Chinook Salmon Rearing In The San Francisco Bay−Delta System: Identification Of Geochemical Markers To Determine Delta Use

prepared by Phillis, Corey C

submitted to Science Program 2004

compiled 2005−01−06 16:56:21 PST

Project

This proposal is for the Science Program 2004 solicitation as prepared by Phillis, Corey C.

The submission deadline is 2005−01−06 17:00:00 PST (approximately 4 minutes from now).

Proposal updates will be disabled immediately after the deadline. All forms, including the signature form, must be completed, compiled and acknowledged in order to be eligible for consideration and review. Allow at least one hour for Science Program staff to verify and file signature pages after they are received.

Instructions

Information provided on this form will automatically support subsequent forms to be completed as part of the Science PSP submission process. Please be mindful of what information you enter and how it may be represented in the Personnel, Task and Budget forms. Please provide this information before continuing to those forms.

Proposal Title	***Chinook salmon rearing in the San Francisco Bay−Delta system: Identification of geochemical markers to determine Delta use***	
Institutions	The Regents of California (Berkeley Campus, Department of Earth &Planetary Sciences) Lawrence Livermore National Laboratory	*List each institution involved, one per line.*
Proposal Document		*You have already uploaded a proposal document. View it to verify that it appears as you expect. You may replace it by uploading another document*
Project Duration	***24 months***	

Is the start date a determining factor to the successful outcome of the proposed effort?
X No.
− Yes. Anticipated start date of this effort:

Select all of the following study topics which apply to this proposal.
X life cycle models and population biology of key species
X environmental influences on key species and ecosystems
− relative stresses on key fish species
X direct and indirect effects of diversions on at−risk species
− processes controlling Delta water quality
− implications of future change on regional hydrology, water operations, and environmental processes
− water management models for prediction, optimization, and strategic assessments
− assessment and monitoring
X salmonid−related projects
X Delta smelt−related projects

Select as many keywords as necessary to describe this proposal (minimum of 3).
− ***adaptive management***
− ***aquatic plants***
− ***benthic invertebrates***
− ***biological indicators***
− ***birds***
− neotropical migratory birds
− shorebirds
− upland birds
− wading birds
− waterfowl
− ***climate***
− climate change
− precipitation
− sea level rise
− snowmelt
X contaminants / toxicants / pollutants
− contaminants and toxicity of unknown origin

− emerging contaminants
− mercury
− nutrients and oxygen depleting substances
− organic carbon and disinfection byproduct precursors
− persistent organic contaminants
− pesticides
X salinity
− sediment and turbidity
X selenium
X trace metals
− database management
− economics
− engineering
− civil
− environmental
− hydraulic
− environmental education
− environmental impact analysis
− environmental laws and regulations
− environmental risk assessment
X fish biology
− bass and other centarchids
− delta smelt
− longfin smelt
− other species
X salmon and steelhead
− splittail
− striped bass
− sturgeon
X fish management and facilities
− hatcheries
− ladders and passage
− screens
− forestry
− genetics
− geochemistry
− geographic information systems (GIS)
− geology
− geomorphology
− groundwater
X habitat
− benthos
X channels and sloughs
− flooded islands
− floodplains and bypasses
X oceanic
− reservoirs
− riparian
X rivers and streams
− shallow water
− upland habitat
− vernal pools
− water column
− wetlands, freshwater
− wetlands, seasonal
− wetlands, tidal
− human health
− hydrodynamics
− hydrology
− insects
− invasive species / non−native species / exotic species
− land use management, planning, and zoning
− limnology
− mammals
− large

− small
− microbiology / bacteriology
− modeling
− conceptual
− quantitative
− monitoring
X natural resource management
− performance measures
− phytoplankton
− plants
− primary productivity
− reptiles
− restoration ecology
− riparian ecology
− sediment
− soil science
− statistics
− subsidence
− trophic dynamics and food webs
− water operations
− barriers
− diversions / pumps / intakes / exports
− gates
− levees
− reservoirs
− water quality management
− ag runoff
− mine waste assessment and remediation
− remediation
− temperature
− urban runoff
− water quality assessment and monitoring
− water resource management
− water supply
− demand
− environmental water account
− water level
− water storage
− watershed management
− weed science
X wildlife
X ecology
X management
− wildlife−friendly agriculture
− zooplankton
− administrative

Indicate whether your project area is local, regional, or system−wide. If it is local, provide a central ZIP Code. If it is regional, provide the central ZIP Code and choose the counties affected. If it is system−wide, describe the area using information such as water bodies, river miles, and road intersections.	
− local	ZIP Code:
− regional	ZIP Code: counties:
X system−wide	The project will focus on the Sacramento−San Joaquin Delta, and will reference geochemcial data from the Delta to all other parts of the system.

Does your project fall on or adjacent to tribal lands?
No.

(Refer to California Indian reservations to locate tribal lands.)
If it does, list the tribal lands.

Has a proposal for this effort or a similar effort ever been submitted to CALFED for funding or to any other public agency for funding?

Yes.

If yes, complete the table below.

Status	Proposal Title	Funding Source	Amount	Comments
not funded	***Chinook salmon rearing in the San Francisco Bay−Delta system: Identification of geochemical markers to determine use***	***CalFed Bay−Delta Program***	***$28,400***	***Presented as a short pilot study for the present proposal; was much smaller in scope. The current proposal incorporates this pilot study as well as the full study.***

Has the lead scientist or principal investigator of this effort ever submitted a proposal to CALFED for funding or to any other public agency for funding?
Yes.

If yes, provide the name of the project, when it was submitted, and to which agency and funding mechanism if was submitted. Also describe the outcome and any other pertinent details describing the proposal's current status.

Holocene and Last Interglacial paleosalinity from sediments in San Francisco Bay, 7/1/99 − 6/30/01, National Science Foundation (funded, $25,000 completed)

Salmon Stock Origin as Determined by Otolith Geochemistry − A Pilot Study, 01/01/01 − 06/30/04, Department of Water Resources (funded, $250,044, completed)

Advanced Ion Probe Sample Preparation and Mounting Techniques 01/21/04 − 11/30/04, Lawrence Livermore National Lab. (funded, $85,218, completed)

Isotopic Analysis Small Samples 01/21/04 − 11/30/04, Lawrence Livermore National Lab. (funded, $30,400, completed)

Advanced Ion Probe Sample Preparation and Mounting Techniques 01/21/04 − 11/30/04, Lawrence Livermore National Lab. (funded, $85,218, completed)

California paleo−streamflow records from the Last Interglacial, 7/1/01 − 12/30/03, National Science Foundation (funded, $144,067, completed)

Acquisition of a Gas Source Mass Spectrometer for Earth and Planetary Sciences Research, University of California, Berkeley 09/15/01 − 08/31/04, National Science Foundation (funded, $188,600, completed)

Doctoral Dissertation Research: Paleoecological Changes in San Francisco Estuary Marshes using Stable Carbon Isotopes and Pollen, 8/01/01 − 1/31/03 (funded, $9,850, completed)

Doctoral Dissertation Research: Development of Geochemical Proxies for Bleaching Events and the Associated Stressors in the Great Barrier Reef 09/01/03 − 02/28/05, National Science Foundation (funded, $12,000, current)

Sediment Supply and Marsh Development in the San Francisco Estuary, 9/01/03 − 8/31/06 UC Sea Grant / CALFED (funded, $301,101, current)

Paleoclimate Variability in California and Impacts on the San Francisco Estuary, 12/01/02 − 09/30/04, U.S.G.S. (funded, $30,180, completed)

The Creation of Mounded Landscapes by Hunter−Gatherers: An Integrated Approach to the Prehistoric Shell Mounds of the San Francisco Bay, 03/01/04 − 02/28/06, National Science Foundation (funded, $25,000, current)

Advanced Ion Probe Sample Preparation and Mounting Techniques, 11/22/04 − 09/30/05, Lawrence Livermore National Lab (funded, $19,939, current)

Holocene History of Seasonal Variation of San Francisco Bay, California Inferred from Mussel Shell Calcite, 1001/04 − 9/30/05, Lawrence Livermore National Laboratory (funded, $28,000, current).

Climate Change And Ecosystem Response In Suisun Bay, San Francisco Bay Estuary, And Upstream, 9/01/06 − 8/31/08, California Bay Delta Authority (pending $553,335)

Technician Support for Earth Science Research, University of California, Berkeley, 1/01/05 − 12/31/07 National Science Foundation (pending $223,461)

Holocene Paleoclimate Records from the San Francisco Bay Estuary, California, 1/01/05 − 12/31/06 National Science Foundation (not funded)

All applicants must identify all sources of funding other than the funds requested through this solicitation to support the effort outlined in their proposal. Applicants must include the status of these commitments (tentative, approved, received), the source, and any cost−sharing requirements. Successful proposals that demonstrate multiple sources of funding must have the commitment of the non−Science Program PSP related funding within 30 days of notification of approval of Science Program PSP funds. If an applicant fails to secure the non−Science Program PSP funds identified in the proposal, and as a result has insufficient funds to complete the project, CBDA retains the option to amend or terminate the award. The California Bay−Delta Authority reserves the right to audit grantees.

Status	Proposal Title	Funding Source	Period Of Commitment	Requirements And Comments

Are you specifically seeking non−federal cost−share funds for this proposal?
No.

In addition to the general funds available, are you targeting additional funds set aside specifically for collaborative proposals?
No.

List people you feel are qualified to act as scientific reviewers for this proposal and are not associated with CALFED.

Full Name	Organization	Telephone	E−Mail	Expertise
Paul L. Koch	***University of California, Santa Cruz***	***831−459−5861***	***pkoch@earthsci.ucsc.edu***	***geochemistry***
Rachel Barnett−Johnson	***University of California, Santa Cruz***	***831−239−8782***	***rachel.c.johnson@noaa.gov***	***fish biology, salmon and steelhead***
Robert W. Gauldie	***University of Hawaii at Manoa***	***808−956−3184***	***gauldie@higp.hawaii.edu***	***geochemistry***
Eric C. Volk	***Washington Department of Fish and Wildlife***	***360−902−2200***	***volkecv@dfw.wa.gov***	***fish biology***

Executive Summary

Provide a brief but complete summary description of the proposed project; its geographic location; project objective; approach to implement the proposal; hypotheses being tested; expected outcomes; and relationship to Science Program priorities. The Executive Summary should be a concise, informative, stand−alone description of the proposed project. *(This information will be made public on our website shortly after the closing date of this PSP.)*

The importance of the San Francisco Bay−Delta system to the native juvenile salmonid rearing is poorly understood and existing techniques are unable to address the most important issue, the relationship between fish residence time in the Delta and the Bay to success in later life stages, particularly becoming a successful spawner. In our previous work, we developed geochemical markers in otoliths to characterize the early life history of juvenile Chinook salmon in the Sacramento−San Joaquin river system (Ingram and Weber, 1999; Weber et al., 2002; Weber, 2002; Weber et al., in press). To date, we have developed geochemical tracers for Sacramento River salmon otoliths that (1) distinguish between hatchery−raised and naturally spawned salmon using sulfur isotopes (d34S), (2) determine a fish's natal river of origin using strontium isotopes (87Sr/86Sr), and (3) can identify the timing of downstream migration from spawning grounds using carbon isotopes (d13C) and (4) of ocean entry using strontium−calcium ratio (Sr/Ca). The missing piece in our work in this river system is a marker or set of markers to determine the timing and duration of use of different parts of the San Francisco Bay−Delta system.

Here, we propose to focus our effort on developing geochemical markers to determine the timing and duration of Delta and Bay use. We will focus on Delta use because the role of the Delta in salmonid rearing is a major question in Central Valley ecosystem and water management, and because we expect the salinity gradient to provide a ready reference for migration from Chipps Island to the Golden Gate. But we will include samples collected between the Delta and the ocean to provide a complete picture of the geochemical markers in the system. To the extent possible, we will identify geochemical markers that identify sub−regions of the Delta.

The otolith geochemical markers that we would establish under CalFed funding would significantly increase our knowledge of the importance of the Delta to salmonid rearing. They would also be applicable to other species that move in and out of the Delta. More broadly, these markers would give us complete geochemical coverage of the system. As a result, we would be able to map the juvenile out−migration of individual spawning chinook salmon from natal watershed to the ocean. This capability would allow us to close the circle on understanding the ultimate importance of differences in outmigration behavior and habitat use. With this full out−migration capability, we would be able to establish a baseline for the importance of Delta and other habitats to successful maturation, and we would be able to examine how salmonid habitat use, particularly in the Delta, is affected by year−to−year environmental variations.

