Proposed Designation of Critical Habitat for the Southern Distinct Population Segment of North American Green Sturgeon

Draft Biological Report

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EXECUTIVE SUMMARY

Section 4 of the Federal Endangered Species Act requires the designation of critical habitat for threatened and endangered species. This report contains a biological assessment in support of a proposed critical habitat designation for the threatened Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*; hereafter, "Southern DPS"). A critical habitat review team (CHRT) consisting of 9 Federal biologists was convened to evaluate critical habitat for the Southern DPS. The CHRT was tasked with compiling and assessing the best available data to identify habitat features essential to the conservation of the species, determine the geographical area occupied by the species, delineate specific areas within the geographical area occupied that contain at least one essential habitat feature, identify special management considerations or protections required within each area, and evaluate the conservation value of each specific area for the Southern DPS. The CHRT defined the geographical area occupied to range from the California/Mexico border north to the Bering Sea, AK. Within the geographical area occupied, 39 specific areas were delineated within freshwater rivers, coastal bays and estuaries, and coastal marine waters. The CHRT also identified 7 presently unoccupied areas that may be essential to conservation, but for which there is insufficient information at this time to determine whether any are essential for conservation. This report summarizes the available data on green sturgeon presence, distribution, and use of each specific area and the CHRT's evaluation of the conservation value ratings for each area. The assessment and findings provided in this report are used in conjunction with other agency analyses (e.g., economic analyses) to support NMFS' proposed critical habitat designation.

BACKGROUND

On April 7, 2006, NMFS determined that the Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*; hereafter, "Southern DPS") is at risk of extinction in the foreseeable future throughout all or a significant portion of its range and listed the species as threatened under the Endangered Species Act (ESA) (71 FR 17757). The ESA requires NMFS to designate critical habitat for threatened and endangered species. To prepare the critical habitat designation for the Southern DPS, a critical habitat review team (CHRT) was convened, consisting of 9 biologists from NMFS and other Federal agencies with experience working on green sturgeon-related research and management issues, or experience in developing a critical habitat designation. The CHRT reviewed and summarized available information on green sturgeon, including recent biological surveys and reports, peer-reviewed literature, NMFS status reviews for green sturgeon (Moyle *et al.*, 1992; Adams *et al.*, 2002; Biological Review Team (BRT), 2005), and the proposed and final listing rules for green sturgeon (70 FR 17386, April 6, 2005; 71 FR 17757, April 7, 2006). The CHRT used this information to identify and evaluate critical habitat for the Southern DPS. This report contains a biological assessment of the life history, movements, and habitat use of the Southern DPS to support a proposed critical habitat designation for the Southern DPS of green sturgeon.

CRITICAL HABITAT

The ESA defines critical habitat under Section 3(5)(A) as:

> "(i) the specific areas within the geographical area occupied by the species at the time it is listed…, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and
>
> (ii) specific areas outside the geographical area occupied by the species at the time it is listed… upon a determination by the Secretary that such areas are essential for the conservation of the species."

Section 4(a)(3)(B)(i) of the ESA precludes from designation any lands owned by, controlled by, or designated for the use of the Department of Defense that are covered by an integrated natural resources management plan that the Secretary [of Commerce] has found in writing will benefit the listed species.

Section 4(b)(2) of the ESA requires NMFS to designate critical habitat for threatened and endangered species "on the basis of the best scientific data available and after taking into consideration the economic impact, impact on national security, and any other relevant impact, of specifying any particular area as critical habitat." This section grants the Secretary discretion to exclude any area from critical habitat if he determines "the benefits of such exclusion outweigh the benefits of specifying such area as part of the critical habitat." The Secretary may not exclude an area if it "will result in the extinction of the species."

Once critical habitat is designated, section 7 of the ESA requires Federal agencies to insure that they do not fund, authorize, or carry out any actions that will destroy or adversely modify that habitat. This is in addition to the requirement under section 7 of the ESA that Federal agencies insure their actions do not jeopardize the continued existence of listed species.

GREEN STURGEON LIFE HISTORY AND STATUS

This section provides background information on green sturgeon life history and status relevant for understanding the habitat use and needs of this species. The green sturgeon is an anadromous fish species, meaning adults spend time in the ocean but migrate into freshwater rivers to spawn. Green sturgeon are long-lived and the most marine-oriented of the sturgeons of the family Acipenseridae. The North American form of green sturgeon (hereafter, "green sturgeon") is related to the Asian form (*Acipenser mikadoi*, also called Sakhalin sturgeon), but is most likely a different species (Artyukhin *et al.*, 2007). Green sturgeon are one of two sturgeon species occurring on the U.S. West coast, the other being white sturgeon (*A. transmontanus*). Adults can grow up to 270 cm in total length (TL) and 175 kg in weight (Moyle, 2002). However, adults greater than 2 m TL and 90 kg in weight are not common (Skinner, 1962). Maximum ages most likely range from 60 to 70 years or older (Emmett *et al.*, 1991). Females tend to be older and larger than males, but males reach maturity at younger ages (Nakamoto *et al.*, 1995). Until recently, few studies have focused on green sturgeon due to its low abundance and low commercial value compared to white sturgeon.

Green sturgeon range from the Bering Sea, Alaska, to Ensenada, Mexico. A few green sturgeon have been observed off of the southern California coast, including fish less than 100 cm TL (Fitch and Lavenberg, 1971; Fitch and Schultz, 1978, cited in Moyle *et al.*, 1992). Green sturgeon abundance increases north of Point Conception, California (Moyle *et al.*, 1995). Green sturgeon occupy freshwater rivers from the Sacramento River up through British Columbia (Moyle, 2002), but spawning has been confirmed in only three rivers: the Rogue River in Oregon and the Klamath and Sacramento rivers in California. Based on genetic analyses and spawning site fidelity (Adams *et al.*, 2002; Israel *et al.*, 2004), NMFS determined green sturgeon are comprised of at least two distinct population segments (DPSs):

(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 ("Southern DPS"). The only known spawning population for the Southern DPS is in the Sacramento River.

The Northern DPS and Southern DPS are distinguished based on genetic data and spawning locations, but their distributions outside of natal waters generally overlap with one another (Chadwick, 1959; Miller, 1972; California Department of Fish and Game (CDFG), 2002; Erickson and Webb, 2007; Moser and Lindley, 2007; Lindley *et al.*, 2008). Both Northern DPS and Southern DPS fish occupy coastal waters from southern California to Alaska and are known to aggregate in the Columbia River estuary and Washington estuaries in the late summer (Israel *et al.*, 2004; Moser and Lindley, 2007; Lindley *et al.*, 2008). Thus, green sturgeon observed in coastal bays, estuaries, and coastal marine waters outside of natal rivers may belong to either DPS. However, the Northern DPS of green sturgeon is not classified as a listed species under the ESA. Tagging or genetics data are needed to determine to which DPS an individual belongs. The distribution of green sturgeon, and specifically of the Southern DPS, is described in detail under the section titled "Geographical Area Occupied by the Species and Specific Areas within the Geographical Area Occupied."

Spawning

Spawning frequency is not well known, but the best information suggests that adult green sturgeon spawn every 2 - 4 years (Lindley and Moser, NMFS, pers. comm., cited in 70 FR 17386, April 6, 2005; Erickson and Webb, 2007). Beginning in late February, adult green sturgeon migrate from the ocean into fresh water to begin their spawning migrations (Moyle *et al.*, 1995). Spawning occurs from March to July, with peak activity from mid-April to mid-June (Emmett *et al.*, 1991). Confirmed spawning populations in North America are in the Rogue (Erickson *et al.*, 2002; Farr and Kern, 2005), Klamath, and Sacramento rivers (Moyle *et al.*, 1992; CDFG, 2002). Klamath and Rogue river populations appear to spawn within 100 miles (161 km) of the ocean, whereas spawning in the mainstem Sacramento River has been documented over 240 miles (391 km) upstream, both downstream and upstream of Red Bluff Diversion Dam (RBDD) (Brown, 2007).[1] Spawning most likely occurs in fast, deep water (> 3 m deep) over substrates ranging from clean sand to bedrock, with preferences for cobble substrates (Emmett *et al.*, 1991; Moyle *et al.*, 1995). Green sturgeon females produce 59,000 to 242,000 eggs, with fecundity increasing with fish length and age (Van Eenennaam *et al.*, 2006). Green sturgeon eggs are the largest of any sturgeon species, ranging from 4.04 to 4.66 mm in diameter and have a thin chorionic layer (Van Eenennaam *et al.*, 2001; Van Eenennaam *et al.*, 2006). Eggs are broadcast spawned and likely adhere to substrates or settle into crevices of river bedrock or under gravel (Deng, 2000; Van Eenennaam *et al.*, 2001; Deng *et al.*, 2002). Van Eenennaam *et al*. (2001) previously reported that green sturgeon eggs have weak adhesiveness, but have since retracted that statement, noting instead that green sturgeon eggs are quite adhesive within a few minutes after release from the female.[2] Optimum flow and temperature requirements for spawning and incubation are unclear, but spawning success in most sturgeons is related to these factors (Detlaff *et al.*, 1993). Average daily water flow ranged from 198 - 306 m^3/s in the Sacramento River (Brown, 2007), and from 58 - 292 m^3/s in the Rogue River (Erickson and Webb, 2007)

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[1] B. Poytress, US Fish and Wildlife Service (USFWS), Red Bluff, CA. Unpublished green sturgeon sampling data in the Sacramento River, 2008. Personal commun., July 2008.
[2] J. Van Eenennaam, UC Davis, Davis, CA. Personal commun, February 20, 2008.

during the spawning months. Spawning may be triggered by small increases in water flow (Schaffter, 1997; Brown, 2007). Adult green sturgeon occur in the Sacramento River when temperatures are between 8 - 14°C (Moyle, 2002). In laboratory studies, the optimal thermal range for green sturgeon development was from 11 to 17 - 18°C, and temperatures ≥ 23°C were lethal to embryos (Van Eenennaam *et al.*, 2005).

Development of early life stages

Green sturgeon embryos have poor swimming ability and exhibit a strong drive to remain in contact with structure, preferring cover and dark habitats to open bottom and illuminated habitats in laboratory experiments (Kynard *et al.*, 2005). Newly emerged green sturgeon larvae in the laboratory hatched at 144 - 216 hours, or 6 - 9 days, after fertilization (incubation temperatures ranged from 15 - 15.7°C) and ranged from 12.6 - 15 mm in length (Van Eenennaam *et al.*, 2001; Deng *et al.*, 2002). Unlike other acipenserids, newly hatched larvae did not swim up toward the water surface within the first 5 days post hatch (dph), but remained in clumps near the bottom. By 5 - 6 dph, larvae exhibited nocturnal behavior, remaining clumped near the bottom during the day and actively swimming at night (Van Eenennaam *et al.*, 2001; Deng *et al.*, 2002). Upon onset of feeding at 10 dph (23.0 – 25.2 mm length) (Deng *et al.*, 2002), larvae are believed to initiate downstream migration from spawning areas, staying close to the bottom and periodically interrupting downstream movement with upstream foraging bouts (Kynard *et al.*, 2005).

Little is known about larval rearing habitat and requirements. Temperatures of 15°C are believed to be optimal for larval growth, whereas temperatures below 11°C or above 19°C may be detrimental for growth (Cech *et al.*, 2000, cited in COSEWIC, 2004). Substrate may also affect growth and foraging behavior. Larvae reared on flat-surfaced substrates (slate-rock and glass) had higher specific growth rates than larvae reared on cobble or sand, most likely due to lower foraging effectiveness and greater activity levels in cobble and sand substrates (Nguyen and Crocker, 2007). Larvae complete metamorphosis to the juvenile stage at 45 dph, when fish range from 62.5 to 94.4 mm in length (Deng *et al.*, 2002).

Juveniles continue to grow rapidly, reaching 300 mm in 1 year and over 600 mm within 2 - 3 years (based on Klamath River fish; Nakamoto *et al.*, 1995). Laboratory experiments indicate juveniles may occupy fresh to brackish water at any age, but are able to completely transition to salt water by around 1.5 years in age (about 533 dph; mean TL of 75.2 ± 0.7 cm) (Allen and Cech, 2007). Early juveniles at 100 and 170 dph tolerated prolonged exposure to salt water, but experienced decreased growth and activity levels and, in some cases, mortality for individuals at 100 dph, whereas juveniles at 533 dph exhibited successful osmoregulation in salt water salinities (Allen and Cech, 2007). These results were consistent with the Nakamoto *et al*. (1995) study indicating that juveniles rear in fresh and estuarine waters for about 1 to 4 years before dispersing into salt water (at lengths of about 300 to 750 mm). Early juveniles also exhibit nocturnal behavior in all activities and initiate directed downstream movement in the fall, most likely to migrate to wintering habitats (Kynard *et al.*, 2005). Juvenile green sturgeon prefer temperatures of 15 - 16°C with an upper limit of 19°C, beyond which swimming performance may decrease and cellular stress may occur (Mayfield and Cech, 2004; Allen *et al.*, 2006). Laboratory measurements of oxygen consumption by juveniles ranged from 61.78 ± 4.65 mg O_2 hr^{-1} kg^{-1} to 76.06 ± 7.63 mg O_2 hr^{-1} kg^{-1}, with a trend of increasing oxygen consumption with increasing body mass (Allen and Cech, 2007). Studies on juveniles feeding in San Pablo Bay, Suisun Bay, and the Sacramento-San Joaquin Delta identified prey items of shrimp (*Neomysis awatchensis, Crangon franciscorum*), amphipods (*Corophium* spp., *Photis californica*), isopods (*Synidotea laticauda*), clams (*Macoma* spp.), annelid worms, and unidentified crabs and fishes (Ganssle, 1966; Radtke, 1966).

Adults and subadults

The CHRT defined life stages as follows: adults as sexually mature fish, subadults as sexually immature fish that have entered coastal marine waters (usually at 3 years of age), and juveniles as fish that have not yet made their first entry into marine waters. Green sturgeon spend a large portion of their lives in coastal marine waters as subadults and adults between spawning episodes. Subadult male and female green sturgeon spend at least approximately 6 and 10 years at sea, respectively, before reaching reproductive maturity and returning to freshwater to spawn for the first time (Nakamoto *et al.*, 1995). Adult green sturgeon spend as many as 2 – 4 years at sea between spawning events (Lindley and Moser, NMFS, pers. comm., cited in 70 FR 17386, April 6, 2005; Erickson and Webb, 2007). The average length at maturity for green sturgeon is estimated to be 152 cm TL (14 - 16 years) for males and 162 cm TL (16 - 20 years) for females in the Klamath River (Van Eenennaam *et al.*, 2006), and 145 cm TL for males and 166 cm TL for females in the Rogue River (Erickson and Webb, 2007). The maximum size of subadults is approximately 167 cm TL (Erickson and Webb, 2007).

Adult green sturgeon enter freshwater rivers every few years to spawn. Adults typically begin their upstream spawning migration in the spring and either migrate downstream after spawning, or reside within the river over the summer. In the Klamath River, tagged adults exhibited four movement patterns: (1) upstream spawning migration; (2) spring outmigration to the ocean; (3) summer holding (June to November) in deep pools with eddy currents (for those that do not exhibit post-spawning spring outmigration); and (4) outmigration after summer holding (Benson *et al.*, 2007). Use of summer holding sites has also been observed in the Rogue River (Erickson *et al.*, 2002) and in the Sacramento River.[1] Deep holding pools greater than 5 m in depth are believed to be important for spawning as well as for summer holding.[2] Winter outmigration from the Klamath and Rogue rivers was initiated when temperatures dropped to 10 - 12°C or below 10°C, and discharge increased to greater than 100 m^3/s (Erickson *et al.*, 2002; Benson *et al.*, 2007). In the Sacramento River, tagged adult green sturgeon were present through November

[1] R. Corwin, US Bureau of Reclamation (USBR), Red Bluff, CA. Unpublished green sturgeon observations. Personal commun., February 2008.
[2] R. Corwin, USBR, Red Bluff, CA, and B. Poytress, USFWS, Red Bluff, CA. Personal commun., May 2008.

and December, before moving downstream with increased winter flows.[1] Subadults may also migrate upstream, but for unknown purposes. Adults and subadults also occupy the San Francisco Bay, San Pablo Bay, Suisun Bay, and Sacramento-San Joaquin Delta adjacent to the Sacramento River. Adults and subadults primarily inhabit the Delta and bays during summer months, most likely for feeding and growth (Kelly *et al.*, 2007; Moser and Lindley, 2007), but also enter the Delta and bays during their spring migration to the Sacramento River and during their winter outmigration from the Sacramento River to the ocean.

Outside of natal waters, adult and subadult green sturgeon inhabit coastal marine waters from the Bering Sea to southern California, primarily occupying waters within 110 meters (m) depth (Erickson and Hightower, 2007). Tagged subadults and adults have been documented to make sustained coastal migrations of up to 100 km per day (S. Lindley and M. Moser, NMFS, pers. comm. cited in BRT, 2005), but may also reside in aggregation/feeding areas in coastal marine waters for several days at a time.[2] There is evidence that green sturgeon inhabit certain estuaries on the northern California, Oregon, and Washington coasts during the summer, and inhabit coastal marine waters along the central California coast and between Vancouver Island, British Columbia, and southeast Alaska over the winter (Lindley *et al.*, 2008). Large aggregations of green sturgeon occur in the Columbia River estuary and Washington estuaries and include green sturgeon from all known spawning populations (Moser and Lindley, 2007). Large numbers of green sturgeon also occur off Vancouver Island, BC (Lindley *et al.*, 2008). Seasonal migrations to these oversummering and overwintering habitats are most likely driven by the presence of food resources. Although adult and subadult green sturgeon occur in coastal marine waters as far north as the Bering Sea, green sturgeon have not been observed in freshwater rivers or coastal bays and estuaries in Alaska.

Adults and subadults inhabit a wide range of environmental conditions within coastal bays and estuaries. Adults and subadults in Willapa Bay and the San Francisco Bay Estuary occurred across the entire temperature and salinity range (11.9 – 21.9°C; 8.8 – 32.1 ppt), experienced large fluctuations in temperature and salinity (up to 2°C h^{-1} and 1 practical salinity unit (PSU) h^{-1}), and occupied a wide range of dissolved oxygen levels from 6.54 to 8.98 mg O_2/l (Kelly *et al.*, 2007; Moser and Lindley, 2007). Tagged adults and subadults in the San Francisco Bay Estuary occupied shallow depths during directional movements, but stayed close to the bottom during non-directional movements, presumably because they were foraging (Kelly *et al.*, 2007). Similar to freshwater rivers, winter outmigration from Willapa Bay was initiated when water temperatures dropped below 10°C (Moser and Lindley, 2007).

Adult and subadult green sturgeon in the Columbia River estuary, Willapa Bay, and Grays Harbor feed on crangonid shrimp, burrowing thalassinidean shrimp (primarily the burrowing ghost shrimp *Neotrypaea californiensis*), amphipods, clams, juvenile

[1] M. Thomas, UC Davis, Davis, CA, and R. Corwin, USBR, Red Bluff, CA. Unpublished green sturgeon tagging data. Personal commun., February 2008.
[2] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. February 2008.

Dungeness crab (*Cancer magister*), anchovies, sand lances (*Ammodytes hexapterus*), lingcod (*Ophiodon elongatus*), and other unidentified fish species (P. Foley, unpublished data cited in Moyle et al., 1995; C. Tracy, minutes to USFWS meeting, cited in Moyle *et al.*, 1995; O. Langness, WDFW, pers. comm., cited in Moser and Lindley, 2007; Dumbauld *et al.*, 2008). Burrowing ghost shrimp made up about 50 percent of the stomach contents of green sturgeon sampled in 2003 (Dumbauld *et al.*, 2008). Subadults and adults feeding in bays and estuaries may be exposed to contaminants that may affect their growth and reproduction. Studies on white sturgeon in estuaries indicate that the bioaccumulation of pesticides and other contaminants adversely affects growth and reproductive development and may result in decreased reproductive success (Fairey *et al.*, 1997; Foster *et al.*, 2001a; Foster *et al.*, 2001b; Kruse and Scarnecchia, 2002; Feist *et al.*, 2005; Greenfield *et al.*, 2005). Green sturgeon are believed to experience similar risks from contaminants (70 FR 17386, April 6, 2005).

Status of Green Sturgeon

On April 7, 2006, NMFS issued a Final Rule to list the Southern DPS of green sturgeon as threatened under the ESA and to keep the Northern DPS on the NMFS Species of Concern List (71 FR 17757). The decision to list the Southern DPS as threatened was based on an evaluation of the status of the Southern DPS and of existing efforts to protect the species. NMFS identified 7 extinction risk factors for the Southern DPS (BRT, 2005; 71 FR 17757, April 7, 2006):

1) Concentration of spawning into one spawning river, increasing the risk of catastrophic extinction;
2) Loss of spawning habitat in the upper Sacramento and Feather rivers due to migration barriers;
3) A general lack of population data, but suspected small population size;
4) Entrainment by water project operations;
5) Potentially limiting or lethal water temperatures;
6) Commercial and recreational fisheries harvest; and
7) Toxins and exotic species.

NMFS determined that green sturgeon population numbers in the Sacramento River and Delta system have declined substantially and that the Southern DPS would likely become endangered in the near future if ongoing threats were not addressed. Past and ongoing Federal, state, and local protective efforts have contributed to the conservation of the Southern DPS, but NMFS believes these efforts alone do not sufficiently reduce the extinction risks faced by the Southern DPS.

PHYSICAL OR BIOLOGICAL FEATURES ESSENTIAL FOR CONSERVATION

Joint NMFS-U.S. Fish and Wildlife Service regulations at 50 CFR 424.12(b) state that in determining what areas are critical habitat, the agencies "shall consider those physical and biological features that are essential to the conservation of a given species and that may require special management considerations or protection." Features to consider may include, but are not limited to:

(1) Space for individual and population growth, and for normal behavior;
(2) Food, water, air, light, minerals, or other nutritional or physiological requirements;
(3) Cover or shelter;
(4) Sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and generally;
(5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

The regulations also require agencies to "focus on the principle biological or physical constituent elements" (hereafter referred to as "Primary Constituent Elements" or PCEs) within the specific areas considered for designation, which "may include, but are not limited to, the following:… spawning sites, feeding sites, seasonal wetland or dryland, water quality or quantity, … geological formation, vegetation type, tide, and specific soil types."

The CHRT recognized that the different systems occupied by green sturgeon at specific stages of their life cycle serve distinct purposes and thus may contain different PCEs. Based on the best available scientific information, the CHRT identified PCEs for freshwater riverine systems, estuarine areas, and coastal marine waters.

The specific PCEs essential for the conservation of the Southern DPS in freshwater riverine systems include:

1. *Food resources*. Abundant food items for larval, juvenile, subadult, and adult life stages. Although the CHRT lacked specific data on food resources for green sturgeon within freshwater riverine systems, juvenile green sturgeon most likely feed on fly larvae (based on nutritional studies on the closely-related white sturgeon).[1] These food resources are important for juvenile foraging, growth, and development during their downstream migration to the Delta and bays. In addition, subadult and adult green sturgeon may forage during their downstream post-spawning migration, while holding within deep pools (Erickson *et al.*, 2002), or on non-spawning migrations within freshwater rivers. Subadult and adult green sturgeon in freshwater rivers most likely feed on benthic prey species similar to those fed on in bays and estuaries, including shrimp, clams, and benthic fish (Moyle *et al.*, 1995; Erickson *et al.*, 2002; Moser and Lindley, 2007; Dumbauld *et al.*, 2008).

2. *Substrate type or size* (i.e., structural features of substrates). Substrates suitable for egg deposition and development (e.g., bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to "collect" eggs and provide protection from predators, and free of excessive silt and debris that

[1] J. Stuart, NMFS, Sacramento, CA. Personal commun., January 2008.

could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high flow conditions), and subadults and adults (e.g., substrates for holding and spawning). For example, spawning is believed to occur over substrates ranging from clean sand to bedrock, with preferences for cobble (Emmett *et al.*, 1991; Moyle *et al.*, 1995). Eggs likely adhere to substrates, or settle into crevices between substrates (Deng, 2000; Van Eenennaam *et al.*, 2001; Deng *et al.*, 2002). Both embryos and larvae exhibited a strong affinity for benthic structure during laboratory studies (Van Eenennaam *et al.*, 2001; Deng *et al.*, 2002; Kynard *et al.*, 2005), and may seek refuge within crevices, but use flat-surfaced substrates for foraging (Nguyen and Crocker, 2007). For more details, see the sections on *Spawning* and *Development of early life stages* in this biological report.

