

Centre of Independent Experts review of the
Internal Draft Recovery Plan
Southern Distinct Population Segment
North American Green Sturgeon
Acipenser medirostris

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Executive Summary

The internal draft recovery plan for the southern distinct population segment (sDPS) of the North American green sturgeon (*Acipenser medirostrus*) provides background on its status, biology, distribution, critical habitat, abundance and trends, threats, conservation efforts and known biological constraints and needs. The goal of this recovery plan is to restore sDPS green sturgeon to a level sufficient to warrant its removal from the Federal List of Endangered and Threatened Wildlife (50 CFR §17.11). The plan presents, recovery goals, and criteria as well as a recovery strategy as outlined in NMFS Interim Recovery Guidance and mandates described in section 4(f)(1)(b) of ESA. They reviewed much of the known information on the green sturgeon from the sDPS. They used published literature, unpublished literature and information to develop their recovery goals and strategy.

Since little is known about green sturgeon at this time and in particular about the sDPS, the recovery team decided to develop interim demographic criteria for recovery and by definition did not give NMFS the ultimate targets for delisting. This is wise, as demographic criteria cannot be developed without the appropriate background information, which at this time does not exist.

Threats to this species were outlined in general and then specific threat matrices were developed for each of the four habitat units that the sDPS green sturgeon occurs: the Sacramento watershed, the San Francisco Delta and estuary, coastal bays and estuaries, and nearshore marine. To support the primary objective of eliminating or abating the greatest threats in the four geographic habitat units, they proposed to develop the four supporting programs of research, monitoring, outreach and funding.

It is clear that current information on population dynamics, distribution, movement and factors leading to reproductive success are not adequate to assess the status or recovery of this species in the sDPS. After lack of knowledge, the most important threats identified by the recovery team were to sDPS population viability were: 1) habitat destruction, modification or curtailment (e.g. barriers to migration, sedimentation, etc.), 2) overutilization for recreational, commercial, scientific, or educational purposes (take and reduced genetic diversity), 3) disease and predation, and 4) other natural or man-made factors (competition for habitat or take).

This recovery plan has the potential to be one of the most important documents on green sturgeon. It will lay the foundation for research, mitigation of anthropogenic effects, and conservation that will hopefully lead to the recovery of this important species to the west coast. Clearly, this is a work-in-progress and was evaluated as such. While I did highlight some areas of concern, this document is an excellent platform for further development of the recovery plan for sDPS green sturgeon and for green sturgeon throughout its entire range.

Specifically, I would recommend that Phase 1 becomes the main focus of this document with all of the costs and activities outlined in detail so that the recovery team has the greatest chance of better defining the criteria and the best strategy for recovery in Phases 2-4.

Introduction

The primary objective of the CIE review of the “Internal Draft Recovery Plan Southern Distinct Population Segment North American Green Sturgeon (*Acipenser medirostris*)”, as contracted by the NMFS Office of Science and Technology, is to provide an impartial review, evaluation and recommendation(s) to ensure that the best available science is utilized in NMFS management decisions. Further, it is to ensure that the contents of the draft plan are factually supported, the methodology is sound and the conclusions are scientifically valid. The report is a 95 page document consisting of text, figures, tables, an additional 80 pages of Appendices and an excel worksheet identifying the recovery action, category, activity and implementation schedule.

Background

The sDPS of green sturgeon was listed as a threatened species under the Endangered Species Act effective April 7, 2006 (71 FR 17757) and will likely be elevated to endangered status through all of its range in the sDPS. The goal of this recovery plan is to restore sDPS green sturgeon to a level sufficient to warrant its removal from the Federal List of Endangered and Threatened Wildlife (50 CFR §17.11). The scope for the recovery team was broad. They reviewed much of the current information relevant to the development of the recovery plan for green sturgeon from the sDPS. They used this information to develop a draft of the objectives, criteria, strategy and program for the recovery of sDPS of green sturgeon in California. Threats were discussed and then more specifically outlined in the Appendices A-E and the implementation schedule was described in Appendix F.

Importance of the recovery plan is clear

It is very concerning that estimates based on genetic work (Israel and May 2010) suggested that between 10-28 adults successfully spawned in the river each year between 2002 and 2006, and 175-250 adults were counted on the spawning site using a Didson visual census approach. Both estimates suggest the importance of this recovery plan and the focus on spawning in the Sacramento River system.

Terms of Reference for this peer review

1. Do the basic elements of the draft recovery plan meet the minimum standards for recovery plans outlined in the NMFS Interim Recovery Guidance and mandates described in section 4(f)(1)(b) of ESA?
2. Is there a logical and consistent flow between the goal, objectives, criteria, and actions?
3. Does the plan incorporate the best scientific information available?
4. Does the plan address data gaps appropriately in relation to the formulation of recovery criteria and research actions (e.g. lack of information on contaminants to develop threats-based recovery criteria)?

5. Does the data provided by Mora et al. 2009 provide NMFS the best means for evaluating current and future habitat potential and the development of criteria to restore historical green sturgeon habitat within California's Central Valley?
6. Does the plan provide clear guidance for the public, conservationists, managers, regulators, and others to act in a relevant manner over the next several decades to facilitate recovery of sDPS green sturgeon?
7. Recommendations for improvements?

