A-242

I. EXECUTIVE SUMMARY

Ia. Project Title and Applicant Names - Discharge of Agricultural Drainwater into the Bay/Delta: Effects on Selenium Bioaccumulation. Dr. Scott Ogle, Jeffrey Cotsifas, Pacific Eco-Risk Laboratories, Martinez, CA.

Ib. Project Description and Primary Ecological Objectives - This is a proposal to determine the effect of planned discharges of seleniferous agricultural drainwater into the Bay/Delta on selenium bioaccumulation by the bivalve *Potamocorbula amurensis*, the primary food of sturgeon in the Bay/Delta. Current monitoring suggests that the selenium concentrations in these bivalves and in the sturgeon may already be indicative of adverse effects. The planned discharge of agricultural drainwater into this system may well further increase the bivalve and sturgeon selenium levels to the point of reproductive failure by the sturgeon. The immediate ecological objective of this study is to determine how the planned discharges of ag drainwater into the Bay/Delta will affect selenium bioaccumulation in this food chain before actual toxicity and reproductive failure in sturgeon occur.

Ic. Approach, Tasks, Schedule - The basic approach to this study will be to expose *Potamocorbula amurensis*, the primary food item of these sturgeon, to the environmental media (water + suspended particulates, including plankton) that would result from discharges of ag drainwater into the Bay. The resulting selenium bioaccumulation information will then be evaluated to determine the likelihood of toxicity and reproductive failure in sturgeon that would result from such ag drainwater discharges before they are implemented. The tasks that comprise this study are as follows:

- collection of site waters;
- collection of test organisms;
- preparation of test exposure media;
- performance of bioaccumulation experiments;
- chemical analysis to determine selenium concentrations in tissue and water samples;
- evaluation of data;
- preparation of Final Report.

Assuming that funding is available by November, 1997, this project will be initiated in November, with the actual bioaccumulation experiments taking place over the 12 months of 1998.

Id. Justification for Project and Funding by CALFED - Both white sturgeon and green sturgeon (the latter of which is a CALFED priority species) have undergone significant population declines. Selenium bioaccumulation and toxicity may already be playing a role in these declines. Additional input of selenium into the Bay/Delta could prove disastrous and lead to further reproductive failure in these fish. The information generated by this study will help to prevent this problem by determining how planned discharges of seleniferous waters into the Bay affect selenium bioaccumulation before state and federal agencies commit to such actions.

Despite the obvious need for this information, there are currently no funds at the relevant agencies to support this project. If this study is to be performed, CALFED funding will be necessary.

Ie. Budget Costs and Third Party Impacts - The total cost for this study will be $142,308. No third party impacts are anticipated.

If. Applicant Qualifications - Both Dr. Ogle and Mr. Cotsifas are eminently qualified to successfully perform the proposed work. Both have extensive experience conducting studies addressing selenium bioaccumulation and toxicity, and both are also experienced in the collection and maintenance of *Potamocorbula amurensis*.

Ig. Monitoring and Data Evaluation - Test data will be analyzed following EPA guidelines and using appropriate statistical software. The resulting bioaccumulation information will then be evaluated to determine the ecological risk posed by the planned discharges of seleniferous ag drainwater into the Bay/Delta.

Ih. Local Coordination with Other Programs/Compatibility with CALFED Objectives - The proposed study is independent of any ongoing studies, although it will the necessary next step before discharge of ag drainwater into the Bay take place. Where possible, this study will be coordinated with sampling and monitoring activities taking place within the Grasslands Bypass Project and the San Francisco Estuary Regional Monitoring program.

By generating information that may be critical in preventing selenium toxicity and reproductive failure in white sturgeon and green sturgeon, the objectives of this study are the same as for CALFED: ecosystem restoration and improvement of the health of the Bay-Delta system.

II. TITLE: Discharge of Agricultural Drainwater into the Bay/Delta: Effects on Selenium Bioaccumulation

Principal Investigators: Dr. Scott Ogle
Pacific Eco-Risk Laboratories,
827 Arnold Dr., Suite 100
Martinez, CA 94553
Phone: (510)313-8080
Fax: (510)313-8089
e-mail: scottogle@eco-risk.com

Jeffrey Cotsifas
Pacific Eco-Risk Laboratories,
827 Arnold Dr., Suite 100
Martinez, CA 94553
Phone: (510)313-8080
Fax: (510)313-8089
e-mail: cotsifas@eco-risk.com

Organization: Pacific Eco-Risk is a private small business, organized as a general partnership. The Federal Tax # is: 68-0353085.

Technical/Financial Contact: Dr. Scott Ogle

RFP Project Group: Services

Date: July 28, 1997

III. PROJECT DESCRIPTION

IIIa. Project Description and Approach

For almost two decades, selenium contamination of surface waters and bioaccumulation by aquatic organisms has been recognized as a major problem in California. Scientists first observed this problem as shorebird and waterfowl reproductive failure at Kesterson Reservoir (Ohlendorf et al 1986a), which received highly seleniferous agricultural (ag) drainwater from the San Luis Drain (SLD). Selenium bioaccumulation through the food chain was determined to be the cause of the observed toxicity (Ohlendorf et al. 1986a; Saiki 1986; Ohlendorf et al. 1990).

