# Southern Distinct Population Segment of the North American Green Sturgeon
***(Acipenser medirostris)***

## 5-Year Review:
## Summary and Evaluation

**National Marine Fisheries Service**
**West Coast Region**
**Long Beach, CA**

**5-YEAR REVIEW**
**Species reviewed: Southern Distinct Population Segment of the North American Green Sturgeon** (*Acipenser medirostris*)

## 1.0 GENERAL INFORMATION

**1.1 Lead Regional or Headquarters Office:** *Phaedra Doukakis, West Coast Regional Office, Protected Resources Division, Long Beach, CA, 858 3342838*

### 1.2 Methodology used to complete the review:

The 5-year review was conducted by a contractor in collaboration with personnel at the NOAA NMFS West Coast Region (Long Beach office). The review process included collecting information through the following: 1) a literature search for information published since the last review (2006); 2) publication of a Federal Register (FR) notice soliciting new information about North American green sturgeon (77 FR 64595; October 24, 2012); and 3) email and phone contact with knowledgeable individuals at universities, tribal agencies, and state and federal government agencies (Appendix A). Eleven (11) responses to the FR notice were received from 11 different agencies or individuals and included information on population abundance, reviews of recent literature, lists of agency reports summarizing fieldwork, fisheries data, salvage, and academic scientific studies. A draft version of this report was reviewed by West Coast Region and NMFS Northwest Fisheries Science Center personnel in addition to those listed in Appendix B. This report describes the most relevant of the new information about North American green sturgeon and how it relates to the status of the Southern Distinct Population Segment (DPS) of green sturgeon (*Acipenser medirostris*). Some information on the Northern DPS is also included where relevant. Since the Northern DPS is not listed under the Endangered Species Act, a full review of its status is not included here, but a review has been conducted, added to our file and made publically available.

### 1.3 Background:

#### 1.3.1 FR Notice citation announcing initiation of this review:

A Federal Register notice (Federal E-Rulemaking Portal Docket number: NOAA-NMFS-2012-0198) announced the initiation of this review (77 FR 64595; October 24, 2012)

#### 1.3.2 Listing history

<u>Original Listing</u>
**FR notice:** 71 FR 17757
**Date listed:** April 7, 2006
**Entity listed:** Southern Distinct Population Segment of North American green sturgeon
**Classification:** Threatened

### 1.3.3 Associated rulemakings

Critical Habitat: On Oct. 9, 2009, NMFS designated critical habitat for the Southern DPS of North American green sturgeon (74 FR 52300).

ESA 4(d) rule: On June 2, 2010, NMFS published final Endangered Species Act protective regulations (ESA 4(d) rule) for the Southern DPS of North American green sturgeon (75 FR 30714).

### 1.3.4 Review History

Status Review: In 2002, a status review was conducted by a Biological Review Team (BRT) in response to a 2001 petition to list North American green sturgeon under the Endangered Species Act (Adams *et al*. 2002). The BRT identified the Northern and Southern DPS structure that is currently applied and concluded that green sturgeon in both DPSs should be placed on the Species of Concern list (then the Candidate species list) and their status reviewed within five years (Adams *et al*. 2002). In 2005, NMFS' Southwest and Northwest Fisheries Science Centers updated the Status Review as a result of a 2004 court ruling remanding to NMFS for further consideration the issue of whether green sturgeon are endangered or threatened in a "significant portion of the species' range" (BRT 2005). The BRT updated the review and concluded that the Northern DPS was not in danger of extinction now or likely to become endangered in the foreseeable future throughout all of its range. All but one member of the BRT concluded that green sturgeon in the Southern DPS were likely to become endangered in the foreseeable future throughout all of its range.

On April 7, 2006, NMFS published notification of the listing of the Southern DPS of North American green sturgeon as Threatened (71 FR 17757). The DPS structure for North American green sturgeon was originally defined as follows: (1) a Northern DPS consisting of populations in coastal watersheds northward of and including the Eel River (''Northern DPS''); and (2) a Southern DPS consisting of coastal and Central Valley populations south of the Eel River, with the only known spawning population in the Sacramento River (''Southern DPS'') (71 FR 17757; April 7, 2006). The definition was slightly revised for accuracy with the announcement of critical habitat as follows: (1) a Northern DPS consisting of populations originating from coastal watersheds northward of and including the Eel River (*i.e.,* the Klamath and Rogue rivers) ("Northern DPS"); and (2) a Southern DPS consisting of populations originating from coastal watersheds south of the Eel River, with the only known spawning population in the Sacramento River ("Southern DPS") (74 FR 52300; Oct. 9, 2009). In the April 7, 2006 listing notification (71 FR 17757), the Northern DPS was identified as a NMFS Species of Concern but was not listed under the ESA. NMFS stated that it would revisit the status of both DPSs' in five years' time. This 5-year review focuses on the status of only the listed entity *i.e.,* the Southern DPS. The Northern DPS status is the focus of a separate informal report that has been added to our record.

### 1.3.5 Species' Recovery Priority Number at start of 5-year review

The 2010-2012 NMFS Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species (available at http://www.nmfs.noaa.gov/pr/laws/esa/noaa_esa_report_072213.pdf) lists Southern DPS green sturgeon with a Recovery Priority Number of 5. A Recovery Priority Number of 5 indicates a moderate magnitude of threat in some regions, a high recovery potential in many regions, and the presence of conflict with economic and resource use interests.

#### 1.3.6 Recovery Plan or Outline

**Name of plan or outline**: Federal Recovery Outline, North American Green Sturgeon Southern Distinct Population Segment (http://swr.nmfs.noaa.gov/gs/jd/Green_Sturgeon_sDPS_Recovery_Outline.pdf)
**Date issued**: December 2010
**Dates of previous revisions, if applicable**: N/A

## 2.0 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?

Yes.

#### 2.1.3 Was the DPS listed prior to 1996?

No.

#### 2.1.4 Is there relevant new information for this species regarding the application of the DPS policy?

Yes. Studies published since 2006 confirm the DPS structure of North American green sturgeon as defined in Section 1.3.4 of this review. These new studies are covered in Sections 2.3.1.3 and 2.3.1.5 of this review. Briefly, Israel *et al*. (2009) detailed genetic analysis of 20 collections of green sturgeon samples and 10 microsatellite loci and examined DPS composition in different estuaries along the US west coast. The study upholds the Northern and Southern DPS determination of spawning rivers. Telemetry studies and unpublished data also confirm the DPS structure (Lindley *et al*. 2008, 2011).

### 2.2 Recovery Criteria

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

No.

## 2.3 Updated Information and Current Species Status

### 2.3.1 Biology and Habitat

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

Research conducted and published since 2006 confirms and enhances our understanding of the biology and life history of Southern DPS green sturgeon, including reproductive characteristics. The following is a summary of this new information. Where reference is made to North American green sturgeon, the information is relevant to both DPSs or the original work did not specify the DPS under study. The DPS is specified where known. Much of the laboratory work conducted to date used Northern DPS broodstock, but the results are relevant to our understanding of green sturgeon biology and are reviewed here.

North American green sturgeon are thought to reach sexual maturity at about 15 years of age (Van Eenennaam *et al*. 2006) or a total length of 150-155 cm for Southern DPS individuals. Southern DPS green sturgeon typically spawn every three to four years (range two to six years) and spawning occurs primarily in the Sacramento River (Brown 2007; Poytress *et al*. 2012; pers. comm. with Mike Thomas, UC Davis, June 16, 2015; see Section 2.3.1.5 on Feather River spawning). Adult Southern DPS green sturgeon enter San Francisco Bay in late winter through early spring and spawn from April through early July, with peaks of activity influenced by factors including water flow and temperature (Heublein *et al*. 2009; Poytress *et al*. 2011).

Spawning primarily occurs in cool sections of the upper mainstem Sacramento River in deep pools containing small to medium sized gravel, cobble or boulder substrate (Poytress *et al*. 2009-2011; Wyman *et al.* unpublished). Water flow is an important cue in spawning migration for both Northern and Southern DPS green sturgeon (Benson *et al.* 2007; Erickson and Webb 2007; Heublein *et al*. 2009; Poytress *et al*. 2011, 2012; UC Davis, unpublished data). Brown (2007) documented Southern DPS green sturgeon spawning both above and directly below the site of the Red Bluff Diversion Dam (RBDD) on the Sacramento River. Continued research has identified several other spawning sites based on egg and larval surveys (Poytress *et al*. 2009-2013) and telemetry studies (Heublein *et al*. 2009; Thomas *et al*. 2013b). Seven discrete sites have been identified in the upper Sacramento River (Poytress *et al.* 2009-2013). Six of these sites are currently available to Southern DPS green sturgeon since one site was directly below the closed RBDD gates and was effectively eliminated when the RBDD was decommissioned in 2011. Prior to decommissioning, the gates at RBDD would be lowered for several months of the year from late spring through summer, prohibiting many Southern DPS green sturgeon from ascending upstream to spawn. Behavioral observations in Thomas *et al*. (2013b) indicate that males may fertilize the eggs of multiple females. Post-spawn fish may hold for several months in the Sacramento River and outmigrate in the fall or winter, or move out of the river quickly during the spring and summer months, although the holding behavior is most commonly observed (Heublein *et al*. 2009; DWR 2013; Thomas *et al.* unpublished).

North American green sturgeon eggs primarily adhere to gravel or cobble substrates, or settle into crevices (Moyle *et al*. 1995; Van Eenennaam *et al*. 2001; Poytress *et al*. 2011). Eggs incubate for a period of seven to nine days and remain near the hatching area for 18 to 35 days prior to dispersing (Van Eenennaam *et al.* 2001; Deng *et al.* 2002; Poytress *et al.* 2012). In the laboratory, metamorphosis from larvae to juvenile of Northern DPS green sturgeon occurred at approximately 45 days post-hatch, at lengths of 62-94 mm (Deng *et al.* 2002). In the laboratory, juvenile Northern DPS green sturgeon were highly tolerant to changes in salinity during the first 6 months (Allen *et al*. 2011) and the ability to transition to seawater occurred at 1.5 years of age (Allen and Cech 2007). Based on length of juvenile sturgeon captured in the San Francisco Bay Delta, Southern DPS green sturgeon migrate downstream toward the estuary between 6 months and 2 years of age (Radtke *et al*. 1966). Little is known about Southern DPS green sturgeon rearing and foraging in the San Francisco Bay Delta and estuary, but a telemetry study tracking juvenile sturgeon has been conducted and data analysis is currently underway (pers. comm. with Mike Thomas, UC Davis, January 7, 2014).

