel invasion on the Hudson River biota; (3) predation by increased abundance of striped bass in the Hudson River estuary; and (4) elevated late summer and fall bottom temperatures. For each stressor, an index was developed that was intended to track the intensity of the stressor.

1. Power Plant Mortality

The index of entrainment mortality at Indian Point was the conditional mortality rate ("CMR"). An annual CMR for entrainment can be interpreted as the fractional reduction in age-1 abundance of a year class of fish due to the effects of entrainment, assuming the absence of density-dependent mortality. Estimates of CMRs for entrainment at Indian Point from 1974 through 1997 were taken from the Draft Environmental Impact Statement ("DEIS") for State Pollution Discharge Elimination System Permits for Bowline Point, Indian Point 2 & 3, and Roseton Steam Electric Generating Stations (Central Hudson Gas & Electric Corp. et al. 1999). CMR estimates for entrainment at Indian Point for 1998 through 2003 were computed for this analysis using the same methods documented in the DEIS. CMR estimates were computed separately for striped bass, white perch, American shad, bay anchovy, spottail shiner, Atlantic tomcod, and river herring.

The indices of entrainment mortality are listed in Table B-4.

2. Zebra Mussels

The invasive zebra mussel (*Dreissena polymorpha*) first appeared in the Hudson in 1991 and became a dominant species in the Hudson River by September 1992 (Strayer et al. 1996). Strayer et al. (2004) reported that "(z)ebra mussels were quantitatively important only in freshwater parts of the Hudson, and their effects extend from the head of the estuary (rkm 248) down to approximately rkm 100 (Strayer et al. 1996; Caraco et al. 1997; Pace et al. 1998)." Based on this characterization, the indicator variable for zebra mussel effects was set to zero (i.e., no effect) for the period 1974 through 1992, and was set to one (i.e., effect was present) for the years 1993 through 2004. Also, an index of the spatial distribution of fish within the Hudson River was defined (see Section II.C.4, below), based on the relative abundance of fish downriver of rkm 100.

The index of zebra mussel effects is listed in Table B-5.

3. Striped Bass Predation

The index of striped bass predation was intended to represent the predatory pressure of adult striped bass on the fish community of the Hudson River estuary. Post yolk-sac larvae abundance was used as a surrogate for adult abundance under the assumption that PYSL abundance represented reproductive potential which, in turn, was roughly proportional to spawning abundance. Accordingly, the striped bass PYSL abundance index based on the LRS was used as the index of striped bass predation.

The index of striped bass predation is listed in Table B-6.

4. Temperature

For all species except Atlantic tomcod, the index of water temperature was based on water temperature in the bottom stratum of the river and was computed in two steps. First, a riverwide average temperature for each week within a season was computed. The weekly average value was computed as the weighted average, where the weighting factor for each region (1 through 12) was the volume of the bottom stratum in the region. The second step was to average the weekly values over all weeks (in which all 12 standard regions were sampled) within the season.

For Atlantic tomcod, an alternative index of water temperature was computed: a degree-day index based on data recorded at the Poughkeepsie Water Works ("PWW"). The annual PWW degree-day index was computed as the sum (January through December) of daily temperatures above 24°C. Days with water temperatures below 24°C did not contribute to the annual sum. The temperature of 24°C was chosen because growth in age-0 Atlantic tomcod from the Hudson River slows when water temperatures exceeded 20°C and ceased when water temperatures exceeded 24°C (Chambers and Witting, 2005).

The indices of water temperature are listed in Table B-7.

C. Fish Population Response Metrics

1. Survival Indices

Each survival index was defined as a ratio of abundance indices from two life stages: the denominator of the ratio was the earlier life stage and the numerator was a subsequent life stage. Therefore, the ratio was proportional to the fraction of the earlier life stage that survived to the subsequent life stage. Because the methods and data used for the abundance indices (see Section II.A, above) are species-specific, the definitions of the survival indices are also species-specific.

- The survival index for striped bass from PYSL to YOY was defined as the ratio of the YOY abundance index (based on BSS data) to the PYSL abundance index (based on LRS data).
- The survival index for white perch from PYSL to YOY was defined as the ratio of the YOY abundance index (based on BSS data) to the PYSL abundance index (based on LRS data).
- The survival index for alewife from PYSL to YOY was defined as the ratio of the alewife YOY abundance index (based on BSS data) to the river herring YOY abundance index (based on LRS data).
- The survival index for American shad from PYSL to YOY was defined as the ratio of the YOY abundance index (based on FSS data) to the PYSL abundance index (based on LRS data).
- The survival index for bay anchovy from PYSL to YOY was defined as the ratio of the YOY abundance index (based on FSS data) to the PYSL abundance index (based on LRS data).
- The survival index for spottail shiner from eggs to YOY was defined as the ratio of the YOY abundance index (based on BSS data) to the egg abundance index (based on BSS data).
- The survival index for Atlantic tomcod from age-1 to age-2 was defined as the ratio of the age-2 abundance index (based on ATMR data) to the age-1 abundance index (based on ATMR data).

- The survival index for Atlantic tomcod from eggs to age-1 was defined as the ratio of the egg abundance index (based on ATMR data) to the age-1 abundance index (based on ATMR data).

The survival indices are listed in Table B-8.

2. Abundance Indices

Because some stressors can act directly on the abundance of certain life stages, the abundance indices listed in Tables B-1 through B-3 were also used as response metrics.

3. Growth Indices

The growth index was intended to represent the relative amount of growth in juvenile fish that occurred during a standard set of weeks (31 through 42) in the fall of each year. Annual growth indices (1979 through 2004) were computed from BSS and FSS data.

The growth index for each species and year was computed in three steps. First, the average fish length was calculated for each week and region. Then, a weighted average length was computed for each week, where the weight for each region was the YOY abundances in the region. The third step was to conduct a log-linear regression analysis of the weighted-average length ($\overline{L}_W$) against week number (W):

$$\overline{L}_W = L_{W_{\min}} \times e^{\rho(W - W_{\min})}.$$

The slope estimate ($\hat{\rho}$) from that regression analysis represented the average growth rate during the fall season, and was used as the index of growth for the species in that year.

The growth indices are listed in Table B-9.

4. Spatial Distribution Indices

This index was intended to address the possible effects of zebra mussels on fish distribution patterns, and was defined as the portion of the total population that occurred downstream of rkm 100.

For American shad and bay anchovy, the spatial distribution indices for YOY were based on data from the FSS for weeks 31 through 42. For striped bass, white perch, blueback herring, alewife and spottail shiner, the spatial distribution indices for YOY were based on data from the BSS for weeks 31 through 42. The spatial distribution indices for PYSL were computed for striped bass, white perch, bay anchovy, American shad, river herring, and Atlantic tomcod based on data from the LRS from weeks 18 through 26. For Atlantic tomcod, which spawn in late winter/early spring, data from the LRS included juveniles in addition to PYSL. Annual spatial indices based on LRS data were computed for 1974 through 2004. Annual spatial indices based on BSS data were computed for 1974 through 2004. Annual spatial indices based on FSS data were computed for 1979 through 2004.

For each species, life stage, region (R), and year, the fraction of the riverwide abundance inhabiting areas within the region or downriver of the region ($\hat{F}_{R,y}$) was estimated using the following formula:

$$\hat{F}_{R,y} = \frac{\left(\sum_{r=1}^{R} \overline{SC}_{r,y}\right)}{\left(\sum_{r=1}^{12} \overline{SC}_{r,y}\right)}$$

where

$$\overline{SC}_{r,y} = \left(\frac{1}{\sum_{W=W_{\min}}^{W_{\max}} \delta_{W,y}}\right) \sum_{W=W_{\min}}^{W_{\max}} SC_{r,W,y} \times \delta_{W,y} .$$

The upper boundary of Region 6 is between rkm 99 and rkm 100. Therefore, the index of spatial distribution was defined as $\hat{F}_{6,y}$.

The spatial distribution indices are listed in Table B-10.

III. CORRELATION ANALYSES

A correlation analysis was conducted to identify significant correlations between (1) stressor indices and (2) indices of fish population response metrics. For each stressor, a set of relevant response variables was selected based on impact hypotheses and life history considerations. For example, zebra mussel effects were paired with the proportion of a population downriver of rkm 100, and temperature was paired with juvenile growth rate.

A correlation analysis was also conducted to identify significant correlations between (1) abundance indices and (2) indices of fish population response metrics. Relevant combinations of abundance and response metrics were selected based on impact hypotheses and life history considerations.

The correlation analyses were conducted using Spearman (rank) correlation coefficients to account for possible non-Normality of the indices. The correlation analyses were based on annual index values and were conducted separately for each species.

Results from the correlation analyses are summarized in Tables B-11 through B-26. Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

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V. TABLES

Table B-1. Abundance Indices and Associated Standard Errors ("SE"), Based on Long River Survey Data.

Year Class	White Perch Post Yolk-Sac Larvae Index	White Perch Post Yolk-Sac Larvae SE	Striped Bass Post Yolk-Sac Larvae Index	Striped Bass Post Yolk-Sac Larvae SE	Bay Anchovy Post Yolk-Sac Larvae Index	Bay Anchovy Post Yolk-Sac Larvae SE	American Shad Post Yolk-Sac Larvae Index	American Shad Post Yolk-Sac Larvae SE
1974	139,139,531	9,461,494	116,793,360	14,525,520	9,111,556	2,155,940	32,149,174	5,436,351
1975	418,776,213	14,897,579	167,352,740	11,297,813	167,900,084	21,837,003	38,104,249	3,668,122
1976	571,765,805	26,442,918	55,463,017	3,014,531	341,602,306	88,340,964	30,532,518	4,411,773
1977	628,980,330	32,916,730	147,319,974	9,345,100	108,551,600	47,407,559	31,792,930	6,593,648
1978	852,286,248	54,375,932	113,088,409	9,188,267	13,499,413	2,574,305	14,808,830	1,725,494
1979	889,355,233	27,210,046	111,789,357	10,177,101	31,217,251	4,193,924	76,008,019	8,374,974
1980	731,972,701	29,071,443	193,067,215	15,374,877	282,472,131	47,526,524	62,624,636	6,850,621
1981	878,432,947	57,291,346	565,580,988	29,382,161	386,003,879	40,370,163	107,959,543	9,223,464
1982	1,533,952,669	63,678,126	214,574,357	17,311,853	7,721,685	1,434,887	105,866,404	11,668,608
1983	689,913,421	28,117,162	134,838,042	8,271,457	45,952,457	8,165,287	108,436,433	21,821,939
1984	659,480,715	40,337,372	200,167,635	28,656,262	39,045,805	11,944,143	46,171,178	7,590,296
1985	1,421,323,747	59,947,138	93,874,968	7,700,762	349,889,115	30,127,176	84,264,727	11,412,620
1986	2,052,461,814	98,317,198	171,163,020	8,998,325	118,354,834	10,883,362	152,128,084	17,215,544
1987	1,012,538,712	32,052,565	405,324,057	16,848,690	189,564,190	11,607,205	27,892,890	3,374,299
1988	754,305,782	42,580,552	351,072,816	35,669,346	152,035,433	30,786,324	78,027,604	11,883,534
1989	925,022,100	102,183,412	1,071,325,339	99,670,379	14,134,359	3,081,790	86,573,611	8,951,649
1990	768,296,570	79,095,729	1,295,596,696	153,298,294	890,027	256,957	108,278,134	14,347,189
1991	907,921,874	61,907,978	1,896,058,025	203,606,883	5,602,678,703	551,771,800	43,259,681	5,089,006
1992	1,211,029,021	53,752,949	1,436,836,717	103,392,955	77,338,304	10,339,754	99,755,719	15,257,291
1993	1,231,794,687	50,130,673	2,008,989,233	181,226,826	573,839,976	50,894,605	33,386,515	6,848,737
1994	1,043,697,036	46,808,643	2,009,527,814	204,188,984	583,968,501	47,054,442	37,913,769	3,901,481
1995	623,420,693	29,028,682	939,209,970	99,781,400	839,521,735	64,631,235	24,920,433	3,668,256
1996	1,505,193,548	83,865,093	3,629,518,187	365,724,596	405,338,653	43,811,932	31,112,517	3,986,134
1997	307,236,756	17,277,642	1,252,166,315	211,669,199	1,009,992,702	213,235,143	19,546,174	4,202,344
1998	575,146,100	35,729,754	1,413,117,919	122,712,647	18,860,574	3,243,002	10,840,582	1,389,788
1999	673,636,250	39,842,187	3,468,043,472	358,992,219	287,637,139	29,957,432	19,920,980	4,244,449
2000	1,180,789,474	133,501,704	5,803,754,734	715,393,543	1,355,732	345,802	10,158,022	1,432,512
2001	734,730,398	61,307,779	5,258,385,169	340,997,297	51,298,063	22,554,315	48,974,089	9,013,780
2002	566,273,447	39,302,719	587,019,561	40,128,197	173,651,942	21,508,231	11,487,215	2,321,455
2003	692,003,842	45,947,390	1,853,946,447	202,927,363	6,523,373	2,802,470	11,636,329	1,626,253
2004	721,129,750	39,776,443	1,646,077,551	106,676,037	717,812,470	71,311,509	13,196,538	1,966,124

Table 1. Abundance Indices and Associated Standard Errors ("SE"), Based on Long River Survey Data (continued).

Year Class	River Herring Post Yolk-Sac Larvae Index	SE	Atlantic Tomcod Post Yolk-Sac Larvae Index	SE
1974	1,925,093,580	1,073,772,004	128,306,743	19,426,263
1975	2,177,549,296	197,088,426	67,024,707	19,768,962
1976	1,590,931,203	156,327,051	42,777,042	13,470,065
1977	1,789,369,237	309,551,598	164,621,663	70,515,234
1978	2,483,545,195	230,530,412	54,313,088	10,307,482
1979	1,492,563,623	65,281,612	18,127,435	3,099,375
1980	1,451,864,997	82,238,743	95,402,234	13,128,146
1981	2,097,039,055	238,479,765	74,140,778	13,052,007
1982	2,761,588,726	248,286,854	28,419,800	7,665,326
1983	3,398,542,430	247,313,066	42,683,202	8,311,722
1984	2,263,857,937	168,138,864	147,133,069	25,916,525
1985	2,360,908,396	138,470,331	109,664,584	11,132,251
1986	3,060,453,736	212,481,475	53,404,268	4,770,519
1987	945,121,604	62,594,106	138,570,516	12,594,732
1988	1,205,794,912	101,740,608	78,376,300	10,680,903
1989	1,515,234,476	181,441,810	185,450,859	23,858,579
1990	1,296,493,803	106,557,985	107,915,374	25,158,013
1991	1,105,840,600	89,654,766	116,333,462	14,859,973
1992	1,592,451,980	119,021,893	32,021,214	4,889,565
1993	957,005,646	76,057,902	126,394,886	20,139,893
1994	1,006,699,048	57,426,960	85,456,373	22,227,930
1995	745,594,402	44,387,051	79,816,881	6,641,688
1996	2,092,537,070	119,641,340	51,571,386	5,696,759
1997	338,336,798	21,073,725	110,409,961	28,829,551
1998	599,669,094	37,989,853	53,594,909	8,409,591
1999	658,448,983	38,493,738	17,392,702	2,076,588
2000	1,736,751,090	110,473,230	11,120,807	1,442,773
2001	941,430,470	69,923,386	93,816,691	8,320,053
2002	798,010,496	43,842,607	4,382,650	649,979
2003	608,369,228	39,023,677	38,715,789	3,683,762
2004	681,555,090	40,476,571	115,401,578	16,005,570

Table B-2. Abundance Indices and Associated Standard Errors ("SE"), Based on Beach Seine Survey Data.

Year Class	White Perch Young-of-Year Index	SE	Striped Bass Young-of-Year Index	SE	Spottail Shiner Young-of-Year Index	SE	Spottail Shiner Egg Index	SE
1974	566,346	61,280	1,373,138	264,598	658,945	87,448	1,128,997	107,867
1975	2,342,937	440,999	1,367,496	242,374	1,286,297	193,361	1,578,455	195,841
1976	1,944,220	255,910	864,743	70,734	1,324,434	203,989	0	0
1977	953,799	87,722	1,375,537	124,595	495,690	66,445	0	0
1978	2,675,700	402,374	3,042,920	614,048	1,363,313	148,541	0	0
1979	2,921,393	285,862	794,022	91,389	956,236	97,330	0	0
1980	1,884,895	231,650	1,265,254	147,121	633,323	72,196	312,488	80,635
1981	1,862,222	160,903	1,827,767	152,481	1,865,058	216,442	627,176	96,220
1982	1,967,754	287,490	934,550	97,768	477,090	62,605	173,130	25,821
1983	1,803,266	399,823	1,642,536	191,103	1,070,822	104,909	197,639	51,127
1984	703,959	145,133	1,300,754	173,872	616,182	128,367	222,054	41,973
1985	757,003	82,536	238,259	21,226	543,246	66,532	116,419	17,690
1986	1,036,321	97,303	298,745	31,415	388,736	69,297	276,641	48,687
1987	1,169,236	121,876	2,976,381	314,807	470,267	74,827	234,226	45,133
1988	1,738,310	255,364	1,172,303	68,239	419,874	49,588	276,581	49,087
1989	1,105,280	278,101	1,238,434	116,464	623,204	95,526	272,136	61,641
1990	588,162	75,727	1,486,911	89,409	808,662	101,694	144,012	31,435
1991	580,165	76,201	1,125,126	64,076	855,292	110,557	833,354	126,276
1992	463,555	53,444	1,046,654	53,265	726,888	124,009	453,069	112,051
1993	806,848	97,157	1,640,132	90,969	655,117	95,425	391,317	97,925
1994	315,662	39,618	1,136,106	63,179	1,624,997	289,784	168,358	27,009
1995	425,062	49,042	1,404,935	89,202	603,130	94,204	229,394	41,809
1996	44,925	10,283	299,997	30,506	174,026	39,053	58,663	15,101
1997	571,160	114,812	1,892,597	169,399	1,197,799	170,583	140,490	33,758
1998	270,835	51,992	1,384,364	85,327	273,165	53,055	147,082	40,400
1999	1,411,184	169,447	1,715,282	142,568	2,040,399	243,244	154,889	21,463
2000	304,950	52,787	580,006	52,449	303,081	52,956	164,945	29,160
2001	1,019,516	119,666	2,392,216	170,860	2,143,066	610,761	16,919	5,028
2002	699,145	80,612	1,145,686	60,295	1,132,479	146,862	174,197	50,311
2003	2,177,013	228,303	2,282,684	118,276	2,102,568	257,006	565,369	131,279
2004	632,961	89,075	807,661	70,743	1,031,399	152,802	436,330	79,667

Table 2. Abundance Indices and Associated Standard Errors ("SE"), Based on Beach Seine Survey Data (continued).

