State of California
The Resources Agency
Department of Water Resources

MATRIX OF LIFE HISTORY AND HABITAT REQUIREMENTS FOR FEATHER RIVER FISH SPECIES SP-F15 TASK 1

GREEN STURGEON

Oroville Facilities Relicensing
FERC Project No. 2100

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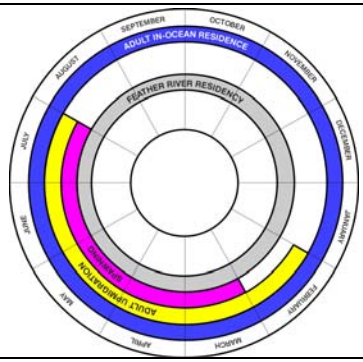
Element	Element Descriptor	General	Feather River Specific
General			
Common name (s)	English name (usually used by fishers and laypeople).	Green sturgeon	
Scientific name (s)	Latin name (referenced in scientific publications).	The scientific name of green sturgeon is *Acipenser medirostris*	
Taxonomy (family)	Common name of the family to which they belong. Also indicate scientific family name.	Green sturgeon belong to the *Acipenseridae* family. Green sturgeon reportedly are modern relics of ancient bony fishes and remain relatively unchanged from their first appearance in the fossil record approximately 200 million years ago. Current knowledge of taxonomy indicates that green sturgeon are in the infraclass Chondrostei with their closest extant relatives being paddlefishes. It is reportedly likely that they form a different taxonomic group than Asian green sturgeon (Environmental Protection Information Center et al. 2001).	
Depiction	Illustration, drawing or photograph.		
Range	Broad geographic distribution, specifying California distribution, as available.	Green sturgeon range from Mexico to southeast Alaska, reportedly the largest range of any sturgeon. Spawning populations of green sturgeon have reportedly been confirmed in the Rogue, Klamath, and Sacramento rivers (Beamesderfer and Webb 2002). The ocean range of green sturgeon reportedly extends from the Bering Sea to Ensenada, Mexico. Green sturgeon are found in estuaries and bays from British Columbia, Canada, to Monterey Bay,	In 1968 anecdotal evidence indicated that tributaries to the Sacramento River such as the Feather River supported spawning populations of green sturgeon. In 1995 anecdotal evidence from angler reports indicated that adult green sturgeon were migrating up the Feather River (Environmental Protection Information Center et al. 2001).

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		California; and in river mouths from the Skeena River, British Columbia, to the Sacramento River, California. The only known green sturgeon spawning populations reportedly are found in Oregon and California (Environmental Protection Information Center et al. 2001). The only known green sturgeon spawning locations reportedly are the Klamath, Sacramento, and Rogue rivers along the west coast of North America; however they reportedly are known to range in near shore waters from Mexico to the Bering Sea (Adams et al. 2002). Spawning has reportedly been confirmed in the upper Klamath and Sacramento rivers by (Fry Jr. 1979), and the spawning range reportedly extends from San Francisco Bay, California (Monaco et al. 1990) to the Skeena River in British Columbia, Canada (Environmental Protection Information Center et al. 2001).	The presence of larval green sturgeon in salmon outmigrant traps has been reported and indicates that the Feather River may support a spawning green sturgeon population (Environmental Protection Information Center et al. 2001). Despite reports of observations of adult green sturgeon in the Feather River, directed efforts reportedly were unable to collect eggs and larvae (Beamesderfer and Webb 2002). Reported angler catches of green sturgeon in the Feather River suggest that a spawning population may exist in the Feather River (DFG 2002).
Native or introduced	If introduced, indicate timing, location, and methods.	Green sturgeon are native to California (Beamesderfer and Webb 2002).	
ESA listing status	Following the categories according to California Code of Regulations and the Federal Register, indicate whether: SE = State-listed Endangered; ST =State-listed Threatened; FE = Federally listed Endangered; FT = Federally-listed Threatened; SCE = State Candidate (Endangered); SCT = State candidate (Threatened); FPE = Federally proposed (Endangered); FPT = Federally proposed (Threatened); FPD = Federally	The Environmental Protection Information Center (EPIC), Center for Biological Diversity (CDB), and WaterKeepers Northern California (WaterKeepers) filed a petition with the National Marine Fisheries Service (NMFS) in June 2001 to list the species as “endangered” or “threatened” (Environmental Protection Information Center et al. 2001). Green sturgeon currently are a candidate species for listing as threatened or endangered under the federal endangered species act (ESA). On January 23, 2003 NOAA Fisheries found that the listing of green sturgeon as threatened or endangered was not warranted (NOAA 2003).	