Description of the Individual Reviewer's Role in the Review Activities

I received access to the report on November 4, 2012. I reviewed the report over the last few weeks of November and the first week of December, spending 10 days on the review during this period. I reviewed the recovery plan in the context of the materials supplied and in the context of the available literature on green and other sturgeons.

Bibliography of material supplied.

- National Marine Fisheries Service. 2012. Recovery Plan for the Southern Distinct Population Segment of the Green Sturgeon (*Acipenser medirostris*). National Marine Fisheries Service, Santa Rosa, CA.
- National Marine Fisheries Service 2006 (2010 Update). Interim Recovery Planning Guidance (<http://www.nmfs.noaa.gov/pr/pdfs/recovery/guidance.pdf>)
- Endangered Species Act (<http://www.nmfs.noaa.gov/pr/pdfs/laws/esa.pdf>)
- Mora, E.A., S.T. Lindley, D.L. Erickson, and A.P. Klimley. 2009. Do impassable dams and flow regulation constrain the distribution of green sturgeon in the Sacramento River, California? *Journal of Applied Ichthyology* 25:39-47.

Summary of Findings for each ToR (1-7)

1. Do the basic elements of the draft recovery plan meet the minimum standards for recovery plans outlined in the NMFS Interim Recovery Guidance and mandates described in section 4(f)(1)(b) of ESA?

4(f)(1)(B) - Each plan must include, **to the maximum extent** practicable, "(i) a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species; (ii) objective, measurable criteria which, when met, would result in a determination . . . that the species be removed from the list; and, (iii) estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal."

"The sDPS green sturgeon recovery planning team attempted to develop quantitative-based demographic and threat-based objective and measurable recovery criteria, but has concluded that sufficient information is not currently available. Although this plan establishes quantitative recovery criteria specific to population demographics, NMFS has concluded that it is not practicable at this time to establish final demographic criteria and quantitative threat-based recovery criteria for delisting of sDPS green sturgeon. The interim recovery criteria focus on achieving population levels consistent with their probability to avoid listing to endangered, rather

than delisting. Interim criteria are also intended to immediately halt the decline of the species and demonstrate a persistent increase in population abundance such that the overall probability of long-term survival is increased.”

I completely agree with their assessment of what are realistic criteria based on the available science and their choice of development of “**interim demographic recovery criteria**” rather than final criteria. I would even suggest that they focus most of their efforts on fully developing Phase 1 of the recovery plan, providing as much detail on actions and costs that will be associated with this most important Phase of the recovery plan.

As requested, I have evaluated sections of 4(f)(1)(B) below:

- i. This plan does attempt to describe site-specific management actions to achieve the goal of the conservation and survival of the green sturgeon in the sDPS.
- ii. No, they have not developed an approach (see comments and justification above) that will yield objective, measureable recovery criteria which would allow the status to be assessed and the green sturgeon removed from the list. I also have a question about the criterion developed in D1— since male and female green sturgeon require 15 and 17 years to reach first spawning, respectively, is a 10 year window an appropriate span to make an evaluation in the change in status? Although it might be impractical, and there is a good chance that requiring any 8 out of a set of 10 year periods will take 17 years to achieve, it would be more reassuring if this period were to include a complete closure to the life cycle. I.e., that fish that hatched at year 1 were recruited to the population and engaged in successful reproduction (D2). I also agree with their assertion that research needs to be conducted on what are “sufficient” and “viable” numbers associated with Criteria D3-6.
- iii. No costs have been developed and therefore it is difficult to evaluate time estimates. The recovery team identified 3 five year phases for the recovery plan. However, until the costs are developed, time estimates are not really helpful at this point. My suggestion is to focus efforts on details for phase 1 and then reassess phase 2 and 3 in year 4 of phase 1.

2. Is there a logical and consistent flow between the goal, objectives, criteria, and actions?

Yes there is a consistent flow between goal, objectives and actions. Since this is an early draft of the recovery plan it is difficult for the recovery team to define many of the actions in detail.

3. Does the plan incorporate the best scientific information available?

Mostly; however, there are other papers that have not been cited and new ones that can be now cited in this document. I realize that many of them deal with green sturgeon from the nDPS, however, their inclusion in this report would be worthwhile. The Mora et al. (2009) paper (TOR 5) was included in this recovery plan and it used nDPS data to assess habitat availability in the Sacramento River system. I am also sure that the recent papers published will be included in the next draft as some of the authors of these papers are on the green sturgeon recovery team. Please see the list of papers in the “Other Pertinent Information and Considerations Section” below.

4. Does the plan address data gaps appropriately in relation to the formulation of recovery criteria and research actions (e.g. lack of information on contaminants to develop threats-based recovery criteria)?

Yes. The recovery team acknowledges the lack of information throughout the draft. It is very clear the biggest threat to this species is lack of information in terms of ecology and anthropogenic impacts. My biggest concern here is the lack of reporting pertinent material in this recovery plan weakens the request for funds to fill knowledge gaps (see 3) and provides a target for interest groups that would not like to see this recovery plan exercised to its fullest. Additionally, even with all of the literature included, very little is known about the green sturgeon and in particular green sturgeon from the sDPS. Clearly research is an immediate priority and a clear plan should be developed for this action.

