ERP DIRECTED ACTIONS

POPULATION BIOLOGY, LIFE HISTORY, DISTRIBUTION, AND ENVIRONMENTAL OPTIMA OF GREEN STURGEON

For

SACRAMENTO/SAN JOAQUIN WATERSHED

Reference
Ecosystem Restoration Program
Prop 50 Bond Funded
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A1. Proposal Title:
Population biology, life history, distribution, and environmental optima of green sturgeon

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A5. Cost Share Partners:*
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N/A

A7. Other Cooperators:*
N/A

A8. Project Topic Area*
Primary: At-Risk Species Assessment
Secondary: Shallow Water and Marsh Habitat-

A9. Project Type*
Primary: Research
Secondary: Monitoring

PART B. Executive Summary

B1. Proposal Title: Population biology, life history, distribution, and environmental optima of green sturgeon

B2. Project Description:

Regulatory biologists of the National Marine Fisheries Service (NMFS) designated the Southern distinct population segment of green sturgeon, *Acipenser medirostris*, which inhabits the San Francisco Bay estuary, as "threatened" on 7 April 2006 under the Endangered Species Act (ESA). Section 4(b) of the ESA mandates that NMFS designate critical habitat including "cover or shelter... [and] sites for breeding, reproduction, [and] rearing of offspring" (NOAA 2006). Due to this change in regulatory status, there is an immediate need for in-depth information about the population biology, such as the number of spawning females, life history, such as the age maturity of males and females and frequency of spawning, and habitat requirements of the species. We propose to conduct telemetric, physiological, reproductive, and genetic studies to provide state and federal agencies such as NMFS and the California Department of Fish and Game (CDFG) with information on the size of the population and its critical habitat within the Sacramento-San Joaquin watershed to inform the development of a recovery plan for the species. The distribution of spawning adults and juveniles, carrying individually coded beacons, will be continuously monitored using automated listening stations situated throughout the Sacramento River, Delta, and San Francisco Bay Estuary. The environment where adult green sturgeon are found to spawn will be characterized. Juveniles of different age cohorts will be tracked to identify important rearing habitats throughout the river, delta, and bay and to describe those habitats. Information derived from this research will permit the designation of critical habitat for different age classes of green sturgeon and inform the decisions of regional resource managers. Experiments will be conducted in a recently fabricated 3-m diameter chamber to determine the preferences of young-of-the-year and age-1 green sturgeon for particular temperatures and salinity gradients, when the fish are accustomed to different thermal and saline conditions. Ultrasound imaging, correlated with histological stages from biopsies, will be used to determine gender, measure gonadic growth, detect the condition of ovaries in pre-spawning, post-spawning, and atretic (reabsorbtion of egg before spawning) states and to determine the age of maturity of female green sturgeon and their spawning periodicity. Genetic analysis will be carried out on juvenile green sturgeon captured between April and July over three consecutive spawning migrations (2006-2008) in the main stem of the Sacramento River. The DNA of multiple individuals above Red Bluff Diversion Dam will be compared to estimates of spawner abundance during previous years, as well as in different reaches of the Sacramento River. Genetic monitoring of estuarine green sturgeon aggregations of coastal migrants (subadults, adults) will provide additional information on any temporal differences in the proportion of northern and southern populations between years.

PART C. Work Plan

C1. Project Background and Information:

The green sturgeon has long been classified as a "Species of Special Concern" in California, yet little biological information existed for this species prior to 1999. For that reason, the Anadromous Fish Research Program (AFRP) supported an intensive study of basic green sturgeon biology by a multidisciplinary team of scientists (Cech, Doroshov, Klimley, and May, PIs) at the University of California, Davis. Many of initial studies were completed in the laboratory and focused on the physiology and reproductive biology of the species, but genetic samples were collected throughout the species' range and telemetric studies were carried out to describe the movements and distribution of subadult and adult GS in the San Francisco Bay Estuary. This research program continued for another two years with support from CALFED (Klimley, Cech, Doroshov, May, and Werner, PIs), which expanded its geographic scope to include tracking the movements of fish, tagged in San Pablo Bay, throughout the Sacramento-San Joaquin watershed.

We have presented the results of these studies at scientific conferences such as the Biennial CALFED Bay-Delta Program Science Conference, the San Francisco Bay-Delta Estuary State of the Estuary Conference, and the meeting of the California-Nevada Chapter of the American Fisheries Society (AFS). Articles developed from presentations at a symposium, entitled "Green sturgeon and their environment" that was held at the 2005 AFS meeting in Sacramento, will soon appear in a Special Issue of *Environmental Biology of Fishes*. See the references in bold at the end of the proposal for the many scientific papers resulting from this research program. However, we need to collect more biological information, where life history data are lacking, to provide the National Marine Fisheries Service (NMFS) with a sufficient basis on which to manage this species and ensure that green sturgeon do not decline further in abundance in the Sacramento-San Joaquin watershed.

The population of green sturgeon is currently thought to be comprised of two genetically distinct segments (Israel et al., 2004): a northern segment consisting of fish that spawn in the Rogue River, Oregon, (OR) (Erickson et al. 2002), and the Klamath River, California (CA) (Van Eenennaam et al. 2001) and a southern segment defined as coastal and Central Valley populations spawning south of the Eel River, and thought to be comprised solely of fish spawning in the Sacramento River, CA, watershed (Brown in press). These two populations, which are genetically isolated, are now managed by NMFS separately, since it is likely they are undergoing distinct population dynamics and may require different strategies to maintain their viability. An expansive tidal estuary and massive watershed containing multiple large tributaries distinguish the Sacramento River from the Rogue and Klamath Rivers which are typified by small estuaries, short length, and smaller watersheds.

Regulatory biologists of NMFS designated the southern distinct population segment (DPS) of the green sturgeon as "threatened" on 7 April 2006 under the Endangered Species Act.

Section 4(b) of the ESA mandates that NOAA Fisheries designate critical habitat including "cover or shelter... [and] sites for breeding, reproduction, [and] rearing of offspring" (NOAA 2006). Just prior to the listing, Dr. David Woodbury of NMFS requested a meeting[1] on 4 April at the University of California, Davis (UCD), hosted by Drs. Joe Cech and Pete Klimley, for regulatory biologists from the Santa Rosa and Sacramento offices of NMFS to listen to summaries of the research conducted by graduate students, staff, and faculty at UCD on the reproduction, physiology, movements, and genetics of green sturgeon. These studies were conducted for contract ERP-02D-P57 between UCD and the California Bay Delta Authority. During this meeting, Mike Aceituno and Melissa Neuman informed the group that NMFS will conduct a jeopardy analysis in the next two years, which will require identification of critical habitat within the watershed for juvenile and adult green sturgeon, and lead to the formulation of a recovery plan for the species based on this knowledge. To date, little is known about adult and juvenile migrations, and required spawning, holding, and rearing habitat. We propose to conduct telemetric, physiological, reproductive, and genetic studies that provide NMFS with the scientific basis upon which to develop a recovery strategy for green sturgeon.

Task 1: Telemetric Studies (Klimley, A.P., Principle Investigator [PI])

Research focused on the spawning migrations of adult green sturgeon is currently being conducted by the UC Davis Biotelemetry Lab with funding from CALFED, which will expire 30 Sept. 2006. In May 2004, an array of 35 automated listening stations (Vemco Ltd, VR2, Fig. 1) was established along the approximately 480 km-long Sacramento River from the Delta to the ACID dam in Redding, CA (see Fig. 7, the Project Map, in Section E5). Additionally, other arrays either have been or are currently being established by collaborating researchers.

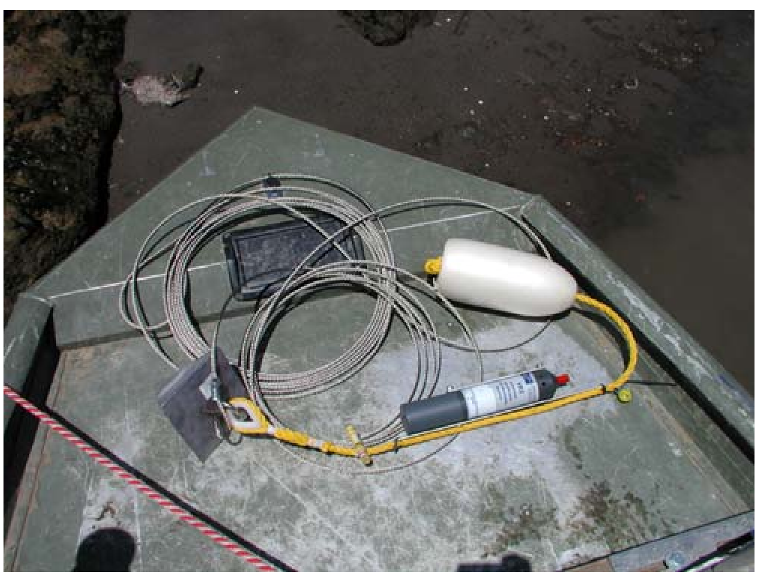

Fig. 1. Tag-detecting monitor (VR-02, Vemco Ltd.) attached to a mooring prior to installation in the Sacramento River.

The National Marine Fisheries Service is maintaining arrays of listening stations across the mouth of San Francisco Bay (i.e., Golden Gate), CA and at the mouth of Willapa Bay, WA. The Army Corps of Engineers will soon situate arrays of stations across the San Pablo and Bay Bridges in San Francisco Bay and at the dredge

[1] Participants: Witalis (NMSF), Tucker (NMFS), Bellmer (NMFS), Leet (NMFS), Jahn (NMFS), Moody (NMFS), Kozlowski (Jones & Stokes), Woodbury (NMFS), Kelly (UCD), Israel (UCD), Drauch (UCD), Klimley (UCD), Cech (UCD), Aceituno (NMFS), McClain (NMFS), Kaufman (UCD), Stuart (NMFS), Linares (UCD), Allen (UCD), Heublein (UCD), Neuman (NMMFS), Collings (NMFS), and Van Eenennaan (UCD).

disposal site near Alcatraz Island and a nearby control, non-dredge site (see also Fig. 10). Joint state-federal funds have been awarded by the Science Group for the Long Term Management Strategy (LTMS) for Dredged Disposal to purchase and deploy 50 of these stations. The Bay Planning Commission, which is composed of members of private organizations including the Port of Oakland, is raising funds to place additional monitors in the channels of local marinas and port facilities. These stations detect the uniquely coded ultrasonic signals from miniature electronic pinger tags (Vemco Ltd, V16) implanted within fish and record the code, date, and time that the signal is detected. The battery life of these tags is projected to be 4.25 years. Starting in April 2004, green sturgeon were captured by gill net in the San Pablo Bay region of the San Francisco Bay Estuary. Fish in excess of 120 cm were surgically implanted with tags and released at the point of capture. Netting operations were targeted at spring (March-April) when adult fish were expected to be migrating up-river to spawn, and autumn (September-October) when fish residing in the estuary are thought to migrate back to the ocean, and have been conducted through April 2006. Additionally, fish have been captured by hook and line in a reach of the Sacramento River near Hamilton City, CA (river kilometer [rkm] 330), in which green sturgeon are occasionally caught by anglers. To date, 291 fish have been captured overall by UC Davis scientists and 95 were tagged in San Pablo Bay and 14 in the Sacramento River. An additional 40 sturgeon have been captured and tagged in the river by biologists working for the Glen-Colusa Irrigation District. A further 140 green sturgeon have been tagged by NMFS biologists in the Willapa and Columbia River estuaries in Washington State. These fish are also primarily from the southern DPS and have been detected by our array.

The initial rate of tag detections was low, with few tagged fish found traveling significant distances up-river. This corresponds to similar experiences by researchers studying green sturgeon on the Rogue River, Orgeon (northern DPS) and also in other species of sturgeon such as shortnose (*A. oxyrinchus desotoi*) and Atlantic (*A. oxyrinchus oxyrinchus*). It has been suggested that the stress stemming from capture, transport, holding, and tagging surgery induces fish to shorten or even abort their migratory movements. However, tag returns in subsequent years have been improving. We have currently detected 63% of all UCD tagged fish in arrays from Washington State to Monterey Bay, CA. Additionally, fish tagged by both UCD and NMFS have been detected in the Sacramento River as far north as Cow Creek (rkm 451). Given the long life of the beacons and the reported spawning interval of 2-5 years for this species, it is expected that tagged fish that may not have spawned the year of tagging due to the handling stress will now be returning to the river. We anticipate a high level of returns over the next two spawning seasons. Additionally, it is expected that some fish may make repeated returns during the life of the tags, providing a measure of spawning periodicity for this species in the wild.

Task 2: Physiological Studies (Cech, Jr., J.J., co-PI)

The temperature of the Sacramento River and Delta can range from approximately 8-23° C through the seasons (Edmunds 1997). The salinity of the San Francisco Estuary at Point San Pablo ranges from 0-15 psu per year (Ruhl 2001). Allen (2005) showed that during their first two years of their life, juvenile green sturgeon can tolerate increasing salinities as they develop reaching full sea water tolerance at a total length of 30 cm. Our objective is to determine the temperature and salinity preferences of young-of-the-year and age-1 green sturgeon, creating a framework of physiological preference parameters, on which to base management decisions. Jobling's (1981) review showed that, when given a choice, fishes select temperatures that are optimal for growth. By including sturgeon preference for temperature and salinity into their life history models, managing agencies can predict habitats for which young-of-the-year sturgeon have a greater affinity.

Although laboratory-based measurements of environmental preference have been conducted for at least three decades (Garside et al. 1977), traditional thermal and salinity preference apparatuses for fishes have significant drawbacks, limiting their usefulness. The presence of confounding variables such as depth-related stratification, apparent cover, or variations in light intensity can influence the results of preference experiments. An annular ring-shaped chamber for aquatic animal preference studies was conceived and constructed to overcome these drawbacks (Myrick et al. 2004). This annular design presents a gradient to the fish, via cross-channel flows of chilled, ambient, and heated water, or of "high," "medium," and "low" (e.g., freshwater) salinity. The constantly moving water maintains the gradient and prevents stratification in the annular preference chamber. The value of this design has been demonstrated for thermal preference in recent papers with juvenile steelhead trout (mean 33 g live weight, Myrick *et al.* 2004) and very small juvenile green sturgeon (mean 38 g live weight, Mayfield and Cech 2004). The primary drawback to these experiments is the existing chamber's small size (1 m diameter), limiting its usefulness only to small fishes. A large scale version of this apparatus has recently been constructed at UCD and provides us with the opportunity to determine temperature and salinity optima for larger, more mature green sturgeon, such as would be found in the lower river and estuary.

Task 3: Developmental Studies (Doroshov, S.I., co-PI)

Knowledge of reproductive development is critical for the protection and restoration of green sturgeon stocks. Information on this species' reproduction was extremely scarce before 1999. With funding from CALFED, we have developed methods for handling and transport of wild-caught broodfish, hormonal induction of spawning, *in vitro* fertilization, egg incubation, and larval rearing, allowing the use of captive-spawned green sturgeon for experimental research (Van Eenennaam *et al,* 2001, 2005b). We described the stages of development from fertilization to metamorphosis (Deng 2000). Comparisons with white sturgeon revealed some morphological differences in development, and that green sturgeon eggs, larvae, and juveniles were twice larger by weight, indicating different reproductive strategies between the two species (Deng *et al.* 2002). The study of routine metabolism in the species' larvae from hatching to 31 d post hatch revealed high metabolic rates and oxygen requirements, especially during the yolk-feeding phase (Gisbert *et al.* 2001). Histology of the digestive system in fed and food-deprived larvae showed that they only briefly withstand starvation after yolk resorption (Gisbert & Doroshov 2003).

Temperature optima for the development and survival of green sturgeon embryos were 12-17^{o} C, with significant increases of abnormality rates at 17.5-22^{o} C and complete mortalities at temperatures >22^{o} C (Van Eenennaam *et al.*, 2005a). The yolk-sac larvae, hatched at incubation temperature 15-16^{o} C, tolerated the range of 22-26^{o} C, but the abnormality rates significantly increased at 24-26 ^{o} C and temperatures >26^{o} C were lethal for larvae (Linares-Casenave *et al.* in prep.). We also examined reproductive traits in two-hundred mature individuals sampled during the spawning migration (April-June, 1999-2003) in the Klamath River (Van Eenennaam *et al.* 2006). The age of the spawning stock ranged between 14-40 years and 152-242 cm in total length, with a bimodal distribution of sexes (older and larger females). Mean fecundity and egg diameter were 142,000 and 4.33 mm respectively, and both traits were correlated with female length. Analysis of the species' development and reproductive traits provided new information needed for the modeling of population dynamics and viability.

We are currently investigating gametogenesis and sexual maturation in captive green sturgeon cohorts. Heretofore, we characterized gonads and sex differentiation, spermatogenesis, and the early phase of ovarian cycle, and correlated germ cell development with the growth of fish. We have male stock that have completed the first reproductive cycle at age 4, but the females are just beginning vitellogenesis at age 6. Vitellogenesis (the synthesis of yolk precursor and egg growth) and a final ovarian maturation (egg maturation and ovulation) are the two most important processes of the female reproductive cycle, determining the age of reproductive maturity and breeding intervals. We anticipate vitellogenesis, final ovarian maturation and spawning of the female green sturgeon in our captive brood-stock, to occur during the period of this project (2007 and 2008).

