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

Corey C Phillis

Final Selection Panel Review

Proposal Title

#0179: Chinook salmon rearing in the San Francisco Bay−Delta system: Identification of geochemical markers to determine Delta use

Funding:

Fund
Amount: **$197,689**

The final Selection Panel concurred with its initial findings on this proposal and recommended funding the proposal at the full amount requested.

Public Comments

No public comments were received for this proposal.

Initial Selection Panel Review

Proposal Title

#0179: Chinook salmon rearing in the San Francisco Bay−Delta system: Identification of geochemical markers to determine Delta use

Funding:

Fund
Amount: **$197,689**

Initial Selection Panel (Primary) Review

Topic Areas

- Environmental Influences On Key Species And Ecosystems
- Salmonid−related Projects

Please describe the relevance and strategic importance of this proposal in the context of this PSP. How does the proposal address the topic areas identified above? What are the broader CALFED Goals this proposal may meet that are not accounted for in these specific topic areas?

The background issue of juvenile salmonids rearing in the Delta and determining residence time is a significant one for salmon biologists and managers. Otolith chemistry is not the only tool available but could be a complimentary tool that could be used along with mark−recapture studies to begin to get a better handle on this issue than mark recapture studies alone.

The budgets of proposals submitted in response to this PSP are larger, on average, than those submitted to CALFED in previous years. The Science Program is committed to getting as much science per dollar as is reasonably possible. With this commitment in mind, can the proposed budget be streamlined? If so, please recommend and clearly justify a new budget total in the space provided.

The budget is reasonable for the amount of sampling and number

of analyses proposed. Work at LLNL is at no charge to the project.

Evaluation Summary And Rating.

Provide a brief explanation of your summary rating and any additional comments you feel are pertinent.

The technical panel has done a good job of identifying the strengths and weaknesses of the proposed study. The diet analysis are unlikely to provide a consistent marker that could be used for identifying salmonid rearing in the delta because species assemblages and diet of fishes are so variable among individuals and between years. Another major disappointment of the proposed study is that it doesn't propose an avenue to apply the techniques they have now developed and wish to develop further. As the TSP review suggests, this work needs to move forward with a study applying the "tool" to salmon population biology with these PI's providing the analytical expertise in collaboration with agency salmon biologists from the central valley. Even if the Delta marker studies they are currently proposing turn out to be fruitless, I believe the technology and "tool" as it presently stands should be able to provide a basis for comparing habitat use assessments of individuals rearing in the Delta for at least a selection of tributaries in the system. I also believe strontium isotope ratios could provide a reasonable estimate of the habitat use in terms of salinity once a salmon reaches the low salinity portion of the estuary. Couldn't they be used to trace the timing of their movement to the sea when coupled with the Sr/Ca ratios and other geochemical markers? If so then the difference in time between when they leave the spawning reaches to when they enter saltwater could provide a rough estimate of time spent rearing in the Delta. I recognize that the Delta would be ambiguous as far as a strontium isotope signal given mixing of the river systems in the Delta. However the pattern of Sr isotopes with age should provide insights into habitat use for salmon juveniles of some tributaries. The Sacramento tributaries generally have Sr isotope ratios below (0.7040) those for the Delta (0.706−0.707) and some of the San Joacquin tributaries

(Merced (0.7085) and Tuolomne (0.7079)) have higher ratios than the Delta. If that is the case then the change in Sr isotope ratio with age (across otolith increments) should provide an entry mark for the Delta because of higher or lower Sr isotope ratios in the Delta relative to their natal streams. Once the salmon start to move into the higher salinity waters of the estuary their otolith Sr isotope ratios should start to climb as they move to saltwater (0.7092). Their Sr/Ca ratios should also climb and provide a contrast to the Sr isotope ratios. There will be some ambiguity for the Feather and Mokelumne juveniles but the fish from the other tributaries should provide a clear basis for testing hypotheses about the survival of salmonids rearing in the Delta verses those that spend little time in the Delta and their ultimate chances of returning as adults. The study as proposed is worthy of support because it may add additional power to the technique and is very reasonably priced. However, a tool not used is a useless tool. The PI's must make an effort to apply this knowledge ASAP. There is an opportunity to link a fisheries group with this skilled group of chemists and provide some useful data on the fate of salmonids reared or not reared in the Delta. The PI's should also carefully consider the comment on using the tool as it stands and attempt to test some of these ideas as part of the proposed project.

