Shortnose Sturgeon (SNS) Status Review Report

External Peer Review for the Center for Independent Experts

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1. Executive Summary

NMFS Office of Science and Technology initiated an external review by the Center for Independent Experts (CIE) of the draft Status Review of shortnose sturgeon (SNS). The Status Review (SRR) was completed by a team of state and federal scientists (Status Review Team: SRT) charged to compile and analyze the best available information on the status of and threats to SNS, distinguish Distinct Population Segments if such exist. Status decisions were then to be developed for each DPS (endangered, threatened, not warranted) based upon best available information. The team also described current protective efforts and their effectiveness. The information presented in the SRR serves as the basis for ESA listing determination. Accordingly, NMFS initiated this CIE peer review. During early January 2009, I conducted a desk peer review of the SRR. I had been supplied with the Status Review Report (SRR) prepared by the SRT and access to ancillary material. I critically analyzed the SRR, developed a series of findings, and prepared this report in response to Terms of Reference related to (1) inclusion and use of best available science; (2) DPS existence and delineation; (4) Extinction Risk Analysis; and (4) research recommendations.

The SRT reviewed information on a river-by-river basis, summarizing published information regarding abundance and distribution, river-specific natural history and habitat information, threats to each riverine system, and current and recommended research. The SRT then evaluated the status of individual populations based upon a population scoring procedure. A RAMAS population viability study was performed by Dr. J. Hightower using best available information on population demographics and various scenarios of population abundances and risks.

The SRT concluded that DPS structure did in fact exist and on the basis of population genetics, delineated five DPSs within the U.S.: 1) Gulf of Maine; 2) Connecticut and Housatonic Rivers; 3) Hudson River; 4) Delaware River and Chesapeake Bay; and 5) Southeast Rivers. Alternative structures were considered using complementary genetic analyses and a range of quantitative and logical frameworks.

Utilizing a novel population health score, the SRT assigned thresholds for threatened and endangered populations. No thresholds for recovered (listing not warranted) were developed. A threat score was developed as a means to corroborate population/DPS designations based upon an expected inverse relationship between population health and threat scores. The SRT concluded that all SNS populations met the ESA listing threshold: the Hudson and Gulf of Maine populations were designated as threatened; all others were designated as endangered. The SRT recognized the improved status of the Hudson and Gulf of Maine populations since the original listing in 1967, but did not concur with recent published literature, which showed substantial (>4-fold) increases in abundance by the Hudson River population during the more recent past (1980-1997).

The SRR was quite comprehensive in its inclusion of best information from published literature, unpublished reports, ongoing surveys and research, interviews, and anecdotal information. The SRT is also to be commended for acknowledging important uncertainties and opposing viewpoints on SNS population structure, abundances, life history, and threats. A few important issues related to uncertain biology or ecology merited expanded treatment. These included species identification, riverine/estuarine dependence, and meta-population connectivity. The SRR also inadequately recognized uncertainty in life history parameters including growth, mortality, reproductive schedules, longevity, and recruitment variability. The treatment on the role of the Holyoke Dam in partitioning the Connecticut River population did not sufficiently present alternative hypotheses.

Evidence for delineation within the species and the genetic delineations between the five DPSs was compelling. Alternative structures were well considered. On the other hand, criteria for which river systems to include within a DPS were not clearly linked to evidence related to historical incidence or whether the system continued to support reproduction. New research described in the SRR on population genetics supports the view that recovery within each DPS could depend upon system exchange, particularly between paired systems: Penobscot-Kennebec, the Connecticut-Hudson, Delaware-Chesapeake, Cape Fear-Winyah, and Savannah-Edisto.

The Extinction Risk Analysis procedure deviated substantially from an earlier one, which used an abundance criterion of 10,000 for Gulf of Maine populations (NOAA 1996). Although status designations warrant considerations other than abundance, lacking in the SRR was a deliberate treatment on rationale for the new population scoring approach and clear decision framework for using available evidence in developing population thresholds. The procedure followed precedent for Atlantic sturgeon for which there occurs no population abundance estimates. This is not the case for SNS where several populations support recent abundance estimates. The previous NOAA criterion, 10,000, has been exceeded for several populations yet there is no discussion about why this previous threshold is no longer under consideration. Importantly the SRR population viability analysis supported the result that a population <10,000 is at risk for extinction, but one > 10,000 is not.

Because Extinction Risk Analysis results did not formally incorporate the three principal analyses of the SRR assessment (population health and threat scoring and the RAMAS population viability model), it failed to integrate best available information. An inverse relationship between population health and threats scores, purported to confirm the sole use of population health scores, was not quantitatively supported. Results from the RAMAS population viability analysis were well supported by available information but were largely ignored in DPS/population listing designations. Overall, I would recommend that the SRT provide much clearer rationale and guidance for designating endangered, threatened, and recovered population. An abundance threshold is clearly needed but was not supplied. The interim 10,000 threshold merited review, particularly as the 1998 Recovery Plan gave highest priority to this activity (NMFS 1998). In addition, the SRT ignored the population viability analysis and provided no threshold for recovered status. Without doing so the procedure seems particularly open to criticism.

I arrived at different conclusions about trends in recent abundance and the current status of the Hudson River population. I did not agree with the conclusion that the Hudson River population has not grown or has only grown slightly during the period 1980-1997. I think the Bain et al. (2007) recent estimate of 56,708 adults qualifies as best available science and should have been accepted as such by the SRT. Competing and apparently conflicting estimates presented in the SRR were preliminary and/or not directly comparable to historical population estimates, which was the principal intent of the peer-reviewed Bain et al. (2007) study.

The Hudson River population should be designated as fully recovered (not warranting listing). No substantial evidence or rationale was produced to indicate that this population had a 50% chance of endangerment in the next 25 year time frame. The population viability analysis indicated only a 9% chance of an 80% decline for this population in the next 100 years. An 80% decline would still constitute a healthy population using the provisional NMFS threshold of 10,000 (56,000*0.2~11,000). Other considerations such as connectivity to other populations merit consideration, but these were not provided specific to the Hudson River population or to the decision framework on designating DPS status.

That the Delaware DPS was designated as endangered rather than threatened was also not consistent with recent population abundance (>10,000) or indeed, the SRR population scoring procedure. Again, considerations of the Delaware population's connectivity with the Chesapeake Bay ecosystem merit considerations, but were not articulated in the rationale or procedure for designated the DPS status.

Recent research has been guided by the recovery plan (NMFS 1998) but mostly has relied on individual scientist-driven inquiry, with little integration with other SNS science or recovery actions. The discovery that colonization can occur between systems deserves priority in evaluating whether natural colonization can restore depleted and extirpated populations. The degree of population interchange is also important to any future modifications of the proposed DPS structure. Monitoring programs for viable populations are critical and should take place at some regular interval to evaluate DPS status. Research directed at improving demographic inputs (verified ageing procedures, improved estimates of reproductive schedule) merits priority.

The history of status review and recovery planning shows poor performance for this species related to delayed coordination and prioritization of monitoring, research, and assessment activities. Although funding for assessment and research is inadequate, the past ESA paradigm, which emphasizes protection over recovery, has also curtailed restoration. A model that is increasingly favored for endangered species emphasizes (1) a strong conceptual model for recovery, (2) focused research questions that address that model, (3) monitoring directed towards assessment of recovery performance indicators, and (4) adaptive management that permits changes to the underlying model and population status.

A new regulatory structure that could better address recovery goals for this species and promote adaptive management is a federal-state partnership exemplified by the Maine Atlantic Salmon Commission. Such partnerships can provide structure, expertise, and resources beyond what NMFS alone can accomplish. Importantly, they can more efficiently develop strategic recovery plans, promote regular assessment activities, and facilitate adaptive responses to actions and research.

2. Introduction

2.1. Background

The subject of this peer review is a status review report for shortnose sturgeon (SNS) (*Acipenser brevirostrum*) that is being prepared for the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) by a team of Federal and state biologists. NMFS has Endangered Species Act (ESA) jurisdiction of species listed at 50 CFR 223.102 and 224.101. SNS was listed as an "endangered species threatened with extinction" under the Endangered Species Preservation Act on March 11, 1967. SNS as a species remained on the endangered species list with the enactment of the ESA.

NMFS initiated this SNS status review in July 2007 to update the biological information on the status of the species. The status review compiled and analyzed the best available information on the status of and threats to the species; it also considered if SNS should be identified and assessed as Distinct Population Segments (DPSs). If it is determined that the species meets the requirements to be divided into DPSs, NMFS in turn considers each DPS independently for listing consideration under the ESA. That is, each DPS is reviewed and may or may not be proposed for listing under the ESA as threatened or endangered. Listing or reclassifying each DPS separately allows NMFS to protect and conserve species and the ecosystems upon which they depend before large-scale decline occurs; it may also allow for more timely and less costly protection and recovery on a smaller scale.

