california water impact network

California Sportfishing Protection Alliance

"An Advocate for Fisheries, Habitat and Water Quality"

AQUALLIANCE
DEFENDING NORTHERN CALIFORNIA WATERS

April 22, 2011

Erin Foresman
US Environmental Protection Agency
75 Hawthorne Street
San Francisco, CA 94105.

Submitted via email to:
foresman.erin@epa.gov

Subject: docket EPA-R09-OW-2010-0976, Advanced Notice of Proposed Rulemaking for Water Quality in the San Francisco Bay-Delta Estuary

Dear Ms. Foresman:

Thank you for the opportunity to comments on USEPA's Advanced Notice of Proposed Rulemaking (ANPR) for the Bay-Delta Estuary. The ANPR solicits public input on how EPA and the State of California can achieve water quality and aquatic resource protection goals in the Bay Delta Estuary and how to best use Clean Water Act programs to improve Delta water quality.

A broad range of pollutants as well as water withdrawals affect water quality and aquatic resources in the Bay-Delta. Water from the Sacramento River is relatively clean compared to the waters of the San Joaquin River that are heavily polluted with salts, selenium, boron, nutrients and other contaminants. Any diversion of Sacramento River water around the Delta through an isolated facility will increase the concentration and residence time of pollutants in the Bay-Delta estuary from the San Joaquin River and other sources. Elimination of dilution and an increase in the residence time of a wide range of pollutants will worsen water quality problems. Therefore any alternative conveyance around the Delta that reduces the amount of Sacramento River water in the Bay-Delta estuary will exacerbate existing water quality problems and result in greater violations of existing water quality standards and criteria, furthering the decline of the overall ecosystem.

We have specific comments and recommendations below on how USEPA and the State of California can achieve water quality and aquatic resource protection goals in one of the West Coast's most ecologically diverse and important aquatic habitats.

Selenium

This metallic pollutant is pervasive throughout the Bay-Delta estuary, with the main sources being roughly equal between oil refineries and agricultural pollution from the western San Joaquin Valley. A major source of agricultural selenium in the estuary is agriculture in the western San Joaquin Valley from irrigation as well as from periodic storm runoff from those same areas that generate large pulse loadings of selenium in the sloughs and river channel of the San Joaquin.

Such uncontrolled discharges and overland flow from watershed areas in the coast range upslope (west) of the San Luis Unit of the CVP carry significant loads of selenium that bioaccumulate and contribute to selenium loading of the San Joaquin River and Bay-Delta estuary. Bioaccumulation mobilizes and propagates selenium's toxicity into the food webs of the river and the estuary. Both USEPA and California have the authority to require NPDES permits for additional stormwater discharges that are currently not directly regulated under the Clean Water Act by using their residual designation authority. EPA and/or California may require a permit for an unregulated stormwater discharge if it determines that either (1) stormwater controls are needed for the discharge based on waste load allocations that are part of total maximum daily loads that address the pollutant(s) of concern; or (2) the discharge or category of discharges within a geographic area contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. In the absence of action by California, USEPA should issue NPDES permits for western San Joaquin Valley watersheds contributing to stormwater selenium loading of the San Joaquin River and the Bay-Delta.

While the San Joaquin River downstream of the Merced River has been delisted as water quality impaired because of dilution water from the Merced River, selenium contamination continues to drain into the Bay-Delta with predictable results. The Clean Water Act Section 303(d) list of water quality limited stream segments lists 41,736 acres in the Delta, 5,657 acres in the Carquinez Straights, 70,992 acres in San Francisco Bay Central, 9,024 acres in San Francisco Bay south and 68,349 acres in San Pablo Bay as impaired by selenium.[1] Agriculture is a major source of those water quality impairments. Health advisories are in effect for scaup, scoter and benthic feeding ducks in many of those areas.

A study by the U.S. Fish and Wildlife Service[2] for USEPA identified that several bird species protected under the Migratory Bird Treaty Act are considered "species most at risk" from selenium contamination in the San Francisco Bay. Greater scaup, lesser scaup, black scoter, white-winged scoter, surf scoter and bald eagle are listed as

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[1] http://www.waterboards.ca.gov/water_issues/programs/tmdl/docs/303dlists2006/epa/state_usepa_combined.pdf

[2] http://www.swrcb.ca.gov/rwqcb2/water_issues/programs/TMDLs/northsfbayselenium/Species_at_risk_FINAL.pdf, accessed 4/20/11.

