Development Of A Spatially Explicit Ecosystem Model To Explore Physicochemical Drivers Of Step Changes In POD Species Abundance And Distribution In The Sacramento-San Joaquin Delta And Suisun Bay

submitted to Science Program 2010 Solicitation

compiled 2010-06-30 15:03:23 PST

Primary Investigator: Larry Brown

Project Information and Executive Summary

Proposal Title	Development of a spatially explicit ecosystem model to explore physicochemical drivers of step changes in POD species abundance and distribution in the Sacramento-San Joaquin Delta and Suisun Bay
Primary Contact Organization Name	US Geological Survey
Primary Contact Organization Type	federal agency
Salutation of Primary Contact	
First Name	Marissa
Last Name	Bauer
Street Address	6000 J STREET
City	Sacramento
State or Province	CA
Mailing Code	95819
Telephone	916-278-3299
E-mail Address	mbauer@usgs.gov
Total Amount Requested	$356,483
Primary Topic Area	Food Webs of Key Delta Species and their Relationship to Water Quality and other Drivers
Secondary Topic Area(s)	Native Fish Biology and Ecology
Descriptive Keywords	**fish biology**; **habitat**; **modeling**; **trophic dynamics and food webs**
Compliance statement	This project will not require compliance of this nature.
Staff and/or subcontractors received funding for at least one project *not* listed above:	*Project Title:* CAScADE *Amount Funded:* $1,662,870 *Date Awarded:* Mar 1, 2006-Sept 30, 2009 *Lead Organization:* *Project Number:* SCI-05-C01-84

Executive Summary

The purpose of this proposed work is to improve a dynamic food web model of the Sacramento-San Joaquin Delta and Suisun Bay, so that we can move from using it as a hypothesis-exploration tool towards using it as a decision-support tool. Our major objective is to develop a spatial ecosystem model that can be used to explore physicochemical factors that may have driven spatial shifts in habitat and resultant shifts in abundance for key Delta species. We seek to examine the effects of multiple potential physicochemical/habitat factors on Pelagic Organism Decline (POD) fishes. To date we have modeled the fish food web of the Delta using Ecopath with Ecosim (EwE 6) software. We have begun hypothesis exploration work using time-dynamic simulations of the modeled food web. The development of a spatial component of the EwE model (Ecospace) will allow us to incorporate spatial dynamics to further explore the freshwater/low-salinity, pelagic, and littoral habitats within the Delta. Spatial modeling is accomplished through identifying foraging, dispersal, and predator avoidance parameters for each functional group (species) relative to a range of defined habitats. This model can be used in conjunction with Monte Carlo simulations of the time-dynamic module as a tool for exploring the impacts of resource management decisions, and help to optimize the utility and effects of such decisions.

Contacts and Project Staff

Primary Contact

E-Mail	mbauer@usgs.gov
Last Name	Bauer
First Name	Marissa
Organization	US Geological Survey
Work Telephone	916-278-3299

Primary Investigator

E-Mail	lrbrown@usgs.gov
Last Name	Larry
First Name	Brown
Organization	USGS
Work Telephone	unknown
Qualifications	See Appendix for complete CV of this Participant.

Participant #2

Salutation	
Last Name	Bauer
First Name	Marissa
Title	Biologist
Organization	USGS
Position	Co-PI
Responsibilities	Ecospace Module Development Assimilate habitat preference data for focal species Develop GIS Basemap for model Assimilate physico-chemical data Incorporate new spatial and habitat data into the model Initiate test runs for hypothesis testing Project management
E-mail	mbauer@usgs.gov
Qualifications	See Appendix for complete CV of this Participant.

Participant #3

Salutation	Dr.
Last Name	Townsend
First Name	Howard
Title	Ecologist/Ecosystem modeler
Organization	NOAA
Position	Co-PI
Responsibilities	Ecosim Mote Carlo Simulations Develop forcing functions based on habitat relationships elucidated using the Ecospace module Project management
E-mail	howard.townsend@noaa.gov
Qualifications	See Appendix for complete CV of this Participant.

Participant #4

Salutation	

Last Name	Feyrer
First Name	Frederick
Title	Fish Biologist
Organization	USBR
Position	Co-PI
Responsibilities	In-kind support of expert local knowledge
E-mail	FFeyrer@usbr.gov
Qualifications	See Appendix for complete CV of this Participant.

Participant #5

Salutation	
Last Name	TBD
First Name	NOAA Tech
Title	Modeling Technician
Organization	NOAA
Position	Subcontractor
Responsibilities	Ecosim Monte Carlo Simulations Ecospace Base map development
E-mail	
Qualifications	

Conflict of Interest

Primary Investigator Larry Brown

To assist Science Program staff in managing potential conflicts of interest as part of the review and selection process, we requested applicants provide information on who will directly benefit if their proposal is funded, that were not listed on the Contacts and Project Staff Form.

Co-PI(s)

Subcontractor

Individuals who helped with proposal development

Last Name	First Name	Organization	Role

Task and Budget Summary

Task #	Task Title	Start Month	End Month	Personnel Involved	Description	Task Budget
1	Project Coordination	1	24	Larry Brown	Dr. Brown will oversee project management and administrative activities, plan for progress report development, and review all project products and deliverables.	$54,911
2	Initial data assimilation	1	12	Marissa Bauer	Assimilate habitat preference data for focal species, develop a GIS Basemap for the model, assimilate physico-chemical data, and incorporate new spatial and habitat data into the model	$122,117
3	Model completion and runs	13	24	Marissa Bauer	Initiate test runs of Ecospace model for hypothesis testing	$135,451
4	Ecosim Monte Carlo Simulations	1	12	NOAA Tech TBD	Train with NOAA colleagues who have developed Ecosim programming code for Monte Carlo simulations in management/policy exploration	$21,423
5	Ecospace Base map development	6	18	NOAA Tech TBD	GIS basemap development	$22,581
6	Project collaboration	1	24	Dr. Howard Townsend	Provide EwE/ecosystem modeling expertise. Review project products and deliveralbes.	$0
7	Project review	1	24	Frederick Feyrer	Provide expert local knowledge on fish biology. Review project products and deliveralbes.	$0
					Budget total	$356,483

Schedule of Deliverables

Each Science Program 2010 Solicitation grant recipient must provide the required minimum deliverables (listed below) for each project.

Required minimum deliverables

- Semi-annual Progress Reports (due July 15 and January 15)
- Final Progress Report (Due at end of project)
- One page project summary for public audience at beginning of project
- One page project summary for public audience upon project completion
- Management implications of project findings
- Project closure summary report or copy of draft manuscript
- Presentation at Bay-Delta Science Conference
- Presentations at other events at request of Delta Science Program staff
- Copy of all published material resulting from the grant

Additional deliverables	Description	Start Month	End Month
Meeting with Delta council to discuss management sceanrios	Discuss management scenarios of interest to run and evaluate	12	24

Total Project Budget Summary by Task and by Fiscal Year

Note: This budget summary **automatically links** to the costs and totals on the **"Budget Detail"** worksheet.
DO NOT CHANGE FORMULAS OR ENTER NUMBERS INTO ANY CELLS EXCEPT THE SHADED CELLS for "Cost Share" and "Other Matching Funds"

BUDGET SUMMARY	Total Amount for Year 1	Total Amount for Year 2	Total Amount for Year 3	Total Amount for All Years
Total Costs for Task One	$ 26,786.11	$ 28,125.01	$ -	$ 54,911.12
Total Costs for Task Two	$ 122,117.17	$ -	$ -	$ 122,117.17
Total Costs for Task Three	$ -	$ 135,451.18	$ -	$ 135,451.18
Total Costs for Task Four	$ 21,423.00	$ -	$ -	$ 21,423.00
Total Costs for Task Five	$ -	$ 22,581.00	$ -	$ 22,581.00
Total Costs for Task Six	$ -	$ -	$ -	$ -
Total Costs for Task Seven	$ -	$ -	$ -	$ -
Total Costs for Task Eight	$ -	$ -	$ -	$ -
Total Costs for Task Nine	$ -	$ -	$ -	$ -
Total Costs for Task Ten	$ -	$ -	$ -	$ -
Total Costs for Task Eleven	$ -	$ -	$ -	$ -
Total Costs for Task Twelve	$ -	$ -	$ -	$ -
Total Costs for Task Thirteen	$ -	$ -	$ -	$ -
Total Costs for Task Fourteen	$ -	$ -	$ -	$ -
Total Costs for Task Fifteen	$ -	$ -	$ -	$ -
Total Costs for Project Tasks	$ 170,326.28	$ 186,157.19	$ -	$ 356,483.48
1/Cost Share	$ 30,000.00	$ 30,000.00	$ -	$ 60,000.00
2/ Other Matching Funds	$ -	$ -	$ -	$ -

1/ *Cost share funds* are specifically dedicated to your project and can include private and other State and Federal grants. Any funds listed in this line must be further described in the text of your proposal (see Chapter 3, Section D, of the PSP document)

2/ *Other matching funds* include other funds invested consistent with your project in your project area for which the ERP grant applicant is not eligible. Any funds listed in this line must be further described in the text of your proposal (see Chapter 3, Section D, of the PSP document)

BUDGET FOR TASK ONE (Administrative)	TOTAL AMOUNT TASK 1 All Years	Year 1 Amount per hour	Year 1 Number of Hours	Year 1 Total Amount for Year 1	Year 2 Amount per hour	Year 2 Number of Hours	Year 2 Total Amount for Year 2	Year 3 Amount per hour	Year 3 Number of Hours	Year 3 Total Amount for Year 3
Personnel										
Research Biologist	$ 21,392.00	$ 65.22	160	$ 10,435.20	$ 68.48	160	$ 10,956.80	$ -	0	$ -
Biologist	$ -	$ 27.67	0	$ -	$ 29.05	0	$ -	$ -	0	$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 21,392.00**			**$ 10,435.20**			**$ 10,956.80**			**$ -**
1/ Benefits as percent of salary	33%			$3,443.62			$3,615.74			$0.00
Personnel Total (salary + benefits)	**$28,451.36**			**$13,878.82**			**$14,572.54**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)	93%			$ 12,907.30			$ 13,552.47			$ -
Total Costs for Task One	**$ 54,911.12**			**$ 26,786.11**			**$ 28,125.01**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes.
No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

Detailed Budget Breakdown by Task and by Fiscal Year

		Year 1			Year 2			Year 3		
BUDGET FOR TASK TWO	TOTAL AMOUNT TASK 2 All Years	Amount per hour	Number of Hours	Total Amount for Year 1	Amount per hour	Number of Hours	Total Amount for Year 2	Amount per hour	Number of Hours	Total Amount for Year 3
Personnel										
Research Biologist	$ -	$ 65.22		$ -	$ 68.48		$ -	$ -		$ -
Biologist	$ 28,776.80	$ 27.67	1040	$ 28,776.80	$ 29.05		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 28,776.80**			**$ 28,776.80**			**$ -**			**$ -**
[1/] Benefits as percent of salary	33%			$9,496.34			$0.00			$0.00
Personnel Total (salary + benefits)	**$38,273.14**			**$38,273.14**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ 10,000.00			$ 10,000.00			$ -			$ -
2/ Travel and Per Diem	$ 15,000.00			$ 15,000.00			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 25,000.00**			**$ 25,000.00**			**$ -**			**$ -**
[5/] Overhead Percentage (Applied to Personnel & Other Costs)	93%			$ 58,844.02			$ -			$ -
Total Costs for Task Two	**$ 122,117.17**			**$ 122,117.17**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK THREE	TOTAL AMOUNT TASK 3 All Years	Amount per hour	Number of Hours	Total Amount for Year 1	Amount per hour	Number of Hours	Total Amount for Year 2	Amount per hour	Number of Hours	Total Amount for Year 3
Personnel										
Research Biologist	$ -	$ 65.22	0	$ -	$ 68.48	0	$ -	$ -		$ -
Biologist	$ 30,212.00	$ 27.67	0	$ -	$ 29.05	1040	$ 30,212.00	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -

	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 30,212.00**			**$ -**			**$ 30,212.00**			**$ -**
[1/] Benefits as percent of salary	33%			$0.00			$9,969.96			$0.00
Personnel Total (salary + benefits)	**$40,181.96**			**$0.00**			**$40,181.96**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ 10,000.00			$ -			$ 10,000.00			$ -
2/ Travel and Per Diem	$ 20,000.00			$ -			$ 20,000.00			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 30,000.00**			**$ -**			**$ 30,000.00**			**$ -**
[5/] Overhead Percentage (Applied to Personnel & Other Costs)	93%			$ -			$ 65,269.22			$ -
Total Costs for Task Three	**$ 135,451.18**			**$ -**			**$ 135,451.18**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			**Year 2**			**Year 3**		
BUDGET FOR TASK FOUR	**TOTAL AMOUNT TASK 4 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
Research Biologist	$ -	$ 65.22		$ -	$ 68.48		$ -	$ -		$ -
Biologist	$ -	$ 27.67		$ -	$ 29.05		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -

Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
1/ Benefits as percent of salary	33%			$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ 11,100.00			$ 11,100.00			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 11,100.00**			**$ 11,100.00**			**$ -**			**$ -**
5/Overhead Percentage (Applied to Personnel & Other Costs)	93%			$ 10,323.00			$ -			$ -
Total Costs for Task Four	**$ 21,423.00**			**$ 21,423.00**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK FIVE	**TOTAL AMOUNT TASK 5 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
Research Biologist	$ -	$ 65.22		$ -	$ 68.48		$ -	$ -		$ -
Biologist	$ -	$ 27.67		$ -	$ 29.05		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
1/ Benefits as percent of salary	33%			$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**

Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ 11,700.00			$ -			$ 11,700.00			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 11,700.00**			**$ -**			**$ 11,700.00**			**$ -**
[5/] Overhead Percentage (Applied to Personnel & Other Costs)	93%			$ -			$ 10,881.00			$ -
Total Costs for Task Five	**$ 22,581.00**			**$ -**			**$ 22,581.00**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			**Year 2**			**Year 3**		
BUDGET FOR TASK SIX	**TOTAL AMOUNT TASK 6 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
Ecologist/Ecosystem modeler	$ -	$ -	160	$ -	$ -	160	$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[1/] Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -

4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Six	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK SEVEN	**TOTAL AMOUNT TASK 7 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
Fish Biologist	$ -	$ -	160	$ -	$ -	160	$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[1/] Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Seven	**$ -**			**$ -**			**$ -**			**$ -**

Detailed Budget Breakdown by Task and by Fiscal Year

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes.
No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK EIGHT	**TOTAL AMOUNT TASK 8 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[1/] Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Eight	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes.
No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

Year 1 Year 2 Year 3

BUDGET FOR TASK NINE	TOTAL AMOUNT TASK 9 All Years	Amount per hour	Number of Hours	Total Amount for Year 1	Amount per hour	Number of Hours	Total Amount for Year 2	Amount per hour	Number of Hours	Total Amount for Year 3
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[1/] Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Nine	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK TEN	**TOTAL AMOUNT TASK 10 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -

	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
1/ Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Ten	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			**Year 2**			**Year 3**		
BUDGET FOR TASK ELEVEN	**TOTAL AMOUNT TASK 11 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**

1/ Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Eleven	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK TWELVE	**TOTAL AMOUNT TASK 12 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
1/ Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**

Detailed Budget Breakdown by Task and by Fiscal Year

Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Twelve	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK THIRTEEN	**TOTAL AMOUNT TASK 13 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
1/ Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -

4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Thirteen	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes.
No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK FOURTEEN	**TOTAL AMOUNT TASK 14 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[1/] Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Fourteen	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes.
No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

BUDGET FOR TASK FIFTEEN	TOTAL AMOUNT TASK 15 All Years	Year 1 Amount per hour	Year 1 Number of Hours	Year 1 Total Amount for Year 1	Year 2 Amount per hour	Year 2 Number of Hours	Year 2 Total Amount for Year 2	Year 3 Amount per hour	Year 3 Number of Hours	Year 3 Total Amount for Year 3
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[1/] Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Fifteen	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes.
No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

Development of a spatially explicit ecosystem model to explore physicochemical drivers of step changes in POD species abundance and distribution in the Sacramento-San Joaquin Delta and Suisun Bay

Larry Brown (Lead PI), and Marissa Bauer (USGS), Howard Townsend (NOAA), and Fred Feyrer (USBR)

1. Project Purpose

1a. Introduction

We propose to make improvements to the Sacramento-San Joaquin Delta and Suisun Bay (herein referred to as the Delta) ecosystem model we have developed using the Ecopath with Ecosim software (Christensen and Walters 2004), so that it will be useful as a decision support tool for resource management. To date we have modeled the fish food web of the Delta and we have begun some hypothesis exploration work using temporal simulations of the modeled food web (Townsend et al., 2010 (*in prep*); Bauer et al. 2010 (*in prep*)) In addition, we have begun including forcing functions that describe the effects of habitat changes and invasive species on the food web. For this proposal, we plan to further expand on the existing model by creating a spatial model that allows explicit modeling of habitat impacts on the food web and species abundance and distributions. We also plan to improve the ability of the model to account for uncertainty in parameter estimates through Monte Carlo simulations, in order to allow managers to better understand the levels of risk associated with different management scenarios.

We have developed a mass-balanced trophic ecosystem model for the Sacramento-San Joaquin Delta and Suisun Bay using Ecopath with Ecosim (EwE 6) software, as a part of a larger effort in the Pelagic Systems Dynamics working group at the National Center for Ecological Analysis and Synthesis (NCEAS). The current model incorporates two modules – 1) Ecopath to develop a mass-balanced snapshot of the ecosystem, which provides a baseline for comparison as well as a reasonably constrained set of initial conditions for simulation modeling, 2) Ecosim for dynamic simulation of the ecosystem over time. We have used the dynamic simulation of this model to begin to explore direct and indirect drivers of ecosystem dynamics of the Delta, with emphasis on the Pelagic Organism Decline species.