Water temperature is an important factor for North American green sturgeon spawning and viability, with field and laboratory studies indicating ranges that are thermally optimal. Temperatures in the upper Sacramento River documented during the estimated Southern DPS spawning period have ranged from 10.1°C to17.6 °C (Poytress *et al*. 2009-2012). Van Eenennaam *et al*. (2005) found that the hatching rate for Northern DPS green sturgeon eggs in the lab was slightly reduced when incubation temperatures were less than 11°C and that 17-18°C may be the upper thermal optima for embryogenesis. Laboratory studies examining larval survival between 18°C and 28°C found significant deformities in Northern DPS green sturgeon larvae reared in water temperatures of 20°C and greater and impacts on larval survival at temperatures greater than 26°C (Linares-Casenave *et al*. 2013). Developmental abnormalities were also observed in another study of Northern DPS green sturgeon larvae in laboratory conditions at 26°C (Werner *et al.* 2007). Optimal bio-energetic performance of age-0 and age-1 Northern DPS green sturgeon in the laboratory occurred at temperatures between 15-16°C, with an upper limit of 19°C (Mayfield and Cech 2004). Juvenile Northern DPS green sturgeon (mean age: 150 days) can handle elevated temperatures in the laboratory (up to 24°C tested) without showing compromised swimming performance, but temperatures above 19°C were correlated with higher expression of heat shock proteins (Allen *et al.* 2006). While much of the laboratory data reviewed above has been generated using Northern DPS broodstock, it is likely applicable to the life-history of the Southern DPS.

Subadult and adult North American green sturgeon spend most of their life in the coastal marine environment. Tagging data indicate that green sturgeon typically occupy depths of 20-70 m while in marine habitats (Erickson and Hightower 2007; Huff *et al.* 2011) and make rapid vertical ascents while in marine environments, often at night (Erickson and Hightower 2007). Temperatures occupied in the marine environment ranged from 7.3-16 °C, with a range of mean temperatures from 10.5-12.5 °C (Erickson and Hightower 2007;

Huff *et al.* 2011). It should be noted that the depth and temperature range occupied within the marine coastal environment by individual green sturgeon studied varied considerably and thus a range of thermal regimes can be occupied by subadult and adult green sturgeon in coastal and marine environments. Southern DPS green sturgeon are found in high concentrations in coastal bays and estuaries along the west coast of North America during the summer and autumn, particularly in Willapa Bay, Grays Harbor, and the Columbia River estuary. Recent data indicate that the majority of these fish are either immature or in the early stages of maturation (WDFW and ODFW 2012). Additional information on spatial distribution is provided in the corresponding section below.

Overall, the new information on the biology of the species provides insights for protecting Southern DPS green sturgeon habitat in freshwater and marine environments. Access to spawning habitat has been improved with the decommissioning of RBDD. Although removal of RBDD eliminated a known spawning area, the overall impact of its removal is positive in addressing the passage issue and allowing more green sturgeon to access spawning areas above RBDD (Thomas *et al.* unpublished); nevertheless, recruitment data are not presently available to measure the impact of the removal of RBDD on Southern DPS reproduction. Laboratory and field studies indicate optimal thermal regimes in freshwater environments, while field studies suggest the thermal profiles occupied by green sturgeon in the marine environment. Limited studies have been conducted to examine rearing and foraging of juvenile Southern DPS green sturgeon in the San Francisco Bay Delta and Estuary. Estuaries along the West coast are important habitats for subadult and adult Southern DPS green sturgeon. No changes to the species status or threats are evident since the last review, although the threat posed by RBDD as a passage barrier has been eliminated.

### 2.3.1.2 Abundance and demographic trends

Since 2006, modeling, genetic, and field-based studies, many targeting species other than green sturgeon, have provided information on the Southern DPS green sturgeon population. Young-of-year presence has been incidentally documented during juvenile salmonid monitoring efforts at the RBDD and near the Glenn Colusa Irrigation District (GCID) pumping facility, both located on the upper Sacramento River. Using rotary screw traps set downstream of RBDD, USFWS captured approximately 7,500 larval Southern DPS green sturgeon from 1994 to 2011, with approximately 3,700 larvae collected in 2011 (Poytress *et al.* 2012). Over 2,000 Southern DPS green sturgeon larvae were also collected in fyke nets and rotary screw traps at GCID between 1986 and 2003. Caution is needed in interpreting these data as reflective of abundance since the surveys were not designed to measure green sturgeon abundance. Annual distributions of larvae have been found to peak during June and July at RBDD (with the exception of 2012 when only a June peak was observed) and July at GCID (Adams *et al.* 2002, 2007; Poytress *et al.* 2011-2013).

Israel and May (2010) used genetic analyses to estimate the number of Southern DPS green sturgeon spawning individuals in the upper Sacramento River (above RBDD). The study was conducted prior to the decommissioning of RBDD, so the results are relevant to spawning success above RBDD when it was operational. Their kinship analysis of larvae collected at RBDD indicated an estimated 10-28 individual Southern DPS green sturgeon effectively reproduced above RBDD in the upper Sacramento River annually (Israel and May 2010). This effective spawning population estimate was stable over the five year sampling period (2002-2006). It is important to note that the sampling design presents limitations. Water column sampling was limited, sample sizes were generally small, and sampling did not include animals spawning downstream of RBDD, so these numbers do not represent a complete estimate of the effective adult spawning population during the sampling period. Sampling may have also preferentially selected for larvae from spawning occurring immediately above RBDD. As noted above, the study was also conducted prior to the decommissioning of RBDD (2011) when upriver access by Southern DPS green sturgeon to spawning habitat was limited.

The California Department of Fish and Wildlife (CDFW) conducts annual field sampling for sturgeon in San Pablo and Suisun Bays in the months of August through October. Reports from 2005-2012 describe encounters with relatively small numbers of subadult and (to a lesser extent) adult Southern DPS green sturgeon (2005: 14; 2006: 28; 2007: 17; 2008: 14; 2009: 103; 2010: 37; 2011: 16; 2012: 17; 2013: 7 ; 2014: 30); annual reports are available at http://www.dfg.ca.gov/delta/data/sturgeon/bibliography.asp). The high capture rate in 2009 occurred because of encounters with a large aggregation of green sturgeon, particularly in San Pablo Bay (pers. comm. with Marty Gingras, CDFW, May 10, 2013). Since the study is primarily designed to study white sturgeon, the results cannot be interpreted for estimates of or trends in Southern DPS abundance.

Dual Frequency Identification Sonar (DIDSON) surveys of aggregating sites in the upper Sacramento River are providing the first data on the number of spawning adults in the Southern DPS population. Preliminary results from 2010-14 surveys indicated the presence of the following number of adult Southern DPS green sturgeon in the Sacramento River (with 95% confidence interval): 2010: 164 ± 47; 2011: 220 ± 42; 2012: 329 ± 57; 2013: 338 ± 61; 2014: 526 ± 64; pers. comm. with Ethan Mora, UC Davis, May 6, 2015). Sampling in 2010-12 on the Klamath and Rogue Rivers, where, presumably, only Northern DPS green sturgeon occurred, indicated higher numbers of Northern DPS green sturgeon for those years (Klamath 2010: 349 ± 52; 2011: 471 ± 42; 2012: 386 ± 45; Rogue 2010: 327 ± 50; 2011: 454 ± 46; 2012: 329 ± 27; pers. comm. with Ethan Mora, UC Davis, May 6, 2015). Based on these numbers and estimates of mean spawning periodicity, the total number of adults in the Northern DPS population is estimated at 2,334 ± 1,221 (pers. comm. with Ethan Mora, UC Davis, May 6, 2015). The total number of adults in the Southern DPS population is 1,348 ± 524 (pers. comm. with Ethan Mora, UC Davis, May 6, 2015).

A few caveats must be considered regarding the total run size of Northern and Southern DPS green sturgeon (pers. comm. with Ethan Mora, UC Davis, May 6, 2015; May 19, 2015). Video surveys to verify that the animals in the study area were green sturgeon were conducted annually, but data analysis has only been performed for 2010, when 100% of the animals were positively identified as green sturgeon. This 100% green sturgeon assumption was used for all other years. The numbers above also do not include the green sturgeon in between sampling units during sampling periods. The estimates also do not include green sturgeon spawning in the Feather River (see Section 2.3.1.5).

ODFW and WDFW generated estimates of subadult and adult Northern and Southern DPS green sturgeon in Willapa Bay, Grays Harbor and the Columbia River based on tagging and recapture studies and subsequent analyses (ODFW & WDFW 2014). Two modeling approaches were used. The Jolly-Seber POPAN formulation estimated a population of 40,445 sub-adult and post spawn adult green sturgeon (95% CI 25,273 to 65,274). The Robust Design method suggested a lower population abundance estimate of 4,027 to 39,959.). Based upon genetic information, 60% of these individuals would belong to the Southern DPS. Caveats to the methods are discussed and the authors conclude an estimate of 40,000 subadult and adult green sturgeon is a reasonable estimate given the results of DIDSON work in natal rivers (ODFW & WDFW 2014). It should be noted that these estimates are unpublished and have not been peer-reviewed, so caution should be taken in interpreting and utilizing these preliminary estimates.

The number of holding areas (i.e., specific areas in the river where green sturgeon congregate) occupied by Southern DPS green sturgeon in the Sacramento River for the five years surveyed was small (22) when compared to the number holding areas that were considered suitable based on depth and were surveyed (125) (pers. comm. with Ethan Mora, UC Davis, May 19, 2015). Holding areas with sturgeon were, however, distributed across most (i.e., 75 miles) of the study area. There was also a difference in the holding areas occupied by sturgeon during any given sampling year: some areas were occupied in all years, some in just one year, and some in two, three, or four years. Thus, there is temporal and spatial variation in the holding areas occupied by Southern DPS green sturgeon within the Sacramento River.

