BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED

Project Information

1. **Proposal Title:**

   BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED

2. **Proposal applicants:**

   Peter Klimley, University of California, Davis

3. **Corresponding Contact Person:**

   Ahmad Hakim-Elahi
   The Regents of the University of California
   Office of the Vice Chancellor for Research Sponsored Programs, 118 Everson Hall One Shields Avenue University of Davis Davis CA 95616
   530 752 2075
   vcresearch@ucdavis.edu

4. **Project Keywords:**

   At-risk species, fish
   Fish, Anadromous
   Sturgeon biology

5. **Type of project:**

   Research

6. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

7. **Topic Area**:

   At-Risk Species Assessments

8. **Type of applicant:**

   University

9. **Location - GIS coordinates:**

Latitude:	38.575
Longitude:	-121.592
Datum:	

Describe project location using information such as water bodies, river miles, road intersections, landmarks, and size in acres.

The biology of the green sturgeon will be studied throughout the Sacramento/San Joaquin River and Klamath watersheds.

10. **Location - Ecozone:**

    3.1 Keswick Dam to Red Bluff Diversion Dam, 3.2 Red Bluff Diversion Dam to Chico Landing, 3.3 Chico Landing to Colusa, 3.4 Colusa to Verona, 3.5 Verona to Sacramento, 12.1 Vernalis to Merced River, 12.2 Merced River to Mendota Pool, 12.3 Mendota Pool to Gravelly Ford, 12.4 Gravelly Ford to Friant Dam, 1.1 North Delta

11. **Location - County:**

    Colusa, Fresno, Glenn, Merced, Sacramento, San Joaquin, Stanislaus, Sutter, Tehama, Yolo

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    Yes

    If yes, please list the city: Davis

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    Yes **If yes, please list the tribal lands:** Yurok

14. **Location - Congressional District:**

    3rd

15. **Location:**

    California State Senate District Number: 4

    California Assembly District Number: 8

16. **How many years of funding are you requesting?**

    2

17. **Requested Funds:**
    a) Are your overhead rates different depending on whether funds are state or federal?

       Yes

       If yes, list the different overhead rates and total requested funds:

State Overhead Rate: 10.0

Total State Funds: 982,061

Federal Overhead Rate: 48.5

Total Federal Funds: 1,219,387

b) Do you have cost share partners already identified?

Yes

If yes, list partners and amount contributed by each:

Univ. of California, Davis 85,478

c) Do you have potential cost share partners?

No

d) Are you specifically seeking non-federal cost share funds through this solicitation?

No

If the total non-federal cost share funds requested above does not match the total state funds requested in 17a, please explain the difference:

18. **Is this proposal for next-phase funding of an ongoing project funded by CALFED?**

Yes

If yes, identify project number(s), title(s) and CALFED program (e.g., ERP, Watershed, WUE, Drinking Water):

98-C15 (B81738)	**Phase 1- Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watershed**	**ERP, CMARP, Anadromous Fisheries Research Program**
00FC200142 (CalFed agreement No.)	**Phase 2 - Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watershed**	**ERP, CMARP, Anadromous Fisheries Research Program**

Have you previously received funding from CALFED for other projects not listed above?

No

19. **Is this proposal for next-phase funding of an ongoing project funded by CVPIA?**

Yes

If yes, identify project number(s), title(s) and CVPIA program (e.g. AFRP, AFSP, b(1) other).

11332-1-G005	**Phase 3&4 - Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watershed**

Have you previously received funding from CVPIA for other projects not listed above?

No

20. **Is this proposal for next-phase funding of an ongoing project funded by an entity other than CALFED or CVPIA?**

No

Please list suggested reviewers for your proposal. (optional)

21. **Comments:**

Environmental Compliance Checklist

BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED

1. **CEQA or NEPA Compliance**
   a) Will this project require compliance with CEQA?

      No

   b) Will this project require compliance with NEPA?

      No

   c) If neither CEQA or NEPA compliance is required, please explain why compliance is not required for the actions in this proposal.

      The Green Sturgeon is not an endangered or threatened species.

2. **If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).** *If not applicable, put "None".*

   CEQA Lead Agency: None
   NEPA Lead Agency (or co-lead:) None
   NEPA Co-Lead Agency (if applicable): None

3. **Please check which type of CEQA/NEPA documentation is anticipated.**

   CEQA
   -Categorical Exemption
   -Negative Declaration or Mitigated Negative Declaration
   -EIR
   Xnone

   NEPA
   -Categorical Exclusion
   -Environmental Assessment/FONSI
   -EIS
   Xnone

   If you anticipate relying on either the Categorical Exemption or Categorical Exclusion for this project, please specifically identify the exemption and/or exclusion that you believe covers this project.

4. **CEQA/NEPA Process**
   a) Is the CEQA/NEPA process complete?

      Not Applicable

   b) If the CEQA/NEPA document has been completed, please list document name(s):

5. **Environmental Permitting and Approvals** (*If a permit is not required, leave both Required? and Obtained? check boxes blank.*)

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

STATE PERMITS AND APPROVALS

Scientific Collecting Permit

CESA Compliance: 2081

CESA Compliance: NCCP

1601/03

CWA 401 certification

Coastal Development Permit

Reclamation Board Approval

Notification of DPC or BCDC

Other

FEDERAL PERMITS AND APPROVALS

ESA Compliance Section 7 Consultation

ESA Compliance Section 10 Permit

Rivers and Harbors Act

CWA 404

Other

PERMISSION TO ACCESS PROPERTY

Permission to access city, county or other local agency land.
Agency Name:

Permission to access state land.
Agency Name:

Permission to access federal land.
Agency Name:

Permission to access private land.
Landowner Name:

6. **Comments.**

Land Use Checklist

BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED

1. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

2. **Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?**

   Yes

3. **Do the actions in the proposal involve physical changes in the land use?**

   No

   If you answered no to #3, explain what type of actions are involved in the proposal (i.e., research only, planning only).

   The proposed project will study the green sturgeon and does not involve changes in land use.

4. **Comments.**

Conflict of Interest Checklist

BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED

Please list below the full names and organizations of all individuals in the following categories:

- Applicants listed in the proposal who wrote the proposal, will be performing the tasks listed in the proposal or who will benefit financially if the proposal is funded.
- Subcontractors listed in the proposal who will perform some tasks listed in the proposal and will benefit financially if the proposal is funded.
- Individuals not listed in the proposal who helped with proposal development, for example by reviewing drafts, or by providing critical suggestions or ideas contained within the proposal.

The information provided on this form will be used to select appropriate and unbiased reviewers for your proposal.

Applicant(s):

Peter Klimley, University of California, Davis

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

If yes, please list the name(s) and organization(s):

A.P. Klimley	H.T. Harvey & Associates
D. Hillemier	Yurok Indian Tribe
C.C. Crocker	San Francisco State University
D.W. Kohlhorst	Calif Dept of Fish and Game

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

If yes, please list the name(s) and organization(s):

J.J. Cech, Jr UCD

S.I. Doroshov UCD

B.P. May UCD

Comments:

Budget Summary

BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED

Please provide a detailed budget for each year of requested funds, indicating on the form whether the indirect costs are based on the Federal overhead rate, State overhead rate, or are independent of fund source.

State Funds

Year 1												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary** *(per year)*	**Benefits** *(per year)*	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	Physiological Studies	2520	44184	884	1500	11500	0	0	9856	67924.0	5807	73731.00
2	Developmental (Reproductive) Studies	984	23700	5475	1500	5000	0	0	0	35675.0	3568	39243.00
3	Genetic Studies	1565	48090	10931	1500	8100	11100	2500	0	82221.0	7972	90193.00
4	Telemetric Studies	1260	22092	442	1000	7000	203823	0	4928	239285.0	9253	248538.00
5	Sturgeon Capture and Tagging	0	0	0	0	0	42474	0		42474.0	2500	44974.00
6	Management of Project	0	0	0	0	0	18134	0	0	18134.0	1813	19947.00
		6329	138066.00	17732.00	5500.00	31600.00	275531.00	2500.00	14784.00	485713.00	30913.00	516626.00

Year 2												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary** *(per year)*	**Benefits** *(per year)*	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	Physiological Studies	2520	44184	884	1500	11500			9856	67924.0	5807	73731.00
2	Developmental (Reproductive) Studies	984	24648	5694	1500	5000				36842.0	3684	40526.00
3	Genetic Studies	1565	48090	10931	1500	11100	11100			82721.0	2500	85221.00
4	Telemetric Studies	1260	22092	442	2500	7000	157148		4928	194110.0	9403	203513.00
5	Sturgeon Capture and Tagging	0	0	0	0	0	42474			42474.0	2500	44974.00
6	Management of Project	0	0	0	0	0	18134			18134.0	1813	19947.00
		6329	139014.00	17951.00	7000.00	34600.00	228856.00	0.00	14784.00	442205.00	25707.00	467912.00

Year 3												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary** *(per year)*	**Benefits** *(per year)*	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Grand Total=984538.00

Comments.

Budget Justification

<u>BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED</u>

Direct Labor Hours. Provide estimated hours proposed for each individual.

Total Year 1 & Year 2 Task 1 1. Graduate Student 2520 hours 2. Graduate Student 2520 hours Task 2 Staff Research Associate IV 984 hours Postgraduate Reseacher III 984 hours Task 3 Adjunct Associate Professor 1050 hours Postgraduate Researcher I 2080 hours Task 4 Graduate Student 2520 hours

Salary. Provide estimated rate of compensation proposed for each individual.

Task 1 - Year 1 and 2 1. Graduate Student - $17.53 per hour 2. Graduate Student - $17.53 per hour Task 2 - Year 1 Senior Research Associate - $29.88 per hour Postgraduate Researcher - $18.29 per hour Task 2 - Year 2 Senior Research Associate - $31.07 per hour Postgraduate Researcher - $19.02 per hour Task 3 - Year 1 and 2 Adjunct Associate Professor - $50.00 per hour Postgraduate Researcher I - $21.00 per hour Task 4 - Year 1 and 2 Graduate Student - $17.53 per hour

Benefits. Provide the overall benefit rate applicable to each category of employee proposed in the project.

Task 1 Graduate Student - 0.02 Task 2 Senior Research Associate - 0.25 Postgraduate Researcher III - 0.20 Task 3 Senior Research Associate - 0.25 Postgraduate Researcher I - 0.20 Task 4 Graduate Student - 0.02

Travel. Provide purpose and estimate costs for all non-local travel.

Total Year 1 & Year 2 Task 1 $3,000 - travel and per diem to attend scientific meeting Task 2 $3,000 - In-state travel to collect wild broodstock and transport to UCD or spawn on river; field trips to biopsy tagged fish. Task 3 $3,000 - Travel and per diem for scientic meeting. Task 4 $2,000 - Travel to Klamath River for telemetric studies. $1,500 - Travel and per diem for scientific meeting.

Supplies & Expendables. Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.

Total Year 1 & Year 2 Task 1 $23,000 - Fish foods, reagents, chemicals, steroid analysis supplies, assays, office supplies, tank rentals. Task 2 $10,000 - Field supplies for broodstock collection and spawning; lab supplies for embryo/larval sutdies; histology recharges; tank recharges; water, and feed costs for fish. Task 3 $2,700 - office $$2,500 - computing $14,000 - molecular reagents Task 4 $10,000 - Supplies, gasoline and maintenance of boat $4,000 - Moorings for monitors

Services or Consultants. Identify the specific tasks for which these services would be used. Estimate amount of time required and the hourly or daily rate.