Prior to 2000, the four most abundant resident pelagic fishes surveyed by the fall midwater trawl survey conducted by the California Department of Fish and Game, included two native species, delta smelt (*Hypomesus transpacificus)* a federal listed endangered species, and longfin smelt (*Spirinchus thaleicthys)* a state listed endangered species, and two introduced species, threadfin shad (*Dorosoma petenense)* and striped bass (*Morone saxatilis*)*)*. Beginning in the early 2000's, abundance indices of these four pelagic fishes showed concurrent declines in multiple surveys. Between survey years 2002-2005 delta smelt and age-0 striped bass experienced record abundance lows, while threadfin shad and longfin smelt experienced near record lows (Sommer et al. 2007). The most alarming aspect of this decline was that it occurred

during a series of relatively wet years when these fishes would be expected to experience good survival and increasing populations (Sommer et al. 2007). The multi-species decline, termed the Pelagic Organism Decline (POD), has been verified by statistical analyses (Thomson et al. 2010) and is under investigation by IEP and others, including multiple state, federal, and university researchers.

With our model, we seek to simultaneously examine the effects of multiple potential drivers on one or more POD fishes and place these patterns in the broader context of estuarine degradation. Current model drivers include: 1) decreased primary productivity/Chlorphyll-*a*; 2) Invasive species, including *Corbula amurensis* (*Corbula*), *Limnoithona tetraspina* (*Limnoithona)*, and submerged aquatic vegetation (SAV). Specifically, we have explored the food web impacts of the invasive species by forcing increases in biomass of these species in the model. In addition we have also explored the habitat impacts of SAV by using forcing functions and habitat mediation functions. With the current parameterization of the model, decreased primary productivity and increased SAV are the best drivers for improving the simulation model's fit to data (relative abundance indices for the POD species and largemouth bass). This modeling approach can be used to address multiple areas of concern for the POD fishes and to evaluate management options through scenario simulation. We are especially looking for factors that explain decrease in POD species as well as increases in other species such as largemouth bass. Preliminary analysis using the Delta EwE model simulations shows a shift from a pelagic food web to a SAV-associated food web.

The development of a spatial component of the EwE model, (Ecospace) will allow us to further explore the freshwater, low salinity, pelagic, and littoral habitats within the Delta. Spatial modeling is accomplished through identifying foraging, dispersion, and predator avoidance parameters for each functional group relative to a range of defined habitats. Once we have completed the hypothesis exploration phase with the spatial model we will have a working model of the system that can be used in conjunction with time-dynamic Monte Carlo simulations as a tool for exploring the impacts of resource management decisions, and help to optimize the utility and effects of such decisions.

1b. Project Goals and Objectives

The major objectives of this project are as follows:

Objective 1: Develop a spatially explicit Ecospace model of the Sacramento-San Joaquin Delta and Suisun Bay using the current Delta Ecopath model and other local data.

Objective 2: Develop the Monte Carlo simulation capacity of the time-dynamic model to help account for parameter uncertainty in model estimates.

Objective 3: Use the Ecopath suite of modules (Ecopath, Ecosim, Ecospace) to test relevant hypotheses regarding the pelagic organism decline

Objective 4: Demonstrate how EwE can be used as a tool by managers by exploring how selected management scenarios might affect species abundance and distributions of POD and other species of interest.

1c. Hypotheses

Hypothesis testing is an inherent feature of EwE modeling. We have used the modeling suite to do initial hypothesis testing on factors that are associated with the POD and concomitant increases in other species (e.g., largemouth bass). Our initial tests were coarse as we used forcing functions to drive food web interactions. For example we used a primary production forcing function to drive the food web. The forcing function was derived from data on chlorophyll-a, thus we could not adequately explore the causes for change in primary production (e.g., did invasive species and habit changes cause shifts in trophic flows?). Because this initial forcing function was fairly coarse (and perhaps indirectly captured the effects of invasive species on primary production), we did not see strong effects of some invasive species (e.g., *Corbula*) on primary production and the food web.

The development of a spatial modeling component of the Delta EwE model will allow for finer resolution hypothesis testing and exploration of the habitat and food web changes in the Delta. A spatial model will allow habitat shifts to emerge from the physical parameters of the model and allow the distribution and abundance of fish to shift as a result. Compared to the coarse forcing function used earlier, this will help us explore whether invasive species have been major contributors to habitat and species shifts or if exogenous factors have caused habitat shifts. By developing a spatial model that more explicitly captures habitat dynamics, we will be able to incorporate more realism into the model and re-evaluate hypotheses that we have previously tested. In this study we will evaluate the following hypothesis:

1. The decrease in phytoplankton production has driven changes in pelagic fish abundance

2. Shifts in physico-chemical parameters of the ecosystem have enabled the expansion of SAV since the early 1980s, which has resulted in predominance of a SAV-based food web over a pelagic food web.

3. Introductions of invasive species, *Corbula* and *Limnoithona*, has driven changes in pelagic fish abundance

Once these hypotheses have been tested and we have a reasonable working model, we can then use the model as a tool for management scenario evaluation. For example, we would demonstrate how changes in water management policy affect salinity (and the location of X2) of the system. And how in turn, salinity shifts affect patterns in the food web and distributions of SAV and pelagic habitat.

1d. Supporting Information

The EwE Delta food web model builds on the Durand (2008) Delta food web conceptual model by further expanding the fish food web model described in his work. Our work will benefit from the Durand model because major drivers of the system have been identified and described qualitatively. With the development and addition of the Ecospace model to the current EwE Delta model, we will be incorporating important system drivers noted by several authors

[Durand (2008) , Cloern (2007), and Cole and Cloern (1984), Jasby et al (1995), Kimmerer (2002 a and b)] such as habitat, salinity, and water diversions into the ecosystem model. The Ecospace model will also allow us to address key uncertainties of the Delta food web as noted by Durand (2008) such as the role of fish populations in structuring the zooplankton community and how mortality from piscivorous fish on young native fishes affects the Delta food web. Our proposed hypothesis testing takes into account some of these uncertainties and further examines our current understanding of the fish food web in a quantifiable manner.

2. Background

2a. Conceptual Models

Two conceptual models have been developed to describe the spatial model of the Delta and how it could be used for scenario and policy exploration. Figure 1 is a visual representation of the EwE model, consisting of the Ecopath, Ecosim, Ecospace and Ecotrace modules. The conceptual model shows how data needs, modeling abilities, research and application are linked. The Ecopath and Ecosim modules, which have already been developed for the Delta, inform the Ecospace module, creating an opportunity to explore various management and policy options. For example, the effect of controlling SAV or changing fishing regulations for largemouth bass in the Delta can be explored and examined as the model simulates the ecosystem's response to such a decision. Figure 2 represents the foodweb linkages in the Delta Ecopath model that will be informing the initial parameters of the Ecospace model.

2b. Modeling Background

The modeling approach we are planning to implement is similar to the work of de Mutsert (2010). In this work, de Mutsert did a Before-After-Control-Impact study to determine the impact of reintroducing freshwater and sediments into a portion of the Mississippi which had been hydrologically isolated on food web pathways. The study was focused on important fisheries species of the local ecosystem. As a part of the study, the author developed an ecosystem model of the system (Breton Sound) to simulate changes in species biomass distributions under different salinity scenarios. This model can be used to evaluate different restoration scenarios in the system, i.e., how much freshwater will flow, affects to commercially and recreationally important fish species populations.

Ecosystem modeling can be used to project ecosystem responses to disturbances and to identify processes and relationships within the ecosystem that are not easily measured, or have been overlooked (Fulton et al. 2003; Field et al. 2006; Chen et al. 2008). For example, ecosystem models can be used to quantify the direct and indirect effects of anthropogenic changes to a system by allowing the researcher to compare a baseline model built from actual survey data to future projections generated by the model. Ecosystem models, such as the Delta EwE model, that are driven by long-term data sets have enormous potential to be used as an adaptive management

tool by policy makers, scientists, and managers (Ma et al. 2010; Straile 2002). A model that is built from the best available data can also give insight into which ecological areas of a system would benefit from additional research, or if a different research approach is needed.

Ecopath with Ecosim is a suite of static and spatial modeling applications developed by researchers at the University of British Columbia's Fishery Centre. To date, over 100 ecosystem models using the EwE software have been published. EwE was initially built for estimating biomass and food consumption rates of multiple functional groups, (e.g. species) in a steady-state aquatic system (Christensen and Pauly, 1992). EwE is grounded in theoretical ecology applications of analyzing energy flows within a system (Odum, 1969; Ulanowicz, 1986). The concept of being able to examine more than one species at a time in a model was one of the key features that set Ecopath apart from its single-species model counterparts.

EwE software has been used in a wide range of ecosystem analyses including food web research, fisheries catch analysis, and ecosystem response to anthropogenic change. Libralato et al. (2006) used EwE to identify keystone functional groups within Prince William Sound and the Gulf of Thailand. Booth and Zeller (2005) used EwE to look at the interactions of mercury with marine mammals and climate change. Villanueva et al. (2008) used EwE to explore the roll of introduced species in a lake ecosystem. A detailed EwE ecosystem model for the Chesapeake Bay containing 45 functional groups at all trophic levels is being developed due to a management need for a quantified estimate of trophic pathways within the Bay (Christensen et al., 2008). EwE will help analyze how one species affects another within the food web and how various species impact both target and non-target species. The Sacramento-San Joaquin Delta and Suisun Bay model was developed with similar goals in mind.

Ecopath

The Ecopath model uses mass-balance principles to link functional biomass groups within a dynamic system to create a static snapshot of the resources and energy flows within the ecosystem (Christensen and Pauly, 1992; Pauly et al., 2000; Christensen and Walters, 2004). A functional group can represent a group of tropically similar species, a single species, or a group of species split into age categories ("multi-stanza groups"). Ecopath is used to specify initial conditions for biomass (B) and production (P) of each functional group. By defining the biomass and production of each functional group at a single point in time, Ecopath provides a static, time-invariant description of the ecosystem.

The parameters of an Ecopath model are based on satisfying two principle equations. The first equation describes how the production term for each group can be divided for an arbitrary time period as follows.

Production = catch + predation + net migration + biomass accumulation
+ other mortality

In mathematical terms:

$$B_i (P/B)_i EE_i = Y_i + E_i + BA_i + \sum_{j=1}^{n} B_j (Q/B)_j DC_{ji} \quad \text{Eq. 1}$$

where for each functional group (i), B_i is total biomass ($t \cdot km^{-2}$) during the period of question, $(P/B)_i$ is the production to biomass ratio ($year^{-1}$), where P ($t \cdot km^{-2}$) is the production of functional group i and B ($t \cdot km^{-2}$) is the biomass of functional group I. EE_i is the ecotrophic efficiency, defined as the fraction of the production that is consumed within or harvested from the system, Y_i is the yield, catch in weight, or fishery harvest (note that $Y_i = F_i B_i$ where F is the fishing mortality rate). E_i is the net migration rate (emigration – immigration), BA_i is the biomass accumulation rate for (i), $(Q/B)_j$ is the food consumption per unit biomass for consumer j ($year^{-1}$), where Qj is the biomass of prey (i) consumed by the consumer or predator j and B_j is the biomass of the consumers or predators of (i), and DC_{ji} is the average fraction of i in the diet of j (note that $DC_{ji} = 0$ when j does not eat i).

For each functional group, Ecopath requires input of diet composition (DC), fishery harvest (Y) and three of the following four parameters, B, P/B, QB, and EE. Mass-balance principles are used to estimate the fourth or unknown parameter. If all four parameters are known, then Ecopath can be used to estimate biomass accumulation rate, or net migration rate. If only 3 of the 4 parameters are known, the conservation of energy within each functional group is maintained by fitting the fourth parameter so that production is matched to losses within the model (Christensen et al. 2000). Equation (1) enables the estimates of biomass, production, and consumption to be used in constructing a diagram of energy flow (Mackay, 1981, Ulanowicz, 1986).

The second equation is based on the principle of conservation of matter and is as follows:

Consumption = production + respiration + unassimilated food Eq. 2

This equation balances the energy flows of each functional group and develops the mass-balance idea that consumption by a group equals the production by the group plus "waste". The energy flowing into a group equals that flow out of the group and it does so for all functional groups. This mass-balance is necessary to constrain the initial parameterization of the model, so that future Ecosim simulations are reasonable and grounded in data as much as possible. This constraint also helps develop estimates for the fourth unknown parameter in Equation (1), if only 3 of the 4 are available.

The consumption over biomass (Q/B) ratio is the consumption or intake of food by a functional group over a specified time period (e.g. one year). Ecopath expresses absolute consumption as an energy flow expressed in $t \cdot km^{-2}\ year^{-1}$, while the corresponding Q/B is on a per year basis (Christensen et al. 2008). Thus, the Q/B input parameter entered into Ecopath for each functional group in this model is expressed as Q/B $year^{-1}$.

It is important to note that production refers to the elaboration of tissue by a functional group over a discrete time period specified by the model. For most EwE models, including this one, production is accounted for on an annual basis. Mass-balance constraints assume that

production over biomass is equal to total mortality (*Z*) used by fisheries biologists (Allen 1971). Thus, estimates of the instantaneous rate of total mortality can be used interchangeably with the production over biomass ratio (*P/B*) input. In the simplest terms, production includes fishery yield (F) plus predation (M2), plus net migration (NM), plus biomass accumulation (BA), plus other mortality (M0) (Eq. 3) (Christensen et al. 2008).

$$P/B = Z = F + M2 + NM + BA + M0 \qquad \text{Eq. 3}$$

Ecosim

Ecosim is a tool for making dynamic projections given the Ecopath mass-balanced output. Ecosim modeling is constructed by re-expressing Equation (1) as a series of coupled differential equations as shown in equation (4).

$$\frac{dB_i}{dt} = g_i \sum_{j=1}^{n} c_{ji} - \sum_{j=1}^{n} c_{ij} + I_i - (M_i + F_i + e_i)B_i \qquad \text{Eq. 4}$$

Where; g_i is growth efficiency, F_i is the instantaneous rate of fishing mortality, e_i is the rate of emigration, I_i is the rate of immigration, c_{ij} (c_{ji}) is the consumption of biomass pool *i* (*j*) by biomass pool *j* (*i*).

The system of equations is used to represent spatial dynamics of the entire ecosystem and is combined with age/size-structured delay-difference equations to represent populations that have complex life histories. A key feature of Ecosim is the expression of the consumption or biomass flow rates among linked species or functional groups. Consumption of prey *i* by predator *j* is modeled as follows (Christensen et al. 2005).

$$Q_{ij}(B_i, B_j) = \frac{a_{ij} v_{ij} B_i B_j}{(2v_{ij} + a_{ij} B_j)}, \qquad \text{Eq. 5}$$

Where; a_{ij} is the rate of effective search for prey *i* by predator *j* F_i is the instantaneous rate of fishing mortality and v_{ij} is the behavioral exchange rate between vulnerable and invulnerable prey pools.

Departures from an equilibrium state within the ecosystem are modeled by forcing functions and by trophic mediation functions. Forcing functions link external variables, such as salinity, to production or components of production; e.g., changes in salinity are linked to changes in the production of diatoms (i.e., primary production). Trophic mediation functions are used to model changes in the internal relationships between predator and prey groups. An example of a mediation function is the affect of SAV on predation of small/juvemile fish. In this case SAV is included in the model because it is eaten by some other trophic groups; however, it also potentially plays an important role in that it decreases predators' access to smaller fish.

Ecospace

A major deficiency of the Ecopath and Ecosim approach is the assumption of homogenous spatial behavior. This has been addressed through the development of Ecospace

(Walters et al. 1999), a dynamic, spatial version of Ecopath, incorporating all the key elements of Ecosim. Ecospace allows for the inclusion of seasonal changes and spatial preferences to be included in the model. Spatial modeling is created by identifying foraging, dispersion, and predator avoidance parameters for each functional group relative to a range of defined habitats.

Ecospace dynamically allocates biomass across a gridded basemap. The base map is used to designate fixed habitat parameters while accounting for: movements from a cell to its four adjacent cells, of rate *m*, modified by whether a cell is defined as 'preferred habitat' or not; user-defined increased predation risk and reduced feeding rate in non-preferred habitat; level of "takes" at cells (e.g., as might be encountered at pumping stations). Ecospace also allow for designation of transient habitat patterns. For example general current patterns, wind/geostrophic forcing patterns for surface currents, as well as general salinity patterns, and patterns in primary productivity.

3. Approach and Scope of Work

Our major objective is to move our food web modeling efforts from a hypothesis exploration tool, towards a tool for decisions support. We will build from the existing Delta EwE model to accomplish two major tasks. First, we will create a spatial food web model (Ecospace module) that includes habitat parameters for simulating potential scenarios. The spatial model will help to capture spatial as well as temporal dynamics. The graphics for this model will enable multiple resource managers to view the model and potential management scenarios. For example, if "takes "of fish (associated with water management) in specific areas have impacts on the local food web and species distributions, how can different "take " scenarios maximize the utility of the water resource and minimize the impact on fish. The relatively quick runtime (~5 minutes) will allow mangers to explore the effects of a wide range of potential management scenarios.

Secondly, we will implement Monte Carlo simulation capabilities for management scenarios using the Ecosim module so that uncertainty in input parameter can be taken into account for running management scenarios. Monte Carlo simulations engage a temporal simulation model with a rapid run time (~5 seconds). This allows for hundreds of runs that can take into account parameter uncertainty. Management scenarios that can be explored visually and spatially using the spatial model can then be run in the faster temporal simulation system. Multiple runs in which data-based parameter estimates are allowed to change (within the range if associated uncertainty) can be completed for each scenario to determine if certain scenarios are less feasible or more risky given the uncertainty in the data.

