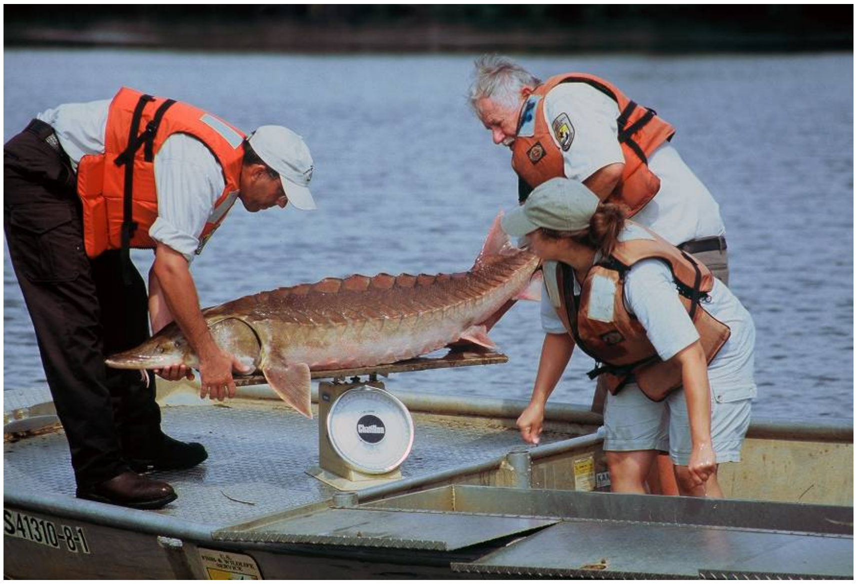
GULF STURGEON (*Acipenser oxyrinchus desotoi*)

5-Year Review:
Summary and Evaluation



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Southeast Region
Panama City Ecological Services Field Office
Panama City, Florida

National Marine Fisheries Service
Southeast Region
Office of Protected Resources
St. Petersburg, Florida

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GULF STURGEON (*Acipenser oxyrinchus desotoi*)
5-YEAR REVIEW

I. GENERAL INFORMATION

1.1. Methodology used to complete the review

A public notice initiating this review and requesting information was published on April 16, 2008, with a 60-day response period (73 FR 20702). The public notice was supplemented with a request for information by postcard dated April 17, 2008, mailed directly to 130 entities (individuals, natural resources agencies, conservation organizations) that could likely have information pertinent to this review. One (1) set of comments/data was received in response to the public notice and postcards, which was incorporated as appropriate into this 5-year review.

The lead recovery biologists for the NMFS and the FWS gathered and synthesized information regarding the biology and status of the Gulf sturgeon. Our information sources included:

- the Gulf Sturgeon Recovery/Management Plan (1995);
- peer-reviewed scientific publications;
- grey literature (annual reports);
- information presented at annual Gulf sturgeon meetings;
- ongoing field survey results and information shared from Gulf sturgeon researchers (both Service and State biologists);
- the final rule listing the Gulf sturgeon as threatened (56 FR 49653) (September 30, 1991); and
- the final rule designating critical habitat for the Gulf sturgeon (68 FR 13370) (March 19, 2003).

We submitted a peer-review draft of this document to 16 professional biologists with expertise on the Gulf sturgeon and its habitats. We provided written guidance to ensure that we relied upon the best available information and that we made sound conclusions based upon this information. Appendix B details how we addressed all comments received from peer reviewers.

All literature and documents used for this review are on file at the FWS Panama City Field Office and at the NMFS SERO.

1.2. Reviewers

1.2.1. NMFS

1.2.1.1. SERO (Southeast Regional Office)

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1.2.3. Peer Reviewers

Jim Clugston, U.S. Geological Survey (retired)
Jared Flowers, North Caroline Cooperative Fish and Wildlife Research Unit
Dewayne Fox, Delaware State University
Alan Huff, Florida Fish and Wildlife Conservation Commission (retired)
Phil Kirk, U.S. Army Corps of Engineers
Bill Pine, University of Florida
Todd Slack, U.S. Army Corps of Engineers
Ken Sulak, U.S. Geological Survey

1.3. Background

1.3.1. FR Notice announcing initiation of this review:

April 16, 2008, 73 FR 20702

1.3.2.

1.3.3. Species status

1.3.3.1. NMFS

NMFS currently considers the status of the Gulf sturgeon as stable.

1.3.3.2. FWS

FY2009 recovery data call: stable. Seven riverine systems have evidence of reproducing populations, some variability in population size has been noted: 1) The Suwannee River population appears to be slowly increasing; 2) population size in the Escambia River system may have declined following a hurricane event; and, 3) hurricane effects to the populations within the Pearl and Pascagoula Rivers are unknown as research has been extremely limited in those systems since Hurricanes Ivan (2004) and Katrina (2005).

1.3.4. Recovery achieved

FWS assigns Gulf sturgeon a 2 out of 4 indicating 26-50% of recovery objectives have been achieved.

1.3.5. Listing history

Original Listing: 56 FR 49653
Date listed: September 30, 1991
Entity listed: subspecies
Classification: threatened

1.3.6. Associated rulemakings

The Services designated critical habitat for the Gulf sturgeon on March 19, 2003 (68 FR 13370).

1.3.7. Review history

This is the first 5-year review completed for the Gulf sturgeon. The Services completed a Recovery Plan in 1995. The FWS has internally responded to "Recovery Data Calls" (most recently in 2009). The Services have participated in exercises to review recovery progress in conjunction with annual Gulf sturgeon workshops since 1998.

1.3.8. Species' recovery priority number at start of review:

1.3.8.1. NMFS

NOAA Fisheries issued guidelines in 1990 (55 FR 24296) for assigning listing and recovery priorities. Three criteria are assessed to determine a species' priority for recovery plan development, implementation, and resource allocation: 1) magnitude of threat; 2) recovery potential; and 3) existing conflict with activities such as construction and development. NOAA Fisheries has fewer priority categories than FWS.

NMFS has assigned a recovery priority number of 8 out of 12 (a moderate degree of threat, low to moderate potential for recovery, and little conflict with economic activities) to the Gulf sturgeon. Additional rationale for this recovery number is provided in the 2006-2008 Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species.

1.3.8.2. FWS

FWS has assigned a recovery number of 12 out of 18 (a subspecies with a moderate degree of threat and a low recovery potential) to the Gulf sturgeon (48 FR 43098).

The different priority rankings (NMFS and FWS) reflect FWS consideration of taxonomic criteria (genus, species, subspecies).

1.3.9. Recovery plan

Name of plan: Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) Recovery/Management Plan.
Date issued: September 22, 1995 (this plan was signed by the NMFS, FWS, and Gulf States Marine Fisheries Commission).

2. REVIEW ANALYSIS

2.1. Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1. Is the species under review a vertebrate?

Yes.

2.1.2. Is the species under review listed as a DPS?

No.

2.1.3. Is there relevant new information for this species regarding the application of the DPS policy?

Yes. Based on the best available information, the Services believe the current listing is valid. However, we have new information that indicates an analysis and review of the species should be conducted in the future to determine if the application of the Distinct Population Segment (DPS) policy could be appropriate for the Gulf sturgeon.

The 1995 Recovery Plan was completed before policies were issued by the Services on the treatment of DPSs under the Act (61 FR 4722; February 7, 1996). Currently there is a lack of information to separate the species into population segments in accordance with the DPS policy across various genetic/geographic subdivisions. However, the Services believe that additional data from ongoing genetics analyses and tagging studies may allow us to determine whether Gulf sturgeon DPSs are identifiable.

2.2. Recovery Criteria

2.2.1. Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes.

2.2.2. Adequacy of recovery criteria

2.2.2.1. Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

No (see discussion in section 2.2.3).

2.2.2.2. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

No. Although the tasks outlined in the 1995 Recovery Plan address threats relative to listing factors (e.g., habitat modification, overutilization, etc.), the Plan lacks criteria that would measure progress towards reducing these threats. The Services should develop such criteria in a revised recovery plan. We summarize new information about threats and progress towards reducing threats in section 2.3.2.

2.2.3. List the recovery criteria as they appear in the recovery plan and discuss progress.

1. ***Short-term Objective*** *– to prevent further reduction of existing wild populations of Gulf sturgeon within the range of the subspecies. This objective will apply to all management units within the range of the subspecies. Ongoing recovery actions will continue and additional actions will be initiated as needed.*

Criteria
A. Management units will be defined using an ecosystem approach based on river drainages. The approach may also incorporate genetic affinities among populations in different river drainages.

The criteria have been partially met through the Services' designation of Gulf sturgeon critical habitat in 2003 (68 FR68 13370). In the critical habitat rule we recognized seven extant reproducing populations that are associated with seven river drainages (Pearl, Pascagoula, Escambia, Yellow, Choctawhatchee, Apalachicola, and Suwannee). We noted that conservation of all seven populations was necessary to minimize the potential for inbreeding, to retain potentially important selective pressure at the margins of the species' range, and to provide a rescue effect between adjacent populations in the event of a local extirpation or a decline to extremely low numbers. We determined that physical and biological features within specific habitats occupied by these seven populations (seven riverine units and seven adjacent estuarine/marine units) are essential for the conservation of the species. Our current understanding of the biology of the Gulf sturgeon is still consistent with the findings of the critical habitat rule, but we realize that tagging and genetics data may provide a biological basis for dividing the Gulf sturgeon into two or more discrete population segments.

B. A baseline population index for each management unit will be determined by fishery independent catch-per-unit-effort (CPUE) levels.

This criteria has not been met. Recognizing the problems inherent with CPUE as a recovery monitoring metric in the years following completion of the 1995 Recovery Plan, the Services did not establish baseline CPUE indices as proposed in the Recovery Plan's recovery criteria. Researchers have instead gravitated towards mark-recapture models and age-structured population models (Morrow et al. 1999, Sulak and Clugston 1999, Pine et al. 2001, Pine and Allen 2005, Flowers 2008, Pine and Martell 2009). Researchers confirmed that high variability in CPUE was due to differences in the spatial distribution, sampling gear, deployment methods, and environmental conditions that affected sampling efficiency (e.g., tides, currents, bottom snags, floating debris, and winds), and sampling crew experience (K. Sulak, USGS, pers. comm.). We review the information that has emerged from these and other studies in section 2.3.1. This information suggests that some Gulf sturgeon populations are likely stable or slowly increasing, and that the Suwannee population is more rapidly increasing. The status of some Gulf sturgeon populations, particularly in the western portion of their geographic range, is unknown due to lack of recent survey.

C. Change from the baseline level will be determined by fishery independent CPUE over a three to five year period. This time frame will be sufficient to detect a problem and to provide trend information. The data will be assessed annually.

Currently, seven rivers are known to support reproducing populations of Gulf sturgeon. No population estimate has been made that would satisfy the recovery criteria of evaluating a change from baseline within statistically valid limits over a three to five year period. However, surveys continue on rivers throughout the range and population estimates have been developed using criteria other than CPUE as listed in Appendix A.