5. Does the data provided by Mora et al. (2009) provide NMFS the best means for evaluating current and future habitat potential and the development of criteria to restore historical green sturgeon habitat within California's Central Valley.

No it does not. This is a really good paper that uses information from the Klamath and Rogue nDPS green sturgeon rivers to predict green sturgeon utilization in sDPS river systems. However, there are quite a few shortcomings in this paper that the authors also acknowledge. Their paper only studies adults and by definition this is restricted to the period surrounding spawning. This leaves out the more vulnerable early life history stages (egg, larvae and juveniles) which inhabit the system year-round until they are old enough to migrate to sea. This is a huge gap. Another area of concern, and it is big, is the reliance on air temperatures as a proxy for water temperature. As they suggest, there will be a high probability that air temperature will not predict water temperature in this system because of the management of the reservoir operations. Additionally, recent work on the genetics of the nDPS and the sDPS suggest that these groups are distinct. This is an important point because the populations may utilize their natal rivers differently suggesting we interpret Mora et al. (2009) with caution. There are also dams on the Klamath and Rogue Rivers suggesting this may not in fact be the best data to predict pre-dam distribution in the Sacramento system. As suggested in the sDPS recovery plan, more work needs to be done within the California Central Valley to be able to generate better models to evaluate current and future habitat potential which can lead to the development of criteria that can be used to conserve and restore the sDPS green sturgeon. I would recommend that numerical habitat models for all life history stages for green sturgeon be constructed to affect this goal (e.g. Guay et al. 2000 CJFAS 57:2065-2075).

6. Does the plan provide clear guidance for the public, conservationists, managers, regulators, and others to act in a relevant manner over the next several decades to facilitate recovery of sDPS green sturgeon?

Yes and no. This is not the fault of the recovery team at all. It is a result of lack of information on this species and this species specific to the sDPS. The plan that they developed will become a platform, essentially a living document, which can be modified as more information becomes available. The terms of reference and the criterion they develop are excellent and will provide the

public with a general map of where things should head. However, there will have to be recognition, as the recovery team suggests that this is an interim recovery plan until more information becomes available and the plan can be finalized.

7. Recommendations for improvements?

I would recommend focusing on Phase 1 and fleshing it out in great detail with actions and costs developed. I am suggesting that the recovery team develops a complete, not an interim, Phase 1 of the recovery plan with a review and further development of Phase 2 in year 4 of Phase 1. This way the document will provide a more concrete guide on what needs to be done so that the information will be available to further develop the later phases of the recovery plan.

Transnational importance needs to be addressed.

Based on the fact that sDPS green sturgeon are found all the way to Alaska and spend time in Canadian waters, has there been an effort by the recovery team to involve DFO or Canadian scientists in this recovery plan? If not I would recommend this be added to the recovery plan (see below).

As indicated in the Interim Endangered and Threatened Species Recovery Planning Guidance Version 1.3 NMFS (2010) section 2.2.3 on Transnational and Transboundary Species in the Trilateral Agreement between Mexico, Canada and the US, Appendix D, Article III, that there will be involvement of all parties involved with the species in question. I was also under the impression that there is a bilateral agreement between NMFS and DFO that allows for coordination of recovery efforts. Should this be started at this time or at least mentioned? This is particularly important as we need to know the determinants of population dynamics of green sturgeon which are influenced by their migratory behaviour and reliance on habitat in other jurisdictions. This information will most likely play a role on recovery efforts in the sDPS. This is particularly important in light of Israel et al.'s (2010) suggestion that "genetic findings suggest that stock complexity in green sturgeon is pervasive and support precautionary, interjurisdictional approaches for managing green sturgeon beyond rigid, regulatory boundaries"

Science questions and suggestions

What is the extent of dredging in this system? I would be concerned from the perspective of the juveniles in this region. This would also feed into any work done on contaminants.

Are you concerned with the potential for endocrine disruption affecting green sturgeon, such as Feist et al. (2005; was cited in the references but not mentioned in the text) and other work? It was only mentioned in passing on line 1 page 32. Based on the listed industries on the Sacramento River I would anticipate that this may be a challenge to green sturgeon and is worthy of expansion in the recovery plan.

Does the water fluctuate enough near the spawning grounds to beach larvae? I realize that this may be trivial compared to the larvae lost from entrainment but I had to mention it as it is of concern in other sturgeon rivers.

For example:

Clarke, K. D., T. C. Pratt, R. G. Randall, D. A. Scruton, and K. E. Smokorowski. 2008. Validation of the flow management pathway: effects of altered flow on fish habitat and fishes downstream from a hydropower dam, Canadian Technical Report of Fisheries and Aquatic Sciences Report 2784.

Bell, E., S. Kramer, D. Zajanc, and J. Aspittle. 2008. Salmonid fry stranding mortality associated with daily water level fluctuations in trail bridge reservoir, Oregon. North American Journal of Fisheries Management 28:1515-1528.

