

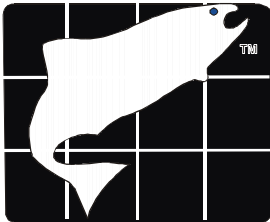
**HISTORICAL AND CURRENT INFORMATION ON GREEN
STURGEON OCCURRENCE IN THE SACRAMENTO AND SAN
JOAQUIN RIVERS AND TRIBUTARIES**

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SUMMARY

A key question in the listing consideration for green sturgeon under the U.S. Endangered Species Act has been whether lost spawning habitats together constitute a major geographical area in which the sturgeon was once viable, but is no longer. Historical and current distribution in Sacramento River, San Joaquin River, and tributaries was a source of particular confusion and speculation. This report examines the historical and current information on the occurrence of green sturgeon in freshwater portions of the Sacramento-San Joaquin system upstream from the Delta. Information included: 1) reviews of the scientific literature, 2) updates on sturgeon assessment projects underway since the 2002 status review, 3) surveys of other fish sampling activities with a potential to capture green sturgeon, 4) historical records, 5) interviews of local fishing experts, and 6) snorkel surveys we conducted of potential sturgeon habitat in the Feather, Yuba, and American rivers.

No evidence was found to indicate that green sturgeon were historically present, are currently present, or were historically present and have been extirpated from the San Joaquin River upstream from the Delta. Historical information was inadequate to determine if green sturgeon were absent, rare, common, or abundant prior to development within the San Joaquin Basin. Current information is inadequate to conclude that green sturgeon no longer occur in the system. Every documented observation of green sturgeon juveniles or unidentified sturgeon larvae in the San Joaquin River has occurred in the Delta. Green sturgeon observed in the Delta could easily, and most likely, have originated from the Sacramento rather than the San Joaquin River. Anecdotal information indicates that small numbers of adult white sturgeon occur in the San Joaquin mainstem upstream from the Delta. Spawning by white sturgeon is suspected to occur in wet, high water years but has never been confirmed. Catches of two unidentified juvenile sturgeon in the Mokelumne River at Woodbridge (RM 39) in 2003 could be the first documentation of sturgeon spawning in a San Joaquin tributary.

Historical and recent information confirms that both green and white sturgeon occasionally range into the Feather, Yuba, and Bear rivers but numbers are low. Intensive sampling in recent years found no evidence of spawning and there is no data that spawning occurs now or occurred in the historical time frame. Several references noted potential natural and man-made barriers in the Feather River to upstream movements during low flow years and speculated that significant movement of green or white sturgeon into the Feather River would be limited to wet, high water years. Because of a lack of historical information on presence or absence of green sturgeon spawning in the Feather River, it remains unclear whether suitable spawning habitat is available or has ever been available, development and water use may have made conditions unsuitable for spawning during most years, or if conditions were always marginal for green sturgeon.

Spawning migrations and spawning by green sturgeon in the upper Sacramento River mainstem have been well documented over the last 15 years and additional studies of adult spawning migrations are ongoing. Spawning migrations and areas were undetected until relatively recently. White sturgeon also migrate into and spawn in the mainstem Sacramento River with spawning apparently concentrated lower in the system than for green sturgeon. White and green sturgeon juveniles, subadults, and adults are widely distributed in the Sacramento-San Joaquin Delta and estuary areas including San Pablo Bay. No sightings of white or green sturgeon have been reported in Sacramento River tributaries downstream from Shasta Dam other than the Feather River system.



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INTRODUCTION

The National Marine Fisheries Service (NOAA Fisheries) found on January 29, 2003 that neither the Northern nor the Southern Distinct Population Segment of the North American green sturgeon warranted listing as an endangered or threatened species (68 FR 4433). However, the Environmental Protection Information Center, Center for Biological Diversity, and Oregon Natural Resources Council sued in April 2003, claiming NOAA Fisheries' decision was arbitrary. On March 2, 2004, the U.S. District Court determined that NOAA Fisheries "arbitrarily and capriciously" failed to consider "whether lost spawning habitats together constitute a major geographical area in which the sturgeon once was viable, but is no longer." The Court highlighted the NOAA Fisheries Biological Review Team's (BRT) conclusion that green sturgeon no longer spawn in several river systems including the San Joaquin, the Eel, the South Fork Trinity, and the Umpqua rivers. The Court concluded that "this matter must be remanded for further analysis and decision of the issue of whether the green sturgeon are endangered or threatened in a significant portion of its range." NOAA Fisheries subsequently issued a request for additional information including documentation of the current geographic extent and magnitude of spawning.

Historical and current distribution in Sacramento River tributaries and San Joaquin River was a source of particular confusion and speculation. Green sturgeon are widely reported throughout the Delta¹ but their distribution in other freshwater portions of the system is unclear. The BRT noted that "green sturgeon reportedly spawn in the Feather River, but this has not been substantiated" (Adams et al. 2002). Reports of sturgeon in the Feather River are anecdotal and it is unclear whether green sturgeon do indeed spawn in the Feather River or if Sacramento River fish occasionally range into the Feather for spawning or foraging purposes. The BRT also observed, "there is no documentation of green sturgeon spawning in the San Joaquin River, but there probably was spawning before construction of large-scale hydropower and irrigation development" (Adams et al. 2002). However, no evidence was presented for assumed spawning in the San Joaquin system. Moyle et al. (1992) stated "some spawning may also take place (or once did) in the lower San Joaquin River, as young green sturgeon have been taken at Santa Clara Shoal, Brannan Island State Recreational Area and a single specimen from Old River is in the CAS (California Academy of Sciences) collection." However, these south Delta observations could represent Sacramento-origin fish.

This report reexamines the historical and current information on the occurrence of green sturgeon in the Sacramento and San Joaquin rivers and their tributaries. This examination included a review of specific references identified in the initial NOAA review of green sturgeon status and additional information obtained subsequent to that review. Additional information included: 1) reviews of the scientific literature, 2) updates on sturgeon assessment projects underway since the 2002 status review, 3) surveys of other fish sampling activities with a potential to capture green sturgeon, 4) exploration of historical records, 5) interviews of local fishing experts, and 6) snorkel surveys we conducted of potential sturgeon habitat in the Feather, Yuba, and American rivers. The focus of this work was on freshwater areas upstream of the Sacramento-San Joaquin Delta.

¹ The delta is generally defined by the Fremont Weir on the Sacramento River just upstream of Verona and the head of Old River on the San Joaquin just south of Stockton.

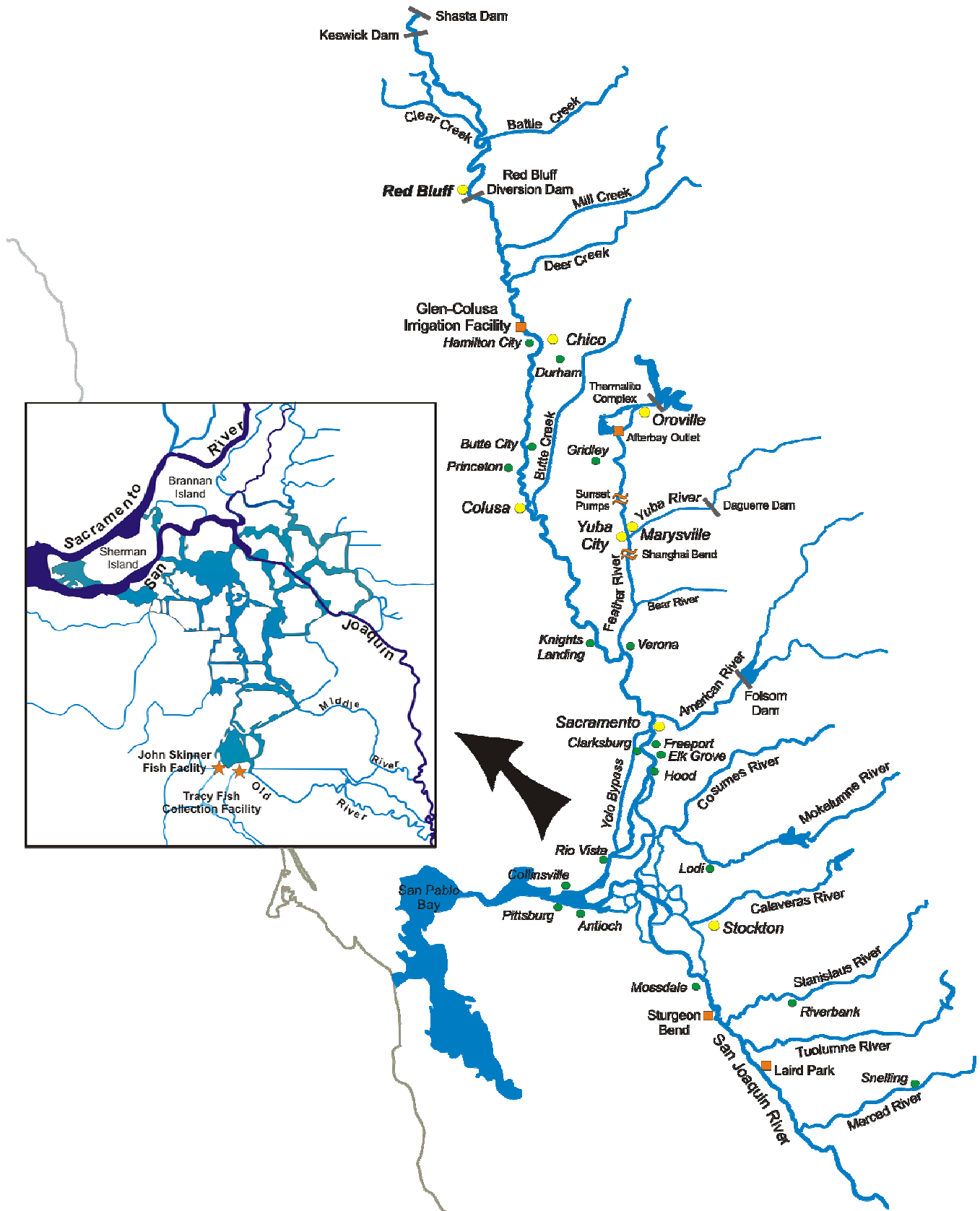


Figure 1. Map of Sacramento and San Joaquin Rivers.



INFORMATION SOURCES

Scientific Literature

An extensive review of the available scientific literature was conducted by NOAA Fisheries Biological Review Team (BRT) as part of the initial listing petition evaluation and this information is contained in the administrative record for the January 29, 2003, 12-month finding. We reviewed documents in the record for specific references to occurrence of green sturgeon in freshwater portions of the Sacramento and San Joaquin river systems. We also conducted an extended search for additional historical material from the University of California at Davis (UCD) library.

The BRT's review file which was provided by Craig Wingert of NOAA Fisheries, consisted of documents ranging from e-mail communications to biological reports, with the most relevant information located within documents listed as primary sources of information in the BRT's status review (Adams et al. 2002).

Additional information in the UCD library was investigated using "forward searching" through the Web of Science search engine. This method of searching identifies papers that cite a specific resource within its text subsequent to publication of the original reference. This approach potentially identifies scientific references to green sturgeon, even though the report's title may not focus directly on green sturgeon. Although several citations were found, they were already part of our existing files and little new information was identified. This result highlighted the comprehensive coverage of the conventional scientific literature by the original NOAA status review.

Recent Sturgeon Projects

Since the 2002 status review, a variety of research and monitoring activities have developed new information on green sturgeon that was unavailable during the initial listing considerations. We identified, reviewed and summarized these monitoring efforts based on project proposals, progress reports, and phone interviews with project implementers.

Five projects involving green sturgeon have been completed or are in progress in the Sacramento and San Joaquin systems. UCD is conducting a multiyear green sturgeon biological assessment that includes Feather River juvenile sampling and adult telemetry in the Sacramento. The California Department of Water Resources (CDWR) conducted a sturgeon assessment in the Feather River as part of the FERC relicensing process. The U.S. Fish and Wildlife Service (USFWS) investigated green sturgeon spawning with CALFED funding. The Glenn-Colusa Irrigation District (GCID) is conducting a fish passage improvement project that includes green sturgeon. Finally, the California Department of Fish and Game (CDFG) conducts a periodic sturgeon sampling inventory in San Pablo Bay.

Green Sturgeon Biological Assessment - UC Davis

A biological assessment of green sturgeon has been underway for the past several years with CALFED-Bay Delta funding (Cech et al. 1998, 1999, 2000, 2001). The project involves the UCD, CDFG, San Francisco State University (SFSU), USFWS, Yurok Tribe, and Hoopa Tribe. The principle investigator is Joseph J. Cech, Jr., Professor, UCD, while co-principal investigators include or have included: Serge I. Doroshov, Gary P. Moberg (deceased), and A. Pete Klimley, Professors, and Bernard P. May, Associate Researcher, UCD; Raymond G. Schaffter, Fishery



Biologist, and David M. Kohlhorst, Senior Fishery Biologist, Bay-Delta and Special Water Projects Division, CDFG; and Carlos E. Crocker, Assistant Professor, SFSU.