D. The short-term objective will be considered achieved for a management unit when the CPUE is not declining (within statistically valid limits) from the baseline level.

Gulf sturgeon researchers have recommended that population parameters estimated from mark-recapture methods be used instead of CPUE to monitor Gulf sturgeon recovery. Morrow et al. (1999) and Flowers (2008) both recommended incorporating a minimum population size into revised recovery criteria in addition to a stable or increasing population size trend.

2. ***Long-term Objective A*** *– to establish population levels that would allow delisting of the Gulf sturgeon by management units. Management units could be delisted by 2023 if required criteria are met. While this objective will be sought for all management units, it is recognized that it may not be achievable for all management units.*

Notably, management units are not listed entities under the ESA and therefore they cannot be de-listed. Rather, management units allow the Services to develop geographically specific recovery tasks that are appropriate to address unique threats to units smaller than the listed entity.

Criteria
A. The timeframe for delisting is based on known life history characteristics including longevity, late maturation, and spawning periodicity.

These criteria are still valid. New data support the previous conclusions that Gulf sturgeon are slow to recolonize areas that it formerly occupied, live long lives, have slow growth, and a high age at maturity. Restoration of the population age-structure will take many more years than previously thought.

B. A self-sustaining population is one in which the average rate of natural recruitment is at least equal to the average mortality rate over a 12-year period (which is the approximate age at maturity for a female Gulf sturgeon).

Currently, seven rivers are known to support reproducing populations of Gulf sturgeon. No population estimate has been made that would satisfy the recovery criteria to determine if the average rate of natural recruitment is at least equal to the average mortality rate over a 12-year period.

C. This objective will be considered achieved for a management unit when the population is demonstrated to be self-sustaining and efforts are underway to restore lost or degraded habitat.

The demographic recovery criteria in the 1995 Recovery Plan relied upon catch-unit-effort (CPUE) data, which has proven too variable to serve as a practical monitoring metric. Demographic parameters estimated from mark-recapture studies appear better suited for this purpose. Using the mark-recapture data, general estimates of population size at a riverine scale have recently been calculated (Appendix A). New information shows a roughly stable or slightly increasing population trend in eastern (Florida) river systems. The number of Gulf sturgeon in the Escambia River system may have recently declined due to hurricane impacts. The Suwannee River population appears to be slowly increasing. Due to lack of research since Hurricanes Ivan and Katrina, no data are available to determine the current size of the Gulf sturgeon populations in the western portion of the geographic range (i.e., Pearl and Pascagoula Rivers) of Gulf sturgeon.

3. *Long-term Objective B –* *to establish, following delisting, a self-sustaining population that could withstand directed fishing pressure within management units. Note that the objective is not necessarily the opening of a management unit to fishing, but rather, the development of a population that can sustain a fishery. Opening a population to fishing will be at the discretion of state(s) within whose jurisdiction(s) the management unit occurs. As with Long-term Objective A, the objective may not be achievable for all management units, but will be sought for all units.*

Criteria:
A. All criteria for delisting must be met.

This criteria remains valid; however, the delisting criteria need to be revised to accommodate a different method to determine demographic recovery criteria as CPUE is too variable of a metric.

B. This objective will be considered attained for a given management unit when a sustainable yield can be achieved while maintaining a stable population through natural recruitment.

Flowers (2008) describes how the historic overexploitation of Gulf sturgeon led to a change in the age-structure of the populations that reduced annual reproductive output. Given Gulf sturgeon life history characteristics such as long life, slow growth, and high age at maturity, restoration of the population age-structure will take many more years than previously thought.

C. Particular emphasis will be placed on the management unit that encompasses the Suwannee River, Florida, which historically supported the most recent stable fishery for the subspecies.

The Suwannee River population appears to be slowly increasing and may be regaining a semblance of its pre-exploitation age structure, with a shift from 10% mature individuals in 1996 to 40% in 2007 (presentation by K.Sulak, USGS at the 2008 Annual Gulf sturgeon meeting).

However, as previously noted, the ESA specifies that only species included on the list published in the Federal Register can be removed from such list (ESA Section 4(c)(2). Because the Gulf sturgeon as a species is on the published list (50 CFR 17) only that unit, and not the management unit, may be considered for de-listing.

2.3. Updated Information and Current Species Status

The 2003 rule designating critical habitat represents our most recent comprehensive review of information relevant to the conservation and status of the Gulf sturgeon. Therefore, the following is based largely upon data and literature compiled since 2003.

2.3.1. Biology and Habitat

2.3.1.1. New information on the species' biology and life history

Brooks and Sulak (2004 and 2005) described the distribution of Gulf sturgeon food resources in the Suwannee River estuary. They found that benthic infauna biomass was greater in the summer than in the winter, and that the spatial distribution of likely prey items was patchy (high in certain areas and low in others).

Additional studies examining Gulf sturgeon prey have been conducted based on Heard et al.'s (2000) assessment of the benthic macro invertebrate assemblages in Choctawhatchee Bay suggesting that ghost shrimp, *Lepidophthalmus louisianensis,* was an important food for Gulf sturgeon greater than 1 m in length. McLelland and Heard (2004, 2005) later analyzed the benthic macro-invertebrate assemblages from two sites off the northern Gulf of Mexico coast of Florida and Alabama where Gulf sturgeon were located by telemetry and believed to be foraging during winter. They reported in 2004 that annelids comprised the main group of organisms collected at both sites and with the exception of the high density of tube building polychaetes collected at the Alabama site, little difference in the benthic invertebrate populations was noted between the two sites. The density of benthic organisms did not substantially differ from 2004 to 2005. However, McLelland and Heard (2005) noted there were a few shifts in population structure: 1) an absence of the tube dwelling polychaete, *Hobsonia florida,* at the Alabama site that was predominate in 2004 and was replaced by the polychaete, *Mediomastusa ambiseta*; and 2) an increase in the number of mollusks with a decrease in arthropods at the Florida site. They speculated that the possible changes in the macro-invertebrate structure could reflect a response to increased nutrient loading from runoff or perhaps a physical shift due to the effects of Hurricane Ivan that made landfall in eastern Alabama in August 2004.

Edwards et al. (2003) tracked the movements of Gulf sturgeon in the Suwannee River estuary using ultrasonic tags and a fixed array of receivers. Tagged individuals displayed a pattern of directed slow, steady travel over several kilometers followed by periods of randomly directed travel. This pattern is consistent with a foraging strategy that is adapted to a patchy distribution of food resources by an animal that lacks advance knowledge of the location of the patches or an ability to detect the patches from afar. If applicable, this strategy may help to explain the regular detection of telemetry-tagged Gulf sturgeon from different natal river systems in the same marine foraging areas such as the nearshore islands. It is also possible that adults can learn the location of optimal foraging areas and revisit year after year. In a follow-up paper reporting results of satellite pop-up archival tags, Edwards et al. (2007) discussed mixing of Gulf sturgeon from different populations and overlap of winter habitat utilization. Similarly, in a multi-year study Ross et al. (2009) found Gulf sturgeon from both the Pascagoula and Pearl Rivers broadly overlap and use the shallow water along the Gulf barrier islands as foraging grounds in the winter. These marine habitats utilized by the Gulf sturgeon were all less than 7 m deep, generally well oxygenated, and with relatively clear water; bottom substrates were mostly coarse sand and shell fragments or fine sand (Ross et al. 2009). Also, Gulf sturgeon tagged in seven Florida panhandle river systems were monitored from Carrabelle, FL to Mobile Bay, AL during the winter period in the coastal waters of the Gulf of Mexico. Gulf sturgeon from different river systems were located occupying the same area of marine habitat.

Harris et al. (2005) also tracked the movements of Gulf sturgeon in the Suwannee River estuary using ultrasonic tags and sampled benthic infauna. Locations of tagged Gulf sturgeon were associated with sandy substrates and high abundances of known prey items. Gulf sturgeon individuals appeared to use different portions of the estuary in fall compared to spring.

Randall and Sulak (2007) estimated yearly recruitment of Gulf sturgeon using 19 years of mark-recapture data for the Suwannee River population. Recruitment was positively correlated with high flows in September and December. They suggested that higher survival of age-0 sturgeon may be related to increased availability of lower-salinity estuarine feeding habitats in wet years.

Similar to shortnose sturgeon, Randall and Sulak (2007) found some evidence to suggest a Gulf sturgeon fall spawning event in the Suwannee River. Limited data on both adult migration patterns and back-calculation to determine age of small fish indicate that a second spawning event may be occurring.

Flowers et al. (in-review) utilized field data from the Suwannee and Apalachicola Rivers to assess bioenergetics of Gulf sturgeon. Using length-at-age incremental growth data from mark-recapture studies, similar bioenergetic parameter estimates were found, except for slight differences in growth between males from the Suwannee River. Given the common homogenous near-shore foraging areas utilized by the Gulf sturgeon, similarities in energy uptake and metabolism across the species are not unexpected.

2.3.1.2. Abundance, population trends, demographic characteristics

Currently, seven rivers are known to support reproducing populations of Gulf sturgeon. No population estimate has been made that would satisfy the recovery criteria of evaluating a change from baseline within statistically valid limits over a three to five year period or an assessment to determine if the average rate of natural recruitment is at least equal to the average mortality rate over a 12-year period. The demographic recovery criteria in the 1995 Recovery Plan relied upon catch-unit-effort (CPUE) data, which has proven too variable to serve as a practical monitoring metric. Demographic parameters estimated from mark-recapture studies appear better suited for this purpose. Using the mark-recapture data, general estimates of population size can be calculated. Although variable, most populations appear relatively stable with a few exceptions (Appendix A). The number of Gulf sturgeon in the Escambia River system may have recently declined due to hurricane impacts, and the Suwannee River population appears to be slowly increasing. Due to lack of research since Hurricanes Ivan and Katrina, no data are available to determine the current size of the Gulf sturgeon populations within the Pearl and Pascagoula Rivers.

Research on Gulf sturgeon population characteristics in the past 5 years has been limited to the eastern five populations. The FWS Panama City Field Office has annually monitored one or more of the four Florida Panhandle rivers (Escambia, Yellow, Choctawhatchee, and Apalachicola) since 2003 (fiscal year annual reports USFWS 2003-2008). USGS researchers completed the first assessment of the Yellow River population (Berg 2004, Berg et al. 2007). Advances in modeling population dynamics have been made, especially for the Apalachicola and Suwannee River populations (Flowers 2008, Pine and Martell 2009).