Give additional comments, information, etc. here.

Applicant

This proposal is for the Science Program 2004 solicitation as prepared by Phillis, Corey C.

The submission deadline is 2005−01−06 17:00:00 PST (approximately 4 minutes from now).

Proposal updates will be disabled immediately after the deadline. All forms, including the signature form, must be completed, compiled and acknowledged in order to be eligible for consideration and review. Allow at least one hour for Science Program staff to verify and file signature pages after they are received.

Instructions

Information provided on this form will automatically support subsequent forms to be completed as part of the Science PSP submission process. Please be mindful of what information you enter and how it may be represented in the Personnel, Task and Budget forms. Please provide this information before continuing to those forms.

All information on this page is to be provided for the agency or institution to whom funds for this proposal would be awarded.

Applicant Institution	***The Regents of California (Berkeley Campus, Department of Earth &Planetary Sciences)***	*This list comes from the project form.*
Applicant Institution Type	***public institution of higher education***	

Institution Contact

Please provide information for the primary person responsible for oversight of grant operation, management, and reporting requirements.

Salutation	***Prof.***
First Name	***Lynn***
Last Name	***Ingram***
Street Address	***307 McCone Hall***
City	***Berkeley***
State Or Province	***CA***
ZIP Code Or Mailing Code	***94720***
Telephone	***1 (510) 643−1474*** *Include area code.*
E−Mail	***ingram@socrates.berkeley.edu***

Additional information regarding prior applications submitted to CALFED by the applicant organization or agency and/or funds received from CALFED programs by applicant organization or agency may be required.

Personnel

This proposal is for the Science Program 2004 solicitation as prepared by Phillis, Corey C.

The submission deadline is 2005−01−06 17:00:00 PST (approximately 4 minutes from now).

Proposal updates will be disabled immediately after the deadline. All forms, including the signature form, must be completed, compiled and acknowledged in order to be eligible for consideration and review. Allow at least one hour for Science Program staff to verify and file signature pages after they are received.

Instructions

Applicants must provide brief biographical sketches, titles, affiliations, and descriptions of roles, relevant to this effort, of the principal and supporting project participants by completing a Personnel Form. This includes the use of any consultants, subcontractors and/or vendors; provide information on this form for all such people.

Information provided on this form will automatically support subsequent forms to be completed as part of the Science PSP submission process. Please be mindful of what information you enter and how it may be represented in the Task and Budget forms.

Information regarding anticipated subcontractor services must be provided regardless if the specific service provider has been selected or not. If the specific subcontractor has not been identified or selected, please list TBD (to be determined) in the Full Name field and the anticipated service type in the Title field (example: Hydrology Expert).

Please provide this information before continuing to those forms.

Ingram, B. Lynn, PhD.

*This person is the **Lead Investigator**. Contact information for this person is required.*

Full Name	***Ingram, B. Lynn, PhD.***	example: Wright, Jeffrey R., PhD.
Institution	***The Regents of California (Berkeley Campus, Department of Earth &Planetary Sciences)***	*This list comes from the project form.*
Title	***Professor***	*example: Dean of Engineering*
Position Classification	***primary staff***	
Responsibilities	Project oversight and direction; oversight of carbon, oxygen and sulfur isotopic analyses	
Qualifications		*You have already uploaded a PDF file for this question. Review the file to verify that appears correctly.*
Mailing Address	***Dept. Of Earth &Planetary Sciences, University of California, 307 McCone Hall***	
City	***Berkeley***	
State	***CA***	
ZIP	***94720***	
Business Phone	***510−643−1774***	
Mobile Phone	***none***	
E−Mail	***ingram@eps.berkeley.edu***	

Describe other staff below. If you run out of spaces, submit your updates and return to this form.

Weber, Peter K., PhD.

Full Name	***Weber, Peter K., PhD.***	example: Wright, Jeffrey R., PhD. Leave blank if name not known.
Institution	***Lawrence Livermore National Laboratory***	*This list comes from the project form.*

Title	***Chemist***	*example: Dean of Engineering*
Position Classification	***primary staff***	
Responsibilities	Oversight and direction of project; oversight and direction of otolith preparation and analysis; oversight and direciton of environmental sample collection and analysis.	
Qualifications		***This is only required for primary staff.*** *You have already uploaded a PDF file for this question. Review the file to verify that appears correctly.*

Phillis, Corey C.

Full Name	***Phillis, Corey C.***	example: Wright, Jeffrey R., PhD. Leave blank if name not known.
Institution	***The Regents of California (Berkeley Campus, Department of Earth &Planetary Sciences)***	*This list comes from the project form.*
Title	***Research Associate***	*example: Dean of Engineering*
Position Classification	***primary staff***	
Responsibilities	Field Sampling, sample preparation,electron probe and LA−ICP−MS operation, data analysis, presentation of results.	
Qualifications		***This is only required for primary staff.*** *You have already uploaded a PDF file for this question. Review the file to verify that appears correctly.*

Work−Study Student

Full Name		example: Wright, Jeffrey R., PhD. Leave blank if name not known.
Institution		*This list comes from the project form.*
Title	***Work−Study Student***	*example: Dean of Engineering*
Position Classification	***secondary staff***	
Responsibilities	Assist with field sampling, otolith preparation and data management.	
Qualifications		***This is only required for primary staff.*** *Upload a PDF version of this person's resume that is no more than five pages long. To upload a resume, use the "Browse" button to select the PDF file containing the resume.*

Conflict Of Interest

This proposal is for the Science Program 2004 solicitation as prepared by Phillis, Corey C.

The submission deadline is 2005−01−06 17:00:00 PST (approximately 4 minutes from now).

Proposal updates will be disabled immediately after the deadline. All forms, including the signature form, must be completed, compiled and acknowledged in order to be eligible for consideration and review. Allow at least one hour for Science Program staff to verify and file signature pages after they are received.

Instructions

To help Science Program staff manage potential conflicts of interest in the review and selection process, we need some information about who will directly benefit if your proposal is funded. We need to know of 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.

Applicant	The Regents of California (Berkeley Campus, Department of Earth &Planetary Sciences)
Submittor	Phillis, Corey C
Primary Staff	Ingram, B. Lynn, PhD.
Primary Staff	Weber, Peter K., PhD.
Primary Staff	Phillis, Corey C.
Secondary Staff	*Work−Study Student

Are there other persons not listed above who helped with proposal development?
No.

If there are, provide below the list of names and organizations of all individuals not listed in the proposal who helped with proposal development along with any comments.

Tasks

This proposal is for the Science Program 2004 solicitation as prepared by Phillis, Corey C.

The submission deadline is 2005−01−06 17:00:00 PST (approximately 4 minutes from now).

Proposal updates will be disabled immediately after the deadline. All forms, including the signature form, must be completed, compiled and acknowledged in order to be eligible for consideration and review. Allow at least one hour for Science Program staff to verify and file signature pages after they are received.

Instructions

Utilize this Task Table to delineate the tasks identified in your project description. Each task and subtask must have a number, title, brief description of the task (detailed information should be provided in the project description), timeline, list of personnel or subcontractors providing services on each specific task, and list of anticipated deliverables (where appropriate). When creating subtasks, information must be provided in a way that avoids duel presentation of supporting tasks within the overall task (i.e. avoid double counting). Information provided in the Task Table will be used to support the Budget Form. Ensuring information regarding deliverables, personnel and costs associated with subtasks are only provided once is imperative for purposes of avoiding double counting of efforts within the Budget Form.

For proposals involving multiple institutions (including subcontractors), the table must clearly state which institutions are performing which tasks and subtasks.

Task ID	Task Name	Start Month	End Month	Personnel Involved	Description	Deliverables
1.1	*Field Sampling*	*1*	*18*	*Phillis, Corey C. *Work−Study Student*	Collect water samples and juvenile chinook prey items in the Sacramento River, San Joaquin River, Delta, and San Francisco Bay Estuary for trace element and stable isotope analyses. Samples will be collected in late winter and early spring. Performed by UC Berkeley.	Provide samples necessary to perform a river−to−bay overview of potential geochemical markers to be used in otolith analyses.
2.1	*Water Sample Preparation*	*1*	*18*	*Phillis, Corey C.*	Prepare water samples for trace element and isotopic analysis. Water samples must be filtered for trace element and oxygen isotopic analyses. Performed by UC Berkeley.	Water samples prepped and ready for analysis.
2.2	*Water Sample Analysis (C and O isotopes by IRMS)*	*1*	*18*	*Phillis, Corey C.*	Analyze water samples for Oxygen isotopes using Isotope Ratio Mass spectrometry (IRMS). Performed by UC Berkeley.	Water Carbon and Oxygen isotopic composition of study site for potential use as geochemical markers.
2.4	*Water Sample Analysis (trace element composition by ICP−MS)*	*1*	*18*	*Phillis, Corey C.*	Analyze trace element composition of water samples using ICP−MS. Performed by UC Berkeley.	Water trace element composition of study site for potential use as geochemical markers.
3.1	*Prey Item/Gut Content Sample Preparation*	*1*	*20*	*Phillis, Corey C.*	Take juvenile chinook salmon gut contents for sulfur isotopic composition analysis. Prepare collected prey items for sulfur isotopic composition analysis by doing lipid extraction and weighing out samples in tin cups for analysis. Performed by UC Berkeley	Juvenile chinook salmon prey item and gut content samples prepped and ready for sulfur isotopic composition analysis.
3.2	*Prey Item/Gut Content Sample Analysis (by IRMS)*	*1*	*20*	*Phillis, Corey C.*	Analyze juvenile chinook salmon prey items and gut content for sulfur isotopic composition using IRMS. Performed by UC Berkeley.	Sulfur isotopic composition of junvenile chinook salmon prey items.
4.1	*Otolith Sample Preparation*	*1*	*22*	*Phillis, Corey C. *Work−Study Student*	Remove, clean, mount and section otoliths for in situ analysis and micromilling. Performed by UC Berkeley.	Prepared otoliths for analysis.
4.4	*In Situ Otolith Trace Element Analysis (by LA−ICP−MS)*	*1*	*22*	*Phillis, Corey C.*	Analyze otoliths for trace elements. Performed by UC Berkeley.	Otolith trace element data.
4.6	*In Situ Otolith Isotopic Analysis (by SIMS)*	*1*	*22*	*Weber, Peter K., PhD.*	Analysis of selected samples for confirmation of IRMS data. Performed by LLNL.	High spatial resolution otolith isotopic data to confirm IRMS data.

				Phillis, Corey C.		
4.5	***Otolith Sr Isotopic Analysis (by LA−ICP−MS)***	***1***	***22***	***Phillis, Corey C.***	Analyze otolith Sr isotopic composition. Performed by Berkeley.	Otolith Sr isotope data.
4.3	***Otolith Isotopic Microanalysis (by Micromill IRMS)***	***1***	***22***	***Phillis, Corey C.***	Analayze otolith C and O isotopes spatially in otolith by micromilling for IRMS. Performed by UC Berkeley.	Otolith C and O isotopic data.
5.1	***Data Analysis and Presentation of Results***	***1***	***24***	***Weber, Peter K., PhD. Phillis, Corey C.***	Analyze, integrate, and interpret data from the project. Performed by UC Berkeley.	Scientific publication(s) and project report.
4.2	***In Situ Otolith Sr/Ca Analysis (by electron microprobe)***	***1***	***18***	***Weber, Peter K., PhD. Phillis, Corey C.***	Characterization of otolith Sr/Ca ratio. Performed by LLNL.	High resolution otolith Sr/Ca ratio data to characterize the rise in this ratio with exposure to higher salinity water.

Budget

This proposal is for the Science Program 2004 solicitation as prepared by Phillis, Corey C.

The submission deadline is 2005−01−06 17:00:00 PST (approximately 4 minutes from now).

Proposal updates will be disabled immediately after the deadline. All forms, including the signature form, must be completed, compiled and acknowledged in order to be eligible for consideration and review. Allow at least one hour for Science Program staff to verify and file signature pages after they are received.