"species most at risk" from selenium contamination and all are covered by the Migratory Bird Treaty Act. By allowing continued discharges of selenium in excess of Basin Plan objectives from the Grasslands Bypass Project, there is downstream contamination and selenium bioaccumulation in the Bay-Delta, and increasing likelihood of MBTA violations by the United States.

In 2009, the U.S. Fish and Wildlife Service recommended to USEPA an avian egg selenium standard of 5 mg/kg for the Great Salt Lake in order to comply with the Migratory Bird Treaty Act.[3] Biological indicators of selenium contamination are much better than weekly of monthly water samples that can mask short-term spikes and variations in selenium loads. In the words of the U.S. Fish and Wildlife Service, "Avian and Fish Production are two of the most sensitive endpoints for selenium." It would therefore be appropriate for USEPA to develop, recommend and adopt selenium avian and fish egg criteria for the Bay-Delta ecosystem.

In addition, the existing selenium water quality objectives are not protective of aquatic species. That fact was recognized by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service in their 2000 joint Biological Opinion for the California Toxics Rule Biological Opinion (p 9-10)[4] which required that USEPA perform the following actions related to selenium:

1. EPA will revise its recommended 304(a) acute and chronic aquatic life criteria for selenium by January 2002.

2. EPA will propose revised acute and chronic aquatic life criteria for selenium in California by January of 2003.

Both of those requirements are **years overdue** and there is no firm timeline for completion of either action. The selenium water quality objectives in the San Joaquin River upstream of the Merced River and in Mud Slough have been **waived for nearly a quarter of a century** and are exceeded regularly because of the Grasslands Bypass Project and unregulated discharges. Removal of a significant amount of clean water from the Sacramento River through a Peripheral Canal or Tunnel will only increase selenium residence time and species exposure in the Bay-Delta, resulting in further species declines.

Furthermore, according to information obtained by C-WIN from William Beckon of the U.S. Fish and Wildlife Service, the existing selenium 5 µg/l Basin Plan Water Quality objective for moving waters will result in a mortality rate of between 10 and 20% for juvenile salmonids.[5] Weekly selenium measurements in the San Joaquin River at Hills

[3] http://www.c-win.org/webfm_send/142, accessed 4/20/11.
[4] http://www.c-win.org/webfm_send/40, accessed 4/20/11.
[5] E-mail from William Beckon to Tom Stokely, October 4, 2010. Attachment 1.

Ferry from August 2009 to January 2010 averaged 15.765 µg/l with one measurement at 52 µg/l. Clearly, even if selenium water quality objectives at Hills Ferry are being met, there is still a significant risk to salmonids. Green Sturgeon are also at risk from selenium downstream in the Bay-Delta estuary.

USGS Professional Paper 1210[6] states "*Land retirement is a key strategy to reduce drainage because it can effectively reduce drainage to zero if all drainage-impaired lands are retired*." The Bureau of Reclamation, in its San Luis Feature Re-evaluation EIS economic analysis[7] concluded that retirement of drainage problem lands in the San Luis Unit is the most cost effective solution. The Environmental Working Group has identified an additional $10 million/year in crop subsidies to those drainage problem lands in Westlands[8]. USEPA should encourage retirement of drainage problem lands in the Western San Joaquin Valley as a means of reducing pollution, saving taxpayer funds and reducing water demand from the Delta.

Selenium Recommendations:

1. USEPA should revise its recommended 304(a) acute and chronic aquatic life criteria for selenium per the California Toxics Rule Biological Opinion by the end of 2011.
2. USEPA should propose and implement revised acute and chronic aquatic life criteria for selenium in California per the California Toxics Rule Biological Opinion by the end of 2011.
3. USEPA should develop, propose, and implement avian and fish egg selenium criteria for the Bay-Delta ecosystem.
4. USEPA should implement biological selenium monitoring programs for avian and fish eggs, as well as other species.
5. USEPA should encourage the State of California to issue NPDES permits for western San Joaquin Valley watersheds causing uncontrolled wet weather selenium discharges, or in the absence of state action, USEPA should issue the NPDES permits by mid 2012.
6. USEPA should encourage retirement of drainage problem lands in the Western San Joaquin Valley as a means of reducing pollution, saving taxpayer funds, and reducing exported water demand from the Delta. Such action would be consistent with the recent state mandate for all regions to reduce their reliance on Delta exports.

