# Biological Restoration, Improvements, and Multdisciplinary Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone. Phase Two: Importance of Marsh Ponds, Algae, and other Features along Marsh Channels.

## Project Information

1. **Proposal Title:**

   Biological Restoration, Improvements, and Multdisciplinary Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone. Phase Two: Importance of Marsh Ponds, Algae, and other Features along Marsh Channels.

2. **Proposal applicants:**

   Christopher Kitting, California State University, Hayward
   Karl Malamud-Roam, Contra Costa Mosquito & Vector Control District

3. **Corresponding Contact Person:**

   Frank Martino, Vice President
   California State University, Hayward
   25800 Carlos Bee Blvd Hayward CA 94542
   510 885-3713
   fmartino@csuhayward.edu

4. **Project Keywords:**

   **Bioindicators and Biomonitoring**
   **Habitat Restoration, Estuarine shallow water**
   **Wetlands, Tidal**

5. **Type of project:**

   Implementation_Full

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

   No

7. **Topic Area**:

   Shallow Water, Tidal and Marsh Habitat

8. **Type of applicant:**

   University

9. **Location - GIS coordinates:**

Latitude: 38.052

Longitude: -122.059

Datum: NAD 83

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

Restorations to increased tidal action would be at Tubbs I., N San Pablo Bay, several sites ~10 km west of Martinez (at Weapons Detachment Concord), with an initial restoration plan for West Big Break, near Antioch. >750 acres total for restoration.

10. **Location - Ecozone:**

    1.4 Central and West Delta, 2.1 Suisun Bay & Marsh, 2.3 Sonoma Creek, 2.5 San Pablo Bay

11. **Location - County:**

    Contra Costa, Solano

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    No

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    10

15. **Location:**

    **California State Senate District Number:** 7

    **California Assembly District Number:** 15

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

    3

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

       Yes

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

| | | |
|---|---|---|
| State Overhead Rate: | | 25% of total dir. |
| Total State Funds: | 1,351,655 | |
| Federal Overhead Rate: | 47% of salaries/benefits | |
| Total Federal Funds: | 1,294,292 | |

b) Do you have cost share partners already identified?

Yes

If yes, list partners and amount contributed by each:

**California State University, Hayward 250,796**

**Contra Costa Mosquito & Vector Contrl Dis 125,000**

**SF Bay Wildlife Society 1,200**

**plus in kind from several agencies**

c) Do you have potential cost share partners?

**No**

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

No

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

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

Yes

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

| | | |
|---|---|---|
| **98-C1042** | **Biological Restoration and Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone: an Ecosystem Approach to Improve Effectiveness of Bay/Delta Restoration.** | **Category III: Bay/Delta Restoration** |

**(contract 114209J018)**

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

**No**

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

    **No**

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

    No

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

    No

    **Please list suggested reviewers for your proposal.** (optional)

| | | | |
|---|---|---|---|
| **Dr. Joy B. Zedler** | **University of Wisconsin** | **608-262-8629** | **jbzedler@facstaff.wisc.edu** |
| **Dr. Robert J. Orth** | **VIMS, Virginia** | **804-684-7392** | **jjorth@vims.edu** |
| **Dr. Christopher P. Onuf** | **USGS/ NWRC, Corpus Christi** | **361-985-6266** | **chris_onuf@usgs.gov** |

21. **Comments:**

# Environmental Compliance Checklist

## Biological Restoration, Improvements, and Multdisciplinary Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone. Phase Two: Importance of Marsh Ponds, Algae, and other Features along Marsh Channels.

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

      Yes

   b) Will this project require compliance with NEPA?

      Yes

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

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

   <u>CEQA Lead Agency:</u> Contra Costa Mosquito and Vector Control District
   <u>NEPA Lead Agency (or co-lead:)</u> Contra Costa Mosquito and Vector Control District
   <u>NEPA Co-Lead Agency (if applicable):</u>

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

   **CEQA**
   **-**Categorical Exemption
   **X**Negative Declaration or Mitigated Negative Declaration
   **-**EIR
   **-**none

   **NEPA**
   **-**Categorical Exclusion
   **X**Environmental Assessment/FONSI
   **-**EIS
   **-**none

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

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

      No

      If the CEQA/NEPA process is not complete, please describe the dates for completing draft and/or final CEQA/NEPA documents.

Draft is complete. Final doc's by August, '02, through Contra Costa Mosquito and Vector Control District

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

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

**LOCAL PERMITS AND APPROVALS**

| | |
|---|---|
| Conditional use permit | Required |
| Variance | |
| Subdivision Map Act | |
| Grading Permit | |
| General Plan Amendment | |
| Specific Plan Approval | Required |
| Rezone | |
| Williamson Act Contract Cancellation | |
| Other | |

**STATE PERMITS AND APPROVALS**

| | |
|---|---|
| Scientific Collecting Permit | Required, Obtained |
| CESA Compliance: 2081 | Required |
| CESA Compliance: NCCP | Required |
| 1601/03 | |
| CWA 401 certification | Required |
| Coastal Development Permit | |
| Reclamation Board Approval | |
| Notification of DPC or BCDC | Required |
| Other | |

**FEDERAL PERMITS AND APPROVALS**

| | |
|---|---|
| ESA Compliance Section 7 Consultation | Required |
| ESA Compliance Section 10 Permit | Required |
| Rivers and Harbors Act | |
| CWA 404 | Required |
| Other | |

**PERMISSION TO ACCESS PROPERTY**

| | |
|---|---|
| Permission to access city, county or other local agency land.<br>Agency Name: | Required, Obtained |
| Permission to access state land.<br>Agency Name: Dept of Fish and Game | Required, Obtained |
| Permission to access federal land.<br>Agency Name: US Navy | Required, Obtained |
| Permission to access private land.<br>Landowner Name: | |

6. **Comments.**

# Land Use Checklist

## Biological Restoration, Improvements, and Multdisciplinary Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone. Phase Two: Importance of Marsh Ponds, Algae, and other Features along Marsh Channels.

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

   No

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

   Yes

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

   **No**

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

   Land use remains Wildlife Preserve. Tidal Action would be restored, with marsh ponds connected while excavating invasive plants.

4. **Comments.**

   Our major sites, at Weapons Detachment Concord, had complete permits for our proposed (declined) CALFED work last year, but those permits then expired. The permits are in prep, again through CC Mosqito &Vector Cntrl District.

# Conflict of Interest Checklist

## Biological Restoration, Improvements, and Multdisciplinary Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone. Phase Two: Importance of Marsh Ponds, Algae, and other Features along Marsh Channels.

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

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

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

**Applicant(s):**

Christopher Kitting, California State University, Hayward
Karl Malamud-Roam, Contra Costa Mosquito & Vector Control District

**Subcontractor(s):**

Are specific subcontractors identified in this proposal? Yes

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

| | |
|---|---|
| K.Malamud-Roam | CCMosqVectorContrlDistr |
| Navad Nur | PtReyes Bird Obs |
| Joy Andrews | CSU Hayward |
| Bryan Winton | SP Bay Nat Wldlf Ref |
| Ken Burger | E Bay Reg Pks Distr |
| None | None |
| None | None |
| None | None |
| None | None |

**Helped with proposal development:**

Are there persons who helped with proposal development?

Yes

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

**John Rees     CSU Hayward**

**Vicky Ivy     CSU Hayward**

**K. Malamud-Roam     CC MosqVectorCntrlDistr**

**Laura Hanson     CC Mosq Vector Cntrl Distr**

**Comments:**

# Budget Summary

## Biological Restoration, Improvements, and Multdisciplinary Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone. Phase Two: Importance of Marsh Ponds, Algae, and other Features along Marsh Channels.

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

Federal Funds

| Year 1 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Task No.** | **Task Description** | **Direct Labor Hours** | **Salary** *(per year)* | **Benefits** *(per year)* | **Travel** | **Supplies & Expendables** | **Services or Consultants** | **Equipment** | **Other Direct Costs** | **Total Direct Costs** | **Indirect Costs** | **Total Cost** |
| 1 | Project Initiation, Supervision, and General Reporting | 695 | 20248 | 2815 | 800 | | | | 1200 | 25063.0 | 10840 | 35903.00 |
| 2 | Pilot and Major Marsh Community Restoration | 1349 | 32436 | 4679 | 2000 | 3600 | 107275 | | 10730 | 160720.0 | 17444 | 178164.00 |
| 3 | Physical and Biological Comparative Monitoring of Marsh Treatments | 1635 | 39626 | 4824 | 6500 | | 110257 | 10800 | 9600 | 181607.0 | 20892 | 202499.00 |
| 4 | Chemical Monitoring of Water, Sediments, andMajor Plants and Animals | 1495 | 24465 | 4403 | 1000 | 4650 | | 8850 | 540 | 43908.0 | 13568 | 57476.00 |
| | | 5174 | 116775.00 | 16721.00 | 10300.00 | 8250.00 | 217532.00 | 19650.00 | 22070.00 | 411298.00 | 62744.00 | 474042.00 |

| Year 2 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Task No.** | **Task Description** | **Direct Labor Hours** | **Salary** ***(per year)*** | **Benefits** ***(per year)*** | **Travel** | **Supplies & Expendables** | **Services or Consultants** | **Equipment** | **Other Direct Costs** | **Total Direct Costs** | **Indirect Costs** | **Total Cost** |
| 1 | Project Initiation, Supervision, and General Reporting | 507 | 15260 | 2140 | 1800 | | | | 1500 | 20700.0 | 8178 | 28878.00 |
| 2 | Pilot and Major Marsh Community Restoration | 1004 | 21031 | 2718 | 2000 | 3600 | 6000 | | 5930 | 41279.0 | 11162 | 52441.00 |
| 3 | Physical and Biological Comparative Monitoring of Marsh Treatments | 2783 | 73673 | 11207 | 8500 | | 147061 | 4400 | 13200 | 258041.0 | 39894 | 297935.00 |
| 4 | Chemical Monitoring of Water, Sediments, andMajor Plants and Animals | 1327 | 24210 | 4487 | 1000 | 3650 | | | 540 | 33887.0 | 13488 | 47375.00 |
| | | 5621 | 134174.00 | 20552.00 | 13300.00 | 7250.00 | 153061.00 | 4400.00 | 21170.00 | 353907.00 | 72722.00 | 426629.00 |

| Year 3 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Task No.** | **Task Description** | **Direct Labor Hours** | **Salary** *(per year)* | **Benefits** *(per year)* | **Travel** | **Supplies & Expendables** | **Services or Consultants** | **Equipment** | **Other Direct Costs** | **Total Direct Costs** | **Indirect Costs** | **Total Cost** |
| 1 | Project Initiation, Supervision, and General Reporting | 695 | 22831 | 3187 | 1800 | | | | 1500 | 29318.0 | 12228 | 41546.00 |
| 2 | Pilot and Major Marsh Community Restoration | 478 | 14014 | 2059 | 2000 | 1600 | 4000 | | 7100 | 30773.0 | 7554 | 38327.00 |
| 3 | Physical and Biological Comparative Monitoring of Marsh Treatments | 2941 | 79474 | 12057 | 6500 | | 115292 | 3400 | 12800 | 229523.0 | 43020 | 272543.00 |
| 4 | Chemical Monitoring of Water, Sediments, and Major Plants and Animals | 1503 | 28265 | 5036 | 1000 | 3650 | | | 1400 | 39351.0 | 15651 | 55002.00 |
| | | 5617 | 144584.00 | 22339.00 | 11300.00 | 5250.00 | 119292.00 | 3400.00 | 22800.00 | 328965.00 | 78453.00 | 407418.00 |

**Grand Total=1308089.00**

**Comments.**

The Dean of the CSUH School of Science will match Prof. Kitting's time at 75% of the requested amount, and will match Prof. Andrew's time at 100% of the requested amount. He will also match the equipment request for a Microwave Digester for metals analysis at 100% of the request. This University support comes to $66,681 in year one, $78,223 in year two, and $89,362 in year three (using the Federal indirect cost rate).

# Budget Justification

## Biological Restoration, Improvements, and Multdisciplinary Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone. Phase Two: Importance of Marsh Ponds, Algae, and other Features along Marsh Channels.

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

Prof. Chris Kitting, PI Year 1: Task 1: 281 Task 2: 396 Task 3: 432 Task 4: 96 Prof. Joy Andrews Year 1: Task 4: 440 Technical Associate Year 1: Task 1: 238 Task 2: 381 Task 3: 477 Task 4: 79 Student Assistants Year 1: Task 1: 176 Task 2: 572 Task 3: 286 Task 4: 880 Lab Assistant Year 1: Task 3: 440 Prof. Chris Kitting, PI Year 2: Task 1: 140 Task 2: 172 Task 3: 990 Task 4: 96 Prof. Joy Andrews Year 2: Task 4: 440 Technical Associate Year 2: Task 1: 191 Task 2: 260 Task 3: 693 Task 4: 87 Student Assistants Year 2: Task 1: 176 Task 2: 572 Task 3: 660 Task 4: 704 Lab Assistant Year 2: Task 3: 440 Prof. Chris Kitting, PI Year 3: Task 1: 281 Task 2: 172 Task 3: 990 Task 4: 96 Prof. Joy Andrews Year 3: Task 4: 440 Technical Associate Year 3: Task 1: 238 Task 2: 130 Task 3: 693 Task 4: 87 Student Assistants Year 3: Task 1: 176 Task 2: 176 Task 3: 858 Task 4: 880 Lab Assistant Year 3: Task 3: 400

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

Prof. Chris Kitting: $28,710 per quarter Prof. Joy Andrews: $18,914 per quarter Technical Associate: $11,380 per quarter Student Assistants: $10-15 per hour Lab Assistant: $12 per hour A cost of living/merit increase of 5% is budgeted in years two and three.

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

Faculty release time: 25% Faculty summer salary/academic year overload: 5% Student assistants and non-benefitted staff: 10%

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

Task 1: travel expenses to CALFED and related meetings are budgeted at $800 in year 1, $1,800 in year 2 and 3. Task 2: Transportation costs and boat use is budgeted at $2,000 in each year of the project. Task 3: Transportation costs are calculated at $2,500 in each year of the project. Boat use is calculated at $4,000 in years one and three, and $6,000 in year two. Task 4: Transportation costs and boat use are budgeted at $1,000 in each year of the project.

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

Task 2: Supplies are budgeted at $3,600 in years one and two, and $1,600 in year three. Task 4: AA (metals analysis) supplies are budgeted at $2,250 in year one, $1,250 in years two and three. Carbon and nutrient analyzer supplies are budgeted at $2,400 in each year of the project.

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

Task 2: CCMVCD will connect restored channels to ponds via wiers. This item is budgeted at $88,000 in year one. CCMVCD will contribute an additional $125,000 in matching funds to this task. SFBWS will undertake plant salvage and transplant operations. This item is budgeted at $9,775 in year one, with SFBWS contributing an additional $1,200 in matching funds. East Bay Regional Parks (or

CCMVCD) will subcontract for permitting expenses for the Delta shore restoration pilot project. $9,500 in year one, $6,000 in year two and $4,000 in year three is budgeted for this activity. Task 3: CCMVCD will conduct hydrology and vegetation monitoring and management. The CCMVCD staff will be compensated at approximately $26/hour. $35,500 has been budgeted in year one, $38,500 in year two, and $40,425 in year three. Bird monitoring will be conducted by PRBO/SF Bay Wildlife Society/Friends of San Pablo Bay. Agency staff will be compensated at approximately $23/hour. The cost for this activity is $64,600 in year one, $62,700 in year two, and $72,600 in year three. Other vegetation monitoring will be conducted by the SF Bay Wildlife Society, at a cost of $1,757 in year one, $1,861 in year two, and $2,267 in year three. Staff will be compensated at rates ranging from $18-30/hour. The SFBWS will provide matching contributions of $480 in year one, $510 in year two, and $540 in year three. In year two, the San Francisco Bay Wildlife Society will produce a video documentary, with EcoLogic. This activity is budgeted at $44,000.