Selenium contamination and bioaccumulation have also been linked to reproductive failure, mortalities, and fish population declines in several different aquatic systems; in one contaminated lake, it was discovered that of 20 fish species once present, 16 species had been eliminated (Lemly 1985).

In California, selenium problems are not limited to Kesterson; monitoring in San Francisco Bay revealed that diving ducks had selenium concentrations similar to those at Kesterson (Ohlendorf 1986b), suggesting the potential for similar toxicity problems. A subsequent Bay/Delta monitoring program, the Selenium Verification Study, revealed that white sturgeon tissue selenium concentrations increased several-fold over the five-year study (Table 1), and were approaching those observed for fish exhibiting reproductive failure in other aquatic systems (Gillespie and Baumann 1986).

Sturgeon feed primarily upon bivalves (McKechnie and Fenner 1971; SWRCB 1991), and the selenium levels in the bivalves they eat determine their selenium exposure and bioaccumulation. Interestingly, the introduced Asian clam *Potamocorbula amurensis* has become the predominant food item consumed by sturgeon since 1988 (SWRCB 1991). Recent studies have revealed that *Potamocorbula* selenium levels are as much as three-fold greater than levels in the former bivalves eaten by sturgeon (Luoma and Linville, in press). Even more alarming is the fact that the reported *Potamocorbula* selenium levels meet or exceed most dietary toxicity thresholds established for fish (Table 1), suggesting that the white sturgeon may already be adversely affected by the selenium concentrations in these bivalves. Furthermore, given their similar feeding ecologies (Houston 1988; Artyukhin and Andronov 1990), it seems likely that green sturgeon, a CALFED priority species, are similarly being exposed to elevated dietary selenium, and that their tissue selenium levels are also undergoing dangerous increases.

In response to these problems, regulatory measures have been implemented to reduce selenium loading into the Bay. However, these may be rendered futile by the recent initiation of the Grasslands Bypass Project in which selenium-contaminated ag drainwater is diverted around the Grasslands Water District (GWD) and discharged directly into the San Joaquin River; there are serious concerns that this may result in increased selenium transport into the San Joaquin River, and from there, into the Bay/Delta. This problem may itself be exacerbated by legally-mandated plans to extend the SLD directly to a discharge point somewhere in the Northern San Francisco Bay system.

Given that *Potamocorbula* selenium levels already meet or exceed levels known to be toxic to fish, and that sturgeon selenium levels are similarly near concentrations known to be symptomatic of toxicity, the

potential for increased selenium in Northern San Francisco Bay could prove disastrous, not only for white sturgeon, but also for green sturgeon which have been identified as a priority species by CALFED. Furthermore, given that current problems have occurred in waters with selenium levels that are already very low (Cutter 1986), even slight increases could push the system over the edge.

With this in mind, we are proposing to determine how increased waterborne selenium resulting from discharge of ag drainwater into the Bay/Delta will affect selenium bioaccumulation in this critical food chain. Specifically, we propose to collect ambient water from the proposed site of ag drainwater discharge (between Pittsburgh and Antioch) and from the SLD, to mix these waters at dilutions that cover the range predicted for such discharges from the SLD into the Bay/Delta, and to determine the selenium bioaccumulation that results in *Potamocorbula* from the SLD inputs. The resulting bioaccumulation information will allow for an assessment of the risk that such ag drainwater discharges pose to sturgeon (and other organisms that may feed on these clams).

IIIb. Geographic Boundaries of Project

This study will investigate the effects of discharge of agricultural drainwater into the Bay/Delta. Currently, there are several options being discussed regarding the site of such discharge, ranging from the southeastern edge of the delta up to downstream of the confluence of the Sacramento and San Joaquin Rivers entering Suisun Bay. This latter site is the current leading candidate for the eventual discharge site, and our study addresses effects on selenium bioaccumulation in that area.

IIIc. Expected Benefits

Selenium bioaccumulation in this estuary has already resulted in Northern San Francisco Bay being identified as an "impaired water body" by the US EPA's 304(L) process. Furthermore, the fish tissue analyses conducted by the Selenium Verification Study indicate that sturgeon tissue selenium concentrations are dangerously high, and may already be adversely affecting both the white sturgeon and the green sturgeon, the latter of which has been identified as a priority species by CALFED.

Current plans being discussed for the disposal of ag drainwater include discharge into the San Joaquin River from which they will flow into the Bay/Delta, or direct discharge via the SLD into the Bay/Delta. The resulting increases in selenium bioaccumulation may well push an already precarious situation over the edge, such that sturgeon may begin to experience the reproductive failure that has been observed for other fish species contaminated by selenium. The results of this study will allow for the evaluation of this problem before such ag drainwater discharges become problematic, and may well serve to prevent the white sturgeon and green sturgeon from suffering additional population losses.