[6] http://pubs.usgs.gov/of/2008/1210/, accessed 4/21/11.
[7] http://www.usbr.gov/mp/nepa/documentShow.cfm?Doc_ID=2240, accessed 4/21/11.
[8] http://ewg.org/Throwing-Good-Money-at-Bad-Land, accessed 4/20/11.

Nutrients

In addition to selenium, salt and boron discharges from the Grasslands area, G. Fred Lee and Associates[9] disclosed that summer/fall 2000 and 2001 studies found that Mud and Salt Sloughs and the San Joaquin River upstream of Lander Avenue watersheds are the primary sources of nutrients and algae/oxygen demand that lead to the dissolved oxygen problem in the Stockton Deepwater Ship Channel. It is possible that these nutrients are also leading to blue green algae (*Microcystis aeruginosa*) outbreaks in the Delta.

Nutrient Recommendation:

USEPA should do whatever it can within its regulatory, fiscal and scientific resources to significantly reduce nutrient discharges from the western San Joaquin Valley into the San Joaquin River and Bay-Delta estuary. Implementation of the selenium recommendations above would concurrently lead to a reduction in nutrients in the San Joaquin River and Bay-Delta. Failure to reduce this pollution will continue to contaminate the Bay-Delta estuary. Failure to reduce the pollution combined with a significant reduction in freshwater from the Sacramento River through construction and operation of a Peripheral Canal/Tunnel will be catastrophic for the Bay-Delta estuary.

Fish Migration/Delta Salinity

Lack of adequate protection for the Bay-Delta by California in the early 1990's resulted in USEPA promulgating its own water quality objectives for the Bay-Delta estuary which included salinity standards and standards for the percentage of surviving outmigrating salmon smolts.

Recommendation:

USEPA should review its earlier Bay-Delta water quality objectives and in the absence of enforcement by California regulators or California's promulgation of less protective water quality objectives, USEPA should reclaim Clean Water Act jurisdiction for the Bay-Delta.

Additional Information:

We include incorporate a copy of a February 11, 2011 letter from our organizations to the National Research Council with an annotated bibliography of related information on anadromous fish survival associated with San Joaquin River tributaries, Delta water quality, climate trends in the Feather River region and selenium bioaccumulation and other research.

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[9] http://www.gfredlee.com/SynthesisRpt3-21-03.pdf, accessed 4/20/11.

Thank you for the opportunity to comment on USEPA's Advanced Notice of Proposed Rulemaking. We look forward to your response.

Sincerely,

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Attachments

E-mail from William Beckon to Tom Stokely, October 4, 2010.
C-WIN, CSPA and AquAlliance Letter to Laura Helsabeck, National Research Council, February 11, 2011