I am a bit concerned about Recovery Criterion TC: "Disease and predation of sDPS green sturgeon has been eliminated or reduced such that the threats assessment results in medium or lower rankings for all threats identified under listing factor C." Predation is a natural and selective process and the way this is written suggests that it has to be eliminated. Is this the intent? I hope not. Maybe minimizing it through restoration of natural habitat with the associated heterogeneity would help but this conjures up images of manipulating predator abundance - which is often not ideal - it becomes a rather vicious cycle.

As suggested in the sDPS recovery plan, more work needs to be done within the California Central Valley to be able to generate better models to evaluate current and future habitat potential which can lead to the development of criteria that can be used to conserve and restore the sDPS green sturgeon. I would recommend that numerical habitat models (logistic, spatial autocorrelation ...) for all life history stages for green sturgeon be constructed to affect this goal (e.g. Guay et al. 2000 CJFAS 57:2065-2075; Rosenfeld 2003 TAFS 132(5):953-968; Gillenwater et al. 2006 Ecological Engineering 28(3):311-323; Wall et al. 2004 CJFAS 61(6):954-973; Diebel et al. 2010 CJFAS 67(1):165-176).

Minor points and suggestions

Although there is a nice acronym list on page 14, at the beginning of the document, it is not complete. For example, BMP and ACID are not defined anywhere in this document. There are many acronyms that are not defined in this plan. This needs to be fixed so that the document is accessible to the public.

Page 17 para 1. Snout is larger than green sturgeon.

Page 17 para 2. Season-to-season and year-to-year.

Page 17 para 3. I do not understand how nutritional studies on white sturgeon larvae suggest what green sturgeon larvae feed on. It is not clear here. Citation?

Page 21. Map inset -- Russian River and Feather River slightly off-shifted relative to other names.

Page 27 line 5. "not changes" should be changed to "no changes"

You could add another threat F-Lack of knowledge on this species.

Page 43 para 2. I assume VSP means viable sturgeon population? It is not defined here.

Page 46 line 9: is it NRTWS 2009 or 2006. This was done throughout.

Page 53 line 5. Need to insert the reference here (reference).

I am confused with comment on page 52: “In addition to having a marine-oriented life history and long life span, sDPS green sturgeon have persisted over the millennia because they exhibit a slow growth rate, low annual juvenile survival, and late sexual maturity, relative to most other anadromous fish species.” It does not make sense that they persisted because of these attributes, particularly, their low annual juvenile survival. How do these attributes make them more persistent? If anything it makes them more vulnerable to extinction.

Do you need a title for the matrix on page 55?

Page 75 SFBDE.A.2.3.1 sounds are affecting.

Page 75 line 15. Missing parenthesis after 2008)

Page 76 line 7 delete extra period after resources..

Page 76 line 11 delete extra space after 1999).

Page 78 SFBDE.A.5.1.3. the case of the first two Restores should be changed to lower case in this section.

Page 80 line 4. The document should be consistent in not capitalizing green sturgeon, and it should be changed to lower case here and elsewhere. There is also a constant switching back and forth between GS and green sturgeon. It is best to use one and be consistent.

Page 84. Recovery Objective 3 and 4 are very important and do need development.

Page 84 RP.1.1.1 The “C” in criteria should be capitalized to be consistent throughout this section.

Page 85 RP.1.1.6. is covered in R.P. 1.1.3, so this should be deleted or the section should be removed from 1.1.3.

Page 85 Finish RP.4.1.2. “...”

Page 86 line 12. Change diversity; 1. genetic to – 1) genetic to be consistent with point 2).

Page 86 EOP.1.1 The word “man” should be changed to people.

The authors need to go over the references. Many references cited in the text were not listed in

the references section and some in the references section were not cited in the text.

For example--

Bakke et al. 2010; Crosier et al. 2006; Dryer 1993; Duke et al. 1999; EPIC 2001; Falconer 1981; Farr and Kern 2005; Feist 2005; Gadomski and Parsley 2005 (also out of order); Heppel 2007; Herry et al. 2009 (also out of order); Herren and Kawasaki 2001; Jager 2001; Kogut 2008; MacArthur and Wilson 1967; NMFS 2007b; there are two NMFS 2008 in the references one should be a and the other b?; PFMC 2011; what is ODFW 2005b – Dan Erickson reference?; Pacific Fisheries Information Network 2011; Paragamian and Hansen 2008; Reedsport 2008 (also in the wrong order); Ryman and Liarke 1991; Silvestre et al. 2010.

Others listed in text but not in references:

E.g. Israel and May 2010.

Other pertinent information and considerations

I realize that this is a work in progress and has taken some time to develop and this is most likely reflected in some information about the green sturgeon biology and ecology not making it into this document. However, arguments for more research to fill gaps are weakened if there is an incomplete review of the existing information. I have added some papers that are relevant to the development of this recovery plan which I hope will provide a more complete picture of what research has been done on the following topics that may be of use to the further development of this plan.