As part of the status review, NMFS assembled a Status Review Team (SRT) consisting of Federal and state biologists to compile and review the best available commercial and scientific information on SNS and to present its factual findings to NMFS Service in a Status Review Report. The SRT also summarizes ongoing protective efforts in the Status Review Report, to determine to what degree these protective measures abate risks to the SNS. The scientific and commercial information presented in the status review report should contain essential factual elements upon which NMFS can base ESA listing determination (endangered, threatened or not warranted). NMFS is required to use the best available scientific and commercial data in making determinations and decisions under the ESA. As such, it is critical that the status review contain the best available information relevant to the status of, and factors and threats affecting, SNS and that all scientific findings are both reasonable, and supported by valid information contained in the document

NMFS Office of Science and Technology (OST) coordinates and manages a contract for obtaining external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of stock assessments and various scientific research projects. The primary objective of the CIE peer review is to provide an impartial review, evaluation, and recommendations in accordance to a prescribed Statement of Work and Terms of Reference.

2.2. Terms of Reference

The review addressed the following Terms of Reference:

Evaluate the adequacy, appropriateness and application of data used in the SNS Status Review Report.

1. In general, does the Status Review Report include and cite the best scientific and commercial information available on the species and its habitats, including threats to the species and to its habitat?
2. Where available, are opposing scientific studies or theories acknowledged and discussed?
3. Are the scientific conclusions sound and derived logically from the results?

Evaluate the recommendations made in the SNS Status Review Report.

1. Concerning distinct population segments, is the species delineation supported by the information presented and currently available?
2. Are the results of the Extinction Risk Analysis supported by the information presented?
3. Review the research recommendations made in the Status Review Report and make any additional recommendations, if warranted.

2.3. Description of activities in the Review

As a CIE reviewer, I conducted a desk peer review of the SRR. I have expertise specific to SNS to conduct the scientific peer review in the following categories: (1) Life history and population dynamics; (2) Physiological, behavioral, and/or morphological variation; (3) Habitat requirements of SNS; (4) Regulatory mechanisms for managing the species; (5) Other natural or man-made impacts affecting SNS; (6) Propagation of SNS; and (7) Conservation actions including restoration efforts and recovery activities for SNS. I was supplied with the Status Review Report (SRR) prepared by the SRT on 15 December. In addition electronic access was provided for the Endangered Species Act and the report, "Recognition of Distinct Vertebrate Population Segments (DPS) Under the Endangered Species Act." I also made extensive use of my personal library of reprints and books for documents referenced in the SRR. Upon receipt of the SRR, I noted that whole sections were missing references, whereupon I contacted the CIE Lead Coordinator, who arranged for their prompt delivery. Apparently an older version of references had been included in the SRR.

My review activities consumed a full seven work days during early January. During that period, I critically analyzed the Status Review Report, developed a series of findings, and prepared this report in response to the Terms of Reference (see Section 2.2).

3. Information used in the SRR

The SRT comprised a team of state and federal biologists that provided both data as well as individual expert opinions to ensure that this status review report (SRR) provides the best available information. The SRR presented a summary of published literature and other currently available scientific information regarding the biology and status of the SNS, as well as an assessment of existing regulatory mechanisms and current conservation and research efforts that may yield protection. Notably, when species- or genera-specific information was not available for the SNS, the SRT considered threat information from knowledge about other sturgeon species. Information included description of taxonomy, species distribution and natural history, and new research findings on population structure in support of DPS determinations.

The SRT reviewed information on a river-by-river basis, summarizing published information regarding abundance and distribution (both historic and current), river-specific natural history and habitat information, threats to the riverine system per the ESA listing factors, and current and recommended research. A summary of existing regulatory authorities relative to sturgeon was provided, as well as a synopsis of ongoing take permitted under ESA section 10 and a current inventory of SNS at research facilities. This assessment allowed the SRT to then evaluate the status of each riverine population via a four-step extinction risk analysis. As part of this risk analysis a RAMAS population viability study was performed by Dr. J. Hightower using best available information on population demographics and various scenarios of population abundances and risks. Ongoing research activities were also presented in the SRR.

4. Review of findings made in the SRR

4.1. Adequacy, appropriateness and application of data

4.1.1. Inclusion of best available information

Lack of long-term dedicated monitoring and research programs on SNS justified a heavy reliance on many diverse sources of information. The SRT has demonstrated solid scholarship and knowledge about past and ongoing research. Of particular importance were more intensive treatments of data and their analysis in issues of genetic differentiation among DPSs, and analysis of abundance trends in certain systems (e.g., the Connecticut, Hudson and the Altamaha). I did not find substantial instances of data presented in the SRR that I would outright disqualify as unsuitable.

A problem with use of diverse sources of information is how to weigh them in interpretations, conclusions, and recommendations. In most instances, there was clear priority given to using peer-reviewed science over other types of information, and the SRT was careful in acknowledging uncertainty associated with the latter. National Academy of Science and American Fisheries Society sponsored syntheses on what constitutes best available science in fisheries and conservation decision making (NRC 2002; Sullivan et al. 2005) clearly prioritize peer-reviewed science over other types of information. I was impressed by the inclusion of very recent published studies as well as strong treatment of an extensive historical literature throughout the SRR. I also thought the in-depth critical review of published estimates of Hudson River population abundance was very useful and deserved emphasis in the SRR. In this review however published peer-reviewed estimates (Bain et al. 2007) were given equal weighting against preliminary estimates by the same group (a contract report: Bain et al. 1998a, and a proceedings abstract: Bain et al. 2000), which did not receive peer-review. I thought it was not appropriate to include the earlier estimates. Similarly, preliminary estimates by Dovel (1978) in advance of the peer-reviewed paper (Dovel et al. 1992) were of limited use in evaluating past abundance levels in the Hudson River.

A few River Summaries (Section 6) provided statements and interpretations without citations, when I felt there was published or grey literature that could support them. These included the Maine and South Carolina Rivers sections. Still, I did not find myself disagreeing with overall interpretations and conclusions within those sub-sections. Although I am sympathetic to the strong opinions of scientists directly engaged in species conservation, I would suggest that some of the language related to threats in the Savannah River was overstated and perhaps beyond the context of the SRR (e.g., statement on the economic benefits of the Augusta Dam – p. 278).

I found a few important issues not considered as ESA factors. First, issues related to flow and dam storage seemed incompletely considered. Spawning success and recruitments of SNS and other sturgeons are strongly linked to seasonal flow patterns, which are modified by flow regulation and watershed development (Parsley and Beckman 1994; Limburg and Schmidt 1990; Woodland and Secor 2007). Also dams can store (contain) sediments and contaminants that are suddenly released either through floods or deliberate dredging. An important planned dredging activity is upstream of Troy Dam on the Hudson River, required to remove contaminated sediments. This could cause sudden releases of sediments and PCBs into critical spawning habitats below the dam.

I thought climate deserved a more central role as a future threat to SNS recovery. The climate change section (5.1.6.) was difficult to follow. There were contradictory statements in this section that conditions will become either wetter or drier. This section seemed to over-emphasize the role of changed flow and under-emphasize the more certain trend of warming (IPPC 2007). Climate change has a central role in Atlantic salmon recovery and I would expect it to have a strong role for sturgeon recovery, particularly for southern populations. I thought warming should have played a stronger role in River Summary description of threats as well as received a separate score in the extinction risk evaluation matrix (Table 36).

Under Section 5.5.4. *Escapement of hatchery/captive fishes,* I thought that the invasion of Savannah River hatchery fish into the ACE system deserved mention (Smith et al. 2002). Even modest hatchery stocking efforts can show spill-over effects into adjacent systems. Similarly, escapement of hatchery-produced SNS held at the University of Florida facility at Gainesville should be listed (p. 298), although presumably these would interact with Gulf sturgeon if accidentally released.

No summary and evaluation occurred for Section 5.4. *Inadequacy off existing regulatory mechanisms*. Also as there are so many overlapping authorities, some flow diagram would have been helpful in terms of showing how science informs management.

4.1.2. Theory, uncertainty, and opposing Views

There are indeed some critical conundrums for this species, which do not have easy answers. What does the presence of one or several adults in a small estuarine system represent? How does a dam's position relative to the fall line curtail the historical range? Were historical (or recent) records of SNS mis-identified Atlantic sturgeon? Do adults spawn annually? Overall these issues were raised, given fair treatment and a defensible interpretation made. A few important instances where I thought the SRT presented an incomplete treatment are presented below.

I very much appreciated the honest discussion on uncertainties in distinguishing SNS from Atlantic sturgeon, which can introduce important uncertainty into past and recent assessments of SNS incidence. Still, where do we go from here? Is this error thought important in current designations of DPS populations as threatened or endangered? Some overall critical evaluation on how this error likely plays out in current assessment seemed wanting in a summary for this section (p. 22) or elsewhere. Also, while I am familiar with the Dadswell et al. (1984)

information on taxonomy, much of the important information (Hilton pers. comm. and Daman-Randall et al. in progress) was unavailable to the reviewer. It would have been helpful to include more of this up-to-date information within Section 3.2.1. It would seem ripe to do a multivariate analysis across populations or use genetics forensically for more accurate species identification. I was surprised that these ideas did not show up in the list of recommended research.