Task 4: Genetic Studies (May, B.P, co-PI)

With funding from CALFED, genetic data on more than 1200 green sturgeon, ranging in distribution from Washington State estuaries to spawning areas on the Sacramento River have been collected. This information is beginning to yield critical information for the management and protection of the species. Ten polymorphic microsatellite DNA loci have been utilized to characterize individual genotypes for analyzing the population structure of the species, the proportion of distinct populations in mixed estuarine aggregations, and the relatedness of juveniles captured in natal spawning areas. The majority of these markers are tetrasomic (exhibiting four gene doses), which makes traditional genetic analyses difficult without transformation of the data into the more common disomic pattern, exhibited by most organisms.

Genetic data have proven critical to delineating greens sturgeon populations, one on the Sacramento River (Southern DPS) and one spawning in the Klamath and Rogue Rivers (Northern DPS). Based on an analysis of spawning adults and juveniles from multiple years from four rivers on a neighbor joining gene tree (Fig. 2), the fish in the Klamath, Umpqua and Rogue Rivers are genetically distinct from the fish in the Sacramento River. Individual genotypes, representing each sample's genetic fingerprint, have also been examined with the program STRUCTURE to evaluate the origins of green sturgeon present in the estuarine aggregations. This program clusters the individuals from each region into populations by minimizing the genetic signatures of genetic mixtures (Hardy-Weinberg disequilibrium, significant F_{IS} values).

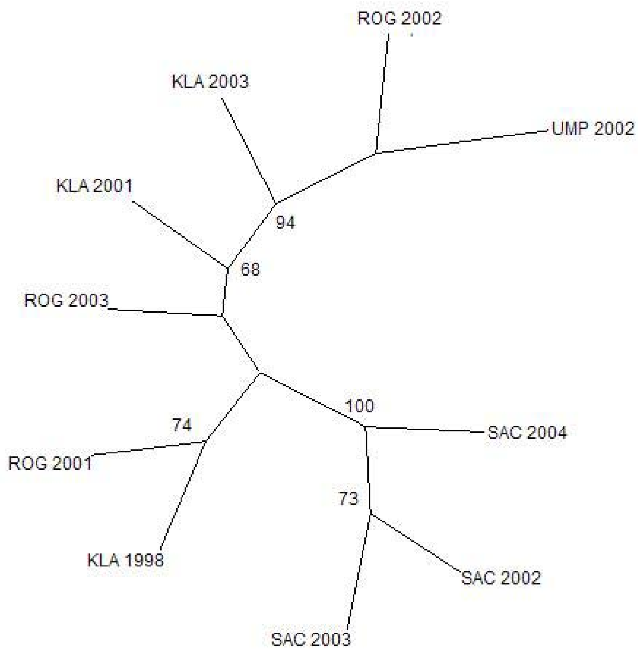

Figure 2. A neighbor-joining tree showing the relationship between in-river collections from the southern and northern green sturgeon DPSs. Bootstrap values were calculated from 1000 replicates, and values greater than 50 are noted. Locations are coded as follows: KLA=Klamath, ROG=Rogue, UMP=Umpqua, SAC=Sacramento River, and year of collection is noted adjacent to location code.

The analysis demonstrates that the DNA samples from San Pablo Bay, CA, the Columbia River, WA, and Willapa Bay, WA are representative of fish from the Northern and Southern DPS's in similar proportions (Fig. 3); however, Southern DPS fish dominate green sturgeon collected in these locations, and by-catch of green sturgeon in estuaries located in the northern DPS warrants additional management consideration. These proportions appear to be temporally stable among collections from different years but similar locations (Columbia River, San Pablo Bay). Green sturgeon collected from Grays Harbor, WA, and Winchester Bay, OR, appear to also represent a mixed group, although more equitably divided between southern and northern DPS's. Potential hypotheses for this may be the distinct environmental conditions in the smaller estuaries compared to the larger estuaries, which are dominated by southern DPS fishes, or the proximity of Winchester Bay to coastally migrating northern DPS fishes and a spatial limitation of southern DPS migration into Grays Harbor, which is the most northern estuary that has been sampled. We propose to continue genetic monitoring of green sturgeon in estuaries via fisheries-independent methods (agency surveys) and fisheries-dependent methods (by-catch, commercial, and recreational fisheries) is critical to identifying the threats of these fisheries in estuaries, regardless of their location in northern or southern DPS waters.

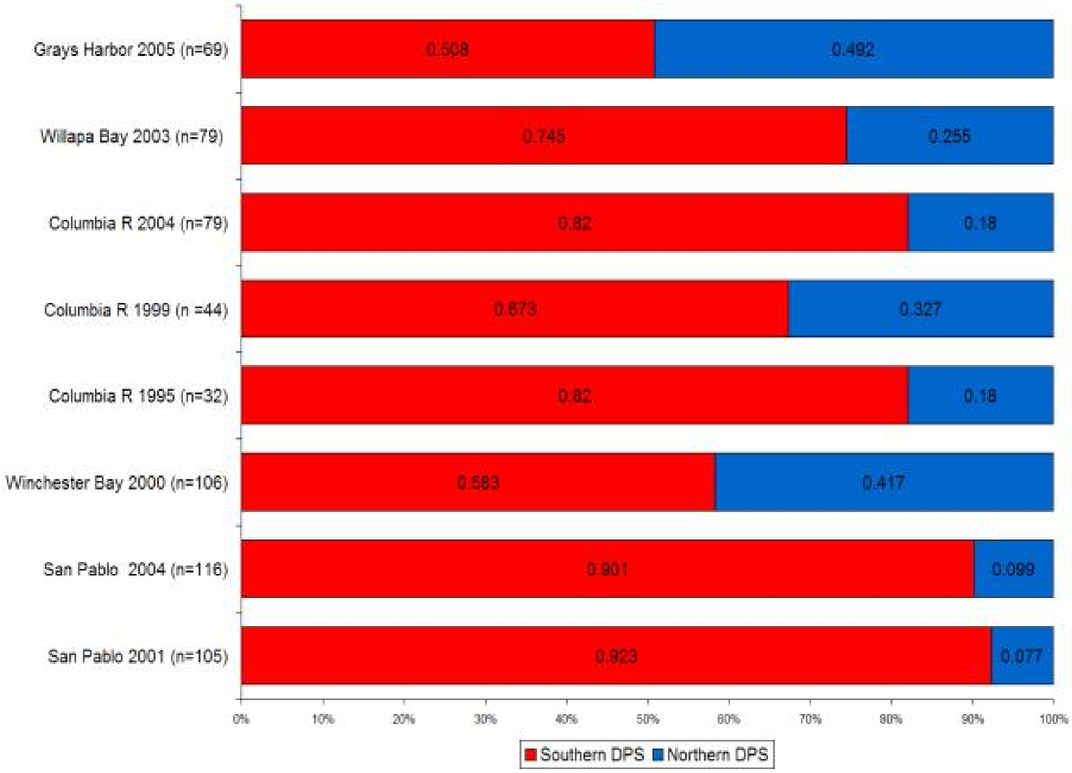

Fig. 3. Proportion of green sturgeon originating from Southern and Northern DPSs in estuarine collections from five locations.

The ability of genetic data to identify the kinship of individuals has provided the basis for deriving the minimum number of green sturgeon spawning in distinct segments of the Sacramento River. By transforming individual's genotypes (disomic and tetrasomic data) into allelic phenotypes, using the presence or absence of each allele, the genetic identity of fish collected from discrete reaches of the river can be compared to individuals of known relationship. In previous phases of this research, full sibling families (individuals with brother-sister relatedness) were spawned as part of the reproductive biology tasks. Gene trees have been constructed to show the relationship between these known full-sibling individuals and juveniles collected at Red Bluff Diversion Dam (see Fig. 4). We estimated a range of 18-42 annual spawners above the dam from tissue samples taken from juveniles during 2002-2005, though we have not yet identified a clear relationship between the abundance of spawners and the number of samples, the period over which they were collected, or the water year type occurring during a particular year. We propose to continue genetic monitoring of individuals captured in distinct reaches, to evaluate whether relationships exist between our genetic estimates of spawner abundance and sampling design or environmental factors. If green sturgeon samples are collected rigorously, it is possible this method can serve an index of spawner adundance in the Sacramento River.

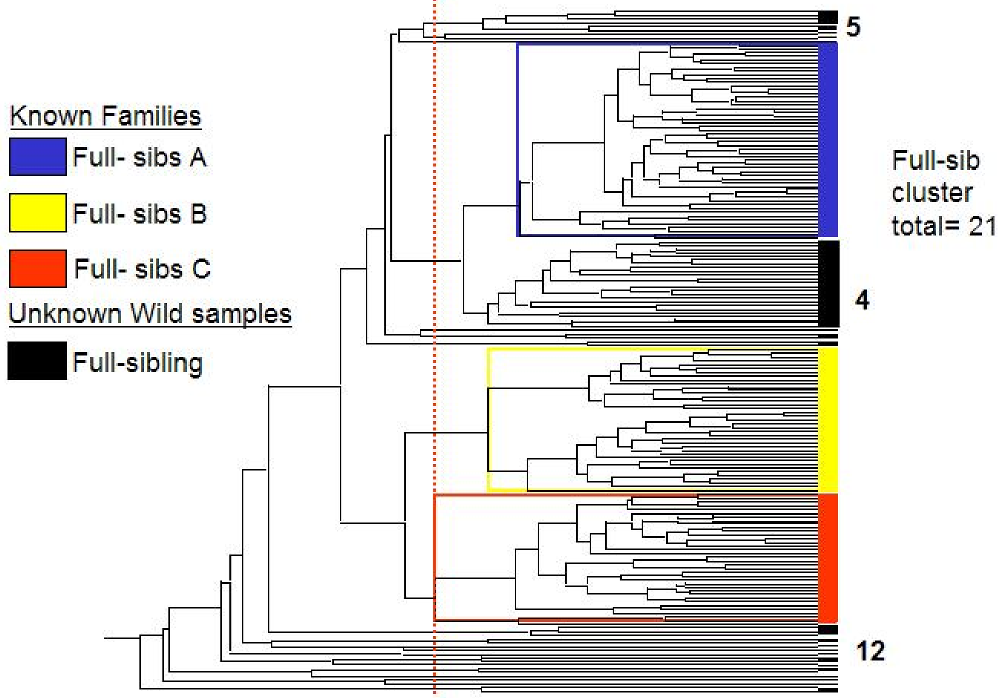

Fig. 4. A UPGMA dendrogram demonstrating the partitioning of full-sibling clusters of wild juveniles. Three known full-sibling families (spawned in previous CALFED-funded study phases) are used to partition individuals originating from the same set of parents. The dashed vertical red line represents the largest relatedness values (longest branches within a known full-sibling family) to partition a family from the same spawning pair. Each cluster (group of individual) with a coalescent point at or to the right of the dotted line infers a single breeding pair of green sturgeon. The number to the right represent the number of full-sibling clusters in each region of the gene tree.

Task 5: Project Management and Information Dissemination (Klimley, A.P., PI)

The green sturgeon was long classified as a "Species of Special Concern", yet little biological information existed for this species prior to 1999. For that reason AFRP supported an intensive study of its basic biology by a multidisciplinary team of scientists (Cech, Doroshov, Klimley, and May, PIs) at the University of California, Davis. The studies included laboratory research focused on the physiology and reproductive biology of the species, genetic analyses of samples collected throughout the species' range, and field telemetric studies to describe the movements and distribution of subadult and adult GS in the San Francisco Bay Estuary. CALFED continued to support this research program another two years (Klimley, Cech, Doroshov, May, and Werner, PIs), which permitted the expansion of its geographic scope to include tracking the movements of fish, tagged in San Pablo Bay, throughout the Sacramento-San watershed.

We have presented the results of these studies at scientific conferences such as the Biennial CALFED Bay-Delta Program Science Conference, the San Francisco Bay-Delta Estuary State of the Estuary Conference, and the meeting of the California-Nevada Chapter of the AFS. The results of presentations given at the symposium, entitled "Green sturgeon and their environment," held at the 2005 AFS meeting in Sacramento will soon appear in a Special Issue of *Environmental Biology of Fishes*. See the bold references in the "Reference" section for the articles published on green sturgeon resulting from this research program.

C2. Project Goals and Objectives:

Task 1: Telemetric Studies

1) Describe the timing and duration of movements of adult green sturgeon during their spawning migration in the Sacramento River.
2) Find reaches of river where adult green sturgeon spawn and describe the environmental properties of these reaches.
3) Determine interval between repeated spawning in at-large fish.
4) Describe the large-scale movement patterns of juvenile green sturgeon of different age cohorts during their rearing period in the Sacramento River, Delta, and Estuary.
5) Identify regions of Sacramento River, Delta, and Bay where juveniles reside and characterize the environmental properties associated with their rearing habitat(s).

Task 2: Physiological Studies (Cech, Jr., J.J., co-PI)

1) Experimentally demonstrate the preferences of young-of-the-year and age-1 green sturgeon for temperatures and salinities gradients throughout the Sacramento River and Delta, when accustomed to certain thermal and saline conditions where they reside.

Task 3: Developmental Studies (Doroshov, S.I., co-PI)

1) Determine the age and size at first maturity and breeding intervals
2) Develop and evaluate noninvasive diagnosis of sex and maturity in green sturgeon, using ultrasound.

Task 4: Genetic Studies (May, B.P, co-PI)

1) Determine the number of green sturgeon spawning in distinct segments of the Sacramento River between 2006 and 2008.
2) Determine the proportion of green sturgeon originating from the Sacramento River found in San Pablo Bay during 2006.

Task 5: Project Management and Information Dissemination (Klimley, A.P., co-PI)

1) Submit progress reports twice yearly with an accounting of budgetary expenses.

2) Organize a cluster of posters, one for each Task, at a public meeting during Year 1 of the grant.
3) Hold a symposium, at which talks will be given reporting the biological information collected during the grant period, at the California-Nevada chapter meeting of the American Fisheries Society at the end of Year 2.
4) Prepare final report at end of two year, grant period.

C3. Approach/Methodology:

Task 1: Telemetric Studies

With the monitor array already in place and a large number of tagged fish at large, we are ideally positioned to identify critical riverine habitat for adults of this threatened species. Additionally, the existing array can be used to study the downstream movements of tagged juvenile green sturgeon, determining the rate of movement downstream during out-migration, depth, salinity and temperature preferences, and identifying the location of holding and rearing habitat.

Continuation of on-going adult spawning migration study. An array of 35 VR2 monitors is already in place in the Sacramento River, augmented by additional arrays maintained by NOAA, the Army Corps of Engineers, and other regional agencies. Specific reaches of the river are of critical interest to us. Therefore, we propose to increase monitor coverage in those areas. A total of ten additional tag-detecting monitors will be placed during Year 1 at suspected spawning sites near Cow Creek, Jelly's Ferry (rkm 430), Bend (rkm 409), and Payne's Creek (rkm 405) as well as at Hamilton City, where the fish are thought to hold over summer. Two monitors will be placed at each location to ensure tags are detected. The monitors will be maintained and downloaded monthly during the summer by UCD and collaborators at United States Fish and Wildlife Service (USFWS).

The fish currently at large are internally tagged with pingers whose signal interval varies randomly between 40-114 seconds. These long inter-pulse intervals are suitable for long-term monitoring studies because it maximizes battery life; however, the long interval is not optimal for manual relocations since the long periods increase the chance of the listener passing by the fish without detecting it. To address this, five additional sturgeon will be tagged each year in the Sacramento River using high power tags with a short interval (5-30 seconds) and a depth sensor. Fish will be captured by hook and line in spring (April-May) once they have already entered the river and started their upstream migration. To minimize handling stress, fish will be externally tagged. Tags will be affixed to the sturgeon with a tether by either passing through the dorsal fin or through the dorsal musculature. A genetic tissue sample will also be collected from a fin for use in Task 4. The fish will not be anesthetized or removed from the water, and handling time will be limited to 1-2 minutes.

When sturgeon are known to be in the system, either newly-tagged fish or returning migrants detected within the array, we will attempt to find their exact location using a portable receiver (Vemco Ltd, VR100), targeting our efforts in the reach bracketed by the monitor at which the fish was most recently detected and the next adjacent monitor downstream or upstream respectively. The positions of relocated fish will be recorded and the habitat of that location described using multiple techniques. Current speed will be measured with a velocity meter at the depths at which the fish was detected, and a multi-parameter water quality sensor will record water temperature, salinity, and oxygen content as a function of depth. Additionally, we will use a remotely operated vehicle (ROV) to assess the local substrate composition and available cover. To verify that spawning is actually occurring in these reaches, benthic D-nets will be used to capture eggs and larvae in these reaches and aged to evaluate if they were spawned in the reach. To validate that ultrasonically-tagged green sturgeon are spawning, DNA from eggs and larvae and potential parents, located upstream of the collection point, will be analyzed to determine the parent-offspring relationship (see Task 4).

Juvenile movements and identification of critical rearing habitat. While research is ongoing to identify critical habitat for spawning adults, little is known about the movements of green sturgeon during the juvenile stage (<100 cm). Based on captures in rotary screw traps operated by the USFWS and CDFG, the species is thought to reside in the river during its first year of life, slowly moving downriver during this period. The species is known to become tolerant of saline conditions at approximately 30 cm, a length attained in the wild at about age 1+, which correlates with the collection of larger juvenile fish (20-100 cm TL) at lower-river fish salvage facilities and netted in the delta (Radtke 1966). Juveniles are then thought to reside in the estuary for 1-4 years before initiating their first oceanic out-migration.