We have developed the baseline snapshot of the SFE ecosystem, using the Ecopath module of the EwE software. To parameterize this initial model we made extensive use of existing data from research and monitoring studies in the area (Table 1). Developing this module

has enabled us to use the Ecosim module to explore hypotheses about the changing roles of native and non-native species and how habitat factors have lead to those shifts.

In these initial stages of model development, we have established a quantitative description of the ecosystem structure and function. One of the primary points we have discovered is that habitat changes (especially submerged aquatic vegetation) have been associated with food web shifts over the past 25 years that have been a major factor associated with the POD. One major limitation to our current modeling efforts has been that the Ecosim software does not explicitly model changes in habitat. To incorporate information on habitat and physico-chemical into our food web modeling efforts, we have developed forcing functions using sparse data to create general trends. We then used the general trends as forcing functions to drive food web interactions, this allowed us to explore hypotheses about how habitat changes and invasive species may have been a major causal factor for the POD.

Using forcing functions for this modeling system is a somewhat coarse approach. However, by developing a spatially explicit model (Ecospace) that takes in changes in phyisco-chemical aspects of the habitat, we can better understand the reasons for habitat shifts that are important causal factors for the POD. In addition, a spatial model will be a useful tool for demonstrating how factors that influence habitat (such as water management) affect key fish species in the delta.

In turn, habitat patterns that are elucidated in the spatial model can be used to create forcing functions. Forcing functions and Ecosim are useful for completing multiple runs. The run time for Ecosim is on the order of a few seconds; however, for Ecospace the run time is on the order of 2-3 minutes. Thus, Ecosim is readily adaptable for Monte Carlo (MC) simulation runs, as MC simulation is important for taking into account uncertainty in model parameter estimates. Thus the combination of Ecosim and Ecospace provide a valuable set of tools for resource management and exploring combinations of policies that affect the Ecosystem.

Task 1: Project Coordination – To properly manage the project, PIs will hold quarterly teleconferences to update on progress and plan for progress report development, Project oversight will be led by the USGS-Sacramento Team. All personnel will be involved in report development. After completion of model development the USGS Team will coordinate request/efforts to use the model for management strategy evaluation as request by the Delta Stewardship Council and other management agencies.
Potential future applications of this work, which we will begin to scope as a part of this project, include:

- Fully incorporating hydrodynamics through model coupling
- Develop climate change scenarios that influence hydrodynamics of the system to investigate how habitat and food web structure will be affected

Task 2 and 3: Initial data assimilation and Ecospace Module Development- To build the Ecospace module we will:

- Assimilate habitat preference data for focal species
- Assimilate physico-chemical data such as seasonal salinity dynamics
- Incorporate new spatial and habitat data into the model and initiate test runs for hypothesis testing

These tasks will be coordinated primarily by the USGS staff.

Task 4 and 5: Ecosim Mote Carlo Simulations - To develop the capacity to use Monte Carlo simulations in Ecosim we will:

- Train with NOAA colleagues who have developed Ecosim programming code for Monte Carlo simulations in management/policy exploration
- Develop forcing functions based on habitat relationships elucidated using the Ecospace module
- Develop GIS Basemap for model (Task 5)

These tasks will be coordinated primarily by the NOAA staff.

Tasks 6 and 7: Project collaboration and review- In-kind support will be supplied by both USBR biologist and NOAA ecologist for modeling and local fish biology expertise. These tasks will be primarily conducted by NOAA and USBR staff.

Scientific Approach for Tasks 1 and 2.

Task 1: Ecospace Module Development

The current model contains 40 trophic groups (species or groups of species). Information on habitat preferences of these species must be compiled. Habitat data includes fixed habitat features such as bottom type (sandy, rocky, silty, etc.) and depth. In addition, preferences for transient habitat features (e.g., salinity) will also be assimilated. The range of habitat preferences will be used to determine habitat groupings for an overall map of the system. The preference will be read into the Ecospace modeling system

A GIS-based map of the Delta and Suisun bay will be developed. The map will be read into the EwE Modeling system and a gird of the map will be developed. Using habitat categories, each grid will be assigned a habitat type. In the modeling system, trophic groups will show an affinity for preferred habitat types during simulations..

Assimilate data on seasonal salinity dynamics and other pertinent transient features of the habitat. Incorporate transient habitat features into the modeling system.

Run model to test hypotheses and develop forcing functions.

Task 2: Ecosim Mote Carlo Simulations

Meet NOAA colleagues to work on programming code for Ecosim. Develop code for Monte Carlo runs that allow parameter values and forcing functions to vary based on uncertainty in the data.

Analyze output from Ecospace model to develop trends and statistics tests for forcing functions. Re-test hypotheses allowing for parameter uncertainty and uncertainty in forcing functions.

4. Feasibility

There are multiple reasons why we believe this project is feasible. First, the proposed project is a valuable extension of the current Delta Ecopath model that has been in development over the past two years. The current model establishes the baseline conditions of the Delta for simulation modules (Ecosim and Ecospace). We have completed initial runs of the Ecosim module to begin hypothesis exploration. The initial model development and gathering of pertinent data for the model is usually the time-limiting factor for using the EwE modeling suite, which in this case, is already complete. Thus, any further development of the Delta model will begin with the major inputs to the model readily available. As this is primarily a data gathering and modeling project, we are not constrained by data collection permits or weather, so this limits the factors that might cause delays. Project management decisions will be coordinated during quarterly teleconferences. Regular informal communications about project developments will occur routinely.

5. Budget

5a. Budget Justification

We anticipate this work to take two years. The details of the budget are shown in the budget spreadsheet file. The labor includes 50% time for Bauer, 8% time for Brown, and 15% time for the NOAA modeling technician over the two year time period. Two months of in-kind support (cost sharing) in the form of project consultation and review will be provided by Townsend and Feyrer each project year. Travel costs to coordinate project progress, presentation and work includes 2 trips per year for presentations for Delta Stewardship events and for coordination and model develop/application review meetings.

5b. Subcontracting

Funding will be provided to the National Oceanic and Atmospheric Administration (NOAA) for Tasks 3 & 4 via an Interagency Agreement. USGS may execute this agreement in approximately 60 days.

5c. Overhead Justification

1. USGS California Water Science Center (Tasks 1, 2, 3)

Overhead applied to personnel and other costs cover indirect costs that support the delivery of reimbursable products. Costs include facilities, publications, executive, technical,

administrative, and financial functions at all levels of the bureau. Rates are reviewed and established annually.

2. USGS California Water Science Center / Interagency Agreement with NOAA (Tasks 4 & 5) Interagency Agreement (IA) with NOAA will be subject to USGS California Water Science Center overhead rate. NOAA will not charge any additional overhead for this IA.

5d. Cost Share

1. U.S. Bureau of Reclamation (USBR) will utilize federal funds to provide technical assistance and review of project deliverables (Task 7). Fred Feyrer will spend approximately one month each year of the funding to consult with the biologists on model development and applications. During Year 1, USBR will provide cost share assistance in the amount of $15,000. During Year 2, USBR will provide cost share assistance in the amount of $15,000.

2. NOAA will utilize federal funds to provide technical assistance and review of project deliverables (Task 8). Howard Townsend will spend approximately 1-2 months each year of the funding to consult with the model technician and biologists on model development and applications. During Year 1, NOAA will provide cost share assistance in the amount of $15,000. During Year 2, NOAA will provide cost share assistance in the amount of $15,000.

6. Relevance to DSP

This proposal most directly addresses Topic 2 (Food Webs of Key Delta Species and their Relationship to Water Quality and other Drivers). This is because the primary focus of this work is to understand how physico-chemical factors of the Delta have influence habitat and resulted in food web shifts for key Delta species. We will use a spatial model to understand the growth and expansion of a non-native SAV and its role in a potential food-web shift. We will also explore how anthropogenic factors that have resulted in changes in nutrients, sediments and salinity have likely paved the way for increasing SAV abundance and distributions. The spatial model will allow us to better understand the current shift from a pelagic food web to a SAV-supported food web. This work is important for understanding the relative impact of critically important food web drivers.

By spatially modeling habitat attributes and incorporating the habitat preferences of key delta species, we will better understand how multiple factors have combined to result in shifts in abundance and distribution of key species. This understanding will enable us to use the model to explore how management and restoration activities might be implemented to increase abundance of species of concern. This work may help explain how habitat shifts influence food web shifts and the resultant changes in fish distribution and abundance. In addition, Ecospace is a good tool for visualizing temporal and spatial changes in the ecosystem and understanding how water resource management might affect changes.

This work will also provide the foundation for developing a coupled hydrodynamic-ecosystem model which can be used for water and ecosystem management decision support system development.

Relevance to DSP outside this PSP

Development of a spatial component of the Delta EwE model holds great potential to inform larger Delta Science goals. The ability to test multiple hypotheses in a relatively short time allows for greater flexibility in investigating ecosystem–wide stressors and response. For example, the EwE model could potentially be useful in assessing the success of various restoration strategies of the Bay Delta Conservation Program wetlands restoration plan. The EwE model could also prove useful in analyzing some of the key uncertainties specified in the Durand (2008) conceptual model.

7. Qualifications

Larry R. Brown is a Research Biologist with the U.S. Geological Survey, California Water Science Center. Dr. Brown has over 25 years experience working in California aquatic systems. He is a recognized expert on the ecology of California fishes and has published extensively on California fishes, benthic macroinvertebrates and benthic algae. Dr. Brown is currently involved in studies of the effects of urbanization on stream systems across the United States, modeling of responses of stream macroinvertebrate communities to land use changes, the effects of climate change on selected fish species in the Central Valley watershed and San Francisco Estuary, and factors associated with declines in pelagic fish populations of the San Francisco Estuary. In the course of his work, Dr. Brown has authored or coauthored over 50 scientific articles and reports.

Marissa Bauer is a biologist with the US Geological Survey, California Water Science Center under the direction of Dr. Larry Brown. She is completing her M.S. Project entitled *An Ecosystem Model of the Sacramento-San Joaquin Delta*, which involved developing the Ecopath model for the Sacramento-San Joaquin Delta that will be used in this project. Marissa has worked extensively with Dr. Townsend in developing the Delta EwE model and has some of the most extensive local knowledge of EwE modeling techniques and applications.

Howard Townsend is an Ecologist with the National Oceanic and Atmospheric Administration, Chesapeake Bay Office. Dr. Townsend has over 10 years experience developing quantitative models of populations and ecosystems. He is a national expert in modeling for resource management. Dr. Townsend is currently in developing models of coastal and estuarine systems, with a focus on models to be used for the management of fisheries and bird populations and ecosystems. He has worked extensively on developing standards for using multispecies and ecosystem models for resource management.

Frederick Feyrer is a fish biologist at the US Bureau of Reclamation's Applied Science Branch in Sacramento, California. He has extensive experience conducting research and

advising management on fishes in the San Francisco Estuary. In addition to editing a book on the early life history of fishes, he has authored or coauthored over 30 peer reviewed scientific journal articles. As a member of the Interagency Ecological Program's Management Team, the Pelagic Organism Decline Management Team, and the Delta Smelt Working Group, he has experience managing and coordinating large complex research and monitoring efforts that directly inform management decisions. He also serves on the Delta Native Fishes Recovery Team, a working group at the University of California, Santa Barbara's National Center for Ecological Analysis and Synthesis that is modeling factors contributing to the Pelagic Organism Decline, the State Water Resources Control Board's Independent Team of Experts for developing flow criteria in the estuary, and has appeared in Federal District Court as an expert scientific witness for the Federal Government.

Figure 1: Conceptual model of the EwE model: Data needs, modeling abilities, research and application are linked. Potential Ecospace research outputs and applications are denoted in red.

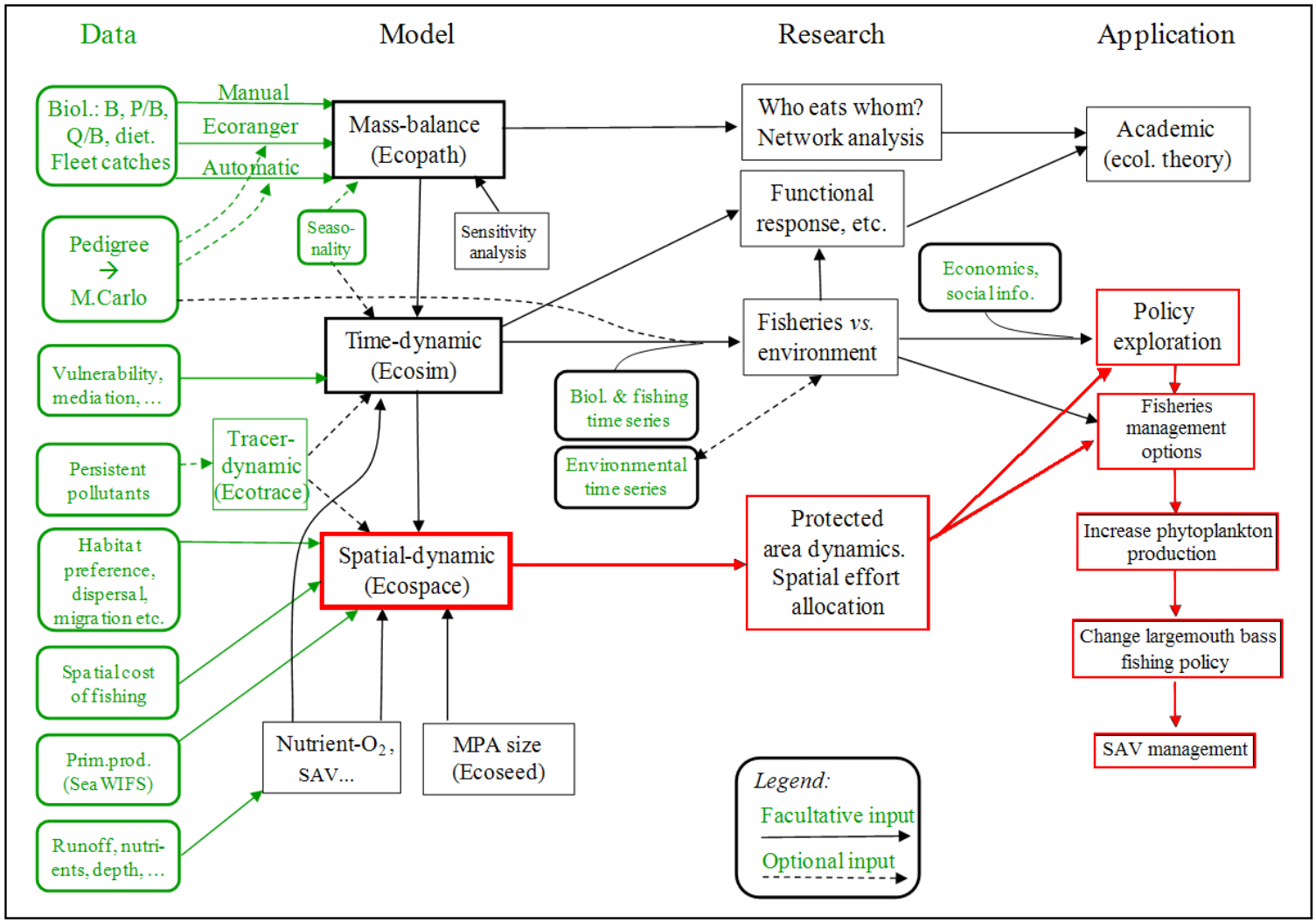

Figure 2: Conceptual model of food web linkages within the Delta Ecopath model

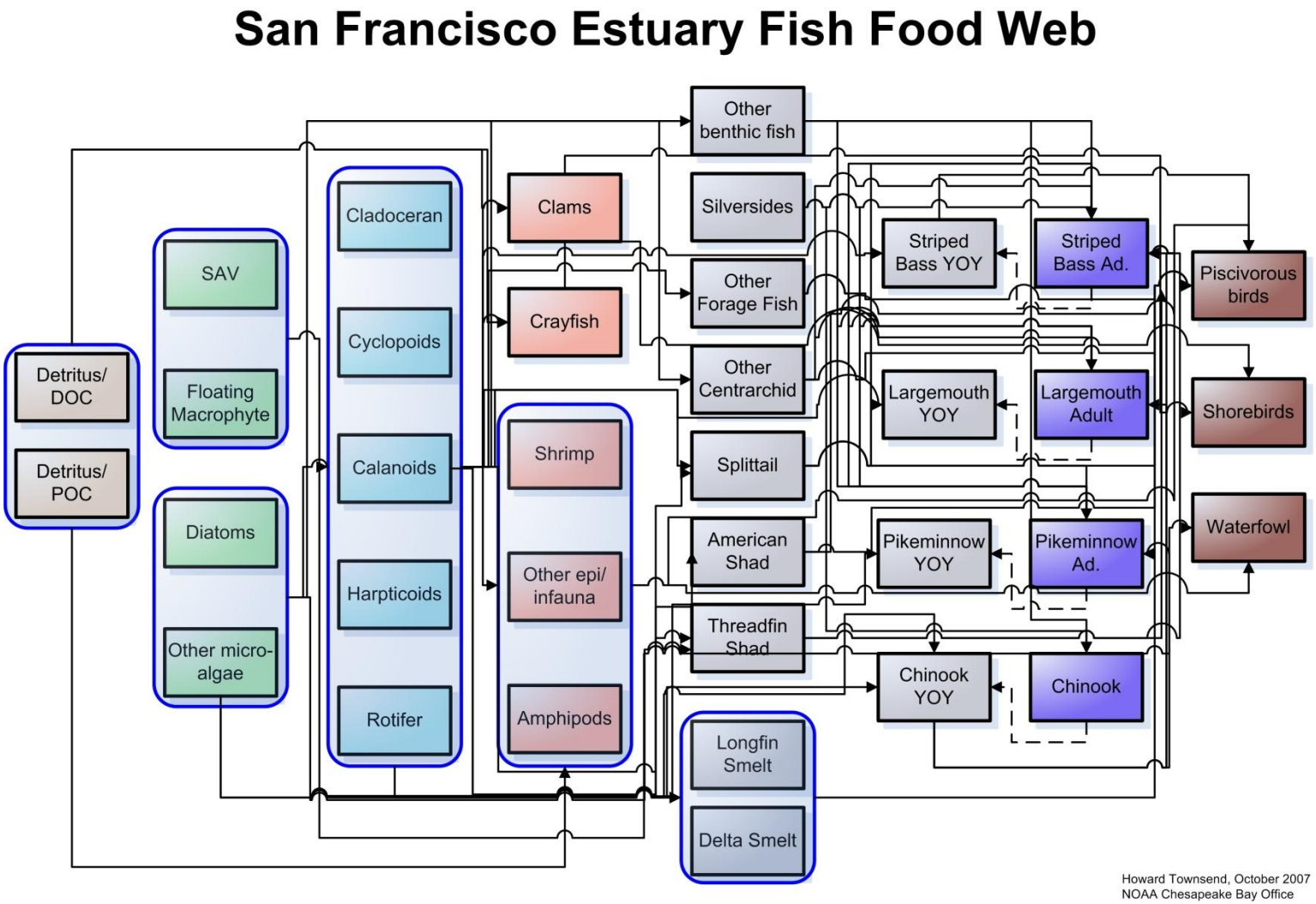

Table 1: Data sources used in the Delta Ecopath model.

