1. Cover Sheet

South Bay Salt Pond Restoration Project
Restoring the Wild Heart of the South Bay

Restoration Funding Application
Cover Sheet

APPLICANT INFORMATION

Name of Organization(s) Requesting Funding: UC Regents

Mailing Address: 1850 Research Park Drive, Davis, CA 95618

Federal Employee Identification Number: 94-6036494

Principal Investigator: Dr. James Hobbs

Title: Project Scientist Institution: University of California, Davis

Telephone: 707-480-018 Email address: jahobbs@ucdavis.edu

Grant Administrator: David Ricci
Contracts and Grants Analyst

Telephone: 530-754-8094 Email address: vcresearch@ucdavis.edu

PROJECT INFORMATION

RFP Study Topic # 7

Project Title: Monitoring the Response of Fish Assemblages to Restoration in the South Bay Salt Ponds

Funding Request per year $129,747 Number of years: 2

Confirmed in-kind or matching contributions: $

Source of in-kind or matching contributions:

Purpose and Objectives: develop a comprehensive monitoring approach to evaluate the effects of salt pond restoration on fish assemblages and the dynamic response of sentinel fish species. Objectives include testing different sampling gears to determine the optimal sampling protocol. Quantify the distribution and abundance of fish assemblages of ponds in different stages of restoration, and evaluate the benefits of restoration on sentinel species health parameter.

Proposed starting date: 5/2009 Estimated completion date: 4/2011

Signature: 10/23/08
Principal Investigator

Signature: Date: 12/4/08
Grant Administrator

2. Monitoring the Response of Fish Assemblages to Restoration in the South Bay Salt Ponds

Principal Investigator:

James Hobbs

Interdisciplinary Center for Inductively Coupled Plasma Mass Spectrometry

University of California, Davis. 1 Shields Ave. 95616, Email:

jahobbs@ucdavis.edu Phone : (707) 480-0188

Participation Investigators:

Peter B. Moyle

Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, 1

Shields Ave, Davis, CA 95616, Email: pbmoyle@ucdavis.edu, Phone: (530)752-6355

Pat Crain

Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, 1

Shields Ave, Davis, CA 95616, Email: pkcrain@ucdavis.edu, Phone: (530)754-4907

a) Abstract

In this study we propose to develop a flexible, comprehensive monitoring program to evaluate the effects of restoration on the fish species assemblages and sentinel species health in salt pond habitats located in the Alviso complex in South San Francisco Bay, California. First we will employ several commonly used and new fish sampling techniques in restored pond habitats and adjacent marsh and slough habitats to compare gear effectiveness for characterizing the distribution and relative abundance of fish species. Next we will monitor salt pond habitats of different restoration age to assess the temporal trajectory of pond restoration effects on fish assemblages. We will also conduct detailed investigations into the health of the sentinel species *Gillichthys mirabilis,* measuring indicators of health such as growth, reproductive output, feeding condition, and survival in pond A8. We plan to collaborate with researches from the USGS (Collin Eagle-smith and Josh Collins) conducting mercury studies on avian populations in the South Bay. Our interdisciplinary approach to assessing fish health with exposure to pollutants such as mercury will provide novel diagnostic evidence of the potential impacts of re-introducing legacy contaminants into the environment from restoration activities. Our experience in marsh ecology and restoration provides us with the background necessary for developing a comprehensive, state of the art monitoring program for the Salt Pond Restoration Program.

b. Background and Justification

The South Bay Salt Pond (SBSP) Restoration Project is planning to restore large areas of Salt Ponds in the South Bay to tidal marsh and pond habitats, to compensate for habitat lost due to development over the past 150 years. This restoration will likely have substantial ecological benefits to the system, such as increasing Federally Endangered or Threatened species such as the California clapper rail and Salt marsh harvest mouse populations that are dependent upon tidal marsh. However, the lower salinity salt ponds in the area, currently support dense populations of common estuarine fish species, such as longjaw mudsucker, threespine stickleback, rainwater killifish, Inland (Mississippi) silverside, and topsmelt that are important prey species for piscivorous waterbirds in the regions such as Forster's terns (Ackerman et al 2007). It is unclear how salt pond restoration will alter the fish community in the salt ponds and adjacent sloughs and marshes, or how associated changes in water quality might influence growth, reproduction, or survival of key species. A robust monitoring program designed to evaluate changes in fish assemblages, abundance, and diversity is an important component of the adaptive management framework being implemented by the SBSP Restoration Project.

In order to evaluate the impacts of restoration activities on estuarine ecosystems, pilot studies have been conducted to monitor species assemblages of fishes and invertebrates as indicators of estuarine ecosystem quality (Meija et al 2008, Thompson and Lowe 2004, Brown 2003, Thompson and Nichols 1984). Often, comparisons of indicator parameters are made before and after restoration and in unaltered control sites (Kent 2000, Kennish 1999). However, this approach may be limited to situations where the parameters of concern are measured prior to restoration and continued funding for monitoring studies is available. While the pilot studies provided ancillary information

regarding species use of these habitats, the limited scope of the studies, limits managers' abilities to understand the process by which habitats and species assemblages will change. Another approach to restoration monitoring is to make comparisons among sites of variable restoration age (URS 2008, Simenstad et al 2000). Both approaches have their strengths and weaknesses. Control sites, particularly in salt marsh habitats can often be very problematic as no two marshes are very similar in many biologically relevant variables, and comparisons among marshes of differing restoration history can be difficult to compare due to the false assumption that measured differences are a result of restoration age rather than other factors that could be involved (Kent 2000).