Fig. 5. Miniature coded ultrasonic beacon recently developed by Vemco, Ltd. of Halifax for tracking juvenile sturgeon and salmon smolts. This miniature tag has a diameter of 7 mm, minimum length of 17.5 mm, and a battery life of approximately 200 days.

We propose to capture juvenile green sturgeon in two locations in the Sacramento River watershed. First, 20 of the small juveniles (10-15 cm) routinely caught in the rotary screw traps at Red Bluff Diversion Dam will be transferred to holding tanks at Coleman National Fish Hatchery operated by USFWS. Fish will be held in captivity, fed ad libitum rations, and grown to a length of 20 cm, the smallest size capable of carrying a tag. At this size, a small, coded ultrasonic beacon (Vemco Ltd., V7-2H, Fig. 5) will be < 2% body mass of the fish, below the customary 2% tag to fish mass ratio. The fish will be anesthetized and internally tagged, and then returned to the river where their movements will be detected with the existing VR2 monitor array. Additionally, 30 young-of-the-year green sturgeon will be captured by gill net in the Sacramento River Delta (see capture location, Fig. 6), in the putative nursery grounds of the species. These fish will be tagged when captured and immediately released. Genetic samples will be collected from all captured fish for use in Task 4. An additional 52 monitors will be placed throughout the Delta to record the movements of the species during this critical rearing period. Due to the shorter battery life of these small tags (approximately 200 days), tagging will be conducted during the spring and summer of each year. Ten additional monitors will be purchased in Year Two to replace equipment lost or damaged in the river and delta arrays during high winter flows.

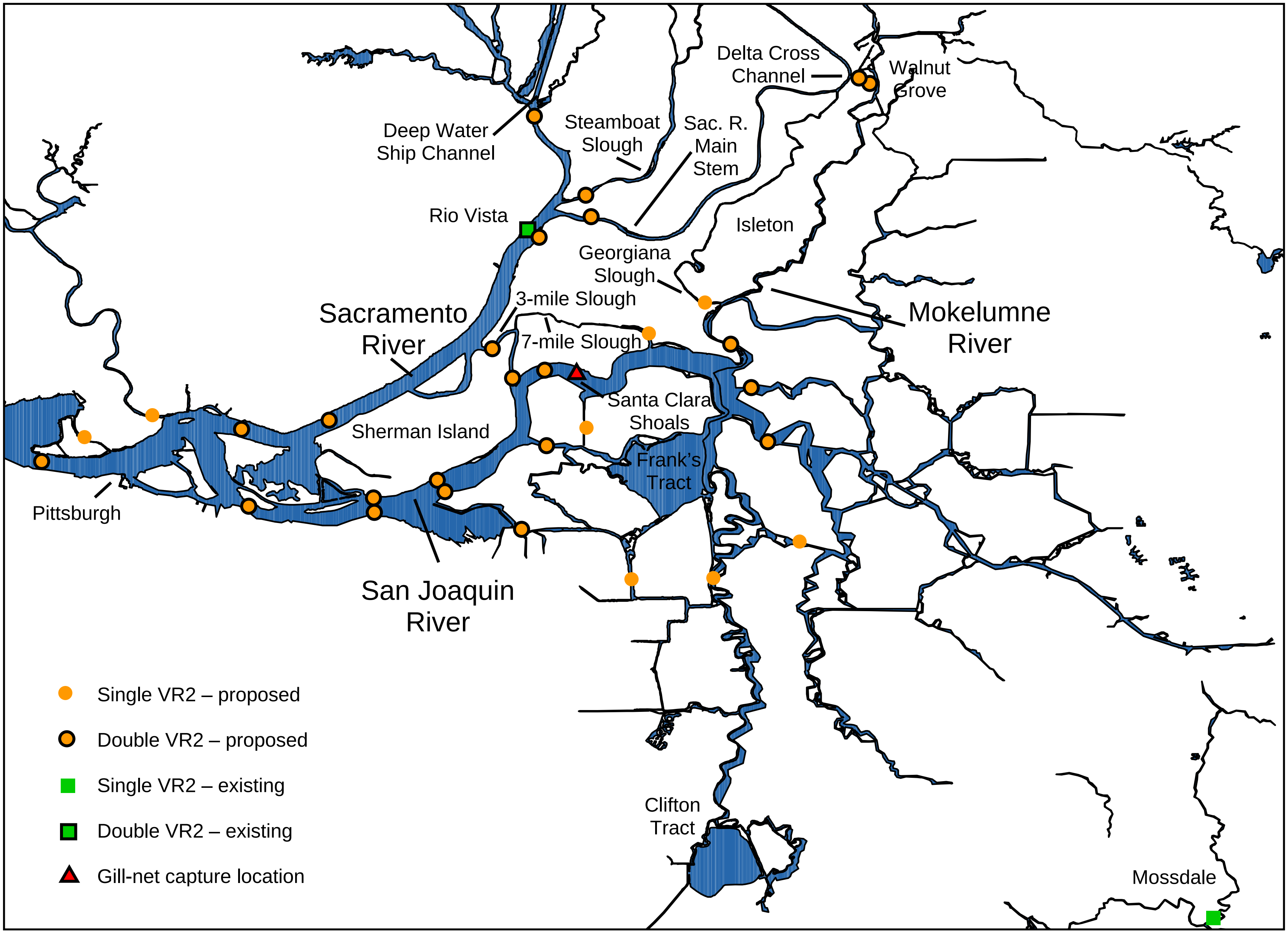

Fig. 6. Distribution of VR2 monitors in the Delta. This array will help us answer the following questions: 1) do GS range widely or remain in a small portion of the delta, and if so, which region is most important, 2) do GS pass regularly between the Sacramento and San Joaquin watersheds, 3) in which general habitats (deep channel, narrow slough, shallow bay) do they reside in, and 4) do the flows in the Delta-Cross channel affect GS movements?

In addition to the movement records from the monitors, thermal loggers attached to the VR2's will also record water temperatures. We will combine the time series of temperature measurements with time series of flows recorded by existing meters situated throughout the Delta. A series of high resolution maps exist for the Sacramento River, giving the percentages of different types of habitat per designated reach length and location. Additionally, NMFS scientists have created a database within ArcView for the Sacramento River as part of a CALFED-funded, UCD-NMFS project on the rates of survival and outmigration of salmon smolts. Using these data sources, synoptic maps of temperature as well as salinity, oxygen, and flow vectors from other sources will be superimposed on maps of the distribution of juvenile sturgeon to describe their residency patterns, physiological needs and preferred habitats. Information of this nature will permit NMFS to designate critical habitat and draft a recovery plan in accordance with the requirements of the ESA. Additionally, a clear understanding of the habitat requirements of the species at different stages of its life history will be of great value for determining the influence of hydrology on the availability of habitat.

Task 2: Physiological Studies

A large, 3-m diameter chamber for testing the thermal and saline preferences of fishes was recently completed by staff of the UCD Engineering School based on our specifications (Fig. 7). It is situated at the UCD Center for Aquatic Biology and Aquaculture. Replicated measurements of preferences of sub-adult sturgeon (>500 g live weight) can be made within the chamber. We propose to conduct preference tests with green sturgeon in 1-h experiments, with the location of the fish and the corresponding water temperature data recorded at 2-min intervals. Fish will be able to swim easily around the entire annulus, minimizing possible space and time autocorrelation. Because juvenile green sturgeon are

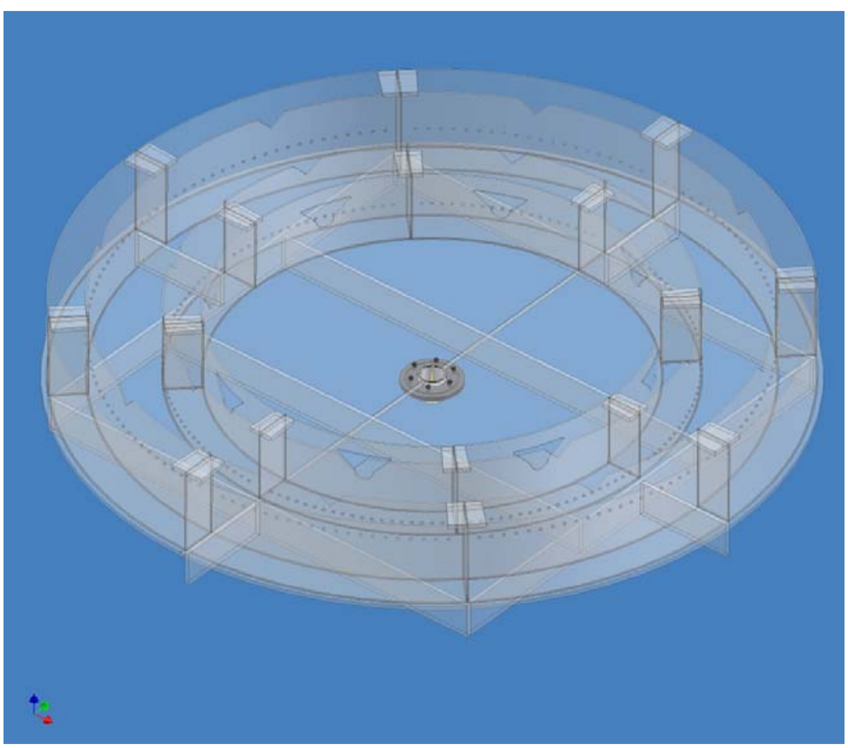

Fig. 7. Annular chamber for aquatic animal preference studies. When set up for temperature preference studies, this design presents a thermal gradient to the fish, via cross-channel flows of chilled, ambient, and heated water that flows from the outer ring's mixing chambers to the (central) drain. The chamber can also be set up to present salinity gradients from fresh to saline water.

not captured commonly in riverine and estuarine habitats, the laboratory data would establish preference limits and predict the likely distribution of these fish throughout the Sacramento-San Joaquin Estuary. We will determine the preferences of young-of-the-year and age-1 green sturgeon for temperatures and salinities ranging from 8-25°C and 0-15 psu (practical salinity units), respectively, when acclimated to 8, 12, 16, 20, and 25°C and 0, 5, 10, 15, and 20 psu. The results from these experiments would be used with United States Geological Service (USGS) hydrographic models, to construct spatially explicit life-history models of these fish.

Taking an eco-physiological approach to improving our understanding of green sturgeon habitat use involves testing their responses to two key environmental conditions that young-of-the-year fish will encounter: temperature and salinity. Temperature is a critical environmental variable, because of its profound effect on fishes and other ectothermic organisms (Randall et al. 2002). The temperatures of the Sacramento River and its estuary are influenced both by natural and anthropogenic factors. Water temperatures are controlled by input from tributary streams, incident radiation (which is reduced by riparian cover), and air temperatures as well as by man-made water releases from upstream reservoirs and agricultural runoff. Salinity also can alter sturgeon habitat use. Local salinities may be influenced by tidal intrusion into the estuary and by large water diversions for human use. Although the water flowing into the Sacramento Delta is diverted for agricultural use, the high spring flows from snow melting in the Sierras occur at the sturgeons' spawning time and can quickly flush larvae and small juveniles down stream (Moyle 2002). This will force the larvae and juveniles to make choices on habitat types, characterized by temperatures and salinities. Using our experimentally derived understanding of the preferences of the species, we may be able to identify favored habitats and likely juvenile sturgeon movements using USGS temperature and salinity models of the estuary. Predicted high affinity regions can become the focal point of habitat monitoring and restoration projects to protect this threatened species. The value of the laboratory-derived data would be their accuracy (especially if derived from fish with different temperature acclimation histories), speed (many life stages measured within a few months, after set up), and low cost.

Task 3: Developmental Studies

Based on our previous studies with the white sturgeon (Doroshov et al. 1997), we hypothesize that green sturgeon males mature earlier and at smaller size compared with females, and the reproductive cycles are annual in males and biennial in females. To test these hypotheses, we will continue rearing captive stocks of the species (N=55), which include two year-classes from the Klamath River and one mixed age cohort from the Sacramento River. The Klamath River stocks originated from wild brood fish bred at UCD in 1999 (n=22, age 7, mean weight 21 kg) and in 2000 (n=25, age 6, weight 18.5 kg). The Sacramento River fish were captured as larvae below the Red Bluff Diversion Dam during 1995 and 1996 (n=8, age 10-11, weight 23 kg). These stocks are reared in three 20-foot diameter flow-through outdoor tanks and fed artificial salmonid diet. Fish are individually tagged with a passive integrated transponder (PIT tag) and are sampled twice a year (May and November) for histological stage of gonad development and changes in length and weight. We will characterize gametogenesis, the full ovarian cycle and the repeated testicular cycles, age and size at first maturity, cycle time-intervals and gamete fertility. We will also develop a noninvasive diagnostic technique for determining gender and stage of maturity, using ultrasonography (Fig. 8).

Gametogenesis, reproductive cycle, and age and size at maturity. Gonads of individually tagged fish will be biopsied twice a year (May and November), and the fish weight and length will be measured. Gonadal tissue fixed in buffered formalin will be processed by conventional histology: dehydration, paraffin embedding, sectioning at 5-6 um, and staining with the H&E and PAS stains (Doroshov *et al.* 1991). Histological slides will be analyzed under a compound scope with a digital camera and imaging software. The staging of gametogenesis in males and females will follow Van Eenennaam and Doroshov (1998) and will be illustrated by photomicrographs. Stages of gametogenesis will be correlated with fish size and age, and the cycle interval will be determined as the time between the onset of vitellogenesis (female) or meiosis (male) and gonad maturation (eggs with peripheral germinal vesicles and differentiated sperm). Growth curves will be provided for each stock and sex. Mature green sturgeon, identified during the November sampling period, will be held in a cold water, and ovulation and spermiation will be induced by gonadotropin-releasing hormone (Van Eenennaam et al. 2001). The egg fertility, hatchability, and the size and viability of larvae will be measured to characterize the success of captive breeding techniques.

Non-invasive detection of gender and sexual maturity. Our study provides the unique opportunity to develop an ultrasound technique for detecting gender and the key stages of gonad maturity in green sturgeon (Fig. 8). Ultrasonography has recently been effective in

Fig. 8. Ultrasound transducer applied to the ventrum of a salmonid to determine its reproductive state. This same technology can be used to determine the histological stages of reproduction in green sturgeon in a less invasive way than surgery.

several sturgeon species (Colombo et al., 2004; Wildhaber et al., 2005) and is becoming the method of choice due to the elimination of the evasive surgical biopsy, which is particularly important for threatened and endangered species (Fig. 9). Ultrasound imaging has been used to measure ovary size in striped bass (Will et al., 2002), detect vitellogenic eggs in flatfishes and haddock (Martin-Robishaud and Rommens, 2001) and pre-spawning and post-spawning ovaries and testes in steelhead (Evans et al., 2004). Currently available laptop-sized, ultrasound models provide high capacity image storage, USB connection to the PC or network, and a variety of high resolution transducers. We propose to use ultrasound imaging, correlated with histological stages from biopsies, for detection of gender (testes or ovaries), measurement of gonad growth (length and cross-sectional area), detection of vitellogenic ovarian follicles (hyperechoic egg chorion), and the detection of pre-spawning, post-spawning, and atretic ovaries (changes in water content and echogeneity of gonadal tissues). The preliminary tests using the ultrasound system will be conducted with readily available farmed white sturgeon, which will be scanned with different transducers and at different stages of reproductive development and selectively euthanized and autopsied to precisely measure gonads and stage of development.

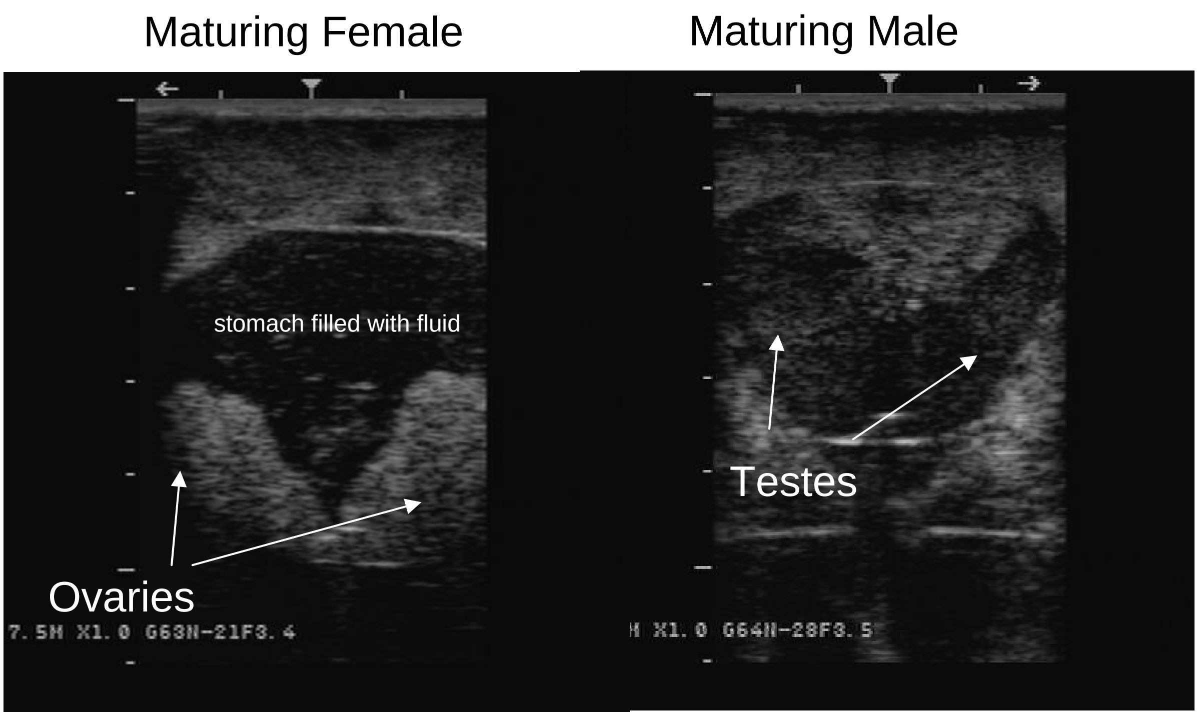

Fig. 9. Sonographs showing ovaries and testes of female and male Chinook salmon.