Instructions

All applicants must complete a budget for each task and subtask. The Budget Form uses data entered in the Task Form, thus tasks should be entered before starting this form. Failure to complete a Budget Form for each task and/or subtask will result in removal of the application from consideration for funding.

CBDA retains the right to request additional information pertaining to the items, rates, and justification of the information presented in the Budget Form(s).

Supporting details on how costs were derived for each line item must be included in the justification section for each item. The cost detail for each item should include the individual cost calculations associated with each line item to provide the basis for determining the total amount for each budget category.

Following are guidelines for completing the justification section of this form:

Labor (Salary &Wages)
: Ensure each employee and associated classification is correctly identified for each task and subtask. This information will automatically be provided once the Staff Form has been completed. Provide estimated hours and hourly rate of compensation for each position proposed in the project.

Employee Benefits
: Benefits, calculated as a percentage of salaries, are contributions made by the applicant for sick leave, retirement, insurance, etc. Provide the overall benefit rate and specify benefits included in this rate for each employee classification proposed in the project.

Travel
: Travel includes the cost of transportation, subsistence, and other associated costs incurred by personnel during the term of the project. Provide purpose and estimated costs for all travel. Reoccurring travel costs for a particular task or subtask may be combined into one entry. The number of trips and cost for each occurrence must be clearly represented in the justification section for reoccurring travel items of this nature.

  Any reimbursement for necessary travel and per diem shall be at rates specified by the California Department of Personnel Administration for similar employees (www.dpa.ca.gov/jobinfo/statetravel.shtm).

Equipment
: Equipment is classified as any item of $5,000 or more and has an expected life of three years or more. Equipment purchased in whole or in part with these grant funds must be itemized. List each piece of equipment and provide a brief description and justification for each.

Supplies
: Provide a basic description and cost for expendable research supplies. Costs associated with GIS services, air photos, reports, etc. must be listed separately and have a clear justification associated with each entry. Postage, copying, phone, fax and other basic operational costs associated with each task and subtask may be combined unless the cost associated with one particular service is unusually excessive.

Subcontractor Services
: Subcontractor services (Professional and Consultant services) include the total costs for any services needed by the applicant to complete the project tasks. Ensure the correct organization is entered in the Personnel Form so that it appropriately appears on the Budget Form. The applicant must provide all associated costs of all subcontractors (i.e. outside service providers) when completing this form. Applicants must be able to demonstrate that all subcontractors were selected according to an applicant's institutional requirements for the selection of subcontractors (competitive selection or sole source justification).

  CBDA retains the right to request that a subcontractor provide cost estimates in writing prior to distribution of grant funds.

  CBDA retains the right to request consultant, subcontractor, and/or outside service provider cost estimates in writing prior to distribution of grant funds.

Indirect Costs (Overhead)
: Indirect costs are overhead expenses incurred by the applicant organization as a result of the project but are not easily identifiable with a specific project. The indirect cost rate consists of a reasonable percentage of all costs to run the agency or organization while completing the project. List the cost and items associated with indirect costs. (These items may include general office expenses such as rent, office equipment, administrative staff, operational costs, etc. Generally these items are represented by the applicant through a predetermined percentage or surcharge separate from other specific costs of items necessary to complete a specific task or subtask.)

If indirect cost rates are different for State and Federal funds, please identify each rate and the specific items included in the calculation for that rate.

Task 1.1, Field Sampling: Labor	**Justification**	**Amount**
Phillis, Corey C.	***32hrs @ $20/hr***	***640***
***Work−Study Student**	***32hrs @ $12/hr***	***384***
Task 1.1, Field Sampling: Benefits	**Justification**	**Amount**
Phillis, Corey C.	*26% of Salary*	***165***
***Work−Study Student**	*1.4% of Salary*	***16***
Task 1.1, Field Sampling: Travel Expenses	**Justification**	**Amount**
Meals	***3 days travel @ $40/day x 2 people***	***240***
Mileage	***500 miles @ $0.34/mile***	***170***
Parking/Tolls	***$3 bridge toll***	***3***
Lodging	***$84/person/night x 2 nights***	***336***
Task 1.1, Field Sampling: Supplies And Expendables	**Justification**	**Amount**
Task 1.1, Field Sampling: Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 1.1, Field Sampling: Equipment	**Justification**	**Amount**
Task 1.1, Field Sampling: Other Direct	**Justification**	**Amount**
Task 1.1, Field Sampling: Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***489***
	Task 1.1 Total	$2,443
Task 2.1, Water Sample Preparation: Labor	**Justification**	**Amount**
Phillis, Corey C.	***50hrs @ $20/hr***	***1000***
Task 2.1, Water Sample Preparation: Benefits	**Justification**	**Amount**
Phillis, Corey C.	*26% of Salary*	***260***
Task 2.1, Water Sample Preparation: Travel Expenses	**Justification**	**Amount**
Task 2.1, Water Sample Preparation: Supplies And Expendables	**Justification**	**Amount**
Task 2.1, Water Sample Preparation: Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 2.1, Water Sample Preparation: Equipment	**Justification**	**Amount**
Task 2.1, Water Sample Preparation: Other Direct	**Justification**	**Amount**
Task 2.1, Water Sample Preparation: Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***315***
	Task 2.1 Total	$1,575
Task 2.2, Water Sample Analysis (C And O Isotopes By IRMS): Labor	**Justification**	**Amount**
Phillis, Corey C.	***230hrs @ $20/hr***	***4600***
Task 2.2, Water Sample Analysis (C And O Isotopes By IRMS): Benefits	**Justification**	**Amount**
Phillis, Corey C.	*26% of Salary*	***1196***
Task 2.2, Water Sample Analysis (C And O Isotopes By IRMS): Travel Expenses	**Justification**	**Amount**
Task 2.2, Water Sample Analysis (C And O Isotopes By IRMS): Supplies And Expendables	**Justification**	**Amount**

Task 2.2, Water Sample Analysis (C And O Isotopes By IRMS): Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 2.2, Water Sample Analysis (C And O Isotopes By IRMS): Equipment	**Justification**	**Amount**
Task 2.2, Water Sample Analysis (C And O Isotopes By IRMS): Other Direct	**Justification**	**Amount**
Analysis Cost	***150 samples @ $20/sample***	***3000***
Task 2.2, Water Sample Analysis (C And O Isotopes By IRMS): Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***2199***
	Task 2.2 Total	$10,995
Task 2.4, Water Sample Analysis (Trace Element Composition By ICP−MS): Labor	**Justification**	**Amount**
Phillis, Corey C.	***100hrs @ $20/hr***	***2000***
Task 2.4, Water Sample Analysis (Trace Element Composition By ICP−MS): Benefits	**Justification**	**Amount**
Phillis, Corey C.	***26% of Salary***	***520***
Task 2.4, Water Sample Analysis (Trace Element Composition By ICP−MS): Travel Expenses	**Justification**	**Amount**
Mileage	***10 trips x (180miles @ $0.34/mile)***	***612***
Parking/Tolls	***$3 bridge toll per trip x 10 trips***	***30***
Task 2.4, Water Sample Analysis (Trace Element Composition By ICP−MS): Supplies And Expendables	**Justification**	**Amount**
Task 2.4, Water Sample Analysis (Trace Element Composition By ICP−MS): Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 2.4, Water Sample Analysis (Trace Element Composition By ICP−MS): Equipment	**Justification**	**Amount**
Task 2.4, Water Sample Analysis (Trace Element Composition By ICP−MS): Other Direct	**Justification**	**Amount**
Geochemical Analysis Cost	***50 samples hours @$ 51/sample hour***	***2550***
Task 2.4, Water Sample Analysis (Trace Element Composition By ICP−MS): Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***1428***
	Task 2.4 Total	$7,140
Task 3.1, Prey Item/Gut Content Sample Preparation: Labor	**Justification**	**Amount**
Phillis, Corey C.	***250hrs @ $20/hr***	***5000***
Task 3.1, Prey Item/Gut Content Sample Preparation: Benefits	**Justification**	**Amount**
Phillis, Corey C.	***26% of Salary***	***1300***
Task 3.1, Prey Item/Gut Content Sample Preparation: Travel Expenses	**Justification**	**Amount**
Task 3.1, Prey Item/Gut Content Sample Preparation: Supplies And Expendables	**Justification**	**Amount**
Task 3.1, Prey Item/Gut Content Sample Preparation: Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 3.1, Prey Item/Gut Content Sample Preparation: Equipment	**Justification**	**Amount**
Task 3.1, Prey Item/Gut Content Sample Preparation: Other Direct	**Justification**	**Amount**
Task 3.1, Prey Item/Gut Content Sample Preparation: Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***1575***

	Task 3.1 Total	$7,875
Task 3.2, Prey Item/Gut Content Sample Analysis (By IRMS): Labor	**Justification**	**Amount**
Phillis, Corey C.	***50hrs @ $20/hr***	***1000***
Task 3.2, Prey Item/Gut Content Sample Analysis (By IRMS): Benefits	**Justification**	**Amount**
Phillis, Corey C.	***26% of Salary***	***260***
Task 3.2, Prey Item/Gut Content Sample Analysis (By IRMS): Travel Expenses	**Justification**	**Amount**
Task 3.2, Prey Item/Gut Content Sample Analysis (By IRMS): Supplies And Expendables	**Justification**	**Amount**
Task 3.2, Prey Item/Gut Content Sample Analysis (By IRMS): Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 3.2, Prey Item/Gut Content Sample Analysis (By IRMS): Equipment	**Justification**	**Amount**
Task 3.2, Prey Item/Gut Content Sample Analysis (By IRMS): Other Direct	**Justification**	**Amount**
Analysis Cost	***300 samples @ $20/sample***	***6000***
Task 3.2, Prey Item/Gut Content Sample Analysis (By IRMS): Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***1815***
	Task 3.2 Total	$9,075
Task 4.1, Otolith Sample Preparation: Labor	**Justification**	**Amount**
Phillis, Corey C.	***640 hours @ $20/hour***	***12800***
***Work−Study Student**	***900 hours @ $12/hour***	***10800***
Task 4.1, Otolith Sample Preparation: Benefits	**Justification**	**Amount**
Phillis, Corey C.	***26% of salary***	***3328***
***Work−Study Student**	***1.4% of salary***	***152***
Task 4.1, Otolith Sample Preparation: Travel Expenses	**Justification**	**Amount**
Task 4.1, Otolith Sample Preparation: Supplies And Expendables	**Justification**	**Amount**
Other	***glass rounds $1/each x 500 rounds***	***500***
Other	***epoxy $70/kit x 5 kits***	***350***
Other	***crystal bond $10 /pack x 2***	***20***
Other	***polishing supplies (sand paper, alumina, silica, polishing laps)***	***800***
Other	***Chemicals (ethanol, nitric acid, HCl acid)***	***330***
Task 4.1, Otolith Sample Preparation: Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 4.1, Otolith Sample Preparation: Equipment	**Justification**	**Amount**
Task 4.1, Otolith Sample Preparation: Other Direct	**Justification**	**Amount**
Thin Section Lab Hourly Rate	***50hour @ $40/hour***	***2000***
Task 4.1, Otolith Sample Preparation: Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***7770***
	Task 4.1 Total	$38,850
Task 4.4, In Situ Otolith Trace Element Analysis (By LA−ICP−MS): Labor	**Justification**	**Amount**
Phillis, Corey C.	***400 hrs @ $20/hr***	***8000***
Task 4.4, In Situ Otolith Trace Element Analysis (By LA−ICP−MS): Benefits	**Justification**	**Amount**
Phillis, Corey C.	***26% of Salary***	***2080***

