5,21 90K FI-201

Executive Summary

Project Title: **Selenium and mercury risk to California Clapper Rails in Saline Emergent Wetlands of the Northern portions of San Francisco Bay - establishing risk thresholds in sediment for North Bay restoration projects to assist recovery of California Clapper Rails.**

Applicant Name: Dr. Steven Schwarzbach, U.S. Fish and Wildlife Service

Project Description:
This proposed project would investigate selenium and mercury interaction potential with regard to Clapper rail nest success, and the potential for selenium modification of bioaccumulation factors for mercury in benthic rail prey and in fail to hatch clapper rail eggs in the north bay. Comparisons will be made with previous toxic threshold estimates for mercury in the south bay. A secondary objective will be to evaluate the selenium and mercury status of fail to hatch rail eggs in selected marshes of the north bay and estimate what contribution these contaminants might make to clapper rail nest failure in the north bay.

Approach/Tasks/Schedule
The approach will be to assess clapper rail nest success in three to five north bay marshes. Total selenium and total and methyl mercury will be analyzed in sediment and benthic biota samples as well as failed eggs of rails. Concentrations of both selenium and mercury in the failed eggs will be compared with concentrations found in Heinz and Hoffman's 1997 feeding study with mercury and Selenium. Dietary concentrations of selenium and mercury will be compared with observed bioaccumulation of mercury in south bay samples where selenium is found at lower concentrations to examine the effect of elevated selenium on mercury bioaccumulation factors. Known low effect concentrations in avian diets and avian eggs will be used in combination with bioaccumulation factors in the north bay to estimate toxic risk thresholds in sediment. The project should be completed in one field season with a final report completed 6 months after receipt of the analytical data. The target date for completion of a final Report is June 1999.

Project Justification
Most of the desirable tidal marsh restoration alternatives currently exist within the north bay. South bay populations have been documented to be contaminated with mercury and a fraction of rail reproduction (between 24% and 38%) potentially lost to mercury. North bay restoration alternatives, to be successful in recovering the clapper rail, will need to have sediment concentrations of selenium and mercury which can sustain rail reproduction.

Budget
The project seeks CalFed funding for 86 biologist days to conduct nest searches, collect sediment and benthic biota samples, process and ship samples, coordinate with other field investigations and to prepare a report of results on mercury and selenium status of rails in the north bay as well as develop north bay toxic threshold estimates for sediment concentrations of mercury, methyl mercury and selenium. Biologist day costs requested are $43,258. Funds for analytical chemistry for methyl mercury, total mercury and selenium as well as metal scans with ICP-MS is requested in the amount of $44,800. Other costs are $1,550. The total CalFed funding request is $89,608.

Applicant Qualifications

The principle investigator, S.E. Schwarzbach earned a doctorate degree from UC Davis in Ecology in 1989, where he specialized in avian wildlife toxicology. He currently serves as the chief of the Environmental Contaminants Division of the Sacramento Field Office, USFWS. He has designed and directed numerous multi disciplinary field studies of environmental contaminant impacts to fish and wildlife in California including studies in the Klamath Basin, Sacramento Valley, Tulare Basin, San Luis Refuge Complex, and intertidal marshes of San Francisco Bay. Contaminant studies in which Dr. Schwarzbach has been involved have focused on mercury, selenium, organophosphate pesticides, aquatic herbicides, organochlorines, trifluoracetic acid, acid mine drainage, ammonia, and eutrophication effects upon water quality. Dr. Schwarzbach supervises a staff of 10 permanent biologists and administers a 1.4 million dollar annual budget. His personal scientific interests have most recently been particularly focused on mercury and selenium effects upon reproduction of birds of the San Joaquin Valley and San Francisco Bay. He is also currently a co-investigator of mercury impacts to birds and amphibians in the Cache Creek Drainage.

Monitoring and data evaluation

This project will coordinate with another ongoing project in saline emergent habitats at the eastern edge of the north bay. This other project, conducted by LBL (Angus McGrath), examines sediment fluxes of contaminants and the relationship of those fluxes to sediment dynamics and microbial methylation of mercury within sediment. These factors will be studied in a marsh which in recent years has been occupied by clapper rails. This project will determine performance measures which future projects may utilize. By coordinating with LBL more detailed understanding of toxic thresholds for clapper rails in marsh sediments will be possible. This project will also compare results with previous studies of rail success and mercury status in 1991, 1992 and 1994 in the south bay. The project will utilize two different methodologies (egg/sediment ratios and target diet) to estimate toxic thresholds for mercury and selenium and will compare the two methods.