Once the ultrasound images and measurements have been calibrated using white sturgeon, we will systematically use ultrasound scanning when examining green sturgeon before gonadal biopsy are taken, store and analyze the images, and correlate the ultrasound data with histological stage of development. We anticipate accurate detection of gender (given the advanced age of our fish) and classification of at least four key stages of gonad development (immature, maturing, pre-spawning, and post-spawning or atretic), based on changes in gonad size and the echogeneity of germinal and somatic tissues.

Task 4: Genetic Studies

Green sturgeon spawning monitoring. Genetic analysis will be carried out on juvenile green sturgeon captured between April and July over three consecutive years (2006-2008) in the main stem of the Sacramento River. The DNA of multiple individuals above Red Bluff Diversion Dam will be compared to estimates of spawner abundance during previous years based on samples of their DNA, as well as in different reaches of the Sacramento River. We will collect individual microsatellite genotypes from juveniles collected during the summer by biologists from the USFWS, CDFG, and UCD during 2007 and 2008. Both cooperating agencies will use rotary screw traps to collect juveniles, one situated at Red Bluff Diversion Dam (Bill Poytress, pers. comm., USFWS) and the other at the Glenn-Colusa Irrigation Districts' intake (Diane Coulon, pers. comm., CDFG). Between June and August 2007 and 2008, biologists of UCD will collect juveniles using benthic D-nets to document spawning in reaches where ultrasonically tagged green sturgeon have been recorded by automated tag-detecting monitors. Genetic methods will analyze the relationship between tissue samples collected from tagged adults and juvenile and eggs collected by UCD biologists to verify spawning relationship of offspring with tagged individuals.

The methodology used to estimate the number of spawning pairs of green sturgeon upstream from captured juveniles was developed with past CALFED funding. We will build upon this procedure, which combines records of the DNA from groups of full siblings grown in the laboratory and wild juvenile green sturgeon collected by collaborators to identify full-siblings (brother-sister) to estimate the maximum number of contributing pairs in a sample. This theoretical method utilizes multiple jackknife sampling of the dataset to determine confidence intervals of the estimates.

Assessment of estuarine green sturgeon. We will collect genetic information about the estuarine green sturgeon aggregations of coastal migrants (subadults, adults) using tissue samples of green sturgeon obtained from CDFG, California Department of Water Resources, and UCD studies between 2006 and 2008. California Department of Fish and Game will conduct experimental fishing for sturgeon during 2006 and 2008. Biennial samples of subadult and adult green sturgeon will be compared to consider any temporal differences in the proportion of DPSs between years. In addition, surveys coordinated by the Interagency Ecological Program in the Delta may obtain green sturgeon egg and larvae for genetic analysis. Individual microsatellite DNA genotypes will be constructed for each individual at 10 to 15 loci. Two approaches, population clustering and individual assignment, will be compared to assess the proportion of green sturgeon from the northern and southern DPSs in each sample. A novel approach, which considers additional age and length information to assess the relationships assignment, among individuals of discrete age/length, will be developed to quantify the number of spawning individuals contributing to each discrete life history stages.

Application to management. Direct and indirect estimates of the number of spawning fish in discrete segments of the Sacramento River is lacking for green sturgeon. If the spawning population is monitored for a number of years, and a spawning periodicity determined, it will be possible to determine estimates of adult abundance. Annual estimates of spawning number of fish can be used to develop indices of productivity. The results of this additional research would continue to provide an annual estimate of number of green sturgeon above Red Bluff Diversion Dam. Additionally, these results will permit us estimate the number of green sturgeon spawning downstream of Red Bluff Diversion Dam, by distinguishing downstream full sibling clusters from clusters originating above the dam.

Understanding the relative contribution of Distinct Population Segments to mixed aggregations of coastal migrant green sturgeon is critical for managing the respective populations. Additionally, the ability to assign individuals to a population of origin could allow managers to use estuarine abundance information to determine the strength of age-classes, once an age/size-stage curve is constructed for southern green sturgeon DPS. This information is important in consideration of the viability of a population.

Task 5: Project Management and Information Dissemination

Progress reports will be submitted to CALFED twice yearly with an accounting of budgetary expenses. A cluster of posters will be created during Year 1 describing the methods and objectives of Tasks 1-4 of the sturgeon research program. The presentations will be included in a poster session at either the Biennial CALFED Bay-Delta Program Science Conference or the San Francisco Bay-Delta Estuary State of the Estuary Conference, depending on the start date of the grant. These two conferences are attended by consultants, agency scientists, and university scientists from around the region that will be interested in learning about our ongoing studies of the green sturgeon. The PI and graduate students working on the grant will organize a symposium on the biology of the green sturgeon at the end of Year 2 to be held at the California-Nevada Chapter meeting of the American Fisheries Society. Talks will be given with the results collected for Tasks 1-4 during the two year grant period. These results will then be published in an issue of *Environmental Biology of Fishes* or *Transactions of the American Fisheries Society*. The PI will also prepare the final report at end of the two-year, grant period.

C4. Tasks and Deliverables:

Task	**Task Title**	**Deliverable**	**Estimated Completion Dates**
1	Telemetric Studies	• Scientific paper(s) characterizing spawning habitat of adult green sturgeon in Sacramento River and distribution of juveniles in Delta	• 30 months within start date of contract
2	Physiological Studies	• Scientific paper(s) on the temperature and salinity preferences of juveniles	• 30 months within start date of contract
3	Developmental Studies	• Scientific paper(s) on the oogenesis in female and non-invasive determination of gonadal state in male and females	• 30 months within start date of contract
4	Genetic Studies	• Scientific paper(s) on the size of distribution of spawning population in the Sacramento River and genetic composition of the estuarine aggregations	• 30 months within start date of contract
5	Project Management and Information Dissemination	• Semi-Annual Progress Report • Posters from Biennial CALFED Bay-Delta Program Science Conference • Abstracts from California-Nevada Chapter meeting of the American Fisheries Society • Draft Final Report • Final Report • Project Close Out Report • Final Invoice	• Semi-annual report.Due 10th of July, Jan. • Within 12 months of contract start • Within 22 months of contract start • Within 22 months of contract start • Within 24 months of contract start • 30 days prior to end of the contract term • 30 to 60 days after Final Report is approved

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C5. Subcontractors:
(If Applicable; description of tasks and qualifications)

C6. Work Schedule:

Start Date: 1 October 2006
End Date 30 September 2008

Task 1: Telemetric Studies

Year 1 (2006-07): Capture, tag, and release 5 adults and 20 juveniles in river and 30 juveniles in delta. Maintain existing monitor array in river, deploy and maintain expanded array in Delta. Prepare annual report.

Year 2 (2007-08): Capture, tag, and release 5 adults and 20 juveniles in river and 30 juveniles in delta. Maintain monitor array. Prepare final report and manuscripts for publication.

Task 2: Physiological Studies

Year 1 (2006-07): Complete set-up, testing, and calibration of large environmental-preference chamber. Conduct preliminary tests with young-of-the-year green sturgeon juveniles in temperature and salinity gradients. Prepare annual report.

Year 2 (2007-08): Complete tests with young-of-the-year green sturgeon and with yearling green sturgeon juveniles in temperature and salinity gradients. Prepare final report and manuscripts for publication.

Task 3: Developmental Studies

Year 1 (2006-07): Complete histological analysis of gametogenesis and classification of stages. Conduct preliminary tests with the ultrasound, using farmed white sturgeon with known stage of development. Prepare annual report.

Year 2 (2007-08): Complete analysis of size and age at maturity and cycle time-interval in the green sturgeon stocks. Evaluate fertility of captive GS gametes and viability of larvae. Conduct the ultrasound study with the GS and summarize results. Prepare final report.

Task 4: Genetic Studies

Year 1 (2006-07): Complete genetic analysis of in river and estuarine green sturgeon samples. Coordinate standardized collection of samples for Year 2. Prepare annual report.

Year 2 (2007-08): Complete genetic analysis of in river and estuarine green sturgeon samples. Evaluate annual results in light of previous years' results. Prepare final report.

Task 5: Project Management and Information Dissemination

Year 1 (2006-07): Prepare semi-annual reports every six months. Organize poster session for Biennial CALFED Bay-Delta Program Science Conference.

Year 2 (2007-08): Prepare semi-annual report after six months. Host symposium on the biology of GS at the California-Nevada Chapter meeting of the American Fisheries Society. Prepare final report.

C7. Special Equipment and Supplies Required:

Task 1: Aluminum-hulled, outboard, jet-drive work boat for tracking adult green sturgeon in Sacramento River, setting nets to capture juveniles in the Delta, and for retrieving automated monitors to download files of tag-detections.

Task 3: Portable ultrasound receiver and transducer to provide images of the testes and ovaries of GS and determine their state of maturity.

C8. Project Impacts (beneficial or adverse):

Regulatory biologists of NMFS designated the southern population of the green Sturgeon, *Acipenser medirostris*, which inhabits the San Francisco Bay estuary, as "threatened" on 7 April 2006 under the Endangered Species Act. There is an immediate need for in-depth information about the population biology such as the number of spawning females, life history such as the age maturity of males and females and frequency of spawning, and habitat requirements of the species. Section 4(b) of the ESA mandates that NOAA Fisheries designate critical habitat including "cover or shelter... [and] sites for breeding, reproduction, [and] rearing of offspring."[2] To date, little is known about adult and

[2] Ibid. p17765.

juvenile migrations, and required spawning, holding, and rearing habitat. The telemetric (Task 1), physiological (Task 2), developmental (Task 3), and genetic studies (Task 4) proposed will provide this much needed information, and enable NMFS to conduct a jeopardy analysis, which will require identification of critical habitat within the watershed for juvenile and adult green sturgeon. Based on this analysis, NMFS will then be able to formulate a recovery plan for the species.

C9. Stakeholders and Interested Parties:

National Marine Fisheries Service

C10. Consistency with CALFED ERP Goals:*

1). Identify Project Applicability to Eco-Elements

Primary: Freshwater Fish Habitats
Secondary: Central Valley Stream Temperatures

2). Identify Project Applicability to ERP Goals and Objectives:

This study will provide an understanding where green sturgeon spawn, the environmental conditions promoting spawning, and those conditions present in nursery areas, where juveniles grow into subadults. This knowledge could be used to increase the suitability of habitat in the Delta and Suisun Bay for juvenile and adult sturgeon. In this respect, it would result in our reaching "Goal 1: endangered and other at-risk species, Objective 1: (to) achieve, first recovery, and then large self-sustaining populations of the following at-risk native species…(i.e.) the green sturgeon." Knowledge of the environmental preferences of the species could be used to achieve "Goal 2: ecological processes, Objective 1: establish and maintain hydrologic and hydrodynamic regimes for the Bay and Delta that support the recovery and restoration of native species".

3). Identify Project Applicability to Environmental Water Quality Constituents:

Primary: Nutrients and Oxygen Depleting Substances
Secondary: Sediment

4) Identify Project Applicability to CALFED ERP Stage 1 Milestones:

Milestone 17. "…Where appropriate provide adequate flows for…green sturgeon."

Milestone 66. "…Where appropriate provide adequate flows for…green sturgeon."

Milestone 96. "…Where appropriate provide adequate flows for…green sturgeon."

Milestone 115. "Conduct in-stream flow studies to determine the flows necessary to support all life stages of anadromous and estuarine fish species."

C11. Related Projects*

1). If this project is related to another restoration project, identify other projects by number and program (e.g. CALFED, CVPIA), and if CALFED, identify that relationship by category:

PART D. Budget Summary

D1. Budget

See attached worksheet.

PART E. Project Location Information

E1. Project Location(s): Sacramento River, Delta, and San Francisco Bay

E2. County or Counties Project is Located In: Multiple

E3. ERP Eco-Region, Eco-Zone, and Eco-Unit Project is Located In:*

E4. Project Centroid:
Latitude/Longitude Coordinates

E5. Project Map:
See Fig. 10 on following page.

E6. Digital Geographic File:*

E7. Congressional District:

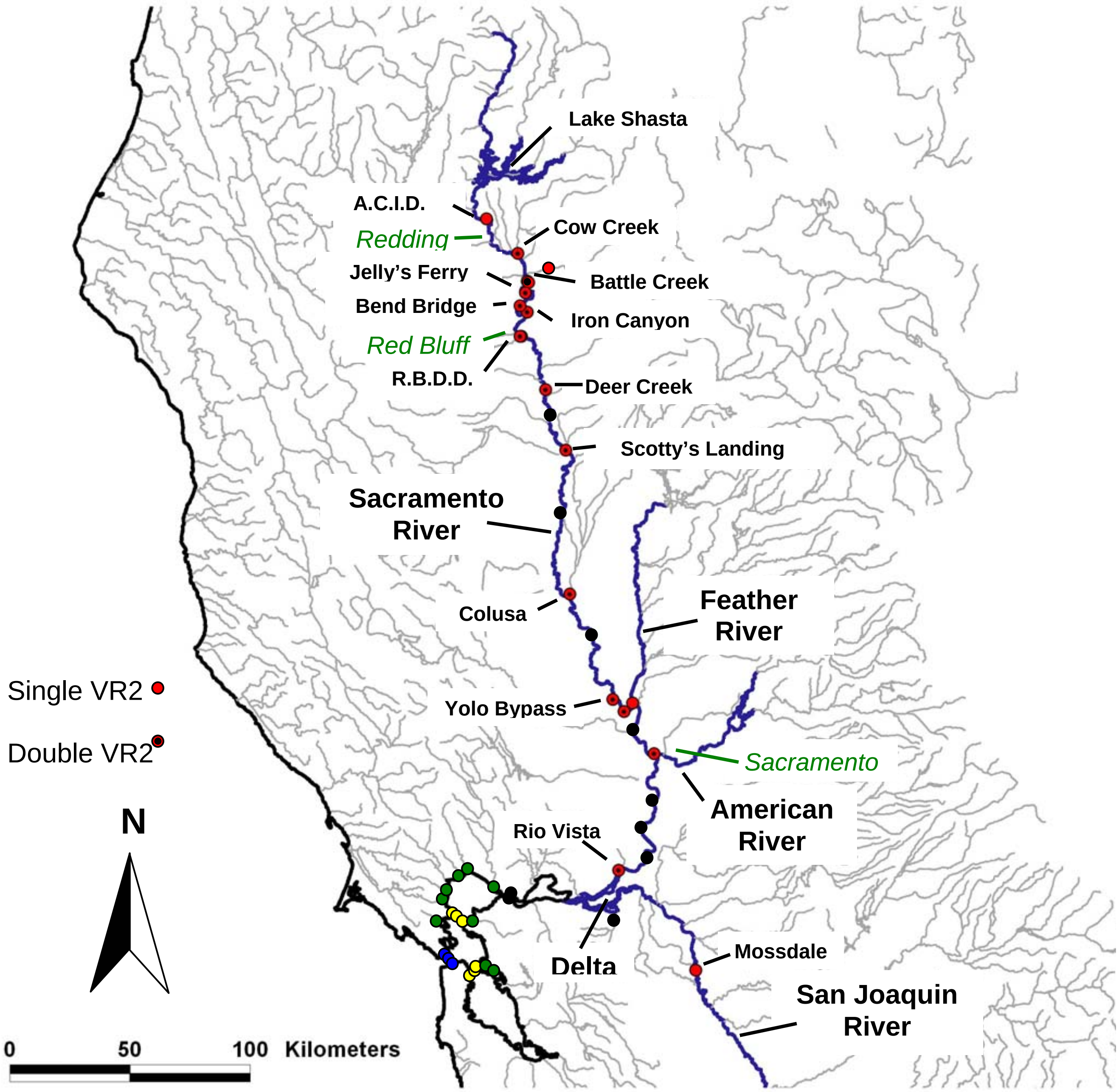

Fig.10. Sites of monitors (red circles) currently deployed in Sacramento River to identify green sturgeon spawning habitat. Note additional monitors will be placed throughout the Delta (not shown here, see Fig. 6). Sites of monitors in additional arrays to be established by UCD and NMFS for CALFED-funded salmon smolt study (black circles), Army Corps of Engineers (yellow circles), Bay Planning Coalition (green circles), and NMFS (blue circles). Note that all monitors are not shown in these additional arrays.

PART F. Environmental Information

F1. CEQA/NEPA Compliance

1). Will this project require compliance with CEQA, NEPA, both, or neither:* *Neither will be required.*

2). Is your project covered by either a Statutory or Categorical Exemption under CEQA or a Categorical Exclusion under NEPA:*

3). If your project requires additional CEQA/NEPA analysis, please indicate which type of documents will be prepared:

- Initial Study/Negative Declaration
- Environmental Assessment/FONSI
- EIR/CEQA Findings of Fact
- EIS/ Record of Decision

4). If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).