This biological assessment is a multi-phase, multi-year project investigating several green sturgeon biological characteristics. Project goals were to: 1) determine baseline information regarding the species' biological requirements in the Sacramento-San Joaquin watershed, 2) evaluate the feasibility of green sturgeon culture for future mitigation considerations, 3) address key areas of scientific uncertainty, including subadults' and adults' movements, and 4) develop a conceptual model for management of this species in the lower Sacramento-San Joaquin watershed. This research project is ongoing and final results are pending. Key activities and findings to date include:

Occurrence of spawning in the Feather River. Surveys for green sturgeon larvae and eggs in the Feather River were conducted using substrate nets, conical drift nets, and a screw trap during 2000 and 2001 (Schaffter and Kohlhorst 2002). No evidence of sturgeon spawning in the Feather River between Boyd's Pump (rkm 37.0) and the Thermalito Afterbay Outlet (rkm 94.9) was found since no sturgeon were captured. It was unclear whether no larvae or eggs were observed because no sturgeon were present; sampling was ineffective (artificial substrates may not effectively collect green sturgeon eggs which are poorly adhesive and artificial substrates in several areas were vandalized); or survival was low in late spring when water temperatures rise below the Thermalito Afterbay. Drought low flows during study years (4,000 cfs) may have prevented sturgeon migration into the Feather River (Schaffter and Kohlhorst 2002). Sturgeon passage was thought to be blocked at flows less than 10,000-20,000 cfs by a natural clay sill barrier near Shanghai Bend and a diversion dam upstream from Marysville. Elevated temperatures during low flow years may also exceed ranges preferred by spawning sturgeon (Schaffter and Kohlhorst 2002).

Freshwater distribution and movements. Twenty adult green sturgeon were tagged with both sonic and radio transmitters in San Pablo Bay during 2001 and 2002 by the CDFG. Freshwater migrations are being monitored by UCD at a series of 40 monitors that are being deployed at the mouth of tributaries and in the mainstream along the length of the Sacramento River (Pete Klimley UCD, personal communication 2004). Monitoring stations are concentrated at the Red Bluff Diversion Dam, but stretch up to Redding. Results are not yet published but this work may allow researchers to identify mainstem spawning grounds and to help clarify some tributary use. The UCD tracking team also exchanged acoustic monitoring frequency and tag numbers with researchers in Washington in case Sacramento-San Joaquin Delta green sturgeon were detected during ocean migrations (John Kelly UCD, personal communication 2004).

Genetic stock structure. Microsatellite DNA was analyzed from green sturgeon collected from the San Pablo Bay (n = 46), Sacramento River (n = 8), Klamath River (n = 66), Rogue River (n = 34), and the Columbia River Estuary (n = 32) (Israel et al. In press). Variation in six loci showed significant differentiation among green sturgeon from different areas. Differences in genotype frequencies were highly significant between collections from the Columbia River and San Pablo Bay in comparison to populations from the Klamath and Rogue rivers. Klamath and Rogue samples were not distinguished from each other. The analysis does not support the hypothesis that the San Pablo Bay and Columbia River collections are derived from the Klamath and Rogue river populations (Israel et al. In press). Columbia River samples appear to represent a mixed stock that is partially but not solely derived from the same population as San Pablo Bay. Data also suggest that not all spawning populations have been identified (Israel et al. In press).



Physiology. Fourteen subadult green sturgeon (52 -134 cm) were collected from San Pablo Bay and eight were sacrificed to evaluate sexual development. Adults were also sampled from the Klamath River. Results indicate that green sturgeon exhibit late sexual maturity, low fecundity, large and poorly adhesive eggs, and are uniquely different in reproductive strategy when compared to white sturgeon (Cech et al. 2000). Age-0 and age-1 green sturgeon spawned from wild Klamath River broodstock and reared at UCD were used to test the effects of temperature on food consumption, growth, and food conversion rate; metabolic rate and activity; and thermal preference. All tested parameters were positively correlated with temperature. Temperature preferences varied with acclimation temperature: fish acclimated at 24°C preferring 20.4°C and fish acclimated at 11°C and 19°C preferring 15°C (Cech et al. 2000). Lethal temperatures for embryos (20-23° C) are similar to white sturgeon. Sac-fry were subject to various stress response tests in a UCD laboratory and cortisol levels were measured. Initial results suggest that fry are able to respond to stress as early as 8 days post-hatch, exhibit an increased stress response at night, and exhibit a longer post-stress recovery period under cooler water temperatures (Cech et al. 2000).

Feather River Sturgeon Assessment - CDWR

The CDWR sampled for sturgeon in the Feather River during 2002 and 2003 under Task 3A of Oroville Facilities Relicensing Study Plan F3.2: *Evaluation of Project Effects on Non-salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam* (CDWR 2002). Studies included evaluations of sturgeon distribution, spawning locations and timing, habitat usage, residence time, and outmigration patterns in the lower Feather River and the degree to which migration impediments may contribute to the relatively low number and inconsistent observations of sturgeon in the Feather River (Seesholtz 2003; Niggemyer and Duster 2003a, 2003b). No additional sampling effort is planned at this time, but is contingent upon review from FERC.

Egg and Larval Sampling. No egg or larval green sturgeon were collected during extensive sampling with artificial substrates and drift nets. In 2002, sturgeon egg and larval surveys were conducted during July and August as a trial run prior to the targeted 2003 spawning season. These surveys were conducted in the Low Flow Channel (LFC) at Robinson Riffle, RM 62; Steep Riffle and Pool, RM 61; Eye Riffle and Pool, RM 60; and the Fish Barrier Dam. In 2003, larval sampling was conducted three times a week at night, February 24 through August 21 using a surface and benthic conical drift net. Sampling occurred in the LFC at Eye Pool; in the High Flow Channel (HFC) at Big Hole Islands approximately one mile below the Thermalito Afterbay Outlet; and in the HFC downstream of the natural barrier at Shanghai Bend. Artificial substrates were placed in 2003 in the HFC above Big Hole Islands boat ramp (RM 58.5) and from Shanghai Bend to Boyd's Pump (RM 25-23) from March 17 through June 26, 2003. According to Seesholtz (2003), observed temperature ranges of 48-68°F were within the thermal tolerances of these fish.

Adult Sampling. No green sturgeon were observed or collected in 2002 or 2003 in investigations with scuba surveys and angling. However, Alicia Seesholtz (CDWR, personal communication 2004) recently informed us that Tim Viera (CDWR field technician) observed two adult sturgeons, one green and one white, at Shanghai Bend in the Feather River while angling on June 1, 2004. His identification, based upon coloration and rostral shape, was corroborated by an angling guide. Scuba divers had searched for sturgeon on two separate occasions during 2002 downstream of potential migration barriers on the Feather River (June 6 at



Sunset Pumps, RM 38.5, and the Fish Barrier Dam, RM 67; and July 30 at the Fish Barrier Dam). A third site, the natural barrier at Shanghai Bend (RM 25.5), was scheduled for survey but hazardous conditions at the site prevented diving. On August 19 2003, a scuba survey was conducted in the pool below the Fish Barrier Dam. From March through May of 2003, 326 angling hours were spent in areas from Verona to Star Bend, and at Shanghai Bend, the Jesus Hole, and Sunset Pumps attempting to capture sturgeon for the radio telemetry study.

Passage assessment. Three potential sturgeon upstream migration barriers (natural barrier at Shanghai Bend, man-made barrier at Sunset Pumps, Steep Riffle two miles upstream of the Thermalito Afterbay Outlet) were evaluated by a team of sturgeon and fish passage experts during representative low and high flow conditions on November 9, 2002, and July 15, 2003, respectively (Niggemyer and Duster 2003a, 2003b). Daily average flows in the Feather River near Gridley (CDEC Station ID: GRL) were approximately 2,074 cfs and 9,998 cfs during the November 2002 and July 2003 assessments, respectively. The November 2002 experts included Dr. Joseph Cech, Scott Lankford, and Jason Webber, UCD; Eric Theiss, NOAA Fisheries; Michael Perrone and Dave Gonzalez, CDWR; and David Olson and Thomas Duster, Surface Water Resources, Inc. (SWRI). The July 2003 experts included Eric Theiss, NOAA Fisheries; Rich DeHaven, USFWS; Alicia Seesholtz and Dave Gonzalez, CDWR; and David Olson, Adrian Pitts, and Thomas Duster, SWRI. The expert team believed that Shanghai Bend and Sunset Pumps likely bar green sturgeon passage at low river stages due to the height of their waterfalls, high water velocities of their mid-channel chutes, and also a lack of attraction flow in Shanghai Bend's side-channel. One section of the channel at Sunset Pumps was believed to be passable under high flow conditions. Steep Riffle was deemed to be passable at both low and high flows. These qualitative evaluations were originally intended to be verified with tracking studies but no adults were found to be tagged.



Figure 2. Photo of a natural barrier at Shanghai Bench in the Feather River under low flow conditions in July 2004.



Green Sturgeon Spawning in the Sacramento River - USFWS

In 2001, the Northern Central Valley Fish and Wildlife Office of the USFWS investigated the spawning area of green sturgeon in the upper Sacramento River (Brown 1998, Brown 2002). The project was funded by the CALFED Bay-Delta Program. The objectives of the study included: (1) identify green sturgeon spawning sites and spawning period, (2) evaluate the availability and use of specific sites, and (3) establish baseline habitat needs such as, substrate type, velocity, temperature, and depth.

Two green sturgeon eggs were collected below Red Bluff Diversion Dam (RBDD)(RM 243) in the substrate nets and one green sturgeon larvae was captured above RBDD in a drift net. Artificial substrate mats (22) were deployed for egg collection within a 10-mile reach below RBDD, and between RBDD and Anderson Cottonwood Irrigation District (RM 298.5) during the spawning period beginning in mid-April and ending in mid-July. Drift nets were also deployed to capture drifting larva at one site below and two sites above RBDD: near the boat ramp at RM 242, Dog Island at RM 246, and Bend Bridge at RM 258). Flows ranged from 198 to 306 m/s from late March through mid-May. Water temperature ranged from 51°F to 61°C immediately below the dam and 47°F to 59°F above the dam.

Brown (2002) concluded that temperature and flow within the study area both upstream and downstream of the RBDD were probably not a limiting factor for spawning since they were similar to those observed in past successful rearing programs. In a follow-up phone conversation, Kurt Brown indicated that he felt that the lower extent of green sturgeon spawning grounds on the Sacramento River was immediately below the RBDD. Based on his observations and fieldwork, the majority of available spawning areas were thought to be located above RBDD. Upstream passage restrictions associated with dam gate operations could affect habitat availability although the net effect on green sturgeon is unknown (Brown 2002). RBDD gates are opened to improve winter-run Chinook salmon passage. The gates were first opened in 1986 and since 1992 the practice has been to close gates from May 15 to September 15. Upstream passage of sturgeon may be prevented when the gates are lowered since spawning adults appear to be too large to negotiate the current fish ladder. In 2004, the gates were closed seven days earlier than normal which likely prevented green sturgeon passage beginning on May 8th. USFWS staff indicated that they observed three green sturgeon milling below the dam within two weeks after lowering the gates².

Glenn-Colusa Irrigation District Fish Monitoring Program

In 1998, GCID began a fish monitoring study in the vicinity of their Sacramento River Gradient Facility to obtain pre- and post-construction information on migration timing and potential passage issues for salmon, steelhead, green sturgeon, and white sturgeon. Principal investigator is Dave Vogel, Natural Resources Scientists (NRS), Red Bluff. Information on adult migration timing will be used to tailor diversion operations to either avoid diverting, or to divert water less frequently during peak fish migration periods which would help to reduce fish loss

² Green sturgeon are reported to spawn from March through July with fish often migrating into spawning prior to that time (Moyle et al. 1995). May 15 gate closures at RBDD could prevent upstream passage during the latter portion of the green sturgeon spawning period and limit spawning by any later-migrating fish to downstream areas. The fraction of the spawning population that migrate before and after May 15, and the relative suitability for spawning of upstream and downstream areas is unknown.



(Ben Pennock GCID manager, personal communication 2004). In addition, GCID wanted to ensure that upstream passage of adults was not an issue for any species once the Gradient Facility was completed as part of the long-term fish passage solution.

GCID staff captured approximately 24 green sturgeon by angling in 2002 and 2003 (approximately 12 per year) and tagged each with a radio-tag (Moncrief GCID, personal communication 2004). White sturgeon were also tagged. Fish were monitored within the vicinity of the GCID facility through early 2004. Monitoring frequencies were all exchanged with UCD in the event that any GCID tags that still have active batteries are detected by the new UCD study. Results are not yet available, but a draft summary report is pending and is expected to be completed by the end of this year. Once the summary is finalized, the report will be distributed to anyone who requests a copy (Dave Vogel NRS, personal communication 2004). Moncrief (GCID, personal communication 2004) indicated that the project was able to reach its desired objectives and no passage issues were identified.

San Pablo Bay Sturgeon Sampling - CDFG

CDFG conducts semi-annual sturgeon assessments based on mark and recapture of fish collected with trammel nets in San Pablo Bay. The focus is on white sturgeon but green sturgeon are also collected in some years. Green sturgeon catches are variable from year to year, ranging from five to 110 (CDFG 2002). David Kolhorst, long-time leader of the San Pablo Bay trammel monitoring project, has retired and been replaced by Marty Gingras who confirmed that CDFG would continue to conduct trammel net sampling during September and October in two-year intervals, every two years (i.e., sample 2001-2002 and then sample again in 2005-2006).