Selection Panel (Discussion) Review

fund this amount: $**197,689**
note:
fund

The Panel acknowledged that this project team has accomplished significant results in developing isotopic and chemical signatures for identifying the residence time of salmonids during different life stages (as represented by the size of the otolith at the time it accreted a given chemical/isotopic signature).

This proposal seeks to add to the power of the markers this team has already developed and to support additional developmental work. However, the Panel believed that this methodology has already advanced enough to move to the application phase (i.e., specifically addressing management questions) and that it is important to keep members of this project team involved in the technology development, but find a way to advance this work into the application phase. The Selection Panel agreed with the Technical Panel's recommendation that this project team incorporate salmonid biologists so that the new techniques developed here can be finely−tuned to management needs and so that they can begin to incorporate their tool into management applications.

Panel Ranking: Fund with modifications

Technical Synthesis Panel Review

Proposal Title

#0179: Chinook salmon rearing in the San Francisco Bay−Delta system: Identification of geochemical markers to determine Delta use

Final Panel Rating
above average

Technical Synthesis Panel (Primary) Review

TSP Primary Reviewer's Evaluation Summary And Rating:

PI s propose extending already extensive library of otolith geochemical markers of Sacromento−San Joaquin system to address the relative importance of varying residence time by Chinook salmon in the Delta v. riverine and Bay habitats. Habitat use patterns may vary interannually due to climate and watershed practices and studies using otolith geochemical tracers could permit annual resolution in ranking the importance of the Delta as nursery habitat. Due to microsampling methods pioneered by the PI s and others it should be possible to interrogate otoliths adult salmon (recruits) and infer what nursery rearing habitat patterns predominate, or how they vary interannually. This proposal is largely exploratory in an effort to discover a useful marker for Delta residency. Life history transects (ontogenetic patterns) of Sr:Ca in concert with del13C or del34S are proposed as a potential marker of Delta residency. To substantiate relations between otolith chemistry and Delta rearing, the investigators will use recaptured fish from hatchery releases in the Delta. For del34S, gut contents will also be analyzed and related to otolith composition.

Additional Comments:

The PI s are pioneers in the use of geochemical stable istope ratios as tracers of riverine origins of salmonids. While the development of this approach and other stable isotope tracers has been impressive, past research products by the PI s have focused on the lives of individual fish (relatively small sample sizes). The PI s are aware of the potential pitfalls in using some of the markers proposed, especially Hg and Se. If successful, the technology may be transferable to questions of habitat use by other species in the Bay Delta. The challenge for the PI and field in general will be to draw inferences across reasonably large sample sizes to make population−level inferences. I felt the proposal would have been substantially improved by involvement of a population ecologist. The cost is reasonable and the ultimate idea for an application sound. The proposal suffers for want of a solid experimental design and near term application. The budget is reasonable as the PI s are contributing much of their own time. Reviewers recognized strength of potential application, appropriateness of using strategically released hatchery fish to examine delta v. non−delta otolith responses, and exceptional instrumental and analytical capabilities of PI s. Criticisms included lack of methods to relate tracers to duration of residency (daily increments), justification for diet tracer work, exploratory nature of the project and some skepticism that a stable marker could be found for delta residency. Further, one referee commented that any R development would have little near term consequence for questions of interest to managers or policy makers.