IIId. Background and Biological/Technical Justification

Selenium is Recognized as a Toxic Contaminant in Surface Water of California - For almost two decades, selenium bioaccumulation by aquatic organisms has been recognized as a major

problem here in California. In the early 1980s, scientists first began observing selenium toxicity problems at Kesterson Reservoir: waterfowl and shorebirds nesting in and around Kesterson Reservoir were suffering extreme teratogenesis and subsequent reproductive failure (Ohlendorf et al. 1986a). Studies soon revealed that the agricultural drainwater that flowed into Kesterson contained high levels of selenium, and the resulting bioaccumulation of selenium through the food chain was determined to be the cause of the observed toxicity (Ohlendorf et al. 1986; Saiki 1986; Ohlendorf et al. 1990).

Selenium Bioaccumulation Causes Toxicity and Reproductive Failure in Fishes - Selenium toxicity is not limited to waterfowl and Kesterson Reservoir. Selenium has been linked to reproductive failure, mortalities, and fish population declines in several different aquatic systems. As early as 1957, elevated selenium was being linked to drastic declines in fish populations. Introductions of several fish species into Sweitzer lake (Colorado) proved unsuccessful due to mortalities that occurred shortly after stocking (Barnhart 1957), and it was eventually concluded that foodborne bioaccumulation of selenium eventually killed the fish (Barnhart 1957).

Monitoring at Belews Lake (North Carolina) revealed that within three years after selenium discharges into the lake began, larval fish for many species could not be found. Analyses of water and biota revealed high levels of selenium, particularly in mature fish ovaries, and it was concluded that food chain uptake of selenium was resulting in impaired fish reproduction (Cumbie and VanHorn 1978). It was subsequently reported that of 20 fish species once present in Belews Lake, 16 species had been eliminated (Lemly 1985).

Analyses of fish tissues from Hyco Reservoir, which also received selenium discharges, indicated elevated selenium in mature fish (Sager and Cofield 1984; Baumann and Gillespie 1986). Fish spawning experiments revealed that larval fish from Hyco Reservoir females did not survive the swim-up stage (Gillespie & Baumann 1986). Monitoring of fish at Martin Creek Reservoir (Texas), another selenium-impacted ecosystem, revealed dramatic decreases in fish biomass (Garrett and Inman 1984).

These studies have all hypothesized that foodborne uptake of selenium is leading to the observed toxicity, and laboratory feeding studies have since confirmed that elevated dietary selenium can cause reproductive failure in fish (Woock et al. 1987; Coyle et al. 1993).

Is Selenium Affecting Fishes in the San Francisco Bay/Delta? - A considerable amount of seleniferous ag drainwater is discharged in the San Joaquin River where it flows into the Bay/Delta and industrial effluent discharges are also significant sources of selenium in San Francisco Bay (Cutter 1986). Selenium monitoring in San Francisco Bay (the Selenium Verification Study) revealed that white sturgeon tissue selenium concentrations increased dramatically in 1989-1990, several-fold greater that had been observed in the previous three years of the monitoring program (SWRCB 1991). Even more alarming, these sturgeon selenium concentrations were approaching those observed for fish exhibiting reproductive failure in other aquatic systems (Gillespie and Baumann 1986). Adult white sturgeon populations have steadily declined since 1986 (M. Dunne, CA Dept. Fish & Game, personal communication), and selenium bioaccumulation may be playing a role in these declines.

Why are the Sturgeon Tissue Selenium Levels So High? - The primary dietary item of sturgeon is bivalves (McKechnie and Fenner 1971; SWRCB 1991). Selenium bioaccumulation by

these bivalves are of critical importance in determining selenium exposure and bioaccumulation by these sturgeon. Interestingly, the recently introduced Asian clam *Potamocorbula amurensis* had become the predominant food item for sturgeon by 1988-89 (SWRCB 1991). In the earlier 1986-1988 selenium monitoring, the tissue selenium of *Corbicula fluminea*, a previous dominant bivalve food item for sturgeon, was reported to range from 0.42-0.86 ppm, wet weight. However, subsequent monitoring of *Potamocorbula* in Northern San Francisco Bay reported tissue selenium levels that were three-fold greater than tissue selenium levels reported for *Corbicula* in 1986-88 (Luoma and Linville, in press). This increase in bivalve selenium is almost certainly the cause for the increased sturgeon selenium levels observed since 1988.

Even more alarming is the fact that the *Potamocorbula* selenium levels, as high as 19 ppm, dry wt, meet or exceed most dietary toxicity thresholds that have been indicated for fish (Table 1), suggesting that white sturgeon may already be adversely affected. Furthermore, given their similar feeding ecologies, it seems likely that green sturgeon, a CALFED priority species, are similarly being exposed to elevated dietary selenium, and that their tissue selenium levels are also undergoing dangerous increases.