Task 4.4, In Situ Otolith Trace Element Analysis (By LA−ICP−MS): Travel Expenses	Justification	Amount
Task 4.4, In Situ Otolith Trace Element Analysis (By LA−ICP−MS): Supplies And Expendables	**Justification**	**Amount**
Task 4.4, In Situ Otolith Trace Element Analysis (By LA−ICP−MS): Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 4.4, In Situ Otolith Trace Element Analysis (By LA−ICP−MS): Equipment	**Justification**	**Amount**
Task 4.4, In Situ Otolith Trace Element Analysis (By LA−ICP−MS): Other Direct	**Justification**	**Amount**
Elemental Analysis On Quadropole ICP−MS At UC Davis	***100 sample hours @ $51/hour***	***5100***
Task 4.4, In Situ Otolith Trace Element Analysis (By LA−ICP−MS): Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***3795***
	Task 4.4 Total	$18,975
Task 4.6, In Situ Otolith Isotopic Analysis (By SIMS): Labor	**Justification**	**Amount**
Weber, Peter K., PhD.	***No Cost***	***0***
Phillis, Corey C.		
Task 4.6, In Situ Otolith Isotopic Analysis (By SIMS): Benefits	**Justification**	**Amount**
Weber, Peter K., PhD.	***No Cost***	***0***
Phillis, Corey C.		
Task 4.6, In Situ Otolith Isotopic Analysis (By SIMS): Travel Expenses	**Justification**	**Amount**
Task 4.6, In Situ Otolith Isotopic Analysis (By SIMS): Supplies And Expendables	**Justification**	**Amount**
Task 4.6, In Situ Otolith Isotopic Analysis (By SIMS): Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 4.6, In Situ Otolith Isotopic Analysis (By SIMS): Equipment	**Justification**	**Amount**
Task 4.6, In Situ Otolith Isotopic Analysis (By SIMS): Other Direct	**Justification**	**Amount**
Analysis Cost	***No Cost***	***0***
Task 4.6, In Situ Otolith Isotopic Analysis (By SIMS): Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***0***
	Task 4.6 Total	$0
Task 4.5, Otolith Sr Isotopic Analysis (By LA−ICP−MS): Labor	**Justification**	**Amount**
Phillis, Corey C.	***160hrs @ $20/hr***	***3200***
Task 4.5, Otolith Sr Isotopic Analysis (By LA−ICP−MS): Benefits	**Justification**	**Amount**
Phillis, Corey C.	***26% of Salary***	***832***
Task 4.5, Otolith Sr Isotopic Analysis (By LA−ICP−MS): Travel Expenses	**Justification**	**Amount**
Task 4.5, Otolith Sr Isotopic Analysis (By LA−ICP−MS): Supplies And Expendables	**Justification**	**Amount**
Task 4.5, Otolith Sr Isotopic Analysis (By LA−ICP−MS): Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 4.5, Otolith Sr Isotopic Analysis (By LA−ICP−MS): Equipment	**Justification**	**Amount**
Task 4.5, Otolith Sr Isotopic Analysis (By LA−ICP−MS): Other Direct	**Justification**	**Amount**
Isotopic Analysis On LA−ICP−MS At UC Davis	***90 sample hours @ $121/hour***	***10890***
Task 4.5, Otolith Sr Isotopic Analysis (By LA−ICP−MS): Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***3731***

	Task 4.5 Total	$18,653
Task 4.3, Otolith Isotopic Microanalysis (By Micromill IRMS): Labor	**Justification**	**Amount**
Phillis, Corey C.	***600 hrs @ $20/hr***	***12000***
Task 4.3, Otolith Isotopic Microanalysis (By Micromill IRMS): Benefits	**Justification**	**Amount**
Phillis, Corey C.	***26% of Salary***	***3120***
Task 4.3, Otolith Isotopic Microanalysis (By Micromill IRMS): Travel Expenses	**Justification**	**Amount**
Task 4.3, Otolith Isotopic Microanalysis (By Micromill IRMS): Supplies And Expendables	**Justification**	**Amount**
Other	***Micromill Drill Bits, 20 bits @ $20/bit***	***400***
Task 4.3, Otolith Isotopic Microanalysis (By Micromill IRMS): Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 4.3, Otolith Isotopic Microanalysis (By Micromill IRMS): Equipment	**Justification**	**Amount**
Task 4.3, Otolith Isotopic Microanalysis (By Micromill IRMS): Other Direct	**Justification**	**Amount**
Analysis Cost	***400 samples @ $20/sample***	***8000***
Task 4.3, Otolith Isotopic Microanalysis (By Micromill IRMS): Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***5880***
	Task 4.3 Total	$29,400
Task 5.1, Data Analysis And Presentation Of Results: Labor	**Justification**	**Amount**
Weber, Peter K., PhD.	***No Cost***	***0***
Phillis, Corey C.	***1398 hrs @ $20/hr***	***27960***
Task 5.1, Data Analysis And Presentation Of Results: Benefits	**Justification**	**Amount**
Weber, Peter K., PhD.		
Phillis, Corey C.	***26% of Salary***	***7270***
Task 5.1, Data Analysis And Presentation Of Results: Travel Expenses	**Justification**	**Amount**
Conferences	***CALFED x 2 people***	***300***
Lodging	***$84/night x 2 people x 2 nights***	***336***
Task 5.1, Data Analysis And Presentation Of Results: Supplies And Expendables	**Justification**	**Amount**
Task 5.1, Data Analysis And Presentation Of Results: Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 5.1, Data Analysis And Presentation Of Results: Equipment	**Justification**	**Amount**
Task 5.1, Data Analysis And Presentation Of Results: Other Direct	**Justification**	**Amount**
Task 5.1, Data Analysis And Presentation Of Results: Indirect (Overhead)	**Justification**	**Amount**
Standard UC Overhead	***25% of direct costs***	***8967***
	Task 5.1 Total	$44,833
Task 4.2, In Situ Otolith Sr/Ca Analysis (By Electron Microprobe): Labor	**Justification**	**Amount**
Weber, Peter K., PhD.	***No Cost***	***0***
Phillis, Corey C.	***250 hours @ $20/hour***	***5000***
Task 4.2, In Situ Otolith Sr/Ca Analysis (By Electron Microprobe): Benefits	**Justification**	**Amount**
Weber, Peter K., PhD.	***No Cost***	***0***
Phillis, Corey C.	***26% of Salary***	***1300***
Task 4.2, In Situ Otolith Sr/Ca Analysis (By Electron Microprobe): Travel Expenses	**Justification**	**Amount**
	Justification	**Amount**

Task 4.2, In Situ Otolith Sr/Ca Analysis (By Electron Microprobe): Supplies And Expendables		
Task 4.2, In Situ Otolith Sr/Ca Analysis (By Electron Microprobe): Subcontractors	**Justification**	**Amount**
No subcontractor was assigned to this task.		
Task 4.2, In Situ Otolith Sr/Ca Analysis (By Electron Microprobe): Equipment	**Justification**	**Amount**
Task 4.2, In Situ Otolith Sr/Ca Analysis (By Electron Microprobe): Other Direct	**Justification**	**Amount**
Analysis Cost	***No Cost***	***0***
Task 4.2, In Situ Otolith Sr/Ca Analysis (By Electron Microprobe): Indirect (Overhead)	**Justification**	**Amount**
Standar UC Overhead	***25% of direct costs***	***1575***
	Task 4.2 Total	$7,875
	Grand Total	$197,689

− The indirect costs may change by more than 10% if federal funds are awarded for this proposal.

What is the total of non−federal funds requested?

Chinook salmon rearing in the San Francisco Bay-Delta system:
Identification of geochemical markers to determine Delta use

B. Lynn Ingram
Department of Earth and Planetary Science
University of California, Berkeley
307 McCone Hall
Berkeley, CA 94720-4767
ingram@eps.berkeley.edu
510-643-1474

Peter K. Weber
Chemical Biology and Nuclear Science
Lawrence Livermore National Laboratory
L-231, P.O. Box 808
Livermore, CA 94551-0808
weber21@llnl.gov
925-422-3018

Corey C. Phillis
Department of Earth and Planetary Science
University of California, Berkeley
307 McCone Hall
Berkeley, CA 94720-4767
corey@berkeley.edu
510-643-4326

January 5, 2005

ISSUE STATEMENT

The importance of the San Francisco Bay-Delta system to the native juvenile salmonid rearing is poorly understood (Fig. 1). Fish surveys in this system provide snap shots of the population as it travels down the rivers and enter and exit the Bay-Delta complex (Kjelson et al. 1982; Brandes et al. 2001; MacFarlane and Norton, 2002). But existing techniques are unable to address the most important issue, the relationship between fish residence time in the Delta and the Bay to success in later life stages, and most importantly, to becoming a successful spawner.

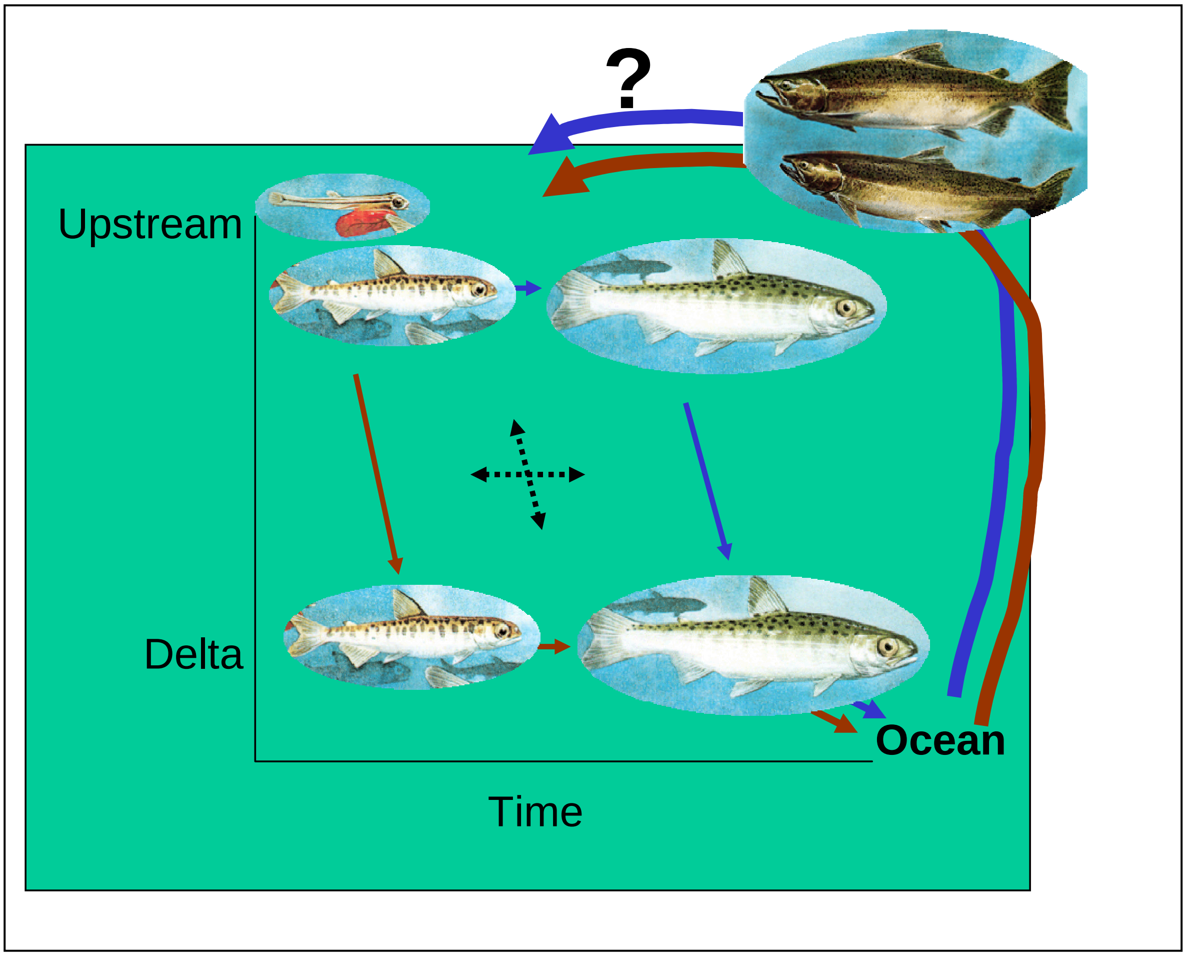

Figure 1. The central research question in this proposal is, What is the role of the Delta in salmon rearing? This figure shows a schematic representation of the continuum of rearing and outmigration possibilities for junvenile chinook salmon, and poses the question, which history is more likely to result in adults returning to spawn. The methods developed in this proposal would allow researchers to close the loop between juvenile behavior and adult spawning success.