Year 1 & Year 2 Task 3 $14,000 - Sequencer/genotyper lease $8,000 - Equipment maintenance Task 4 Sub a: Senior Fisheries Ecologist (100% time, 2 months, and benefits for 2 years)tagging, interrogating monitors, analysis 640 hours @$100 per hour. Sub b: Biologist and Technician (100% time, 4.4 month/year, benefits, for 2 years)tagging fish, deploying monitors and interrogating. Biologist - 130.5 hours - $16 per hour Technician - 130.5 hours - $10 per hour Sub c: Graduate Student (50% time, 6 months/year, and benefits for 2 years) Assisting in the radio tracking of Green Sturgeon in the Sacramento and San Joaquin rivers. Task 5 CDFG boat operator (100% time, 2 months/year for 2 years) Sturgeon capture and tagging Task 6 Senior Fisheries Ecologist (100% time, 1 month/year, and benefits) Project management. 320 hours @ $100 per hour

Equipment. Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items.

Task 3 - Year 1 Freezer - $2,400

Project Management. Describe the specific costs associated with insuring accomplishment of a specific project, such as inspection of work in progress, validation of costs, report preparation, giving presentatons, reponse to project specific questions and necessary costs directly associated with specific project oversight.

Task 6 - Year 1 & Year 2 Cost is one month of time for co-ordinating the project, preparing the quarterly reports, co-ordinating the workshops at such time presentations will be made. 320 hours @ $100 per hour

Other Direct Costs. Provide any other direct costs not already covered.

Total Year 1 & Year 2 Task 1 Graduate Student Fee Remission - $19,712 Task 4 Graduate Student Fee Remission - $9,856

Indirect Costs. Explain what is encompassed in the overhead rate (indirect costs). Overhead should include costs associated with general office requirements such as rent, phones, furniture, general office staff, etc., generally distributed by a predetermined percentage (or surcharge) of specific costs.

Overhead rates for UCD are federally negotiated. The current rates are: Federal - 48.5% State - 10%

Executive Summary

BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED

The green sturgeon (GS, Acipenser medirostris) is an anadromous, native fish that occurs in low numbers in our Bay/Delta system. It is classified as a CALFED At-Risk Species (Priority Group I), but very little is known about its life history. Basic GS life history information is critical to this species' protection, and our projects targeted research focus is on describing the biological characteristics of this species and its habitats for conservation and potential restoration. We have completed Phase 1 & 2 studies of GS and given technical presentations of our results at two workshops, at the annual meeting of the California-Nevada Chapter of the American Fisheries Society, and at the 4th International Sturgeon Symposium. One M.S. thesis has been completed on GS developmental biology and another is nearing completion, a manuscript has been published, another accepted for publication in the same journal, and several others on the genetics and physiology of sturgeon are in preparation. We are currently conducting Phases 3 and 4 of GS research. Phase 5 will have six tasks: 1. determine juvenile GS developmental stage-related swimming performance, salinity tolerance, salinity preference, gill chloride cell activation, and osmoregulatory responses and stress responses to environmental changes; 2. establish reliable artificial reproduction for research and the methodology for determining sex and gonadal maturity; 3. use unique genetic markers to identify sibling among GS located on their breeding areas by telemetry, plankton tows, and egg traps in order to estimate the number of breeding adults at each spawning; 4. determine the movements and distribution of adult GS tagged with ultrasonic and radio beacons, and tracked either by airplane, automobile, boat or listening stations, within the Sacramento, San Joaquin, and Klamath Rivers and describe the habitats, in which they reside, with particular attention paid to their spawning grounds; 5) capture subadult and adult GS during a one month period in winter (Jan./Feb.) and a similar period in summer (Aug.) in San Pablo Bay (using trammel net samples) and provide GS for Tasks 2 & 3; and 6) project management. Fisheries biologists from UC Davis, CDFG, BML, SFSU, and the Yurok Tribe will join in this collaborative effort to provide valuable information for adaptive management approaches to increase our Bay-Delta GS stocks. This project will provide valuable information to decision-makers using adaptive management to resolve scientific uncertainties in our GS life history conceptual model and assist in GS recovery, a specific ERP, Evaluating green sturgeon habitat, including barriers, diversions, flows and temperaturesis a high priority (Strategic Goal 1, At-risk Species Assessments (p. 31).

Proposal

University of California, Davis

BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED

Peter Klimley, University of California, Davis

BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED

Amount Requested: $984,539 (@ 10% overhead) or $1,203,985 (@48.5% overhead) for 2 yrs

Applicant: A.Peter Klimley, Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, 1 Shields Ave., Davis, CA 95616; ph: 530-752-7641, FAX: 530-752-4154, e-mail: apklimley@ucdavis.edu, pklimley@harveyecology.com

Participants and Collaborators: J.J. Cech, Jr. (UCD), S.I. Doroshov (UCD), B.P. May (UCD), A.P. Klimley (UCD, BML), C.E. Crocker (SFSU), D.W. Kohlhorst (CDFG), R.G. Schaffter (CDFG)

C. PROJECT DESCRIPTION

The green sturgeon (GS, *Acipenser medirostris*) is an anadromous, native fish that occurs in low numbers in our Bay/Delta system (Moyle, 1976). While GS has a lower value in commercial fisheries of the Pacific Coast, compared to white sturgeon (WS, *A. transmontanus*), it is a highly valuable species in traditional tribal fisheries and in the biodiversity of Pacific Northwest's ecosystems. Basic GS life history information is critical to this species' protection, and our project's targeted research focus is on describing the biological characteristics of this species and its habitats for conservation and potential restoration. The GS is classified as a CALFED At-Risk Species (Priority Group I), but very little is known about its life history. Basic GS life history information is critical to this species' protection.

1. Statement of the Problem

Physiology. Studies on juvenile GS are planned to reveal more about characteristics of their emigration to the ocean. Juvenile fish can be more susceptible physiologically to changes in their environment and stand a greater risk of predation than adult fish. Because fish populations are heavily influenced by the success of young life history stages, the study of the transition of this anadromous fish species from the freshwater environment to the saltwater environment is particularly important. Which temperatures, salinities, and dissolved oxygen concentrations do the juvenile GS behaviorally select and what are their tolerance-limits to these variables? What do these "preferences" and tolerance limits of the developing juveniles indicate about emigration rates from the rivers to the estuary and ocean? What are the osmoregulatory impacts of salinity changes on yearling (and older fish) that give us clues about their habitats and movements? Environmental requirements data are quantitatively linked via bioenergetic models (Jobling, 1994) that allow predictions of physiological shortcomings (e.g., reduced growth, reproduction, survival) associated with environmental stresses (measured by tolerance limits and hormonal responses) that lead to populational declines (Wedemeyer et al., 1990). Stress negatively impacts the health, growth and reproductive success of fish. Stress responses (e.g., to temperature changes, low water quality) can lower reproductive success and may account for unexplained failure of populations to reproduce normally. However, studies to test this hypothesis are not possible until a fundamental understanding of the GS' stress response is developed.

Reproductive Biology. Late sexual maturity, long gonadal cycles, and conservative spawning behavior make reproductive potential of sturgeons highly sensitive to fishing mortality (Boreman, 1997) and changes in river flow (Dettlaff et al., 1993). While all species of sturgeon have similar reproductive strategy, they differ in sexual maturation rates, spawning migration patterns, selection of spawning habitat, and larval/juvenile ecology (Holcik, 1985; Bemis and Kynard, 1997). Information on the American GS reproduction is limited to our studies on the Klamath River (CalFed and USDI/USFWS/AFRP Projects). We initiated development of artificial spawning techniques (Van Eenennaam et al., 2001), evaluated reproductive conditions of Klamath River broodstock (Van Eenennaam and Doroshov, 2001), and characterized early development (Deng, 2000; Deng et al., in press). However, some important aspects of GS reproduction remain unknown. The artificial spawning, supporting research on physiology, reproduction, and genetic markers of GS (Phase 1, Tasks 1,2, and 3) was hindered by the low egg fertility and hatchability (Van Eenennaam et al., 2001). We obtained representative data on gonads and gametes of mature broodstock (Van Eenennaam and Doroshov, 2001) but not on the intermediate stages of gonad development, which would elucidate the GS' sexual maturation and reproductive potential. The low adhesivity of GS' eggs, poor pigmentation of hatched larvae, and their behavior (photonegative, demersal, limited mobility) indicate that GS require specific spawning habitat (rocky substrate with the crevices, Deng et al., in press). However, the GS' spawning sites and embryo/larval habitat remain unknown. Resolving these uncertainties will significantly improve our capabilities to protect reproductive potential of GS.

Genetics. Young GS are difficult to morphologically distinguish from sympatric WS. However, the development of a mitochondrial DNA marker, which uses a specific restriction enzyme site, yields a single DNA sequence in WS and two smaller sequences in GS. Further, amplified fragment length polymorphism (AFLP) differences between GS and WS were used to prepare primers from DNA sequences that show a seven base-pair deletion in GS, compared with WS. We need to extend our knowledge of the genetic variability to GS in the Sacramento, San Joaquin, and Klamath Rivers.

Movements and Distribution. Finally, we know very little about the GS' movements, including the important spawning-related migrations along the ocean-estuary-river path. Do subadults move from the ocean into San Pablo Bay during the late summer to feed? How long do migrating, adult GS remain in the estuary? What are spawning GS' locations and movements in the Klamath River (where spawning GS can be reliably accessed through Yurok Tribe cooperation), and what would this indicate about the GS spawning sites and these sites' physical characteristics in the Sacramento/San Joaquin watershed? Disturbingly, during "wet" years, sturgeon are being stranded at the Fremont Weir (unable to enter the Sacramento River channel after apparently migrating up the Yolo Bypass), and information is vitally needed on GS (and WS) movements and swimming performance to assess proposed solutions to this stranding problem.

a. Results to Date. American GS are known to spawn in the Sacramento and Klamath Rivers (Moyle et al., 1994), and the adults are present in the lower reaches of the Columbia and Fraser Rivers (Houston, 1988). Artyukhin and Andronov (1990) described spawning runs of the Asian GS (considered the same species *A. medirostris* Ayres or, as subspecies *A. medirostris mikadoi* Hilgendorf) in the Tumnin River and succeeded in the artificial spawning of two females. However, they provided no detailed descriptions of early GS development. Our CALFED project's (Project No. 98-C15 [B81738], Phases 1 and 2) concentrated on measuring GS' food consumption, metabolic, and growth responses; determining its spawning, egg fertility, and larval survival characteristics; developing genetic techniques for distinguishing GS (from WS and between GS stocks), and searching Feather River habitats for evidence of GS spawning (see Appendix 1 for detailed review). Through these activities, we collected samples of gonads and finrays from 30 wild-caught adults (Klamath River) and 14 subadults (San Pablo Bay) to examine gonadal development in relation to age, body size, and sex. We also conducted the first artificial spawning of North American GS (May 1999) on the Klamath River (in collaboration with the Yurok Tribe), reared GS juveniles at UC Davis campus, photographed the developmental stages of the embryos and larvae, and are preparing a manuscript describing their normal development. The resulting juvenile GS were used in studies of ration size and temperature effects on food consumption rate, growth rate, and food conversion efficiency. Studies were also conducted on GS juveniles' metabolic (oxygen consumption) rates, and preliminary data were collected on the developing GS' stress responses.