A key to successful adaptive management of marsh restoration is having a dynamic, flexible monitoring program that can adapt to conditions as the marshes evolve with restoration. These types of monitoring activities can provide information on species distribution and relative abundance in a system; however, they may not encapsulate population dynamic response to perturbations such as marsh restoration. Our previous work with the Pacific Estuarine Ecosystem Indicator Research (PEEIR), monitored *Gillichthys mirabilis* population abundance, recruitment, and size-class structure on an annual basis from 2002-2007 at four study sites with varying contaminant levels in San Francisco and Tomales Bays (Figure 1). At Stege Marsh in Alameda County; a highly contaminated marsh, *Gillichthys mirabilis* abundance, recruitment and growth were significantly reduced compared to reference sites in Tomales Bay (McGourty et al, *in review*). These studies highlight the need for a comprehensive, multidisciplinary approach to monitoring and emphasize the role of sentinel species studies for habitats undergoing restoration.

The longjaw mudusucker (*Gillichthys mirabilis*) is a resident estuarine fish ranging from Baja to Humboldt Bay, California (Moyle 2002) and is one of the most abundant fishes in intertidal salt marsh and salt pond habitats in the South Bay, making it an ideal sentinel species for restoration in these habitats (Meija et al 2008, Desmond et al 2000; Talley 2000; West and Zedler 2000). In addition, mudsuckers are among the four most abundant prey fish for piscivorous waterbirds (Ackerman et al. 2007), making them an excellent indicator of community-level influences of marsh restoration. Seeking shelter in emergent pools and crab burrows during low tide, *G. mirabilis* forages at high tide in marsh plains on crustaceans and polychaetes (West and Zedler 2000). Breeding is thought to occur year round, with a peak from winter to early spring (Nordby 1982). *Gillichthys mirabilis* is most abundant during the summer months when temperatures are warmest and new moons correspond with nocturnal high spring tides, and least abundant after retreating to burrows beginning in late fall through early spring (Moyle 2002).). Additionally, mudsuckers are among the only fish species that are commonly found in both the pre-restoration habitat (salt ponds) and the post-restoration habitat (tidal marsh). These factors make mudsuckers and excellent tool for evaluating the influence of salt pond conversion to tidal marsh on fish abundance.

c. Study Objectives

Our proposed study objectives can be organized into those study questions that address fish communities and those that address species population dynamics. Our sampling approach is designed to address as many of the proposed study question as possible while allowing us to focus our study on the following objectives.

Fish Communities Study

1. Which sampling gears are most effective at characterizing fish assemblage?
2. What species will use restored habitats, before, during after restoration?
3. How will the restoration effect fish assemblages?
4. What fish assemblages use discrete habitat types?

Sampling restored ponds and adjacent habitats with a variety of gear types will allow us to determine which gears type is most effective at monitoring fish assemblages, which species use these habitats, where they are coming from, and how they may change over time by comparing restoration projects before and after restoration and projects of different ages.

Sentinel Species Population Dynamics Study.

5. Is restored habitat of similar value for fish in terms of growth, feeding, reproduction and survival as reference sites?
6. Will increased tidal habitat improve these parameters?
7. Will restoration result in increased mercury concentrations in sentinel species?

We will use the longjaw mudsucker *Gillichthys mirabilis* as our sentinel salt marsh fish species. We will combine measures of fish condition and otolith growth a mark-recapture tagging study to determine survival in planned restoration ponds (Pond A8). We also plan to collaborate with Dr. Collin Eagles-Smith from the USGS on mercury concentrations in the mudsuckers. Our approach will provide a comprehensive profile of fish health in relation to pond restoration.

Hypothesis/Conceptual Models that we intend to address with this monitoring approach.

H_1: Older restoration ponds will have reduced species diversity compared to newer restoration ponds.
H_0: No differences in diversity will be measured.

H_1: species such as *Gillichthys mirabilis, Leptocottus armatus* and *Acanthogobius flavimanus will* become increasing associated with intertidal marsh habitats and *Atherinops affinis, Atherinopsis californiensis, Gasterosteus*

aculeatus will become increasing associated with deeper channel habitats in older restoration ponds.
H_0: No differences in habitat association will be measured.

As salt ponds accrete sediment and transform from homogenous shallow water habitats to complex marsh creek habitats, species diversity may decrease as pelagic species may be lost due to reduction in total habitat volume (i.e. transformation from open waters to marsh creeks). However we may expect to see increased density (numbers per volume) as pelagic species are confined to channel habitats. Benthic, marsh associated species may increase in abundance due to the increase in overall marsh habitat. We would also expect to see an increase in structuring of fish assemblages as marsh formation occurs. Benthic species such as the *Gillichthys mirabilis, Leptocottus armatus* and *Acanthogobius flavimanus* should be associated intertidal marsh habitat. Pelagic species (*Atherinops affinis, Atherinopsis californiensis, Gasterosteus aculeatus)* will become increasing associated with channel habitats as they begin to form. These hypotheses will be tested in this study by quantifying the species abundance across ponds of differing restoration history (breaches in 2004-2006).