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

Task 3: Two YSI underwater data loggers with O2 electrodes will be purchased at $3,000 each in the first year of the project. Field equipment, replacement, repairs and safety gear is budgeted at $2,400 in year one, $4,400 in year two, and $3,400 in year three. A scanner and portable computer will be required for this task; they are budgeted at $2,400 in year one. Task 4: A Hach carbon analyzer will be required. The analyzer is budgeted at $3,400 in year one of the project. A microwave digester for metals analysis will be purchased in year one as well. The CSUH School of Science will match CALFED funding for this item, which is budgeted at $5,450 request and $5,450 match.

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

Task 1 represents project initiation, supervision, and general reporting. Please refer to the salary information above for Task 1, which describes the necessary personnel and time to be devoted to these activities. Other direct costs associated with project management are travel expenses to CALFED and related meetings (already described under Travel), and general publication costs, including illustrations (already described under Other Direct Costs).

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

Task 1: General publication costs, including illustrations, are budgeted at $1,200 in year one, and $1,500 in years two and three. Task 2: Repairs are budgeted at $2,000 in year one, and $1,500 in years two and three. Remote lab use is budgeted at $700/month, which represents a partial cost only. In year one, this item is budgeted for 8 months, while in years two and three it is budgeted for 4 months each. Plant and animal acquisition is calculated at $2,000 in year one of the project. Remote lab expenses (communications, copies) are budgeted at $1,300 per year. Publication costs are calculated at $330 in years one and two, and $1,500 in year three. Task 3: Remote lab use is budgeted at $700/month, which represents a partial cost only. In year one, this item is budgeted for 4 months, in year two 8 months, and in year three it is budgeted for 6 months. Remote lab expenses (communications, copies, modifications) are budgeted at $3,500 in year one, $4,300 in years two and three. Publication and illustration costs are calculated at $900 in years one and two, and $1,900 in year three. Task 4: Publications costs are included at $540 in years one and two, and $1,400 in year three.

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

The submitted budget uses the Federal indirect cost rate for California State University, Hayward which is 47% of salaries, wages and benefits. This rate results in a lower total request than the CSUH state rate, which is 25% of total direct costs.

# Executive Summary

## Biological Restoration, Improvements, and Multdisciplinary Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone. Phase Two: Importance of Marsh Ponds, Algae, and other Features along Marsh Channels.

Applicant Information: California State University, Hayward (CSUH Foundation), Participants and Collaborators: Dr. Chris Kitting, Cal State Univ. Hayward; in collaboration with Dr. Karl Malamud-Roam, Contra Costa Mosquito and Vector Control; Dr. Nadav Nur, Point Reyes Bird Observatory; Dr. Joy Andrews, Chemistry, CSUH; Bryan Winton, USFWS San Pablo Bay National Wildlife Refuge; and Ken Burger, East Bay Regional Park District. Summary Description of Project. Our project is located in CALFED Ecozone 2, in North San Pablo Bay (Tubbs Is.), South Suisun Bay (E of Martinez) and West Big Break (near Antioch). It is a Phase II tidal marsh restoration and comparative monitoring project, using non-destructive physical-chemical-biological monitoring with replication throughout each recent and new marsh restoration and (adjacent, ~100-yr-old, relatively natural) reference marshes. Goals are to identify and improve factors that enhance productivity and sustainability of dwindling native populations. Specific objectives of our Phase II proposed project encompass tidal marsh environments from mesohaline to fresh-water in Ecozone 2: (1) further increase tidal action, (2) connect marsh ponds to channels with sills and novel sediment/fish wiers, (3) subsequently monitor and thus compare our reference marshes with our replicate restored marshes both with and without experimental pond connections, as field manipulations. We would compare persistent metals (Se, Hg, Pb), water quality, and biotic diversity and productivity (bird, fish, invertebrate, plant, and major algae populations), (4) identify and improve factors that enhance productivity such as maintain marsh ponds with moderate benthic algae, (5) identify and remedy limiting factors for key species and their food webs within restored marsh systems, specifically for delta smelt and splittail, and (6) offer new training at the CSUH Contra Costa Campus, integrated with our monitoring. Thus, we would restore, improve, monitor, maintain, and teach about marshes through adaptive management, to improve these and other Bay/Delta restorations. Our primary, testable hypothesis is that particular conditions in our reference and restoration marshes will yield different population densities of resident fishes and their food sources, and that rates of colonization into our marsh restorations by larval and juvenile fishes will tend to improve through time at restored marshes, with suitable conditions. Our project directly addresses uncertainty #10 (Shallow-water, tidal, and fresh-water habitat) as a limiting factor in overall restoration efforts, including habitat and water quality. Our related marsh morphology addresses CALFED uncertainty #s 1 (Natural Flow regimes), #7 (Channel Dynamics, Sediment Transport, and Riparian Vegetation) and #9 (Bypasses as Habitat). Results of our work will be presented to agencies and major conferences, where colleagues provide feedback. We plan to publish this work in academic and applied journals, and disseminate it in lectures and a reviewed TV documentary. This proposal directly targets the following ERP strategic goals: Goal 1: At-Risk Species; Life cycle stages and habitats of delta smelt and Sacramento splittail. Goal 2: Ecosystem Processes and Biotic Communities; Rehabilition of natural processes and biotic communities in the Estuary. Goal 4: Habitats; Marsh habitats worldwide are recognized as refugia and nurseries for larval and juvenile fishes. Goal 5: Non-native Invasive Species; Tidal marshes have become homes for a variety of non-native invasive plant and animal species, whose effects we seek to control. Goal 6: Sediment and Water Quality; We propose to compare sediments, water, and organisms in additional restored and reference marshes for heavy metals, especially lead, mercury, and copper, for nutrients (N and P) and carbon flux.

# Proposal

## California State University, Hayward

## Biological Restoration, Improvements, and Multdisciplinary Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone. Phase Two: Importance of Marsh Ponds, Algae, and other Features along Marsh Channels.

Christopher Kitting, California State University, Hayward
Karl Malamud-Roam, Contra Costa Mosquito & Vector Control District

Narrative and appendices for CALFED proposal:

**Biological Restoration, Improvements, and Multdisciplinary Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone. Phase Two: Importance of Marsh Ponds, Algae, and other Features along Marsh Channels.**

By Dr. Chris Kitting, California State University, Hayward (CSUH Foundation), 25800 Carlos Bee Blvd., Hayward, CA 94542-3035 Phone: (510)885-3471; FAX (510)885-4747; contact: Chris Kitting, e-mail:ckitting@csuhayward.edu
in collaboration with others (see executive summary and forms,) including Dr. Karl Malamud-Roam, Contra Costa Mosquito and Vector Control.



**PROJECT DESCRIPTION** ***1.Statement of Problem***

*a. Description of Problem*. Phase I discovered that our three various marsh restorations with connected marsh ponds yielded >~20x more abundant fishes and invertebrates (largely natives) than at our two other restorations. The latter marshes yield animal abundances simlar to those of our >two Suisun Bay historical marshes (~100 yr old, never diked,) which all showed few invertebrates and fishes, and lacked connections to marsh ponds. Our Phase II project is designed to further restore our recent and new marshes to increased tidal action and to increase the size of SUITABLE aquatic animal habitat by adding or connecting MARSH PONDS to channels (as ~large-scale field manipulation experiments), especially near restorations (and historical marsh reference sites) that presently yield very few aquatic animals. Our partner restorations anticipated 5-10 years of monitoring, and only 2.5 were possible to contract in Phase I. Proposed comparative monitoring through 2005, including marsh functions as they develop, is critical to detect longer-term responses to marsh establishment, variable rainfall, temperature, etc. as inter-annual variables. Ongoing Dept of Fish and Game and Interagency sampling in deeper water has shown the value of longer-term monitoring.

We use integrated multidisciplinary monitoring to compare a range of ~replicate marshes to identify and improve the physical, chemical, geomorphic, and biological factors that are most limiting in successful shallow-water marsh restoration efforts in the North Bay/Suisun Bay Ecological Zone (CALFED Management Zone 2) of the San Francisco Estuary, hereafter referred to as “the Estuary.” As emphasized in the CALFED mission statement and in the literature cited below, successful marsh restoration includes the creation of suitable, sustainable, low/no-maintenance habitat in which both native and/or economically desirable non-native aquatic and terrestrial species (both species of concern and beneficial others) can successfully maintain viable populations.

*Review of Relevant Studies*. Ecological restoration should follow scientific principles, yet must conform to specific attributes of sites being restored, Estuarine restoration is guided by hydrodynamic laws common to all estuaries, and yet must address site-specific issues, such as climate, geology, and the suite of estuarine species present. In San Francisco Bay Estuary, the

"$X_2$" value, a distance (in km) of the 2 ppt isohaline position measured from the Golden Gate Bridge, can be estimated in past years from a kneading of physical data common to estuaries worldwide (fresh water flows, tidal fluxes, etc.), but the effects that $X_2$ at any given time has on specific populations on Estuary species of interest (e.g. the native mysid *Neomysis mercedis*, longfin smelt) is confined only to the San Francisco Estuary (Kimmerer and Monosmith, 1992; Jassby, 1992). Estuaries are difficult to model due to poorly understood linkages among the physical parameters, water chemistry, geomorphology, and the biology of the species that inhabit the given estuary (Walters, 1997). Some estuaries offer broad generalities for comparison in restoration efforts Estuary (Ogden and Davis, 1994 in Everglades restoration), but lack the specifics of San Francisco Bay. Recent National Academy of Science reviews by Zedler and Turner show that such marsh restoration nationwide has not been adequate to keep up with habitat loss. Interdisciplinary work may be a major improvement, as the next Am Soc of Limnology and Oceanography conference adopted the them of "Inter-disciplinary Linkages in Aquatic Sciences and Beyond." Particular concerns for the San Francisco Estuary and its threatened and endangered fish species, have focused on environmental chemistry and animal biology, although we propose to integrate plant, algal, and avian work too. In many cases, the biology and limitations of threatened Estuary species are not known, such as the delta smelt (Brown and Sitts, 1999). Specifically, the role of shallow-water habitats in the life history of the delta smelt, and the optimum structure and other environmental parameters of marshes that encourage healthy smelt populations, are not understood (Ibid, 1999). Recent evidence points to our proposed Big Break reference site as a likely delta smelt breeding area (L. Brown, pers. comm.). The approach of providing more tidal amplitude to increase fish populations is locally supported by Balling et al. (1979, 1980), and is expected to deter invasive plants (via tidal salt water) and aerate water through circulation.

Phase I suggested the direct or indirect importance of connected marsh ponds here (Kitting 2001, 2002), while moderate algae from marsh ponds may be a more direct effect (after Van Montfrans et al. 1982, Kitting et al. 1984). Our hypothesized importance of connected marsh ponds may be analogous to Sommer et al. (2001) documenting the importance of seasonal floodplains for native fishes. West and Zedler (2000 ), along with our comparative sampling at their sites in San Diego, support our recent hypothesis that connected marsh ponds are associated with abundant animals. Collins et al. (1987) show how sediment can fill such ponds within a decade or so, but animals and ponds may be most abundant where marshes are EXPANDING naturally, where these animals probably evolved. Especially nearby sedimentation and sealevel rise may produce new ponds as old ones sediment in. Furthermore, our fish wier design (available through this project) should maintain connected ponds without sediment acccumulation. Increased marsh water volume from connected ponds might even minimize sedimentation in connected channels.

*<u>Objective of Proposed Study</u>*. A key to successful aquatic habitat restoration, including shallow water tidal habitats, is to ensure that as many environmental linkages as possible are included. These linkages include physical, chemical, geomorphic, and biological factors that determine restoration activities. The objectives of our proposed project within the North San Francisco/Suisun Bay ecological management zone include: (1) further increase tidal action to shores, (2) connect marsh ponds to channels with sills and novel sediment/fish wiers, (3) monitor and thus compare our reference marshes with our replicate restored marshes both with and without experimental pond connections, as field manipulations. We would compare persistent metals (Se, Hg, Pb), water quality, and biotic diversity and productivity (bird, fish, invertebrate, plant, and major algae populations), (4) identify and improve factors that enhance productivity, (4) subsequently identify and remedy limiting factors for key species and their food webs within the marsh systems we are restoring, specifically with regard to delta smelt and splittail, and (5)

subsequently identify and remedy limiting factors for key species and their food webs within the marsh systems we are restoring, specifically with regard to delta smelt and splittail. We also would (6) offer new training at the CSUH Contra Costa Campus, integrated with our monitoring. Thus, we would restore, improve, monitor, maintain, and teach about marshes through adaptive management, to improve these and other Bay/Delta restorations and their adaptive management.

At no further cost to CALFED, we also would compare these results with our extra sampling at less accessible, ancient (>~1000-yr-old) marshes nearby (Brown Island) and estuaries north and south, such as in Mendocino, Tomales, Elkhorn Slough, and Morro Bays, as volunteers if necessary. Our additional collaboration with SFEI's proposed monitoring plan may enable frequent, thorough sampling at ancient and additional replicate marshes. Our related NSF proposal also is in prep.

**b. Conceptual Model.** _Technical Basis for Our Model_. We have used our initial, Phase I observations and monitoring results, which compare both "replicate" and very different marshes, as well as the different physical and biological factors found in each, to formulate the hypothesis that a positive correlation exists between increased population densities of most aquatic animals (including splittail and even dense HERRING in marshes) and the presence of marsh "ponds" (shallow, permanent quiet-water areas) along constructed channels. By experimentally connecting presently isolated ponds to marsh channels used in most of our previous replicate restorations (and monitoring them, in comparison with control (or unmodified, reference) sites, we will use these large-scale field experimental manipulations to test for an increase in populations of zooplankton, zoobenthos, and native fishes. An alternative hypothesis is that west-coast migratory fishes may be less dependent on marsh conditions in general, as west coast marshes are younger, rarer, and more isolated in comparison with estuaries on the U.S. east and south coasts (after Onuf et al. 1978).

A diagrammatic model of our project, based on our recent evidence, is shown in Figure 1 of the Appendix (Existing Project Status). Each trophic level passes the necessary nutrients and energy to the next level, producing a "healthy" marsh habitat, with sufficient nutrients present for primary productivity, and with a healthy primary and secondary (zooplankton and zoobenthos) productivity in place to ensure food for both resident fishes and larval and juvenile fishes whose adults inhabit deeper areas of the Estuary. If nutrients (hypothetically concentrated by marsh birds), algal or plant foods, or zooplankton and/or zoobenthos are insufficient to sustain native larval and juvenile fishes, energy flow within the entire system is stifled, and as a result, native adult fish populations will suffer. As energy passes from one level to the next, other limiting factors come into play, described in detail under "Relevant Uncertainties," below. We have found, for example, that ponds within marshes which are not subject to vigorous tidal flushing, have higher densities of zooplankton (and apparently algae) than shallow-water areas with vigorous tidal flushing. The mechanism(s) for these differences are not yet known, but could relate to the "floodplain" phenomenon observed in such areas as the Yolo Bypass during wet years (see scientific uncertainty #9, "Bypasses as Habitat" of PSP, and Sommer et al. 2001) and reservoirs of productive food (Kitting et al. 1994, Miltner et al. 1995).

_Source of Information for our Model._ Our model of a tidal marsh habitat is based on a generalized aquatic ecosystem model, and on data gathered from Phase I of our work on tidal marshes in CALFED's Ecozone 2. Trophic levels in these marshes can sustain higher productivity if certain conditions are improved, such as addition of ponds along channels, which, we hypothesize, will act as nutrient reservoirs and as sources of food and refugia for fishes between high tides. Among our reference and restored marshes, high, dissolved nitrogen (N) and phosphorus (P) levels may be correlated with higher population densities of zooplankton, zoobenthos, and resident fishes. Larval and juvenile fishes of species whose adults are found in deeper parts of the Estuary (delta smelt, Sacramento blackfish, possibly splittail) grow in shallow-water marshes where adults are rarely found. We hypothesize that juveniles either leave these shallow-water areas and grow to adulthood in deeper parts of the Estuary, or they may entirely die in marshes, due to unfavorable environmental conditions, such as temperature extremes in shallow water. As in the Gulf of Mexico, eggs and/or larval fishes may enter tidal Estuary marshes after spawning takes place just outside the marsh (Kitting et al., pers. obs.).