Element	Element Descriptor	General	Feather River Specific
	proposed (Delisting); the date of listing; or N = not listed.		
Species status	If native, whether: Extinct/ extirpated; Threatened or Endangered; Special concern; Watch list; Stable or increasing. If introduced, whether: Extirpated (failed introduction); highly localized; Localized; Widespread and stable; Widespread and expanding.	Green sturgeon are classified as a species of special concern in California (Moyle 2002). Reportedly, little is known about green sturgeon because of their generally low abundance, limited spawning distribution, and low commercial and sport fishing value compared to white sturgeon (Environmental Protection Information Center et al. 2001).	
Economic or recreational value	Indicate whether target species sought for food or trophy. Whether desirable by recreational fishers, commercial fishers, or both.	Green sturgeon reportedly have low commercial and sport fishing value compared to white sturgeon (Environmental Protection Information Center et al. 2001).	
Warmwater or coldwater	Warmwater if suitable temperature range is similar to basses; coldwater if suitable temperature range is similar to salmonids.	Green sturgeon are a coldwater species (Moyle 2002).	
Pelagic or littoral	Environment: Pelagic - living far from shore; Littoral - living near the shore.	Although reported to disperse widely in the ocean, green sturgeon reportedly also are commonly observed in bays and estuaries (Beamesderfer and Webb 2002).	
Bottom or water column distribution	Environment: bottom (benthic) or along water column.	Green sturgeon reportedly are a demersal (bottom dwelling) fish (Environmental Protection Information Center et al. 2001; NOAA 2002).	
Lentic or lotic	Environment: Lentic - pertaining to stagnant water, or lake-like; Lotic - moving water, or river-like.	Adults reportedly are most often observed in the seawater and mixing zones of bays and estuaries and are occasionally found in the lower stretches of some rivers (Environmental Protection Information Center et al. 2001).	

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Adults			
Life span	Approximate maximum age obtained.	Green sturgeon reportedly live for over 50 years (Beamesderfer and Webb 2002). The life span of green sturgeon reportedly possibly ranges from 60 to 70 years (Moyle 2002). The life span of green sturgeon reportedly is over 40 years (USFWS 1995c).	
Adult length	Indicate: Length at which they first reproduce; average length and maximum length the fish can attain.	Adult green sturgeon reportedly can attain lengths of up to 9 feet (2.7 meters). Males reportedly mature at 15 to 17 years of age and are typically 5 to 6 feet (1.5 to 1.8 meters) in length at maturity. Females mature at 20 to 25 years of age and are typically 6 to 7 feet (1.8 to 2.1 meters) in length at maturity (Beamesderfer and Webb 2002). Green sturgeon reportedly become sexually mature at approximately 15 to 20 years of age and 4.3 to 4.6 feet (1.23 to 1.4 meters) in length (DFG 2001). The maximum size of green sturgeon in the Klamath River reportedly was 7.5 feet (2.3 meters) (DFG 2001). Green sturgeon reportedly grow approximately 2.8 inches (7 centimeters) per year for 15 to 20 years until they reach sexual maturity at 4.3 to 4.6 feet (1.3 to 1.4 meter) in length (USFWS 1995b). Green sturgeon reportedly may reach up to 7 feet (2.1 meters) in length (USFWS 1995c). Adult green sturgeon reportedly may reach 7.5 feet (2.3 m) in length and weigh up to 350 lb (159 kg); however, the average size is approximately 6.5 feet (2 m) and 198 lb (90 kg) (Skinner 1982).	

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Adult weight	Indicate: Weight at which they first reproduce; average weight and maximum weight the fish can attain.	The largest green sturgeon caught in the Klamath river reportedly was 180 pounds (81.6 kilograms), and was estimated to be about 40 years old. Historical anecdotal accounts report green sturgeon catches weighing up to 350 pounds (158.8 kilograms) (DFG 2001). Green sturgeon reportedly may weigh approximately 350 pounds (159 kilograms), and approximately average 198 pounds (90 kilograms) (Environmental Protection Information Center et al. 2001; SWRI 2002). Green sturgeon reportedly may weigh up to 350 pounds (159 kilograms) (USFWS 1995c). Adult green sturgeon reportedly can weigh up to 350 pounds (159 kilograms), but in the San Francisco Bay, most are probably less than approximately 100 pounds (45 kilograms) (USFWS 1995b).	
Physical morphology	General shape of the fish: elongated, fusiform, laterally compressed, etc.	Green sturgeon are elongated in shape (Wang 1986).	
Coloration	Indicate color, and color changes, if any, during reproduction phase.	Green sturgeon are olive green in color, with an olivaceous stripe down each side of their body (Environmental Protection Information Center et al. 2001).	
Other physical adult descriptors	Unique physical features for easy identification.	Green sturgeon have a mostly cartilaginous skeleton. Externally, green sturgeon have a heavy, sandpaper-like skin with rows of scutes (bony plates) along the dorsal, left, and right sides of the body, long, narrow, shovel-like snouts with four barbels underneath the snout, and a toothless mouth with protrusible lips (Environmental Protection Information Center et al. 2001). Green sturgeon are similar in appearance to white sturgeon (with which they co-occur), except that the	