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should be possible to interrogate otoliths adult salmon (recruits) and infer what nursery rearing habitat patterns predominate, or how they vary interannually. This proposal is largely exploratory in an effort to discover a useful marker for Delta residency. Life history transects (ontogenetic patterns) of Sr:Ca in concert with del13C or del34S are proposed as a potential marker of Delta residency. To substantiate relations between otolith chemistry and Delta rearing, the investigators will use recaptured fish from hatchery releases in the Delta. For del34S, gut contents will also be analyzed and related to otolith composition.

Technical Synthesis Panel (Discussion) Review

TSP Observations, Findings And Recommendations:

Chinook Salmon Rearing in the San Francisco Bay−Delta System: Identification of Geochemical Markers to Determine Delta Use

Reviewers recognized the strength of the potential application and the impressive past results obtained by the researchers in assigning past habitat use by individual fish, but felt a problem with this proposal is that no population ecologist was involved. Reviewers would like to see more use of the markers in a population ecology context.

Panelists felt that the presented data on otolith markers indicated that the application was feasible. Another shortcoming identified by the panel was that there was no explanation of how adults would be sampled and how geological information associated with the juvenile stage of otolith growth will be extracted. Overall, the reviewers considered this promising research, although some problems with the approach were identified.

Rating: above average

Technical Review #1

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

Review Form

Goals

Are the goals, objectives and hypotheses clearly stated and internally consistent? Is the idea timely and important?

Comments	**Goals, objectives, and hypotheses are well developed and consistent. They address timely issues relating to the importance of temporal patterns of though−Delta passage of future spawners to recruitment.**
Rating	**excellent**

Justification

Is the study justified relative to existing knowledge? Is a conceptual model clearly stated in the proposal and does it explain the underlying basis for the proposed work? Is the selection of research, pilot or demonstration project, or a full−scale implementation project justified?

Comments	**This proposal closes the loop on a knowledge base the PIs have been building to understand anadromous salmonid recruitment issues and bottlenecks related to water management. This proposal covers the last (or nearly last) elements needed to complete the model. It will address the question of how long and when successful spawners spend time in the Delta on their outward migration. It is a major project and well justified.**
Rating	**excellent**

Approach

Is the approach well designed and appropriate for meeting the objectives of the project? Is the approach feasible? Are results likely to add to the base of knowledge? Is the project likely to generate novel information, methodology, or approaches? Will the information ultimately be useful to decision makers?

Comments	The approach is state−of−the−art and fully appropriate to addressing important issues. Based on prior success of PIs, it is entirely feasible. It will fill important gaps in our knowledge of factors relating to salmonid recruitment success. It will help managers regulate Delta flows in a manner that will favor recruitment of anadromous salmonids.
Rating	excellent

Feasibility

Is the approach fully documented and technically feasible? What is the likelihood of success? Is the scale of the project consistent with the objectives and within the grasp of authors?

Comments	The record of the PIs is outstanding in terms of prestigious funding and high−quality publications in this area of interest and attests to the feasibility and high likelihood of their success.
Rating	excellent

Monitoring

If applicable, is monitoring appropriately designed (pre−post comparisons; treatment−control comparisons)? Are there plans to interpret monitoring data or otherwise develop information?

Comments	
Rating	not applicable

Products

Are products of value likely from the project? Are contributions to larger data management systems relevant and considered? Are interpretive (or interpretable) outcomes likely from the project?

Comments	Peer−reviewed publications of management interest and new tools for managers are the likely products.
Rating	excellent

Additional Comments

Comments

Capabilities

What is the track record of authors in terms of past performance? Is the project team qualified to efficiently and effectively implement the proposed project? Do they have available the infrastructure and other aspects of support necessary to accomplish the project?

Comments	The collaboration of experts from UC Berkeley, UC Davis, and Lawrence Livermore Lab with excellent track records, facilities, and experience on the cutting edge of otolith microchemistry and in related isotope issues in the Sac−SanJ system, make this the best team to address the proposal's objectives. They have successfully done similar work and this proposal will build on an existing data base and profit from their past experience in the system.
Rating	excellent

Budget

Is the budget reasonable and adequate for the work proposed?