- CEQA Lead Agency:
- NEPA Lead Agency (Must be a Federal Agency):

5). If your project is not covered under items 2 or 3, and you checked no to question 1, please explain why compliance is not required for the actions in this proposal:

6). If the CEQA/NEPA process is not complete, please describe the estimated timelines for the process and the expected date of completion:

7). If the CEQA/NEPA document has been completed, what is the name of the document and provide State Clearinghouse number:

F2. Environmental Permitting and Approvals

Please indicate what permits or other approvals may be required for the activities contained in your proposal and which have already been obtained. Please indicate all that 1) are needed, and 2) if needed, have been obtained:

1). Local Permits and Approvals

- Conditional use permit
- Variance
- Subdivision Map Act
- Grading permit
- General plan amendment
- Specific plan approval
- Rezone
- Williamson Act Contract cancellation

- Other

2) State Permits and Approvals:
- Scientific collecting permit
- CESA compliance: 2081.1; Take authorization
- CESA compliance: 2080.1; Consistency determination
- CESA compliance: NCCP
- 1602: Lake or Streambed Alteration Permit
- CWA 401 certification
- Coastal development permit
- Reclamation Board approval
- Notification of DPC or BCDC
- Other

3) Federal Permits and Approvals:
- ESA compliance Section 7 consultation
- ESA compliance Section 10 permit: *We will prepare an application to sample individuals of the southern population of green sturgeon, which has been categorized as "threatened" by NMFS.*
- Rivers and Harbors Act
- CWA 404
- Other

PART G. Land Use Questionnaire

G1. Land Use Changes

1). Do the actions in the proposal involve physical changes in the land use, or potential future changes in land use (Yes/No): *No*

- If yes, describe what actions will occur on the land involved in the proposal.
- If no, explain what type of actions are involved in the proposal (i.e., research only, planning only).

2). How many acres of land will be subject to a land use change under the proposal:

3). Is the land subject to a land use change in the proposal currently under a Williamson Act contract (Yes/No):

4). For all lands subject to a land use change under the proposal, describe what entity or organization will manage the property and provide operations and maintenance services.

5). Does the applicant propose any modifications to the water right or change in the delivery of the water (Yes/No):

- If yes, please describe the modifications or changes:

G2. Current Land Use and Zoning

1). What is the current land use of the area subject to a land use change under the proposal:

2). What is the current zoning and general plan designation(s) for the property:

3). How is the land categorized on the Important Farmland Series (IFL) maps (published by the California Department of Conservation):

- Current land use:
- Current zoning:
- Current general plan designation:
- Mapping Category on the IFL Series Map:

G3. Land Acquisition

1). Will the applicant acquire any land under the proposal, either in fee or through a conservation easement (Yes/No): *No*

- If yes, describe the number of acres that will be acquired and whether the acquisition will be of fee title or a conservation easement:
- Total number of acres to be acquired under proposal:
- Number of acres to be acquired in fee:
- Number of acres to be subject to conservation easement:

2). For land acquisitions (fee title or easements), will existing water rights be acquired (Yes/No):

G4. Land Access

1). Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal (Yes/No): No

- If yes, attach written permission for access from the relevant property owner(s).

PART H. Qualifications of PIs

(ABBOTT) PETER KLIMLEY (PI, Tasks 1 & 5)

CONTACT INFORMATION
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University Of California, One Shields Avenue, Davis, California 95616
Tel: 530-752-5830, Fax: 530-752-4154, E-mail: apklimley@ucdavis.edu

EDUCATION
Ph.D. Scripps Institution of Oceanography, University of California, San Diego. 1982 (Marine Biology)
M.S. Rosenstiel School of Marine and Atmospheric Science, Univ. of Miami, Florida. 1976 (Biological Oceanography)
B.S. State University of New York, Stony Brook. 1970 (Zoology)

EMPLOYMENT
1999-Pres. Adjunct Associate Professor, Department of Wildlife, Fish, & Conservation Biology, University of California, Davis.
2001-2002 Senior Fisheries Ecologist, H.T. Harvey & Associates, San Jose.
1996-2001 Associate Research Behaviorist, Bodega Marine Laboratory, UC Davis.
1987-1995 Assistant Research Behaviorist, Bodega Marine Laboratory, UC Davis.

RESEARCH ASSOCIATE
2005-Pres. Research Associate, Clemson University, South Carolina
2003-Pres. Research Associate, Centro de Investigaciones Interdisciplanarios de Ciencias Marinas, La Paz, Mexico.
1997-Pres. Research Associate, Institute of Marine Science, Univ. of Calif., Santa Cruz.
1993-Pres. Research Associate, Point Reyes Bird Observatory, Bolinas

RESEARCH INTERESTS
Animal behavior and behavioral ecology of marine vertebrates; conservation, marine fisheries biology, ecology, and oceanography, development of behavioral and environmental sensors, computer-decoded telemetry, automated data logging, archival tags.

SOCIETIES
American Association for the Advancement of Science, American Elasmobranch Society, American Society of Ichthyologists and Herpetologists, Association for the Study of Animal Behavior, Sigma Xi , Member.

EDITOR
1997-Pres. *Oecologia*, Off-board Editor.
1995-Pres. *American Scientist*, Consulting Editor, Animal Behavior & Marine Biology.

REVIEWER

African Journal of Marine Science (South Africa), *Animal Behavior* (U.S.A.), *Australian Journal of Marine and Freshwater Research* (Australia), *Canadian Journal of Zoology* (Canada), *Ciencias Marinas* (Mexico), *Copeia* (U.S.A.), *Environmental Biology of Fishes* (Canada), *Experimental Marine Biology and Ecology (U.K.)*, *Fisheries Bulletin* (U.S.A.), *INTERFACE*, The Royal Society (U.K.), *Journal of Fish Biology* (U.K.), *Journal of Fisheries Management* (U.S.A.), *Marine Biology* (Germany), *Marine Ecology Progress Series* (U.S.A.), *Naturwissenschaften* (Germany), *Oecologia* (U.S.A.),*Transactions of the American Fisheries Society* (U.S.A.)

HONORS

1998 Certificate of Excellence in recognition of "excellence in concept, design and manufacture" for *Great White Sharks: The Biology of Carcharodon carcharias*, Bookbuilders West Book Show.

1995 SNAP EXCEL Silver Award, Magazines: Feature Article, "The predatory behavior of the white shark," *American Scientist*.

1994 Presidential Nomination, American Elasmobranch Society.

INTERNET

2005-Pres. Tagging of Pacific Pelagics (TOPP), Profile of APK (http://www.toppcensus.org).

2004-Present Biotelemetry Laboratory, Biographies of APK and graduate students with project descriptions (http://wfcb.ucdavis.edu/www/faculty/Pete).

1997-Present Dr. Hammerhead, NOVA/PBS Web Page, research featured and questions about shark biology answered [see www.pbs.org/wgbh/nova/sharks/masters/hammerhead.html].

SYMPOSIA

2005 The Green Sturgeon and Its Environment, 39th Annual Meeting, California-Nevada Chapter, American Fisheries Society, Holiday Inn Capital Plaza, Sacramento (with P.J. Allen, J.A. Israel, and J.T. Kelly).

2000 Revisiting the *Umwelt*: Environments of Animal Communication, University Club, UC Davis (with C.M. Greene, D.H. Owings, and L.A. Hart).

1992 Biology of the White Shark, Bodega Marine Laboratory, UC Davis, organized with D. Ainley.

BOOKS

Klimley, A.P. In prep. *The Biology of the Sharks, Rays, and Chimaeras.* California University Press, Berkeley.

Klimley, A.P., P. Allen, J. Israel, and J. Kelly (Eds). In press. *The green sturgeon, Acipenser medirostris, and Its Environment.* Kluwer Press, Amsterdam.

Klimley, A.P. 2003. *The Secret Life of Sharks: A Leading Biologist Reveals the Mysteries of Shark Behavior*. Simon and Schuster, New York, 292 pp.

Greene, C.M., D.H. Owings, L.A. Hart, and A.P. Klimley. 2002. Revisiting the *Umwelt*: Environments of Animal Communication. Monograph, *Journal of Comp.Psychology*.

Klimley, A.P. and D.G. Ainley (Eds). 1996. *Great White Sharks: The Biology of Carcharodon carcharias*. Academic Press, San Diego, 528 pp.

PUBLICATIONS (articles in bold are relevant to proposal)

Kelly, J.T., A.P. Klimley, and C.E. Crocker. *In Press*. Movements of green sturgeon, *Acipenser medirostris*, in the San Francisco Bay Estuary, California. *Env. Biol. Fish.*

Klimley, A.P., J.T. Kelly, and R.L. Kihslinger. 2005. Directional and non-directional movements of bat rays, *Myliobatis californica*, in Tomales Bay, California. *Environmental Biology of Fishes*, 74:79-88.

Klimley, A.P., J.E. Richert, and S.J. Jorgensen. 2005. The home of blue water fish. *American Scientist*, 93:42-49.

Kelly, J.T and A.P. Klimley. 2003. The occurrence of the white shark, *Carcharodon carcharias*, at Point Reyes Headlands, California. *Bulletin of California Fish and Game*, 89: 187-196.

Muhlia-Melo, A., P. Klimley, R. González-Armas, S. Jorgensen, A. Trasviña-Castro, J. Rodriguez-Romero, and A. Amador-Buenrostro. 2003. Study of the pelagic assemblages of the Espiritu Santo seamount during El Niño 97-98 conditions. *Geophysica Internacional*, 42: 473-481.

Klimley, A.P., S.J. Jorgensen, A. Muhlia-Melo, and S.C. Beavers. 2003. Movements of yellowfin tuna (Thunnus albacares) to and from Espiritu Santo Seamount in Gulf of California. Fisheries Bulletin, 101: 684-692.

Greene, C.M., D.H. Owings, L.A. Hart, A.P. Klimley. 2002. Revisiting the *umwelt*: environments of animal communication. *Journal of Comparative Psychology*, 116: 115.

Kihslinger, R.L. and A.P. Klimley. 2002. Species identity and the temporal characteristics of fish acoustic signals. *Journal of Comparative Psychology,* 116: 210-214.

Klimley, A.P., S. C. Beavers, T.H. Curtis, and S.J. Jorgensen. 2002. Movements and swimming behavior of three species of sharks in La Jolla Canyon, California. *Environmental Biology of Fishes*, 63: 117-135.

Klimley, A.P., B.J. Le Boeuf, K.M. Cantara, J.E. Richert, S.F. Davis, S. Van Sommeran, and J.T. Kelly. 2001. The hunting strategy of white sharks at a pinniped colony. Marine Biology, 13: 617-636.

Klimley, A.P., B.J. Le Boeuf, K.M. Cantara, J.E. Richert, S.F. Davis, and S. Van Sommeran. 2001. Radio-acoustic positioning: a tool for studying site-specific behavior of the white shark and large marine vertebrates. *Marine Biology*, 138:429-446.

Klimley, A.P. 1999. Sharks beware. *American Scientist*, 87: 488-491.

Klimley, A.P. and C. Holloway. 1999. Homing synchronicity and schooling fidelity by yellowfin tuna. *Marine Biology*, 133: 307-317.

Klimley, A.P. and S.C. Beavers. 1998. Playback of ATOC-type signal to bony fishes to evaluate phonotaxis. *Journal of Acoustic Society of America*, 104:2506-2510.

Klimley, A.P., F. Voegeli, S.C. Beavers, and B.J. Le Boeuf. 1998. Automated listening stations for tagged marine fishes. *Marine Technology Journal*, 32: 94-101.

Klimley, A.P. and C. Holloway. 1997. Benchmark tests of accuracy of two archival tags. P. 34 *in* Boehlert, G.W. (Ed.), Application of Acoustic and Archival Tags to Assess

Estuarine, Nearshore, and Offshore Habitat Utilization and Movement by Salmonids. NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWFSC-236, 62 pp.
Klimley, A.P. 1996. Dancing with sharks. *Natural History Magazine*, 105:54-55.
Sillman, A.J., G.A. Letsinger, S. Patel, E.R. Loew, and A.P. Klimley. 1996. Visual pigments and photoreceptors in two species of shark, *Triakis semifasciata* and *Mustelus henlei*. *Journal of Experimental Zoology*, 276:1-10.
Klimley, A.P. and D.G. Ainley. 1996. White shark research in the past: a perspective. Pp. 3-4 *in* Klimley, A.P. & D.G. Ainley (Eds.), IBID.
Klimley, A.P. and S.D. Anderson. 1996. Residency patterns of white sharks at the South Farallon Islands, California. Pp. 365-373 *in* Klimley, A.P. and D.G. Ainley (Eds.), IBID.
Klimley, A.P., P. Pyle, and S.D. Anderson. 1996. The behavior of white shark and prey during predatory attacks. Pp. 175-191 *in* Klimley, A.P. and D.G. Ainley (Eds.), IBID.
Klimley, A.P., P. Pyle, and S.D. Anderson, 1996. Is the Tail Slap an agonistic display among white sharks? Pp. 241-255 *in* Klimley, A.P. and D.G. Ainley (Eds.), IBID.
Anderson, S.D., A. P. Klimley, P. Pyle, and R.H. Henderson. 1996. Tidal height and white shark predation at the South Farallon Islands. Pp. 275-279 *in* Klimley, A.P. and D.G. Ainley (Eds.), IBID.
Goldman, K.J., S. D. Anderson, J.E. McCosker, and A.P. Klimley. 1996. Temperature, swimming depth, and diel movements of a white shark at the South Farallon Islands, Central California, with comments on thermal physiology. Pp. 111-120 *in* Klimley, A.P. and D.G. Ainley (Eds.), IBID.
Mollet, H., G.M. Cailliet, A.P. Klimley, D.A. Ebert, A.T. Testi, and L.J.V. Compagno. 1996. A review of length validation methods for large white sharks. Klimley, A.P. and D.G. Ainley (Eds.), IBID.
Pyle, P., S.D. Anderson, A.P. Klimley, and R.P. Henderson. 1996. Environmental factors affecting the occurrence and behavior of white sharks at the South Farallon Islands, California. Pp. 281-291 *in* Klimley, A.P. and D.G. Ainley (Eds.), IBID.
Klimley, A.P. 1995. Hammerhead city, *Natural History,* 104:32-39.
Klimley, A.P., E.D. Prince, R.W. Brill, and K. Holland. 1994. Archival tags 1994: present and future. *NOAA Technical Memorandum*, NMFS-SEFSC-357, 30 pp.
Klimley, A.P. 1994. The predatory behavior of the white shark. *American Scientist*, 82:122-133 (won Silver Excel Award for best feature article of year).
Klimley, A.P. 1993. Highly directional swimming by scalloped hammerhead sharks, *Sphyrna lewini*, and subsurface irradiance, temperature, bathymetry, and geomagnetic field. *Marine Biology*, 117:1-22.
Klimley, A.P., I. Cabrera-Mancilla, and J.L. Castillo-Geniz. 1993. Descripcion de los movimientos horizontales y verticales del tiburon martillo *Sphyrna lewini*, del sur de Golf de California, Mexico. *Ciencias Marinas*, 19:95-115.
Klimley, A.P., S.D. Anderson, P. Pyle, and R.P. Henderson. 1992. Spatio-temporal patterns of white shark (*Carcharodon carcharias*) predation at the South Farallon Islands, California. *Copeia*, 1992:680-690.
Galvan-Magaña F., H. Nienhuis, and A.P. Klimley. 1989. Seasonal abundance and feeding habits of sharks of the Lower Gulf of California. *California Fish and Game*, 75:74-84.

Klimley, A.P. and S.B. Butler. 1988. Immigration and emigration of a pelagic fish assemblage to seamounts in the Gulf of California related to water mass movements using satellite imagery. *Marine Ecology Progress Series,* 49:11-20.

Klimley, A.P., S.B. Butler, D.R. Nelson, and A.T. Stull, 1988. Diel movements of scalloped hammerhead sharks (*Sphyrna lewini* Griffith and Smith) to and from a seamount in the Gulf of California. *Journal of Fish Biology*, 33:751-761.

Klimley, A.P. 1987. Field studies of the white shark, *Carcharodon carcharias*, in the Gulf of Farallones National Marine Sanctuary. Pp. 33-36 *in* Croom, M.M. (Ed.), Current Research Topics in the Marine Environment. Gulf of the Farallones National Marine Sanctuary, San Francisco.

Cigas, J. and A.P. Klimley. 1987. A microcomputer interface for decoding telemetry data and displaying them numerically and graphically in real time. *Behavioral Research Methods, Instruments, and Computers*, 19:19-25.

Klimley, A.P. 1987. The determinants of sexual segregation in the scalloped hammerhead, *Sphyrna lewini*. *Environmental Biology of Fishes*, 18:27-40.

Klimley, A.P. 1985. Schooling in the large predator, *Sphyrna lewini*, a species with low risk of predation: a non-egalitarian state. *Ethology*, 70:297-319.

Klimley, A.P. and D.R. Nelson. 1985. Functional analysis of schooling in the scalloped hammerhead shark (*Sphyrna lewini)*. Research Reports, *National Geographic Society*, 21:227-229.

Klimley, A.P. 1985. The areal distribution and autoecology of the white shark, *Carcharodon carcharias*, off the west coast of North America. *Southern California Academy of Sciences, Memoirs*, 9:15-40.

Klimley, A.P. and D.R. Nelson. 1984. Diel movement patterns of the scalloped hammerhead shark (*Sphyrna lewini*) in relation to El Bajo Espiritu Santo: a refuging central-position social system. *Behavioral Ecology and Sociobiology,* 15:45-54.