Is this Selenium Problem Getting Better, or Worse? - In recognition of this and other selenium-related problems, the San Francisco Bay Regional Water Quality Control Board has implemented regulatory measures to reduce selenium loading into Northern San Francisco Bay. However, these remediation efforts may be rendered futile by recent developments surrounding ag drainwater discharge options currently being considered and/or implemented. In response to the toxicity problems observed at Kesterson, the Grasslands Water District sued the Federal Government to terminate release of selenium-contaminated ag drainwater into the Water District's land. The proposed solution was the Grasslands Bypass Project, in which selenium-contaminated ag drainwater is diverted around the Grasslands Water District and discharged directly into the San Joaquin River. While protecting the Grasslands Water District from selenium toxicity, there are serious concerns that this program may result in increased selenium transport into the San Joaquin River, and from there, into the Bay/Delta system. This potential problem may itself be exacerbated by revived plans to extend the San Luis Drain: in 1985, agricultural interests sued the U.S. Bureau of Reclamation in Federal Court, and won a decision that forces the Bureau to renew the planned extension of the San Luis Drain and convey ag drainwater to a discharge point somewhere in the Northern San Francisco Bay system.

Given that the current *Potamocorbula* tissue selenium levels already meet or exceed levels known to be toxic to fish, and that the sturgeon tissue selenium levels are similarly near concentrations known to be symptomatic of toxicity, the potential for increased selenium concentrations in Northern San Francisco Bay could prove disastrous, not only for the white sturgeon, but also for the green sturgeon, which has been identified as a priority species by CALFED. Furthermore, given that the current problems have occurred in waters with selenium concentrations that are already very low (Cutter 1986), even slight increases could push the system over the edge.

IIIe. PROPOSED STUDY

With this in mind, we are proposing a study to determine how increased water selenium concentrations resulting from potential discharge of ag drainwater into the Bay/Delta will affect selenium bioaccumulation in this critical food chain. Specifically, we propose to collect ambient water from the

proposed site of ag drainwater discharge and ag drainwater from the SLD, to mix these waters at dilutions that cover the range predicted for such discharges from the SLD into the Bay/Delta, and to determine the selenium bioaccumulation that results in *Potamocorbula* from the ag drainwater inputs. The resulting bioaccumulation information will allow for an assessment of the risk that such ag drainwater discharges pose to sturgeon (and other organisms that may feed on these clams).

Task 1. Collection of Site Waters - On a weekly basis, ambient waters will be collected from two locations: the proposed discharge site (the Pittsburgh/Antioch area), and the SLD. The receiving water samples will be collected from the Dept. of Water Resources' Mallard Island Sampling Station, immediately downstream of the confluence of the Sacramento and San Joaquin Rivers and between Antioch and Pittsburgh. The SLD water will be collected at the Grasslands Bypass Project Station B which is the site of discharge of ag drainwater from the SLD into Mud Slough. These water samples will be placed on ice and transported back to our testing lab in Martinez.

Task 2. Collection of Test Organisms - Based upon results of the current USGS monitoring of *Potamocorbula* selenium concentrations, we will collect these bivalves from the site where they currently exhibit the lowest levels of tissue selenium. Sediments (containing the test organisms) will be collected using either a stainless steel Ponar dredge or a modified bucket dredge. These sediments will then be passed through polyethylene sieves and the resident bivalves collected. The bivalves will rinsed off and placed in labeled polyethylene bags containing clean seawater at the ambient salinity. These bivalves will be transported to the laboratory where they will be maintained in aquaria containing clean fine-grained sand and clean seawater at the ambient salinity from the clam collection site (clean seawater will from the U.C. Davis Bodega Bay marine laboratory). The clams will be fed suspensions of clean algae (i.e., *Isochrysis sp.*, *Thalassiosira sp.*, an/or *Skeletonema sp.*) until they are used in the tests.

Task 3. Preparation of the Exposure Media - During the recent federal court case which forced renewal of plans to extend the SLD, modelling studies were presented which characterized the various discharge scenarios of ag drainwater into the Bay/Delta. These studies will be reviewed to determine the range of drainwater dilutions that are predicted for discharges from the SLD. Then receiving water will be mixed with SLD drainwater at those dilutions, and the resulting media will be incubated under full-spectrum (identical to natural sunlight) fluorescent lighting for 48 hrs in order to allow for the suspended phytoplankton and other particulates present in the waters to come to equilibrium with the new selenium concentration regimes. Two sets of media will be established and staggered by 24 hrs to allow harvesting of test media on a daily basis. The media will be vigorously aerated during this exposure period to reflect the mixing that takes place *in situ*.

Task 4. Performance of Bioaccumulation Testing - Recognizing that selenium concentrations vary seasonally in ag drainwater (Karkoski 1994), the proposed testing will take place four times over a one year period: January, April, July, and October. Each set of bioaccumulation tests will extend through a minimum of 28 days exposure, although actual termination of the bioaccumulation testing will be dependent upon observation of equilibrium tissue selenium concentrations in the clams (determined by on-going chemical analyses of the clam tissues, described below).