Attachment 1

Tom Stokely

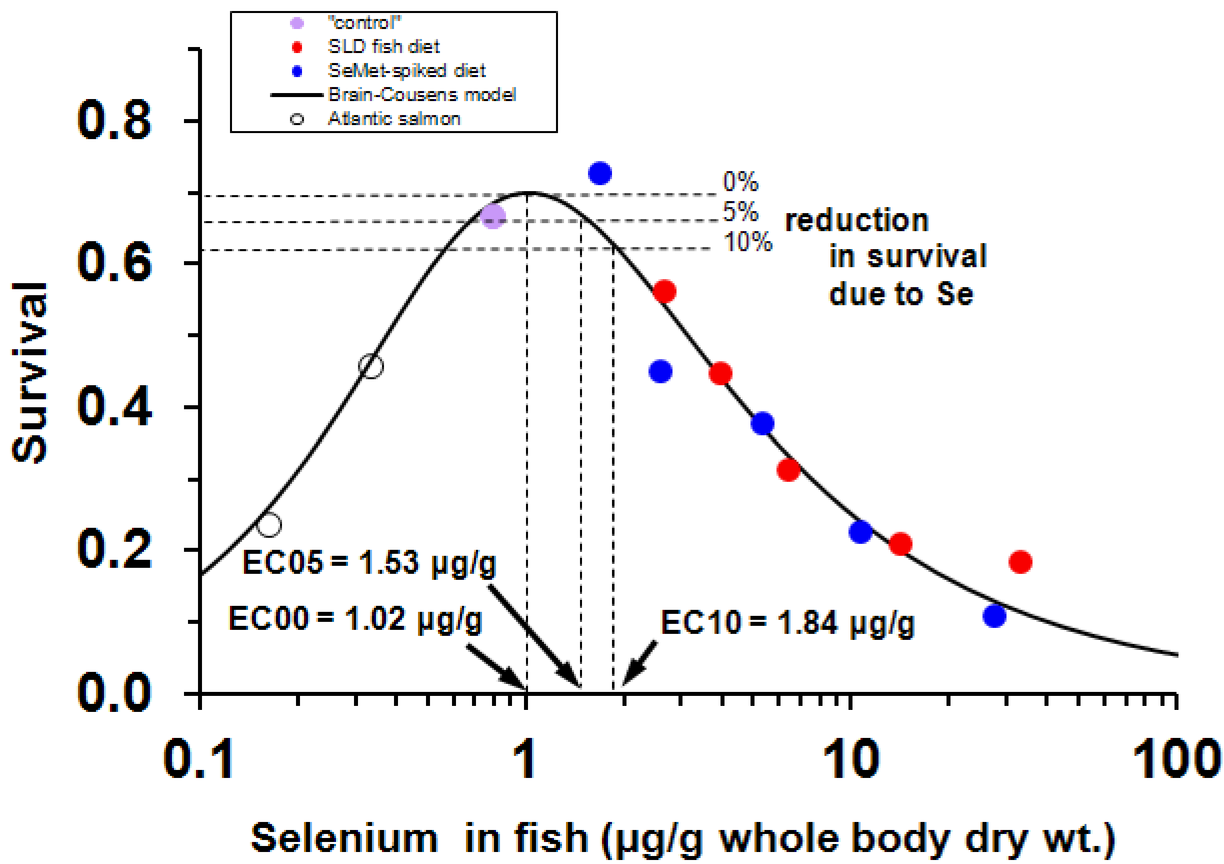
From: <William_Beckon@fws.gov>
To: "Tom Stokely" <tstokely@att.net>
Cc: <Thomas_Maurer@fws.gov>
Sent: Monday, October 04, 2010 3:16 PM
Subject: Re: What are salmonid mortality levels for Se in water column above 20% mortality?

Tom,

Here's a table for up to 60% mortality due to selenium. Higher mortality than that corresponds to environmentally unrealistic selenium concentrations in water.

Mortality	Tissue selenium	Water selenium
Percent	µg/g whole body dry wt.	µg/L
5%	1.531	1.92
10%	1.844	3.31
20%	2.486	7.98
30%	3.273	17.92
40%	4.336	41.01
50%	5.901	101.57
60%	8.447	291.87

These data are based on the following relationship and on Mike Saiki's data for juvenile salmon bioaccumulation in the SJ River. Depending on what model you use, and how you round off, you get slight variations from these numbers.



Thank you for your interest. If you have any further questions, please ask.

Bill

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"Tom Stokely" <tstokely@att.net>

28.09.2010 17:01

Please respond to
"Tom Stokely" <tstokely@att.net>

To <William_Beckon@fws.gov>

cc "Dennis Lemly" <dlemly@fs.fed.us>

Subject What are salmonid mortality levels for Se in water column above 20% mortality?

Mr. Beckon,

The attached graph (10%-20%toxicity of selenium...pdf) is from a PowerPoint you gave at the CALFED Science Conference in 2008. It shows toxicity levels of selenium in the water column at Hills Ferry at 10% (3.2 ppb) and 20% (7.6 ppb). (Please verify my numbers in parentheses.)

What is the mortality/water column toxicity at 30%, 40%, 50%, 60%, 70%, 80% and 90%? In other words, what water column levels of Se cause those mortality rates?

Numbers at Hills Ferry averaged over 15.6 ppb from Aug 11, 2009 to Jan 20, 2010. Once it was 52 ppb.

Since Jan 2005 (taken from attached excel file), the weekly samples were as follows:
40 times above 5 ppb
19 times above 10 ppb
9 times above 20 ppb
2 times above 50 ppb

Obviously, I'd like to know what these numbers mean to juvenile salmon and steelhead. It may be in one of your reports, but I'm not smart enough to figure it out.