In our previous work, we developed geochemical markers in otoliths to characterize the early life history of juvenile Chinook salmon in the Sacramento-San

Joaquin river system (Ingram and Weber, 1999; Weber et al., 2002; Weber, 2002; Weber et al., in press). We use otoliths because they form daily bands during the juvenile life stage, which can be used to construct a chronology of an individual fish's early life (Neilson and Geen, 1982; Campana and Neilson, 1985; Campana, 1999). We perform micro-chemical analyses that provide approximately one-week temporal resolution in juveniles (~30-micron lateral resolution) (Weber et al., 2002; Weber et al., in press). To date, we have developed geochemical tracers for Sacramento River salmon otoliths that (1) distinguish between hatchery-raised and naturally spawned salmon using sulfur isotopes ($\delta^{34}S$), (2) determine a fish's natal river of origin using strontium isotopes ($^{87}Sr/^{86}Sr$), and (3) can identify the timing of downstream migration from spawning grounds using carbon isotopes ($\delta^{13}C$) and (4) of ocean entry using strontium-calcium ratio (Sr/Ca). The missing piece in our work in this river system is a marker or set of markers to determine the timing and duration of use of different parts of the San Francisco Bay-Delta system (Fig. 2).

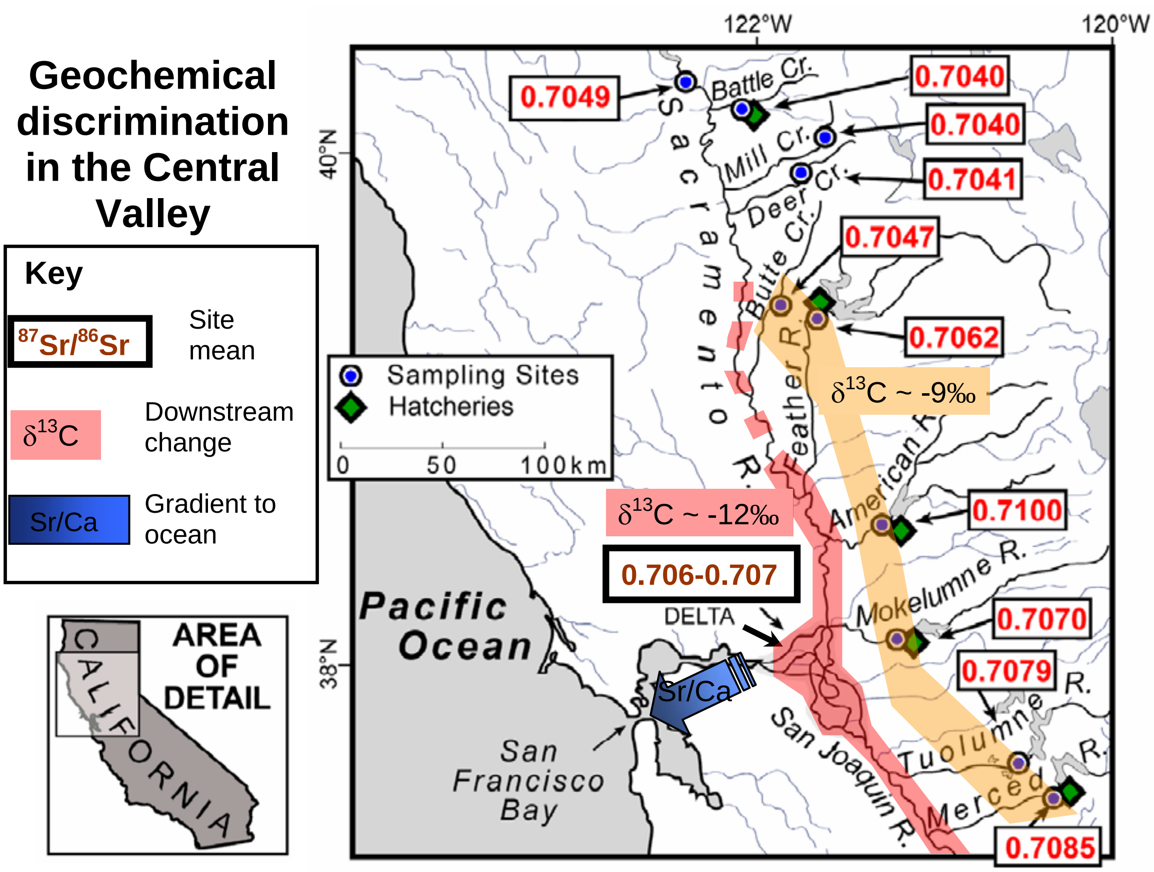

Figure 2. Map of the distribution of key geochemical markers in the Sacramento-San Joaquin river system. Sulfur isotopes (not included) can distinguish between hatchery and naturally spawned fish.

Here, we propose to focus our effort on developing geochemical markers to determine the timing and duration of Delta and Bay use. We will focus on Delta use because the role of the Delta in salmonid rearing is a major question in Central Valley ecosystem and water management, and because we expect the salinity gradient to provide a ready reference for migration from Chipps Island to the Golden Gate. But we will include samples collected between the Delta and the ocean to provide a complete picture of the geochemical markers in the system. To the extent possible, we will identify geochemical markers that identify sub-regions of the Delta.

We are in a strong position to take on this problem. Prof. Ingram and Dr. Weber have extensive experience in the Sacramento-San Joaquin river system, including six years working on otolith chemistry. We have an archive of hundreds of samples from the Bay and Delta collected by the U.S. Fish and Wildlife Service, the California Department of Fish and Game and ourselves. We have otolith microchemistry data from outmigrating juveniles and returned adults that point towards specific geochemical markers in otoliths as strong candidates for distinguishing Delta and Bay use from other periods of the salmonid life cycle. We have access to the analytical equipment we need at the University of California, Berkeley (UCB), Lawrence Livermore National Laboratory (LLNL), and the University of California Davis. And we have a reliable and experienced staff member, Corey Phillis, in the Ingram Laboratory at the University of California, Berkeley, to take on the project under the joint direction of Prof. Ingram and Dr. Weber.

We are very excited about this work because of its potential to expand our understanding of salmonid habitat use. We would be particularly interested to use these markers to study how year-to-year environmental variations (such as ENSO) affect Delta and Bay use. We have in hand a set of adult otoliths to which we are already applying our techniques to understand spawning sources, and with which we could study Delta and Bay use on an interannual basis. While this question of interannual variability is larger than can be addressed in this study, the tools that we would develop would help to address such questions, and therefore would be a major contribution to the toolkit of researchers and managers in this system.

RESEARCH PLAN

Otoliths are calcium carbonate concretions in the inner ear of bony fish. They accrete with discernable daily increments in juvenile chinook salmon (Neilson and Geen, 1982; Campana and Neilson, 1985). The chemistry of these increments can be directly related to the chemistry of the water the fish were living in and/or the food they were eating at the time that the increments were deposited (Campana, 1999). The goal of this project is to identify the chemical markers that can be used to constrain Delta use in the Sacramento-San Joaquin river system that can be measured in otolith growth increments using microanalytical techniques. This project will cover two years. In the first year, we will do broad surveying to identify promising Bay and Delta markers. In the second year, we will focus on promising markers to establish their reliability to uniquely identify Delta and/or Bay residence.

Our approach is to do directed surveying of the spatial distribution of geochemical markers in the Delta and Bay. For samples, we will primarily rely on our archive of juvenile chinook salmon. We will receive additional fish samples from Delta monitoring and complement these samples with our own field sampling for water and prey items for their period of outmigration. For this project, we will prioritize geochemical markers that study based on (1) our knowledge of what can be detected in otoliths, (2) our knowledge of geochemical drivers, such as regional geology, nutrient cycling, and the hydrologic cycle, and (3) our extensive previous work in the Sacramento-San Joaquin river system.

Step 1 is to constrain departure from the Delta. We will use otolith Sr/Ca as the reference for departure from the Delta because it is relatively easy to measure and it is directly related to the salinity of the water the fish is residing in at the time of otolith $CaCO_3$ deposition (Fig. 3). The salinity gradient between the Delta and the ocean results in an increase in the Sr/Ca ratio, as indicated in Figure 2. The change in Sr/Ca with salinity will be examined using our collection of juvenile chinook salmon collected at Chipps Island by the U.S. Fish and Wildlife Service, and by the California Department of Fish and Game at various locations in the Bay. Period of increasing Sr/Ca would to the first order define the period of Bay residence. Changes in otolith Sr/Ca ratio during freshwater residence are smaller and are not likely to be useful for distinguishing Delta residence from river residence.

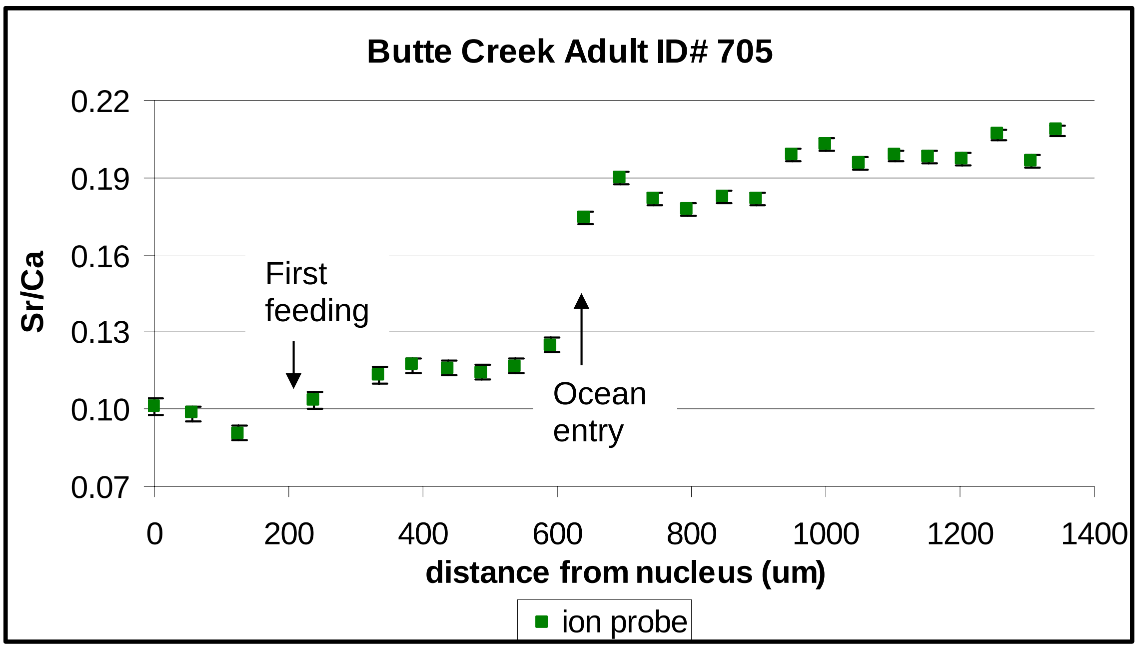

Figure 3. Otolith Sr/Ca profile in the otolith of an adult chinook salmon showing ocean entry. Based on this easily measured parameter, departure from the Delta can be constrained. The data are presented as ion ratios. Error bars are 2 standard errors.

With Sr/Ca to constrain departure from the Delta, theoretically only one additional marker—a Delta entry marker—is necessary to constrain Delta residence. Conceptually, this marker could take various forms: a positive marker (present in the Delta and not in the river), a negative marker (the opposite), or a combination. On the Bay and ocean side, the otolith could reflect the same signal as in the river or the Delta, or could have a third level. Figure 4 presents two examples of hypothetical marker that would constrain Delta residence. In this example, Marker 2 would be sufficient by itself to constrain Delta residence, but such a remarkable marker is highly unlikely in the Delta, and therefore it is important to have Sr/Ca as a reference. Environmental complexities may necessitate the identification of more than two markers to provide sufficient discrimination power to determine duration of Delta residence.