Year Class	Alewife Young-of-Year Index	Alewife Young-of-Year SE	Blueback Herring Young-of-Year Index	Blueback Herring Young-of-Year SE
1974	583,238	74,805	3,647,758	502,857
1975	572,550	107,585	10,888,524	1,249,788
1976	352,263	96,375	21,621,271	3,075,761
1977	517,792	49,081	31,795,371	4,717,652
1978	1,027,891	174,698	22,993,451	4,200,939
1979	340,271	59,099	8,221,314	1,461,758
1980	93,783	17,894	8,892,467	2,207,337
1981	477,348	84,403	32,066,440	9,586,015
1982	116,606	24,817	10,164,307	1,750,817
1983	214,922	42,154	16,326,879	2,278,723
1984	49,776	10,864	3,577,323	786,742
1985	119,509	22,024	3,323,511	664,762
1986	119,468	48,899	1,555,182	357,032
1987	80,611	13,768	6,188,101	773,111
1988	87,080	15,727	5,887,963	1,008,925
1989	43,711	12,956	3,230,116	497,839
1990	157,159	25,580	9,436,487	1,274,900
1991	335,535	63,111	3,530,392	596,059
1992	40,507	9,371	6,642,282	1,599,250
1993	69,438	11,826	4,234,168	531,496
1994	148,030	30,079	9,584,696	1,308,960
1995	91,731	22,716	3,202,735	892,613
1996	47,371	14,912	4,044,353	890,186
1997	291,323	54,177	12,075,530	2,541,612
1998	40,865	30,194	155,761	32,365
1999	445,167	79,622	5,691,570	776,702
2000	76,445	37,606	2,342,499	572,561
2001	330,876	70,451	5,268,663	704,402
2002	60,954	13,491	1,438,577	299,230
2003	452,292	87,223	10,203,281	1,459,824
2004	218,118	35,902	5,091,421	620,888

Table B-3. Abundance Indices and Associated Standard Errors ("SE"), Based on Fall Shoals Survey and Atlantic Tomcod Mark Recapture Data.

Year Class	Bay Anchovy Young-of-Year (FSS) Index	SE	American Shad Young-of-Year (FSS) Index	SE	Atlantic Tomcod Ages 1 and 2 (ATMR) Index	SE
1974	-	-	-	-	3,666,156.2	667,339
1975	-	-	-	-	3,680,086.9	375,142
1976	-	-	-	-	19,210,329.2	2,767,571.7
1977	-	-	-	-	2,434,397.0	458,488.1
1978	-	-	-	-	5,894,583.8	917,687.4
1979	-	-	-	-	9,128,535	1,692,155.4
1980	-	-	-	-	4,747,440	3,355,405.2
1981	-	-	-	-	25,066,665.0	14,468,003
1982	-	-	-	-	12,983,676.9	2,899,705
1983	-	-	-	-	6,657,331.2	1,302,504.2
1984	-	-	-	-	-	-
1985	218,612,898	21,269,766	1,591,435	190,139	2,093,677	171,796
1986	132,925,173	13,133,411	3,104,605	640,844	-	-
1987	246,910,112	26,982,497	647,070	157,299	3,526,907.2	570,280
1988	422,678,791	38,213,532	997,871	144,252	5,897,656.7	524,801.4
1989	349,952,337	26,107,654	2,754,815	198,752	6,804,809.4	1,239,300.2
1990	161,039,442	14,450,450	1,139,272	235,276	3,208,815.0	615,208.4
1991	190,474,265	11,540,891	680,209	72,781	388,763.0	84,175.2
1992	185,902,303	13,738,226	1,306,732	147,744	2,553,778.3	319,857.2
1993	249,913,241	19,475,645	464,702	48,446	663,439.1	155,295.9
1994	206,642,043	14,141,476	1,036,782	88,932	2,384,183	659,618.4
1995	439,617,793	28,732,239	471,444	75,896	88,492.5	50,523.4
1996	102,941,191	5,959,974	2,859,373	451,439	3,277,909.3	1,637,090
1997	283,382,412	17,014,202	913,970	107,851	1,291,980.5	302,916.5
1998	189,541,611	9,166,785	232,260	56,459	592,891.0	241,105.3
1999	165,375,818	9,972,244	853,411	135,639	181,179.0	59,983.3
2000	57,208,944	3,577,181	878,405	100,807	2,504,266	624,327.3
2001	109,701,139	8,052,515	1,006,787	162,014	40,875	28,743.1
2002	171,692,430	10,652,063	497,537	57,524	108,528.0	76,363
2003	148,898,706	11,753,477	351,278	47,131	1,653,319	425,310
2004	218,178,981	17,899,774	336,973	63,105	-	-

Table B-4. Estimates of Indian Point Conditional Mortality Rate (CMR) for entrainment.

Year Class	White Perch CMR	Striped Bass CMR	Spottail Shiner CMR	Bay Anchovy CMR	American Shad CMR	River Herring CMR	Atlantic Tomcod CMR
1974	7.45	5.65	0.87	7.31	0.22	0.83	3.65
1975	8.65	7.78	1.04	6.61	0.35	1.42	6.75
1976	3.22	4.73	1.38	3.45	0.33	1.85	8.76
1977	7.27	13.89	1.41	13.78	0.38	2.47	10.15
1978	5.28	8.55	2.32	12.54	0.24	1.26	10.6
1979	8.02	11.92	1.62	10.8	0.2	2.24	18.8
1980	3.36	11.87	1.66	18.44	0.03	0.48	25.47
1981	6.54	4.17	3.43	18.56	0.2	0.57	11.68
1982	4.33	6.99	2.06	4.19	0.44	0.81	17.47
1983	17.23	7.36	3.17	9.04	0.09	3.05	7.69
1984	8.92	17.25	1.58	6.26	7.5	5.34	16.58
1985	0.55	3.97	1.77	10.06	0	0.02	34.5
1986	4.07	16.26	1.55	5.07	3.56	0.92	11.36
1987	0.66	2.3	1.53	9.99	0	0.04	14.61
1988	7.94	11.63	4.1	17.73	0.15	0.51	23.94
1989	4.03	5.96	8.32	7.96	0.28	1.41	4.49
1990	3.48	6.12	2.18	20.85	0.43	2.94	5.52
1991	1.4	4.95	3.92	9.09	0.07	0.41	6.99
1992	2.7	6.16	0.99	7.12	0.05	0.41	14.11
1993	2.34	5.6	0.89	7.08	0.13	0.23	3.67
1994	3.14	6.81	1.1	5.94	0.12	0.49	7.57
1995	1.92	4.22	2.54	14.99	0.1	0.12	5.77
1996	4.88	12.01	1.89	15.55	0.42	0.49	8.47
1997	1.29	1.42	0.64	6.62	0.05	0.6	10.35
1998	4.87	8.46	0.45	7.82	0.12	0.59	10.01
1999	4.16	11.35	2.57	13.81	0.23	3.66	21.54
2000	7.31	4.03	1.63	7.77	1.86	4	11.23
2001	5.69	8	2.56	15.4	0.3	1.82	20.97
2002	11.96	13.77	3.03	10.57	1.23	4.84	23.25
2003	7.67	12.26	1.21	12.97	0.19	1.85	20.43
2004	-	-	-	-	-	-	-

Table B-5. Zebra Mussel Index.

Year Class	Zebra Mussel Index
1974	0
1975	0
1976	0
1977	0
1978	0
1979	0
1980	0
1981	0
1982	0
1983	0
1984	0
1985	0
1986	0
1987	0
1988	0
1989	0
1990	0
1991	0
1992	0
1993	1
1994	1
1995	1
1996	1
1997	1
1998	1
1999	1
2000	1
2001	1
2002	1
2003	1
2004	1

Table B-6. Striped Bass Predation Index.

Year Class	Striped Bass PYSL Index
1974	116,793,360
1975	167,352,740
1976	55,463,017
1977	147,319,974
1978	113,088,409
1979	111,789,357
1980	193,067,215
1981	565,580,988
1982	214,574,357
1983	134,838,042
1984	200,167,635
1985	93,874,968
1986	171,163,020
1987	405,324,057
1988	351,072,816
1989	1,071,325,339
1990	1,295,596,696
1991	1,896,058,025
1992	1,436,836,717
1993	2,008,989,233
1994	2,009,527,814
1995	939,209,970
1996	3,629,518,187
1997	1,252,166,315
1998	1,413,117,919
1999	3,468,043,472
2000	5,803,754,734
2001	5,258,385,169
2002	587,019,561
2003	1,853,946,447
2004	1,646,077,551

Table B-7. Temperature Indices.

Year Class	FSS Temperature Index	PWW Degree-Day Index
1974	-	
1975	-	
1976	-	18.8
1977	-	57.7
1978	-	60.8
1979	22.5	61.3
1980	22.4	128.1
1981	19.8	98.0
1982	-	64.3
1983	24.0	107.9
1984	22.8	91.2
1985	21.5	63.1
1986	21.5	61.1
1987	19.9	111.1
1988	24.6	121.1
1989	22.2	65.2
1990	22.7	68.4
1991	21.5	108.9
1992	20.2	6.5
1993	22.2	97.1
1994	22.2	103.6
1995	22.6	94.9
1996	22.3	28.6
1997	22.4	63.7
1998	23.5	94.1
1999	23.2	136.8
2000	21.7	0.9
2001	23.1	98.9
2002	23.5	121.6
2003	22.6	106.8
2004	22.5	18.8

Table B-8. Survival Indices.

Year Class	White Perch PYSL to YOY Index	Striped Bass PYSL to YOY Index	Spottail Shiner Egg to YOY Index	Bay Anchovy PYSL to YOY Index	American Shad PYSL to YOY Index	River Herring PYSL to YOY Index	Atlantic Tomcod Egg to Age-1 Index	Atlantic Tomcod Age-1 to Age-2 Index
1974	0.0041	0.0118	0.5837	-	-	0.0030	-	-
1975	0.0056	0.0082	0.8149	-	-	0.0053	-	0.2008
1976	0.0034	0.0156	-	-	-	0.0138	0.4411	0.0103
1977	0.0015	0.0093	-	-	-	0.0184	0.0371	0.0249
1978	0.0031	0.0269	-	-	-	0.0100	0.2826	0.0460
1979	0.0033	0.0071	-	-	-	0.0077	0.1731	-
1980	0.0026	0.0066	2.0267	-	-	0.0064	-	-
1981	0.0021	0.0032	2.9737	-	-	0.0155	-	-
1982	0.0013	0.0044	2.7557	-	-	0.0039	-	0.0699
1983	0.0026	0.0122	5.4181	-	-	0.0049	0.0613	-
1984	0.0011	0.0065	2.7749	-	-	0.0018	-	-
1985	0.0005	0.0025	4.6663	0.6248	0.0189	0.0015	-	-
1986	0.0005	0.0017	1.4052	1.1231	0.0204	0.0006	-	-
1987	0.0012	0.0073	2.0077	1.3025	0.0232	0.0068	-	0.2014
1988	0.0023	0.0033	1.5181	2.7801	0.0128	0.0050	0.1235	0.3714
1989	0.0012	0.0012	2.2900	24.7590	0.0318	0.0023	0.1186	0.1251
1990	0.0008	0.0011	5.6152	180.9377	0.0105	0.0084	0.0298	0.0448
1991	0.0006	0.0006	1.0263	0.0340	0.0157	0.0035	0.0055	1.3636
1992	0.0004	0.0007	1.6044	2.4038	0.0131	0.0042	0.3153	0.1078
1993	0.0007	0.0008	1.6741	0.4355	0.0139	0.0045	0.0154	0.4661
1994	0.0003	0.0006	9.6520	0.3539	0.0273	0.0097	0.3110	-
1995	0.0007	0.0015	2.6292	0.5237	0.0189	0.0044		-
1996	0.0000	0.0001	2.9665	0.2540	0.0919	0.0043	-	0.2314
1997	0.0019	0.0015	8.5259	0.2806	0.0468	0.0366	0.0148	0.2933
1998	0.0005	0.0010	1.8572	10.0496	0.0214	0.0003	0.0173	0.1004
1999	0.0021	0.0005	13.1733	0.5749	0.0428	0.0093	0.0160	1.0951
2000	0.0003	0.0001	1.8375	42.1978	0.0865	0.0015	0.7792	-
2001	0.0014	0.0005	126.6690	2.1385	0.0206	0.0065	-	-
2002	0.0012	0.0020	6.5011	0.9887	0.0433	0.0019	-	-
2003	0.0031	0.0012	3.7189	22.8254	0.0302	0.0186	-	-
2004	0.0009	0.0005	2.3638	0.3039	0.0255	0.0079	-	-

Table B-9. Growth Rate Indices

Year Class	White Perch Index	Striped Bass Index	Spottail Shiner Index	Bay Anchovy Index	American Shad Index	Alewife Index	Blueback Herring Index
1974	0.0972	0.0727	0.0844	-	-	0.0265	0.0810
1975	0.0605	0.0495	0.0624	-	-	0.0420	0.0563
1976	0.0873	0.0542	-	-	-	-	-
1977	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-
1979	0.0725	0.0697	0.0768	-	-	0.0571	0.0894
1980	0.0790	0.0729	0.0742	-	-	0.0337	0.0658
1981	0.0578	0.0501	0.0651	-	-	0.0350	0.0632
1982	0.0769	0.0460	0.0733	-	-	0.0454	0.0591
1983	0.0845	0.0919	0.1417	-	-	0.0916	0.1037
1984	0.1142	0.0942	0.0824	-	-	0.0752	0.0669
1985	0.0611	0.1245	0.0520	0.0288	0.0234	0.0525	0.0304
1986	0.0640	0.0433	0.0534	0.0703	0.0716	0.0459	0.0604
1987	0.0750	0.0685	0.0864	0.0311	0.0466	0.0630	0.0555
1988	0.0589	0.0532	0.0691	0.0928	0.0813	0.0520	0.0573
1989	0.0973	0.0712	0.0788	0.0870	0.0661	0.0815	0.0858
1990	0.1081	0.0866	0.0998	0.1000	0.0711	0.0585	0.0603
1991	0.0620	0.0591	0.0552	0.0505	0.0572	0.0510	0.0808
1992	0.0933	0.0840	0.0616	0.0617	0.0759	0.0412	0.0581
1993	0.0732	0.0589	0.0621	0.0475	0.0346	0.0271	0.0200
1994	0.0362	0.0372	0.0502	0.0890	0.0546	0.0425	0.0204
1995	0.1088	0.0823	0.0793	0.0668	0.0460	0.0471	0.0845
1996	0.1073	0.1070	0.1168	0.0642	0.0853	0.0729	0.0384
1997	0.0764	0.0657	0.0716	0.0997	0.0756	0.0461	0.0322
1998	0.0813	0.0802	0.0603	0.0732	0.0520	0.0670	0.0454
1999	0.0457	0.0671	0.0414	0.0256	0.0320	0.0086	0.0316
2000	0.0813	0.0773	0.0732	0.0781	0.0824	0.0797	0.0610
2001	0.0961	0.0652	0.0978	0.0763	0.0637	0.0710	0.0686
2002	0.0624	0.0625	0.0637	0.0400	0.0445	0.0366	0.0982
2003	0.0732	0.0517	0.0863	0.0841	0.0493	0.0536	0.0465
2004	0.0515	0.0474	0.0592	0.1006	0.0601	0.0411	0.0715

Table B-10. Spatial Distribution Indices -- The Fraction of Standing Crop that is Downriver of rkm 100.