Estimates of growth, mortality, age structure, reproductive schedules, longevity, and recruitment rely on ageing SNS, which entails uncertainty that merited discussion on p. 23 and elsewhere. Throughout the report, estimated ages and related parameters have been assumed with certainty. Using annuli in fin rays (spines) to infer age has been difficult to verify (Stone et al. 1982; Collins and Smith 1996; Woodland and Secor 2007) and merits additional research. To my knowledge only Woodland and Secor (2007) attempted to verify ages but they had to rely on the less rigorous marginal increment analysis (Campana 2001). Further, some controversy remains on whether fin spine removal is non-deleterious (Collins and Smith 1996; Moser et al. 2000), which deserved discussion.

Current estimates of reproductive schedules supplied in Section 3.2.3.and in River Summaries are very coarse and rely on relatively few studies, most of which are fairly dated (Dadswell 1984, Gilbert 1989). Interestingly, for the Hudson River and Connecticut, the SRT suggested that spawning frequency may be annual for females, which would indicate more rapid recovery rates (although documentation for this suggestion was lacking). A discussion on the role of reproductive schedules on likely recovery rates (e.g., Gross et al. 2002) seems critical in my opinion but was missing from Section 3. Use of modern histological techniques, research hatcheries and electronic tagging methods in developing improved reproductive schedule estimates for SNS should receive high research priority – this did not make the list of research recommendations.

An interesting and potentially important issue is how spawning operates in tidal versus fluvial systems. This distinction is not made in Section 3 or the River Summaries. Factors that affect spawning behavior, larval drift and recruitment success could vary substantially across systems classified with either fluvial or tidal spawning grounds. Some Maine and North Carolina systems impress me as having very limited tidal/fluvial ranges for SNS reproduction. Kynard (1997) and Coutant (2004) have discussed critically the role of river size and population viability of sturgeons, which are considered "big river species." For instance, I find it incredible that Merrimack SNS can complete their life history within a 35 km stretch of estuary. The concept that certain systems, due to their size, are incapable of supporting SNS populations should have been discussed.

There was inconsistent treatment of the potential (historical) upstream limit of SNS within individual systems. In some systems, any dams below the fall line were viewed as curtailments; in others the SRT stated that SNS distributions were likely not constrained despite dam location below the fall line. What comprises historical ranges and spawning areas of SNS is likely uncertain and a more deliberate treatment of this uncertainty across systems seemed warranted. As indicated above, I think current theories should be emphasized in discussions of the within-river range of SNS and which river systems historically supported SNS reproduction. Without such an organizing construct, it was difficult to fully evaluate myriad threats across individual systems.

The opportunity to rebuild populations through natural straying should have been a much stronger concept throughout the SRR in my opinion. In the Executive Summary of the SRR, “The SRT realized that some rivers within each population were likely of greater biological significance than others as they appeared to function as sources for other rivers.” Yet, this function was not part of the Extinction Risk Analysis. There was also excellent discussion on the potential role of the navigational C&D Canal on possible invasion and colonization of the Chesapeake Bay by the moderately abundant Delaware population of SNS (p. 203). The complete overlap of genetic markers supports this view as does the infrequent occurrence of SNS in the upper Chesapeake but not the lower Chesapeake Bay as referenced in section 6.9. That adult SNS are now undertaking spawning-like behaviors in the Potomac is a very encouraging signal that adjacent populations can recolonize extirpated or depleted populations. Straying could be showing similar source-sink dynamics across other system pairs - Penobscott-Kennebec, the Connecticut-Hudson, Delaware-Chesapeake, Cape Fear-Winyah, and Savannah-Edisto, where the depleted population is being subsidized.

The other side of the benefit to the subsidized population is the potential cost to the source population. There is a concentration of Delaware SNS that aggregates near the C&D canal. Conceivably the canal could result in net advection of sturgeon out of the Delaware comprising a sink much like the Holyoke Dam, which only permits downstream dispersal of sturgeon in the Connecticut. This problem merited discussion.

Zoogeography seems inadequately addressed despite supportable inferences related to the role the Pleistocene played in the current population structure of SNS. The idea of a North Atlantic refuge (Georges Bank?) was proposed by Waldman et al. (2002) for SNS, and deserved discussion in interpreting patterns of distribution and genetic separation.

The treatment on the role of the Holyoke Dam in partitioning the Connecticut River population did not sufficiently present alternative hypotheses. The Holyoke Dam is clearly a threat to the population integrity of the Connecticut River population and DPS, but there remains critical uncertainty regarding the sustainability of upper versus lower CT River population segments separated by the Dam. The SRR presented the view that the most important spawning habitat occurs in the upper segment with minimal and oft unsuccessful spawning in the lower segment. Under this scenario there is some continued loss of production of upper segment recruits and adults to the lower segment but these fish cannot return. A problem with this view is that if ~20 spawners are lost to the lower segment each year, then it would seem unlikely that this could be sustained by the very small number of estimated adults (~300) in the upper segment (estimated c. 10 years ago). Further the lower segment abundance estimate is c. 1200 adults. Something is missing here. Alternative hypotheses might include (1) there is substantial undetected emigration by juveniles into the lower segment; (2) reproduction in the lower segment is more substantial than recognized in the SRR; or (3) the lower segment is dependent upon colonization from a non-Connecticut source population. The last possibility is feasible: even a low rate of straying of <1% from the relatively large Hudson River population (50-60 K abundance) could swamp any upper segment Connecticut River contribution to lower segment recruitments. Some alternative hypotheses were examined by Root (2002), which deserved reference.

4.1.3. Life History and River Summary Conclusions

Overall, I thought conclusions were well reasoned and supported by the diverse and disparate data that the SRT had available to them. In many instances, SRT members were required to draw inferences across systems or sturgeon species due to lack of specific information on a population, river system or DPS – I thought this was appropriate. I did not agree with several important conclusions concerning the current abundance level of the Hudson River population.

The Hudson River is unique in supporting two population abundance assessments one in 1979-1980 and the other for the period 1995-1997. Further, a fisheries-independent long-term monitoring program occurred annually over the period of the two assessments. The SRT concluded that considerable uncertainty occurred in the two estimates of population abundance, and suggested that the reported 4-5 fold increase in abundance between the two assessments could not be confidently distinguished from lack of a trend. I reviewed methods and analysis presented in Dovel et al. (1992) and Bain et al. (2007) and did not agree with the SRT's findings. Rather, I found the evidence presented by Bain et al. (2007) to be compelling support for the interpretation that there has been a substantial increase in abundance in the Hudson River during the period 1980 - 1995.

Although several alternative mark-recapture models were used in two other reports by Bain's group (referenced in SRT), these were preliminary (indeed, one cited reference was an abstract from a research conference) and did not receive peer review. Further, Bain et al. 2007 was quite careful to provide a single estimate that was based upon similar methodology and estimation procedures as the earlier Dovel estimate. That was the study's intent as opposed to estimates from other analyses presented in Table 18, which contain unknown mixtures of different portions of the Hudson River population. The complementary approaches between the Bain et al. and Dovel et al. studies included targeted tag-recapture samples that occurred in the same wintering and spawning regions, limiting abundance estimates to the spawning population, and a closed population estimation procedure.

The more recent adult estimate, 56,708 and its lower confidence limit, was considerably higher than Dovel's estimate in 1980 (13,844) and its upper confidence interval. The SRT was correct to point out that a second estimate (61,057) that Bain et al. provided was for a population that contained some unknown fraction of juveniles and should be viewed cautiously as juvenile distribution areas are not as well understood as the wintering and spawning aggregation sites.

A substantive criticism is that while the winter aggregation was similarly sampled by the Dovel and Bain et al. studies, the spawning aggregation was more broadly sampled by Dovel et al. Bias could be introduced if Bain et al. sampled only one of several aggregations of spawners. Exploring the logic further, consider several scenarios:

1. Spawners aggregate in staging areas that were sampled by Dovel but not by Bain et al., but then all eventually migrate into the up-estuary region sampled in both studies. This should not bias estimates by Dovel et al. or Bain et al. Such an up-estuary migration has not been demonstrated through tagging but is suggested by the up-estuary shift in distribution reported by Dovel et al. (1992).
2. The winter aggregation is well mixed and sampled and separate portions of this aggregation then move to different spawning regions. Under this scenario, targeted sampling on only one major spawning region should not introduce substantial bias between winter marking and spring recapture. (The estimate applies to the originally marked winter aggregation, not the spawning aggregation).
3. The winter aggregation at Esopus only contains a portion of the adult population. If this aggregation preferentially moves to a specific spawning region that is under-sampled and

fish from other wintering areas move to Bain et al.'s targeted spawning region, then a positive bias would result (recapture rates would be under-estimated). Although it is known that SNS over-winter in other parts of the Hudson River, no similarly large aggregations as the Esopus one has been discovered. Evidence against missing large segments of wintering adults also comes from recapture rates, which were similar between spring (R_{Sp}) and the subsequent winter (R_{Win}) (1995: R_{Sp} =0.037; R_{Win} =0.041; 1996: R_{Sp} =0.081; R_{Win} =0.074; estimated from Table 1, Bain et al. 2007). This indicated that the same group of fish was being tracked between wintering and spawning grounds. Further, there is no evidence (albeit one way or the other) to suggest that differing overwintering groups of SNS use different spawning regions.