3. *Water flow*. A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages (see section on *Spawning* in this biological report). Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (11 - 19°C) (Cech *et al.*, 2000, cited in COSEWIC, 2004; Mayfield and Cech, 2004; Van Eenennaam *et al.*, 2005; Allen *et al.*, 2006). Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs (Deng *et al.*, 2002; Parsley *et al.*, 2002), and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in (and potentially suffocating the eggs (Deng *et al.*, 2002)) and to maintain surfaces for feeding (Nguyen and Crocker, 2007). Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning success is most certainly associated with water flow and water temperature. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about 400 m^3/s (average daily water flow during spawning months: 198 - 306 m^3/s) (Brown, 2007). Post-spawning downstream migrations are triggered by increased flows, ranging from 174 - 417 m^3/s in the late summer (Vogel, 2005) and greater than 100 m^3/s in the winter (Erickson *et al.*, 2002; Benson *et al.*, 2007).[1]

4. *Water quality*. Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages (see sections on *Development of early life stages* and *Adults and subadults* in this biological report). Suitable water temperatures would include: stable water temperatures within spawning reaches (wide fluctuations could increase egg mortality or deformities in developing embryos); temperatures within 11 - 17°C (optimal range = 14 - 16°C) in spawning reaches for egg incubation (March-August) (Van Eenennaam *et al.*, 2005); temperatures below 20°C for larval development (Werner *et al.*, 2007); and temperatures below 24°C

[1] M. Thomas, UC Davis, Davis, CA, and R. Corwin, USBR, Red Bluff, CA. Unpublished green sturgeon tagging data. Personal commun., February 2008.

for juveniles (Mayfield and Cech, 2004; Allen *et al.*, 2006). Suitable salinity levels range from fresh water (< 3 parts per thousand or 3‰) for larvae and early juveniles (about 100 dph) to brackish water (10‰) for juveniles prior to their transition to salt water. Prolonged exposure to higher salinities may result in decreased growth and activity levels and even mortality (Allen and Cech, 2007). Adequate levels of dissolved oxygen are needed to support oxygen consumption by early life stages (ranging from 61.78 to 76.06 mg O_2 hr^{-1} kg^{-1} for juveniles) (Allen and Cech, 2007). Suitable water quality would also include water with acceptably low levels of contaminants (i.e., pesticides, organochlorines, elevated levels of heavy metals, etc.) that may disrupt normal development of embryonic, larval, and juvenile stages of green sturgeon. Waters free of elevated levels of such contaminants would protect green sturgeon from adverse impacts on growth, reproductive development, and reproductive success (e.g., reduced egg size and abnormal gonadal development) likely to result from exposure to contaminants (Fairey *et al.*, 1997; Foster *et al.*, 2001a; Foster *et al.*, 2001b; Kruse and Scarnecchia, 2002; Feist *et al.*, 2005; Greenfield *et al.*, 2005).

5. *Migratory corridor. A* migratory pathway necessary for the safe and timely passage of Southern DPS fish within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for passage). We define safe and timely passage to mean that human-induced impediments, either physical, chemical, or biological, do not alter the migratory behavior of the fish such that its survival or the overall viability of the species is compromised (e.g., an impediment that compromises the ability of fish to reach their spawning habitat in time to encounter con-specifics and to reproduce). Unimpeded migratory corridors are necessary for adult green sturgeon to migrate to and from spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries. For example, unimpeded passage throughout the Sacramento River up to Keswick Dam (rkm 486) is important, because barriers to passage (such as the Red Bluff Diversion Dam, or RBDD, located at rkm 391) could reduce the total spawning area available to green sturgeon, increasing competition for the remaining habitat.

6. *Depth*. Deep (≥ 5 m) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow to maintain the physiological needs of the holding adult or subadult fish (see section on *Adults and subadults* in this biological report). Deep pools of ≥ 5 m depth with high associated turbulence and upwelling are critical for adult green sturgeon spawning and for summer holding within the Sacramento River.[1] Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, and/or refuge from high water temperatures (Erickson *et al.*, 2002; Benson *et al.*, 2007).

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[1] R. Corwin, USBR, Red Bluff, CA, and B. Poytress, USFWS, Red Bluff, CA. Personal commun., May 2008.

7. *Sediment quality*. Sediment quality. Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of elevated levels of contaminants (e.g., elevated levels of selenium, polyaromatic hydrocarbons (PAHs), and organochlorine pesticides) that can result in adverse effects on any life stages of green sturgeon. Based on studies of white sturgeon, bioaccumulation of contaminants from feeding on benthic species may adversely affect the growth, reproductive development, and reproductive success of green sturgeon (see section titled *Adult and subadults* in this biological report).

The specific PCEs essential for the conservation of the Southern DPS in estuarine areas include:

1. *Food resources*. Abundant food items within estuarine habitats and substrates for juvenile, subadult, and adult life stages. As described previously (see *Green sturgeon life history and status*), prey species for juvenile, subadult, and adult green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fish, including crangonid shrimp, burrowing thalassinidean shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult green sturgeon within the bays and estuaries.

2. *Water flow*. Within bays and estuaries adjacent to the Sacramento River (i.e., the Sacramento-San Joaquin Delta and the Suisun, San Pablo, and San Francisco bays), sufficient flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds. Sufficient flows are needed to attract adult green sturgeon to the Sacramento River to initiate the upstream spawning migration (Kohlhorst *et al*., 1991, cited in CDFG, 2002).[1]

3. *Water quality*. Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures for juvenile green sturgeon should be below 24°C. At temperatures above 24°C, juvenile green sturgeon exhibit decreased swimming performance (Mayfield and Cech, 2004) and increased cellular stress (Allen *et al.*, 2006). Suitable salinities range from brackish water (10‰) to salt water (33‰). Juveniles transitioning from brackish to salt water can tolerate prolonged exposure to salt water salinities, but may exhibit decreased growth and activity levels (Allen and Cech, 2007), whereas subadults and adults tolerate a wide range of salinities (Kelly *et al.*, 2007). Subadult and adult green sturgeon occupy a wide range of dissolved oxygen levels, but may need a minimum dissolved oxygen level of at least 6.54 mg 0_2/l (Kelly *et al.*, 2007; Moser and Lindley, 2007). As described above, adequate levels of dissolved oxygen are also required to support oxygen consumption by juveniles (ranging from 61.78 to 76.06 mg O_2 hr^{-1} kg^{-1}) (Allen and Cech, 2007).

[1] J. Stuart, NMFS, Sacramento, CA. Personal commun., February and March, 2008.

Suitable water quality also includes waters with acceptably low levels of contaminants (e.g., pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal development of juvenile life stages, or the growth, survival, or reproduction of subadult or adult stages.

4. *Migratory corridor.* A migratory pathway necessary for the safe and timely passage of Southern DPS fish within estuarine habitats and between estuarine and riverine or marine habitats. We define safe and timely passage to mean that human-induced impediments, either physical, chemical, or biological, do not alter the migratory behavior of the fish such that its survival or the overall viability of the species is compromised (e.g., an impediment that compromises the ability of fish to reach thermal refugia by the time they enter a particular life stage). Within the bays and estuaries adjacent to the Sacramento River, unimpeded passage is needed for juvenile green sturgeon to migrate from the river to the bays and estuaries and eventually out into the ocean. Passage within the bays and the Delta is also critical for adults and subadults for feeding and summer holding, as well as to access the Sacramento River for their upstream spawning migrations and to make their outmigration back into the ocean. For bays and estuaries outside of the Delta and the Suisun, San Pablo, and San Francisco bays, unimpeded passage is necessary for adult and subadult green sturgeon to access feeding areas, holding areas, and thermal refugia, and to ensure passage back out into the ocean.

5. *Depth*. A diversity of depths necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Subadult and adult green sturgeon occupy a diversity of depths within bays and estuaries for feeding and migration. Tagged adults and subadults within the San Francisco Bay estuary primarily occupied waters over shallow depths of less than 10 m, either swimming near the surface or foraging along the bottom (Kelly *et al.*, 2007). In a study of juvenile green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from 1 – 3 meters deep, indicating juveniles may require shallower depths for rearing and foraging (Radtke, 1966). Thus, a diversity of depths is important to support different life stages and habitat uses for green sturgeon within estuarine areas.

6. *Sediment quality*. Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of elevated levels of contaminants (e.g., elevated levels of selenium, PAHs, and organochlorine pesticides) that can cause adverse effects on all life stages of green sturgeon (see description of *Sediment quality* for riverine habitats above).

The specific PCEs essential for the conservation of the Southern DPS in coastal marine areas include:

1. *Migratory corridor.* A migratory pathway necessary for the safe and timely passage of Southern DPS fish within marine and between estuarine and marine habitats. We define safe and timely passage to mean that human-induced

impediments, either physical, chemical, or biological, do not alter the migratory behavior of the fish such that its survival or the overall viability of the species is compromised (e.g., an impediment that compromises the ability of fish to reach abundant prey resources during the summer months in Northwest Pacific estuaries). Subadult and adult green sturgeon spend most of their lives in marine and estuarine waters outside of their natal rivers. Unimpeded passage within coastal marine waters is critical for subadult and adult green sturgeon to access oversummering habitats within coastal bays and estuaries and overwintering habitat within coastal waters between Vancouver Island, BC, and southeast Alaska. Passage is also necessary for subadults and adults to migrate back to San Francisco Bay and to the Sacramento River for spawning.

2. *Water quality*. Coastal marine waters with adequate dissolved oxygen levels and with acceptably low levels of contaminants (such as pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal behavior, growth, and viability of subadult and adult green sturgeon. Based on studies of tagged subadult and adult green sturgeon in the San Francisco Bay estuary, CA, and Willapa Bay, WA, subadults and adults may need a minimum dissolved oxygen level of at least 6.54 mg 0_2/l (Kelly *et al.*, 2007; Moser and Lindley, 2007). As described above, exposure to, and bioaccumulation of, contaminants may adversely affect the growth, reproductive development, and reproductive success of subadult and adult green sturgeon. Thus, waters free of elevated levels of such contaminants are required for the normal development of green sturgeon for optimal survival and spawning success.

3. *Food resources*. Abundant food items for subadults and adults, which likely include benthic invertebrates and fish. Green sturgeon spend most of their lives in marine and estuarine waters along the coast. Abundant food resources are important to support subadults and adults over long-distance migrations, and may be one of the factors attracting green sturgeon to habitats far to the north (off the coast of Vancouver Island and Alaska) and to the south (Monterey Bay, CA, and off the coast of southern California) of their natal habitat. Although data on prey species in coastal marine waters is lacking, prey species likely include benthic invertebrates and fish species similar to those fed upon by green sturgeon in bays and estuaries (e.g., shrimp, clams, crabs, anchovies, sand lances) (see section titled *Adults and subadults* in this biological report).

GEOGRAPHICAL AREA OCCUPIED BY THE SPECIES AND SPECIFIC AREAS WITHIN THE GEOGRAPHICAL AREA OCCUPIED

One of the first steps in the critical habitat designation process is to define the geographical area occupied by the species at the time of listing. The CHRT relied on data from tagging and tracking studies, genetic analyses, field observations, records of fisheries take and incidental take (e.g., in water diversion activities), and opportunistic sightings to provide information on the current range and distribution of green sturgeon and of the Southern DPS of green sturgeon. The range of green sturgeon extends from the Bering Sea, Alaska, to Ensenada, Mexico. Within this range, Southern DPS fish are confirmed to occur from Graves Harbor, Alaska, to Monterey Bay, California.[1] Green sturgeon have been observed northwest of Graves Harbor, AK, and south of Monterey Bay, CA, but have not been identified as belonging to either the Northern or Southern DPS. The CHRT concluded that there are no barriers or habitat conditions preventing Southern DPS green sturgeon detected in Monterey Bay, CA, and in Graves Harbor, AK, from moving further south or further north, and that the green sturgeon observed in these areas could belong to either the Northern DPS or the Southern DPS. Based on this reasoning, the geographical area occupied by the Southern DPS was defined as the entire range occupied by green sturgeon (i.e., from the Bering Sea, AK, to Ensenada, Mexico). The geographical area occupied encompassed all areas where the presence of Southern DPS fish has been confirmed, as well as areas where the presence of Southern DPS fish is likely (based on the presence of confirmed Northern DPS fish or green sturgeon of unknown DPS). Areas outside of the United States cannot be designated as critical habitat (50 CFR 424.12(h)). Thus, the geographical area occupied under consideration for this designation is limited to areas from the Bering Sea, AK (excluding Canadian waters), to the U.S.-California/Mexico border. For freshwater rivers, the CHRT concluded that green sturgeon of each DPS are likely to occur throughout their natal river systems, but, within non-natal river systems, are likely to be limited to the estuaries and would not occur upstream of the head of the tide. For the purposes of this evaluation of critical habitat, the CHRT defined all green sturgeon observed upstream of the head of the tide in freshwater rivers south of the Eel River (i.e., the Sacramento River and its tributaries) as belonging to the Southern DPS, and all green sturgeon observed upstream of the head of the tide in freshwater rivers north of and including the Eel River as belonging to the Northern DPS. Thus, for freshwater rivers north of and including the Eel River, the areas upstream of the head of the tide were not considered part of the geographical area occupied by the Southern DPS.

The CHRT then identified "specific areas" within the geographical area occupied. To be eligible for designation as critical habitat under the ESA, each specific area must contain at least one PCE that may require special management considerations or protection. For each specific area, the CHRT noted whether the presence of Southern DPS green sturgeon is confirmed or likely (based on the presence of Northern DPS fish or green sturgeon of unknown DPS) and verified that each area contained one or more PCE(s) that may require special management considerations or protection. The following paragraphs summarize the CHRT's methods for delineating the specific areas and describe each specific area, including the presence of Southern DPS green sturgeon and one or more PCE(s) requiring special management considerations or protection. Figures 1 – 5 show maps of the occupied specific areas delineated and considered by the CHRT for designation.

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[1] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. Personal commun., February 2008.

Freshwater riverine systems, bypasses, and the Delta

Green sturgeon occupy several freshwater river systems from the Sacramento River, CA, north to British Columbia, Canada (Moyle, 2002). As described in the previous section, Southern DPS green sturgeon occur throughout their natal river systems (i.e., the Sacramento River, lower Feather River, and lower Yuba River), but are likely to be restricted to the estuaries in non-natal river systems (i.e., north of and including the Eel River). The CHRT delineated specific areas where Southern DPS fish occur, including: the Sacramento River, the Yolo and Sutter bypasses, the lower Feather River, and the lower Yuba River. The CHRT defined the specific areas to include riverine habitat from the river mouth upstream to and including the furthest known site of historic and/or current sighting or capture of green sturgeon, as long as the site is still accessible. The specific areas were extended upstream to a geographically identifiable point. The riverine specific areas include areas that offer at least periodic passage of Southern DPS fish to upstream sites and include sufficient habitat necessary for each riverine life stage (e.g., spawning, egg incubation, larval rearing, juvenile feeding, passage throughout the river, and/or passage into and out of estuarine or marine habitat). The CHRT also delineated a specific area in the Sacramento-San Joaquin Delta. Each specific area is described in detail below. Table 1 summarizes the PCEs present and activities that may adversely modify the PCEs within each specific area and necessitate special management considerations or protection.

(1) *Sacramento River, CA*: The Sacramento River is the only area where spawning by Southern DPS green sturgeon has been confirmed and where all life stages of the Southern DPS are supported. The CHRT divided the Sacramento River into two specific areas to more specifically describe the PCEs present and the activities of Southern DPS fish within each area. The CHRT chose the RBDD as the dividing point, because the RBDD presents a barrier to upstream migration when the gates are lowered (typically from May 15 to September 15 each year).

(a) *Upper Sacramento River, CA* (from the Red Bluff Diversion Dam (RBDD; river kilometer (rkm) 391) to Keswick Dam (rkm 486)): The upper Sacramento River area from upstream of the RBDD gates to Keswick Dam is largely recognized as the main spawning reach for adult Southern DPS green sturgeon. Spawning likely begins in March and extends through early summer (Brown, 2007). The upper Sacramento River also supports egg incubation, larval and juvenile rearing, feeding, and migration, and adult, and possibly subadult, migration and holding. PCEs present to support these activities include: food resources for feeding; substrates suitable for spawning, egg deposition and development, and larval development; water flow, water quality, and sediment quality; seasonal migratory corridors (when the RBDD gates are raised); and deep holding pools for adults.

Adults are known to occur as far upstream as Keswick Dam and occur in the river through November/December.[1] Subadults are likely to enter the Sacramento River as well, though for unknown reasons. Juvenile Southern DPS fish have been collected at the RBDD from May through November (two were 180 - 400 mm TL; eight were 215 - 315 mm TL) and most likely overwinter in the river, occupying the area from Hamilton City to Keswick Dam from July to December (USFWS, 1992; CDFG, 2002; Gaines and Martin, 2002). In 2008, the first egg samples were collected in the upper Sacramento River.[2] Larval Southern DPS fish have been collected at RBDD from early May through August, with peak catches in June and July (CDFG, 2002; Gaines and Martin, 2002). One larval Southern DPS fish (24 mm TL) was collected above RBDD at Bend Bridge on July 13, 2001 (Brown, 2007). Larvae are believed to rear in the late spring to late summer for at least 1 - 2 months before migrating downstream (CDFG, 2002). Southern DPS adults and/or subadults have been observed at the mouths of tributaries to the Sacramento River, but not in the tributaries. No juveniles, larvae, or eggs have been observed in surveys within the tributaries.

Several special management concerns exist within the upper Sacramento River area. Adult Southern DPS fish cannot migrate upstream to access spawning habitats within this area when the RBDD gates are closed, typically from May 15 to September 15 each year. While some gates are partially open during this period, high flow rates under the gates create a velocity barrier to upstream migration. On the other hand, adult Southern DPS fish within the upper Sacramento River can migrate downstream past the RBDD during this period. However, if the gates are not raised high enough, there is the possibility of injury or mortality. Due to atypical gate operations in Spring 2007, approximately 10 dead adult green sturgeon were found at or downstream of the RBDD, with scraping, trauma, and other injuries indicating that mortality was caused by the fish getting trapped in the partially-opened gates of the RBDD.[3] Since this incident, gate operations have changed where the gates must be either completely closed or raised to a height equal to or greater than one foot (under which green sturgeon are documented to successfully pass).[4] Other concerns include the presence and operation of dams resulting in altered water flow and substrate composition and reduced water quality, operation of water diversions, NPDES activities and activities resulting in non-point source pollution (e.g., Iron Mountain Mine, agricultural outfalls), and in-water

[1] M. Thomas and R. Corwin, U.S. Bureau of Reclamation (USBR), Red Bluff, CA. Unpublished green sturgeon tagging data. Personal commun., February 2008.
[2] B. Poytress, USFWS, Red Bluff, CA. Unpublished green sturgeon sampling data in the Sacramento River, 2008. Personal commun., July 2008.
[3] E. Campbell, NMFS, Sacramento, CA. Unpublished data from U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service on green sturgeon mortalities at Red Bluff Diversion Dam in Spring 2007. June 2007.
[4] M. Thomas, UC Davis, Davis, CA, and R. Corwin, USBR, Red Bluff, CA. Unpublished 2007 green sturgeon telemetry data. Personal commun., July 2008.

construction or alterations (e.g., bridge repairs, gravel augmentation, bank stabilization).

(b) *Lower Sacramento River, CA* (from the Sacramento I-Street Bridge to the RBDD, excluding the Yolo and Sutter bypasses): The lower Sacramento River area extends from the downstream side of the RBDD gates to the upper boundary of the legal Delta (marked by the Sacramento I-Street Bridge). The lower Sacramento River serves as an important migratory corridor for adult Southern DPS green sturgeon to and from upstream spawning grounds and for larval and juvenile Southern DPS green sturgeon on their downstream migration from fresh water rearing habitats to the Delta and bays. Although the upper Sacramento River is believed to be the primary spawning area for adult Southern DPS fish, spawning also occurs in the lower Sacramento River. The lower Sacramento River also supports egg incubation; larval and juvenile rearing, feeding, and migration; and adult, and possibly subadult, holding and migration. Similar to the upper Sacramento River, the PCEs present include: food resources for feeding; substrates suitable for spawning, egg deposition and development, and larval development; water flow, water quality, and sediment quality; migratory corridors; and deep holding pools for adults.

Adult Southern DPS green sturgeon enter the river in March (Schaffter, 1997) and spawning likely occurs from late spring to early summer (CDFG, 2002; Brown, 2007). Tagged adult Southern DPS fish were observed holding-over in summer months and aggregating within low velocity pools with eddies. In June 2007, 4 tagged adults were observed to be holding together in a deep pool.[1] Tagged adults were detected upstream of Hamilton City through November/December, before moving downstream with increased flows.[2] Subadults also likely occur in the lower Sacramento River, but for reasons unknown. Juvenile Southern DPS fish (≥ 100 mm) have been collected at the Glenn-Colusa Irrigation District (GCID) from July through December (CDFG, 2002), and one juvenile (60 mm) was collected at Hamilton City in 1974 (Kohlhorst, 1976), most likely on their downstream migration to the Delta. Larval Southern DPS fish (20 – 50 mm) first appear at GCID in early May to June and are found through October (CDFG, 2002). Larvae are believed to rear in the river from late spring to late summer for at least 1 - 2 months before moving downstream (CDFG, 2002). Two green sturgeon eggs were collected on artificial substrates just downstream of RBDD on June 14, 2001 (Brown, 2007), the first collection of confirmed green sturgeon eggs in the Sacramento River. In 2008, multiple egg samples were collected about 15 rkm downstream of

[1] R. Corwin, USBR, Red Bluff, CA. Unpublished green sturgeon observations. Personal commun., February 2008.
[2] M. Thomas, UC Davis, Davis, CA, and R. Corwin, USBR, Red Bluff, CA. Unpublished green sturgeon tagging data. Personal commun., February 2008.

the RBDD.[1] Adult, subadult, and juvenile Southern DPS fish are more likely to use the tributaries to the lower Sacramento River than the tributaries to the upper Sacramento River; however, no adults, juveniles, or larvae have been observed in the tributaries.[2]

Several special management concerns exist in the lower Sacramento River. Although dams do not pose as much of a threat to passage for adults in this area, dams and water diversions do alter water flow, substrate composition, and water quality important for adult, juvenile, larval, and egg life stages. Other activities occurring in this area that alter water flow and substrate composition and reduce water quality include: dredging, in-water construction or alterations (e.g., bridge repairs, gravel augmentation, bank stabilization), agricultural pesticide application, and other NPDES activities and activities generating non-point source pollution (e.g., Iron Mountain Mine, agricultural outfalls).

(2) *Yolo Bypass, CA*: The Yolo Bypass is located to the west of, and is partially encompassed by, the lower Sacramento River and empties out into the Delta. The Yolo Bypass is a major flood control tool that is intermittently available as habitat for green sturgeon and other fish species when flooded (approximately every 1 to 3 years). PCEs present in this area include food resources, water quality, sediment quality, and migratory corridors. Subadult and adult Southern DPS fish have been observed in the Yolo Bypass, as well as juvenile Southern DPS fish that likely get swept into the bypass by water flow.[3] During flood years, the Yolo Bypass serves as an important migration corridor for Southern DPS adults on their upstream and downstream migrations to and from the Sacramento River. Southern DPS adults and subadults are likely attracted to the bypass by water flow. Although feeding by green sturgeon within the bypass has not been documented, the bypass provides a high macroinvertebrate forage base that may support feeding. Special management considerations or protection may be needed to address concerns with water flow and water quality in the bypasses. For example, water diversion operations, or the improper management or lack of management of the flood control structure, could alter water flow and reduce water levels, increasing the risk of stranding and poaching of green sturgeon, and pollution from agricultural runoff could adversely affect water quality.

(3) *Sutter Bypass, CA*: The Sutter Bypass is located to the east of the lower Sacramento River and is also a major flood control tool for the Sacramento Valley. The Sutter Bypass is smaller than the Yolo Bypass, but is flooded first, flowing into the Feather River and then into the Yolo Bypass. PCEs present in the Sutter Bypass include food resources, water quality, sediment quality, and migratory corridors. The Sutter Bypass floods on the same cycle as the Yolo

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[1] B. Poytress, USFWS, Red Bluff, CA. Unpublished green sturgeon sampling data. Personal commun., July 2008.
[2] J. Stuart, NMFS, Sacramento, CA. Personal commun., February 2008.
[3] J. Stuart, NMFS, Sacramento, CA. Unpublished observations. Personal commun., February 2008.

Bypass (approximately every 2 to 3 years) and also provides a high macroinvertebrate forage base that may support green sturgeon feeding. Subadult and adult Southern DPS fish and a few juvenile Southern DPS fish have been observed migrating through the Sutter Bypass. Similar to the Yolo Bypass, water diversion operations, improper management or lack of management of the bypass, and agricultural runoff that could alter water flow and water quality are concerns for this area and may require special management considerations or protection.

(4) *Lower Feather River, CA* (from the confluence with the Sacramento River upstream to the Oroville Dam, rkm 116): The lower Feather River is a tributary to the Sacramento River. Conditions in the lower Feather River are highly influenced by the Oroville Dam facilities located around rkm 116. PCEs present within the lower Feather River include water flow, water quality, depths, and unobstructed migratory pathways (up to the Oroville Dam) to support adult, and possibly subadult, migration. As described above, green sturgeon observed in the lower Feather River are believed to belong to the Southern DPS. Green sturgeon are known to occur in the lower Feather River below Oroville Dam. The presence of adult, and possibly subadult, Southern DPS fish within the lower Feather River has been confirmed by photographs, anglers' descriptions of fish catches (P. Foley, pers. comm. cited in CDFG, 2002), incidental sightings (California Department of Water Resources (CDWR), 2005), and occasional catches of green sturgeon reported by fishing guides (Beamesderfer *et al.*, 2004). Since 2006, several green sturgeon have been observed in the lower Feather River, including one individual tagged in Willapa Bay, WA.[1] Spawning within the lower Feather River is possible, but has not been confirmed (CDFG, 2002; CDWR, 2005; Adams *et al.*, 2007). Several sampling surveys have been conducted in recent years to look for evidence of spawning, but no green sturgeon juveniles, larvae, or eggs have been collected to date (CDWR, 2001; 2002; 2003; 2005). It is important to note that the sampling methods used may not have been well-suited for sampling green sturgeon juveniles, larvae, and eggs.

Special management concerns are similar to those in the upper and lower Sacramento River, including the operation of dams and water diversion operations resulting in the alteration of water flow and reduced water quality (including thermal issues associated with the Thermalito Dam), in-water construction or alterations (e.g., bridge repairs, gravel augmentation, bank stabilization), and NPDES activities and other activities resulting in non-point source pollution (e.g., agricultural pesticide application, agricultural runoff and outfalls).