In addition, we have determined GS' growth responses to elevated temperatures (24^{o} C), and we have made juvenile GS available for the Fish Treadmill research project (CALFED Project # 99-N02) at UC Davis investigating fish swimming performance and behavior in the complex flows in front of fish screens. We have characterized the GS' response to acute stressors by measuring changes in plasma cortisol (Daly et al., 1999), glucose, and lactate concentrations, as well identifying environmental factors (temperature and time of day) that modify the stress response.

Phases 3 and 4 (CVPIA/AFRP, USFWS Agreement No. 11332-1-G005) continues these studies and includes preliminary studies of GS movements in the Sacramento-San Joaquin/Bay Delta Watershed. These phases (October, 2001 through September, 2003) have five objectives: 1. determine juvenile GS' temperature, dissolved oxygen, and salinity tolerance limits (using laboratory tanks/assays) and behavioral tendencies (using annular gradient tank); swimming performance (using swimming flumes); and stress responses (using laboratory tanks/assays, Task 1); 2. characterize GS gonadal sex differentiation, stages of gametogenesis, fecundity and egg size in relation to age and body size (using samples from captive and wild populations); investigate GS chorion function and substrate attachment in fertilized eggs (using histochemical staining for glycoproteins and scanning electron microscopy); and determine optimal temperature ranges for GS larval development, growth, and survival (using laboratory tanks, Task 2); 3. develop genetic techniques to accurately identify GS at all life history stages and examine the uniqueness of GS stocks (using nuclear microsatellite and mitochondrial DNA markers, Task 3); 4. determine the directions and rates of movement of adult/subadult GS in San Pablo Bay, the Yolo Bypass Toe Drain, and the Klamath River and the relative importance of temperature, salinity, and water current direction (using ultrasonic and radio telemetry, Task 4); and 5. assess the distribution and abundance of GS in San Pablo Bay (using trammel net samples, Task 5) and provide GS for Tasks 1-4.

b. Conceptual Model. Phase 5 will have four objectives: 1. determine juvenile GS' developmental stage-related swimming performance, salinity tolerance, salinity preference, gill chloride cell activation, and osmoregulatory responses and stress responses to environmental changes; 2. establish reliable artificial reproduction for research and the methodology for determining sex and gonadal maturity; 3. use unique genetic markers to identify sibling among GS located on their breeding areas by telemetry, plankton tows, and egg traps in order to estimate the number of breeding adults at each spawning; 4. determine the movements and distribution of adult GS tagged with ultrasonic and radio beacons, and tracked either by airplane, automobile, boat or listening stations, within the Sacramento, San Joaquin, and Klamath Rivers and describe the habitats, in which they reside, with particular attention paid to their spawning grounds; 5) capture subadult and adult GS during a one month period in winter (Jan./Feb.) and a similar period in summer (Aug.) in San Pablo Bay (using trammel net samples) and provide GS for Tasks 2 & 3. Fisheries biologists from UC Davis, CDFG, BML, SFSU, and the Yurok Tribe will join in this collaborative effort to provide valuable information for adaptive management approaches to increase our Bay-Delta GS stocks through resolution of current scientific uncertainties in our GS life history conceptual model (Figure 1).

Figure 1 shows our conceptual model linking the GS' life history in the Sacramento-San

Joaquin watershed ecosystems (river, including bypass, and estuary) to the Pacific Ocean. The rectangles represent the known ecosystems that the anadromous GS occupy at various life stages, yet many scientific uncertainties exist regarding their spatio-temporal pattern(s) and movements (arrows) in this system. The questions raised and samples/experiments started and proposed (see Statement of the Problem, above) are shown as the question marks (regarding distribution of the juveniles) and (lettered) approaches listed near the various life stages. Resolving more of the key spatio-temporal patterns (i.e., putting approximate dates [times of year] and/or fish ages with life stages in the various ecosystem components) will remove these uncertainties and provide valuable information to decision-makers using adaptive management to assist Sacramento-San Joaquin watershed GS population recovery, a specific ERP (Vol. 1, WS and GS, pp. 146-148; Vol. 2, WS and GS, p. 276) and AFRP (pp. 40-41, 70-71, and 95) objective of CALFED and CVPIA.

c. Hypotheses Being Tested. We will test several hypotheses to help achieve the CALFED Ecosystem Restoration Goal (#1) for GS: recovery towards large, self-sustaining populations, minimizing the need for future listing as an endangered species (CALFED Ecosystem Restoration Program Plan, Strategic Plan for Ecosystem Restoration, p. 21). Hypotheses letters refer to lettered approaches in conceptual model (Figure 1).

A. Spawning requirements are dependent on season (spring), river flow (temperature and current velocity), and spawning substrate (bedrock or gravel) (Tasks 2, 4, 5).

B. GS account for <10% of the sturgeon egg production in the Feather/Sacramento Rivers. Feather/Sacramento River GS are being caught in the Oregon and Washington ocean fisheries. The relative contribution of each GS stock to a mixed stock ocean fishery will be determined during Phase 5 (Task 3).

C. Egg incubation occurs in the bedrock crevices, as suggested by their low adhesive properties (Phases 3 and 4, Task 2).

D. Optimal river temperature range GS larvae is most likely within 14-20^{o}C (Phases 3 and 4, Task 2).

E. Stress responses are activated at a significantly earlier age than those of WS (Phase 2, Task 1), but are significantly more sensitive to increased temperature and decreased dissolved oxygen stressors than to increased salinity stressors (Phase 2, Task 1). Chronic and acute stress responses occur in response to environmental changes and are measurable with biochemical, hormonal, and whole animal approaches (Phase 5, Task 1).

F. Swimming performance, in terms of critical swimming velocity (cm/s, Brett 1964) significantly increases as the fish grow in length, and increases as temperature increases (to some maximum within its temperature tolerance range, Task 1).

G. GS become more salt water tolerant through activation of gill chloride cells, as they develop during their first year, and GS are more salt water tolerant than WS at the same size (Task 1).

H. Movement is more directed (and movement rate is significantly greater) with the water current axis (strong rheotaxis, either positive or negative) in rivers than its direction and movement rate toward the salinity gradient axis in San Pablo Bay (Task 4). GS movement directions are correlated (non-random distribution) with temperature (Task 4). GS move upstream (only) in

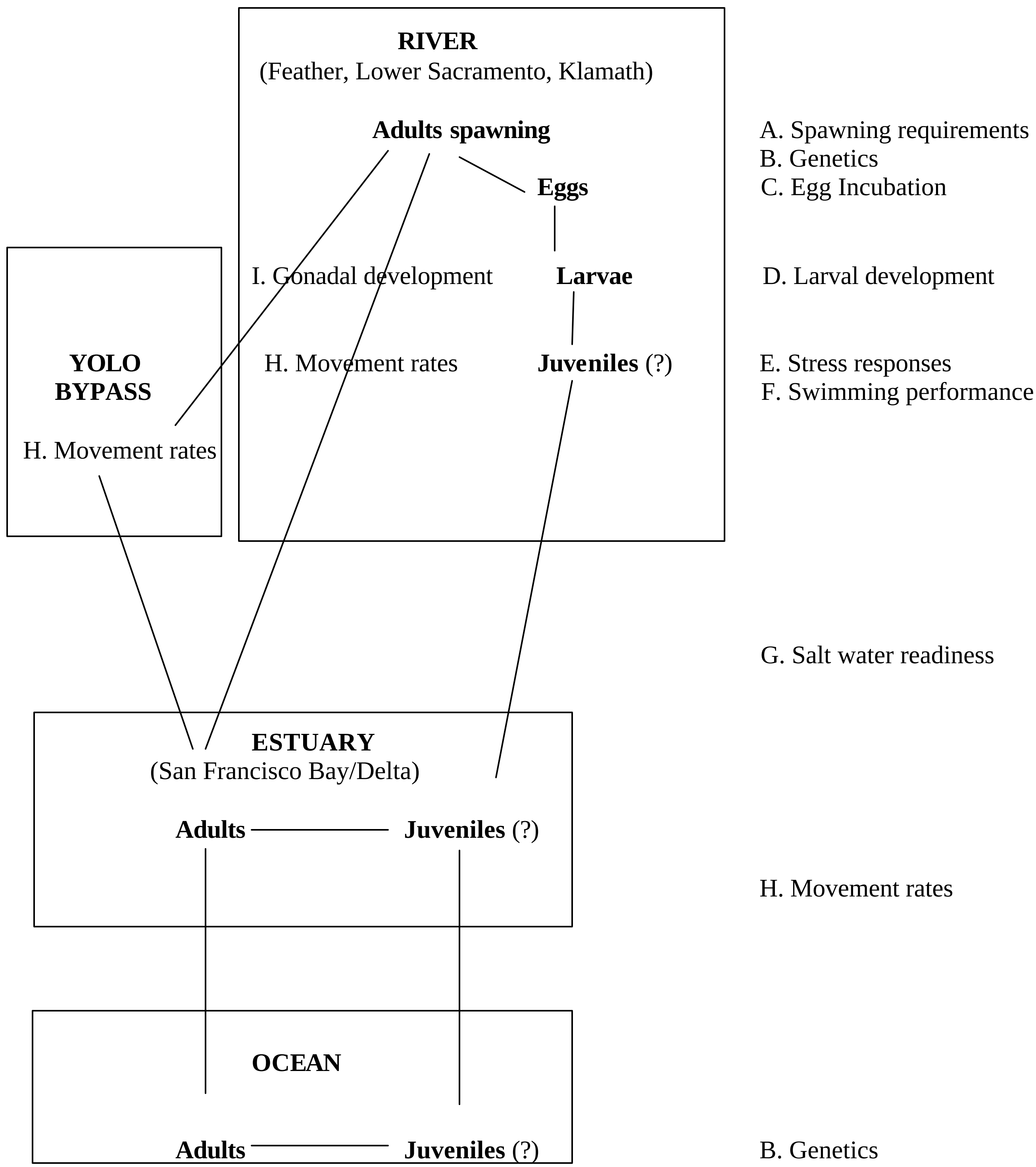

Figure 1. Conceptual model, with (lettered) targeted research elements, for GS distribution and movements in the Sacramento-San Joaquin watershed and linked ecosystems.

the Yolo Bypass (towards their putative spawning sites in the Feather and Sacramento Rivers) at a rate that is non-significantly different than that shown in the main channels of the Sacramento and Klamath Rivers (in the latter, pre-spawning adults are known to be reliably accessed, Tasks 4, 5). GS migrate up the headwaters of the Sacramento Ri ver between Battle Creek and Shasta Lake. GS migrate up the Klamath beyond Dillon Creek (Phase 5, Tasks 4, 5). GS remain in deep, slow moving pools near the headwaters of rivers (Phase 5, Task 4).