Important corroborating evidence for an increase in abundance comes from the Fall Shoals Survey (FSS), a utility survey that since 1985 samples the entire length of the Hudson River estuary in a standardized manner with a 3-m beam trawl. The survey shows a > 4-fold increase in relative abundance of SNS during that period. The SRT suggested that the FSS was not well suited for sampling SNS because it did not specifically target the freshwater regions where SNS occur (Figure 26). I did not think this statement was well supported because the survey should consistently represent all portions of the freshwater-brackish water distribution of SNS; the survey effort is merely less efficient. The critical element is that its standard methodology supports inferences on year-to-year relative abundance. Further the FSS is a central source of information for abundance indices of Atlantic sturgeon juveniles (similar size range to adult SNS). FSS abundance indices for Atlantic sturgeon have been calibrated against other NY survey programs and showed similar trends (ASMFC 1998). Thus, the survey seems a critical source of long-term information on SNS abundance trends. Indeed, in a somewhat speculative argument, the SRT suggested an inverse correlation between SNS and Atlantic sturgeon observed in the FSS series could be related to carrying capacity (Figure 27). An important issue is size selectivity of the trawl. Woodland and Secor (2007) indicated that the mean size captured (67 cm TL) would correspond with fish 6-10 years of age. Thus, the FSS survey should lag a similar number of years behind trends in YOY abundance. Gear selectivity and the power of the survey to detect abundance trends merit high research priority.

Several pieces of evidence point to a pattern of strong year-classes during the 1980s and early 1990s, which could have driven an increase in abundance. The SRT deemed some of these lines of evidence uncertain and did not consider others. The increasing trend in the FSS series showed a sudden positive shift in abundance in the early 1990s. The SRT suggested that this shift would be unlikely given the longevity/life history of SNS (p. 169), which is inconsistent with the view that sturgeon populations grow by strong year-class formation (e.g., they epitomize periodic strategists; Winemiller and Rose 1992; see also Gross et al. 2002 for role of strong year-classes for recovery in sturgeons). Evidence from Dadswell (1979), Fleming et al. (2003); and ASMFC (1998) showed that year-classes of Saint John and Ogeechee SNS and Hudson River Atlantic sturgeons can be quite variable. Also consistent with high recruitment in the early 1980s was an anomalously large number of juveniles impinged on an intake screen in 1982 cited in the report (p. 177). The analysis of Woodland and Secor (2007), which used residuals from a catch curve to index year-class strength, supported a trend of increasing recruitment during the period between 1980 and 1997. Trends in recruitment estimated during this period were similar to trends in the FSS.

Taken together there is a strong weight of evidence argument to be made for a substantial recovery of SNS in the Hudson River to abundance levels well in excess of the previous 1979-

1980 estimates. Therefore, I did not agree with the SRT's suggestion that the trend in Hudson River population abundance during the past 20 years might be flat (overlapping confidence intervals and relatively stable sampling data: p. 309). A second argument, which compared a 30,000 total population estimate from Dovel et al. to a 60,000 estimated from Bain et al. (p. 168) was inappropriate as juveniles were not consistently sampled across the two studies, nor representatively sampled in either study.

Several minor findings, which contained uncertainties that merited additional recognition, are listed below:

- I did not think the idea that southern populations show determinant growth was supported (P. 23) given the generality of indeterminate growth in sturgeons and other fishes and growth curves supplied in Dadswell et al. (1984). I am not sure where this idea came from.

- That sturgeon are physotomous was implicated in the SRR as causing enhanced internal damage in sturgeons as compared to physoclistous fish (p. 82). I am aware of no information to support this statement.

- A study by Gilberson (2004) showed there were suppressed feeding and growth rates by SNS in the presence of Atlantic sturgeon juveniles the same size. A similar study embedded in a dissertation (Niklitschek 2001) found just the opposite – Niklitschek inferred that a larger relative mouth size made SNS more efficient foragers than Atlantic sturgeon.

- For size limits in Saint John River on sturgeons, no management rationale was presented – are these to avoid recruitment overfishing for Atlantic sturgeon and/or protect SNS? The view that water quality is an issue due to raw sewage discharge in Saint John's Harbor might be counterbalanced by high flushing rates (p. 114). I don't know this system well, but suspect high tidal amplitudes.

- The view that NH sturgeon are extirpated (p. 144) seemed unsupported by historical evidence that they ever occurred there.

- The issue of fin rot and PCBs (Dovel et al. 1992; p. 99) was informed by more recent observations in the Hudson River (referenced later in Hudson River summary) that showed no incidence of fin rot. Given that PCBs remain high, it seems unlikely that there is a relationship.

- I am unaware that snakehead has invaded the Delaware Estuary (p. 197); no documentation was provided. Also, in other systems where snakeheads occur, I would doubt predation could occur on SNS as snakeheads tend to occur in only shoal littoral freshwater habitats (< 2 m).

- Despite early indications (Dauer 1995), the Chesapeake Bay is not widely recognized as improving. During the past decade the Bay's condition has declined in terms of incidence of hypoxia and anoxia despite Chesapeake Bay Program actions.

4.2. Distinct Population Segments

The SRR contained a very comprehensive and well supported treatment of genetic delineation of populations and the proposed DPS structure. Evidence was well presented and interpretations provided strong rationale for the proposed DPS. The complementary analyses of mt-DNA and n-DNA provided compelling evidence for this DPS structure. The analysis could have been strengthened by inclusion of direct evidence of reproduction (early life stages, ripe adults), but the SRT is to be commended for including a very recent state-of-the-art and detailed analysis of n-DNA and putting it in a careful comparative framework with previous genetic work. This analysis considered several analytical and pooling frameworks to strengthen overall inferences. I particularly found the correspondence analyses helpful. Less helpful were the permutations of different DPS combinations, seeking the highest among-DPS variance (Table 8). At such small levels of improvement ~ 2%, there was high risk of selecting a structure without biological meaning. Fortunately, this analysis was not central in delineating DPSs.

I concurred that, despite the lack of strong genetic differentiation, the St. John River merits its own DPS based upon jurisdiction considerations and its zoogeographical role. Another important consideration is that management in Canada allows recreational harvest and aquaculture for this population, which does not occur for the other DPSs. I also found strong rationale for not including the Merrimack as a separate DPS.

It was unclear what led to inclusion of many small individual river systems in the DPS structure. Very small systems that may have never supported viable populations were included in the southeast (NC in particular) but not included elsewhere (e.g., down-east Maine, lower Chesapeake). This should not affect DPS structure, but could modify nomenclature. For instance, the Housatonic and Chesapeake do not seem to merit designations within DPSs as these do not support viable populations. Inclusion of non-viable systems could also bias DPS health and threat scoring systems (Tables 35-36).

The potential of certain source populations within a DPS to provide strays to adjacent systems seems critically important in defining DPS. I thought there was an opportunity to emphasize this point earlier as a criterion, although there was very nice discussion on this issue on p. 56. See also my previous comment under Section 4.1.2. There is clearly an important theme and new understanding of SNS metapopulation structure and connectivity that I thought merited a broader treatment and emphasis in this and future assessments.

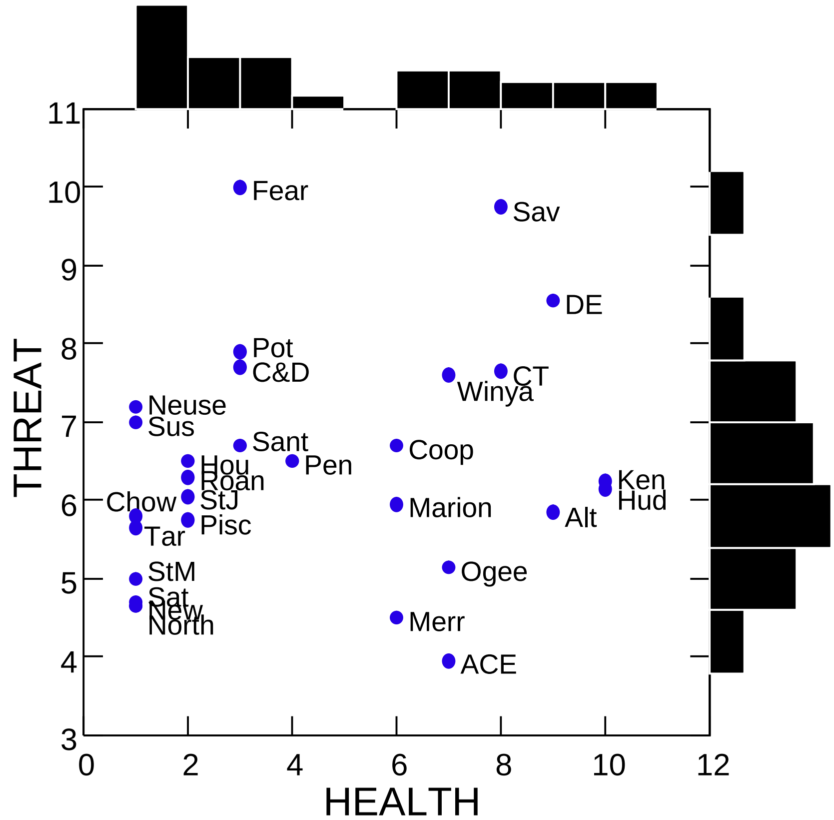
4. 3. Extinction Risk Analysis

The SRT used a procedure that had previously been applied to Atlantic Sturgeon in evaluating extinction risk – a process where indices of population health and threats were compiled according to a simple scoring scheme. In addition a population viability analysis (RAMAS) was performed. Not described was the process of bringing these three pieces of information together in DPS/population designations of endangered, threatened, or recovered. The sole reliance of the designation on the population scoring procedure was clearly stated in the Executive Summary and elsewhere in the SRR. The threat scoring procedure was proposed as a means to calibrate the population health scoring procedure. There was no guidance on how the population viability analysis was used in arriving at population designations.