Reference List

Physiology

- Allen, P. J., Nicholl, M., Cole, S., Vlazny, A., and Cech, J. J. 2006. Growth of Larval to Juvenile Green Sturgeon in Elevated Temperature Regimes. *Transactions of the American Fisheries Society* 135: 89-96.
- Gisbert, E., Cech, J. J., and Doroshov, S. I. 2001. Routine Metabolism of Larval Green Sturgeon (*Acipenser Medirostris* Ayres). *Fish Physiology and Biochemistry* 25: 195-200.
- Gisbert, E. and Doroshov, S. I. 2003. Histology of the Developing Digestive System and the Effect of Food Deprivation in Larval Green Sturgeon (*Acipenser Medirostris*). *Aquatic Living Resources* 16: 77-89.
- Kaufman Robert C., Houck, A. N. N. G., and Cech Joseph J., Jr. 2007. Effects of Temperature and Carbon Dioxide on Green Sturgeon Blood - Oxygen Equilibria. *Environmental Biology of Fishes* 79: 201-210.
- Kaufman Robert C., Houck, A. N. N. G., and Cech Joseph J., Jr. 2006. Effects of Temperature and Carbon Dioxide on Green Sturgeon Blood-Oxygen Equilibria. *Environmental Biology of Fishes* 76: 119-127.
- Lankford, S. E., Adams, T. E., and Cech, J. J. 2003. Time of Day and Water Temperature Modify the Physiological Stress Response in Green Sturgeon, *Acipenser Medirostris*.

- Comparative Biochemistry and Physiology a-Molecular & Integrative Physiology 135: 291-302.
- Mayfield, R. B. and Cech, J. J. 2004. Temperature Effects on Green Sturgeon Bioenergetics. Transactions of the American Fisheries Society 133: 961-970.
- Sardella Brian A. and Kueltz Dietmar. 2009. Osmo- and Ionoregulatory Responses of Green Sturgeon (*Acipenser Medirostris*) to Salinity Acclimation. Journal of Comparative Physiology B-Biochemical Systemic and Environmental Physiology 179: 383-390.
- Sardella Brian A., Sanmarti Enio, and Kultz Dietmar. 2008. The Acute Temperature Tolerance of Green Sturgeon (*Acipenser Medirostris*) and the Effect of Environmental Salinity. Journal of Experimental Zoology Part a-Ecological Genetics and Physiology 309A: 477-483.
- Sillman, A. J., Beach, A. K., Dahlin, D. A., and Loew, E. R. 2005. Photoreceptors and Visual Pigments in the Retina of the Fully Anadromous Green Sturgeon (*Acipenser Medirostris*) and the Potamodromous Pallid Sturgeon (*Scaphirhynchus Albus*). Journal of Comparative Physiology a-Neuroethology Sensory Neural and Behavioral Physiology 191: 799-811.
- Werner Inge, Linares-Casenave Javier, Van Eenennaam Joel P., and Doroshov Serge I. 2007. The Effect of Temperature Stress on Development and Heat-Shock Protein Expression in Larval Green Sturgeon (*Acipenser Medirostris*). Environmental Biology of Fishes 79: 191-200.

Distribution, Movement and Behaviour

- Allen Peter J., Hobbs James A., Cech Joseph J., Jr., Van Eenennaam Joel P., and Doroshov Serge I. 2009. Using Trace Elements in Pectoral Fin Rays to Assess Life History Movements in Sturgeon: Estimating Age at Initial Seawater Entry in Klamath River Green Sturgeon. Transactions of the American Fisheries Society 138: 240-250.
- Allen Peter J., Mckenroe Maryann, Forostyan Tetyana, Cole Stephanie, Nicholl Mary M., Hodge Brian, and Cech Joseph J., Jr. 2011. Ontogeny of Salinity Tolerance and Evidence for Seawater-Entry Preparation in Juvenile Green Sturgeon, *Acipenser Medirostris*. Journal of Comparative Physiology B-Biochemical Systemic and Environmental Physiology 181: 1045-1062.
- Benson Ryan L., Turo Scott, and Mccovey Barry W., Jr. 2007. Migration and Movement Patterns of Green Sturgeon (*Acipenser Medirostris*) in the Klamath and Trinity Rivers, California, Usa. Environmental Biology of Fishes 79: 269-279.
- Erickson Daniel L. and Webb Molly A. H. 2007. Spawning Periodicity, Spawning Migration, and Size at Maturity of Green Sturgeon, *Acipenser Medirostris*, in the Rogue River, Oregon. Environmental Biology of Fishes 79: 255-268.
- Grans, A., Axelsson, M., Pitsillides, K., Olsson, C., Hojesjo, J., Kaufman, R. C., and Cech, J. J., Jr. 2009. A Fully Implantable Multi-Channel Biotelemetry System for Measurement of Blood Flow and Temperature: a First Evaluation in the Green Sturgeon. Hydrobiologia 619: 11-25.
- Huff David D., Lindley Steven T., Rankin Polly S., and Mora Ethan A. 2011. Green Sturgeon Physical Habitat Use in the Coastal Pacific Ocean. Plos One 6.
- Huff David D., Lindley Steven T., Rankin Polly S., and Mora Ethan a. 2011. Green Sturgeon Physical Habitat Use in the Coastal Pacific Ocean. Plos One 6: e25156.

