SWAMP
Surface Water Ambient Monitoring Program

Monitoring Plan	2011

Sources of Pyrethroid Insecticides to Cache Slough During Spawning of Delta Smelt

December 2011

This project was coordinated with monitoring supported by the Interagency Ecological Program for the San Francisco Estuary.

Water Boards

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APPENDIX __: MONITORING PLAN

MONITORING PLAN

Central Valley Water Board

Surface Water Ambient Monitoring Program (SWAMP)

Special Study:

SOURCES OF PYRETHROID INSECTICIDES TO CACHE SLOUGH DURING SPAWNING OF DELTA SMELT

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SOURCES OF PYRETHROID INSECTICIDES TO CACHE SLOUGH DURING SPAWNING OF DELTA SMELT

Project Director: Donald P. Weston[1]
Contract Manager: Meghan Sullivan[2]

[1] Department of Integrative Biology, University of California, 1050 Valley Life Sciences Building, Berkeley, California 94720-3140;
[2] Central Valley Water Board, 11020 Sun Center Drive #200, Rancho Cordova, CA 95670

Background

The Sacramento-San Joaquin Delta has attracted renewed attention recently because of the decline in populations of several pelagic fish species, notably Delta smelt, striped bass, longfin smelt and threadfin shad. Abundance indices for all four species are at or near record lows, and though the cause(s) for the decline in these Delta populations are not known, toxic contaminants are among the possibilities often suggested.

Delta smelt are among the species at risk, and protection of the species, as well as the Delta ecosystem it represents, has become a high priority for management agencies. One of the most critical regions of the Delta for the delta smelt is the Cache Slough area. While spawning is dispersed throughout the Delta in wet years, during dry years the Cache Slough region is the primary spawning grounds for the species. Not only is spawning of the species spatially limited, but it is temporally limited, with adults gathering during the winter months in preparation for the April/May spawn. Smelt larvae remain in the Cache Slough area for several weeks after hatching. In June/July many move out of the Cache Slough complex and spread throughout the Delta, though some remain year around. The spatial and temporal concentration of much of the Delta's delta smelt population within the Cache Slough area makes the species very vulnerable to habitat degradation, including contaminant effects. A single toxic event in February to June affecting delta smelt or their food resources could have significant population consequences.

Problem Statement

- IEP-funded monitoring with H. azteca by the UC Davis Aquatic Toxicity Laboratory found infrequent toxicity throughout the Delta, but toxicity was more frequent in the Cache Slough area than anywhere else. Addition of piperonyl butoxide (PBO) often increased toxicity, implicating pyrethroids as the cause.
- Similar monitoring with the copepod Eurytemora affinis found copepod toxicity to be most frequent in the same area, with toxicity seen in the Cache Slough area in every one of three sampling events (Teh et al., 2008). Pyrethroids were detectable at concentrations approaching LC_{50}s to sensitive species in three of four samples.

- When in water samples, pyrethroids have been found to be extremely toxic to aquatic life, with H. azteca EC_{50}s often near 2 ng/L (Weston and Jackson, 2009), and E. affinis LC_{50}s only slightly greater (Teh et al., 2009).
- Urban runoff from many California communities has been found to nearly always contain pyrethroids at concentrations that would be acutely toxic to H. azteca and E. affinis (Weston and Lydy, 2010).
- Urban runoff from Vacaville causes Ulatis Creek, which flows to Cache Slough, to reach pyrethroid concentrations 4-10 times acutely concentrations to H. azteca, and the effluent from the city's municipal wastewater treatment plant contained pyrethroids at acutely toxic concentrations on about half the sampling occasions (Weston and Lydy, 2010).
- Pyrethroid toxicity to H. azteca due to urban runoff has been found to affect the water column, not only bed sediments as previously known, and to be capable of impacting large water bodies. We have found pyrethroid-related toxicity extending over 30 miles of the American River after multiple storm events (Weston and Lydy, 2010).