In summary, recent studies are providing preliminary information on the population abundance of Southern DPS green sturgeon. Future surveys and abundance estimates will provide a basis for understanding the population trajectory of the Southern DPS. Since there are no past survey data or abundance estimates that can be used as a reference point, these data do not provide a basis for changing the status of the Southern DPS. These data do suggest that the spawning population of the Southern DPS is smaller than the Northern DPS, which is consistent with the threatened listing for the Southern, but not the Northern, DPS. It should be noted, however, that the confidence interval for the Southern and Northern DPS total adult population estimate overlaps when one considers the lower bound of the Northern DPS estimate and the upper bound of the Southern DPS estimate (Northern DPS: 1,113-3,555 adults; Southern DPS: 824-1,872 adults). The spawning population of the Southern DPS in the Sacramento River congregates in a limited area of the river compared to potentially available habitat. The reason for this is unknown. This is concerning given that a catastrophic or targeted poaching event impacting just a few holding areas could affect a significant portion of the adult population. No comparable data on holding area occupancy within the Sacramento River were available at the time of the last status review making it difficult to assess whether the current observations reflect an improvement or decline in the species status. Removal of RBDD did allow Southern DPS green sturgeon to freely access a larger area of the river over their entire spawning period (Thomas *et al.* unpublished), so the Southern DPS likely now holds in a larger area of the river compared to prior to the decommissioning of

RBDD in 2011. Continued monitoring of the adult population in the Sacramento River will provide valuable trend data and information to enhance spatial protection. Of note is the fact that all of the holding areas where green sturgeon were found in the Sacramento River in the DIDSON survey area (Highway 32 overcrossing to the city of Redding) are currently included in the area where CDFW restrictions prohibit fishing for all sturgeon species (See Section 2.3.2.2). No changes to the species status or threats are evident since the last review based on the reviewed information on abundance and demographic trends.

#### 2.3.1.3 Genetic applications

Israel *et al*. (2009) detailed the genetic analysis of 20 collections of green sturgeon samples using 10 microsatellite loci to examine the DPS composition in different estuaries along the US west coast. The samples studied were collected from the Sacramento (N=266; 2002-2006), Klamath (N=124; 1998, 2001, 2003), and Rogue (N=113; 2000, 2002, 2004) River spawning populations as well as from non-spawning, estuary sites including San Pablo Bay (CA) (N=219; 2001, 2004) in the south, and Winchester Bay (OR) (N=119; 2000, 2002), Columbia River (WA) (N=175; 1995, 1999, 2004), Willapa Bay (WA) (N=98; 2003), and Grays Harbor (WA) (N=82; 2005) in the north. The study upholds the distinction between Northern and Southern DPS spawning rivers.

The areas sampled differed in the composition of Northern and Southern DPS green sturgeon. Overall, the majority of individuals in northern estuaries originated from the threatened Southern DPS, except for in Winchester Bay and Grays Harbor. Winchester Bay had a large range in stock composition (0.16–0.55 originating from the Southern DPS) between years and sampling methods, so no generalization could be made. Grays Harbor had nearly equal proportions of Northern and Southern DPS green sturgeon, with slightly more Northern DPS (0.54–0.59) than Southern DPS green sturgeon. The Columbia River and Willapa Bay had more Southern (0.69–0.88) than Northern DPS green sturgeon. San Pablo Bay samples were almost exclusively from Southern DPS green sturgeon. This mixed composition in northern estuaries means that conservation efforts must include all estuaries throughout the range of the Southern DPS green sturgeon. Protective regulations governing green sturgeon take exist across this range (See Section 2.3.2.2) and the magnitude of some other threats in northern estuaries have decreased since 2006 (See Section 2.3.2.5). The information summarized in this section does not change the status of the species or the imminence or magnitude of any threat since the genetic data only confirm the DPS structure and add detail to the DPS composition in different estuaries during the sampling periods.

#### 2.3.1.4 Taxonomic classification or changes in nomenclature

There were no relevant studies examining taxonomic classification since the last status review.

#### 2.3.1.5 Spatial distribution

Work published after 2006 enhances our knowledge of North American green sturgeon spatial habitat use and distribution. In general, subadult (from the age of ocean entry to age of first spawning) and adult North American green sturgeon spend most of their lives in oceanic environments where they occupy nearshore coastal waters from the Bering Sea, Alaska (Colway and Stevenson 2007) to Baja California, Mexico (Rosales-Casian and Almeda-Juaregui 2009). Information submitted for this review indicates that North American green sturgeon are observed infrequently in Alaskan waters (ADFG 2012).

Telemetry data and genetic analyses suggest that Southern DPS green sturgeon generally occur from Graves Harbor, Alaska to Monterey Bay, California (Moser and Lindley 2007; Lindley *et al*. 2008, 2011) and, within this range, most frequently occur in coastal waters of Washington, Oregon, and Vancouver Island and near San Francisco and Monterey bays (Huff *et al*. 2012). Within the nearshore marine environment, tagging and fisheries data indicate that Northern and Southern DPS green sturgeon prefer marine waters of less than a depth of 110 m (Erickson and Hightower 2007).

Adult and subadult Southern DPS green sturgeon have been observed in large concentrations in the summer and autumn within coastal bays and estuaries along the west coast of the US, including the Columbia River estuary, Willapa Bay, and Grays Harbor (Moser and Lindley 2007, Lindley *et al*. 2008, 2011; WDFW and ODFW 2012). These areas, particularly Willapa Bay, are likely used for foraging and possibly as thermal refugia (Moser and Lindley 2007). The Umpqua River estuary seems to be a preferred habitat for the Northern DPS (Lindley *et al*. 2011). Recent fieldwork indicates that Southern DPS green sturgeon generally inhabit specific areas of coastal estuaries near or within deep channels or holes, moving into the upper reaches of the estuary, but rarely into freshwater (WDFW and ODFW 2012). Green sturgeon in these estuaries may move into tidal flats areas, particularly at night, to feed (Dumbauld *et al*. 2008). Adult Southern DPS green sturgeon were tracked by ship in the San Francisco Estuary (Kelly and Klimley 2012; Kelly *et al.* 2007). Individual Southern DPS green sturgeon occupied the flats during low flows and moved within the channels during high flows, generally swimming near the bottom. There is some evidence that they display 'rheotaxis', gaining directional information from the flow of the water. Southern DPS green sturgeon display within population level diversity in their spatial and temporal use of coastal estuaries that somewhat corresponds to the individual size of the animal (Lindley *et al.* 2008, 2011). Green sturgeon also move extensively within an individual estuary and between different estuaries (e.g., between Willapa Bay and the Columbia River) during the same season (Moser and Lindley 2007; WDFW and ODFW 2012).

Lindley *et al.* (2008) tagged 213 subadult and adult Northern and Southern DPS green sturgeon in the Columbia River estuary, Klamath River, Rogue River, San Pablo Bay (California), and Willapa Bay (Washington) with ultrasonic pingers and tracked the animals through arrays of automated hydrophones deployed along the North American west coast. The authors found that most, but not all, green sturgeon migrated annually along the continental shelf, traveling from U.S. to Canadian waters in the fall and returning in the spring. The work corroborates earlier findings of concentrations of green sturgeon in the northwest Vancouver Island area during May through June and October through November.  The work also noted detection of only one tagged green sturgeon in southeast Alaska, reinforcing the idea that green sturgeon only rarely enter Alaskan waters.  The tagged green sturgeon was later confirmed as belonging to the Southern DPS.

Expanding on this, Lindley *et al.* (2011) described the movements of 355 Northern and Southern DPS green sturgeon tagged with acoustic transmitters in the Columbia River estuary, the Klamath River, the Rogue River, San Pablo Bay, the Sacramento River, Willapa Bay, and Grays Harbor.  The authors describe green sturgeon occurrence in estuarine and coastal sites (Columbia River estuary, Willapa Bay, Grays Harbor, and the estuaries of smaller rivers in Oregon, particularly the Umpqua River estuary) in summer months as noted above.  Green sturgeon from different natal rivers exhibited different patterns of habitat use, with San Francisco Bay used only by Sacramento River fish and the Umpqua River estuary used mostly by fish from the Klamath and Rogue rivers.  The Columbia River was visited by fish from the Rogue and Klamath River populations as well as the Sacramento, with the Northern DPS found in higher proportion to the Southern DPS in 2005 in the Columbia River estuary, and the Southern DPS found in higher proportion in 2006.  Based on genetic analysis of samples collected in 1995, 1999, and 2004, Israel *et al*. (2009) found that Southern DPS green sturgeon occurred at higher frequency in the Columbia River in the three years sampled.  As such, there may be substantial inter-annual variation in the use of some habitats like the Columbia River.  Relatively small sample sizes may have biased these results.

Lindley *et al*. (2011) further confirmed the green sturgeon DPS structure given that green sturgeon tagged in the Klamath or Rogue Rivers were not detected at the Golden Gate Bridge area and green sturgeon tagged in San Pablo Bay/Sacramento River area were not detected in the Rogue or Klamath Rivers.  Green sturgeon tagged in the Klamath River were detected in the Rogue River, consistent with the idea that green sturgeon originating from the two rivers belong to one DPS.  Movement between the two rivers was infrequent.  Northern DPS green sturgeon showed a high affinity for the Umpqua River estuary.  Newer acoustic tagging studies in the Umpqua estuary found that only a few tagged fish (three of 20) were subsequently detected in the Sacramento River (WDFW and ODFW 2012).  In the San Francisco Bay estuary, spawning Southern DPS adults equipped with acoustic tags appear to utilize the area as a migration corridor, passing through the estuary within a matter of days (Heublein *et al.* 2009).  Additional telemetry data suggest that subadults and non-spawning adults utilize the San Francisco Bay area in the summer for other reasons, possibly to feed, as residency periods are longer (Lindley *et al.* 2011).

Section 2.3.1.1 describes current knowledge regarding spawning behavior and timing of Southern DPS green sturgeon in the Sacramento River below Keswick and Shasta dams.  Whether Southern DPS green sturgeon ever spawned above the Keswick and Shasta dams has been debated (Beamesderfer 2005), with the original status review indicating spawning in these reaches (Adams *et al*. 2007).  An analysis based on the habitat occupied at present versus the habitat available above the dams indicates that green sturgeon likely did occupy areas above the dams before dam construction (Mora *et al*. 2009). Adult green sturgeon have been observed in other rivers such as the lower Yuba River downstream of Daguerre Point Dam (Cramer Fish Sciences 2011). Although sturgeon have been observed in the Russian River, the only known photo is of a white sturgeon. Data from angler self-reporting through the Sturgeon Report Cards distributed by CDFW indicate report of six green sturgeon in the San Joaquin River between 2007 and 2011 (in Jackson and Van Eenennaam 2012). Modeling indicates that spawning could have been supported in the San Joaquin River based on the habitat that existed in this system historically (Mora *et al*. 2009).