Year	White Perch		Striped Bass		Spottail Shiner	Bay Anchovy		American Shad	
	PYSL	YOY	PYSL	YOY	YOY	PYSL	YOY	PYSL	YOY
Class	Index	Index	Index	Index	Index	Index	Index	Index	Index
1974	0.4102	0.3501	0.6199	0.8947	0.0783	1.0000	-	0.0209	-
1975	0.4373	0.7000	0.7998	0.9192	0.0772	1.0000	-	0.1802	-
1976	0.1782	0.5473	0.7834	0.9109	0.1804	1.0000	-	0.0380	-
1977	0.2008	0.3872	0.7088	0.8765	0.0668	0.9999	-	0.0139	-
1978	0.2638	0.6703	0.8044	0.9554	0.1594	1.0000	-	0.0274	-
1979	0.3384	0.6210	0.8876	0.9027	0.2137	1.0000	-	0.0351	-
1980	0.2276	0.6592	0.7788	0.8260	0.0709	0.9998	-	0.0198	-
1981	0.2585	0.6813	0.5834	0.9247	0.0874	0.9998	-	0.0267	-
1982	0.3628	0.7975	0.8013	0.9668	0.2880	1.0000	-	0.0461	-
1983	0.4220	0.5556	0.8632	0.8634	0.1347	0.9997	-	0.0293	-
1984	0.2366	0.7919	0.8475	0.9402	0.0794	0.9997	-	0.3433	-
1985	0.1420	0.6204	0.6800	0.9004	0.0749	0.9982	0.8978	0.0015	0.3707
1986	0.2147	0.7541	0.8164	0.9115	0.0962	1.0000	0.9178	0.0104	0.1426
1987	0.0984	0.4309	0.4985	0.9110	0.0145	0.9964	0.9547	0.0012	0.1960
1988	0.3191	0.7514	0.7726	0.8233	0.1086	0.9249	0.8584	0.0032	0.3732
1989	0.4646	0.7267	0.7884	0.9188	0.1493	0.9557	0.8974	0.1272	0.1777
1990	0.3406	0.4131	0.5434	0.8682	0.0743	1.0000	0.9365	0.0539	0.3500
1991	0.2109	0.3581	0.7037	0.6287	0.0165	0.9835	0.6000	0.0036	0.2074
1992	0.2616	0.5105	0.8321	0.8619	0.0344	0.9964	0.8679	0.0154	0.3391
1993	0.1911	0.3349	0.7026	0.8189	0.0593	0.9966	0.7392	0.0029	0.2788
1994	0.2156	0.4619	0.8595	0.8084	0.0767	0.9995	0.9240	0.0077	0.3255
1995	0.2054	0.3869	0.7445	0.8986	0.0143	0.9888	0.7635	0.0049	0.3529
1996	0.1587	0.7707	0.7570	0.7614	0.1261	0.9978	0.9603	0.0062	0.2600
1997	0.2799	0.4857	0.8852	0.8555	0.0774	1.0000	0.8117	0.0078	0.1259
1998	0.2646	0.5741	0.8162	0.8603	0.0351	0.9986	0.8190	0.0202	0.0674
1999	0.1919	0.6035	0.7352	0.7392	0.0220	0.9987	0.8487	0.0235	0.2024
2000	0.6546	0.5040	0.9908	0.7759	0.1723	0.9797	0.8889	0.1399	0.2930
2001	0.1508	0.4677	0.7024	0.8177	0.0193	1.0000	0.9302	0.0438	0.2072
2002	0.2851	0.2743	0.8712	0.7682	0.0008	1.0000	0.7100	0.0879	0.0657
2003	0.3001	0.4981	0.8249	0.8803	0.0572	1.0000	0.9507	0.0132	0.1721
2004	0.2150	0.1672	0.8196	0.6875	0.0407	0.9997	0.9363	0.0364	0.1225

Table 10. Spatial Distribution Indices -- The Fraction of Standing Crop that is Downriver of rkm 100 (continued).

Year Class	Alewife PYSL Index*	Alewife YOY Index	Blueback Herring PYSL Index*	Blueback Herring YOY Index	Atlantic Tomcod PYSL Index
1974	0.0448	0.9065	0.0448	0.2928	0.9903
1975	0.0650	0.8709	0.0650	0.1996	0.9902
1976	0.1571	0.6064	0.1571	0.1818	0.9912
1977	0.0575	0.5622	0.0575	0.4164	0.9953
1978	0.0985	0.5909	0.0985	0.1202	0.9854
1979	0.1189	0.4444	0.1189	0.1452	0.9860
1980	0.0193	0.5528	0.0193	0.0663	0.9528
1981	0.0844	0.4460	0.0844	0.3646	0.9853
1982	0.0704	0.7575	0.0704	0.2143	0.9663
1983	0.1715	0.2247	0.1715	0.1088	0.9960
1984	0.2939	0.3330	0.2939	0.2982	0.9778
1985	0.0086	0.4559	0.0086	0.3012	0.9496
1986	0.0776	0.3842	0.0776	0.1475	0.9741
1987	0.0077	0.3363	0.0077	0.2725	0.8921
1988	0.0545	0.7762	0.0545	0.2218	0.9609
1989	0.0894	0.7374	0.0894	0.1058	0.9980
1990	0.1879	0.4526	0.1879	0.0988	0.9712
1991	0.0228	0.0304	0.0228	0.0101	0.9837
1992	0.0595	0.4622	0.0595	0.5121	0.9976
1993	0.0097	0.2508	0.0097	0.2744	0.9950
1994	0.0265	0.5730	0.0265	0.3236	0.9915
1995	0.0184	0.1994	0.0184	0.1357	0.9411
1996	0.0186	0.4721	0.0186	0.6749	0.9852
1997	0.1830	0.2906	0.1830	0.0769	0.9935
1998	0.0448	0.8889	0.0448	0.0846	0.9928
1999	0.1857	0.2304	0.1857	0.2034	0.9732
2000	0.2224	0.1696	0.2224	0.1666	0.9024
2001	0.0698	0.1830	0.0698	0.0800	0.9721
2002	0.2350	0.0914	0.2350	0.3404	0.9938
2003	0.1196	0.5519	0.1196	0.2539	0.9934
2004	0.1376	0.5527	0.1376	0.1861	0.9849

Table B-11. Striped Bass

Response Metric	Stressor				Yearclass
	Indian Point Entrainment Mortality (CMR)	Zebra Mussels	Striped Bass Predation	Temperature	
PYSL-to-YOY Survival		**-0.69**			**-0.84**
PYSL Abundance					**+0.84**
YOY Abundance					
YOY Growth Rate					
% PYSL Downriver of rkm 100					
% YOY Downriver of rkm 100		**-0.63**			**-0.68**
Yearclass		**+0.84**	**+0.84**		

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-12. Striped Bass

Response Metric	Response Metric: PYSL-to-YOY Survival	Response Metric: PYSL Abundance	Response Metric: YOY Abundance	Yearclass
PYSL-to-YOY Survival				**-0.84**
PYSL Abundance				**+0.84**
YOY Abundance				
Yearclass	**-0.84**	**+0.84**		

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-13. White Perch

Response Metric	Stressor				Yearclass
	Indian Point Entrainment Mortality (CMR)	Zebra Mussels	Striped Bass Predation	Temperature	
PYSL-to-YOY Survival	**+0.44**	**-0.36**	**-0.57**	**+0.42**	**-0.53**
PYSL Abundance	-0.34				
YOY Abundance			**-0.54**		**-0.51**
YOY Growth Rate					
% PYSL Downriver of rkm 100					
% YOY Downriver of rkm 100		**-0.40**			**-0.37**
Yearclass		**+0.84**	**+0.84**		

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-14. White Perch

Response Metric	Response Metric			Yearclass
	PYSL-to-YOY Survival	PYSL Abundance	YOY Abundance	
PYSL-to-YOY Survival			**+0.76**	**-0.53**
PYSL Abundance				
YOY Abundance	**+0.76**			**-0.51**
Yearclass	**-0.53**		**-0.51**	

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-15. American Shad

Response Metric	Stressor: Indian Point Entrainment Mortality (CMR)	Stressor: Zebra Mussels	Stressor: Striped Bass Predation	Stressor: Temperature	Yearclass
PYSL-to-YOY Survival		**+0.58**			**+0.55**
PYSL Abundance			-0.31		**-0.46**
YOY Abundance					**-0.57**
YOY Growth Rate					
% PYSL Downriver of rkm 100					
% YOY Downriver of rkm 100					**-0.48**
Yearclass		**+0.84**	**+0.84**		

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-16. American Shad

Response Metric	Response Metric			Yearclass
	PYSL-to-YOY Survival	PYSL Abundance	YOY Abundance	
PYSL-to-YOY Survival				**+0.55**
PYSL Abundance			**+0.75**	**-0.46**
YOY Abundance		**+0.75**		**-0.57**
Yearclass	**+0.55**	**-0.46**	**-0.57**	

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-17. Atlantic Tomcod

Response Metric	Stressor				Yearclass/ Year
	Indian Point Entrainment Mortality (CMR)	Zebra Mussels	Striped Bass Predation	Temperature (PWW degree-days)	
Egg-to-Age1 Survival				-0.59	
Age1-to-Age2 Survival			+0.45		+0.56
Egg Abundance					-0.42
PYSL Abundance	-0.36				
Age1 Abundance			-0.65		-0.72
% PYSL Downriver of rkm 100					
Yearclass/ Year		+0.84	+0.84		

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-18. Atlantic Tomcod

Response Metric	Response Metric				Yearclass/ Year
	Egg-to-Age1 Survival	Age1-to-Age2 Survival	Egg Abundance	Age1 Abundance	
Egg-to-Age1 Survival				+0.61	
Age1-to-Age2 Survival					+0.56
Egg Abundance					-0.42
Age1 Abundance	+0.61				-0.72
Yearclass/ Year		+0.56	-0.42	-0.72	

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-19. Alewife

Response Metric	Stressor				Yearclass
	Indian Point Entrainment Mortality (CMR)	Zebra Mussels	Striped Bass Predation	Temperature	
PYSL-to-YOY Survival					
PYSL Abundance			-0.56		-0.70
YOY Abundance			-0.34		-0.40
YOY Growth Rate					
% PYSL Downriver of rkm 100					
% YOY Downriver of rkm 100		-0.33			-0.45
Yearclass		+0.84	+0.84		

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-20. Alewife

Response Metric	Response Metric			Yearclass
	PYSL-to-YOY Survival	PYSL Abundance	YOY Abundance	
PYSL-to-YOY Survival				
PYSL Abundance				**-0.70**
YOY Abundance				**-0.40**
Yearclass		**-0.70**	**-0.40**	

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-21. Blueback Herring

Response Metric	Stressor: Indian Point Entrainment Mortality (CMR)	Stressor: Zebra Mussels	Stressor: Striped Bass Predation	Stressor: Temperature	Yearclass
PYSL-to-YOY Survival					
PYSL Abundance			**-0.56**		**-0.70**
YOY Abundance			-0.31		**-0.45**
YOY Growth Rate					
% PYSL Downriver of rkm 100					
% YOY Downriver of rkm 100					
Yearclass		**+0.84**	**+0.84**		

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-22. Blueback Herring

Response Metric	Response Metric: PYSL-to-YOY Survival	Response Metric: PYSL Abundance	Response Metric: YOY Abundance	Yearclass
PYSL-to-YOY Survival				
PYSL Abundance				**-0.70**
YOY Abundance				**-0.45**
Yearclass		**-0.70**	**-0.45**	

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-23. Bay Anchovy

Response Metric	Stressor: Indian Point Entrainment Mortality (CMR)	Stressor: Zebra Mussels	Stressor: Striped Bass Predation	Stressor: Temperature	Yearclass
PYSL-to-YOY Survival					
PYSL Abundance					
YOY Abundance			**-0.53**		
YOY Growth Rate					
% PYSL Downriver of rkm 100					
% YOY Downriver of rkm 100					
Yearclass		**+0.84**	**+0.84**		

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-24. Bay Anchovy

Response Metric	Response Metric			Yearclass
	PYSL-to-YOY Survival	PYSL Abundance	YOY Abundance	
PYSL-to-YOY Survival				
PYSL Abundance				
YOY Abundance				
Yearclass				

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-25. Spottail Shiner

Response Metric	Stressor: Indian Point Entrainment Mortality (CMR)	Stressor: Zebra Mussels	Stressor: Striped Bass Predation	Stressor: Temperature	Yearclass
Egg-to-YOY Survival		**+0.42**		+0.38	**+0.40**
PYSL Abundance					
YOY Abundance					
YOY Growth Rate					
% YOY Downriver of rkm 100		**-0.40**			**-0.51**
Yearclass		**+0.84**	**+0.84**		

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

Table B-26. Spottail Shiner

Response Metric	Response Metric			Yearclass
	Egg-to-YOY Survival	PYSL Abundance	YOY Abundance	
Egg-to-YOY Survival				**+0.40**
PYSL Abundance				
YOY Abundance				
Yearclass	**+0.40**			

Correlation coefficients significant at the 0.05 level are printed in black and correlation coefficients significant at the 0.10 level are printed in gray. A blank cell in the table indicates that the correlation coefficient was not significant at a probability level of 0.10 or lower. Cells shaded gray indicate pairs of indices that were not considered relevant, based on impact hypothesis and/or life history considerations.

APPENDIX C

Potential Effects of Striped Bass Predation on Juvenile Fish in the Hudson River

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Abstract

This study addressed the question of whether the increase in striped bass (*Morone saxatilis*) abundance in the Hudson River that began after 1990, and the associated increase in predatory demand, could have been responsible for observed declines in juvenile abundance of river herring (i.e., blueback herring (*Alosa aestivalis*) and alewife (*Alosa pseudoharengus*)), Atlantic tomcod (*Microgadus tomcod*) and white perch (*Morone americana*), and the apparent decline in juvenile survival of striped bass, in the Hudson River. Seasonal (August through October) predatory demand of Hudson River striped bass (ages 1 through 13) was estimated to have increased from an average of 3.4 million kg yr^{-1} for the period 1982-1990 to an average of 15.0 million kg yr^{-1} for the period 1991-2004. Juvenile river herring average abundance declined 60% since 1990, juvenile Atlantic tomcod average abundance declined 69%, juvenile white perch average abundance declined 59%, and juvenile striped bass survival declined 87%. It was estimated that the observed declines in juvenile abundance and the apparent decline in striped bass juvenile survival could be explained by the increase in striped bass predatory demand if: 1) 3.3% of the seasonal predatory demand of age 1 through age 13 Hudson River striped bass was satisfied by consumption of juveniles of the four taxa, or 2) 11.1% of the seasonal predatory demand of age 1 and age 2 Hudson River striped bass was satisfied by consumption of juveniles of the four taxa. Historical information on the fraction of the Hudson River striped bass stock that inhabits the Hudson River from August through October, combined with historical information on dietary preferences of Hudson River striped bass, appear consistent with these levels of consumption.

Introduction

Background

The Atlantic coast population of striped bass (*Morone saxatilis*) experienced a major increase in abundance over the past decade in response to changes in fishery regulation (Richards and Rago 1999). The average biomass of the population (age 1 and older) increased over five-fold from 16,800,000 kg to 87,900,000 kg for the period 1983-1990 to the period 1991-2004 (ASMFC 2005). The increase in abundance of the population raised concerns that the predatory demand of the restored stock might deplete stocks of some forage species (Hartman 2003, Uphoff 2003, and Savoy and Crecco 2004).

In the Hudson River, one of three major spawning estuaries of the Atlantic coast population of striped bass (ASMFC 2005), the abundances of juvenile blueback herring (*Alosa aestivalis*) and alewife (*Alosa pseudoharengus*), collectively referred to as river herring, and Atlantic tomcod (*Microgadus tomcod*) and white perch (*Morone americana*) have declined since about 1990 (Central Hudson Electric and Gas Corporation et al. 1999 and Hurst et al. 2004). During the same period, striped bass juvenile abundance has remained fairly stable while the abundance of larval striped bass abundance has increased substantially. White perch, river herring and striped bass spawning occurs in late May and June in the Hudson River. Juvenile striped bass, white perch and river herring are collected by beach seines from late July through October (Central Hudson Electric and Gas Corporation et al. 1999). Atlantic tomcod hatching occurs in late February and early March (Dew and Hecht 1994), and juveniles are present by late April (Central Hudson Electric and Gas Corporation et al. 1999). These five species comprised

85% of the average catch of estuarine and diadromous species collected by beach seines from 1980 through 2000 (Hurst et al. 2004).

Pre-spawning striped bass enter the lower Hudson River estuary in mid- to late fall and overwinter in the lower Hudson River (McLaren et al. 1981, and Clark 1968). In April, adult striped bass, including some immature fish, begin to migrate to the upriver spawning grounds (Bear Mountain Bridge (river km 74) to Newburgh-Beacon Bridge (river km 98)), often with immatures migrating first followed by older mature fish (McLaren et al. 1981). The peak period of spawing is typically between April and May After spawing, most adult striped bass migrate to the lower river and then out of the river to the Atlantic coast (McLaren et al. 1981). However, some portion of the adult population remains in the river, perhaps year-round (Secor and Piccoli 1996). Recaptures of tagged age 2 (immature) striped bass in the Hudson River have been reported in each month, April through November, and in each year, 1987 through 1992 (Dunning et al. 2006), providing positive evidence of their presence in the river through the fall.

The historical commercial fishery for striped bass in the Hudson River was open from May through November prior to its closure after 1975 over concerns of PCB contamination (McLaren et al. 1988). Commercial fishing generally was conducted with gill nets from the George Washington Bridge (river km 19) to Hudson, NY (river km 181). In 1976, 1977 and 1978, a study was conducted to simulate the commercial fishery from April through June with three commercial fishers fishing two days per week each week. The catch rate of striped bass greater than 250 mm declined each month from an average of 659 fish in April, to an average of 342 fish in May, to an average of 258 in June (Texas Instruments 1980), indicating that perhaps as much as 39% of the adult stock were still present in the river in June. A 2001 recreational fishery survey of the Hudson River (Normandeau Associates, Inc. 2003) estimated striped bass catch per unit effort (CPUE) for shore-based fishing of 13.5 (fish per 100 angling hours) in spring (mid-March through mid-June) and 3.3 in late summer (August through September), suggesting that late summer abundance could have been 24% of the spring abundance. Shore-based fishing was the predominant fishing mode in the portion of the Hudson River downriver of the striped bass spawning grounds. That study also estimated striped bass harvest (mean total length of 727 mm) per unit effort (HPUE) for shore-based fishing of 1.1 (fish per 100 angling hours) in spring and 0.2 in late summer, suggesting that late summer abundance of larger striped bass could have been 18% of the spring abundance. In fall (October through November) the shore-based fishing CPUE for striped bass increased to 29.9 (fish per 100 angling hours) and the HPUE increased to 1.1, possibly due to the arrival of over-wintering pre-spawners.