Functional Group	Biomass Data Source	P/B Data Source	Q/B Data Source
Striped Bass	b	Stevens et al. (1985)	Froese and Pauly (2004)
Largemouth Bass	USFWS beach seine	Randall and Minns (2000)	**a**
Sturgeon	c	c	Froese and Pauly (2004)
Chinook 0	**a**	Randall and Minns (2000)	Cech and Myrick (1999)
Catfish	Schaffter (1997)	Schaffter and Kohlhorst (1997)	Froese and Pauly (2004)
Other cenntrarchids	USFWS beach seine	Randall and Minns (2000)	Froese and Pauly (2004)
Delta Smelt	FMT	**a**	Froese and Pauly (2004)
Longfin Smelt 1+	FMT	**a**	Froese and Pauly (2004)
Tule Perch	USFWS beach seine	Froese and Pauly (2004)	Froese and Pauly (2004)
Starry Flounder	DFG bay study	Field et al. (2006)	Froese and Pauly (2004)
Pikeminnow 1	DFG bay study	Ruzicka et al. (2007)	Froese and Pauly (2004)
American Shad	FMT	Crecco et al. (1983)	Froese and Pauly (2004)
Splittail 0	FMT	Moyle et al., (2004)	Froese and Pauly (2004)
Threadfin Shad	FMT	Froese and Pauly (2004)	Froese and Pauly (2004)
Gobies/Sculpins	DFG bay study	Randall and Minns (2000).	Froese and Pauly (2004)
Silversides	USFWS beach seine	Froese and Pauly (2004)	Froese and Pauly (2004)
Jellyfish	d	Field et al. (2006)	**a**
Crangon f.	Benthic survey	Field et al. (2006), Ruzicka et at. (2007)	Field et al. (2006)
other Shrimp	**a**	Field et al. (2006), Ruzicka et at. (2007)	Field et al. (2006)
Corbicula clams	J. Thompson, pers.com	Christensen et al. (2000)*	**a**
Corbula clams	d	Jørgensen et al. (2000)	**a**
Mysids	DFG zooplankton survey	Ruzicka et at. (2007)	Ruzicka et at. (2007)
Amphipods	**a**	Ruzicka et at. (2007)	Ruzicka et at. (2007)
Other Epi/infauna	**a**	Jorgensen et al. (2000)	**a**
Cladocerans	**a**	e	e
Calanoids	**a**	e	e
Cycloploid	**a**	e	e
Harpticoids	**a**	e	e
Limnoithona	d	e	e
SAV	d	e	-
	a	e	-
Other Micro-algae	a	e	-
Detritus (DOC-POC)	a	-	-

a) Parameter calculated by model
b) Petersen mark-recapture estimates, F. Feyrer pers. Com.
c) DFG tagging studies, fishing report cards, abundance estimates, and survival data
d) Species will be 'forced' into the system via a forcing function time series that represents the population increase using Ecosim.
e) Commonly accepted literature value

FMT: DFG fall midwater trawl survey
Christensen et al. (2000)*: estimated from an empirical equation of Thomas Brey (1999; 2000), included in the Ecopath software (see Christensen et al. (2000)] for a description of the algorithm
Trophic level: Calculated by model based on input parameters and diet composition

References

Allen, K.R. 1971. Relation between production and biomass. Fish. Res. Board Can. 28 (1971), pp. 1573–1584.

Bauer, M., Townsend, H., Brown, L., and Feyrer, F. 2010 (in prep). Establishing Baseline Conditions for the San Francisco Estuary: An Ecopath Model describing the Estuary in the Early 1980s.

Booth, S and Zeller, D. 2005. Mercury, Food Webs, and Marine Mammals: Implications of Diet and Climate Change for Human Health. Environmental Health Perspectives, 133, 521–526.

Chen, Z., Qiu, Y., Jia, X., and Xu, S. 2008. Using an Ecosystem Modeling Approach to Explore Possible Ecosystem Impacts of Fishing in the Beibu Gulf, Northern South China Sea. Ecosystems, v. 11, n. 8, p. 1318-1333.

Christensen, V., Walters, C.J. and Pauly, D. 2005. Ecopath with Ecosim: a User's Guide. Fisheries Centre, University of British Columbia, Vancouver. November 2005 edition, 154 p. (available online at www.ecopath.org)

Christensen, V. and Pauly, D., 1992. Ecopath II - a software for balancing steady-state ecosystem models and calculating network characteristics. Ecol. Model., 61:169-185.

Christensen, V. and Walters, C.J., 2004. Ecopath with Ecosim: methods, capabilities and limitations. Ecol. Model., 172 :109-139.

Christensen, V., Beattie A., Buchanan, C., Martell, SJD., Latour, RJ.,Preikshot, D., Sigrist, M., Uphoff, JH., Walters, CJ., Wood,RJ., and Townsend, H. Fisheries ecosystem model of the Chesapeake Bay: Methodology, parameterization, and model exploration. Draft Technical Report for submission to NOAA Technical Report Series. Current revision: 9 June 2008.

Christensen, V., Walters, C.J., Pauly, D. 2000. Ecopath with Ecosim: a User's Guide, October 2000 Edition. Fisheries Centre, University of British Columbia, Vancouver, Canada and ICLARM, Penang, Malaysia, 130 pp.

Cloern, J. E. 2007. Habitat Connectivity and Ecosystem Productivity: Implications from a Simple Model. Am. Nat. 169: E21-E33.

Cole, B. E., and Cloern, J. E. 1984. Significance of biomass and light availability to phytoplankton productivity in San Francisco Bay. Mar. Ecol. Prog. Ser. 17: 15-24.

Crecco, V., Savoy, T., and Gunn, L., 1983. Daily Mortality Rates of Larval and Juvenile American Shad (Alosa sapidissima) in the Connecticut River with Changes in Year-Class Strength: Can. J. Fish. Aquat. Sci. , v. 40, p. 1719-1728.

de Mutsert, K. 2010. The Effects of a Freshwater Diversion on Nekton Species Biomass Distributions, Food Web Pathways, and Community Structure in a Louisiana Estuary. Ph.D. dissertation. Louisiana State University, Department of Oceanography and Coastal Sciences.

Durand J. 2008. Delta Foodweb Conceptual Model. Sacramento (CA): Delta Regional Ecosystem Restoration Implementation Plan.

Field, J.C., Francis, R.C. and Aydin, K. 2006.Top-down modeling and bottom-up dynamics: linking a fisheries-based ecosystem model with climate hypotheses in the Northern California current, Prog. in Ocea. 68, pp. 238–270.

Froese, R. and Pauly, D. (eds) (2004) FishBase. World Wide Web electronic publication http://www.fishbase.org, version 16 February 2004.

Fulton, E.A., Smith, A.D., and Johnson, C.R. 2003. Effect of complexity on marine ecosystem models. Mar. Ecol. Prog. Ser., v.256, p. 1-16.

Jassby, A.D., Kimmerer, W.J., Monismith, S.G., Armor, C., Cloern, J.E., Powell, T.M., Schubel, J.R., and Vendlinski, T.J. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecol. Appl. 5: 272-289.

Jørgensen, S.E., Patten, B.C. and Straskraba, M. 2000. Ecosystems emerging. 4. Growth, Ecol. Model. 126 (2–3), pp. 249–284.

Kimmerer, W. J. 2002a. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? Mar. Ecol. Prog. Ser. 243: 39-55.

Kimmerer, W. J. 2002b. Physical, biological, and management responses to variable freshwater flow into the San Francisco Estuary. Est. 25: 1275-1290.

Libralato S., Christensen, V., and Pauly, D. 2006. A method for identifying keystone species in food web models, Ecol. Model., 195 (3-4), pp. 153-171.

Ma, H., Townsend, H. Zhang, X., Sigrist, M., and Christensen, V. 2010. Using a fisheries ecosystem model with a water quality model to explore trophic and habitat impacts on a fisheries stock: A case study of the blue crab population in the Chesapeake Bay. Ecol. Model., v. 221, n. 7, p. 997-1004.

Mackay, A. 1981. The generalized inverse. Prac. Comp. (September):108-110.

Moyle, P.B., Baxter, R.D, Sommer, T., Foin, T.C, and Matern, S.A. 2004, Biology and Population Dynamics of Sacramento Splittail (Pogonichthys macrolepidotus) in the San Francisco Estuary: A Review: San Fran. Est. and Wat. Sci., v. 2.

Odum, E.P. 1969.The strategy of ecosystem development. Sci. 164:262–270.

Pauly, D., Christensen, V. and Walters, C., 2000. Ecopath, Ecosim, and Ecospace as tools for evaluating ecosystem impact of fisheries. ICES J. Mar. Sci., 57:697-706.

Randall, R.G., and C.K. Minns. 2000. Use of fish production per unit biomass ratios for measuring the productive capacity of fish habitats. Can. J. Fish. Aquat. Sci., 57: 1657-1667.

Ruzicka J.J., Brodeur R.D., and Wainwright, T.C. 2007. Seasonal food web models for the Oregon inner-shelf ecosystem: investigating the role of large jellyfish. Calif Coop Ocean Fish Invest Rep 48:106–128.

Schaffter R.G and Kohlhorst (1997) 1997, Mortality rates of white catfish in California's Sacramento-San Joaquin Delta: Ca Fish and Game, v. 83, p. 45-56.

Schaffter, R.G., 1997, Growth of white catfish in California's Sacramento-San Joaquin Delta: Ca Fish and Game, v. 83, p. 57-69.

Sommer, T., Armor, C., Baxter, R., Breuer, R., Brown, L., Chotkowski, M., Culberson, S., Feyrer, F., Gingras, M., Herbold, B., Kimmerer, W., Mueller-Solger, A., Nobriga, M., and Souza, K., 2007, The Collapse of Pelagic Fishes in the Upper San Francisco Estuary: El Colapso de los Peces Pelagicos en La Cabecera Del Estuario San Francisco: Fish., v. 32, p. 270-277.

Stevens, D.E., Kohlhorst, D.W., and Miller, L.W. 1985. The decline of striped bass in the Sacramento-San Joaquin estuary, California. Tran. Amer. Fish. Soc. 114:12-30.

Thomson, J., Kimmerer, W., Brown, L., Newman, K., Mac Nally, R., Bennett, W., Feyrer, F., and Fleishman, E. 2010. Bayesian change-point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecol. App.. doi: 10.1890/09-0998

Townsend, H., Bauer, M., Brown, L., and Feyrer, F. 2010 (in prep). An Ecosystem Model for testing potential causes of the San Francisco Estuary Pelagic Organisms Decline.

Ulanowicz, 1986. R.E. Ulanowicz, Growth and Development: Ecosystem Phenomenology. In: , Springer-Verlag, New York (1986), p. 203.

Villanueva, M.C.S., Isumbisho, M., Kaningini, B., Moreau, J., and Micha, J., 2008, Modeling trophic interactions in Lake Kivu: What roles do exotics play? Ecol. Mod., v. 212, p. 422-438.

Walters, C., Pauly, D. and Christensen, V. 1999. Ecospace: prediction of mesoscale spatial patterns in trophic relationships of exploited ecosystems, with emphasis on the impacts of marine protected areas. Ecosys. 2, pp. 539–554.

2010 PSP SIGNATURE PAGE

The applicant for this proposal must submit the signature form by printing it, having it signed, scanning the signed form, and uploading the scanned document by using the "upload" button on the signature page form on our website. If you do not have access to a scanner, you may submit your signed form via FAX to (916) 445 - 7311. Please send only one form per FAX transmission.

Failure to sign and submit this form, by the submission deadline, will result in the application not being considered for funding. The Primary Contact for this proposal will receive e-mail confirmation as soon as this signature page has been processed.

By signing below, I declare that:

- All representations in this proposal are truthful;
- I am authorized to submit the application on behalf of applicant (if applicant is an entity or organization);
- I have read and understand the conflict of interest section in the main body of the PSP and waive any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent provided in this PSP, and
- I have read and understood all attachments of this PSP.

Proposal Title:	Development of a spatially explicit ecosystem model to explore physicochemical drivers of step changes in POD species abundance and distribution in the Sacramento-San Joaquin Delta and Suisun Bay
Lead Investigator:	Larry Brown
Organization:	US Geological Survey
Proposal #:	2010.01-0019

Signatory for the applicant organization: SHARON E GREGG

(Please print the name of the signatory) Acting on behalf of ERIC D RICHARD, DIRECTOR

Sharon E Gregg

Signature

6/29/2010

Date

Curriculum Vitae

Larry R. Brown

U.S. Geological Survey, WRD
Placer Hall
6000 J Street
Sacramento, CA 95819-6129
Phone: (916) 278-3098
e-mail: lrbrown@usgs.gov

EDUCATION:

1974 - 1978 B.S., Biological Sciences, University of California, Irvine, California.

1979 - 1980 B.S., Wildlife and Fisheries Biology, University of California, Davis, California.

1980 - 1982 M.S., Ecology, University of California, Davis, California. Thesis: Age, growth, feeding and behavior of Sacramento squawfish (*Ptychocheilus grandis*), in Bear Creek, Colusa County, California.

1983 - 1988 Ph.D., Ecology, University of California, Davis, California. Dissertation: Factors determining the distribution of three species of sculpin (*Cottus*) in the Pit River drainage, California. I studied the physiology, habitat preferences, and interspecific behavior of three species of sculpin endemic to the Pit River drainage to determine if the distribution of the three species could be explained on the basis of these factors.

FIELD OF INTEREST: Fish Ecology/Aquatic Ecology

RESEARCH EXPERIENCE:

August 2004-present Research Biologist (GS-0401-14-05), U.S. Geological Survey, Water Resources Discipline, Sacramento, California. I serve as technical specialist and team leader for the California Water Science Center on problems relating to aquatic biology and ecology with wide latitude in developing a research program. In particular, I oversee the design, implementation, and interpretation of all ecological studies associated with the National Water Quality Assessment Program in California. The river systems being studied include the San Joaquin River, Sacramento River, and Santa Ana River. I am a member of the Pelagic Organism Decline (POD) management team of the Interagency Ecological Program. I also write proposals and conduct other ecological studies in California. The latter role includes both internal activities such as review of ecological components of other USGS programs and external activities such as participation in expert panels, review teams, and work groups.

Employer/Supervisor, Debra Curry, Placer Hall, 6000 J Street, Sacramento, CA, 95819-6129, (916) 278-3178.

February 1999- August 2004 Research Biologist (GS-0401-13-06), U.S. Geological Survey, Water Resources Discipline, Sacramento, California. I am responsible for the design, implementation, and interpretation of all ecological studies associated with the National Water Quality Assessment Program in California. The river systems being studied include the San Joaquin River, Sacramento River, and Santa Ana River. The studies include surveys of fishes, benthic invertebrates, and algae and studies of contaminants in river sediments and tissues of biota. I also write proposals and conduct other ecological studies in California and serve as the California District expert on ecological issues. The latter role includes both internal activities such as review of ecological components of other USGS programs and external activities such as participation in expert panels, review teams, and work groups.

Employer/Supervisor, Charles Kratzer, Placer Hall, 6000 J Street, Sacramento, CA, 95819-6129, (916) 278-3076.

June 1997 - January 1999 Fishery Biologist (GS-0482-12-06), Scientific Support Branch, Mid-Pacific Region, U.S. Bureau of Reclamation, Sacramento, California. This was a two-year (maximum) temporary assignment from the U.S. Geological Survey. I represented the Bureau of Reclamation in a wide variety of interagency work groups and committees. In particular, I was a member of the Management Team of the Interagency Ecological Program and represented the Bureau of Reclamation on the Steering Committee for the design of a Comprehensive Monitoring and Assessment Program for the CALFED Program. I also provided ecological expertise to Regional and Area office staff.