(5) *Lower Yuba River, CA* (from the confluence with the Feather River upstream to the Daguerre Dam, rkm 19): The Yuba River is a tributary to the Feather River. PCEs present include water flow, water quality, depths, and migratory corridors to support adult, and possibly subadult, migration. As described above, green sturgeon observed in the lower Yuba River are believed to belong to the Southern DPS. We have very few observations of green sturgeon in the lower Yuba River

[1] A. Seesholtz, California Department of Water Resources, Oroville, CA. Personal commun., July 2008.

compared to the Sacramento River and lower Feather River. Of three adult or subadult sturgeon observed below Daguerre Dam in 2006, one was confirmed to be a green sturgeon based on photographs and expert opinions.[1] Historical accounts of sturgeon in the Yuba River have been reported by anglers, but these accounts do not specify whether the fish were white or green sturgeon (Beamesderfer *et al.*, 2004). Spawning is possible in the river, but has not been confirmed and is less likely to occur in the Yuba River than in the Feather River. No green sturgeon juveniles, larvae, or eggs have been observed in the lower Yuba River to date. The lower Yuba River is subject to the same management concerns as described for the lower Feather River.

(6) *Sacramento - San Joaquin Delta, CA* (the legal Delta, excluding Montezuma Slough): The specific area in the Sacramento-San Joaquin Delta (hereafter referred to as the "Delta") is defined by the legal boundaries of the Delta (California Water Code Section 12220), with one modification. The CHRT defined the boundary between the Delta and Suisun Bay by a line extending from the mouth of Spoonbill Creek across the channel to the city of Pittsburg, CA, resulting in Chipps Island being fully contained within the Suisun Bay specific area. The Delta provides important rearing habitat for juveniles and subadults and important feeding and migratory habitat for juveniles, subadults, and adults. PCEs present within the Delta include food resources (e.g., shrimp, amphipods, isopods, clams, annelid worms, crabs, and fish); water flow, water quality, and sediment quality for migration and normal behavior, growth, and viability; and migratory corridors for migration between the Sacramento River system and the adjacent bays. Subadult and adult Southern DPS fish likely occur throughout the Delta. In Spring 2003, one adult over 2 m TL was taken in the Tracy Fish Collection Facility located in the South Delta (Wang, 2006). Larger numbers of juveniles are caught each year in the South Delta, in the Tracy Fish Collection Facility (operated by the U.S. Bureau of Reclamation (USBR)) and the John E. Skinner Delta Fish Protective Facility (operated by the CDWR) (CDFG, 2002). Juveniles are collected throughout the year in the south Delta and the western Delta at the Federal and state facilities and in gill-net/set-line sampling (CDFG, 2002; Bay Delta and Tributaries Project (BDAT), 2005). Relatively large catches of juveniles were taken at the Santa Clara Shoal from June to August, primarily in areas 3 – 8 ft deep (Radtke, 1966).

Many activities occur within the Delta that may affect the PCEs. The operation of diversions (e.g., pumps, the Delta cross channel, deep-water shipping channel locks), dredging activities, in-water construction or alterations (e.g., levee building, bank stabilization, sand mining), power plant operations resulting in thermal effluent, habitat restoration activities, and NPDES activities and activities resulting in non-point source pollution (e.g., agricultural returns) could alter water flow, reduce water quality, and affect food resources in the Delta.

[1] G. Reedy, South Yuba River Citizens League, Nevada City, CA. Email with subject: Green sturgeon in the Yuba. Pers. comm., December 2006. Follow-up pers. comm. with A. Seesholtz, CDWR, Oroville, CA, April 2008.

Bays and Estuaries

Southern DPS green sturgeon occupy coastal bays and estuaries from Monterey Bay, CA, to Puget Sound, WA. The Suisun, San Pablo, and San Francisco bays serve as important habitat areas for juvenile, subadult, and adult Southern DPS fish. These bays support rearing, feeding, and growth, and serve as an important migratory/connectivity corridor between the Sacramento River system and coastal marine waters. Outside of their natal system, subadult and adult Southern DPS fish also occupy coastal bays and estuaries in California, Oregon, and Washington, including estuarine waters at the mouths of non-natal rivers. Coastal bays and estuaries are believed to serve as important summer habitats for subadult and adult green sturgeon, supporting migration, feeding, and growth (Moser and Lindley, 2007; Lindley *et al.*, 2008). The CHRT included all coastal bays and estuaries for which there was evidence to confirm the presence of green sturgeon, noting where there were confirmed Southern DPS fish, confirmed Northern DPS fish, or confirmed green sturgeon of unknown DPS. As stated in the previous section, based on the definitions for the Northern DPS and Southern DPS, any green sturgeon observed upstream of the head of the tide in freshwater rivers north of and including the Eel River were assigned to the Northern DPS. Thus, areas upstream of the head of the tide on these rivers were not included as part of the occupied specific areas for the Southern DPS. Each specific area was defined to extend from the mouth of the bay or estuary upstream to the head of the tide. The boundary at the mouth of each bay or estuary was defined by the COLREGS demarcation line. COLREGS demarcation lines delineate "those waters upon which mariners shall comply with the International Regulations for Preventing Collisions at Sea, 1972 (72 COLREGS) and those waters upon which mariners shall comply with the Inland Navigation Rules" (33 CFR 80.01). Waters inside of the 72 COLREGS lines are Inland Rules waters and waters outside of the 72 COLREGS lines are COLREGS waters. The following paragraphs describe the 20 specific areas identified within coastal bays and estuaries. Table 1 summarizes the PCEs present and activities that may adversely modify the PCEs such that special management considerations or protection may be required.

(1) *Elkhorn Slough, CA* (from the mouth upstream to the head of the tide): A shallow, tidal embayment, Elkhorn Slough is located on the California coast within Monterey Bay. There is very little data on green sturgeon presence in, and use of, Elkhorn Slough. Adult and/or subadult green sturgeon of unknown DPS were collected in Elkhorn Slough and adjacent areas (i.e., Moss Landing Harbor, Jetties Slough, and Bennett Slough) in surveys from the 1970s to 1990s (Yoklavich *et al.*, 2002). One green sturgeon skeleton was collected on Moss Landing Beach, just north of Elkhorn Slough (D. Catania, pers. comm. cited in Moyle *et al.*, 1992) and one green sturgeon 546 mm in length was impinged and died at the Moss Landing Power Plant in 2006.[1] Both green sturgeon were of unknown DPS. Based on the detection of tagged Northern DPS fish and

[1] C. Raifsnider, Tenera Consulting, San Francisco, CA, and J. Steinbeck, Tenera Consulting, San Luis Obispo, CA. Unpublished data on green sturgeon impingements at coastal power plants in California. Personal commun., September 2006.

Southern DPS fish in Monterey Bay,[1] green sturgeon in Elkhorn Slough could belong to either the Southern or the Northern DPS. PCEs present in this area include food resources, water quality, and migratory corridors that may support feeding and migration by subadults and adults. Special management concerns for this area include effects on benthic food resources and water quality due to dredging and operation of the Moss Landing Power Plant.

(2) *Suisun Bay, CA*: The specific area within Suisun Bay extends from the boundary between Suisun Bay and the Delta (delineated by a line extending from the mouth of Spoonbill Creek across the channel to the city of Pittsburg, CA) to Carquinez Bridge, including Montezuma Slough and Suisun Marsh. Suisun Bay is adjacent to the Delta, in the Central Valley, CA. Suisun Bay supports juvenile, subadult, and adult Southern DPS fish, serving as important rearing habitat and an important migratory corridor from the San Pablo and San Francisco bays to and from the Delta and Sacramento River system. PCEs present in this area include food resources (e.g., *Corophium* spp., *Crago franciscorum*, *Neomysis awatchensis*, and annelid worms (Ganssle, 1966)), depths, water flow, water quality, and migratory corridors to support juvenile rearing, feeding, and migration and subadult and adult feeding and migration. Juvenile Southern DPS fish occur in Suisun Bay throughout the year, with relatively high numbers of juveniles taken in otter/midwater trawl sampling in Carquinez Strait (Ganssle, 1966; CDFG, 2002). Adult and subadult Southern DPS fish occupy Suisun Bay and Carquinez Strait from February to December.[2] Tagged adult and subadult fish exhibited both non-directional movements close to the bottom (indicative of foraging behavior) and directional movements close to the surface, occupying a wide range of temperatures, salinities, and dissolved oxygen levels (Kelly *et al.*, 2007). Subadult and/or adult Southern DPS fish also likely occupy the Suisun Marsh and Montezuma Slough in areas up to tidal influence.[3] Activities that may disturb benthic habitats, such as dredging, deposition of dredged material, and in-water construction or alterations (e.g., wharfs, piers, pile driving, bridge construction, bank stabilization) could have an effect on food resources and water quality within the bay.

(3) *San Pablo Bay, CA* (from Carquinez Bridge to Richmond-San Rafael Bridge, including tidally influenced areas of Petaluma River, Napa River, and Sonoma Creek): San Pablo Bay is located between Suisun and San Francisco bays. San Pablo Bay serves as important rearing habitat for juvenile Southern DPS fish, as well as for oversummering subadults and adults. It also serves as a migration corridor for adults en route to, and from, spawning grounds in the upper Sacramento River. Similar to Suisun Bay, PCEs present include food resources (e.g., *Corophium* spp., *Crago franciscorum*, *Macoma* spp., *Photis californica*,

[1] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. 2008. Unpublished green sturgeon tagging data. Personal commun., February 2008.
[2] M. Thomas, UC Davis, Davis, CA, and R. Corwin, USBR, Red Bluff, CA. Unpublished green sturgeon tagging data. Personal commun., February 2008.
[3] J. Stuart, NMFS, Sacramento, CA. Personal commun., February 2008.

Synidotea laticauda, unidentified crab, and fish (Ganssle, 1966)), depths, water quality, and migratory corridors to support juvenile rearing, feeding, and migration, and subadult and adult feeding and migration.

Juveniles are present throughout the year (Ganssle, 1966; CDFG, 2002) and subadults and adults occur throughout most of the year (from February to December).[1] As in Suisun Bay, tagged subadults and adults exhibited benthic foraging behavior as well as directional movements near the surface, and showed a high tolerance for the range of temperatures, salinities, and dissolved oxygen levels within the bay (Kelly *et al.*, 2007). Subadult and/or adult Southern DPS fish have been observed in tidally influenced areas at the mouths of Petaluma River and Napa rivers.[2] Subadult and adult Southern DPS fish tagged in San Pablo Bay are known to migrate as far south as Monterey Bay, CA, and as far north as Graves Harbor, Alaska, with particularly large concentrations oversummering in the Columbia River estuary and Washington estuaries and overwintering in waters off Vancouver Island, British Columbia (Chadwick, 1959; Miller, 1972; CDFG, 2002; Lindley *et al.*, 2008).[3] Management concerns for this area are the same as those described for Suisun Bay. In addition, thermal effluent from power plants and pollution from oil refineries and other industries could reduce water quality and thus affect Southern DPS critical habitat.

(4) *San Francisco Bay, CA* (bordered by Richmond-San Rafael Bridge and the mouth of the bay, including tidally influenced areas of tributaries and sloughs in south San Francisco Bay): San Francisco Bay is a large estuary located along the central California coast, connecting the San Pablo and Suisun bays to the Pacific Ocean. San Francisco Bay serves as an important rearing and migratory habitat for juvenile Southern DPS green sturgeon prior to entering marine waters. It also serves as an important migratory corridor for subadults and adults from the ocean to and from the bays and Sacramento River system. Similar to Suisun and San Pablo bays, the PCEs present include food resources, depths, water quality, and migratory corridors to support rearing, feeding, and migration of juveniles, and feeding and migration of subadults and adults. Juveniles are believed to be present throughout the year (CDFG, 2002). Subadults and adults are present from February through December (some individuals outmigrate from the Sacramento River in November/December).[4] Southern DPS fish in the San Francisco Bay exhibited behavior similar to that observed in Suisun and San Pablo bays (Kelly *et al.*, 2007). Subadults and adults likely occur within tidally influenced areas of the sloughs surrounding

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[1] M. Thomas, UC Davis, Davis, CA, and R. Corwin, USBR, Red Bluff, CA. Unpublished green sturgeon tagging data. Personal commun., February 2008.
[2] D. Woodbury, NMFS, Santa Rosa, CA. Unpublished observations. Personal commun., February 2008.
[3] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. Personal commun., February 2008.
[4] M. Thomas, UC Davis, Davis, CA, and R. Corwin, USBR, Red Bluff, CA. Unpublished green sturgeon tagging data. Personal commun., February 2008.

San Francisco Bay.[1] Management concerns in San Francisco Bay are similar to those in Suisun and San Pablo bays. The areas bordering San Francisco Bay are densely populated, resulting in water quality and sediment quality concerns. The waters and sediments of San Francisco Bay have been listed as impaired due to levels of mercury, chlordane, diazinon, dieldrin, dioxin compounds, PCBs, DDT, selenium, PAHs, zinc, and other contaminants (California's Final 2002 303(d) List, available at: http://www.epa.gov/region09/water/tmdl/303d-2002.html). In addition, a proposed tidal energy project at the Golden Gate Bridge could affect water quality and passage for green sturgeon.

(5) *Tomales Bay, CA* (from the mouth upstream to the head of the tide, including tidally influenced areas of Lagunitas Creek and Walker Creek): Tomales Bay is a long, narrow inlet located just north of San Francisco Bay in Marin County, CA. Tomales Bay provides good habitat for benthic foragers, with lots of shallow flat areas between 1 - 2 m in depth. PCEs present include food resources and water quality to support subadults and adults. Small numbers of green sturgeon have been observed in Tomales Bay (Blunt, 1980, D. Catania pers. comm., and R. Plant pers. comm cited in Moyle *et al.*, 1992). It is not known whether the fish belong to the Northern DPS or to the Southern DPS, and there are currently no receivers in the bay to detect tagged green sturgeon. Special management concerns for Tomales Bay include effects on food resources and water quality from various activities, including aquaculture (i.e., oyster farming), in-water construction or alterations (e.g., wharf construction, recreational boat launches, pile driving, bank stabilization), water diversions (in the upstream basin), point and non-point source pollution (e.g., agricultural runoff), and habitat restoration. Sediment contamination and high mercury levels have resulted from historical mining activities.

(6) *Noyo Harbor, CA*: Noyo Harbor is located at the mouth of the Noyo River in Mendocino County, CA, north of Tomales Bay. Aside from one specimen collected from the Noyo River (D. Catania, pers. comm, cited in Moyle *et al.*, 1992), there are no other data on the presence of green sturgeon in the area. It is not known whether the green sturgeon collected belonged to the Northern or the Southern DPS. PCEs present include food resources and water quality to support subadults and adults. However, the habitat may not be as suitable for green sturgeon as Tomales Bay, because there are few mudflats and the harbor is highly dredged. Management concerns include effects on food resources, water quality, and sediment quality due to dredging activities and point and non-point source pollution (e.g., high sediment loads resulting from logging operations upstream).

(7) *Humboldt Bay system, CA*: The Humboldt Bay system, located on the northern California coast, is a deep water bay with a narrow opening at the mouth that opens into Arcata Bay to the north and Humboldt Bay to the south. The

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[1] J. Stuart, NMFS, Sacramento, CA, and D. Woodbury, NMFS, Santa Rosa, CA. Personal commun., February 2008.

Humboldt Bay system contains PCEs including food resources, water quality, and migratory corridors to support subadult and adult life stages of green sturgeon. Survey records indicate green sturgeon were commonly observed in the Humboldt Bay system, with larger numbers taken in Arcata Bay. In South Humboldt Bay, 3 green sturgeon were caught in trawl surveys conducted over 10 years (Samuelson, 1973, cited in Moyle *et al*., 1992). In Arcata Bay, 50 green sturgeon ranging in size from 57.2 – 148.6 cm TL were tagged in August 1956 (data recovered from CDFG files by D. Kohlhorst, pers. comm., cited in Moyle *et al.*, 1992) and 9 green sturgeon ranging from 73 – 112 cm TL were caught in 1974 (Sopher, 1974, cited in Moyle *et al.*, 1992). More recently, 8 green sturgeon (78 – 114 cm TL) were collected in 1988 and 1989 (Moyle *et al.*, 1992), and additional green sturgeon were captured and tagged in 1992 and 1993 in Arcata Bay (CDFG, 2002).

The Humboldt Bay system is believed to be an important oversummering habitat for Southern DPS green sturgeon, for feeding, growth, and migration. Tagged Southern DPS subadults and adults were detected in the Humboldt Bay system in 2006 and 2007 (Pinnix, 2008b), including fish tagged in San Pablo Bay (detections: n = 6 in 2006; n = 16 in 2007) and in the Sacramento River (detections: n = 3 in 2007). Tagged Southern DPS fish spent several months within the system, entering in April to June and remaining until September to October, with larger numbers of detections in Arcata Bay (Pinnix, 2008a). Green sturgeon of unknown DPS (tagged in Willapa Bay and Grays Harbor, WA) were also detected in the system in 2006 (n = 3) and in 2007 (n = 6) (Pinnix, 2008b).

Activities occurring in the Humboldt Bay system that may affect the PCEs include oyster aquaculture operations that could alter benthic habitats and affect food resources, and NPDES activities and activities resulting in non-point source pollution (e.g., industrial pollution, sewer outfalls) that could reduce water quality. However, aquaculture operations occur in deeper benthic areas that typically may not be used for foraging by green sturgeon.

(8) *Eel River, CA* (from the mouth to the head of the tide): The mouth of the Eel River is located on the northern California coast in Humboldt County, just south of Humboldt Bay. PCEs present include food resources, water flow, water quality, and migratory corridors to support subadult and adult green sturgeon. The presence of Southern DPS green sturgeon is likely, but not confirmed, based on the presence of Northern DPS adult, subadult, and juvenile green sturgeon in the estuary (S. Cannata, CDFG, pers. comm., cited in CDFG 2002) and in the river (Murphy and DeWitt, 1951, cited in Moyle *et al*., 1992; CDFG, 2002). An acoustic receiver installed in 2007 detected one tagged Northern DPS green sturgeon in the estuary in 2008,[1] and may provide more information on use of the area by tagged Southern DPS and Northern DPS fish in the future. Management concerns include altered food resources and water quality resulting

[1] S. Lindley, NMFS, Santa Cruz, CA. Personal commun., May 2008.

from timber harvest upstream, road building, gravel mining, grazing, levee modifications, and other in-water construction or alterations.

(9) *Klamath/Trinity rivers, CA* (from the mouth to the head of the tide): The Klamath/Trinity River estuary is located along the northern California coast, in southwestern Del Norte County. The estuary contains food resources, water flow, water quality, and migratory corridors for subadult and adult migration. Northern DPS green sturgeon are known to spawn in the Klamath/Trinity river and occur within the estuary and further upstream (Adams *et al.*, 2002). The presence of Southern DPS fish is categorized as likely based on the presence of Northern DPS fish, but, although tagged Southern DPS subadults and adults have been observed in coastal marine waters outside the mouth of the estuary, no tagged Southern DPS fish have been detected in the estuary.[1] A low proportion of green sturgeon sampled in the Klamath/Trinity River were assigned to the Southern DPS based on genetic analyses (10-16%, or 16 fish, of 124 sampled) (Israel and May, 2006), but this was attributed to analysis error.[2] Special management concerns for the Klamath/Trinity River estuary include in-water construction or alterations (e.g., timber harvest, road construction and maintenance) that could affect food resources and reduce water quality.

(10) *Rogue River, OR* (from the mouth to the head of the tide): The Rogue River estuary is located on the southern Oregon coast, adjacent to the city of Gold Beach in Curry County. The estuary extends upstream to approximately river mile 4.5 and provides PCEs including food resources, water flow, water quality, and migratory corridors for subadult and adult migration. Northern DPS green sturgeon have been confirmed to spawn in the Rogue River (Erickson *et al.*, 2002; Farr and Kern, 2005). The presence of Southern DPS fish is categorized as likely based on the presence of Northern DPS fish, but thus far, no tagged Southern DPS subadults or adults have been detected in the Rogue River estuary.[1] A low proportion of green sturgeon sampled in the Rogue River have been assigned to the Southern DPS based on genetic analyses (8.3 – 15.2%, or 13 fish, of 113 fish sampled) (Israel and May, 2006), but, similar to the Klamath/Trinity River, this was attributed to analysis error.[3]

Several special management concerns exist for the Rogue River estuary. The lower estuary is highly modified, due to filling of the estuary for dikes, a marina, and the development of and placement of riprap along the north shore (Hicks, 2005). These modifications could affect water quality, water flow, and food resources for green sturgeon.

(11) *Coos Bay, OR*: Coos Bay is located in Coos County in southwestern Oregon. Coos Bay is the deepest and largest bay on the Oregon coast, extending about

[1] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging and tracking data. Personal commun., February 2008.
[2] J. Israel, UC Davis, Davis, CA. Personal commun., February 2008.
[3] J. Israel, UC Davis, Davis, CA. Personal commun., February 2008.

10.2 river miles upstream and covering an area of about 17.7 square miles. Coos Bay provides important summer habitat for subadult and adult green sturgeon. Data indicate larger numbers of green sturgeon and greater use of this area compared to other non-natal coastal estuaries in California (except for Humboldt Bay) and Oregon (except for Winchester Bay). From February 2000 to February 2004, ODFW captured and collected tissue samples from 12 green sturgeon (DPS unknown) in Coos Bay (Rien *et al.*, 2000; Farr *et al.*, 2001; Farr and Rien, 2002; Farr and Rien, 2003; Farr and Kern, 2004; Farr and Kern, 2005). Tagged Southern DPS subadults and adults from San Pablo Bay have also been detected in Coos Bay.[1] PCEs present include food resources, water flow, water quality, and migratory corridors to support migration and possibly feeding by subadult and adult green sturgeon. Several activities could affect these PCEs, however, including road building (resulting in sedimentation), urbanization (resulting in pollution and increased peak flows), stream channelization, wetland filling and draining, and development and silviculture (resulting in the loss of large woody debris and forested land cover) (Lower Pony Creek Watershed Committee, 2002; Oregon Department of Forestry, 2004).

(12) *Winchester Bay, OR*: Winchester Bay is located at the mouth of the Umpqua River, in Douglas County, OR. Winchester Bay is the second deepest and largest bay on the Oregon coast, extending about 29.2 river miles upstream and covering an area of about 10.8 square miles. PCEs present include food resources, water flow, water quality, and migratory corridors to support migration and possible feeding by subadult and adult green sturgeon. Winchester Bay is also an important oversummering area for subadult and adult green sturgeon. Adult and subadult green sturgeon are more commonly captured in Winchester Bay than in Coos Bay. From February 2000 to February 2001, 126 green sturgeon were captured in Winchester Bay and tissue samples collected (Rien *et al.*, 2000; Farr *et al.*, 2001). A large proportion of green sturgeon captured in Winchester Bay have been assigned to the Southern DPS based on genetic analyses (58%, or 62 fish, of 106 fish sampled (Israel and May, 2006). In addition, tagged Southern DPS subadults and adults were detected in the Winchester Bay in the 1950s (one green sturgeon, 117 cm TL, tagged in San Pablo Bay; Chadwick, 1959) and more recently in 2005 and 2006.[2] Green sturgeon have been observed upstream of the head of the tide in Umpqua River, including one adult (1.8 m in length) caught at rkm 164 in April 1979 and two juveniles (about 10 cm in length) regurgitated from two smallmouth bass caught at rkm 134 in July 2000 (Biological Review Team (BRT), 2005). These green sturgeon are believed to belong to the Northern DPS. No green sturgeon were

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[1] L. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data, cited in the NMFS Memo to the Record from Churchill Grimes, subject: Fishery take of Southern DPS green sturgeon in northern waters, dated October 23, 2006. Personal commun., October 2006.

[2] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. Personal commun., February 2008.

observed above tidal influence in the Umpqua River in sampling surveys conducted by the ODFW in 2002, 2003, and 2004 (BRT, 2005).

Several activities occurring in the bay could affect the PCEs, including channel modifications/diking, road building (sedimentation), wetland filling and draining, other in-water construction or alterations (e.g., docks, marinas, stream channelization), urbanization (pollution and increased peak flows), NPDES activities and activities resulting in non-point source pollution (e.g., urbanization), and development and silviculture (loss of large woody debris and forest land cover) (USDA Forest Service, 1997; Oregon Department of Forestry, 2004).

(13) *Siuslaw River, OR* (from the mouth to the head of the tide): The Siuslaw River estuary is located in Lane County on the Oregon coast. The estuary extends upstream to river mile 22.8 and is surrounded by wetlands. PCEs in this area include water flow, water quality, and migratory corridors to support migration by subadults and adults. Several management concerns exist regarding in-water construction or alterations affecting habitat. For example, tide gates have restricted water flow and may affect passage, forestry and road building activities have increased landslides and sedimentation, forestry and grazing activities have impaired riparian vegetation, diking and levee construction may alter water flow and water quality, and the loss of large woody debris and forest land cover may affect water quality (USDI Bureau of Land Management, 1996; USDA Forest Service, 1998; Ecotrust and Siuslaw Watershed Council, 2002). Little data exists on green sturgeon use of the Siuslaw River estuary. Green sturgeon adults and subadults are considered rare in the area (Emmett *et al.*, 1991). Northern DPS fish tagged in the Rogue River were detected in the Siuslaw River estuary in 2006, but no Southern DPS fish have ever been detected in the area.[1]

(14) *Alsea River, OR* (from the mouth to the head of the tide): The Alsea River estuary is located near the city of Waldport in Lincoln County on the Oregon coast. The estuary is wide, extending upstream to river mile 11.5 and covering 0.8 square miles. PCEs present in the area include water flow, water quality, and migratory corridors to support migration by subadults and adults. Several activities occur within the estuary that may affect these PCEs. For example, modified hydrology associated with forestry and road building activities may lead to loss of appropriate channel substrates; impaired riparian vegetation and loss of large woody debris and forest land cover may result from forestry, road building, agriculture, grazing, and residential development; overallocation of surface water for irrigation and municipal uses alters water flow and water quality; and diking and filling of wetlands may affect benthic habitats (USDA Forest Service *et al.*, 1999). Very little data exist on green sturgeon within the

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[1] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. Personal commun., February 2008.