H_1: Growth, feeding and reproduction in *Gillichthys mirabilis* will be greater in reference sites versus restoration ponds.
H_0: No differences will be measured.

As salt ponds accrete sediment and transform from homogenous shallow water habitats to complex marsh creek habitats, feeding conditions, growth and ultimately reproduction for *Gillichthys mirabilis* should benefit. *Gillichthys mirabilis* are a sentinel indicator species of salt marsh habitat health in the San Francisco Bay Estuary. Our previous research has established a clear link between contaminated marshes and growth and reproduction. We would expect that initially these population parameters would be greater in reference marsh sites compared to salt pond habitats. Salt ponds of differing restoration age should show an increasing benefit to *Gillichthys mirabilis* population parameters.

d. Study area

In year 1 of this study we will focus on the restored ponds, adjacent extant saltmarshes and sloughs in the Alviso Salt Pond complex. We will sample pond habitats of differing restoration age 2004-2006 (Collins and Grossinger 2004) . In the oldest sections we will sample ponds A1, A2W and A3W. For the mid-aged ponds we will sample A6, A8, A9 and A11. For newest restoration ponds we will sample A19-21. These ponds will also encompass the different restoration targets, and environmental conditions(full tidal restoration, and partial tidal and managed ponds; water temperature, salinity) (South Bay Salt Pond Restoration Project Final EIR 2007). We will sample fringing marsh habitats directly adjacent to the restoration ponds and the major sloughs (Mountain View, Guadalupe, Alviso, Coyote Creek and Mud slough). Mark-Recapture survival studies of

longjaw mudsucker *Gillichthys mirabilis* will take place in pond A8 and the adjacent fringing salt-marsh. (See Figure 1.)

e. Approach

In this study we propose to monitor fish assemblage in the Alviso complex using a comparative approach among ponds of differing breach history (breaches from 2004-2006) with a variety of sampling techniques. We will measure 3-5 pond habitats per breach age (2004, 2005 and 2006) and restoration plan (full tidal restoration, partial tidal and managed ponds) for a maximum of 15 pond sites. In year 1 of this study we will compare different sampling gears in pond habitats (trawls, fyke, seine, gill nets, minnow traps, pop-up nets, plankton nets and light traps) for species abundance and life-stage occurrence to determine the optimal monitoring gears. Adjacent intact saltmarsh habitats will also be sampled for sentinel species studies with 3-5 sub-site replicates among standard marsh channel orders with beach seines, pop-up nets and baited minnow traps. Slough habitats will also be sampled with 3-5 replicates along Guadalupe, Alviso, Coyote and Mud Sloughs using otter trawls. Sampling this series of habitats and marsh histories will also provide for flexibility to incorporate a before after and control (BACI) design depending on the restoration alternative that ultimately result (e.g. a 50:50 verses a 90:10 marsh restoration decision). A diversity of sampling gears will be used to encompass the variable habitat types, (subtidal deep and shallow waters, intertidal marsh channels, marsh panes and managed salt ponds.) and native species and species of special concern (e.g. steelhead, Chinook salmon) that occur and may result from future program alternatives. To sample deep subtidal habitats we will use employ small boat based otter trawls, plankton trawls and gill netting. To sample shallow subtidal habitats we will use beach seines, fykes, pop-up nets and minnow traps. Intertidal marsh channels will also be sampled with seines minnow traps and light traps.

Fish community composition and sentinel species will be monitored from March-October during nocturnal spring tides to maximize marsh/pond utilization of fishes and to encompass the maximum species diversity. First we will sample resident marsh species with baited minnow traps in first order channels in conjunction with the sentinel species monitoring portion of the study. Target species will include the native longjaw mudsucker and the non-native yellowfin goby. At each of the 3-5 sites, 12 replicate traps will be deployed across 1-3 order channels, 4 traps per channel order. Trawling will be conducted using a four-seam otter trawl with a 1.5 X 4.3 m opening, a length of 5.3 m, and mesh sizes of 35 mm stretch in the body and 6 mm stretch in the cod end similar to the UC Davis Suisun Marsh Survey (Stover et al 2004). The trawl is towed at approximately 4 km/hr for 5 minutes in the small sloughs and for 10 minutes (to compensate for small catches) in the large sloughs. 3-5 replicate trawls will be conducted directly adjacent to the pond sites to quantify the species pool that will gain access to the marsh restoration. Monthly sampling in pond habitats will be conducted with 10 m beach seines having a stretched mesh size of 6 mm, with 3-5 replicate hauls near the entrance and exit points for each of 3-5 ponds. Pop-up nets (3m x 3m x 2m) will be set at approximately 10 meters from the intake and outtakes for each pond site. Fyke nets (10m length with 1 m opening) will be set at the pond breach intake from the slough and outtakes back into the slough or adjacent pond and all fish catches will be expressed at catch per unit of effort CPUE. For each site the tidal

stage, temperature (°C), salinity (‰), specific conductance (μS), water transparency (secchi depth in cm), and dissolved oxygen (mg/l and % saturation) will be recorded with a handheld YSI. Contents of each sampling device will be placed into large containers of water. Fishes will be identified, measured to the nearest mm standard length, and returned to the site of capture. When possible, sensitive native species will be processed first and immediately released. The abundance of macro-invertebrates will also be recorded. We anticipate sampling activities will take 4-5 days per month.