Sincerely,

Tom Stokely
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tstokely@att.net
http://www.c-win.org/[attachment "Selenium in lower SJR WY1997-2010.xlsm" deleted by William Beckon/SAC/R1/FWS/DOI] [attachment "10%- 20% toxicityofSeleniumtoSalmonids.pdf" deleted by William Beckon/SAC/R1/FWS/DOI] [attachment "SJR selenium violations Aug 2009-2010- Hills Ferry, Table 18.pdf" deleted by William Beckon/SAC/R1/FWS/DOI]

Attachment 2

california water impact network

California Sportfishing Protection Alliance

"An Advocate for Fisheries, Habitat and Water Quality"

AQUALLIANCE
DEFENDING NORTHERN CALIFORNIA WATERS

February 11, 2011

Laura Helsabeck, Associate Staff Officer
Water Science and Technology Board
National Research Council
500 Fifth Street, NW
Washington DC 20001

Subject: **Additional California Delta Research Materials for Consideration by the Committee on Sustainable Water and Environmental Management in the California Bay-Delta**

Dear Ms. Helsabeck:

Thank you for encouraging Tim Stroshane of the California Water Impact Network to submit additional research materials about the California Bay-Delta that we believe are important for the Committee on Sustainable Environmental and Water Management in California's Bay-Delta to consider in their present deliberations. It is our understanding that submission of these materials is still timely with regard to the Committee's schedule for producing its final report on the Delta this coming November 2011.

We also understand that the Committee keeps a public file of documents that have been submitted, along with the transmittals of parties accompanying these documents. We would like our materials to be included there if deemed appropriate.

The California Water Impact Network, the California Sportfishing Protection Alliance, and AquAlliance have identified research materials in the following areas:

- Anadromous fish survival associated with San Joaquin River tributaries
- Delta water quality
- Climate trends in the Feather River region
- Selenium bioaccumulation and other research

We attach an annotated bibliography of these materials to facilitate both staff and committee members' review of these items.

In addition, following on Tim Stroshane's remarks to the Committee in San Francisco on December 8, 2010, we include a copy of a letter put together by members of the Environmental Water Caucus of California. The letter outlines a nonstructural alternative for environmental review by the Delta Stewardship Council, as the Council moves forward with its efforts to craft its state-mandated Delta Plan by 2012. This nonstructural alternative would emphasize source control of stressors that now affect Delta beneficial uses, as well as conservation and water use efficiency measures. There are 30 NGO signatories to this letter, a formidable consensus, including several of the NGOs who have been active with the Bay Delta Conservation Plan.

In addition, C-WIN, CSPA, and AquAlliance wish to make the National Research Council aware of the suit we filed with the Center for Biological Diversity and two Delta-based water agencies to overturn the "Monterey amendments" to State Water Project water service contracts. We recently submitted an informational letter about this to the Delta Stewardship Council, also in connection with the Delta Plan. We provide it as an attachment for your attention as well.

Again, thank you for the opportunity to communicate these research materials and the Environmental Water Caucus letter to staff and the Committee. If you or others associated with the Committee have further questions, please do not hesitate to contact any of us, or Tim Stroshane of C-WIN. He can be reached at (510) 524-6313 or via email at Tim.Stroshane@c-win.org.

Sincerely,

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Attachments

Annotated Bibliography of Materials Submitted

Anadromous Fish Studies

Mesick, C. 2005. Recommended Streamflow Schedules To Meet the AFRP Doubling Goal in the San Joaquin River Basin. Prepared for the US Fish and Wildlife Service Anadromous Fish Restoration Program.

Mesick, C. 2010a. Instream Flow Recommendations For The Stanislaus, Tuolumne, And Merced Rivers To Maintain The Viability Of The Fall-Run Chinook Salmon Populations. Prepared for the California Sportfishing Protection Alliance. February 14.

> Here Mesick provides instream flow recommendations specific to the Stanislaus, Tuolumne, and Merced rivers by water year type as inflow to the mainstem San Joaquin River, updating the flow schedules he drew up for the Fish and Wildlife Service in 2005.

Mesick, C. 2010b. Comments on The Draft Technical Report On The Scientific Basis For Alternative San Joaquin River Flow And Southern Delta Salinity Objectives. Delivered on behalf of the California Sportfishing Protection Alliance to the State Water Resources Control Board, December 3.