Studies in the Feather River have documented spawning by Southern DPS green sturgeon (Seesholtz et al. 2014). Seesholtz and Manuel (2012) performed DIDSON surveys in the river and estimated 21-28 sturgeon in-river for 2011 and at least three to four sturgeon in-river during the 2012 spawning season. Visual information confirms that these counts include green sturgeon. The reason that fewer sturgeon were observed in 2012 is possibly due to a lack of high flow events upstream in the Feather River in that year (pers. comm. with Alicia Seesholtz, DWR, May 8, 2013). A total of 53 images of sturgeon were observed in the Feather River DIDSON surveys in 2013, comprising a minimum of six individuals (pers. comm. with Alicia Seesholtz, DWR, January 17, 2014). Two green sturgeon were captured and tagged in the Feather River in 2011. Seesholtz *et al*. (2014) described egg mat studies that collected 13 fertilized green sturgeon eggs in June of 2011, indicating that Southern DPS green sturgeon are using the Feather River for spawning. This report further detailed sturgeon sightings (biologist, angler sighting or catch, acoustic detection) from the late 1990s through 2011. The breach of Shanghai Bench on the Feather River in early 2012 likely eliminated this naturally formed passage barrier (flow dependent) in the lower Feather River (pers. comm. with Alicia Seesholtz, DWR, May 13, 2013). Tagged green sturgeon have been recorded as making upstream and downstream forays from the breached area (DWR 2013).

In 2011, WDFW and ODFW (2012) found an age-0 North American green sturgeon in the Columbia River downstream of the Bonneville Dam. This is the first time an age-0 green sturgeon has been observed in the Columbia River. The specimen was retained and preserved, and genetic analysis has confirmed that the animal is a green sturgeon.

Data generated since 2006 regarding the spatial occupancy of Southern DPS green sturgeon reinforces the DPS structure and the importance of coastal and estuarine habitats along the west coast of the US. New research documents spawning by the Southern DPS in the Feather River. While the research gives greater insight into the geographic areas occupied by the Southern DPS, the research does not identify any new threats or point to a change in the imminence or magnitude of any existing threats. Based on this, the new information does not support any change in species status.

#### 2.3.1.6 Habitat

One primary concern for Southern DPS green sturgeon is spawning habitat suitability in terms of water flow and temperature in the Sacramento, Yuba, and Feather rivers.

Comparative analyses of historic and contemporary hydrologic and thermal regimes indicate that habitats in all of these rivers are different than they were before dam construction (see Section 2.3.2.1). What is less clear is the impact that this has had on green sturgeon spawning and recruitment. Mora *et al*. (2009) suggest that flow regulation has had mixed effects on habitat suitability.

In the Sacramento River, the removal of RBDD as a barrier to migration has increased the use of upstream spawning habitat by Southern DPS green sturgeon (Thomas *et al.*, unpublished). Southern DPS green sturgeon are now spawning in higher reaches of the river as compared to the last review. Modeling studies predict that Southern DPS green sturgeon would use additional areas on the Sacramento River in the absence of impassable dams (Mora *et al*. 2009). This modeling work also found that suitable spawning habitat historically existed on portions of the San Joaquin, lower Feather, American, and Yuba rivers, much of which is currently inaccessible for green sturgeon due to the presence of barriers.

Flood bypass systems along the Sacramento River pose a challenge to Southern DPS green sturgeon during spawning migrations. Green sturgeon are particularly affected at the Yolo and Sutter bypasses and by Tisdale and Fremont weirs (Thomas *et al*. 2013a). In 2011, 24 Southern DPS green sturgeon that had been stranded in two flood diversion areas after a high flow event were equipped with acoustic transmitters and moved out of the stranding area to track their subsequent survival and migration (Thomas *et al*. 2013a). Acoustic tagging data indicate that seventeen of the tagged animals continued migrating upstream and 22 of the tagged animals out-migrated. Thomas *et al*. (2013a) present a modeling analysis indicating that rescue of the animals is important for population viability, but also note that fish passage improvement (rather than continued rescue) is a more appropriate long-term goal for mitigating this threat. Improvements to bypass systems will occur as part of required actions as per the Reasonable and Prudent Alternatives (RPA's) within the biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project (NMFS 2009a, 2011).

WDFW and ODFW (2012) noted two issues that may affect prey resources for Southern DPS green sturgeon in coastal bays and estuaries. Over the past five years, the presence of Japanese eelgrass (*Zostera japonica*) has increased in the upper intertidal mudflats in coastal estuaries of Northern California, Oregon, and Washington (in ODFW and WDFW 2012). This negatively impacts habitat for burrowing shrimp, which are a major component of the green sturgeon diet in these estuaries. Information is not yet available regarding the impacts of these changes on green sturgeon. Visual surveys in Willapa Bay, Washington, where *Z. japonica* is found, indicated that North American green sturgeon feeding pits are most dense in areas of high burrowing shrimp abundance and lowest in areas with high *Z. japonica* stem densities (pers. comm. with Mary Moser, NMFS, June 18, 2015). This indicates that green sturgeon may have difficulty feeding in the substrate that has been invaded by Japanese eelgrass (pers. comm. with Mary Moser, NMFS, June 18, 2015). An invasive isopod affecting blue mud shrimp (*U. pugettensis*) in northern estuaries (Chapman *et al.* 2012) could have an impact on green sturgeon prey resources, but the issue requires additional research (pers. comm. with Olaf Langness, WDFW, and Brett Dumbauld, USDA-ARS, May 22, 2013).

New information on Southern DPS habitat indicates that the Southern DPS still faces threats posed by impassable barriers and flood bypass systems. The removal of RBDD has, however, resulted in additional spawning habitat availability and utilization. Hydrological and thermal regimes in spawning habitats are altered as compared to historic profiles, which could impact recruitment and recovery (see Section 2.3.2.1). Invasive species may be impacting Southern DPS prey resources in coastal estuaries. Overall, the new information does not provide conclusive data indicating that habitat conditions and factors have changed in severity or degree of threat since 2006, since additional research is needed.

### 2.3.2 Five-Factor Analysis

#### 2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range

The final rule listing Southern DPS green sturgeon indicates that the principle factor for the decline in the DPS is the reduction of spawning to a limited area in the Sacramento River (71 FR 17757; April 7, 2006). Keswick Dam on the Sacramento River and Oroville Dam on the Feather River were noted as impassible barriers (71 FR 17757; April 7, 2006). No change in the status of these dams has occurred since 2006. Potential barriers to adult migration also include Red Bluff Diversion Dam (RBDD), Sacramento Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, the Anderson Cottonwood Irrigation District (ACID) dam and the Delta Cross Channel Gates on the Sacramento River, and Shanghai Bench and Sunset Pumps on the Feather River (BRT 2005; 71 FR 17757; April 7, 2006). The Fish Barrier Dam on the Feather River and the Daguerre Dam on the lower Yuba River are also recognized as limiting the distribution of the Southern DPS (74 FR 52300; October 9, 2009). Two cited barriers (RBDD and Shanghai Bench) have undergone changes since 2006. As discussed above, the decommissioning of RBDD now permits passage of Southern DPS green sturgeon during all months when they are present in the river. The breach of Shanghai Bench on the Feather River in early 2012 likely eliminated this naturally formed passage barrier (flow dependent) in the lower Feather River (pers. comm. with Alicia Seesholtz, DWR, May 13, 2013).

Temperature and flow have been shown to be relevant parameters with respect to spawning, survival and growth of North American green sturgeon (see Section 2.3.1.). In the Sacramento River, the California State Water Resource Control Board Water Rights Orders 90-05 and 91-01 and the RPA issued for the long-term operations of the Central Valley Project and State Water Project (NMFS 2009a, 2011) requires maintenance of 13.3°C water temperature at a compliance point ranging from RBDD to above the confluence of the Sacramento River and Clear Creek. The CALFED Science Review Panel (2009) felt temperatures associated with this compliance point may reduce the growth rate of larvae and post-larvae relative to warmer temperatures (CALFED Science

Review Panel 2009). Under laboratory conditions, Mayfield and Cech (2004) reported optimal bio-energetic performance of age 0 and age 1 Northern DPS green sturgeon from 15 to 19°C. Summer water temperatures in the upper Sacramento River have typically been below this range. However, the compliance point has not been maintained in the Sacramento River during periods of 2014 and 2015 due to the historic drought. This change in temperature management has increased water temperatures throughout the green sturgeon spawning range in the Sacramento River. Summer flows are also expected to decrease as a result of the drought conditions. The effects of these water temperature and summer flow changes in the Sacramento River on survival and recruitment of green sturgeon requires further attention. NMFS' Southwest Fisheries Science Center is developing a study to model egg, larval, and juvenile green sturgeon survival as influenced by different conditions in the Sacramento River (i.e., water temperature, flow, food availability). UC Davis will be undertaking green sturgeon growth trials in the laboratory under varying temperatures and rations to inform this model. Development of a green sturgeon monitoring plan is also currently underway and juvenile year class indices may be available to compare effects of water temperature and flow on recruitment in the future.

In summary, the available information generated since 2006 indicates that impassible barriers still pose a threat to Southern DPS green sturgeon, although the threat is reduced with the removal of RBDD. Maintenance of a temperature compliance point of 13.3°C on the Sacramento River was in place when the last review was written. With the removal of RBDD, Southern DPS green sturgeon are spawning in greater numbers in higher reaches and the larvae are now rearing in the area influenced by the temperature compliance point. That said, the compliance point has not been consistently maintained and summer flows have been reduced due to recent drought conditions. Laboratory, modeling, and field studies will be conducted to look at the impact of flow and temperature regimes on spawning and recruitment of the Southern DPS. Given the present data, there is no evidence that the threat posed by modification of habitat has increased in severity since the last review.

### 2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes

In the final rule, past and present commercial and recreational fishing as well as poaching were recognized as factors that pose a threat to the Southern DPS (71 FR 17757; April 7, 2006). No estimate of an annual rate of mortality due to poaching has become available since the last review. The threat posed by commercial and recreational fishing has decreased since 2006 given that intentional lethal take of green sturgeon has been prohibited through fishing regulations. Regulations prohibit retention of green sturgeon in California, Oregon, and Washington state fisheries and in federal fisheries in the US and Canada (see below for additional details on regulations). These regulations pertain to the range of both Southern and Northern DPS green sturgeon to address the possibility of capture of the threatened Southern DPS throughout the coast.