Compatability with CALFED objectives

This project focuses on on non-flow related factors of water quality impacts to high risk species (California clapper rail) and habitats (Saline emergent marsh remnants in the north bay). These impacts although not "flow related" are influenced by flow and are potentially influenced by CALFED alternatives which may alter the pathway by which San Joaquin water reaches San Francisco bay and thereby may alter the loading of selenium to the bay. Currently most San Joaquin River water is exported south and does not reach the bay except at very high flows. Products from this project will help assess mercury and selenium status of remnant rails on the eastern edge of the north bay and will assist in establishing guidelines for sediment in future restorations of saline emergent marsh in the north bay. Providing clear indications of risk can reduce uncertainty and thereby reduce conflict and contribute to implementability of projects with broad ecosystem benefits.

Selenium and mercury risk to California Clapper Rails in Saline Emergent Wetlands of the Northern portions of San Francisco Bay- establishing risk thresholds in sediment for North Bay restoration projects to assist recovery of California Clapper Rails.

by
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Type of Organization: Federal Agency

RFP Project Group type: Other Services

III. Project Description

a. Project description and approach

This proposed project would investigate selenium and mercury interaction potential with regard to Clapper rail nest success, and the potential for selenium modification of bioaccumulation factors for mercury in benthic rail prey and in fail to hatch clapper rail eggs in the north bay. Comparisons will be made with previous toxic threshold estimates for mercury in the south bay. A secondary objective will be to evaluate the selenium and mercury status of fail to hatch rail eggs in selected marshes of the north bay and estimate what contribution these contaminants might make to clapper rail nest failure in the north bay.

The approach will be to assess clapper rail nest success in three to five north bay marshes. Total selenium and total and methyl mercury will be analyzed in sediment and benthic biota samples as well as failed eggs of rails. Concentrations of both selenium and mercury in the failed eggs will be compared with concentrations found in Heinz and Hoffman's 1997 feeding study with mercury and Selenium. Dietary concentrations of selenium and mercury will be compared with observed bioaccumulation of mercury in south bay samples where selenium is found at lower concentrations to examine the effect of elevated selenium on mercury bioaccumulation factors. This is of significance because avian embryos do not benefit from joint exposure to mercury and selenium. The toxicity is additive and the effect of one is to increase the concentration of the other in the avian egg (Heinz and Hoffman, 1997).

A seasonal component that evaluates wet and dry season concentrations in sediment and benthic biota will also be a part of the study. The significance is that a previous south bay investigation in Alviso Slough indicated methyl mercury concentrations increased by a factor of 20 in sediment from January to April. Assistance from the Lawrence Berkeley Laboratory will be provided to assess the relative importance of sediment hydrodynamics versus microbial methylation in this seasonal sediment increase, if indeed it occurs in the north bay. This is important to assess when estimating toxic thresholds of mercury in sediment to the rail and for evaluating wetland restoration alternatives that may help recover the rail. Selenium will also be evaluated for seasonal fluctuations in sediment as well.

b. Location and Geographic boundaries

The project will focus on saline emergent wetlands occupied by California clapper rails in the north bay in the vicinity of current refinery discharges between Martinez and Richmond. Comparisons will be made with previously collected data in tidal marshes occupied by California clapper rails in the south bay.

c. Expected Benefits

Clapper rail toxic threshold estimates for total and methyl mercury in sediment have been developed based upon south bay mercury concentrations in fail to hatch rail eggs, and synoptically collected sediment and invertebrate prey. Mercury data in rail eggs from the north bay is extremely limited and no mercury or selenium data in rails exists after 1986. In the only study of randomly collected clapper rail eggs, Lonzarich e t al. (1992) found that both mercury and selenium were higher in the north bay in 1986 than in the south bay. Mercury concentrations in other media (sediment, prey, water) are higher in the south bay. Selenium discharges to the north bay could significantly increase the bioaccumulation factors for mercury and mercury may also increase bioaccumulation factors for selenium. Luoma and Linville have reported in the recently issued 1995 annual report of the Regional Monitoring Program for the San Francisco Estuary that concentrations of selenium in resident north bay bivalves have tripled above the historically elevated concentrations. While selenium may be protective of mercury toxicity at low concentrations the potential to enhance storage of mercury in avian tissues and to increase toxicity of mercury in avian feeding studies to embryos has been recently documented at the Patuxent Wildlife Research Center (Heinz and Hoffman, 1996).