Results of surveys to assess abundance of Gulf sturgeon within the 7 river drainages with known reproducing populations are summarized in Appendix A. Estimates listed refer to numbers of individuals greater than a specified size, which varies depending on sampling gear, and in some cases, to numbers of individuals that use a particular portion of the river (e.g., a summer holding area or one migratory pathway among several). Therefore, the estimates are not a reliable source to determine trends as frequently studies and years are not directly comparable due to key differences in methods and assumptions. Multiple estimates for a single year and river result from the application of multiple models or represent updated results incorporating additional data. Recently, new studies have been initiated in the western range of the species (Pearl and Pascagoula Rivers), but results are not yet available for this review.

Mark-recapture studies have confirmed the general fidelity of individual Gulf sturgeon returning to particular rivers (NOAA and USFWS 2003), presumably their natal rivers. Gulf sturgeon reproduction is not known to currently occur in several basins (e.g., Mobile Basin) where it most likely occurred historically. A recent survey collected two Gulf sturgeon in Mobile Bay near Fairhope, AL (Mettee et al. 2009) after intensive netting. In addition to slowly recolonizing its former range, insights have emerged from population models in recent years suggesting that Gulf sturgeon life history characteristics also render the species slow to recover in abundance within its current range. Working with data from the Suwannee River population, Pine et al. (2001) identified three parameters (i.e., egg-to-age-1 mortality, the percentage of females that spawn annually, and adult mortality) as those most sensitive in determining the trajectory of population size. Pine et al. (2001) predicted that slight increases in estimated annual adult mortality (from 16% to 20%) would shift the population from an increasing trend into a decline. Flowers (2008) used an age-structured model to conclude that the Apalachicola population is probably slowly recovering, but still needs many years before returning to anywhere near its pre-exploitation abundance. Sulak (2008 Gulf sturgeon workshop) reported an analysis of mark-recapture data for the Suwannee River that suggests this population is regaining a semblance of its pre-exploitation age structure, with a shift from 10% mature individuals in 1996 to 40% in 2007.

Given the variety in methods, Gulf sturgeon population estimates are relatively imprecise, with more than half of the confidence intervals reported (Appendix A) exceeding 65% of the value reported in the third column. This is perhaps owing to the low capture/recapture probabilities associated with sampling this species, which was estimated to be < 10% using closed-system models by Zehfuss et al. (1999), although another researcher argues that recapture rates for Gulf sturgeon are consistently high (K. Sulak, USGS, peer review comments on draft of this document). Although the trends may not be statistically significant, these surveys indicate a roughly stable or a slowly increasing trend in number of individuals at a riverine population scale. It is not necessary in this review to compare and contrast the methods of these various studies; however, the many differences suggest a need to standardize data reporting so that a clearer picture of range-wide status becomes possible. Along similar lines, an online reference database including tag numbers and telemetry frequencies for all researchers would facilitate the rapid recognition of inter-river movements and the rapid notification of interception.

Flowers (2008) describes the rapid decline in Gulf sturgeon landings as likely reflective of rapid erosion of the population age-structure of the large, older, highly fecund individuals being removed which led to a rapid change in the age-structure of the population and thereby reducing annual reproductive output and population recovery. Using several formulations (varying key input parameters, such as annual natural mortality) of an age-structured mark-recapture model (ASMR), Pine and Martell (2009) analyzed all available Gulf sturgeon sampling data collected since the late 1970's for the Apalachicola and Suwannee Rivers. For the Apalachicola River data, the models generally estimated population sizes (age 1+ Gulf sturgeon) of less than 500 individuals in the early 1980's, which increased to about 2,000 fish in 2005. These estimates are substantially higher than for other non-age-structured models. This is partly because estimates from Pine and Martell (2009) include younger age-classes than those included in Zehfuss et al. (1999). Despite key differences in input data and model assumptions, a general trend of gradually increasing abundance is apparent in the Apalachicola River. Similarly, for the Suwannee River data, the ASMR models estimated abundance in the early 1980's of about 3,000 age 1+ sturgeon, increasing to about 10,000 in 2004. These estimates are higher than the abundance estimates from Chapman or Sulak, for similar reasons as in the Apalachicola River analyses. Pine et al. (2001) found a positive population growth of about 5% annually for adults within the Suwannee River Gulf sturgeon population, and therefore in number to about 10,000 individuals in 2004.

2.3.1.3. Taxonomic classification or changes in nomenclature

No changes.

2.3.1.4. Spatial distribution, trends in spatial distribution

Historically, Gulf sturgeon occurred from the Mississippi River east to Tampa Bay. Sporadic occurrences were recorded as far west as the Rio Grande River in Texas and Mexico, and as far east and south as Florida Bay (Wooley and Creteau 1985, Reynolds 1993). The sub-species' present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi respectively, east to the Suwannee River in Florida. The species is anadromous: feeding in the winter months in the marine waters of the Gulf of Mexico including bays and estuaries, migrating in the spring up freshwater rivers to spawn on hard substrates, and then spending summers in the lower rivers before emigrating back out into estuarine/marine waters in the fall.

Researchers have conducted telemetry studies in all seven river systems. These studies have substantially advanced our understanding of Gulf sturgeon locations during their migrations between riverine, estuarine, and marine habitats. Gulf sturgeon travel great distances to use specific areas for spawning in the spring, for "holding" in the summer and fall, and for feeding in the winter. With the deployment of fixed-location telemetry receivers in the estuarine and marine environments, a picture of the behavior of age 3+ Gulf sturgeon is emerging of individual fish traveling relatively quickly between areas where they spend an extended period of time (Edwards et al. 2003, Edwards et al. 2007, Randall 2008). To date, published research directed at age 0-2 individuals has been limited to the Suwannee River population by Sulak and Clugston (1998 and 1999). Young-of-year (YOY) individuals have been found to disperse widely downstream of spawning sites, while sometimes traveling upstream of known spawning sites (Clugston et al. 1995, Sulak and Clugston 1999), and eventually arriving in estuarine feeding areas in winter months.

Sub-adult and adult Gulf sturgeon overwintering in Choctawhatchee Bay were generally found to occupy the sandy shoreline habitat at depths of 2-3 m (Fox *et al* 2001, Parauka *et al* 2001).

The 1995 Recovery Plan devotes a paragraph to the possible importance of springs and other cool water refugia to Gulf sturgeon within the riverine environment. Sulak et al. (2007) examined temperature, prey availability, and summer movements of Gulf sturgeon in the Suwannee River and concluded that temperature and prey availability did not explain Gulf sturgeon selection of summer holding areas. Hightower et al. (2002) also found that water temperatures in holding areas where Gulf sturgeon were repeatedly found in the Choctawhatchee River were similar to temperatures where sturgeon were only occasionally found elsewhere in the river. While the factor responsible for concentrating Gulf sturgeon within small areas is unknown, it may be refuge from high-velocity currents.

Many researchers have improved our knowledge of sturgeon movement and habitat use. Rogillio et al. (2007) and Ross et al. (2009) both documented use of barrier-island passes in Mississippi Sound and the Chandeleur Islands for winter feeding. Spawning and associated movement patterns in the Pascagoula River were described by Heise et al. (2004, 2005). The FWS discovered near-shore areas of concentrated feeding activity for adults from multiple riverine systems in the waters near Tyndall Air Force Base/Panama City Beach , FL, and Perdido, FL to Gulf Shores, AL (USFWS 2002, 2003, 2004, 2005, and 2006). Spawning sites were verified by egg collection on the Apalachicola River, FL (USFWS 2006a, Pine et al. 2006, Scollan and Parauka 2008), and the Yellow River, FL (Kreiser et al. 2008). Juvenile movements in the Apalachicola River, and Apalachicola Bay, FL were traced by Randall (2008). In June 2009, the U.S. Army Corps of Engineers (Corps) collected three YOY Gulf sturgeon in the Brothers River, a tributary to the Apalachicola River (P. Kirk, USCOE, pers. com.). Adult Gulf sturgeon were observed in a previously unreported tributary, the Withlacoochee River, FL (Suwannee River tributary), in the fall of 2005 (E. Nagid, FFWC, November 2005 Gulf sturgeon Workshop) and in May 2006 (G. Warren, FFWC Apalachicola, pers. com.). Trophic habitat in the estuary of the Suwannee River, FL was described by Sulak et al. (2009). Juveniles (estimated age 8-9 months) were collected in the Santa Fe River, FL in December 2006 (Flowers and Pine 2008); this observation is significant, because the Santa Fe is not known to support spawning and it is not known if the juveniles were spawned there or searching for habitat. Additional information was gained on feeding habits and movements in the estuary of the Suwannee River, FL (Harris 2003, Harris et al. 2005). Parkyn et al. (2007) described overall seasonal movements in the Suwannee River, FL drainage.

Reproducing populations continue to be evident in seven river systems. At a riverine scale, no estimate of the number of Gulf sturgeon has been calculated that would satisfy the recovery criteria to consider a change from the threatened listing status. Most population estimates have a high degree of statistical uncertainty (i.e., large confidence intervals) and many do not provide data over the three to five year period required to determine if the average rate of natural recruitment is at least equal to the average mortality rate over a 12-year period. Further, the demographic recovery criteria in the 1995 Recovery Plan relied upon catch-unit-effort (CPUE) data, which has proven too variable to serve as a practical monitoring metric. The Services believe that demographic parameters estimated from mark-recapture studies appear better suited for this purpose as general estimates of population size can be made. Although population size of Gulf sturgeon is variable across their range, most populations appear to be relatively stable in number (Appendix A).

2.3.2. ESA Definitions/Listing Determinations

The ESA provides the following definitions:

"endangered species" is defined as "any species which is in danger of extinction throughout all or a significant portion of its range."

"threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

The process for determining whether a species (as defined above) should be listed is based upon the best available scientific and commercial information. The status is determined from an assessment of factors specified in section 4 (a)(1) of the ESA that may be contributing to decline, including:
(A) The present or threatened destruction, modification, or curtailment of its habitat or range;
(B) Overutilization for commercial, recreational, scientific, or educational purposes;
(C) Disease or predation;
(D) Inadequacy of existing regulatory mechanisms; or
(E) Other natural or manmade factors affecting the continued existence of the species.

Based on the information in the preceding section, the Services believe the Gulf sturgeon continues to meet the definition of a threatened species given: 1) the highly variable abundance estimates limited to riverine populations in the east of the sub-species' range, coupled with the unknown status of western populations; 2) results of population modeling that indicate slight increases in annual mortality would quickly shift trends from increasing to decreasing; 3) the unknown age-structure of all but two populations; 4) their long-lived, slow growing and late maturing life history characteristics; and 5) unknown population bottlenecks and overwintering habitats.

The best available information does not indicate that Gulf sturgeon are currently in danger of extinction. The geographic range of the species is not known to have been truncated. Seven riverine systems continue to have evidence of reproducing populations. New information shows a roughly stable or slightly increasing population trend in the eastern (Florida) systems; however, population size and structure of some populations, particularly in the western part of the range, is unknown due to lack of recent survey.

2.3.3. Five-Factor Analysis

Under each factor, we note the impacts and threats that were analyzed in the 1991 listing rule, followed by observations about new threats and progress at relieving threats.