We believe pyrethroids are far more likely to affect delta smelt indirectly through toxicity to critical prey organisms for the species, rather than direct acute toxicity to the fish itself. LC_{50}s for sensitive invertebrates are less than 10 ng/L, and within the range of concentrations observed in the Delta, but LC_{50}s for fish are in the hundreds of ng/L and well above environmentally realistic concentrations for Delta waters. Therefore, the most likely route through which pyrethroids could adversely affect smelt is through toxicity to their copepod prey, such as Eurytemora forbesi and Pseudodiaptomus affinis.

Target Audience and Management Decisions

The Sacramento-San Joaquin River Delta is a maze of river channels and islands covering approximately 2,978 square kilometers (CVRWQCB, 2006). The Delta is valued as an area supporting aquatic life and riparian vegetation that provide recreational opportunities, including fishing. The Delta is also the major source of drinking water for over 20 million people, two-thirds of our State's population. A wide variety of interests, such as agriculture, urban, industry, fish and wildlife, environmental, and recreation, all have a vital stake in the Delta and all have a need to understand the health of the Delta and its complex interrelationships.

The Interagency Ecological Program (IEP) formed the Pelagic Organism Decline (POD) work team in response to population declines of pelagic fish species in the Delta. The POD is currently investigating hypotheses related to the role of aquatic contaminants and potential linkage with declining biota abundance. The current project will provide critical information to many of the interested POD stakeholders and member agencies. For example, management decisions related to pesticide use and water quality impacts are made by the California Department of Pesticide Regulation (DPR), the Regional Water Quality Control Boards (Water Boards), the US EPA, and other agencies. These agencies work together to establish which pesticide products are available for agriculture, urban, and other uses, and permissible application practices for these products.

The project report will consider the needs of the IEP, DPR, and the Water Boards. The information gained from this project will also assist Water Board staff in reporting for 305(b) requirements as well as in determinations of whether Delta water bodies should be placed on the 303(d) impairment list, and if stressor identification and load allocation assessments for total maximum daily load (TMDL) development are necessary.

Assessment Question
Information to support management decisions can be obtained by answering the following assessment question: What are the principal routes by which pyrethroids are entering the Cache Slough complex during the February to June period when the habitat is used by spawning Delta smelt?

Monitoring Goal
The goal of this study is to determine the pyrethroid concentration in the water entering the Cache Slough complex from approximately ten waterways that discharge to it.

Linkage to Beneficial Uses
The Delta provides habitat for aquatic ecosystems that include benthic and water column invertebrates, which form important links in food webs supporting many native fish species. This study focuses on potential impacts to these aquatic invertebrate communities and the ecosystems they support.

Spatial Scale
All sampling will occur in Cache Slough and associated sloughs, and in the waterways that discharge to these waterbodies. The sampling area is bounded by Vacaville to the west, Sacramento to the north, Walnut Grove to the east, and Rio Vista to the south

Temporal Scale
Samples will be collected over a year, from early 2011 through early 2012. Sampling of four rain events is anticipated, as well as three irrigation season events in May/June of 2011.

Indicators and Measurement Parameters
The indicator used to assess pyrethroid sources to the Cache Slough complex will be chemical analyses of whole, unfiltered water column samples. Chemical analytes will consist of eight commonly used pyrethroid pesticides: bifenthrin, cyfluthrin, cypermethrin, esfenvalerate, lambda-cyhalothrin, deltamethrin, fenpropathrin, and permethrin. The whole water samples will be extracted by liquid:liquid extraction using dicloromethane, and then analyzed for pyrethroids by gas chromatography with electron capture detection. Sampling is expected to yield about 111 samples for whole water analysis (+ 30 QA = 141). Nominal reporting limits for pyrethroids in water samples are anticipated to be 3 ng/L, though we are often able to report to 1 ng/L provided there are no unexpected matrix interferences.