Most of the desirable tidal marsh restoration alternatives currently exist within the north bay. South bay populations have been documented to be contaminated with mercury and a fraction of rail reproduction (between 24% and 38%) potentially lost to mercury. North bay restoration alternatives, to be successful in recovering the clapper rail, will need to have sediment concentrations of selenium and mercury which can sustain rail reproduction. This project will attempt to quantify what those sediment concentrations are and what processes effect them by assessing the north bay mix of selenium and mercury exposures and how they vary with space and time while simultaneously assessing the mercury and selenium status in clapper rail prey and fail to hatch eggs..

d. Background and Biological/Technical Justification

Previous work by the Fish and Wildlife Service has identified mercury as the pollutant of greatest concern to rails. Some rail eggs have been found to contain elevated concentrations of mercury. Among avian species sampled in San Francisco Bay, rail eggs are among the most contaminated sampled with a maximum fresh wet weight concentration of 2.57 mg/kg found in one south-bay egg and south-bay marsh means in 1992 ranged from 0.399 to 0.829 mg/kg fww total mercury (T-Hg) and 24 % to 38% of assessable eggs were classified as non-viable (Schwarzbach, 1993). Reproduction in birds has been found to be sensitive to elevated mercury concentrations in eggs in both laboratory and field investigations with a threshold for impaired hatchability occurring between 0 .5 and 1.5 mg/kg (fww) (Fimreite, 1971).

Heinz and Hoffman (1997) have recently shown additive toxicity of mercury and selenium to the avian embryo with storage of each element in the adult liver and the egg enhanced by the presence of the other in the diet at elevated concentrations. North San Francisco Bay is one of the rare sites in North America where there is bulk contamination of an ecosystem by both elements. There are two sources of selenium to the north bay: Riverine inputs of selenate dominated agricultural drainwater and oil refinery discharge dominated by the selenite form of selenium. Selenium is found in high concentrations in San Joaquin Valley Crude oil. Five refineries which use this oil discharge effluent in the range of 400 to 700 ppb, exceeding EPA chronic criteria by two orders of magnitude. Selenium in the selenite form dominates refinery inputs to the bay. Selenite has a high affinity for sorption onto clay edges and iron oxides (Cutter, 1990), thus sediment dynamics of selenium will be important in the inter-tidal marsh fate of refinery effluent selenium. Likewise intertidal marsh surficial sediment has been shown to be the site of greater and more persistent methyl mercury formation (Olson and Cooper, 1976). The avian egg has been frequently used as a monitoring tool for evaluating bioavailability and ecological risk from mercury because mercury is dose dependently transferred to the egg and to a large degree reflects egg mercury reflects local exposure. Within the San Francisco Bay region the highest concentrations of mercury in bird eggs yet found were in fail-to-hatch eggs of California clapper rail (*Rallus longirostris obsoletus*) in the south bay in 1992. Among randomly sampled eggs the highest concentrations found were in eggs of caspian terns (*Sterna caspia*) from Calaveras Point (1989), black-necked stilts (*Himantopus mexicanus)* from Hayward Marsh (1994), and clapper rails in the northern reaches of San Francisco Bay (1986) (Schwarzbach, Hothem and Ohlendorf, 1997). The highest selenium in clapper rails was also found in the northern portion of the Bay. Rails while challenging to work with are the most important and appropriate avian species for evaluation of mercury and selenium risks in the north bay because of their non-migratory nature, their benthic foraging niche, their precarious population status and recovery needs for clean marsh habitat, and their previously documented mercury contamination.

e. Proposed Scope of work

Task 1. Sediment collection

Bed Sediment from the top 4 cm will be collected as described in Schwarzbach et al (1997). Bed Sediment from slough bottoms will be analyzed for percent moisture, total selenium, total mercury, methyl mercury and percent organic carbon.