Other Fish Sampling Activities

A wide variety of fish sampling activities are conducted in rivers and streams throughout the Sacramento-San Joaquin System. Many programs are focused on migration patterns and relative abundance of juvenile or adult salmonids but have the potential to observe green sturgeon adults or juveniles if any were present. Sampling includes ladder video counts, snorkel surveys, rotary screw traps, weir counts, electrofishing surveys, and seining surveys. We interviewed other researchers that have conducted, or are conducting related fisheries research within the Central Valley via telephone, informal personal discussions, and e-mail.

Upper Sacramento River

Larval and post larval green sturgeon are caught each year in a rotary screw trap at the RBDD (Johnson and Martin 1997, Gaines and Martin 2001, CDFG 2002). A total of 2,608 juvenile sturgeon were captured from 1994-2000. All were assumed to be green sturgeon since 124 of these fish were grown by UCD to an identifiable size and all were green sturgeon. Young sturgeon appear in catches from early May through August. Most range in size from 1 to 3 inches. Juveniles up to 16 inches have also been taken in the trap and impinged on screens. Catch rates were greatest in 1995 and 1996 and were lowest in 1999 and 2000.

Upper Sacramento Tributaries

No green sturgeon have reported by salmonid monitoring programs in Clear, Battle, Butte, Deer, Mill creeks (Matt Brown USFWS, personal communication 2004; Colleen Harvey-Arrison CDFG, personal communication 2004). Sampling on these tributaries includes ladder counts (Battle Creek), snorkel surveys (Deer, Butte, Clear and Battle creeks), and rotary screw trapping



(Deer, Mill, Clear and Butte creeks). Ladder counts have occurred annually between March and July 1995-2004 on Battle Creek. Snorkel surveys have been conducted to estimate spring-run and/or winter-run Chinook salmon escapement in each of the creeks except Mill Creek. Snorkel surveys have been conducted in August 1992-2004 in Deer Creek; June to August in 1994-2004 in Butte Creek; and May to October 1995-2004 in Battle Creek. Rotary screw trap sampling is conducted annually during periods from October to May 1995-2004 on Deer and Mill Creeks (spring-run), September to June 1996-2004 on Butte Creek, and since 1998 on Battle Creek.

American River

No green sturgeon have been reported by salmonid monitoring programs in the American River (Mike Healey CDFG, personal communication 2004; John Hannon USBR, personal communication 2004; Trevor Kennedy Fishery Foundation of California, personal communication 2004). Fish sampling methods included snorkeling, rotary screw traps, and seines. Snorkel surveys have been conducted to determine salmonid distribution from February 1993 to January 1994 and February 2004 to present. Rotary screw trap sampling is conducted annually from December to July 1993-2004. Seining surveys to capture steelhead for PIT tagging have recently been conducted on the American River beginning in mid-June and ending in September or late-October.

Yuba River

During various monitoring activities, only two adult sturgeon (unconfirmed species but believed to be white sturgeon) have been observed (Bill Mitchell Jones and Stokes, personal communication 2004). Both were observed milling below Daguerre Point Dam (RM 12) during the 1990s. Although there is a fish ladder at Daguerre Point Dam, it was designed for salmonid passage and it is believed that adult sturgeon are unable to ascend the structure. Since 2002, two rotary screw traps (one above and one immediately below Daguerre Point Dam) have been operated between June and September. In addition, a Vaki River Watcher has been operated intermittently since July 2003 at the Daguerre Point Dam fish ladder.

San Joaquin River Mainstem

The CDFG assesses salmonid smolt numbers by trawling each year in the mainstem San Joaquin River at Mossdale. Seining also occurs at several sites on the mainstem between Mossdale and the mouth of the Tuolumne River. No sturgeon have been collected or observed in either of these sampling programs (Tim Heyne CDFG, personal communication 2004).

Mokelumne River

Michelle Workman of EBMUD (personal communication 2004) indicated that no adult sturgeon have ever been captured or observed in various sampling efforts within the river, however, two unidentified juvenile sturgeon (<150 mm) were captured during 2003 in a rotary screw trap at the Woodbridge Dam³. Fish sampling efforts include fish ladder counts, rotary screw traps, electrofishing, and seining. Ladder (video/trapping) counts have been conducted

³ She believed that the juveniles had been sent to UCD for species identification, but she had not received any results. After contacting several individuals at UCD, we determined that the samples were still in the possession of Jose Setka, a UC Davis student and EBMUD employee. The samples have now been forwarded to Josh Israel of UCD for species identification using recently developed genetic markers. Results are pending.



annually between September and December since 1990 and year-round since 2001. Rotary screw traps are operated annually during periods, on average, from December to July 1993-2004. Electrofishing is conducted once each quarter (i.e., once per season) from 1996 to 2004. Seining has been conducted on a monthly basis between January and July 1996-2004.

Cosumnes and Calaveras Rivers

Trevor Kennedy (Fishery Foundation of California, personal communication 2004) and Rob Fuller (S.P. Cramer and Associates, personal communication 2004) indicated that no sturgeon have been captured or observed during their several years of monitoring in these tributaries. Nor had they knowledge of anecdotal reports of sturgeon sightings in either basin. Juvenile salmonids are sampled on the lower Cosumnes and Calaveras rivers by snorkel survey and rotary screw trap. Snorkel surveys have been conducted bi-weekly from March through October 2002-2004 on the Calaveras River by the FFC. Rotary screw traps are operated annually during periods, on average, from January to May 2002-2004 on the Calaveras River by SPC.

Stanislaus River

A single sturgeon observation has been reported in the Stanislaus River. Rob Fuller (SPC Fish Technician) observed a sturgeon carcass (species unknown) at the Jacob Meyer's Park boat ramp in Riverbank in May or June 1999. The approximately 3 ft. fish had been filleted and all that remained was the head and tail. No sturgeon have been captured during various monitoring activities including rotary screw traps, snorkel surveys, seining, and a weir trap. Rotary screw traps have been operated annually generally from mid-December to June 1993-2004 by S.P. Cramer and Associates. Snorkel surveys have also been conducted bi-weekly from March 2000-2004 by the Fishery Foundation of California. Seining has been conducted between January and May 2000-2002 by S.P. Cramer and Associates. Weir counts have been conducted between September 2003 and April 2004 by S.P. Cramer and Associates.

Tuolumne and Merced Rivers

Salmonids are sampled on the lower Tuolumne and Merced rivers by rotary screw trap, seining, and spring float surveys (Jason Guignard CDFG, personal communication 2004; Tim Ford Turlock Irrigation District, personal communication 2004). Rotary screw traps are operated on both rivers to sample juvenile salmonids annually in spring by CDFG since 1995 on the Tuolumne River and 1998 on the Merced River. Seining has been conducted every other week between January and May 1986 to 2004 on the Tuolumne River by Turlock Irrigation District. Steelhead redd surveys were also conducted on the Tuolumne by CDFG during winter and spring of 2004. Sampling results were discussed with Tim Heyne of CDFG. Based on his recollection, sturgeon have never been captured within the basin with the exception of possibly one small sturgeon captured during the 1980s in a local canal that originating from the Delta.

South Delta Collection Facilities

Juvenile green sturgeon are observed each year from two south Delta water diversion facilities (CDFG 2002). According to CDFG 2004, the State Water Project (SWP), operated by the CDWR, and the Central Valley Project (CVP), operated by the USBR, export water out of the San Francisco Bay-Delta for urban and agricultural use in California. When water is exported, fish become entrained into the diversion. Since 1957, the USBR has salvaged fish at the Tracy Fish Collection Facility (TFCF). CDFG's Fish Facilities Unit, in cooperation with CDWR, began salvaging fish at the Skinner Delta Fish Protective Facility (SDFPF) in 1968. The



salvaged fish are trucked daily and released at several sites in the western Delta. Salvage of fish at both facilities is conducted 24 hours a day, seven days a week at regular intervals. Entrained fish are subsampled for species composition and numbers. CDFG (2002) reported estimates of the number of green sturgeon entrained based on expansions of these sample numbers. Annual estimates from both facilities ranged from 0 to juvenile 7,313 green sturgeon. Estimated numbers exceeded 500 green sturgeon per year in 8 of 12 years from 1974 through 1985, but were less than 200 per year prior to 1974 and from 1986 to present.

Historical Records

We undertook a more extensive review of various historical records in an attempt to augment the limited scientific information on green sturgeon in Central Valley rivers and streams. Current information on green sturgeon occurrence in several areas is limited to anecdotal observations and we were hopeful that additional observations might be uncovered with further investigation. This review included CDFG file information, Board of Fish Commissioner Reports, water rights hearing records, and newspaper and library archives. Little new information was found and most generally corroborated other reports and conclusions. Noteworthy observations included two accounts of large sturgeon in the Feather River during the early 1900s and a series of newspaper articles on relatively recent sturgeon observations in the San Joaquin.

California Department of Fish and Game

We obtained CDFG documents, ranging from reports to memos, for the period 1941 to 2002 from various sources including California State University Chico, the University of California at Davis, and the California State Library (Sacramento). We also reviewed file information at CDFG's Region 2 Office in Rancho Cordova and interviewed retired CDFG sturgeon experts Dave Kohlhorst and Ray Schaffter. Most of the CDFG documents obtained from these sources were already included in NOAA's review files. Most green sturgeon information in CDFG records was contained in a series of research reports from the Bay-Delta area during the 1960s and 1970s) and from more recent unpublished CDFG data from trammel net surveys in San Pablo Bay (1990s through 2002). This review provided little new information on green sturgeon distribution in freshwater portions of the Sacramento-San Joaquin system in addition to that which has already been available from other sources. A 1918 note in California Fish and Game journal included an interesting account and photo of a large (white) sturgeon captured in the Feather River:

“Few Sturgeon Left. During August, 1915, a giant sturgeon was caught in the Feather River, two miles east of Live Oak, by W.A. McAuslin. With the aid of J.J. Haken, Mr. Auslin soon landed the fish. Small white fish baited to three bass hooks at the end of a common chalk line were used in its capture. The sturgeon swam into shallow water and after shooting it several times the men had no difficulty in landing it. This fish, a male was seven feet long and weighed one hundred and sixty pounds. Another fish, evidently its mate was seen in the river at the same time. This fish was caught before the sturgeon was given total protection. Once extremely abundant in our larger streams and considered poor food, the sturgeon, now that it is the nearest extinct of all of our food fishes, is considered a delicacy and every attempt is being made to increase its numbers.”



Figure 3. “Giant sturgeon weighing 160 pounds, caught near Live Oak, California, in August, 1915 “ (Anonymous 1918).

California Board of Fish Commissioners Reports

A Board of Fish Commissioners (forerunner of the current Fish and Game Commission) was established in 1870. This agency released Biennial Reports of the Commissioners of Fisheries of the State of California which detailed the status of fisheries for all of California. We obtained biennial reports for the period of 1870 to 1892 from CSUS library. Reports describe extensive sturgeon fisheries in the Bay-Delta areas and document sturgeon landings. This information has been widely publicized and included in previous reviews of sturgeon information. The sole reference in these reports to green sturgeon was by Lockington (1879) in a white sturgeon species description:

“*Acipenser brachyrhynchus*, Ayres, Sturgeon — This (white sturgeon) is the only species of sturgeon which is brought to the market in abundance, as the fishermen have a prejudice against the long-nosed or green sturgeon, *Acipenser acutirostris*, Ayres, which is abundant in the bay and rivers and creeks flowing into it, asserting that it is poisonous... Dr. Ayres described a third species, *Acipenser medirostris*⁴, but I have not yet recognized it.”

⁴ *A. acutirostris* and *A. medirostris* were both subsequently classified as green sturgeon (Jordan et al. 1928).



Historical Water Rights Decisions

Records of water right decisions for Central Valley rivers and streams were reviewed for specific reference to sturgeon. The records are available from the California Department of Water Resources. This review focused most intensively on CDFG testimony during the 1950s for the major projects in the San Joaquin and Feather rivers.

We initially scanned all State Water Rights decision documents from 1927 to present and identified those that could potentially contain information pertaining to green sturgeon (i.e., decisions located within Central Valley tributaries considered large enough for green sturgeon to possibly have existed). Of the more than 1,000 documents scanned, approximately 18% of the documents were located within relevant tributaries such as the Feather (32), American (33), Yuba (28), San Joaquin (40), Stanislaus (11), Tuolumne (8), and Merced (5) rivers, and other combinations of associated tributaries (20).

During review of these documents, it became apparent that documents prior to the 1940s would not contain any useful information. From the 1920s through 1930s, the prominent topics discussed during the hearings pertained to concerns that an applicant may infringe upon current water rights of the objecting party. The water rights' decision regarding timing, amount of water, and form of diversion was subsequently made based on a review of the available flows. During these hearings, there was rarely a natural resource agency representative present, so fish and wildlife concerns were not addressed.