Our coordinated approach of testing these hypotheses will resolve key scientific uncertainties in the conceptual model (Figure 1) and will significantly assist in GS recovery, a specific ERP (Vol. 1, WS and GS, pp. 146-148; Vol. 2, WS and GS, p. 276) and AFRP (pp. 40-41, 70-71, and 95) objective of CALFED and CVPIA. (regarding distribution of the juveniles) and (lettered) approaches listed near the various life stages. Resolving more of the key spatio-temporal patterns (i.e., putting approximate dates [times of year] and/or fish ages with life stages in the various ecosystem components) will remove these uncertainties and provide valuable information to decision-makers using adaptive management to assist Sacramento-San Joaquin watershed GS populational recovery, a specific ERP (Vol. 1, WS and GS, pp. 146-148; Vol. 2, WS and GS, p. 276) and AFRP (pp. 40-41, 70-71, and 95) objective of CALFED and CVPIA.

d. Adaptive Management. The various samples and experiments that comprise this project should systematically remove the scientific uncertainties shown in the conceptual model. Also, as data are collected and analyzed, more quantitative hypotheses can be posed to more accurately determine the spatio-temporal patterns of GS distribution and abundance in the Sacramento-San Joaquin watershed ecosystems. For example, the salt water tolerance (Phase 3) and the growth rate responses to temperature experiments (Phases 1 and 2) on developing, juvenile GS will better define their environmental (niche) requirements and indicate their emigratory timing capabilities (and, therefore, likely distribution) in the system for a particular year (and its river temperature regime).

e. Educational Objectives. Although the project is targeted research, several UC Davis and SFSU graduate and undergraduate students will be part of the research team to reduce scientific uncertainties concerning GS life history. Regular reports at workshops, meetings, and in the IEP Newsletter, and peer-reviewed publications will help disseminate results to the interested public and to professionals. Dr. Carlos Crocker brings SFSU students to the project.

2. Proposed Scope of Work

a. Location. Project field locations will be in San Pablo Bay, the Sacramento River/Yolo Bypass system, and Klamath River. Although the Klamath is not technically part of the Sacramento-San Joaquin watershed, river tracking of GS is planned there because it is an established GS spawning site and we enjoy an excellent working relationship with our Yurok Tribe colleagues. The various laboratory studies are planned at UC Davis.

b. Approach. *Task 1, Physiological Studies.* The study of the transition of juvenile GS during their emigration to the ocean will include four parts. 1. Swimming performance of juvenile GS from post-larval to saltwater-tolerant juveniles will be measured (critical swimming velocity in a Brett-type swimming chamber, Brett , 1964; Beamish 1978) and will be compared with that of same-size white sturgeon (WS). These critical swimming velocity measurements are an established measure of performance for bottom-oriented, as well as mid-water-oriented river species (Myrick and Cech, 2000) and will be relatable to these species' comparative abilities to hold and move in currents of different velocities. This information is critical for adaptive fish and water management efforts currently underway. 2. GS salinity tolerances and preferences will be measured during juvenile development. Salinity tolerances will be assessed using replicated, individual and group GS containers of aerated water. Container water will be changed (2 ppt salinity increase every 8 h for experimental fish and 0 ppt increase for controls) until 50% of the fish lose equilibrium (endpoint), following Young and Cech (1996). 3. GS gills will be examined histologically for development of saltwater (alpha) chloride cell development. These cells, located on the gill filaments, at the base of the lamellae, allow the fish to regulate internal ionic concentrations in hypertonic (saltwater) environments. As the fish transition from freshwater to saltwater, the external ion concentrations dramatically increase, requiring activation of regulating mechanisms (including gill chloride cells) to maintain desired internal ion concentrations (reviewed by Karnaky, 1997). Gill tissues will be sampled during development as salinity tolerance increases. Chloride cell density, from microscopic examination of gill tissues, will be quantified as the fish develop and compared with salinity tolerances and levels of hormones (plasma cortisol, thyroxine, tri-iodothyronine; from blood samples) thought to contribute to saltwater readiness in salmonids (reviewed by Hoar, 1988) and sturgeon (McEnroe and Cech, 1987). Larger (yearling and older) juveniles will be cannulated (Deng et al., 2000) and exposed to environmental salinity changes, via salt or freshwater additions to their laboratory tanks. Blood samples from the cannulae will be analyzed for plasma Na^+ (flame photometer), Cl^- (chloride titrator), and osmolality (vapor pressure osmometer) to determine their ability to tolerate trans-estuarine movements into either hypertonic (marine) or hypotonic (freshwater) environments (McEnroe and Cech, 1985). Appropriate statistical models (ANOVA, Kruskal-Wallis, and post-hoc tests) will be used to compare means. The fourth part of the study will consist of collecting GS size (length, weight) and corresponding hydrographic (water salinity, temperature, velocity) data from on-going field research/monitoring studies (Archimedes screw traps in freshwater locations and seining and fyke trap methods in slow water pre-estuary and estuarine reaches of drainages) catching juvenile GS from the Sacramento and Klamath Watersheds, providing important “ground-truthing” for the laboratory data. Cooperation is being arranged with various agencies (e.g., USFWS, Curt Brown & George Guillen; CDFG) and the Yurok Tribe (Dave Hillemeier). In addition, previous data obtained as bycatch from salmon-based surveys will be used to help pinpoint GS sampling locations. This research will clarify the early life history of GS, and provide guidance for preserving GS in our Sacramento - San Joaquin Watershed.

Investigations into the effects of chronic stress on GS are currently being developed by exposing groups of fish to three different stress regimes: no stress (control), acute stress, and chronic stress. Critical swimming velocity (U_{crit}), metabolic scope for activity (Brett, 1964; Cech, 1990), metabolic substrates (glucose, lactate, and liver glycogen), and the acute plasma (cortisol) response to stress and ACTH infusion (Belanger et. al., in press) will be measured in each group as performance indicators. Quantification of glucocorticoid receptor (GR) density and affinity in the liver, red blood cells and gills of fish from each stress regime will determine if down regulation of GR occurs with chronic stress and if it is a tissue-specific or a widespread phenomenon in GS (Maule and Shreck, 1990). These data will provide a measure of the animal’s relative ability to respond to stress. Furthermore, in order to correlate the mal-adaptive effects of chronic stress with increased cortisol levels we also plan to block the animal’s ability to produce cortisol by immunizing the fish against segments of both the C-terminus and N-terminus amino acid sequence of green sturgeon ACTH, which we will clone using molecular techniques (Baptice et. al., 1995). Immunized fish will then be chronically stressed tested as described above. Appropriate statistical models (ANOVA, Kruskal-Wallis, and post-hoc tests) will be used to compare means. If the proposed model is supported, it would provide evidence for a physiological trait that could be contributing to GS’ low population size.

Task 2: Reproductive Studies. These studies will include three parts aimed to: (1) increase reliability and efficiency of artificial spawning, (2) characterize gametogenesis and gonadal cycle, and (3) assess the sex and gonadal maturity stage of wild GS used in tracking studies (linked with task 4). The first part will focus on improving spawning and egg incubation techniques to increase egg fertility and hatchability. Hormone-induced spawning and in vitro fertilization developed for WS (Conte et al., 1988; Webb et al., 1999) were generally successful with GS (Van Eenennaam et al., 2001), except for the low egg fertility (26-47 %) and hatchability (1-23%) creating an unreliable supply of juveniles for research (CalFed Project 98-C15, Report for Phase 1). We hypothesize that low fertility was effected by hormone treatment (leading to eggs "overripeness") and by coelomic fluid (collected with ova) known to inhibit sperm activation in in vitro fertilization (Dettlaff et al., 1993). The low egg hatchability was effected by incubation of GS' eggs, which have thin and fragile chorions, in the MacDonald jars. The design of these jars (strong jet of inflowing water to keep the eggs suspended) is well-suited for WS' eggs with the thick and tough chorions, but compromises development of GS'embryos during organogenesis. To improve egg fertility, we will change the current hormone treatment protocol and subject the ova to rinsing with river water before fertilization (sturgeon ova retain fertilization capacity in water, Dettlaff et al., 1993), in order to remove coelomic fluid.

To improve hatchability, we will test the modified upwelling jars (trout type), in which the water flow is distributed more evenly through a perforated screen. Spawning trials will be conducted with a minimum number of four "spawnable" (i.e. in a responsive stage and good health) females caught in the lower Klamath River. The female spawning readiness, egg fertility and hatchability will be evaluated using standard protocols (Van Eenennaam et al., 2001). Two females will be injected with GnRHa alone, and the other two with GnRHa and domperidone (dopamine antagonist), at reduced dose levels to avoid "overripeness" (premature oocyte maturation). The ova of each female will be divided into several batches and subjected to fertilization treatment (rinsed vs. non-rinsed) and incubation treatment (modified vs. MacDonald jars). The effects of treatments will be examined by factorial analysis of variance. Achieving a fertilization rate of 70% and hatching rate of 30-50% will be sufficient for practical artificial reproduction and reliable supply of juveniles. Rearing of GS larvae from hatching to metamorphosis has been highly successful (Van Eenennaam et al., 2001; Deng et al., in press) and is not a priority at present time.

Knowledge of gametogenesis and stage of gonad development in sturgeon provides critical information for stock management (Van Eenennaam and Doroshov, 1998), but the representative samples are difficult to obtain from wild population (CalFed Project 98-C15, Report for Phase 1). In the second part of reproductive studies, we propose to characterize gametogenesis during the first reproductive cycle in two GS stocks reared at UC Davis (progeny of fish spawned in 1999 and 2000, mean weight 3 and 6 kg at age 1 and 2 years). We hypothesize that sexual maturation in GS is dependent on body size and season, as in WS and other acipenserids (Doroshov et al., 1997), and the gametogenesis of cultured stock can be used as a template for wild fish of similar size. We will collect gonadal biopsies from individually marked fish (n=50 in each stock) at least twice a year (spring and fall), to account for seasonality. Histological processing and classification of stages will follow reported procedures for the white (Doroshov et al., 1991; Chapman et al., 1996; Doroshov et al., 1997) and Atlantic (Van Eenennaam and Doroshov, 1998) sturgeon. Stages in male and female will be classified, correlated with body size and season, and illustrated by photographs. Study will provide insight in GS' reproductive cycle and guidance for observations on gonad development in the field.

In the third part, we will implement in vivo gonadal biopsy to assess the sex and stage of maturity of wild-caught GS, in conjunction with sturgeon movement studies (task 4). Knowing sex and maturity will add information on factors determining GS' movements and tracking sturgeon to spawning sites. Feeding behavior may play primary role in the movement of GS with intermediate stages of gametogenesis. The movements of mature or post-spawned adults are expected to depend on gonad development. Both the feeding and reproductive behavior in sturgeon are supported by their acute olfactory sense (Kasumyan, 1999) and acoustic communication (Tolstoganova et al., 1999). We will collect gonadal biopsies in collaboration with telemetry investigators (Task 4), from wild GS used for tracking studies in the San Pablo Bay and Klamath River. Small gonad fragments will be removed aseptically through minor (1-2 cm) abdominal incision, which will be closed with a PDS, Ethicon, suture (the procedures are detailed in a recent workshop brochure, Van Eenennaam et al., 2001a). In the case of mature females in the Klamath River' spawning run, we will collect the ovarian follicles by catheter, fix them by boiling, bisect hardened oocytes and measure polarization index (distance of germinal vesicle from animal pole) by using image analysis. This index quantifies the oocyte maturity and female spawning readiness of females, and can be used to estimate the proximity of spawning grounds to sampling and radiotagging sites (Van Eenennaam et al., 1996).

Task 3, Genetic Analyses. In Phases 1 and 2, nuclear and mitochondrial DNA markers were developed to distinguish between early life history stages of GS and WS. In addition, nuclear microsatellite markers were developed that could characterize genetic variation within and between GS populations along the western coast of the U.S. In this phase, our evaluation of genetic variation in green sturgeon populations indicated that estuarine green sturgeon samples from the Columbia River are very different from the Klamath River breeding population. Some biologists have argued that GS caught at the mouth of the Columbia River are exclusively composed of Klamath River green sturgeon. Phases 3 and 4 are continuing this effort by enlarging the suite of microsatellite loci used to examine genetic variation among green sturgeon, paying special attention to developing disomic vs. tetrasomic loci. We are using these markers and those already developed to characterize allele frequencies, distributions of possible component populations from the Sacramento-San Joaquin Delta, Rogue, Klamath, and other basins where adult spawning and juvenile green sturgeon samples have been collected by our cooperators. This comparison of stocks is essential to determine the uniqueness of our Sacramento-San Joaquin basin GS and gain insight into the seasonal migrations of this species.