Klimley, A.P. and S.T. Brown. 1983. Stereophotography for the field biologist: measurement of lengths and three-dimensional positions of free-swimming sharks. *Marine Biology*, 74:175-185.

Klimley, A.P. and S.T. Brown. 1983. A stereophotographic technique for the determination of lengths of free-swimming sharks. *CIBCASIO Transactions*, 11:110-137.

Klimley, A.P. 1982. Social organization of schools of scalloped hammerhead shark, *Sphyrna lewini* (Griffith and Smith), in the Gulf of California. *Dissertation*, University of California, San Diego, 341 pp.

Klimley, A.P. 1981. Grouping behavior in the scalloped hammerhead. *Oceanus,* 24:65-71.

Klimley, A.P and D.R. Nelson 1981. Schooling of scalloped hammerhead, *Sphyrna lewini*, in the Gulf of California. *Fishery Bulletin*, 79:356-360.

Klimley, A.P. 1980. Observations of courtship and copulation in the nurse shark, *Ginglymostoma cirratum*. *Copeia*, 1980:878-882.

Klimley, A.P. and A.A. Myrberg, Jr. 1979. Acoustic stimuli underlying withdrawal from a sound source by adult lemon sharks, *Negaprion brevirostris* (Poey). *Bulletin of Marine Science*, 29:447-458.

Myrberg, Jr., A.A., C.R. Gordon, and A.P. Klimley. 1978. Rapid withdrawal from a sound source by open ocean sharks. *Journal of the Acoustical Society of America*, 64:1289-1297.

Klimley, A.P. 1978. Nurses at home and school. *Marine Aquarist,* 8:5-13.

Myrberg, Jr., A.A., C.R. Gordon, and A.P. Klimley. 1976. Attraction of free-ranging sharks by low frequency sound, with comments on its biological significance. Pp. 205-239 *in* A. Schuijf and A.D. Hawkins (Eds.), Sound Reception in Fishes. Elsevier Press, New York.

Klimley, A.P. 1976. Analysis of acoustic stimulus properties underlying withdrawal in the lemon shark, *Negaprion brevirostris* (Poey). *Thesis*, Rosenstiel School of Marine and Atmospheric Science, 80 pp.

Klimley, A.P. 1976. The white shark: a matter of size. *Sea Frontiers,* 22:2-8.

Myrberg, Jr., A.A., C.R. Gordon, and A.P. Klimley. 1975. Rapid withdrawal from a sound source by sharks under open ocean and captive conditions. *Technical Report*, University of Miami, 24 pp.

Myrberg, Jr., A.A., C.R. Gordon, and A.P. Klimley. 1975. Attraction of free-ranging sharks by acoustic signals in near-subsonic range. *Technical Report*, University of Miami, 32 pp.

Klimley, A.P. 1975. A new look at shark attack. *Triton*, 1975:11-15.

Klimley, A.P. 1974. An inquiry into the causes of shark attacks. *Sea Frontiers*, 20:66-75.

GRADUATE GROUP MEMBERSHIPS

1999-Pres. Membership, Graduate Group in Ecology, UC Davis.

1998-Pres. Membership, Animal Behavior Graduate Group, UC Davis.

*Articles relevant to ultrasonic tagging technology are in bold font.

JOHN T. KELLY (Researcher, Task 1)

CONTACT INFORMATION

Biotelemetry Laboratory, Department of Wildlife, Fish & Conservation Biology, University of California, Davis, One Shields Drive Davis, CA 95616
Office phone: 530-752-5830, E-mail: jtkelly@ucdavis.edu

EDUCATION

Ph.D. University of California, Davis. 2006 (Animal Behavior)
M.S. University of California, Davis. 2001 (Animal Behavior)
B.S. University of Miami, Florida. 1995 (Marine Science and Biology with general honors)

RESEARCH INTERESTS

The movements and migrations of fishes and other aquatic organisms; the role of sensory physiology in orientation and navigation; flow-vector kinesis; rheotropism; passive electroreception; magnetoreception; behavior and physiology of fishes; ultrasonic, radio, and satellite tracking and telemetry; conservation and management of native fishes and associated fisheries.

EMPLOYMENT

10/01 – 6/06	Graduate Student Researcher, Green Sturgeon Telemetry Study, UCD Biotelemetry Laboratory, Department of Wildlife, Fish & Conservation Biology, University of California, Davis, One Shields Avenue, Davis, CA 95616.
7/01 – 8/01	Graduate Student Researcher, Fish Treadmill Project, Cech Laboratory, Department of Wildlife, Fish & Conservation Biology, University of California, Davis, One Shields Avenue, Davis, CA 95616
10/00 – 1/01	Graduate Student Researcher, White shark study at Point Reyes Headlands, Bodega Marine Laboratory, UC Davis, One Shields Avenue, Davis, CA 95616.
11/98 – 10/99	Fish and Wildlife Biologist (GS-07), U.S. Fish and Wildlife Service, Sacramento Field Office, Habitat Conservation Division, Energy Planning & Instream Flow Branch, 2800 Cottage Way, Sacramento, CA 95821.
11/96 – 12/97	Marine Biologist, The Nature Conservancy, Florida and Caribbean Marine Conservation Science Center, University of Miami, P.O. Box 249118, Coral Gables, FL 33124.
9/95 – 11/96	Research Assistant, The Nature Conservancy, Florida and Caribbean Marine Conservation Science Center, University of Miami, P.O. Box 249118, Coral Gables, FL 33124.

SOCIETIES AND AFFILIATIONS

Sigma Xi, Associate Member
Phi Sigma, Member
American Society of Ichthyologists and Herpetologist, Member
American Fisheries Society, Member

American Elasmobranch Society, Member

PUBLICATIONS (articles in bold are relevant to proposal)

In Prep or Submitted:

Kelly, J.T. and A.P. Klimley. *Submitted*. Movements in water currents: flow-vector kinesis by green sturgeon, *Acipenser medirostris*, in an estuary. *Mar. Biol.*

Kelly, J.T., S.E. Lankford, J.J Cech and A.P. Klimley. *In Prep*. The energetic costs of swimming using flow-vector kinesis in green sturgeon.

Published:

Kelly, J.T., A.P. Klimley, and C.E. Crocker. *In Press*. Movements of green sturgeon, *Acipenser medirostris*, in the San Francisco Bay Estuary, California. *Env. Biol. Fish.*

Curtis, T.H., J.T. Kelly, K.L. Menard, R.K. Laroche, R.E. Jones and A.P. Klimley. 2006. Observations on the behavior of white sharks scavenging from a whale carcass at Point Reyes, California. *Cal. Fish and Game* 92(3):000-000.

Klimley, A.P., R.L. Kihslinger, and J.T. Kelly. 2005. Directional and non-directional movements of bat rays (*Myliobatis californica*) in Tomales Bay, California. *Env. Biol. Fish.* 74:79-88

Kelly, J.T. and A.P. Klimley. 2003. The occurrence of the white shark, *Carcharodon carcharias*, at the Point Reyes Headlands, California. *Cal. Fish Game* 89(4):187-196

Lema, S.C. and J.T. Kelly. 2002. The production of communication signals at the air-water and water-substrate boundaries. *J. Comp. Psych.* 116(2):145-150

Klimley, A.P., B.J. Le Boeuf, K.M. Cantara, J.E. Richert, S.F. Davis, S. Van Sommeran and J.T. Kelly. 2001. The hunting strategy white sharks (*Carcharodon carcharias*) near a seal colony. *Mar. Biol.* 138:617-636

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PRESENTATIONS, POSTERS & ABSTRACTS

Kelly, J.T. and A.P. Klimley. 2006. Selective tidal stream transport and rheotactic orientation by green sturgeon, *Acipenser medirostris*, in the San Francisco Bay Estuary, California. Annual Meeting of the American Society of Ichthyologists and Herpetologists, New Orleans, NO. 12-17 July. *Abstract*.

Kelly, J.T., A.P. Klimley and C.E. Crocker. 2005. Movements of Adult and Sub-adult Green Sturgeon (*Acipenser medirostris*) in the San Francisco Bay Estuary. Green Sturgeon and the Environment Symposium, 39th Annual American Fisheries Society California-Nevada Chapter Conference, Sacramento, CA. 17-19 March. *Presentation, Abstract*.

Kelly, J.T., A.P. Klimley and C.E. Crocker. 2003. Movement of adult and sub-adult green sturgeon (*Acipenser medirostris*) in the San Francisco Estuary. 6th Biennial State of the Estuary Conference, Oakland, CA. 22-24 October. *Poster, Abstract*.

Kelly, J.T. and A.P. Klimley. 2001. The occurrence of white sharks (*Carcharodon carcharias*) at the Point Reyes Headlands. Gulf of the Farallones Research Symposium, San Francisco. 25 October. *Presentation, Abstract*.

Kelly, J.T. 2000. The Aerial Behavior of Cetaceans. Presented at the Animal Behavior NSF RTG workshop: "Communication: The Animal in the Context of Its Environment", at the University of California, Davis. *Presentation*.

Chiappone, M., R. Sluka, K.M. Sullivan, E. Schmitt, G. Bustamante, J. Kelly, S. Bolden, M. Vega, E. Pugibet, F.X. Geraldes and R.E. Torres. 1997. Comparison of grouper assemblages in northern areas of the wider Caribbean: Habitat and fishing effects. 50th Annual Meeting of the Gulf and Caribbean Fisheries Institute, Merida, Mexico. 9-14 November. *Presentation, Abstract.*

EDITOR

2005 – present Environmental Biology of Fishes, Associate Editor

BOOKS

Klimley, A.P., Allen, P.J., J.A. Israel, and J.T. Kelly (eds.). *In Prep*. Green Sturgeon and its Environment. Springer Science & Business Media B.V.

SYMPOSIA

Green Sturgeon and the Environment, held at the 39th Annual American Fisheries Society California-Nevada Chapter Conference, Sacramento, CA. 17-19 March, 2005. Organized with P.J. Allen, J.A. Israel and A.P. Klimley.

JOSEPH J. CECH, JR. (PI, Task 2)

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EDUCATION

B.S. University of Wisconsin, Madison, 1966 (Zoology)
M.A. University of Texas, Austin, 1970 (Zoology)
Ph.D. University of Texas, Austin, 1973 (Zoology)

POSITIONS

Resident Zoologist, Sea Search I, R/V Dante Deo, Caribbean Sea and S. Pacific Ocean, 1965-66; Research Asst., Univ, Texas Marine Sci. Inst., 1966, 1968-72; Teaching Asst., Univ. Texas, 1967; Research Assoc. Univ. Texas Marine Sci. Inst., 1973; Research Assoc., The Research Institute of the Gulf of Maine, 1973-1975; Lecturer, Univ. Maine at Portland-Gorham, 1975; Asst. Professor 1975-1981, Assoc. Professor 1981-1987, Professor of Fisheries Biology, Univ. California, Davis, 1987-present; Associate Editor, *Transactions of the American Fisheries Society*, 1991-1993; Chair, UC Davis Dept. Wildlife, Fish, and Conservation Biology, 1992-1997; Member, *Copeia* Editorial Board, 1997-1998, 2000-2002; Director, UC Davis Center for Aquatic Biology and Aquaculture, 2002-present.

AWARDS AND HONORS

Member: Phi Sigma, Phi Kappa Phi, Sigma Xi; NIH Predoctoral Fellow 1970-73; Invited participant: NATO Advanced Study Institute on Environ. Physiol. Fishes, 1979, Lennoxville, Quebec; NATO Advanced Research Workshop on Evol. Biol. Primitive Fishes, 1985, Bamfield, B.C. Canada; IUPS Discussion Panel on Controversies: Circulation and Respiration, 1986, Vancouver, B.C.; Organizer: 2nd Biennial International Symposium on "Fish Physiology, Toxicology, and Water Quality Management", 1990, Sacramento, Calif.; Invited speaker: 3rd Biennial International Symposium on "Fish Physiology, Toxicology, and Water Quality Management, 1992, Nanjing, PRC; Fellow: American Institute of Fishery Research Biologists, 1992; Honorable Mention, Most Significant Paper in *Transactions of the American Fisheries Society*, Vol.121, 1992; Outstanding Faculty Adviser Award, College Agric..Environ. Sci.: 1992-93; Plenary speaker, "High Performance Fish" First International Fish Physiology Symposium, Vancouver, B.C.: 1994; Excellence in Fisheries Education Award (with P.B. Moyle), American Fisheries Society, 1995; Fellow: American Association for the Advancement of Science, 1996; Oustanding Mentor Award: UC Davis ProFemina Research Consortium 1997; Mentoring for Professional Diversity Award: Equal Opportunities Section, American Fisheries Society, 1999. Award of Excellence, California-Nevada Chapter, American Fisheries Society, 2000; Congressional Legion of Honor, Physiology Section, American Fisheries Society, 2000; UC Davis Prize for Teaching and Scholarly Achievement, 2001; USDA Excellence in Teaching Award, Western Region, 2003.

SELECTED PUBLICATIONS (since 1990, from >125 peer-reviewed articles and books; articles in bold are relevant to proposal)

Cech, J.J., Jr. 1990. Respirometry. pp. 335-362. In: C.B. Schreck and P.B. Moyle (eds.) Methods for fish biology. American Fisheries Society. Bethesda.

Cech, J.J., Jr., S.J. Mitchell, D.T. Castleberry, and M. McEnroe 1990. Distribution of California stream fishes: influence of environmental temperature and hypoxia. *Env. Biol. Fish.* 29:95-105.

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Sanderson, S.L., Cech, J.J., Jr., and M. Patterson. 1991. Fluid dynamics in suspension-feeding blackfish. *Science* 251:1346-1348.

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Hopkins, T.E. and J.J. Cech, Jr. 1992. Physiological effects of capturing striped bass in gill nets and fyke traps. *Trans. Am. Fish. Soc.* 121:819-822.

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Young, P.S. and J.J. Cech, Jr. 1993. Improved growth, swimming performance, and muscular development in exercise-conditioned young-of-the-year striped bass (*Morone saxatilis*) *Can. J. Fish. Aquat. Sci.* 50:703-707.

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Young, P.S. and J.J. Cech, Jr. 1993. Effects of exercise conditioning on stress responses and recovery in cultured and wild young-of-the-year striped bass, *Morone saxatilis*. *Can. J. Fish. Aquat. Sci.* 50:2094-2099.

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Lankford, S.E., T.E. Adams, and J.J. Cech, Jr. 2003. Time of day and water temperature modify the physiological stress response in green sturgeon, *Acipenser medirostris*. *Comp. Biochem Physiol*. 135A:291-302.

Miklos, P., S.M. Katzman, and J.J. Cech, Jr. 2003. Effect of temperature on oxygen consumption of the leopard shark, *Triakis semifasciata*. *Env. Biol. Fish.* 66:15-18.

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Moyle, P.B. and J.J. Cech, Jr. 2004. Fishes: introduction to ichthyology. 5th ed., Prentice Hall.

Myrick, C.A., D.K. Folgner, and J.J. Cech, Jr. 2004. An annular chamber for aquatic animal preference studies. *Trans. Am. Fish. Soc.* 133:426-432.

Marine, K.R. and J.J. Cech, Jr. 2004. Effects of high water temperature on growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook salmon. *N. Amer. J. Fish. Manage.* 24:198-210.

Houck, A.G. and J.J. Cech, Jr. 2004. Effects of dietary methyl mercury on juvenile Sacramento blackfish bioenergetics. *Aquat. Toxicol.* 69:107-123.

Mayfield, R.B. and J.J. Cech, Jr. 2004. Temperature effects on green sturgeon bioenergetics. *Trans. Am. Fish. Soc.* 133:961-970.

Gregory, J.A., J.B. Graham, J.J. Cech, Jr., N. Dalton, J. Michaels, and N.C. Lai. 2004. Pericardial and pericardioperitoneal canal relationships to cardiac function in the white sturgeon (*Acipenser transmontanus*). *Comp. Biochem. Physiol.* 138A:203-213.

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Warren, D.E., S. Matsumoto, J.M. Roessig, and J.J. Cech, Jr. 2004. Cortisol response of green sturgeon to acid-infusion stress. *Comp. Biochem. Physiol.* 137A:611-618.

Cech, J.J., Jr., M. McEnroe, and D.J. Randall. 2004. Coho salmon haematological, metabolic and acid-base changes during exercise and recovery in sea water. *J. Fish. Biol.* 65:1223-1232.

Cech, J.J., Jr. and S.I. Doroshov. 2004. Environmental requirements, preferences, and tolerance limits of North American sturgeon. pp. 73-86. In: F.W.H. Beamish, G. LeBreton, and R.S. McKinley (eds.) Biology of North American Sturgeon and Paddlefish. Kluwer Publ. Dordrecht.

Roessig, J.M., C.M. Woodley, J.J. Cech, Jr., and L. Hansen. 2004. Effects of global climate change on marine and estuarine fish and fisheries. *Rev. Fish Biol. Fisheries* 14:251-275.

Swanson, C., P.S. Young, and J.J. Cech, Jr. 2004. Close encounters with a fish screen: integrating physiological and behavioral approaches to protect endangered species in exploited ecosystems. *Trans. Am. Fish. Soc*. 134:1111-1123.

Myrick, C.A. and J.J. Cech, Jr. 2004. Temperature effects on juvenile anadromous salmonids in California'a central valley: what don't we know? *Rev. Fish. Biol. Fisheries* 14:113-123.