The test treatments will consist of 100% receiving water and mixtures of receiving water + ag drainwater covering the range of expected dilutions (e.g., 0.1%, 1%, and 10% drainwater). There will

be five replicates per treatment, each consisting of approximately 100 large *Potamocorbula* within a 20 L aquaria. Each day, approximately 90% of the test water in each tank will be replaced with freshly incubated test media. Each tank will be gently aerated to help keep particulates in suspension and available for feeding by the bivalves.

Every seven days, 10 bivalves will be sampled from each tank (an additional five "replicate" sets of 10 organisms will be collected at the beginning of each test for determination of the initial selenium concentrations). These bivalves will be placed in depuration test media consisting of filtered treatment media for 48 hrs to allow for depuration of gut contents. Then, each clam will be dissected, using appropriate clean techniques, and the soft tissues collected. These tissues will be composited for the 10 organisms per each replicate. The composited tissue samples will then be frozen, and shipped to the analytical laboratory for selenium analyses. Water samples will also be collected every seven days (and at the initiation of the tests); these will be filtered through a 0.45 membrane filter to collect/remove any particulates, and both water and suspended particulates will be analyzed for selenium. Appropriate QA measures (i.e., blank and duplicate analyses, spike recovery, and analyses of NBS tissues) will be implemented to validate the chemical analyses.

When the selenium analysis results indicate that the clam tissues have achieved equilibrium concentrations (i.e., no statistical difference between the current sample and the previous week's sample), the test will be terminated.

IIIf. Monitoring and Data Evaluation

Test data will be analyzed following EPA guidelines and using appropriate statistical software (e.g. ToxCalc). The resulting bioaccumulation information will then be compared to the 100% receiving water treatment to determine whether or not significant increases in bivalve tissue selenium resulted from exposure to the ag drainwater. These results will then be correlated to the analyzed selenium concentration measured for both the suspended particulates and the water samples to determine the level of selenium loading that results in unacceptable increases in bioaccumulation in the bivalves.

Reporting of Results - Upon completion of all testing and all chemical analyses, a Final Report will be prepared. This report will describe and summarize each of the study tasks described above. More importantly, this report will also include an evaluation as to whether the planned discharges of ag drainwater will increase selenium bioaccumulation in the Bay/Delta above the already dangerous levels. It is expected that this information will also be submitted for publication in an appropriate peer-reviewed scientific journal.

IIIg. Implementability

Collection of test organisms from the field will require obtaining a Collection Permit from the Dept. Fish & Game. These permits are issued on a routine basis in response to written requests, and obtaining such a permit will proceed without trouble.

Table 1. Dietary Se concentrations reported to cause impairment in fish and waterfowl. Date included in this summary are limited to those diets which included organic selenium as a component of the diet.

Species	Diet/Se Form	Dietary Se Concentration	Effect	Reference
Chinook salmon	Artificial (seleniferous fish meal)	9.6 ug/g, dry wt	reduced survival	Hamilton et al. 1990
Chinook salmon	artificial diet (seleno-dl-methionine)	18.2	reduced survival, growth	Hamilton et al. 1990
Bluegill	Natural diet (seleniferous mayflies)	13.3 ug/g, wet wt	Death	Finley 1985
Bluegill	Artificial Diet (selenomethionine)	13 ug/g, wet wt (14 ug/g, dry wt)	Impaired reproduction	Woock et al .1987
Bluegill	Artificial Diet (seleno-l-methionine)	13 ug/g, wet wt (18.8 ug/g, dry wt[b])	reduced condition factor	Cleveland et al. 1993
Bluegill	artificial diet (seleno-l-methionine)	33.3 ug/g, dry wt	impaired reproduction	Coyle et al. 1993
Fathead Minnow	Artificial Diet (25% selenate 50% selenite 25% selenomethionine)	20 ug/g, dry wt	Reduced Growth	Ogle and Knight 1989
Fathead minnows	Natural Diet (seleniferous rotifers)	~ 40 ug/g, dry wt	reduced growth	Dobbs et al. 1996
Striped Bass	Natural diet (seleniferous fish)	9.6 ug/g, wet wt (40.5 ug/g, dry wt)	Death	Coughlan and Velte 1989

a. As this is derived from a data set with an atypical dose-response, this data is questionable.

b. dry wt conversion based upon 30.7% moisture in Oregon moist pellet diet reported by Hamilton et al. 1990.

I-005245

Information Cited

Artyukihn EN, Andronov AE (1990) A morphological study of the green sturgeon, Acipenser medirostris: some aspects of the ecology and zoogeopgraphy of Acipenseridae. J Ichthyol 30:11-21

Barnhart RA (1957) Chemical factors affecting the survival of gamefish in a western Colorado reservoir. PhD Diss, Colorado St Univ, Ft Collins, Co, USA

Baumann PC, Gillespie RB (1986) Selenium bioaccumulation in gonads of largemouth bass and bluegill from three power plant cooling reservoirs. Environ Toxicol Chem 5:695-701

Cleveland L, Little EE, Buckler DR, Wiedmeyer RH (1993) Toxicity and bioaccumulation of waterborne and dietary selenium in juvenile bluegill (Lepomis macrochirus). Aquat Toxicol 27:265-280