During Phase 5 we will continue to resolve component population samples and identify eggs and larval stage samples as they are received from CDFG and other cooperating departments and programs. The markers we currently possess can uniquely differentiate between individuals. The telemetric monitoring of GS on their breeding areas, plankton tows and egg traps in the Sacramento-San Joaquin Rivers (Task 4) will provide opportunity for identifying siblings. This will provide information for estimating the number of breeding adults at each breeding location. Currently, computer programs are being developed in the Genomic Variation Laboratory to evaluate the relatedness among a cohort for estimating parental contribution (Beyer and May, unpublished). For this analysis, we propose to build a database of juvenile green sturgeon genotypes that can also be cross-referenced by future sampling efforts for understanding migration patterns and oceanic movement of individual fish. In addition, we will focus our efforts on analyzing oceanic mixed stocks of GS through estimates of individual pair-wise relatedness between each individual in the mixed stock and each individual from a known stock. We hope this procedure will provide another way for us to estimate component populations present in the mixed-stock fishery in the Sacramento-San Joaquin Delta, at the Columbia River mouth, and off the Oregon coast. This type of analysis is necessary because few breeding individuals are obtained from some of the component populations. This type of pairwise relatedness measure for estimating component populations will be used as a second estimate to be compared to traditional mixed stock analysis estimates. This analysis will allow us to understand each stock's contribution to the total catch and monitor oceanic movement.

Task 4, Telemetric Monitoring. Future plans to restore GS populations must be formulated with knowledge of the spatial distribution of the species as well as its environmental requirements. Radio and ultrasonic telemetry has been used effectively to track various species of sturgeon (Kieffer and Kynard, 1996; Schaffter, 1997; Auer, 1999; Fox et al., 2000; Erickson et al., unpub. man.). Phases 3 & 4 describe the subadult and adult GS' movements and natural habitats by tagging and tracking individuals with depth-sensing ultrasonic transmitters within San Pablo Bay (and associated Delta waters), especially regarding relevant habitat characteristics. GS are being caught in trammel nets set in San Pablo Bay during late summer and fall. (Task 5). The decrease in rate of capture between September and October and later recapture of GS with fin-tags north of San Francisco after 3 mo to >1 year indicate that adults leave the bay in late fall and migrate along the coast northward toward the coast of Oregon (D. Kohlhorst, pers. com.). CDFG fished for GS in August 2001 (catching 39 GS) to capture individuals early during their outward migration and we have begun tracking them in the bay. We intend to place transmitters on 10 adult GS during each year using two methods: 1. insertion of internal tags into the peritoneum of five GS, closure of incision (sutures), maintenance of the individuals in captivity (SFSU tanks with continuous bay water flows) until the insertion wound heals (ca. 3 d), and release of the GS at the site of capture; and 2. attachment (stainless steel wire) of external tags to GS and immediate release. Tagged GS will be tracked continuously, exchanging tracking crews at 12 hr intervals, for periods of 1-3 d, using a 7.5-m research skiff (Klimley, 1993; Klimley et al., in press). The geographic coordinates of the GS and local water temperature is being recorded at 10 sec intervals by an automated telemetry system (directional hydrophone interfaced with an ultrasonic receiver, laptop computer, and differential-corrected global positioning system to automatically pair the temperature measurements with geographic coordinates. GS tracks are being superimposed on bathymetric maps and satellite images of sea surface temperature using ArcView software to identify bay thermal regime preferences.

We also will tag five GS with radio tags in the Yolo Bypass, the primary floodplain of the Sacramento Delta. Before flowing into this basin, water must pass over the Fremont Weir, where, at all but the highest flow levels, there is an elevation difference between the Yolo Bypass and the Sacramento River at the weir. During high flow periods, upstream-migrating GS are attracted into the basin and become concentrated in a 2.4-km reach below the Fremont Weir and unable to proceed further upstream because of the inadequate fish ladder at the center of the weir. We will capture and tag GS in the Yolo Bypass (in cooperation with T. Sommer, DWR), determine their residence time in the Bypass, and track them as they proceed upstream. This stranding problem is well known by CDFG wardens and recently made local TV news as a lead story. We will provide CDFG with movements (and swimming performance, see Task 1) data that may be critical in their solution of this "problem."

Phase 5 will focus on the upward migration of adult GS in the Sacramento (and, for the comparative purposes, Klamath) watersheds. Nineteen GS were recently tagged and tracked in the Rogue River, Oregon (Erickson et al., unpub. man.). These individuals stayed in deep, low-gradient reaches on the river and migrated upstream to km 39 on the river. Individuals' home ranges were restricted within the reaches, making the species very vulnerable to habitat modifications. We will track the movements of GS within two rivers and describe the physical properties (substrate type, water temperature, and flow) of their microhabitats. Forty GS will be tagged with radio and ultrasonic beacons in the Delta. The subadult and adult GS will be captured using trammel nets by CDF&G (or a comparable contractor) during a 1-month period during winter (Jan./Feb.) when upmigration is anticipated, and if this produces a limited catch, during Aug. when 39 subadult and adult GS were captured during 2,001. These beacons will be long lived (48 mon) and coded for individual identification. We will record the passage of individuals through the Sacramento/San Joaquin River drainage with automated tag-detecting monitors. GS will be detected as they pass four monitors in the Delta and 16 monitors in the Sacramento and San Joaquin Rivers situated between the major tributaries leading from the Cascade and Sierra Nevada mountains. The monitors (Vemco, Ltd., VR-01) are capable of detecting tags at a distance of 500 m in the open ocean, and, placed in the center of a river, will detect the passage of tagged fish on either side. Attached will be thermal loggers that record water temperature at hourly intervals. The monitors at each site will be interrogated monthly. We will also determine the bimonthly distribution of GS by searching for radio tags in an antenna-equipped airplane. Once individuals are located from monitor records and aerial censuses, we will search in those reaches of the river for tagged GS with an antenna-equipped car and inflatable. Adult GS will then be tracked continuously for 2-3 day periods, characterizing GS microhabitat over 24-hr periods. Plankton tows will be carried out at these sites and egg traps deployed to collect egg samples for genetic analysis (Task 3). A concerted effort will be made to identify spawning habitat. Mature adult GS captured during August may soon leave the bay and enter the ocean, and for that reason, the beacons used will have an extended life of four years to detect them during their subsequent upstream migration.

Because adult GS are rarely caught while migrating upstream in the Sacramento River, we will conduct a tandem tracking study in the Klamath River, where individuals are frequently captured. Biologists of the Yurok tribe will tag 20 adult GS with similar coded beacons. Twenty tag-detecting monitors will be deployed along the Klamath and Trinity Rivers to record the passage of tagged GS and these monitors will be interrogated bi-monthly or monthly, depending on time of year. Loggers attached to the monitors will record water temperature hourly. Fish and Wildlife Service biologists have received funding to conduct radio tracking using a boat, automobile, and/or airplane. The Yurok Tribe biologists will inform the radio trackers, between which of the monitors the sturgeon reside, and the sturgeon will be tracked intensively over 24-hr periods, characterizing their preferred habitat in terms of substrate type, water temperature, and current speed. Sampling for eggs will also be carried out at those reaches of the river where GS linger. We intend to characterize the favored habitat for spawning by adults. A fin clip will be taken from each tagged GS for genetic analysis (Task 3) to determine GS population structure and the relatedness of breeding individuals; histological samples will be removed by a catheter that is inserted in the vent of the GS to estimate the time of spawning in the watershed.

Task 5, Sturgeon Capture and Tagging. CDFG has monitored WS mortality rates and abundance since 1954 using mark-recapture techniques. Sturgeon are generally captured for tagging using trammel nets in San Pablo Bay during September and October and recaptured by anglers during subsequent tagging operations. GS have also been captured and tagged, but in much lower numbers than WS. We suspect that higher catches of GS in September than in October are related to migratory behavior, either because of summer estuary use, as in the Columbia River estuary, or post-spawning movement out of the estuary. We will contract CDFG (or a commercial fisherman) to set trammel nets during winter (Jan./Feb.) to capture upmigrating adult sturgeon at well set nets during the summers (Aug.) of 2003 and 2004. GS were frequently captured during this period in 2,001.

Task 6, Project Management. Klimley and Cech will manage the project jointly. This will involve frequent inspection of the work in progress. They will work with the co-investigators and supervise graduate students, give scientific presentations, and prepare jointly authored publications.

c. Monitoring and Assessment Plans. CALFED-supported biological studies with GS are ongoing (Project No. 98-C15). For aspects of Tasks 1-3, the experimental approach, design, methods, and analyses have already been subjected to rigorous discussion and review. Detailed descriptions of all aspects of these tasks are provided in the Biological Monitoring/Research and Quality Assurance Plan submitted to CALFED earlier this year and are attached as Appendix 2. For Tasks 4 and 5, data collection, monitoring and assessment, use standard field, laboratory, and statistical techniques (briefly described in Approach above) that will be similarly described in an updated Biological Monitoring/Research Plan. Descriptions of the current work and preliminary results have been presented at two workshops (Davis, CA, and Weitchpec, CA) and at the annual meeting of the California-Nevada Chapter of the American Fisheries Society (Ventura, CA). In addition, a manuscript describing GS spawning, egg fertility, and larval survival has been recently submitted to the peer-reviewed *Transactions of the American Fisheries Society.*

d. Data Handling and Storage. Data handling and storage are described in the Biological Monitoring/Research Plan, attached as Appendix 2. These protocols will be updated as necessary for this next-phase research program.

e. Expected Products and Outcomes. Quarterly reports will include financial status, activities during the quarter, tasks completed, deliverables produced, problems encountered, and a description of modifications to the contract. A final technical report describing results of the studies will be submitted by the end of the project (March 31, 2003). Results of these studies have been and will continue to be presented at scientific and technical meetings (see Monitoring and Assessment Plan, above). Results of these studies will also be described in IEP Newsletter articles, and in manuscripts submitted for publication in peer-reviewed scientific journals. One manuscript from the project has been accepted for publication in the *Canadian Journal of Fisheries and Aquatic Sciences* and another submitted to the *Transactions of the American Fisheries Society.* All data will be stored by the Principal Investigator for a minimum of five years after project completion.

f. Work Schedule. Funding for this next-phase targeted research is requested for a two-year period beginning April 1, 2003 (expected completion date of Phase 3). The proposed work and schedule outlined below are based on seasonal sampling and year-round laboratory studies as detailed above (see Approach) and contingent on adequate funding, personnel, and fish availability. For this period, six tasks are identified (Table 1, and see Approach for specific activities involved in Tasks 1-5). Project management (Task 6) will be conducted by the Principal Investigator, A. P. Klimley, with J. J. Cech, Jr., who will be assisted by the co-investigators and a research assistant

Table 1. Tasks and schedule for proposed biological assessment of GS studies.