Lankford, S.E., T.E. Adams, R.A. Miller, and J.J. Cech, Jr. 2005. The cost of chronic stress: impacts of a non-habituating stress response on metabolic variables and swimming performance in sturgeon. *Physiol. Biochem. Zool*. 78:599-609.

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Myrick, C.A. and J.J. Cech, Jr. 2005. Effects of temperature on the growth, food consumption, and thermal tolerance of age-0 Nimbus-strain steelhead. *N. Amer. J. Aquacult.* 67:324-330.

Allen, P.J. M. Nicholl, S. Cole, A. Vlazny, and J.J. Cech, Jr. 2006. Growth of larval to juvenile green sturgeon in elevated temperature regimes. *Trans. Am. Fish. Soc*. 135:89-96.

DENNIS E. COCHERELL (Researcher, Task 2)

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EDUCATION

B.S. University of California, Davis. 2005 (Wildlife, Fish & Conservation Biology)
A.S. Las Positas College. 1999

RESEARCH INTERESTS

Temperature preference of native CA fishes; swimming performance, behavior, stress responses and recovery of sturgeon near fish passage and transport-related structures; environmental requirements of native CA fishes for potential restoration/aquaculture; physiological ecology (including bioenergetics, stress responses, and osmoregulation); effects of pulsed-flows on condition and distribution of CA stream fish.

EMPLOYMENT

3/05 – Pres. Junior Specialist, Cech Laboratory, Department of Wildlife, Fish & Conservation Biology, University of California, Davis, One Shields Avenue, Davis, CA 95616

9/02 – 2/05 Undergraduate Research Assistant, Cech Laboratory, Department of Wildlife, Fish & Conservation Biology, University of California, Davis, One Shields Avenue, Davis, CA 95616

PROFESSIONAL SOCIETIES

American Fisheries Society

TECHNICIAL REPORTS AND PRESENTATIONS

Anderson E.K, D.E. Cocherell, A. Kawabata, Z.Q.R. Chen, H.Bandeh, M. Hannum, K. Carr, M. Cayar, I. Haltas, M.L. Kavvas, D. Kratville, S. Hamilton, L. Kanemoto, J. Webber, J.J. Cech, Jr., K.L. Hochgraf, C. Wilkinson, M. McGee Rotondo, R. Padilla, R. Churchwell. 2005. White Sturgeon Hydraulic and Passage Study. Final Report to CA Department of Water Resources.

Cocherell, D.E. 2006. Adult white sturgeon passage behavior, swimming performance, passage efficiency, and stress responses. Bioengineering Symposium, 40th Annual American Fisheries Society California-Nevada Chapter Conference, San Luis Obispo, CA. 30 March. *Presentation, Abstract.*

POSTERS

Cocherell, D.E., A. Kawabata, E.K. Anderson, D. Kratville, S. Hamilton, L. Kanemoto, J. Webber, Z.Q.R. Chen, H. Bandeh, K. Carr, M. Cayar, I. Haltas, C. Wilkinson, M. McGee Rotondo, R. Padilla, R. Churchwell, M.L. Kavvas, and J.J. Cech, Jr. A Fish Ladder for Adult White Sturgeon? Preliminary Results (A): Passage Efficiency.
75th State of the Estuary Conference. Oakland, CA, October 4-6, 2005.
86th Western Society of Naturalists, Seaside, CA. November 17-20, 2005.
Interagency Ecological Program Workshop. Pacific Grove, CA. March 1-3, 2006.
AFS Cal-Neva meeting, San Luis Obispo, CA. March 30-April 1, 2006.

Cocherell, D.E., A. Kawabata, D. Kratville, S. Hamilton, Z.Q.R. Chen, H. Bandeh, R. Churchwell, M.L. Kavvas, and J.J. Cech, Jr. A Fish Ladder for Adult White Sturgeon? Preliminary Results (B): Stress during Passage. 75th State of the Estuary Conference. Oakland, CA, October 4-6, 2005. 86th Western Society of Naturalists, Seaside, CA. November 17-20, 2005. Interagency Ecological Program Workshop. Pacific Grove, CA. March 1-3, 2006. AFS Cal-Neva meeting, San Luis Obispo, CA. March 30-April 1, 2006.

Hamilton, S., S. Chun, J. Miranda, D. Cocherell, G.Jones, J. Graham, L.C. Thompson, J.J. Cech Jr., and Peter A. Klimley. Radio-telemetry studies assessing pulsed flow impacts on the distribution of fishes in the American River. Interagency Ecological Program Annual Workshop. Pacific Grove, CA. March 1-3, 2006
Pulsed Flow Program Workshop Abstracts: UC Davis, July 15, 2005

Hamilton, S., S. Chun, J. Graham, D. Cocherell, G. Jones, J. Miranda , D. Kratville, and J.J. Cech Jr.. Laboratory investigations of stream fish longitudinal and lateral displacement from simulated pulse flows. Interagency Ecological Program Annual Workshop. Pacific Grove, CA. March 1-3, 2006 Pulsed Flow Program Workshop Abstracts: UC Davis, July 15, 2005

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EDUCATION

M.S. Moscow State University, Moscow. 1959 (Zoology)
Ph.D. Institute of Oceanology, Russian Academy of Science, Moscow. 1967 (Biology)

EMPLOYMENT

Fish Biologist, Institute of Freshwater Reservoirs, Russian Academy of Science, 1959-1960; Researcher, Institute of Marine Fisheries and Oceanography, Moscow, 1961-1966; Senior Researcher and Director of Marine Aquaculture Laboratory, Institute of Marine Fisheries and Oceanography, Moscow, 1967-1975; Aquaculture Expert, Food and Agriculture Organization U.N., 1975-1977; Visiting Lecturer, School of Fisheries, University of Washington, 1977; Associate Professor of Animal Science, University of California-Davis, 1978-1983; Professor of Animal Science, University of California-Davis, 1984-Present.

RESEARCH INTERESTS

My research has focused, over the past 25 years, on reproductive physiology and developmental biology of sturgeons. We investigated endocrine and environmental control of gametogenesis and reproductive cycles in white sturgeon, and developed diagnostic techniques allowing the domestication and breeding of this valuable species in sustainable aquaculture production system. During the past six years, my laboratory participated in collaborative research on green sturgeon. We characterized reproductive parameters of breeding stock of the Klamath River, developed artificial spawning and culture techniques, and studied developmental biology of embryos and larvae, including their thermal tolerance and effect of thermal stress on development. We are currently interested in studying sexual maturation and gametogenesis (germ cell development) of green sturgeon, which will provide information on the age and size at first maturity, and the cycle duration and seasonality in male and female.

SOCIETIES

American Fisheries Society
World Aquaculture Society
World Sturgeon Conservation Society

AWARDS

Distinguished Service Award, from California Aquaculture Association (1988)
Honorary Life Membership, from World Aquaculture Society (2000)
Outstanding Contribution Award, from the U.S. Department of Agriculture (2004)
Achievement Award from World Sturgeon Conservation Society (2004)

SELECTED PUBLICATIONS (from > 100 papers and books; articles in bold are relevant to proposal)

Van Eenennaam, J.P., R.K. Stocker, R.G. Thiery, N.T. Hagstrom and S.Doroshov. 1990. Egg Fertility, Early Development and Survival from Crosses of Diploid Female x Triploid Male Grass Carp (*Ctenopharyngodon idella*). *Aquaculture 86*: 111-125.

Bordner, C.I., S.I. Doroshov, D.E. Hinton, R.E. Pipkin, R.B.Fridley, F.Haw. 1990. Evaluation of Marking Techniques for Juvenile and Adult White Sturgeon Reared in Captivity. *Am. Fish. Soc. Symp.* 7: 293-303.

Moberg, G.P., S.I. Doroshov, F.A. Chapman, K.J. Kroll, J.P. Van Eenennaam and J.G. Watson. 1991. Effects of various hormone implants on vitellogenin synthesis and ovarian development in cultured white sturgeon. Pp. 389-399 *in*: P.Williot (ed.) *ACIPENSER.* Cemagref Publ., Bordeaux.

Kroll, K.J. and S.I. Doroshov. 1991. Vitellogenin: potential vehicle for selenium bioaccumulation in the oocytes of the white sturgeon (*Acipenser transmontanus*). Pp. 99-106 *in:* P.Williot (ed.) *ACIPENSER.* Cemagref Publ., Bordeaux.

Washburn, B.S., D.J. Frye, S.S.O. Hung, S.I. Doroshov and F.S. Conte. 1990. Dietary effects on tissue composition, oogenesis and the reproductive performance of female rainbow trout (*Oncorhynchus mykiss*). *Aquaculture* 90:179-195.

Doroshov, J.N., J.P. Van Eenannaam, F.A.Chapman and S.I. Doroshov. 1991. Histological study of the ovarian development in wild white sturgeon (*Acipenser transmontanus*). Pp. 129-136 *in:* P.Williot (ed.) *ACIPENSER.* Cemagref Publ., Bordeaux.

Moberg, G.P., J.G. Watson, H. Papkoff, K.J. Kroll and S.I. Doroshov. 1991. Development of radioimmunoassays for two sturgeon gonadotropins. *Proc. 4th Int. Symp. Reprod. Physiol. Fish.* Scott, A.P., J.P. Sumpter, D.E. Kime, and M.S. Rolfe (editors). *Fish Symp 91*, Sheffield, U.K.

Bidwell, C.A., K.J. Kroll, E. Severud, S.I. Doroshov, and D.M. Carlson. 1991. Identification and preliminary characterization of white sturgeon (*Acipenser transmontanus*) vitellogenin mRNA. *Gen. Comp. Endocrinol*. 83:415-424.

Sherwood, N.M., S. Doroshov, and V. Lance. 1991. Gonadotropin-Releasing hormone (GnRH) in bony fish that are phylogenetically ancient: reedfish (*Calamoichthys calabaricus*), sturgeon (*Acipenser transmontanus*), and alligator gar (*Lepisosteus spatula*). *Gen. Comp. Endocrinol*. 84:44-57.

Kroll, K.J., J.P. Van Eenennaam, and S.I. Doroshov. 1992. Effect of water temperature and formulated diets on growth and survival of larval paddlefish. *Trans. Am. Fish. Soc*. 121:538-543.

Buddington, R.K., J.R. Hazel, S.I. Doroshov, and J.P. Eenennaam. 1993. Ontogeny of the capacity for homeoviscous adaptation in white sturgeon (*Acipenser transmontanus*). *J. Exp. Zool.* 265:18-28.

Kroll, K.J., J.P. Van Eenennaam, S.I. Doroshov, and J. Linares. 1994. Growth and survival of paddlefish fry raised in the laboratory on natural and artificial diets. *Prog. Fish Cult.*56:169-174.

Bailey, H.C., C. Alexander, C. Digiorgio, M. Miller, S.I. Doroshov and D.E. Hinton. 1994. The effect of agricultural discharge on striped bass (*Morone saxatilis*) in California's Sacramento-San Joaquin drainage. *Ecotoxicology* 3:123-142.

Ciereszko, A., K. Dabrowski, F. Lin, and S.I. Doroshov. 1994. Identification of trypsin-like activity in sturgeon spermatozoa. *J. Exp. Zool.* 268:486-491.

Teplitz, R.L., J.E. Joyce, and S.I. Doroshov. 1994. A preliminary ploidy analysis of diploid and triploid salmonids. *Can. J. Fish. Aquat. Sci.* 51(Suppl.1):38-41.

Logan, S.H., W.E. Johnston, and S.I. Doroshov. 1995. Economics of joint production of sturgeon (*Acipenser transmontanus* Richardson) and roe for caviar. *Aquaculture* 130:299-316.

Bailey, H.C., and S.I. Doroshov. 1995. The duration of the interval associated with successful inflation of the swimbladder in larval striped bass (*Morone saxatilis*). *Aquaculture* 131: 135-143.

Moberg, G.P., J.G. Watson, S. Doroshov, H. Papkoff, and R.J. Pavlick, Jr. 1995. Physiological evidence for two sturgeon gonadotropins in *Acipenser transmontanus*. *Aquaculture* 135: 27-39.

Van Eenennaam, J.P., S.I. Doroshov, G.P. Moberg, J.G. Watson, D.S. Moore, and J. Linares. 1996. Reproductive conditions of the Atlantic sturgeon (*Acipenser oxyrinchus*) in the Hudson River. *Estuaries* 19(4): 769-777.

Swanson, C., R.C. Mager, S.I. Doroshov, and J.J. Cech, Jr. 1996. Use of salts, anesthetics, and polymeres to minimize handling and transport mortality in delta smelt. Trans. Am. Fish. Soc. 125: 326-329.

Van Eenennaam, A. L., J.P. Van Eenennaam, J.F. Medrano, and S.I. Doroshov. 1996. Rapid identification of meiotic gynogenesis and polyploidy in white sturgeon (*Acipenser transmontanus* Richardson). *Aquaculture* 147: 177-189.

Chapman, F.A., J.P. Van Eenennaam, and S.I. Doroshov. 1996. The reproductive condition of white sturgeon, *Acipenser transmontanus*, in San Francisco Bay, California. *Fish. Bull.* 94: 628-634.

Doroshov, S.I., G.P. Moberg, and J.P. Van Eenennaam. 1997. Observations on the reproductive cycle of cultured sturgeon (*Acipenser transmontanus* Richardson). *Env. Biol. Fish.* 48: 265-278.

Carrasco, L.A.P., S.I. Doroshov, D.J. Penman and N. Bromage. 1998. Long-term, quantitative analysis of gametogenesis in autotriploid rainbow trout, *Oncorhynchus mykiss*. *J. Reprod. Fertility* 113: 197-210.

Van Eenennaam, J.P. and S.I. Doroshov. 1998. Effects of age and body size on gonadal development of Atlantic sturgeon. *J. Fish Biol.* 53: 624-637.

Doroshov, S.I., J.P. Van Eenennaam and G.P. Moberg. 1999. Development of white sturgeon broodstock. *J. Appl. Ichthyol.* 15: 326-327.

Amiri, B.M., M. Maebayashi, S. Adachi, G.P. Moberg, S.I. Doroshov and K. Yamauchi. 1999. In vitro steroidogenesis by testicular fragments and ovarian follicles in a hybrid sturgeon, Bester. *Fish Physiol. Biochem*. 21: 1-14.

Van Eenennaam, A.L., J.P. Van Eenennaam, J.F. Medrano and S.I. Doroshov. 1999. Evidence of female heterogametic genetic sex determination in white sturgeon. *J. Heredity* 90 (1): 231-233.

Webb, M.A.H., J.P. Van Eenennaam, S.I. Doroshov, G.P. Moberg. 1999. Preliminary observations on the effects of holding temperature on reproductive performance of female white sturgeon, *Acipenser transmontanus* Richardson. *Aquaculture* 176: 315-329.

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Webb, M.A.H., J.P. Van Eenennaam, and S.I. Doroshov. 2000. Effects of steroid hormones on in vitro oocyte maturation in white sturgeon (*Acipenser transmontanus*). *Fish Physiol. Biochem*. 23: 317-325.

Czesny, S., K. Dabrowski, J.E. Christensen, J. Van Eenennaam and S. Doroshov. 2000. Discrimination of wild and domestic origin of sturgeon ova based on lipids and fatty acid analysis. *Aquaculture* 189: 145-153.

Antonio, D.B., C. Swanson, J.J. Cech, Jr., R.C. Mager, S.I. Doroshov, and R.P. Hedrick. 2000. Prevalence of mycobacterium in wild and captive delta smelt. *Calif. Fish Game* 86: 233-243.

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Van Eenennaam, J.P. , M.A.H. Webb, Xin Deng, S.I. Doroshov, R. Mayfield, JJ. Cech, Jr., D.C. Hillemeier, and T.E. Willson. 2001. Artificial spawning and larval rearing of Klamath River green sturgeon. *Trans. Am. Fish. Soc*. 130: 159-165.

Webb, M.A.H., J.P. Van Eenennaam, G.W. Feist, J. Linares-Casenave, M.S. Fitzpatrick, C.D. Schreck, and S.I. Doroshov. 2001. Effects of thermal regime on ovarian maturation and plasma sex steroids in farmed white sturgeon, *Acipenser transmontanus*. *Aquaculture* 201: 137-151.

Gisbert, E., J.J. Cech, Jr. and S.I. Doroshov. 2001. Routine metabolism of larval green sturgeon (*Acipenser medirostris* Ayres). *Fish Physiol. Biochem.* 25: 195-200.

Deng, X., J.P. Van Eenennaam, and S.I. Doroshov. 2002. Comparison of early life stages and growth of green and white sturgeon. Pp. 237-248 *in*: W. Van Winkle, P.J. Anders, D.H. Secor, and D.A. Dixon (eds.) Biology, Management and Protection of North American sturgeon. Am. *Fish. Soc. Symp.* 28. Bethesda, Maryland.

Webb, M.A.H., G.W. Feist, J.M. Trant, J.P. Van Eenennaam, M.S. Fitzpatrick, C.B. Schreck, and S.I. Doroshov. 2002. Ovarian steroidogenesis in white sturgeon (*Acipenser transmontanus*) during oocyte maturation and induced ovulation. *Gen. Comp. Endocrinol.* 129: 27-38.

Linares-Casenave, J., J.P. Van Eenennaam, S.I. Doroshov. 2002. Ultrastructural and histological observations on temperature-induced follicular ovarian atresia in the white sturgeon. *J. Appl. Ichthyol.* 18: 382-390.