Sediment traps and erosion pins will be deployed to study sediment dynamics at one north bay location. Sediments from traps are weighed to determine a net sedimentation rate and analyzed to determine the percentage of organic particulates and analyzed for methyl and total mercury and total selenium. This work will be done by a companion proposal

submitted by LBL (Angus McGrath).

Benthic Biota collection
Benthic biota will be collected and preserved as described in Schwarzbach et al (1997). Target biota will include bivalves, crabs and mud snails. Biota and sediment will be collected in close proximity.

Task 2. Rail Nest Surveys

California clapper rails are known to nest from as early as mid march to as late as July (Harvey 1988). Biologists from the Sacramento Field Office will conduct nest searches for California clapper rail nests within the tidal marsh at five north Bay marshes in the spring as soon as permits are secured. Site locations tentatively include South Hampton Bay which we hypothesize to be among the most contaminated, Wildcat Creek where the highest selenium value yet found in a rail egg was found in 1986 and Corte Madera, perhaps the best rail habitat left in the North Bay. Two other sites occupied by rails will be selected as well. Nest searches will be conducted at low tide on foot by biologists experienced in finding rail nests. Any nests found will be flagged (at distance), recorded with a GPS unit and marked on a map. Eggs in the nest will be candled and candling of each egg recorded on videotape. Each egg will be labeled with pencil to allow the fate of individual eggs to be followed. The initial nest visit will not exceed 20 minutes. Based upon candling a date of hatch and pip will be estimated. A return to the nest will be scheduled for a day after the projected hatch date. Eggs will be recandled and status estimated. Any eggs still alive will be left to continue incubation. If and when it is determined that eggs will not hatch, fail to hatch eggs will be collected for assessment of embryo development and chemical analysis to determine concentrations of selenium and mercury. It is anticipated that likely no more than ten nests are will be found and evaluated.

Analytical chemistry (task 1 and 2)

Analytical chemistry on Rail eggs and benthic biota and sediment samples collected by FWS will be performed by the Trace Element Research Laboratory at Texas A&M University under contracts held by the Fish and Wildlife Service for analytical chemistry services. Additional sediment samples from at least one tidal marsh, most likely South Hampton Bay, will also be evaluated in more detail by the Earth Sciences Division of Lawrence Berkeley National Laboratory, depending upon their funding status. This will allow a comparison of methods for sediment between laboratories and help assess the validity of LBL protocols for use in interpreting FWS sediment collections over the last 6 years in the south bay. Total and methyl mercury results will be obtained for all biota and sediment samples as will total selenium percent moisture and total organic carbon for the sediment samples.

Task 3: Data Analysis and Report Preparation

Geometric means will be determined for selenium, total mercury and methyl mercury for each taxa group of benthic prey, surficial sediment and fail to hatch rail eggs for each marsh sampled. Ratios of methyl mercury in egg to breeding season sediments for each marsh to will be calculated and compared with winter ratios. A multifactor analysis will be used to assess the impact of selenium on mercury bioaccumulation ratios in both rail eggs and prey. Toxic thresholds will be estimated for mercury and selenium using two methods - an egg/sediment ratio method and a dietary model as done previously for south bay marshes. Results in the north bay will be compared with the south bay. Seasonal comparisons will be made with regard to variation in benthic prey and sediment and examined for the extent to which biota track changes in sediment. This latter analysis will be done in conjunction with LBLs more detailed assessment of sediments and pore water fluxes at South Hampton Bay.

IV. Costs and Schedule

Fall 97:	State and federal permits for clapper rail will be obtained/renewed. Access to potential study sites will be obtained. Site selections finalized.
January 98	First round of sediment and benthic biota sampling commences.
Early March 98:	Nest Searches for clapper rails begin and continue monthly at five north bay sites. Nest visits once nests are found occur again at projected hatch date and perhaps one intervening visit to candle and remove failed eggs.
April 98:	Second round of sediment and benthic biota sampling occurs.
July 98:	Third round of sediment and benthic biota sampling occurs.
August 98:	All Samples have been submitted for analysis.
January 99:	Analysis of Chemical Data - Coordination of interpretation of data by LBL and FWS on rail status, sediment toxic thresholds, and sediment dynamics.
June 99:	Draft Report completed for review/publication with an evaluation of rails

Table 1. Project Cost Request Summarized by Task.