Retention of North American green sturgeon is not currently permitted in any state fishery. As of 2006, WDFW and ODFW prohibited the commercial retention and sale of green sturgeon in the Columbia River and WDFW subsequently made this commercial restriction effective state-wide. Sale of green sturgeon incidentally caught during commercial ocean fisheries and coastal estuarine shad fisheries was prohibited in Oregon in January 2010. The retention of green sturgeon in the Columbia River recreational fisheries was prohibited effective January 1, 2007 and WDFW later made this recreational restriction effective statewide. Oregon made this closure statewide in all waters outside the Columbia River on March 15, 2010. In California, state regulations prohibit take (as defined by the state as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill), and possession of green sturgeon in the sport fishery has been prohibited since 2006; commercial harvest of any sturgeon species has been prohibited by the state since 1917 (pers. comm. with Marty Gingras, CDFW, June 11, 2013 and November 16, 2013). The CDFW further prohibits take of any sturgeon (white or green) in the Sacramento River between Keswick Dam to the Highway 162 Bridge in order to protect spawning green sturgeon (CCR, Title 14, Sec. 5.80, 5.81).

State officials performed observations of commercial fisheries in 2011 and 2012 in the lower Columbia River and Grays Harbor and Willapa Bay estuaries to detect rates of encounters with green sturgeon. Encounters occurred mostly in the summer/fall period. Most encounters were observed in Willapa Bay (WDFW and ODFW 2012). Estimates based on past encounters suggest that Washington commercial fisheries outside of the lower Columbia River annually encounter 311 Southern DPS green sturgeon (pers. comm. with Kirt Hughes, WDFW January 30, 2015). No error range was provided with this point estimate. An estimated 271 Southern DPS green sturgeon are annually encountered in lower Columbia River commercial fisheries (NMFS 2008). No error range was provided with this point estimate.

Agency statistics from self-reporting and observation give additional information about North American green sturgeon encounters in recreational fisheries in Washington and Oregon. In 2011, a total of 259 individual green sturgeon were encountered by recreational fisheries in the lower Columbia River (WDFW and ODFW 2012). This number is on the higher end of what is generally observed annually (see Table 2 in WDFW and ODFW 2012). A small number of green sturgeon (≤10) are still annually retained in this fishery due to misidentification. This number is far fewer than the number of animals that were retained before retention was prohibited in 2007 (up to 533 individuals in 1985). Of the 259 individuals encountered, 223 would be expected to be Southern DPS green sturgeon based on the higher range estimate of Israel *et al*. (2009). NMFS (2008) estimated fewer Southern DPS green sturgeon handled in the lower Columbia (52), with 7-10 still retained annually due to misidentification. In Washington, recreational fisheries outside of the Columbia River may encounter up to 64 Southern DPS green sturgeon annually (pers. comm. with Kirt Hughes, WDFW January 30, 2015). Angler self-reported data from Oregon indicate encounters of green sturgeon are low but fluctuate, from a high of 209 individual green sturgeon in 1996 to a low of 12 individuals in 2010 and 0 in 2011 (in WDFW and ODFW 2012). Most of this capture occurs in Tillamook River and Bay and the Umpqua River and Bay sport catch areas. No green sturgeon have been reported in Washington coastal and Puget Sound recreational fisheries (outside of Willapa Bay and Grays Harbor) since the 2007 closure to retention, although anglers are only required to report fish kept, not those released.

New information indicates a correction is needed regarding historic and present fishing in Willapa Bay. The 2002 status review (Adams *et al.* 2002) and the 2005 update (BRT 2005) as well Adams *et al.* (2007) reference Treaty catch of green sturgeon in Willapa Bay in 1986, 1994 and 1998. After further investigation, it has been discovered that treaty fisheries for green sturgeon have never occurred in Willapa Bay and do not occur at present. Thus, reference to tribal fisheries in Willapa Bay in our rule regarding take prohibitions for the species (75 FR 30714; June 2, 2010) was erroneous.

Southern DPS green sturgeon are encountered annually by California recreational fishers based on self-reporting and creel. Table 1 summarizes data from sturgeon report cards submitted annually by anglers. Creel surveys conducted in recreational fisheries also report green sturgeon encounters. California commercial passenger fishing vessels (CPFV) report encounters with sturgeons, but have not recorded sturgeon to the species level in the past. CPFV operators were instructed to record sturgeon to the species level in 2011, but data were not available at the time of report writing (pers. comm. with Marty Gingras, CDFW, January 7, 2014). From 86 to 289 Southern DPS green sturgeon are estimated to be annually encountered in the California Halibut trawl fishery (NMFS 2012).

Table 1. Information collected through CDFW sturgeon report cards. Data sources: Gleason *et al.* 2008; Dubois *et al.* 2009-2012, 2014; Dubois 2013.

| Year | # Cards Issued | # Cards Returned | # Cards with sturgeon recorded | # Green sturgeon released | Average length of green sturgeon measured at release | Main areas encountered |
|---|---|---|---|---|---|---|
| 2007 [1] | 41,000 | 6,573 | 1,801 | 311 | 37 inches | Sac. River Red Bluff to Colusa, Rio Vista to Chipps Island |
| 2008 | 57,000 | 4,843 | 1,993 | 240 | 31.6 inches | Sac. River Red Bluff to Colusa, Rio Vista to Chipps Island |
| 2009 | 57,000 | 5,478 | 1,914 | 215 | 29 inches | Sac. River Rio Vista to Chipps Island, Suisun |

[1] Note that 2007 data are not from the entire year since the report card program started that year and cards were first issued in February 2007.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | Bay |
| 2010 | 67,000 | 6,611 | 1,628 | 151 | 40 inches | Sac. River Rio Vista to Chipps Island, Suisun Bay |
| 2011 | 112,000 | 9,841 | 1,831 | 89 | 31.3 inches | San Pablo Bay, Suisun Bay |
| 2012 | 113,000 | 12,082 | 2,000 | 175 | 36 inches | Suisun Bay, Sac. River Rio Vista to Chipps Island |
| 2013 | 50,990 | 10,242 | 2,257 | 168 | 32 inches | Sac. River Rio Vista to Chipps Island, Suisun Bay |

Both Southern and Northern DPS green sturgeon are encountered in the state-regulated California halibut bottom trawl fishery in coastal marine waters. From 2002 through 2010, an estimated 104 to 786 green sturgeon encounters occurred per year in the fishery (Al-Humaidhi *et al.* 2012). The majority of the green sturgeon encountered likely belonged to the Southern DPS, based on the location of the encounters (primarily in coastal marine waters adjacent to San Francisco Bay) (Al-Humaidhi *et al.* 2012) and genetic data (see NMFS 2012).

In Alaska, North American green sturgeon is listed as a “nominee” species in the State of Alaska Wildlife Action Plan and designated as a “Species of Greatest Conservation Need” under the Aquatic Habitat Implementation Plan, which is part of the Comprehensive Wildlife Conservation Strategy. The Alaska Department of Fish and Game (ADFG) indicates that information about green sturgeon is limited to a few anecdotal reports of sightings and captures in Alaska waters, mostly in Alaska District 8 and District 11 (encompassing the mouths of the Stikine and Taku, respectively) driftnet fisheries. ADFG has received no reports of regular sightings of sturgeon. The North Pacific Groundfish Observer Program, which observes Federal groundfish fisheries off Alaska, has recorded rare encounters with green sturgeon in trawl fisheries in the Bering Sea (1982:1; 1984:2; 2005:1; 2006:3; 2009:1; 2012:1; 2013:1; 2015:1; NPGOP data received April 2015). It is unknown whether the green sturgeon encountered belonged to the Northern DPS or the Southern DPS.

In Canada, North American green sturgeon are occasionally encountered by commercial bottom trawlers, with most catches off the north or southwest ends of Vancouver Island. The species is also encountered in recreational hook and line white sturgeon and salmon gillnet and seine fisheries in the Fraser River at low encounter rates. Green sturgeon is listed as a species of Special Concern under Canada’s Species at Risk Act (SARA) and is protected by the federal Fisheries Act, which prohibits destruction of fish habitat. A Management Plan for the species is required under the Species at Risk Act, and is currently under development.

Currently, Canada prohibits retention of North American green sturgeon in recreational and commercial fisheries, and all commercial fisheries are required to release by-catch at sea with the least possible harm. The commercial groundfish bottom trawl fishery has 100% at-sea observer coverage, while the commercial hook and line/trap groundfish fisheries have 100% at-sea monitoring as either observers or electronic monitoring. Dockside monitoring is also in place for groundfish (i.e. groundfish trawl, rockfish hook and line, sablefish, halibut, lingcod and dogfish). This monitoring, in addition to logbooks, enables more accurate accounting of green sturgeon by-catch in these fisheries. Food, social and ceremonial First Nations fisheries may retain green sturgeon if they are encountered. No capture statistics are available for these fisheries.

Canadian fisheries closures established to protect large areas of significant bottom habitat (e.g. rockfish conservation areas and groundfish bottom trawl closures) also serve to protect some North American green sturgeon habitat. Additionally, standard operating practices for industries and regulatory agencies with authority in the Fraser River have been developed to mitigate impacts to freshwater habitat for green sturgeon.

Take of Southern DPS green sturgeon in Federal fisheries was prohibited as a result of the ESA 4(d) protective regulations (ESA 4(d) Rule) issued in 2010 (75 FR 30714; June 2, 2010). Northern and Southern DPS green sturgeon are, however, incidentally encountered in the west coast Pacific Groundfish fisheries, including the Limited Entry (LE) groundfish bottom trawl sector and the at-sea Pacific hake/whiting sector (at-sea hake sector) (Al-Humaidhi *et al.* 2012). Incidental catch of green sturgeon in these fisheries has varied over the years. The LE groundfish bottom trawl sector encountered an estimated 0 to 43 green sturgeon per year from 2002 through 2010 (Al-Humaidhi *et al.* 2012). Based on the location of the encounters and data on green sturgeon stock composition in marine and coastal estuarine waters, the majority of the green sturgeon encountered likely belonged to the Southern DPS (NMFS 2012), but more extensive genetic sampling of encountered animals is needed. Most of the fish were released alive. In the at-sea hake sector, three green sturgeon were encountered from 1991 through 2011 and all had died (Al-Humaidhi *et al.* 2012; NMFS 2012). Data are not available on whether the fish belonged to the Southern DPS or Northern DPS. The impact of these fisheries on green sturgeon populations is estimated to be small (NMFS 2012).