- Huff David D., Lindley Steven T., Wells Brian K., and Chai, F. E. I. 2012. Green Sturgeon Distribution in the Pacific Ocean Estimated From Modeled Oceanographic Features and Migration Behavior. *Plos One* 7.
- Huff David D, Lindley Steven T, Wells Brian K, and Chai, F. E. I. 2012. Green Sturgeon Distribution in the Pacific Ocean Estimated From Modeled Oceanographic Features and Migration Behavior. *Plos One* 7: e45852.
- Kelly John T. and Klimley, A. Peter. 2012. Relating the Swimming Movements of Green Sturgeon to the Movement of Water Currents. *Environmental Biology of Fishes* 93: 151-167.
- Klimley, A. Peter, Allen Peter J., Israel Joshua A., and Kelly John T. 2007. The Green Sturgeon and Its Environment: Introduction. *Environmental Biology of Fishes* 79: 187-190.
- Klimley, A. Peter, Allen Peter J., Israel Joshua A., and Kelly John T. 2007. The Green Sturgeon and Its Environment: Past, Present, and Future. *Environmental Biology of Fishes* 79: 415-421.
- Kynard, B., Parker, E., and Parker, T. 2005. Behavior of Early Life Intervals of Klamath River Green Sturgeon, *Acipenser Medirostris*, With a Note on Body Color. *Environmental Biology of Fishes* 72: 85-97.
- Moser Mary L. and Lindley Steven T. 2007. Use of Washington Estuaries by Subadult and Adult Green Sturgeon. *Environmental Biology of Fishes* 79: 243-253.
- Nguyen Rosalee M. and Crocker Carlos E. 2007. The Effects of Substrate Composition on Foraging Behavior and Growth Rate of Larval Green Sturgeon, *Acipenser Medirostris*. *Environmental Biology of Fishes* 79: 231-241.
- Nguyen Rosalee M. and Crocker Carlos E. 2006. The Effects of Substrate Composition on Foraging Behavior and Growth Rate of Larval Green Sturgeon, *Acipenser Medirostris*. *Environmental Biology of Fishes* 76: 129-138.
- Webb Molly A. H. and Erickson Daniel L. 2007. Reproductive Structure of the Adult Green Sturgeon, *Acipenser Medirostris*, Population in the Rogue River, Oregon. *Environmental Biology of Fishes* 79: 305-314.

Genetics

- Anders, P. J., Drauch-Schreier, A., Rodzen, J., Powell, M. S., Narum, S., and Crossman, J. A. 2011. A Review of Genetic Evaluation Tools for Conservation and Management of North American Sturgeons: Roles, Benefits, and Limitations. *Journal of Applied Ichthyology* 27: 3-11.
- Boerk Karrigan, Drauch, A., Israel, J. A., Pedroia, J., Rodzen, J., and May, B. 2008. Development of New Microsatellite Primers for Green and White Sturgeon. *Conservation Genetics* 9: 973-979.
- Israel, J. A. and May, B. 2010. Indirect Genetic Estimates of Breeding Population Size in the Polyploid Green Sturgeon (*Acipenser Medirostris*). *Molecular Ecology* 19: 1058-1070.
- Israel Joshua A., Bando, K. Jun, Anderson Eric C., and May Bernie. 2009. Polyploid Microsatellite Data Reveal Stock Complexity Among Estuarine North American Green Sturgeon (*Acipenser Medirostris*). *Canadian Journal of Fisheries and Aquatic Sciences* 66: 1491-1504.
- Van Eenennaam, A. L., Murray, J. D., and Medrano, J. F. 1999. Karyotype of the American Green Sturgeon. *Transactions of the American Fisheries Society* 128: 175-177.

Welsh, A. B., Blumberg, M., and May, B. 2003. Identification of Microsatellite Loci in Lake Sturgeon, *Acipenser Fulvescens*, and Their Variability in Green Sturgeon, *a-Medirostris*. *Molecular Ecology Notes* 3: 47-55.

Morphology and Development

Artyukhin Evgenii N., Vecsei Paul, and Peterson Douglas L. 2007. Morphology and Ecology of Pacific Sturgeons. *Environmental Biology of Fishes* 79: 369-381.

Gisbert Enric and Doroshov Serge I. 2006. Allometric Growth in Green Sturgeon Larvae. *Journal of Applied Ichthyology* 22: 202-207.

North, J. A., Farr, R. A., and Vescei, P. 2002. A Comparison of Meristic and Morphometric Characters of Green Sturgeon *Acipenser Medirostris*. *Journal of Applied Ichthyology* 18: 234-239.

Xin, D., Van Eenennaam, J. P., and Doroshov, S. I. Comparison of Early Life Stages and Growth of Green and White Sturgeon. 28, 237-247. 2002. American Fisheries Society Symposium.

Anthropogenic Effects

Gessner Joern, Van Eenennaam Joel P., and Doroshov Serge I. 2007. North American Green and European Atlantic Sturgeon: Comparisons of Life Histories and Human Impacts. *Environmental Biology of Fishes* 79: 397-411.

Iguchi Taisen, Irie Fumi, Urushitani Hiroshi, Tooi Osamu, Kawashima Yukio, Roberts Mike, Norrgren Leif, and Hutchinson Thomas. 2006. Availability of in Vitro Vitellogenin Assay for Screening of Estrogenic and Anti-Estrogenic Activities of Environmental Chemicals. *Environmental Sciences : an International Journal of Environmental Physiology and Toxicology* 13: 161-83.