Fish health Metrics:

Indicators of fish health (conditions, growth and fecundity) will be measured on the sentinel species, *Gillichthys mirabilis*. Whole fish condition will be estimated using standard fisheries techniques such as weight-length based measures and through age and growth analysis from otolith microstructure analysis. We will examine 8-10 individual *Gillichthys mirabilis* from each habitat type and across restoration age projects. Individuals will be euthanized in the field, weighed wet and measured for standard length. Condition factor will be calculated as:

wet weight of fish (Wt)/ standard length ($Lt^{3)}$

Fish heads will be severed and stored in 95% etoh for otolith analysis and bodies will be preserved for diet, and metals analysis (*see companion mercury studies, Eagles-Smith*). Growth rate will be evaluated from otolith age with a random effects maximum likelihood model (*see McGourty et al for details*). Fish diet composition will be determined to the lowest possible taxon.

Survival Study:

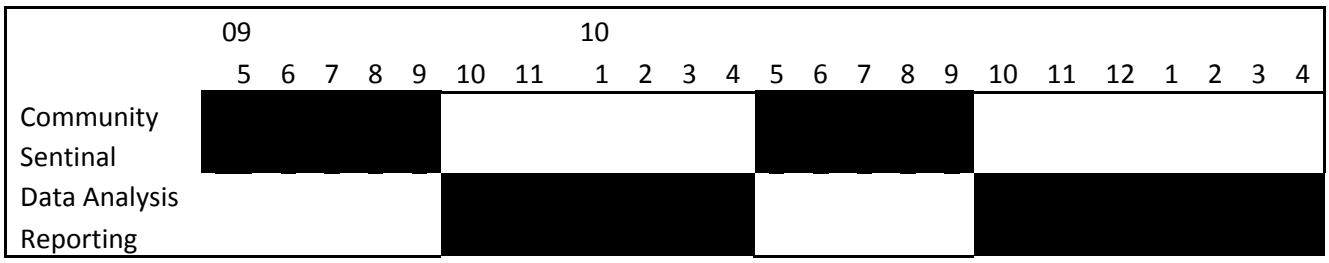
At pond A8 in the Alviso slough complex, *Gillichthys mirabilis* survival will be assessed with a mark-recapture study. Initially up to 500 individual will be marked from the adjacent salt-marsh habitat with alpha-numerical fluorescent tags (Northwest Technologies). Fish will also be immersed in a dye (Alizarin Red-S) to mark the otolith at time of tagging and fish length and weight will be measured. Monthly, recaptures will be quantified and unmarked fish will also be marked. To assess movement into new restoration ponds, we will sample inside pond A8 in fall 2009 for marked mudsuckers. Survival will be analyzed with a Cormack-Jolly-Seber model in the program MARK. Survival will be assessed in relation to growth and condition. Movements in and out of pond A8 will also be examined with unique markings for fish capture inside and outside the pond.

f. Data Archiving Procedures

We will make data available from field studies upon quality assurance assessment with an online database. Database format will be similar to our Susuin Marsh online database (http://www.iep.ca.gov/suisun/dataReports).

g. Work Schedule

We anticipate beginning sampling pond habitats in May of 2009 and continuing through Oct, and contingent upon continued funding in year 2; field sampling would begin again in May of 2009 and continue through October 2010. Analysis of data and report writing will take place from Nov-April of each year.



h. Expected Products

We will provide annual and final reports to the SBSP Restoration Project Lead Scientist by April of each year reviewing progress, important finding, budgeting updates and any potential problems occurred. In addition we will brief the Science Program with oral and poster presentations during the annual Science Symposia and any other relevant workshops hosted by the restoration project. We anticipate two publications to come from this research. A peer review publication regarding the fish species assemblage study among different aged ponds and a second publication regarding the fitness and survival of sentinel species in restored pond and adjacent marsh habitats.

Figure 1. Map of Study Area. Yellow dots depict planned pond restoration sites for sampling; red dots depict slough and bay sampling sites.

3. Literature Cited

Ackerman, J. T., C. A. Eagles-Smith, G. H. Heinz, S. E. Wainwright-De La Cruz, J. Y. Takekawa, T. L. Adelsbach, A. K. Miles, D. J. Hoffman, S. E. Schwarzbach, T. H. Suchanek, and T. C. Maurer. 2007. Mercury in birds of the San Francisco Bay-Delta: trophic pathways, bioaccumulation and ecotoxicological risk to avian reproduction. 2006 Annual Administrative Report to CALFED, U. S. Geological Survey, Western Ecological Research Center, and U. S. Fish and Wildlife Service, Environmental Contaminants Division, 41 pp.