Assessing the potential impact of by-catch handling of Southern DPS green sturgeon in commercial and recreational fisheries requires an understanding of by-catch mortality in different gear types. While immediate mortality can be more directly measured and detected and is expected to be low, some delayed mortality may occur. The issue of delayed, post-release mortality requires further study. An existing study suggests by-catch mortality estimates of 5.2% in commercial gillnet fisheries and 2.6% in recreational hook and line fisheries (Robichaud *et al*. 2006). By-catch mortality in commercial trawl fisheries has not been estimated, but a satellite tagging study in collaboration with the CA halibut fishery is currently underway to estimate this parameter. Efforts made by state and federal agencies to monitor, minimize, and evaluate the effects of fisheries capture of green sturgeon are ongoing. Studies to better understand the circumstances under which by-catch mortality increases are needed to guide fishery management efforts.

Outreach by all state agencies has been undertaken regarding North American green sturgeon catch and handling regulations. State commercial and sport fishing rules pamphlets indicate prohibitions on green sturgeon retention. These regulations as well as posters at boat launch and bank fishing sites also offer information on distinguishing between green and white sturgeon. WDFW requires commercial gillnet fishers in Willapa Bay and Grays Harbor to report all green sturgeon encounters. In 2012, WDFW also deployed onboard commercial fishing vessel monitoring. All fishermen in the Willapa Bay and Grays Harbor region must attend a Fish Friendly Best Fishing Practices class. Monitoring of commercial fisheries in the Columbia River has occurred annually since 2002 and has increased in scope in recent years. Since January 2004, the California Halibut trawl fishery has carried federal observers who record all green sturgeon encounters, although coverage rates have been fairly limited (Al-Humaidhi *et al*. 2012). The Pacific groundfish fisheries are observed at higher rates and data indicate fewer encounters with green sturgeon as compared to the California Halibut fishery (Al-Humaidhi *et al*. 2012).

The ESA 4d Rule provides an exemption from take prohibitions for Southern DPS green sturgeon for commercial and recreational fisheries if those fisheries activities are conducted in accordance with a NMFS-approved Fishery Management and Evaluation Plan (FMEP) (75 FR 30714; June 2, 2010). The FMEP has nine required elements, including setting maximum incidental take levels that will not reduce survival or recovery of the Southern DPS, effective monitoring and evaluation planning, enforcement and education, and reporting of the amount of incidental take on a biannual basis (75 FR 30714; June 2, 2010). Washington has submitted a draft FMEP and Oregon and California may submit plans in the future. Through the FMEP process and the NOAA Fisheries observer programs recording of green sturgeon by-catch in certain fisheries, a more comprehensive understanding of the total by-catch of green sturgeon, and ways to mitigate it, will be available.

Since the ESA 4(d) Rule was promulgated in 2010 (75 FR 30714; June 2, 2010), take for scientific purposes has been managed by NMFS under the ESA 4(d) research program and ESA Section 10(a)(1)(A) permits. Authorized take of Southern DPS green sturgeon for scientific purposes has been tracked since 2006. In reviewing projects involving Southern DPS green sturgeon, NMFS seeks to minimize the impact of scientific research and maximize the benefits to the species. A protocol for sturgeon research developed by NMFS provides guidelines for all scientific research that involves Southern DPS green sturgeon (Kahn and Mohead 2010). The protocol's recommendations are designed to minimize stress and potential mortality to sturgeon due to research activities.

In summary, the level of lethal take of Southern DPS green sturgeon is not expected to have increased since 2006, but has decreased because of state and federal regulations that prohibit their retention in almost all fisheries. Lethal take still occurs as a result of by-catch mortality and a limited number of permitted activities. The impact of lethal take on the overall population abundance of Southern DPS is still unknown. No estimate of an annual rate of mortality due to poaching has become available since the last review.

### 2.3.2.3 Disease or predation

Disease was not recognized as a principle factor in listing the Southern DPS due to a lack of sufficient information. No new information has become available that changes this conclusion. Predation by introduced species was recognized as a possible threat to long-term survival of the Southern DPS. No new information is available on this threat.

Steller sea lions (*Eumetopias jubatus*) are known to feed on sturgeon in the Columbia River. Observations by the U.S. Army Corps of Engineers have recorded only white sturgeon being consumed (WDFW and ODFW 2012). In 2009, however, a photograph of a sea lion eating a green sturgeon was taken in the Rogue River. Researchers in Washington and Oregon have also reported puncture wounds and scrapes on North American green sturgeon consistent with pinniped attacks. CDFW also notes predation on Southern DPS green sturgeon by California sea lions (*Zalophus californianus*) in the Sacramento River, bays and Delta. (CDFW 2013). Steller and California sea lion abundance has increased in recent decades (Carretta *et al.* 2013; NMFS 2013). WDFW has also observed markings on North American green sturgeon that could be consistent with shark attack. A North American green sturgeon was identified in the stomach contents of a white shark captured off Central California (Klimley 1985). The impact of predation on adult and subadult North American green sturgeon is unknown. Although sea lion abundance has increased, there is no new information to support that the threat of predation by sea lions or sharks has changed in severity since the last review.

### 2.3.2.4 Inadequacy of existing regulatory mechanisms

The final rule concluded that inadequacy of existing regulatory mechanisms has significantly contributed to the decline of the Southern DPS and to the severity of threats that the species currently faces (71 FR 17757, April 7, 2006). Although there have been improvements to fishing regulations to eliminate harvest and reduce by-catch mortality, and some passage barriers have been removed, less has been accomplished through regulatory mechanisms to reduce other threats (i.e., those posed by still existing migration barriers, water diversions). As such, inadequacy of existing regulatory mechanisms regarding Southern DPS green sturgeon habitat remains an important threat.

As stated above in Section 2.3.2.2, the states of California, Oregon, and Washington have enacted regulations to prohibit retention of North American green sturgeon in all commercial and recreational fisheries. Canada has similar regulations in place. In October 2009, NMFS published the final rule to designate critical habitat for Southern DPS green sturgeon (74 FR 52300; October 9, 2009) and in June 2010 published the ESA 4(d) Rule for Southern DPS green sturgeon (75 FR 30714; June 2, 2010). This ESA 4(d) Rule describes situations where exemptions and exceptions to the take prohibitions of Southern DPS green sturgeon may be issued for purposes of research, salvage, and fisheries activities.

### 2.3.2.5 Other natural or manmade factors affecting its continued existence

The final rule did not recognize this as a primary factor in the decline of the Southern DPS. No new data are available on risks posed by non-native species or on the threat posed by ship strikes.

In the final rule, the threat posed by juvenile entrainment to the continued existence of the Southern DPS was considered to be uncertain. Thousands of diversions exist in the Sacramento River and Delta that could potentially entrain Southern DPS green sturgeon (Mussen *et al.* 2014). Data on entrainment of Southern DPS green sturgeon is limited. Many large diversions have been screened (250 cfs and higher) and projects are planned for screening some smaller diversions (up to 250cfs) (Vogel 2013; pers. comm. with Dan Meier, USFWS, July 5, 2013). The effectiveness and impact of screening for green sturgeon requires further study given that screen criteria are currently designed to reduce salmon entrainment and impingement. For example, Southern DPS green sturgeon spawn upstream and downstream of the new Red Bluff Permanent Pumping Plant (Poytress *et al*. 2009-2013), which operates utilizing Chinook salmon screening criteria. Though the new diversion facility meets NMFS's screening criteria, the impact on larval or juvenile Southern DPS green sturgeon that pass this site during some of the highest diversion rates is unknown and evaluation of screening criteria in regard to green sturgeon is needed. Laboratory experiments conducted using juvenile green sturgeon from the Northern DPS broodstock exposed the animals to screened diversions within a swimming flume (Poletto *et al.* 2014a). The study indicates that green sturgeon (150-198 dph; 29.6 ± 0.2 cm (mean ± SE) in fork length (FL), mass of 147.1 ± 3.1 g) contact screens and become impinged upon them more frequently than similarly-sized white sturgeon (Poletto *et al.* 2014a). Deterrent treatments (acoustic vibrations, strobe lights) did not reduce the number of impingements for either species (Poletto *et al.* 2014a). The long-term impact of repeated impingement has not been studied.

Laboratory studies showed that juvenile (28-38 cm fork length; mean fork length 34.9 cm (SE 0.6)) Northern DPS green sturgeon broodstock are highly vulnerable to entrainment through unscreened diversion pipes (Mussen *et al.* 2014). Water diversion rates had an important impact on the study, with lower diversion rates resulting in lower entrainment rates. Additional laboratory experiments using Northern DPS green sturgeon broodstock (34.9 ± 0.3 cm in total length; 128-141 days post hatch in age) exposed animals to a sweeping velocity and diversion rate similar to typical operational flows to see if pipe modification and strobe lights would decrease entrainment rates (Poletto *et al.* 2014b). The terminal pipe plate and upturned pipe plate treatments significantly reduced entrainment rates, while strobe lights did not. The authors recommended installation of terminal pipe plates as the more feasible way to reduce entrainment in the river (Poletto *et al.* 2014b). Further study is needed to understand changes associated with ontogeny and to define conditions where fish are most susceptible, so as to better apply the findings to conservation of the Southern DPS within the river and estuary environment.

A recent publication highlights laboratory flow velocities within diversions that overwhelm green sturgeon larvae of different sizes (Verhille *et al.* 2014). The study used Northern DPS broodstock, but makes recommendations regarding the water diversion velocities that could overwhelm Southern DPS larval and juvenile green sturgeon in different reaches of the Sacramento River and the Delta and Bays. The study recommends that water diversion flows at water diversion structures likely to be encountered by green sturgeon in the upper and middle reaches of the Sacramento River from May through the summer should be limited to 29 cm $s^{-1}$. In the middle reaches of the Sacramento River, the maximal velocity should be 54 cm $s^{-1}$ during the night from July until the following May. During October and November, maximal diversion velocities should not exceed 40 cm $s^{-1}$ in the middle and lower reaches of the Sacramento River and the Delta and Bays.

A better understanding of the threat posed by unscreened diversions could be gathered by comparing when and where vulnerable stages of Southern DPS green sturgeon (e.g., eggs or newly emerged) occur in the river with the location and operation of unscreened diversions that may be diverting at critical locations during critical periods. Only limited field data exist on entrainment of the Southern DPS in unscreened diversions. For example, from 2009-2012, a study of entrainment was conducted at 11 unscreened agricultural diversions on the Sacramento River between Knights Landing (RM 91) and Colusa (RM 143), where most of the remaining unscreened diversions on the Sacramento River are located, as well as one unscreened diversion in the delta (Vogel 2013). The selected diversions that were monitored were between 9 cfs and 128 cfs. Two green sturgeon were observed over the sampling period, one at each of two sites. No data were presented in the report on the size of the individuals encountered. It should be noted that the methods used in the study likely would not collect larval green sturgeon, so the study results do not adequately reflect Southern DPS green sturgeon entrainment in the area.