Hudson River striped bass in their first year of life are primarily consumers of invertebrates but become largely piscivorous during their second year of life (Walter et al. 2003, and Gardinier and Hoff 1982), at which time they grow to exceed 200 mm (Texas Instruments 1980). Stomach content studies of adult striped bass in the Hudson River were conducted in 1974, 1976 and 1977 (Gardinier and Hoff, 1982) and from 1990 through 2006 (Kahnle and Hattala, 2007). In 1976 and 1977, 380 striped bass from 200 mm to over 800 mm were collected with a 900 foot haul seine in April and May; 102 contained recognizable food items. In 1974, 317 striped bass (including 13 between 200 mm and 275 mm) were collected with beach seines and otter trawls from April through November. The only recognizable finfish present in stomachs of striped bass larger than 200 mm were Atlantic tomcod, white perch, striped bass, spottail shiner and unidentified clupeids (likely blueback herring, alewife and American shad, which are common in the Hudson River). From 1990 through 2006 stomach contents of 1859 mature striped bass (modal length 659-700 mm TL) were examined, 89% of which were collected in the spring. Approximately 15% of the stomachs from spring collected striped bass contained food items, and 33% of stomachs from the fall and summer collected striped bass contained food items. The dominant food items were unidentified fish (35.5%), crabs (16.1%), herring (18.1%), Atlantic menhaden (4.6%), isopods (4.3%) and white perch (3.6%). A stomach content study conducted in winter months of 1991-1992 (with water temperature less than 10°C) collected 137 striped bass larger than 200 mm (Dunning et al. 1997). The primary finfish identified were blueback herring, clupeids, white perch, and striped bass.

Objective and Analysis Approach

The objective of this study was to determine whether the increase in predatory demand of Hudson River striped bass, accompanying the increase in abundance of the recovered striped bass stock, could have been responsible for the observed changes in abundance of juvenile Atlantic tomcod, river herring, white perch and striped bass. The approach used to address this objective was developed in response to the availability of relevant historical data. Estimates of year- and age-specific abundances (age 1 through age 13+) and instantaneous mortality rates for the coastwide striped bass stock from 1982 through 2004, and an estimate of the fractional contribution of Hudson River striped bass to the coastwide stock, were available from the Atlantic States Marine Fisheries Commission ("ASMFC") stock assessment (ASMFC 2005). Estimates of the annual abundance of larval and juvenile life stages of the five species in the Hudson River for 1977 through 2004 were available from a series of annual reports referred to as Hudson River Year Class Reports (e.g., EA 1996), which document sampling results from the Hudson River Monitoring Program ("HRMP") funded by electric generators on the Hudson River. Season- and age-specific estimates of abundance of age 1 and older striped bass inhabiting the Hudson River were not available for the period of interest. Furthermore, with the exception of the studies cited in a previous paragraph, season- and age-specific characterizations of diets of Hudson River striped bass also were not available.

The analysis approach contained four steps. The first was the development of a method that would be supported by the available data for estimating instantaneous mortality rates that might be due to predation. Existing multispecies virtual population analysis methods and ecosystem balancing methods (Magnusson 1995, Whipple et al. 2000, and Christensen et al. 2005), which can generate separate estimates of mortality rate due to predation, were not selected due to their extensive data requirements. The second step was the estimation of the changes in juvenile abundances for two stanzas of years (1977 to 1991 was referred to as Period 1, and 1991 to 2004 was referred to as Period 2), and estimation of the changes in annual predatory demand of Hudson River striped bass for the two stanzas of years. Over the 28 years of interest, August through October has been the consistent sampling season for juvenile fish by the HRMP; therefore, estimates of juvenile abundance were restricted to that three month season. These estimates of change, expressed in terms of ratios, were used as the primary inputs to the analysis. The third step was estimation of the instantaneous mortality rates that might be due to predation. The final step was a comparison of the potential juvenile biomass consumed by striped bass predation (kg yr^{-1}), which was computed using the estimated mortality rates for possible predation, to the estimated predatory demand of Hudson River striped bass. The purpose of the final step was to confirm that the magnitude of predation required to produce the observed change in juvenile abundance was no greater than the predatory demand of Hudson River striped bass.

To address the possibility that different age classes of striped bass might exert different levels of predation on juvenile fish in the Hudson River, the assessment was conducted separately for two age groups of possible predators: ages 1 through 13 striped bass, and age 1 and age 2 striped bass only. Secor and Piccoli (1996) found evidence of size-dependent dispersion of striped bass from the Hudson River with male age 2 striped bass spending most of their year in mesohaline portions of the estuary.

Methods and Data

Underlying System of Equations

For the purpose of estimating instantaneous mortality rates that were possibly due to predation in the two periods, three ratios were defined. Ratios (of a variable in Period 2 to the same variable in Period 1) were selected as the basic inputs to the analysis because scaling factors that are common to the two periods (e.g., gear efficiency) would cancel out in ratios; this can help eliminate possible biases that otherwise could arise due to possible errors in specifying those scaling factors. Because the focus of the study was the overall change in predatory demand and juvenile abundance between the two periods, and not detailed inter-annual variability, the underlying system of equations was defined in terms of average conditions (rates) for each period.

The first ratio was the potential change in juvenile biomass consumed by striped bass, defined as a ratio of average biomass possibly consumed in Period 2 ($\overline{C}_2$) to the average possibly consumed in Period 1 ($\overline{C}_1$):

$$R_c = \frac{\overline{C}_2}{\overline{C}_1}. \qquad (1)$$

The second was the change in average juvenile abundance, defined as the ratio of average abundance during the juvenile sampling season (i.e., August through October) in Period 2 ($\overline{N}_2$) to the average in Period 1 ($\overline{N}_1$):

$$R_n = \frac{\overline{N}_2}{\overline{N}_1}. \qquad (2)$$

The third was the change in the number of fish entering the juvenile life stage, defined as the ratio of the average number entering the juvenile life stage in Period 2 ($\overline{L}_2$) to the average in Period 1 ($\overline{L}_1$):

$$R_l = \frac{\overline{L}_2}{\overline{L}_1}. \qquad (3)$$

The three ratios were expressed in terms of the mortality rates of interest through the following standard equations from fishery science (Ricker 1975). For each period, the annual seasonal consumption of juvenile biomass by predation (which is directly analogous to the fishery yield) in period *j* was defined as:

$$C_j = \left(m_{p,j}t\right)B_j \frac{1-e^{\left(g_j - m_j - m_{p,j}\right)t}}{\left(m_j + m_{p,j} - g_j\right)t}, \qquad (4)$$

where g_j is the daily growth rate during the season; m_j is the background daily mortality rate (i.e. all mortality except mortality due predation); m_{pj} is the additional daily mortality rate due to predation during the season; and t is the duration of the season (days). The biomass at the beginning of the season, B_j, was defined as:

$$B_j = w_j \overline{N}_j \frac{\left(m_j + m_{p,j}\right)t}{1-e^{\left(m_j - m_{p,j}\right)t}} \qquad (5)$$

where w_j is the weight per fish at the beginning of the season. The average annual juvenile abundance during the sampling season was defined as:

$$\overline{N}_j = \overline{L}_j e^{-(m'_j + m_{p,j})t'} \frac{1 - e^{(m_j - m_{p,j})t}}{(m_j + m_{p,j})t} \qquad (6)$$

where m'_j is the background daily mortality rate from the beginning of the juvenile life stage to the beginning of August, $\overline{L}_j$ is the average abundance at the beginning of the juvenile life stage during period j, and t' is the duration (days) from the beginning of the juvenile life stage to the beginning of the juvenile sampling season.

Combining equations (1) through (6) gives the following two equations which form the basis for the analysis:

$$\frac{R_c}{R_n} = \frac{\left((m_{p,2}t) w_2 \frac{(m_2 + m_{p,2})t}{1 - e^{(m_2 + m_{p,2})t}} \frac{1 - e^{(g_2 - m_2 - m_{p,2})t}}{(m_2 + m_{p,2} - g_2)t} \right)}{\left((m_{p,1}t) w_1 \frac{(m_1 + m_{p,1})t}{1 - e^{(m_1 + m_{p,1})t}} \frac{1 - e^{(g_1 - m_1 - m_{p,1})t}}{(m_1 + m_{p,1} - g_1)t} \right)} \qquad (7)$$

and

$$\frac{R_n}{R_l} = \frac{e^{-(m'_2 + m_{p,2})t'} \frac{1 - e^{(m_2 - m_{p,2})t}}{(m_2 + m_{p,2})t}}{e^{-(m'_1 + m_{p,1})t'} \frac{1 - e^{(m_1 - m_{p,1})t}}{(m_1 + m_{p,1})t}} \qquad (8)$$

The right hand sides of equations (7) and (8) contain only underlying rates (and initial weight per fish for equation (7)), and the left hand side of the equations contain the measurable quantities.

Approximations

Estimates of the instantaneous mortality rates due to possible predation for Period 1 and Period 2 can be identified through an exhaustive search (by computer) for values of $m_{p,1}$ and $m_{p,2}$ that satisfy the non-linear equations (7) and (8), given input values for the two ratios of ratios and estimates for the growth rates and background mortality rates. Alternatively, equations (7) and

(8) can be linearized, and approximate closed-form solutions for $m_{p,1}$ and $m_{p,2}$ can be derived (see Appendix A). The closed-form solutions provide a more convenient method for conducting the analysis and also provide a basis for developing variance estimates (see Appendix B).

The approximation for the ratio of ratios in equation (7) is:

$$\frac{R_c}{R_n} \doteq \left(\frac{m_{p,2}}{m_{p,1}}\right)\alpha \tag{9}$$

where α is the ratio (Period 2 to Period 1) of the average juvenile weight per fish at the mid-point of the season. The logarithm of the ratio of ratios in equation (8) is approximately:

$$\ln\left(\frac{R_n}{R_l}\right) \doteq \left(m_{p,1} - m_{p,2}\right)\left(t' + \frac{t}{2}\right) + \beta \tag{10}$$

where β is the difference between the juvenile background mortality rates for Period 1 and Period 2.

Combining equations (9) and (10) provides approximate solutions for the potential predation mortality rates in the two periods expressed in terms of functions of the two ratios of ratios:

$$\tilde{m}_{p,1} \doteq \frac{\ln\left(\frac{R_n}{R_l}\right) + \beta}{\left(1 - \frac{R_c}{\alpha R_n}\right)\left(t' + \frac{t}{2}\right)} \tag{11}$$

and

$$\tilde{m}_{p,2} \doteq \frac{\ln\left(\frac{R_n}{R_l}\right) + \beta}{\left(\frac{\alpha R_n}{R_c} - 1\right)\left(t' + \frac{t}{2}\right)} \tag{12}$$

Changes in Juvenile and Larval Abundances

The ratio of abundances of post yolk-sac-larvae (Table 2) was used as a surrogate for the ratio of abundance of fish entering the juvenile life stage (R_l) because field data on the number of fish entering the juvenile life stage were not available. Average abundance indices for post yolk-sac larvae were computed as the average of weekly standing crop estimates from Hudson River Year Class Reports. Weekly standing crop estimates for post yolk-sac larvae were based on data collected by the HRMP's Longitudinal River Survey ("LRS") which sampled with 1 m ichthyoplankton nets attached to epibenthic sleds (to sample the bottom stratum) and Tucker trawls (to sample the mid-water stratum). Annual abundance indices based on LRS data were computed for 1977 through 2004, based on data from stratified random sampling from the George Washington Bridge north to the Federal Dam at Troy, NY during May and June. Alewife and blueback herring were treated as a single taxonomic group (river herring) because they could not be reliably identified to species as post yolk-sac larvae.

The ratios of average abundances (R_n) of juvenile river herring, Atlantic tomcod, white perch and striped bass (Table 3) were based on annual indices of juvenile abundance. Annual juvenile abundance was computed as the average of weekly standing crop estimates from Hudson River Year Class Reports (e.g., EA 1996). Weekly standing crop estimates for juvenile fish inhabiting the beach zone of the Hudson River were based on data collected by the HRMP's Beach Seine Survey ("BSS"), which sampled with 100 ft beach seines from the George Washington Bridge to the Federal Dam at Troy, NY. Weekly standing crop estimates for juvenile fish inhabiting the shoals, bottom and channel of the Hudson River were based on data collected by the HRMP's Fall Shoals Survey ("FSS"), which sampled with beam trawls (to sample the bottom stratum) and Tucker trawls (to sample the mid-water stratum) from the George Washington Bridge to the Federal Dam at Troy, NY.

Annual abundance indices based on BSS data were computed for 1977 through 2004, using data from biweekly sampling in August through October. Annual abundance indices based on FSS data were computed for 1985 through 2004, using data from biweekly sampling in August though October. The FSS was conducted from 1979 to 1984; however, beam trawls replaced epibenthic sleds for sampling the bottom and shoal strata in 1985. To avoid possible confounding effects of the gear change, FSS data prior to 1985 were not included in the analysis. However, because BSS and FSS indices of abundance (1985-2004) were significantly correlated, juvenile abundance indices for a given species from the BSS from 1979 through 1984 were used to predict FSS abundance indices (as if beam trawl sampling had occurred in those years) for the years prior to 1985.

For each species, annual average (August through October) juvenile abundance estimates (Table 3) were computed by adjusting the annual average standing crop estimates from the BSS and FSS for gear efficiency and summing the resulting abundance estimates:

$$\overline{N}_y = \frac{\overline{A}_{BSS,y}}{q_{BSS}} + \frac{\overline{A}_{FSS,y}}{q_{FSS}} \qquad (13)$$

where $\overline{A}_{BSS,y}$ and $\overline{A}_{FSS,y}$ are the reported average (August through October) standing crop estimates from the two programs for year y, and q_{BSS} and q_{FSS} are gear efficiencies for the two sampling programs. Gear efficiency estimates used for this computation are those reported in Central Hudson Electric and Gas Corporation et al. (1999), which were based on gear efficiency studies (Normandeau Associates Inc. 1984, Kjelson and Colby 1977, and Loesch 1976) and on comparisons of striped bass BSS catch rates to striped bass mark-recapture estimates of abundance. For the BSS, the gear efficiency was assumed to be 4%; and for the FSS, the gear efficiency was assumed to be 8.85, the average of the reported beam trawl gear efficiency (15%) and the reported Tucker trawl gear efficiency (2.7%).

The estimates of juvenile abundance computed as described above are generally consistent with other estimates reported in the literature. Young et al. (1988) reported estimates of juvenile white perch abundance in the Hudson River based on mark-recapture studies from 1974 through 1979. The estimates ranged from 13 million to 205 million with and average of 74 million. The estimated average juvenile white perch abundance for Period 1 of 65.5 million from this study is consistent with those mark-recapture estimates. McLaren et al. (1988) reported mark-recapture estimates of abundance for one year old (roughly mid-February) Hudson River Atlantic tomcod for 1975 to 1980 which ranged from 2.5 to 8.9 million, with an average of 5.8 million. To be consistent with the Period 1 estimate (Table 2) of 54 million juveniles, the mortality rate from mid-September to mid-February would have to be approximately Z=2.2 (5 months). Although estimates of survival rates for juvenile Hudson River Atlantic tomcod could not be found in the literature, McLaren et al. (1988) reported annual mortality rates from age 1 to age 2 for Atlantic tomcod. The average for 1975 through 1979 was Z=2.8 (12 months), which is not inconsistent if both the difference in age and the difference in duration are considered.

Changes in Predatory Demand

For the purpose of assessing whether the change in predatory demand could have been responsible for the observed changes in juvenile abundance, the ratio of potential consumption of juvenile biomass by striped bass (R_c) was assumed to be the same as the ratio (Period 2 to Period 1) of predatory demands of striped bass:

$$R_p = \frac{\overline{H}_2}{\overline{H}_1} \quad (14)$$

where $\overline{H}_j$ is the average of annual estimates of predatory demand during period *j*.

Estimates of the annual predatory demand exerted by the Hudson River stock were based on estimates of annual production by the Hudson River stock and an assumed trophic efficiency between striped bass and their prey. Age-specific estimates of annual production, $H_{a,y}$ (kg yr^{-1}), of age-1 and older striped bass were based on the production formulation from Ricker (1975):

$$H_{a,y} = G_{a,y}\overline{B}_{a,y} = \frac{G_{a,y}SB_{a,y}W_a\left(1-e^{G_{a,y}-Z_{a,y}}\right)}{\left(Z_{a,y}-G_{a,y}\right)} \quad (15)$$

where $SB_{a,y}$ is the estimated abundance of age *a* striped bass in year *y*, W_a is the average weight of age *a* striped bass at the beginning of the year, $G_{a,y}$ is the annual growth rate for age *a* striped bass in year *y*, and $Z_{a,y}$ is the annual mortality rate for age *a* striped bass in year *y*. Annual predatory demand, $P_{a,y}$, was estimated by dividing annual production by trophic efficiency, assumed to be 10% (Pauly and Christensen 1995, Jennings and Mackinson 2003, and Jennings et al. 2002).