Lee Jang-Won, De Riu Nicola, Lee Seunghyung, Bai Sungchul C., Moniello Giuseppe, and Hung Silas S. O. 2011. Effects of Dietary Methylmercury on Growth Performance and Tissue Burden in Juvenile Green (*Acipenser Medirostris*) and White Sturgeon (*A. Transmontanus*). *Aquatic Toxicology* 105: 227-234.

Lee Jang-Won, Kim Jae-Won, De Riu Nicola, Moniello Giuseppe, and Hung Silas S. O. 2012. Histopathological Alterations of Juvenile Green (*Acipenser Medirostris*) and White Sturgeon (*Acipenser Transmontanus*) Exposed to Graded Levels of Dietary Methylmercury. *Aquatic Toxicology* 109: 90-99.

Aquaculture

Van Eenennaam, J. P., Linares-Casenave, J., and Doroshov, S. I. 2012. Tank Spawning of First Generation Domestic Green Sturgeon. *Journal of Applied Ichthyology* 28: 505-511.

Van Eenennaam Joel P., Linares-Casenave Javier, Muguet Jean-Benoit, and Doroshov Serge I. 2008. Induced Spawning, Artificial Fertilization, and Egg Incubation Techniques for Green Sturgeon. *North American Journal of Aquaculture* 70: 434-445.

Appendices

I do not see how the Miradi figures add anything to this document. The lines connect to all of the boxes. I think that the tables developed are sufficient and easier to read.

Why is the spreadsheet included as it is incomplete? Is this going to be included in the draft version available to the public? Wouldn't it be better to just do estimates for phase 1 years 1-5 then indicate that you will revisit the costs associated with Phases 2 and beyond?

Conclusions and Recommendations

This recovery plan has the potential to be one of the most important documents on green sturgeon. It will lay the foundation for research, mitigation of anthropogenic effects, and conservation that will hopefully lead to the recovery of this important species to the west coast. Clearly, this is a work-in-progress and was evaluated as such. While I did highlight some areas of concern, I am confident that this document will provide an excellent platform for further development of the recovery plan for sDPS green sturgeon and for green sturgeon throughout its entire range.

Although not central to the major objectives of this recovery plan for the green sturgeon sDPS, there are a number of studies that should have been incorporated into and/or acknowledged in this report (please see "other pertinent information and considerations" section).

It is clear that current information on population dynamics, distribution, movement and factors leading to reproductive success are not adequate to accurately assess the status of this species, which makes it extremely difficult to generate a recovery plan. It is also clear that more of the river system needs to return to its historical condition in order to protect this species. This is extremely difficult because of the tremendous number of stakeholders. I liked the fact that public outreach is an important part of this recovery plan, as this will be the vehicle for changes in attitudes for the various stakeholders; a very challenging but important objective. A return of the river to historical conditions, or at least amelioration of current impacts, would allow an increase in productivity, genetic diversity, and therefore promote recovery of the sDPS green sturgeon. Clearly river diversion and pollution from a host of sources plays the major role in the viability of this sDPS. In light of this, I would strongly recommend that more research on ecophysiology and ecotoxicology also be highlighted in the recovery plan which will allow better interpretation of results and the potential effects of river diversion and pollution on green sturgeon in the sDPS.

As indicated in the Interim Endangered and Threatened Species Recovery Planning Guidance Version 1.3 NMFS (2010) section 2.2.3 on Transnational and Transboundary Species, I recommend that the recovery plan include transnational aspects of this fish's habitat utilization requiring involvement of researchers and managers from both sides of the border.

I strongly recommend that effort be made to make the Phase 1 section of the proposal a finished and complete section with actions and costs outlined in detail for the research and other activities to be conducted. This is the most important phase of this recovery plan. Research in Phase 1 should examine the entire life history of green sturgeon and potential anthropogenic effects at each stage, from egg-to-egg, in order to generate models that are relevant to sDPS. Cost estimates of all of these activities should be determined and entered into Appendix F. This is of paramount importance. It will inform the future path for the recovery plan and allow the recovery team required information and time to better define Phase 2 and beyond.

Appendices

Appendix 1.

Bibliography of all material provided

National Marine Fisheries Service. 2012. Recovery Plan for the Southern Distinct Population Segment of the Green Sturgeon (*Acipenser medirostris*). National Marine Fisheries Service, Santa Rosa, CA.

National Marine Fisheries Service 2006 (2010 Update). Interim Recovery Planning Guidance (<http://www.nmfs.noaa.gov/pr/pdfs/recovery/guidance.pdf>)

Endangered Species Act (<http://www.nmfs.noaa.gov/pr/pdfs/laws/esa.pdf>)

Mora, E.A., S.T. Lindley, D.L. Erickson, and A.P. Klimley. 2009. Do impassable dams and flow regulation constrain the distribution of green sturgeon in the Sacramento River, California? *Journal of Applied Ichthyology* 25:39-47.

Appendix 2.