Relevant Uncertainties. Our conceptual model in Figure 1 can be related to uncertainties and limiting factors of concern in CALFED's restoration efforts in Ecological Zone 2. Our project directly addresses uncertainty #10 (Shallow-water, tidal, and fresh-water habitat) as a limiting factor in overall Estuary restoration efforts. In our model, "marsh morphology" relates to CALFED uncertainty #'s 1 (Natural Flow regimes), 7 (Channel Dynamics, Sediment Transport, and Riparian Vegetation) and 9 (Bypasses as Habitat). All three of these uncertainties may be limiting to native fish populations in our marshes. *Natural flow regimes*, in our case channel morphology and the presence or absence of connected marsh ponds in both our reference and marshes to be restored, could be critical to both nutrient availability and ability of juvenile native fishes to feed and grow successfully. *Marsh channel dynamics and associated sediment transport* and (not riparian, but emergent) marsh vegetation could be critical to both nutrient availability and survival of small native fishes. *Bypasses*, or in our case, marsh "ponds," standing areas of shallow water, we hypothesize to be crucial to buildup sufficient nutrients, as sites for increased primary and secondary productivity, and as nurseries for abundant small fishes. "Phytoplankton and emergent vegetation" and "zooplankton and zoobenthos" in our model addresses uncertainties #1 (Natural Flow Regimes), 3 (Decline in Productivity) and 6 (Non-native Invasive Species). We hypothesize that both primary and secondary productivity depend on marsh morphology, possibly the presence of attached marsh ponds. Declines in overall Estuary productivity could be tied at least in part to loss of shallow-water marsh habitat and degradation of that marsh acreage that remains, especially with regard to sufficient, connected, marsh "pond" areas. We have found many native and non-native plants and animal**s** in both our reference and restored marshes. At one site, we found non-native hydroids in very high densities, lining the pipes through which tidal action fed the marsh. The size, and probably the presence, of the pipes were undoubtedly a risk to zooplankton and larval fishes, which had to pass what amounted to gauntlet of extended stinging tentacles on the inside of the pipes. Through adaptive management, ecological bottlenecks now present in our marshes can be investigated, and, as appropriate, modified to remedy any marsh degradation, or design or construction flaws. Thus, we can test possible solutions to marsh restoration problems.

**Hypotheses being Tested.** Testable Hypotheses. Our work is based on the comparison of replicated types of marshes. Our overarching, testable hypothesis, based on our conceptual model, is that different conditions in our reference and restoration marshes may yield different population densities of fishes, particularly larval and juvenile fishes whose adults live in deeper areas of the Estuary (e.g. delta smelt and splittal); fish abundances or export rate of our shallow-water marsh restorations by may differ, depending on the "health" (rate of energy transfer up the food web, with minimal limiting factors) of the marsh in question. A second hypothesis is that each of our suitably restored marshes will accrue habitat value through time, and will eventually exceed that of reference marshes. In particular, we hypothesize that both the presence of intertidal vegetation and invertebrate food resources are vital for fishes to colonize restored marshes. Our restorations thus may attain animal densities (or productivities) exceeding those in reference and other marshes.

*CALFED Goals and Uncertainties Being Addressed.* The following Ecosystem Restoration Plan (ERP) Strategic Goals are being addressed in our project: Goal 1: Recovery of At-Risk Species. Our project is directly addressing the recovery of two at-risk species, delta smelt and Sacramento splittail. We aim to identify uncertainties which improve survival of delta smelt larvae and juveniles in our marshes, using the hypothesis that shallow-water areas of the Estuary (perhaps not only in tidal marsh Estuary areas), are critical for the recovery of healthy delta smelt populations. Our project will also address the importance of shallow water tidal marshes for establishment of healthy splittail populations in the Estuary. Goal 2: Ecosystem Processes and Biotic Communities. Through our shallow-water marsh restoration efforts we aim to achieve marshes which will persist with a minimal amount of human intervention, and which will have natives as dominant species. Uncertainties addressed here in our project include the role of large standing-water areas, or marsh "ponds" in nuseries for food and larval and juvenile native species in tidal marshes. Goal 4. Estuary Habitats. We are aiding, though monitoring and adaptive management, restoration of functioning areas of tidal, mesohaline to virtually fresh-water marshes. Uncertainties addressed here include whether native species will benefit as much as introduced species in tidal marsh restoration. Goal 5: Non-native Invasive Species. With respect to non-native species, we have two goals in our adaptive management plan of marsh restoration:(1) the removal of non-native plant and animal colonists in our marshes, as appropriate (yellow-fin gobies, green crabs, mitten crabs, all as requested by DFG), and (2) to eliminate conditions that encourage the establishment of healthy populations of non-natives in our marshes (e.g., the role of "pipes" as conduits of water to marshes, which harbor populations of introduced hydroids), identifying and eliminating "bottlenecks" in tidal flow to marshes, such as modifying silt deposits or gates and other structures to enable fishes to pass into marshes).

**d. Adaptive Management.** *Relation of Our Conceptual Model to the Adaptive Management Design (Healey Ladder)*. Each trophic level in our conceptual model can be related to the "Healey Ladder" and "Healey Adaptive Management Process" of the adaptive management process. In our proposed project, restorations can be considered both as "pilot" and "large-scale" implementation projects, which will vary from 1 to 300 acres (Step 4-Healey Ladder). Through monitoring, each trophic level will be assessed as to whether limiting factors or bottlenecks are at work during the restoration process. Advice will be given to our colleagues as to how these limiting factors apparently can be minimized. Under "initiate restoration actions" (Step 4 of the adaptive management process), "Learning" in our case relative to the Healey ladder would consist of information gleaned in the context of Monitoring (Step 5 of the Healey ladder), and of ongoing results of each or our restoration projects being "fed-back" into each restoration (through Step 6 of the ladder) to improve habitat conditions for native species (back to Step 4). An adaptive management loop from Steps 4, through Steps 5 and 6, and back to Step 4 will be established so that we can continually feed information by means of a learning process back to managers in order to continually improve the restoration process.

*Justification for the Proposed Project*. As in many estuaries, San Francisco Estuary has lost many of its low-salinity marshes, known to be so important to many estuarine fish species (e.g. Schubel 1992). Shallow-water tidal marsh areas have been converted for agriculture around the Estuary, resulting in a small remaining fraction of functioning estuarine tidal marshes, areas known to be highly productive and nurseries for young fishes (Wetzel 1975). The justification for our project overall is based on our approach of increasing key areas of tidal marsh to increase the Estuary area and quality of low-salinity habitat. Our project directly addresses the uncertainty that an increase in the area of low-salinity marshes *should* result in increased overall Estuary productivity and population density and habitat of threatened Estuary fish species. Our project is, in one sense, both pilot and full-scale restoration, as relatively large areas (~900 acres) will be restored to increased tidal action and aquatic biological function, yet such areas are relatively small compared with the total potential Estuary tidal marsh area suitable for restoration. Our simultaneous monitoring of both reference and restoration marshes will enable a continuous fine-tuning and resolution of uncertainties, limiting factors, and bottlenecks in restored marshes. Testing changes in restoration design based on our adaptive management practices will support or modify our hypotheses about improved habitat for larval and juvenile native threatened species (delta smelt, splittail), and about other CALFED ERP goals. The improvements would be used in future restoration projects, both by ourselves and others throughout the world.

**e. Educational Objectives**. The proposed project has an additional, educational objective, as PI's, collaborators, student assistants, and our audiences will learn and train others throughout the duration of the project, and beyond it. Furthermore, we propose partial support to enable new advanced CLASSES in Estuary and Delta restoration, integrated with our monitoring, and based at our new, nearby Contra Costa Campus of CSUH (Figure at end) as encouraged by Senator Tom Torlakson and CALFED. These classes would be integrated with our other proposed monitoring work, and would be open to local and visiting students and teachers, to train future generations of informed citizens and restoration scientists. At no cost to CALFED, our project partners and former grad students recently HOSTED several US senators and congressmen, plus State Senator Torlakson's Office to SHOW them our marsh restorations, including access via a boat tour near Concord. Military Base conversion is timely at our sites.The tour was very well received, focusing (then) on land acquisition for restoration and research. Our team is proposing NSF "Ecosystem Studies" funds too, for further research about mechanisms behind limiting factors at marsh restorations there. Our separately proposed biochemical and molecular assessments of mixed function oxidases can detect effects of otherwise hidden, sublethal toxins at our various sites. We already are supplying specimens to UC Berkeley for stable isotopic analyses of fish food webs, analogous to Kitting et al. (1984).

Our recent discovery has been especially important: a closest relative (known from Central Valley ancient San Joaquin fossils only, Hydrobia andersoni) of the California brackishwater snail (on the endangered species list) was thought to be EXTINCT for >2 million years, but we recently documented it colonizing and thriving only at three of our restoration sites with marsh ponds(!), where endangered/threatened fishes also colonized. Such a living fossil has important implications for the sustainability and mobility of these geologically young LOCAL habitats. Such discoveries we again propose to circulate and edit through CALFED, then colleagues, then the general public through a video documentary, then to be broadcast through the CSUH cable network. Our producer at Eco Logic Productions, Dan Baron, M.S., is experienced in education and video production, and has produced National Geographic's first program on restoration, of kelp forests. The present partner, SF Bay Wildlife Society, recently released a successful video about Bay watersheds, narrated by Kitting. Television can be a very effective tool in public education. Our video would be reviewed in our CALFED reports before finalizing and broadcasting via our CSUH TV station, etc.

## *2. Proposed scope of work*

### a . Location and Geographic Boundaries of the Project.

*Counties Where Project is Located*: Sonoma County; Contra Costa County. *Ecozone included*: Suisun Marsh/San Francisco Bay (Zone 2). San Pablo Bay is Zone 2.5. Suisun Bay Marsh is 2.1. A reference site for preparing restoration permitting is on the border between 2.1 and the Central and West Delta, Zone 1.4.

***Map with Outline of Project Sites*** **(**One wide and four detailed maps attached, in appendix**)**

*Digital Geographic Coordinates of Project Sites:* (A table of restoration sizes and GPS boundaries and centers, for NAD 83 datum, immediately follows the proposal. Also noted on maps in appendix):
*Photographs of Project Sites:* (attached, with maps in appendix)

**b. Approach.** *Sampling; Methods and Techniques.* We would improve and employ integrated, non-destructive physical-chemical-biological monitoring, with replication, throughout each restoration (and adjacent reference marshes) to evaluate and improve restoration success through adaptive management (Kitting 1993). Our restored marshes would be sampled before, during, and after restoration to increased tidal action. These marshes include those restored to full tidal action, and others restored to increased, though still "muted" tide action. Emphasis will be placed on monitoring habitats for CALFED priority fishes, particularly delta smelt, splittail, Chinook salmon (all runs), steelhead, green and white sturgeon, and their food resources (zooplankton and zoobenthos). We include sampling at mouths of intertidal channels to gain unusually complete censuses of large fishes in portions of these marshes. Random number tables provide numbers of steps between each replicate sample. Our sampling protocol, schedule, and logistics are designed to minimize impacts to each site. For example, kayaks are used as access to more remote sites. Muddy equipment is washed (and misted with alcohol) to minimize any transfer, among sites, of aquatic animal pathogens present in marsh mud. Non-destructive sampling of biota is performed via standardized field photography and counting of specimens prior to returning from the field. Seasonally, sediment accumulation or net erosion in sediment traps (or with sediment "pins") also is assessed.

Approximately monthly, zooplankton are enumerated from replicate 0.25-$m^3$ tows. Ichthyoplankton also are checked from 1-$m^3$ tows. Similarly, epibenthic sampling is performed in replicate 0.05-$m^2$ thrown cage samplers after Weinstein pers. comm. and Huh and Kitting (1985), adding quantification of major algae (after Kitting et al. 1984). Sunken "minnow" traps (like crayfish traps with 2 mm mesh) as refugia (with extra 2 mm mesh inside) sometimes with white LED lights inside (as light traps for delta smelt etc.) are used for sampling larger, less abundant epibenthos and nekton, such as large crustacea (including crabs and crayfish) and certain fishes. Larger fyke nets seasonally sample the above large taxa and larger fishes passing through the mouth of each marsh. The latter methods are adopted by our inter-agency wider-scale monitoring planned in North Bay CALFED marshes. Occasional mortality, and removal of common invasive species (such as yellowfin goby and mitten crab) may enable additional assessment of diets of the common fishes or invertebrates associated with marshes. If overfishing desirable species can deplete them, perhaps selectively killing invasive species can deplete THEM, especially during our intensive sampling. Care (nets extending above water) is taken to prevent risks to air-breathing animals such as beavers, otters, muskrats, turtles, and frogs, whose presence in each area is tabulated qualitatively. Occasional specimens are preserved for reference/voucher specimens of small species, and will be maintained at the university.

*Data Collection, Equipment, and Facilities.* Physical, chemical, and biological data (previous and additional factors) will be gathered systematically for each reference and restoration marsh site. Sampling locations are identified and logged via Garmin WAAS GPS (wide area augmentation system global positioning system, accurate within a few meters). Other information, logged approximately monthly (see basic data table in appendix), includes site identification, date/time/tide, physical factors (below), and replicated animal abundances with 1-$m^3$ plankton tows, thrown cages (benthos), and fish live traps/artificial refugia (with fine mesh inside). Physical factors include approximate wind and water current, and quantitative data on physical factors of: water depth, clarity (secchi depth), and basic surface and bottom water parameters (with YSI probes and now YSI 600XL recorders, seasonally for continuous ~3-wk records of): temperature, depth, salinity/conductivity, pore water salinity/conductivity (subsurface, if different), redox, and $O_2$ content. Sediment accumulation or net erosion in sediment traps (and sediment "pins", and standardized photographs) also are assessed seasonally, along with analyses of large fishes (in fyke nets and sonar), plant densities (in permanent quadrats), metals, nutrients, and carbon flux (after Morgan and Kitting 1984) seasonally. Comparisons of carbon flux are requested by CALFED, and were begun locally by Jasby and Cloern (2000).

We use office and laboratory space at the main and Contra Costa CSUH campus, in mobile labs, and at CCMVCD.

_Analytical Procedures._ Nutrient anions including nitrate and phosphate, cations, and dissolved transition metals will be measured using a Dionex DX 500 Ion Chromatograph. Total N, P and organic C will be measured using a microwave digestion (for orthophosphate) then Hach COD reactor and colorimetry. Total metals are determined (EPA procedures) by microwave digestion followed by atomic absorption using a Perkin Elmer Aanalyst 300.

_Construction Procedures (including enhancing recent restorations)._ Tidal amplitudes will be increased in large portions of each of our restoration regions, periodically as necessary, through widening or removing physical bottlenecks, silt deposits, and invasive vegetation clogging channels, sometimes by hand or with small equipment, including water pressure. Native marsh vegetation threatened by these activities will be transplanted locally, to replace patches of invading plants and to stabilize sediments that slump into channels, especially near openings to tidal creeks. In particular, existing but presently isolated ponds or newly excavated ponds (where invasive vegetation is removed, generally by hand) will be connected to restored channels at most sites. Connections will be equipped with wiers to maintain adjustable minimum water levels in marsh ponds at low tide. CCMVCD is donating much of their restoration work for any more extensive excavation necessary to provide shallow ponds along channels. To prepare for future restorations, our use of reference sites at western Big Break (far from Marsh Creek,) with and without marshes and ponds, will enable permitting to proceed there, to maintaining suitable, potential restoration sites in line for future implementation**.** Additional data collection and analyses proposed here also will take place in conjuction with an array of specific restoration activities already funded through CCMVCD: First, the introduction of substantial tidal action in the Peyton Slough/Shell Marsh complex will begin in late 2002 or early 2003, following the completion of a mandated toxic cleanup in Peyton Slough. Second, the third restoration phase at the Point Edith marsh complex has been funded and permitting is underway for tidal enhancement to hundreds of acres of marsh and numerous ponds in late 2002.