During the late 1940s, some discussions from CDFG began to appear in the transcripts. By the 1950s, CDFG began attending more hearings and becoming more involved in the process, especially with larger watersheds, such as the American and Feather rivers. During this time, CDFG's contribution to hearings was consistent and generally repetitive, whereby, CDFG representatives would state that anadromous salmonid runs were present within the watershed and were critical to recreational activities and the local economy. CDFG would tentatively object to any and all water diversions until an official document was presented detailing the level of baseline flows available for fish based on time of year and water year type (i.e., dry or wet). Once these parameters were established, 'unappropriated flows' could then be discussed without objection from CDFG. Recommended monthly baseline flows appeared minimal (e.g., ranging from 250 to 619 cfs monthly baseline flows for fish in the American River, Decision 893, 1958) and appeared to usually be received with moderate to light resistance by parties seeking water.

During the proceedings, discussions regarding the watershed were primarily concentrated on channel morphology, precipitation, and available flow based upon water year type. The only reference made to fish communities was directed toward either general salmonid biological requirements or the need for maintenance flows for anadromous fish. An engineer, not a biologist, generally completed field surveys, so any field data collected usually did not document fish presence.

No water rights decisions were identified that mentioned any sturgeon species. Given an apparent lack of focus on non-salmonid anadromous species in the water rights decisions, these records do not confirm or deny the historical presence of green sturgeon within affected areas of the basin. It remains unclear whether sturgeon were present and not a priority concern or were not present in significant numbers. Information on water diversion types and amounts of water contained within these historical reports might help identify changes to the environment that may



have affected the ability of these watersheds to support a sturgeon population. However, scientific information is lacking on the specific habitat requirements of green sturgeon needed to confidently infer habitat suitability of different conditions.

Newspaper and Library Archives

Historical letters, newspaper clippings, and other reports were reviewed from collections in the Library of Congress, Modesto Bee archives, Marysville-Yuba City Appeal Democrat archives and Butte County archives digitally recorded at Chico State.

In the Library of Congress, we focused our searches on areas entitled, “California, First-Person Narratives, 1849-1900” and “The Chinese in California, 1850-1925.” The latter subject was chosen based on previous articles which emphasized the historic Chinese use of green sturgeon in California. Information was limited to descriptions of Bay-Delta fisheries.

Modesto Bee archives were searchable back to 1989. The paper’s archives date back to approximately 1900, but prior to 1989 are only available on microfiche with no option to search stories or article titles by key word. We found seven articles referring to sturgeon but no specific mention of green sturgeon. Most of the articles stem from a poaching incident near Laird Park on the San Joaquin River where a white sturgeon was illegally harvested. Articles also noted that spawning by sturgeon (species unspecific) is thought to occur in two spots in the lower San Joaquin River, poaching is a chronic problem especially in years of low flows, significant legal harvest of sturgeon also occurs, and that harvest numbers were thought to have declined over the last two decades. Articles are summarized below:

Waiting to Snag Some Snaggers (Scott 1993) Hugh Rutherford (CDFG warden) took a journalist in April to two likely breeding areas on the San Joaquin River, Sturgeon Bend and Laird County Park, to try and catch fishermen snagging sturgeon. Hooking a breeding bound sturgeon legally is neither easy nor common and Rutherford stated he had never seen a legally caught fish out there, they have all been snagged. No sturgeon or snagging was observed that day.

Catch of Night: Angler Accused in Poaching Case (Lewis 1995) Through a night-vision scope, warden Hugh Rutherford watched for nearly five hours until he saw what he wanted to see. Around midnight he watched a fisherman land a 40 year old female white sturgeon that was 6’ 4-1/2” with 30 pounds of eggs. In the San Joaquin River, the last spawning ground is near Laird County Park where females lay eggs in the shallow gravels. Snaggers wait there with 3- to 4-inch shark hooks, 200-pound test line and 1-pound weights. As the female bumps the line, a quick yank sinks the hooks deep into the side of the fish and it is dragged in. While sturgeon fishing is legal from February through April, snagging is never legal. For several years the take has been down. Two decades ago legal seasonal hauls of 200 to 300 were recorded from the San Joaquin. Now legal catch is more like 20.

Poaching Case Fishy, Defense Lawyer Says (Lewis 1995) The lawyer for a Westley man charged for poaching claims his client is a victim of a vendetta and a long-running feud prompted the arrest of the 39-year-old man. DFG said poaching problems in the San Joaquin River are chronic and partially to blame for the decline in sturgeon numbers.

Big Fish Yields Big Fine (Palomares 1995) On August 22, 1995 a Westley man was convicted on two counts for sturgeon poaching. The first count was for possessing an oversize sturgeon and the second count was for snagging at Laird County Park. He was part of an angling group that had been poaching for years. Sturgeon are on the decline in the San Joaquin River, which is why DFG has restricted the method of fishing and size of fish that can be legally taken.



Nature Gives Sturgeon a Little Added Protection (Keo 1996) Rain in the San Joaquin River allows more room for sturgeon to breed as the river swells keeping away poachers that are in search of the coveted eggs. In the San Joaquin River, the last spawning ground is in gravelly shallows near Laird County Park. When the water rises, the area becomes too deep for poachers to set up their traps.

Poachers' Growing Craftiness Makes Wardens' Jobs Tough (Jardine 1998) Three game wardens patrol Tuolumne County and three patrol Stanislaus County. Catching poachers is becoming more of a problem for wardens because poachers are becoming more cunning and sophisticated. Sturgeon poaching is common because the roe (sold as caviar) is often sold for over \$100 per pound. A man from Westley, CA was arrested for poaching in 1995, sentenced to 3 years probation, and fined \$2,000. In another incident a few years earlier, a guy was stopped by the CHP because they thought he was overloaded with logs. It turns out he had 18 sturgeon in the back of his truck.

Appeal-Democrat archives date back to 1850 but were key-word searchable back to 2000. No information pertaining to sturgeon was found in archives from 2000-present.

In the Butte County archives, we discovered an interesting picture and reference to a sturgeon captured on the Feather River in 1901 (Figure 4). The sturgeon species is unidentifiable. The location of the picture appears to be in the lower section of the river based upon the broad channel width in the background.



Figure 4. “A giant sturgeon from the Feather River being hauled away by horse and wagon” (Morris E. Phares, photographer, Butte County Archives). Unidentified sturgeon species indicated by red arrow.



Local Fishery Knowledge

We conducted an outreach/interview effort with fishing guides and bait shop operators in areas upstream from the Delta to determine whether people potentially fish for sturgeon, or encounter sturgeon while fishing for other species. A total of 37 phone interviews were conducted in the areas of Red Bluff, Chico, Durham, Oroville, Princeton, Marysville, Sacramento, Elk Grove, Stockton, Lodi, St. Helena, and Crescent City. Guides and bait shops were identified primarily from the yellow pages of telephone directories. Approximately half of the listed guides and bait shops were successfully contacted.

Twelve of 37 interviewees provided at least some limited information regarding green sturgeon capture or sightings within the Sacramento-San Joaquin basin (Table 1). The remainder of interviewees had never captured, seen, or had any knowledge of green sturgeon.

Green sturgeon are not a targeted recreational species but are inadvertently captured while fishing for other species in the Sacramento River. Most interviewed guides did a majority of their fishing in the Delta, Sacramento River, and lower portions of the San Joaquin River, and seldom ventured into tributaries. Most guides that fish on the Sacramento River fish for white sturgeon from January through May with the best months being February and March. They fish from the San Joaquin Delta (Suisun Bay) up to Butte City. Every guide has their favorite location such as Pittsburg, Antioch, Rio Vista, Hood, Clarksburg, Freeport, Freemont, Colusa, and Princeton. Several guides report catching two or three green sturgeon each year but most are not able to recall when or where they caught their last one. Some of the guides noted that green sturgeon are in the river year-round whereas the white sturgeon are only in the river when it is time for spawning. It was also noted that white sturgeon only go as far up the river as Butte City whereas green sturgeon can be found further up river.

Several anglers said they have heard about sturgeon in the Feather River. They believed that they can be found at the mouth of the Yuba River, at the Thermolito Afterbay above Gridley, and in deep holes downstream of that point. One guide reported seeing an unidentified sturgeon in the Yuba River. However, no guide reported catching a sturgeon in the Feather River. Three guides said that there were no sturgeon in the American River and the rest had not heard or did not have knowledge of their presence there. No angler reported catching any sturgeon within the San Joaquin River upstream from the Delta in the recent time period. One guide reported observing a sturgeon in the Merced River approximately 55 years ago. It was unknown whether this fish was a green sturgeon or a white sturgeon. Several guides also fish the Klamath River and have incidentally caught and released green sturgeon or observed Native Americans netting green sturgeon. One guide caught a green sturgeon on the Smith River 15 years ago.

Several individuals who had caught sturgeon were unaware that there are two different species in the basin. Several guides believed that the inability of some recreational anglers to identify the difference between the species can contribute to the poor handling or unnecessary take of green sturgeon. Many guides and bait shop personnel were surprised to hear that sturgeon were candidates for threatened/endangered species status and indicated that they would treat the species differently now that they were informed of the issues.



Figure 5. Photo of a 7 foot green sturgeon caught and released by angler on the Sacramento River 6 miles north of Chico in October 2003 (from posting on fishing message board fishsniffer.com).



Figure 6. Photo of partial sturgeon carcass observed by S.P. Cramer fisheries technicians on July 8, 2004 at Boyd's Ramp Boat Launch on the Feather River (RM 22.5).



Table 1. Summary of guide and bait shop interviews regarding green sturgeon.

No.	Type	Region	River(s)	Target Species	Comments
1	Guide	Chico	Sacramento	Salmon	Doesn't fish for sturgeon but occasionally catches and releases one while salmon fishing. Sees white sturgeon below Butte City and green sturgeon above Butte City. Green sturgeon may be present any time of the year.
2	Guide	Chico	Sacramento	Sturgeon	Fishes for sturgeon about 20 days per year and has been guiding in the Sacramento for 15 years. Recognizes that white sturgeon come up the Sacramento River in February and March to spawn and can be found in Anderson Hole and Pontoon Hole. No green sturgeon information.
3	Guide	Chico	Sacramento, Smith, Feather, Yuba	Salmon, Steelhead	Usually doesn't fish for sturgeon but sees them as he is fishing for other species. Occasionally catches sturgeon when he is bouncing roe for salmon. The best place to look for sturgeon in the Sacramento River is at the Hamilton City Bridge. Sturgeon can be found in the Feather River at the forebay. Saw an unidentified sturgeon on the Yuba River 3 years ago upstream from Hallwood and followed it with his boat. He also fishes coastal rivers and caught a green sturgeon in the Smith River 15 years ago. They also occasionally catch them on the Klamath River.
4	Bait	Chico	Sacramento, Feather, Delta	Sturgeon	Fishing for sturgeon has been excellent in March and April near Butte City on the Sacramento River. The best place in the Delta is near Rio Vista. Is unaware of anyone who fishes for sturgeon on the Feather River but suspects sturgeon are there. White sturgeon are seasonal but green sturgeon are present in small numbers in the Sacramento River year-round. People occasionally catch green sturgeon and release them because they are not good to eat.
5	Bait	Chico	Sacramento	-	No account of green sturgeon.
6	Bait	Chico	Feather	-	No account of green sturgeon.
7	Guide	Chico	American, Feather, Sacramento	Salmon, Steelhead, Sturgeon	Usually catches 2-3 white sturgeon a year in Sacramento River between Meridian and Pittsburg. Best time is from March through April and when the water is muddy. Has seen green sturgeon roll in the Sacramento while fishing for salmon. Doesn't fish the Feather but has seen green sturgeon there. The best place to look for sturgeon on the Feather is in the Thermolito afterbay at Gridley. There are no sturgeon in the American.
8	Guide	Chico	American, Feather, Sacramento	Salmon, Steelhead, Sturgeon	Fishes for sturgeon in the Sacramento River in February and March. Has not caught a green sturgeon this year but someone from his church caught one. Does not fish for sturgeon in the Feather but has seen sturgeon there as he fishes for other species. Has heard no accounts of sturgeon in the American



No.	Type	Region	River(s)	Target Species	Comments
					River but imagines they are there.
9	Guide	Chico	Feather, Sacramento	Salmon, Steelhead, Sturgeon	Has fished the Sacramento River for 30 years. Fishes for white sturgeon at Princeton, Colusa, and Knights Landing. White sturgeon move into this area in February and March. Green sturgeon are present in this area year-round. Usually catches a few green sturgeon every year but it has been a few years since he caught one. Said sturgeon can be found in the Feather River at the Thermolito afterbay outlet and in holes below. Expressed concern about illegal harvest of sturgeon that he has seen and also noted difficulty of many anglers distinguishing sturgeon species.
10	Guide	Chico	Feather	Salmon	No account of green sturgeon.
11	Bait	Oroville	Sacramento, Feather	Salmon	Did not know of anyone fishing for sturgeon in the Feather River or the American River. No account of green sturgeon.
12	Bait	Sacramento	Sacramento	Sturgeon	Believes best place to fish for sturgeon is near Colusa where they spawn. The best time is November to February and when the river is muddy. Has not heard of anyone catching green sturgeon this year.
13	Bait	Sacramento	Sacramento	Sturgeon	Fishes the Sacramento River and recommends areas near Clarksburg or Hood for sturgeon. Has caught a few small green sturgeon over the years and has heard of several people catching green sturgeon this year.
14	Bait	Sacramento	Sacramento	Sturgeon	No account of green sturgeon.
15	Bait	Sacramento	Sacramento	Sturgeon	Not aware of anyone catching a green this year.
16	Guide	Sacramento	Sac, San Joaquin	Sturgeon	Fishes the Delta 25-30 days per year. Best area for sturgeon is in the San Joaquin channel from the mouth of the Mokelumne to Antioch. Best time is after a rain from November to May. Caught one green sturgeon 15 years ago on the Sacramento River at Walnut Grove. Sturgeon are not in the American River but has heard of them in the Feather.
17	Guide	Delta	Sac, Feather	Salmon, Steelhead	Does not fish for sturgeon but has seen other anglers catch them on the Sacramento and at the mouth of the Feather River. No account of green sturgeon.
18	Bait	Delta	Mok, Sac, Delta	-	No account of green sturgeon.
19	Bait	Delta	Sacramento	Sturgeon	Account from a customer of a keeper green sturgeon caught in April in the Sacramento near Light 14. The fish was released because greens are not good to eat. The best sturgeon fishing in the area is near Rio Vista.
20	Guide	Delta	Sacramento	Trout, Salmon	Also fishes the Klamath and Smith rivers but does not fish for sturgeon. No account of green sturgeon
21	Guide	Delta	Sacramento	-	No account of green sturgeon.
22	Bait	Delta	San Joaquin	-	No account of green sturgeon.