2.3.3.1. Present or threatened destruction, modification or curtailment of its habitat or range

The 1991 listing rule cited the following impacts and threats:

- Dams on the Pearl, Alabama, and Apalachicola rivers; also on the North Bay arm of St. Andrews Bay.
- Channel improvement and maintenance activities: dredging and de-snagging.
- Water quality degradation.
- Contaminants.

New observations:

2.3.3.2. Habitat – dams

All of the dams noted in the listing rule continue to block passage of Gulf sturgeon to historical spawning habitats and thus either reduce the amount of available spawning habitat or entirely impede access to it. Since Gulf sturgeon were listed, several new dams have been proposed on rivers that support Gulf sturgeon (Table 1). Effects of these dams on Gulf sturgeon and their habitat continues to be investigated as well as potential mitigating factors, including assessing the effects of dam operations, on downstream habitats. A short summary of these efforts follows.

Biologists from Clemson University, Georgia Department of Natural Resources, FWS, NMFS, and the Corps are investigating the feasibility of fish passage at Jim Woodruff Lock and Dam on the Apalachicola River (Isely et al. 2005 – workshop presentation). While Gulf sturgeon do not appear to enter the lock, Alabama shad and striped bass have utilized the lock to pass upstream. At this time, it is still unclear whether upstream sturgeon passage through the lock is feasible and if passage would result in a conservation benefit to the Gulf sturgeon. A study using hatchery-reared Gulf sturgeon tagged and released above the Dam into Lake Seminole found that some fish passed downstream into the Apalachicola River, possibly through the navigation lock, while others remained in the reservoir (Weller 2002). None of the tagged fish were observed to travel upstream to areas of potential spawning habitats.

Two dams, Pools Bluff and Bogue Chitto Sills, also impact Gulf sturgeon movements in the Pearl River drainage. Upstream passage is likely possible over these structures during some flow conditions, but the extent to which passage occurs is still unknown. New studies to survey the Pearl River for Gulf sturgeon and track movements began in summer 2009 (S. Bolden, NMFS, pers. com).

The effects on Gulf sturgeon from the Corps' operation of Federal dams and reservoirs in the Apalachicola River basin were assessed in recent biological opinions (USFWS 2006a, 2007, and 2008). The latest of these opinions concluded that some lethal take of Gulf sturgeon eggs or larvae could occur under certain circumstances of rapidly declining river stages during the spawning season. Based on further analysis of flow records and operational practices, the Corps determined that it appears feasible to operate the system in a manner that would avoid take of eggs and larvae in most, if not all, circumstances (USACE 2009). Flowers et al. (in press) examined the possibility of reduced recruitment associated with low flows in the Apalachicola River system and suggested that decreased spawning habitat availability could prolong population recovery or reduce population viability.

Except for the proposed dams on the Pearl River and the Yellow River, the dams listed in Table 1 would be constructed upstream of both designated Gulf sturgeon critical habitat and areas known to be inhabited by Gulf sturgeon. However, if constructed these dams/reservoirs could alter flow, channel morphology, and water quality well downstream and within designated critical habitat.

Table 1. Summary of dams proposed within the geographic range of the Gulf sturgeon by river drainage.

Drainage Basin	State	Stream	Notes
Pearl	MS	Mainstem	Proposed LeFleur Lakes reservoir near Jackson, MS, in vicinity of possible sturgeon spawning area.
Escambia/Conecuh	AL	Murder Creek	Proposed reservoir site is on a tributary that joins the Conecuh River near a known summer resting area for sturgeon.
Escambia/Conecuh	AL	Big Escambia Creek	Proposed reservoir site is on a tributary that joins the Escambia River near the FL/AL border.
Choctawhatchee	AL	Little Choctawhatchee River	Proposed reservoir site is on a tributary that joins the Choctawhatchee River upstream of known spawning sites.
Yellow	FL	Mainstem	Feasibility study completed by Corps for proposed site near Milligan, FL. Dam would impede passage to known spawning site upstream in AL.
Apalachicola	GA	Various	There have been various proposals for new water supply reservoirs, all upstream of the Jim Woodruff Dam on the FL/GA border.

In summary, access to historic Gulf sturgeon spawning habitat continues to be blocked by existing dams and the ongoing operations of these dams also effect downstream habitat. Several new dams are being proposed that would increase these threats to the Gulf sturgeon and its habitat. Dams continue to impede access to upstream spawning areas, and continue to adversely affect downstream habitat including both spawning and foraging areas.

2.3.3.3. Habitat – dredging

Riverine, estuarine, and coastal navigation channels are often dredged to support commercial shipping and recreational boating. Dredging activities can pose significant impacts to aquatic ecosystems by: 1) direct removal/burial of organisms; 2) turbidity/siltation effects; 3) contaminant re-suspension; 4) noise/disturbance; 5) alterations to hydrodynamic regime and physical habitat; and 6) loss of riparian habitat (Chytalo 1996, Winger et al. 2000). The direct lethal effects to Gulf sturgeon resulting from interaction with dredges is discussed later in Section 2.3.3.12.

Dredging operations may also destroy benthic feeding areas, disrupt spawning migrations, and re-suspend fine sediments causing siltation over required substrate in spawning habitat. Because Gulf sturgeon are benthic omnivores, the modification of the benthos affects the quality, quantity, and availability of prey.

Maintenance dredging for the navigation channel on the Apalachicola River last occurred in 2001. Although the channel is still authorized as a Federal navigation project, the State of Florida denied the Corps' application for water quality certification in 2005 (letter dated October 11, 2005 from FDEP Secretary Colleen Castille to Curtis Flakes, USACE). It appears unlikely that periodic or routine dredging in the inland waterway would resume in the foreseeable future. However, occasional maintenance dredging near the mouth of the Apalachicola River still occurs for that segment, which is part of the Gulf Intra-Coastal Waterway.

Maintenance dredging occurs regularly in numerous navigation channels that traverse the bays, passes, and river mouths of all seven river drainages that are used by Gulf sturgeon. Most of this dredging occurs within designated Gulf sturgeon critical habitat and may modify foraging habitat as well as causing injury or killing Gulf sturgeon.

In summary. dredging and disposal to maintain navigation channels, and removal of sediments for beach renourishment occurs frequently and throughout the range of the Gulf sturgeon and within designated Gulf sturgeon habitat annually. This activity has, and continues to threaten the species and affect its designated critical habitat.

2.3.3.4. Habitat – point and non-point discharges

Evaluations of water and sediment quality in Gulf Sturgeon habitat on the northern Gulf of Mexico coast, have consistently shown elevated pollutant loading. This has been observed in both tidal coastal rivers of the type that the sturgeon use in the spring and summer (Hemming et al. 2006, 2008). Perhaps better understood is the widespread contamination throughout the overwintering feeding habitat of the Gulf sturgeon (Brim 1998, 2000, NWFWMD 1997, 1998, 2000, 2002, Hemming 2002, 2003a, 2003b, 2004, 2007). Although the specific effects of these widely varied pollutants on sturgeon in their various life stages is not clearly understood, there is ample evidence summarized below to show potential deleterious effects to Gulf sturgeon and their habitat.

Sulak et al. (2004) suggest that successful egg fertilization for Gulf sturgeon may require a relatively narrow range of pH and calcium ion concentration. These parameters vary substantially along the length of the Suwannee River. Egg and larval development are also vulnerable to various forms of pollution and other water quality parameters (e.g., temperature, dissolved oxygen (DO)).

Potential threats to Gulf sturgeon critical habitat were documented in the upper Choctawhatchee and lower Pea Rivers (Popp and Parauka 2004, Newberry and Parauka in press). Potential habitat threats were identified based on degraded habitat characteristics, such as erosion, riparian condition, presence of unpaved roads, and presence of agriculture.

Pollution from industrial, agricultural, and municipal activities is believed responsible for a suite of physical, behavioral, and physiological impacts to sturgeon worldwide (Karpinsky 1992, Barannikova 1995, Barannikova et al. 1995, Khodorevskaya et al. 1997, Bickham et al. 1998, Khodorevskaya and Krasikov 1999, Billard and Lecointre 2001, Kajiwara et al. 2003, Agusa et al. 2004). Although little is known about contaminant effects on Gulf Sturgeon, a review estimating potential reactions has been performed (Berg 2006). It was found that loss of habitat associated with pollution and contamination has been documented for sturgeon species (Verina and Peseridi 1979, Shagaeva et al. 1993, Barannikova et al. 1995). Specific impacts of pollution and contamination on sturgeon have been identified to include muscle atrophy, abnormality of gonad, sperm and egg development, morphogenesis of organs, tumors, and disruption of hormone production (Graham 1981, Altuf'yev et al. 1992, Dovel et al. 1992, Georgi 1993; Romanov and Sheveleva 1993, Heath 1995, Khodorevskaya et al. 1997, Kruse and Scarnecchia 2002). The extreme of this situation can be observed in the Caspian Sea, likely the most polluted sturgeon habitat in the world. Researchers there have suggested that nearly 90% of sturgeon suffer from organ pathologies and decreased physiological condition associated with sub-lethal levels of pollution (Veshchev 1995, Akimova and Ruban 1996, Luk'yanenko et al. 1999, Kajiwara et al. 2003). In addition, nearly 20% of the female sturgeon experience some impact to egg development. Although there has been a reduction in pollution export into the Caspian Sea, the severity of past pollution and nature of the pollutants ensure their presence in the sediments, water column, and tissues of organisms will continue.

More recently, pharmaceuticals and other endocrinologically active chemicals have been found in fresh and marine waters at effective concentrations (reviewed in Fent *et al.* 2006). These compounds enter the aquatic environment via wastewater treatment plants, agricultural facilities, and farm runoff (Folmar et al. 1996, Culp et al. 2000, Wildhaber et al. 2000, Wallin et al. 2002). These products are the source of both natural and synthetic substances including, but not limited to, polychlorinated biphenyls, phthalates, pesticides, heavy metals, alkylphenols, polycyclic aromatic hydrocarbons, 17β-estradiol, 17α-ethinylestradiol, and bisphenol A (Pait and Nelson 2002, Aguayo et al. 2004, Nakada et al. 2004, Iwanowicz et al. 2009, Björkblom et al. 2009). The impact of these exposures on Gulf sturgeon is unknown, but other species of fish are affected in rivers and streams. For example, one major class of endocrine disrupting chemicals, estrogenic compounds, have been shown to affect the male to female sex ratio in fish in streams and rivers via decreased gonad development, physical feminization, and sex reversal (Folmar et al. 1996). Settlement of these contaminants to the benthos may affect benthic foragers to a greater extent than pelagic foragers due to foraging strategies (Geldreich and Clarke 1966).