Comments	The PIs have requested little for themselves and contribute a lot. Most of the funding is for an experienced tech who will conduct most of the lab and field work. The budget is not charged for a great deal

	of work to be done at LL.
Rating	excellent

Overall

Provide a brief explanation of your summary rating.

Comments	A thorough and well−written proposal that clearly justifies and describes the work to be done. It also documents the PIs capabilities in this area of research.
Rating	excellent

Technical Review #2

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

Review Form

Goals

Are the goals, objectives and hypotheses clearly stated and internally consistent? Is the idea timely and important?

Comments	**The authors propose to investigate otolith geochemistry to determine the importance of the San Francisco Bay−Delta (hereafter Delta) system to native juvenile salmonids. More accurately, they plan to develop techniques that could be used to answer this question. Current surveys are necessarily "snap−shots" of habitat use, without the ability to determine residence times within certain habitats. Otolith geochemistry approaches, combiined with more traditional daily age estimation from otolith increments, holds the promise of solving the time component of habitat residency providing suitable geochemical markers of the habitats of interest can be identified. The authors have already developed such signatures from other habitats occupied by salmonids, particularly in freshwater, and therefore it seems logical to extend this work to the Delta. The work is timely and important because, as the authors suggest, this will give coverage of the life cycle of salmon in terms of our ability to determine habitat use in freshwater through estuarine systems. If successful, this will mean that the oceanic phase will be the only unknown in terms of aour ability to constrain salmonid movements on this system.**
Rating	**very good**

Justification

Is the study justified relative to existing knowledge? Is a conceptual model clearly stated in the proposal and does it explain the underlying basis for the proposed work? Is the selection of research, pilot or demonstration project, or a full−scale implementation project justified?

Comments	The authors make a strong case for the importance of this work. The conceptual model and the underlying basis for the work are relatively simple, as they stem directly from earlier research performed in the system by the PIs. The identification of Delta−specific signatures (and perhaps even intra−Delta signatures) is a logical progression from their within−river research. I think that this task will be harder, but the authors seem to be well aware of this.
Rating	very good

Approach

Is the approach well designed and appropriate for meeting the objectives of the project? Is the approach feasible? Are results likely to add to the base of knowledge? Is the project likely to generate novel information, methodology, or approaches? Will the information ultimately be useful to decision makers?

Comments	I thought that the general approach outlined here meshed very well with the general objectives of the work proposed here. While other researchers are focusing their efforts − both in the Delta system and elsewhere − the future of otolith geochemistry in, in my opinion, likely to be in isotope geochemistry. Some of the work proposed here is not necessarily new. For instance, Sr/Ca ratios will be used as a marker of egress from the Delta. This is likely work, due to the fact that otolith Sr/Ca reflects [Sr/Ca]water, and the non−linear mixing curve between freshwater and seawater means that almost all of the change in Sr/Ca

	ratios in the water occurs at salinities below 10ppt. More tricky will be identifying a Delta entry marker from the river. The authors propose to focus on S, C and O − these are obvious choices, and should provide some interesting contrasts (S from nutrients, C from a mixture of DIC and metabolic C, and O presumably in equilibrium with water). Preliminary data presented here suggests that at least S has some promise. Another obvious marker would be Sr isotopes, and the authors provide a logical way to evaluate this tracer, despite the fact that they are not necessarily convinced that it will be useful. And I think that it is also a good idea to look at some elements in otoliths, particularly Mn and Ba (I am suitably sceptical concerning Se and Hg). The project is, however, clearly exploratory and will not, in of itself, provide information that will be useful for decision makers. If successful, a significant amount of work will still need to be done before managers will be able to use these data. Ultimately, however, I have no doubt that if successful, these data will be very useful to decision makers.
Rating	very good

Feasibility

Is the approach fully documented and technically feasible? What is the likelihood of success? Is the scale of the project consistent with the objectives and within the grasp of authors?