No.	Type	Region	River(s)	Target Species	Comments
23	Bait	Delta	San Joaquin	-	No account of green sturgeon.
24	Bait	Delta	San Joaquin	-	No account of green sturgeon.
25	Guide	San Joaquin	Stan, Tuol	Trout	No account of green sturgeon.
26	Bait	San Joaquin	San Joaquin	Sturgeon	No account of green sturgeon.
27	Bait	San Joaquin	Stanislaus	Trout, Bass, Catfish	No account of green sturgeon.
28	Bait	San Joaquin	Stanislaus	Trout, Bass, Catfish	No account of green sturgeon.
29	Bait	San Joaquin	Tuolomne	Trout, Bass, Catfish	No account of green sturgeon.
30	Bait	San Joaquin	Tuolomne	Trout, Bass, Catfish	No account of green sturgeon.
31	Bait	San Joaquin	Merced	Trout, Bass, Catfish	A sturgeon (he didn't know whether it was white or green) was observed by the owner of Ol' Indian Guide Fishing Trips (he no longer guides but sells bait). He saw it 55 years ago while fishing with his father in a slough off the Merced River at Snelling (Callow ranch).
32	Bait	San Joaquin	Merced	Trout, Bass, Catfish	No account of green sturgeon.
33	Bait	San Joaquin	Merced	Trout	No account of green sturgeon.
34	Bait	San Joaquin	San Joaquin	Trout, Bass, Catfish	No account of green sturgeon.
35	Bait	San Joaquin	San Joaquin	Trout, Bass, Catfish	No account of green sturgeon.
36	Bait	San Joaquin	San Joaquin	Trout, Bass, Catfish	No account of green sturgeon.
37	Guide	San Joaquin	San Joaquin	Trout, Bass, Catfish	No account of green sturgeon.



Tributary Spawner Surveys

We conducted reconnaissance-level snorkel surveys in the Feather, Yuba, and American rivers in late spring/early summer 2004 in an attempt to locate any green sturgeon that might have entered these rivers to spawn. Snorkel surveys were concentrated in areas of suitable deep water sturgeon habitat. Sample dates were selected based on optimum viewing conditions. Surveys were conducted by paired samplers.

Feather River

Feather River survey sites included Shanghai Bend, Jesus Hole, Thermalito Outlet, and Steep Riffle (Figure 7). All sites were surveyed on June 10 or 11 and Shanghai Bend was surveyed a second time on July 8 (Table 2). All survey sites included large areas of deep water that could provide suitable sturgeon resting habitat. No live sturgeon were observed but this survey was not adequate to conclude that sturgeon were absent. Deep water, poor visibility, and rapid velocities made visual assessment challenging.

One dead sturgeon of undetermined species was observed by surveyors in July, 2004 (Figure 6). An adult sturgeon carcass in the Feather River near Boyd's Ramp Boat Launch at RM 22.5. The body was filleted and the caudal fin was intact but the head was missing. The tail was collected for genetic testing to determine the species.

Yuba River

Yuba River survey sites included the Yuba/Feather confluence, the lower 3 miles, and a reach near Hallwood (Figure 7). Access to potential sturgeon holding areas directly below Daguerre Point Dam (Yuba River) was restricted to the public. Sites were surveyed on one or two occasions on June 10 and/or July 8 (Table 2). No barriers were apparent to potential green sturgeon movement in the lower 3 miles even at the lower flows observed during the survey. Clean gravel, deep holes, and cool water were available within this reach and at Hallwood although it is unknown if these conditions are suitable for spawning by green sturgeon. High water clarity allowed deep holes to be efficiently assessed.

One 11-inch juvenile fish that appeared to be a sturgeon was observed at the confluence of the Yuba and Feather rivers. This fish was distinguished by a unique tail shape and swimming motion but the sighting was fleeting and the observation cannot be considered conclusive. No other sturgeon or possible sturgeon were observed.

American River

Four American River sites were surveyed on July 12 (Figure 7, Table 2). Lower river sites were selected to supplement a multi-year snorkeling effort in the upper reach by John Hannon of USBR and Trevor Kennedy of FFC which has observed no sturgeon. There were a few deep holes (approximately 15 to 20 foot in depth) in the lower reaches but substrate was primarily silt or sand and water quality was poor. No sturgeon were observed.

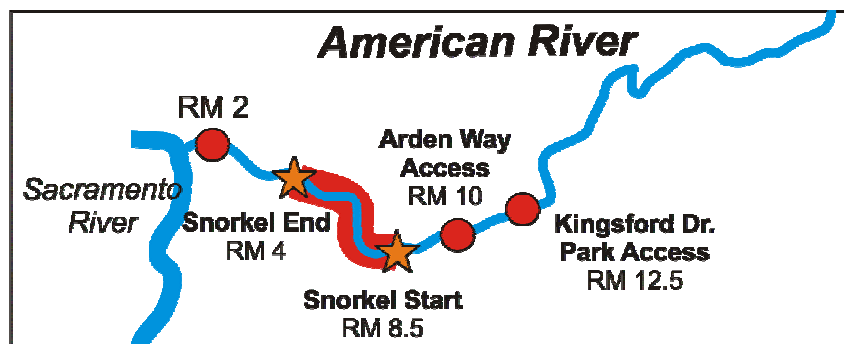
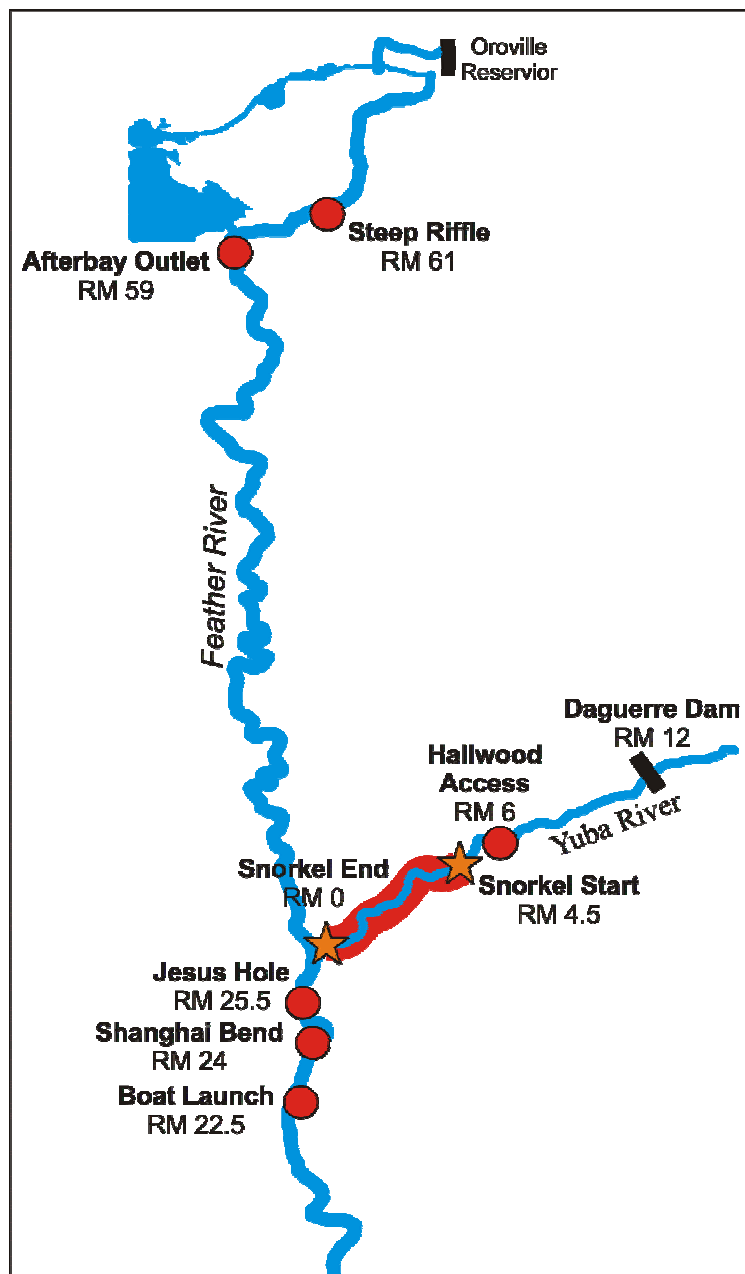


Figure 7. Sites of snorkel surveys conducted by S.P. Cramer staff in spring and early summer of 2004 in attempt to locate green sturgeon in the Feather, Yuba, and American rivers.



Table 2. Sites, dates, and conditions of snorkel surveys conducted by S.P. Cramer staff in spring and early summer of 2004 in attempt to locate green sturgeon in the Feather, Yuba, and American rivers.

River	Location	Distance (ft)	Date	Habitat Type	Max Depth (ft.)	Visibility (ft.)	Species Identified
Feather	Shanghai Bend (RM 24)	400	June 11	Pool	27	3	None Observed
Feather	Shanghai Bend (RM 24)	600	July 8	Pool	27	5	Pikeminnow and Speckle Dace
Feather	Jesus Hole (RM 25.5)	30	June 10	Glide	30	2	None Observed
Feather	Afterbay Outlet (RM 59)	200	June 11	Pool	20	1	None Observed
Feather	Steep Riffle (RM 61)	50	June 11	Riffle and Pool	12	5	Sacramento Sucker
Yuba	RM 4.5	1,800	June 10	Glide, Riffle, Pool series	9	15	Shad, Sacramento Sucker, Striped Bass, Steelhead/Rainbow Trout, Lamprey
Yuba	Hallwood (RM 6)	500	June 10	Riffle and Pool	10	15	Sacramento Sucker, Striped Bass, Shad, Steelhead/Rainbow Trout
Yuba	Hallwood (RM 6)	650	July 8	Riffle and Pool	10	15	Sacramento Sucker, Striped Bass, Shad, Steelhead/Rainbow Trout
Yuba	Confluence	1,200	July 8	Glide	10	12	Sacramento Sucker, <u>possible sturgeon juvenile</u>
Yuba	RM 3.5	3.5 miles	July 8	Glide, Riffle, Pool series	10	15	Sacramento Sucker, Shad, Pikeminnow, Striped Bass, Steelhead/Rainbow Trout
American	RM 2	200	July 12	Glide	35	2	None Observed
American	RM 8.5	4.5 miles	July 12	Glide	40	6	Sacramento Sucker
American	Arden Way access (RM 10)	400	July 12	Glide and Riffle	6	5	Sacramento Sucker
American	Kingsford Dr. access (RM 12.5)	700	July 12	Glide	10	7	None Observed



Figure 8. Photo of Thermolito Afterbay outlet on the Feather River in July 2004.



Figure 9. Yuba River near Hallwood, July 2004.



GREEN STURGEON OCCURRENCE BY AREA

San Joaquin River and Tributaries

No adult or juvenile green sturgeon have been documented to occur in the San Joaquin River upstream from the Delta although directed sturgeon studies have never been undertaken in that area (Table 3). We were unable to corroborate suggestions by Moyle et al. (1992) that some spawning by green sturgeon may take place or once did in the lower San Joaquin River. No evidence was found to indicate that green sturgeon were historically present, are currently present, or were historically present and have been extirpated from the San Joaquin River. Historical information was inadequate to determine if green sturgeon were present or absent prior to development. Current information is inadequate to conclude that green sturgeon are no longer present. Our review is consistent with observations by CDFG and USFWS. CDFG (2002) concluded “we know of no evidence that green sturgeon historically spawned in the San Joaquin River.” USFWS (1995) observed “no studies have been conducted to definitively determine whether and where sturgeon spawn in the San Joaquin River.”