Several characteristics of the Gulf sturgeon (i.e., long lifespan, extended residence in riverine and estuarine habitats, benthic predator) predispose the species to long-term and repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants. Chemicals and metals such as chlordane, DDE, DDT, dieldrin, PCBs, cadmium, mercury, and selenium settle to the river bottom and are later incorporated into the food web as they are consumed by benthic feeders, such as sturgeon or macroinvertebrates. Some of these compounds may affect physiological processes and impede the ability of a fish to withstand stress, while simultaneously increasing the stress of the surrounding environment by reducing DO, altering pH, and altering other water quality properties.

While laboratory results are not available for Gulf sturgeon, signs of stress observed in shortnose sturgeon exposed to low DO included reduced swimming and feeding activity coupled with increased ventilation frequency (Campbell and Goodman 2004). Niklitschek (2001) observed that egestion levels for Atlantic and shortnose sturgeon juveniles increased significantly under hypoxia, indicating that consumed food was incompletely digested. Behavioral studies indicate that Atlantic and shortnose sturgeon are quite sensitive to ambient conditions of oxygen and temperature: in choice experiments juvenile sturgeons consistently selected nomoxic over hypoxic conditions (Niklitschek 2001). Beyond escape or avoidance, sturgeons respond to hypoxia through increased ventilation, increased surfacing (to ventilate relatively oxygen-rich surficial water), and decreased swimming and routine metabolism (Nonnette et al. 1993, Crocker and Cech 1997, Secor and Gunderson 1998, Niklitschek 2001).

The majority of published data regarding contaminants and sturgeon health are limited to reports of tissue concentration levels. While these data are useful and allow for comparison between individuals, species, and regions, they do not allow researchers to understand the impacts of the concentrations. There is expectation that Gulf sturgeon are being negatively impacted by organic and inorganic pollutants given high concentration levels (Berg 2006). Gulf sturgeon collected from a number of rivers between 1985 and 1991 were analyzed for pesticides and heavy metals (Bateman and Brim 1994); concentrations of arsenic, mercury, DDT metabolites, toxaphene, polycyclic aromatic hydrocarbons, and aliphatic hydrocarbons were sufficiently high to warrant concern. More recently, 20 juvenile Gulf sturgeon from the Suwannee River, FL, exhibited an increase in metals concentrations with an increase in individual length (Alam et al. 2000).

Federal and state water quality standards are protective of most taxa in many habitats. However, impacts of reduced water quality continue to be realized at species-specific, and habitat-specific scales and magnification through the trophic levels continues to be assessed. The result is that current water quality standards are not always protective of federally listed species (Augsburger et al. 2003, Augsburger et al. 2007). To compound the issue, many previously identified water quality problems as realized through violation of state water quality standards are addressed through the necessarily slow and deliberate process of regulated point, and non-point source, pollutant load reductions (Total Maximum Daily Loads, TMDLs) for chemicals that have specific quality criteria. Because there are thousands of chemicals interacting in our natural environment, many of them of human design, many do not have Federal or state water quality standards associated with them. Further, effects of most of these chemicals on the Gulf sturgeon or other protected species are poorly understood. For these reasons point and non-point discharges to the Gulf sturgeon's habitat continue to be a threat.

2.3.3.5. Habitat – climate change

Climate change has potential implications for the status of the Gulf sturgeon through alteration of its habitat. The Intergovernmental Panel on Climate Change (IPCC 2007) concluded that it is very likely that heat waves, heat extremes, and heavy precipitation events over land will increase during this century. Warmer water, sea level rise and higher salinity levels could lead to accelerated changes in habitats utilized by Gulf sturgeon. Saltwater intrusion into freshwater systems could negatively impact freshwater fish and wildlife habitat (FWC 2009) resulting in more saline inland waters that may eventually lead to major changes in inland water ecosystems and a reduction in the amount of available freshwater. Changes in water temperature may alter the growth and life history of fishes, and even moderate changes can make a difference in distribution and number (FWC 2009). Freshwater habitats can be stressed by changes in both water quality and levels because of anticipated extreme weather periods as mean precipitation is expected to decrease along with an increase in precipitation intensity. Both droughts and floods could become more frequent and more severe, which would affect river flow, water temperature, water quality, channel morphology, estuarine salinity regimes, and many other habitat features important to the conservation of Gulf sturgeon.

A rise in water temperature may create conditions suitable for invasive and exotic species. Higher water temperatures combined with increased nutrients from storm runoff may also result in increased invasive submerged and emergent water plants and phytoplankton which are the foundation of the food chain (FWC 2009). New species of freshwater fishes may become established with warmer water temperatures (FWC 2009). The rate that climate change and corollary impacts are occurring may outpace the ability of the Gulf sturgeon to adapt given its limited geographic distribution and low dispersal rate.

2.3.3.6. Overutilization for commercial, recreational, scientific, or educational purposes

All directed fisheries of Gulf sturgeon have been closed since 1972 in Alabama, 1974 in Mississippi, 1984 in Florida, and 1990 in Louisiana (USFWS 1995). Overutilization due to directed harvest is no longer a threat. Although confirmed reports are rare, it is still a common opinion among Gulf sturgeon researchers that possibly significant Gulf sturgeon mortality occurs as bycatch in fisheries directed at other species. Berg et al. (2004) noted finding a dead juvenile Gulf sturgeon on a trot line in the Blackwater River. We discuss the bycatch issue in greater detail under section 2.3.2.8 as a regulatory issue.

2.3.3.7. Disease or predation

No additional information regarding the threat of disease or predation is available.

2.3.3.8. Inadequacy of existing regulatory mechanisms

Direct take of Gulf sturgeon is still prohibited in all four states within the current range of the species. However, fisheries directed at other species that employ various trawling and entanglement gear in areas that sturgeon regularly occupy pose a risk of incidental bycatch. One such fishery is directed at gars (family Lepisosteidae) in southeast Louisiana, where Gulf sturgeon mortality in entanglement gear has been observed (D. Walther, USFWS, pers. comm.). Louisiana Wildlife and Fisheries Commission staff proposed a ban on commercial netting freshwater areas of southeast Louisiana (the Florida Parishes which include East Baton Rouge, East Feliciana, West Feliciana, Livingston, St. Helena, St. Tammany, Tangipahoa, and Washington) in September 2006. The ban was intended to reduce the incidental bycatch of Gulf sturgeon. The resolution was not adopted.

Relocation trawling associated mostly with channel dredging and beach nourishment projects, which was initially intended to remove sea turtles in close proximity to dredges, has successfully moved several Gulf sturgeon in recent years. Between January 2005 and April 2006 relocation trawling captured and successfully moved two Gulf sturgeon near Mobile Bay, AL: 5 near Gulf Shores, AL, 1 near Destin, FL, and 8 near Panama City Beach, FL. These captures in near-shore waters illustrate the relative vulnerability of Gulf sturgeon to incidental bycatch in fisheries that use trawls. Bycatch in shrimp trawls has been documented but has likely been mitigated by sea turtle and fish excluder devices. However, informal conversations with shrimpers suggest that Gulf sturgeon are commonly encountered in Choctawhatchee Bay during nocturnal commercial fishing (D. Fox. Delaware State Univ., pers. com.).

Amendment Three of the Florida Constitution, known as the net ban, was approved by voter referendum in November 1994 and implemented in July 1995. The amendment was implemented in July 1995 and made unlawful the use of entangling nets (i.e., gill and trammel nets) in Florida waters. Other forms of nets (i.e., seines, cast nets, and trawls) were restricted, but not totally eliminated. For example, these types of nets could be used only if the total area of net mesh did not exceed 500 square feet. Implementation of the net ban has likely benefited sturgeon as they are residents of near-shore waters during much of their life span.

Florida's net ban has likely benefited or accelerated Gulf sturgeon recovery. Gulf sturgeon commonly occupy estuarine and coastal habitats where entangling gear was commonly used. Capture of small Gulf sturgeon in mullet gill nets was documented by state fisheries biologists in the Suwannee River fishery in the early 1970s. Large mesh gill nets and runaround gill nets were the fisheries gear of choice in historic Gulf sturgeon commercial fisheries. Absence of this gear in Florida eliminates it as a potential source of mortality of Gulf sturgeon.

Although a number of steps have been taken to reduce the potential for Gulf sturgeon to be incidentally caught by anglers or commercial operations, existing regulatory mechanisms are inadequate to prevent take of adult Gulf sturgeon due to fishing bycatch. Because the loss of a few reproducing adults directly affects population size and growth, inadequately regulated bycatch continues to be a threat.

2.3.3.9. Other natural or manmade factors affecting its continued existence

The 1991 listing rule cited the following impacts and continuing threats:

- Life history characteristics make the species slow to recolonize areas from which extirpated.
- Threat of hybridization with white sturgeon (*A. transmontanus*).

2.3.3.10. Life history characteristics and population growth

As described in Section 2.3.1.2, all new data support the previous conclusion that Gulf sturgeon are slow to recolonize areas where it was formerly found such as the Mobile River system. In addition, population growth has been shown to be very slow. Sulak (2008 Gulf sturgeon workshop) reported that it has taken nearly 100 years for the Suwannee River population to regain a semblance of its age structure prior to exploitation (early 1900's), with a shift from 10%

mature individuals in 1996 to 40% in 2007. However, recent population models for the Suwannee River population (Pine et al. 2001) predicted that slight increases in estimated annual adult mortality (from 16% to 20%) would shift the population from an increasing trend into a decline. Using an age-structured model, (Flowers 2008) concluded that the Apalachicola River population is probably slowly recovering, but will take in excess of 100 years from the time of fishery closure to reach is pre-exploitation abundance. Although we are learning more about the population structure, there continues to be a number of uncertainties requiring additional research.

2.3.3.11. Dredging

Hydraulic dredges (e.g., hopper) can lethally harm sturgeon directly by entraining sturgeon in dredge drag arms and impeller pumps. Mechanical dredges have also been documented to kill shortnose, Atlantic, and Gulf sturgeon (Dickerson 2005). Potential impacts from hydraulic dredge operations may be avoided by imposing work restrictions during sensitive time periods (i.e., spawning, migration, staging, feeding) when sturgeon are most vulnerable to mortalities from dredging activity. When possible, it is best to schedule dredging when sturgeon are not likely to be in the project area.

Dickerson (2005) summarized observed takings of 24 sturgeon from dredging activities conducted by the Corps and observed between 1990 and 2005 (2 Gulf; 11 shortnose; and 11 Atlantic). Of the three types of dredges included (hopper, clam and pipeline) in the report, hopper dredges captured the most sturgeon. Notably, reports include only those limited trips when an observer was on board to document capture and does not include sturgeon purposefully removed from the project area prior to dredging activities.

To reduce take of listed species, relocation trawling may be utilized to capture and move sea turtles and sturgeon. In relocation trawling, a boat equipped with nets precedes the dredge to capture sturgeon and sea turtles and then releases the animals out of the dredge pathway, thus avoiding lethal take. Relocation trawling has been successful and routinely moves sturgeon in the Gulf of Mexico. Seasonal in-water work periods, when the species is absent from the project area, also assists in reducing incidental take.