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		barbells are usually closer to the mouth than the tip of the snout. There also are one to two large scutes behind the dorsal fin both, which are lacking on white sturgeon (USFWS 1995b).	
Adult food base	Indicate primary diet components.	Green sturgeon reportedly feed on bottom-dwelling animals, including fish (DFG 2001). Green sturgeon reportedly feed on benthic invertebrates, crustaceans, and fish (SWRI 2002). Within bays and estuaries, green sturgeon reportedly feed on sand lances, callianassid shrimp, anchovies, clams, and snails (SWRI 2002). Green sturgeon reportedly feed on shrimp, crabs, worms, amphipods, isopods, and small, disabled or dead fish (Environmental Protection Information Center et al. 2001).	
Adult feeding habits	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder.	Green sturgeon feed with their ventral protrusible mouths using suction (DFG 2001). Reportedly, green sturgeon are opportunistic carnivores but can withstand long periods of deprivation during spawning migrations (Environmental Protection Information Center et al. 2001; SWRI 2002). Green sturgeon reportedly can be active hunters (Environmental Protection Information Center et al. 2001). Green sturgeon are benthic feeders. In Washington state, green sturgeon reportedly mainly feed on sand lances and callianassid shrimp. In the Columbia River estuary, green sturgeon reportedly feed on anchovies, and potentially also on clams (USFWS 1995b). In streams, adult green sturgeon reportedly feed on	

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		benthic insects, crustaceans and annelids (Adams et al. 2002).	
Adult in-ocean residence time	For anadromous species, age when they migrate to the ocean and duration spent in the ocean before returning to freshwater to spawn.	Most of the adult life of green sturgeon reportedly is spent in the ocean where they migrate long distances between ocean feeding grounds and freshwater spawning grounds. In some cases migrations have been reported to be over 200 miles (321.9 kilometers) long. In the summer and fall, there are large concentrations of adult sturgeon in estuaries (Beamesderfer and Webb 2002). It has been reported that green sturgeon return to freshwater to spawn when they are approximately 20 years old and 4.3 feet (1.3 meters) in length (NOAA 2002). Green sturgeon reportedly move into estuaries and bays to feed and spend most of their adult life in the ocean (Environmental Protection Information Center et al. 2001). Male green sturgeon reportedly spend between 3 and 9 years at sea while females spend between 3 and 13 years at sea (Environmental Protection Information Center et al. 2001). Green sturgeon reportedly spend most of their life in salt water, but spawn in freshwater every 4 to 11 years during the spring and summer months (Pacific States Marine Fisheries Commission 2003). Green sturgeon reportedly spawn every three to five years (Tracy 1990).	
Adult habitat characteristics in-ocean	For anadromous species, description of the ocean habitat utilized: whether along major current systems, gyres, pelagic (beyond continental	Green sturgeon reportedly are mostly seen along inshore waters to depths of approximately 200 feet (60 meters). Adults reside in subtidal zones and are most often observed in seawater and mixing zones of bays and estuaries, where they feed. In estuaries,	

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	shelves) and neritic (above continental shelves) zones, etc.	green sturgeon are reportedly concentrated in deep areas with soft bottoms and move into intertidal areas to feed at high tide (Environmental Protection Information Center et al. 2001). Green sturgeon reportedly live in nearshore oceanic waters, bays, and estuaries (NOAA 2002).	
Adult Upstream Migration (Immigration)			
Range of adult upstream migration timing	Time of year adults migrate upstream. If applicable, indicate for various runs.	Adult green sturgeon migration reportedly begins in February (Beamesderfer and Webb 2002). Adult green sturgeon reportedly begin to enter the Sacramento-San Joaquin Delta and move up the Sacramento River in early spring (DFG 2001). Green sturgeon reportedly migrate upstream from February through late July (DFG 2002). The most extensive upstream migrations of green sturgeon reportedly occur in the Klamath and Trinity rivers of California, where green sturgeon have been documented 93 miles (150 km) upstream (Environmental Protection Information Center et al. 2001). Upstream spawning migrations reportedly occur between late February and late July and spawning is believed to occur from March to July with a peak from mid-April to mid-June (Emmett et al. 1991).	Historical sightings of green sturgeon in the Feather River reportedly have occurred in the spring. A single male was radio tagged at Freeport on March 1991 and was tracked to the mouth of the Feather River a few days later. In the Spring of 1993, 7 adult green sturgeon [5.1 to 6.1 feet (1.5–1.9 meters) in size] were sighted at the Thermalito Afterbay (Wang 1986).
Peak adult upstream migration timing	Time of year most adults migrate upstream. If applicable, indicate for various runs.	Green sturgeon are usually seen in the rivers in fall as an incidental catch of the salmon fishery; it has been assumed that they move into freshwater during the fall and winter to spawn in the spring (Houston 1988).	
Adult upstream migration water temperature tolerance	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	In the Klamath River, the water temperature tolerance of upmigrating adult green sturgeon reportedly probably ranges from 44.4°F to 60.8°F (6.9°C to 16°C). Reportedly, no green sturgeon were found in areas of the river outside this surface water	