The last status review and update (Adams *et al*. 2002; BRT 2005) noted a decrease in green sturgeon entrainment in the period after 1986 compared to the period before 1986, although the magnitude of the difference was later recognized to be smaller than originally thought (Adams *et al.* 2007). It has also been recognized that the entrainment estimates suffer from problems of species identification (green sturgeon where not identified until 1981 at the federal facility), and that estimates were expanded catches from brief sampling periods (Adams *et al.* 2007). Salvage data from the Skinner Fish Protective Facility for the period from October 2005 to November 2012 indicates that few Southern DPS green sturgeon are encountered at the facility. Southern DPS green sturgeon encounters by year are as follows (observed number, estimated number salvaged): 2006: 6,39; 2007: 1,2; 2008: 0,0; 2009: 0,0; 2010: 0,0; 2011: 1,2; 2012: 0,0 (DWR 2012). Similarly, data from the Tracy Fish Collection Facility and the USFWS Delta Juvenile Fish Monitoring Program using beach seines and trawls from 2006 to 2012 show most juvenile green sturgeon were encountered in 2006 (326 individuals), with fewer seen in recent years (2007: 12; 2008: 8; 2009: 0; 2010: 0; 2011: 12; US Bureau of Reclamation (USBR) 2012). One conclusion is that the presence of juveniles in the Bay-Delta has been episodic, with 2006 a high recruitment year, as it was for white sturgeon (CDFW 2013). Surveys in Grays Harbor and Willapa Bay (2010) and Grays Harbor, Willapa Bay, the Umpqua River and the Columbia River (2011-2012) noted an increase in 4-6 year olds in these areas/years, which may be a result of the high recruitment year of 2006 (WDFW and ODFW 2012). The reviewed information suggests that number of green sturgeon entrained remains low.

The application of chemicals and pesticides to control burrowing shrimp (i.e., ghost shrimp *(Neotrypaea californiensis)* and mud shrimp *(Upogebia pugettensis)*) populations in Washington estuaries may still pose a threat to North American green sturgeon. The chemical carbaryl had been used for this purpose in Willapa Bay and Grays Harbor because of the threat of burrowing shrimp to oyster aquaculture. Since green sturgeon feed on burrowing shrimp, a potential negative impact from carbaryl application may occur, but little is known about the nature of this impact (Dumbauld *et al*. 2008). Exposure to carbaryl also may make green sturgeon more vulnerable to predation (NMFS 2009b). An out-of-court settlement in response to litigation on carbaryl application mandated a phase-out of carbaryl use (pers. comm. with Bruce Kauffman, WDFW, September 6, 2013). The chemical imidacloprid, a proposed alternative to carbaryl, was slated to come into use in 2015, but state and federal agency concerns over the effect of the chemical mean that additional research on its potential impacts will be required before it can be used. University of Washington researchers have done some studies on potential impacts of imidacloprid on green sturgeon, but the results have not been published (pers. comm. with Olaf Langness, WDFW, April 30, 2015). Carbaryl is also used in Central Valley agriculture, but effects on green sturgeon have not been studied.

Selenium contamination in San Francisco Bay, San Pablo Bay, and Suisun Bay poses a potential threat to Southern DPS green sturgeon because green sturgeon feed on benthic invertebrates, including the Asian clam, *Corbula amurensis*, which is an effective bio-accumulator. Selenium micro-injection experiments indicate that the yolk sac larvae of green sturgeon are more sensitive to selenium than those of white sturgeon (in USFWS 2012). Using a regression approach and data from white sturgeon as a proxy, USFWS (2012) calculated selenium concentrations in the tissue and diet of green sturgeon and offered benchmark selenium concentrations in different life stages. Exposure of green sturgeon to L-Selenomethionine (Se-Met), a common natural food source of selenium, in the laboratory at levels in the range of Selenium levels reported in the benthic macro-vertebrate community of San Francisco Bay, had adverse effects on green sturgeon, including significant mortality and reduced growth rate (De Riu *et al.* 2014). Exposure had a more severe pathological effect on green sturgeon as compared to white sturgeon (De Riu *et al.* 2014). De Riu *et al.* 2014 concluded that white sturgeon is a poor surrogate model for green sturgeon dietary SeMet toxicity. Laboratory experiments in which green sturgeon were exposed to dietary methylmercury indicate that green sturgeon are more susceptible to being adversely affected by dietary methylmercury as compared to white sturgeon as evidenced by higher mortality and lower growth rates (Lee *et al.* 2011). No additional information is available on the impacts of other chemicals, pesticides, or heavy metals on Southern DPS green sturgeon.

Climate change has the potential to impact Southern DPS green sturgeon in the future, but it is unclear how changing oceanic, nearshore and river conditions will affect the Southern DPS overall. In freshwater environments (e.g., Sacramento River system), water flow and temperature are important factors influencing green sturgeon spawning and recruitment success (see Section 2.3.1.1). Climate change models predict increased runoff in the winter with reduced spring flows over the course of the 21$^{st}$ century (CH2M HILL 2014). Reservoir operations will also be impacted by climate change, with reservoirs filling up earlier and excess water being released to ensure for flood control capacity. These changes in water temperature and flow in the Sacramento, Feather, and Yuba rivers may impact the timing and success of Southern DPS green sturgeon spawning. It is difficult to predict how the Southern DPS may respond to these changing conditions and how climate change impacts in the nearshore and estuarine environment will also impact spawning timing and success. For example, the salinity in the Sacramento River is projected to increase by 33%, on average, in the 21st century (CH2M HILL 2014). This will result in declining habitat quality and food web productivity, which will likely impact the health of green sturgeon sub-adults. Laboratory experiments confirm the potential negative impacts of salinity and prey base changes predicted for the San Francisco Bay Delta on green sturgeon (Sardella and Kultz 2014; Haller *et al.* 2015; Vaz *et al.* 2015). Similar climate-change induced habitat quality impacts in estuaries in Washington and Oregon could affect the health of sub-adult and non-spawning adult Southern DPS green sturgeon. The prey-base for the Southern DPS could be further impacted by ocean acidification. Changing ocean conditions could also impact Southern DPS green sturgeon since subadults and adults use ocean habitats for migration and potentially for feeding. Based on their use of coastal bay and estuarine habitats, subadults and adults can occupy habitats with a wide range of temperature, salinity, and dissolved oxygen levels, so predicting the impact of climate change in these environments is difficult (Kelly *et al*. 2007; Moser and Lindley 2007). Overall, our knowledge of the environmental impact of climate change is increasing, but the direction of the impact on the Southern DPS is unknown at this point in time. Monitoring potential impacts into the future is important.

An emerging threat is the development and operation of offshore and near shore kinetic energy projects. Impacts of such projects on North American green sturgeon could occur due to direct mortality impacts or habitat loss and sensitivity to low levels of electromagnetic fields associated with the operations that could impact migration and habitat use (Nelson *et al.* 2008). The site of a proposed wave energy project off of Reedsport, OR, was studied in terms of habitat use by North American green sturgeon and potential impacts of the project to the species. The wave energy project will not go forward as planned, but the study will produce inference for projects at other sites near estuaries that are heavily used by green sturgeon (pers. comm. with Daniel Erickson, ODFW, January 27, 2015). Additional kinetic energy installations have been proposed in the past in the Columbia River. The effect of electromagnetic fields from a high voltage, DC cable leading from Pittsburg to San Francisco has been studied, based on detections of acoustically tagged green sturgeon before and after the cable was installed in 2010, with results yet to be fully analyzed (pers. comm. with A. Peter Klimley, UC Davis, September 24, 2013; May 26, 2015).

In summary, no new information is available regarding the threats posed by non-native species. While efforts have been made to screen some large diversions, entrainment still poses a threat to Southern DPS green sturgeon. No changes in NMFS or CDFW screen criteria have been made since the last review. Carbaryl has been phased out and a new chemical may be used in its place in the future, which could impact the Southern DPS. Selenium is still likely a threat to the Southern DPS. The threat of climate change and ocean acidification to Southern DPS green sturgeon cannot be measured using the available information, but changing freshwater and nearshore environments could impact Southern DPS green sturgeon health, spawning and recruitment. The emerging threat posed by nearshore and offshore energy development is under study and requires continued attention into the future. The threats covered in this section are numerous. Overall, the new information does not support a conclusion that the threats have increased in severity since the last review, but many of the threats require close attention into the future.

### 2.4 Synthesis

The DPS structure of the North American green sturgeon has not changed since the last review. The Southern DPS occupies the same range as originally defined. Spawning has now been confirmed in the Feather River. The spatial structure of Southern DPS green sturgeon within the Sacramento River and in coastal environments is now better defined. Limited occupancy within the Sacramento River is concerning, and trends in this pattern and the number of individual green sturgeon present in the river should be monitored into the future. Protective measures instituted by CDFW to prohibit any sturgeon fishing where Southern DPS green sturgeon reproduce are important and should be maintained.

Many of the principle factors considered when listing Southern DPS green sturgeon as threatened are relatively unchanged. Recent studies confirm that the spawning area utilized by Southern DPS green sturgeon is small. Confirmation of Feather River spawning is encouraging and the decommissioning of RBDD and breach of Shanghai Bench makes spawning conditions more favorable, although Southern DPS green sturgeon still encounter impassible barriers in the Sacramento, Feather and other rivers that limit their spawning range. The relationship between altered flows and temperatures in spawning and rearing habitat and Southern DPS green sturgeon population productivity is uncertain. Entrainment as well as stranding in flood diversions during high water events also negatively impact Southern DPS green sturgeon. The prohibition of retention in commercial and recreational fisheries has eliminated a known threat and likely had a very positive effect on the overall population, although recruitment indices are not presently available.

New information allows preliminary calculation of baseline information on spawning adult population abundance, although uncertainties exist because of the preliminary nature of the data. Since the current time series is temporally limited, there is no basis for examining trends over time. Annual DIDSON surveys could serve to track Southern DPS green sturgeon spawning populations into the future. Additional future work utilizing this and other data sources (e.g. Beamesderfer *et al.* 2007) to look at abundance within a modeling framework would be useful and could provide a baseline for understanding the impact of various sources of Southern DPS take. Studies measuring fisheries by-catch mortality by gear type would assist in measuring the impact of by-catch of Southern DPS green sturgeon in state and federal fisheries. Information gathered through the FMEP process will assist in understanding and limiting fisheries impacts.