Alsea River estuary, though a report stating green sturgeon adults and subadults are rare in this area was prepared by Emmett *et al.* (1991).

(15) *Yaquina Bay, OR* (from the mouth to the head of the tide): Yaquina Bay is a small bay located at the mouth of Yaquina River, near Newport in Lincoln County, Oregon. Yaquina Bay extends upstream to river mile 21.8 and covers 6.3 square miles. PCEs present include water flow, water quality, and migratory corridors to support migration by subadults and adults. Several activities may affect these PCEs, including dredging of the lower estuary, in-water construction (e.g., urbanization; diking and draining of wetlands for urban development, agriculture, and grazing), and development and silviculture (resulting in the loss of large woody debris and forest land cover) (Brophy, 1999; Jones and Moore, 2000; Garono and Brophy, 2001). The presence of the Southern DPS is likely based on the presence of green sturgeon of unknown DPS, but not confirmed. Green sturgeon are reported to be common in Yaquina Bay (Emmett *et al.*, 1991), most likely using the bay as oversummering habitat, though to a lesser extent than Winchester Bay and Coos Bay. From February 2000 to February 2004, 24 green sturgeon adults and/or subadults were captured by ODFW in Yaquina Bay and tissue samples collected (Rien *et al.*, 2000; Farr *et al.*, 2001; Farr and Rien, 2002; Farr and Rien, 2003; Farr and Kern, 2004; Farr and Kern, 2005). Green sturgeon have not been observed upstream of the head of the tide.

(16) *Tillamook Bay, OR* (from the mouth to the head of the tide): Tillamook Bay is a small inlet located on the northern Oregon coast in Tillamook County. The head of the tide extends upstream into Kilchis River (up to river mile 2.0), Miami River (to rm 0.8), Tillamook River (to rm 6.0), Trask River (rm 4.3), and Wilson River (rm 3.1), and covers an area of 14.2 square miles. PCEs present in the bay include water flow, water quality, and migratory corridors to support migration of subadults and adults. Several activities occur within the bay that may affect these PCEs. For example, water quality may be affected by dredging (to support ocean traffic), forestry, grazing, agriculture, and urbanization around and in the bay; and the benthic habitat, water flow, and water quality may be modified by wetland diking, filling, and draining related to grazing and agriculture, as well as stream channelization and the loss of large woody debris and forested land cover resulting from development and silviculture (Tillamook Bay National Estuary Project, 1999). The presence of Southern DPS fish is likely based on the presence of green sturgeon of unknown DPS, but not confirmed. Green sturgeon are reported to be rare in Tillamook Bay (Emmett *et al.*, 1991). From February 2000 to February 2004, 9 green sturgeon adults and/or subadults were captured in sampling surveys by ODFW and tissue samples collected (Rien *et al.*, 2000; Farr *et al.*, 2001; Farr and Rien, 2002; Farr and Rien, 2003; Farr and Kern, 2004; Farr and Kern, 2005). Green sturgeon have not been observed upstream of the head of the tide.

(17) *Lower Columbia River and estuary* (from the mouth upstream to Bonneville Dam (rkm 146), including tidally influenced waters of tributaries): The lower

Columbia River estuary is an important oversummering habitat supporting large numbers of green sturgeon. The specific area within the lower Columbia River estuary extends from the mouth of the Columbia River to the Bonneville Dam at rkm 146, including tidally influenced waters upstream to river mile 26.5 on the Willamette River. PCEs present include food resources, water flow, water quality, depth, and migratory corridors to support migration, aggregation and holding, and feeding by subadult and adult green sturgeon. In the mid-1930s prior to installation of the Bonneville Dam, green sturgeon were observed up to the Cascade Rapids. Currently, large concentrations of green sturgeon, the majority of which are subadults, occur in the estuary as far upstream as Bonneville Dam, but predominately occupy the lower 60 rkm (WDFW, 2002, Letter to Ms. Donna Darm (5 pp., plus enclosures, 28 pp.), cited in Adams *et al.*, 2002; WDFW and ODFW, 2002). From 1985-2001, large numbers of green sturgeon (ranging from 1,000s in the 1980s to 100s in more recent years) were taken as bycatch in the white sturgeon fishery in the Columbia River (Beamesderfer, 2000, cited in Adams *et al.*, 2002). From February 2000 to February 2004, 160 green sturgeon were captured in the Columbia River estuary for tissue sampling (Rien *et al.*, 2000; Farr *et al.*, 2001; Farr and Rien, 2002; Farr and Rien, 2003; Farr and Kern, 2004; Farr and Kern, 2005). Both Northern DPS and Southern DPS green sturgeon occur in the Columbia River estuary (Israel *et al.*, 2004), with a larger proportion of green sturgeon sampled assigned to the Southern DPS based on genetic analyses (67-82%, or 121 fish, of 155 fish sampled) (Israel, 2006; Israel and May, 2006). Tagged Southern DPS fish from San Pablo Bay and the Sacramento River have also been detected in the lower Columbia River estuary in the 1950s (two green sturgeon tagged in San Pablo Bay; Chadwick, 1959), 1960s and 1970s (one green sturgeon tagged in San Pablo Bay; Miller, 1972), and in 2005 and 2006.[1] Based on CDFG tagging studies from September 1954 to October 1990, Southern DPS green sturgeon occupy the Columbia River estuary from July to December (n = 8 fish, 104 - 130 cm TL; CDFG, 2002). Southern DPS green sturgeon primarily aggregate in the estuary during the summer, with peak abundance in August (Adams *et al.*, 2002), presumably for optimization of growth, thermal refuge, and feeding (although all of 50 green sturgeon stomachs examined to date have been empty (Rien, 2001)). There is no evidence for spawning by green sturgeon within the Columbia River estuary, although at least one ripe adult was observed (WDFW, 2002, Letter to Ms. Donna Darm (5 pp., plus enclosures, 28 pp.), cited in Adams *et al.*, 2002).

Many activities occur in the lower Columbia River estuary that may affect the PCEs. For example, dredging could affect food resources; dams and other in-water construction or alterations (e.g., wetland diking, filling, and draining; urbanization; docks; marinas) could alter water flow and quality; and NPDES activities and activities resulting in non-point source pollution (e.g., waterborne and sediment-associated chemical contaminants, LNG terminals) could reduce

[1] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. Personal commun., February 2008.

water quality (Lower Columbia River Estuary Program, 1999; Lower Columbia River Fish Recovery Board, 2004). Impoundment of the Columbia River by hydropower dams has altered the hydrograph in the Columbia River estuary and offshore plume. This has likely altered habitat available to green sturgeon, particularly in the summer.

(18) *Willapa Bay, WA* (from the mouth to the head of the tide, including tidally influenced waters of tributaries): Willapa Bay is also recognized as an important oversummering habitat for green sturgeon. Willapa Bay is located north of the Columbia River on the south western Washington state coast, in Pacific County. Two main tributaries to Willapa Bay are Willapa River and Naselle River. The specific area covers 134.3 square miles and includes tidally influenced waters extending to river mile 10 on Naselle River. Willapa Bay is a very productive estuary with abundant food resources (e.g., burrowing shrimp, other benthic invertebrates) to support feeding by green sturgeon adults and subadults, based on gut content studies (Moser and Lindley, 2007; Dumbauld *et al.*, 2008) and anecdotal accounts (Feldman *et al.*, 2000). Other PCEs present in this area include water flow, water quality, depth, and migratory corridors to support migration, aggregation, and holding by subadult and adult green sturgeon. Green sturgeon are reported to be more common in Willapa Bay than white sturgeon (Emmett *et al.*, 1991). Historically, the largest harvests of green sturgeon were taken in Willapa Bay, numbering about 3,000 to 4,000 fish per year in the 1960s, but harvests have declined to few or none in recent years (WDFW, 2002, Letter to Ms. Donna Darm (5 pp., plus enclosures, 28 pp.), cited in Adams *et al.*, 2002). Large concentrations of green sturgeon aggregate in Willapa Bay in the summer months and occur from May to November (Adams *et al.*, 2002; Moser and Lindley, 2007), including both Northern DPS and Southern DPS fish. Genetic analyses indicate that a high proportion of green sturgeon within the estuary belong to the Southern DPS (75%, or 59 fish, of 79 fish sampled) (Israel and May, 2006). Green sturgeon are believed to optimize growth potential by foraging in the estuary (Moser and Lindley, 2007). Tagged green sturgeon from all spawning areas have been detected in Willapa Bay in 2002 – 2004 (S. Lindley and M. Moser, pers. comm. cited in BRT, 2005; Moser and Lindley, 2007). Tagged green sturgeon exhibited a high degree of intra-estuarine movement throughout Willapa Bay as well as inter-estuarine movement between Willapa Bay and the Columbia River estuary (Moser and Lindley, 2007).

Several activities occur within the estuary that may affect the PCEs and require special management. The pesticide carbaryl is used by oyster aquaculture operations to control burrowing shrimp, thereby reducing this important food resource for green sturgeon (Feldman *et al.*, 2000; Moser and Lindley, 2007). Dredging operations (for oysters), in-water construction or alteration (e.g., bank stabilization, aids to navigation), and pollution from NPDES activities and activities resulting in non-point source pollution could affect water quality, depths, or benthic food resources. In addition, the spread of non-native grasses such as *Spartina alterniflora* on mudflats may inhibit access to mudflats for foraging and alter the composition of benthic invertebrate communities that serve as food resources for green sturgeon.[1]

(19) *Grays Harbor, WA* (from the mouth to the head of the tide, including tidally influenced waters of tributaries): Like the Columbia River estuary and Willapa Bay, Grays Harbor provides important oversummering habitat for both Northern DPS and Southern DPS adult and subadult green sturgeon. Grays Harbor is an estuarine bay located in Grays Harbor County on the Washington state coast, north of Willapa Bay. Grays Harbor covers approximately 91.8 square miles. Green sturgeon have been detected at the mouth of the Chehalis River and at Sturgeon Landing, but not upstream of the head of the tide. The specific area thus includes tidally influenced waters extending upstream to river mile 33 on the Chehalis River, a tributary to Grays Harbor. PCEs present in this area include food resources, water flow, water quality, depth, and migratory corridors to support feeding, migration, and aggregation and holding by green sturgeon adults and subadults. Large concentrations of green sturgeon occur in Grays Harbor, with peak abundances in August (Adams *et al.*, 2002). Historically large numbers of green sturgeon were caught in tribal and commercial fisheries, totaling up to about 500 green sturgeon landed per year (WDFW, 2002, Letter to Ms. Donna Darm (5 pp., plus enclosures, 28 pp.), cited in Adams *et al.*, 2002). A large proportion of green sturgeon sampled were assigned to the Southern DPS, based on genetic analyses (~ 51%, or 35 fish, of 69 fish sampled) (Israel and May, 2006). The presence of Southern DPS fish has also been confirmed by tagging studies. One Southern DPS fish tagged in San Pablo Bay in October 1967 was recaptured in Grays Harbor on July 25, 1969 (Miller, 1972). In CDFG tagging studies from September 1954 to October 1990, 3 Southern DPS green sturgeon (106 – 127 cm TL) tagged in San Pablo Bay were recaptured in Grays Harbor in the commercial gill net fishery (CDFG, 2002). In 2006, several Southern DPS fish tagged in San Pablo Bay and the Sacramento River were detected in Grays Harbor.[2] Some individual green sturgeon spend the entire summer in Grays Harbor, whereas others move between estuaries. The estuary is believed to provide refuge and abundant food resources to support optimal growth potential in green sturgeon (Moser and Lindley, 2007).

Similar to Willapa Bay, several activities occur within Grays Harbor that may affect the PCEs and require special management. Application of carbaryl in association with oyster aquaculture to control burrowing shrimp populations affects this important food resource, and possibly other prey species, for adult and subadult green sturgeon. Commercial shipping and pollution from point and non-point sources (e.g., agriculture, pulp mill runoff) may also reduce water quality with the discharge of contaminants into the water.

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[1] M. Moser, NMFS, Seattle, WA. Personal commun., February 2008.
[2] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. Personal commun., February 2008.

(20) *Puget Sound, WA*: Puget Sound is a large bay/estuary extending from the Strait of Juan de Fuca at the northern Washington state coast south to Olympia, WA, and covering 1,017.8 square miles. The mouth separating Puget Sound from the Strait of Juan de Fuca is defined at Admiralty Inlet. PCEs present within Puget Sound include food resources, water flow, water quality, depths, and migratory corridors for feeding, migration, and aggregation and holding of subadult and adult green sturgeon. Observations of green sturgeon in Puget Sound are much less common compared to the other estuaries in Washington. A few green sturgeon adults and/or subadults have been incidentally captured in fisheries harvest in Puget Sound, mostly in trawl fisheries (Adams *et al.*, 2002). Both Northern DPS and Southern DPS green sturgeon adults and/or subadults have been detected in the area. In 2006, two Southern DPS green sturgeon tagged in San Pablo Bay were detected near Scatchet Head, south of Whidbey Island.[1] However, the extent to which Southern DPS green sturgeon use Puget Sound is unknown. Because Puget Sound is a large, closed system, green sturgeon entering the area may reside for a long time. One tagged green sturgeon was detected over several months over a two year period, suggesting the fish was foraging and perhaps holding or resting in the area. No tagged green sturgeon of either DPS has been detected in Hood Canal.[2]

The activities occurring in Puget Sound and the special management concerns associated with them are similar to those in Willapa Bay and Grays Harbor. In particular, the application of carbaryl for oyster aquaculture and its effects on burrowing shrimp and other prey populations is also a concern in Puget Sound. Dredging and in-water construction or alterations (e.g., pile driving, bridge construction, bank stabilization) could affect benthic habitats and alter water flow and water quality. In addition, pollution from commercial shipping and NPDES activities and activities generating non-point source pollution could reduce water quality within the area, particularly in the areas near large cities like Seattle.

Coastal Marine Waters

Subadult and adult green sturgeon spend most of their lives inhabiting marine and estuarine waters from southern California to Alaska. The available data suggest that these are important habitats within which green sturgeon make seasonal, long-distance migrations most likely associated with foraging and aggregation areas along the coast. Green sturgeon primarily occur within the 110 m depth bathymetry (Erickson and Hightower, 2007). Green sturgeon tagged in the Rogue River and tracked in marine waters typically occupied the water column at 40 – 70 m depth, but made rapid vertical ascents to or near the surface, for reasons yet unknown (Erickson and Hightower, 2007).

[1] M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. Personal commun., February 2008.
[2] M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. Personal commun., February 2008.

Based on tagging studies of both Southern and Northern DPS fish, green sturgeon primarily spend their time in coastal marine waters migrating between coastal bays and estuaries, including sustained long-distance migrations of up to 100 km per day (S. Lindley and M. Moser, NMFS, pers. comm. cited in BRT, 2005) that are most likely driven by food resources. Some tagged individuals were observed swimming at slower speeds and spending long periods of time (on the order of days) within certain areas, suggesting these individuals were foraging.[1]

Within the geographical area occupied (i.e., the California/Mexico border to the Bering Sea, AK), the CHRT divided the coastal marine waters into 12 specific areas between the estuaries or bays where Southern DPS presence is categorized as confirmed (see Appendix A for further information on how areas in coastal marine waters meet the definition of specific areas eligible for consideration as critical habitat). The presence of green sturgeon and Southern DPS fish within each specific area was based on data from tagging and tracking studies, records of fisheries catch, and NOAA Observer Program records. Tagged Southern DPS subadults and adults have been detected in coastal marine waters from Monterey Bay, CA, to Graves Harbor, AK, including the Strait of Juan de Fuca (Lindley *et al.*, 2008). Data on green sturgeon bycatch from NOAA's West Coast Groundfish Observer Program (WCGOP) confirm the presence of green sturgeon from Monterey Bay, CA, to Cape Flattery, WA, with the greatest catch per unit effort in coastal waters from Monterey Bay to Humboldt Bay, CA.[2] It is important to note that several tagged Southern DPS green sturgeon have been detected off Brooks Peninsula on the northern tip of Vancouver Island, BC (Lindley *et al.*, 2008). Although WCGOP data were not available for bycatch of green sturgeon off southeast Alaska (green sturgeon were only captured in the bottom trawl fishery and bottom trawl fishing is prohibited off southeast Alaska), green sturgeon have been captured in bottom trawl fisheries throughout coastal waters off British Columbia (Lindley *et al.*, 2008), confirming that the distribution of green sturgeon extends north of Vancouver Island. Patterns of telemetry data, corroborated by the fisheries records, suggest that Southern DPS fish occupy oversummering habitats in coastal bays and estuaries in California, Oregon, and Washington and occupy overwintering grounds off central California (as far south as Monterey Bay) and in coastal waters between Vancouver Island and southeast Alaska (Lindley *et al.*, 2008).[3] Based on the tagging data and the information described above, the CHRT identified the coastal marine waters from Monterey Bay, CA, to Vancouver Island, BC, as an important migratory/connectivity corridor for subadult and adult Southern DPS green sturgeon to migrate to and from oversummering habitats and overwintering habitats. Coastal marine waters of southeast Alaska were not considered part of the core migratory/ connectivity corridor for green sturgeon, but were recognized as an important area at the northern extent of the overwintering range.

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[1] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Personal commun., February 2008.
[2] West Coast Groundfish Observer Program (WCGOP), NMFS, Seattle, WA. Unpublished green sturgeon bycatch data from January 2002 to April 2007. July 2008.
[3] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. February 2008.

Several activities were identified that may affect the PCEs within coastal marine waters and require special management consideration or protection. The fact that green sturgeon were only captured in the bottom trawl fishery (based on the WCGOP bycatch data) provides evidence that green sturgeon are associated with the benthos and thus exposed to activities that disturb the bottom. Of particular concern are activities that affect prey resources. Prey resources likely include species similar to those fed on by green sturgeon in bays and estuaries (e.g., burrowing ghost shrimp, crangonid shrimp, amphipods, isopods, Dungeness crab). These species occur throughout the specific areas identified in coastal marine waters. Activities that can affect prey resources include: commercial shipping or NPDES activities or activities resulting in non-point source pollution that can discharge contaminants and result in bioaccumulation of contaminants in green sturgeon; disposal of dredged materials that can bury prey resources; and bottom trawl fisheries that can disturb the bottom (but may result in beneficial or adverse effects on prey resources for green sturgeon). In addition, proposed tidal and wave energy projects as well as petroleum spills from commercial shipping activities may affect water quality or hinder the migration of green sturgeon along the coast and may necessitate special management of the PCEs. Table 1 lists the PCEs present and the activities occurring within each area that may necessitate special management considerations or protection. The following paragraphs describe each of the 12 specific areas identified within coastal marine waters.

(1) *CA/Mexico border to Monterey Bay, CA* (from the California/Mexico border to the southernmost point at the mouth of Monterey Bay): Coastal marine waters from the California/Mexico border to Monterey Bay, CA, contain water quality and provide migratory corridors necessary to support migration by subadult and adult green sturgeon. Food resources to support feeding may also be present in this area. The presence of the Southern DPS within this area is likely (based on the collection of green sturgeon of unknown DPS), but not confirmed. The southernmost receiver for detecting acoustically tagged green sturgeon is located at Carmel, CA, and no Southern DPS fish have been detected there, despite detections of Southern DPS fish in Monterey Bay just north of Carmel.[1] The sparse data the CHRT had on green sturgeon presence in coastal marine waters off southern California consisted of records of fisheries interactions. The first record of green sturgeon south of Monterey Bay was in April 1941, when one green sturgeon weighing 7 ¼ pounds was caught in 10 fathoms of water in a bait net set between Huntington Beach and Newport (Roedel, 1941). In April 1957, another green sturgeon (774 mm TL and weighing 3 pounds and 14 ounces) was speared in waters 18 feet deep while it was swimming over sandy bottom between small rocky reefs just north of Point Vicente, Los Angeles County (Norris, 1957). More recently, green sturgeon were incidentally caught in the commercial California halibut set net fishery using one-panel trammel nets. One

[1] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. February 2008.

green sturgeon was captured in July 1991 just north of Santa Barbara and another was captured in March 1993 off of San Pedro.[1]

Several special management concerns exist for the coastal waters off of southern California. Benthic prey resources may be affected by the deposition of dredge material and bottom trawl fisheries. Water quality may be affected by effluent from facilities located on the coast, including desalination plants (hypersaline outfalls), power plants (thermal effluent), LNG projects, and aquaculture. In addition, in-water construction or alterations (e.g., piers), and proposed wave energy or tidal energy projects may affect fish passage along the coast by taking up space in the water column and creating barriers to migration.

(2) *Monterey Bay, CA, to San Francisco Bay, CA* (from the southern point at the mouth of Monterey Bay to the southern point at the mouth of San Francisco Bay; including Monterey Bay): PCEs present in this area include food resources, water quality, and migratory corridors to support feeding and migration by subadult and adult green sturgeon. Telemetry data suggest that Southern DPS green sturgeon use areas off the central California coast (as far south as Monterey Bay) during the spring (Lindley *et al.*, 2008).[2] Accounts of green sturgeon in coastal marine waters from Monterey Bay to San Francisco Bay come from incidental catch in fisheries and power plants and tagging studies. From May 1999 to January 2000, 8 green sturgeon of unknown DPS were incidentally caught in the commercial California halibut set net fishery (using one-panel trammel nets) in or just north of Monterey Bay, including one individual measured at 94 cm in length.[3] One green sturgeon (546 mm in length) was found impinged and dead on the water intake screen at the Moss Landing Power Plant in January 2006.[4] From August 2001 to January 2007, 138 green sturgeon were incidentally caught on observed bottom trawl vessels participating in the West Coast Groundfish fishery in the Princeton (Half Moon Bay) port group.[5] Upon exiting the San Francisco Bay system, Southern DPS subadults and adults are known to migrate south as far as Monterey Bay. One Southern DPS fish (65 cm TL) tagged in San Pablo Bay in September 1948 was recaptured in Monterey Bay in April 1949 (CDFG, 2002). Two green sturgeon tagged in San Pablo Bay in October 1967 were recaptured in December 1967, one in Monterey Bay (117 cm TL; CDFG, 2002) and one near Santa Cruz, CA (Miller, 1972). In 2004 and 2005, Southern DPS fish tagged in San Pablo Bay were detected in Monterey Bay (Lindley *et al.*, 2008).

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[1] R. Rasmussen, NMFS, La Jolla, CA. Unpublished green sturgeon bycatch data for commercial California halibut set net fishery. Personal commun., July 2006.

[2] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. February 2008.

[3] R. Rasmussen, NMFS, La Jolla, CA. Unpublished green sturgeon bycatch data for commercial California halibut set net fishery. Personal commun., July 2006.

[4] J. Steinbeck, Tenera Environmental, San Luis Obispo, CA, and C. Raifsnider, Tenera Environmental, San Francisco, CA. Unpublished green sturgeon impingement data. Personal commun.,

[5] J. Majewski, NOAA West Coast Groundfish Observer Program (WCGOP), Seattle, WA. Letter to Melissa Neuman (2 pp.). Personal commun., January 29, 2007.

Special management concerns for the coastal marine waters from Monterey Bay to San Francisco Bay include potential effects on benthic habitats and food resources caused by the operation of bottom trawling fisheries, and effects on water quality associated with effluent from desalination plants (hypersaline outfalls; occur up to Santa Cruz) and power plants (thermal effluent).

(3) *San Francisco Bay, CA, to Humboldt Bay, CA* (from the southern point at the mouth of San Francisco Bay to the southern point at the mouth of Humboldt Bay): The coastal marine waters from San Francisco Bay to Humboldt contain PCEs including food resources, water quality, and migratory corridors to support feeding, migration, and aggregation by subadult and adult green sturgeon. Relatively large numbers of green sturgeon are believed to occupy this area. From August 2001 to January 2007, 325 of 406 green sturgeon incidentally caught on bottom trawl vessels participating in the West Coast Groundfish fishery were caught by vessels in the San Francisco port group.[1] Southern DPS green sturgeon migrating out of the San Francisco Bay system are believed to primarily move north. One Southern DPS fish (145 cm TL) tagged in San Pablo Bay in October 1979 was recaptured off Bodega Head in November 1979 (CDFG, 2002). In 2006 and 2007, detections of large numbers of Southern DPS subadults and adults in Humboldt Bay confirm that inter-estuarine movements from San Pablo Bay to Humboldt Bay are common (Pinnix, 2008b, a).[2]

Several activities occurring along the coast may impact the PCEs and require special management. Bottom trawl fisheries could alter benthic habitats and affect benthic food resources for green sturgeon. In addition, proposed tidal energy projects may take up space within the water column and pose a barrier to passage for green sturgeon migrating through the area.

(4) *Humboldt Bay, CA, to Coos Bay, OR* (from the southern point at the mouth of Humboldt Bay to the southern point at the mouth of Coos Bay): Both subadult and adult green sturgeon occur within coastal marine waters from Humboldt Bay, CA, to Coos Bay, OR. PCEs present to support migration, feeding, and aggregations of subadult and adult green sturgeon include food resources, water quality, and migratory corridors. These waters serve as a migration corridor for Southern DPS migrating north from Central Valley, CA, to Coos Bay and further north to oversummering and overwintering habitats, as described above. Several activities occur within coastal marine waters between Humboldt Bay and Coos Bay that may affect the migration and feeding of green sturgeon. Bottom trawl fisheries and dredge deposition could affect benthic habitats and food resources. In addition, proposed tidal energy projects may take up space in

[1] J. Majewski, NOAA WCGOP, Seattle, WA. Letter to Melissa Neuman (2 pp.). Personal commun., January 29, 2007.
[2] S. Lindley, NMFS, Santa Cruz, CA, and M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. Personal commun., February 2008.

the water column and block passage for green sturgeon migrating north or south along the coast.