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		temperature range (USFWS 1995c).	
Adult upstream migration water temperature preference	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	The migration of the green sturgeon reportedly was tracked in the Tumnin River, Russia during late-May to early-July at water temperatures of 44.9°F to 52.7°F (7.2°C to 11.5°C) (Artyukhin and Andronov 1990).	
Adult Holding (Freshwater Residence)			
Water temperature tolerance for holding adults	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Water temperatures at capture sites in the Rogue River, Oregon reportedly ranged from 59°F to 73.4°F (15°C to 23°C) (Erickson et al. 2002). Green sturgeon reportedly have been captured in the Columbia and Fraser rivers at water temperatures ranging from 32°F to 73.4°F (0°C to 23°C) (Houston 1988).	
Water temperature preference for holding adults	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.		
Water depth range for holding adults	Reported range of observed (minimum and maximum) water depth utilization.	Adult green sturgeon reportedly are usually found in the Sacramento, Rogue, and Shasta/Trinity river systems in deep, off channel areas with little current (Bryant 2003).	
Water depth preference for holding adults	Reported range of most frequently observed water depth utilization.	Green sturgeon reportedly preferred holding sites in the Rogue River that were greater than 16.4 feet (5 meters) deep in low-gradient reaches or off channel coves (Erickson et al. 2002).	
Substrate preference for holding adults	If bottom dwellers, indicate substrate: mud, sand, gravel, boulders, aquatic plant beds, etc. If gravel, indicate range or average size of gravel.	Within estuaries, sturgeon reportedly tend to concentrate in deep areas with soft bottoms. In rivers, adults and juveniles reportedly have been found primarily on clean sand (Environmental Protection Information Center et al. 2001). Adult green sturgeon reportedly are primarily found in marine environments on clean sand substrates (Conservation Management Institute 2003).	
Water velocity	Reported range of observed	Green sturgeon reportedly were most often found in	

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range for holding adults	(minimum and maximum) water velocity utilization.	the Rogue River in areas with little to no current (Erickson et al. 2002).	
Water velocity preference for holding adults	Reported range of most frequently observed water velocity utilization.	Most individuals reportedly left the Rogue River system when flows exceeded approximately 330 ft^3/sec (100 m^3/sec) (Erickson et al. 2002).	
Other habitat characteristics for holding adults	General description of habitat (e.g. turbid or clear waters, lentic or lotic, presence of aquatic plant beds, debris, cover, etc.).	Green sturgeon are reportedly euryhaline and adults generally reside in subtidal areas (Conservation Management Institute 2003).	
Timing range for adult holding	Time of year (earliest-latest) and duration of stay from upstream migration to spawning.	All individuals tagged by Erickson et al. (2002) reportedly emigrated from the Rogue River system during the autumn and winter, when water temperatures dropped below 50°F (10°C) and flows increased.	
Timing peak for adult holding	Time of year when maximum number of adults are present before spawning.	Most adult green sturgeon reportedly were observed residing in the Tumnin River, Russia in late May to June (Artyukhin and Andronov 1990).	
Spawning			
Fecundity	Average or range in the number of eggs females lay in a spawning season.	The number of eggs green sturgeon females lay in a spawning season increases with body size, reportedly ranging from 50,000 to 200,000 eggs per female. The reported rate of fecundity for green sturgeon is less than other species of sturgeon (Beamesderfer and Webb 2002). The reported average number of eggs green sturgeon females lay in a spawning season is 127,500 eggs, and ranges from 51,000 to 224,00 eggs per female (Environmental Protection Information Center et al. 2001). Female green sturgeon reportedly lay 60,000 to 140,000 eggs in a spawning season. This rate of fecundity is lower in green sturgeon than in white sturgeon because green sturgeon are smaller and lay bigger eggs than white sturgeon (DFG 2001; DFG 2002; SWRI 2002; USFWS 1995b).	