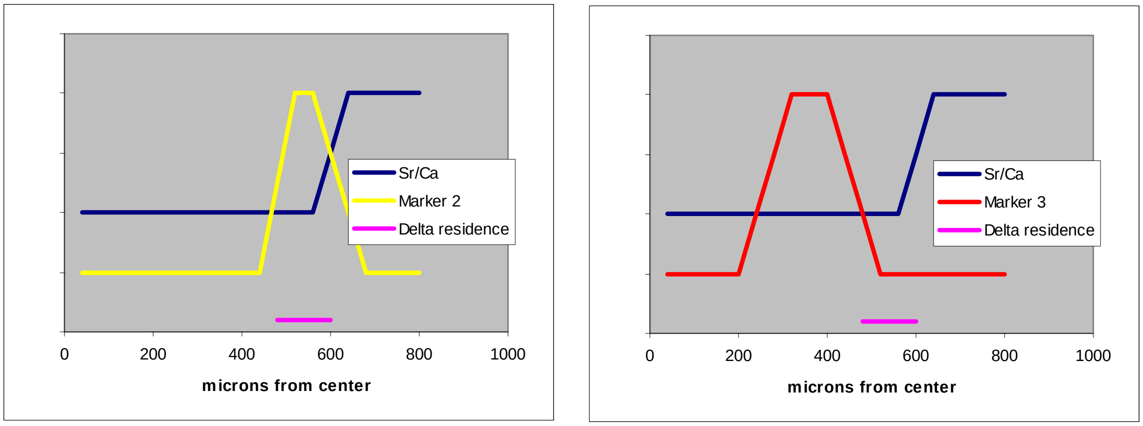

Figure 4. Conceptual model: Profiles of otolith Sr/Ca and a hypothetical markers that would constrain Delta residence. The otolith chemistry profiles on the left represent a positive marker, and on right is a negative marker. Temporal duration of Delta residence would be determined by band counting.

We have identified a number of promising markers that could be used in combination with Sr/Ca to constrain Delta residence. The most promising ones are isotopic ratios, which are expressed in delta notation (e.g., for carbon isotopic composition, $\delta^{13}C = [(^{13}C/^{12}C)_{unknown}/(^{13}C/^{12}C)_{reference} - 1] \times 1000$, in units of permil). We have previously noted changes in sulfur ($\delta^{34}S$), carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotopic compositions of otolith bands associated signatures related to the Delta and Bay, but we have not had the resources to focus on this region to map the changes as are necessary for this work. For example, the data in Figure 5 indicates that otolith $\delta^{34}S$ may be useful for constraining Delta residence. The data are for two adult chinook salmon, one of which is hatchery-raised and other of which was naturally-spawned. Because of the differences in the life history of the two fish, the otolith $\delta^{34}S$ values diverge after first feeding. What is of interest for this project is the fact that the signatures reconverge just before ocean entry. The value at which they reconverge is potentially a Delta signature. Otolith $\delta^{34}S$ is determined by the nutrient source at the time that the otolith increments are deposited (Weber et. al. 2002). We have similarly intriguing data for otolith $\delta^{13}C$ and $\delta^{18}O$. Figure 6 shows how otolith $\delta^{34}S$ and otolith $\delta^{13}C$ could be used in combination with Sr/Ca to potentially constrain Dela residence.

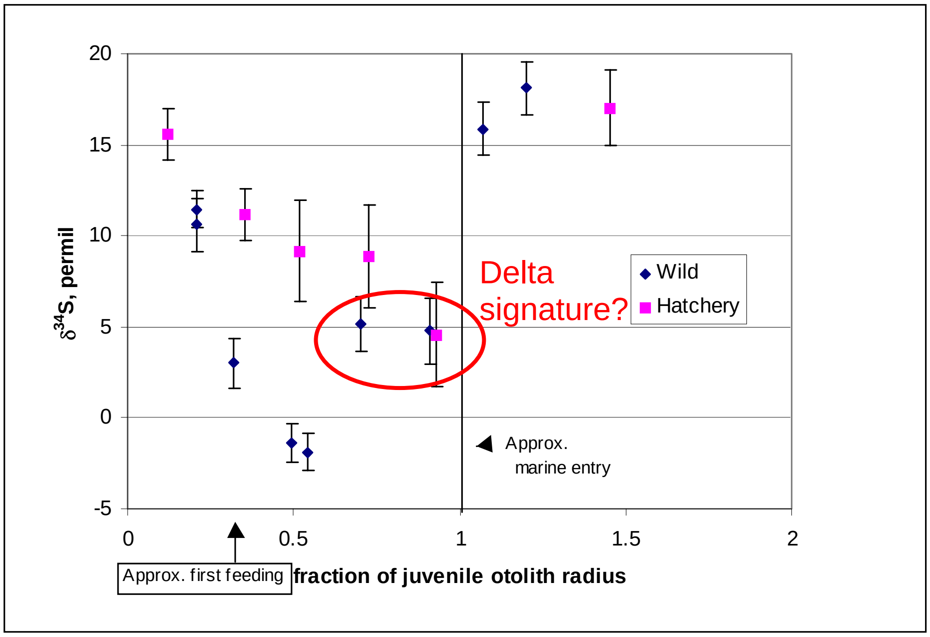

Figure 5. Otolith δ^{34}S for two adult chinook salmon, showing potential Delta δ^{34}S signature.

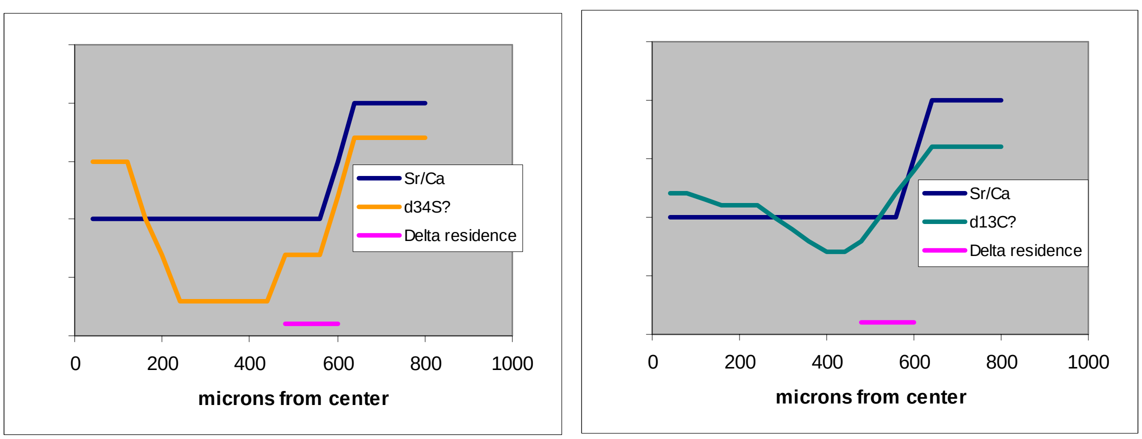

Figure 6. Potential otolith chemical profiles that would constrain Delta residence, based on data in hand. δ^{34}S and δ^{13}C would be studied under CalFed funding.

We will also examine other markers that could provide constraint on this problem. We will measure the Sr isotopic ratio (^{87}Sr/^{86}Sr) in a limited number of otoliths to make a more complete assessment of the value of this marker in the Delta. Our previous work suggested that this marker would be of limited usefulness for the Delta because the Delta ^{87}Sr/^{86}Sr ratio is very similar to the ^{87}Sr/^{86}Sr ratios in the Feather, Mokelumne, and lower Sacramento and San Joaquin rivers (Fig. 2). Furthermore, Delta ^{87}Sr/^{86}Sr ratios can have large temporal variations. However, with recent instrumental advances (Ramos et al. 2004) and with the importance of the ^{87}Sr/^{86}Sr ratio to the overall geochemical mapping of the Sacramento-San Joaquin river system (Ingram and Weber 1999; Weber 2002), it is important to include this marker in this study. We will also examine trace elements that may be related to Delta circulation, including Ba and Mn, and contaminants associated with the Delta and Bay, such as Hg and Se. The work on Hg and Se is speculative, but if successful, these would be ground breaking measurements, not only for our work, but also for contaminant work in the Bay and Delta.

We will analyze samples collected from throughout the Delta to develop a database of the geographic distribution of geochemical markers. This study will be based on our archive samples, and selective new sampling in the Delta. The primary samples for this study will be CWT juvenile chinook salmon released near and in the Delta and recaptured as part of the USFWS Delta monitoring (>300 samples). These samples include CWT juvenile chinook salmon released in the lower Sacramento River and recaptured at the same location in the lower Sacramento River (~30 samples) and in the Delta (~20 samples) in 1999. The release-recapture samples will allow us to relate otolith chemistry just upstream of the Delta to otolith chemistry in the Delta to constrain movement from the mainstem into the Delta. These samples also have the distinct benefit of providing good control on the duration that the fish were in the lower Sacramento. We will then sample from our archive of samples to test our results. We will primarily use fish for which we not only know when and where the fish were captured, but also when and where they were released.

Out-migration from the Delta will be constrained using juvenile chinook salmon collected in the San Francisco Bay by the California Department of Fish and Game, which we have in our archive (~70). We also have food item and water samples from the lower Sacramento River, the Delta, and the Bay, which we will analyze for further comparison of geochemical signatures between sites.

In addition to the archival samples, water and prey samples will be collected in March, April and May of the first year of the grant. These samples will be related to juvenile chinook salmon collected in the Delta and Bay by the USFWS and DFG in field monitoring of that year.

The primary approach to surveying the geochemical markers will be to make microanalyses of the outer increments of otoliths. In the case of $\delta^{34}S$, however, we will focus on analyzing prey items because this is a simpler and cheaper method. Inferences from the $\delta^{34}S$ analyses of prey will be confirmed by making otolith $\delta^{34}S$ measurements. Water sample $\delta^{18}O$ and water DIC $\delta^{13}C$ will be used to confirm otolith measurements. Water trace element data will also be used in a similar fashion, although the link between water chemistry and otolith chemistry is not as direct as in the case of the stable isotopes.

METHODS

All sample preparation will be carried out at UCB. Otoliths will be analyzed for carbon and oxygen isotopic composition, and for trace element composition. Food items will be analyzed for sulfur isotopic composition. Water samples will be analyzed for carbon and oxygen isotopic composition, and trace element composition. Initial Sr/Ca characterization of the otoliths will be performed by electron microprobe at LLNL. Further in situ trace element analyses of otoliths, with the exception of Se, will be performed at UCD using the new laser sampling system coupled to the quadrapole ICP-

MS. Selenium analyses will performed at LLNL by secondary ion mass spectrometry because of the high sensitivity of that instrument for elements such as Se that preferentially produce negative ions. For most of the isotopic analyses, otolith samples will be microsampled at UCB using Prof. Ingram's micromill and then analyzed using her isotope ratio mass spectrometer. Limited S, C and O isotopic analyses will be performed at LLNL by secondary ion mass spectrometry to confirm other work. Water and food item isotopic analyses will also be performed in Prof. Ingram's lab. Water trace element chemistry will be carried out at UCD by quadrapole ICP-MS. Otolith Sr isotope data will be collected with the UCD laser sampling system coupled to the multicollector ICP-MS. The data will be compared to our database of geochemical signatures for the Sacramento-San Joaquin river system, and to the marine signatures, to determine discrimination power.

We anticipate making 400 C and O isotope analyses on otoliths by IRMS (both $\delta^{13}C$ and $\delta^{18}O$ data are produce with each analysis). This will include at least 20% replicates for quality control. The outer layers of ~150 otoliths will be analyzed by this method, and an additional 25 to 50 will be subsampled over the entire period of otolith growth to provide isotopic profiles. Three hundred S isotope analyses of prey items and gut contents will be made by IRMS. This will include gut contents and tissue samples from approximately one-third of the fish sampled for otoliths (~150 samples) and field samples (~100). Duplicate samples will be made for ~20%. One hundred and fifty samples will be analyzed for water C and O isotopes by IRMS. This will include ~75 for $\delta^{18}O$ and ~75 for DIC $\delta^{13}C$. All water samples collected for this study will be analyzed for trace elements (150). Approximately three runs per sample will be necessary to allow for dilutions (50 hours). In situ trace element analyses will be performed on all otoliths. The 100 hours allows for experimental work on Hg in otoliths. Selected otoliths will be analyzed for $^{87}Sr/^{86}Sr$ (90 hours). The analytical time allotted for these measurements allows for calibration. We have a unique set of $^{87}Sr/^{86}Sr$ standards for these measurements, which will insure quality control. Electron probe Sr/Ca analyses at LLNL will be performed on all otoliths, as necessary. The exploratory Se otolith analyses by secondary ion mass spectrometry at LLNL will be performed during two days; additional work will be performed if shown to be promising. In situ otolith stable isotope analyses by secondary ion mass spectrometry at LLNL will be performed on a "as needed" basis. There will be no cost for the analytical work at LLNL.