Estimates of the coastwide abundance of age 1 through age 13 striped bass for 1982 to 2004 ($SB_{a,y}$) were from the 2005 Stock Assessment (Table 18a, ASMFC 2005). Because striped bass post yolk-sac larval abundance (an indicator of spawning stock abundance) was relatively stable from 1977 through 1990, the average age-specific abundances from 1982 through 1990 were assumed to be representative of the averages for all years in Period 1 (1977 through 1990). For each age class (age 1 and older) and year the total striped bass mortality rate ($Z_{a,y}$) was computed as the sum of reported age- and year-specific fishing mortality rate (Table 16, ASMFC 2005) and a constant natural mortality rate of 0.15 (ASMFC 2005). The fraction of the coastwide abundance of striped bass that was of Hudson River origin was assumed to be 13%

(ASMFC 2005). Age- and year-specific annual growth rates ($G_{a,y}$) were estimated from reported average weights at age (Table 13, ASMFC 2005) assuming approximately exponential growth (Ricker 1975) over successive two-year intervals:

$$\hat{G}_{a,y} = 0.5 \ln\left[\frac{\overline{W}_{a+1,y+1}}{\overline{W}_{a-1,y-1}}\right] \qquad (16)$$

where $\overline{W}_{a,y}$ is the reported average weight for age a striped bass in year y, and the initial weight for each age group and year, $\hat{W}_{a,y}$,was estimated as:

$$\hat{W}_{a,y} = \overline{W}_{a,y} \frac{-\hat{G}_{a,y}}{1-e^{\hat{G}_{a,y}}} \qquad (17)$$

Estimates of coastwide predatory demand of striped bass computed using these methods (Table 1) are consistent with other published estimates. Hartman (2003) estimated the annual coastwide predatory demand of the striped bass population to be 17.9 mt in 1982 and 147.9 mt in 1995. His estimates were based on age- and year-specific coastwide striped bass abundance and survival estimates from ASMFC (2000). Using those same inputs and the methods described above for this study, the estimates of coastwide predatory demand of striped bass are 17.3 mt in 1982 and 135.7 mt in 1995. The estimates listed in Table 1 used updated abundance and survival estimates from ASMFC (2005), which account for the difference in comparison to Hartman's estimates. Uphoff (2003), also using ASMFC abundance estimates from 2000, estimated the annual coastwide potential consumption of Atlantic menhaden by striped bass to be 26 mt in 1982-1983, and 190 to 200 mt from 1994 to 1998.

The seasonal pattern of predatory demand by striped bass was characterized based on average monthly water temperatures in the Hudson River and the consumption component of a bioengergetics model for striped bass (Hartman and Brandt 1995). The fraction of the annual consumption (τ) that occurred from August through October was approximated as:

$$\tau = \frac{\sum_{m=8}^{10} CR_m}{\sum_{m=1}^{12} CR_m} \qquad (18)$$

where CR_m is the predicted consumption rate (gm gm^{-1} day^{-1}) for the average water temperature in month m. This approximation does not account for possible month-specific variability in growth and mortality rates of striped bass. Estimates of month-specific water temperature, required for the bioenergetics model of the seasonal pattern of consumption, were from Poughkeepsie Water Works data (Table B-4, EA 1996). The consumption from August through October was estimated to be 41.8% of the annual total. The average seasonal predatory demand (Table 1) for each period was estimated as the product of the average annual predatory demand for the period and the fraction of the annual consumption that occurred from August through October.

Estimation of Instantaneous Mortality Rates Due to Possible Predation

Instantaneous mortality rates for possible predation, that were consistent with the estimated ratios (R_n, R_l, R_p), were identified through exhaustive search (by computer) of candidate values of $m_{p,1}$ and $m_{p,2}$ using equations (7) and (8). Because the question being addressed was whether the increase in striped bass predation could have caused the observed changes in juvenile abundance, all other things being equal, background mortality rates, growth rates, and initial weights were assumed to have remained the same for the two periods. Approximate estimates also were computed using the equations (11) and (12); and for the reason noted above, the parameter α was set equal to 1, and the parameter β was set equal to 0.

Variance estimates for the approximations were computed using the methods described in Appendix B.

Estimation of Potential Consumption of Juvenile Biomass

The potential juvenile biomass consumed by striped bass was computed using equation (4) with the estimates of instantaneous mortality due to potential predation and the estimates of average seasonal juvenile abundance. Also required for estimating potential juvenile biomass consumed by striped bass were estimates of daily background mortality rates and growth rates of the juvenile fish, and initial weights of the juvenile fish.

For each species, the background daily mortality rates (Table 4) for the three month sampling season (August through October) were estimated as a power function of dry weight (Peterson and Wroblewski, 1984):

$$m = \frac{1}{t}\sum_{i=1}^{t} 0.00525\left(0.2we^{gi}\right)^{-0.25} \qquad (19)$$

where dry weight is assumed to be 20% of wet weight (Peterson and Wroblewski, 1984). Similarly, the background daily mortality rate for the interval from the start of the juvenile life stage to August was estimated as:

$$m' = \frac{1}{t'}\sum_{i=1}^{t'} 0.00525\left(0.2we^{gi}\right)^{-0.25} \qquad (20)$$

The duration of the juvenile sampling season (t) was set to 90 days (August through October), and (based on life history considerations discussed in the Introduction) the interval from the beginning of the juvenile stage to the beginning of the juvenile sampling season (t') was set to 15 days for white perch, river herring and striped bass, and set to 90 days for Atlantic tomcod.

For each species, the daily juvenile growth rate through October (Table 4) was estimated from the beginning and ending weights, assuming approximate exponential growth during that interval, as (Ricker 1975):

$$g = \frac{\ln\left(\frac{w_{end}}{w_{start}}\right)}{t + t'} \tag{21}$$

and the weight of species s at the beginning of August (Table 4) was estimated as:

$$w = w_{start} e^{gt'} \tag{22}$$

Estimates of the average weight per fish at the beginning and end of the juvenile life stage were derived from reported lengths and length-weight relationships. For river herring, the lengths at the beginning and end of the juvenile stage were set to 25mm and 92mm (Mullen et al. 1986), respectively, and the length-weight relationship was from PSEG (2006). For Atlantic tomcod, the initial length (for mid-May) and the final length (for the end of October) were set to 25mm and 120mm, respectively, (McLaren et al. 1988); and the length-weight relationship was from Dew and Hecht (1994). For white perch, the lengths at the beginning and end of the juvenile stage were set to 25mm and 80mm, respectively (Texas Instruments 1980); and the length-weight relationship was from Klauda et al. (1988). For striped bass, lengths at the beginning and end of the juvenile stage were set to 30mm and 95mm, respectively (Dey 1981); and the length-weight relationship was from Fay et al. (1983).

Sensitivity Analysis to Address Assumptions

A sensitivity analysis was conducted to address: 1) the possible effects of density dependent mortality occurring between the larval and juvenile life stages, 2) the effects of possible errors in the estimation of background mortality rates on the predicted juvenile biomass to predation, and 3) an alternative assumption regarding the fraction of the coastwide stock that was from the Hudson River. Other input parameters, which did not require formal sensitivity analyses, but which could affect results are discussed at the end of this section.

For Atlantic tomcod, river herring and white perch, the historical data indicated a decline in larval abundance from Period 1 to Period 2, and for striped bass an increase was indicated. The results presented above assume the ratio of abundance (Period 2 to Period 1) of fish entering the juvenile life stage is the same as the ratio of larval abundance. However, if density dependent effects were present, the ratio of abundance of fish entering the juvenile stage could have been closer to unity. To address this possibility, the analyses were re-run with values for the ratio of abundance of fish entering the juvenile stage (R_l) ranging from the estimated value (r_l) based on post yolk-sac larval abundances to a value of R_l=1 (i.e. constant recruitment to the juvenile life stage). An index of the degree of density dependent effects (I) was defined as:

$$I = \frac{(R_l - r_l)}{(1 - r_l)} \qquad (23)$$

with a range from 0 (for $R_l = r_l$) to 1 (for R_l=1).

The equation used to estimate the background mortality rate for juvenile fish (equations (19) and (20)) is a theoretically derived relationship for pelagic marine ecosystems (Peterson and Wroblewski 1984). Other authors (e.g. McGurk (1993), Lorenzen (1996) and Houde (1997)) have reported natural mortality rates of fish in marine and other ecosystems also as power functions of weight, but with empirical estimates for the coefficients that differ somewhat from those of Peterson and Wroblewski (1984). To address the effects of possible errors in the assumed background mortality rate, the analyses were re-run with the background mortality rates set to 0 and with the background mortality rates set to 2 times of the initial estimates.

Estimates of the coastwide abundance of age 1 striped bass, combined with indices of juvenile abundance from the major spawning areas of striped bass (ASMFC 2005) indicate that the proportion of the coastwide population of age 1 striped bass that is from the Hudson River has changed from Period 1 to Period 2 (see Appendix C). The average estimated contributions from the Hudson River for Periods 1 and 2 are 20.9% and 8.9% respectively. Assuming these proportions apply to age 1 and age 2 striped bass, then the ratio of predatory demands (R_p) for age 1 and age 2 striped bass would decline from 3.44 (Table 1) to 1.46. To address the effects of this alternative assumption regarding the contribution of Hudson River striped bass to the coastwide stock, the analyses were re-run the analysis with the alternative estimate for R_p for age 1 and age 2 striped bass.

Other input parameters of concern were the trophic conversion efficiency, the fraction of the annual predatory demand exerted during the three month fall season, and gear efficiencies. Selection of alternative values for these parameters would not affect estimates of instantaneous mortality rates possibly due to predation because, as noted above, the inputs to the analyses are ratios in which scaling factors that are common to both periods cancel out. However, if one of these factors varied substantially between the two periods, then the degree of change in that factor would determine the effect on estimates of instantaneous mortality rates possibly due to predation. The possible effects of changes in these factors between the two periods were viewed as second order considerations for this study; and therefore, sensitivity analyses of those possible changes were not undertaken.

Because the estimates of juvenile biomass possibly consumed by predation use these input parameters directly (not in ratios) estimates of juvenile biomass possibly consumed by predation would be affected by assumed gear efficiencies. A change of the assumed gear efficiency (e.g. doubling) would cause an inversely proportional change (i.e., halving) of the estimate of juvenile biomass possibly consumed. Similarly, a change of the assumed trophic conversion efficiency (e.g. doubling) would cause an inversely proportional change (i.e., halving) of the estimate of predatory demand. A change of the assumed fraction of the annual predatory demand exerted during the three month fall season (e.g., doubling) would cause a directly proportional change (i.e., doubling) of the estimate of predatory demand. Because the sensitivities of the estimates to these assumptions were clear, no additional analyses were conducted to address them.

Results

Estimates of Instantaneous Mortality Rates Possibly Due to Predation

Estimates of the seasonal instantaneous mortality rates possibly due to predation by striped bass (Tables 5 and 6) were higher for juvenile striped bass than for juveniles of the other three taxa. The estimated rates were slightly higher under the assumption that predation was by age 1 and age 2 striped bass only, than under the assumption that predation was by age 1 through age 13 striped bass. The estimated instantaneous mortality rates for Period 2 were 12 to 15 times higher than for Period 1 assuming predation was by all age classes; and were 10 to 12 times higher than Period 1 assuming predation by age 1 and age 2 striped bass only. For river herring, Atlantic tomcod and white perch, the estimates based on the approximations were very similar to the estimates based on exhaustive search; however, for striped bass the approximations underestimated the Period 2 rate and overestimated the Period 1 rate. The bias in the approximations for larger mortality rates was expected because the Paloheimo approximation works best with small mortality rates (Paloheimo 1961). Coefficients of variation for the estimates (based on the approximate standard errors) were 3-12% for striped bass, 31-39% for river herring, 10-13% for Atlantic tomcod, and 9-14% for white perch.

Comparison of Juvenile Biomass Possibly Consumed by Striped Bass to Hudson River Striped Bass Predatory Demand

The estimated juvenile biomass possibly consumed by striped bass during the three month season (Tables 7 and 8) was 148,000 kg in Period 1 and 509,000 kg in Period 2 assuming predation by age 1 and age 2 striped bass only, and was 112,000 kg in Period 1 and 498,000 kg in Period 2 assuming predation by age 1 through age 13 striped bass. Assuming predation by age 1 and age 2 striped bass only, the juvenile biomass possibly consumed by striped bass was 11.11% of the estimated seasonal predatory demand, and assuming predation by age 1 through age 13 striped bass, the juvenile biomass possibly consumed was 3.33%. Estimated consumption of juvenile striped bass was higher than the estimated consumption of the other three taxa, approximately 2 times higher than river herring, 4 times higher than Atlantic tomcod, and over 5 times higher than white perch.

Effects of Changes in Assumptions -- Sensitivity Analyses

Reducing the assumed background mortality rate had the effect of increasing the estimates of juvenile biomass possibly consumed by striped bass (Figures 2 and 3); increasing the assumed background mortality rate reduced the estimates of juvenile biomass possibly consumed by striped bass. Increases in the assumed degree of density dependent effects up to an index value between 0.5 and 0.75 caused the estimates of the juvenile biomass possibly consumed by striped bass to increase. Further increases in the assumed degree of density dependent effects, with the index increasing to 1, caused estimates of the juvenile biomass possibly consumed by striped bass to decrease (Figures 2 and 3). Changing the assumed proportion of the coastwide stock of age 1 and age 2 striped bass from 13% in both periods to 20.9% in Period 1 and 8.9% in Period 2 caused estimates of seasonal juvenile biomass possibly consumed by striped bass to increase. For Period 1 the estimate increased from 148,000 kg to 409,000 kg, and for Period 2 the estimate increased from 509,000 kg to 600,000 kg.

Considering the combined effects of alternative assumptions for background mortality rates and degree of density dependent effects, estimates of the percent of seasonal predatory demand potentially satisfied by consumption of juveniles of the four taxa were less than 18% for predation by age 1 and age 2 striped bass only, and were less than 6% for predation by age 1 through age 13 striped bass. Under the assumption that 20.9% (in Period 1) and 8.9% (in Period 2) of the coastwide stock of age 1 and age 2 striped bass were Hudson River fish, the maximum estimate of the percent of seasonal predatory demand potentially satisfied by consumption of juveniles of the four taxa increased from 18% to 28% (Figure 4).

Discussion

The percent of the seasonal predatory demand that could be satisfied by juvenile biomass consumed by striped bass has two components: 1) the fraction of the Hudson River striped bass population that inhabits the river from August through October, and 2) the contribution of the juvenile target species to the diet of striped bass in the river during those months. For example, if 75% of age 1 and age 2 striped bass from the Hudson River stock were present in the river from August through October, and 40% of their diet while in the river was satisfied by juveniles of the target species, then 30% of the predatory demand would be satisfied by those juvenile fish. The estimated percents of seasonal predatory demand that would be needed to explain the observed declines in juvenile abundance appear consistent with what is known about the fraction of the stock that inhabits the river in fall, and with what is known about Hudson River striped bass dietary preferences. The findings of Secor and Piccoli (1996) demonstrated that some fraction of the adult stock inhabits the river year-round; the simulated commercial fishery study indicated that more than one third of the spawning stock may have remained in the river in June; and the 2001 recreational fishery survey indicated that as much as 18%-24% of the striped bass abundance present in the river during the spring was present in the river by late summer. The available stomach content studies (Gardinier and Hoff 1982, Dunning et al 1997, and Kahnle and Hattala 2007) found clupeids, Atlantic tomcod, white perch, and striped bass among the dominant identifiable food items in age 1 and older in the Hudson River.

This study focused on the decline in juvenile abundance of four forage taxa as measured by sampling that occurred from August through October, and did not explicitly address possible reductions in spawning stock biomass that could have been caused by the reductions in juvenile abundance. However, the data on post yolk-sac larvae river herring, Atlantic tomcod and white perch abundance suggest that a reduction in spawning has occurred for these taxa, which may be due, in part, to the increased mortality during the juvenile stage. The reduction in spawning might also be due to increased mortality in older life stages of these taxa – possibly due, in part, to striped bass predation on age 1 or older fish. For striped bass, estimates of post yolk-sac larval abundance suggest a six-fold increase in larval abundance from Period 1 to Period 2, which is consistent with the apparent increase in adult abundance. However, the data on striped bass juveniles shows no corresponding increase in juvenile abundance. The analysis presented in this paper demonstrated that striped bass predation alone could have kept the juvenile abundance from increasing. Other possible explanations include a drastic reduction in the juvenile background mortality rate, or density dependent out-migration of juveniles.

The results from this study indicate that the increase in predatory demand of Hudson River striped bass could have been responsible for the decline in juvenile abundance of river herring, Atlantic tomcod and white perch, and responsible for the apparent decline in survival of striped bass from the post yolk-sac larvae to juveniles. The required magnitude of consumption of juvenile biomass to account for the declines in juvenile abundance appears to be well below the estimated predatory demand of Hudson River striped bass, whether considering all ages, or only age 1 and age 2 striped bass. The sensitivity analyses suggest this result is fairly robust to possible violations in assumptions and to possible errors in input parameter values. However, a field survey to estimate the biomass of juvenile fish consumed by Hudson River striped bass in the fall would be needed to confirm the proposition that Hudson River striped bass, in fact, were responsible for the declines in juvenile abundance.

Acknowledgements

I gratefully acknowledge the very thoughtful comments and suggestions on the first draft of this manuscript from four anonymous reviewers and an associate editor of the Transactions of the American Fisheries Society. I also acknowledge the many field crews and scientists who, since the mid 1970's, collected the data on age-0 Hudson River fishes that I relied on for this study; and I acknowledge the scientists of the ASMFC its member states for their many years of collecting and analyzing data on the Atlantic coastal striped bass stock, the results of which were key inputs to this study.

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Table 1. Estimates of average predatory demand ($\hat{\bar{P}}_j$) of striped bass populations for the two periods of years (j) with estimated standard errors (in parentheses) and ratios of estimated predatory demands (Period 2 to Period 1).