Project Phase and Task	**Biologist day costs***	**Analytical Services Contract**	**Publication costs**	**Miscellaneous and other Direct Costs****	**Total Cost**
Task 1 CalFed; no O&M	$16,599	$39,550		$800	$56,949
Task 2 CalFed; no O&M	$12,575	$5,250		$250	$18,075
Task 3 CalFed; no O&M	$14,084		$500		$14,584
Total	43,258	$44,800	$500	$1,050	$89,608

*Sacramento Field Office Environmental Contaminants Division biologist day costs @$503/day includes all travel, training, leave, benefits and office overhead per biologist day.

**Costs include dry ice, disposable clean sample containers, and shipping costs.

V. **Applicant Qualifications**

Dr. Steven Schwarzbach U.S. Fish and Wildlife Service.

The principle investigator, S.E. Schwarzbach earned a doctorate degree from UC Davis in Ecology in 1989, where he specialized in avian wildlife toxicology. He currently serves as the chief of the Environmental Contaminants Division of the Sacramento Field Office, USFWS. He has designed and directed numerous multidisciplinary field studies of environmental contaminant impacts to fish and wildlife in California including studies in the Klamath Basin, Sacramento Valley, Tulare Basin, San Luis Refuge Complex, and intertidal marshes of San Francisco Bay. Contaminant studies in which Dr. Schwarzbach has been involved have focused on mercury, selenium, organophosphate pesticides, aquatic herbicides, organochlorines, trifluoracetic acid, acid mine drainage, ammonia, and eutrophication effects upon water quality. Dr. Schwarzbach supervises a staff of 10 permanent biologists and administers a 1.4 million dollar annual budget. His personal scientific interests have most recently been particularly focused on mercury and selenium effects upon reproduction of birds of the San Joaquin Valley and San Francisco Bay. He is also currently a co-investigator of mercury impacts to birds and amphibians in the Cache Creek Drainage.

Selected Publications/Posters/Presentations of S.E. Schwarzbach

Assessing Risk from Methyl-mercury in tidal marsh sediments to reproduction of California clapper rails in south San Franciso Bay using threshold diet and threshold egg concentration approaches. Schwarzbach SE, Henderson J, and JD Albertson. Draft Manuscript submitted to Environmental Toxicology and Chemistry, (in reveiw). Poster presentation at 17th annual meeting of Society of Environmental Toxicology and Chemistry, Nov. 1996 Washington DC.

CFC Alternatives Under A Cloud. Schwarzbach S.E., 1995. Nature, 376: 297-298, 27 July, 1995.

Incidental Kill of Dunlin and Killdeer by Strychnine. Warnock, N. and Schwarzbach S.E., 1995. Journ. of Wildl. Dis. 31(4):566-569.

Mercury in California Clapper Rail Eggs, Invertebrate prey and sediments form tidal Wetlands in south San Franciso Bay. Schwarzbach SE, Albertson J, Roster D., 1993.Platform presentation at Society of Environmental Toxicology and Analytical Chemistry, November, 1993.

Organochlorines in Waterbird Eggs from Klamath and Sacramento Wildlife Refuges. Schwarzbach SE, 1992. SETAC poster presentation, November 1992.

***Reconnaissance Investigation* of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Sacramento National Wildlife Refuge Complex, California, 1988-89.** Dileanis P.D., Sorenson S., Schwarzbach S.E., Maurer T.C., 1992. US Geological Survey, Water Resources Investigations Report 90-4203 report 79 pp.

Organochlorines in eggs of three species of Waterbirds at Colusa NWR: effects on productivity and nest success. Schwarzbach S.E. and Berendzen S., April 1992. Presentation at Sacramento NWR conference on integrated waterbird management.

Mercury in Biota and Sediments from Creeks and Sloughs of South San Francisco Bay. Schwarzbach, S.E., and Palawski, K., Novenber 1991. Poster presentation at society of Environmental Toxicology and Chemistry for presentation

at 12th annual meeting, Seattle Wash Nov. 1991.

The role of Dicofol Metabolites in the Eggshell thinning response of Ring Doves. S.E. Schwarzbach. Arch. Environ. Contam. Toxicol.20, 200-205 (1991).

Metabolism and storage of p,p' dicofol in american Kestrels (Falco sparverius): Comparisons with Ring Neck Doves (Streptopelia risoria) S.E. Schwarzbach, D Michael Fry, B.E. rosson, David M. Bird. arch. Environ. Contam. toxicol. 20, 206-210 (1991).