Brown, L.R. 2003. editor. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1 (October 2003), Article 2. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/

Collins. J.N. and R.M. Grossinger. 2004. Synthesis of scientific knowledge concerning estuarine landscapes and related habitats of the South Bay Ecosystem. Technical report of the South Bay Salt Pond Restoration Project. San Francisco Estuary Institute, Oakland CA.

Cope, J.M. and A.E. Punt. 2007. Admitting ageing error when fitting growth curves: an example using the von Bertalanffy growth function with random effects. *Canadian Journal of Fisheries and Aquatic Sciences* 64: 205-218.

Desmond, J.S., Zedler, J.B., and G.D. Williams. 2000. Fish use of tidal creek habitats in two southern California salt marshes. *Ecological Engineering* 14: 233-252.

Kennish, M.J. 1999 1st edition. Estuary Restoration and Maintenance: The National Estuary Program. CRC Press, pg 376.

Kent, D.M., 2000 2nd Edition. Applied Wetland Science and Technology. CRC Press. Pg 472.

Mejia, F., M.K. Saiki and J.T. Takekawa. 2008. Relation between species assemblages of fishes and water quality in salt ponds and sloughs in south San Francisco Bay. *The Southwest Naturalist* 53(3):335-345.

McGourty K.R., J.A. Hobbs., L.L. Lewis., N Ikemiyagi., J Cope., Green., and W.A. Bennett. *in review Estuaries and Coasts.* Using fish abundance and distribution in determining habitat quality of intertidal salt marsh in San Francisco and Tomales Bays

Moyle, P.B. 2002. Inland fishes of California, 2nd edition. University of California Press, Berkeley, California.

Nordby, C.S. 1982. The comparative ecology of ichthyoplankton within Tijuana Estuary and in adjacent nearshore waters. Master's thesis, San Diego State University, San Diego, CA, 101 pp.

Orsi, J. (ed). 1999. Report on the 1980-1985 fish, shrimp, and crab sampling in the San Francisco Estuary, California. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Technical Report Number 63.

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). 1999. Bay protection and toxic cleanup program: regional toxic hot spot cleanup plan. San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

SFEI (1997). What about the Marshes?: The Wetlands Pilot Study. RMP News 3: Issue 2.

Simenstad C, Toft J, Higgins H, Cordell J, Orr M, Williams P, Grimaldo L, Hymanson Z, Reed D. 2000. Sacramento/San Joaquin Delta Breached Levee Wetland Study (BREACH). Preliminary report. Seattle (WA): Wetland Ecosystem Team, University of Washington, School of Fisheries.

Talley, D.M. 2000. Ichthyofaunal utilization of newly-created versus natural salt marsh creeks in Mission Bay, California. *Wetlands Ecology and Management* 8: 117-132.

Thompson, B.E. and S. Lowe. 2004. Assessment of macrobenthos response to sediment contamination in the San Francisco Estuary, USA. *Environmental Toxicology and Chemistry* 23: 2178-2187.

Thompson, J.K., and F.H. Nichols. 1984. Benthic macrofauna of a south San Francisco Bay, California, mud flat, 1974 to 1983: U.S. Geological Survey Open-File Report p. 84-759, 200 p.

URS Corp 2008. Fisheries in Restored South Bay Wetlands and Adjacent Habitats. Final Report for NOAA Restoration Center Southwest Region Santa Rosa Ca.

West, J.M. and J.B. Zedler. 2000. Marsh-creek connectivity: fish use of a tidal salt marsh in Southern California. *Estuaries* 23: 699-710.

4. Qualification of PI's

JAMES A. HOBBS PhD.

Interdisciplinary Center for ICP_MS PES 1210 Mailstop 1
Davis, CA.95616
University of California, Davis. (707)480-0188
E-mail:jahobbs@ucdavis.

Education

PhD, Conservation Biology, Graduate Group in Ecology University of California, Davis. December. 2004.

Dissertation: "Microscale Patterns-Macroscale implications: The Application of otolith microstructure and microchemistry to assess nursery habitat quality for the threatened smelt in the San Francisco Estuary".

Research Experience

Sea-Grant CALFED Post-Doctoral Researcher, UC Berkeley &Bodega Marine Laboratory, 9/2004-8/2008. Dr. B. Lynn Ingram, Geography Department, UC Berkeley.

Pre-Doctoral Researcher, UC Davis, Bodega Marine Laboratory, 8/1998-9/2004
Advisors, Peter Moyle and Bill Bennett.

Relevant Publications

K.R McGourty, **J.A. Hobbs,** W.A. Bennett. L.L. Lewis, N Ikemiyagi. Using fish abundance and distribution in determining habitat quality of Intertidal salt marsh in San Francisco and Tomales Bays. *In Review*. Estuaries

Rose, W.E., **J.A. Hobbs,** R. Nisbet, P.G. Green, G. Cherr, S. Anderson
Validation of Otolith Growth Rate Analysis Using Cadmium-Exposed Larval Topsmelt
Environmental Toxicology and Chemistry, 2005, Oct. 5

Feyrer, F.F**., J.A. Hobbs,** M.A. Baerwald, T Sommer, Q.Z. Yin, K Clark, B May and W.A Bennett "*Otolith microchemistry provides information complimentary to microsatellite DNA for a migratory fish*. Transactions of the American Fisheries Society 2007 136(2) 469-476.