Every observation of green sturgeon juveniles or unidentified sturgeon larvae in the San Joaquin River has occurred in the Delta downstream from Old River. Old River is in the tidally-influenced portion of the south delta downstream from free flowing sections of the San Joaquin (Figure 1). Moyle et al.’s (1992) suggestion was based on observations of juvenile green sturgeon in CDFG fish surveys just upstream of the confluence with the Sacramento River (Radtke 1966) and a specimen collected at south Delta fish screens and preserved in the California Academy of Sciences museum collection. Juvenile green sturgeon are regularly salvaged from south Delta water export facilities and have been seined from the Clifton Court Forebay adjacent to pumping facilities (CDFG 2002). Larval sturgeon of unidentified species have also been collected from Delta reaches of the San Joaquin River (Stevens and Miller 1970).

Green sturgeon observed in the Delta including Old River and the south Delta water facilities could have originated from the Sacramento River rather than the San Joaquin River. Larvae observed in the San Joaquin side of the Delta could have emigrated from the Sacramento River through the Mokelumne River, Georgiana Slough, or Three Mile Slough (Stevens and Miller 1970). CDFG (2002) concluded “based on movement of other fishes in the Delta, young green sturgeon found in the lower San Joaquin could easily, and most likely, come from the known spawning population in the Sacramento River.” The Delta is a network of channels with complex water movement patterns driven by river discharge, tidal cycles, and water export operations. Water regularly flows in different directions depending on the balance between competing influences. In addition, a Delta Cross Channel is operated to shunt water from the Sacramento River into the San Joaquin side of the Delta via the Mokelumne River to facilitate south Delta export operations. Juvenile green sturgeon rear in the Delta for several years prior to emigration (CDFG 2002). Most of the green sturgeon sampled by Radtke (1966) or salvaged at facilities (CDFG 2002) were 8 inches or longer which indicates that they were at least one year of age and had ample opportunity to range widely within the Delta including the lower San Joaquin River.

Anecdotal information indicates that small numbers of adult sturgeon are regularly observed in the San Joaquin River upstream from the Delta (Table 3). All of these identified to date have been white sturgeon. Spawning is suspected to occur in wet years but has never been confirmed (Shaffter 2004 personal communication). Small fisheries for sturgeon occur in spring between



Mossdale and the Merced River (Kohlhorst 1976, Scott 1993, Lewis 1995, Palomares 1995, Keo 1996, Jardine 1998). Tags from white sturgeon tagged in San Pablo Bay have been caught by anglers in the San Joaquin River (Kohlhorst et al. 1991). Catches of two unidentified juvenile sturgeon in the Mokelumne at Woodbridge (RM 39) in 2003 could be the first documentation of sturgeon spawning in a San Joaquin tributary.

Feather River

A review of historical and recent information confirms that both green and white sturgeon occasionally range into the Feather and Yuba rivers but numbers are low and there is no data that spawning occurs now or occurred in the historical time frame (Table 4). The presence of both white and green sturgeon has been regularly reported by anglers over the years from the early 1900's to present. Tagged white sturgeon have been observed or tracked into the Feather River by CDFG on at least three occasions (Miller 1972, Schaffter 1997, Schaffter and Kohlhorst 2002). CDFG also reported observations of subadult white sturgeon (3 ft. in length) during snorkel surveys. During field studies for this report, SPCA fish technicians observed a filleted sturgeon carcass at a boat ramp near RM 22.

The presence of green sturgeon in the Feather River has been confirmed by two expert sightings. In June 2004, Tim Viera, a CDWR field technician reported seeing two adult sturgeons (one green and one white) while angling at Shanghai Bend. In 1993, Patrick Foley (UCD) obtained specific descriptions of green sturgeon from anglers, observed green sturgeon photos in local bait shops, and reported catches of seven adult green sturgeon by anglers fishing in the Themolito Afterbay Outlet.

Sturgeon also regularly occur in the Yuba and Bear rivers (large tributaries of the Feather River). Two reports of sturgeon (unidentified species) were documented in the pool below Daguerre Point Dam on the Yuba River. A fishing guide also provided a credible report of a sturgeon sighting in the Yuba River upstream from Hallwood. Adult sturgeon were observed in the Bear River in at least 3 years and in one year approximately 100 sturgeon were trapped there in pools as a result of reduced flows. (Seven fish confiscated from poachers in this area were all white sturgeon).

This series of observations supports general descriptions of green sturgeon distribution as including the Feather River (Wang 1986, USFWS 1995, CDFG 2002). Observations are not consistent with suggestions that sturgeon have become extinct from the Feather River. However, numbers of green and white sturgeon in the Feather River appear relatively low and may vary substantially from year to year. Most reports of sturgeon have been incidental to other activities and sampling efforts focused specifically on sturgeon have frequently failed to observe or collect sturgeon (Schaffter and Kohlhorst 2002, Niggemeyer and Duster 2003, Kohlhorst CDFG retd., personal communication; snorkel surveys documented in this report). Schaffter and Kohlhorst (2002) concluded that the Feather River appears little used by sturgeon since the construction of Oroville Dam and associated structures.

Several references suggest that natural and man-made barriers in the Feather River appear to limit upstream movements during low flow years (Schaffter and Kohlhorst 2002, Niggemeyer and Duster 2003) and speculate that significant movements of sturgeon into the Feather River may be limited to high flow years (Schaffter and Kohlhorst 2002, CDFG 2002). Schaffter (personal communication 2004) noted that even historical use of the Feather River may have



been limited to high flow years because the bench at Shanghai Bend is a natural barrier. Schaffter and Kohlhorst (2002) noted that during high flows, like those observed in 1993 when Foley reported adult green sturgeon in the river, flows in the Feather River are augmented by Sacramento River water via the Sutter Bypass and these conditions may attract both green and white sturgeon into the Feather River. We note that it is unclear whether hypothesized sturgeon movements would be representative of historical use or an artifact of fish homing to Sacramento River water diverted into the Feather. Anadromous fish have been widely reported to home in freshwater to water of their natal streams and Sacramento water in the Feather might provide a false homing signal. Schaffter and Kohlhorst (2002) suggested that elevated temperatures associated with development may also exceed ranges preferred by spawning sturgeon during low flow years although Seesholtz (2003) observed temperature ranges within the thermal tolerances for these fish.

Spawning by white and green sturgeon has been suspected in the Feather River because of the consistent presence of adults (USFWS 1995, CDFG 2002). However, no observations of spawning behavior, eggs, larvae, or juvenile green sturgeon have been reported in the historical or current time frame. No evidence was uncovered that sturgeon previously spawned in the Feather River with spawning absent in modern times. Intensive sampling efforts for spawning green sturgeon from 2000-2003 failed to locate significant numbers of adult fish or evidence of spawning (Schaffter and Kohlhorst 2002, Niggemeyer and Duster 2003). This sampling occurred during drought years and it is possible that spawning might occur in the Feather River system only during high flow conditions in wet years. It is also possible that sturgeon movements into the Feather system are for feeding rather than spawning purposes. Extensive feeding migrations in freshwater have been documented for white sturgeon and green sturgeon have also been known to migrate into freshwater for purposes other than spawning (e.g. Columbia and Fraser rivers). Because of the lack of historical evidence for spawning in the Feather River, it remains unclear whether suitable spawning habitat for green sturgeon is available or has ever been available, development and water use may have made conditions unsuitable for spawning or if conditions were always marginal for green sturgeon.

Sacramento River

Spawning migrations and spawning by green sturgeon in the upper Sacramento River mainstem have been well documented over the last 15 years and additional study of adult spawning migrations are ongoing (Table 5). Anglers fishing for white sturgeon or salmon commonly report catches of green sturgeon from the Sacramento River at least as far upstream as Hamilton City. Reports are verified in at least one case by a photo. Spawning migrations and areas were undetected until relatively recently. Eggs, larvae, and post larval green sturgeon are now commonly reported in sampling directed at green sturgeon and other species. Young-of-the-year green sturgeon have been observed annually since the late 1980s where fish sampling efforts were underway at Red Bluff Diversion Dam and the Glenn-Colusa canal. Focused sampling efforts for juveniles and adults have demonstrated that green sturgeon can be successfully captured in the Sacramento River where desired.

White sturgeon also migrate into and spawn in the mainstem Sacramento River with spawning apparently concentrated lower in the system than for green sturgeon (CDFG 2002). Most spawning by white sturgeon occurs from Knights Landing to several miles upstream of Colusa (Schaffter 1997). White and green sturgeon juveniles, subadults, and adults are widely



distributed in the Sacramento-San Joaquin Delta and estuary areas including San Pablo. White sturgeon historically ranged into upper portions of the Sacramento system including the Pit River and a substantial number were trapped in and above Lake Shasta Dam when Shasta Dam was closed in 1944 (USFWS 1995). Successful reproduction apparently occurred until the early 1960s (USFWS 1995). Landlocked white sturgeon populations have been widely observed in the Columbia and Fraser systems but no landlocked green sturgeon population are documented.

No current use by sturgeon of Sacramento River tributaries, other than the Feather River system, has been reported. For instance, sturgeon have not been observed in the American River by anglers or others sampling for other fish species (Table 5).

**Table 3. References related to the potential occurrence of green or white sturgeon in the San Joaquin River. (Both sturgeon species were included in this summary because of the limited information available for each and lack of species identification in several references.)**

Year	Observation	Reference
1940-60	No references to sturgeon of any kind were located in records of water right decisions for Central Valley rivers and streams. CDFG testimony in these proceedings highlighted concerns over anadromous fish species but did not identify species.	CDWR
~1950	A fishing guide interviewed during preparation of this report seeing a sturgeon (species unidentified) in a slough of the Merced River near Snelling while fishing with his father.	This report
1963-64	Delta fish surveys by CDFG with gillnet and otter trawls between September 1963 and August 1964 found juvenile green sturgeon to be common in the western Delta (gill net n=138, otter trawls n=28). Sizes ranged from 20 to 60 cm. Peak catches occurred in summer in gill nets at Santa Clara Shoal, Brannan Island State Recreational Area which is in the Delta portion of the San Joaquin River channel (RM 17). Three to five sites sampled per season in the south Delta yielded no green sturgeon. Juvenile white sturgeon were also common in Delta surveys and several were collected in the south Delta including one 102 cm white sturgeon captured at Mossdale (RM 54).	Radtke 1966
1965-66	Yolk sac stage sturgeon (species unknown) were captured by CDFG in tow nets in the lower San Joaquin River from 1966 and 1967 between Suisan Bay and Venice Island (RM 25). Findings included “The survey by the Inland Fisheries Study has given us good evidence of spawning in the Sacramento River system, but we still have no evidence of spawning in the San Joaquin system. Thirteen of the 85 larvae caught by the Delta Study were taken in the San Joaquin side of the Delta, but these could have emigrated from the Sacramento River through the Mokelumne River, Georgiana Slough, and Three Mile Slough.”	Stevens and Miller 1970
--	One juvenile collected in the Old River at the Tracy Fish Screens in Museum collection (year of collection unknown) (http://www.calacademy.org/research/ichthyology/collection/FieldedSearch.asp).	California Academy of Sciences 1967
--	“Anglers often catch sturgeon (species unidentified) in late winter and early spring in the San Joaquin River between Mossdale and the mouth of the Merced River. This migration is probably for the purpose of spawning, but no definitive evidence for this exists.	Kohlhorst 1976
1968-2001	An estimated 18,000 juvenile green sturgeon have been salvaged from pumping facilities in the south Delta from 1968 through 2001. Numbers were greatest in the early 1970s peaking at an estimated 7,300 in 1974. Before 1974 and since 1985, estimated salvage of green sturgeon has ranged from 0 to 168 fish per year.	CDFG 2002
1974-88	A total of 1,455 white sturgeon tags from fish tagged in San Pablo and Suisun bays were subsequently returned by anglers. Of these, 5 were returned from fish caught by anglers in the San Joaquin River upstream of the Delta between March and May. Authors concluded: “Movement of white sturgeon into the San Joaquin River in the spring suggests spawning occurs there also, although no sampling to collect sturgeon eggs or larvae has been done in the San Joaquin system. If the number of tag returns from each river is a valid indicator of the relative number of spawning fish, over ten times (spring tag return ratio of 53:5) as many white sturgeon spawn in the Sacramento River as in the San Joaquin River. Flows in the San Joaquin River are only about 1/8 those in the Sacramento River.”	Kohlhorst et al. 1991
1992-93	Forty-four (44) green sturgeon ranging in size from 16 in. to 67 in. were captured by Kodiak seine in Clifton Court Forebay by CDFG.	CDFG 2002
1993-98	A series of articles in the Modesto Bee newspaper noted that spawning by sturgeon (species unspecific) is thought to occur in the San Joaquin River near Sturgeon Bend (RM 74.5 just downstream from Stanislaus River) and Laird County Park (RM 90.2 upstream from the Tuolumne River). Significant legal harvest of sturgeon occurs in the San Joaquin River but poaching is a chronic problem especially in low flow years. Harvest numbers are thought to have declined over the last two decades.	This report
1999	Unidentified sturgeon carcass was observed by a fisheries technician in the lower Stanislaus River at the Jacob Meyers’ boat ramp	Rob Fuller,