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Nest construction	Location and general description of nest -- substrates, aquatic plants, excavations, crevices, habitat types, etc.	Green sturgeon reportedly spawn in deep, turbulent mainstem areas of rivers. Green sturgeon eggs are broadcast over large cobble where they settle into cracks (Beamesderfer and Webb 2002).	
Nest size	Size and average dimensions of the nest.	Green sturgeon reportedly do not build nests; instead, adults broadcast spawn into the water column (Pacific States Marine Fisheries Commission 2003).	
Spawning process	Indicate whether nest builder, broadcast spawner, or other.	Green sturgeon reportedly are broadcast spawners (SWRI 2002; USFWS 1995b).	
Spawning substrate size/characteristics	Range of substrates used during spawning (e.g. mud, sand, gravel, boulders, beds of aquatic plants). Indicate presence of plant/wood debris, crevices at spawning sites. If gravel, indicate range of average size.	Green sturgeon reportedly use substrates ranging from clean sand to bedrock as spawning substrates (Environmental Protection Information Center et al. 2001). Green sturgeon reportedly spawn on substrates consisting primarily of cobble (SWRI 2002). Green sturgeon reportedly prefer to spawn in the lower reaches of large rivers, with swift currents and large cobble (Pacific States Marine Fisheries Commission 2003). Green sturgeon reportedly spawn on substrates ranging from sand to large cobble (Emmett et al. 1991).	
Preferred spawning substrate	Indicate preferred spawning substrate (e.g. mud, sand, gravel, boulders, plant bed, etc).	Green sturgeon reportedly prefer to spawn over large cobble, with crevices in which eggs can become trapped and develop, and over areas with rocky bottoms (Beamesderfer and Webb 2002). Green sturgeon reportedly prefer to spawn in large cobble (Environmental Protection Information Center et al. 2001; SWRI 2002; USFWS 1995b).	
Water temperature tolerance for spawning	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Green sturgeon reportedly can spawn in water temperatures ranging from 46.4°F to 57.2°F (8°C to 14°C) (DFG 2002; Moyle 2002; SWRI 2002).	

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		Green sturgeon reportedly tolerate spawning water temperatures ranging from 50°F to 70°F (10°C to 21.1°C) (DFG 2001). Water temperatures above 68°F (20°C) are reported to be lethal to green sturgeon embryos and water temperatures below 51.8°F (11°C) or above 66.2°F (19°C) are reported to reduce growth (Cech et al. 2000).	
Water temperature preference for spawning	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Green sturgeon reportedly prefer to spawn in water temperatures ranging from 46.4°F to 57.2°F (8°C to 14°C). Green sturgeon reportedly require colder temperatures and clearer waters than white sturgeon (Environmental Protection Information Center et al. 2001; USFWS 1995b). The reported range of optimal water temperatures for green sturgeon spawning is unclear, but spawning success is related to water temperature (Beamesderfer and Webb 2002).	
Water velocity range for spawning	Minimum and maximum speed of water current the spawning fish can tolerate.	Green sturgeon reportedly spawn in deep, fast-water (DFG 2001). Green sturgeon spawning reportedly occurs in deep, fast water (DFG 2001). Green sturgeon eggs are reportedly broadcast spawned and externally fertilized in relatively high water velocities (DFG 2002). Adult green sturgeon reportedly have historically been caught by recreational fisherman in relatively deep, fast-moving water during the spawning season (SWRI 2002).	
Water velocity preference for spawning	Preferred water current (flow velocity) during spawning.	The reported preferred water velocity for green sturgeon spawning is unclear, but spawning success is related to water velocity (Beamesderfer and Webb 2002).	

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		Fast water velocities are reportedly preferred by green sturgeon during spawning (Environmental Protection Information Center et al. 2001).	
Water depth range for spawning	Reported range of observed (minimum and maximum) water depth utilization.	Green sturgeon reportedly spawn in holes greater than 9 feet (2.7 meters) in depth (Environmental Protection Information Center et al. 2001).	
Water depth preference for spawning	Reported range of most frequently observed water depth utilization.	Green sturgeon reportedly likely spawn at depths greater than 9.8 feet (3 meters) (Environmental Protection Information Center et al. 2001). Green sturgeon reportedly spawn at depths greater than 9 feet (2.7 meters) in relatively high velocity pool habitats (SWRI 2002; USFWS 1995b).	
Range for spawning timing	Earliest and latest time of season or year in which spawning occurs.	Green sturgeon reportedly spawn from March through July (Beamesderfer and Webb 2002; SWRI 2002). In the Sacramento River, green sturgeon reportedly spawn from March through June; in the Klamath River, spawning reportedly occurs from March through July (DFG 2001). Green sturgeon reportedly move to estuaries and the lower reaches of rivers between late winter and early summer, and ascend rivers to spawn in the spring and early summer. Adult green sturgeon reportedly leave the rivers soon after spawning (Environmental Protection Information Center et al. 2001). Green sturgeon reportedly spawn from March through July (DFG 2002; USFWS 1995b).	
Peak spawning timing	Time of year most fish start to spawn.	Most green sturgeon reportedly spawn between April and June (Beamesderfer and Webb 2002). Most green sturgeon reportedly spawn between mid-April and mid-June (SWRI 2002; DFG 2002; Environmental Protection Information Center et al. 2001; USFWS 1995b).	