TASK	SCHEDULE
Task 1. GS Environmental Tolerance Limits and Behavioral Tendencies, Stress	April 2003-March 2005
Task 2. Reproductive Biology of GS	Sacramento/San Joaquin, 2003-2005
Task 3. Genetic Analysis	April 2003-March 2005
Task 4. Telemetry	Sacramento/San Joaquin, 2003-2005
Task 5. Extension of CDFG Sturgeon Tagging Period to Increase GS Captures	Sacramento/San Joaquin 2003-2005
Task 6. Project Management	April 2003-March 2005

No zoning regulations, planning ordinances or other constraints that could impact the schedule and

g. Feasibility. This proposal requests next-phase funding for continuation and expansion of a successful, ongoing research program that addresses uncertainties associated with the life history of an At-Risk Priority 1 CALFED species. The project has already produced detailed quantitative data that will be used to develop GS management and conservation strategies. The targeted research outlined in this proposal is feasible, independent of the outcomes of other projects, and independent of natural conditions (e.g., weather), although inadequate supplies of implementability of the project are known.

D. APPLICABILITY TO CALFED ERP GOALS AND IMPLEMENTATION PLAN AND CVPIA PRIORITIES

Relationship to ERP/CVPIA Priorities, Restoration, and System-Wide Ecosystem Benefits: The GS is a CALFED at-risk species (Priority Group I, ERP Strategic Plan for Ecosystem Restoration, Table 4-1), and the proposed assessments will focus on the biological characteristics of this species and its habitats with the objective of providing information useful for their eventual recovery and protection. Our coordinated approach will resolve scientific uncertainties regarding GS life history and their spatio-temporal use of linked ecosystems (Figure 1). This will assist in GS recovery, included in CALFED Goals 1 and 3, at-risk species and harvestable species recovery and protection, as a specific ERP objective (Vol. 1, White and Green Sturgeon, pp. 146-148), and as a CVPIA goal (AFRP, pp. 40-41, 70-71, and 95). This next-phase, targeted research also contributes to the overall CALFED effort to restore ecological health and improve water management for beneficial uses of the Bay-Delta system (e.g., improved management of the Yolo Bypass for fisheries resources). This project also relates to the CALFED-funded Fish Treadmill Project (#99-N02), which aims to quantify the adverse impacts of water diversions and fish screens on GS as well as other priority species through targeted research on fish screen design and operation.

E. QUALIFICATIONS (2 pages)

JOSEPH J. CECH, JR., Ph.D., Professor of Fisheries Biology, UC Davis, 1987 to present.

Five Selected Publications: 1. Young, P.S. and J.J. Cech, Jr. 1996. Environmental tolerances and requirements of splittail. Trans. Am. Fish. Soc. 125:664-678. **2.** Crocker, C.E. and J.J. Cech, Jr. 1997. Effects of environmental hypoxia on oxygen consumption rate and swimming activity in juvenile white sturgeon, *Acipenser transmontanus*, in relation to temperature and life intervals. Env. Biol. Fish. 50:383-389. **3.** Swanson, C., P.S. Young, and J.J. Cech, Jr. 1998. Swimming performance of delta smelt: maximum performance, and behavioral and kinematic limitations on swimming at submaximal velocities. J. Exp. Biol. 201:333-345. **4.** Crocker, C.E. and J.J. Cech, Jr.

1998. Effects of hypercapnia on blood-gas and acid-base status in the white sturgeon, *Acipenser transmontanus*. J. Comp. Physiol. B168:50-60. **5**. Crocker, C.E., A.P. Farrell, A.K. Gamperl, J.J. Cech, Jr. 2000. Cardio-respiratory responses of white sturgeon to environmental hypercapnia. Am. J. Physiol. 279:R617-R628.

SERGE I. DOROSHOV, Ph.D., Professor of Animal Science, UC Davis: 1983 to present.

Five Selected Publications: **1.** 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. **2.** Doroshov, S.I., G.P. Moberg and J.P. Van Eenennaam. 1997. Observations on the reproductive cycle of cultured white sturgeon, *Acipenser transmontanus*. Env. Biol. Fish. 48:265-278.
3. Van Eenennaam and S.I. Doroshov. 1998. Effects of age and body size on gonadal development of Atlantic sturgeon. J. Fish Biol. 53: 624-637. **4.** Doroshov, S.I., J.P. Van Eenennaam and G.P. Moberg. 1999. Development of white sturgeon broodstock. J. Appl. Ichthyol. 15: 326-327; **5.** Webb, M.A.H., J.P. Van Eenennaam, G.W. Feist, J. Linares-Casenave, M.S. 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: 137-151.

BERNARD (BERNIE) PAUL MAY, Ph.D, Adjunct Professor, 1999 to present.

Five Selected Publications: **1.** Marsden, J.E., A. Spidle, and B. May. 1996. Review of genetic studies of *Dreissena* spp. Amer. Zool. 36:259-270. **2.** May, B., C.C. Krueger, and H.L. Kincaid. 1997. Genetic variation at microsatellite loci in sturgeon: primer sequence homology in *Acipenser* and *Scaphirhynchus*. Can. J. Fish. Aquat. Sci. 54: 1542-1547. **3.** May, B., T.A. Gavin, P.W. Sherman, and T.M. Korves. 1997. Characterization of microsatellite loci in the Northern Idaho ground squirrel, *Spermophilus brunneus* Mol. Ecol. 6:399-400. **4.** May, B. 1998. Starch gel electrophoresis of allozymes. In: Molecular Genetic Analysis of Populations: A Practical Approach. 2nd Ed. A.R. Hoelzel, ed. Oxford Univ. Press. **5**. McQuown, E.C., B.L. Sloss, R.J. Sheehan, J. Rodzen, G. Tranah, and B. May. Microsatellite anaysis of genetic variation in sturgeon: new primer sequences for *Scaphirynchus* and *Acipenser*. Trans. Am. Fish. Soc. 279:R617-R628.

A. PETER KLIMLEY, Ph.D., Fisheries Ecologist, H.T. Harvey & Associates, San Jose; 2000 to present; Adjunct Associate Professor, UC Davis, 1998 to present.

Five Selected Publications: **1.** 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. **2.** Klimley, A.P. and C. Holloway. 1999. Homing synchronicity and schooling fidelity by yellowfin tuna. Mar. Biol. 133: 307_317. **3**. Klimley, A.P., F. Voegeli, S.C. Beavers, and B.J. Le Boeuf. 1998. Automated listening stations for tagged marine fishes. Mar. Tech. J., 32: 94-101. **4**. Klimley, A.P. and D.G. Ainley (Eds). 1996. Great White Sharks: The Biology of *Carcharodon carcharias*. Academic Press, San Diego. **5.** Klimley, A.P. 1993. Highly directional swimming by scalloped hammerhead sharks, Sphyrna lewini, and subsurface irradiance, temperature, bathymetry, and geomagnetic field. Mar. Biol. 117:1-22.

CARLOS E. CROCKER, Ph.D., Assistant Professor of Biology, SFSU, 2000 to present.

Five Selected Publications: **1**. Deng, D.D., Refstie, S., Hemre, G.I., Crocker, C.E., Chen, H.Y., Cech, J.J., and Hung, S.S. 2000. A new technique for feeding, repeated sampling of blood and continuous collection of urine in white sturgeon. Fish Physiol. Biochem. (in press). **2.** Crocker, C.E., Cech, J.J., Jr., Farrell, A.P., and Gamperl, K. 2000. The Effects of Hypercapnia on Cardiovascular Performance in White Sturgeon, *Acipenser transmontanus*. Am. J. Physiol. (in press). **3.** Crocker C.E. and Cech J.J., Jr. 1998. Effects of Hypercapnia on Blood-Gas, Acid-Base Balance in White Sturgeon, *Acipenser transmontanus*. J. Comp. Physiol. B. 168:50-60. **4.** Crocker, C.E. and Cech, J.J., Jr. 1997. The effects of environmental hypoxia on oxygen consumption rate and swimming activity in juvenile white sturgeon, *Acipenser transmontanus*: temperature and life stage effects. Env. Biol. Fish 50:383-389. **5.** Crocker, C.E. and Cech, J.J., Jr. 1996. The effects of hypercapnia on growth of juvenile white sturgeon, *Acipenser transmontanus*. Aquaculture. 47: 293-299.

RAYMOND G. SCHAFFTER, M.S., Biologist, California Dept. Fish and Game 1973-present.

Five Selected Publications: 1. Schaffter, R. G. 1980. Fish occurrence, size and distribution in the Sacramento River near Hood, California during 1973 and 1974. CDFG, Anadromous Fisheries Branch Report No 80-3. **2**. Schaffter, R.G., P.A. Jones, and J.G. Karlton. 1983. Sacramento River and tributaries bank protection and erosion control report. CDFG. Sacramento, CA. **3.** Schaffter, R. G. 1997. White sturgeon spawning migrations and location of spawning habitat in the Sacramento River. Calif. Fish Game 83:1-20. **4.** Schaffter, R. G. 1997. Growth of white catfish in California's Sacramento-San Joaquin Delta. Calif. Fish Game 84:57-67. **5.** Schaffter, R.G. 1997. Mortality rates of white catfish in California's Sacramento-San Joaquin Delta. Calif. Fish Game 84:45-56.

DAVID W. KOHLHORST, M.A., Senior Biologist (Specialist), CDFG, 1995 to present.

Five Selected Publications: **1.** Kohlhorst, D.W. 1979. Effect of first pectoral fin ray removal on survival and estimated harvest rate of white sturgeon in the Sacramento-San Joaquin Estuary. Calif. Fish Game 65:173-177. **2.** Kohlhorst, D.W. 1980. Recent trends in the white sturgeon population in California's Sacramento-San Joaquin Estuary. Calif. Fish and Game 66:210-219. **3.** Kohlhorst, D.W., L.W. Miller, and J.J. Orsi. 1980. Age and growth of white sturgeon collected in the Sacramento-San Joaquin Estuary, California, 1965-1970 and 1973-1976. Calif. Fish Game 66:83-95. **4.** Kohlhorst, D.W., L.W. Botsford, J.S. Brennan, and G.M. Cailliet. 1991. Aspects of the structure and dynamics of an exploited central California population of white sturgeon (*Acipenser transmontanus*). Pages 277-292 *in:* P. Willoit, editor. Acipenser: First International Symp. on the Sturgeon. CEMAGREF, Bordeaux, France. **5.** Stevens, D.E., D.W. Kohlhorst, L.W. Miller, and D.W. Kelley. 1985. The decline of striped bass in the Sacramento-San Joaquin Estuary, California. Trans. Am. Fish. Soc. 114:12-30.

F. COST

a. Budget. CALFED next-phase funding is requested for a two-year period to support continued GS research. Cost of the project depends on funding source: $984,539 if funded through a state agency and $1,203,985 if funded through a federal agency. Details of the overall budget, including state and federal overhead rates, are described in Tables 2 and 3 (MS Excel file name: GS.CalFed.2001.xls, Table 1=budget with state overhead rates, Table 2=budget with federal overhead rates); Budget Justification with expenses itemized, including subcontracts. Items in subcontracts, their direct and indirect costs, are in separate Excel files.

b. Budget Justification. *Task 1*: Funding is requested for support of two Graduate Research Assistants (50% time, 9 months, 100% time 3 months/year, benefits, and student fee remissions for

BIOLOGICAL ASSESSMENT OF GREEN STURGEON IN THE SACRAMENTO-SAN JOAQUIN WATERSHED

Amount Requested: $984,539 (@ 10% overhead) or $1,203,985 (@48.5% overhead) for 2 yrs

Applicant: A. Peter Klimley, Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, 1 Shields Ave., Davis, CA 95616; ph: 530-752-7641, FAX: 530-752-4154, e-mail: apklimley@ucdavis.edu, pklimley@harveyecology.com

Participants and Collaborators: J.J. Cech, Jr. (UCD), S.I. Doroshov (UCD), B.P. May (UCD), A.P. Klimley (UCD, BML), C.E. Crocker (SFSU), D.W. Kohlhorst (CDFG), R.G. Schaffter (CDFG)

B. EXECUTIVE SUMMARY

The green sturgeon (GS, *Acipenser medirostris*) is an anadromous, native fish that occurs in low numbers in our Bay/Delta system. It is classified as a CALFED At-Risk Species (Priority Group I), but very little is known about its life history. Basic GS life history information is critical to this species' protection, and our project's targeted research focus is on describing the biological characteristics of this species and its habitats for conservation and potential restoration.