Yesaki, T.Y., R. Ek, J. Siple, J.P. Van Eeenennaam, S.I. Doroshov. 2002. The effects of iodophor disinfection and transportation on the survival to hatch of fertilized white sturgeon (*Acipenser transmontanus*) eggs. *J. Appl. Ichthyol.* 18: 639-641.

Gisbert, E. and S.I. Doroshov. 2003. Histology of the developing digestive system and the effect of food deprivation in larval green sturgeon (*Acipenser medirostris*). *Aquat. Liv. Res*. 16: 77-89.

Linares-Casenave, J., K.J. Kroll, J.P. Van Eenennaam, S.I. Doroshov. 2003. Effect of ovarian stage on plasma vitellogenin and calcium in cultured white sturgeon. *Aquaculture* 221: 645-656.

Mager, R.C., S.I. Doroshov, J.P. Van Eenennaam and R.L. Brown. 2004. Early life stages of delta smelt. *Am. Fish. Soc. Symp.* 39: 169-180.

Baskerville-Bridges, B., J.C. Lindberg, and S.I. Doroshov. 2004. The effect of light intensity, alga concentration, and prey density on the feeding behavior of delta smelt larvae. *Am. Fish. Soc. Symp.* 39: 219-227.

Feist, G., J.P. Van Eenennaam, S.I. Doroshov, C.B. Schreck, R.P. Schneider and M.S. Fitzpatrick. 2004. Early identification of sex in cultured white sturgeon, *Acipenser transmontanus*, using plasma steroid levels. *Aquaculture* 232: 581-590.

Cech, J.J., Jr. and S.I. Doroshov. 2004. Environmental requirements, preferences, and tolerance limits of North American sturgeons. Pp. 73-86 *in:* G.T.O. LeBreton, F.W.H. Beamish and R.S. McKinley (eds.) *Sturgeons and paddlefish of North America*. Kluwer Academic Publishers, Dordrecht.

Van Eenennaam, J.P., J. Linares-Casenave, X. Deng, and S.I. Doroshov. 2005. Effect of incubation temperature on green sturgeon embryos, *Acipenser medirostris*. *Env. Biol. Fish.* 72: 145-154.

Van Eenennaam, J.P., J. Linares-Casenave, S.I. Doroshov, D.C. Hillemeier, T.E. Willson, and A.A. Nova. 2006. Reproductive conditions of the Klamath River green sturgeon. *Trans. Am. Fish. Soc.* 135: 151-163.

JOEL P. VAN EENENNAAM (Researcher, Task 3)

CONTACT INFORMATION

Department of Animal Science University of California One Shields Ave., Davis, CA 95616
Office phone: 530-752-2058/1484, Fax: 530-752-0175, E-mail: jpvaneenennaam@ucdavis.edu

EDUCATION

B.S. Michigan State University. 1977 (Fisheries & Wildlife)

M.S. University of California, Davis. 1985 (International Agricultural Development, Reproductive Biology of Fish)

EMPLOYMENT

1985-present, Staff Research Associate, Department of Animal Science, University of California, Davis; 1983-1985, Research Assistant, Department of Animal Science, University of California, Davis; 1982, Aquaculture Technician, Fish Breeders of California, Niland, California; 1977-1981, Fisheries Extension Agent, Accelerated Rural Development Program, Khon Kaen, Thailand.

AWARDS

1999-00	Department of Animal Science Staff Performance Award
1998-99	Department of Animal Science Staff Recognition Award
1995-96	Department of Animal Science Staff Recognition Award
1990	Outstanding Performance Award, Administrative and Professional Staff Program

MEMBERSHIPS AND AFFILIATIONS

World Aquaculture Society
National Aquaculture Association
American Fisheries Society
National Society for Histotechnology
World Sturgeon Conservation Society

PUBLICATIONS

Van Eenennaam, J.P., R.K. Stocker, R.G. Thiery, N.T. Hagstrom and S.Doroshov. 1990. Egg fertility, early development and survival from crosses of diploid female x triploid male grass carp (*Ctenopharyngodon idella*). Aquaculture 86: 111-125.

Doroshov, J.N., J.P. Van Eenannaam, F.A.Chapman and S.I. Doroshov. 1991. Histological of the ovarian development in wild white sturgeon (*Acipenser transmontanus*). In: P.Williot (ed.), "Acipenser" Proceedings of the 1st International Sturgeon Symposium, Bordeaux, France. CEMAGREF Publ., pp.129-136.

Kroll, K.J., J.P. Van Eenennaam, S.I. Doroshov, J.E. Hamilton, and T.R. Russell. 1992. Effect of water temperature and formulated diets on larval paddlefish. Transactions of the Amererican Fisheries Society 121: 538-543

Buddington, R.K., J.R. Haxel, S.I. Doroshov, and J.P. Van Eenennaam**.** 1993. Ontogeny of the capacity for homeoviscous adaptation in white sturgeon (*Acipenser transmontanus*). Journal of Experimental Zoology 265: 18-28.

Kroll, K.J., J.P. Van Eenennaam, S.I. Doroshov, and J. Linares. 1994. Growth and survival of paddlefish fry raised in the laboratory on live and formulated diets. Progressive Fish Culturist 56: 169-174.

Van Eenennaam, A.L., J.P. Van Eenennaam, J.F. Medrano, and S.I. Doroshov. 1996. Rapid verification of meiotic gynogenesis and polyploidy in white sturgeon (*Acipenser transmontanus* Richardson). Aquaculture 147:177-189.

Van Eenennaam, J.P., S.I. Doroshov, G.P. Moberg, J.G. Watson, D.S. Moore, and J. Linares. 1996. Reproductive conditions of the Atlantic sturgeon (*Acipenser oxyrinchus*) in the Hudson River. Estuaries 19:769-777.

Chapman, F.A., J.P. Van Eenennaam, and S.I. Doroshov. 1996. The reproductive condition of white sturgeon, *Acipenser transmontanu*s, in San Francisco Bay, California. Fishery Bulletin, 94: 628-634.

Doroshov, S.I., G.P. Moberg, and J.P. Van Eenennaam. 1997. Observations on the reproductive cycle of cultured white sturgeon, *Acipenser transmontanus*. Environmental Biology of Fishes 48: 265-278.

Van Eenennaam, J.P., and S.I. Doroshov. 1998. Effects of age and body size on gonadal development in Atlantic sturgeon (*Acipenser oxyrinchus* Mitchill). Journal of Fish Biology 53: 624-637.

Van Eenennaam, A.L., J.P. Van Eenennaam, J.F. Medrano, and S.I. Doroshov. 1999. Evidence of female heterogametic sex determination in white sturgeon. Journal of Heredity 90(1): 231-233.

Webb, M.A.H., J.P. Van Eenennaam, S.I. Doroshov, and G.P. Moberg. 1999. Preliminary observations on the effects of holding temperature on reproductive performance of female white sturgeon, *Acipenser transmontanus* Richardson. Aquaculture 176: 315-329.

Webb, M.A.H., J.P. Van Eenennaam and S.I. Doroshov. 2000. Effects of steroid hormones on in vitro oocyte maturation in white sturgeon. Fish Physiology and Biochemistry 23: 317-325.

Czesny, S., K. Dabrowski, J.E. Christensen, J. Van Eenennaam and S. Doroshov. 2000. Discrimination of wild and domestic origin of sturgeon ova based on lipids and fatty acid analysis. Aquaculture 189: 145-153,

Van Eenennaam, J.P., M.A.H. Webb, X. Deng, S. I. Doroshov, R. Mayfield, J.J. Cech, Jr., D. Hillemeier, and T. Willson. 2001. Artificial spawning and larval rearing of Klamath River green sturgeon. Transactions of the American Fisheries Society 130: 159-165.

Webb, M.A.H., J.P. Van Eenennaam, G. Feist, J. Linares-Casenave, M. Fitzpatrick, C.B. Schreck, and S.I. Doroshov. 2001. Effects of thermal regime on ovarian maturation and plasma sex steroids in farmed white sturgeon, *Acipenser transmontanus*. Aquaculture 201 (1-2): 137-151.

Deng, X., J.P. Van Eenennaam, and S.I. Doroshov. 2002. Comparison of early life stages and growth of green and white sturgeon. Pages 237-248 in W. Van Winkle, P.J. Anders, D.H. Secor, and D.A. Dixon (editors). Biology, management and protection of North American sturgeon. American Fisheries Society, Symposium 28, Bethesda, Maryland.

Yesaki, T.Y., R. Ek, J. Siple, J.P. Van Eenennaam, and S.I. Doroshov. 2002. The effects of iodophor disinfection and transportation on the survival to hatch of fertilized white sturgeon (*Acipenser transmontanus*) eggs. Journal of Applied Ichthyology 18: 639-641.

Linares-Casenave, J., J.P. Van Eenennaam, and S.I. Doroshov. 2002. Ultrastructural and histological observations on temperature-induced follicular ovarian atresia in the white sturgeon. Journal of Applied Ichthyology 18: 382-390.

Linares-Casenave, J., K.J. Kroll, J.P. Van Eenennaam, and S.I. Doroshov. 2003. Effects of ovarian stage on plasma vitellogenin and calcium in cultured white sturgeon. Aquaculture 221:645-656.

Feist, G., J.P. Van Eenennaam, S.I. Doroshov, C.B. Schreck, R.P. Schneider, and M.S. Fitzpatrick. 2004. Early identification of sex in cultured white sturgeon, *Acipenser transmontanus*, using plasma steroid levels. Aquaculture 232: 581-590.

Van Eenennaam, J.P., F.A. Chapman, and P.L. Jarvis. 2004. Aquaculture. Pp. 277-311 in G.T.O. LeBreton, F.W.H. Beamish and R.S. McKinley (ed). Sturgeons and Paddlefish of North America. Fish and Fisheries Series Vol. 27. Kluwer Academic Publishers, Dordrecht.

Mager, R.C., S. I. Doroshov, J.P. Van Eenennaam, and R.L. Brown. 2004. Early life stages of delta smelt. American Fisheries Society Symposium 39: 169-180.

Van Eenennaam J.P., J. Linares-Casenave, X. Deng, and S.I. Doroshov. 2005. Effect of incubation temperature on green sturgeon embryos, *Acipenser medirostris*. Environmental Biology of Fishes 72:145-154.

Van Eenennaam J.P., J. Linares-Casenave, S.I. Doroshov. D. C. Hillemeier, T. E. Willson, and A. A. Nova. 2006. Reproductive conditions of the Klamath river green sturgeon (*Acipenser medirostris*). Transactions of the American Fisheries Society 135: 151-163.

Werner, I., J. Linares-Casenave, J.P. Van Eenennaam, and S.I. Doroshov. *In Press.* The effect of temperature stress on development and heat-shock protein expression in larval green sturgeon (*Acipenser medirostris*). Environmental Biology of Fishes.

Gessner, J., J.P. Van Eenennaam, and S.I. Doroshov. *In Press*. North American green and European Atlantic sturgeon: comparisons of life histories and human impacts. Environmental Biology of Fishes.

BERNIE MAY (PI, Task 4)

CONTACT INFORMATION

Department of Animal Science, Meyer Hall, University of California, Davis, CA 95616.
Office Phone: (530) 754-8123; E-mail: bpmay@ucdavis.edu

EDUCATION

Ph.D. The Pennsylvania State University. 1980 (Genetics)
M.S. University of Washington. 1975 (Fisheries)
B.S. University of Washington. 1973 (Molecular Biology)

EMPLOYMENT

1995 to pres.	Adjunct Professor, Director, Genomic Variation Laboratory, Department of Animal Science, Univ. of California, Davis, CA 95616.
1992-1995	Senior Research Associate and Director, Genome Variation Analysis Facility, Dept. Natural Resources, Fernow Hall, Cornell University.
1988-1992	Senior Research Associate (SRA II in 1989) and Director, CLEEG, Dept. Natural Resources, Cornell University
1981-1988	Research Associate (SRA in 1985) and Director, The Cornell Laboratory for Ecological and Evolutionary Genetics (CLEEG), Section of Ecology and Systematics, Cornell University
1980-1981	Research Associate, Department of Plant Pathology,The Pennsylvania State University

RESEARCH INTERESTS

My research over the past three decades has centered around the use of discrete Mendelian data to answer a broad array of biological questions in fungi, fish, plants, invertebrates, birds, and mammals. One of my primary roles has been to provide a genetics perspective to the collaborative projects with which I have been involved. During the past 10 years my laboratory has come to focus primarily on questions in conservation biology regarding the "genetic health" and "genetic integrity" of natural populations of threatened and endangered fish species. Examples of these questions include: How do we identify populations for preservation?, How do we measure loss of genetic variability?, What remnants of native populations remain after extensive stocking with non-indigenous populations?, How different must two populations be for them to be maintained and managed separately? My program also includes a major emphasis on mapping QTLs in aquaculture species and some effort devoted to the use of AFLPs and microsatellites to detect the effects of toxicants on the gene pools of indigenous species. I am currently developing the use of expression technologies as a more suitable technology to examine the effects of toxicants and disease.

GRADUATE STUDENT THESIS COMMITTEES

NAME	GRAD. GROUP	DEGREE	YEAR (expected)
M. Bagley	Genetics	PhD	1997
M. Brown	Ecology	MS	1998
J. Agresti	Genetics*	MS	1999
E. McQuown	Animal Science*	MS	2000
G. Tranah	Ecology*	PhD	2001
L. Daniels	Genetics	MS	2001
J. Rodzen	Genetics*	PhD	2001
N. Belfiore	Ecology*	PhD	2001
H. Ernest	Ecology	PhD	2001
S. Blankenship	Genetics	PhD	2001
K. Bucklin	Genetics	PhD	2002
B. Sacks	Ecology	PhD	2002
J. Beyer	Genetics*	MS	2002
A. Fowler	Ecology	PhD	2002
A. Whitehead	Pharm. & Tox.	PhD	2002
F. Rodriguez	Genetics*	PhD	2003
C. Floyd	Ecology	PhD	2003
E. Meredith	Genetics*	MS	2004
Z. Hogan	Ecology	PhD	2004
K. Williamson	Ecology*	PhD	2004
K. Rodrigue	Animal Science	MS	2004
C. Conway	Ecology*	PhD	2005
M. Teglas	Comp. Path.	PhD	2005
T. O'Hare	Animal Science	MS	2005
K. Coykendall	Genetics*	PhD	2005
S. Ostermann	Ecology	PhD	2005
Y. Chen	Ecology*	PhD	2006
A. Welsh	Ecology*	PhD	2006
R. Topinka	Ecology*	PhD	(2006)
C. Gitter	Animal Science	MS	(2006)
E. Heeg	Ecology	MS	(2006)
W. Savage	Ecology	PhD	(2006)
M. Stephens	Ecology*	PhD	(2006)
J. Israel	Ecology*	PhD	(2007)
M. Caulder	Forensic Science	MS	(2007)
R. Robles	Ecology	PhD	(2007)
M. Baerwald	Genetics*	PhD	(2007)
R. Schwartz	Ecology*	PhD	(2008)
J. Hull	Ecology	PhD	(2008)
J. Petersen	Genetics*	PhD	(2009)
K. Börk	Ecology*	PhD	(2010)
R. Simmons	Genetics*	PhD	(2010)
A. Drauch	Ecology*	PhD	(2011)

* - Chair

REVIEWER FOR (recent)
AAAS, Biotechniques, Cons. Genet., J. of Great Lakes Research, J. of Hered. (assoc. ed. 1997 to 2001), Mol. Ecol., N. Am. J. Fish. Science, National Science Foundation (Panel Member), Sea Grant (Panel Chair), USDA competitive Research Grants

PROFESSIONAL SOCIETIES
AAAS, American Fisheries Society

SCIENTIFIC ARTICLES (PUBLISHED AND IN PRESS) (last five years only, articles in bold are relevant to proposal)

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EDUCATION

Ph.D. Candidate	University of California, Davis. Anticipated completion date: December 2006 (Ecology)
B.S.	University of California, Santa Cruz. 2005 (Biochemistry and Molecular Biology)

EMPLOYMENT

2001-Present	Graduate Researcher, Department of Animal Science, University of California, Davis.
2001-2006	President, Salmonid Restoration Federation, Redway, CA.
2000-2001	Member, Americorps Watershed Stewards Project, Fortuna CA.
1999-2000	Field Research Assistant, Humboldt State University Foundation, Arcata, CA
1997-2000	Co-founder, Ecological Preservation, Education, and Restoration Education Program (EcoPrep), Arcata, CA
1997-1998	Field Technician, Resources Northwest Inc., Seattle, WA.

RESEARCH INTERESTS

Conservation genetics of anadromous Pacific fishes, genetic stock identification, population demography, aquatic species recovery implementation, aquatic conservation planning, adaptive ecosystem management, phylogeography of Klamath River fishes.

SOCIETIES

American Fisheries Society, Salmonid Restoration Federation, Society for Conservation Biology

REVIEWER

CALFED Science Program (U.S.A.), Conservation Genetics (U.K.), North American Journal of Fisheries Management (U.S.A.), Transactions of the American Fisheries Society (U.S.A.), Fisheries (U.S.A.), Environmental Biology of Fishes (Canada)

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2005	George S. and Marjorie Butler University Fellowship
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SYMPOSIA

2006 Sacramento River sturgeon, Upcoming 4th Biennial CALFED Science Conference, Sacramento CA.

2005 The green sturgeon and its environment, 39th Annual Meeting, California-Nevada Chapter, American Fisheries Society, Sacramento CA.

BOOK

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