2.3.3.12. Hurricanes

Mortality of Gulf sturgeon as a result of hurricanes has occurred in the Escambia River following Hurricane Ivan in 2004 (USFWS 2005) and in the northern Gulf of Mexico following Hurricane Katrina in 2005. The impacts of Katrina to the population in the Pearl River are largely unknown, because few large sturgeon have been intercepted post-hurricane in the Pearl River, but it is thought many were killed (T. Ruth, LADFW, pers. com.). Reports from conservation officers on rescue and recovery in Pascagoula the first few days after Katrina reported at least eight dead Gulf sturgeon (Mike Beiser, MSDEQ, pers. com.).

2.3.3.13. Collisions with boats

Collisions between jumping Gulf sturgeon and fast-moving boats on the Suwannee River and elsewhere are a relatively recent and new source of sturgeon mortality and pose a serious public safety issue as well. The FFWC reported that in 2006, nine people were injured by direct strikes and two were injured after swerving to avoid a jumping Gulf sturgeon while boating on the Suwannee River. Nine people were also involved in incidents with jumping sturgeon during 2007, including a fatal incident: two people were ejected from their boat while turning abruptly to avoid a jumping sturgeon and one subsequently drowned. FFWC documented three collisions in the Suwannee River in 2008, and one incident as of this writing in 2009. As a result of these incidents, FFWC now maintains a public awareness campaign about the risk to the boating public with the message "Go slow on the Suwannee." Placards have been posted and distributed along the Suwannee River in areas where Gulf sturgeon are frequently spotted jumping and in areas of high boat traffic. Gulf sturgeon factsheets, large signs, and stickers provide life history information and warn boaters to proceed at slow speeds in the spring and summer. USFWS, USGS, and NMFS have collaborated with FFWC in the information campaign to alert boaters to the collision hazard and urging slower speeds.

The reason why sturgeon jump and expend energy is unknown; one hypothesis is that jumping is a form of group communication that serves to maintain group cohesion (Sulak et al. 2002). Edwards et al. (2007) note that sturgeon jump in marine waters as well.

Ship strikes may be an emerging threat to Gulf sturgeon; ship strikes are a documented threat to Atlantic sturgeon (Assrt 2007). FFWC personnel pulled a live juvenile Gulf sturgeon (< 1 m TL) with a partially severed tail from the Apalachicola River immediately following the passage of a barge tow at river mile 3.5 on September 29, 2004 (E. Lovestrand, pers. comm. 2004). The individual died within an hour after being rescued.

Public outreach and education is improving to alert boaters to slow down in areas where Gulf sturgeon are known to jump. However, the number of boating trips has been and is likely to continue increasing. Combined with the potential of extended droughts in the southeast that result in lowering the water level and subsequently concentrates both sturgeon and boaters into a smaller riverine cross-section, this threat is likely to increase. Boating collisions along with the potential mortality of adult Gulf sturgeon will threaten the stability of these small populations.

2.3.3.14. Red tide

Red tide is the common name for a harmful algal bloom (HAB) of marine algae (*Karenia brevis*) that can make the ocean appear red or brown. *K. brevis* is one of the first species ever reported to have caused a HAB and is principally distributed throughout the Gulf of Mexico, with occasional red tides in the mid- and south-Atlantic United States. *K. brevis* naturally produces a brevetoxin that is absorbed directly across the gill membranes of fish or through ingestion of algal cells.

While many HAB species are nontoxic to humans or small mammals, they can have significant effects on aquatic organisms. Fish mortalities associated with *K. brevis* events are very common and widespread. The mortalities affect hundreds of species during various stages of development. Intoxication begins with binding of PbTx to specific receptor sites in fish excitable tissues (Baden and Mende 1982). Signs of intoxication in fish include violent twisting and corkscrew swimming, defecation and regurgitation, pectoral fin paralysis, caudal fin curvature, loss of equilibrium, quiescence, vasodilation, and convulsions, culminating in death due to respiratory failure. Mortality typically occurs at concentrations of 2.5 x 10^5 *K. brevis* cells/L, which is often considered to be a lethal concentration. However, it is known that fish can die at lower cell concentrations and can also apparently survive in much higher concentrations (at 3 million cells/L). In some instances, mortality from red tide is not acute but may occur over a period of days or weeks of exposure to subacute toxin concentrations.

Since the 1990's the blooms of red tide have been increasing in frequency; the most recent outbreak occurred in 2007 and 2008. Red tide was the probable cause of death for at least 20 Gulf sturgeon in Choctawhatchee Bay in 1999 (USFWS 2000). Dead and dying Gulf sturgeon were reported to the FWRI Fish Kill Hotline in January 2006 attributed to post-bloom exposure (http://research.myfwc.com/features). More frequent or prolonged algal blooms may result from longer growing seasons predicted with climate change (FWC 2009). Red tides will likely continue to increase in frequency. Based on the best available information, toxins associated have likely killed Gulf sturgeon at both the juvenile and adult life stages. Because the loss of a small number of reproducing adults can have a significant overall effect on the status and trend of the population red tide is a threat to the Gulf sturgeon.

2.3.3.15. Aquaculture

In 2001, Florida Department of Agriculture's Division of Aquaculture (Department) established requirements for sturgeon aquaculture in the State. An application and permitting procedure requires sturgeon aquaculture producers to adhere to best management practices (BMPs), as provided by Chapter 597, Florida Statutes. Aquaculture producers obtain an aquaculture certificate of registration (http://www.floridaaquaculture.com). Chapter 9 of the Statute describes BMPs for sturgeon culture acknowledging that sturgeon aquaculture is a high-risk effort that requires holding of sturgeon for five to eight years before product is available for market. The manual also states that Florida sturgeon culture is currently limited to native Atlantic sturgeon and a few nonnative species. The sturgeon BMPs were developed after the threats or risks of hybridization from aquaculture activities were assessed in a risk assessment workshop sponsored by the Department, FFWC, and Mote Marine Laboratory in April 2000. The sturgeon BMPs require site selection and facility design to prevent the escape of all life stages, reporting of imports, health and escape, and minimum standards for protecting and maintaining offsite water quality and wildlife habitat. Failure to comply with the BMPs can result in a misdemeanor of the first degree, and is subject to a suspension or revocation of certification. The Department may, in lieu of, or in addition to the suspension or revocation, impose on the violator an administrative fine in an amount not to exceed $1,000 per violation per day.

Although BMPs have been issued for Florida, and the Department monitors farms with sturgeon onsite, the risk of hybridization and escapement still occurs. The best screening of water pipes to ensure fish do not escape via irrigation systems does not guarantee that full containment, especially for fish of smaller sizes. Effects of wind and rain associated with hurricanes and unusual weather events can cause overflow of tanks, impacts to irrigation systems, and result in unintended escape of fish. The geographic location of many farms nearby streams and rivers would allow easy entry of farmed fish into sturgeon habitat. As many farms use spring-fed wells as a their source for irrigation, sturgeon raised in farms have likely acclimated to local water temperatures and would presumably survive in local rivers. While effects of intra-specific competition between native and non-natives sturgeons are unknown, it is likely that habitat overlapping would occur as well as a potential for introduction of disease. Other states within the geographic range of the Gulf sturgeon have not implemented similar licensing, monitoring or BMPs.

Therefore, while Florida has issued BMPs and monitors sturgeon farms, the threat of introduction of captive fish into the wild, and potential hybridization continues.

2.4. Synthesis

In the 1995 Recovery Plan, recovery criteria were formulated anticipating the delineation of "management units" for delisting decisions. While this concept pre-dates the Services' 1996 Distinct Population Segment (DPS) policy, it is consistent with the DPS policy and some evidence in this review could contribute to a DPS determination. However, further evidence is necessary to establish the discreteness and significance of two or more river-based DPSs for the Gulf sturgeon.

The demographic recovery criteria in the 1995 Recovery Plan relied upon catch-unit-effort (CPUE) data, which has proven too variable to serve as a practical monitoring metric. Demographic parameters estimated from mark-recapture studies appear better suited for this purpose. Possible parameters to better estimate population status include total number of individuals, age structure (proportions of individuals in various age classes), sex ratio, genetic effective population size, and spawning success.

Mortality rate is a critical aspect in any population. Pine et al (2001) reported that Gulf sturgeon population models are especially sensitive to small increases in mortality affecting the populations. Flowers (2008) describes the historic overexploitation of Gulf sturgeon led to a change in the age-structure of the populations that reduced annual reproductive output. Given Gulf sturgeon life history characteristics such as long life, slow growth, and high age at maturity, restoration of the population age-structure will take many more years as characterized by Sulak for the Suwannee River. Care should be taken to eliminate mortality from anthropogenic sources including indirect mortality from sampling programs, fishery bycatch, mortalities from dredging operations, point and non-point sources, and boater collisions.

Abundance numbers (Appendix A) indicate a roughly stable or slightly increasing population trend over the last decade in the eastern river systems (Florida), with a much stronger increasing trend in the Suwannee River and a possible decline in the Escambia. Populations in the western portion of the range (Mississippi and Louisiana) have never been nearly as abundant, and their current status is unknown as comprehensive surveys have not occurred in the past five years. The life history characteristics of the species make current status of all the future generations vulnerable to threats. Any decline in population number would have chronic impacts and be realized via fewer progeny over many future generations.

The 1995 Recovery Plan did not include measurable criteria relative to reducing the impacts of the five listing factors of the Act that are necessary to monitor progress towards recovery. Data are not yet available to determine if population recovery is limited by factors affecting recruitment (e.g., spawning habitat quantity or quality), adult survival (e.g., incidental catch in fisheries directed at other species), or the late-maturing, intermittent reproductive characteristics of the species. It seems probable that riverine populations are being affected by various factors operating in concert and synergistically on a river-specific scale.

Direct impacts to the Gulf sturgeon and its habitat continue to affect its continued existence through: 1) present or threatened destruction, modification or curtailment of its habitat or range; 2) inadequacy of existing regulatory mechanisms; and 3) other natural or manmade factors. These factors include impacts to habitats by dams, dredging, point and nonpoint discharges, climate change, bycatch, red tide, and collisions with boats. Additional threats may include ship strikes and potential hybridization due accidental release of non-native sturgeon. The juvenile stage of Gulf sturgeon life history is the least understood, and perhaps the most vulnerable as this cohort remains in the river for the first years of its life and is therefore exposed to most of the threats faced by the species and its habitat. Further, the species long-lived, late-maturing, intermittent spawning characteristics make recovery a slow process. This review has found that the current recovery criteria are not adequate. Therefore, we are not recommending reclassification.