Metabolite porfiles in tissues of American Kestrels and Ring Neck Doves Fed p,p' Dicofol: Relationship to Shell Thinning and Species Sensitivity . S.E. Schwarzbach, , D.M. Fry, B. Narloch, B.E. Rosson, D.M. Bird. Platform Presentation at Society of Environmental Toxicology and Chemistry for presentation at 9th annual meeting, Wash DC Nov. 1988.

A Reconnnaisance Investigation of the Impacts of Irrigtion Drainwater for Management of Wildlife Habitat in the Klamath Basin. Sorenson s., schwarzbach S/E/ 1991 [USGS publication # ....]

Disposition of ^{14}C Ring Labeled Dicofol in Breeding ring Doves. B Narloch, S.E. Schwarzbach, L. Shull. Poster presentation at Northern Ca. Chapter Meetinf of SOT , May 1988 Sf Ca.

Eggshell Thinning in Ring Doves Exposed to p,p' Dicofol. S.E. Schwarzbach, L. Shull, C.R. Grau. Arch. Environ. *Contam. toxicol.* 17, 219-227 (1988)

***Effects of p,p' Dicofol upon reproduction in ring* Doves.** S.E. Schwarzbach, L. Shull, C.R. Grau. Presentation at society of Environmental Toxicology and Chemistry (SETAC) 7th annual meeting Washington D.C. Nov. 1986.

Hematological effects of Bunker C oil on Common Murres. D.M. Fry, L. Addiego, S.E. Schwarzbach, C.R. Grau. Pacific Seabird Group Bull 13:28 (*1986*)

VI. Compliance with Standard Terms and Conditions.

The applicant is a representative of a federal agency, the U.S. Fish and Wildlife Service. The Fish and Wildlife Service agrees to comply with terms and conditions to the extent allowed by federal law. It is the applicant's understanding from table D of the RFP that no supplemental forms are required of federal agencies at the time of proposal submittal.

Key References pertinent to this proposal:

Cutter, G.A., and San Diego-McGlone, M.L.C. (1990): Temporal variability of Selenium fluxes in San Francisco Bay., Sci. Total Environ. 97/98, 235.

Harvey T., 1988. Breeding biology of the Calif. clapper rail in south San Francisco Bay. Trans. West. Sect. Wildl. Soc. 24:98-104.

Heinz G.H. and D. J. Hoffman, 1997. Combined Effects of Mercury and Selenium on Mallard Reproduction. Platform presentation 17th annual meeting of the Society of Env. Tox. And Chem. Nov. 17-21, 1996, Washington D.C.

Lonzarich, D.G., T.E. Harvey and **J.E. Takekawa**. 1992. Trace element and organochlorine concentrations in California clapper rail (*Rallus longirostris obsoletus*) eggs. *Arch. Environ. Contam. Toxicol.* **23**:147-153.

Luoma Samuel N. and Regina Linville, 1997. A Comparison of Selenium and Mercury Concentrations in Transplanted and Resident Bivalves from North San Francisco Bay. In the 1995 Regional Monitoring Program annual Report Pp. 160-175.

Olson, B.H. and **R.C. Cooper.** 1976. Comparison of aerobic and anaerobic methylation of mercuric chloride by San Francisco Bay sediments. *Water Research* **10**:113-116.

Schwarzbach S., Henderson J., and J.D. Albertson, 1997. Two estimates of Toxic thresholds of methyl mercury in sediment to reproduction of Calif. Clapper rails. Submitted to Env. Tox. And Chem. 2/97 (in review).

Schwarzbach S. Hothem R. and H. Ohlendorf, 1997. Mercury in avian eggs from San Francisco Bay: A review and comparison with Central Valley cohorts. Abstract submitted to SETAC for 18th Annual meeting to be held in San Francisco Calif. Nov. 1997.

USFWS, 1997. Draft Report: *Effects of Dredging Activity at Cargill's A7 Dredge Lock on Mercury Risk to California Clapper Rails*. March 1997,

Zawislanski, P.T. and A.B. Crawley, 1997. Selenium Cycling Study in the San Francisco Bay: A partnership Involving Federal and State Government and Industry. SPE37885. 8pp.