I am not sure that this was the intention, but by indicating that the threatened threshold population health score was > 8 (p. 301), the SRT precluded determination of a restored/recovered population. Populations <9 were endangered, those >8 were threatened (maximum score=10). It seemed an important oversight not to have a scoring threshold for a recovered (listing not warranted) population.

The most quantitatively rigorous element, the population viability analysis, seemed to be under-utilized as no findings/recommendations followed directly from the analysis. This analysis indicated that the largest populations such as the Hudson and Delaware were not threatened using conservative demographic inputs and risk-prone scenarios, which would seem a central result in the overall SRR. The acceptance/critical review of this result and its implications received no treatment in the SRR.

In the Executive summary and elsewhere in the SRR, calibration is attributed to an inverse relationship between the population health and threat scores. I did not believe that this was supported conceptually or quantitatively. Systems may have experienced stresses >100 years ago that have lasting effects on poor population health scores, yet in recent times those same systems could be deemed healthy in terms of dams, water quality and other threats. I think this applies to some of the New England populations that were historically affected by dams or water quality. Further, and more importantly, in plotting one score against the other– no inverse relation was apparent (see scatter plot and frequency histograms below; data from Tables 35-36). The proposed 6.4 threat score threshold did not separate groups of data by health scores, rather data seemed clumped by population health scores into those populations that have abundance scores >2 (not shown below) yielding overall health scores >5. Further, health scores were skewed towards <3 corresponding to systems where SNS are absent or occur only incidentally (see comment related to inclusion of extirpated systems in DPSs above). Thus, the important SRR finding that ”a consistent inverse relationship of health to threats…” was not supported by the data.



Although the threat scores were not correlated to population health, they are still quite useful, particularly in examining populations in a comparative framework. Considering end-members, one might interpret that (1) the ACE system is more likely to recover than other populations given the combination of moderate health and low threat scores; (2) the Satilla and North River systems are among the least likely to experience recovery; (3) populations were healthy in the Hudson and Kennebec rivers despite moderately high threat scores; (4) the Savannah population, now moderately healthy, is facing greater threats than other populations; and (5) among presumed reproducing populations, the viability of the Cape Fear population is at greatest risk. Clearly the framework has merit in drawing comparative inferences that can inform risk conclusions within DPS units and recovery actions. Further, I can conceive of productive ways that the RAMAS results could have been placed into a comparative framework to support results and decision-making, but these were not pursued by the SRT.

I concurred with the designation framework of 25 years although I could not find reference to a 30 year generation time in NMFS (1998). I would have expected a much shorter generation time; was 30 years the average longevity across populations?

I found that results from the RAMAS population viability analysis were well supported by available information but were largely ignored in DPS/population designations. Population parameter inputs were appropriately drawn from published data. Often conservative estimates were used (e.g., 30,000 instead of 60,000 adult abundance for the Hudson River), which would contribute to a more likely finding of extinction risk. Large catastrophic events were reasonably modeled to further evaluate worse-case scenarios. Extinction probabilities to these threats were significant for smaller populations (Cooper and Altamaha) but nil for the Hudson River. An important finding is that “observed variability …in recruitment and survival will not drive [modeled] populations to extinction."   Apparently their life history (longevity; low adult mortality) affords some resiliency – this finding was similar to those made by Gross et al. (2002). As stated earlier, although the model framework and principal results were presented within the SRR, results and interpretations were not explicitly used in population designations.

Based upon the RAMAS analysis, I failed to understand the basis for the conclusion of a 50% endangerment risk in the Hudson River and other large populations (i.e., the Kennebec and Delaware). Other considerations may be important – for instance, maintenance of high abundances in source populations to promote colonization to adjacent systems - but these were not clearly articulated nor brought into an a priori decision making framework.

Population health sub-scores included those for abundance, life history stage presence, and trends. For population abundance a total top score of 5 indicated that this comprised 50% of the overall health score. I think the SRT ended up with abundance ranks that were justifiable but not explicated anywhere in the document. In general, it seemed that 1~incidence or no abundance; 2~dozens of SNS; 3~hundreds; 4~thousands; 5>10,000. Demographic sub-score values seemed appropriate but juvenile needs definition – are these YOY, yearlings, both? I did not think population trend score warranted inclusion. The rigor of trend analysis will vary considerably across systems based upon data available, which is very scarce outside of the Hudson, Delaware and Altamaha and perhaps a few others. Trends should be standardized to some time period and there is no way to evaluate among all the systems, whether trends are real or spurious. Finally, this carries a strong weight (3) and penalizes uncertainty with a 0 score where no data exists (59% of the systems; no other scores include a 0 rank). I think a population health score based upon abundance and life stages was supported and would have provided a more rigorous index. With the exception of the Trend category, I found myself in general agreement with the ranks presented in Table 35 based upon evidence presented in the SRR.

I had relatively few differences in rankings in the large matrix of threats presented in Table 36. Due to atmospheric warming, I would have ranked higher threats for the Water Quality sub-scores for GA and FL systems. Category D, contributed nothing to the overall stress score. I thought that certain systems might merit a 'threats of immediate concern' utilizing the SRT's strong system-specific expertise evident in the River Summaries. Some examples that I found of particular concern included:

- Brewer site dredging in the Penobscot (critical overwintering site)
- Holyoke Dam (source – sink dynamics for the Connecticut River population)
- Fairless Hill Generation Plant, Delaware (impingement of larvae in principal spawning habitat)
- Bycatch in Cape Fear, Edisto (direct mortality on adults)
- Navigational dredging in the Savannah (lost juvenile/adult habitats)
- Atmospheric warming in GA and FL systems (system extirpation)

Despite lack of a formal way to consider the three extinction risk criteria, I concurred with the SRT's population and DPS designations based upon weight of evidence with the exception of the Hudson River and Delaware/Chesapeake DPSs. In particular the Hudson River DPS did not show evidence of a 50% chance of endangerment in the next 25 year time frame. The RAMAS model showed that the probability of an 80% decline in the Hudson River was low (9%) over the next 100 years. Further an 80% decline would result in an abundance level still in excess of the nominal proposed 10,000 adult abundance threshold (NOAA 1996).

For the Delaware/Chesapeake Bay DPS designation of endangered, additional explanation seemed warranted. The Delaware is apparently a fairly abundant population with an estimated spawning population of 12,000. This by itself would seem to warrant a threatened designation, but including the Chesapeake system seems to imply that either (1) there is a viable (endangered) Chesapeake population that depends on the Delaware and/or (2) this is a unique evolving metapopulation, where natural colonization from the Delaware could restore SNS to portions of the Chesapeake. I think the SRT should be explicit regarding these assumed population structures and associated DPS designation. (Although not supported as well by genetic differentiation, a similar designation argument might be feasible for the Hudson and Connecticut, were they in the same DPS).

4.4. Non-regulatory conservation measures

Individual conservation groups and government restoration programs are noted in the SRR, including the Seaboard Fisheries Institute, Nature Conservatory, Penobscot River Restoration Project, and Hudson River Estuary Program, and the Chesapeake Bay Foundation. An important omission is the Hudson River Foundation, which has made large non-government investments towards SNS restoration through strategic research efforts over the past two decades (Foundation-supported research reports can be accessed through http://www.hudsonriver.org/ls/).

4.5. Research recommendations

The history of status review and recovery planning (Section 1.3) shows poor performance for this species related to delayed coordination and prioritization of monitoring, research, and assessment activities. Recent research has been guided by the recovery plan (NMFS 1998) but mostly has relied on individual scientist-driven inquiry, with little integration with other SNS science or recovery actions. Listed research questions under the River Summaries have merit but need to be integrated within and across regions (DPSs). Research should be based upon recovery objectives. It is well beyond the ambit of this review to list such objectives, but I would emphasize that, similar to other endangered species recovery programs, it is productive to start with a conceptual model for recovery within (or, better still - across) DPSs, and then use this to guide research questions, monitoring, assessment, and adaptive management (e.g., NRC 2004; Wildhaber et al. 2007).