3. RESULTS

3.1. Recommended Classification

Based on the best available information, we believe that the Gulf sturgeon continues to meet the definition of a threatened species. While some riverine populations (e.g., Suwannee and Choctawhatchee; see Appendix A) number in the thousands, abundance of most populations is in the hundreds. Loss of a single year class could be catastrophic to some riverine populations with low abundance. Further, while directed fisheries no long occur, many threats continue and new ones are arising. New information should be available in the near future to better inform an analysis and review of the Gulf sturgeon relative to the DPS policy.

3.2. New Recovery Priority Number

No change (NMFS 8, USFWS 12).

4. RECOMMENDATIONS FOR FUTURE ACTIONS

4.1. Recovery Plan Updating

We have preliminary information that may support an analysis and review of the species regarding application of the DPS policy. The 1995 Recovery Plan was completed before policies were issued by the Services on the treatment of DPSs under the Act (61 FR 4722; February 7, 1996). Currently there is a lack of information to separate the species into population segments in accordance with the DPS policy across various genetic/geographic subdivisions. Once the ongoing genetic analysis investigating potential population structure is complete, the Services will determine if data support application of the DPS policy to the Gulf sturgeon.

The demographic recovery criteria of the 1995 plan do not reflect the best available and most up-to date information on the biology of the species. The 1995 criteria rely upon monitoring trends in catch per unit effort (CPUE) as an index to population abundance, but CPUE is too highly variable for assessing population trends. Further, the 1995 criteria do not directly address the five statutory listing/recovery factors. Five-factor-based criteria are necessary for measuring progress towards reducing threats and for determining when the protections of the Act are no longer necessary for the taxon. New criteria in a revised recovery plan should use demographic parameters that can be estimated from mark-recapture studies, including population abundance, and other appropriate metrics organized according to the statutory five factors. Since the 1995 Recovery Plan, the Services issued new guidance in 2006 regarding development of recovery planning. The new requirements include public participation, and focus on species-specific recovery programs that accommodate the unique biological capabilities and needs of the species while addressing the specific circumstances of its endangerment. An updated Gulf sturgeon Recovery Plan would need to take this new guidance into consideration.

Although the criteria of the 1995 Recovery Plan require substantial revision, the plan's outline of recovery actions has proven a useful conservation tool. Most of the progress to date towards improving our understanding of Gulf sturgeon biology and reducing threats to its survival has come from projects and studies predicated on actions formulated in the Recovery Plan, including substantial new information on migratory movements and habitats used for spawning and adult feeding, population models, population monitoring, and genetics. Despite this progress, it is still unclear whether habitat-related factors are slowing or precluding an increase in some sturgeon populations, or whether this relatively long-lived, late-maturing species will simply require additional decades of protection. A revised Recovery Plan should focus explicitly on identifying and then relieving possible limiting factors and on improving the monitoring methods that will demonstrate whether these efforts are successful.

4.2. Research

Two recent papers have highlighted the precarious position of sturgeons. The Endangered Species Committee of the American Fisheries Society (AFS) indicated that 88% of the Acipenseridae family in North America is imperiled (Jelks et al. 2008). Of the eight North American species, AFS considers four endangered (shortnose sturgeon, *A. brevirostrum*, white sturgeon, *A. transmontanus*, pallid sturgeon, *Scaphirhyncus albus*, and Alabama sturgeon, *S. suttkusi*), one threatened (Gulf sturgeon; *A. oxyrinchus desotoi)*, and two vulnerable (lake sturgeon, *A. fulvescens* and Atlantic sturgeon, *A. oxyrinchus oxyrinchus*). On the other hand, Munro et al. (2007) indicated that two major types of management measures that increase the hope for recovery of anadromous sturgeons have been implemented: 1) fishing has been banned for nearly all populations; and 2) consideration of the importance of habitat restoration has been renewed.

Standardization of survey and monitoring protocols needs to be established in order to assess the status of Gulf sturgeon populations across the range. Specific sampling metrics need to be set for inter-basin comparison of population trends. Emerging technologies that would allow remote sensing or counting of sturgeon as they migrate into rivers should be explored. Care should be taken when determining a sampling protocol to allow ample opportunity to the researcher to conduct unique investigations along with census. Results of these surveys should be reported in a standard fashion to the Services so that population trends can be determined and monitored. Posting of data to an on-line database may be considered as well as location information on chart/maps. Some metric of spawning success should be developed to allow analysis of this factor relative to population dynamics.

A better understanding of some basic life history characteristics (habitat needs, energetics, and pollution impacts) would greatly assist in predicting impacts of threats, and understanding population dynamics. Surveys across the geographic range to update population estimates, particularly in the western portion of the geographic range would assist in determining species status and population trends.

Early life stage survival has emerged as a relatively sensitive variable in the age-structured population models developed for the Gulf sturgeon (2001), but no studies have yet attempted to measure it in the field. Developing methods that would estimate annual survival rates from egg to age 3 could contribute information vital to understanding limiting factors and facilitating recovery.

Communication with individual states responsible for issuing Gulf sturgeon research permits should improve. The states have permitting authority (56 FR 49658; September 30, 1991) and no annual reporting to the Services is required. Summary information regarding permits granted, along with a description of the action would greatly assist the Services in tracking research and recovery. Adding Gulf sturgeon to ESA Section 6 agreements with the states would facilitate such annual reporting while providing potential funding for state research and management activities.

Additional analyses to determine genetic structure are essential to understand population structure. Archived tissue samples need to be analyzed and additional samples need to be collected to ensure adequate representation of each river with a known reproducing population. Genetic data along with tagging returns need to be analyzed to determine distinctiveness and effective population structure of Gulf sturgeon.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of GULF STURGEON (*Acipenser oxyrinchus desotoi*)

Current Classification: Threatened
Recommendation resulting from the 5-Year Review: **No change is needed**

Review Conducted By:

Jerry Ziewitz, U.S. Fish and Wildlife Service

Dr. Stephania Bolden, National Marine Fisheries Service

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Gail A. Carmody Date 8/24/09

REGIONAL OFFICE APPROVAL:

Acting
Lead Regional Director, Fish and Wildlife Service

Approve Aaron L Valenta Date 9-22-09

NATIONAL MARINE FISHERIES SERVICE

5-YEAR REVIEW of GULF STURGEON (Acipenser oxyrinchus desotoi)

Current Classification: Threatened
Recommendation resulting from the 5-Year Review: **No change is needed**

Review Conducted By:

Jerry Ziewitz, U.S. Fish and Wildlife Service

Dr. Stephania Bolden, National Marine Fisheries Service

APPROVAL:

Lead Assistant Regional Administrator for Protected Resources, National Marine Fisheries Service

Approve ______________ Date 9/30/09

REGIONAL OFFICE APPROVAL:

Lead Regional Administrator, National Marine Fisheries Service

for

Approve James E. Weaver Date 9/30/2009

APPENDIX A

Gulf sturgeon abundance estimates, with confidence intervals (CI), for the seven known reproducing populations.

Note: Estimates refer to numbers of individuals greater than a certain size, which varies between studies (source column) depending on sampling gear, and in some cases, to numbers of individuals that use a particular portion of the river (e.g., a summer holding area or one migratory pathway among several). Estimates are sorted by river, then by researcher and year, because estimates are not necessarily comparable between researchers due to key differences in methods and assumptions. Multiple estimates for a single year and river result from the application of multiple models or represent updated results incorporating additional data. Refer to original publication for details.

River	Year of data collection	Abundance Estimate	Lower Bound 95% CI	Upper Bound 95% CI	Source
Pearl	1993	67	28	not reported	Morrow et al. 1996
	1994	88	59	171	Morrow et al. 1996
	1995	124	85	236	Morrow et al. 1996
	1996	292	202	528	Morrow et al. 1998
	2001	430	323	605	Rogillio et al. 2001
Pascagoula	1999	162	34	290	Ross et al. 2001
	1999	193	117	363	Ross et al. 2001
	1999	200	120	381	Ross et al. 2001
	2000	181	38	323	Ross et al. 2001
	2000	206	120	403	Ross et al. 2001
	2000	216	124	429	Ross et al. 2001
Escambia	2003	558	83	1,033	USFWS 2004
	2004	573	402	745	USFWS 2004
	2006	451	338	656	USFWS 2007
Yellow	2001	566	378	943	Berg et al. 2007
	2002 spring	500	319	816	Berg et al. 2007
	2002 fall	754	408	1,428	Berg et al. 2007
	2003 spring	841	487	1,507	Berg et al. 2007
	2003 fall	911	550	1,550	Berg et al. 2007
Choctawhatchee	1999	3,000	not reported	not reported	USFWS 2000
	2000	2,500	not reported	not reported	USFWS 2001
	2001	2,800	not reported	not reported	USFWS 2002
	2007	2800	not reported	not reported	USFWS 2008
	2008	3314	not reported	not reported	USFWS 2009
Apalachicola	1983	282	181	645	Wooley and Crateau 1985
	1984	103	62	299	Barkuloo 1988
	1985	96	74	138	Barkuloo 1988
	1986	60	37	157	Barkuloo 1988
	1987	111	64	437	Barkuloo 1988
	1988	131	84	305	Barkuloo 1988
	1980	500	not reported	not reported	Pine and Martell 2009[a]

River	Year of data collection	Abundance Estimate	Lower Bound 95% CI	Upper Bound 95% CI	Source
	2005	2,000	not reported	not reported	Pine and Martell 2009 [a]
	1990	108	75	196	USFWS 1990
	1998	270	135	1,719	USFWS 1998
	1999	321	191	1,010	USFWS 1999
	2004	350	221	648	USFWS 2004
	1983	149	115	208	Zehfuss et al. 1999
	1983	111	76	146	Zehfuss et al. 1999
	1984	87	59	150	Zehfuss et al. 1999
	1984	119	87	150	Zehfuss et al. 1999
	1985	101	87	127	Zehfuss et al. 1999
	1985	117	92	142	Zehfuss et al. 1999
	1986	65	47	105	Zehfuss et al. 1999
	1986	108	92	142	Zehfuss et al. 1999
	1987	116	70	225	Zehfuss et al. 1999
	1987	103	78	128	Zehfuss et al. 1999
	1988	109	81	164	Zehfuss et al. 1999
	1988	88	69	107	Zehfuss et al. 1999
	1989	62	37	131	Zehfuss et al. 1999
	1989	91	61	120	Zehfuss et al. 1999
	1990	112	88	155	Zehfuss et al. 1999
	1990	218	114	321	Zehfuss et al. 1999
	1991	95	35	406	Zehfuss et al. 1999
	1991	144	83	205	Zehfuss et al. 1999
Suwannee	1992	2,285	1,887	2,683	Carr et al. 1996
	1987	2,473	2,002	2,944	Chapman et al. 1997
	1988	2,144	1,865	2,423	Chapman et al. 1997
	1989	3,055	2,650	3,460	Chapman et al. 1997
	1990	3,049	2,677	3,421	Chapman et al. 1997
	1991	2,097	1,779	2,415	Chapman et al. 1997
	1992	2,832	2,283	3,381	Chapman et al. 1997
	1993	5,312	3,588	7,036	Chapman et al. 1997
	1994	2,898	2,250	3,546	Chapman et al. 1997
	1995	3,370	1,807	4,933	Chapman et al. 1997
	1996	4,295	1,703	6,887	Chapman et al. 1997
	1982	3,000	not reported	not reported	Pine and Martell 2009 [a]
	2004	10,000	not reported	not reported	Pine and Martell 2009 [a]
	1987	2,059	1,490	2,890	Randall 2008
	1988	1,895	1,544	2,349	Randall 2008
	1989	2,118	1,777	2,543	Randall 2008
	1990	2,473	2,166	2,839	Randall 2008
	1991	2,923	2,516	3,409	Randall 2008
	1992	3,379	2,855	4,011	Randall 2008
	1993	4,273	3,442	5,321	Randall 2008
	1994	3,508	2,821	4,376	Randall 2008
	1995	3,579	3,122	4,119	Randall 2008
	1996	5,525	3,524	8,684	Randall 2008

