Potential Influence of Pyrethroids, Metals, Sediment Characteristics, and Water Quality Conditions on Benthic Communities in Cache Slough

Lenwood Hall

William Killen

Ronald Anderson

University of Maryland

Wye Research and Education Center

Queenstown, Maryland

and

Raymond Alden III

Northern Illinois University

Background

- Cache Slough is ~ 18 km in length and is located in the northwest Delta area of CA
- Other investigators have recently reported potentially toxic water concentrations of pyrethroids in the Cache Slough area
- It is an important spawning and nursery area for Delta Smelt and other important fish species (Longfin Smelt, Sacramento Splittail, Chinook Salmon)

Key Fish Species in Cache Slough

Delta Smelt

Sacramento Splittail

Longfin Smelt

Chinook Salmon

Objectives

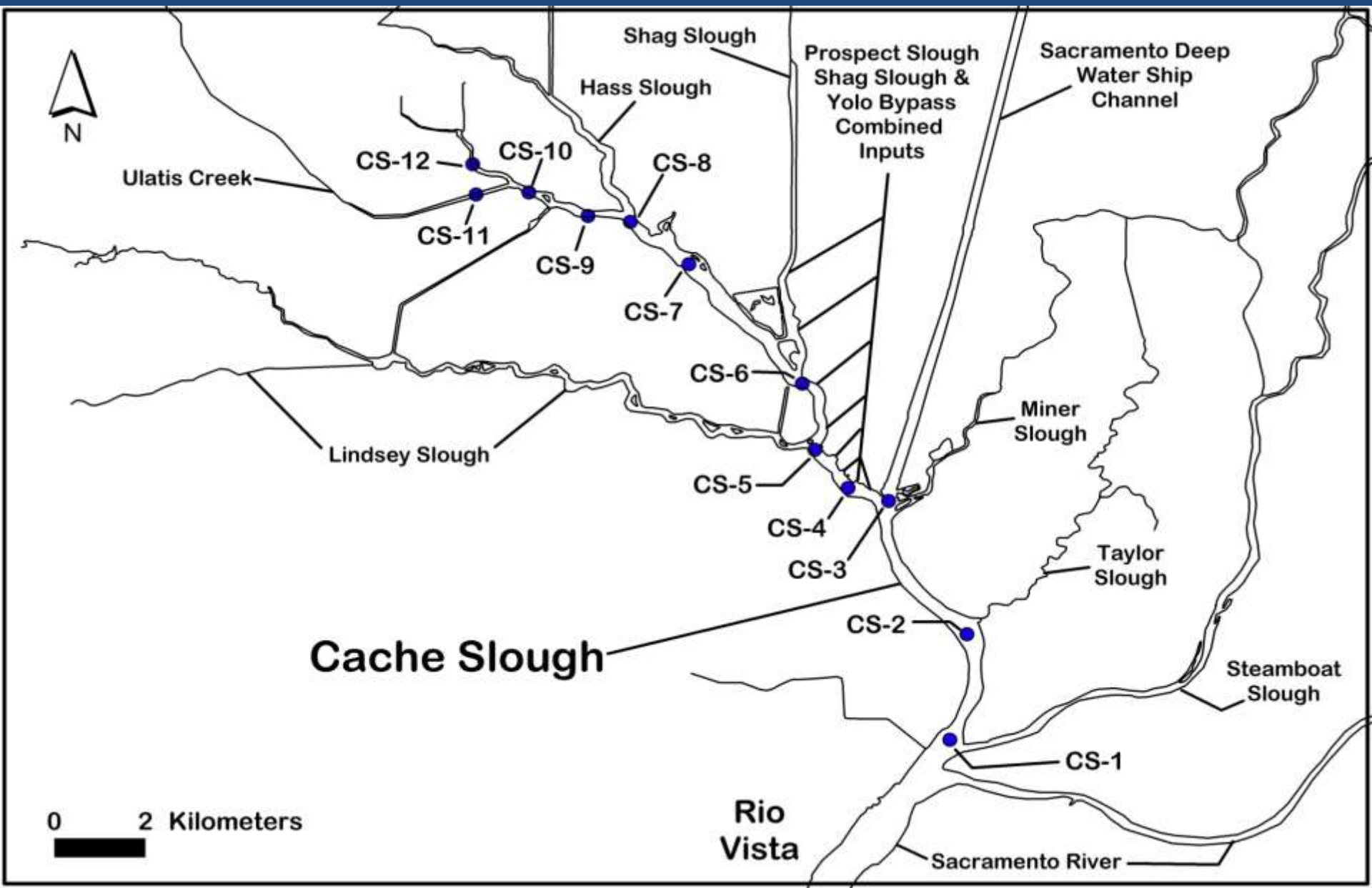
- Collect and identify benthic macroinvertebrates (BMIs) from 12 sites in the Cache Slough area in the spring and fall of 2012 and 2013
- Measure pyrethroids , total organic carbon (TOC), grain size, total metals and SEM/AVS in sediment from all sites where benthic organisms are collected
- Measure basic water quality parameters at each site
- Use univariate regressions and stepwise multiple regressions to determine relationship between benthic metrics and pyrethroids, metals, TOC and grain size