Stock	Season	Ages	$\hat{\bar{P}}_1$ (kg)	$\hat{\bar{P}}_2$ (kg)	Ratio of Average Predatory Demands (R_p)
Atlantic Coastwide	January-December	1 – 13+	61,829,229 (2,031,616)	274,937,594 (5,853,828)	
Hudson River	August-October	1 - 13+	3,363,749 (110,398)	14,957,667 (318,097)	4.45
Hudson River	August-October	1 and 2 Only	1,332,950 (89,354)	4,583,020 (246,129)	3.44

Table 2. Average index values for post yolk-sac larval ("PYSL") abundance ($\hat{L}_j$) for the two periods of years (j) with estimated standard errors (in parentheses) and ratios of average PYSL abundances (Period 2 to Period 1).

Taxon	$\hat{L}_1$	$\hat{L}_2$	Ratio of Average PYSL Abundance (R_l)
Striped Bass	362,055,919	2,371,617,937	6.55
	(13,868,061)	(76,310,566)	
River Herring	2,008,741,295	990,192,857	0.49
	(50,041,415)	(19,314,422)	
Atlantic Tomcod	92,730,226	66,887,806	0.72
	(6,329,898)	(3,548,958)	
White Perch	985,594,499	855,285,920	0.87
	(15,678,812)	(15,857,150)	

Table 3. Estimates of average seasonal (August through October) juvenile abundance ($\hat{\bar{N}}_j$) for the two periods of years (j) with estimated standard errors (in parentheses) and ratios of average estimated juvenile abundances (Period 2 to Period 1).

Taxon	$\hat{\bar{N}}_1$	$\hat{\bar{N}}_2$	Ratio of Average Juvenile Abundances (R_n)
Striped Bass	68,372,839	57,132,380	0.84
	(1,312,794)	(903,684)	
River Herring	1,118,600,941	448,416,556	0.40
	(30,380,270)	(14,130,644)	
Atlantic Tomcod	54,150,749	16,859,655	0.31
	(2,671,040)	(995,044)	
White Perch	65,493,845	26,860,369	0.41
	(1,782,169)	(779,541)	

Table 4. Life history parameter estimates for juvenile striped bass, river herring, Atlantic tomcod and white perch.

Parameter	Taxon			
	Striped Bass	River Herring	Atlantic Tomcod	White Perch
Juvenile Growth Rate, g (day^{-1})	0.032	0.047	0.030	0.034
Initial Weight of Juvenile Fish, w (gm)	0.286	0.034	0.095	0.179
Background Mortality Rate -- August through October, m	0.606	0.847	0.470	0.669
Background Mortality Rate -- Beginning of Juvenile Life Stage to the Beginning of August, m'	0.151 (15 days)	0.250 (15 days)	0.922 (90 days)	0.169 (15 days)
(duration in parentheses)				

Table 5. Estimates of average seasonal (August through October) instantaneous mortality rates possibly due to predation by age 1 and age 2 striped bass for Period 1 (1977-1990) and Period 2 (1991-2004). For estimates based on approximation, estimated standard errors are listed (in parentheses).

Prey Taxon	Estimates Based on Exhaustive Search		Estimates Based on Approximation	
	$\hat{m}_{p,1}$	$\hat{m}_{p,2}$	$\hat{\tilde{m}}_{p,1}$	$\hat{\tilde{m}}_{p,2}$
Striped Bass	0.611	6.172	1.157	4.760
			(0.137)	(0.199)
River Herring	0.049	0.475	0.048	0.410
			(0.015)	(0.159)
Atlantic Tomcod	0.103	1.287	0.112	1.232
			(0.014)	(0.150)
White Perch	0.149	1.737	0.178	1.489
			(0.018)	(0.134)

Table 6. Estimates of average seasonal (August through October) instantaneous mortality rates possibly due to predation by age 1 through age 13 striped bass for Period 1 (1977-1990) and Period 2 (1991-2004). For estimates based on approximation, estimated standard errors are listed (in parentheses).

Prey Taxon	Estimates Based on Exhaustive Search		Estimates Based on Approximation	
	$\hat{m}_{p,1}$	$\hat{m}_{p,2}$	$\hat{\tilde{m}}_{p,1}$	$\hat{\tilde{m}}_{p,2}$
Striped Bass	0.449	5.894	0.834	4.437
			(0.048)	(0.141)
River Herring	0.037	0.457	0.036	0.398
			(0.011)	(0.154)
Atlantic Tomcod	0.077	1.255	0.084	1.205
			(0.008)	(0.146)
White Perch	0.113	1.712	0.133	1.445
			(0.018)	(0.134)

Table 7. Estimates of average seasonal (August through October) juvenile biomass possibly consumed by predation by age 1 and age 2 striped bass ($\hat{C}_j$) for Period 1 (1977-1990) and Period 2 (1991-2004), and corresponding percent of seasonal predatory demand of age 1 and age 2 Hudson River striped bass.

Prey Taxon	$\hat{C}_1$ (kg)	$\hat{C}_2$ (kg)	Percent of Seasonal Predatory Demand
Striped Bass	76,652	263,547	5.75%
River Herring	39,804	136,821	2.99%
Atlantic Tomcod	18,073	62,137	1.36%
White Perch	13,420	46,147	1.01%
Total	147,949	508,652	11.11%

Table 8. Estimates of average seasonal (August through October) juvenile biomass possibly consumed by predation by age 1 through age 13 striped bass ($\hat{\bar{C}}_j$) for Period 1 (1977-1990) and Period 2 (1991-2004), and corresponding percent of seasonal predatory demand of age 1 through age 13 Hudson River striped bass.

Prey Taxon	$\hat{\bar{C}}_1$ (kg)	$\hat{\bar{C}}_2$ (kg)	Percent of Seasonal Predatory Demand
Striped Bass	58,215	258,862	1.73%
River Herring	29,741	132,319	0.88%
Atlantic Tomcod	13,671	60,787	0.41%
White Perch	10,281	45,713	0.31%
Total	111,908	497,681	3.33%

Figure 1. Estimates of annual predatory demand of the Atlantic coast striped bass stock, ages 1 through 13.

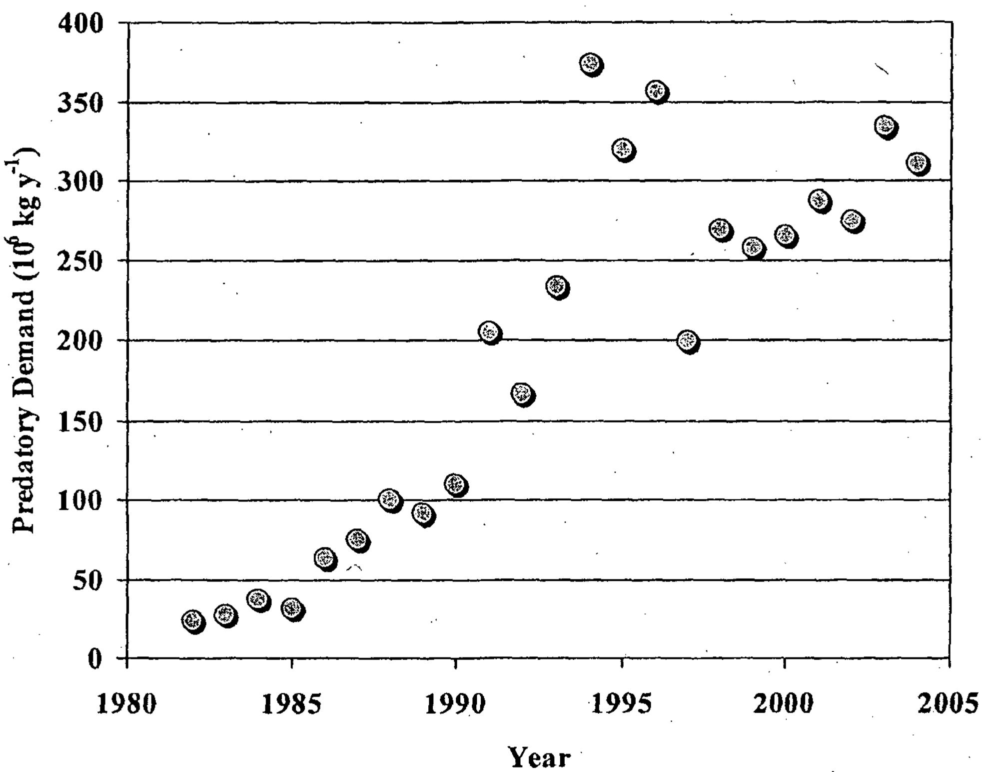


Figure 2. Estimates of the percent of seasonal predatory demand of age 1 and age 2 Hudson River striped bass potentially satisfied by consumption of juveniles of the four taxa, as functions of the index of density dependent effects (see text) and assumed background mortality rates. Curve A is for the estimated background mortality rates (see text), curve B is for background mortality rates of zero, and curve C is for two times the estimated background mortality rates. The proportion of the coastwide population of age 1 and age 2 striped bass that were Hudson River fish was assumed to be 13% in Period 1 and Period 2.

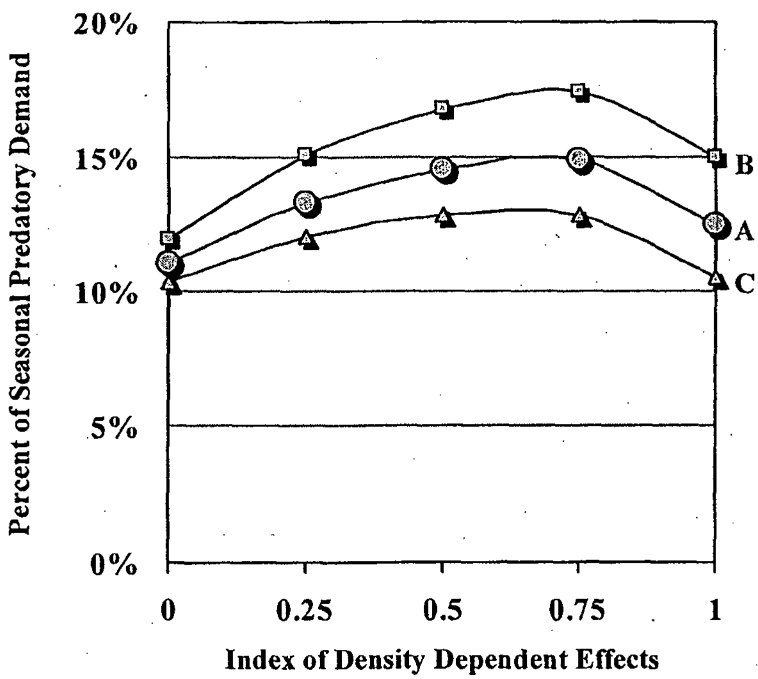


Figure 3. Estimates of the percent of seasonal predatory demand of age 1 and age 2 Hudson River striped bass potentially satisfied by consumption of juveniles of the four taxa, as functions of the index of density dependent effects (see text) and assumed background mortality rates. Curve A is for the estimated background mortality rates (see text), curve B is for background mortality rates of zero, and curve C is for two times the estimated background mortality rates. The proportion of the coastwide population of age 1 and age 2 striped bass that were Hudson River fish was assumed to be 20.9% in Period 1 and 8.9% in Period 2.

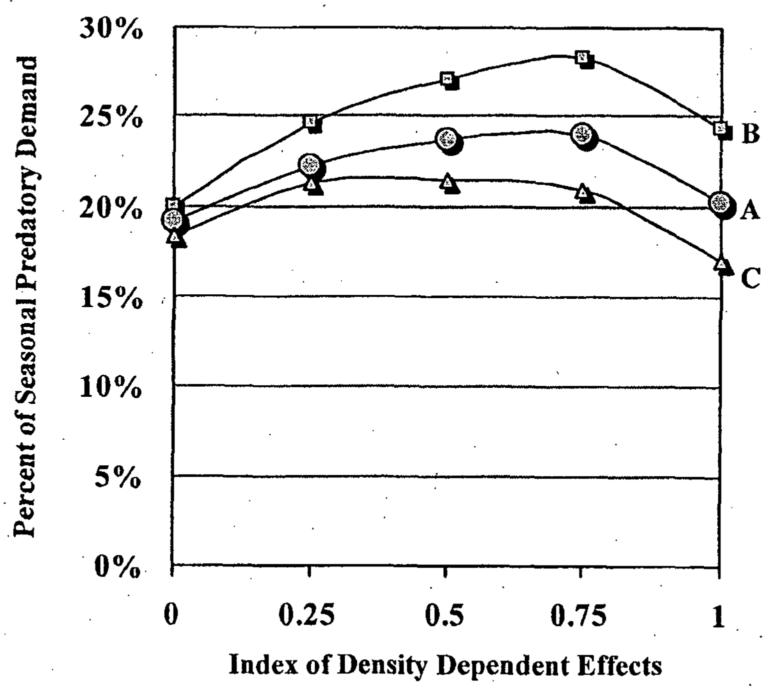
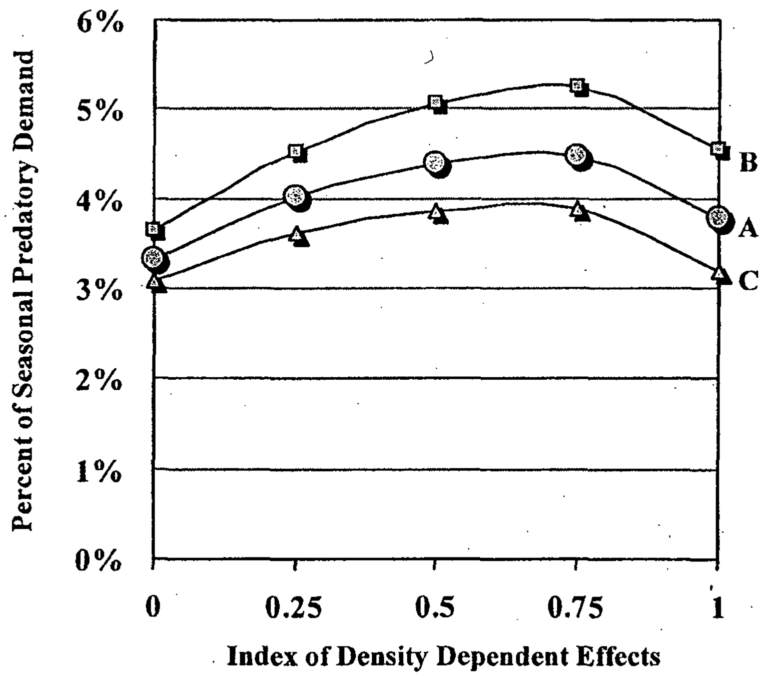


Figure 4. Estimates of the percent of seasonal predatory demand of age 1 through age 13 Hudson River striped bass potentially satisfied by consumption of juveniles of the four taxa, as functions of the index of density dependent effects (see text) and assumed background mortality rates. Curve A is for the estimated background mortality rates (see text), curve B is for background mortality rates of zero, and curve C is for two times the estimated background mortality rates. The proportion of the coastwide population of age 1 through age 13 striped bass that were Hudson River fish was assumed to be 13% in Period 1 and Period 2.



Appendices

Appendix A: Derivation of Approximations

The approximations were based on the following equivalences:

$$\frac{R_c}{R_n}=\frac{\left(\dfrac{\overline{C}_2}{\overline{C}_1}\right)}{\left(\dfrac{\overline{N}_2}{\overline{N}_1}\right)}=\frac{\left(\dfrac{\overline{C}_2}{\overline{N}_2}\right)}{\left(\dfrac{\overline{C}_1}{\overline{N}_1}\right)} \qquad \text{(A1)}$$

and

$$\frac{R_n}{R_l}=\frac{\left(\dfrac{\overline{N}_2}{\overline{N}_1}\right)}{\left(\dfrac{\overline{L}_2}{\overline{L}_1}\right)}=\frac{\left(\dfrac{\overline{N}_2}{\overline{L}_2}\right)}{\left(\dfrac{\overline{N}_1}{\overline{L}_1}\right)} \qquad \text{(A2)}$$

The first order Taylor series approximation (evaluated at $m_{P,j}=0$) for the numerator (with $j=2$) or denominator (with $j=1$) of equation (A1), that expresses that term as a function of the mortality rate for predation, is:

$$\frac{\overline{C}_j}{\overline{N}_j} \doteq m_{p,j}tw_j\left(\frac{1-e^{(-m_j t)}}{m_j t}\right)^{-1}\left(\frac{1-e^{-(m_j-g_j)t}}{(m_j-g_j)t}\right) \qquad \text{(A3)}$$

which, using the approximation from Paloheimo (1961) can be written as:

$$\frac{\overline{C}_j}{\overline{N}_j} \doteq m_{p,j}tw_j\left(e^{-\frac{m_j t}{2}}\right)^{-1}\left(e^{-\frac{(m_j-g_j)t}{2}}\right) \doteq m_{p,j}tw\, e^{\left(\frac{gt}{2}\right)} \qquad \text{(A4)}$$

Therefore, an approximation for the ratio of ratios in equation (A1) is:

$$\frac{R_c}{R_n} \doteq \left(\frac{m_{p,2}}{m_{p,1}}\right)\alpha \qquad \text{(A5)}$$

where α is the ratio (Period 2 to Period 1) of the average juvenile weight per fish at the mid-point of the season.

Again using the approximation from Paloheimo (1961), the numerator (with j=2) or denominator (with j=1) of equation (A2) was approximated as:

$$\frac{\overline{N}_j}{\overline{L}_j} \doteq e^{-(m'_j+m_{p,j})t'} e^{-\frac{(m_j+m_{p,j})t}{2}} \qquad \text{(A6)}$$

Therefore, the logarithm of the ratio of ratios in equation (A2) is approximately:

$$\ln\left(\frac{R_n}{R_l}\right) \doteq \left(m_{p,1}-m_{p,2}\right)\left(t'+\frac{t}{2}\right)+\beta \qquad \text{(A7)}$$

where β is the difference between the juvenile background mortality rates for Period 1 and Period 2.