RELEVANCE TO EXISTING PROGRAMS

This research is relevant to the goals of managing the freshwater fishery, mitigating habitat loss and contamination, and managing and planning ecosystem restoration. The identification of geochemical markers specific to the Delta would provide managers with a new tool to monitor and understand Delta use by salmonids. The information that could be gained by this new method would be more comprehensive than could be gained by previous methods, because it would allow Delta and Bay use to be placed within the context of the entire life history of a spawning fish. This information would be useful to management decisions ranging from water management to restoration efforts. This method would also likely be transferable to other species that migrate in and out of the Delta, such as striped bass, smelt, and splittail.

DELIVERABLES

We will produce the following data:

- Otolith Sr/Ca by electron microprobe
- Otolith Sr, Ba, Mn, Hg and other by LA-ICP-MS
- Otolith Se by secondary ion mass spectrometry
- Otolith C and O isotopes sampled by micromill for isotope ratio mass spectrometry (IRMS)
- Otolith S, C and O isotopic composition for selected samples by secondary ion mass spectrometry
- Otolith Sr isotope composition by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS)
- Food item S isotopes by IRMS
- Water C and O isotopes by IRMS
- Water trace element composition by ICP-MS

We will also produce a report on geochemical markers for determining residence in the Delta and Bay, including all data generated under this grant. The report will relate the geochemical data for the Delta and Bay to the rivers in the Sacramento-San Joaquin system and the ocean. The report will assess the ability to distinguish Bay and Delta residence from residence elsewhere. The work under this grant will also be the basis for peer-reviewed publications.

BUDGET

The budget covers the salary and benefits for one staff member (Corey Phillis) for 24 months and one part-time work-study student. The budget also covers sample analyses at UCB and UCD. Analyses will be performed at LLNL without charge to the project.

QUALIFICATIONS

Prof. Ingram is an expert in geochemical markers in the San Francisco Bay Estuary. She has worked in the Estuary for 14 years. Dr. Weber is an expert in otolith geochemistry and microchemical analysis. He has worked in the Sacramento-San Joaquin river system for six years. Corey Phillis has a B.S. in Marine Biology and previously did salmon population work for NMFS in Santa Cruz, as well as work for three different graduate students' research projects. For the last 19 months he has been a staff researcher at UC Berkeley in charge of the field work, sample collection, sample preparation, microanalysis, and statistical analysis of data necessary to Dr. Weber's otolith geochemistry analyses.

REFERENCES

Brandes PL, and McLain JS. 2001. Juvenile chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In: Brown RL, editor.

Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179. Volume 2. Sacramento (CA): California Department of Fish and Game. p 39-136.

Campana, S. E., 1999, Chemistry and composition of fish otoliths: pathways, mechanisms and applications: Marine Ecology Progress Series, v. 188, p. 263-297.

Campana, S. E., and J. D. Neilson, 1985, Microstructure of fish otoliths: Canadian Journal of Fisheries and Aquatic Sciences, v. 42, p. 1014-1032.

Ingram, B. L., and P. K. Weber, 1999, Salmon origin in California's Sacramento-San Joaquin river system as determined by otolith strontium isotopic composition: Geology, v. 27, p. 851-854.

Kjelson, M. A., P. F. Raquel, and F. W. Fisher, 1982, Life history of Fall-run juvenile chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California, *in* V. S. Kennedy, ed., Estuarine Comparisons, New York, Academic Press, p. 393-411.

MacFarlane RB, Norton EC, 2002, Physiological ecology of juvenile chinook salmon (Oncorhynchus tshawytscha) at the southern end of their distribution, the San Francisco Estuary and Gulf of the Farallones, California: Fishery Bulletin, v. 100 (2), p. 244-257.

Neilson, J. D., and G. H. Geen, 1982, Otolith of chinook salmon (*Oncorhynchus tshawytscha*): daily growth increments and factors influencing their production: Canadian Journal of Fisheries and Aquatic Sciences, v. 39, p. 1340-1347.

Ramos, F.C., J.A. Wolff, and D.L. Trollstrup, 2004, Measuring $^{87}Sr/^{86}Sr$ in minerals and groundmass from basalts using LA-MC-ICPMS: Chemical Geology.

Weber, P. K., 2002, Geochemical Markers in the Otoliths of Chinook Salmon in the Sacramento-San Joaquin River System, California: Ph.D. Dissertation thesis, University of California, Berkeley, California.

Weber, P. K., C. R. Bacon, I. D. Hutcheon, B. L. Ingram, and J. L. Wooden, in press, Ion microprobe measurement of strontium isotopes in calcium carbonate with application to salmon otoliths: Geochimica et Cosmochimica Acta.

Weber, P. K., I. D. Hutcheon, K. D. McKeegan, and B. L. Ingram, 2002, Otolith sulfur isotope method to reconstruct salmon (*Oncorhynchus tshawytscha*) life history: Canadian Journal of Fisheries and Aquatic Sciences, v. 59, p. 587-591.

Principal Investigator: B. Lynn Ingram

Department of Earth and Planetary Science
Berkeley, CA 94720
ingram@socrates.berkeley.edu
(510) 643-1474

Education

Ph.D 1992	Geology, Stanford University
M.S. 1989	Geology, University of California, Los Angeles
B.S. 1984	Geology (Paleobiology), University of California, Los Angeles

Professional Experience

1998 -	Associate Professor, University of California, Berkeley
1995-1998	Assistant Professor, University of California, Berkeley
1994-1995	Adjunct Assistant Professor, University of California, Berkeley
1992-94	U.S. Department of Energy, Global Change Distinguished Postdoctoral Fellow, Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory
1992	Inorganic Geochemist, Ocean Drilling Program (JOIDES Resolution), North Pacific Transect (Leg 145)
1989-92	Research and Teaching Assistant, Stanford University.

Five Publications Related To Research

1. Ingram, B. L. and Sloan, D. (1992) Strontium isotopic composition in estuarine sediments as paleosalinity and paleoclimate indicator, *Science* 255, 68-72.
2. Ingram, B. L., De deckker, P., Chivas, A. R., Byrne, A.R., and Conrad, M. E. (1998) Stable isotopes, Sr/Ca and Mg/Ca in biogenic carbonates from Petaluma Marsh, Northern California, USA, *Geochim. Cosmochim. Acta*. V. 62, pp. 3229-3237.
3. Ingram, B. L., and J. C. Lin (2002). Geochemical tracers of sediment source to San Francisco Bay. *Geology* 30, 575-578.
4. Ingram, B. L., Ingle, J. C., and Conrad, M. E. (1996) A 2,000-yr record of San Joaquin and Sacramento river inflow to San Francisco Bay, California, *Geology* 24, 331-334.
5. Ingram, B. L., Ingle, J. C., and Conrad, M. E.(1996) Stable isotope record of Late Holocene Paleosalinity and Paleodischarge in San Francisco Bay, California, *Earth and Planetary Science Letters* 141, 237-247.

Five Other Significant Publications

1. Ingram, B. L., and Weber, P.K. (1999) Salmon origin in California's Sacramento-San Joaquin river system as determined by otolith strontium isotope compositions. *Geology* 27, 851-854.
2. Ingram, B. L., Coccioni, R., Montanari, A., and Richter, F. M. (1994) Strontium isotopic composition of mid-Cretaceous Seawater, *Science* **264**, 546-550.
3. Ingram, B. L. (1995) High-resolution dating of deep-sea clays using Sr isotopes in fossil fish teeth, *Earth and Planetary Science Letters* 134, 545-555.
4. Ingram, B. L. (1998) Differences in radiocarbon age between shell and charcoal from a Holocene shellmound in northern California, *Quaternary Research* 49, 102-110.
5. Ingram, B. L., and Ingle, J. C. (1998) Strontium isotope ages of the marine Merced Formation, near San Francisco, California. *Quaternary Research* 50, 194-199.

Synergistic Activities

- employing and training undergraduate students from underrepresented groups (women and minorities) in laboratory
- developing exhibit on San Francisco Bay geology for Lawrence Hall of Science (hands-on science museum located at the Lawrence Berkeley National Laboratory)
- developed new track in Earth Science major for Marine Sciences, and developed two new courses required for the track (Geological Oceanography and Paleoclimatology)
- developing undergraduate course at UC Berkeley for teaching oceanography to K-12 students
- analysis of California paleoclimate data and co-author of white paper for Calfed (to be used by California policy makers in developing water policy)

Recent Collaborators: James Kennett, Douglas Kennett, Roger Byrne, Kent Lightfoot

Current graduate students and Postdoctoral researchers: Frances Malamud-Roam (Postdoctoral fellow), Peter Weber (Postdoctoral fellow), Brendan Roark (Ph.D student), Peter Schweikardt (Ph.D student), Kathleen Johnson (Ph.D student)

Graduate Advisors: Mark Barton, James Ingle, Simon Brassell

PETER K. WEBER

Lawerence Livermore National Laboratory
L-231, P.O. Box 808
Livermore, CA 94551-0808
Office: 925-422-3018; Lab: 925-422-0203

EDUCATION:

Ph.D., Geography, University of California, Berkeley — 2002
Dissertation: Geochemical Markers in the Otoliths of Chinook Salmon in the Sacramento-San Joaquin River System, California (Chair: B.L. Ingram).

M.A., Geography, University of California, Berkeley — 1997
Thesis: Terrestrial biomarkers and fluorescence in massive *Porites* corals from South Sulawesi, Indonesia (Chair: D.R. Stoddart).

B.S., Physics, Antioch University — 1987

Chemical Engineering, Carnegie-Mellon University — transferred 1984

HONORS AND AWARDS:

Outstanding Student Paper, Biogeosciences Section, American Geophysical Union Fall Meeting, 2000.
Best Student Presentation, CALFED Science Conference, 2000.
Recipient, Etta Ogden Holway Scholarship, 2000.
President, Geography Graduate Students Association, 1995-1997.
Recipient, Sigma Xi Research Grant, 1996
Honorable Mention, National Science Foundation Fellowship, 1995.
Recipient, U.C. Regents Fellowship, 1994-95.
Undergraduate: President's Letter of Recognition, Dean's List, Tau Beta Pi Honorary Engineering Society, Lambda Sigma Honorary Society.

RESEARCH INTERESTS:

Environmental geochemistry; biogeochemistry; biogenic carbonates; microbial chemistry and geochemistry; elemental and isotopic tracers; microchemical analysis and imaging; secondary ion mass spectrometry.

RESEARCH EXPERIENCE:

Chemist, Lawrence Livermore National Laboratory — 2003-present

Post Doctoral Researcher, Lawrence Livermore National Laboratory — 2002-2003

Graduate Student Researcher, University of California, Berkeley
- Analysis of otoliths, waters, and other environmental samples by SIMS, SHRIMP-RG, ICP-MS, ICP-AES, IRMS & micromill (w/ Ingram & Hutcheon). — 1998-2002
- Trace element analysis of marsh sediments from the San Francisco Bay Estuary by AAS to determine changes in fresh water inflow (for L.E. Wells). — 1994-96
- Lead-210 dating of sediments from the Bolinas Lagoon to determine changes in sedimentation rates over the past 150 years (w/ A.R. Byrne). — Spring 1995

Graduate Student Instructor, University of California, Berkeley — Fall 1996
- Biology and Geomorphology of Tropical Islands

PUBLICATIONS:

J.P. Bradley, Z.R. Dai, R. Erni, N.D. Browning, G.A. Graham, P.K.Weber, J.B. Smith, I.D. Hutcheon, H. Ishii, S. Bajt, C. Floss, F.J. Stadermann, and S. Sandford (in press). Organic carbon and amorphous silicate carriers of the astronomical 2175 Å feature, *Science*.

C. Galli Marxer; M.L. Kraft, P.K. Weber, I.D. Hutcheon, and S.G. Boxer (in press). Supported membrane composition analysis by secondary ion mass spectrometry with high lateral resolution, *Biophysical Journal*.

M. Wainwright, P.K. Weber, J.B. Smith, I.D. Hutcheon, B. Klyce, N.C. Wickramasinghe, J.V. Narlikar, and P. Rajaratnam (in press). Studies on bacteria-like particles sampled from the stratosphere, *Aerobiologia*.