_Statistical Analysis and Quality Control Procedures_. Biological data are tabulated with at least four replicates per sampling date, per site (usually twice that). Sampling is performed approximately once per month, more frequently if the situation dictates (e.g., presence of species of concern). Orders of magnitude differences among data sets at sites are statistically distinguishable using sets of four replicates. In the field, data are entered into our standardized data tables (analogous to those recently adopted by DFG) from our computer database. Significant qualitative observations are noted and communicated to others of the team for confirmation as required. Consistency among team-mates and Sr. scientists is achieved through together sampling >~8 replicate samples per site (>~40 samples), or more, until observations are consistent. As each season or year of data is obtained, graphic and (often non-parametric) statistical analyses of data, as appropriate, will be conducted. Our Quality Assurance/Quality

Control procedures are filed with CALFED, and include careful standardization of methods and confirmed species identification, performed by photography and experienced PI's and their personally trained and supervised assistants. Each senior staff will continue to collect and analyze data first-hand throughout the project.

Criteria Used in Hypothesis Testing. Some of our criteria used for hypothesis testing are qualitative**:** e.g. that both energent vegetation (shade) habitats in connected marsh ponds, and invertebrate food resources, will be necessary (and that neither is sufficient, alone) for native fishes to colonize restored marshes. Subsequently, qualitatively similar replicate sites can be grouped. Other criteria are quantitative, for testing statistical differences among groups, via nonparametric statistics: e.g. that suitably restored marshes will tend to accrue increased habitat value through time, and exceed that of our historical reference marshes. A less conclusive, but useful, criterion may have to be based on intermediate probabililities (such as in weather forecasting), seeking merely increased probabilities of a successful population recruitment (analogous to Kitting and Morse 1998). Our hypothesized improvements in these restorations, through the process of adaptive management, would lead to productivities (export of zooplankton, zoobenthos, and fishes) greatly exceeding those in our reference and other Estuary marsh communities. Already, three of our four restored and reference marshes that have high animal abundances yielded herring or splittail populations over ~50x the maximum population densities reported in DFG monitoring (the latter, apparently in deeper water). We cannot yet confirm abundant delta smelt in our brackish water marshes, but new, lower-salinity marshes proposed should uncover relatively dense delta smelt marsh populations.

**c. Performance: Monitoring and Assessment Plans.** Comparative, multidisciplinary monitoring, compared with historical reference marshes, forms a major focus of the project. Our separate work on relatively pristine bays north and south will provide a yardstick to assess San Francisco Bay Estuary improvements on a broader scale, too. Our attached data sheet (near the document's end) notes of field monitoring components, as is included in our QA/QC monitoring plans on file with CALFED. Feedback from our quarterly CALFED reports, colleagues at scientific meetings, in our university course evaluations, and from our subsequent, peer-reviewed manuscripts all assess the clarity and completeness of our resulting products, including presentations. We and others have found that our monitoring will be adequate to determine the success of our restored marshes relative to CALFED goals (see section c :"Hypotheses being tested" in this proposal, for identification of our CALFED goals.) Emphasis will be placed on the monitoring of suitable habitats for CALFED priority fishes, particularly delta smelt and splittail, but including Chinook salmon (all runs), steelhead, and green and white sturgeon. Comparative monitoring will be an essential and integral part of these marsh restorations. Analysis of species colonization, migration and other environmental parameters will take place throughout the project. The monitoring and experimental design used to assess the outcome of the restorations will follow the scientific protocol of successful biological restoration work carried out elsewhere: Zedler's PERL and CRC handbooks, Hymanson and Kingma's Coastal Conservancy Handbook, or the recent SFEI CMARP website (http://www.iep.water.ca.gov/ cmarp/reports/).

Water quality monitoring will be conducted to determine how these restorations may improve water quality parameters important for drinking water quality, fish viability and suitability of fish for human consumption. Fish and invertebrate survival can be closely linked to dissolved oxygen (DO) levels (e.g. Sagasti et al. 2001). Factors affecting DO such as temperature, salinity, presence of nutrient anions (nitrate, phosphate) and particulate organic carbon will also be measured. Levels of toxic selenium, mercury, copper, cadmium and zinc also will be compared in sediment, plants and common resident fish species to determine whether bioavailability and biomagnification change during the restoration process.

Sample collection procedure protocols and quality control measures will be followed to ensure lack of contamination and accurate results. Sample containers will be acid washed, and all acid preservation and digestion will be done with trace metal grade acid. Field blank and trip blanks will be taken into the field, and duplicate samples will be taken. Digestion blanks, duplicates (1 per 10 samples) and spikes (1 per 10 samples) and standardized NIST samples will be included to ensure proper sample digestion. Analytical calibration ($R^2$ >.995) and blanks, spikes and replicates of each measurement will ensure proper analysis.

**d. Data Handling and Storage.** Data are logged directly into our standardized, initialed data tables in Microsoft Excel (see sample data sheet attached). Dept. of Fish and Game recently adopted such a format required for scientific permit reporting. Data are checked and analyzed/interpreted (and backed up, off campus) by the responsible PI: Kitting for physical factors, algae, and nekton (swimming animals), and an associate for plankton and epibenthos (small animals on bottom). Our data website (ftp://imctwo.csuhayward. edu/marsh) and our USFWS collaborators' websites (M\Data\SFB\WetRes\Plants\VegTI799.xls and M\Data\SFB\WetRes\Birds \Data\SBTI899.xls plus link) are used for posting such results on the internet, as requested.

**e. Expected Products/Outcomes.** We will submit quarterly reports and annual reports, in a scientific paper format, to the collaborating agencies throughout the project. If desired, our drafts of major reports are available in advance to these collaborators, for their comments. Results of our work are prepared and presented to agencies and major conferences, where our oral presentations will provide feedback from colleagues. We plan to publish our work in academic and applied journals. Reprints acknowledge the collaborating agencies as appropriate.

**f. Work Schedule.** *Project Start and Completion Dates* Project start date: September, 2002; Project completion date: by August, 2005, or earlier as contracted.
*Tasks.* (All four tasks are described in the budget appendices. A complete spreadsheet with details and matching is available. CALFED asked that only requested funds (and hours) be tabulated in the proposal forms (not extensive, matched hours by coPIs).

As in our previously funded CALFED Phase I, this work is comparative, and thus requires multiple types of replicate sites in each task. Additional separation of project tasks would require negotiation. Partial funding of a task would allow less frequent sampling. It is not possible to identify all project management as a separate task, as each senior scientist manages his/her specialty, as described in our table. Task 1 can be considered general project management, noted as required if any other task is funded.

**TIME LINE and SCHEDULE MILESTONES**

| Year 1 | | | | Year 2 | | | | Year 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| qrt 1 | qrt 2 | qrt 3 | qrt 4 | qrt 1 | qrt 2 | qrt 3 | qrt 4 | qrt 1 | qrt 2 | qrt 3 | qrt 4 |

**(Task One, administration and general reporting, throughout.)**

**Task 2. Marsh restoration and vegetation/connected marsh pond establishment during summer, yr 1. West Big Break permitting for future restorations. Benchmarks would be reports on project completions.**

**Task 3. Physical and biological monitoring and improvements and outreach, throughout. Benchmarks would be formal presentations and manuscripts.**

**Task 4. Water chemistry monitoring and improvements. Benchmarks would be formal presentations and manuscripts.**

**g. Feasibility.** *Demonstration of Project Feasibility*. We have proposed a work schedule and workload that can be completed in the time allotted, thanks to major matching funds from CSUH and CCMVCD. Based on the experience of the first phase of our project, the project approach for this second phase is similar to the first, and we have experienced very few disruptions in our monitoring schedule, laboratory work, data entry, and information dissemination through papers and meeting participation. In the second phase, we are undertaking several more sites that were *not* proposed in the first phase. Restorations and monitoring of these sites will require more time, but we have budgeted appropriately for this extra work. Our Phase I progress exceeded contracted requirements. Letters of support are available.

*Description of Methods*. Our methods are outlined in the "Approach" section of the proposal, above, as are the references to our scientific and technical procedures used (see Section I: References). Our mobile and floating laboratories, normally kept packed and ready, and their secure "hangar" (being rebuilt) make this intensive multidisciplinary field work practical. Weather has not been a major issue for completing our work in Phase I of our project, and we do not see any problems for Phase II. Alternative sites to restore nearby are available through our collaborators (especially CCMVCD), if necessary. For example, in the unlikely event that EBRPD might not reach the permitting stage, CCMVCD would be able to complete extra permitting nearby. We have planned other contingencies and requirements, such as permitting issues, to enable the prompt start and completion of Phase II of our project.

*Permits and Agreements Necessary for Project Implementation.* Our partner, CCMVCD, is experienced with permitting for restoration near these sites. Necessary permits and agreements are complete or in prep at all sites (see online form). An additional MOU. for manipulation of sensitive fish species is pending, which is not critical for the proposed work, but could allow additional mesocosms to manipulate delta smelt densities experimentally within the marshes, analogous to Kitting et al. (1997 and in prep) and tidal pond experiments with snapper in cages (Guerro-Tortolero et al. 1999) sustainable at our periodically observed, high fish densities. Other scientific permits are complete, and can be renewed.

*Private Property and Right of Access Issues.* All property and right of access issues have been approved, and are now in effect. Property managers are our partners. Other documents are noted in required proposal forms.

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

**1.ERP Goals and CVPIA Priorities.** This proposal targets solutions in all of the following ERP strategic goals: *Goal 1:* *At-Risk Species.* We are concentrating on the following species for life cycle stages and habitats: delta smelt, Sacramento splittail, white sturgeon, green sturgeon, and all runs of salmon. The habitats studied are shallow-water tidal marshes. Our work is focusing in particular on finding and minimizing local stressors associated with larval, juvenile, and adult stages of delta smelt and splittail, especially habitat salinity, temperature, and adequate food resources. Knowledge gained from our work in these shallow-water habitats is shedding light on the role of these features in the life cycle of the delta smelt and splittail, and can enlarge and improve habitats for these threatened species; _Goal 2:_ _Ecosystem Processes and Biotic Communities._ Our proposal and previous work directly addresses the rehabiliation of natural processes and biotic communities in the Estuary;. specifically, how we can improve our somewhat degraded "reference" marshes as well as restored marshes so as to improve habitat for endangered species, again for delta smelt and splittail, but for other important species such as salmon and salt-marsh harvest mice. Our proposal directly addresses productivity in shallow-water tidal marshes and how increased productivity, through marsh modification (connected ponds) and removal or modification of bottlenecks (gates, pipes, silt deposits) can benefit threatened species as well as the overall health of marshes and the general Estuary; _Goal 4: Habitats._ Marsh habitats worldwide are recognized as refugia and nurseries for larval and juvenile fish. We have shown certain of our tidal marshes to harbor juvenile and adult splittail, and dense Pacific herring (the latter two at extraordinarily high population densities) and other native species also concentrate in these marshes. Our proposal and previous work directly addresses the protection and functional restoration of shallow-water tidal marshes as areas of increased general productivity and as fish nurseries; _Goal 5:_ _Non-native Invasive Species (NIS)._ Shallow-water tidal marshes, like most Estuary habitats, have become homes for a variety of non-native invasive species, including plants (which can block channels and crowd out native plants), invertebrates (hydroids, mitten crabs, green crabs) and fishes (largely yellowfin goby and cameleon goby). Some of these introductions may be of neutral benefit (introduced copepods as fish food, having replaced native copepod species), while some are obviously destructive (hydroids capturing plankton and perhaps larval fish; introduced fishes consuming or otherwise displacing native species). We will address NIS goal II: limiting the spread, or when possible, eliminating local NIS populations through adaptive management. Hydroids can be deprived of much of their habitat (hard substrates associated with strong currents), and non-native fish species can be selectively removed locally during routine sampling procedures. _Goal 6: Sediment and Water Quality._ We propose to sample sediments, water, and organisms in selected restored and reference marshes for nutrients, carbon flux, and heavy metals, especially lead, mercury, and copper (critical in Shell Marsh, and apparently can repel fish migration; Goldstein et al. 1999). Toxicity levels will be related to other ecosystems to determine if threshold levels are exceeded, and if so, what effects heavy metals are having on higher trophic levels. Our comparisons of nutrients in and carbon flux through marshes will test for potential limitations in these marsh communities.

**2. Relationship to Other Ecosystem Restoration Projects**. Our overall aim is to systematically improve, monitor, and compare an array of paired reference and restored marshes throughout CALFED Ecological Zone 2, through the use of adaptive management. With CALFED ERP goals as guidelines, we seek to test conditions for increased populations of native threatened fish species, improve shallow-water marsh ecosystem processes through marsh modification, and improve general marsh habitat and microhabitat (after Holt, Kitting and Arnold 1983), reduce, as much as possible, the impact of non-native species, and determine the role of heavy metals or nutrients in increasing environmental stress in shallow-water marshes. Phase I of our project has begun this process, and has shown that many of our tidal marshes do harbor threatened larval and juvenile fish species (see attachment of our progress to date). We have begun to use our results to aid and advise other restoration efforts in this ecological zone, CALFED and otherwise, particularly with regard to methods of habitat improvement and sampling species non-destructively. We have worked successfully in this manner to continue with this phase of the project with the US Fish and Wildlife Service San Pablo Bay National Wildlife Refuge (North San Pablo Bay and Tubbs Island, with Contra Costa Mosquito and Vector Control (Shell Marsh, Pt Edith Marshes, Weapons Detachment Concord marshes), and with East Bay Parks (W Big Break marshes), all of whom have future restorations planned. Especially through our collaboration with SFEI's monitoring proposal, we would coordinate our methods and data with those additional SFEI monitoring sites, and sites studied by our partners, such as SPBNWR at Tolay Creek. We also have begun to coordinate our sampling and reporting with the Interagency Ecological Program, through Dept. Water Resources (e.g. Rees and Kitting 1999 through 2001). Our use of former military bases with relatively undisturbed buffer lands supports productive Base Conversion and new wildlands. Our participation in related local, national, and international meetings assists coordination with broader ecosystem restoration efforts.

**3. Requests for Next-Phase Funding.**. See the attached two-page summary of our existing project progress to date, plus Appendix tables. This proposal both continues and expands work performed in the first stage of the project.

**4. Previous Recipients of CALFED or CVPIA funding.** <u>Previous CALFED Project Title:</u> Biological Restoration and Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone: An Ecosystem Approach to Improve Effectiveness of Bay/Delta Restoration. <u>Previous (recent) CALFED Project No.</u> # 114209J018.
<u>*Current Project Status and Progress to Date*</u> (See Appendix: summary of our complete report)

**5. System-Wide Ecosystem Benefits**. <u>*Synergistic, System-Wide Ecosystem Benefits*</u>. Our project will improve shallow-water marsh ecosystem functioning throughout Ecological Zone 2. Improved shallow-water tidal marsh productivity and increase in populations of threatened fish species ultimately benefits productivity and threatened fish populations in the entire Estuary. Increased productivity in shallow-water marshes will also improve conditions for other non-aquatic marsh biota, such as waterfowl and other marsh-dependent birds (including clapper and other rails), and mammals (otters, beaver, salt-marsh harvest mice). Our project compliments marsh restoration efforts in the Napa and Petaluma Rivers, and Northern Marin County (similar habitats), and in southern Suisun Bay by working with Shell (McNabney) Marsh and its Marsh Management Advisory Committee, with Contra Costa Mosquito and Vector Control, and with Delta Science Center and EBRPD, eastward up Big Break, Marsh Creek, and Dutch Slough, planned for furure major restorations, with future habitats to be based partly on our findings.