Two cross-cutting research priorities across DPS systems are (1) analysis of population structure and (2) monitoring/assessment of viable populations, which should be given highest priority in my opinion. Given a fairly exhaustive initial look across systems for genetic structure, I would have given priority to (1) evaluating questions of colonization across systems and (2) uncovering evidence of spawning for those populations that have been identified through genetic analysis. Only a single system, the Hudson River, supported a long term monitoring program to evaluate population trends in abundance over decades (the FSS, see Section 4.1.3). This monitoring program holds promise in capturing abundance trends in sturgeon, but as the SRT noted there are issues related to size selectivity and distribution of sampling effort. Further, the survey's power to detect trends in abundance deserves priority in analysis. New directed or ship-of-opportunity monitoring programs should be established for other viable populations such the Kennebec, Delaware, and Altamaha. Such monitoring programs are critical in evaluating recovery, but will also afford important opportunities to better evaluate population health through more rigorous demographic analyses of these key populations. As indicated previously, research directed at improving demographic inputs (verified ageing procedures, improved estimates of reproductive schedule) merits priority in establishing recovery benchmarks and assessing population status.

5. Summary of Findings made by the CIE Peer Reviewer (listed by ToR)

Evaluate the adequacy, appropriateness and application of data used in the SNS (SNS) Status Review Report.

5.1. In general, does the Status Review Report (SRR) include and cite the best scientific and commercial information available on the species and its habitats, including threats to the species and to its habitat?

- SNS comprises a data-poor species. The SRR was quite comprehensive in its inclusion of best information from published literature, unpublished reports, ongoing surveys and research, interviews, and anecdotal information.
- In most instances, the SRT weighted peer-reviewed and other sources of information appropriately. In one important instance – presentation of abundance estimates for the Hudson River – I thought that due weight was not given to peer-reviewed science.
- I found relatively few but important issues not considered as ESA factors related to flow, dam storage, climate and hatcheries.

5.2. Where available, are opposing scientific studies or theories acknowledged and discussed?

- The SRT is to be commended for acknowledging important uncertainties and opposing viewpoints on SNS population structure, abundances, life history, and threats. A few important issues related to uncertain biology or ecology merited expanded treatment. These included species identification, life history estimates, riverine/estuarine dependence, meta-population connectivity, and Connecticut River population segments.
- Without further guidance within the SRR, it was not possible to evaluate the role past and current species mis-identification might have had in evaluating the current status of SNS.
- The SRR inadequately recognized uncertainty in life history parameters including growth, mortality, reproductive schedules, longevity, and recruitment variability.
- A general concept (or concepts) about the estuarine/fluvial nature of spawning and early rearing habitat was missing, despite past proposals (e.g., Kynard 1997; Coutant 2004) and the importance of this and related concepts in determinations of past and current threats.
- Recent geological history deserved additional attention in interpreting population and DPS structure.
- An overall impression after reading the SRR is that increased evidence of between-system migrations supports an exciting new understanding of SNS within the context of metapopulations. I felt that the SRT did not adequately use this as an overall concept in engaging issues of between system connectivity for paired rivers/estuaries: Penobscott-Kennebec, the Connecticut-Hudson, Delaware-Chesapeake, Cape Fear-Winyah, and Savannah-Edisto.

- The treatment on the role of the Holyoke Dam in partitioning the Connecticut River population did not sufficiently present alternative hypotheses.

5.3. Are the scientific conclusions sound and derived logically from the results?

- Overall, I thought conclusions were well reasoned and supported by the diverse and disparate data that the SRT had available to them. I arrived at different conclusions for the Hudson River population, which is arguably the best studied among populations.
- I did not agree with the conclusion that the Hudson River population has not grown or has only grown slightly during the period 1980-1997. I think the Bain et al. (2007) recent estimate of 56,708 adults qualifies as best available science and should have been accepted as such by the SRT.
- Several minor findings (presented in detail Section 4.1.1.) contained uncertainties that merited additional recognition.

5.4. Concerning distinct population segments, is the species delineation supported by the information presented and currently available?

- Yes, I concurred that using genetic discontinuities is the best available approach for defining DPSs. The proposed DPSs are well supported by state-of-the-art genetic analyses.
- No clear rationale was presented for including those rivers showing no evidence of SNS occurrence. In some DPSs too many rivers/populations seem to be included.
- The possibility of connectivity between individual populations should have been made more explicit in assigning DPSs.

5.5. Are the results of the Extinction Risk Analysis supported by the information presented?

- Because Extinction Risk Analysis results did not formally incorporate the three principal analyses of the SRR assessment (population health and threat scoring and the RAMAS population viability model), it failed to integrate best available information. Extinction risk designations solely relied on the population health score and did not explicitly include information on threats or population viability. An inverse relationship between population health and threats scores, purported to confirm the sole use of population health scores, was not quantitatively supported.
- Results from the RAMAS population viability analysis were well supported by available information but were largely ignored in DPS/population designations.
- Thresholds for population health scores were delimited in a manner only to separate endangered from threatened DPSs. It was not possible to designate a population as fully recovered.
- With the exception of population trend sub-scores, the Population health scores were adequately weighted. I found the categorization and weighting of threats well supported for this species.
- Despite lack of a formal way to integrate the three extinction risk criteria, I concurred with the SRT's population and DPS designations based upon weight of evidence with the exceptions of (1) the Hudson River DPS, which I did not think showed evidence of a 50% chance of endangerment in the next 25 year time frame; and (2) the Delaware-Chesapeake

DPS, which due to the established threshold should have been designated as threatened rather than endangered.

5.5. Review the research recommendations made in the SRR and make any additional recommendations, if warranted.

- The SRR contained a worthwhile list of research topics that I could glean from River Summaries and the past Recovery Plan list. What was lacking was a framework for prioritizing these research questions around conceptual models of recovery and ongoing monitoring programs.
- Two cross-cutting research priorities across DPS systems are (1) analysis of population structure and connectivity and (2) monitoring/assessment of viable populations. These two areas should receive highest priority in my opinion.

6. Conclusions and Recommendations

The SRT reviewed best available information related to life history, population structure and connectivity, population abundance and demographics specific to many individual river systems, and a population viability analysis. On this basis, they arrived at critical interpretations of DPS structure and compiled scores of population health and threats for each proposed DPS. Population health scores were assigned to DPS. Based upon threshold criteria for this score, DPSs were designated either endangered or threatened.

6.1. DPS Conclusions and Recommendations

Five DPSs were delineated: 1) Gulf of Maine; 2) Connecticut and Housatonic Rivers; 3) Hudson River; 4) Delaware River and Chesapeake Bay; and 5) Southeast Rivers. Evidence for the genetic delineations between these segments was compelling. Alternative structures were well considered in quantitative and logical frameworks. The Saint John's DPS showed less genetic separation than other DPSs but deserved unique status due to differences in regulatory structure for this Canadian DPS, which included some degree of exploitation and commercial hatcheries for the species. Criteria for which river systems to include within a DPS were not clearly linked to evidence related to historical incidence, or whether the system could continue to support SNS reproduction.

An important geographic gap in the current distribution is inadvertently obscured by the proposed DPS structure. No viable populations occur in the center part of the species' range - between Delaware Bay and the Cape Fear River (MD, VA, and most of NC). The designation of a DE-Chesapeake DPS and SE DPS obscures this gap by implying that a viable population occurs in the Chesapeake, whereas most evidence is to the contrary. The inclusion of many small NC rivers in the SE DPS could be taken as evidence of a much broader range by SNS in the central part of their range than currently exists.

With the genetic analysis, the SRR presents exciting new discoveries, presenting important opportunities to guide restoration efforts for SNS species. The previous understanding was that colonization between species was very rare. The new view is that recovery could depend upon system exchange, particularly between paired systems: Penobscott-Kennebec, the Connecticut-Hudson, Delaware-Chesapeake, Cape Fear-Winyah, and Savannah-Edisto.

Recommendations

- Include river systems within DPSs for only those systems where evidence exists for historical incidence or recent evidence of genetic structure and/or reproduction.
- Designate DPSs by principal viable populations within each DPS.
- Further emphasize role of connectivity between populations within DPSs.

6.2 Extinction Risk Summary and Recommendations

The SRT developed a procedure for delineating endangered versus threatened status among populations and DPSs; no threshold for a recovered population (de-listing criteria) was considered. Based upon a population health scoring system, the Gulf of Maine and Hudson River DPSs were considered threatened and the remaining DPSs were considered endangered. The population scoring procedure relied upon three sub-scores on abundance, life history stage presence, and abundance trends. The overall score was calibrated against a threat score that comprised over a dozen sub-scores related to important stresses such as dams, water quality, bycatch, and dredging. A population viability analysis was conducted on three different types of populations (Hudson, Altamaha, Cooper), representing a range of abundances and geographic extent.