We have completed Phase 1 & 2 studies of GS and given technical presentations of our results at two workshops, at the annual meeting of the California-Nevada Chapter of the American Fisheries Society, and at the 4th International Sturgeon Symposium. One M.S. thesis has been completed on GS developmental biology and another is nearing completion, a manuscript has been published, another accepted for publication in the same journal, and several others on the genetics and physiology of sturgeon are in preparation. We are currently conducting Phases 3 and 4 of GS research. Phase 5 will have five objectives: 1. determine juvenile GS' developmental stage-related swimming performance, salinity tolerance, salinity preference, gill chloride cell activation, and osmoregulatory responses and stress responses to environmental changes; 2. establish reliable artificial reproduction for research and the methodology for determining sex and gonadal maturity; 3. use unique genetic markers to identify sibling among GS located on their breeding areas by telemetry, plankton tows, and egg traps in order to estimate the number of breeding adults at each spawning; 4. determine the movements and distribution of adult GS tagged with ultrasonic and radio beacons, and tracked either by airplane, automobile, boat or listening stations, within the Sacramento, San Joaquin, and Klamath Rivers and describe the habitats, in which they reside, with particular attention paid to their spawning grounds; 5) capture subadult and adult GS during a one month period in winter (Jan./Feb.) and a similar period in summer (Aug.) in San Pablo Bay (using trammel net samples) and provide GS for Tasks 2 & 3. Fisheries biologists from UC Davis, CDFG, BML, SFSU, and the Yurok Tribe will join in this collaborative effort to provide valuable information for adaptive management approaches to increase our Bay-Delta GS stocks. This project will provide valuable information to decision-makers using adaptive management to resolve scientific uncertainties in our GS life history conceptual model and assist in GS recovery, a specific ERP (Vol. 1, WS and GS, pp. 146-148; Vol. 2, WS and GS, p. 276) and AFRP (pp. 40-41, 70-71, and 95) objective of CALFED and CVPIA.

2 years), supplies/rentals (fish food, reagents, chemicals, gases, molecular biology supplies, steroid analyses supplies, and physiological measurements supplies, assays, office supplies, tank rental charges), travel for specimen collection and meeting attendance, and University of California, Davis overhead.

Task 2: Funding is requested for a Staff Research Associate and Postgraduate Researcher (50% time, 6 months/year, benefits for 2 years), supplies/rentals (fish food, reagents, chemicals, histological supplies, film and developing, assays, office supplies, tank rental charges), travel for specimen collection and meeting attendance, and University of California, Davis, overhead.

Task 3: Funding is requested for an Adjunct Associate Professor (100% time, 3.3 months/year, and benefits for 2 years), one Postgraduate Researcher (100% time, 6.5 month/year for 2 years), sequencer/genotyper lease and maintenance, supplies (reagents, chemicals, gases, office supplies), equipment (one freezer), travel for specimen collection and meeting attendance, and University of California, Davis overhead.

Task 4: Funding is requested for a Graduate Research Assistant (50% time, 9 months, 100% time, 3 months/year, benefits, and student fee remission for 2 years), supplies (supplies and maintenance of boat, construction materials for monitor moorings), travel for specimen tracking and meeting attendance, and University of California overhead for subcontracts (a-c).

Sub a: Funding is requested for a Senior Fisheries Ecologist (100% time, 2 months, and benefits for 2 years), supplies/rentals (ultrasonic and radio transmitters, tag-detecting monitors, temperature loggers, office supplies, and airplane rental), equipment (scanning radio receiver) and H.T. Harvey & Associates overhead (see …Harvey.Task4.Yr1.xls and …Harvey.Task4.Yr2.xls).

Sub b: Funding is requested for a Biologist and Technician (100% time, 4.4 month/year, benefits, for 2 years), supplies, and Yurok Tribe overhead (see …Yurok.Task4Yr1&2.xls).

Sub c: Funding is requested for support of one graduate student (50% time, 6 months/year, and benefits for 2 years) and San Francisco State University overhead (see SFSU.Task4.Yr1&2).

Task 5 (sub): Funding is requested for one CDFG boat operator (100% time, 2 months/year for 2 years), supplies/rentals (nets and net repair supplies), and CDFG and University of California, Davis overhead (see ...CDFG.Task5.Yr1&2.xls).

Task 6 (sub): Funding is requested for support of a Senior Fisheries Ecologist (100% time, 1 month/year, and benefits, office assistance, travel, and Harvey & Associates and University of California, Davis overhead (see …Harvey.Task6.Yr1.xls, …Harvey.Task6.Yr2.xls).

c. Cost Sharing. "Leveraged" support ($85,478) will be provided by UC Davis (5% of two investigators' salaries and benefits while working on the GS project).

G. LOCAL INVOLVEMENT

Most of the infrastructure/equipment required for this project is already available at UC Davis, Bodega Marine Laboratory, SFSU Romberg Center for Marine Studies, and CDFG Bay Delta and Special Water Projects Division. Collaboration with the Yurok and Karuk Tribal Fisheries biologists has been arranged or initiated

H. COMPLIANCE WITH STANDARD TERMS AND CONDITIONS

The University of California, Davis, and the California Department of Fish and Game are public organizations of the State of California. Both organizations comply with the standard terms and conditions of non-discrimination and non-collusion. There are no conflicts of interest.

I. LITERATURE CITED

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J. THRESHOLD REQUIREMENTS

UC Davis and San Francisco State University are State-assisted public research and educational institutions. California Fish and Game is a constitutionally mandated agency of the State of California. Tax Identification Number for UC Davis is 94-603-6494.

Table 1. Two-year budget for green sturgeon project with 10% (state) overhead rate.

			Subject to Overhead								Exempt from Overhead		
Year	Task	Direct Labor Hours	Salary	Benefits	Travel	Supplies & Expendables	Services and consultations	Total Cost subject to overhead	Overhead (10% for all tasks)	Services & consultations exceeding $25,000	Equipment	Graduate Student Fee Remission	Total Cost
1	Task 1	2,520	44,184	884	1,500	11,500		58,068	5,807		0	9,856	73,731
	Task 2	984	23,700	5,475	1,500	5,000	0	35,675	3,568		0	0	39,243
	Task 3	1,565	48,090	10,931	1,500	8,100	11,100	79,721	7,972		2,500	0	90,193
	Task 4	1,260	22,092	442	1,000	7,000	62,000	92,534	9,253	141,823	0	4,928	248,538
	Task 5	0	0	0	0	0	25,000	25,000	2,500	17,474	0	0	44,974
	Task 6	0	0	0	0	0	18,134	18,134	1,813	0	0	0	19,947
Total Year 1		**6,329**	**138,066**	**17,732**	**5,500**	**31,600**	**73,100**	265,998	26,600		**2,500**	**14,784**	**516,626**
2	Task 1	2,520	44,184	884	1,500	11,500	0	58,068	5,807		0	9,856	73,731
	Task 2	984	24,648	5,694	1,500	5,000	0	36,842	3,684		0	0	40,526
	Task 3	1,565	48,090	10,931	1,500	11,100	11,100	82,721	2,500		0	0	85,221
	Task 4	1,260	22,092	442	2,500	7,000	62,000	94,034	9,403	95,148	0	4,928	203,513
	Task 5	0	0	0	0	0	25,000	25,000	2,500	17,474	0	0	44,974
	Task 6	0	0	0	0	0	18,134	18,134	1,813	0	0	0	19,947
Total Year 2		**6,329**	**139,014**	**17,951**	**7,000**	**34,600**	**73,100**	**271,665**	**21,394**		**0**	**14,784**	**467,913**
Total 2 yrs		**12,658**	**277,080**	**35,683**	**12,500**	**66,200**	**146,200**	**537,663**	**47,994**		**2,500**	**29,568**	**984,539**

Table 2. Two-year budget for the green sturgeon project with 48.5% (federal) overhead rate.

			Subject to Overhead								Exempt from Overhead		
Year	Task	Direct Labor Hours	Salary	Benefits	Travel	Supplies & Expendables	Services and consulations	Total Cost subject to overhead	Overhead (48.5% for all tasks)	Services & consultations exceeding $25,000	Equipment	Graduate Student Fee Remission	Total Cost
1	Task 1	2,520	44,184	884	1,500	11,500	0	58,068	28,163	0	0	9,856	96,087
	Task 2	984	23,700	5,475	1,500	5,000	0	35,675	17,302	0	0	0	52,977
	Task 3	1,565	48,090	10,931	1,500	8,100	11,100	79,721	12,125	0	2500	0	94,346
	Task 4	1,260	22,092	442	1,000	7,000	62,000	92,534	44,879	141,823		4,928	284,164
	Task 5	0	0	0	0	0	25,000	25,000	12,125	17,474	0	0	54,599
	Task 6	0	0	0	0	0	18,134	18,134	8,795	0	0		26,929
Total Year 1		**6,329**	**138,066**	**17,732**	**5,500**	**31,600**	**73,100**	**265,998**	**102,469**		**2,500**	**14,784**	609,102
2	Task 1	2,520	44,184	884	1,500	11,500		58,068	28,163	0	0	9,856	96,087
	Task 2	984	24,648	5,694	1,500	5,000		36,842	17,868	0	0	0	54,710
	Task 3	1,565	48,090	10,931	1,500	11,100	11,100	82,721	40,120	0	0	0	122,841
	Task 4	1,260	22,092	442	2,500	7,000	62,000	94,034	45,606	95,148	0	4,928	239,716
	Task 5	0	0	0	0	0	25,000	25,000	12,125	17,474	0	0	54,599
	Task 6	0	0	0	0	0	18,134	18,134	8,795	0	0	0	26,929
Total Year 2		**6,329**	**139,014**	**17,951**	**7,000**	**34,600**	**73,100**	**271,665**	**131,758**		**0**	**14,784**	594,883
Total 2 yrs		**12,658**	**277,080**	**35,683**	**12,500**	**66,200**	**146,200**	**537,663**	**234,227**		**2,500**	**29,568**	1,203,985

Task 1: Physiological Studies
Task 2: Developmental (Reproductive) Studies
Task 3: Genetic Studies
Task 4: Telemetric Studies
Task 5: Sturgeon Capture and Tagging
Task 6: Management of Project

H.T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

Project Name: Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watershed

Project Number:

Proposal Number: 3045

Date: 19 September 2,001

Task	**Personnel Hours by Task**						**Subtask Cost**
	Peter Klimley, Ph.D.				Graphic/GIS	Support	
Tagging, interrogating monitors, analysis	320						$ 32,000.00
							$ -
							$ -
							$ -
Totals	**320**	**0**	**0**	**0**	**0**	**0**	$ 32,000
Technical Assignment	Fisheries Ecologist						