## QUALIFICATIONS

### <u>Dr. Christopher L. Kitting, Professor of Biological Sciences, CSUH</u>

Professor Kitting earned his Biological Sciences Ph.D. in 1979 with a Stanford University Fellowship. Kitting currently serves on several review panels for environmental effects on aquatic organisms. Kitting serves on the Board of the San Francisco Bay Wildlife Society and Program Committee for the Delta Science Center. His collaborative work with Alameda County marsh construction recently earned an EPA National Excellence award. His subsequent work received nominations for outstanding professor awards and for an Environmental Achievement Award on the Delta. He was an invited speaker at three Regional Bay Vegetation Research Workshops, a 1991 Estuarine Research Symposium on Advances in Ecological Methods, and Conference for Educators at the California Academy of Sciences. He is a member of the American Fisheries Society, and Society of Ecological Restoration, ASLO, Ecological Society of America, and other groups. Recently he was acknowledged for assistance to the National Marine Estuary Program through Louisiana State University, and locally. He presents principles of limiting resources to undergraduate and graduate students in laboratory and field exercises, in grant reports, and at international research meetings. In his 25 major publications, most emphasize dynamics of vegetation effects on animal populations. Recent relevant examples: (1) Kitting, C.C. Ouverney, and F.Canabal. Small Fishes Concentrated During the First Five Years Outside an Experimental Wastewater Marsh in San Francisco Bay. Proc. Soc.Wetl.Sci.1994. DM Kent and JJ Zentner, Eds. pp. 90-103. (2) Kitting 1994. Shallow populations of small fishes in local eelgrass meadow food webs. Alameda Naval Air Station's Natural Resources and Base Closure. Audubon Society, Berkeley, CA pp 65-83. (3) Kitting 1996. Comparing naturally occurring population, as field bioassays of environmental health. in D.M. Kent and J. Zentner, Eds. Proc. Soc.Wetl.Sci. II. (80-83). (4) Kitting and D.E. Morse 1997. Feeding effects of postlarval red abalone, Haliotis rufescens (Mollusca: Gastropoda) on encrusting coralline algae. Molluscan Res. 18:183-196. (5) Kitting 2001. Pulmonate mollusca persisting in California Delta marshes with high tidal and physical/chemical extremes. Western Society of Malocologists Annual Report 43 (in press). (6) Kitting 2002. Marsh conditions associated with high population densities of patchy snails appearing in restored marshes of San Francisco Bay Estuary . Western Society of Malacologists Annual Report 44 (in press). (7) Evans, K.L. and Kitting (in review) Feeding activity and growth in freshwater sponges from the California Delta. (8) Ouverney, C.C. and Kitting. (for Bull. Environ.Contam.Toxicol.) Field Bioassays on Common Epibenthic Organisms Near a Treated Wastewater Marsh in South San Francisco Bay.

**Dr. Karl Malamud-Roam**, Contra Costa Mosquito and Vector Control, is Contra Costa Mosquito & Vector Control District's Principle Investigator**,** as CCMVCD's Marsh Restoration Specialist for over 9 years. He has designed and implemented eight tide marsh restoration and enhancement projects in the San Francisco Estuary, covering over 300 acres. He is the project manager for the million-dollar, 200-acre Shell Marsh Restoration Project. He is also Project Manager for the 2000-acre Point Edith Marsh Project, and has overseen implementation and evaluation of two pilot projects to date. Currently he is developing a natural resources inventory and integrated natural resources management and restoration plan for the latter site. Dr. Malamud-Roam earned his doctorate at UC-Berkeley, where his dissertation was on hydrology and ecology of muted-tidal marshes. His primary study sites are the marshes discussed in this proposal. He has a BA in Biology from Princeton University, an MA in Physical Geography from UC-Berkeley, and he is the author of one book chapter and four articles, all on the tidal hydrology and ecology of this area.

**Dr. Nadav Nur**, Point Reyes Bird Observatory, 4990 Shoreline Hwy, Stinson Beach, CA 94970 Dr. Nur is the Director of Population Ecology at Point Reyes Bird Observatory. He was Alexander von Humboldt Research Fellow, at the University of Tübingen from 1986-1987. From 1989 to the present Dr. Nur has served as the quantitative and population ecologist for the Point Reyes Bird Observatory. He is also an adjunct professor at San Francisco State University since 1998. Dr. Nur's research interests focus on population modeling, quantitative ecology and statistical analysis of landbirds, seabirds, shorebirds and marine mammals. He has been studying tidal marsh birds in the San Francisco Estuary since 1996, working at 50 marshes from Suisun Bay and the Delta to south San Francisco Bay. He has been a Principal Investigator (PI) or co-PI on over 20 grants awarded in the last 10 years from federal, state and private funding sources (including NSF, EPA, National Biological Service, US Fish & Wildlilfe Service, CA Dept. Fish & Game, and CALFED). Dr. Nur is author or co-author of over 50 scientific publications, including *A Statistical Guide to Data Analysis of Avian Monitoring Programs*, published in 1999 by the US Fish & Wildlife Service. He is lead author of the Population Viability Analysis incorporated into the draft Snowy Plover Recovery Plan and has served on two working groups of the CMARP arm of CALFED.

**Dr. Joy C. Andrews, Assistant Professor of Chemistry, CSUH**

Dr. Andrews, an environmental chemist, received her Ph. D. in Biophysical Chemistry at the University of California, Berkeley in 1995, funded by a University Fellowship and a CSU Doctoral Incentive award. She was a Postdoctoral Associate at Lawrence Berkeley National Lab in 1995-1996. Her role in this project will be to monitor the water quality of the restored and control marshes on an ongoing basis.

Dr. Andrews has taught water quality courses involving field studies, laboratory analyses and biological remediation at UC Berkeley and CSUH. She is currently supervising several graduate students in water quality analysis projects involving ion chromatography, atomic absorption spectroscopy and x-ray absorption spectroscopy, with studies in biological remediation of heavy metals, especially by plants.

While at LBNL, Dr. Andrews served on the Environmental Safety and Health Committee from 1992-1995, and won an Outstanding Graduate Instructor award in 1990. She has been a member of the American Chemical Society since 1988, with subdivision memberships in environmental chemistry and biological chemistry. Before entering the academic field she was employed at Environmental Analytical Laboratories in Richmond, CA specializing in heavy metals analysis of water, soil and air samples.

She has co-authored a book on water quality analysis, “The Chemistry of Water” (1997, University Science Books) as well as numerous papers in leading edge chemistry journals and conference proceedings on the analysis of metals, especially in plants. She has reviewed papers for Environmental Science and Technology; Water, Air and Soil Pollution; and has served on a review panel for the US EPA. Recent papers include

“X-ray Absorption Spectroscopy of Thiocrown Complexes Used in the Remediation of Mercury Contaminated Water”, by D. B. Bishop, G. D. McCool, A. J. Nelson, John G. Reynolds and **J. C. Andrews**; invited paper for *Microchemical Journal*, submitted for publication.

“Field, Laboratory and X-ray Absorption Spectroscopic Studies of Mercury Accumulation by Water Hyacinths”, by S. G. Riddle, H. H. Tran, J. G. DeWitt and **J. C. Andrews**, *Environmental Science and Technology,* in press.

“Field, Lab and X-ray Absorption Spectroscopic Studies of Mercury Absorbed by Water Hyacinths”, by **J. C. Andrews,** S. G. Riddle, H. H. Tran, C. Kitting, and J. G. DeWitt (2001) *American Chemical Society Division of Environmental Chemistry Preprints of Extended Abstracts 41(1)*, 452-457.

“Uptake of Mercury from Roots to Shoots of *Eichhornia crassipes* studied with Hg L3 XAS”, by S. G. Riddle, H. H. Tran, J. G. DeWitt, and **J. C. Andrews** (1999) Stanford Synchrotron Radiation Laboratory Activity Report.

"Nickel Speciation in Datura innoxia: A XANES Study", by E. Cooper, **J. C. Andrews**, and J. G. DeWitt (1999) Stanford Synchrotron Radiation Laboratory Activity Report.

## Collaborating Participants

Our six major collaborators from four agencies, including CSUH, are listed under “participants and collaborators” in the executive summary. Over 20 additional, significant collaborating assistants, working under these professionals on this project, are listed in our acknowledgements of our annual reports to CALFED (on file).

See Table 1 for the organization of the staff and resources for the proposed project.
We do not foresee any conflicts of interest or insurmountable problems to complete the work within the proposed timeline.

**Table 1. Organization of Staff and Resources for the Proposed Project.**

| Staff Member And Tasks | Technical Role | Administrative Role | Project Management Role |
|---|---|---|---|
| Chris Kitting and asst. (Tasks 1-4) | Field sampling; collection and entering of physical, algae, and fish data; its interpretation; report and paper preparation | Overseeing overall expenditures and bookkeeping | Overall Project PI. Also coordinating assistants and collaborators |
| Associate (e.g. K Evans) (Tasks 1-4) | Field sampling; collection, enumeration identification, of zooplankton and zoobenthos; their | Coordinating facilities | Overseeing student assistants and technician |

| | | | |
|---|---|---|---|
| | data entry and interpretation; report and paper preparation | | |
| Navad Nur | Coordinating bird sampling and reporting | Oversees related bird data | Oversees his assistants |
| Joy Andrews, Associate (Task 4) | Analysis of CHEMISTRY; data interpretation and preparation | | Overseeing student assistants |
| Karl Malamud-Roam (funded by CCMVCD directly) | Shell Marsh and Pt Edith area planning and connection of marsh ponds to restored channels | Overseeing expenditures and reporting for CCMVCD portion | Oversees Shell Marsh and Pt Edith area restorations and staff for plant monitoring there. |
| Cynthia Vinson or Successor (funded by indirect costs) | | Bookkeeping, billing, dispersing funds | |

**COST** (see forms) **1. Budget.** Designated for state or federal sources.
*Detailed and Summary Budget*. (See summary budget forms, and detailed budget in appendix).
*Budget Justification*. Our proposed **Phase Two** budgets are available in a Microsoft Excel "Workbook." The tables detail each of four tasks, for each year, plus summary (Yrs1+2+3). Tasks, categories, allocations, rates, and organization are based on our presently contracted budget, for Phase 1. Task One, General Project Management, is now separated, as CALFED requests. As in the past, our partner institutions have line items where appropriate. Funds requested from CALFED are in the appendix form. Additional funds from CSUH will match at least 3/4 of faculty academic salaries and benefits (fall, winter, spring), and will fund almost all expenses for new restoration classes proposed for our new Contra Costa Campus. Faculty salaries from the campus cover 3 of 4 quarters per year, so a faculty member must raise any funds for the fourth quarter, plus any release time from full-time teaching. Scientific and other permits require senior scientists present during biological sampling, which also has assisted quality control, safety, and public relations.

Moderately increased costs reflect this 2002 forecast, plus ~50% expanded effort and expenses for ~60% more restoration and ~100% more reference sites, compared with Phase One funding. Our proposed +- 15% reallocation among categories, if necessary, reflected our updated agreement in our present contract, to accommodate unforeseen expenses efficiently. As noted, no changes in total cost are proposed.

This proposal cycle is our final opportunity for funding, to enable the valuable comparisons and large-scale field experimental restorations (to add more tidal amplitude or marsh ponds to restorations) in Phase Two. Due to a change in CALFED funding cycles, and our rejected original proposal for Phase Two, a 12-month hiatus between Phase One and Phase Two will occur, allowing inexpensive, volunteered mesocosm experiments to simulate marsh pond effects, and prepare for successful restoration implementation as proposed. Phase One work and funding have been completed on schedule, with the final report completion, on schedule. The major budget request is in salaries, and each staff member has a major commitment to this project, as described in the required tables. The budget is consistent with university policy, including time released from classes (largely matched by the university), time paid during summer, and during academic breaks ("Article 36" of current faculty agreements). The California State University has pledged to close a salary gap between recent senior faculty salaries here, compared with comparable institutions nationwide. Because the resulting salary steps have become retroactive from the state (recently planned to be retroactive two years), each of these proposed salaries reflect the target amounts. Phase I salary budgets were adequate only because the PI was able to donate most of his sabbatical leave (during reduced state salary) to Phase 1. If the state eventually rejects these target amounts for academic year salaries, we propose that any salary excess be available for a new faculty member, who would then share the commitment to this project. Thus, the budget notes " associate" listed with faculty in the itemized budget. Assistants are noted with a range of salary, to reflect various degrees of expertise. Several of our graduate research assistants (e.g. H. Kingma, coauthor of a restoration monitoring handbook) are established professionals, although these state pay scales tend to remain low.

*Type of Extent of Travel.* All of our funded travel will be within the state of California, to restoration and monitoring sites, and to conferences within the state. Teams conduct approximately monthly trips to each pair of sites. Standard state rates are used for travel, normally in university vehicles charged at that rate. Some sites are accessible only by boat. Boat rates, established by CSUH Boat Committee, help cover the actual receipts for repairs, maintenance, supplies, and replacement equipment.

*Types of Supplies*. Mainly for field work (containers, boots, etc. and nets, damaged in shallows).

*Service Contracts.* None, other than repair costs anticipated in attached budget.

*Consultants and Organizations* Our partners described here have line items in our budget. CSUH Foundation again would be the contractor with CALFED. Marsh construction is accomplished directly by our partner, CCMVCD, who again is donating much of their their work in return for our proposed assistance in planning and monitoring (required for permits). Such partners bill the CSUH Foundation, where all partners are prepared to cover CALFED's 10% holdback until a task is complete, then fully reimbursed by CALFED via CSUH Foundation. Several thousand dollars in consulting funds are included for continued advise and confirmation of any difficult specimens, by J. Wang, S. McGinnis, and other authorities. L. Brown (USGS) also agreed kindly to review and advise our progress.

*Equipment Purchases.* Proposed Yr 1 has virtually all of the "equipment" purchases. Actual equipment would be for chemical analysis. Field "equipment" would have a limited life-span, underwater. After those initial purchases, funding would be spent steadily, then invoiced to CALFED, as scheduled for the 90% reimbursement until project/report completion.

The major equipment item is a microwave digestor, which would make the numerous orthophosphate and metal analyses efficient enough to compare the range of sites, as proposed. The university will share over half the cost. Equipment and other expenses, including expenses for remote labs for much of this work, as proposed, are justified in our methods sections, and in our report of present progress.

*Overhead Rate.* General office and laboratory function is covered in the overhead rate, along with accounting expenses and general administration. As noted on budget, CSUH has a state overhead rate of 25% of total direct costs (=20% of total grant costs.) As noted in budget, the CSUH federally negotiated rate for indirect costs would be 47% of salaries, wages, and benefits. (The latter comes out as the cheaper total request, in this case.)

*Project Management Task.* All of the senior staff noted are involved in project management. They ensure that work areas are complete, and inspect others' work in progress. Each PI is responsible for his/her area of expertise and reporting his/her part of required periodic reporting requirements. Project questions should be addressed to (1) Chris Kitting- scientific/technical questions; (2) Cynthia Vinson and/or Chris Kitting – budgets, costs, and financial allocation.

**2. Cost-Sharing.**

*Cost Sharing Arrangements.* As noted on budget, CSU Hayward will match much of the faculty release time from classes. It also will match a major equipment expense. Also during the project, Contra Costa Mosquito Vector Control District (CCMVCD) again will provide much of the restoration work described near Shell Marsh, Point Edith, and Edith East, at no extra cost to

CALFED. San Pablo Bay National Wildlife Refuge again will provide access to their restorations, and bird monitoring at Tubbs Island (with PRBO, who also will add comparisons of bird populations at our additional sites, via transects and point surveys seasonally).
Time of commitment of funds: steadily, though decreasing slightly throughout contract. Phasing in additional time by personnel helps balance initial restoration expenses and equipment purchases.