Evaluation of new information generated since the last review does not suggest a significant change in the status of Southern DPS green sturgeon. With respect to threats, the available information indicates that some threats, such as those posed by fisheries and impassable barriers, have been reduced. The emerging threat posed by nearshore and offshore energy development requires continued attention into the future. Since many of the threats cited in the original listing still exist, the Threatened status is still applicable.

## 3.0 RESULTS

### 3.1 Recommended Classification:

No change is needed.

### 3.2 New Recovery Priority Number *(indicate if no change; see Appendix E)*:

No change.

## 4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The recovery plan for Southern DPS green sturgeon is not yet complete, but is expected to be available before the next Status Review. Finalizing the plan and implementing priority recovery actions are primary future action recommendations. Actions stemming from this review that would assist in improving the status of and available information about Southern DPS green sturgeon are as follows:

1. *Continue monitoring and studying key life history stages and modeling population abundance:* Monitoring data on the abundance of adults in the Sacramento River is one of the most important new pieces of information available since 2006. Monitoring in future years would provide information on trends in adult Southern DPS green sturgeon abundance in the Sacramento River and the relationship between abundance and different river conditions. The monitoring data could be further used to parameterize a life cycle model for Southern DPS green sturgeon. Modeling work to generate an overall abundance estimate would be useful in understanding the status of Southern DPS green sturgeon, tracking recovery, and contextualizing take (see 2 below). Historic catch data could also be used to develop an understanding of historic abundance. Development of a population viability model and other modeling efforts are currently underway for Southern DPS green sturgeon using inputs from DIDSON survey, age and growth studies, and distributional data. Additional research attention needs to be devoted to studying abundance and habitat preference of juvenile green sturgeon in riverine, the Sacramento San Joaquin Delta and San Francisco Bay environments.

2. *Achieve a comprehensive understanding of annual take of Southern DPS green sturgeon:* While take prohibitions have decreased the total lethal take of Southern DPS green sturgeon for scientific, commercial, and recreational purposes since the last status review, a comprehensive understanding of total take is still needed. Encouraging coastal states to complete the FMEP process would be useful in achieving this objective and would provide a mechanism for tracking take. Consolidated tracking of the total authorized and actual take under Section 10(a)(1)(A) permits, Section 7 consultations, and Section 4(d)

research programs would assist in better decision-making. Research devoted to measuring post-release mortality in fisheries, but also associated with all take (e.g., research), is needed to accurately track and minimize lethal take.

3. *Improve spawning habitat availability and quality:* Documented spawning in the Feather River and the removal of RBDD as a migration barrier are positive developments. Impassible barriers still limit access of Southern DPS green sturgeon to historical spawning areas in the Feather, Yuba, and Sacramento rivers. Some of these barriers could be candidates for removal or re-engineering for improved access (*i.e.*, Sunset Pumps weir, Daguerre Point Dam, *etc.*). Water management in the Central Valley will continue to be an important issue in the coming years, especially with respect to the impact of drought conditions. Future reviews should consider any significant change in water management and habitat conditions for Southern DPS green sturgeon.

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Appendix A. Outreach on green sturgeon 5 year status review

*Email and phone contact was used to reach out to the following green sturgeon experts and people who might have information to contribute to the status review.*

University

- UC Davis: Joe Cech, Dennis Cocherell, Fred Conte, Serge Doroshov, Nann Fangue, R. Kaufman, Peter Moyle, Michael Thomas, Joel Van Eenennaam, Pete Klimley, Ethan Mora (response from Cocherell, Fangue, Moyle, Thomas, Klimley, Mora)

Agency

- California Department of Fish and Wildlife: Russ Bellmer, Marty Gingras, Paul Reilly (response from Bellmer, CDFW)
- California Department of Water Resources: Alicia Seesholtz, Roger Churchwell (response from Seesholtz, DWR)
- Cramer Fish Sciences: Brad Cavallo, Ray Beamesderfer
- Department of Fisheries and Oceans, Canada: Larry Hildebrand, Jonathan Thar, Murray Manson, Greg Workman (response from general DFO email, Manson, Workman)
- Glenn-Colusa Irrigation District: Dave Vogel
- National Marine Fisheries Service: Steve Lindley, Mary Moser, Jay Ogawa, John Carlos Garza, Colby Brady (response from Brady, Garza, Ogawa)
- Oregon Department of Fish and Wildlife: Ruth Farr, Dan Erickson (response from ODFW, Erickson)
- US Bureau of Reclamation: Josh Israel (response from Israel, USBR)
- USDA-ARS: Brett Dumbauld (response)
- USFWS: Richard Corwin, Bill Poytress, Zac Jackson, Bill Pinnix (response from Poytress, USFWS)
- USGS: Mike Parsley
- Washington Department of Fish and Wildlife: Brad James, Phillip Dionne, Olaf Langness, Kirt Hughes (response from Langness, WDFW)

Tribe

- Quileute Tribe: Kris Northcut
- Quinault Tribe: Joe Schumacker (response)
- Shoalwater Bay Tribe: Steven Spencer (response)
- Yurok Tribe: Dave Hillemeier (response), Barry McCovey

*A letter was sent to the following contacts and agencies to solicit updated information on the status of Northern and Southern DPS green sturgeon.*

- Alaska Department of Fish and Game: Cora Campbell, Commissioner, cc: Jeff Regnart, Director of the Division of Commercial Fisheries, Doug Vincent-Lang, Acting Director of the Division of Wildlife Conservation (response through submitted comments)

- Bureau of Indian Affairs (Northwest Regional Office): Stanley M. Speaks, Regional Director, cc: Kris Northcut, Quileute Tribe; Joe Schumaker, Quinault Indian Nation, Steven Spencer, Shoalwater Bay Tribe; Russ Svec, Makah Indian Tribal Council
- Bureau of Indian Affairs (Pacific Regional Office): Amy Dutschke Regional Director, , cc: Toz Soto, Karuk Tribe; Dave Hillemeier, Yurok Tribal Fisheries Program; Barry McCovey, Yurok Tribal Fisheries Program; Stephen Kullman, Wiyot Tribe (response from Dale Morris)
- Bureau of Reclamation; Donald R. Glaser, Regional Director, Mid Pacific Regional Office, Sacramento, cc: Robert Chase, Red Bluff; Sue Fry, Sacramento; Josh Israel, Sacramento; Frank Michny, Sacramento (response through submitted comments)
- California Department of Fish and Wildlife: Charlton H. Bonham, Director, Sacramento, cc: Marty Gingras, Stockton; Russ Bellmer, Sacramento; Paul Reilly, Monterey; Tom Barnes, San Diego (response through submitted comments)
- California Department of Water Resources: Mark W. Cowin, Director, cc: Alicia Seesholtz, West Sacramento (response through submitted comments)
- Northwest Indian Fisheries Commission: Billy Frank, Jr., Chairman, cc: William Beattie, Olympia
- Oregon Department of Fish and Wildlife: Roy Elicker, Director, cc: Tom Rein, Clackamas
- USFWS (Region 8): Ren Lohoefener, Regional Director, Pacific Southwest Region (Region 8), Sacramento, cc: Dan Castleberry, Sacramento (response through submitted comments)
- USFWS (Region 1): Robyn Thorson, Regional Director, Pacific Region (Region 1), Portland (email response from Grant Canterbury with cc: to Marilet Zablan, Jana Grote, Larry Rabin)
- Washington Department of Fish Wildlife: Phil Anderson, Director, cc: Kirt Hughes, Montesano; Olaf Langness, Vancouver (response through submitted comments)

Appendix B. External review process

External experts and agencies were contacted to comment on a draft version of this review. We asked for comment on the accuracy and comprehensiveness of the information presented in the review, advice on the reasonableness of judgments made from scientific evidence presented, and any other comments the expert or agency wished to provide. We explicitly asked that no recommendations on the ESA classification of the species be provided. Reviewers were asked to use track changes or comments functions when amending or commenting upon the document and/or to provide a summary of comments as a separate document.

Individuals contacted for review included Dan Erickson (Oregon Department of Fish and Wildlife), Dr. Peter Klimley (UC Davis), Karen Leslie (Department of Fisheries and Oceans, Canada), and Dr. Ray Beamesderfer (R2 Research Consultants). Agencies contacted included Alaska Department of Fish and Game, Bureau of Indian Affairs (Pacific Regional Office), Bureau of Indian Affairs (Northwest Regional Office), California Department of Fish and Wildlife, California Department of Water Resources, Oregon Department of Fish and Wildlife, US Fish and Wildlife Service (Pacific Region (Region 1)), US Fish and Wildlife Service (Pacific Southwest Region (Region 8)), US Bureau of Reclamation (Mid Pacific Regional Office) and Washington Department of Fish and Wildlife. Tribal councils contacted included those at the Hoopa, Karuk, Makah, Quileute, Quinault, Shoalwater, Wiyot, and Yurok tribes.

The following experts and agencies commented on the draft report: Dr. Peter Klimley (UC Davis), Mr. Dan Erickson (Oregon Department of Fish and Wildlife), Ms. Karen Leslie (Department of Fisheries and Oceans, Canada), The Alaska Department of Fish and Game, Bureau of Reclamation (Mid-Pacific Region, Sacramento), California Department of Fish and Wildlife, Department of Water Resources (Sacramento), Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, US Fish and Wildlife (Region 1 and 8), and The Shoalwater Tribal Nation.

**NATIONAL MARINE FISHERIES SERVICE**
**5-YEAR REVIEW**
Southern Distinct Population Segment of the North American Green Sturgeon
*(Acipenser medirostris)*

**Current Classification**: Threatened

**Recommendation resulting from the 5-Year Review:**

____Downlist to Threatened
____Uplist to Endangered
____Delist
X__No change is needed

**Review Conducted By:**

National Marine Fisheries Service, West Coast Regional Office

**REGIONAL OFFICE APPROVAL**:

**Lead Regional Administrator, NOAA Fisheries**

Approve: William Stelle Date: July 29, 2015
*The Lead Region must ensure that other Regions within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. Written concurrence from other regions is required.*

**HEADQUARTERS APPROVAL**:

**Assistant Administrator, NOAA Fisheries**

X Concur _____ Do Not Concur

Signature____________________ Date 8/11/15