Value of Study

- Sediment concentrations of pyrethroids will provide perspective to water column concentrations previously reported in the Cache Slough area
- Benthic sampling will provide new benthic data for this waterbody
- Sediment metals data for the study area will provide new information not currently available
- BMI data from this study area would be useful for the Biological Objectives Process in California

Cache Slough and Tributary Locations in CA

Cache Slough Sample Sites



Study Design

- 12 sites were sampled during the spring and fall of 2012 and 2013
- Sites were selected based on a reconnaissance sampling trip in advance of spring sampling
- Different types of habitat were a criterion in the site selection process
- Confluence points from various water bodies were considered in the site selection process
- Non-wadeable water body that was sampled by boat

Study Design

- Depth ranges from 1.5 to 9 m depending on tidal cycle
- Benthic communities were sampled from 5 randomly selected locations along a 100 m transect and the sample was composited
- Sediment samples were collected using a petite ponar (2-3 cm)
- Benthic ID work was conducted by CDFG
- Pyrethroids, metals, TOC, grain size were measured on the same sample used for BMIs

Cache Slough Sampling

Study Design

- Basic water quality was measured at each site (temperatue, pH, salinity, conductivity, DO, and turbidity)
- Univariate regressions and stepwise multiple regressions analysis were used to determine relationships between various benthic metrics and (a) pyrethroids; (b) metals (bulk metals and SEM/AVS); (c) grain size; and (d) TOC.

Ranges and Mean TOC and Grain Size Values for 12 Cache Slough Sites Sampled in Spring and Fall of 2012 and 2013

% TOC		% Silt/Clay	
Spring	Fall	Spring	Fall
0.6 – 4.4	0.7 – 1.7	31 - 97	35 - 99
Mean = 1.3	Mean = 1.1	Mean = 75.5	Mean = 83.7

Number of Metals TEL Exceedances by Metal and Season for Cache Slough sites in 2012 and 2013 (24 values)

Metal	Spring	Fall	TEL (ug/g dw)
As	15	13	5.9
Cd	0	3	.596
Cr	21	23	37.3
Cu	19	19	35.7
Pb	0	0	35
Hg	5	4	.174
Ni	24	24	18
Zn	1	1	123.1

Natural Sources of Cr, Ni, As and Cu in Cache Slough

- Discussions with geologists at UC Davis (Peter Green, Randal Southard) and CA Geological Survey (Ron Churchill)
- Serpentine soils in Solano County area near Cache Slough
- Serpentine soils are naturally high in Cr and Ni (Bonifacio et al. 2010)
- Arsenic (2.1 – 13.8 ug/g) and copper (6.3 – 62 ug/g) in Solano county soils are similar to range reported in sediment

Number of SEM/AVS Ratios > 1 with at least one metal exceeding a TEL for Cache Slough sites by season in 2012 and 2013 (12 sites per season)

Season/Year	# SEM/AVS Ratios >1	Range SEM/AVS Ratios
Spring 2012	8	1.4 – 9.8
Spring 2013	7	1.1 -3.9
Fall 2012	10	1.3 – 2.8
Fall 2013	5	1.2 – 3.0

Pyrethroids Measured in Sediment

Bifenthrin
Cypermethrin
Cyfluthrin
Deltamethrin
Esfenvalerate
Fenpropathrin
Lambda – cyhalothrin
Permethrin

Sum of Pyrethroid Toxic Units (TUs) Based on *Hyalella* from Spring and Fall 2012 (values > 1 in yellow)

Station	Sum of Pyrethroid TUs	
	Spring	Fall
CS-1	0.31	0.14
CS-2	0.15	0.13
CS-3	0.25	0.12
CS-4	0.05	0.07
CS-5	0.16	0.11
CS-6	0.12	0.14
CS-7	0.35	0.28
CS-8	**1.97**	0.49
CS-9	**1.39**	0.26
CS-10	**1.07**	0.27
CS-11	**1.24**	0.33
CS-12	0.28	0.29