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Project Name: Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watershed
Project Number:
Proposal Number: 3045
Date: 19 September 2,001

PROJECT BUDGET

I. Personnel Costs			
Professional Staff	**Hours**	**Rate**	**Total**
Peter Klimley, Ph.D.	320	$ 100	$ 32,000
0	0		$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
Graphic/GIS	20	$ 75	$ 1,500
Support	40	$ 60	$ 2,400
		Subtotal	**$ 35,900**
Subcontractual Services			
		$ -	$ -
		$ -	$ -
General Administrative Expense Percentage:		10%	$ -
		Subtotal	**$ -**

II. Direct Costs	**Miles/Days**	**Rate**	
Travel ($0.345/mile)	4000	$ 0.345	$ 1,380
Per Diem (days x rate)	10	$ 125	$ 1,250
GIS (per hour surcharge)		$ 10	$ -
Equipment			$ 4,500
Expendable Supplies			$ 82,060
Miscellaneous			$ 10,000
Service Fees (10%)			$ 9,919.00
Subtotal:			**$ 109,109**

III. Total Budget	**$ 145,009**

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Project Number:

Proposal Number: 3045

Date: 19 September 2,001

	Personnel Hours by Task						Subtask Cost
Task	***Peter Klimley, Ph.D.***				Graphic/GIS	Support	
Tagging, interrogating monitors, analysis	320						$ 32,000.00
							$ -
							$ -
							$ -
							$ -
Totals	**320**	**0**	**0**	**0**	**0**	**0**	$ 32,000
Technical Assignment	Fisheries Ecologist						

H.T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

Project Name: Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watershed
Project Number:
Proposal Number: 3045
Date: 19 September 2,001

PROJECT BUDGET

I. Personnel Costs			
Professional Staff	**Hours**	**Rate**	**Total**
Peter Klimley, Ph.D.	320	$ 100	$ 32,000
0	0	$ 55	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
0	0	$ -	$ -
Graphic/GIS	20	$ 75	$ 1,500
Support	40	$ 60	$ 2,400
		Subtotal	**$ 35,900**
Subcontractual Services			
		$ -	$ -
		$ -	$ -
General Administrative Expense Percentage:		10%	$ -
		Subtotal	**$ -**

II. Direct Costs	**Miles/Days**	**Rate**	
Travel ($0.345/mile)	4000	$ 0.345	$ 1,380
Per Diem (days x rate)	30	$ 125	$ 3,750
GIS (per hour surcharge)		$ 10	$ -
Equipment			$ -
Expendable Supplies			$ 41,628
Miscellaneous			$ 10,000
Service Fees (10%)			$ 5,675.80
Subtotal:			**$ 62,434**

III. Total Budget	**$ 98,334**

Personnel and Travel Expenses

Month	Crew (biologist and technician) Days/Month	Hours/ Day	Biologist wage/hr	Technician wage/hr.	Personnel Sub-total	Travel (assumes 60 miles per crew day @ $.32/mile)	Comments
April	17	8	16	10.5	$3,604.00	$280.50	Install 16 receivers (two per day) One day of training for three crews. Two days to download for three crews.
Mid April - Late May	30	8	16	10.5	$6,360.00		Capturing adults and implanting tags. One biologist and one technician from Mid-April through May, five days per week eight hours per day (this supplements the same type of effort by USFWS for capturing broodstock and implanting radio tags).
May	9	8	16	10.5	$1,908.00	$148.50	two downloads per month (three crews working 1.5 days each - 5-6 receivers each)
June	9	8	16	10.5	$1,908.00	$148.50	two downloads per month (three crews working 1.5 days each - 5-6 receivers each)
July	4.5	8	16	10.5	$954.00	$74.25	two downloads per month (three crews working 1.5 days each - 5-6 receivers each)
August	4.5	8	16	10.5	$954.00	$74.25	one download per month (three crews working 1.5 days each - 5-6 receivers each)
September	4.5	8	16	10.5	$954.00	$74.25	one download per month (three crews working 1.5 days each - 5-6 receivers each)
October	4.5	8	16	10.5	$954.00	$74.25	one download per month (three crews working 1.5 days each - 5-6 receivers each)
November	9	8	16	10.5	$1,908.00	$148.50	two downloads per month (three crews working 1.5 days each - 5-6 receivers each)
December	9	8	16	10.5	$1,908.00	$148.50	two downloads per month (three crews working 1.5 days each - 5-6 receivers each)
January	4.5	8	16	10.5	$954.00	$74.25	one download per month (three crews working 1.5 days each - 5-6 receivers each)
Post Season Analysis/Report	25	8	16		$3,200.00	$412.50	One Biologist for two months
				Sub-total	$25,566.00	**$1,658.25**	
				Benefits @ 33%	$8,436.78		
				Personnel Total	**$34,002.78**		

Program Supplies (Drills, expoxy, Tagging supplies, etc..)	**$1,200.00**
Sub-Total	$36,861.03
Indirect @ 27% (not for tags and receivers)	$9,952.48
Total	**$46,813.51**
Total if U.C. Davis purchases receivers and tags	**$46,813.51**

Note: This budget assumes that each crew will contribute a laptop for downloading the receivers.

Listed below are proposed locations for stationary receivers and type of access

Location	Access Type
Lower Estuary	Short boat trip or truck
Upper Estuary	Short boat trip or truck
Near Blue Creek	Boat trip
Below Trinity	Short boat trip or truck
Above Trinity	Short boat trip or truck
Hoopa Valley	Short boat trip or truck
Below South Fork Trinity	Short boat trip or truck
South Fork Trinity	Short boat trip or truck
Above South Fork Trinity	Short boat trip or truck
Above Grays Falls	Short boat trip or truck
Above Trinity Confluence in Klamath	Short boat trip or truck
Between Weitchpec and Orleans	Short boat trip or truck
Below Salmon R.	Short boat trip or truck
In Salmon R.	Short boat trip or truck
Above Salmon R.	Short boat trip or truck
Above Ishi Pishi	Short boat trip or truck

Note: If have enough receivers, perhaps should put one near Orleans

San Francisco State University

Item	Amount
Student salaries/year	12,000
Travel to tracking sites	2500
Supplies/expendibles	3500
Total	18,000

Personnel Calendar/Worksheet

updated May for SEP 2000 saleries **Program Element: EXTENDED STURGEON TAGGING:AUGUST 2001** DWK 5/11/2000

Month (20 days per month)

Classification	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL DAYS
DFG													DFG
Sr. Fishery Biol.													0
Assoc. Fishery Biol.													0
Fishery Biologist								10					10
F&W Habitat Asst. (doug)													0
F&W Asst. II													0
F&W Asst. I													0
DeckHand								24					24
Supervising Lab Asst.													0
Senior Lab Asst.													0
Lab Asst.													0
Mate (F&G vessel)								24					24
F&W Scientific Aid								48					48
DWR													DWR
Env Specialist III													0
Env. Specialist II													0
Env. Specialist I													0
F&W Scientific Aid													0

DFG Total Days DFG permanent	58
DWR Total Days DWR	0

Program Element: EXTENDED STURGEON TAGGING:AUGUST 2001

updated May for SEP 2000 saleries

classification	Planning Salaries (annual)	total cost by class
DFG		
Senior Fishery Biologist	$66,968	$0
Associate Fishery Biologist	$59,629	$0
Fishery Biologist	$37,116	$1,428
F&W Habitat Asst. (doug)	$40,672	$0
F&W Asst. II	$37,440	$0
F&W Asst. I	$34,345	$0
DeckHand	$32,223	$2,974
Supervising Lab Asst.	$34,832	$0
Senior Lab Asst.	$32,360	$0
Lab Asst.	$29,977	$0
Mate (Fisheries Vessel)	$41,908	$3,868
F&W Scientific Aid (midrange)	$21,416	$3,954
DWR		
Environmental Scientist III		$0
Environmental Scientist II		$0
Environmental Scientist I		$0
F&W Scientific Aid		$0

DFG	Subtotal Perm. Person.	$8,270	
	Staff Benefits, perm (20.0%)	$1,654	
	Scientific Aid	$3,954	
	Staff Benefits, temp (8%)	$316	
	Total Personnel	$14,195	
	General Expenses ($6,800/PY)	$908	
	Rent ($350/PY)	$0	
	Equipment	$0	
	Nets	$0	
	Travel	$0	
	Tags	$0	
	Vehicle Ops	$850	3400 mi @ $0.25/Mi
	Boat Ops	$800	160 hrs.@$5.00
	Fuel (Boat)	$960	160 hrs. @ $6.00/hr.
	Minor Equipment	$0	
	Total Equiment& Operating Expense	$3,518	
	SubTotal Expendi.(personnel&Equip.)	$17,713	
	Overhead (19.9%)	$3,525	
	Total DFG Expenditures	$21,237	

H. T. HARVEY & ASSOCIATES
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Project Name: Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watershed

Project Number:

Proposal Number: 3045

Date: 19 September 2,001

	Personnel Hours by Task					Subtask Cost
Task	***Peter Klimley, Ph.D.***			Graphic/GIS	Support	
Project Management/Reports/Meetings	160					$ 16,000.00
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
Totals	**160**	**0**	**0**	**0**	**0**	$ 16,000
Technical Assignment	Fisheries Ecologist					

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PROJECT BUDGET

I. Personnel Costs			
Professional Staff	**Hours**	**Rate**	**Total**
Peter Klimley, Ph.D.	160	$ 100	$ 16,000
0	0	$ -	$ -
Graphic/GIS	0	$ 75	$ -
Support	0	$ 60	$ -
		Subtotal	**$ 16,000**
Subcontractual Services			
		$ -	$ -
		$ -	
General Administrative Expense Percentage:		10%	$ -
		Subtotal	**$ -**

II. Direct Costs	**Miles/Days**	**Rate**	
Travel ($0.345/mile)	2000	$ 0.345	$ 690
Per Diem (days x rate)	10	$ 125	$ 1,250
GIS (per hour surcharge)		$ 10	$ -
Equipment			$ -
Expendable Supplies			
Biological Data Base Searches			$ -
Service Fees (10%)			$ 194.00
Subtotal:			**$ 2,134**

III. Total Budget	**$ 18,134**

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	Personnel Hours by Task							Subtask Cost
Task	***Peter Klimley, Ph.D.***					Graphic/GIS	Support	
Project Management/Reports/Meetings	160							$ 16,000.00
								$ -
								$ -
								$ -
								$ -
Totals	**160**	**0**	**0**	**0**	**0**	**0**	**0**	$ 16,000
Technical Assignment	Fisheries Ecologist							

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PROJECT BUDGET

I. Personnel Costs			
Professional Staff	**Hours**	**Rate**	**Total**
Peter Klimley, Ph.D.	160	$ 100	$ 16,000
0	0	$ -	$ -
0	0	$ -	$ -
Graphic/GIS	0	$ 75	$ -
Support	0	$ 60	$ -
		Subtotal	**$ 16,000**
Subcontractual Services			
		$ -	$ -
		$ -	
General Administrative Expense Percentage:		10%	$ -
		Subtotal	**$ -**

II. Direct Costs	**Miles/Days**	**Rate**	
Travel ($0.345/mile)	2000	$ 0.345	$ 690
Per Diem (days x rate)	10	$ 125	$ 1,250
GIS (per hour surcharge)		$ 10	$ -
Equipment			$ -
Expendable Supplies			
Biological Data Base Searches			$ -
Service Fees (10%)			$ 194.00
Subtotal:			**$ 2,134**

III. Total Budget	**$ 18,134**