Employer/Supervisor, Ken Lentz, U.S. Bureau of Reclamation, MP-151, Scientific Support Branch, 2800 Cottage Way, Sacramento, CA, 95825, (916) 978-5035.

August 1991 - June 1997 Physical Scientist (GS-1301-12-05), San Joaquin-Tulare Basins Study Unit and Sacramento Basin Study Unit of the National Water Quality Assessment Program, U.S. Geological Survey, Sacramento, California. I was responsible for the design, implementation, and interpretation of ecological surveys of fishes, benthic invertebrates, and algae. These surveys established baseline conditions for long-term monitoring of water quality and described the present conditions for biota in the flowing surface waters of the San Joaquin Valley of California. I was also responsible for collection of specimens for analysis of trace elements and pesticides in tissues and for interpretation of the resulting data.

Employer/Supervisor, Neil M. Dubrovsky, Placer Hall, 6000 J Street, Sacramento, CA, 95819-6129, (916) 278-3078.

1987 - June 1991 Post-graduate Researcher, Eel River Project, Coho Salmon Project, and American River Project, Dept. of Wildlife and Fisheries Biology, University of California, Davis, California. I was responsible for all aspects of the above studies. The Eel River project involved a survey of the distribution and abundance of fishes in the Eel River drainage, yearly population estimates at a number of stations in the drainage, and the study of the effects of the introduction of Sacramento squawfish into the drainage. The coho salmon project involved the preparation of a status report for coho salmon in California based on a literature review and unpublished

data. The American River project involved collection and analysis of seining and electrofishing data to determine the habitat requirements of the resident and anadromous fishes.

Employer/Supervisor, Peter B. Moyle, Department of Wildlife, Fisheries, and Conservation Biology, University of California, Davis, CA, 95616, (530) 752-6355.

1986 - 1987 Research Assistant, San Joaquin Valley Project, Dept. of Wildlife and Fisheries Biology, University of California, Davis, California. I was responsible for all aspects of the study, which involved a survey of the distribution and abundance of the fishes of the mid-elevation streams of the San Joaquin Valley, with special emphasis on the endemic Kern brook lamprey, and a study of inter-drainage variation in the morphology of California roach.

Employer/Supervisor, Peter B. Moyle, Department of Wildlife, Fisheries, and Conservation Biology, University of California, Davis, CA, 95616, (530) 752-6355. 30 hours per week.

1985 - 1986 Research Assistant, Index of Biotic Integrity Project, Dept. of Wildlife and Fisheries Biology, University of California, Davis, California. I conducted fish sampling, data analysis, and wrote the reports for this project, which attempted to develop a method for using the abundances of fish to monitor the `health' (water quality) of streams.

Employer/Supervisor, Peter B. Moyle, Department of Wildlife, Fisheries, and Conservation Biology, University of California, Davis, CA, 95616, (530) 752-6355. 20 hours per week.

1983 - 1985 Research Assistant, Pit River Project, Dept. of Wildlife and Fisheries Biology, University of California, Davis, California. I conducted fish sampling (boat electroshocking, gill netting, seining, snorkel surveys, and three-pass population estimates), collected microhabitat data and did some data analysis.

Employer/Supervisor, Peter B. Moyle, Department of Wildlife, Fisheries, and Conservation Biology, University of California, Davis, CA, 95616, (530) 752-6355. 20 hours per week.

1982 - 1983 Research Assistant, Feather River Project, Dept. of Wildlife and Fisheries Biology, University of California, Davis, California. I assisted in the gathering of data required for hydraulic simulation studies (IFG4) and in the conduct of three-pass population estimates.

Employer/Supervisor, Peter B. Moyle, Department of Wildlife, Fisheries, and Conservation Biology, University of California, Davis, CA, 95616, (530) 752-6355. 20 hours per week.

1980 - 1982 Research Assistant, Suisun Marsh Project, Dept. of Wildlife and Fisheries Biology, University of California, Davis, California. I assisted in monthly sampling of the

marsh, using seines and otter trawls. I also collected and analyzed food habit and growth data.

Employer/Supervisor, Peter B. Moyle, Department of Wildlife, Fisheries, and Conservation Biology, University of California, Davis, CA, 95616, (530) 752-6355. 20 hours per week.

1979 - 1980 Independent Research Project, Dept. of Wildlife and Fisheries Biology, University of California, Davis, California. I conducted a comparative study of the age, growth and diet of Tahoe sucker from a Sierra Nevada reservoir and its tributary streams.

Employer/Supervisor, Joseph J. Cech, Department of Wildlife, Fisheries, and Conservation Biology, University of California, Davis, CA, 95616, (530) 752-3103. I worked as a volunteer for Bruce Vondracek, one of Dr. Cech's graduate students, to earn research credit.

TEACHING EXPERIENCE:

1992-1994 Instructor, Concepts in Aquatic Ecology, U.S. Geological Survey National Training Center, Denver, Colorado. I taught the portion of this week-long course dealing with the ecology of fishes.

Spring 1991 Lecturer, Marine Sciences 142 (Ichthyology), University of California, Santa Cruz, California. I taught a one quarter course in Ichthyology. Lectures covered taxonomy, evolution, and ecology of fishes. The laboratory stressed classification and identification of local California species. Student evaluations of the class and my performance generally ranged from good to outstanding. Original evaluations are on file at the Marine Sciences office.

1990 Guest lecturer in Biology of Fishes, U.C.D.

1985 Guest lecturer in Biology of Fishes, U.C.D.

Fall 1985 Teaching Assistant to Dr. Peter B. Moyle, WFB 120 (Fish Ecology), Dept. of Wildlife and Fisheries Biology, University of California, Davis, California. I had complete responsibility for the laboratory section of the class. My duties included lecturing, leading laboratory activities, writing tests, and grading.

Fall 1984 Teaching Assistant to Dr. Peter B. Moyle, WFB 120 (Fish Ecology), Dept. of Wildlife and Fisheries Biology, University of California, Davis, California. I had complete responsibility for the laboratory section of the class. My duties included lecturing, leading laboratory activities, writing tests, and grading.

Fall 1980 Teaching Assistant to Dr. Nadine Jacobsen, WFB 130 (Physiological Ecology), Dept. of Wildlife and Fisheries Biology, University of California, Davis, California. My duties included lecturing in discussion sections, conducting laboratory demonstrations and grading tests, term papers and oral presentations.

RESEARCH GRANTS/CONTRACTS:

2007 POD-NCEAS: I serve on the Pelagic Organisms Decline (POD) Management Team with the particular role of facilitating the interactions of the team with the National Center for Ecological Analysis and Synthesis at University of California-Santa Barbara. $300,000 per year

2006 CASCaDE: Computational Assessments of Scenarios of Change for the Delta Ecosystem. I am a co-Principal Investigator on this project that will begin to assess the responses of fish populations to selected scenarios of climate change. $102,000

2005 Algae as a biological Indicator of stream condition, Kings River Experimental Watershed. I am the Principal Investigator on this project to assess the utility of monitoring stream algae as part of a test of several forest management practices in experimental watersheds. This is a continuation of the 2001 project. $60,000

2003 The role of the alien clam *Corbicula fluminea* in the regulation of organic carbon in the San Joaquin River watershed: implications for management in the Sacramento-San Joaquin Delta. I am a co-Principal Investigator on this project that will begin to assess the impact of an alien clam on the food web of rivers in the San Joaquin River basin. Total: $1,662,870, my portion: $189,927.

2003 Analysis of Interagency Ecological Program Fisheries data sets. I am currently receiving funds from the CALFED Science Program to analyze existing data collected as part of IEP monitoring programs. I also work on CALFED Science issues of mutual interest as part of this agreement. $ 430,000

2001 Algae as a biological Indicator of stream condition, Kings River Experimental Watershed. I am the Principal Investigator on this pilot project to assess the utility of monitoring stream algae as part of a test of several forest management practices in experimental watersheds. $28,000

2000 Ecological Role of Grizzly Bay as Shallow-water Nursery Habitat for Resident Fishes. I am a co-Principal Investigator on this project that will assess the importance of Grizzly Bay as nursery habitat for larvae of resident fishes of the Sacramento-San Joaquin Delta. $334,000.

2000 Assessment of Habitat Use of the Chinese Mitten Crab (*Eriocheir sinensis*) in the Freshwater Habitats of the San Joaquin River Basin. This study documented at habitat use and distribution of the recently introduced mitten crab in selected streams of the San Joaquin River Drainage. $46,000

1996 San Joaquin River Drainage Contaminants. This study addressed concentrations of organochlorine contaminants in the tissues of biota before and after a large flood event. The purpose is to determine if large floods can affect bioavailability of contaminants. National Biological Service. $6,000

1996 Yosemite National Park Study. This study involved monitoring of benthic macroinvertebrate and periphyton communities in relation to stream restoration activities in the Park. Memorandum of Understanding between U.S. Geological Survey, NAWQA Program and National Park Service. $13,000

1995 Yosemite National Park Study. This study involved monitoring of water quality and determining the relationship between water quality and periphyton communities. Memorandum of Understanding between U.S. Geological Survey, NAWQA Program and National Park Service. $20,000

1990 American River studies: intensive fish surveys. California Department of Fish and Game. $48,000 written with Peter B. Moyle, P.I. and David C. Vanicek, P.I.

1989 Eel River fish survey: fourth year studies. California Department of Fish and Game. $82,000, written with Peter B. Moyle, P.I.

1988 Eel River fish survey: third year studies. California Department of Fish and Game. $78,000, written with Peter B. Moyle, P.I.

1987 Eel River fish survey: second year studies. California Department of Fish and Game. $71,000, written with Peter B. Moyle, P.I.

1985 Factors determining the distribution of three species of sculpin (*Cottus*) in the Pit River drainage, California. Jastro-Shields Graduate Research Scholarship, University of California, Davis. $1,500.

1984 Factors determining the distribution of three species of sculpin (*Cottus*) in the Pit River drainage, California. Jastro-Shields Graduate Research Scholarship, University of California, Davis. $1,500.

PROFESSIONAL SOCIETIES:

Sigma Xi
Ecological Society of America
American Fisheries Society
California-Nevada Chapter American Fisheries Society
American Institute of Fishery Research Biologists
Estuarine Research Federation
California Estuarine Research Society
North American Benthological Society

HONORS:

California State Scholarship, U.C. Irvine, 1974-1978
Phi Beta Kappa, U.C. Irvine, 1978

Jastro-Shields Graduate Research Scholarship, College of Agricultural and Environmental Sciences, U.C.D. 1984 and 1985.
U.S. Geological Survey Performance Award, 1992, 1993, and 1994
U.S. Fish and Wildlife Service Certificate of Appreciation for participation in the Delta Native Fishes Recovery Team, 1995
American Fisheries Society, Certified Fisheries Biologist, 1997
Citation for Participation in the Data Assessment Team, 1998
U.S. Bureau of Reclamation Performance Award, 1999
American Institute of Fishery Research Biologists, Fellow, 2005
U.S. Geological Survey, Western Region, Excellence in Science Award, 2006
California-Nevada Chapter American Fisheries Society, Award for Distinguished Professional Achievement, 2007

PROFESSIONAL SERVICE:

2008-present, Thesis Committee for Marissa Bauer, California State University, Chico. Major Professor: John Nishio.
2006-2009, Co-editor of American Fisheries Society Symposium volume 72, Biology, Management, and Conservation of Lampreys in North America.
2006-2007, Advisor to CALFED Post-doctoral Fellowship recipient Christa Woodley, University of California, Davis, CA. Other advisors: Peter Moyle and William Bennett.
2005-2009, Dissertation Committee for Lenny F. Grimaldo, University of California, Davis, CA. Major Professor: Peter Moyle.
2005-2007, Program Co-Chair, 2007 Annual Meeting of the American Fisheries Society
2005-2006, Conference Co-chair for 4th CALFED Science Conference
2004, Member of Scientific Review Panel, Lower Klamath River Science Conference, June 7-10.
2003-2005, Co-Editor of American Fisheries Society Symposium volume, Effects of Urbanization on Stream Ecosystems
2003-2004, Member of organizing committee for 3rd CALFED Science Conference
2003-2004, Co-Editor of American Fisheries Society Symposium volume, Early Life History of Fishes in the San Francisco Estuary and Watershed
2003, Organized Symposium for 2003 American Fisheries Society Annual Meeting, Effects of Urbanization on Aquatic Ecosystems
2002-2004, Dissertation Committee for Joaquin B. Feliciano, University of California, Davis, CA. Major Professor: Peter Moyle.
2002-2004, Dissertation Committee for Joe Merz, University of California, Davis, CA. Major Professor: Peter Moyle.
2002-2003, Co-Program Chair for the 2nd CALFED Science Conference
2002, Member of Scientific Review Panel, Surface Water Ambient Monitoring Program of the California State Water Resources Board, May 21-22.
2002-2004, Ph.D. Dissertation Committee for Robert Leidy, University of California, Davis, CA. Major Professor: Peter Moyle.
2002, Ph.D. Orals Committee for Robert Leidy, University of California, Davis, CA. Major Professor: Peter Moyle.
2002, Screening panel member for selection of candidates for National Marine Fisheries Service Recovery Teams for Central Valley salmonids (2002) and coho salmon (2002)

2002-2003, President, Water Quality Section, American Fisheries Society
2001-2002, President, California-Nevada Chapter, American Fisheries Society
2000 and 2001, Selection Committee, EPA Science Achievement Award, Biology/Ecology
2000, Co-Program Chair, for the 1st CALFED Science Conference
1999 and 2000, Session Chair, Annual Meeting, California-Nevada Chapter, American Fisheries Society
Referee for various journals including: Transactions of the American Fisheries Society, Environmental Biology of Fishes, Canadian Journal of Fisheries and Aquatic Sciences, North American Journal of Fisheries Management, Copeia, and Journal of Fish Biology

REFERENCES:

Dr. Peter B. Moyle, Professor, Department of Wildlife, Fisheries, and Conservation Biology, University of California, Davis, CA 95616
Phone: (530) 752-6355
FAX: (530) 752-4154
e-mail: pbmoyle@ucdavis.edu

Dr. Terry M. Short, Regional Biologist, U.S. Geological Survey, 345 Middlefield Road, Mail Stop 470, Menlo Park, CA 94025-3591
Phone: (650) 329-4324
FAX: (650) 329-4463
e-mail: tmshort@usgs.gov

Dr. Bret C. Harvey, Aquatic Ecologist, Pacific Southwest Forest and Range Experiment Station, Redwood Sciences Laboratory, U.S. Forest Service, 1700 Bayview Drive, Arcata, CA 95521
Phone: (707) 825-2926
FAX: (707) 822-5628
e-mail: bch3@axe.humboldt.edu

Dr. Neil M. Dubrovsky, Supervisory Hydrologist, U.S. Geological Survey, Water Resources Division, Placer Hall, 6000 J Street, Sacramento, CA 95819-6129
Phone: (916) 278-3078
FAX: (916) 278-3071
e-mail: nmdubrov@usgs.gov

Dr. Michael R. Meador, Biologist, U.S. Geological Survey, Water Resources Division, 409 National Center, 12201 Sunrise Valley Drive, MS 413, Reston, VA, 20192
Phone: (703) 648-5620
e-mail: mrmeador@usgs.gov

PUBLICATIONS:

Brown, L.R. and P.B. Moyle. 1981. The impact of squawfish on salmonid populations: a review. North American Journal of Fisheries Management 1:104-111.

Vondracek, B., L.R. Brown and J.J. Cech, Jr. 1982. Comparison of age, growth and feeding of the Tahoe sucker from Sierra Nevada streams and a reservoir. California Fish and Game 68:36-46.

Baltz, D.M., B. Vondracek, L.R. Brown and P.B. Moyle. 1987. Influence of temperature on microhabitat choice by fishes in a California stream. Transactions of the American Fisheries Society 116:12-20.

Vondracek, B., D.M. Baltz, L.R. Brown and P.B. Moyle. 1989. Spatial, seasonal and diel distribution of fishes in a California reservoir dominated by native fishes. Fisheries Research 7:31-53.

Brown, L.R. 1989. Temperature preferences and oxygen consumption of three species of sculpin (*Cottus*) from the Pit River drainage, California. Environmental Biology of Fishes 26:223-236.

Brown, L.R. 1990. Age, growth, feeding and behavior of Sacramento squawfish (*Ptychocheilus grandis*) in Bear Creek, Colusa County, California. The Southwestern Naturalist 35:249-260.

Brown, L.R. 1991. Differences in habitat choice and behavior among three species of sculpins (*Cottus*), in artificial stream channels. Copeia 1991:810-819.

Brown, L.R. and P.B. Moyle. 1991. Changes in habitat and microhabitat use of an assemblage of stream fishes in response to predation by Sacramento squawfish (*Ptychocheilus grandis*). Canadian Journal of Fisheries and Aquatic Sciences 48:849-856.

Baltz, D.M., B. Vondracek, L.R. Brown, and P.B. Moyle. 1991. Seasonal changes in microhabitat selection by rainbow trout in a small stream. Transactions of the American Fisheries Society 120:166-176.

Brown, L.R., P.B. Moyle and W.A. Bennett. 1992. Morphological variation among populations of California roach, *Lavinia symmetricus*: implications for conservation strategies. Biological Conservation 62:1-10.

Brown, L.R. and P.B. Moyle. 1992. Native fishes of the San Joaquin drainage: status of a remnant fauna. Pp. 89-98, *in*, D.F. Williams, T.A. Rado, and S. Byrne, (eds.), Proceedings of the conference on endangered and sensitive species of the San Joaquin Valley, California. California Energy Commission, Sacramento, California.