River	Year of data collection	Abundance Estimate	Lower Bound 95% CI	Upper Bound 95% CI	Source
	1997	4,061	3,310	4,998	Randall 2008
	1998	7,606	5,983	9,702	Randall 2008
	1999	4,944	4,075	6,017	Randall 2008
	2000	4,217	3,149	5,660	Randall 2008
	2001	5,021	3,771	6,706	Randall 2008
	2002	5,220	3,805	7,185	Randall 2008
	2005	1,817	1,303	2,544	Randall 2008
	2006	9,728	6,487	14,664	Randall 2008
	1991	7,650	not reported	not reported	Sulak and Clugston 1999
	1998	7,650	not reported	not reported	Sulak and Clugston 1999
	2007	14,000	not reported	not reported	Sulak 2008

[a] The primary author cited characterizes these as “preliminary estimates” in reviewing this document.

* Juveniles not included in 2007 estimate.

+ Juveniles, subadults and adults included in 2008 estimate.

APPENDIX B
Summary of peer review for the 5-year review of
GULF STURGEON (*Acipenser oxyrinchus desotoi*)

A. Peer Review Method

See "B" below.

B. Peer Review Charge

On June 1, 2009, we sent out a letter and the "**Policy for Peer Review in Endangered Species Act Activities (59 FR 34270)"** through email to 16 professional biologists with expertise on the Gulf sturgeon and its habitats. The letter requested a critical review of the scientific information and data presented and asked them to identify missing literature or other relevant information. The letter was sent to the following individuals. We received comments from eight of these, which are summarized in section "C" below.

Steve Carr, Caribbean Conservation Corporation
Frank Chapman, University of Florida
Jim Clugston, U.S. Geological Survey (retired)
Jared Flowers, North Carolina Cooperative Fish and Wildlife Research Unit
Dewayne Fox, Delaware State University
Joe Hightower, North Carolina Cooperative Fish and Wildlife Research Unit
Alan Huff, Florida Fish and Wildlife Conservation Commission (retired)
Phil Kirk, U.S. Army Corps of Engineers
Scott Mettee, Alabama Geological Survey
Daryl Parkyn, University of Florida
Bill Pine, University of Florida
Howard Rogillio, Louisiana Department of Wildlife and Fisheries (retired)
Steve Ross, Eco-Consulting Services
Tim Ruth, Louisiana Department of Wildlife and Fisheries
Todd Slack, U.S. Army Corps of Engineers
Ken Sulak, U.S. Geological Survey

C. Summary of Peer Review Comments/Report

Jim Clugston, U.S. Geological Survey (retired), Gainesville, FL. Dr. Clugston's comments:

1. Overall assessment of the Gulf sturgeon is realistic based on the available data.
2. The Services did a good job at pointing out the shortcomings of the data in specific systems and the problems with using CPUE as a recovery metric. The "Recommendations for Future Actions" appear reasonable.
3. He suggested that the section on waterborne contaminants (pg. 18) could be expanded to say more about basic nutrient increases and the subtle effect on food chains, etc., as that is a big concern in the Suwannee River.
4. He inquired about the threat of hybridization with white sturgeon and suggested it be included in the aquaculture section.

Jared Flowers, North Carolina Cooperative Fish and Wildlife Research Unit, Raleigh, NC. Mr. Flowers expressed general support for the review. He was pleased with the discussion in which we recommended discontinuing our reliance upon CPUE as a monitoring metric as described in the 1995 Recovery Plan. He recommended that the Services consider genetic effective population size as an alternative metric, and provided references for its use. He offered numerous wording recommendations (e.g., substituting the word "individuals" for "fish").

Dewayne Fox, Delaware State University, Dover, DE. Dr. Fox found the status review well written and had mostly minor editorial comments. Suggested that we provide additional information on the following topics:

1. A table listing the year and location of the annual Gulf sturgeon workshops.
2. Gulf sturgeon bycatch in the commercial shrimp fishery.
3. Additional references and scientific names; clarification of some references.

Alan Huff, Florida Fish and Wildlife Conservation Commission (retired), St. Petersburg, FL. Dr. Huff supported our assessment that Gulf sturgeon are stable or increasing He noted that it would be a very positive thing to work through the DPS process. He suggested improving the red tide discussion and provided a copy of the FWC Summit Report on climate change. He suggested changing the term summer "resting" to summer "holding" throughout the document. He provided grammatical edits and identified several inconsistencies in formatting.

Phil Kirk, U.S. Army Corps of Engineers, Vicksburg, MS. Dr. Kirk agreed that more research on the biology and survival of age 0-to age-3 fish is needed. He did not recommend changes to the document.

Bill Pine, University of Florida, Gainesville, FL. Dr. Pine provided a copy of an in-press paper: "Spawning site selection and potential implications of modified flow regimes on viability of Gulf sturgeon populations". He provided minor editorial suggestions and posed several questions about the intended meaning of statements in the draft review.

Todd Slack, U.S. Army Corps of Engineers, Vicksburg, MS. Mr. Slack suggested grammatical and style edits and provided new information via recently published papers and e-mails. He clarified results of genetics analyses to which he had contributed. He suggested a modification to the Table 1 heading to clarify its contents. He provided an update on coastal restoration efforts post-hurricanes, requested clarification of relocation trawling efforts and observed takings of sturgeon by dredges. Lastly, he suggested that the anticipated increase in storm activity as a result of climate change would increase frequency of fish kills.

Ken Sulak, U.S. Geological Survey, Gainesville, FL. Dr. Sulak provided many comments:

- The draft review relied too much upon a few recent papers and he recommended additional information for our use.
- He objected to our statement that juvenile Gulf sturgeon (not young-of-the-year) "possibly" use the riverine environment for feeding.
- He noted that Gulf sturgeon from different populations mix in the riverine environment as well as the marine environment.

- He characterized as premature our statement that the species apparently no longer reproduces in the Mobile River drainage.
- He noted that several researchers have archived tissue samples that could be used for genetics analysis of population structure.
- He believes that the Suwannee population is increasing more rapidly than our characterization of "most populations are stable or slowly increasing".
- He urged us to cite several oral presentations made by him and various colleagues at recent sturgeon symposia.
- He disagreed with our characterization of Gulf sturgeon population estimates as "imprecise".
- He objected to our mention of an observation of a young-of-year sturgeon in the Santa Fe River without an accompanying reference to his work and that of others that previously documented upstream movements.
- He believes the Suwannee population meets the criteria for delisting and should be delisted.

D. Response to Peer Review

Jim Clugston, U.S. Geological Survey (retired), Gainesville, FL. We added language about waterborne contaminants, and about potential hybridization with white sturgeon.

Jared Flowers, North Carolina Cooperative Fish and Wildlife Research Unit, Raleigh, NC. We accepted all of Mr. Flowers' editorial and terminology recommendations. We added genetic effective population size to the list of parameters that might substitute for CPUE as a recovery monitoring metric in a revised recovery plan.

Dewayne Fox, Delaware State University, Dover, DE. We accepted all of Dr. Fox's editorial and terminology recommendations, added additional references where suggested, clarified language he identified as problematic, cited his review as a personal communication about potential Gulf sturgeon bycatch in commercial fisheries in and near Choctawhatchee Bay, and added language describing potential gaps in distribution to highlight the importance of the western stocks.

Alan Huff, Florida Fish and Wildlife Conservation Commission (retired), St. Petersburg, FL. We accepted all of Dr. Huff's editorial and terminology recommendations, and we enhanced the red tide and climate change sections.

Phil Kirk, U.S. Army Corps of Engineers, Vicksburg, MS. No modifications required.

Bill Pine, University of Florida, Gainesville, FL. We accepted all of Dr. Pine's editorial and terminology recommendations. We used the "in-press" manuscript that he provided in our discussion of potential impacts of flow alterations to the Gulf sturgeon. We added a footnote to his citations in Table 1 indicating the "preliminary" nature of his population estimates in Pine and Martel 2009. We clarified and expanded upon several sections where he had questions about our intended meaning.

Todd Slack, U.S. Army Corps of Engineers, Vicksburg, MS. We accepted all of Mr. Slack's editorial and terminology recommendations and incorporated the new information provided (Ross et al. 2009) into the review. We agreed that an increase in hurricanes could result in additional fish kills and added that to our climate change section. We clarified the text in the genetics section regarding intra-drainage differences and low assignment rates as he suggested.

Ken Sulak, U.S. Geological Survey, Gainesville, FL. We responded to Dr. Sulak's comments as follows:

- Where pertinent, we cited the additional references he provided. We could not rely upon the oral presentations at recent sturgeon symposia that he listed, because these were not available to us.
- We removed our reference to the "possibility" of riverine feeding by age 1+ juvenile Gulf sturgeon.
- We recognized that Gulf sturgeon from different populations mix in the riverine environment as well as the marine environment.
- We rewrote our statements pertaining to an apparent extirpation from the Mobile River system to instead acknowledge that we have no direct evidence of current Gulf sturgeon reproduction in this river system.
- Additional genetic analyses are underway. Dr. Sulak will be contacted on potential tissue samples.
- We acknowledge that the Suwannee population appears to be increasing more rapidly than all others.
- Because the oral presentations Dr. Sulak mentions are not available to us, we cannot rely upon them.
- We restated our characterization of population estimates as "imprecise", explaining that the confidence intervals are relatively broad (more than half are plus or minus 30 percent or more around the estimates). We acknowledge that recapture probabilities for Gulf sturgeon in his mark-recaptures studies are higher than reported by Zehfuss et al. (1999).
- We reduced our emphasis on the observation of a young-of-year sturgeon in the Santa Fe River and added reference to previous studies that have documented upstream movements.
- River-based populations would need to meet the criteria for Distinct Population Segments for the Service to delist any separately from the rest of the taxon. Based on existing information at this time, we do not recommend changing the listing status of the Gulf sturgeon.