(5) *Coos Bay, OR, to Winchester Bay, OR* (from the southern point at the mouth of Coos Bay to the southern point at the mouth of Winchester Bay): Southern DPS subadults and adults occur within coastal marine waters from Coos Bay to Winchester Bay, OR, during their migrations up and down the coast. From August 2001 to January 2007, 8 out of 406 green sturgeon incidentally caught on observed West Coast groundfish bottom trawl vessels were caught by vessels in the Charleston, OR, port group.[1] PCEs present in this area include food resources, water quality, and migratory corridors to support feeding, migration, and aggregation of subadult and adult green sturgeon. Several activities occur within the area that may affect these PCEs. Benthic food resources could be affected by bottom trawl fisheries and proposed tidal energy projects may create obstacles for migration of green sturgeon by taking up space in the water column.

(6) *Winchester Bay, OR, to the Columbia River estuary* (from the southern point at the mouth of Winchester Bay to the southern point at the mouth of the Columbia River estuary): The coastal area from Winchester Bay, OR, to the Columbia River estuary provides PCEs including food resources, water quality, and migratory corridors to support feeding, migration, and aggregation of subadult and adult green sturgeon. Several records of green sturgeon within these marine waters indicate this area is important for migration. From February 2000 to February 2001, 4 green sturgeon of unknown DPS were captured for tissue sampling off of Newport, OR (Farr *et al.*, 2001). From August 2001 to January 2007, 9 green sturgeon were incidentally caught on observed West Coast groundfish bottom trawl vessels in the Astoria port group (n = 7 fish), Garibaldi (Tillamook) port group (n = 1 fish), and Newport port group (n = 1 fish).[2] Southern DPS fish migrating between San Pablo Bay and Winchester Bay, the Columbia River estuary, and other coastal waters as described above migrate through this area. Several activities may affect green sturgeon habitat conditions within these coastal waters. Bottom trawl fisheries could affect benthic habitats and food resources for green sturgeon. In addition, proposed tidal energy projects may create obstacles hindering migration and passage in these waters.

(7) *Columbia River estuary to Willapa Bay, WA* (from the southernmost point at the mouth of Columbia River estuary to the southernmost point at the mouth of Willapa Bay): The specific area encompassing coastal marine waters from the Columbia River estuary to Willapa Bay, WA, provides PCEs including food resources, water quality, and migratory corridors to support feeding, migration, and aggregation of subadult and adult green sturgeon. Tracking of tagged green

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[1] J. Majewski, NOAA WCGOP, Seattle, WA. Letter to Melissa Neuman (2 pp.). Personal commun., January 29, 2007.
[2] J. Majewski, NOAA WCGOP, Seattle, WA. Letter to Melissa Neuman (2 pp.). Personal commun., January 29, 2007.

sturgeon indicated substantial exchange of green sturgeon between the Columbia River estuary and Willapa Bay (WDFW, 2002, Letter to Ms. Donna Darm (5 pp., plus enclosures, 28 pp.), cited in Adams *et al.*, 2002; Moser and Lindley, 2007). In 2004, 8 green sturgeon were detected in both Willapa Bay and the Columbia River estuary over the summer (Moser and Lindley, 2007). In addition, several green sturgeon tagged in the Columbia River estuary were detected in Willapa Bay (Moser and Lindley, 2007). Thus, the coastal marine waters between the two estuaries are an important migratory corridor for these inter-estuarine exchanges. Special management considerations or protection may be needed to address the effects of bottom trawl fisheries on benthic habitats and benthic food resources.

(8) *Willapa Bay, WA, to Grays Harbor, WA* (from the southernmost point at the mouth of Willapa Bay to the southernmost point at the mouth of Grays Harbor): The specific area from Willapa Bay, WA, to Grays Harbor, WA, provides PCEs including food resources, water quality, and migratory corridors to support feeding, migration, and aggregation by subadult and adult green sturgeon. As described in the previous section, Southern DPS subadults and adults tagged in San Pablo Bay and Sacramento River occupy these coastal marine waters in their migrations to and from Willapa Bay and Grays Harbor. Similar to other areas along the coast of Oregon and Washington, special management considerations or protection may be required to address adverse effects on benthic habitats and food resources by bottom trawl fisheries.

(9) *Grays Harbor, WA, to the Washington-U.S./Canada border* (from the southern point at the mouth of Grays Harbor, WA, to the Washington-U.S./Canada border): The specific area from Grays Harbor, WA, to the U.S.-Washington/ Canada border contains PCEs including food resources, water quality, and migratory corridors to support feeding, migration, and aggregation of subadult and adult green sturgeon. From August 2001 to January 2007, 1 green sturgeon of unknown DPS was incidentally caught on an observed West Coast groundfish bottom trawl vessel that was part of the Westport port group.[1] In 2004 and 2005, Southern DPS fish tagged in San Pablo Bay were detected at Cape Elizabeth on the Washington state coast (Lindley *et al.*, 2008). Southern DPS subadults and adults migrate through coastal marine waters off of Washington state on their way to and from Grays Harbor, the Strait of Juan de Fuca, and overwintering sites off of Vancouver Island, British Columbia (Lindley *et al.*, 2008). Several activities associated with special management concerns include the disturbance of benthic habitats and food resources caused by bottom trawl fisheries and potential effects on migration and passage of subadult and adult green sturgeon due to proposed tidal energy projects.

(10) *Strait of Juan de Fuca, WA* (within U.S. waters): The specific area delineated for the Strait of Juan de Fuca extends from the Tatoosh Island – Bonilla Point

[1] J. Majewski, NOAA WCGOP, Seattle, WA. Letter to Melissa Neuman (2 pp.). Personal commun., January 29, 2007.

BC line at the mouth to Admiralty Inlet, marking the boundary between the Strait and Puget Sound. The northern border of the specific area is delineated by the U.S./Canada border drawn through the middle of the Strait and a line drawn along the base of the San Juan Islands. The specific area extends north into Rosario Strait up to a line drawn across Rosario Strait from the northern tip of Lopez Island to Fidalgo Head, to include an acoustic receiver located in Rosario Strait where Southern DPS green sturgeon have been detected. In total, the specific area delineated within the Strait of Juan de Fuca covers 798.8 square miles (2,068.9 sq km).

The Strait of Juan de Fuca connects Puget Sound and the waters surrounding the San Juan Islands in northern Washington State to the Pacific Ocean. Depths are greater at the mouth but become shallower further into the strait. Water temperatures are lower and more similar to marine waters than to Puget Sound. The PCEs present within the Strait of Juan de Fuca include food resources to support summer feeding and water quality and migratory corridors to support migration by subadults and adults. From August 2001 to January 2007, 3 green sturgeon of unknown DPS were incidentally caught on observed West Coast groundfish bottom trawl vessels that were part of the Neah Bay port group.[1] In 2004 and 2005, Southern DPS subadults and adults tagged in San Pablo Bay were detected in the Strait of Juan de Fuca, but none were detected at receivers in the Strait of Georgia (Lindley *et al.*, 2008). Green sturgeon likely enter and migrate some distance into the Strait of Juan de Fuca, but turn around and migrate along the western coast of Vancouver Island up to overwintering habitats off Brooks Peninsula, rather than migrating through the Strait of Georgia. Some also migrate through the Strait of Juan de Fuca to Puget Sound. In 2006, 2 Southern DPS fish were detected at 2 receivers located just south of Anacortes in Rosario Strait.[2] However, green sturgeon have not been detected at any of the receivers further north in the waters surrounding the San Juan Islands and to the east of Vancouver Island, despite monitoring for tagged fish (primarily salmon) in this area. Thus, the specific area was not extended further north past Rosario Strait or the base of the San Juan Islands.[3] Special management concerns for the Strait of Juan de Fuca include effects on benthic habitats and food resources by bottom trawl fisheries and by dredging and the deposition of dredge materials.

(11) *U.S.-Alaska/Canada border to Yakutat Bay, AK* (from the Alaska-U.S./Canada border to the northernmost point at the mouth of Yakutat Bay): PCEs present within this area include food resources, water quality, and migratory corridors to support feeding, migration, and aggregation by subadult and adult green sturgeon. Two Southern DPS green sturgeon, one tagged in San Pablo Bay and

[1] J. Majewski, NOAA WCGOP, Seattle, WA. Letter to Melissa Neuman (2 pp.). Personal commun., January 29, 2007.
[2] M. Moser, NMFS, Seattle, WA. Unpublished green sturgeon tagging data. Personal commun., March 2008.
[3] M. Moser, NMFS, Seattle, WA. Personal commun., April 3, 2008.

one tagged in Willapa Bay (assigned to the Southern DPS based on genetic analyses), were detected at a receiver near Graves Harbor, AK, just south of Yakutat Bay (Lindley *et al.*, 2008).[1] These two detections in the winter of 2004 - 2005 in southeast Alaska, additional detections of green sturgeon off Vancouver Island in the fall of 2005, and green sturgeon bycatch data along the northern British Columbia coast suggest that green sturgeon spend their winters in waters between Vancouver Island and southeast Alaska and their summers along the coasts of California, Oregon, and Washington (Lindley *et al.*, 2008). Special management considerations or protections may be required to address water quality issues related to the discharge of contaminants in commercial shipping and the potential for proposed tidal energy projects in the area that may pose a barrier to migration.

(12) *Coastal Alaskan waters northwest of Yakutat Bay, AK* (from the northernmost point at the mouth of Yakutat Bay to the Bering Strait, including the Bering Sea): The specific area includes coastal marine waters within 110 m depth off of Alaska from Yakutat Bay, AK, northwest to and including the Bering Sea. The eastern boundary is defined by the U.S./Russia and U.S./Siberia border. The northern boundary for the Bering Sea was delineated as a line across the Bering Strait. Data on green sturgeon within coastal Alaskan waters northwest of Yakutat Bay and in the Bering Sea are sparse. In 2006, 2 green sturgeon of unknown DPS were incidentally caught on observed Alaska groundfish bottom trawl vessels. One was caught in March in the Bering Sea, on the north side of Unimak Island (136 cm FL) and the other was caught in April in the Gulf of Alaska, on the southwest side of Kodiak Island (145.5 cm TL).[2] Other than the 2 green sturgeon caught in 2006, there are no records of green sturgeon bycatch in the Alaska groundfish fishery.[3] One green sturgeon was reportedly caught at the drainage of Naknek River in Kvichak Bay (within Bristol Bay) 12 years ago, but this record has not been confirmed.[4] Special management concerns within this specific area include the disturbance of benthic habitats and food resources by the operation of bottom trawl fisheries and adverse effects on water quality from commercial shipping. Other activities, such as LNG projects, and proposed tidal projects, may also affect water quality and passage. However, these activities occur far up into Cook Inlet, near the city of Anchorage, and are not likely to affect the coastal marine waters along the outer coast where green sturgeon are likely to be present.

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[1] S. Lindley, NMFS, Santa Cruz, CA, and J. Israel, UC Davis, Davis, CA. Unpublished green sturgeon tagging and genetics data. Personal commun., September 2007.

[2] D. Stevenson, NMFS, Seattle, WA, and J. Ferdinand, NOAA North Pacific Groundfish Observer Program, Seattle, WA. Unpublished observer data on green sturgeon bycatch. Personal commun., September 2006.

[3] J. Ferdinand, NOAA North Pacific Groundfish Observer Program, Seattle, WA. Personal commun., November 2006.

[4] G. Augustine, U.S. Air Force, Elmendorf Air Force Base, AK. Personal commun., March 5, 2008.

Canadian Waters

Although critical habitat cannot be designated within waters outside of the United States, the information available on green sturgeon in Canadian waters is briefly discussed here to emphasize the importance of these areas for green sturgeon and to summarize existing protections for green sturgeon in these waters. As discussed above, several tagged adult Southern DPS green sturgeon have been detected off Brooks Peninsula on the northern tip of Vancouver Island, British Columbia (Lindley *et al.*, 2008). Coastal waters between Vancouver Island and southeast Alaska are believed to contain important overwintering grounds for subadult and adult green sturgeon (Houston, 1988; Lindley *et al.*, 2008). The use of overwintering habitats within Canadian waters emphasizes the importance of maintaining the migratory/connectivity corridor from Monterey Bay, CA, to Vancouver Island, BC, and of protecting the U.S. waters directly to the north in southeast Alaska. Green sturgeon have been recognized as a species of Special Concern in Canada since 1987 and are on the red list in British Columbia, meaning they are a candidate for listing as extirpated, endangered, or threatened (B.C. Conservation Data Centre, 2007. BC Species and Ecosystems Explorer. B.C. Ministry of Environment, Victoria, BC. Available at: http://srmapps.gov.bc.ca/apps/eswp/ (accessed August 15, 2007)). The retention of green sturgeon in sport fisheries is prohibited in both marine and fresh waters of British Columbia (Department of Fisheries and Oceans, 2007. 2007 – 2009 British Columbia Tidal Waters Sport Fishing Guide. Available at: http://www.pac.dfo-mpo.gc.ca/recfish/). Although the area is outside of proposed critical habitat for the Southern DPS, the CHRT encourages continued protections for green sturgeon within Canadian waters.

UNOCCUPIED AREAS

Section 3(5)(A)(ii) of the ESA authorizes the designation of "specific areas outside the geographical area occupied at the time [the species] is listed" if these areas are essential for the conservation of the species. Regulations at 50 CFR 424.12(e) emphasize that the agency "shall designate as critical habitat areas outside the geographical area presently occupied by a species only when a designation limited to its present range would be inadequate to ensure the conservation of the species." The CHRT considered that a critical habitat designation limited to presently occupied areas may not be sufficient for conservation, because such a designation would not address one of the major threats to the population identified by the Status Review Team - the concentration of spawning into one spawning river (i.e., the Sacramento River), and, as a consequence, the high risk of extirpation due to a catastrophic event.

The CHRT identified seven unoccupied areas in the Central Valley, CA, that may provide additional spawning habitat for the Southern DPS of green sturgeon and considered whether these areas are essential for conservation of the species. These seven areas include areas behind dams that are currently inaccessible to green sturgeon and areas below dams that are not currently occupied by green sturgeon. The areas include: 1) reaches upstream of Oroville Dam on the Feather River; 2) reaches upstream of

Daguerre Dam on the Yuba River; 3) areas on the Pit River upstream of Keswick and Shasta dams; 4) areas on the McCloud River upstream of Keswick and Shasta dams; 5) areas on the upper Sacramento River upstream of Keswick and Shasta dams; 6) reaches on the American River; and 7) reaches on the San Joaquin River.

Of these seven areas, the CHRT identified reaches upstream of Daguerre Dam on the Yuba River as the most important for conserving the species because: (1) the current habitat conditions are likely to support spawning; (2) adult Southern DPS fish currently occupy habitat just below the Daguerre Dam; (3) although the Yuba River is part of the Sacramento River drainage basin, it is separated spatially from the current, single spawning population on the upper Sacramento River such that if a catastrophic mortality event were to occur in the upper Sacramento River, a Yuba River population could safeguard the species from extinction; and (4) there is a greater potential for removal of the Daguerre Dam, or restoration of fish passage at the dam, in the near future than for any of the other dams located within the unoccupied areas identified by the CHRT . The CHRT also felt that reaches on the San Joaquin River, from the South Delta to the Goodwin Dam on the Stanislaus River, are important for conserving the Southern DPS for some of the same reasons mentioned above, in particular because the San Joaquin and Stanislaus rivers are part of an entirely different drainage basin than the current single spawning area in the upper Sacramento River. However, the CHRT was less certain regarding the prospects for reestablishing a spawning population in this area, because current conditions on the mainstem San Joaquin River are poor and it is uncertain whether conditions favorable for green sturgeon presence and spawning could be restored in this area in the near future.

At this time, the CHRT was able to determine that these seven unoccupied areas *may be essential*, but not that they actually *are essential* to the conservation of the Southern DPS. The CHRT believed it is likely that at least one additional spawning area is needed to support the conservation of the Southern DPS, but that there is insufficient information at this time regarding: (1) the historical use of the currently unoccupied areas by green sturgeon; and (2) the likelihood that the habitats within these unoccupied areas will be restored to conditions that would support green sturgeon presence and spawning (e.g., restoring fish passage and sufficient water flows and water temperatures). The development of a recovery plan could help address the latter question by establishing recovery actions (e.g., removal of barriers on the Yuba River) and recovery criteria (e.g., establishing at least two additional spawning populations for the Southern DPS in rivers south of the Eel River) in order to eventually delist the Southern DPS. Actions that would protect, conserve, and/or enhance habitat conditions for the Southern DPS (e.g., habitat restoration, removal of dams, and establishment of fish passage) within these areas are encouraged. These seven unoccupied areas were not considered further for designation as critical habitat, but are mentioned here as areas about which more information is needed to inform recovery planning and future revisions to the critical habitat designation.

SPECIAL MANAGEMENT CONSIDERATIONS OR PROTECTION

Joint NMFS and USFWS regulations at 50 CFR 424.02(j) define "special management considerations or protection" to mean "any methods or procedures useful in protecting physical and biological features of the environment for the conservation of listed species." Based on discussions with the CHRT and consideration of the draft economic report, a number of activities were identified that may threaten the PCEs such that special management considerations or protection may be required. Major categories of habitat-related activities include: (1) dams; (2) water diversions; (3) dredging and disposal of dredged material (including concerns related to wetland loss and/or removal); (4) in-water construction or alterations, including channel modifications/diking, sand and gravel mining, gravel augmentation, road building and maintenance, forestry, grazing, agriculture, urbanization, and other activities; (5) pollution from point and non-point sources; (6) power plants; (7) commercial shipping (including concerns related to exotic/invasive species introductions or spread); (8) aquaculture; (9) desalination plants; (10) proposed tidal energy or wave energy projects; (11) LNG projects; and (12) habitat restoration (including concerns related to exotic/invasive species introductions or spread) All of these activities may have an effect on one or more PCE(s) via their alteration of one or more of the following: stream hydrology, water level and flow, water temperature, dissolved oxygen, erosion and sediment input/transport, physical habitat structure, vegetation, soils, nutrients and chemicals, fish passage, and stream/estuarine/marine benthic biota and prey resources. The CHRT identified and documented the activities occurring in each specific area as described above and listed in Table 1.

CRITICAL HABITAT REVIEW TEAM

NMFS convened a critical habitat review team (CHRT) to assist in the assessment and evaluation of critical habitat areas for the Southern DPS. The CHRT consisted of 9 Federal biologists from NMFS, the U.S. Fish and Wildlife Service (USFWS), and the U.S. Bureau of Reclamation (USBR) with experience and expertise on green sturgeon biology, consultations, and management, or on the critical habitat designation process. The CHRT used the best available scientific and commercial data and their best professional judgment to: (1) verify the geographical area occupied by the Southern DPS at the time of listing; (2) identify the physical and biological features essential to the conservation of the species; (3) identify specific areas within the occupied area containing those essential physical and biological features; (4) identify activities that may affect these essential features and require the need for special management considerations or protection within each specific area; (5) evaluate the conservation value of each specific area; and (6) determine if any unoccupied areas are essential to conservation of the Southern DPS.

The CHRT has completed 4 of 5 phases of work associated with the evaluation of critical habitat and the completion of the six tasks outlined above. In Phase 1, the CHRT met to discuss the critical habitat designation process, identify and synthesize the best available scientific and commercial information regarding green sturgeon habitat use and distribution, and identify and verify the specific areas within the geographical area occupied. In Phase 2, the CHRT developed a scoring system for evaluating the PCEs and a rating system for determining the overall conservation value of each specific area. The CHRT members individually scored and rated each specific area based on the 2 systems developed in this phase. In Phase 3, the CHRT reviewed the scores and ratings for each specific area and considered additional information about the relationship of each area to the other specific areas and the historical, current, and potential future use of each area by the Southern DPS. Based on the scores, ratings, and additional considerations, the CHRT assigned conservation value ratings of high, medium, or low to each specific area. In Phase 4, the CHRT identified and evaluated unoccupied areas to determine whether any unoccupied areas are essential for conservation. Phase 5 will take place after the proposed critical habitat designation is published in the *Federal Register* and the public comment period is closed. The CHRT will be reconvened to review relevant comments received on the proposed critical habitat designation and any additional information requiring consideration for the final critical habitat designation. The following paragraphs describe the details and key considerations involved in each phase.

CHRT Phase 1

In Phase 1, the CHRT convened for a 2-day meeting to introduce the members to the critical habitat designation process, identify and synthesize the best available scientific and commercial data relevant to critical habitat for the Southern DPS, and identify the geographical area occupied, and delineate and verify the specific areas within the geographical area occupied. First, the CHRT was given a brief overview of the statutory and regulatory requirements under the ESA regarding critical habitat. Next, the CHRT reviewed and discussed available information on green sturgeon distribution and habitat needs, identifying any additional data or data sources. The CHRT then defined the list of PCEs for the Southern DPS, the geographical area occupied by the Southern DPS, and specific areas within the occupied range.

To confirm each specific area met the definition of critical habitat, the CHRT confirmed the presence of one or more PCEs in each area and identified special management considerations or protection that may be required. The CHRT assessed the best available information on green sturgeon distribution and use within each specific area, noting any discrepancies with their own knowledge of an area and any data sources requiring verification. CHRT members followed-up on any discrepancies or data sources requiring verification and provided feedback to the team. Because there were several areas with documented evidence of green sturgeon presence but no information regarding to which DPS the fish belong, the CHRT had to define how an area was considered "occupied" by the Southern DPS. The CHRT defined 3 categories of "occupied": 1) "Confirmed" if there was documented evidence of Southern DPS presence in the area; 2) "Likely" if there was documented evidence of green sturgeon (Northern DPS or DPS unknown) in the area; and 3) "Possible" if there was no documented evidence of green sturgeon presence in the area, but green sturgeon may be present based on professional judgment (e.g., based on habitat conditions, proximity to occupied areas). Specific areas within which the presence of the Southern DPS was confirmed or likely were considered occupied and included in the CHRT's evaluation. The CHRT then confirmed whether each specific area was likely to contain one or more of the PCEs, based on their knowledge of the area and on green sturgeon presence and use of the area. In addition, the CHRT determined whether any current or potential activities occur within the areas that may threaten the PCEs, such that special management considerations or protection may be required. The CHRT used their knowledge of each area and their experience in section 7 consultations to identify activities for each area (Table 1).

CHRT Phase 2

In Phase 2, the CHRT developed and implemented two approaches for evaluating and assigning a conservation value to each specific area. The first approach was a multi-factor scoring system for evaluating the PCEs within each specific area (Tables 2 and 3). Each PCE was scored based on the level of support it provides to each of 4 factors, representing different life stages and associated habitat functions: 1) spawning and egg incubation; 2) larval/juvenile rearing and growth; 3) juvenile and/or subadult/adult migration; and 4) subadult/adult feeding, holding, and/or non-spawning aggregations. The scoring system helped generate discussion and provided a consistent framework for CHRT members to evaluate each specific area, ensuring that each member considered the PCEs and the life stages and habitat functions supported in their evaluations. It also generated quantitative scores (sums of the PCE scores across all factors) that roughly corresponded to high, medium, and low conservation value ratings, but that also showed the variation between areas relative to one another at a finer scale. Each CHRT member provided their initial conservation value rating for each specific area based on the total scores.

Although the resulting quantitative scores roughly corresponded to high, medium, and low conservation value ratings, the CHRT expressed several concerns over directly translating the quantitative scores into categorical ratings. First, the CHRT members commented that scoring the PCEs was somewhat subjective because of a lack of data on the PCEs for many of the specific areas. Second, the assessment of factors 1 and 2 was based on the PCEs, whereas the assessment of factors 3 and 4 was based on the abundance of green sturgeon in the area, rather than on the PCEs. Finally, the scoring system tended to result in lower scores for areas that supported only one life stage, and did not reflect the importance of such areas in the life cycle of green sturgeon.

To address these concerns, the CHRT developed an alternative approach to rate the conservation value of each specific area (Table 4). In this approach, the PCEs supporting each life stage (i.e., eggs/larvae, juveniles, and subadults/adults) were identified for each specific area. Then, the conservation value of each area was rated as High, Medium, or Low, based on consideration of the PCEs present, the life stages supported, the historical and current use of the area, and the overall assessment of the contribution of the area to the conservation of the Southern DPS. The PCE scores, factors, and total scores generated in the scoring system were also considered. CHRT members also recorded a second conservation value rating for each specific area, representing the conservation value rating they would be willing to assign to the area if their first choice was not the majority vote. This "second vote" provided the range over which each CHRT member rated each specific area, with the first vote weighted more heavily than the second.

CHRT Phase 3

In Phase 3, the CHRT members individually scored and rated each specific area and discussed the compiled results to assign final conservation value ratings to each specific area. The results of the multi-factor scoring system were compiled by calculating the mean total score, standard error, and range for each specific area. Then, the initial conservation value ratings were summarized and a score-based conservation value rating for each specific area was determined for comparison. The CHRT then compared the compiled initial conservation value ratings and score-based conservation value rating for each specific area with the compiled conservation value ratings based on the alternative approach. In general, the conservation value ratings for each area were consistent across all three approaches.

The CHRT ultimately relied on the alternative approach to assign the final conservation value ratings for each specific area. The CHRT members believed this approach provided a better representation of the conservation value of each specific area compared to the score-based ratings, because it took into account the presence of green sturgeon and how each area is used. For most areas, there was a clear majority rating. Where there was no clear majority rating, the "second vote" was considered and consensus reached among the CHRT members after discussing the areas and the reasons for the different ratings. In general, the final conservation value ratings were consistent with the scores generated by the multi-factor scoring system (i.e., high-scoring areas generally received a final conservation rating of "High", low-scoring areas a rating of "Low").