Brown, L.R. and P.B. Moyle. 1993. Distribution, ecology, and status of the fishes of the San Joaquin River drainage, California. California Fish and Game 79:96-114.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Status of coho salmon (*Oncorhynchus kisutch*) in California. North American Journal of Fisheries Management 14:237-261.

Brown, L.R., S.A. Matern, and P.B. Moyle. 1995. Comparative ecology of prickly sculpin (*Cottus asper*) and coastrange sculpin (*C. aleuticus*) in the Eel River drainage, California. Environmental Biology of Fishes 42:329-343.

Brown, L.R. and A. Brasher. 1995. Effects of predation by Sacramento squawfish (*Ptychocheilus grandis*) on habitat choice of California roach (*Lavinia symmetricus*) and rainbow trout (*Oncorhynchus mykiss*) in artificial streams. Canadian Journal of Fisheries and Aquatic Sciences 52:1639-1646.

Periera, W.E., Domagalski, J.L., Hostettler, F.D., Brown, L.R., and Rapp, J.B. 1996. Occurrence and accumulation of pesticides and organic contaminants in river sediment, water and clam tissues from the San Joaquin River and tributaries, California. Environmental Toxicology and Chemistry 14:172-180.

Brown, L.R. 1997. Water-quality assessment of the San Joaquin-Tulare basins, California: Analysis of available information on aquatic biology, through 1992. U.S. Geological Survey, Water Supply Paper 2471.

Brown, L.R. and P.B. Moyle. 1997. Invading species in the Eel River, California: successes, failures, and relationships with resident species. Environmental Biology of Fishes 49:271-291.

Brown, L.R. 1997. Concentrations of chlorinated organic compounds in biota in relation to concentrations in bed sediment in streams of the San Joaquin Valley, California. Archives of Environmental Contamination and Toxicology 33:357-368.

Brown, L.R., C.R. Kratzer, and N.M. Dubrovsky. 1999. Integrating chemical, water quality, habitat, and fish assemblage data from the San Joaquin River drainage, California. Pp. 25-62, in, K.M. Scow, G.E. Fogg, D.E. Hinton, and M.L. Johnson (eds.), Integrated assessment of ecosystem health, Lewis Publishers, Boca Raton, FL.

Brown, L.R., A.M. Brasher, B.C. Harvey, and M. Matthews. 1999. Success and failure of invading species in stream systems: case studies from California and Hawaii. Pp. 415-430, in, R. Claudi and J. Leach (eds.), Non-indigenous freshwater organisms in North America: their biology and impact, Lewis Publishers, Boca Raton, FL.

Brown, L.R. 2000. Fish communities and their associations with environmental variables, lower San Joaquin River drainage, California. Environmental Biology of Fishes 57:251-269.

Brown, L.R. and J.T. May. 2000. Macroinvertebrate assemblages on woody debris and their relations with environmental variables in the lower Sacramento and San Joaquin river drainages, California. Environmental Monitoring and Assessment. Environmental Monitoring and Assessment 64:311-329.

Ford, T.J. and L.R. Brown. 2001. Distribution and Abundance of Chinook Salmon and Resident Fishes of the Lower Tuolumne River, California. Pp. 253-304, in, R. Brown (ed.), Fish Bulletin 179: Contributions to the Biology of Central Valley Salmonids.

California Department of Fish and Game, Sacramento, CA.

Leland, H.V., L.R. Brown, and D.K. Mueller. 2001. Distribution of algae in the San Joaquin River, California, in relation to nutrient supply, salinity, and other environmental factors. Freshwater Biology 46:1139-1167.

May, J.T. and L.R. Brown. 2002. Fish community structure in relation to environmental variation within the Sacramento River Basin and implications for streams of the Central Valley, California. Environmental Biology of Fishes 63:373-388.

Brown, L.R. and T.J. Ford. 2002. Effects of flow on the fish communities of a regulated California river: implications for managing native fishes. River Research and Applications 18:331-342.

Meador, M.R., L.R. Brown, and T.M. Short. 2003. Relations between introduced fish and environmental conditions at large geographic scales. Ecological Indicators 3:81-92.

Brown, L.R. 2003. An introduction to the San Francisco Estuary tidal wetlands restoration series. In: L.R. Brown, editor. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1, Article 1. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art1.

Brown, L.R. 2003. Will tidal wetland restoration enhance populations of native fishes? In: L.R. Brown, editor. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1, Article 2. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2.

Brown, L.R. 2003. Potential effects of organic carbon production on ecosystems and drinking water. In: L.R. Brown, editor. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1, Article 3. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art3.

Brown, L.R. 2003. A summary of the tidal wetlands restoration series. In: L.R. Brown, editor. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1, Article 6. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art6.

Dege, M. and L.R. Brown. 2004. Springtime Distribution and Abundance of Larval and Juvenile Fishes in the Upper San Francisco Estuary. Pages 49-66 *in* F. Feyrer, L.R. Brown, R. Brown, and J. Orsii, editors. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Bethesda, Maryland.

Matern, S.A. and L.R. Brown. 2005. Invaders eating invaders: exploitation of novel alien prey by the shimofuri goby in the San Francisco Estuary, California. Biological Invasions 7:497-507.

Brown, L.R. and P.B. Moyle. 2005. Native fish communities of the Sacramento-San Joaquin watershed, California: a history of decline. Pages 75-98 *in* F. Rinne, R. Hughes, and R.

Calamusso, editors. Fish Communities of Large Rivers of the United States. American Fisheries Society, Bethesda, Maryland.

Brown, L.R., C.A. Burton, and K. Belitz. 2005 Aquatic communities of the highly urbanized Santa Ana River Basin, California. Pages 263-290 *in* L. R. Brown, R. M. Hughes, R. Gray, and M. R. Meador, editors. Effects of urbanization on stream ecosystems. American Fisheries Society, Bethesda, Maryland.

Brown, L.R., R.H. Gray, R.M. Hughes, and M.R. Meador. 2005. Introduction to effects of urbanization on stream ecosystems. Pages 1-10 *in* L. R. Brown, R. M. Hughes, R. Gray, and M. R. Meador, editors. Effects of urbanization on stream ecosystems. American Fisheries Society, Bethesda, Maryland.

Burton, C.A., L.R. Brown, and K. Belitz. 2005. Relations of water source and channel type with benthic macroinvertebrate and periphyton communities in the highly urbanized Santa Ana River Basin, California. Pages 239-262 *in* L. R. Brown, R. M. Hughes, R. Gray, and M. R. Meador, editors. Effects of urbanization on stream ecosystems. American Fisheries Society, Bethesda, Maryland.

Giddings, E., L.R. Brown, T. M. Short, and M.R. Meador. 2006. Relation of fish communities to environmental conditions in urban streams of the Wasatch Front, Utah. Western North American Naturalist 66:155-168.

Brown, L.R. and J.T. May. 2006. Variation in spring nearshore resident fish species composition and life histories in the lower Sacramento-San Joaquin Watershed and Delta. San Francisco Estuary and Watershed Science Vol. 4, Issue 1 (July 2006). Article 1. http://repositories.cdlib.org/jmie/sfews/vol4/iss2/art1

Brown, L.R. and D. Michniuk. 2007. Littoral fish assemblages of the alien-dominated Sacramento–San Joaquin Delta, California, 1980–1983 and 2001–2003. Estuaries and Coasts 30:186–200.

Brown, L.R. and J.T. May. 2007. Aquatic vertebrate assemblages of the upper Clear Creek watershed, California. Western North American Naturalist 67:439-451.

Domagalski, J., C. Lin, Y. Luo, Jie Kang, S. Wang, L.R. Brown, and M.D. Munn. 2007. Eutrophication study at the Panjiakou-Daheiting Reservoir system, northern Hebei Province, People's Republic of China: Chlorophyll-*a* model and sources of phosphorus and nitrogen. Agricultural Water Management 94:43-53.

Brown, L.R., J. Thompson, K. Higgins, and L.V. Lucas. 2007. Population density, biomass, and age-class structure of an invasive clam *Corbicula fluminea* in rivers of the lower San Joaquin River watershed, California. Western North American Naturalist 67:572-586.

Brown, L.R., J.T. May, and C.T. Hunsaker. 2008. Species composition and habitat associations of benthic algal assemblages in headwater streams of the Sierra Nevada, California. Western North American Naturalist 68:194–209

Brown, L.R., W. Kimmerer, and R. Brown. 2009. Managing water to protect fish: a review of California's environmental water account. Environmental Management 43:357–368.

Lucas, L.V., J.K. Thompson, and L.R. Brown. 2009. Why are diverse relationships observed between phytoplankton biomass and transport time? Limnology and Oceanography 54:381–390.

Brown, L.R., M.B. Gregory, and J.T. May. 2009. Relation of urbanization to stream fish assemblages and species traits in nine metropolitan areas of the United States. Urban Ecosystems: DOI 10.1007/s11252-009-0082-2.

Brown, L.R. and M.L. Bauer. 2009. Effects of hydrologic infrastructure on flow regimes of California's Central Valley rivers: implications for fish populations. River Research and Applications. DOI: 10.1002/rra.1293

Brown, L.R., T. Cuffney, J.F. Coles, A.H. Bell, J.T. May, F. Fitzpatrick, G. McMahon, J. Steuer. Urban streams across the United States: lessons learned from studies in nine metropolitan areas. Journal of the North American Benthological Society 28:1051–1069.

Moyle, P.B., L.R. Brown, S.D. Chase, and R.M. Quiñones. 2009. Status and conservation of lampreys in California. Pages 279-292 *in* L.R. Brown, R.D. Chase, M. Mesa, R. Beamish, and P.B. Moyle, editors. Biology, Management, and Conservation of Lampreys in North America. American Fisheries Society, Symposium 72, Bethesda, Maryland.

Manuscripts in Press

Thomson, J., W. Kimmerer, L. Brown, K. Newman, R. Mac Nally, W. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change-point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications. doi: 10.1890/09-0998

Mac Nally, R., J. Thomson, W. Kimmerer, F. Feyrer, K. Newman, A. Sih, W. Bennett, L. Brown, E. Fleishman, S. Culberson, and G. Castillo. An analysis of pelagic species decline in the upper San Francisco Estuary using Multivariate Autoregressive modelling (MAR). Ecological Applications. doi: 10.1890/09-1724

Waite, I.R., L.R. Brown, J.G. Kennen, J.T. May, T.F. Cuffney, J.L. Orlando, and K.A. Jones . Comparison of watershed disturbance predictive models for stream benthic macroinvertebrates for three distinct ecoregions in western US. Ecological Indicators.

Wagner, R.W., M. Stacey, L.R. Brown, and M. Dettinger. Statistical models of temperature in the Sacramento-San Joaquin Delta under climate-change scenarios and ecological implications. Estuaries and Coasts.

Manuscripts in Revision

May, J.T., L.R. Brown, T.M. Short, A. Brasher, C. Konrad and T.R. Maret. Responses of macroinvertebrate assemblages to landscape alteration and hydrologic infrastructure in streams of the Western USA. Landscape Ecology.

REPORTS:

Brown, L.R., S.Y. Panshin, C.R. Kratzer, C. Zamora, and J.M. Gronberg. 2004. Occurrence, Distribution, Instantaneous Loads, and Yields of Dissolved Pesticides in the San Joaquin River Basin, California, During Summer Conditions, 1994 and 2001. Scientific Investigations Report 2004-5083.

Brown, L.R. and J.T. May. 2004. Periphyton and Macroinvertebrate Communities at Five Sites in the San Joaquin River Basin, California, during June and September, 2001. U.S. Geological Survey, Scientific Investigations Report 2004-5098.

May, J.T. and L.R. Brown. 2001. Chinese Mitten Crab Surveys of San Joaquin River Basin and Suisun Marsh, California, 2000. U.S. Geological Survey Open-file Report 01-396.

May, J.T. and L.R. Brown. 2000. Fish community structure in relation to environmental variation within the Sacramento River Basin and implications for the greater Central Valley. U.S. Geological Survey Open-file Report 00-247.

Brown, L.R. and T.J. May. 2000. Benthic macroinvertebrate assemblages and their relations with environmental variables in the Sacramento and San Joaquin river drainages, California, 1993-1997. U.S. Geological Survey Water-Resources Investigations Report 00-4125.

Brown, L.R. and T.M. Short. 1999. Biological, habitat, and water quality conditions in the upper Merced River drainage, Yosemite National Park, 1993-1996. U.S. Geological Survey Water-Resources Investigation Report, 99-4088.

Brown, L.R. 1998. Concentrations of chlorinated organic compounds in biota and bed sediment in streams of the lower San Joaquin River drainage, California. U.S. Geological Survey Open-file Report, 98-171.

Brown, L.R. 1998. Assemblages of fishes and their associations with environmental variables, lower San Joaquin River drainage, California. U.S. Geological Survey Open-file Report 98-77.

Dubrovsky, N.M., C.R. Kratzer, L.R. Brown, J.M. Gronberg, and K.R. Burow. 1998. Water quality in the San Joaquin-Tulare basins, California, 1992-1995. U.S. Geological Survey Circular 1159.

Brown, L.R., P.B. Moyle, and D.C. Vanicek. 1991. American River studies: intensive fish surveys. Final Report to California Fish and Game.

Brown, L.R. and P.B. Moyle. 1991. Status report on coho salmon in California. Final Report to the National Marine Fisheries Service.

Brown, L.R. and P.B. Moyle. 1991. Eel River fish survey and studies on the effects of the introduced Sacramento squawfish on the resident fishes. Final Report to California Department of Fish and Game, Contract F-46-R-2.

Brown, L.R. and P.B. Moyle. 1987-1990. Annual Reports on the Eel River Fish Studies. California Department of Fish and Game, Contract F-46-R-2.

Brown, L.R. and P.B. Moyle. 1987. Survey of the fishes of the mid-elevation streams of the San Joaquin Valley. Final Report to California Department of Fish and Game, Contract C-20607.

Moyle, P.B., L.R. Brown, G. Sato, and B. Herbold. 1986. Evaluating the condition of California's streams using indices of biotic integrity: evidence for continuing decline. Technical Completion Report W-659, Water Resources Center, U.C.D.

Moyle, P.B., D.M. Baltz, B. Vondracek, and L.R. Brown. 1985. Fish populations. *in*, Pit 3, 4, and 5 project bald eagle and fish study. Final Report to Pacific Gas and Electric.

PRESENTATIONS:

Brown, L.R. 2010. An update on the U.C. Santa Barbara workgroups. Interagency Ecological Program, 2010 Annual Workshop, Sacramento, California, May 25-26, 2010.

Brown, L.R. 2010. Stream studies in 9 metropolitan areas of the USA: understanding the effects of urbanization across the nation. Seventh National Monitoring Conference, National Water Quality Monitoring Council, Denver, Colorado, April 25-29, 2010.

Brown, L.R. 2010. Climate change and native fishes in the San Francisco Estuary and watershed. Plenary session, 28th Annual Salmonid Restoration Conference and the 44th Annual American Fisheries Society Cal-Neva Conference, Redding, California, March 10-13, 2010.

Brown, L.R. 2009. Assessing the possible effects of climate change on fish populations of Central Valley rivers and the San Francisco Estuary. Seminar presentation to Integrative Graduate Education and Research Training Program, Rapid Environmental Change, University of California, Davis, California, November 24, 2009.

Brown, L.R. and 10 others. 2009. Changing habitats, changing communities: an update on the upper estuary pelagic organism decline. 9th Biennial State of the San Francisco Estuary Conference, Oakland, California, September 29-October 1, 2009.

Brown, L.R. 2009. Increased water temperatures from CASCaDE climate-change scenarios: implications for selected California fishes. Climate Change, Natural Resources, and Coastal Management, A Workshop on the Coastal Ecosystems of California, Oregon, and Washington, San Francisco, California, January 29-30, 2009.

Brown, L.R. 2008. Assessing the possible effects of climate change on fish populations of Central Valley rivers and the San Francisco Estuary. Seminar presentation to Ecology and Environmental Issues class, California State University, Sacramento, California, November 5, 2008.

Brown, L.R. W.A. Bennett, and C. Woodley. 2008. Increased water temperatures from CASCaDE climate-change scenarios: implications for California fishes. 4th Biennial CALFED Science Conference, Sacramento, California, October 22-24, 2008.

Brown, L.R. and M. Bauer. 2008. Streamflow characteristics of California's Central Valley Rivers: implications for native and invasive fishes. 138th Annual Meeting of the American Fisheries Society, Ottawa, Canada, August 17-21, 2008.

Brown, L.R. and M. Bauer. 2008. Streamflow characteristics of California's Central Valley Rivers: implications for native and invasive fishes. 42nd Annual Meeting and Symposium of the California-Nevada Chapter of the American Fisheries Society, Tahoe City, California, April 1-5, 2008.

Brown, L.R., Gregory M.B., and J.T. May. 2008. Relation of urbanization to stream fish assemblages and species traits in nine metropolitan areas of the United States. 2nd Symposium on Urbanization and Stream Ecology, North American Benthological Society, 56th Annual Meeting, Salt Lake City, Utah, May 23-30, 2008.

Brown, L.R. 2007. Challenges and Progress in Ecosystem Restoration in the Sacramento-San Joaquin Delta. International Delta Roundtable, USGS National Wetlands Research Center, Lafayette, Louisiana, November 28-30, 2007.