Sum of Pyrethroid Toxic Units (TUs) Based on *Chironomus* from Spring and Fall 2012

Station	Sum of Pyrethroid TUs	
	Spring	Fall
CS-1	0.023	0.080
CS-2	0.010	0.005
CS-3	0.020	0.005
CS-4	0.001	0.004
CS-5	0.008	0.005
CS-6	0.005	0.019
CS-7	0.015	0.027
CS-8	0.139	0.050
CS-9	0.127	0.014
CS-10	0.102	0.014
CS-11	0.114	0.021
CS-12	0.014	0.018

Sum of Pyrethroid Toxic Units (TUs) Based on *Hyalella* from Spring and Fall 2013 (values > 1 in yellow)

Station	Sum of Pyrethroid TUs	
	Spring	Fall
CS-1	0.25	0.10
CS-2	0.15	0.06
CS-3	0.27	0.09
CS-4	0.26	0.26
CS-5	0.13	0.06
CS-6	0.14	0.06
CS-7	0.35	0.09
CS-8	0.35	0.09
CS-9	0.17	0.17
CS-10	0.41	0.06
CS-11	0.36	0.15
CS-12	0.22	0.16

Spring Benthic Community Results from 2012 and 2013

- 54 to 56 benthic taxa collected at 12 sites during each year
- The 5 most dominant taxa – comprising 74 to 79% of the total # individuals – most of the taxa were considered tolerant or moderately tolerant of general water quality stressors
- The most dominant taxa collected was the amphipod (*Americorophium*) – 25 to 33% of the total # of individuals

Fall Benthic Community Results from 2012 and 2013

- 43 to 44 benthic taxa collected at 12 sites
- The 5 most dominant taxa – comprising 76 – 85 % of the total # individuals – were generally considered tolerant or moderately tolerant
- The most dominant taxa collected was the amphipod (*Americorophium*) – 28 to 37 % of the total # of individuals

Five Dominant BMI Taxa Collected in Cache Slough 2012 - 2013

Americorophium
30.84%

Unid immature
Tubificidae
11.50%

Manayunkiia
speciosa
18.96%

Chironomus
8.15%

Corbicula
7.54%

Benthic Metrics Used for Stepwise Multiple Linear Regression and Response to Impairment

Benthic Metric	Response to Impairment
# Collector/Filterer & Collector/Gatherer	Increase
Abundance	Decrease
% Amphipoda	Variable
% Collector/Filterer & Collector/Gatherer	Increase
% Corbicula	Variable
% Dominant Taxa	Increase
% Oligochaeta	Increase
% Predators	Decrease
% Tolerant Taxa	Increase
Shannon Diversity	Decrease
Taxa Richness	Decrease

Results of stepwise multiple linear regression models of benthic metrics versus TUs for pyrethroids, sediment characteristics and metals to TEL ratios for Cache Slough in 2012 and 2013

Benthic Metrics	Significant Variables
% Coll/Filt & Coll/Gath	+ As
Abundance	- % TOC, - % Silt

Conclusions

- Sediment sites selected from a random process were dominated by fine grain material (silt and clay)
- There were a number of metals TEL exceedances for the four sampling periods with the highest number of exceedences for Cr and Ni
- The sum of pyrethroid TUs based on *Hyalella* exceeded 1 at four sites during the spring of 2012 but all TUs were less than 1 during the other three sampling periods

Conclusions

- **The sum of pyrethroid TUs based on *Chironomus* were considerably less than 1 for all sampling periods**
- **Fifty-four to 56 benthic taxa were reported during the spring while 43 to 44 benthic taxa were reported during the fall**

Conclusions

- The benthic metric % Collector/Filterer & Collector/Gatherer displayed a direct relationship with As based on the 2 year data set
- Based on the multiple year data set, the benthic metric abundance was inversely related to % TOC and % Silt thus suggesting that the number of benthic organisms increased in coarser, less organic-rich sediments

Ranges of Cache Slough Water Quality Parameters for 2012 and 2013

Parameter	Spring	Fall
Temp (C)	12.0 – 16.9	16.2 – 19.1
pH	6.98 – 8.2	7.5 – 8.4
D. O. (mg/L)	7.34 – 10.7	7.2 – 10.0
Cond (uS)	110 – 605	125 – 559
Sal (ppt)	0.1 – 0.4	0.1 – 0.3
Turb (NTU)	6- 255	4.6 – 74

Conclusions

- **Additional data are needed to confirm the significant patterns, as well as potentially detect other relationships that may be present between benthic metrics and environmental stressors**