The CHRT also considered the importance of connectivity among habitats, recognizing that green sturgeon must migrate along the coast to access important oversummering and overwintering habitats in coastal bays and estuaries. Specific areas in coastal marine waters may provide low to medium value habitat for green sturgeon based on the PCEs present. However, such areas may contain high-value connectivity corridors for green sturgeon migrating out of the San Francisco Bay system to bays and estuaries in California, Oregon, Washington, and Canada, without which green sturgeon would not be able to access high-value habitats. The CHRT recognized that even within an area of low to medium conservation value, the presence of a migratory/connectivity corridor that provides passage to high value areas would warrant increasing the overall conservation value of the area to a high. To account for this, the CHRT assigned a separate conservation value rating to areas containing a migratory/connectivity corridor, equal to the rating of the highest-rated area for which it served as a migratory/connectivity corridor.

The CHRT members were then asked to re-examine the conservation value ratings for the specific areas where the presence of the Southern DPS was categorized as likely (based on the presence of Northern DPS fish or green sturgeon of unknown origin), but not confirmed. These areas include the coastal marine waters within 110 m depth from the U.S.-California/Mexico border to Monterey Bay, CA, and from Yakutat Bay, AK, to the Bering Strait (including the Bering Sea), as well as the following coastal bays and estuaries: Elkhorn Slough, CA; Tomales Bay, CA; Noyo Harbor, CA; Eel River estuary, CA; Klamath/Trinity River estuary, CA; Rogue River estuary, OR; Siuslaw River estuary, OR; Alsea River estuary, OR; Yaquina Bay, OR; and Tillamook Bay, OR. The CHRT recognized that a lack of documented evidence for Southern DPS presence within these areas may be because of the lack of monitoring or sampling effort within these areas and that a high degree of uncertainty exists as to the extent to which Southern DPS fish use these areas. The low occurrence of green sturgeon within these areas is indicated by few observations both historically and recently. The CHRT scored all of these areas, except for Tomales Bay, CA, much lower than other areas, reflecting the CHRT's assessment that these areas contribute relatively little to the conservation of the species. For the bays and estuaries, this was based on the limited area and depth to support green sturgeon migration and feeding, as well as the low documented use of these areas by green sturgeon. Tomales Bay, CA, was given a higher score and rated as "Medium," because it is a large, deep embayment providing good habitat for feeding by green sturgeon and is likely the first major bay to be encountered by subadults making their first migration into marine waters. As described above (see *Bays and Estuaries*), green sturgeon are more commonly observed in the Eel River estuary, Klamath/Trinity River estuary, and Rogue River estuary, but are believed to primarily belong to the Northern DPS. For the coastal marine waters, the two areas are outside of the migratory/connectivity corridor identified by the CHRT. Although the CHRT did not include the area in southeast Alaska up to Yakutat Bay, AK, to be part of the primary migratory corridor, this area was rated as "Medium" because it is just north of known overwintering habitats off the coast of British Columbia, and is within the confirmed migratory range of Southern DPS fish.

Based on this information, the CHRT agreed that the conservation value ratings should be reduced by one rating for the specific areas where the presence of the Southern DPS is likely, but not confirmed. This necessitated the creation of a fourth conservation value rating level ("Ultra-low"). Those specific areas that initially received a "Low" rating were assigned a final conservation value rating of "Ultra-low," whereas those areas that initially received a "Medium" rating were assigned a final conservation value rating of "Low." None of the specific areas where the presence of the Southern DPS was likely, but not confirmed, had received a "High" rating.

The final conservation ratings and the justifications for each specific area are summarized in Table 5. The ratings provide an assessment of the relative importance of the specific area to the conservation of the Southern DPS. Areas rated as "High" were deemed to have a high likelihood of promoting the conservation of the Southern DPS, whereas areas rated as "Medium" or "Low" were deemed to have a moderate or low likelihood of promoting the conservation of the Southern DPS. The CHRT recognized that even within a rating category, variation exists. For example, freshwater riverine areas rated as "High" may be of greater conservation value to the species than coastal marine areas with the same rating. This variation was captured in the comments provided by the CHRT members for each specific area.

CHRT Phase 4

In Phase 4, the CHRT was asked to identify any unoccupied areas that may be essential for the conservation of the Southern DPS. As described in the section titled "Unoccupied Areas" above, unoccupied areas may be considered for designation only if the areas are determined to be essential for conservation of the species – in other words, if a critical habitat designation limited to presently occupied areas would not be adequate to achieve conservation of the species. The CHRT provided their best professional judgment as to whether limiting critical habitat to occupied areas would be adequate to ensure conservation of the species. The CHRT identified and evaluated seven unoccupied areas in the Central Valley, CA, to determine whether the areas are essential for conservation of the species. To evaluate the unoccupied areas, the CHRT considered several factors, including the historical use of the area by green sturgeon, the status of current habitat conditions, and the potential for restoring habitat conditions to support green sturgeon presence and spawning within the area. The CHRT members scored two factors: (1) the historical importance of the area for green sturgeon prior to habitat degradation and/or passage impairment; and (2) the potential for restoration of habitat conditions for green sturgeon, either naturally or through active conservation and restoration (Tables 6 and 7). The CHRT also identified what activities occur within each area that might trigger a section 7 consultation. As described above in the section titled *Unoccupied Areas*, the CHRT did not have sufficient data to determine that any of the unoccupied areas *are essential* for conservation of the Southern DPS. The CHRT noted that these areas *may be essential* for conservation and emphasized the importance of gathering more information about the use of these areas by green sturgeon.

In this phase, the CHRT also considered whether excluding particular occupied areas from the critical habitat designation would significantly impede conservation or result in extinction of the Southern DPS of green sturgeon. NMFS identified particular areas eligible for exclusion by weighing the benefits of exclusion (i.e., avoidance of economic impacts, impacts on national security, and other relevant impacts of designation) against the benefits of designation (i.e., the conservation value) for each area. The draft ESA 4(b)(2) report provides more details about the 4(b)(2) weighing process and analysis (NMFS, 2008). Fifteen areas identified as eligible for exclusion from designation were presented to the CHRT. The CHRT considered the contribution of each area to conservation and the information available on the life stages present, level of use by the Southern DPS, and habitat functions supported within each area. The CHRT concluded that exclusion of two of the areas (the lower Feather River and Coos Bay) would significantly impede conservation of the species. The CHRT determined that exclusion of Puget Sound, WA, would not significantly impede conservation nor will it result in extinction of the species. Given the very limited data, the CHRT expressed a high degree of uncertainty regarding whether the exclusion of coastal marine waters within 110 m depth from the U.S.-Alaska/Canada border would significantly impede conservation of the species. At this time, NMFS proposes to exclude this area from designation, because the low number of Southern DPS detections in the area and the uncertainty regarding how activities in the area would affect critical habitat indicate that excluding this area would not result in extinction of the species. Finally, the CHRT concluded, and we concur, that exclusion of 11 of the 15 areas eligible for exclusion (including several coastal bays and estuaries and coastal marine waters within 110 m depth off southern California and northwest of Yakutat Bay, AK) would not significantly impede conservation and will not result in the extinction of the Southern DPS. The CHRT considered all of the areas proposed for exclusion from designation and concluded that exclusion of the areas would not significantly impede conservation and will not result in extinction of the Southern DPS. The results of the CHRT's evaluation concerning areas eligible for exclusion are summarized in Table 5. Overview maps of the specific areas proposed for designation as critical habitat are shown in Figures 1 and 2.

CHRT Phase 5

In Phase 5, the CHRT will be re-convened to review comments received on the proposed critical habitat designation and any new information identified that was not considered in the development of the proposed designation. The CHRT may be asked to review and revise their evaluations and conservation value ratings to take into account any relevant comments or new information. The CHRT's final assessment and conclusions about the specific areas considered for designation as critical habitat will be reported in the final critical habitat designation and biological report.

Table 1. Summary of occupied specific areas, and the river miles or surface area covered, the presence of the Southern DPS ("confirmed" based on documented evidence of the Southern DPS or "likely" based on the presence of green sturgeon of the Northern DPS or of unknown DPS), the PCEs present, and activities that may affect the PCEs within each area such that special management considerations or protection may be required.

Specific Area	River miles or area covered	Southern DPS presence	PCEs present *	Activities **
Freshwater Rivers, Bypasses, and the Delta				
Upper Sacramento R., CA	58.9 mi	Confirmed	Dp, Fd, Fl, P, S, Sq, Wq	CON, DAM, DIV, POLL
Lower Sacramento R., CA	182.4 mi	Confirmed	Dp, Fd, Fl, P, S, Sq, Wq	AG, CON, DAM, DIV, DR, POLL
Yolo Bypass, CA	112.3 sq mi	Confirmed	Fd, Sq, P, Wq	AG
Sutter Bypass, CA	23.5 sq mi	Confirmed	Fd, Sq, P, Wq	AG
Lower Feather R., CA	72.7 mi	Confirmed	Dp, Fl, P, Wq	AG, CON, DAM, DIV, POLL
Lower Yuba R., CA	11.5 mi	Confirmed	Dp, Fl, P, Wq	AG, DAM, DIV, POLL
Sacramento- San Joaquin Delta	438.9 sq mi	Confirmed	Dp, Fd, Fl, P, S, Sq, Wq	CON, DIV, DR, POLL, PP, REST
Bays and estuaries, including rivers to the head of the tide				
Elkhorn Slough, CA	1.0 sq mi	Likely	Fd, Sq, P, Wq	DR, PP
Suisun Bay, CA	50.8 sq mi	Confirmed	Dp, Fd, Fl, P, Sq, Wq	CON, DR, REST
San Pablo Bay, CA	127.7 sq mi	Confirmed	Dp, Fd, P, Sq, Wq	CON, DR, POLL, PP, REST
San Francisco Bay, CA	269.9 sq mi	Confirmed	Dp, Fd, P, Sq, Wq	CON, DR, EP, POLL, PP, REST
Tomales Bay, CA	11.5 sq mi	Likely	Fd, P, Sq, Wq	DIV, POLL, REST
Noyo Harbor, CA	<0.1 sq mi	Likely	Fd, P, Sq, Wq	DR, POLL
Eel R., CA	8.5 sq mi	Likely	Fd, P, Sq, Wq	CON, POLL
Humboldt Bay, CA	26.6 sq mi	Confirmed	Fd, P, Sq, Wq	AQ, POLL
Klamath/Trinity R., CA	2.5 sq mi	Likely	Fd, P, Sq, Wq	CON
Rogue R., OR	0.6 sq mi	Likely	Fd, P, Sq, Wq	CON, POLL
Coos Bay, OR	17.7 sq mi	Confirmed	Fd, P, Sq, Wq	CON, LNG, POLL
Winchester Bay, OR	10.8 sq mi	Confirmed	Fd, P, Sq, Wq	CON, POLL
Siuslaw R., OR	0.4 sq mi	Likely	Fd, P, Sq, Wq	CON, POLL
Alsea R., OR	0.8 sq mi	Likely	Fd, P, Sq, Wq	CON, DIV, POLL
Yaquina R., OR	6.3 sq mi	Likely	Fd, P, Sq, Wq	POLL
Tillamook Bay, OR	14.2 sq mi	Likely	Fd, P, Sq, Wq	CON, POLL
Lower Columbia R. and estuary	236.9 sq mi	Confirmed	Fd, P, Sq, Wq	CON, DAM, DR, LNG, POLL
Willapa Bay, WA	134.3 sq mi	Confirmed	Fd, P, Sq, Wq	AQ, CON, EP, POLL
Grays Harbor, WA	91.8 sq mi	Confirmed	Fd, P, Sq, Wq	AQ, POLL, SHIP
Puget Sound, WA	1,017.8 sq mi	Confirmed	Fd, P, Sq, Wq	CON, DR, EP, POLL, SHIP

Table 1 (continued)

Specific Area	River miles or area covered	Southern DPS presence	PCEs present *	Activities **
Coastal Marine Waters (to 110 m depth)				
US-CA/Mexico border to Monterey Bay, CA	2,522.8 sq mi	Likely	Fd, P, Wq	BOT, CON, DESAL, DR, EP, LNG, POLL, PP
Monterey Bay, CA, to San Francisco Bay, CA	1,495.9 sq mi	Confirmed	Fd, P, Wq	BOT, DESAL, POLL, PP
San Francisco Bay, CA, to Humboldt Bay, CA	2,066.7 sq mi	Confirmed	Fd, P, Wq	BOT, EP, POLL
Humboldt Bay, CA, to Coos Bay, OR	1,911.6 sq mi	Confirmed	Fd, P, Wq	BOT, DR, EP, POLL
Coos Bay, OR, to Winchester Bay, OR	186.5 sq mi	Confirmed	Fd, P, Wq	BOT, EP
Winchester Bay, OR, to Columbia R. estuary	2,686.3 sq mi	Confirmed	Fd, P, Wq	BOT, EP, POLL
Columbia R. estuary to Willapa Bay, WA	477.1 sq mi	Confirmed	Fd, P, Wq	BOT
Willapa Bay, WA, to Grays Harbor, WA	403.0 sq mi	Confirmed	Fd, P, Wq	BOT
Grays Harbor, WA, to US-WA/Canada border	1,900.9 sq mi	Confirmed	Fd, P, Wq	BOT, EP, POLL
Strait of Juan de Fuca, WA	798.8 sq mi	Confirmed	Fd, P, Wq	BOT, DR, POLL
Canada/US-AK border to Yakutat Bay, AK	19,567.9 sq mi	Confirmed	Fd, P, Wq	EP, POLL, SHIP
Coastal Alaskan waters northwest of Yakutat Bay, AK, including the Bering Sea, to the Bering Strait	374,826.4 sq mi	Likely	Fd, P, Wq	BOT, EP, LNG, SHIP

* PCE codes: Dp = depth, Fd = food resources, Fl = water flow, P = migratory corridors, S = substrate type or size (structural), Sq = sediment quality (contaminants), Wq = water quality.

** Management activities codes: AG = agriculture, AQ = aquaculture, BOT = bottom trawl fisheries, CON = in-water construction or alterations, DAM = dams, DESAL = desalination plants, DIV = water diversions, DR = dredging and deposition of dredged material, EP = tidal/wave energy projects, LNG = LNG projects, POLL = NPDES activities and activities generating non-point source pollution, PP = power plants, REST = restoration, SHIP = commercial shipping.

Table 2. Definitions and criteria for multi-factor scoring system used to score the PCEs and evaluate the conservation value of the occupied specific areas.

Factors	Criteria
Factor 1: PCE Quality - Support of spawning and egg incubation. Considers the PCE support of spawning and egg incubation provided by the specific areas.	3 = the PCE supports spawning and egg incubation currently. 2 = the PCE supported or likely supported spawning and egg incubation historically and likely supports spawning and incubation currently. 1 = Uncertain but possible that the PCE supports spawning and egg incubation currently or historically. 0 = Unlikely that the PCE supports spawning and egg incubation currently or historically.
Factor 2: PCE Quality - Support of larval/juvenile rearing and growth. Considers the PCE support of larval/juvenile rearing and growth provided by the specific areas.	3 = the PCE supports larval/juvenile rearing and growth currently. 2 = the PCE supported or likely supported larval/juvenile rearing and growth historically and likely supports larval/juvenile rearing and growth currently. 1 = Uncertain but possible that the PCE supports larval/juvenile rearing and growth currently or historically. 0 = Unlikely that the PCE supports larval/juvenile rearing and growth currently or historically.
Factor 3: PCE Quality - Support of juvenile and/or subadult/adult migration. Considers the PCE support of juvenile and/or subadult/adult migration provided by the specific areas.	3 = the PCE supports both juvenile and subadult/adult migration currently. 2 = the PCE currently supports subadult/adult migration for large numbers of subadults/adults relative to other areas. 1 = Uncertain but possible that the PCE historically supported subadult/adult migration for large numbers of subadults/adults. The PCE currently supports subadult/adult migration for low numbers of subadults/adults relative to other areas. 0 = the PCE supports subadult/adult migration for low numbers of subadults/adults relative to other areas, historically and currently.
Factor 4: PCE Quality - Support of subadult/adult feeding, holding, and/or non-spawning aggregations. Considers the PCE support of subadult/adult feeding, holding, and/or non-spawning aggregation provided by the specific areas.	3 = the PCE supports subadult/adult feeding, holding, and/or non-spawning aggregation for large numbers of subadults/adults relative to other areas. 2 = Uncertain but possible that the PCE supports subadult/ adult feeding, holding, and/or non-spawning aggregation for large numbers of subadults/adults relative to other areas. 1 = Uncertain but possible that the PCE supports subadult/ adult feeding, holding, and/or non-spawning aggregation for low numbers of subadults/adults relative to other areas. 0 = Unlikely that the PCE supports subadult/adult feeding, holding, and/or non-spawning aggregation.

Table 3. Multi-factor scoring system table used to score the PCEs and evaluate the conservation value of the occupied specific areas.

Specific Areas	Spawning and incubation							Larval/ Juvenile rearing and growth							Juvenile and/or Subadult/Adult migration							Subadult/Adult feeding, holding, and/or non-spawning aggregation							TOTAL SCORE	Comments & references (include initial conservation value rating)
Rivers/Bypasses/Delta	Fd	S	Fl	Wq	P	Dp	Sq	Fd	S	Fl	Wq	P	Dp	Sq	Fd	S	Fl	Wq	P	Dp	Sq	Fd	S	Fl	Wq	P	Dp	Sq		
Upper Sac R., CA																														
Lower Sac R., CA																														
Yolo Bypass (Sac R.)																														
Sutter Bypass (Sac R.)																														
Lower Feather R., CA																														
Lower Yuba R., CA																														
Sac-San Joaquin Delta, CA																														
Bays/River to the head of the tide	Fd	Fl	Wq	P	Dp	Sq		Fd	Fl	Wq	P	Dp	Sq		Fd	Fl	Wq	P	Dp	Sq		Fd	Fl	Wq	P	Dp	Sq		TOTAL SCORE	Comments & references (include initial conservation value rating)
Elkhorn Slough, CA																														
Suisun Bay, CA																														
San Pablo Bay, CA																														
San Francisco Bay, CA																														
Tomales Bay, CA																														
Noyo Harbor, CA																														
Eel R., CA																														
Humboldt Bay, CA																														
Klamath/Trinity R., CA																														
Rogue R., OR																														
Coos Bay, OR																														
Winchester Bay, OR																														
Siuslaw R., OR																														
Alsea R., OR																														
Yaquina R., OR																														
Tillamook Bay, OR																														
Lower Columbia R. estuary and R.																														
Willapa Bay, WA																														
Grays Harbor, WA																														
Puget Sound, WA																														
Coastal Areas	Fd	Wq	P					Fd	Wq	P					Fd	Wq	P					Fd	Wq	P					TOTAL SCORE	Comments & references (include initial conservation value rating)
CA-Mexico border to Monterey, CA																														
Monterey Bay, CA to SF Bay, CA (including Monterey Bay)																														
SF Bay, CA to Humboldt Bay, CA																														
Humboldt Bay, CA to Coos Bay, OR																														
Coos Bay, OR to Winchester Bay, OR																														
Winchester Bay, OR to Columbia R. estuary																														
Columbia R. estuary to Willapa Bay, WA																														
Willapa Bay, WA to Grays Harbor, WA																														
Grays Harbor, WA to WA, US/Canada border																														
Strait of Juan de Fuca, WA																														
Canadian/AK, US border to Yakutat Bay, AK (including Graves Harbor)																														
Coastal AK waters northwest of Yakutat Bay, AK																														

Table 4. Evaluation table used to rate the conservation value of each specific area. Each CHRT member completed the table individually by entering the PCEs present supporting each life stage (Dp = depth, Fd = food resources, Fl = water flow, P = passage, S = substrates, Sq = sediment quality, and Wq = water quality), their first and second vote for the conservation value rating (High, Medium, Low), and their comments/justification. Responses were compiled to assign final conservation value ratings. Responses for the Upper Sacramento R. area are shown as an example and do not represent actual responses.

Specific Areas	Life Stage			Conservation Value Rating		Notes
	Eggs/ Larvae	Juveniles	Adults/ Subadults	First vote	Second vote	
Rivers/Bypasses/Delta						
Upper Sac R., CA	Fd, Fl, P, S, Sq, Wq	Fd, Fl, S, Wq	Dp, Fd, Fl, P, S, Sq, Wq	High		Important habitat for spawning, rearing, and migration
Lower Sac R., CA						
Yolo Bypass (Sac R.)						
Sutter Bypass (Sac R.)						
Lower Feather R., CA						
Lower Yuba R., CA						
Sac-San Joaquin Delta, CA						
Bays and estuaries (including rivers to the head of the tide)						
Elkhorn Slough, CA						
Suisun Bay, CA						
San Pablo Bay, CA						
San Francisco Bay, CA						
Tomales Bay, CA						
Noyo Harbor, CA						
Eel R., CA						
Humboldt Bay, CA						
Klamath/Trinity R., CA						
Rogue R., OR						
Coos Bay, OR						
Winchester Bay, OR						
Siuslaw R., OR						
Alsea R., OR						
Yaquina R., OR						
Tillamook Bay, OR						
Lower Columbia R. estuary and R.						
Willapa Bay, WA						
Grays Harbor, WA						
Puget Sound, WA						
Nearshore coastal marine waters within 110 m depth						
CA-Mexico border to Monterey, CA						
Monterey Bay, CA to SF Bay, CA (including Monterey Bay)						
SF Bay, CA to Humboldt Bay, CA						
Humboldt Bay, CA to Coos Bay, OR						
Coos Bay, OR to Winchester Bay, OR						
Winchester Bay, OR to Columbia R. estuary						
Columbia R. estuary to Willapa Bay, WA						
Willapa Bay, WA to Grays Harbor, WA						
Grays Harbor, WA to WA, US/Canada border						
Strait of Juan de Fuca, WA						
Canadian/AK, US border to Yakutat Bay, AK (including Graves Harbor)						
Coastal AK waters northwest of Yakutat Bay, AK						

Table 5. Summary of the evaluation and final conservation value ratings for each of the occupied specific areas. For each specific area, the benefit of designation (= final conservation value rating) was determined based on consideration of the PCE scores (from the multi-factor scoring system) and the CHRT's overall assessment of the conservation value of each area. The spread in first votes for each rating is shown in the table (H = high, M = medium, L = low; for some areas, there were less than 8 votes because members of the CHRT did not feel they had the expertise to evaluate and rate those areas). For areas containing migratory corridors, the CHRT also rated the conservation value of the migratory corridor. For areas where the presence of the Southern DPS was likely, but not confirmed (marked by an *), the final conservation value rating was reduced by one rating. For areas identified as eligible for exclusion based on economic, national security, or other relevant impacts, the CHRT considered whether exclusion would significantly impede conservation of the Southern DPS and result in extinction. Finally, notes and comments from discussions with the CHRT are recorded for each area. H = High, M = medium, L = low, U = ultra-low.

Specific area	H	M	L	Benefit of designation	Benefit of designating migratory corridor	Final conservation value rating	Would exclusion hinder conservation?	Comments
Freshwater Rivers, Bypasses, and the Delta								
Upper Sacramento R., CA	8			**H**		**H**		The Southern DPS is unlikely to survive without this area. Identified as one of only 2 areas with extant spawning habitat. All life stages occur in this area and likely at least one of the 4 life stages of green sturgeon are present throughout the year. High total score.
Lower Sacramento R., CA	8			**H**		**H**		The Southern DPS is unlikely to survive without this area. Identified as one of only 2 areas with extant spawning habitat. All life stages occur in this area and likely at least one of the 4 life stages of green sturgeon are present throughout the year. High total score.
Yolo Bypass, CA	2	4	1	**M**		**M**		Identified as an important migratory corridor during high flow events. A potential off-channel rearing/feeding area for juveniles. Potentially high-value habitat if passage problems and stranding risks are minimized. Larger of the 2 bypasses and thus may provide more habitat for green sturgeon.
Sutter Bypass, CA	1	5	1	**M**		**M**		Identified as an important migratory corridor during high flow events. A potential off-channel rearing/feeding area for juveniles. Potentially high-value habitat if passage problems and stranding risks are minimized

Lower Feather R., CA	3	4	1	**M**		**M**	**Yes**	Medium-value based on current habitat conditions, but changes (e.g., restoration of habitat or fish passage) are logistically and financially feasible and could increase the value to a "High." Spawning may have been supported historically (greater likelihood than on the Yuba R.) and may be restored.
Lower Yuba R., CA	1	6	1	**M**		**M**		Medium-value based on current habitat conditions, but changes (e.g., restoration of habitat or fish passage, dam removal) are logistically and financially feasible and could increase the value to a "High." Spawning may have been supported historically (lower likelihood than on the Feather R.) and may be restored in the future.
Sacramento- San Joaquin Delta	6	2		**H**		**H**		The Southern DPS is unlikely to survive without this area. Identified as an important area for juvenile feeding, rearing, and growth prior to ocean migration. An important connectivity corridor for migration between the Sacramento R. system and the ocean.
Bays and Estuaries								
Elkhorn Slough, CA *		1	7	**L**		**U**	**No**	Very little data on green sturgeon use. Appears to be used minimally by green sturgeon, but could be important due to its proximity to Monterey and San Francisco bays. Southern DPS presence likely.
Suisun Bay, CA	7	1		**H**		**H**		The Southern DPS is unlikely to survive without this area. Identified as an important area for juvenile rearing and osmoregulatory transition. An important migratory corridor.
San Pablo Bay, CA	7	1		**H**		**H**		The Southern DPS is unlikely to survive without this area. Identified as an important area for juvenile rearing and osmoregulatory transition. An important migratory corridor. Adults and subadults have been consistently captured in the bay over many decades.