**LOCAL INVOLVEMENT.** Coordination with county and local governments. At each of our sites, land managers and neighbors are our partners in virtually every phase of the restoration to higher tidal action. This relationship holds even if most of the total expenses have been donated, rather than from CALFED. The land owners generally are the managers, except on state lands and Weapons Detachment Concord, used as reference sites, and managed by our partners at CCMVCD. We also are coordinating our program with SFEI, Point Reyes Bird Observatory , and Delta Science Center, particularly with current, related proposals by the Natural Heritage Institute and State Coastal Conservancy for Marsh Creek Restoration (E Big Brk) and DWR on a feasibility study of benefits of restoration activities in Franks Tract, West Big Break, Dutch Slough, and Lower Sherman Lake.

Our project partners in restoration have all neighboring landowner issues under control, for these restorations. US Fish and Wildlife Service has taken care of all permits and local concerns at Tubbs Island. CCMVCD has handled all permitting at our marsh restorations at south Suisun Bay. Colleagues at East Bay Regional Park District anticipated these fiscal needs for permitting future restorations near Antioch (adjacent to our newly proposed reference sites, where we would provide necessary aquatic data). If their Board finds those funds unnecessary, CCMVCD would propose to use those funds for analogous permitting and restorations slightly westward. We have partnered with neighbors to avoid third-party negative impacts.

*Public Outreach; Groups and Individuals affected by the Project.*
Following agency approvals of our progress reports, we would continue public presentations largely through the university, such as at our recent Science Festival program and new Delta classes for graduate students and visiting teachers. We share information with USF&WS and DFG (local fish monitoring, out of the Stockton office), IEP, and San Francisco Estuary Institute. Activities of all these programs/agencies/ organizations are compatible with CALFED objectives, and may become more collaborative through expanding our very useful Marsh Management Committee, begun at Shell (McNabney) Marsh with our colleagues at Mt. View Sanitary District, nearby.

## COMPLIANCE WITH STANDARD TERMS AND CONDITIONS

Our group of colleagues, organizations, and other associates will comply with all state and federal standard terms. Those terms are consistent with State University policy. We have reviewed all terms contained in Attachments (PSP). As a state agency, not all attachments apply in our case, until a new contract will require the interagency agreements, as are in place in our recent contract. Environmental compliance is completed or in progress, as in recent phase one for adjacent land, under jurisdiction of our same partners. Reporting, electronically, would be as quarterly and annual reports, each with physical, biological, and fiscal data and summaries of results. Abstracts from our presentations at management and scientific meetings would summarize findings. Major annual and final reports would include manuscripts suitable for journal publication. After CALFED review, they would be revised as necessary, and submitted to journals.

**I. Literature Cited**

Brown, L. and R. Sitts, 1999. The third delta smelt workshop. IEP Newsletter 12(1): 40-43

Carpenter, S. R., and K. L. Cottingham. 1997. Resilience and restoration of lakes. Conservation Ecology. **1**(1): 2. Available from the Internet. URL: http://www.consecol.org/vol1/iss1/art2

Goldstein, J.N., D.f. Woodward, and A.M. Farag 1999. Movements of Adult Chinook salmon during spawning migration in a metals-contaminated system, Coeur d' Alene River, Idaho. ." Transactions of the American Fisheries Society 128: 121-129.

Guerro-Tortolero et al. 1999. Preliminary study on the effect of stocking density on the growth and survival of the yellow snapper Lutjanus argentiventris confined in cages in a tidal pond. N Am J of Aquaculture 61: 82-84.

Holt, S.A., C.L. Kitting, and C.R. Arnold 1983. Distribution of postlarval redfish in an array of structurally different seagrass meadows." Transactions of the American Fisheries Society 112: 267-271.

Huh, S.H. and C.L. Kitting 1985. Trophic relationships among concentrated populations of small fishes in seagrass meadows. Journal of Experimental Marine Biology and Ecology 91: 29-43.

Hymanson, Z. P. and H. Kingma-Rymek 1995. Procedural guidance for evaluating wetland mitigation projects in California's coastal zone. California Coastal Commission. 131 pp +appen.

Jassby, AD and JE Cloern. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation: Marine and Freshwater Esosystems 10(5): 323-352.

Kitting, C.L., B. Fry, and M.D. Morgan "Detection of Inconspicuous Epiphytic Algae Supporting Food Webs in Seagrass Meadows." Oecologia 62 (1984), 145-149.

Kitting, C. 1993. Environmental Experimental Analysis. Non-destructive Ecological Sampling Methods in San Francisco Bay Area Communities. Class Manual. 28 pp plus appendices.

Kitting, C.L. , C.C. Ouverney, and F.Canabal. 1994. Small fishes concentrated during the first five years outside an experimental wastewater marsh in San Francisco Bay. Proc. Soc. Wetl. Sci. DM Kent and JJ Zentner, Eds. pp. 90-103.

Kitting, C.L. and D.E. Morse 1997. Feeding effects of postlarval red abalone, Haliotis rufescens (Mollusca: Gastropoda) on encrusting coralline algae. Molluscan Res. 18: 183-196.

*Kitting, script editing and narration. "Its Sloughpendous!" A video production for Wetland Field Trips for schools, Don Edwards San Francisco Bay National Wildlife Refuge. SF Bay Wildlife Society. 1999. 20 minutes.

Kitting 2001. Final Report on Ecosystem Restorations and Multidisciplinary Monitoring in San Pablo Bay/ Suisun Bay Marsh Ecological Zone. Final Report to CALFED/USFWS.

Kitting 2002. Marsh conditions associated with high population densities of patchy snails appearing in restored marshes of San Francisco Bay Estuary . Western Society of Malacologists Annual Report 44 (in press).

Miltner, R. J., S.W. Ross, and M.H. Posey 1995. Distribution of juvenile spot (Leiostomus xanthurus) in tidal nurseries. Canadian Journal of Fisheries and Aquatic Sciences 52: 971-982.

Morgan, M.D. and C.L. Kitting 1984. Productivity and utilization of the seagrass Halodule wrightii and its attached epiphytes. Limnology and Oceanography 29: 1066-1076.

Rees, J. and C. Kitting. 2001. Survey of Gelatinous Zooplankton ("Jellyfish") in the San Francisco Estuary: Annotated Species Checklist, Historical Records, and Initial Field Survey. (In press, IEP Technical Report.)

Ogden, J.C., and S.M. Davis, editors**.** 1994. Everglades: the ecosystem and its restoration*.* St. Lucie Press, Del Ray, Florida, USA. Also on internet URL: http://everglades.fiu.edu/taskforce/progress/index.html

Onuf, C.P. M.L. Quammen, G.P. Shaffer, C.H. Peterson, J.W. Chapman, J. Cermak, and R.W. Holmes. 1978. An analysis of the values of central and southern California coastal wetlands. Pp. 186-199 in P.E. Greeson, J.E. Clark, and J.E. Clark, eds. Wetland Functions and Values: The State of our Understanding. American Water Resources Association. Minneapolis, Minnesota.

Sagasti, A , lc schaffner, j. E. Duffy. 2001. Effects of periodic hypoxia on mortality, feeding and predation in an estuarine epifaunal community, JExpMar Biol Eco 258. P257-283.

Schindler, D.W. 1998. Sustaining aquatic ecosystems in boreal regions. Conservation Ecology. **2**(2): 18. Available from the Internet. URL: http://www.consecol.org/vol2/iss2/art18

Schubel, J. R. 1991. On the development of the scientific basis for an estuarine standard for managing freshwater discharge to the San Francisco Bay/Delta Estuary. Testimony of J. R. Schubel. Marine Sciences Research Center, to the California State Water Resources Control Board. 20 pp.

Sommer, T. B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel. 2001. California's Yolo bypass: Evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26: 6-16.

van Montfrans, J., R.J. Orth, and S.A. Vay. 1982, Preliminary studies on grazing by Bittium varium on eelgrass periphyton. Aquat. Bot. 14: 75-89.

Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology 1(2):1. Available from the Internet. URL: http://www.consecol.org/vol1/iss2/art1

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.

Wetzel, R.G. 1975. Limnology. W.B. Saunders Co. Philadelphia. 743 pp.

Zedler et al. -Pacific Estuarine Research Laboratory. 1990. A manual for assessing restored and natural coastal wetlands with examples from southern California. California Sea Grant Report No. T-CSGCP-021. La Jolla, CA.

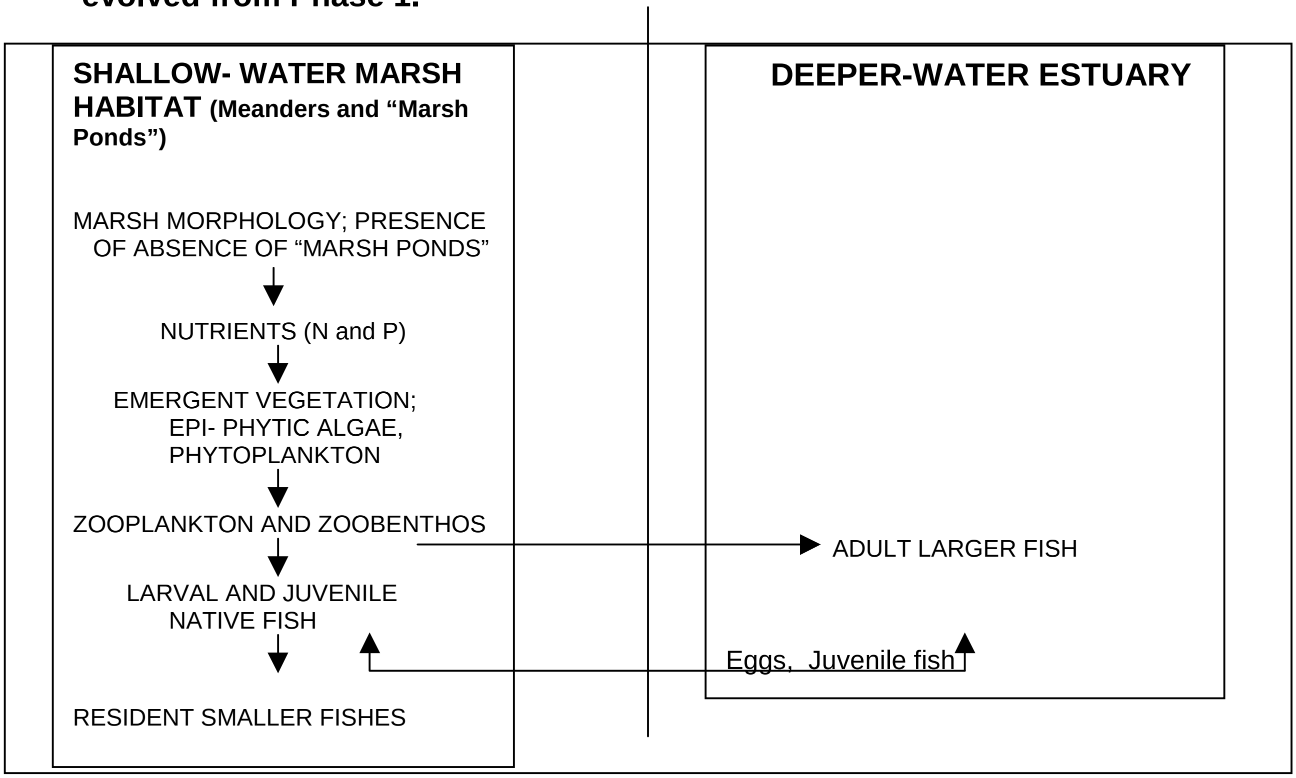
*Required documents are in forms, as instructed.*

Table _. Full Digital Geographic Coordinates of Project's multiple Sites: (NAD 83, and see maps below):

| Site | Action | N edge | S Edge | W Edge | E Edge |
|---|---|---|---|---|---|
| Tubbs Island | Increase Tide Action and connected marsh ponds | N38deg 7.63' | N38deg 7.02' | W122deg 27.00' | W122deg 25.95' |
| Tolay Crk | Stabilize erosion | N38deg 09' | N38deg 7.02' | W122deg 27.02' | W122deg 26.0' |
| Shell/ McNabney Marsh | Increase Tide Action and marsh ponds | N38deg 1.95' | N38deg 1.15' | W122deg 6.83' | W122deg 5.55' |
| Pt Edith | Connect Marsh Ponds | N38deg 3.17' | N38deg 2.90' | W122deg 4.11' | W122deg 3.98' |
| Edith East | Major marsh pond to attach to channel: (e.g. location) | N38deg 2.61' | N38deg 2.30' | W122deg 4.1' | W122deg 3.90' |
| W Big Break | Reference Sites/ RestorationPermit prep | N38deg 0.75' | N38deg 0.53' | W121deg 44' | W121deg 43.6' |

**Geographic Coordiates of Project Sites Center Points** ***table on form, and map is in appendix***

**APPENDIX. FIGURE 1. OUR CENTRAL, BASIC CONCEPTUAL MODEL, evolved from Phase 1.**




## APPENDIX II. Phase I PROJECT PROGRESS AND STATUS

(*CALFED* Coop Agreement # 114209J018.)

*Project Description*. Our Phase 1 project began to identify and improve those factors (including physical, chemical, geomorphic, and biological) which were limiting in tidal marsh restoration efforts in the North Bay/Suisun Bay Ecological Zone (CALFED Management Zone 2) of the San Francisco Estuary, particularly those that limited native fish populations. We with our collaborators at US Fish and Wildlife Service Refuge in North San Pablo Bay (Tubbs Island), and Contra Costa Mosquito and Vector Control District in Southern Suisun Bay (Pt Edith area, McNabney/Shell Marsh. Together, we restored increased tidal action to shores and monitored and compared these restored and reference marshes (see attached data sheet for items monitored). We advised and assisted our collaborators on improving restoration and maintenance/ management of marshes to increase invertebrate and native fish populations, create nurseries for native migratory fishes, and through this adaptive management, detect and correct ecological limiting factors or "bottlenecks," both in marshes being restored and reference sites (degraded pre-restoration sites, or relatively natural marshes).

*Scientific Merit of the Project.* Our major hypothesis, that relatively pristine reference marshes would tend to have higher population densities of fishes and invertebrates than in analogous restored marshes, we clearly rejected thus far. Our various histical marshes to date have quite consistently shown relatively few fishes and invertebrates. A diagrammatic**,** updated conceptual model of our project is shown in Figure 1 (attached). In theory, each trophic level passes the necessary nutrients and energy to the next level, producing a "healthy" shallow-water marsh habitat, with sufficient nutrients present for primary productivity, and with a healthy primary and secondary (zooplankton and zoobenthos) productivity in place to ensure food for both resident fishes, and for larval and juvenile fish whose adults inhabit the deeper water areas of the estuary. As energy passes from one level to the next, other limiting factors may come into play, such as flow and channel dynamics. All these factors, as appropriate, are included for observation, study, and change or modification through adaptive management. Phase I suggested the direct or indirect importance of connected marsh ponds here (Kitting 2001, 2002), while moderate algae from marsh ponds may be a more direct effect (after Van Montfrans et al. 1982, Kitting et al. 1984).