Hobbs, J.A. J.E. Burton, and W.A. Bennett
"*Classification of larval and adult delta smelt to nursery areas using trace elemental fingerprinting*" Transactions of the American Fisheries Society 2007 136(2) 518-527.

GRANTS

Co-P.I. (lead P.I. Dr. William Bennett, other Co. P.I.'s Wim Kimmerer and Swee Teh.)
Monitoring Responses of The Delta Smelt Population to Multiple Restoration Actions in the San Francisco Estuary. As part of the Pelagic Organism Decline Program funded by the Interagency Ecological Program Funded $1.5 million; 2005-2008.

Lead-P.I, (Co-P.I. Dr Josh Isreal and Dr Bernie May)
Population Genetics and Otolith Geochemistry Study in Support of
IEP's Work Plan on Pelagic Organism Decline: Longfin Smelt Funded $490,000; 2008-2010.

Lead-P.I.
Using otolith trace element and strontium isotope ratios to determine duration of juvenile steelhead residency in the Russian River estuary. Funded by the Sonoma County Water Agency $10,000; 2008-2009

Co-P.I. (Lead P.I. Dr Peter Moyle and Co-P.I. Rebecca Quinones)
Otolith and scale microchemistry analysis of Coho and Chinook salmon from mid-Klamath River tributaries. Funded USDA Forest Service, Klamath National Forest $90,000; 2006-2009.

Co-P.I. (Lead P.I. Dr. Frank Lodge)
Estimate survival of in-river and transported yearling Chinook salmon originating from Dworshak hatchery in the lower Columbia River and estuary with emphasis on increasing understanding of causes of differential delayed mortality and estimate of hydrosystem delayed mortality associated with barge and in river life history strategies of Snake River spring/summer Chinook salmon 2008. $1.9 million; 2008-2013.

PETER B. MOYLE
Department of Wildlife, Fish, and Conservation Biology
And
Center for Watershed Science
University of California, Davis
1 Shields Avenue, Davis Ca 95616
pbmoyle@ucdavis.edu
530-752-6355, fax: 530-752-4154
Web site: http://wfcb.ucdavis.edu/www/Faculty/Peter/petermoyle

EDUCATION

1964	University of Minnesota	**B.A.**	**-**	**Zoology**
1966	Cornell University	**M.S.**	**-**	**Conservation**
1969	University of Minnesota	**Ph.D.**	**-**	**Zoology**

UNIVERSITY POSITIONS

1969 - 1972	Assistant Professor, Biology, California State University, Fresno, CA
1972 – present	Assistant to Full Professor, University of California, Davis, California
1982 - 1987	Chair, Department of Wildlife & Fisheries Biology, University of California, Davis, California
2002-present	Associate Director, Center for Watershed Science UCD

PROFESSIONAL SOCIETIES/ORGANIZATIONS

American Fisheries Society (national & local chapters); American Society of Ichthyologists and Herpetologists; Ecological Society of America; Desert Fishes Council; Society for Conservation Biology; AAAS; AIBS

AWARDS

Award of Excellence, Western Division, American Fisheries Society (1991); Haig-Brown Award, California Trout (1993); Distinguished Fellow, Gilbert Ichthyological Society (1993); Fellow, California Academy of Sciences (1993); Bay Education Award, Bay Institute (1994); Public Service Award, UCD (1995); Outstanding Educator Award, American Fisheries Society (1995, with J. J. Cech); Streamkeeper Award, Putah Creek Council (1997); Distinguished Ecologist, Colorado State University (2001); Outstanding Mentor Award, UCD (2003); President's Chair in Undergraduate Education, UCD (2003-2006, with J. Mount). Outstanding Achievement Award, Association of Fisheries Research Biologists (2007); Award of Excellence, highest award of American Fisheries Society (2007).

OTHER

Editorial Boards *Environmental Biology of Fishes*, *Biological Conservation, University of California Publications in Zoology,* and *Biological Invasions*. Expert testimony: Bay/Delta Hearings, State Water Resources Control Board; Congressional hearings, Re-authorization of Endangered Species Act, etc. Head, Delta Native Fishes Recovery Team (1993-1995); Member, Sierra Nevada Ecosystem Project Team (1994-1996); Member, Independent Science Board, CALFED Ecosystem Restoration Program; Board Member, The Natural Heritage Institute; Board member, California Trout; Fisheries Consultant, City and County of San Francisco. Member, National Research Council Committee on Endangered Fishes in the Klamath Basin (2002-2003). Member, Editorial Committee, UC Press (2006-). Member, Delta Risk Management Strategy Steering Committee (2006-2008), DWR. Member, San Joaquin River Restoration Technical Advisory Committee (2007-).