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Spawning frequency (iteroparous/semelparous)	Semelparous - producing all offspring at one time, such as in most salmon. Usually these fish die after reproduction. Iteroparous - producing offspring in successive, e.g., annual or seasonal batches, as is the case in most fishes.	Green sturgeon reportedly produce offspring in successive batches (iteroparous), although subsequent spawning may be delayed from 2 to 5 years (SWRI 2002). Green sturgeon spawning events reportedly may occur every 4 to 11 years (Grimaldo and Zeug 2001).	
Incubation/Early Development			
Egg characteristics	Shape, size, color, in clusters or individuals, stickiness, and other physical attributes.	Green sturgeon eggs are reportedly considerably larger than other sturgeon eggs (Beamesderfer and Webb 2002), and have a thin, chorionic layer (USFWS 1995b). Green sturgeon eggs are reportedly slightly adhesive (DFG 2001). Green sturgeon eggs reportedly adhere to each other and to river substrates (SWRI 2002). Green sturgeon egg size reportedly is approximately 0.15 inches (0.4 centimeters) (DFG 2002; USFWS 1995b).	
Water temperature tolerance for incubation	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Water temperatures above 68°F (20°C) are reportedly lethal to green sturgeon embryos (Beamesderfer and Webb 2002). Green sturgeon embryo mortality was reported at water temperatures above 68°F (20°C), and reduced growth was reported at water temperatures below 51.8°F (11°C) and above 66.2°F (19°C) (Cech et al. 2000).	
Water temperature preference for incubation	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	During the incubation of green sturgeon eggs in Chalikov apparatuses in the Tumnin River, the temperature of the surface water reportedly rose from 49.3°F to 58.5°F (9.6°C to 14.7°C), and the daily water temperature variation was 34.7°F to 35.6°F (1.5°C to 2.0°C) (Artyukhin and Andronov 1990).	

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Time required for incubation	Time duration from fertilization to hatching. Note: Indicate at which temperature range. Incubation time is temperature-dependent.	The time duration from fertilization to hatching for green sturgeon is reportedly typically 4 to 12 days (DFG 2001). The incubation period for green sturgeon eggs is reportedly 196 hours (8.2 days) at 54.9°F (12.7°C) (DFG 2002; Environmental Protection Information Center et al. 2001; SWRI 2002; USFWS 1995b).	
Size of newly hatched larvae	Average size of newly hatched larvae.	The average size of newly hatched green sturgeon larvae reportedly ranges from 0.71 to 0.74 inches (1.8 to 1.9 centimeters) (DFG 2002; Environmental Protection Information Center et al. 2001; SWRI 2002; USFWS 1995b).	
Time newly hatched larvae remain in gravel	Time of year of hatching, and duration between hatching and emergence from gravel.	In the Malkinskiy salmon hatchery, green sturgeon larvae reportedly began to make “spurts” two days after hatching, but their movements were neither very strong nor prolonged (Artyukhin and Andronov 1990).	
Other characteristics of larvae	Alevin -- early life history phase just after hatching (larva) when yolk-sac still present.	Green sturgeon larvae reportedly do not have a pelagic dispersal stage (Beamesderfer and Webb 2002). Green sturgeon larvae reportedly stay close to the bottom and rear in rivers upstream of estuaries. Green sturgeon larvae reportedly do not move up the water column in order to avoid being transported downstream (DFG 2001). Green sturgeon larvae reportedly primarily rely on their yolk sacs for food until first exogenous feeding, which occurs around 10-days post hatch (Cech et al. 2000).	
Timing range for emergence	Time of year (earliest-latest) hatchlings (larvae and alevins) leave or emerge from the nesting/hatching (gravel) sites.	In central San Francisco Bay green sturgeon larvae are found from February through June in the tidal fresh zone (Environmental Protection Information Center et al. 2001).	
Timing peak for emergence	Time of year most hatchlings emerge.	Green sturgeon larvae reportedly began to display nocturnal swim-up behavior at 6 days post hatch (Deng et al. 2002).	