Brown, L.R., S.D. Chase, and P.B. Moyle. 2007. Biology and status of lampreys in California. Program and Abstracts of the 137th Annual Meeting of the American Fisheries Society, San Francisco, California, September 2-6, 2007. (POSTER)

Brown, L.R. and J.T. May. 2006. Variation in species composition and life histories of spring fish assemblages in the lower Sacramento-San Joaquin watershed and Delta. Program and Abstracts of the 136th Annual Meeting of the American Fisheries Society, Lake Placid, New York, September 10-14, 2006. (POSTER)

Brown, L.R. and J.T. May. 2006. Vertebrate aquatic assemblages of the tributary streams to Whiskeytown Reservoir, California. 40th Annual Meeting and Symposium of the California-Nevada Chapter of the American Fisheries Society, San Luis Obispo, March 30-April 1, 2006.

Brown, L.R. 2005. Alien species in the lower Sacramento and San Joaquin River watersheds: ecosystem effects and factors controlling their distribution and abundance. Program and Abstracts of the 135th Annual Meeting of the American Fisheries Society, Anchorage, Alaska, September 11-15, 2005.

Brown, L.R. 2005. From basins to reaches--a USGS-NAWQA perspective on habitat-fish relationships. Program and Abstracts of the 135th Annual Meeting of the American Fisheries Society, Anchorage, Alaska, September 11-15, 2005.

Brown, L.R. 2005. Future fish monitoring in the lower American River: can a salmonid monitoring program provide useful information about resident assemblages? Program and Abstracts of the American River Watershed Conference, Sacramento, April 21-23, 2005.

Brown, L.R. 2005. An Introduction to California Lampreys. Program and Abstracts of the 39th Annual Meeting and Symposium of the California-Nevada Chapter of the American Fisheries Society, Sacramento, March 17-19, 2005.

Brown, L.R. and D. Michniuk. 2004. Nearshore fishes of the Sacramento-San Joaquin Delta. Program and Abstracts of the 3rd Biennial CALFED Science Conference. Sacramento, California, October 4-6, 2004.

Brown, L.R. and D. Michniuk. 2004. Nearshore fish assemblages of the Sacramento-San Joaquin Delta. Program and Abstracts of the 134th Annual Meeting of the American Fisheries Society. Madison, Wisconsin, August 22-26, 2004.

Brown, L.R.. 2004. Mining data in the San Francisco Estuary: new insights into nearshore fish assemblages of the Sacramento-San Joaquin Delta. USGS National Research Program, Western Region, Menlo Park, California, April 2004.

Brown, L.R. and D. Michniuk. 2004. Differences in nearshore fishes of the Sacramento-San Joaquin Delta, over a twenty-year interval. 38th Annual Meeting of the California-Nevada Chapter American Fisheries Society, Redding, California. April 22-24 2004.

Brown, L.R. and D. Michniuk. 2004. Nearshore fishes of the Sacramento-San Joaquin Delta. 2nd Annual Meeting of the California Estuarine Research Society. Bodega Marine Laboratory, March 23-24 2004.

Brown, L.R. 2004. Will tidal wetland restoration enhance populations of native fishes? Interagency Ecological Program Workshop, Lodi, California, February 17-18 2004.

Brown, L.R. 2003. A brief introduction to Central Valley fish assemblages. 10th Annual Meeting of the California Aquatic Bioassessment Workgroup, Sacramento, California, December, 2003.

Burton, C.A. and L.R. Brown. 2003. Associations of biological assemblages with environmental variables in the highly urbanized Santa Ana River Basin, California, U.S.A. 133nd Annual Meeting of the American Fisheries Society. Quebec City, Quebec, Canada, August 10-14, 2003.

Burton, C.A. and L.R. Brown. 2003. Relationship of biological communities to water source and channel type in the highly urbanized Santa Ana River Basin. Program and Abstracts of the joint meeting of the California Estuarine Research Society, California-Nevada Chapter American Fisheries Society, and Western Division American Fisheries Society, San Diego, California. April 14-17.

Brown, L.R. 2003. Emerging Issues in San Francisco Estuary tidal wetlands restoration. Program and Abstracts of the joint meeting of the California Estuarine Research Society, California-Nevada Chapter American Fisheries Society, and Western Division American Fisheries Society, San Diego, California. April 14-17.

Brown, L.R. 2002. Native and Introduced Fishes in the San Joaquin River Drainage, California. University of Idaho, Moscow, Idaho, May 15, and Idaho Department of Fish and Game, Boise, Idaho, May 17.

Brown, L.R. 2002. Introduced Fish Species in the San Joaquin River Drainage, California. New Mexico State University, Las Cruces, New Mexico, February.

Burton, C.A. and L.R. Brown (PRESENTER). 2002. Biological and water quality conditions in the urbanized Santa Ana River Basin, California. 132nd Annual Meeting of the American Fisheries Society. on CD: American Fisheries Society-132nd Annual Meeting, Baltimore, Maryland, August 18-22, 2001. American Fisheries Society, 2002. (POSTER)

Burton, C.A. and L.R. Brown (PRESENTER). 2002. Biological and water quality conditions in the urbanized Santa Ana River Basin, California. in Program and Abstracts of the Thirty-sixth Annual Conference of the California-Nevada Chapter of the American Fisheries Society, Tahoe City, California, April 18-20. (POSTER)

Brown, L.R. 2001. Shallow-water habitat: what is it and is it any good for fish? 5th Biennial State of the Estuary Conference, San Francisco, California, October 9-11, 2001.

Brown, L.R. 2001. Native fish communities of the Sacramento-San Joaquin watershed, California. 131st Annual Meeting of the American Fisheries Society, Phoenix, Arizona, August 19-23, 2001.

Brown, L.R., E.M. Giddings, and M.R. Meador. 2001. Relations between brown trout condition and basin-wide urban land use in selected Utah streams. 131st Annual Meeting of the American Fisheries Society, Phoenix, Arizona, August 19-23, 2001. (POSTER)

Brown, L.R., J.T. May. 2001. Relations of fish, macroinvertebrate, and algae communities with environmental variables in two California river basins. Thirty-fifth Annual Conference of the California-Nevada Chapter of the American Fisheries Society, Santa Rosa, California, March 29-31.

Brown, L.R., M.R. Meador, and T.M. Short. 2000. Assessing relations between introduced fish and water quality at large geographic scales. 130th Annual Meeting of the American Fisheries Society, St. Louis, Missouri, August 20-24, 2000.

Brown, L.R., T.M. Short, and M.R. Meador. 2000. Introduced fish species in the lower San Joaquin River drainage relative to national, regional, and local geographic scales. Thirty-fourth Annual Conference of the California-Nevada Chapter of the American Fisheries Society, Ventura, California. March 2000.

Brown, L.R. and J.T. May. 1999. Macroinvertebrate assemblages on woody debris and their relations with environmental variables in the lower Sacramento and San Joaquin river drainages, California. EMAP Symposium on Western Ecological Systems: Status, Issues, and New Approaches, San Francisco, California. April 1999.

Brown, L.R. and T. Ford. 1998. Resident fish assemblages of the Tuolumne River, California. Thirty-second Annual Conference of the California-Nevada Chapter of the American Fisheries Society, Sacramento, California. April 1998

Brown, L.R. 1997. The importance of geographic scale in assessing the relations of fish assemblages to environmental quality in the lower San Joaquin River drainage, California. The 127th Annual Meeting of the American Fisheries Society, Monterey, California. August 1997.

Brown, L.R. 1996. Fish communities of the San Joaquin River drainage. Invited seminar. Humboldt State University, Arcata, California. October 1996.

Brown, L.R., C. Kratzer, and N.M. Dubrovsky. 1996. Integrating chemical, water quality, and habitat data with fish assemblage data from the San Joaquin River drainage. Critical Methodologies for the Study of Ecosystem Health, a conference organized by the Center for Ecological Health Research, University of California, Davis, California. September 1996.

Brown, L.R. 1996. Invading fishes in the Eel River: successes, failures, and relationships with resident species. Twenty-second Annual Conference of the Humboldt Chapters of The Wildlife Society and The American Fisheries Society. California State University Humboldt, Arcata, California. April 1996.

Brown, L.R. 1996. Annual and spatial variability of fish assemblages at locations in the lower San Joaquin River drainage. Thirty-first Annual Conference of the California-Nevada Chapter of the American Fisheries Society, Ventura, California. March 1996.

Brown, L.R. and P.B. Moyle. 1996. Invading Sacramento squawfish and assemblage organization of fishes in a large coastal drainage of California. Invited seminar. Weber State University, Ogden, Utah. February 1996.

Brown, L.R. 1995. Native and introduced stream fishes of the San Joaquin Valley floor - their relation to quality of water and habitat. Thirtieth Annual Conference of the California-Nevada Chapter of the American Fisheries Society. Napa, California. February 1995.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1995. Historic decline and current status of California coho salmon. Thirtieth Annual Conference of the California-Nevada Chapter of the American Fisheries Society. Napa, California. February 1995.

Brown, L.R. 1994. Responses of fish and macroinvertebrate communities to variations in habitat and water quality in streams of the San Joaquin Valley, California. Thirtieth Annual Conference of the American Water Resources Association, Symposium on National Water Quality Assessment (NAWQA). Chicago, Illinois. November 1994.

Brown, L.R. 1992. Biological and data management aspects of the National Water Quality Assessment Program in the San Joaquin-Tulare Basins, California. Twenty-seventh Annual Conference of the California-Nevada Chapter of the American Fisheries Society. Redding, California. February 1992.

Brown, L.R. 1991. Effects of the introduction of the Sacramento squawfish (*Ptychocheilus grandis*) on the resident fishes of the Eel River, California. Invited seminar. California State University, San Jose, California. March 22.

Brown, L.R. 1990. Effects of the introduction of the Sacramento squawfish (*Ptychocheilus grandis*) on the resident fishes of the Eel River, California. Invited seminar. University of Massachusetts, Amherst. September 6.

Brown, L.R. 1990. History and implications of the introduction of Sacramento squawfish into the Eel River. Fifty-second Annual Meeting of Pacific Fisheries Biologists. Kelseyville, California. March 30.

Brown, L.R. and P.B. Moyle. 1990. Changes in habitat and microhabitat use of an assemblage of stream fishes in response to predation by Sacramento squawfish (*Ptychocheilus grandis*). Twenty-fifth Annual Conference of the California-Nevada Chapter of the American Fisheries Society. Stateline, Nevada. February 3.

Brown, L.R. 1989. Effects of Sacramento squawfish on the habitat and microhabitat use of the resident fishes of the Eel River. Wildlife and Fisheries Biology Proseminar 190. Davis, California.

Brown, L.R. and P.B. Moyle. 1987. Native fishes of the San Joaquin drainage: status of a remnant fauna. Endangered and sensitive species of the San Joaquin Valley, California: a conference on their biology, management, and conservation. Bakersfield, California. December 9.

Brown, L.R. 1986. Microhabitat selection of three species of sculpin from the Pit River drainage, California. Sixty-sixth Annual Meeting of the American Society of Ichthyologists and Herpetologists. Victoria, B.C., Canada.

Brown, L.R. 1986. Factors determining the distribution of three species of sculpin in the Pit River drainage, California. Wildlife and Fisheries Proseminar 190. Davis, California.

Brown, L.R. 1986. Factors determining the distribution of three species of sculpin from the Pit River drainage, California. Twenty-first Annual Conference of the California-Nevada Chapter of the American Fisheries Society. Reno, Nevada.

Brown, L.R. 1985. Depth and substrate selection of three species of sculpin from the Pit River drainage, California. Twentieth Annual Conference of the California-Nevada Chapter of the American Fisheries Society. Sacramento, California.

Brown, L.R. 1982. The effects of squawfish on salmonid populations. Wildlife and Fisheries Proseminar 190. Davis, California.

MARISSA BAUER

U.S. Geological Survey
California Water Science Center
6000 J Street, Placer Hall
Sacramento, CA 95819

Email: mbauer@usgs.gov
Tele: (916) 278-3299
FAX: (916) 278-3071

EDUCATION

2010 M.S., Environmental Science, California State University, Chico, California. Project: An ecosystem model of the Sacramento-San Joaquin Delta, California.

2005 B.S., Environmental Biology and Management, Aquatic Biology Emphasis, University of California, Davis, California.

RESEARCH EXPERIENCE

2006-present Biologist (GS-0499-07-03), U.S. Geological Survey, Water Resources Discipline, Sacramento, California. I assist the California Water Science Center in projects relating to aquatic biology and ecology. Currently I am developing an ecosystem model for the Sacramento-San Joaquin Delta with specific focus on the Pelagic Organism Decline (POD) species. I am leading a pilot study on the Russian River looking at summer algal production rate via accrual of chlorophyll-a and ash-free-dry mass. I assist in technical writing for the San Joaquin River Restoration Program (SJRRP) Fisheries Management Plan and Reintroduction Strategies Document. I also participate in National Water Quality Assessment Program (NAWQA) and Abandon Mine Lands (AML) Investigations of Trace Elements field collections and data report generation.

Employer/Supervisor, Larry Brown, Placer Hall, 6000 J Street, Sacramento, (916) 278-3000.

2005- 2006 Research Assistant, Invasive Species Study, Department of Environmental Science and Policy, University of California, Davis. I conducted work on a Sea Grant funded project researching the effects of an invasive crayfish species, (*Pacifastacus leniusculus*), on an endangered crayfish species, (*Pacifastacus fortis*), in a northern California watershed. Project included a field removal experiment and behavioral laboratory mesocosom experiments.

Employer/Supervisor, Andrew Sih, Department of Environmental Science and Policy, University of California, Davis.

2004-2005 Research Internship, Behavioral Ecology Study, Department of Environmental Science and Policy, University of California, Davis. I collaborated in experimental design, monitoring, and recording of behavioral observations of

native and non-native crayfish interactions. Behavioral assays included: aggression trials, feeding trials, and predator cue response trials

Employer/Supervisor, Andrew Sih, Department of Environmental Science and Policy, University of California, Davis.

2004 Independent Research Project, University of California, Davis, Bodega Marine Laboratory, Bodega Bay, California. Three month concentrated study at Bodega Marine Lab, comprised of intensive course work, completion and presentation of an individual research project. I conducted a population density study of the bay pipefish, (*Syngnathus leptorhynchus*) in Bodega Harbor using a catch and release technique. I collected specimens by seining and then injected each individual with a subcutaneous visible implant elastomer (VIE) before being released.

Employer/Supervisor, Steven Morgan, Bodega Marine Laboratory and Department of Environmental Science and Policy, University of California, Davis.

PUBLICATIONS

Townsend, H., M. Bauer, L. Brown, and F. Feyrer. 2010 (*in prep*). An Ecosystem Model for testing potential causes of the San Francisco Estuary Pelagic Organisms Decline.

Bauer, H. Townsend, L. Brown, and F. Feyrer. 2010 (*in prep*). Establishing Baseline Conditions for the San Francisco Estuary: An Ecopath Model describing the Estuary in the Early 1980s.

Brown, L.R. and M.L. Bauer. 2009. Effects of hydrologic infrastructure on flow regimes of California's Central Valley rivers: implications for fish populations. River Research and Applications. DOI: 10.1002/rra.1293

Pintor, L.M., Sih, A., and Bauer, M.L. 2008. Differences in aggression, activity and boldness between native and introduced populations of an invasive crayfish. Oikos, v. 117, no. 11, p. 1629-1636.

Hothem, Roger L., Bergen, Darrin R., Bauer, Marissa L., Crayon, John J., and Meckstroth, Anne M., 2007, Mercury and trace elements in crayfish from Northern California, Bulletin of Environmental Contamination and Toxicology, v. 79, no. 6, p. 628-632

Hothem, Roger L., Trejo, B.S., Bauer, Marissa L., and Crayon, John J., 2008, Cliff swallows Petrochelidon pyrrhonota as bioindicators of environmental mercury, Cache Creek watershed, California, Archives of Environmental Contamination and Toxicology, v. 55, no. 1, p. 111-121

Technical Papers

Bauer, M.L., J.T. May and L.R. Brown (*in prep*). Data report on aquatic inventory of the major streams of Whiskeytown National Recreation Area and Clear Creek, Shasta County, California. XXX pp

May, J.T., Bauer, M.L., Hothem, R.L., Brown, L.R. 2008, Concentrations of Mercury and OtherMetals in Black bass (Micropterus spp.) from Whiskeytown Lake, Shasta County, California 2005: U.S. Geological Survey Open File Report 2008-xxx, xx p.

Hothem, R.L., D.R. Bergen, M.L. Bauer, and B.S. Trejo. 2008. Mercury and other metals and trace elements in aquatic invertebrates from the Deer Creek Watershed, Nevada County, California, June 2006. Data Summary Report prepared by the U.S. Geological Survey for the Bureau of Land Management, 18pp.

Hothem, R.L., J.T. May, M.L. Bauer, and D.R. Bergen. 2008. Mercury in Biota from the BLM Reservoir, Buena Vista Mine, San Luis Obispo County, California, July 2007. Data Summary Report prepared by the U.S. Geological Survey for the Bureau of Land Management, 52pp.

Abstracts

Bauer, M.L. and Brown, L.R. Translating Climate Change to Effects of Fishes: a Review. Poster abstract submitted to California Estuarine Research Society (CAERS) annual meeting, March 18-20, 2007 at Bodega Marine Libratory, Bodega Bay, CA.

Presentations

Townsend, H., Bauer, M., Brown, L. 2010. An Ecotrophic-Based model of the Sacramento-San Joaquin Delta. 20th Annual meeting of the Interagency Ecological Program, Sacramento, California, May 25-26, 2010.

Townsend, H., Bauer, M., Brown, L. 2009. An ecotrophic-based model of the Sacramento-San Joaquin Delta, California, USA. Ecopath with Ecosim Conference, Vancouver, Canada, September 27-29, 2009.

Brown, L.R. and M. Bauer. 2008. Streamflow characteristics of California's Central Valley Rivers: implications for native and invasive fishes. 138th Annual Meeting of the American Fisheries Society, Ottawa, Canada, August 17-21, 2008.