Current Status of the Project. Completed. Our four sets of shallow-water marsh habitat sites, plus an additional deeper reference site added later (and not formally funded), spanned an array of mesohaline to oligohaline environmental conditions in CALFED Ecological Zone 2. During February-April, 2000, as we have reported to CALFED, USF&WS, and DFG, we detected relatively large population densities of our target fish species, delta smelt and splittail. *Delta smelt:* We sampled (and released live) numerous juvenile Pacific herring at the north San Pablo Bay (Tubbs Is.) in spring 2000 and 2001. This site was restored one year earlier to somewhat higher tidal action (although excavations are now silting in). Systematic, short-distance plankton tows detected ~20-mm-long herring juveniles at ~8/$m^3$ and <~15-mm-long postlarvae at ~32/$m^3$. These herring appeared in February- April for at least several weeks in upper and lower sites in the "muted marsh" on Tubbs Island, North San Pablo Bay. We also found them present, but less common, at two or our three analogous sites, only. All these sites are very shallow water (~1 m at high tide). In March-April, 1999, DFG detected numerous delta smelt juveniles (~20mm long) in the nearby Napa River, while our Tubbs Island marsh sampling yielded only ~1 individual at that time (along with higher zooplankton densities than in March, 2000). We also have been removing (and apparently reducing numbers of) a large population of invasive yellowfin goby at Tubbs Island and in other marshes. This introduced species is a potential predator on fish larvae and juveniles. Our Y2000 population densities (~8/$m^3$) of ~20mm-long herring juveniles at Tubbs I., ascertained with non-destructive methods, apparently exceed by >500X the maximum densities reported in DFG's Bay/Delta sampling for juvenile fishes (DFG sampled in more open, deeper water). We also sampled (and released) several herring postlarvae at our previously restored Weapons Detachment Concord site in March, 2000. *Splittail:* Near Concord in Suisun Bay, we trawled (then released) five adult splittail (per 500 $m^3$), and three other fish species, in our deeper reference site (a 2m-deep slough, at a creek mouth), and one adult splittail (plus one other species, per 500 $m^3$) in a 3-m deep slough, just outside our restored sites. Our routine fyke netting also revealed splittail at two of our three marshes with ponds: one juvenile splittail at our North San Pablo Bay site (at Tubbs Island), which had received increased tidal action one year earlier) plus five adult splittail at one of our Concord marshes (with muted tides and marsh ponds along the channel). As with larval fishes, our adult splittail population densities exceed previous data by ~50X (including data for juveniles). We are continually integrating and interpreting our other monitored data, including physical data, zooplankton and zoobenthos, and heavy metals data, related to our targeted fishes, their food webs, and habitats. For example, to date, marshes with higher densities of zooplankton and zoobenthos also have shown higher fish total populations, and one marsh with a large ponded, shallow-water expanse (Shell Marsh) has the highest animal population densities and diversities among all our marshes (including bird populations and species), although this marsh also has a high level of nutrient input (originating from birds *and* reclaimed water flow from a nearby treatment plant and marsh). Some reference and restored sites sampled, particularly those without ponds along channels, have yielded virtually no plankton or native fishes in our comparative sampling. Also, in our metals sampling and analysis program (previouslyt funded at only one site), analyses of animal tissue have shown concentrations of mercury at marginally high levels (7 ppm) in adult

mitten crab and yellowfin gobies sampled from northern San Pablo Bay marsh, even though the marsh sediments and water do not show correspondingly high levels of metals, including mercury. These animals may be migrating through other, mercury-contaminated regions, or biomagnifying metals up the food web. We found that some of our sites have unusually low mercury concentrations, as they have been dyked for >100 yrs, since mercury increased after the gold rush in the estuary itself. Thus, those restorations can be relatively low in such contaminants.
*Current Status of Project, Accomplishments to Date, Information Generated.* The project is proceeded as planned. See CALFED accomplishments to data (Table 2, attached). A list of our major findings and resulting actions (improved restorations) is attached in the appendix, with partial bibliography, and a table of fishes (ranked by population densities) we detected in our restored marshes.
*Fiscal Status, Regulatory Issues*. Fiscally, our project proceeded as planned. In 1999, we had to increase tidal amplitude at an alternative Tubbs Island site, just west of where originally planned, to allow time to manage salt marsh harvest mouse populations prior to restoration of tidal action.
*Data Collection and Monitoring Program.* Data collected by each PI was entered into a Microsoft Excel datasheet. Monitoring and data analysis was the heart of our program (see sample data sheet attached). We present our results in team meetings, to local agencies, in CALFED quarterly and annual reports, and at scientific meetings. After partner and CALFED approvals or comments in our quarterly reports, more manuscripts based on this material will be submitted for publication in the refereed scientific and habitat management literature. Following this review and approval process, our first papers to come out have been in primarily rapid journals. Manuscripts are submitted to major journals, with our other manuscripts in review with our recent CALFED final report.

**Biological Restoration and Monitoring**
**in the Suisun Marsh/North San Francisco Bay Ecological Zone:**
**an Ecosystem Approach to Improve Effectiveness of Bay/Delta Restoration.** Proposal # 98-C1042. Agreement # 114209J018.
Photographs of marsh construction and resulting communities are at the end of the document.

**Partial bibliography** (>32 different formal papers recently) for other formal CALFED progress thus far by Cal State University Hayward, acknowledging this CALFED program (thus far, during this 2.7 yr project, not including numerous marsh management meeting presentations): Presentations included Partner, USFWS, and CALFED logos for an oral acknowledgement. -each meeting presentation had a different printed abstract, included in CALFED qtrly rpts. * denotes major contributions. More related journal manuscripts are waiting CALFED review. Our collaborators' additional Ph.D. Dissertation and three conference presentations, plus a report on this project, also are listed here, with author affiliation.

First, numerous printed products directly from this work, thus far:

* Andrews, J.C., S. G. Riddle, H. H. Tran, C. Kitting, J. G. DeWitt . 2001. "Field, Lab and X-ray Absorption Spectroscopic Studies of Mercury Absorbed by Water Hyacinths." Division of Environmental Chemistry Preprints of Extended Abstracts 41(1), 452-457.

Davis, C. (in prep) COMPARING ZOOPLANKTON ABUNDANCE AND MOLLUSC RECRUITMENT AMONG RESTORED AND REFERENCE MARSHES IN THE UPPER SAN FRANCISCO BAY ESTUARY, CENTRAL CALIFORNIA. M.S. Thesis, Biol. Sci. CSUH.(see chapter abstract here.)

Diego, C., M. Sugiura, S.G. Riddle, J.C. Andrews. Heavy in the Tubbs Island Restoration Area. Abstract for the American Chemical Society National Meeting, San Francisco, April, 2000, with poster presentations also at CSUH and at the Am Chem Soc Student Research Conference in May, 2000.

Gill, E. and C. Kitting. 2001. Comparisons of Sedimentation Rates and Water Clarity in Historical and Restored Marshes of Upper San Francisco Bay Estuary. Western Societuy of Naturalists Annual Conference. Abstracts. (Ventura, CA 11/01)

Gill, E. (in early prep) Effects of Sedimentation on abundances of Aquatic Animals in Historic and Restored Marshes of Upper San Francisco Bay Estuary. M.S. Thesis, Special Major (Shoreline Processes), CSUH. (First abstract from thesis is below.)

Kitting, C.L. 1999. small fishes and their foods, compared among restored and reference marshes in northern San Francisco Bay. Western Society of Naturalists Abstract. Monterey, CA 12/27/99

* Kitting, C.L. 7/2000. Pulmonate mollusca persisting in California Delta marshes with high tidal and physical/chemical extremes. Oral presentation. American Malacological Society / Western Society of Malocologists Annual Conference & extended abstract in the WSM Annual Report. Vol. 33, 2001.

Kitting, C.L. 8/ 2000. Epibenthic animal colonization of restored and reference marshes in San Francisco Estuary, California. for Millennium International Wetlands Conference, Quebec, with Society of Wetlands Scientists, and others.

Kitting C. , 10/2000. Physical and biological environment of dense herring and splittail populations in upper San Francisco Estuary Marshes. CALFED conference Oral Presentation , Sacramento.

Kitting et al., 10/2000. ECOLOGICAL COMPARISONS OF FOUR MARSHES NEAR SUISUN BAY, RESTORED TO INCREASED TIDE ACTION, AND REFERENCE MARSHES. CALFED conference Poster Presentation , Sacramento.

Kitting, C. 3/2001. Multidisciplinary environmental comparisons with fish abundance among six marshes in the northern San Francisco Bay Estuary. American Fisheries Society Western Conference, Santa Rosa.

Kitting, C. 11/ 2001. MULTIDISCIPLINARY ENVIRONMENTAL COMPARISONS WITH AQUATIC ANIMAL ABUNDANCES AMONG WETLANDS IN SAN FRANCISCO

ESTUARY, CALIFORNIA.  Estuarine Research Federation Mtg. (Conference Address)  St. Petersburg, Florida

* Kitting, C.  2002. Marsh conditions associated with high population densities of unusual snails appearing in certain restored marshes of San Francisco Bay Estuary. Western Society of Malacologists Annual Report Vol. 44.  D. Earnisse, Ed. (in press)

Kitting, C. and S. Webster.  6/2001.  Marsh conditions associated with high population densities of patchy snails appearing in restored marshes of San Francisco Bay Estuary . Western Society of Malacologists Annual Conference, San Diego.

* Koehler, J.  (in prep)  Comparisons of Fish Abundances at Several Restored Tidal Marshes in the San Francisco Estuary.  Biol. Sci. MS Thesis, CSUH.

McGinnis, S.  and J. Koehler.  10/'01   The Use of restored and partially restored brackish water tidal marshes by native and introduced fishes.  State of the SF Estuary submitted abstract.  San Francisco.

Webster, S. C. Kitting, and J. Norton.  10/'01 poster.  STATISTICAL COMPARISONS OF PHYSICAL FACTORS,  ASSOCIATED MARSH ZOOPLANTON, AND  SMALL NEKTON COMMON IN RESTORED MARSH HABITATS THROUGHOUT THE UPPER SAN FRANCISCO BAY ESTUARY.   State of the Estuary Conference.   San Francisco.

* Webster, S. (in prep)  STATISTICAL COMPARISONS OF PHYSICAL FACTORS, ASSOCIATED MARSH ZOOPLANTON, AND  SMALL NEKTON COMMON IN RESTORED MARSH HABITATS THROUGHOUT THE UPPER SAN FRANCISCO BAY ESTUARY.    Masters Thesis.  Environmental Statistics Special Major, Cal State U. Hayward.

+Wood, J.,  H. Spautz, and N. Nur, with L. Vicencio.  2000.  Avian Monitoring for lower Tubbs Restoration Project, San Pablo Bay National Wildlife Refuge.
Annual and Final Reports.

Related progress from CSUH, in support of this CALFED project, also acknowledging CALFED:

*Evans, K. L. 2000.  Aquatic Filtering by Delta Sponges. M.S. Thesis, Cal State U Hayward Biol Sci.

* Evans, K.L. and C.L. Kitting.  2001. Particle feeding and growth in freshwater sponges discovered in the outer California Delta. (submitted for publication)

Rees, J.T.  and C.L. Kitting.  1999.  Pilot survey of gelatinous zooplankton in the San Francisco Estuary.   Interagency Ecological Program Newsletter (and website)12(3): 4-5.
(website: www.iep.ca.gov/report/newsletter/1999summer/body.html)

* Rees, J. T. 1999  Non-indigenous jellyfish in the Upper San Francisco Estuary: Potential impact on zooplankton and fish. IEP Newsletter 12(3):46-50

* Rees, J. T. and C. L. Kitting. 2000. Seasonal comparison of introduced gelatinous zooplankton from San Francisco Bay to the Delta. IEP Newsletter 13(1):9-10.

* Rees, J. T. and L. A. Gershwin, (2000). Non-indigneous hydromedusae in California's upper San Francisco Estuary: life cycles, distribution, and potential environmental impacts. Sciencia Marina 64 (suppl): 73-86.

* Rees, J. and C. Kitting. 2001. Survey of Gelatinous Zooplankton ("Jellyfish") in the San Francisco Estuary: Annotated Species Checklist, Historical Records, and Initial Field Survey. (IEP Technical Report, in press.)

* RIDDLE, S.G., H. H. TRAN, J. G. DEWITT, and J. C. ANDREWS. 2000. Field, Lab and X-ray Absorption Spectroscopic Studies of Mercury Accumulation by Water Hyacinths. Environmental Science and Technology, in press.

Sugiura, M. , J.D. Wilson, J.C. Andrews. 10/00. HEAVY METALS IN THE SHELL MARSH NEAR MARTINEZ, CALIFORNIA. American Chemical Society Western Regional Meeting.

* Sugiura, Masahiko. (in prep for Aug '01). "Ion Chromatography and X-ray Absorption Spectroscopy Studies of Acid Mine Drainage" . MS Thesis, CSUH Dept. of Chemistry.

* Tran, Huy Huu , March, 2001. MERCURY UPTAKE BY WATER HYACINTH (EICHHORNIA CRASSIPES) FROM THE SAN JOAQUIN RIVER. University Master of Science Thesis, California State Univ Hayward, Department of Biological Sciences.

Generally related to this project:

* Malamud-Roam, Karl. 2000. Tidal Regimes and Tide Marsh Hydroperiod in the San Francisco Estuary: Theory and Implications for Ecological Restoration. Ph.D. dissertation, Geography, UC-Berkeley, 850pp + 238 figs. (Abstract is at the end of this CALFED report.)

* "Mercury Bioaccumulation in Corbicula fluminea Associated with Water Hyacinth Beds" by James Donald Lenzen III, December 1999. MS Thesis, Biol Sci., CSUH

* "Microhabitats associated with endangered saltmarsh harvest mice following marsh restoration." by Hope Kingma, in prep. MS Thesis, Biol. Sci., CSUH

* "Animal colonization of a restored freshwater marsh." by S. Lee Miles, in prep. MA Thesis, Environmental Studies, CSUH

*"Its Sloughpendous!" A video production for Wetland Roundup Field Trips, Don Edwards San Francisco Bay National Wildlife Refuge. SF Bay Wildlife Society. 1999. 20 minutes. C. Kitting, script editing.and narration.

## Appendix Table _2_. Results from Phase 1, cont.

Some of the Major Findings and Actions during our Phase 1, 2.5-yr CALFED PROJECT: Comparative monitoring of tidal brackish-water marshes. (Most results have been noted previously in our quarterly CALFED reports, and presented at various agency meetings.)

X indicates that the finding or action directly effects selected CALFED goals or concerns

| Finding and Action | Restoration | Monitoring | Species of Concern | Contami-nants | Introduced Species | Fish Food Resources |
|---|---|---|---|---|---|---|
| 1. Innovative logistics and sampling gear for sampling physical and biological features of sites makes detailed, non-destructive comparative data acquisition more efficient and practical. | | **X** | | | | |
| 2. Flood Control Structure's debris screen was modified to allow fish to pass. More sections are proposed to be redesigned or removed. | **X** | | **X** | | | |
| 3. Winter rainfall following saltmarsh restoration yields colonization by more salt-tolerant native plants, with more invasive plants colonizing after a dry initial winter (based on CCMVCD team, Malamud-Roam and Hanson). | **X** | | | | **X** | |
| 4. Invasive plants begin colonizing restorations in a small enough patch to eradicate, until native vegetation can become established (based on CCMVCD team). Hydrology may control some invasives. | **X** | | | | **X** | |
| 5. Stinging estuarine hydroids, apparently introduced and harmful to small aquatic animals, overgrow various structures near swift currents, such as large pipes through levees. Hydroids are being removed frequently, pipes were replaced, but hydroids recolonize rapidly. Minimizing surface areas of structures, and using larger marsh openings (less current, less surface-to-volume ratio) may decrease the hydroid problem. | **X** | **X** | | | **X** | **X** |
| 6. Stinging jellyfish in brackish water, two to three invasive spp from the Black Sea, described in Rees and Kitting (2001), occur in SF Estuary during late summer through early fall, and become very common in open water, but rarely invade local marshes. Marshes may tear jellyfish gelatinous tissues, and destroy these small (< ~3cm) jellyfish. | **X** | **X** | **X** | | **X** | **X** |
| 7. Sediments accumulate largely from sediment flow along the bottom, rather than from settlement. Thus, marsh openings to the bay should be enlarged where sediments are less likely to flow back. Any sediment removal must be widespread enough to prevent rapid sediment from sloughing back. | **X** | | | **X** | | |
| 8. Low metal contamination occurred in water and sediments of both marshes tested; Yellowfin goby and mitten crabs showed higher levels of contaminants. | | | **X** | **X** | | **X** |
| 9. Summer fish kills were detected at both poorly circulated marsh sites (low tidal amplitude, pre- | **X** | **X** | **X** | | | **X** |