TEACHING

Teach basic courses in fish biology, conservation, fisheries, and watershed ecology. Co-authored (with J. Cech) widely used ichthyology text (5th edition, 2004) and co-edited (with C. Schreck) American Fisheries Society handbook on techniques for working with fish. Active in Graduate Group in Ecology.

RECENT PUBLICATIONS

Author or co-author of over 180 peer-reviewed publications, including six books/monographs.

Moyle, P. B. 2002. *Inland Fishes of California*. Berkeley: University of California Press 502 pp.

Matern, S. A., P. B. Moyle, and L. C. Pierce. 2002. Native and alien fishes in a California estuarine marsh: twenty-one years of changing assemblages. Transactions of the American Fisheries Society 131:797-816.

Moyle, P. B., P. K. Crain, K. Whitener, and J. F. Mount. 2003. Alien fishes in natural streams: fish distribution, assemblage structure, and conservation in the Cosumnes River, California, USA. Environmental Biology of. Fishes 6:277

Marchetti, M. P., T. Light, P. B. Moyle, and J. H. Viers. 2004. Fish invasions in California watersheds: testing hypotheses using landscape patterns. Ecological Applications 14:1507-1525.

Marchetti, M. P, P. B. Moyle, and R. Levine. 2004. Alien fishes in California watersheds: characteristics of successful and failed invaders. Ecological Applications 14:587-596.

Moyle, P.B., R. D. Baxter, T. Sommer, T. C. Foin, and S. A. Matern. 2004. Biology and population dynamics of Sacramento Splittail (*Pogonichthys macrolepidotus)* in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science [online serial] 2(2):1-47.

Hogan, Z. S., P. B. Moyle, B. May, M. J. Vander Zander, and I. G. Baird. 2004. The imperiled giants of the Mekong. American Scientist 92: 228-237.

Moyle P.B. and J. A. Israel. 2005 Untested assumptions: effectiveness of screening diversions for conservation of fish populations. Fisheries 30 (5):20-28

Moyle, P.B. and M. P. Marchetti. 2006. Predicting invasion success: freshwater fishes in California as a model. Bioscience 56:515-524.

Merz, J. F. and P. B. Moyle. 2006. Salmon, wildlife and wine: Marine derived nutrients in human-dominated ecosystems of central California. Ecological Applications 16: 999-1009.

Noss, R. F., J. F. Franklin, W.L. Baker, T. Schoennagel, and P.B. Moyle. 2006. Managing fire-prone forests in the western United States. Frontiers in Ecology and the Environment 9:481-487.

Lund, J., E. Hanak., W. Fleenor, W., R. Howitt, J. Mount, and P. Moyle. 2007. Envisioning futures for the Sacramento-San Joaquin Delta. San Francisco: Public Policy Institute of California. 284 pp.

Moyle P.B., Crain P.K., and Whitener K. 2007. Patterns in the use of a restored California floodplain by native and alien fishes. San Francisco Estuary and Watershed Science 5(3):1-27.

Moyle, P. B. and J. F. Mount 2007. Homogenized rivers, homogenized faunas. Proceedings, National Academy of Sciences 104: 5711-5712.

Ribeiro, F., B. Elvira, M. J. Collares-Pereira, and P. B. Moyle.2008. Life history traits of non-native fishes in Iberian watersheds across several invasion stages: a first approach. Biological Invasions.10:89-102.

Mosepele, K., P. B. Moyle, G. S. Merron, D. Purkey, and B. Mosepele. In press. Fish, floods, and ecosystem engineers: aquatic conservation in the Okavango Delta, Botswana. BioScience

PATRICK KEITH CRAIN
Department of Wildlife, Fish, and Conservation Biology
And
Center for Integrated Watershed Science and Management
University of California, Davis
1 Shields Ave, Davis CA 95616
pkcrain@ucdavis.edu
530-754-4907, fax: 530-752-4154

EDUCATION

1998 University of California, Davis B.S. Wildlife, Fish and Conservation Biology
2005 Sacramento State University M.S. (Conservation Biology emphasis) in progress

WORK RELATED EXPERIENCE

1996 – present	Putah Creek Salmonid and Native Fish Monitoring
1996 – present	Martis Creek Study
1996 – summer	Dye Creek (TNC) Fish Assemblage Study
1999 Present	Suisun Marsh fish study (part time)
1999 – 2003	Cosumnes River Drainage and Floodplain Study
2001 – 2003	North San Joaquin Drainage Delta Island (McCormack Williamson Tract) Study
2003 – present	Restoration of the Sacramento perch to the San Francisco Esturary study
2004 present	Sagehen Creek electrofishing study
2005 2007	EPA study on Sierrra Nevada Mountain Meadows
2006 2008	Department of Water Resources Pit River Drainage Meadow Study.
2007 present	Sacramento perch Pond Study
2008	Delta Largmouth Bass/SAV Study

Certification and Permits

UCD-Department of the Interior Boating safety class December 2005
Smith-Root Electrofishing certification March 2006
Animal Protocol UC Davis # 06-12338 2003-present
DFG Scientific Collecting Permit #SC-009096
UCD Animal Protocol #s 13371, 12338, 15047, 15058