The designation procedure deviated substantially from an earlier one, which used an abundance criterion of 10,000 for Gulf of Maine populations (NOAA 1996 as referenced by Bain et al. 2007) and the principal recommendation by the previous SNS SRT (NMFS 1998) to designate threatened/endangered status based upon a population estimate threshold. Although DPS designations warrant considerations in addition to abundance, the SRR was lacking a deliberate treatment on rationale for the new approach and a clear decision framework for using available evidence (population scores, threat scores, population viability analysis) in developing designations thresholds. The procedure followed a recent approach used for Atlantic sturgeon for which there occurs no population abundance estimates. This is not the case for SNS where several populations have supported recent abundance estimates. A previous NOAA criterion, 10,000 (NOAA 1996) has clearly been exceeded for several populations yet there is no discussion about why this previous threshold is no longer under consideration. Interestingly the population viability analysis would support the view that a population <10,000 is at risk for extinction, while one > 10,000 is not.

Recommendations

- The SRT should provide clearer rationale and guidance for designating endangered, threatened, and recovered status based upon best available science. If designating a recovered population threshold is not part of the SRT's charge, this needs to be stated in the Executive Summary and elsewhere. If it is part of the SRT's charge, then establishing this threshold seems critically important.
- An abundance threshold should be produced for designating status of DPSs. Despite evidence of connectivity among populations, SNS exist in principally closed populations leading to tractable abundance assessments. The interim 10,000 threshold merited review and received none in the SRR. The SNS Recovery Plan gave highest priority to this activity (NMFS 1998).
- Absent an abundance threshold, much greater weight should be given to abundance and population viability analysis in DPS status designations.

- The Hudson River population should be designated as fully recovered. No substantial evidence or rationale was produced to indicate that this population had a 50% chance of endangerment in the next 25 years. Indeed, the population viability analysis showed that the current Hudson River population was resilient to environmental threats and catastrophic events. Other considerations such as connectivity to other populations merit consideration, but these were not provided specific to the Hudson River population or to the decision framework for designating DPS status.
- The Delaware DPS should be designated as threatened rather than endangered. Again, considerations of the Delaware population's connectivity with the Chesapeake Bay ecosystem merit considerations, but were not articulated in the rationale or procedure for designated the DPS status.

6.3. Research and Recovery Planning Summary and Recommendations

Research recommendations are presented for each River Summary and for the past SNS Recovery Plan (NMFS 19998). The SRT did not attempt a synthesis of research recommendations across populations or DPSs. Recent research has been guided by the recovery plan (NMFS 1998) but mostly has relied on individual scientist-driven inquiry, with little integration with other SNS science or recovery actions.

The discovery that colonization can occur between systems deserves priority in evaluating whether natural colonization can restore depleted and extirpated populations. The degree of population interchange is also important to any future modifications of the proposed DPS structure. Monitoring programs for viable populations are essential. These need not occur at annual intervals, but are required to take place at some regular interval (every 10 years?) to evaluate DPS status. Research directed at improving demographic inputs (verified ageing procedures, improved estimates of reproductive schedule) merits priority in establishing recovery benchmarks and assessing population status.

The history of status review and recovery planning shows poor performance for this species related to delayed coordination and prioritization of monitoring, research, and assessment activities. Although funding is inadequate, there is a credible argument that the past ESA paradigm, which emphasizes protection over recovery is also limiting. A model that is increasingly used for endangered species emphasizes (1) a strong conceptual model for recovery, (2) focused research questions that address that model, (3) monitoring geared towards assessment of recovery performance indicators, and (4) adaptive management that permits changes to the underlying model and population status (e.g., NRC 2004; see also Maine Atlantic Salmon Commission Report: http://www.maine.gov/asc/pdf/ATS-2015-9-05.pdf). Current inadequacies in planning, research, monitoring, and assessment cannot support this model for SNS restoration.

Recommendations

- Two cross-cutting research priorities across DPS systems that deserve immediate attention are (1) analysis of population structure and connectivity and (2) monitoring and assessment of viable populations.
- An important next step will be to institute DPS teams that strategically develop recovery goals, monitoring and research needs and long-term assessment plans in an adaptive management framework.

- A new regulatory structure should be considered that better addresses recovery goals for SNS. Federal-state partnerships, such as the Maine Atlantic Salmon Commission, and the NFMS-USFWS-Gulf States Marine Fisheries Commission that manages recovery of Gulf sturgeon are advantageous and can provide structure, expertise, and resources beyond what NMFS alone can provide. Such partnerships develop strategic recovery plans, promote regular assessment activities, and facilitate adaptive responses to actions and research, which has not been accomplished for SNS under the current regulatory framework.

7. Appendices

7.1. References used in this Review (not in SRR)

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7.2. Statement of Work

Statement of Work for Dr. David Secor

External Independent Peer Review by the Center for Independent Experts

Shortnose Sturgeon Status Review Report

Project Background:

The subject of this peer review is a status review report for shortnose sturgeon (*Acipenser brevirostrum*) that is being prepared for the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) by a team of Federal and state biologists.

NMFS has Endangered Species Act (ESA) jurisdiction of species listed at 50 CFR 223.102 and 224.101. The U.S. Fish and Wildlife Service (USFWS) adds species under NMFS jurisdiction to its official list (List), published at 50 CFR 17.11 (for animals) and 17.12 (for plants). Shortnose sturgeon was listed as an "endangered species threatened with extinction" under the Endangered Species Preservation Act on March 11, 1967. Shortnose sturgeon as a species remained on the endangered species list with the enactment of the ESA.

NMFS initiated this shortnose sturgeon status review in July 2007 to update the biological information on the status of the species. The status review will compile and analyze the best available information on the status of and threats to the species; it will also consider if shortnose sturgeon should be identified and assessed as Distinct Population Segments (DPSs) (see 61 FR 4722; February 1, 1996).

If it is determined that the species meets the requirements to be divided into DPSs, NMFS in turn considers each DPS independently for listing consideration under the ESA. That is, each DPS is reviewed and may or may not be proposed for listing under the ESA as threatened or endangered. It is not uncommon for the various DPSs to be listed differently (i.e., one DPS may be listed as endangered; another as threatened). Listing or reclassifying each DPS separately allows NMFS to protect and conserve species and the ecosystems upon which they depend before large-scale decline occurs; it may also allow for more timely and less costly protection and recovery on a smaller scale.

As part of the status review, NMFS assembled a Status Review Team (SRT) consisting of Federal and state biologists to compile and review the best available commercial and scientific information on shortnose sturgeon and to present its factual findings to NMFS Service in a Status Review Report. The SRT was to compile the best available information rather than re-analyze or conduct new analyses or modeling. The SRT also summarizes ongoing protective efforts in the Status Review Report, to determine to what degree these protective measures abate risks to the shortnose sturgeon.

The scientific and commercial information presented in the status review report should contain essential factual elements upon which NMFS can base our ESA listing determination (endangered, threatened or not warranted). NMFS is required to use the best available scientific and commercial data in making determinations and decisions under the ESA. As such, it is critical that the status review contain the best available information relevant to the status of, and factors and threats affecting, shortnose sturgeon and that all scientific findings are both reasonable, and supported by valid information contained in the document. Accordingly, NMFS requires a peer review that focuses on the factual information and scientific validity of the status review report along with the application and interpretation of the available data in making conclusions and recommendations found in the Status Review Report.

Overview of CIE Peer Review Process:

NMFS Office of Science and Technology (OST) coordinates and manages a contract for obtaining external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of stock assessments and various scientific research projects. The primary objective of the CIE peer review is to provide an impartial review, evaluation, and recommendations in accordance to the Statement of Work (SoW), including the Terms of Reference (ToR) herein, to ensure the best available science is utilized for the National Marine Fisheries Service management decisions.

The OST serves as the liaison with the NMFS Project Contact to establish the SoW which includes the expertise requirements, ToR, statement of tasks for the CIE reviewers, and description of deliverable milestones with dates. The CIE, comprised of a Coordination Team and Steering Committee, reviews the SoW to ensure it meets the CIE standards and selects the most qualified CIE reviewers according to the expertise requirements in the SoW. The CIE selection process also requires that CIE reviewers can conduct an impartial and unbiased peer review without the influence from government managers, the fishing industry, or any other interest group resulting in conflict of interest concerns. Each CIE reviewer is required by the CIE selection process to complete a Lack of Conflict of Interest Statement ensuring no advocacy or funding concerns exist that may adversely affect the perception of impartiality of the CIE peer review. The CIE reviewers conduct the peer review, often participating as a member in a panel review or as a desk review, in accordance with the ToR producing a CIE independent peer review report as a deliverable. At times, the ToR may require a CIE reviewer to produce a CIE summary report. The Office of Science and Technology serves as the COTR for the CIE contract with the responsibilities to review and approve the deliverables for compliance with the SoW and ToR. When the deliverables are approved by the COTR, the Office of Science and Technology has the responsibility for the distribution of the CIE reports to the Project Contact. Further details on the CIE Peer Review Process are provided at http://www.rsmas.miami.edu/groups/cie/cieprocess.htm

Requirements for CIE Reviewers:

CIE shall provide four CIE reviewers to conduct a desk peer review (i.e., without travel requirement) of the Shortnose Sturgeon Status Review Report to ensure that its contents can be factually supported and that the methodology and conclusions are scientifically valid. Although there shall be four CIE reviewers in total, the composition of the reviewers may be divided between reviewers with expertise in shortnose sturgeon and reviewers with expertise in other sturgeon species or sturgeons in general. Specifically, it is strongly preferred that as many as two of the four CIE reviewers shall have the combined expertise specific to shortnose sturgeon to conduct the scientific peer review in the following categories;

1. Life history and population dynamics of shortnose sturgeon
2. Shortnose sturgeon genetic, physiological, behavioral, and/or morphological variation throughout the species' range;
3. Habitat requirements of shortnose sturgeon;
4. Predation and disease affecting shortnose sturgeon;
5. Regulatory mechanisms for managing the species;
6. Other natural or man-made impacts affecting shortnose sturgeon;
7. Propagation of shortnose sturgeon; and
8. Conservation actions including restoration efforts and recovery activities for shortnose sturgeon.