Appendix B: Formulae for Variance Estimates

Formulae for variance estimates for the approximate estimates of instantaneous mortality rates due to possible predation were derived using a Taylor series approximation (Kendall and Stuart 1977). Because the variances were intended to represent imprecision due to sampling error, and data for the three component ratios are from independent sampling programs, all covariance terms were set to zero. Lower case symbols (e.g. r_n) indicate estimates of corresponding paramters (e.g. R_n).

For the approximate estimate of the instantaneous mortality rate for Period 1:

$$\hat{\tilde{m}}_{p,1} = \frac{\ln\left(\frac{r_n}{r_l}\right)}{\left(1-\frac{r_n}{r_p}\right)\left(t'+\frac{t}{2}\right)}, \qquad \text{(B1)}$$

the formula for the variance estimate is:

$$\operatorname{var}(\hat{\tilde{m}}_{p,1}) \doteq \left(\frac{dm_{p1}}{dr_n}\right)^2 \operatorname{var}(r_n) + \left(\frac{dm_{p1}}{dr_l}\right)^2 \operatorname{var}(r_l) + \left(\frac{dm_{p1}}{dr_p}\right)^2 \operatorname{var}(r_p) \qquad \text{(B2)}$$

where

$$\frac{dm_{p1}}{dr_n} = \left(\left(r_n^{-1}\left(1-\frac{r_p}{r_n}\right)^{-1}\right) - \left(\left(1-\frac{r_p}{r_n}\right)^{-2} r_n^{-2}\, r_p\right)\right)\left(t'+\frac{t}{2}\right)^{-1} \qquad \text{(B3)}$$

$$\frac{dm_{p1}}{dr_l} = -\left(r_l^{-1}\left(1-\frac{r_p}{r_n}\right)^{-1}\right)\left(t'+\frac{t}{2}\right)^{-1} \qquad \text{(B4)}$$

and

$$\frac{dm_{p1}}{dr_p} = \left(r_n^{-1}\left(1-\frac{r_p}{r_n}\right)^{-2}\right)\ln\left(\frac{r_n}{r_l}\right)\left(t'+\frac{t}{2}\right)^{-1}. \qquad \text{(B5)}$$

For the approximate estimate of the instantaneous mortality rate for Period 2:

$$\hat{\tilde{m}}_{p,2} = \frac{\ln\left(\frac{r_n}{r_l}\right)}{\left(\frac{r_n}{r_p}-1\right)\left(t'+\frac{t}{2}\right)}, \qquad \text{(B6)}$$

the formula for the variance estimate is:

$$\operatorname{var}(m_{P2}) \doteq \left(\frac{dm_{p2}}{dr_n}\right)^2 \operatorname{var}(r_n) + \left(\frac{dm_{p2}}{dr_l}\right)^2 \operatorname{var}(r_l) + \left(\frac{dm_{p2}}{dr_p}\right)^2 \operatorname{var}(r_p) \qquad \text{(B7)}$$

where

$$\frac{dm_{p2}}{dr_n} = \left(\left(r_n^{-1} \left(\frac{r_n}{r_p} - 1 \right)^{-1} \right) - \left(\left(\frac{r_n}{r_p} - 1 \right)^{-2} r_p^{-1} \ln\left(\frac{r_n}{r_l} \right) \right) \right) \left(t' + \frac{t}{2} \right)^{-1} \quad \text{(B8)}$$

$$\frac{dm_{p2}}{dr_l} = -\left(r_l^{-1} \left(\frac{r_p}{r_n} - 1 \right)^{-1} \right) \left(t' + \frac{t}{2} \right)^{-1} \quad \text{(B9)}$$

and

$$\frac{dm_{p2}}{dr_p} = \left(r_p^{-2} r_n \left(\frac{r_n}{r_p} - 1 \right)^{-2} \right) \ln\left(\frac{r_n}{r_l} \right) \left(t' + \frac{t}{2} \right)^{-1} . \quad \text{(B10)}$$

Estimated variances for the component ratios (r_n, r_p, and r_l) were computed using the following formulation (using r_n as an example):

$$\text{var}(r_n) \doteq \left(\frac{\bar{n}_2}{\bar{n}_1} \right)^2 \left(\frac{\text{var}(\bar{n}_2)}{\bar{n}_2^2} + \frac{\text{var}(\bar{n}_1)}{\bar{n}_1^2} \right) \quad \text{(B11)}$$

where

$$\text{var}(\bar{n}_j) = \frac{1}{k^2} \sum_{i=1}^{k} \left(se(n_{ji}) \right)^2 \quad \text{(B12)}$$

$$\bar{n}_j = \frac{1}{k} \sum_{i=1}^{k} n_{ji} \quad \text{(B13)}$$

for year i within period j; and

$$r_n = \frac{\bar{n}_2}{\bar{n}_1} \quad \text{(B14)}$$

Estimates of standard errors (for equation (B12)) for estimates of juvenile and post yolk-sac larval abundance were from the annual Year Class Reports (e.g. EA 1996). For estimates of predatory demand, estimates of standard errors were based on reported coefficients of variation for estimates of age-specific abundance of Atlantic coast striped bass (ASMFC 2005). Parameters other than abundance were treated as constants in the variance estimates.

Appendix C: Estimates of the Proportion of the Coastwide Population of Age 1 Striped Bass from the Hudson River

The proportion of the coastwide population of age-1 striped bass that was of Hudson River origin was estimated from: 1) the time series of estimates of age-1 abundance ($N_{1,y}$), and 2) the time series of juvenile abundance indices for four major spawning areas: Chesapeake Bay Maryland (CBM), Chesapeake Bay Virginia (CMV), Hudson River (HR), and Delaware River (DR). For each year, y, the proportion was estimated as:

$$\rho_y = \frac{\hat{\beta}_{HR} X_{HR,y}}{\hat{\beta}_{CBM} X_{CBM,y} + \hat{\beta}_{CBV} X_{CBV,y} + \hat{\beta}_{HR} X_{HR,y} + \hat{\beta}_{DR} X_{DR,y}} \qquad \text{(C1)}$$

where the $\hat{\beta}$'s are the estimated regression coefficients from a multiple regression of age-1 coastwide abundance against the year-specific juvenile indices ($X_{CBM,y}$, $X_{CBV,y}$, $X_{HR,y}$, $X_{DR,y}$) from the four spawning areas (ASMFC, 2005):

$$N_{1,y} = \beta_{CBM} X_{CBM,y} + \beta_{CBV} X_{CBV,y} + \beta_{HR} X_{HR,y} + \beta_{DR} X_{DR,y} \qquad \text{(C2)}$$

The R^2 for this multiple regression was 0.96 ($p<0.0001$).

APPENDIX D

Appendix D

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Entrainment Susceptibility at Indian Point and Change in YOY Abundance

Cooling water withdrawals impose some incremental mortality on species susceptible to entrainment. The effect of this incremental mortality may be inconsequential to the populations and communities in the water body, or, if the increment is large enough, could potentially lead to either a decrease or a reduced rate of increase in the affected populations. However, in addition to cooling water withdrawals, there are many other factors that can affect population trends, including changes in prey and predator populations, climatic effects, harvesting intensity, habitat modification, invasive species, and water quality. Thus, over any given time period, populations of some species can be expected to increase, while others decrease, regardless of cooling water withdrawals.

If entrainment at IP2 and IP3 were having an adverse impact on the Hudson River fish community, then species with high susceptibility to entrainment would be expected to have decreased, or increased less in abundance, over the past 32 years than would species with low susceptibility. This possibility can be evaluated by examining the relationship between a measure of entrainment susceptibility and a measure of population change derived by comparing the mean abundance of young-of-year ("YOY") fish belonging to various species from 1974-1989 to the mean abundance of the same species of fish from 1990-2005. YOY is selected for the metric because the effects of entrainment have been realized by the time fish reach the YOY stage, and this age group is still within the estuary and can be sampled for most species. The periods 1974-1989 and 1990-2005 were selected so that the two periods of comparison would include equal numbers of years.

Evaluating the relationship between entrainment susceptibility and change in YOY abundance requires selecting those species for which adequate data are available for both variables. Entrainment susceptibility can be characterized quantitatively by evaluating the distribution of entrainable life stages in the Regions from which IP2 and IP3 withdraw water in comparison to all the Regions sampled. The expected effect of continued annual entrainment losses of early life stages, if losses are severe enough to affect population size, is a negative relationship between entrainment susceptibility and the ratio of YOY abundance from the early part of the time series (1974-1989) to the latter part (1990-2005).

METHODS

The process for evaluating the relationship between entrainment susceptibility and changes in YOY abundance is summarized in Figure D-1. The process involves three steps:

(1) Calculate a species-specific metric of entrainment susceptibility based on larval abundance data from the LRS;

(2) Calculate a species-specific metric of change in YOY abundance based on data from the BSS/FSS; and

(3) Determine if entrainment susceptibility is negatively related to change in YOY abundance.

Step 1. Entrainment Susceptibility Based on Larval Distribution (*EntSus*)

A species-specific metric of entrainment susceptibility is calculated from the utilities' LRS for the 32-year period 1974-2005.[1] Species using the Hudson River estuary as a spawning and nursery area vary by season within a year. In addition, the geographic and temporal extent of the LRS sampling varies among years, and some species occur in two or three seasonal periods. These realities are addressed by dividing the LRS database into three seasonal periods and considering only those weeks that were sampled:

- Winter & early spring: Years 1975-1980 and 1995-2005; Weeks 8-16; Regions 1-6
- Late spring: Years 1974-2005; Weeks 17-27; Regions 1-12
- Summer: Years 1991-2005; Weeks 28-41; Regions 1-7

Identification of larvae to species level is not always practical, in which case larvae are classified by genus or family. Differences in taxonomic level of *EntSus* and YOY abundance data are resolved in one of two ways: (a) if BSS/FSS data are adequate at species level but LRS data are not, then use the same genus or family *EntSus* value for each species, or (b) if BSS/FSS

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1 An index of standing crop (the number of fish in an area or volume at a particular time) is estimated by life stage and species. Standing crop indices are calculated for each habitat (shorezone, benthic, water column) in each region and each week by taking the product of the average density in a habitat during that week and the area (shorezone habitat) or volume (benthic and water column habitats) contained in that region. The standing crop index for each region and week is then estimated as the sum of the habitat index values. This value is an index rather than an absolute standing crop value because no adjustment is applied for differences in collection efficiency between sampling gears (ASA, 2005; Chapter 2, Materials and Methods, 2004 Year Class Report).

data are not adequate at species level but LRS data are, then pool species-level LRS abundance data to the genus or family taxonomic level.

Relative abundance of larvae in Regions 3-5, *EntSus*, is the index of entrainment susceptibility. For each sampled year (and each seasonal period when possible), *EntSus* is estimated for each species as the ratio of standing crop in Regions 3-5 to standing crop in all sampled regions. For those species occurring in more than one of the three seasonal periods, annual *EntSus* values are calculated as an average across periods, *p*, weighted by abundance for each period:

$$EntSus_i = \frac{\sum_p SC_{ip} EntSus_{ip}}{\sum_p SC_{ip}}$$

where $EntSus_i$ = fraction of species in the Hudson River estuary in Regions 3-5 in year *i*
SC_{ip} = sum of abundance of the species within seasonal period *p* in year *i*
$EntSus_{ip}$ = value of *EntSus* for seasonal period *p* in year *i*

Annual *EntSus* values are estimated for each species for each year in which the species occurred during 1974-2005. Mean entrainment susceptibility and its variance are calculated for each species based on its annual *EntSus* values.[2]

Step 2. Change in YOY Abundance (*R*)

The utilities' Beach Seine Survey (BSS) and Fall Shoals Survey (FSS) programs are selected as the best measures of change in abundance of YOY fish. These programs have sampled the estuary using similar gear and methodology since 1974, although there have been variations in the Regions sampled and in time of initiation and end of the sampling across the years. To maintain consistent sampling effort and maximize comparability of results, data are restricted to Regions 1-12 and weeks 31-42, approximately corresponding to August through October.

Abundance data by species are categorized into two salinity zones, three habitats, and two time periods. The two salinity zones are brackish (Regions 1-6; river miles 12-61) and freshwater (Regions 7-12; river miles 62-152). The three habitats sampled by these surveys are:

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2 Entrainment susceptibility at Indian Point will change during extreme water years. In wet years some freshwater and anadromous species will be more at risk, while in dry years some marine species will be more at risk.

(a) shorezone (bottom area in water 10 ft or less in depth), sampled with the 100-ft beach seine in the BSS from 1974-2005; (b) benthic (volume of water between river bottom and 3 ft above the bottom), sampled with the beam trawl in the FSS from 1985-2005; and (c) water column (water volume not included in either the shorezone or benthic habitats), sampled with the Tucker trawl in the FSS from 1979-2005. Except for weekly BSS sampling in the 1970s, all of the sampling was done on an alternate week basis.

Time series of abundance data are divided into two periods: Period 1 = 1974-1989; Period 2 = 1990-2005. This division results in equal number of years in the two periods for shorezone habitat (16 years), but unequal number of years for benthic habitat (five years and 16 years) and water column habitat (11 years and 16 years).

The available data for measuring change in abundance provide the potential for six independent estimates of relative abundance change for each species (two salinity zones and three habitats). However, some species may be concentrated in particular habitats or salinity zones. Due to the strong salinity preferences of freshwater and marine fish, only sampling from their preferred salinity zone (freshwater zone for freshwater fish, brackish zone for marine fish) was used. In addition, it is difficult to accurately measure abundance changes for species that occur only occasionally. Thus, species data from a salinity zone-habitat combination are included in the analysis only if the total catch meets a minimum level of catch in at least one of the two periods (see Step 3 below). To adjust for the unequal number of years for benthic and water column habitats mentioned above, the Period 1 catch is adjusted upward by a factor based on the number of years sampled, i.e., 3.20 (=16 yr/5 yr) for benthic and 1.45 (=16 yr/11 yr) for water column.

For each selected salinity zone-habitat, the weighted mean YOY abundance for Period 1, Period 2, and Periods 1 and 2 combined are calculated with the GLM procedure in SAS. Mean abundance for each of these three time intervals is calculated as the weighted mean abundance across the sampling Regions within a salinity zone, where the weight is the proportion of the total amount of a habitat in that salinity zone that occurs within each of its six Regions.

Relative change in YOY abundance for each species, R_i, and its standard error, $se(R_i)$, are calculated based on (Cochran 1977, pp. 30-34)[3]. Since R_i is bounded on the lower side by 0 for

[3] Let:

$\bar{x}_{1ijk}$ = weighted mean cpue in Period 1 for species i in habitat j in salinity zone k decreases in abundance, is 1 if mean abundance is unchanged, and is unbounded above 1 for increases in abundance, a log_{10} transformation is used to normalize the distribution of R values.[4]

$$R_i = \frac{\sum_{jk} \bar{y}_{2ijk} / n_i}{\sum_{jk} \bar{y}_{1ijk} / n_i} = \frac{\bar{y}_{2i}}{\bar{y}_{1i}} = \text{relative change in species i abundance from Period 1 to Period 2}$$

$$se(R_i) = \frac{1}{\sqrt{n_i \bar{y}_{1i}}} \sqrt{\frac{(\sum_{jk} \bar{y}_{2ijk}^2 + R_i^2 \sum_{jk} \bar{y}_{1ijk}^2 - 2R_i \sum_{jk} \bar{y}_{1ijk} \bar{y}_{2ijk})}{n_i - 1}}$$

Step 3. Association between Entrainment Susceptibility and Change in YOY Abundance

Three correlation methods (Pearson, Spearman, and Kendall) are used to evaluate the association between *EntSus* and YOY abundance change using the CORR procedure in SAS. There is no simple mathematical relation between any two of these three methods. When the true correlation coefficient is not zero, it is likely that each coefficient is sensitive to different types of departures from independence (Sokal and Rohlf, 1995).

Availability of data varies among species, and results of correlation analysis could be sensitive to how many species are included in the analysis. Thus a limited sensitivity analysis is performed to evaluate to what extent the correlation results depend on selection criteria. The approach to this sensitivity analysis is to define two cases, Case A and Case B. The species in

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$\bar{x}_{2ijk}$ = weighted mean cpue in Period 2 for species i in habitat j in salinity zone k

$\bar{x}_{\bullet ijk}$ = weighted mean cpue over both Periods for species i in habitat j in salinity zone k

$\bar{y}_{1ijk} = \bar{x}_{1ijk} / \bar{x}_{\bullet ijk}$ = relative mean cpue in Period 1 for species i in habitat j in salinity zone k

$\bar{y}_{2ijk} = \bar{x}_{2ijk} / \bar{x}_{\bullet ijk}$ = relative mean cpue in Period 2 for species i in habitat j in salinity zone k

n_{1i} = number of salinity zone-habitat combinations selected for species i in Period 1.
n_{2i} = number of salinity zone-habitat combinations selected for species i in Period 2.

4 The effectiveness of estimating change in YOY abundance from Period 1 to Period 2 based on BSS/FSS data is limited for some species because these surveys do not sample some habitats that are primary habitats for YOY (i.e., tributaries, bays, wetlands, or shorezone habitat with structure). Although R integrates BSS/FSS YOY abundance data from benthic, water column, and shorezone habitats, the growth and survival of larvae and YOY fish that are most common in these unsampled habitats may be determined by factors that are largely irrelevant for species in the sampled habitats. Examples of such factors are micro-habitats suitable for parental nest building and guarding of young, protection from predators, and availability of food not present in open water habitats. Although species that frequent these habitats exclusively or primarily are not adequately sampled compared to other Hudson River species, there is a relatively small amount of such unsampled habitats in the estuary, and these species are not likely to be affected by IP entrainment because of their preference for these unsampled habitats.