San Francisco Bay, CA	7	1		**H**		**H**		The Southern DPS is unlikely to survive without this area. Identified as an important area for juvenile rearing and osmoregulatory transition. An important migratory corridor between the bays and Sacramento R. system and the ocean.
Tomales Bay, CA *		5	3	**M**		**L**	**No**	Very little data on green sturgeon use. Appears to be used minimally by green sturgeon, but could be important based on its large size and proximity to San Francisco Bay. Southern DPS presence likely.
Noyo Harbor, CA *			8	**L**		**U**	**No**	Very little data on green sturgeon use. The area provides limited area and depth for green sturgeon and likely used minimally. Southern DPS presence likely.
Eel R., CA *		1	7	**L**		**U**	**No**	Limited in area and depth. Southern DPS presence not confirmed. Likely minimally used by the Southern DPS, if at all. Former or intermittent spawning river for the Northern DPS (confirmed presence of larvae, juveniles, and adults in the 1990's and earlier, CDFG 2002).
Humboldt Bay, CA	2	5	1	**M**		**M**		Identified as an important area for summer rearing of Southern DPS subadults and adults that may support feeding and holding.
Klamath/Trinity R., CA*			8	**L**		**U**	**No**	Identified as an important area for Northern DPS fish, but likely minimally used by Southern DPS fish, if at all. Coastal waters outside the estuary are likely more important for Southern DPS fish. Southern DPS presence likely.
Rogue R., OR *			8	**L**		**U**	**No**	Identified as an important area for Northern DPS fish, but likely minimally used by Southern DPS fish, if at all. Coastal waters outside the estuary are likely more important for Southern DPS fish. Southern DPS presence likely.

Coos Bay, OR	1	6	1	**M**		**M**	**Yes**	Identified as an important area for summer rearing of Southern DPS subadults and adults that may support feeding and holding. The CHRT rated this area to be of less importance relative to Winchester Bay, based on the limited number of captures of green sturgeon.
Winchester Bay, OR	3	5		**M**		**M**		Identified as an important area for summer rearing of Southern DPS subadults and adults that may support feeding and holding. The CHRT rated this area to be of greater importance relative to Coos Bay, but less than the Columbia R. estuary, Willapa Bay, and Grays Harbor to the north.
Siuslaw R., OR *			8	**L**		**U**	**No**	Very little data on green sturgeon use. Appears to be used minimally by green sturgeon. Southern DPS presence likely.
Alsea R., OR *			8	**L**		**U**	**No**	Very little data on green sturgeon use. Appears to be used minimally by green sturgeon. Southern DPS presence likely.
Yaquina R., OR *		1	7	**L**		**U**		Very little data on green sturgeon use. There is minimal use by green sturgeon, though likely at a higher rate than in the Siuslaw, Alsea, or Tillamook. Southern DPS presence likely.
Tillamook Bay, OR *			8	**L**		**U**	**No**	Very little data on green sturgeon use. Appears to be used minimally by green sturgeon. Southern DPS presence likely.
Lower Columbia R. and estuary	7	1		**H**		**H**		Identified as an important area for summer rearing, feeding, aggregations, and holding of Southern DPS subadults and adults. A substantial amount of evidence indicates a relatively high frequency of occurrence of Southern DPS fish. Very important for multiple year classes.
Willapa Bay, WA	7	1		**H**		**H**		Identified as an important area for summer rearing, feeding, aggregations, and holding of Southern DPS subadults and adults. A

								substantial amount of evidence indicates a relatively high frequency of occurrence of Southern DPS fish. Very important for multiple year classes.
Grays Harbor, WA		6	2	**H**		**H**		Identified as an important area for summer rearing, feeding, aggregations, and holding of Southern DPS subadults and adults. A substantial amount of evidence indicates a relatively high frequency of occurrence of Southern DPS fish. Very important for multiple year classes.
Puget Sound, WA		5	3	**M**		**M**	**No**	Southern DPS presence (subadults/adults) has been confirmed. The relatively few detections of Southern DPS fish indicate a low frequency of occurrence, but also suggest lengthy use and/or residence time.
Coastal Marine Waters within 110 meters depth								
US-CA/Mexico border to Monterey Bay, CA *			8	**L**		**U**	**No**	Very little data on green sturgeon use. Appears to be used minimally by green sturgeon. Southern DPS presence likely.
Monterey Bay, CA, to San Francisco Bay, CA	3	3	2	**H**	**H**	**H**		Although most Southern DPS subadults and adults exiting San Francisco Bay are believed to migrate north, some portion also migrates south as far as Monterey Bay, potentially to overwinter. Identified as an important migratory/connectivity corridor for Southern DPS to and from Monterey Bay, and may also support feeding.
San Francisco Bay, CA, to Humboldt Bay, CA	5	2	1	**H**	**H**	**H**		Identified as an important component of the migratory/ connectivity corridor for Southern DPS subadults and adults (from San Francisco Bay, CA, to Vancouver Island,

								BC). Noted as an especially important area for subadults making their first migration into marine waters from San Francisco Bay, CA. This area may support subadult/adult aggregations and feeding.
Humboldt Bay, CA, to Coos Bay, OR	5	2	1	**H**	**H**	**H**		Identified as an important component of the migratory/ connectivity corridor for Southern DPS subadults and adults (from San Francisco Bay, CA, to Vancouver Island, BC). May support feeding.
Coos Bay, OR, to Winchester Bay, OR	6	1	1	**H**	**H**	**H**		Identified as an important component of the migratory/ connectivity corridor for Southern DPS subadults and adults (from San Francisco Bay, CA, to Vancouver Island, BC). This area may support subadult/adult aggregations and feeding.
Winchester Bay, OR, to Columbia R. estuary	6	2		**H**	**H**	**H**		Identified as an important component of the migratory/ connectivity corridor for Southern DPS subadults and adults (from San Francisco Bay, CA, to Vancouver Island, BC), particularly to and from oversummering habitats in the Columbia R. estuary and Washington estuaries. This area may support subadult/adult aggregations and feeding.
Columbia R. estuary to Willapa Bay, WA	6	2		**H**	**H**	**H**		Identified as an important component of the migratory/ connectivity corridor for Southern DPS subadults and adults (from San Francisco Bay, CA, to Vancouver Island, BC). Tagging and tracking study results indicate a relatively high level of migration between the Columbia R. estuary and Willapa Bay, two important oversummering areas. This area may support subadult/adult aggregations and feeding.

Willapa Bay, WA, to Grays Harbor, WA	6	2		**H**	**H**	**H**		Identified as an important component of the migratory/ connectivity corridor for Southern DPS subadults and adults (from San Francisco Bay, CA, to Vancouver Island, BC), supporting migration to and from oversummering habitats in Willapa Bay and Grays Harbor. This area may support subadult/adult aggregations and feeding.
Grays Harbor, WA, to US-WA/Canada border	3	3	2	**M**	**H**	**H**		Identified as an important component of the migratory/ connectivity corridor for Southern DPS subadults and adults (from San Francisco Bay, CA, to Vancouver Island, BC), supporting migration to and from oversummering habitats in Oregon and Washington, and overwintering habitats on Vancouver Island, BC. This area may support subadult/adult aggregations and feeding. The CHRT rated the area as medium-value, but rated the migratory/ connectivity corridor as high-value.
Strait of Juan de Fuca, WA		6	2	**M**	**H**	**H**		Identified as an important component of the migratory/ connectivity corridor for Southern DPS subadults and adults (from San Francisco Bay, CA, to Vancouver Island, BC). May support feeding. The CHRT rated the area as medium-value, but rated the migratory/ connectivity corridor as high-value.
Canada/US-AK border to Yakutat Bay, AK	1	4	3	**M**	**M**	**M**	**?**	Identified as a migratory/connectivity corridor for Southern DPS subadults and adults to coastal Alaskan waters, but not a component of the primary migratory zone (from Monterey Bay, CA, to Vancouver

								Island, BC). Little data on green sturgeon use, aside from the detection of 2 Southern DPS fish off of Graves Harbor. At the northern extent of the overwintering range of green sturgeon. The CHRT rated both the area and the migratory/connectivity corridor as medium-value.
Coastal Alaskan waters northwest of Yakutat Bay, AK, including the Bering Sea, to the Bering Strait *	1	1	6	**L**		**U**	**No**	Very little data on green sturgeon use. Appears to be used minimally by green sturgeon. Southern DPS presence likely.

Table 6. Definitions and criteria for evaluation of unoccupied areas identified by the CHRT.

Factor	Criteria
Historical importance: The role the habitat may have played for green sturgeon before habitat degradation and passage impairment.	3 = likely an area of significant spawning and juvenile production
	2 = likely an area of limited spawning and juvenile production
	1 = likely not used for spawning, but perhaps used by other life stages (e.g., summer holding for adults)
	0 = not an area of significant use by any life stage
Potential for restoration : The potential condition of the habitat for green sturgeon, including accessibility and spawning, either naturally or through active conservation/ restoration, given known limiting factors, likely biophysical responses, and feasibility.	3 = there is a high potential and likelihood for restoring green sturgeon presence and spawning in the area. Restoration actions in the planning or implementation phase
	2 = there is some potential and likelihood for restoring green sturgeon presence and spawning in the area. Not in planning, but apparent impediments are not severe or expensive to correct, or restoration planning underway but efficacy for green sturgeon uncertain .
	1 = there is some potential and likelihood for restoring green sturgeon presence in the area, but not spawning. Not in planning, but apparent impediments are not severe or expensive to correct, or restoration planning underway, but efficacy for green sturgeon uncertain. Restoration of limiting habitat conditions is uncertain.
	0 = there is a low potential and likelihood for restoring green sturgeon presence and/or spawning in the area. Impediments are severe, expensive to correct, and political support for corrections unlikely.

Table 7. Evaluation table for consideration of unoccupied areas identified by the CHRT.

Unoccupied area	Historical importance	Potential for restoration	Total score	Section 7 benefits	Comments/ justification on ratings	Comments on boundaries
Upper Sacramento River - Pit River						
Upper Sacramento River - McCloud River						
Upper Sacramento River - upper Sacramento River						
Upper Feather River						
Upper Yuba River						
American River						
San Joaquin River (Area 1) - to Stanislaus River						
San Joaquin River (Area 2) - to Upper San Joaquin and Stanislaus rivers						

Figure 1. Map of occupied specific areas considered for designation in coastal bays and estuaries and coastal marine waters off California.

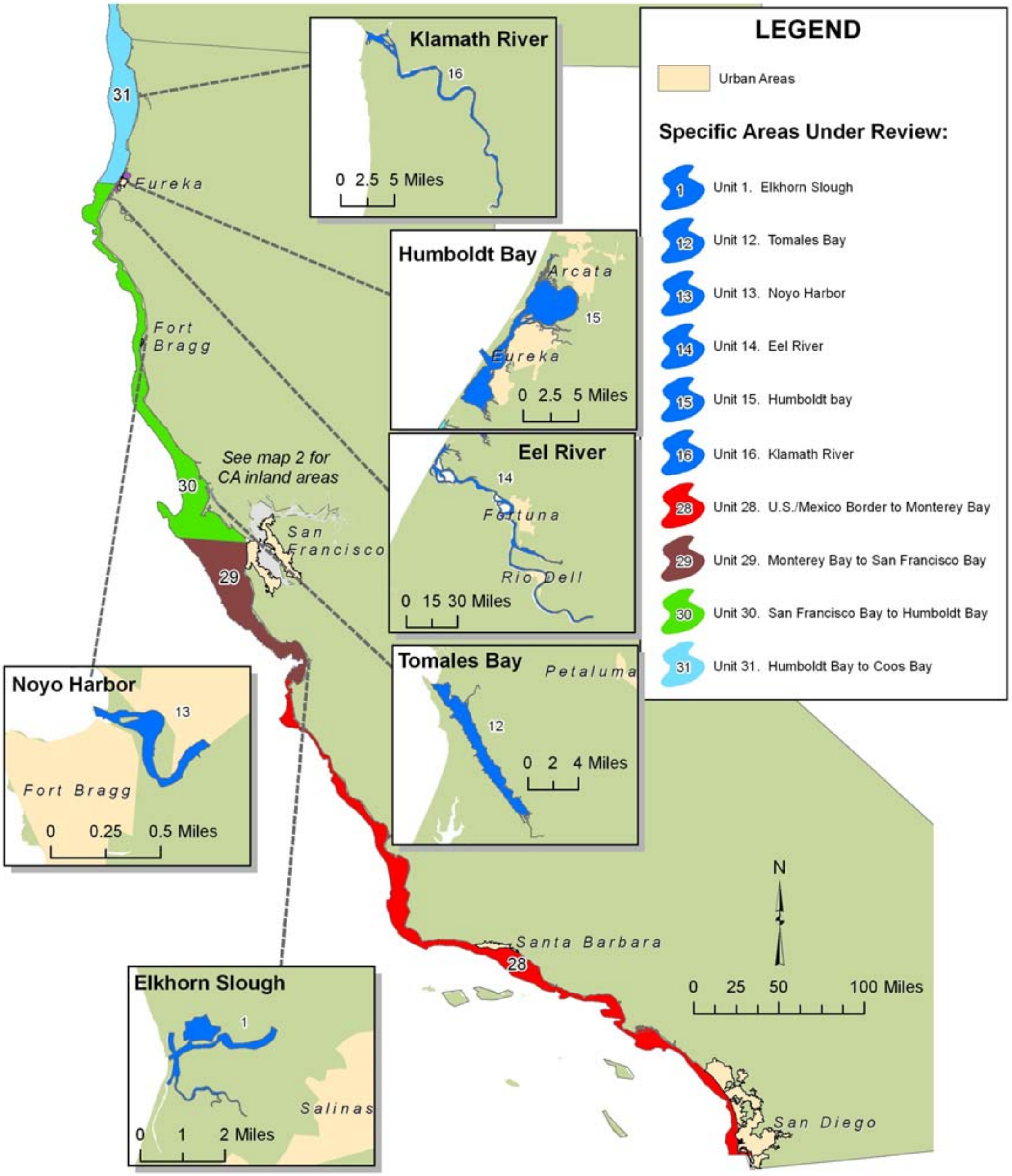


Figure 2. Map of occupied specific areas considered for designation in the Central Valley, California.

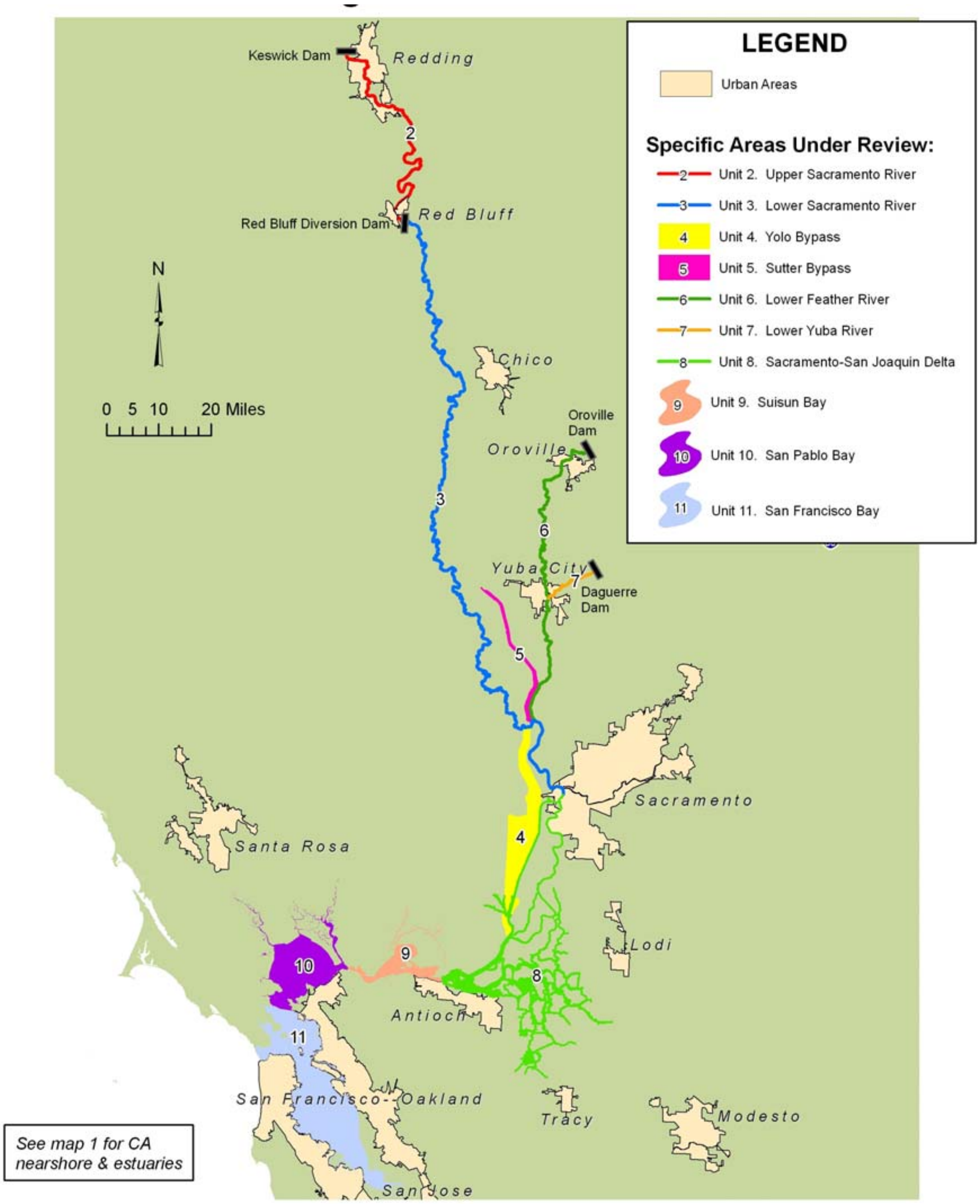


Figure 3. Map of occupied specific areas considered for designation in coastal bays and estuaries and coastal marine waters off Oregon.

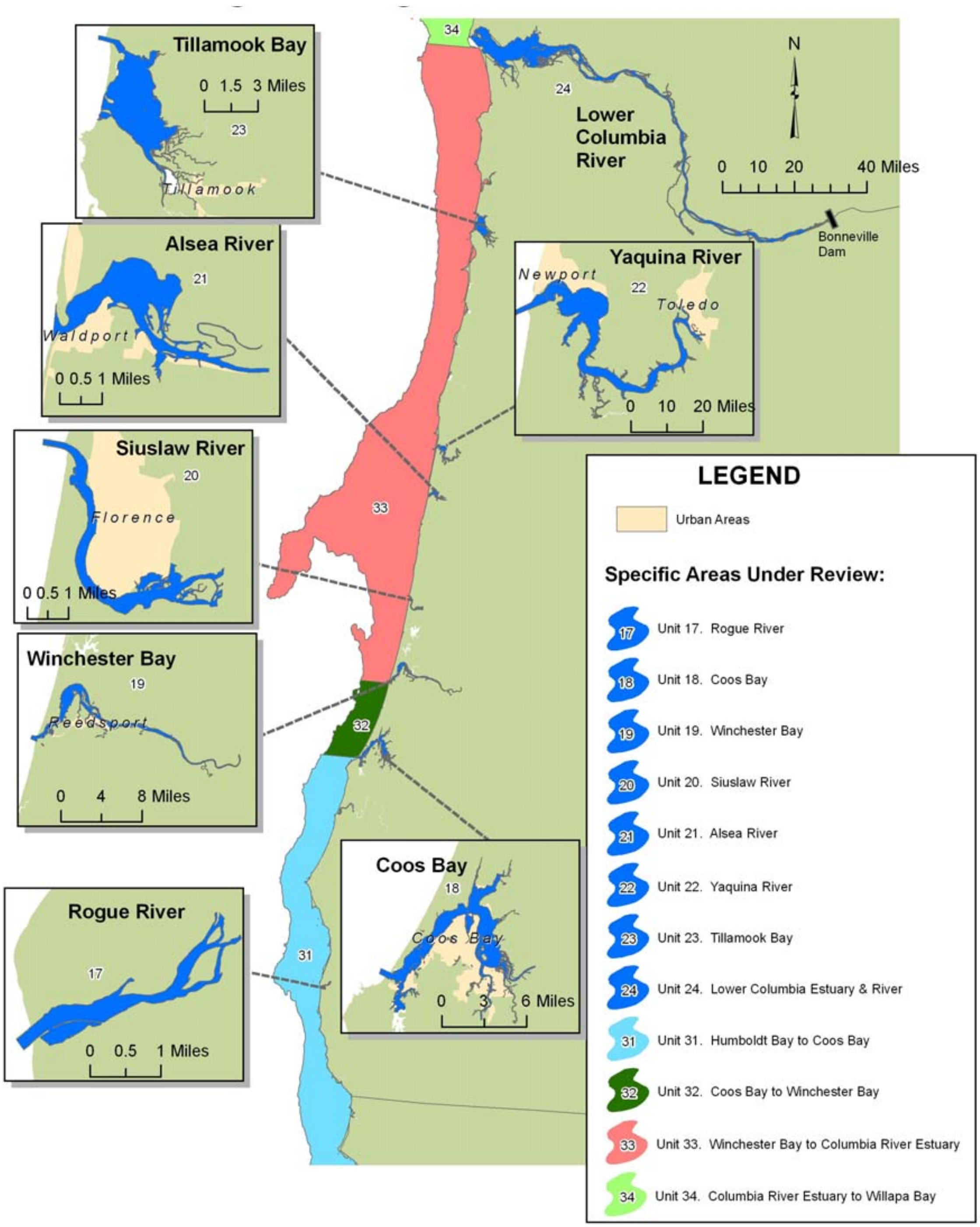


Figure 4. Map of occupied specific areas considered for designation in coastal bays and estuaries and coastal marine waters off Washington.

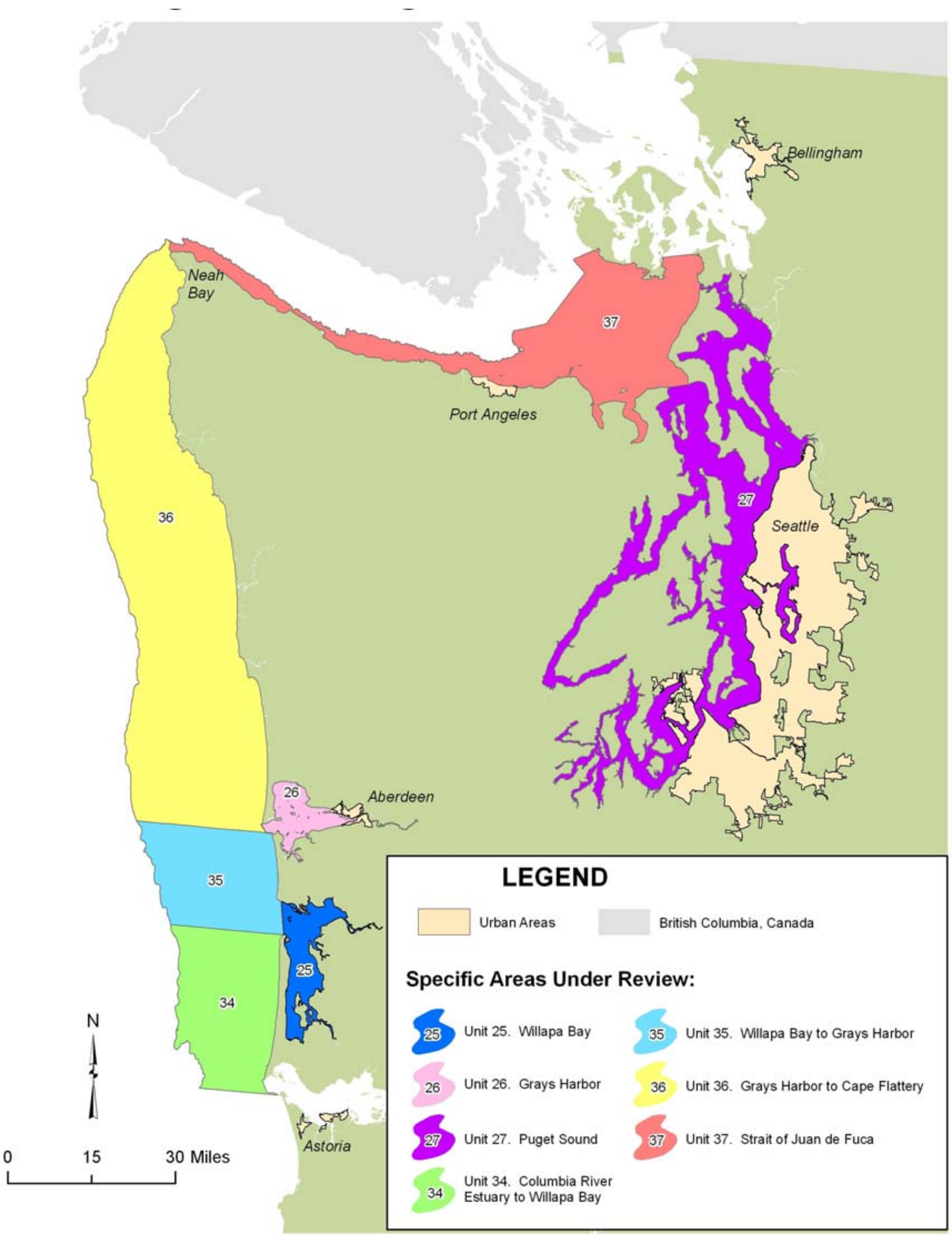
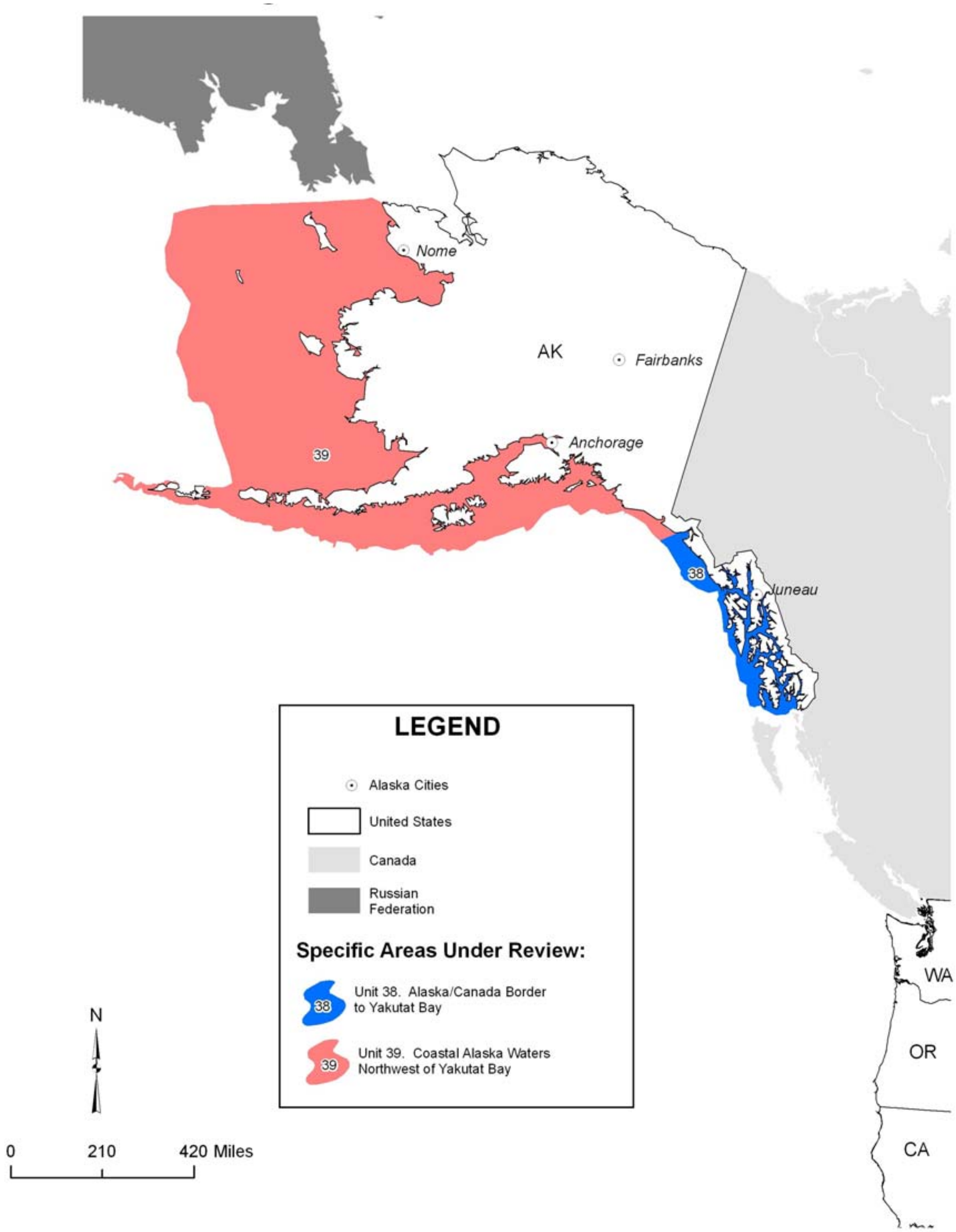


Figure 5. Map of occupied specific areas considered for designation in coastal marine waters off Alaska.