Attachment A: Statement of Work for Dr. Matthew Litvak

External Independent Peer Review by the Center for Independent Experts

Review of Draft Green Sturgeon Recovery Plan

Scope of Work and CIE Process: The National Marine Fisheries Service’s (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer’s Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: The Endangered Species Act (ESA) requires that NOAA’s National Marine Fisheries Service (NMFS) develop and implement recovery plans for the conservation of threatened and endangered species. The southern Distinct Population Segment of North American green sturgeon was listed as a threatened species in 2006. It is a wide-ranging species, spawning in the Sacramento River in Central California, but spending the majority of its life in nearshore marine waters along the west coast of North America. Recovery plans serve as guidelines for achieving recovery goals by describing the steps that must be taken to improve the status of species and their habitat. Although recovery plans themselves are not regulatory documents, their primary purpose is to provide a conservation “road map” for federal and state agencies, local governments, non-governmental entities, private businesses, and stakeholders. The NMFS Recovery Plan for green sturgeon is expected to generate substantial interest from outside parties because it may contain recommendations involving water management in California’s Central Valley. The draft recovery plan will include a large geographic area along the west coast of North America, with much of the focus on California’s Central Valley, thus has the potential for wide-ranging implications. Stakeholder interest likely will lead to inquiries from elected representatives at the state and federal levels. The scope of work should focus on the principal elements required in a recovery plan. These principal elements have been defined in section 4(f)(1) of the federal Endangered Species Act (ESA) and sections 1.1 and 1.2 of the National Marine Fisheries Service Interim Recovery Planning Guidance (NMFS 2006). The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall

have working knowledge and recent experience in the application of fisheries management, conservation biology, restoration practices, water management, and conservation under the ESA. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other pertinent information. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

In additional to the recovery plan report, the NMFS Project Contact will make available background materials to the reviewers for the scope and context of the review. Some of these background documents include;

- o 2006 (2010 Update) NMFS Interim Recovery Planning Guidance (<http://www.nmfs.noaa.gov/pr/pdfs/recovery/guidance.pdf>)
- o Endangered Species Act (<http://www.nmfs.noaa.gov/pr/pdfs/laws/esa.pdf>)
- o Mora, E.A., S.T. Lindley, D.L. Erickson, and A.P. Klimley. 2009. Do impassable dams and flow regulation constrain the distribution of green sturgeon in the Sacramento River, California? *Applied Ichthyology* 25:39-47.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein.

Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

- 1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
- 2) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
- 3) No later than **November 5, 2012**, each CIE reviewer shall submit an independent peer review report addressed to the “Center for Independent Experts,” and sent to Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator David Die via email to ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

- | | |
|----------------------------|---|
| October 1, 2012 | CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact |
| October 15, 2012 | NMFS Project Contact sends the CIE Reviewers the draft plan and background documents |
| October 16-31, 2012 | Each reviewer conducts an independent peer review as a desk review. |
| November 5, 2012 | CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator |
| November 20, 2012 | CIE submits the CIE independent peer review reports to the COR |
| November 27, 2012 | The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director |

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on substitutions. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of

the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:

- (1) each CIE report shall be completed with the format and content in accordance with **Annex 1**,
- (2) each CIE report shall address each ToR as specified in **Annex 2**,
- (3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COT, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COT. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.
2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.
3. The reviewer report shall include the following appendices:
 - Appendix 1: Bibliography of materials provided for review
 - Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference (ToRs)
CIE Peer Review of Green Sturgeon Draft Recovery Plan

The scope of work should focus on the principal elements required in a recovery plan. These principal elements have been defined in section 4(f)(1) of the federal Endangered Species Act (ESA) and sections 1.1 and 1.2 of the National Marine Fisheries Service Interim Recovery Planning Guidance (NMFS 2006).

Section 4(f)(1)(b) of ESA states “each plan must include, to the maximum extent practicable:

- a description of such site-specific management actions as may be necessary to achieve the plan’s goal for the conservation and survival of the species;
- objective, measurable criteria which, when met, would result in a determination...that the species be removed from the list; and,
- estimates of the time required and the cost to carry out those measures needed to achieve the plan’s goal and to achieve intermediate steps toward that goal.”

From section 1.1 of NMFS (2006), a recovery plan should:

- “Delineate those aspects of the species’ biology, life history, and threats that are pertinent to its endangerment and recovery;
- Outline and justify a strategy to achieve recovery;
- Identify the actions necessary to achieve recovery of the species; and
- Identify goals and criteria by which to measure the species’ achievement of recovery.”

The terms of reference (ToRs) for this peer review:

1. Do the basic elements of the draft recovery plan meet the minimum standards for recovery plans outlined in the NMFS Interim Recovery Guidance and mandates described in section 4(f)(1)(b) of ESA?
2. Is there a logical and consistent flow between the goal, objectives, criteria, and actions?
3. Does the plan incorporate the best scientific information available?
4. Does the plan address data gaps appropriately in relation to the formulation of recovery criteria and research actions (e.g. lack of information on contaminants to develop threats-based recovery criteria)?
5. Does the data provided by Mora et al. 2009 provide NMFS the best means for evaluating current and future habitat potential and the development of criteria to restore historical green sturgeon habitat within California’s Central Valley.
6. Does the plan provide clear guidance for the public, conservationists, managers, regulators, and others to act in a relevant manner over the next several decades to facilitate recovery of sDPS green sturgeon?
7. Recommendations for improvements?