> The most important flows from streams tributary to the San Joaquin River are in the late winter through early spring period, and if flows need to be reduced for alternatives development by the State Water Resources Control Board, then it can be most safely done with respect to salmon outmigration in the months of May and June. In addition, in the fall, pulse flows and Delta export rates should be managed to protect salmon, particularly when escapement numbers are low. Dr. Mesick also recommends flow management procedures for dry and critically dry years when salmon escapement numbers are low, while also balancing base flow releases to provide minimally required habitat for spawning and egg incubation in all years for spring flows and fall pulse flows.

Mesick, C. 2009. The High Risk of Extinction for the Natural Fall-Run Chinook Salmon Population in the Lower Tuolumne River due to Insufficient Instream Flow Releases. September 4.

Mesick, C. 2010c. The High Risk of Extinction for the Natural Fall-Run Chinook Salmon Population in the Lower Merced River due to Insufficient Instream Flow Releases. Prepared for the California Sportfishing Protection Alliance. November 30.

> Dr. Mesick's two studies find that declines in escapement for the salmon populations on these rivers is due to inadequate minimum instream flow releases from La Grange and Crocker-Huffman dams in late winter and spring during non-flood years when daily maximum water temperatures exceed the USEPA temperature threshold of 59 degrees F for smoltification. Fish that fail to outmigrate typically die from warming waters and disease in these rivers. These studies include extensive supporting databases.

Delta Water Quality

Lee, G.F. 2003. Update on the Understanding of the Low- DO Problem in the San Joaquin River's Deep Water Ship Channel. IEP Newsletter 16(3): 12-15. Summer.

> DWR and USBR South Delta export pumping plants impact the flow of San Joaquin (SJR) and Sacramento River water into the Delta and through the Delta channels. Flow manipulations from those projects adversely impact water quality in the Delta. Alterations of SJR flow through the Deep Water Ship Channel (DWSC) result from the export pump operations that contribute to low-DO conditions in channel near the Port ofStockton. Low-DO conditions, in turn, lead to blockage of the migration of fall-run Chinook salmon to their home stream for spawning in the SJR tributaries upstream of the DWSC. In addition, low DO in the DWSC near the Port of Stockton also adversely affects aquatic life resources of the DWSC and other areas of the Delta.

Lee, G.F., Jones-Lee, A. 2004. Overview of Sacrament-San Joaquin River Delta Water Quality Issues. 157 pages.

> This report surveys what is known and not known in a variety of water quality areas for the Delta estuary, including nutrient loading, pesticides, toxic contaminants, and salinity problems.

Lee, G.F., Jones-Lee, A. 2010. Comments on Water Quality Issues Associated with SWRCB's Developing Flow Criteria for Protection of the Public Trust Aquatic Life Resources of the Delta. February 11, 2010.

Climate Change Research

Freeman, G. J. 2008. Runoff Impacts of Climate Change on Northern California's Watersheds as Influenced by Geology and Elevation—A Mountain Hydroelectric System Perspective. Paper presented at Western Snow Conference, 2008.

> Northern California watersheds from Lake Almanor north are primarily characterized by porous volcanic basalt rock flows with several large springs that provide a large sustained base flow component into the McCloud, Pit and North Fork Feather Rivers. Relatively low overall elevation sets these watersheds apart as some of the first watersheds in California anticipated to be affected from climate-induced change to snowpack.

Freeman, G.J. 2009. The Hydrology of Climate Change on Battle Creek and the North Fork Feather River. Presentation at Lassen Volcanic National Park Headquarters, Mineral, CA. July 21.

> In this presentation, Freeman indicates that a possible change in snowpack occurred about the mid-late 1970s. Average snowfall at stations indicate overall decreasing snowpack, and full natural flow data reveals increasing average runoff during March, indicating earlier melting periods.

Freeman, G.J. 2010. Tracking the Impact of Climate Change on Central and Northern California's Spring Snowmelt Subbasin Runoff. Paper presented at Western Snow Conference, 2010.

> Orographically influenced subbasins in northern California were least impacted from effects of climate change, while those areas that were either in a rain shadow or were behind topographic barriers revealed larger climate change impacts like reduced snowpack, spring runoff, and sometimes runoff for the water year.

Selenium-Related Research

Beckon, W. 2008. Toxicity of Selenium to Salmonids. U. S. Fish and Wildlife Service, Sacramento, CA. Presented at CalFed Bay-Delta Science Conference, Sacramento, CA, October 24.