Year	Observation	Reference
	in Riverbank in May or June. The approximately 3-ft. fish had been filleted.	SPC personal communication 2004
2003	Two unidentified juvenile sturgeon (<6 in.) were captured in a rotary screw trap at Woodbridge Dam on the Mokelumne River during juvenile salmonid sampling activities. Samples were sent to UCD for genetic identification of species. Results are pending.	Workman EBMUD, personal communication 2004
2004	No other sturgeon were reported in extensive sampling for other fish conducted by various parties in the San Joaquin mainstem, Mokelumne, Cosumnes, Calaveras, Stanislaus, Tuolumne, or Merced rivers.	This report
2004	No current reports of sturgeon were found in a series of interviews of bait shops and fishing guides in the San Joaquin Valley.	This report
--	"Some spawning may also take place (or did once) in the lower San Joaquin River, as young green sturgeon have been taken at Santa Clara Shoal, Brannan Island State Recreational Area, Sacramento County (Radtke 1966) and a single specimen from Old River is in the CAS collection (D. Catania, personal communication)."	Moyle et al. 1992
--	"Tag recoveries and catches in the sport fishery indicate that some adult (white) sturgeon also migrate into the San Joaquin River." "However, no studies have been conducted to definitively determine whether and where sturgeon spawn in the San Joaquin River."	USFWS 1995
--	"We know of no evidence that green sturgeon historically spawned in the San Joaquin River. Based on movement of other fishes in the Delta, young green sturgeon found in the lower San Joaquin could easily, and most likely, come from the known spawning population in the Sacramento River. No sturgeon of either species appear to have (been) trapped behind Friant Dam on the San Joaquin River when it was constructed in the 1940s."	CDFG 2002
--	White sturgeon use the San Joaquin primarily in wet years. No information exists on sturgeon spawning in the San Joaquin – some spawn intermittent spawning may occur in wet years. Doesn't believe green sturgeon have occurred in the San Joaquin River in the recent 50-75 years.	Schaffter CDFG ret'd personal communication 2004



Table 4. References related to the potential occurrence of green or white sturgeon in the Feather and Yuba Rivers. (Both sturgeon species were included in this summary because of the limited information available for each and lack of species identification in several references.)

Year	Observation	Reference
1901	A historical photo from 1901 shows a wagon containing a large sturgeon (species unknown) taken from the Feather River.	Phares 1901
1915	Account and photo of large sturgeon caught on the Feather River (see excerpt and photo on .	Anonymous 1918
1940-60	No references to sturgeon of any kind were located in records of water right decisions for Central Valley rivers and streams. CDFG testimony in these proceedings highlighted concerns over anadromous fish species but did not identify specific species.	CDWR
1959	Account of large sturgeon caught on the Feather River in the early 1900s.	Talbitzer 1959 (in USFWS 1995)
1967	Angler survey checked one 5-foot sturgeon (species not specified) caught near Boyd’s Pump on the Feather River	CFG Region 2 files
1972	In 1967 and 1968, CDFG tagged a total of 2,692 white sturgeon and 54 green sturgeon adults (> 40 inches) from San Pablo Bay. One white sturgeon tag was recovered from the Feather River in April. The exact location, size, or year of the catch was not given. No green sturgeon were reported to be caught in the Feather River.	Miller 1972
--	Green sturgeon were reported to occur in the Feather, Yuba, and American Rivers in a general summary on California’s anadromous fishes. No supporting information was included.	Wang 1986
1975-85	A fishing guide reported that green sturgeon were caught every year during the “mid-1970’s to early 1980’s. Most catches occurred between March and May, with occasional catches in July and August.	Anonymous personal communication In USFWS 1995
1989	A white sturgeon tagged in San Pablo Bay in 1987 was reported recovered by an angler in the Feather River in April 1989.	Schaffter 2002
1989, 90, 91	Green and white sturgeon are known to enter the Bear River (lower Feather tributary) during the spring of most wet and some normal water years. Adult sturgeon were observed in shallow pools between the Highways 70 and 65 bridges during 1989, 1990, and 1992. During July 1989, approximately 100 sturgeon were trapped in pools between Highways 70 and 65 as a result of reduced flows. At least 30-40 sturgeon (weighing from 60 to 100 pounds and at least 5 feet long) were poached from this area during a 2-week period in July. Of the seven sturgeon confiscated by DFG game wardens, all were white sturgeon.	USFWS 1995 (personal communications from Myers and Lenihan)
1991	During spring, 2 radio-tagged adult white sturgeon were tracked 6.4 miles up the Feather River.	Schaffter 1997
1993	In 1993, Patrick Foley, a graduate student at UCD, visited bait shops and talked to anglers regarding green sturgeon in the Feather River. He stated that many anglers gave him specific descriptions of capturing green sturgeon and several pictures within the bait shops confirmed the stories. Seven adult green sturgeon (60.8-73.2 inches) were reported to be caught at the Thermalito Afterbay Outlet.	CDFG 2002
1996	UCD currently has 7 samples of green sturgeon tissue purported to be from the Feather River (Israel et al. 2002) Upon contacting Josh Israel, UCD Animal Science Department, to discuss this reference, he indicated that the exact origin of the seven samples of green sturgeon larvae is not known. The samples were improperly labeled and attempts to contact the individual who collected the samples (Pat Foley, past graduate student at UCD) have been unsuccessful. Life green sturgeon currently held at the UCD aquaculture facility originated from larvae collected at Red Bluff Diversion Dam during this same period (Van Eenennaam, UCD personal communication). It remains unclear whether the archived green sturgeon samples also originated from Redd Bluff Diversion Dam, correspond to the same 7 fish reported by Foley as being caught in the Thermolito Afterbay Outlet, or originate from another source.	Israel et al. 2002



Year	Observation	Reference
--	“Evidence also suggests that sturgeon reproduction occurs in both the Feather and Bear rivers. Adult sturgeon migrated into the Feather River historically and in more recent times.” “Though no spawning or presence of larvae or juveniles has been documented, reproduction is believed to occur in the Feather and Bear rivers because of the presence of adults.” Occurrence was assumed based on anecdotal reports including those listed above.	USFWS 1995
1995	Anecdotal information suggests that sturgeon were seen jumping and breaching in Lake Oroville. (Several local web sites also refer to sturgeon fishing in association with Lake Oroville although it is unclear if references are to the lake or general region.)	Hodges personal communication (in USFWS 1995)
1996-2001	No larval or juvenile sturgeon was captured in rotary screw traps operated by CDWR during winter and spring since 1996. Traps	Cavallo CDWR personal communication (in Schaffter 2002)
2000	CDFG conducted an informal survey of local anglers and bait shops in the spring of 2000 similar to Foley’s 1993 effort. These inquiries yielded no information that sturgeon had been caught in the Feather River recently. CDFG attributed these results to the differences in water years since 1993 was a high flow year and 2000 was a low water year.	CDFG 2002
2000-01	No evidence of green sturgeon was found by CDFG in egg and larval surveys looking specifically for evidence of sturgeon spawning. Drought low flows during study years were thought to have prevented sturgeon migration into the Feather River. Two white sturgeon (both ~ 3 ft total length) were observed near RM 58 in May, 2000. The report concluded “Since the construction of Oroville Dam and associated structures, the Feather River appears little used by sturgeon.”	Cech et al. 2000 Schaffter 2002
2002	CDFG comments to NOAA Fisheries include: “In the Central Valley, the most likely loss of spawning habitat is the Feather River, as Oroville Dam blocks access to potential spawning habitat and Thermalito Afterbay warm water releases may increase temperatures to levels that are undesirable for spawning incubation. Nevertheless, anecdotal evidence suggests that adult green sturgeon are still found in the Feather River in high flow years, presumably as they take advantage of intermittent opportunities for successful spawning.”	CDFG 2002
2002	NOAA Fisheries reviewers reported “green sturgeon reportedly spawn in the Feather River, but this has not been confirmed”.	Adams et al. 2002
2002-03	No evidence of green sturgeon was found by CDWR during studies in 2002 and 2003. CDWR sampled extensively for sturgeon eggs with artificial substrates for eggs, larvae with drift nets, and adults with scuba and angling. CDWR noted potential passage sturgeon problems at several points in the Feather.	Niggemeyer and Duster 2003
2004	Dave Kohlhorst (ODFW, retired) has heard fisherman stories that green sturgeon were present in the Feather River in historic times but has been unable to confirm these reports. He once saw a picture of a green sturgeon in an area bait shop but was unable to confirm whether the is was taken from the Feather or the Sacramento.	Kohlhorst CDFG retd., personal communication 2004
2004	Five local fishing guides had either seen, or knew of other people that have caught sturgeon in the Feather River. No guide reported personally catching a sturgeon in the Feather River. One guide who appeared to be familiar with both species reported seeing green sturgeon in the Feather. All other references were to unidentified sturgeon species. General locations included the Yuba, the Thermalito Afterbay Outlet near Gridley, and in deep holes in the high flow channel below the Thermalito Afterbay Outlet.	This report
2004	Tim Viera (CDWR field technician) observed two adult sturgeons, one green and one white estimated to be > 50 inches, at Shanghai Bend in the Feather River while angling on June 1, 2004. His visual identification, based upon coloration and rostral shape, was corroborated by an angling guide.	Alicia Seesholtz CDWR personal communication 2004



Year	Observation	Reference
2004	One dead sturgeon (species undeterminable) was observed by S.P. Cramer fisheries technicians near Boyd's Ramp Boat Launch in the Feather River at river mile 22.5.	This report
2004	A local fishing guide reported seeing a sturgeon (species unknown) approximately three years ago on the Yuba River 10 miles upstream from Hallwood and following it with his boat.	This report
2004	Two adult sturgeon (believed to be white sturgeon) were observed in the 1990s milling below Daguerre Point Dam in the Yuba River during other fish monitoring efforts.	Mitchell, Jones and Stokes, personal communication 2004
2004	Regional biologist reported observing unidentified sturgeon species below Daguerre Point Dam in the Yuba River.	Massa CDFG, personal communication

**Table 5. References related to the potential occurrence of green sturgeon in the Sacramento River.**

Year	Observation	Reference
1879	Green sturgeon was cited as being “abundant in the bay and the rivers and creeks flowing into it.” Exact freshwater locations were not mentioned and no information was given on how use of freshwater areas was determined.	Lockington 1879
1948-2002	CDFG has tagged 233 green sturgeon during fall in San Pablo Bay as part of a intermittent sturgeon assessment from 1954 - 2001. Another 42 were tagged in 1948 and 1949 in other studies. Eighteen (18) tags have been returned including 3 from the estuary and the remainder from California, Oregon, and Washington commercial fisheries.	CDFG 2002
1965	Two sturgeon larvae (species unidentified) collected in the Sacramento River during a striped bass spawning survey are the first documentation of sturgeon spawning in the system.	Stevens and Miller 1970
1966	Trawl net and gillnet catches confirm that juvenile green sturgeon are widely distributed in the Delta and estuary.	Radke 1966, Ganssle 1966
1966	On June 17 and 18, 1966, two large (60-65 in.) green sturgeon were caught on the Sacramento River under the Sacramento River Bridge in Red Bluff.	Red Bluff Daily News (in EPIC et al. 2002)
1966	On June 27, 1966, the reported an adult green sturgeon measuring 66 inches and 50 pounds was caught in the Sacramento River south of the Red Bluff Bridge.	Sacramento Bee (in EPIC et al. 2002)
1966-1968	A total of 85 sturgeon larvae (species unidentified) were collected in tow nets by CDFG during April and May from the Delta and Sacramento River downstream from Verona.	Stevens and Miller 1970
1972	In 1967 and 1968, CDFG tagged a total of 2,692 white sturgeon and 54 green sturgeon adults (> 40 inches) in San Pablo Bay. Tag returns by anglers indicate that many white sturgeon appear to migrate to the lower Sacramento River in winter prior to the spawning season and move up the Sacramento River from March through June. No green sturgeon tags were recovered from the Sacramento River.	Miller 1972
1973	A total of 257 larvae and nine sturgeon eggs was collected in the Sacramento River between the mouth of the Feather River and Colusa from March 5 to June 17, 1973. No sturgeon were collected in upstream sites that extended to Red Bluff. Species was unidentified but most were suspected to be white sturgeon based on relative numbers of green and white sturgeon in fisheries. However, one larva was identified as potentially being a green sturgeon due to its different size and coloration.	Kohlhorst 1976
1974	During June 17 through July 10, 1974, twelve juvenile sturgeon ranging from 25-60mm were taken at the Glenn-Colusa canal intake near Hamilton City. A 60 mm juvenile taken at Hamilton City in 1974 was developed enough to be identified as a green sturgeon.	Kohlhorst 1976
1991	CDFG radiotagged adult sturgeon in 1990 and 1991 the Sacramento River between Hood and Freeport in late winter and spring including one 72 in. green sturgeon in March of 1991. This fish was located once, 7 days after tagging at which time it had moved upstream above the mouth of the American River.	Schaffter 1997
1991	Four yearling green sturgeon were recovered at the Red Bluff Diversion Dam in October 1991.	Kurt Brown, personal communication (in Moyle et al. 1992)
1992	River guides reported to have taken adult green sturgeon at the Anderson Hole, about 4 miles above the Hamilton Bridge.	George Jewell personal communication (in Moyle et al. 1992)