Coughlan DJ, Velte JS (1989) Dietary toxicity of selenium-contaminated red shiners to striped bass. Trans Amer Fish Soc 118:400-408

Coyle JJ, Buckler DR, Ingersoll CG, Fairchild JF, May TW (1993) Effect of dietary selenium on the reproductive success of bluegills (*Lepomis macrochirus*). Environ Toxicol Chem 12:551-565

Cumbie PM, VanHorn SL (1978) Selenium accumulation associated with fish mortality and reproductive failure. Proc SE Assoc Fish Wildl Agen 32:612-624

Garrett GP, Inman CR (1984) Selenium-induced changes in the fish populations of a heated reservoir. Proc Ann Conf SE Assoc Fish Wildl Agen 38:291-301

Gillespie RB, Baumann PC (1986) Effects of high tissue concentrations of selenium on reproduction by bluegills. Trans Amer Fish Soc 115:208-213

Gillespie RB, Baumann PC, Singley CT (1988) Dietary exposure of bluegills (*Lepomis macrochirus*) to (75)Se: Uptake and distribution in organs and tissues. Bull Environ Contam Toxicol 40:771-778

Hamilton S, Buhl K, Faerber N, Wiedmeyer R, Bullard F (1990) Toxicity of organic selenium in the diet of chinook salmon. Environ Toxicol Chem 9:347-358

Houston JJ (1988) Status of the green sturgeon, Acipenser medirostris, in Canada. Can Field Natur 102:286-290.

Karkoski J (1994) A total maximum monbthly load model for the San Joaquin River. Central Valley Regional Water Quality Control Board, Sacramento, CA.

Lemly, AD (1985) Toxicology of selenium in a freshwater reservoir: Implications for environmental hazard evaluation and safety. Ecotox Environ Safety 10:314-338

Luoma, SN, Linville R (1997) A comparison of selenium and mercury concentrations in transplanted and resident bivalves from North San Francisco Bay. (in press).

Ohlendorf HM (1986a) Embryonic mortality and abnormalitiesof aquatic birds: apparent impacts of selenium from irrigation drainweater. Sci Total Environment 52:49-63.

Ohlendorf HM (1986b) Selenium and heavy metals in San Francisco Bay diving ducks. J Wildl Manag 50:64-71.

Ohlendorf HM (1990) Bioaccumulatiuon of selenium in birds at Kesterson Reservoir, California. Arch Environ Contam Toxicol 19:495-507.

Saiki MK, Lowe TP (1987) Selenium in aquatic organisms from subsurface agricultural drainage water, San Joaquin Valley, California. Arch Environ Contam Toxicol 16:657-670

Saiki MK, Jennings MR, Brumbaugh WG (1993) Boron, molybdenum, and selenium in aquatic food chains from the lower San Joaquin River and its tributaries, California. Arch Environ Contam Toxicol 24:307-319

Woock SE, Garrett WR, Partin WE, Bryson WT (1987) Decreased survival and teratogenesis during laboratory selenium exposures to bluegill, *Lepomis macrochirus*. Bull Environ Contam Toxicol 39:998-1005

IV. COST AND SCHEDULE OF IMPLEMENTATION

IVa. Budget Costs

The budgeted costs for this study are provided in the Cost Breakdown Table on the following page. The total cost for this study will be $142,308.00.

Subcontract Bid and Evaluation Process - The analytical chemistry work component of this study will need to be contracted. We propose to use the same contract lab as is currently being used by the San Francisco Estuary Regional Monitoring Program for this work.

IVb. Schedule Milestones

It is anticipated that this study will take 12 months to complete. The following Schedule Milestones are identified, by task, for this study (schedule assumes funding will be available by October 1997):

1. Review of information regarding discharge of drainwater	November - December 1997
2. Collection of test organisms and maintenance of lab cultures	December 1997 - October 1998
3. Performance of bioaccumulation tests	January - November 1998
4. Reporting of Results	December 1998

IVc. Third Party Impacts

No Third Party Impacts are anticipated for this study.

I-005248

CALFED Category III - Cost Breakdown for Selenium Bioaccumulation Study					
Task	Direct Labor Hours	Direct Salary & Benefits	Labor Overhead	Miscellaneous & Other Direct Costs	Total Cost
Collection and Maintenence of Test organisms	Technician - 80 hrs	$ 14.85	$ 12.15		$ 2,160.00
	Scientist - 100 hrs	$ 22.00	$ 18.00		$ 4,000.00
	Sr Scientist - 20 hrs	$ 33.00	$ 27.00		$ 1,200.00
	Study Director - 8 hrs	$ 44.00	$ 36.00		$ 640.00
				Contract Services - (Boat/Equipment Rental)	$ 2,000.00
Collection of Site Waters	Technician - 24 hrs	$ 14.85	$ 12.15		$ 648.00
	Scientist - 192 hrs	$ 22.00	$ 18.00		$ 7,680.00
	Sr. Scientist - 0 hrs	$ 33.00	$ 27.00		
	Study Director - 12 hrs	$ 44.00	$ 36.00		$ 960.00
				Mileage (@ $0.31/mi) - 9,600 miles	$ 2,976.00
Performance of Bioaccumulation Tests	Technician - 112 hrs	$ 14.85	$ 12.15		$ 3,024.00
	Scientist - 1,100 hrs	$ 22.00	$ 18.00		$ 44,000.00
	Sr. Scientist - 192 hrs	$ 33.00	$ 27.00		$ 11,520.00
	Study Director - 40 hrs	$ 44.00	$ 36.00		$ 3,200.00
				Miscellaneous Lab Supplies (glassware, chemicals)	$ 2,400.00
				Contract Services - (chemical analyses)	$ 51,500.00
Preparation of Reports	Sr. Scientist - 20 hrs	$ 33.00	$ 27.00		$1,200.00
	Study Director - 40 hrs	$ 44.00	$ 36.00		$ 3,200.00
TOTAL COSTS					**$ 142,308.00**