Case B are a subset of the species in Case A. Species in Case A are selected based on LRS data criteria for *EntSus* and on BSS/FSS data criteria for YOY abundance. Species are excluded from Case A to create Case B based on more restrictive criteria for both larval and YOY abundance data. Species selection decisions are made independently for each of these two variables. Thus, a species can be excluded from this evaluation even if data are adequate for one variable but not the other variable.

Species selection criteria for entrainment susceptibility based on larval abundance

Cases A and B. *EntSus* > 0, i.e., minimum of one larva in LRS samples from Regions 3-5 during 1974-2005.

Case A. Minimum average of 100 larvae per year of occurrence collected in LRS samples from Regions 1-12 during 1974-2005.

Case B. Minimum average of 1,000 larvae per year of occurrence collected in LRS samples from Regions 1-12 during 1974-2005.

Species and salinity-zone habitat selection criteria for change in YOY abundance[5]

Case A. Minimum of 100 YOY collected in BSS/FSS samples in at least one SZ-habitat in at least one of the two time periods.

Case B. Minimum of 1,000 YOY collected in BSS/FSS samples in at least one SZ-habitat in at least one of the two time periods.

RESULTS

Entrainment Susceptibility (*EntSus*)

EntSus is a measure of the proportion of larvae in those habitats sampled by the LRS that were collected in Regions 3-5 compared to Regions 1-12.[6] Twenty four (24) species meet the Case A selection criterion for *EntSus*.[7] For these 24 species, mean *EntSus* scores range from 0.45 for striped bass to 0.02 for American shad.[8]

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5 Number of SZ-habitats selected can vary from 1 to 6 for anadromous and estuarine species and from 1 to 3 for freshwater and marine species. If a SZ-habit is selected for Period 1 (or 2), Period 2 (or 1) is included also.

6 The LRS does not sample in some habitats that are critical for many Hudson River fish species for spawning and larval life stages, e.g., tributaries, bays, wetlands, and shorezone habitat with structure.

7 Five of these 24 species are not selected for correlation analysis because they do not meet the Case A selection criterion for YOY abundance.

8 The list of species collected during the intensive entrainment study at Indian Point (1983-1987) was compared with the list of species collected during the 1974-2005 LRS in Regions 1-12. Four species, all marine, were collected only in the Indian Point entrainment study and not in the LRS. These species are not selected for the

Mean annual *EntSus* values for the representative species varied by more than an order of magnitude: striped bass (0.45), bay anchovy (0.42), Atlantic tomcod (0.26), white perch (0.16), alewife and blueback herring (0.05), and American shad (0.02). Most of these seven species were collected as larvae every year, although the average number of larvae collected per year of occurrence varied by two orders of magnitude from alewife/blueback herring (3×10^5) to American shad (2×10^3). Spottail shiner had fewer than 100 larvae/yr occurrence, and no *EntSus* value is calculated.

Change in YOY Abundance

Forty-six (46) species are selected based on the Case A criterion for YOY abundance. However, only 19 of these species are also selected based on the Case A criterion for larval abundance, and thus only these 19 species are selected for the *EntSus-R* correlation analysis.

Correlation Analysis

Table D-1 shows the correlation coefficients and probability values, for both Case A and Case B, for all three correlation indices. Figures D-2 and D-3 provide plots of mean entrainment susceptibility vs. the normalized index of relative change in YOY abundance from Period 1 to Period 2 for both Case A and Case B. For both Cases A and B, all three estimates of the correlation between $Log_{10}(R)$ and *EntSus* are not statistically significantly different from zero (Table D-1). This result is opposite the expected significant negative correlation if Indian Point entrainment were adversely affecting the population trends of susceptible species. Therefore, the effect of Indian Point entrainment on abundance patterns of the fish community, if there is one, is not large enough to be statistically detectable in the 32 years of monitoring data.

Nineteen (19) taxa, representing 31 species, four of the five guilds, 13 taxonomic families, and a broad range of both *EntSus* and *R* values (Table D-2, Figures D-1 and D-2) are selected for Case A. Eleven (11) of these taxa, representing 17 species, are retained in Case B.[9] Plots of *EntSus* vs. $Log_{10}(R)$ illustrate that more species decreased than increased in YOY

EntSus- R analysis. The species (and number of larvae collected) are Atlantic needlefish (3), smallmouth flounder (1), striped searobin (1), and northern searobin (1).

9 Eight taxa are excluded from Case A in creating Case B. The eight taxa are: Atherinid spp., banded killifish, gizzard shad, centrarchid spp, northern pipefish, rainbow smelt, winter flounder, and yellow perch. These taxa are excluded because of not meeting the more restrictive Case B selection criterion for larvae, YOY, or both.

abundance for both cases (Figures D-2 and D-3), but the change in abundance values (R) was only weakly associated with the magnitude of *EntSus* values.

DISCUSSION AND CONCLUSIONS

EntSus is a quantitative index bounded by 0.00 and 1.00. It is based on LRS data for larval abundance in water column and benthic habitats sampled in Regions 3-5 relative to larval abundance in these habitats sampled in Regions 1-12 of the Hudson River estuary. Thus, *EntSus* is an index of risk of entrainment of larvae at Indian Point. It is not an index of impact on the population.

The low correlations observed between *EntSus* and $Log_{10}(R)$ are counter to the expected more negative correlations if Indian Point entrainment were a significant factor influencing population dynamics of the fish community. Although the number of taxa (19) for which both variables could be measured is small, these taxa represent approximately 94% (Case A) and 88% (Case B) of all YOY fish captured in the BSS/FSS programs from 1974-2005.

In conclusion, 32 years of monitoring data do not support the hypothesis that entrainment at Indian Point has caused substantial harm to the fish community of the Hudson River estuary. Although more species have decreased than increased in YOY abundance over this time period, changes in abundance are unrelated to species susceptibility to entrainment at IP2 and IP3.

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Table D-1. Pearson, Spearman, and Kendall correlation coefficients for the association between $Log_{10}(R)$ and mean *EntSus*. A value of *p* represents the probability of a sample correlation coefficient larger than the observed sample correlation coefficient, if the true correlation coefficient is zero.

Case	N		Pearson	Spearman	Kendall
A	19	*r*	0.225	0.182	0.129
		p	0.355	0.457	0.442
B	12	*r*	0.157	-0.042	-0.046
		p	0.625	0.897	0.837

Table D-2. EntSus and $Log_{10}R$ values for Figures 1 and 2, including standard errors. Case A, 19 taxa; Case B, 12 taxa. Sorted by EntSus, low to high, for each case.

Case	Family	Guild	Taxon/Species	EntSus	SE EntSus	R	SE R	Log_{10} R
A	CLUP	A	American shad	0.023	0.009	0.480	0.091	-0.318
A	PLEU	M	Winter flounder	0.030	0.007	0.440	0.374	-0.357
A	CLUP	A	Alewife	0.051	0.008	1.133	0.337	0.054
A	CLUP	A	Blueback herring	0.051	0.008	0.582	0.101	-0.235
A	CLUP	F	Gizzard shad	0.072	0.049	2.011	0.671	0.303
A	SYNG	M	Northern pipefish	0.079	0.024	0.774	0.058	-0.111
A	CYPR	F	Cyprinid unid	0.107	0.013	1.154	0.076	0.062
A	PERC	F	Tesselated darter	0.109	0.012	0.971	0.149	-0.013
A	CENT	F	Centrarchid unid	0.116	0.015	2.271	1.609	0.356
A	MORO	E	White perch	0.158	0.013	0.440	0.072	-0.357
A	PERC	F	Yellow perch	0.201	0.024	0.551	0.197	-0.259
A	CYPD	E	Banded killifish	0.210	0.096	0.306	0.242	-0.515
A	OSME	A	Rainbow smelt	0.260	0.030	0.633	0.087	-0.198
A	GADI	E	Atlantic tomcod	0.263	0.042	0.400	0.134	-0.398
A	CLUP	M	Atlantic menhaden	0.300	0.046	80.026	35.284	1.903
A	SCIA	M	Weakfish	0.302	0.050	0.516	0.265	-0.287
A	ATHE	E	Atherinid sp.	0.339	0.032	3.509	2.487	0.545
A	ENGR	M	Bay anchovy	0.417	0.032	0.720	0.200	-0.142
A	MORO	A	Striped bass	0.454	0.020	1.236	0.380	0.092
B	CLUP	A	American shad	0.023	0.009	0.527	0.109	-0.278
B	CLUP	A	Alewife	0.051	0.008	1.267	0.574	0.103
B	CLUP	A	Blueback herring	0.051	0.008	0.582	0.101	-0.235
B	CYPR	F	Cyprinid unid	0.107	0.013	1.233	1.432	0.091
B	PERC	F	Tesselated darter	0.109	0.012	0.971	0.149	-0.013
B	MORO	E	White perch	0.158	0.013	0.459	0.094	-0.338
B	OSME	A	Rainbow smelt	0.260	0.030	0.821	0.129	-0.086
B	GADI	E	Atlantic tomcod	0.263	0.042	0.346	0.157	-0.461
B	CLUP	M	Atlantic menhaden	0.300	0.046	80.026	35.284	1.903
B	SCIA	M	Weakfish	0.302	0.050	0.398	0.294	-0.400
B	ENGR	M	Bay anchovy	0.417	0.032	0.720	0.200	-0.142
B	MORO	A	Striped bass	0.454	0.020	0.976	0.364	-0.011

Figure D-1. Analysis Flow Chart for Entrainment Susceptibility

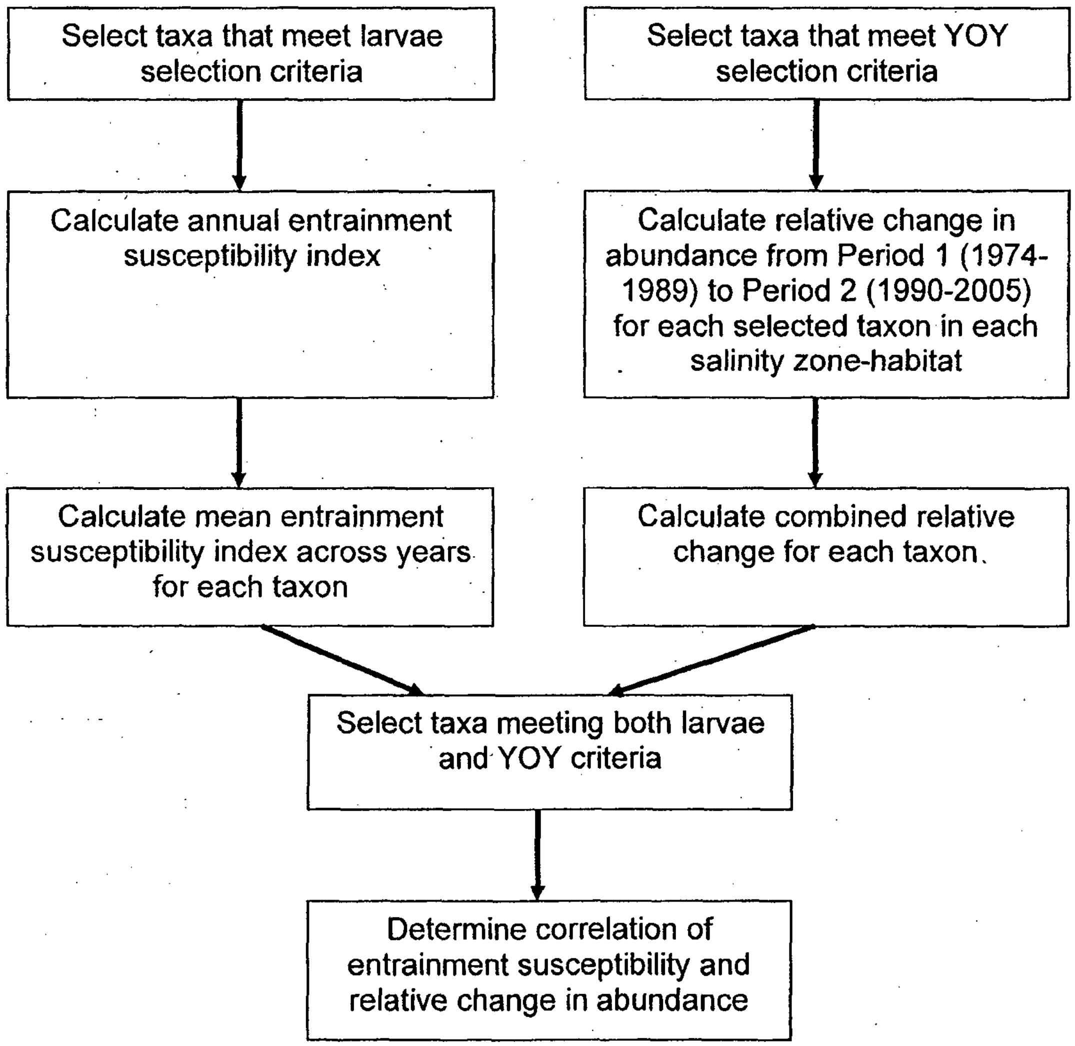

Figure D-2. Association between change in YOY abundance from Period 1 to Period 2, $Log_{10}(R)$, and entrainment susceptibility, *EntSus*, for the 19 taxa selected for Case A. Zero on the logarithmic Y axis corresponds to no change in YOY abundance. Use Table 2 as an aid in determining which species is associated with which point in the figure. $N = 19$; $r = 0.16$; $P = 0.51$

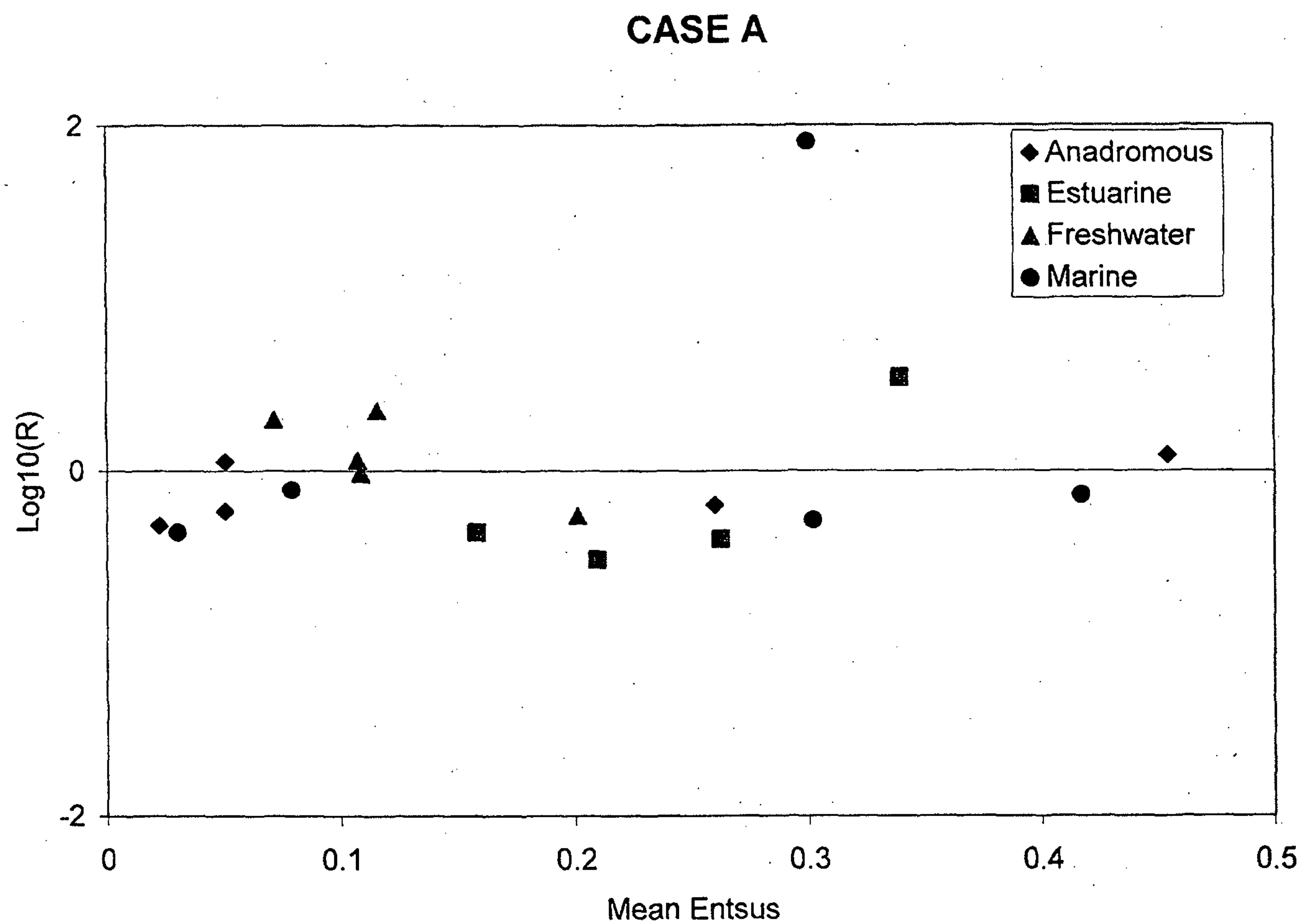

Figure D-3. Association between change in YOY abundance from Period 1 to Period 2, $Log_{10}(R)$, and entrainment susceptibility, *EntSus*, for the 11 fish taxa selected for Case B. Zero on the logarithmic Y axis corresponds to no change in YOY abundance. Use Table 2 as an aid in determining which species is associated with which point in the figure.