1994-2001	Larval and post larval green sturgeon are caught each year in a rotary screw trap at the Red Bluff Diversion Dam. A total of 2,608 juvenile sturgeon were captured from 1994-2000. All 124 of these fish grown by UCD to identifiable size were green sturgeon. Young sturgeon appear in catches from early May through August most range in size from 1 to 3 inches. Juveniles up to 16 inches have also been taken in the trap and impinged on screens. Catch rates were greatest in 1995-96 and were very low in 1999 and 2000.	Johnson and Martin 1997, Gaines and Martin 2001, CDFG 2002
1991-2001	Larval and post larval green sturgeon are caught each year in a rotary screw trap operated year-round since 1991 at the Glenn-Colusa Irrigation District pumping plant (RM 205). Catches have ranged from 23 in 1994 to over 700 in 1993. All 12 of these fish grown by UCD to identifiable size were green sturgeon. Young-of-the-year sturgeon are caught from May through October but peak in June and July.	CDFG 2002
1989-2002	USFWS observed adult sturgeon below the Red Bluff Diversion Dam between RM 232.5 and RM 238 while electrofishing for chinook. From April 3 through May 21, 1991, 19 green sturgeon were noted including one dead fish that was photographed and had pectoral fin removed. (CDFG 2002 flags questions with validity of species identification since only white sturgeon were noted in 1990 and 1992.) Numerous adult sturgeon have been observed in the vicinity of Red Bluff Diversion Dam since 1991 by USFWS personnel.	CDFG 2002, Brown USFWS personal communication (in CDFG 2002)
--	DFG Region 1 files provide some information about white sturgeon distribution in the upper Sacramento River drainage before and after construction of Shasta Dam. Sturgeon probably inhabited the entire PIT River up to Pit River Falls prior to construction of Britton Dam in 1925. A substantial number of white sturgeon were trapped in and above Lake Shasta when Shasta Dam was closed in 1944. These fish and their progeny primarily used the Pit River arm of the lake. Successful reproduction apparently continued until the early 1960s, when construction of additional hydropower dams on the Pit River just above Lake Shasta eliminated the last of the sturgeon spawning habitat.	Healey CDFG personal communication (in USFWS 1995)
2001	Artificial substrate mats and drift nets were fished to collect green sturgeon eggs and larvae from above and below the RDBB. In 2001, substrate mats sampled from March 21 through July 16 and drift net samples were collected from June 26 to July 24. One green sturgeon larvae was captured by a drift net on July 13, at Bend Bridge (above the Red Bluff Diversion Dam) and two green sturgeon eggs were collected in artificial substrate traps below the dam on June 14, 2001. The lower extent of green sturgeon spawning was believed to be immediately below the dam with the majority of available spawning areas located above the dam.	Brown 2002, Brown personal communication 2004
--	“Based on information from catches of sturgeon eggs, larvae, and juveniles in the Sacramento River and data on white sturgeon, it appears that green sturgeon spawn in late spring and early summer from above Hamilton City to above RBDD, maybe as far upstream as Keswick Dam.”	CDFG 2002
2002-04	Adult green sturgeon (24) were captured by angling, radio-tagged, and monitored within the vicinity of the GCID facility. Results are not yet available.	Moncreif GCID personal communication 2004
2004	Adult green sturgeon (20) were radio and sonic tagged in San Pablo Bay during 2001 and 2002 are being monitored with fixed receivers distributed upriver as far as Redding. Results are not yet available.	Klimley UCD personal communication 2004
2004	Interviewed guides and bait shops commonly reported catching, seeing, or hearing about catches of adult green sturgeon in the Sacramento River from the Delta as far upstream as Hamilton City, typically during winter and spring.	This report
2004	No other sturgeon were reported in extensive sampling for other fish conducted by various parties in American River.	This report
2004	None of the bait shops of fishing guide interviewed had ever captured, seen, or heard of anyone else capturing/observing either white or green sturgeon in the American River.	This report



DISCUSSION

Although no systematic and comprehensive survey of green sturgeon distribution and relative abundance has ever been undertaken for the Sacramento-San Joaquin Basin, scattered pieces of anecdotal observations and results of sampling activities for green sturgeon and other species can be assembled to provide a fairly good overview of current distribution patterns of this reclusive species. Information detailed in this report confirms that green sturgeon spawn in the upper Sacramento River following migration from the Delta and estuary. Juvenile, subadult, and adult green sturgeon are widely distributed throughout the Sacramento-San Joaquin River Delta and estuary. Adult green sturgeon occasionally enter the Feather River and its tributaries but have never been observed to spawn there. Green sturgeon have never been reported in the San Joaquin River upstream from the Delta although white sturgeon are regularly observed there.

Historical information on green sturgeon distribution in the Feather and San Joaquin systems is practically non-existent. It remains unclear whether green sturgeon use of the Feather and San Joaquin systems prior to development was more extensive, or those rivers supported discrete populations of green sturgeon, or if once-robust green sturgeon populations have been extirpated from those rivers as there is no data to support any of those conclusions. Altered flows and temperature patterns in the Feather and San Joaquin rivers might generally be inferred to have reduced habitat suitability for green sturgeon. However, habitat requirements for green sturgeon spawning are poorly understood and it remains speculative whether historical conditions were ever suitable for green sturgeon in the Feather and San Joaquin systems.

Identification of historical and current green sturgeon distribution patterns is greatly complicated by their unique life history characteristics and preference for large rivers that are difficult to sample. For instance, spawning migration patterns and habitats in the Sacramento River were undetected until just the last 15 years. Eggs and larvae are particularly difficult to sample. Egg sampling efforts have been hampered by the poorly adhesive nature of green sturgeon eggs (Van Eenennaam et. al 2001) which limit the effectiveness of collecting eggs by traditional artificial substrates. Larval behavior in the laboratory indicates that they exhibit hiding behavior (Deng et al. 2002), and appear to be nocturnal (Cech et al. 2000) which limits the effectiveness of sampling, particularly during the daytime. Spawning migrations typically occur during high, turbid, spring runoff periods. Heavy currents and deep water in preferred river habitats make it difficult to fish traditional sampling gears such as gillnets. Thus, significant green sturgeon populations can easily be overlooked. Just because populations were not reported in the historical or current time frame does not necessarily mean they were not present.

Preliminary findings of genetic studies might have some implications for population structure of green sturgeon in the Sacramento-San Joaquin river system. First, the available evidence suggests that the Feather and San Joaquin rivers do not currently support spawning populations. According to Israel et al. (In press) “the lack of significant linkage disequilibrium and Hardy-Weinberg equilibrium being observed in the San Pablo Bay collection suggests that this group of samples is not a mixed stock”. Second, similarities between adjacent populations in the Rogue and Klamath rivers might suggest that the current Sacramento River spawning population of green sturgeon is representative of any population segments that might have regularly or occasionally used the Feather or San Joaquin systems prior to development. Little is known about green sturgeon homing patterns, however, genetics results could suggest regular



exchange of spawners between adjacent systems. Similar historical behavior patterns in the Sacramento-San Joaquin system would have precluded evolution of distinct genetic populations in different parts of the system.

Genetics data suggest that not all spawning populations have been identified (Israel et al. In press). Samples from green sturgeon intercepted in the Columbia River suggested the existence of one or more spawning populations in addition to the Sacramento system, Klamath, and Rogue populations (Israel et al. In press). Based on tagging data, the transitory fish sampled in the Columbia River estuary are thought to represent an amalgam of several populations. One additional item of potential note uncovered in this review was a report by an angler that green sturgeon may occur in the Smith River (California). No mention of the Smith River occurs in NMFS' status review (Adams et al. 2002). However, USFWS (1995) noted that green sturgeon are found in the lower reaches of the Smith River. These observations highlight the uncertainty in green sturgeon distribution in coastal systems as well as the Sacramento-San Joaquin system addressed by this report.

This review investigated the current and historical distribution of green sturgeon within the Sacramento-San Joaquin system but did not consider implications of this information and makes no judgment as to the more fundamental questions of: 1) which areas represent a significant part of the green sturgeon range, and 2) whether the current range is sufficient to sustain a viable green sturgeon population over the long term. Habitat changes often eliminate a species from the more marginal areas first and constrict distribution to core areas of high productivity. These areas may be adequate to continue to sustain a robust and viable population despite loss of some portions of the historic range. It is the rare North American native animal or plant species that has not suffered some habitat loss over the last two centuries, yet most are not threatened or endangered with extinction. The continued existence of a significant population of green sturgeon in the Sacramento-San Joaquin system even in the face of substantial habitat modifications in some portions of the system is likely an indicator of the continued viability of this population. Results of distribution information summarized in this review are but one element of a comprehensive risk assessment needed to evaluate the status now and into the future for green sturgeon.

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ADDENDUM & ERRATA

Beamesderfer et al. 2004. Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin Rivers and tributaries. Report by S.P. Cramer & Associates to State Water Contractors, Sacramento CA.

Item #1 – Page 2 Summary, last paragraph, last line

“No sightings of Sacramento River tributaries other than the Feather River system by white or green sturgeon has been reported.” should read instead “No sightings of white or green sturgeon have been reported in Sacramento River tributaries downstream from Shasta Dam other than the Feather River system.” (If any sturgeon have in fact seen other rivers, they are keeping it to themselves. There are historical accounts of white sturgeon in the Pit River.)

Item #2 – Recent Feather & Mokelumne samples determined to be white sturgeon

UCD completed genetic species identification tests on recent sturgeon samples from the Feather and Mokelumne rivers and determined both to be white sturgeon (Josh Israel, 8/13/04 email to M. Simpson, SPCA). The Feather River sample was from a filleted adult sturgeon carcass observed by SPCA fisheries technicians in July 2004 near a boat ramp at RM 22.5 (Figure 6 and page 24 paragraph 3). The Mokelumne River sample was a juvenile captured in 2003 in a rotary screw trap at Woodbridge Dam (page 12 paragraph 5) and forwarded to UCD by Jose Setka of the East Bay Municipal Utility District.

The Mokelumne observation is evidence for white sturgeon spawning in that river. White sturgeon are believed to spawn in portions of the San Joaquin system during some years. The Mokelumne sample supports this belief although it is unclear if white sturgeon are artificially attracted into the lower portion of the Mokelumne by diversion of Sacramento River water through the Delta Cross Channel. (No green sturgeon have been documented in the San Joaquin system upstream from the delta.) The Feather River observation corroborates other reports of occasional use of that system by white sturgeon but provides no new information on spawning by white sturgeon in that system. (No spawning by white or green sturgeon has been documented in the Feather River.)

Item #3 - Other general references

Several additional documents discuss green sturgeon distribution in the Sacramento-San Joaquin system based on reviews of other references. These reviews are included here to provide a comprehensive bibliography.

Moyle, P.B. 2002. *Inland Fishes of California*. University of California Press

Suggested that some spawning may also take place (or once did) in the lower San Joaquin River based on observations of young green sturgeon in the delta portion of the river. (Similar to other references already discussed at length in our report. It is likely these fish originated from the Sacramento spawning population.) Moyle also suggested that capture of larval green sturgeon in salmon outmigrant traps indicates that the lower Feather River may be a principle spawning area. No reference was provided for these purported Feather River observations and we were unable to confirm the source. (It is possible that the reference is related to year 1996 samples in the UCD genetics collection discussed on page 34. These samples are incompletely labeled and it is unclear whether they came from the Feather or Sacramento rivers. No other observations corroborate the existence spawning of green sturgeon in the Feather River.)



Moyle, P.B., and 9 coauthors. 1996. Recovery plan for the Sacramento / San Joaquin Delta Native Fishes. U.S. Fish and Wildlife Service, Portland OR.

Green sturgeon are already subject to a Federal recovery plan along with seven other native fish species that depend on the Sacramento-San Joaquin Delta for a significant segment of their life history. The plan includes a summary similar to that in Moyle 2002 (above). The plan concluded that indirect evidence indicates that green sturgeon spawn mainly in the Sacramento River. Suggested that recent (unidentified) data indicates the possibility that green sturgeon spawn in the Feather River. The sole reference to Feather River data was a discussion of photographs reported by Pat Foley of green sturgeon taken by sportfishers. The San Joaquin reference was the same reference to the possibility of spawning as indicated by the observation of juveniles in the delta (also discussed above).

Item #4 - 1910 Feather River white sturgeon account

Further review of the narrative account of a large sturgeon caught by anglers in the Feather River near Oroville in August 1910 (B. Talbitzer, 1959, Case of the virgin sturgeon: the story of Butte County's largest fish catch, Butte County Historical Society Diggin's 3:6-8) suggests that this is the same barely visible fish in a photo obtained from the Butte County archives and initially thought to date from 1901 (Figure 4 in our report). The catch was a local sensation and was reported in newspapers throughout the Sacramento Valley. The eight foot, seven and one-half inch, 287 pound fish shown in the photo accompanying the article appears to be a white sturgeon based on body form and snout shape.



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8/17/04