RICHARD SCOTT OGLE, Ph.D.

Expertise: For over ten years, Dr. Scott Ogle has been directing and/or participating in research in the areas of aquatic ecotoxicology and environmental chemistry. A major area of Dr. Ogle's past research efforts has focused on factors affecting toxicity and bioaccumulation of selenium in aquatic systems, and have established him as an expert in this field. Current research activities include evaluation of the fate and effects of petroleum and petroleum products in the aquatic environment and the investigation of contaminants and toxicity in non-point source and stormwater runoff. Dr. Ogle has directed and participated in numerous projects encompassing all of the standardized EPA and ASTM test procedures as well as projects involving research and development of new testing procedures.

Education: Ph.D. Ecology (Aquatic Ecotoxicology), 1996 , University of California, Davis, CA; M.S. Water Science (Water Pollution Biology), 1988, University of California, Davis, CA; B.S. Fisheries Biology (Water Quality), 1984, Humboldt State University, Arcata, CA

Professional Affiliations/Honors: Society of Environmental Toxicology and Chemistry (SETAC), 1989-1990 SETAC Pre-Doctoral Fellow; Northern California Regional Chapter of SETAC (NorCal SETAC), Meeting Chair for the First, Second and Third Annual NorCal SETAC Conferences, NorCal SETAC Vice-President (1990-1993), Secretary (1993-1994); Ecological Society of America; American Fisheries Society; American Association for the Advancement of Science

Employment: 1994-Present, Principal & Lab Director, Pacific Eco-Risk Labs, Martinez, CA; 1991-1994, Senior Scientist, S.R. Hansen & Associates, Concord, CA; 1991, Teaching Assistant (Fish Physiology), University of California, Davis; 1986-1991, Research Assistant, University of California, Davis; 1985, Biological Aide, US Fish & Wildlife Service, Dixon, CA.

Representative Publications (15+ peer-reviewed publications/50+ technical reports):

- Ogle RS, Cotsifas JS (in preparation) The role of ammonia in the toxicity of estuarine/marine sediments.
- Ogle RS, Cotsifas JS (in preparation) The comparative toxicity of oil and oil products (gasolineand fuel oil) to crustaceans.
- Ogle RS, Knight AW (in review) Selenium in aquatic ecosystems. 3. The roles of waterborne uptake and foodborne uptake in the bioaccumulation of selenate and selenite by fathead minnows and bluegill.
- Ogle, R.S and A.W. Knight. 1996. Selenium in aquatic ecosystems. 1. Effects of sulfate on selenate uptake and toxicity in *Daphnia magna*. Archives of Environmental Contamination and Toxicology 30(2):274-279.
- Saiki, M.K. and R.S. Ogle. 1995. Effects of agricultural drainwater on mosquitofish reproduction from contaminated and control field sites. Transactions American Fisheries Society 124:578-587.
- Ogle, R.S. and A.W. Knight. 1989. The effects of elevated dietary selenium on growth and reproduction of the fathead minnow (*Pimephales promelas*). Archives of Environmental Contamination and Toxicology 18(6):795-805.
- Ogle, R.S., K.J. Maier, P. Kiffney, M.J. Williams, A. Brasher, L.A. Melton, and A.W. Knight. 1988. Bioaccumulation of selenium in aquatic ecosystems. Lake and Reservoir Management 4(2):165-173.

Presentations: Dr. Ogle has presented his research in over 20 presentations at Regional, National, and International Scientific Conferences.

JEFFREY SCOTT COTSIFAS

Expertise: For over seven years, Jeffrey Cotsifas has been conducting research and testing in the areas of aquatic ecotoxicology and environmental chemistry. Jeff's current research interests are in the development and implementation of surface water and sediment porewater toxicity identification/ reduction evaluation (TI/RE) methods using resident aquatic organisms. Jeff is also actively investigating the fate and effects of petroleum and petroleum products in the aquatic environment. Jeff has been very involved in the development of sediment porewater TI/RE guidelines for the San Francisco Bay System as well as evaluating the application of TI/RE methods to stormwater discharges. Jeff is also chair of the Northern California Toxicity Assessment Group (NCTAG) Methods & QA/QC Committee.