> Selenium discharges into the San Joaquin River from the Grasslands Bypass Project killed about 25 percent of the juvenile salmon and steelhead in the San Joaquin River in the 1980s and GBP selenium discharges are estimated to kill still more than 10 percent of juvenile salmon and steelhead presently.

Beckon, W., T.C. Maurer. 2008. Potential Effects Of Selenium Contamination On Federally-Listed Species Resulting From Delivery Of Federal Water To The San Luis Unit. U.S. Fish and Wildlife Service Sacramento Fish and Wildlife, Office Environmental Contaminants Division, Sacramento, CA, for the U. S. Bureau of Reclamation Under Agreement # 05AA210003, March 2008.

> Selenium discharges from the San Luis Unit of the Central Valley Project into the San Joaquin River and Bay-Delta a significant mortality risk to a number of species listed under the Endangered Species Act or protected by the Migratory Bird Treaty Act. These include but are not limited to Green Sturgeon, Chinook salmon, Central Valley Steelhead, Giant Garter Snake and California Clapper Rail.

Kaufman, R.C., A.G. Houck, and J.J. Cech. 2008. Effects of Dietary Selenium and Methylmercury on Green and White Sturgeon Bioenergetics in Response to Changed Environmental Conditions. Presentation at CalFED Bay-Delta Science Conference, October 23.

After dietary exposure to either selenomethionine or methylmercury for a 56-day growth period, the authors measured individual sturgeon's routine and active metabolic rates, swimming performance, and avoidance of a simulated predator. Green sturgeon were more sensitive to methylmercury and selenium than white sturgeon at levels currently found in the Delta. These results imply that, at levels currently found within the San Francisco Bay-Delta estuary, white sturgeon are not a suitable surrogate species for use in predicting effects of toxicants and environmental variability on green sturgeon bioenergetics, given their sensitivity to selenomethionine,. Moreover,.

Kleckner, A.E., A.R. Stewart, K. Elrick, S.N. Luoma. 2010. Selenium Concentrations and Stable Isotopic Compositions of Carbon and Nitrogen in the Benthic Clam *Corbula amurensis* from Northern San Francisco Bay, California: May 1995–February 2010. U.S. Geological Survey. Open-File Report 2010–1252.

The clam-based food webs of San Francisco Bay, California efficiently bioaccumulate selenium and provide pathways for exposure to predators important to the estuary. This study documents changes in monthly selenium concentrations for the clam *Corbula amurensis*, a keystone species of the estuary, at five locations in northern San Francisco Bay from 1995 through 2010. Samples were collected from designated U.S. Geological Survey stations and prepared and analyzed by U.S.G.S. methods. Stable isotopes of carbon and nitrogen in soft tissues of clams also were measured as an indicator of sources of selenium for the clams. Clam selenium concentrations ranged from a low of 2 to a high of 22 micrograms per gram dry weight with strong spatial and seasonal variation over the period of study.

Lemly, A.D., J.P. Skorupa. 2007. Technical Issues Affecting the Implementation of US Environmental Protection Agency's Proposed Fish Tissue– Based Aquatic Criterion for Selenium. Integrated Environmental Assessment and Management — Volume 3, Number 4—pp. 552–558.

The US Environmental Protection Agency is developing a national water quality criterion for selenium that is based on concentrations of the element in fish tissue. Although this approach offers advantages over the current water-based regulations, it also presents new challenges with respect to implementation. A comprehensive protocol that answers to "what, where, and when" is essential with the new tissue-based approach in order to ensure proper acquisition of data that apply to the criterion.

Linville, R.G., S.N. Luoma, L. Cutter, G.A. Cutter. 2002. Increased selenium threat as a result of invasion of the exotic bivalve *Potamocorbula amurensis* into the San Francisco Bay-Delta. Aquatic Toxicology 57 (2002) 51–64.

Following aggressive invasion of bivalve, *Potamocorbula amurensis*, in the San Francisco Bay-Delta in 1986, selenium contamination in the benthic food web increased. Concentrations in this dominant (exotic) bivalve in North Bay were three times higher in 1995–1997 than in earlier studies, and 1990 concentrations in benthic predators (sturgeon and diving ducks) were also higher than in 1986. The contamination was widespread, varied seasonally and was greater in *P. amurensis* than in co-occurring and transplanted species.