All pesticide chemical analyses will be conducted by Dr. Michael Lydy at the Fisheries and Illinois Aquaculture Center, Department of Zoology, Southern Illinois University using SWAMP comparable methods.

Monitoring Objectives

With funding from IEP under a separate contract, we will be sampling the waters of Cache Slough and associated waterbodies for pyrethroid pesticides, toxicity to Hyalella azteca and copepods, and composition of the resident zooplankton community. Based on historical data, we expect pyrethroids to be found in Cache Slough at concentrations causing toxicity to aquatic life, and the SWAMP funding will support field sampling to determine what their sources may be. The sampling will include characterization of pyrethroids at multiple points along the length of the major routes for urban runoff transport to the Slough (Ulatis Creek from Vacaville, and Deep Water Ship Channel from West Sacramento), as well as quantification of pyrethroid inputs through the various tributaries that carry agricultural runoff to Cache Slough.

Monitoring Design

Sampling sites will be chosen to characterize as many potential sources of pyrethroids to the Cache Slough complex as are accessible for sampling. The following sources have been identified:

1. Ulatis Creek (to be sampled at Leisure Town Road, Hawkins Road, Highway 113, and Brown Rd.)
2. New Alamo Creek (sampled at Leisure Town Road)
3. Old Alamo Creek (sampled at Lewis Road)
4. Upper Haas Slough (sampled by boat)
5. Upper Lindsey Slough (sampled by boat)
6. Shag Slough (sampled at Liberty Island Road)
7. Toe Drain (sampled at West Sacramento and near Liberty Island)
8. Deep Water Ship Channel (sampled at Arcade and Courtland Road)
9. Miner Slough (sampled at Highway 84)
10. Steamboat Slough and/or Sacramento River (sampled at Ryer Island ferry)

The above sites will be sampled during three rain events during the rainy season (Nov.-April), with accumulations of at least 0.5 inches, and preferably more. They will also be sampled on three occasions during May and June, a period when rain is not expected, but irrigation runoff could serve as a transport mechanism. We will sample as many of the sites as possible on each occasion, but we may not be able to obtain all samples every time because of access limitations, the timing of rainfall relative to when darkness falls, Ryer Island ferry operation, and other factors. Some of the sites, particularly the creeks, are unaffected by tidal influence so time of sampling with respect to the tidal cycle is irrelevant. Other sites, however, are tidally affected, and while we will try to sample as close to slack low water as possible, this will often not be possible given the number of sites and the brief period of slack low water.

Ulatis Creek is anticipated to be a significant source of pyrethroids, and more intensive sampling in a transect down the length of the creek is anticipated during three rain events in order to establish whether pyrethroids from Vacaville persist all the way to Cache Slough, and to what extent agricultural drains along the creek contribute to its pyrethroid content. This transect sampling will follow a Lagrangian approach in which the same parcel of water is followed as it moves downstream. Ulatis Creek will be divided into 5 reaches of 1.5-2.8 miles in length, with reach boundaries defined by road crossings. The rate of water movement at each end of the reach will be determined, the average value applied to the reach overall, and the time required for water to reach the next sampling point estimated. The same parcel of water will be sampled as it reaches each successive sampling point. In addition the major agricultural drains and other inputs along the creek will be sampled, just prior to the point of discharge. The following samples will be obtained through this transect approach:

ULATIS CREEK

1. Leisure Town Road
2. Byrnes Road
3. Fox Road
4. Hawkins Road
5. Highway 113
6. Brown Road

OTHER INPUTS

1. Agricultural drain at Fox Road
2. Gibson Creek
3. Sweany Creek
4. Agricultural drain at Hawkins Road
5. Agricultural drain at Highway 113
6. Alamo Creek at confluence with Ulatis Creek

Finally, there are approximately 23 agricultural return drains that discharge directly into the Cache Slough complex, and whose contribution would not be captured by sampling of the other sources around the perimeter, as described above. These drains will be sampled on an opportunistic basis since their flow depends on when pumps are turned on, and that in turn is a function of rainfall and/or irrigation activity. If these drains are seen to be discharging while we are in the area, a sample will be taken to characterize the pyrethroid content of that discharge, to the extent access allows.