Comments	The work presented here is well documented and quite feasible. Indeed, most of the work proposed is, at least analytically, now quite straightforward. The development work proposed with SIMS is new, but given the strengths of the authors working with this instrument I don't see this as a problem. Certainly the scope of the project is clearly within the abilities of the authors. This is group of people that

	you would pick to address the objectives proposed here. The likelihood of success of the proposal is a little hard to judge objectively. I think that it will be quite difficult to find a marker to delineate Delta entry from the river. On the other hand, it is an clearly an important question that someone needs to look at. I would say that either way, if this proposal is funded, we will have a definitive answer − this group will do it right.
Rating	very good

Monitoring

If applicable, is monitoring appropriately designed (pre−post comparisons; treatment−control comparisons)? Are there plans to interpret monitoring data or otherwise develop information?

Comments	Not applicable.
Rating	not applicable

Products

Are products of value likely from the project? Are contributions to larger data management systems relevant and considered? Are interpretive (or interpretable) outcomes likely from the project?

Comments	If successful, this project will have identified a way to identify the timing of movement into and out of the Delta, and the amount of time spent in the Delta, for individual salmonids. The markers are also likely to be applicable to other study species. The really interesting part will, of course, be the application of the markers to ecological questions. However, there is simply no way around the fact that the initial study proposed here is necessary first.
Rating	very good

Additional Comments

Comments

Capabilities

What is the track record of authors in terms of past performance? Is the project team qualified to efficiently and effectively implement the proposed project? Do they have available the infrastructure and other aspects of support necessary to accomplish the project?

Comments	The authors have an enviable track record of past performance. Ingram is well regarded geochemist, and Weber has already published a number of significant papers on stable isotopes in otoliths, including pioneering work on S isotopes. Between the instrumention available at UCB and LLNL they will have all the facilities available to them to complete the project.
Rating	very good

Budget

Is the budget reasonable and adequate for the work proposed?

Comments	Overall, I found the budget to be very reasonable given the scope of the work proposed here. Weber's time is made available at no cost to the project, as is instrument time at LLNL. This has led to significant savings to the project.
Rating	very good

Overall

Provide a brief explanation of your summary rating.

Comments	This project follows from previous work conducted by the authors on salmonids in the Sacramento/San Joaquin river system. They propose to develop new markers that

	would allow researchers to determine the timing of Delta residency. The project is a logical extension of their previous work. The techniques proposed are state−of−the−art, and indeed if you were to choose a research group to do the work this would be it. However, because the work is largely exploratory, it will not produce data that is immediately useful to decision makers. This is not the fault of the authors. Overall, this is a solid project to be conducted by excellent scientists with proven track records in th field.
Rating	very good

Technical Review #3

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

Review Form

Goals

Are the goals, objectives and hypotheses clearly stated and internally consistent? Is the idea timely and important?

Comments	The topic of this research is both timely and important. The duration and importance of the Delta for rearing and outmigration of juvenile salmonids is a critical issue with broad implications for natural resource management in the region. The sequence of goals, objectives and hypotheses are clearly coveyed in the introductory material, but some gaps occur later. For example, it is not clear how analyzing diet items or water chemistry will specifically contribute to the overall goals.
Rating	very good

Justification

Is the study justified relative to existing knowledge? Is a conceptual model clearly stated in the proposal and does it explain the underlying basis for the proposed work? Is the selection of research, pilot or demonstration project, or a full−scale implementation project justified?

Comments	The project is very well designed to augment our current understanding of juvenile salmon biology and ecology. The foundational material leading up to the current proposal is concisely and effectively communicated, leading to a strong justification for the scope and scale of the proposed work.
Rating	

	excellent

Approach

Is the approach well designed and appropriate for meeting the objectives of the project? Is the approach feasible? Are results likely to add to the base of knowledge? Is the project likely to generate novel information, methodology, or approaches? Will the information ultimately be useful to decision makers?