Education: M.S. Environmental Management -waterquality (coursework completed),University of San Francisco, San Francisco, CA; B.A. Environmental Studies (Natural Resource Mgt., Marine Biology), 1991,University of California, Santa Barbara, Santa Barbara, CA

Employment 1994 - Present, Principal and Lab Manager, Pacific Eco-Risk Laboratories, Martinez, CA; 1991-1994 Senior Scientist, S.R. Hansen & Associates, Concord, CA

Professional Affiliations: Society of Environmental Toxicology and Chemistry (SETAC); Northern California SETAC; Northern California Toxicity Assessment Group (Committee Chair); International Society for Ecological Economics; Sustainable Futures Society

Representative Publications

Cotsifas JS, Ogle RS (in preparation) Salinity tolerance of the aquatic oligochaete *Lumbriculus variegatus*, and the effects of salinity and hardness on metal toxicity.

Ogle RS, Cotsifas JS (in preparation) The role of ammonia in the toxicity of estuarine/marine sediments.

Ogle RS, Cotsifas JS (in preparation) The comparative toxicity of oil and oil products (gasolineand fuel oil) to crustaceans.

Representative Presentations

Ogle RS, Cotsifas JS, Barron M, Ricker R, Dugan J (1997) Evaluation of crude oil Water Accommodated Fraction toxicity to marine and estuarine crustaceans. Presented at the NorCal SETAC Seventh Annual Meeting, San Francisco, CA, June 2, 1997.

Ogle RS and JS Cotsifas (1997) Ambient water toxicity in San Francisco Bay. Presented at the San Francisco Estuary Regional Monitoring Program Conference, Oakland, CA. February 13, 1997.

Ogle, R.S., J.S. Cotsifas, V. Connor, and C. Foe. 1995. A preliminary survey of sediment toxicity in California's Central Valley. Presented at: NorCal SETAC 5th Annual Meeting, Santa Cruz, CA, Jul 13, 1995.

Ogle, R.S., J.S. Cotsifas, and S.R. Hansen. 1994. Ammonia and sediment toxicity. Presented at the Society of Environmental Toxicology and Chemistry 15th Annual Meeting, Denver, CO. Oct 30- Nov. 3, 1994.

Cotsifas, J.S., R.S. Ogle, an S.R. Hansen. 1993. Salinity tolerance of the freshwater sediment test oligochaete *Lumbriculus variegatus* and the effects of salinity on the toxicity of Cu, Cd, and Cr. Presented at the Society of Environmental Toxicology and Chemistry 14th Annual Meeting, Houston, TX, Nov. 14-18, 1993.

Ogle, R.S., S.R. Hansen, J.S. Cotsifas, and G.G. Wortham. 1993. Selenium bioaccumulation by the clam *Potamocorbula amurensis* in the San Francisco Bay system. Presented at the Society of Environmental Toxicology and Chemistry 14th Annual Meeting, Houston, TX, Nov. 14-18, 1993.

VI. COMPLIANCE WITH TERMS AND CONDITIONS

The terms and conditions provided in Appendix D of the CALFED 1997 Category III Request for Proposals are agreeable to and can be complied with by the Principal Investigator of this project.

As per RFP requirements (Table D-1: Standard contract clauses and related proposal submittal requirements), a copy of Item 8, Statement of Non-Discrimination Compliance, and a copy of item 12, Certification of Small Business Status, are attached. Item 2, Standard Clauses - Service and Consultant Service Contracts for $5,000 & Over With Non-Public Entities, will be provided before or at signing of Final Contract.

Item 8

NONDISCRIMINATION COMPLIANCE STATEMENT

COMPANY NAME: Pacific Eco-Risk Laboratories

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, disability (including HIV and AIDS), medical condition (cancer), age, marital status, denial of family and medical care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME: Richard Scott Ogle

DATE EXECUTED: July 25, 1997

EXECUTED IN THE COUNTY OF: Contra Costa

PROSPECTIVE CONTRACTOR'S SIGNATURE: Richard Scott Ogle

PROSPECTIVE CONTRACTOR'S TITLE: Lab Director

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME: Richard Scott Ogle, Principal & General Partner of Pacific Eco-Risk Laboratories

I-005253

Item 12

Agreement No. _____

Exhibit _____

STANDARD CLAUSES --
SMALL BUSINESS PREFERENCE AND CONTRACTOR IDENTIFICATION NUMBER

NOTICE TO ALL BIDDERS:

Section 14835, et. seq. of the California Government Code requires that a five percent preference be given to bidders who qualify as a small business. The rules and regulations of this law, including the definition of a small business for the delivery of service, are contained in Title 2, California Code of Regulations, Section 1896, et. seq. A copy of the regulations is available upon request. Questions regarding the preference approval process should be directed to the Office of Small and Minority Business at (916) 322-5060. To claim the small business preference, you must submit a copy of your certification approval letter with your bid.

Are you claiming preference as a small business?

X Yes* _____ No

*Attach a copy of your certification approval letter.