P.K. Weber, C.R. Bacon, I.D. Hutcheon, B.L. Ingram, and J.L. Wooden (in press). Ion microprobe measurement of strontium isotopes in calcium carbonate, *Geochimica et Cosmochimica Acta*.

C.R. Bacon, P.K. Weber, K.A. Larson, R. Reisenbichler, J.A. Fitzpatrick, and J.L. Wooden (in press). Ion microprobe Sr isotope and Sr/Ca analyses of otoliths reveal migration and rearing histories of chinook salmon (*Oncorhynchus tshawytscha*), *Canadian Journal of Fisheries and Aquatic Sciences*.

C. Galli Marxer; E.S. Park, P.K. Weber, I.D. Hutcheon, and S.G. Boxer (2004). Lipid membrane composition analyzed by Secondary Ion Mass Spectrometry, *Biophysical Journal Supplement*, 86: 383a.

P.K. Weber, I.D. Hutcheon, K.D. McKeegan, and B.L. Ingram (2002). Otolith sulfur isotope method to reconstruct salmon (*Oncorhynchus tshawytscha*) life history. *Canadian Journal of Fisheries and Aquatic Sciences* 59: 587-591.

B.L. Ingram and P.K. Weber (1999). Salmon origin in California's Sacramento-San Joaquin river system as determined by otolith strontium isotope compositions. *Geology* 27: 851-854.

PUBLICATIONS, in prep:

C.T. Solomon, P.K. Weber, J.J. Cech, B.L. Ingram, M.E. Conrad, M.V. Machavaram, A.R. Pogodina, and R.L. Franklin (in prep). Experimental determination of the sources of carbon to fish otoliths, for application of stable isotope techniques to otolith chronosequences, *Canadian Journal of Fisheries and Aquatic Sciences*.

CONFERENCE PRESENTATIONS:

P.K. Weber, J.B. Smith, and I.D. Hutcheon. Chemical imaging of biological materials by NanoSIMS. Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies, Portland, OR, October 2004.

D.J. Ostrach, C.C. Phillis, P.K. Weber, B.L. Ingram, J.G. Zinkl. Sacramento River striped bass migration history determined by otolith Sr/Ca ratio. 2004 CalFed Bay-Delta Program Science Conference, Sacramento, CA, October 2004.

J.B. Smith, P.K. Weber, G.R. Huss, and I.D. Hutcheon. Nitrogen and carbon isotopic composition of silicon carbide in the CO3.0 meteorite ALHA77307, a NanoSIMS study. Lunar and Planetary Science Conference, Houston, TX, March 2004.

A.J. Westphal, A.L. Butterworth, C.J. Snead, G. Dominguez, P.K. Weber, I.D. Hutcheon, G.R. Huss, C.V. Nguyen, G.A. Grahm, F. Ryerson, and J.P. Bradley. Technique for concentration of carbonaceous material from aerogel collectors using HF-vapor etching. Lunar and Planetary Science Conference, Houston, TX, March 2004.

C. Galli Marxer, E.S. Park, P.K. Weber, I.D. Hutcheon, and S.G. Boxer. Lipid membrane composition analyzed by Secondary Ion Mass Spectrometry. Biophysical Society 48th Annual Meeting, Baltimore, MD, February 2004.

P.K. Weber, B.L. Ingram, and I.D. Hutcheon. New otolith carbon isotope method to distinguish tributary and delta use in juvenile chinook salmon in the Sacramento-San Joaquin river system. CALFED Science Conference, Sacramento, CA, January 2003.

P.K. Weber, C.R. Bacon, I.D. Hutcheon, B.L. Ingram, and J.L. Wooden. The analysis of otolith and calcite strontium isotopic composition with the SHRIMP-RG ion microprobe, American Geophysical Union Fall Meeting, San Francisco, CA, December 2002.

C.R. Bacon, P.K. Weber, K.A. Larson, R. Reisenbichler, I.D. Hutcheon, B.L. Ingram, and J.L. Wooden. Ion microprobe analysis of $^{87}Sr/^{86}Sr$ in $CaCO_3$ and application to otoliths. 12th Annual V.M. Goldschmidt Conference, Davos, Switzerland, August 2002.

M.S. Schulz, A.F. White, C.R. Bacon, P.K. Weber, and T.D. Bullen. SHRIMP RG measurements of $^{87}Sr/^{86}Sr$ in granitoid calcites: Implications for calcite petrogenesis. 12th Annual V.M. Goldschmidt Conference, Davos, Switzerland, August 2002.

P.K. Weber, B.L. Ingram, I.D. Hutcheon, and K.D. McKeegan. Salmon origin as determined by strontium and sulfur isotopic composition. ASLO 2002 Summer Meeting, Victoria, British Columbia, Canada, June 2002.

P.K. Weber, I.D. Hutcheon, K.D. McKeegan, and B.L. Ingram. Sulfur isotopes in otoliths differentiate hatchery and wild salmon. 3rd Biannial Geochemistry SIMS Workshop, Tempe, Arizona, October 2001.

P.K. Weber, I.D. Hutcheon, K.D. McKeegan, and B.L. Ingram. Differentiating between hatchery-raised and wild salmon using sulfur isotopes. 25th Annual Larval Fish Conference, Sandy Hook, New Jersey, August 2001.

P.K. Weber, B.L. Ingram, I.D. Hutcheon, and K.D. McKeegan. Salmon origin as determined by $^{87}Sr/^{86}Sr$ and $\delta^{34}S$ in the Sacramento-San Joaquin river system. 4th International Symposium on Applied Isotope Geochemistry, Pacific Grove, California, June 2001.

P.K. Weber, B.L. Ingram, and I.D. Hutcheon. Salmon stock origin as determined by otolith geochemistry in the Sacramento and San Joaquin watersheds, California. Interagency Ecological Program Workshop, Pacific Grove, California, February 2001.

P.K. Weber, B.L. Ingram, and I.D. Hutcheon, Salmon stock origin as determined by otolith geochemistry in the Sacramento and San Joaquin watersheds, California. American Geophysical Union Fall Meeting, San Francisco, CA, December 2000.

P.K. Weber, B.L. Ingram, and I.D. Hutcheon, Salmon stock origin as determined by otolith geochemistry in the Sacramento and San Joaquin watersheds, California. CALFED Science Conference, Sacramento, California, October 2000.

P.K. Weber, B.L. Ingram, and I.D. Hutcheon, Geochemical markers in salmon otoliths for the Sacramento-San Joaquin river system. Interagency Ecological Program Workshop, Pacific Grove, California, February 2000.

P.K. Weber, B.L. Ingram, and I.D. Hutcheon, Salmon origin and river geochemistry in Sacramento and San Joaquin watersheds, California. Geologic Society of American Cordilleran Section, Berkeley, California, May 1999.

P.K. Weber, B.L. Ingram, and I.D. Hutcheon, The otolith chemistry of chinook salmon in the Sacramento and San Joaquin watersheds. 22nd Annual Larval Fish Conference, Ann Arbor, Michigan, July 1998.

P.K. Weber and D.S. Goodman, Experimental Comparisons of Confocal and Non-Confocal Microscopes. Annual Meeting of the Optical Society of America, Orlando, Florida, October 1989.

Corey C. Phillis

Department of Earth and Planetary Science
University of California, Berkeley
307 McCone Hall
Berkeley, CA 94720-4767
510-643-4326
corey@berkeley.edu

EDUCATION:

Bachelor of Science in Marine Biology, March 2003
University of California at Santa Cruz
One of only two undergraduates to receive a "Friends of the Long Marine Lab" grant in 2001

Courses taken included:

Quantitative Ecology for Conservation Biology	Fish Population Dynamics
Marine Conservation Biology	Ichthyology and Lab
Invertebrate Zoology and Lab	Marine Ecology
Ocean Ecosystems	Field Ecology of Moorea, French Polynesia

EXPERIENCE:

Staff Research Associate, May 2003 to Present
UC Berkeley, Berkeley, California

- Collected water and food item samples in Sacramento-San Joaquin Delta, Sacramento and Feather Rivers, San Joaquin and Merced Rivers, and the South Fork Eel River.
- Collected juvenile steelhead for otolith samples in South Fork Eel River.
- Extracted, cast, sectioned, mounted and polished otoliths for geochemical analysis.
- Prepped and ran water samples on mass spectrometer.
- Performed statistical analysis of ICP-MS and SIMS otolith data to distinguish between hatchery-raised and naturally spawned salmon, and to determine hatchery/wild origin, the onset of exogenous feeding, a fish's natal river of origin, downstream migration from spawning grounds, and ocean entry for Sacramento River salmon

Field and Lab Assistant, February 2002 to September 2002
National Marine Fisheries Service, Santa Cruz, California

- Captured returning steelhead in Scotts Creek; floy-tagged the fish and took standard measurements along with gill, DNA, and scale samples.
- Observed spawning behavior of the steelhead.
- Captured in the creek and lagoon juvenile coho and steelhead, monitored their growth rates and took scale and gill samples.
- Mounted and read scale samples for aging of the fish.
- Provided input on the development of the project and the protocols

Biology Lab Assistant, September 2001 to September 2002
Doak Lab, UC Santa Cruz

- Used Adobe Photoshop to measure plants in digital images from Professor Dan Doak's study sites in Alaska.
- Germinated seeds returned from the field sites in the campus greenhouse.

Graduate Students' Field and Lab Assistant, May 1999 to September 2001
Raimondi-Carr Lab, UC Santa Cruz

- Assisted Jenn Brown with her research on flatfish. Built and set fish cages, sampled fish using otter-trawls and beach seines, removed otoliths and DNA samples from fish. Acquired some small boat handling skills.
- Assisted Sam Forde with her research on barnacle recruitment. Established and monitored barnacle plots. Performed my own side project looking at the foraging activity of a barnacle predator (*Acanthina sp.)*.
- Assisted Amy Ritter with her research on intertidal sculpin. Sampled tidepools, tagged sculpin with elastomer, collected and entered demographic data.

Biology Lab Assistant, October 1998 to December 1999
Jin-Chisolm Lab, UC Santa Cruz, California

- Washed and autoclaved dishes, mixed solutions, and poured LB plates.
- Became familiar with, and used some lab equipment and techniques.
- Printed and developed Electron Microscopy slides.

ACTIVITIES:

- Member, American Fisheries Society, 2003-present
- Certified Scientific Diver, 2002-present
- Attended 27th annual Larval Fish Conference, August, 2003
- Member, UC Santa Cruz SCUBA Club, 2001-2003

Submittor: Phillis, Corey C (corey@berkeley.edu)

Jannet Kim Senior Research **Administrator**	1/6/06
Applicant Signature THE REGENTS OF THE UNIVERSITY OF CALIFORNIA	**Date** THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
Printed Name Of Applicant	**Applicant Organization**

Help is available: help@solicitation.calwater.ca.gov, +1 877 408-9310

We care about the data we collect. Please read our privacy policy.

URL: https://solicitation.calwater.ca.gov/solicitations/2004.01/proposals/0179/forms/60
time: 2004-12-17 09:10:41 PST
user ID: corey
client IP: 128.115.31.37

Chinook Salmon Rearing In The San Francisco Bay-Delta System: Identification Of Geochemical Markers To Determine Delta Use: Signature

This proposal is for the Science Program 2004 solicitation as prepared by Phillis, Corey C.

2004-11-04: In response to user feedback, some of the forms have been corrected and updated. Please read the current versions carefully.

The applicant for this proposal must submit this form by printing it, signing below, and faxing it to +1 877-408-9310.

Failure to sign and submit this form will result in the application not being considered for funding.

The individual signing below declares that:

- all representations in this proposal are truthful;
- the individual signing the form is authorized to submit the application on behalf of the applicant (if applicant is an entity or organization);
- the applicant has read and understood the conflict of interest and confidentiality discussion under the Confidentiality and Conflict of Interest Section in the main body of the PSP and waives any and all rights to privacy and confidentiality1 of the proposal on behalf of the applicant, to the extent provided in this PSP; and
- the applicant has read and understood all attachments of this PSP.

Proposal Title: Chinook salmon rearing in the San Francisco Bay-Delta system: Identification of geochemical markers to determine Delta use

Proposal Number: 2004.01-0179