Luoma, S.N., and Presser, T.S., Viewpoint; Emerging Opportunities in Management of Selenium Contamination: Environmental Science and Technology Publication Date (paper): Nov. 15, 2009. *43,* 8483–8487. http://wwwrcamnl.wr.usgs.gov/Selenium/Library_articles/luoma_presser_Nov15_2009_viewpoint_EST_final.pdf

Regulatory guidelines for selenium will differ greatly as long as different jurisdictions rely on upon different types of data. Traditional dissolved toxicity testing, dietary and/or reproductive toxicity testing, and field observations yield very different conclusions about selenium toxicity. Similarly, a lack of simple and direct linkage between dissolved Se and Se toxicity adds difficulty to evaluating risks from site to site. Unfortunately, no one universal concentration of dissolved Se can be predictive of toxicity across environments. But if selenium biogeo-chemical transformation is considered, and linked to trophic transfer through the food web, then uncertainties about toxicity and site-specificity can be greatly reduced. More importantly, simple models linking these factors allow new opportunities for evaluating choices of new guidelines.

Skorupa, J.P., T.S. Presser, S.J. Hamilton, A.D. Lemly, B. E. Sample. 2004, EPA's Draft Tissue-Based Selenium Criterion: A Technical Review, Presented to U.S. Environmental Protection Agency, June 16.

EPA last promulgated an updated chronic water column criterion for selenium 24 years ago, in 1987. EPA's current chronic water column criterion for selenium is 5 µg/L. Numerous researchers have estimated that the toxicity threshold for selenium lies below 5 µg/L. In addition, three independently conducted studies funded by EPA since 1987 also reached the same conclusion (24-26). This body of work was produced predominantly by the public-service scientific community (27). More recently, a notable counter consensus predominantly from the corporate-service scientific community has asserted that the current chronic criterion of 5 µg/L is overly restrictive.

Silvestre, F., J. Linares-Casenave, S.I. Doroshov, D. Kultz. 2010. A proteomic analysis of green and white sturgeon larvae exposed to heat stress and selenium. Science of the Total Environment 408 (16): 3176-3188.

Temperature and selenium are two environmental parameters that potentially affect reproduction and stock recruitment of sturgeon in the San Francisco Bay/Delta Estuary. To identify proteins whose expression is modified by these environmental stressors, we performed a proteomic analysis on larval green and white sturgeons exposed to 18 or 26 degrees C and micro-injected with Seleno-L-Methionine to reach 8 microgg(-)(1) selenium body burden, with L-Methionine as a control. Selenium and high temperature induced mortalities and abnormal morphologies in both species, with a higher mortality in green sturgeon.

Stewart, A.R., S.N. Luoma, C. Schlekat, M.A. Doblin, K.A. Hieb. 2004. Food Web Pathway Determines How Selenium Affects Aquatic Ecosystems: A San Francisco Bay Case Study. Environmental Science &. Technology 38, 4519-4526.

A combination of food web structure and the physiology of trace element accumulation explain why some species in San Francisco Bay are threatened by a relatively low level of selenium contamination and some are not. Bivalves and crustacean zooplankton form the base of two dominant food webs in estuaries. The dominant bivalve *Potamocorbula amurensis* has a 10-fold slower rate constant of loss for selenium than do common crustaceans such as copepods and the mysid *Neomysis mercedis* (rate constant of loss, ke) 0.025, 0.155, and 0.25 d-1, respectively). Much higher selenium concentrations resulted in bivalve than in the crustaceans. Stable isotope analyses show that this difference propagates up the respective food webs in San Francisco Bay. Several predators of bivalves have tissue concentrations of selenium that exceed thresholds thought to associate with teratogenesis or reproductive failure (liver Se >15 *í*g g-1 dry weight). Deformities typical of selenium-induced teratogenesis were observed in one of these species, Sacramento splittail.

U.S. Department of the Interior (U.S. Fish and Wildlife Service, Bureau of Reclamation, Geological Survey, Bureau of Indian Affairs), 1998, R.A. Engberg (ed), Guidelines for interpretation of the biological effects of Selected constituents in biota, water, and sediment: Selenium. National Irrigation Water Quality Program, USDOI, BOR, Denver, Colorado (http://www.usbr.gov/niwqp/guidelines/pdf/Selenium.pdf).

Based on known margins of safety between normal and toxic dietary exposures, selenium is more toxic than either arsenic or mercury. The known effects of selenium exposure to various classes of organisms is shown in table form.