Brown, L.R. and M. Bauer. 2008. Streamflow characteristics of California's Central Valley Rivers: implications for native and invasive fishes. 42nd Annual Meeting and Symposium of the California-Nevada Chapter of the American Fisheries Society, Tahoe City, California, April 1-5, 2008.

Howard M. Townsend

NOAA-Chesapeake Bay Office
Cooperative Oxford Laboratory
Oxford. MD 21654

e-mail: Howard.Townsend@noaa.gov
Phone: (410) 226-5193
Fax: (410) 225-5925

A. Education

2004 Ph.D. in Biology (Population Biology, with focus in Statistics and Mathematical Modeling), Wake Forest University, Winston-Salem, NC, May 2004

1994 B.S. in Biology (magna cum laude), minor in Chemistry, Wake Forest University, Winston-Salem, NC, May 1994

B. Professional Experience

2004-present NOAA Chesapeake Bay Office
Ecologist (Ecosystem Modeler)

2002–2004 Delmarva Foundation for Medical Care, Inc., Easton, MD
Health Care Scientist

1998–2001 Wake Forest University, Biology Department, Winston-Salem, NC
Research Assistant and Teaching Assistant

1997–1998 U.S. Geological Survey - Patuxent Wildlife Research Center, Laurel, MD
Research Assistant, Environmental Contaminants Research Group

1996 The Nature Conservancy, Ft. Benning, GA
Research Assistant

1994–1995 Benedict English Language Schools, Quito, Ecuador
English Language Instructor

C. Publications

Townsend, H., M. Bauer, L. Brown, and F. Feyrer. 2010 (*in prep*). An Ecosystem Model for testing potential causes of the San Francisco Estuary Pelagic Organisms Decline.

Bauer, H. Townsend, L. Brown, and F. Feyrer. 2010 (*in prep*). Establishing Baseline Conditions for the San Francisco Estuary: An Ecopath Model describing the Estuary in the Early 1980s.

Kimmel, D.G., H. Townsend, T.J.B. Carruthers, and B. Fertig. 2010. Environmental statistics: balancing simplicity and explanatory power. *In*: Integrating and Applying Science: A Practical Handbook for Effective Coastal Ecosystem Assessment, Longstaff, B.J., T.J.B. Carruthers, W.C. Dennison, T.R. Lookingbill, J.M. Hawkey, J.E. Thomas, E.C Wicks, And J. Woerner (eds.), 79 p. IAN Press, Cambridge, MD.

Link, J., T. Ihde, H. Townsend, K. Osgood, M. Schirripa, D. Kobayashi, S. Gaichas, J. Field, P. Levin, K. Aydin, and C. Harvey (eds.). 2010. Report of the 2nd National Ecosystem Modeling Workshop (NEMoW II), Bridging the Credibility Gap - Dealing with Uncertainty in Ecosystem Models. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA Technical Memorandum NMFS-F/SPO-102, 72 p.

Ma, H., H. Townsend, X. Zhang, M. Sigrist, and V. Christensen. 2010. Using a fisheries ecosystem model with a water quality model to explore trophic and habitat impacts on a fisheries stock: A case study of the blue crab population in the Chesapeake Bay. Ecological Modeling 221(7): 997–1004.

Christensen, V., A. Beattie, C. Buchanan, H. Ma, S. Martell, R. Latour, D. Preikshot, M. Sigrist, J. Uphoff, C. Walters, R. Wood, and H. Townsend. 2009. Fisheries Ecosystem Model of the Chesapeake Bay: Methodology, Parameterization, and Model Exploration. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA Technical Memorandum NMFS-F/SPO-106, 146 p.

Jacobs, J., M. Rhodes, A. Baya, R. Reimschuessel, H. Townsend, R. Harrell. 2009. Influence of nutritional state on the progression and severity of mycobacteriosis in striped bass *Morone saxatilis*. Diseases of Aquatic Organisms 87(3): 183-197.

Ma, H., H. Townsend, M. Sigrist, V. Christensen, C. Walters, J. Buszowski, J. Korman, and D. Preikshot. 2009. Constructing Historical Long-Term Primary Production in the Chesapeake Bay for Use in Ecosystem-Based Fisheries Management Models. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA Technical Memorandum NMFS-F/SPO-105, 51 p.

Townsend, H. M. and D. J. Anderson. 2007. Long-term assessment of costs of reproduction in Nazca boobies (Sula granti) using multi-state mark-recapture models. *Evolution* 51(8):1956-1968

H.M. Townsend, T.J. Maness, and D.J. Anderson. 2007. Offspring growth and parental care in sexually dimorphic Nazca boobies (Sula granti). *Canadian Journal of Zoology* 85:686-694

Townsend, H. M. and D. J. Anderson. 2007. Production of insurance eggs in Nazca boobies: costs, benefits, and variable parental quality. *Behavioral Ecology*. 18:841–848

FAO Fisheries Department (invited panel of authors). The ecosystem approach to fisheries. Best practices in ecosystem modelling: Modelling ecosystem interactions for informing an ecosystem approach to fisheries. No. 4 Suppl.2.1. Rome, FAO. 2007. 44p

Townsend, H. M., K. P. Huyvaert, P. J. Hodum, D. J. Anderson. 2002. Nesting distributions of Galápagos boobies (Aves: Sulidae): an apparent case of amensalism. *Oecologia* 132: 419–427.

Anderson, D. J, K. P. Huyvaert, V. Apanius, H. Townsend, C. L.Gillikin, L.D. Hill, F. Juola, E. T. Porter, D. R. Wood, C. Lougheed and H. Vargas. 2002. Population size and trends of the Waved Albatross (Phoebastria irrorata). Marine Ornithology 30: 63–69.

D. Synergistic Activities

1. 2008 to present – Chesapeake Bay Fisheries Ecosystem Workgroup. MD Sea Grant, University of Maryland. Committee to develop quantitative reference points for ecosystem-based fisheries management.
2. 2007 to present – National Center for Ecological Analysis and Synthesis – San Francisco Estuary Pelagic System Dynamics Workgroup. Work group to develop quantitative models to explain the decline in pelagic fish populations of the San Francisco Estuary.

3. 2007 and 2009 National Oceanic and Atmospheric Administration – Marine Fisheries Service, National Ecosystem Modeling Steering Committee. To develop standards for applying multi-species/ecosystem models to fisheries management for NOAA.
4. 2007 United Nations Food and Agriculture Organization panel of experts to develop a report Ecosystem Approaches to Fisheries: FAO Fisheries Department. The ecosystem approach to fisheries. Best practices in ecosystem modelling: Modelling ecosystem interactions for informing an ecosystem approach to fisheries. No. 4 Suppl.2.1. Rome, FAO. 2007. 44p.
5. 2006-present – Atlantic States Marine Fisheries Commission – Multispecies (Modeling) Technical Committee
6. 2004- present: Chesapeake Bay Program – Modeling Subcommittee
7. Manuscript reviewer for *Avian Biology, Canadian Journal of Zoology*, *Diversity and Distributions, Ecography, Environmental Modeling and Software,* and *Journal of Ecological Modelling*
8. Grants reviewer for North Pacific Research Board and Ecosystem-based management tools – Tool Innovation Fund
9. Member American Fisheries Society and Coastal and Estuarine Research Federation

E. Collaborators and other affiliations in the last 48 months

a) Collaborators:
K. Aydin (AFSC),M. Bauer (USGS-BRD),A. Baya (University of Maryland),A. Beattie (Canada Department of Fisheries and Oceans),L. Brown (USGS),C. Buchanan (Interstate Commission for the Potomac River Basin),J. Buskowski (Mountain Software),V. Christensen (University of British Columbia),N. Cyr (NMFS S&T),S. Gaichas (AFSC),R. Gamble (NEFSC),T. Gedamke (SEFSC),J. Field (SWFSC),F. Feyerer (Bureau of Reclamation),C. Harvey (NWFSC),R. Harrell (UMd),K.P. Huyvaert (Colorado State University),T. Ihde (NOAA CBO),J. Jacobs (NOS),J. Korman (Mountain Software),D. Kobayashi (PIFSC),R.J. Latour (Virginia Institute of Marine Sciences),A.K. Leight (NOS),P. Levin (NWFSC),J. Link (NEFSC),J. Love (Maryland Department of Natural Resources),H. Ma (PIFSC),T.J. Manness (Wake Forest University) ,S. Martell (UBC),M. Matsche (Maryland Department of Natural Resources),C. McCullough (Maryland Department of Natural Resources),K. Osgood (NMFS S&T),J. Polovina (PIFSC),D. Preikshot (UBC),R Reimschuessel (US Food and Drug Administration),M. Rhodes (NOS),M. Schirripa (SEFSC),M. Sigrist (NOAA CBO),J.H. Uphoff (Maryland Department of Natural Resources),C.J. Walters (UBC),G. Watters (SWFSC),R.J. Wood (NOS),X. Zhang (NOS)

b) Graduate Advisor:
Dr. David J. Anderson, Wake Forest University, Department of Biology

c) Mentor for:
- Ryan Corbin, Reginald Black (Masters Student, University of Maryland Eastern Shore, Princess Ann, MD)
- Marissa Bauer (Masters Student, California State University)
- Rebecca Burton, Beth Ann Crowell (Summer Teacher Fellows, University of Maryland Center for Environmental Sciences)

Frederick V. Feyrer

Applied Science Branch, U.S. Bureau of Reclamation
2800 Cottage Way, Sacramento, California 95825
(916) 978-5526; ffeyrer@usbr.gov

Education

M.S., Biological Science, California State University, Sacramento, 1999
B.S., Environmental Biology and Management, University of California, Davis, 1995

Professional Experience

2008 - present	Fish Biologist, U.S. Bureau of Reclamation
2007 - 2008	Staff Environmental Scientist, California Department of Water Resources
1999-2007	Environmental Scientist, California Department of Water Resources

Books

Feyrer, F., L.R. Brown, R.L. Brown, and J.J. Orsi, editors. 2004. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Journal Publications

Harrell, W., T. Sommer, and F. Feyrer. Fish migration and residency in a large river floodplain of the Sacramento River, California. Western North American Natrualist (in review).

Sommer, T., M. Nobriga, L. Grimaldo, F. Feyrer, F. Mejia. 2009. A conceptual model of the upstream migration of delta smelt. San Francisco Estuary and Watershed Science (in review).

Feyrer, F., K. Newman, M. Nobriga, and T. Sommer. 2009. Modeling the effects of future freshwater flow on the abiotic habitat of an imperiled estuarine fish. Estuaries and Coasts (in revision).

Mac Nally, R., J.R. Thompson, W.J. Kimmerer, F. Feyrer, K.B. Newman, A. Sih, W.A. Bennett, L. Brown, E. Fleishman, S. Culberson, and G. Castillo. 2009. An analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling. Ecological Applications (in press).

Thomson, J., W. Kimmerer, L. Brown, K. Newman, R. Mac Nally, F. Feyrer, E. Fleishman. 2009. Bayesian change-point analysis of temporal patterns in fish abundances in the upper San Francisco Estuary. Ecological Applications (in press).

Feyrer, F., J. Hobbs, and T. Sommer. 2009. Salinity inhabited by age-0 splittail as determined by direct field observation and retrospective analyses with otolith chemistry. San Francisco Estuary and Watershed Science (accepted).

Feyrer F., T. Sommer, and S.B. Slater. 2009. Old school vs. new school: status of threadfin shad (*Dorosoma petenense*) five decades after its introduction to the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science. Vol. 7, Issue 1, Article 3.

Nobriga, M., and F. Feyrer. 2008. Diet composition in San Francisco Estuary striped bass: does trophic adaptability have its limits? Environmental Biology of Fishes 83:495-503.

Baerwald, M., F. Feyrer, B. May. 2008. Distribution of genetically differentiated splittail populations during the non-spawning season. Transactions of the American Fisheries Society Transactions of the American Fisheries Society 137:1335–1345.

Sommer, T., W. Harrell, Z. Matica, and F. Feyrer. 2008. Habitat associations and behavior of adult and juvenile splittail (Cyprinidae: *Pogonichthys macrolepidotus*) in a managed seasonal floodplain wetland. San Francisco Estuary and Watershed Science. Vol. 6, Issue 2, Article 3.

Nobriga, M., T. Sommer, F. Feyrer, and K. Fleming. 2008. Long-term trends in summertime habitat suitability for delta smelt, *Hypomesus transpacificus*. San Francisco Estuary and Watershed Science. Vol. 6, Issue 1 (February), Article 1.

Feyrer, F., T. Sommer, and J. Hobbs, 2007. Living in a dynamic environment: variability in life history traits of age-0 splittail in tributaries of San Francisco Bay. Transactions of the American Fisheries Society 136:1393-1405.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32:270-277.

Feyrer, F., M. Nobriga, and T. Sommer. 2007. Multi-decadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences 64:723-734

Nobriga, M., and F. Feyrer. 2007. Shallow-water piscivore-prey dynamics in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science Vol.5, Issue 2, Article 4.

Sommer, T., R. Baxter, and F. Feyrer. 2007. Splittail revisited: how recent population trends and restoration activities led to the "delisting" of this native minnow. Pages 25-38 in M.J. Brouder and J.A. Scheuer, editors. Status, Distribution, and Conservation of Freshwater Fishes of Western North America. American Fisheries Society Symposium 53. Bethesda, Maryland.

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

Baerwald, M., V. Bien, F. Feyrer, and B. May. 2007. Microsatellite analysis reveals two genetically distinct splittail (*Pogonichthys macrolepidotus*) populations in the San Francisco estuary. Conservation Genetics 8:159-167.

Feyrer, F, T. Sommer, and W. Harrell. 2006. Managing floodplain inundation for native fish: production dynamics of age-0 splittail in California's Yolo Bypass. Hydrobiologia 573:213-216.

Feyrer, F, T. Sommer, and W. Harrell. 2006. Importance of flood dynamics versus intrinsic physical habitat in structuring fish communities: evidence from two adjacent engineered floodplains on the Sacramento River, California. North American Journal of Fisheries Management 26:408-417.

Nobriga, M., F. Feyrer, and R. Baxter. 2006. Aspects of Sacramento pikeminnow biology in nearshore habitats of the Sacramento-San Joaquin Delta. Western North American Naturalist 66:106-114.

Nobriga, M., F. Feyrer, R. Baxter, and M. Chotkowski. 2005. Fish community ecology in an altered river delta: spatial patterns in species composition, life history strategies, and biomass. Estuaries 28:776-785.

Kimmerer, W., S. Avent, S. Bollens, F. Feyrer, L. Grimaldo, P. Moyle, M. Nobriga, and T. Visintainer. 2005. Variability in length-weight relationships used to estimate biomass of estuarine fish from survey data. Transactions of the American Fisheries Society 134:481-495.

Feyrer, F., T. Sommer, and R. Baxter. 2005. Spatial-temporal distribution and habitat associations of age-0 splittail in the lower San Francisco Estuary watershed. Copeia 2005:159-168.

Feyrer, F., T. Sommer, G. O'Leary, S. Zeug, and W. Harrell. 2004. Fish assemblages of perennial floodplain ponds of the Sacramento River, California (U.S.A.), with implications for the conservation of native fishes. Fisheries Management and Ecology 11:335-344.

Feyrer, F. 2004. Ecological segregation of native and alien larval fish assemblages in the southern Sacramento-San Joaquin Delta. Pages 67-80 in F. Feyrer, L.R. Brown, R.L. Brown, and J.J. Orsi, editors. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Sommer, T., W. Harrell, R. Kurth, F. Feyrer, S. Zeug, and G. O'Leary. 2004. Ecological patterns of early life stages of fishes in a river-floodplain of the San Francisco Estuary. Pages 111-124 in F. Feyrer, L.R. Brown, R.L. Brown, and J.J. Orsi, editors. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Feyrer, F., B. Herbold, S.A. Matern, and P.B. Moyle. 2003. Dietary shifts in a stressed fish assemblage: consequences of a bivalve invasion in the San Francisco Estuary. Environmental Biology of Fishes 67:277-288.

Feyrer, F., and M. Healey. 2003. Fish community structure and environmental correlates in the highly altered southern Sacramento-San Joaquin Delta. Environmental Biology of Fishes 66:123-132.

Feyrer, F., and M. Healey. 2002. Structure, sampling gear and environmental associations, and historical change in the the southern Sacramento-San Joaquin Delta fish assemblage. California Fish and Game 88:126-138

Sommer, T., L. Conrad, G. O'Leary, F. Feyrer, and W. Harrell. 2002. Spawning and rearing of splittail in a model floodplain wetland. Transactions of the American Fisheries Society 131:966-974.

Feyrer, F., and R. Baxter. 1998. Splittail fecundity and egg size. California Fish and Game 84:119-126.

Honors

- Outstanding Professional Accomplishment and Sustained Superior Acomplishment Award, California Department of Water Resources
- Numerous Unit Citations, California Department of Water Resources
- Special Contribution Award, California-Nevada Chapter of the American Fisheries Society
- Certificate of Achievement, Western Division of the American Fisheries Society

Professional Memberships and Service

- Member, American Fisheries Society
- Past service on the executive committee of the AFS California-Nevada Chapter
- Member, Estuarine Research Federation
- Founding Secretary/Treasurer, California Estuarine Research Society
- Past Chair, Resident Fishes Workteam for the Interagency Ecological Program for the San Francisco Estuary

- Member, Systems modeling group investigating pelagic fish declines in the San Francisco Estuary, National Center for Ecological Analysis and Synthesis
- Ad-hoc reviewer for numerous journals
- Convenor of numerous technical sessions and symposia at professional conferences and workshops