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Size at emergence from gravel	Average size of hatchlings at time of emergence.	The smallest of the fish identified as green sturgeon reportedly measured 7.9 to 8.7 in FL (20 to 22 cm) and were captured by gill net and trawl during 1963-1964 by Radtke (1966) (Wang 1986).	
Juvenile Rearing (In Freshwater)			
General rearing habitat and strategies	General description of freshwater environment and rearing behavior.	Unfortunately, rearing habitats of green sturgeon are reportedly not known at the present time (Deng et al. 2002). The continental shelf as well as most coastal bays and estuaries throughout the Pacific Northwest appear to serve as habitat for juvenile green sturgeon (Environmental Protection Information Center et al. 2001).	Juvenile green sturgeon have reportedly been captured in screw traps in the Feather River downstream of its confluence with the Yuba River (USFWS 1995a).
Water temperature tolerance for juvenile rearing	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	All tagged green sturgeon in the Rogue River reportedly emigrated from freshwater during fall and winter when water temperatures fell below 50°F (10°C) (NOAA 2003).	
Water temperature preference for juvenile rearing	Range of suitable, preferred, or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.		
Water velocity ranges for rearing juveniles	Reported range of observed (minimum and maximum) water velocity utilization.		
Water velocities preferred by rearing juveniles	Reported range of most frequently observed water velocity utilization.	Juvenile green sturgeon have reportedly been captured by seining within off-channels and slow-water habitats in estuaries (Nakamoto et al. 1995).	
Water depth range for juvenile rearing	Reported range of observed (minimum and maximum) water depth utilization.	Juvenile green sturgeon reportedly occur in shallow water (Radtke 1966) and probably move to deeper more saline areas as they grow (Environmental Protection Information Center et al. 2001). Juvenile green sturgeon are reportedly found in demersal (near bottom) areas (Sempier 2003).	
Water depth	Reported range of most	Juvenile green sturgeon are reportedly typically found	

Element	Element Descriptor	General	Feather River Specific
preference for juvenile rearing	frequently observed water depth utilization.	in shallow water, preferring deeper and more saline waters where they reportedly experience increased growth (Radtke 1966).	
Cover preferences for rearing juveniles	Type of cover for protection from predators used by rearing juveniles (e.g. crevices, submerged aquatic vegetation, overhanging vegetation, substrate cover, undercover bank, small woody debris, large woody debris).		
Food base of juveniles	Indicate primary diet components. Also indicate the diet changes, if any, as growth occurs.	The primary diet components for juvenile green sturgeon reportedly are small crustaceans, such as amphipods and opossum shrimp. As juvenile green sturgeon develop, they reportedly eat a wider variety of benthic invertebrates, including clams, crabs, and shrimp (DFG 2001). Within bays and estuaries, juvenile green sturgeon reportedly feed on mysid and opossum shrimps, annelid worms, isopods, crabs, and demersal fish. In streams, juvenile green sturgeon reportedly feed on insects, crustaceans, and annelids (DFG 2002; SWRI 2002). Juvenile green sturgeon reportedly feed on shrimps and amphipods, small fish, and possibly mollusks (Beamesderfer and Webb 2002). Juvenile green sturgeon in the Sacramento-San Joaquin Delta reportedly feed on opossum shrimp and amphipods (USFWS 1995b). In streams, juvenile and adult green sturgeon reportedly feed on benthic insects, crustaceans and annelids (Adams et al. 2002).	
Feeding habits of rearing juveniles	Indicate whether plankton eater, algae eater, bottom	Juvenile green sturgeon are opportunistic carnivores and are reportedly able to withstand long periods of	

Element	Element Descriptor	General	Feather River Specific
	feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder. Also indicate change of feeding habits growth occurs.	food deprivation during times of limited food availability (SWRI 2002). Juvenile green sturgeon are benthic feeders (Beamesderfer and Webb 2002).	
Predation of juveniles	Indicate which species prey on juveniles.	Juvenile and adult green sturgeon reportedly have few natural predations, other than humans and large marine mammals (SWRI 2002).	
Timing range for juvenile rearing	Range of time of year (months) during which rearing occurs.	Juvenile green sturgeon reportedly migrate out to sea before they are two years old and primarily during the summer and fall months (Conservation Management Institute 2003). Juvenile green sturgeon reportedly migrate to the ocean by their second year (Love 1996). Juvenile green sturgeon are reportedly taken in traps at the Red Bluff Diversion Dam (RBDD) and the Glenn Colusa Irrigation District's (GCID) facility in Hamilton City, primarily in the months of May through August (NOAA 2003). Juvenile green sturgeon have reportedly been taken in beach seines in the Rogue River estuary from April until the end of November (Farr et al. 2001).	
Timing peak for juvenile rearing	Time of year (months) during which most rearing occurs.	Within the central San Francisco Bay, juvenile green sturgeon are reportedly found from April through November in the seawater mixing and tidal fresh zones (Environmental Protection Information Center et al. 2001). Peak counts of juvenile green sturgeon at RBDD and the GCID facility in Hamilton City reportedly occur in the months of June and July (NOAA 2003).	
Juvenile Emigration			
Time spent in fresh water prior to	Duration (in years and/or months) from emergence to	Juvenile green sturgeon reportedly spend between 1 and 4 years in freshwater; leaving when they reach 1	