Additionally, if specific expertise in shortnose sturgeon cannot be obtained, all four of the CIE reviewers may have more broad expertise in other sturgeon species or sturgeons in general. These reviewers shall have the combined expertise to conduct the scientific peer review in the following categories;

1. Life history and population dynamics of sturgeon species;
2. An understanding of sturgeon genetics, physiology, and behavior;
3. Sturgeon habitat requirements;
4. Predation and diseases affecting sturgeon species;
5. Regulatory mechanisms for managing sturgeon species;
6. Other natural or man-made impacts affecting sturgeons;
7. Sturgeon propagation; and
8. Conservation actions including restoration efforts and recovery activities that have benefited sturgeon species.

Familiarity with ESA is also highly desirable. Each reviewer will be supplied with the Status Review Report prepared by the SRT. Any of the reports and papers cited in the Status Review Report will be made available to the reviewers upon their request.

Each reviewer's duties shall not exceed a maximum of seven work days. Each reviewer shall analyze the Status Review Report and develop a detailed report in response to the ToR (see Annex I). The reviewers shall conduct their analyses and writing duties from their primary locations. Each written report is to be based on the individual reviewer's findings. See Annex II for details on the report outline.

The CIE reviewers shall have the requested expertise necessary to complete an impartial peer review and produce the deliverables in accordance with the SoW and ToR as stated herein (refer to the ToR in Annex 1).

Statement of Tasks for CIE Reviewers:

The CIE reviewers shall conduct necessary preparations prior to the peer review, conduct the peer review, and complete the deliverables in accordance with the ToR and milestone dates as specified in the Schedule section.

<u>Prior to the Peer Review</u>: The CIE shall provide the CIE reviewers contact information (name, affiliation, address, email, and phone) to the Office of Science and Technology COTR no later

than the date as specified in the SoW, and this information will be forwarded to the Project Contact.

Pre-review Documents: Approximately two weeks before the peer review, the Project Contact will send the CIE reviewers the necessary documents for the peer review, including supplementary documents for background information. The CIE reviewers shall read the pre-review documents in preparation for the peer review.

- A copy of the Shortnose Sturgeon Status Review Report, the document to be reviewed. The draft citation follows:

  Shortnose Sturgeon Status Review Team. 2008. Status Review of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. [Date completed]. [xxx] pp.

- Access to an electronic copy of most reference documents cited in the Shortnose Sturgeon Status Review Report.

- Electronic access to the Endangered Species Act text at: http://www.nmfs.noaa.gov/pr/laws/esa/text.htm

- Electronic access to "Recognition of Distinct Vertebrate Population Segments (DPS) Under the Endangered Species Act (FWS and NMFS) (61 FR 4722; February 7, 1996)" at: http://www.nmfs.noaa.gov/pr/pdfs/fr/fr61-4722.pdf

This list of pre-review documents may be updated up to two weeks before the peer review. Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process. Furthermore, the CIE reviewers are responsible for only the pre-review documents that are delivered to them in accordance to the SoW scheduled deadlines specified herein.

Desk Peer Review:

The reviewers shall conduct their analyses and writing duties from their primary locations as a "desk" review. Each written report is to be based on the individual reviewer's findings and no consensus report shall be accepted.

The primary role of the CIE reviewer is to conduct an impartial peer review in accordance to the Terms of Reference (ToR) herein, to ensure the best available science is utilized for the National Marine Fisheries Service (NMFS) management decisions (refer to the ToR in Annex 1).

Terms of Reference: The Terms of Reference (ToR) for the CIE peer review are attached to the SoW as Annex 1. Up to two weeks before the peer review, the ToR may be updated with minor modifications as long as the role and ability of the CIE reviewers to complete the SoW deliverable in accordance with the ToR are not adversely impacted.

Please see Annex 1 attached.

Independent CIE Peer Review Reports:

The primary deliverable of the SoW is each CIE reviewer shall complete and submit an independent CIE peer review report in accordance with the ToR, and this report shall be formatted as specified in the attached Annex 2.

Schedule of Milestones and Deliverables:

The CIE review and milestones shall be conducted in accordance with the dates below;
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13 October 2008	CIE provides COTR with the CIE reviewer contact information, which will then be sent to the Project Contact
12 December 2008	Project Contact will send the CIE Reviewers the pre-review documents
2-16 January 2009	Each reviewer shall conduct an independent peer review
23 January 2009	CIE shall submit draft CIE independent peer review reports to the COTRs
7 February 2009	CIE will submit final CIE independent peer review reports to the COTRs
14 February 2009	The COTRs will distribute the final CIE reports to the Project Contact

Acceptance of Deliverables:

Each CIE reviewer shall complete and submit an independent CIE peer review report in accordance with the ToR, which shall be formatted as specified in Annex 2. The report shall be sent to Manoj Shivlani, CIE lead coordinator, via shivlanim@bellsouth.net and to Dr. David Sampson, CIE regional coordinator, via david.sampson@oregonstate.edu . Upon review and acceptance of the CIE reports by the CIE, the CIE shall send via e-mail the CIE reports to the COTR (William Michaels William.Michaels@noaa.gov) at the NMFS Office of Science and Technology by the date in the Schedule of Milestones and Deliverables. The COTRs will review the CIE reports to ensure compliance with the SoW and ToR herein, and have the responsibility of approval and acceptance of the deliverables. Upon notification of acceptance, CIE shall send via e-mail the final CIE report in *.PDF format to the COTRs. The COTRs at the Office of Science and Technology have the responsibility for the distribution of the final CIE reports to the Project Contacts.

Key Personnel:

Contracting Officer's Technical Representative (COTR):

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Request for Changes:

Requests for changes shall be submitted to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the Contractor within 10 working days after receipt of all required information of the decision on substitutions. The contract will be modified to reflect any approved changes. The Terms of Reference (ToR) and list of pre-review documents herein may be updated without contract modification as long as the role and ability of the CIE reviewers to complete the SoW deliverable in accordance with the ToR are not adversely impacted.

ANNEX 1:

Terms of Reference

CIE peer review of the Shortnose Sturgeon Status Review Report

Evaluate the adequacy, appropriateness and application of data used in the Shortnose Sturgeon Status Review Report.

1. In general, does the Status Review Report include and cite the best scientific and commercial information available on the species and its habitats, including threats to the species and to its habitat?
2. Where available, are opposing scientific studies or theories acknowledged and discussed?
3. Are the scientific conclusions sound and derived logically from the results?

Evaluate the recommendations made in the Shortnose Sturgeon Status Review Report.

1. Concerning distinct population segments, is the species delineation supported by the information presented and currently available?
2. Are the results of the Extinction Risk Analysis supported by the information presented?
3. Review the research recommendations made in the Status Review Report and make any additional recommendations, if warranted.

ANNEX 2

Format and Contents of CIE Independent Reports

The report should follow the outline given below. It should be prefaced with an Executive Summary that is a concise synopsis of goals for the peer review, findings, conclusions, and recommendations. The main body of the report should provide an introduction that includes a background on the purpose of the review, the terms of reference and a description of the activities the reviewer took while conducting the review. Next, the report should include a summary of findings made in the peer review followed by a section of conclusions and recommendations based on the terms of reference. Lastly the report should include appendices of information used in the review (see outline for more details).

1. Executive Summary
    a. Impetus and goals for the review
    b. Main conclusions and recommendations
    c. Interpretation of the findings with respect to conclusions and management advice

2. Introduction
    a. Background
    b. Terms of Reference
    c. Description of activities in the review

3. Review of Information used in the Status Review Report (as outlined in the table of contents in the Status Review Report)

4. Review of the Findings made in the Status Review Report
    a. DPS considerations
    b. Extinction Risk Analysis
    c. Evaluation of Non-regulatory Conservation Measure
    d. Research Recommendations

5. Summary of findings made by the CIE peer reviewer

6. Conclusions and Recommendations (based on the Terms of Reference in Annex I)

7. Appendices
    a. Bibliography of all material provided
    b. Statement of Work
    c. Other