| | | | | | | |
|---|---|---|---|---|---|---|
| restoration), so we arranged to open channels. Fishes appear to be recovering slowly, with increased tidal flux. | | | | | | |
| 10. At a eutrophic site (from #9) isolated from tide action, we allowed more tidal action past contaminated sediments; because contaminants did not increase in the marsh nearby. More flow and metals monitoring is proposed. | **X** | | | **X** | | |
| 11. We relieved channel blockage at vulnerable petroleum pipes, covered with cattails, by opening suddenly a tide gate at high tide, using the water pressure to burst through and erode out some of the plants. | | | | | | |
| 12. Aquatic animals, including adult splittail and juvenile herring, are rarer in reference (relatively natural) or restored marshes unless marsh "ponds," attached to the tidal channels, are present. We propose to connect currently isolated ponds to recently restored (and natural) channels (this proposal). | **X** | **X** | **X** | | | **X** |
| 13. Minnow trap samplers on the bottom can accumulate many yellowfin goby (and small cameleon goby, native sculpin, invertebrates, etc.) live, but population densities of gobies may begin to be depleted after a year of monthly yellowfin goby removal, at least where tidal migration brings them into contact with our live fish traps. | | **X** | | | **X** | |
| 14. We found juvenile herring on incoming and outgoing tides throughout one of our two rich marshes at 5ppt salinity during February-March, reaching very high densities; these fish taken in our routine, non-destructive, small-scale plankton samples, one year after increased tidal amplitude and yellowfin goby removal. The presence of juvenile herring both outside and inside the marsh suggest that the of *mouths* of tidal creeks, along with quiet bay inlets, are important habitats for these fish. Intensive monitoring at these locales vs. elsewhere suggests conditions attractive to herringt larvae. | **X** | **X** | **X** | | | |
| 15. Adult splittail have been found in deeper water (2-3 m), so deeper marsh channels are proposed. | **X** | **X** | **X** | | | |
| 16. Otters and beaver were discover and frequently observed at our Suisun Bay sites, plus additional muskrat and turtles at one site (McNabney Marsh, Martinez). The latter is our only eutrophic site, thus far. A beaver lodge elsewhere apparently blocked a restored tidal creek recently. The creek is proposed here to be re-routed (through a nearby, isolated pond, with wiers to maintain the pond. Frogs also are heard near most of our marshes despite the brackish water. | **X** | **X** | | | | |
| 17. Patches of unusually tall pickleweed were detected at a pre-restoration site. The pickleweed will be salvaged (and placed on nearby, new levee intertidally) before levee setback and new shoreline marsh restoration. | **X** | | | | | |
| 18. Unusually dense populations of salt marsh harvest mouse were detected before restoration to tidal action at a restoration site in North San Pablo | **X** | **X** | **X** | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Bay. (based on McGinnis monitoring.) Levee breach will be gradual, at night, with new intertidal habitat provided in advance, in case it is necessary to improve migration ability of the salt marsh harvest mouse population. | | | | | | |
| 19. Bird populations in a pre-restoration area are less abundant and diverse than in adjacent marshes restored to higher tide action (based on SPBNWR joint monitoring staff, Vicencio and Eagan). | **X** | **X** | | | | |

**Appendix Table _3_. <u>North San Francisco Bay / Outer Delta Marsh Sites: Major Species of Small (and juvenile) Fishes, in approximate order of abundance in CSUH CALFED marsh monitoring:</u>**
(* indicates recruitment detected in restored marshes) - Kitting, Gaos, et al.

| *Common Name* | *Species or taxon* (parenth if introduced) | Reported Spawning Salinity | Reported Spawning Temperature (C) |
|---|---|---|---|
| 1.* Inland Silverside | (Menidia beryllina) | Freshwater - Brackish | 13.2 - 34.2 |
| 2.* Mosqitofish | (Gambusia affinis) | Brackish, mostly Freshwater | 15 (- 30) |
| 3. Yellowfin Goby | (Acanthogobius flavimanus) | Seawater - Brackish | 8 - 13 |
| 4.* Threespine Stickleback | Gasterosteus aculeatus | Freshwater - Brackish | 15 – 19 |
| 5. Chameleon Goby etc. | (Tridentiger trigonecephalus +spp) | Brackish - Seawater | ~ 20 |
| 6.* Prickly Sculpin | Cottus asper | Freshwater - Brackish | 8 - 13 |
| 7.* Staghorn Sculpin | Leptocottus armatus | Brackish - Seawater | 9 - 15.2 |
| 8.* Topsmelt | (Atherinops affinis) | Freshwater - Brackish | 10 – 25 |
| Especially Patchy: | | | |
| 9. * Pacific Herring | Clupea harengus pallasi | Brackish – Seawater (8-18 ppt) | 6 - 15 |
| 10.* Delta Smelt | Hypomesus transpacificus | Freshwater | 7 - 15 |
| 11.* Splittail | Pogonichthys macrolepidotus | Freshwater - Brackish | 9 - 20 |
| 12. Sacramento Squawfish = Pike Minnow | Ptychocheilus grandis | Freshwater | 15.6 + |
| 13. Fathead Minnow | (Pimephates promelas) | Freshwater | 14 + |
| (isolated occurrence:) | | | |
| 14. Striped Bass | (Morone saxatilis) | Brackish –Fresh, mostly Tidal | 14.4 – 23.9 |
| 15.* Chinook Salmon =King Salmon | Oncorhynchus tshawytscha | Brackish - Seawater (up to 12 ppt) | 10 – 14 |
| 16. Threadfin Shad | (Dorosoma petenense) | Freshwater | 14 – 18 |
| 17. White Sturgeon | Acipenser | Freshwater | 8 – 22 , mostly 14- |

Ranges based on McGinnis, Samuel M. (1984). Freshwater Fishes of California. UC Berkeley Press, and Wang, Johnson C.S. (1986). Fishes of the Sacramento-San Joaquin Estuary. Technical Report 9 for Interagency Ecological Study Program. DWR.

Appendix 3. Cooperative agreement (analogous to a subcontract) for line items in budget, for CCMVCD, SFBWS, PRBO, and EBRPD.

Example of our agreements with our collaborators:

CSUH Foundation
California State University
Hayward CA 94542

TO: J. Sommit, President, SF Bay Wildlife Society
(and similarly to Dr. Karl Malamud-Roam, CCMVCD, etc.)

FROM: C.Kitting, Principal Investigator, CALFED grant on Improving North Estuary Restoration

SUBJECT: Agreement between our Cal State U Foundation and SFBWS for budgeted CALFED expenditures.

Thank you for your efforts in assisting in administering funds for such habitat restoration and monitoring.

All CALFED requirements described in their PSP must be adhered to. They are consistent with University policy.

I am happy to document that SFBWS will then be authorized to invoice our Cal State U Foundation, acct 51 51 152, task 3, for quarterly payments for the related bird monitoring expenses, as budgeted in the CALFED proposal, for the basic salary and the additional expenses. SFBWS is to receive 15% of the direct costs. As CALFED now specified, 90% of each invoice will be reimbursed, until the task is complete. At that time, the remaining 10% will be reimbursed from CALFED, via the CSUH Foundation.

CALFED may review results before they are publicized. Resulting publications shall acknowledge support from CALFED. Any major news is required that quarter, for Kitting's quarterly reports to CALFED. Annual reports are required in a concise scientific paper format, including EXCEL data tables and graphs, from the monitoring person. Authors are credited fully, of course.
Chris Kitting can provide the bird monitoring person templates to enable comparison with densities of other animals at these sites, through time.

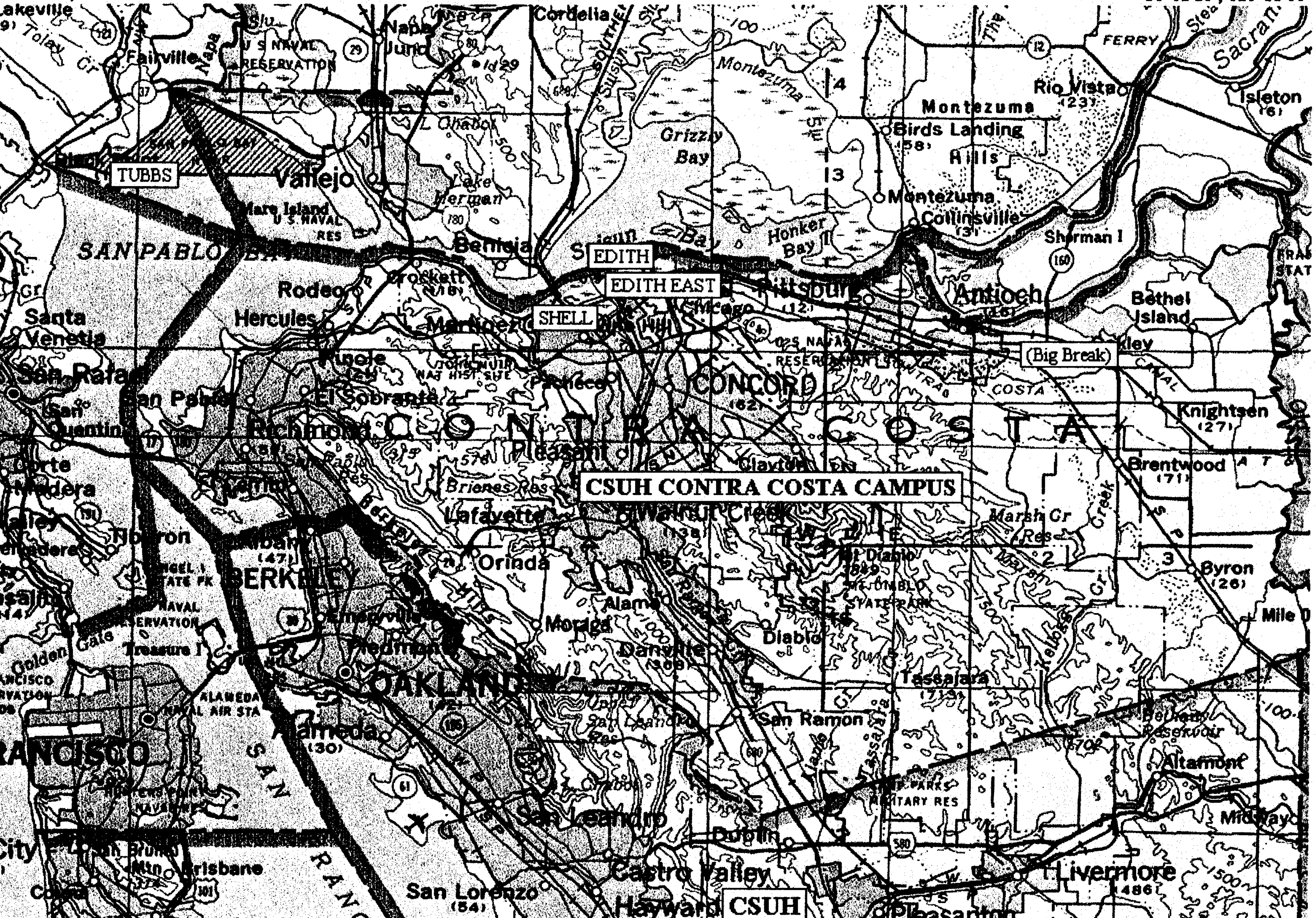
The final invoice, and final report, must be received at our Cal State U Hayward Foundation before mid September, 2001.

Please contact me if further clarification becomes useful.

Thank you, again.

CALFED MARSHES PROPOSED TO PROVIDE INCREASED TIDAL ACTION -CSUH et al.

38°12'28", 122°32'04" 38°12'28", 121°33'01"




37°39'06", 122°32'04" NAD83 37°39'06", 121°33'01"

TN MN 15½°

5 0 5 10 MILES

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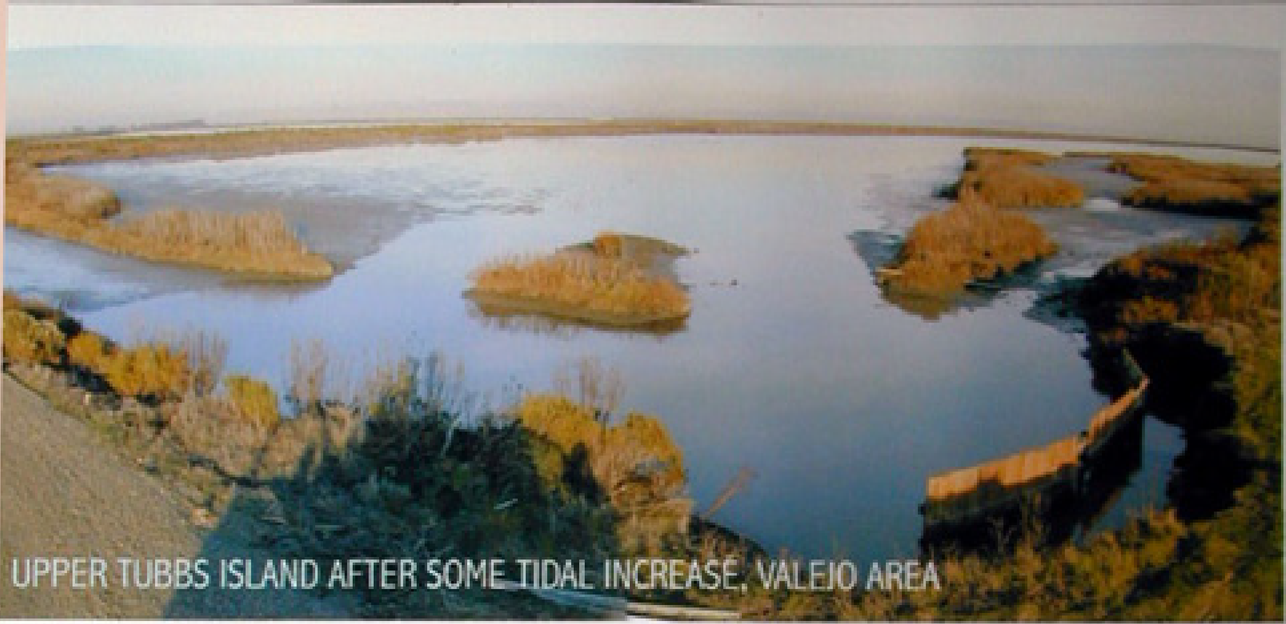
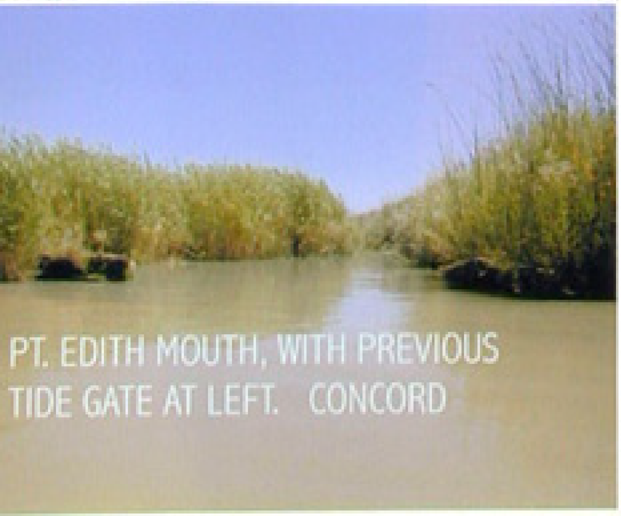
PROPOSED MAJOR CALFED SITES FOR PHASE 2, FROM WEST TO EAST: SAN PABLO AND SUISUN BAYS, THEN OUTER DELTA. PAIRED REFERENCE SITES NEAR EACH, AND SITES AT WEAPONS DETACHMENT, CONCORD, ARE NOT SHOWN. Also See Maps.



UPPER TUBBS ISLAND AFTER SOME TIDAL INCREASE, VALEJO AREA

BBS IS AFTER SOME TIDAL INCREASE, VALEJO

UPPER McNABNEY (SHELL) MARSH, MARTINEZ



PT. EDITH MOUTH, WITH PREVIOUS TIDE GATE AT LEFT. CONCORD

BIG BREAK (A REF AREA FOR NOW), ANTIOC

CSUH Contra Costa Campus near Pittsbugh and the Delta, at far left