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APPENDIX A

MEMO July 14, 2008

TO: The Record

FROM: Melissa Neuman
Southwest Regional Office, Protected Resources Division

SUBJECT: Summary of Data Concerning Critical Habitat for the Southern Distinct Population Segment of Green Sturgeon in the Pacific Ocean.

The critical habitat review team (CHRT) assessed the biological importance of coastal marine areas to green sturgeon, and the primary constituent elements (PCEs) and special management considerations or protection that may be needed within these areas. This memo summarizes the best data available upon which the CHRT and NMFS evaluated critical habitat for the Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*; hereafter, "Southern DPS") within coastal marine areas.

Green sturgeon use of coastal marine areas

The CHRT identified coastal marine areas within 110 m depth as important migratory and feeding habitats for Southern DPS green sturgeon. Subadults enter the ocean after rearing in fresh and estuarine waters as juveniles for 1-4 years, and spend 3-20 years at sea before reaching reproductive maturity and returning to their natal river (i.e., the Sacramento River, CA) to spawn. After spawning, adults migrate out to sea and return to spawn every 2-4 years. Estimated longevity is between 60-70 years (Emmett *et al*., 1991). Thus, green sturgeon spend the majority of their lives in marine and estuarine waters outside of their natal rivers.

The CHRT considered coastal marine areas from Monterey Bay, CA, to Graves Harbor, AK, as particularly important for the Southern DPS because tagging (i.e. hydroacoustic and pop-off archival) and fisheries data confirm that green sturgeon make exclusive use of these areas for extensive migrations (i.e. 1000s of km) spanning a broad temporal range (i.e. many months) (Erickson and Hightower, 2007; Lindley *et al*., 2008; Lindley and Moser, 2008, unpublished data; WCGOP, 2008, unpublished data) (**See Figures A-1 to A-4**). Southern DPS fish migrate through this coastal marine corridor to reach oversummering habitats in bays and estuaries in northern California, Oregon, and Washington and to reach overwintering grounds in coastal waters between Vancouver Island, BC, and southeast Alaska (Lindley *et al*., 2008; Lindley and Moser, 2008, unpublished data). Southern DPS fish also migrate south after exiting San Francisco Bay and occupy marine waters off central California (as far south as Monterey Bay) in the spring, suggesting these areas contain oversummering and overwintering habitats (Lindley *et al*., 2008; Lindley and Moser, 2008, unpublished data). Although most tagged green sturgeon made rapid migrations along the coast, some individuals were observed swimming at slower speeds and spending several days within certain areas, most likely to forage (Lindley and Moser, 2008, unpublished data).

Data obtained from the West Coast Groundfish Observer Program on the bycatch of green sturgeon in bottom trawl fisheries off California, Oregon, and Washington support the tagging results and confirm the presence of green sturgeon from Monterey Bay, CA, to Cape Flattery, WA. CPUE was highest between Monterey and Humboldt bays, CA (WCGOP, 2008, unpublished data). The bycatch data also demonstrate that green sturgeon associate with benthic habitat in that they were collected in bottom trawls and are thus exposed to bottom disturbances.

<u>Specific areas, PCEs, and special management considerations or protection (see .pdf attachments 2 and 3 for corresponding figures)</u>

The CHRT defined 3 primary constituent elements (PCEs) for the coastal marine areas: (1) migratory corridors; (2) prey resources; and (3) water quality. Each PCE is discussed below.

Migratory corridors: Coastal marine areas provide an important migratory/connectivity corridor for the Southern DPS to access oversummering and overwintering habitats along the west coast of North America. The CHRT identified potential threats to passage involving take of green sturgeon, including incidental catch in fisheries. Alternative energy projects may hinder migration, particularly through the production of electromagnetic fields (McIsaac, 2008). A recent workshop at Oregon State University examined the potential ecological effects of wave energy development in the Pacific Northwest (http://hmsc.oregonstate.edu/waveenergy). Although the ecological effects of alternative energy projects on the marine environment remain uncertain and require further study, sturgeon were highlighted as one of the species whose migratory and feeding behavior is most likely to be affected by electromagnetic force fields because they orient themselves in the water column and forage for food using electromagnetic receptors located on their bodies (LeBreton et al. 2005). The CHRT also highlighted the potential problem of ocean "dead zones" (areas of low dissolved oxygen) and petroleum spills, in that they may block migratory routes and restrict the migratory corridor of Southern DPS fish. The link between ocean dead zones, petroleum spills and restricted passage for green sturgeon is largely unstudied. However, recent information suggests that: ocean hypoxia is a growing problem off the U.S. West coast; dissolved oxygen levels may fall below the critical threshold of 5 mg/l (necessary for maintaining fish health and behavior) for extended periods of time (months) and occur over large spatial scales (1000s of km); low dissolved oxygen zones restrict movements of fishes by narrowing the spatial extent of waters with dissolved oxygen levels above 5 mg/l; and fish disappear and have experienced massive die-offs as a result of extended hypoxic or anoxic conditions in coastal marine waters (www.krisweb.com/stream/do.htm, www.piscoweb.org/outreach/topics/hypoxia).

Water quality: Bioaccumulation of contaminants (e.g., pesticides, mercury, heavy metals) adversely affects the growth and reproductive development and success of white sturgeon (Fairey *et al*., 1997; Foster *et al*., 2001a; Foster *et al*., 2001b; Kruse and Scarnecchia, 2002; Feist *et al*., 2005; Greenfield *et al*., 2005). Green sturgeon are believed to experience similar effects. The CHRT identified commercial shipping, desalination plants, disposal of dredged materials, LNG projects, and discharge from industries as potential sources of pollution in coastal marine areas. Structures for alternative energy projects may also release chemicals into the water (McIsaac, 2008). However, in order to link the effects of these activities on water quality to impacts on green sturgeon, more information is needed on contaminant levels within coastal marine areas and their effects on green sturgeon through trophic interactions. Low dissolved oxygen zones and petroleum spills along the coast are also a water quality concern, with potential adverse effects (i.e. impeding safe passage along the migratory corridor) on green sturgeon as described above.

Prey resources: Green sturgeon feed on a variety of benthic invertebrates and fish species in estuaries, including ghost shrimp, mud shrimp, crangonid shrimp, amphipods, isopods, clams, polychaetes, Dungeness crabs, sand lances, and lingcod (Ganssle, 1966; Radtke, 1966; Dumbauld *et al*., 2008). Green sturgeon likely feed on similar species within marine waters. Seasonal migrations of green sturgeon, particularly to overwintering grounds off central California and between Vancouver Island, BC, and southeast Alaska, are likely driven by food resources. Telemetry data indicate potential feeding aggregations along the coast (Lindley and Moser, 2008, unpublished data). Many of the prey resources mentioned above are distributed over broad ranges in near coastal marine habitats along the western coast of North America (http://www.nwrc.usgs.gov/publications/specindex.htm). The CHRT identified commercial shipping activities (particularly petroleum shipping), contaminant spills, disposal of dredged material, and bottom trawling activities as potential threats to prey resources. Commercial shipping activities, particularly petroleum shipping in the event of a petroleum spill, have the potential to negatively effect macrobenthic communities. Numerous studies have shown that total petroleum hydrocarbons are strongly negatively related to macrobenthic species number, abundance and diversity (Boesch and Rabalais, 1990). Additionally, exposure of prey species to petroleum hydrocarbons and other contaminants may result in the bioaccumulation of these contaminants in green sturgeon, resulting in long-lasting effects on the health and survival of green sturgeon. Disposal of dredged material may bury prey resources and alter the macrobenthic community structure in near shore marine environments for many months to years before the natural fauna are re-established (Oliver *et al.*, 1977, Blanchard and Feder, 2003). Disturbance of the benthos from bottom trawling may also affect prey resources, but may have beneficial or adverse effects on green sturgeon foraging, depending on the prey species and characteristics of the bottom habitat (National Research Council 2002).

Based on the available data, the CHRT identified coastal marine areas, from Monterey, CA to Graves Harbor, AK out to the 110 m depth contour, that: 1) meet the definition of critical habitat as defined by the ESA (i.e. it contains at least one PCE with a possible special management concern); 2) contain confirmed Southern DPS fish; and 3) are in need of protection in order to conserve and protect the Southern DPS.

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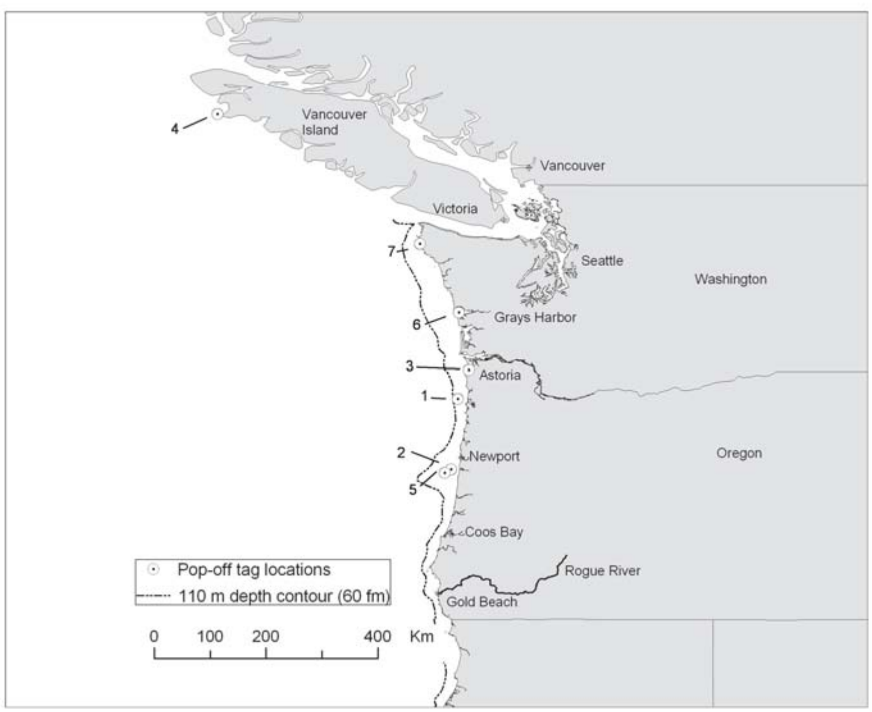


Figure A-1. Map showing the locations of the Rogue River, Oregon, where green sturgeon were tagged with pop-off archival tags (PATs), and the tag recovery sites along the coasts of Oregon, Washington, and British Columbia. The numbers refer to individual specimens; the site for specimen 3 is the point where the PAT was found on the shore after detaching prematurely. From Erickson and Hightower, 2007**.**

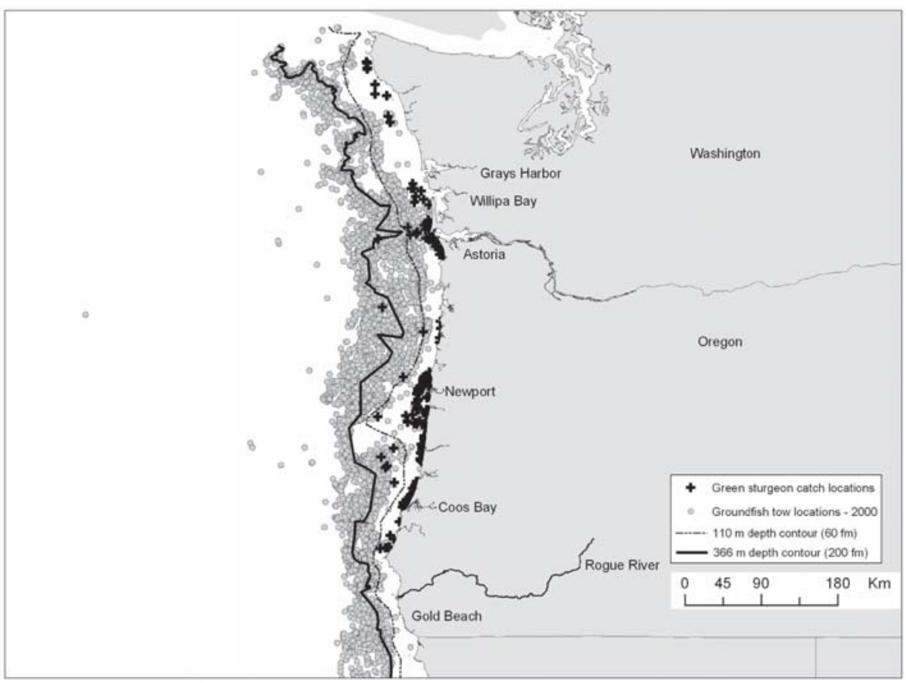


Figure A-2. Map showing the locations of bottom-trawl sets made during 2000 and bottom-trawl sets that caught green sturgeon during 1993–2000 along the Oregon and Washington coasts. The depth contours (110 and 366 m) represent the boundaries of a no-trawl zone (Rockfish Conservation Area) implemented after 2000. From Erickson and Hightower, 2007.

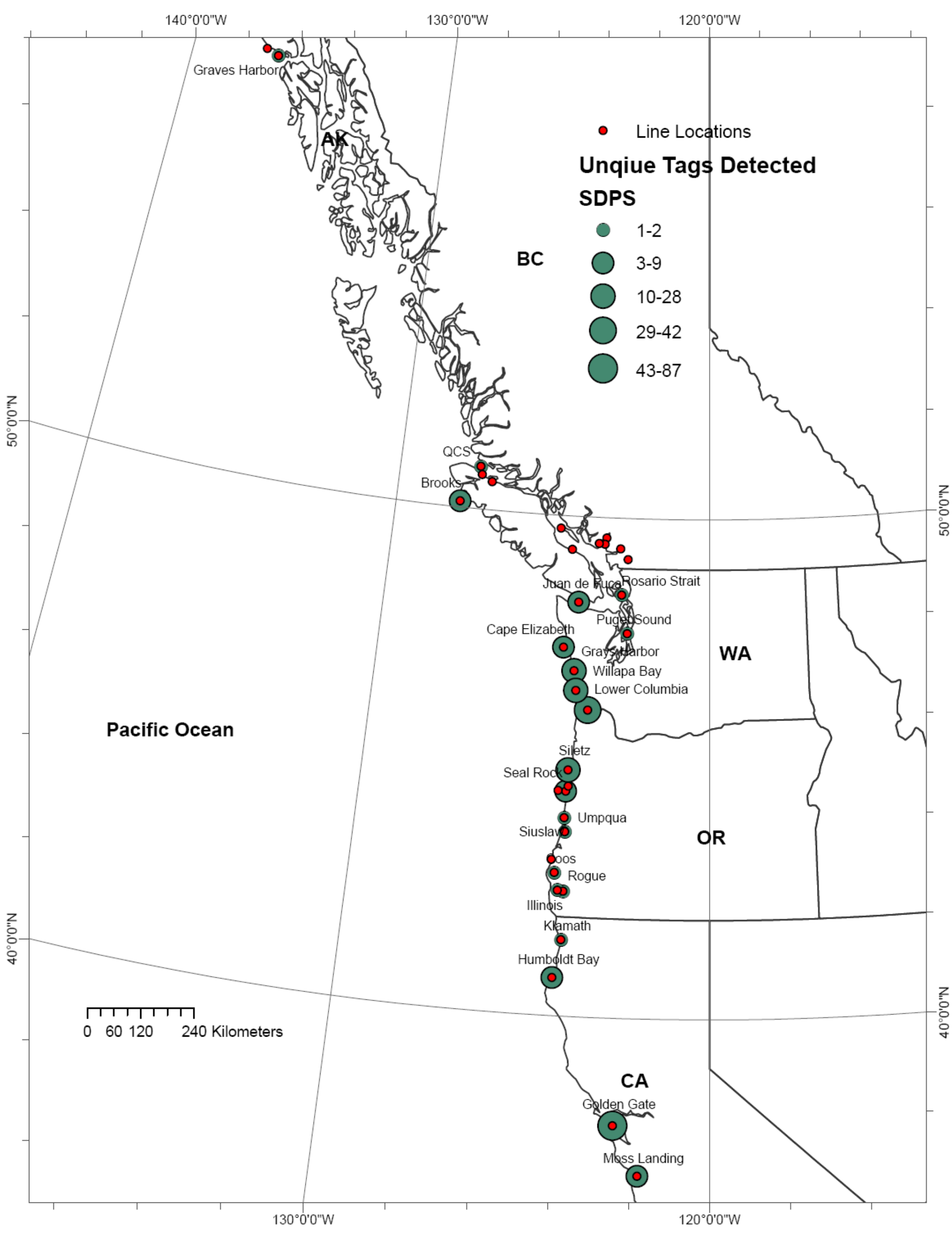
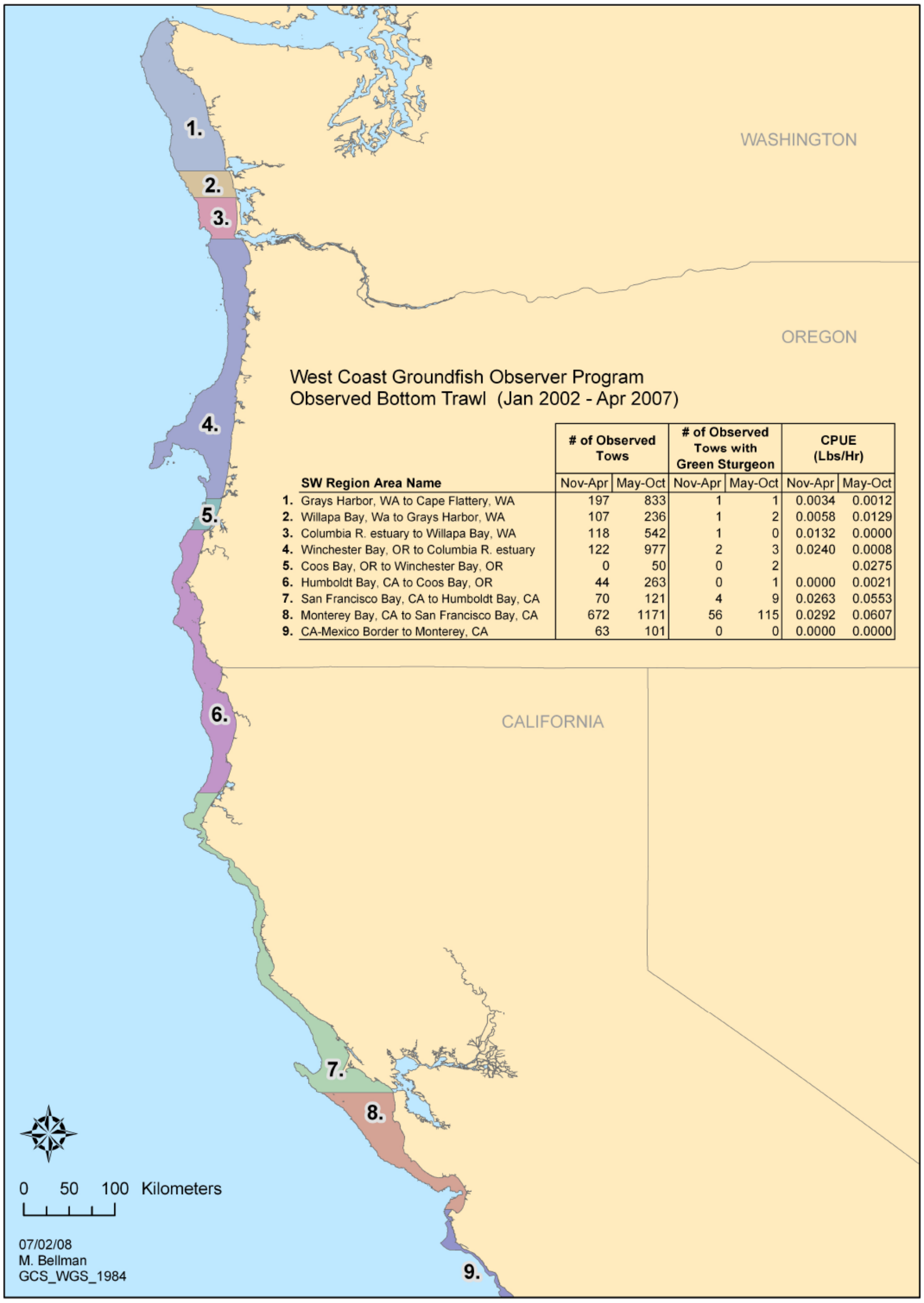


Figure A-3. Unique tag detections (n=161detections) of Southern DPS fish (n=213 total fish tagged) in coastal marine areas (n=115 detections), estuaries and rivers (n=46 detections) along the west coast of North America from 2002-2005. Adapted from Lindley et al., 2008.



	SW Region Area Name	# of Observed Tows		# of Observed Tows with Green Sturgeon		CPUE (Lbs/Hr)	
		Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct
1.	Grays Harbor, WA to Cape Flattery, WA	197	833	1	1	0.0034	0.0012
2.	Willapa Bay, Wa to Grays Harbor, WA	107	236	1	2	0.0058	0.0129
3.	Columbia R. estuary to Willapa Bay, WA	118	542	1	0	0.0132	0.0000
4.	Winchester Bay, OR to Columbia R. estuary	122	977	2	3	0.0240	0.0008
5.	Coos Bay, OR to Winchester Bay, OR	0	50	0	2		0.0275
6.	Humboldt Bay, CA to Coos Bay, OR	44	263	0	1	0.0000	0.0021
7.	San Francisco Bay, CA to Humboldt Bay, CA	70	121	4	9	0.0263	0.0553
8.	Monterey Bay, CA to San Francisco Bay, CA	672	1171	56	115	0.0292	0.0607
9.	CA-Mexico Border to Monterey, CA	63	101	0	0	0.0000	0.0000

Figure A-4. West Coast Groundfish Observer Program bottom trawl data 2002-2007 indicating total number of tows observed, number of observed tows containing green sturgeon, and catch per unit effort (pounds per tow hour) of green sturgeon by marine specific areas (1 through 9 described above) under consideration for proposed critical habitat designation for the Southern DPS (WCGOP, 2008, unpublished green sturgeon bycatch data).