Coordination and Review Strategy

To promote monitoring coordination among agencies and work groups, this study will be reviewed/coordinated on multiple levels. First, there will be close coordination with Water Board staff in Region 5. For example, site reconnaissance and selection will be conducted by the UCB Project Director (PD) and Water Board staff will be consulted prior to finalization of the site list. Water Board staff will be kept appraised of findings throughout the study.

Second, the Contaminants Work Team (CWT) will be kept informed of study findings and given opportunity for suggestions and comment. This will primarily be done through

the periodic meetings of the CWT at which one or more oral presentations on the study will be provided.

Third, this study is closely integrated with IEP-funded sampling within Cache Slough, with oversight provided by the IEP Management Team. One or more presentations will be made to the Management Team during the course of the study, and the presentations will provide an integrated synthesis of both the IEP and SWAMP-funded work. The Management Team includes representatives from many state and federal agencies (e.g., DFG, DWR, Delta Stewardship Council, USGS, USFWS), thus providing a mechanism to integrate study findings into Delta management decisions.

Finally, it is our practice to publish our work in the peer-reviewed literature, and we expect this will be the case with this study as well. Peer review, coordinated by the journal's editor, will insure the work meets or exceeds generally accepted standards of scientific rigor.

This project's findings will inform several other programs including the Irrigated Lands Regulatory Program, the TMDL program, and ecological restoration efforts in the northwest Delta.

Quality Assurance

A project specific Quality Assurance Project Plan (QAPP) will be prepared that is consistent with the EPA 24 Element QAPP Guidelines and the SWAMP Quality Assurance Management Plan. The QAPP will include criteria for data acceptability, procedures for sampling, testing, and calibration, as well as preventative and corrective measures.

Data Management

All data generated by this project will be maintained as described in the SWAMP-accepted project QAPP. UCB staff will be responsible for collection of samples and field data and for entering the field data into the SWAMP database. Southern Illinois University (SIU) will be responsible for providing analytical chemistry data in SWAMP format.

Assessment Benchmarks

There currently exist no enforceable threshold concentrations or Basin Plan Objectives for pyrethroid pesticides in water. The TMDL program has developed thresholds for acute and chronic toxicity using all available toxicity testing data and a modification of EPA protocols to derive criteria. Those thresholds are only for guidance purposes and do not currently have any regulatory basis, but they will be helpful in interpreting the concentration data gathered through this study. In addition, we have published LC_{50} data for Hyalella azteca exposed to a variety of pyrethroids (Weston and Jackson, 2009), and these data will be helpful in identifying those samples in which pyrethroids could present a threat to aquatic life.

Reporting
Data collected from this assessment will be transferred to, and be electronically available from, the SWAMP database. The final project report, probably in the form of a publishable paper, will be prepared by the UCB PD.

Project Schedule

Activity	Date
Monitoring Plan	July 2011
Quality Assurance Plan	December 2011
Sample Collection	May 2011 – February 2012
Chemical Analyses	May 2011 – February 2012
Reporting	
Draft Final Report	March 2012
Final Report	March 2012
Expected Project Completion Date	March 2012

Literature Cited

Teh, S.J., Lesmeister, S., Flores, I., Kawaguchi, M., Teh, C. 2009. Acute toxicity of ammonia, copper, and pesticides to Eurytemora affinis, of the San Franciso Estuary. Final report to the UC Davis Aquatc Toxicology Laboratory.

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Weston, D.P., Jackson, C.J. 2009. Use of engineered enzymes to identify organophosphate and pyrethroid-related toxicity in toxicity identification evaluations. Environ. Sci. Technol. 43:5514-5520.

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