OTHER

Societies: **American Fisheries Society (national and local chapters); Sierra Club**
Teaching: Co-teach a field identification class for Californias inland fishes 2001-2005.
Grants: was largely responsible for writing and successfully obtaining a CALFED grant to study Sacramento perch ($506,000).
Talks and presentations: 2004 CALFED Science Conference, Poster Presentation: "Early life history of the Sacramento perch and relevance to restoration in its native range". 2003 AFS Western Division Conference Poster "Temporal and spatial variation in the condition of larval fish in the Cosumnes River, California," 2003 CALFED Science Conference "Should we create more permanent shallow water habitat in the Delta? Example: McCormack Williamson Tract.", 2002 AFS CALNEVA Conference "Distribution and identification of redeye bass in California." 2001 Salmonid Restoration Conference, "The importance of floodplain habitat to salmon and other California native fishes", 2000 CALFED Science Conference, "Use of the Cosumnes River floodplain by adult fishes", and " Fish assemblages and environmental gradients in the Cosumnes River Basin." 1998 AFS CALNEVA regional meeting, "Age and growth of the Eagle Lake tui chub."

Publications

Moyle, Peter B., Patrick K. Crain, and Keith Whitener. Patterns in the Use of a Restored California Floodplain by Native and Alien Fishes. San Francisco and Estuary Watershed Science. Volume 5, Issue 3 [July 2007]. Article 1.

Ribeiro, F., Crain, P.K., and P.B. Moyle 2004. Variation in condition factor and growth in young-of-year fishes in floodplain and riverine habitats of the Cosumnes River, California. Hydrobiologia 527: 77–84.

Crain, P.K., K. Whitener, and P. B. Moyle. 2004. Use of a restored central California floodplain by larvae of native and alien fishes. Pages 125-140 in F. Feyrer, L. R. Brown, R. L. Brown, and J. J. Orsi, editors. Early life history of fishes in the San Francisco Estuary and watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Moyle, P.B., Crain, P.K., Whitener, K., and Mount, J.F. 2003. Alien fishes in natural streams: fish distribution, assemblage structure, and conservation in the Cosumnes River, California, U.S.A. Env. Bio. Fish. 68:143-162.

Crain, P.K. and D.M. Corcoran. 2000. Age and growth of the tui chub in Eagle Lake, California. Calif. Fish and Game 86:149-155.

5. Budget and staff allocations

South Bay Salt Pond Restoration Project
Selected Monitoring and Applied Studies
Project Budget Worksheet*

Timeframe:**

Budget Categories	Total Project Budget			Total Proposed From Other Sources *(please specify the source, if known)*
	5/09-4/10	**5/10-4/11**	**Total**	
Labor	$ 96,722	$ 96,722	$193,444	
Consultant fees/ Contractual Services				
Travel	$8,400	$8,400	$16,800	
Project specific equipment, supplies/materials	$12,830	$12,500	$15,330	
Overhead (not to exceed 10%)	10%	10%		
Other:_____ ***(please specify)***				
TOTAL	**$129,747**	**$129,384**	**$259,131**	

The University of California Davis minimum overhead charge for state funding is 26%.

A. Salary	**TASK**
Assist. Project Scientist II (JA Hobbs)	Project oversight (25%), Field (50%), Lab(25%)
Jr Specialist II	Field (100%) Fish Communities Study
SRA I	Field (100%) Sentinel Species Study
SRA II PK Crain	Boat Operator and Field Crew Leader
Administrative assistant	Admin(5%)

6. List of Potential Reviewers

Dr. Steven Morgan,
Associate Professor
Bodega Marine Lab
P.O. Box 247
Bodega Bay, Ca. 94923
(707) 377-4024
sgmorgan@ucdavis.edu

Dr. Larry Brown
Research Biologist
U.S. Geological Survey
Placer Hall
6000 J Street
Sacramento, CA 95819-6129
Phone: 916-278-3098
lrbrown@usgs.gov

Dr. Jeff Mount
Associate Professor and Director of the Center for Watershed Sciences
UC Davis
1 Shields Ave, Davis, Ca 95616
Phone 530-752-7092
mount@geology.ucdavis.edu

7. Permits: Dr. Hobbs and field manager Pat Crain are UC Boat Operator Safety certified and can operate all small watercrafts required for the field work. Dr. Hobbs, Dr. Moyle and Pat Crain have a California Department of Fish and Game Scientific Collecting Permits (#SC-009096) and we will apply for a 4d permit for potential capture of protected salmonids in the region. Upon funding we will also apply for access permits for the Don Edwards National Estuarine Reserve. We will also be collaborating with Dr. Collin Eagle-smith and Dr Josh Collins at the U.S.G.S and may gain access and utilize necessary permits under their purview.

8. Animal Care and Use Certification: Currently Dr. Moyle has a UC certified protocol for animal care and use #13371. We will either amend the current protocol or apply for a new protocol given the decision made by the Director of Animal Care and Use at UC Davis. We will also apply for clapper rail certification through the U.S. Fish and Wildlife Service as we will likely be accessing salt-marsh habitats that utilized by protected species.