Comments	**In general, I feel sthe project is very well conceived and designed. Some of the strengths of the proposal include:** **1. The use of tagged fish that are known to have resided in a specified locale for a known duration is an outstanding component of the overall research design. I give the authors my highest kudos for making use of fish that allow them to address what I feel is too often a critical weakness in similar studies.** **2. Using outer otolith increments for fish with an unknown history is a valid approach, and the authors appear aware of potential limitations. These data are important, however, to provide a wide spatial coverage.** **3. The measurement capabilities of the equipment available to the authors appears very adequate to answering the questions being posed.** **Some areas I felt to be weaker in the proposal include:** **1. Part of the justification for this research is the ability to determine the timing and duration of Delta use by returning adult salmon. If I understand correctly, this would require the ability to process adult otoliths to provide daily growth increments in order to determine the actual timing of entry and departure into the Delta. Put another way, the data**

	illustrated in Figure 3 of the proposal would need to have distance from nucleus converted into days. The authors do not provide an indication of whether this is feasible or not. This would not detract from the scientific quality of their investigation, but could severely limit the application of this approach to the intended goal. 2. Related to the above concern is the issue of inter−annual variability. If there is substantial inter−annual variability in the chemical signature of Delta−dwelling juvenile salmon, it would imply that annual monitoring of otolith chemistry would be required to properly match the otolith of a returning adult salmon with the year when it would have resided in the Delta. 3. The analysis of ä34S from prey items did not seem well connected to me to the rest of the study. While it may be “easier” to measure ä34S from prey, diet composition is well known to vary among fish as well as over short periods of time for the same fish. Although the ä34S composition may be less variable, the authors do not indicate that this is the case.
Rating	very good

Feasibility

Is the approach fully documented and technically feasible? What is the likelihood of success? Is the scale of the project consistent with the objectives and within the grasp of authors?

Comments	I feel that all components of the study are very feasible, and the authors are very likely to produce the desired scientific products. I am a bit concerned that the feasibility of eventual application to adult salmon may be limited (as expressed above), however.
Rating	excellent

Monitoring

If applicable, is monitoring appropriately designed (pre−post comparisons; treatment−control comparisons)? Are there plans to interpret monitoring data or otherwise develop information?

Comments	Not Applicable
Rating	good

Products

Are products of value likely from the project? Are contributions to larger data management systems relevant and considered? Are interpretive (or interpretable) outcomes likely from the project?

Comments	This project is very likely to fill an important informational gap in our understanding of juvenile salmon ecology in the Bay−Delta system. As such, the critical product is to better inform resource managers of the importance of various components of this system. I anticipate that the results of this study would be of almost immediate use in decision making, as well as providing a base for the development and implementation of future work on the role of the Delta in salmonid production.
Rating	excellent

Additional Comments

Comments	None

Capabilities

What is the track record of authors in terms of past performance? Is the project team qualified to efficiently and effectively implement the proposed project? Do they have available the infrastructure and other aspects of support necessary to accomplish the project?

Comments	The principle investigators are clearly productive and effective scientists with the knowledge and skills to successfully implement this project. I have no

	reservations on their abilities to provide the products intended from this project. The authors appear to have access to all the equipment and infrastructure necessary to gather and process samples effectively.
Rating	excellent

Budget

Is the budget reasonable and adequate for the work proposed?

Comments	I feel the budget is reasonable for the project, and is in fact somewhat less than other projects I have seen using similar instrumentation.
Rating	excellent

Overall

Provide a brief explanation of your summary rating.

Comments	Overall I think this is a wonderful project that will produce valuable scientific insight into the use of the Delta by juvenile salmon. I would consider this “cutting−edge” science, using state−of−the−art equipment and approaches. My main reservation, expressed above, is whether this approach will be readily implemented on adult salmon. Work as described in this proposal is essential, however, to eventually developing approaches to questions that have vexed fisheries biologists for the past century.
Rating	excellent