Element	Element Descriptor	General	Feather River Specific
emigrating	emigration to the ocean.	to 2.5 feet (0.3 to 0.7 meters) in length (Beamesderfer and Webb 2002; Environmental Protection Information Center et al. 2001). During their early lifestage, green sturgeon reportedly stay in freshwater for up to 2 years (Moyle 2002; USFWS 1995b). Juvenile green sturgeon reportedly spend between 1 and 4 years in fresh water (DFG 2001). Juvenile green sturgeon reportedly inhabit estuaries for 4 to 6 years before migrating to the ocean (Environmental Protection Information Center et al. 2001). Young-of-the-year (YOY) green sturgeon reportedly may rear up to 2 years in the river before migrating back to the estuary or ocean (Grimaldo and Zeug 2001). Juvenile green sturgeon reportedly migrate out to sea before 2 years of age (DFG 2002). Juvenile green sturgeon reportedly inhabit the estuary until they are 4 to 6 years old (USFWS 1995c). Juvenile green sturgeon reportedly spend one to three years in freshwater prior to migrating to the ocean (Nakamoto et al. 1995).	
Water temperature tolerances during emigration	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	All tagged individuals in the Rogue River reportedly emigrated from freshwater during fall and winter when water temperatures fell below 50°F (10°C) (NOAA 2003).	
Water temperature preferences during emigration	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature,		

Element	Element Descriptor	General	Feather River Specific
	observational, or experimental derivation.		
Emigration timing range	Time of year juveniles commence emigration and duration of emigration	Within the Klamath River, juvenile green sturgeon emigration reportedly occurs during the summer and fall months (SWRI 2002). Within the Klamath River, juvenile green sturgeon emigration reportedly occurs from late May through July (Environmental Protection Information Center et al. 2001). Within the Trinity River, juvenile green sturgeon emigration reportedly occurs from early June through September (Environmental Protection Information Center et al. 2001).	
Emigration timing peak	Time of year most juveniles are emigrating.	Within the Klamath River, juvenile green sturgeon emigration reportedly peaks in September (SWRI 2002).	
Size range of juveniles during emigration	Minimum and maximum sizes (inches or mm) of emigrating juveniles. Indicate average size.	Within the Klamath River, juvenile green sturgeon reportedly range from 11.8 to 27.6 inches (30 to 70 centimeters) during emigration (Environmental Protection Information Center et al. 2001; USFWS 1995b).	
Factors associated with emigration	Pulse flows, water temperature changes, turbidity levels, photoperiod, etc.	Diel movements of green sturgeon are reportedly probably related to water temperature and food requirements (Houston 1988). Flow and water temperature reportedly correlated with green sturgeon emigration in the Rogue River (Grimaldo and Zeug 2001).	
Other Potential Factors			
DO	Levels of dissolved oxygen in water expressed in mg/l tolerated by fish.		
pH	Alkalinity/acidity of water (expressed in pH) that fish can tolerate.		
Turbidity	Indicate turbidity or state of	Silt reportedly prevents green sturgeon eggs from	

Element	Element Descriptor	General	Feather River Specific
	water (e.g., clear water or presence of siltation or organic/inorganic matter in water) that fish can tolerate.	adhering to one another, and sand and silt may suffocate the eggs (Environmental Protection Information Center et al. 2001).	
Factors contributing to mortality	Indicate causes of mortality (e.g. fishing/angling mortality, drastic habitat alterations, unfavorable climatic changes, etc).	Predation of green sturgeon is reportedly less than for white sturgeon because green sturgeon have lines of sharp, bony scutes along their bodies, making them less desirable prey (DFG 2001). Opening of the RBDD gates during the green sturgeon spawning period reportedly has provided access to additional spawning areas upstream of Red Bluff (DFG 2001). Green sturgeon are reportedly extremely vulnerable to overharvest and habitat degradation (NOAA 2002). An 88 percent decline in green sturgeon habitat has been reported (Musick et al. 2000), although this has been disputed (Beamesderfer and Webb 2002). Green sturgeon are reportedly susceptible to bioaccumulation of toxic chemicals and to diseases from bacteria, protozoans, fungi, adenovirus, and white sturgeon iridovirus (SWRI 2002). Likely factors negatively affecting green sturgeon abundance that have been reported are: (1) fisheries; (2) modification of spawning habitat; (3) entrainment; and (4) toxic substances (DFG 2002).	A number of presumed green sturgeon spawning populations have apparently been lost in the last 25 to 30 years in California (e.g., South Fork Trinity River, Eel River), and the only known spawning populations are in the Sacramento, Feather, Klamath, and Rogue Rivers, all of which have flow regimes affected by water projects. It is highly probable that these are now the only green sturgeon spawning populations in North America (USFWS 1995b).
General passage considerations (upstream and downstream)	Indicate issues associated with fish passage (e.g. burst speed, max speed, handling stress, survival rates, stressors, body type, etc).	Fish performance characteristics utilized in passage assessments typically include burst speed, sustained speed, and leaping curves. Unfortunately, none of these specific fish performance metrics reportedly are currently available to quantify green sturgeon swimming performance (Mills et al. 2003).	

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